Risk Analysis and Modeling to Improve Hydrogen Fuel Cell Vehicle Repair Garages

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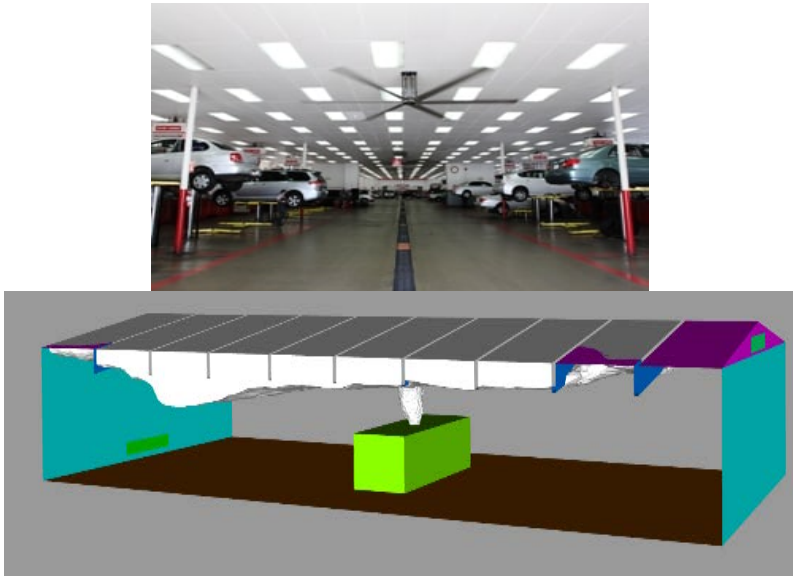

Project # h2011
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Overview

Timeline

- Project start date: April 2018 *
- Project end date: March 2019

**Anticipated project start date*

Barriers

A. Safety Data and Information: Limited Access and Availability
F. Enabling National and International Markets Requires Consistent RCS
G. Insufficient Technical Data to Revise Standards
L. Usage and Access Restrictions

Budget

- Total Project Value: $126k
  - Planned FY18 DOE Funding: $60k
  - Planned QAI Funding: $60k
  - QAI in-kind contributions: $6k

Partners

Quong and Associates, Inc.

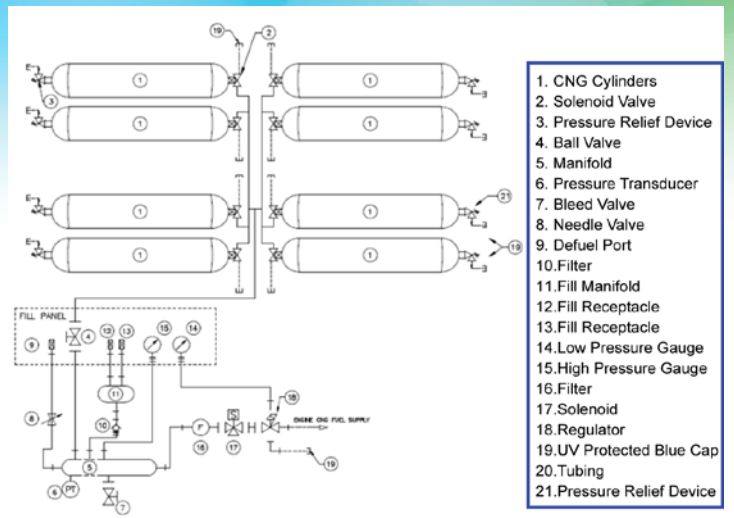
Relevance

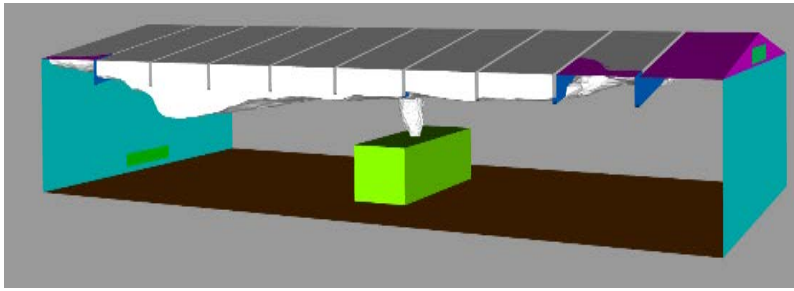
Objective: Perform application-specific risk analyses to identify credible hazard scenarios resulting in unintentional indoor releases of hydrogen during vehicle maintenance operations, characterize key hydrogen release scenarios through detailed modeling, and improve code requirements.

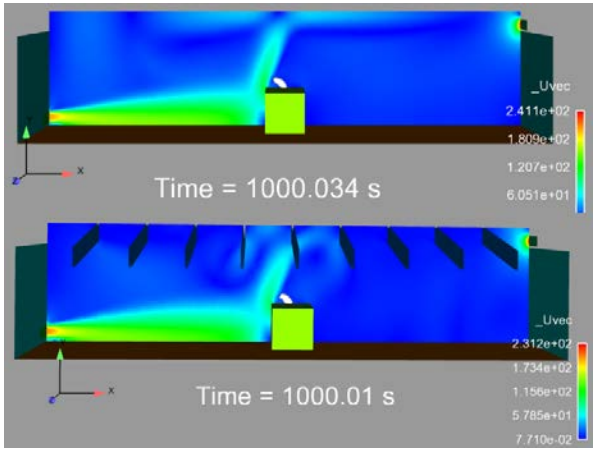
SCS MYRDD Barrier	SNL Goal
A. Safety Data and Information: Limited Access and Availability	Publish publicly-available report based on risk and modeling analyses
F. Enabling National and International Markets Requires Consistent RCS	Perform risk analyses and modeling which enable science-based code decisions
G. Insufficient Technical Data to Revise Standards	Perform detailed modeling for repair garage indoor releases to support code improvement
L. Usage and Access Restrictions	Focus risk and modeling analyses on risk scenarios specific to repair garages

Approach

- Risk Analysis
  - Repair garage application-specific risk assessment and credible scenario development
- Modeling
  - Computational fluid dynamics (CFD) modeling for indoor hydrogen releases
  - Based on identified scenarios from risk assessment
- Code Recommendations
  - Results of risk analyses and modeling will be incorporated into proposals to improve requirements for repair garages while maintaining same level of safety







Accomplishments and Progress

- CRADA documents negotiated and executed
- Project kick-off completed

Response to Last Year's Reviewer Comments

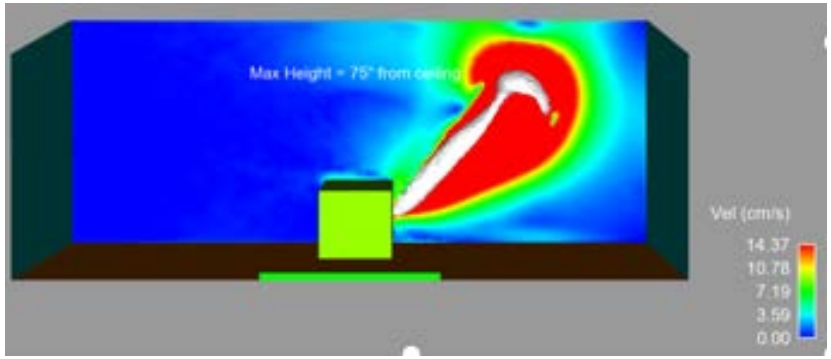
- This is a new project, and was not reviewed last year

Collaborations

- **Quong & Associates**
  - Provide expertise for scenario development for risk analysis
  - Aid in preparation of final report
  - Lead in preparing and submitting proposals to safety codes and standards

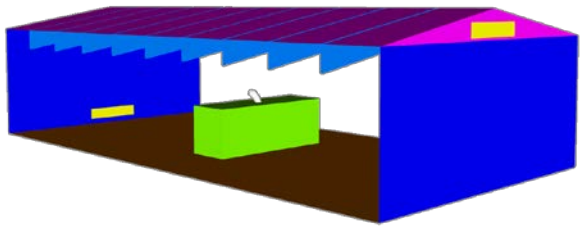
HAZOP Analysis: Indoor LNG and CNG Maintenance Activities in Major Repair Facilities

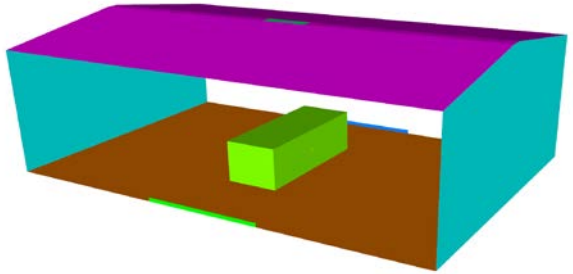
						Prevention Features			Mitigation Features	
HAZOP Number	Component	Operation State	Hazard Scenario	Causes	Consequences	Design	Administrative	Detection Method	Design	Administrative
1	LNG-1 (Overpressure regulator)	3in, 4, 7, 8	Leakage from regulator body	Seal failure, mechanical defect, damage, etc.	Minor leakage of GNG					
2	LNG-1 (Overpressure regulator)	3in, 4, 7, 8	Inadequate regulation of gas flow	Regulator failure	Overpressure of downstream components and potential GNG release					
3	LNG-1 (Overpressure regulator)	3in, 4, 7, 8	Inprocess leakage	Mechanical defect, damage, etc.	Potential minor release of GNG					
4	LNG-2 (Fuel Shutoff Valve	3in, 4, 5, 7	Valve fails to shut completely, or leaks	Failure of seals,spurious operation	Potential catastrophic release of GNG					
5	LNG-3 (Heat exchanger)	3in, 4, 5, 7	Leakage from heat exchanger	Leaks of LNG or GNG due to defective materials, corrosion, thermal fatigue, pressure rupture, etc.	Release of LNG or GNG					
6	LNG-4 (LNG tank)	3in, 4, 5, 7, 8	Overpressure of tank and failure of relief valve to open	Valve failure, insulation failure, excessive hold time	Rupture of tank and catastrophic release of LNG					
7	LNG-4 (LNG tank)	3in, 4, 5, 7, 8	Overpressure of tank and proper operation of relief valve	Excessive hold time, insulation failure	Minor release of GNG					
8	LNG-4 (LNG tank)	3in, 4, 5, 7, 8	Outlet or fitting on tank fails	Manufacturing defect or installation error	Potential catastrophic release of LNG					
9	LNG-4 (LNG tank)	3in, 4, 5, 7, 8	Leak of LNG into the interstitial space between inner and outer tanks	Internal corrosion of tank, fatigue failure	Insulation failure, warming, overpressurization of the outer tank and potential catastrophic release					



Remaining Challenges & Barriers

- Identification of risk-significant scenarios
  - Allow for modeling to be done only on critical release scenarios
- Identification of representative geometries
  - FCV, repair garage, ventilation
  - Necessary for detailed modeling to be generally applicable
- Incorporation of results into safety codes and standards
  - Results and recommendations need to be translated into improved code requirements that maintain same level of safety





Future Work

- Define key scenarios and risk analysis
  - Develop framework with input from QAI and industry for H_2 FCV scenarios
  - Leverage similar NGV risk assessment
- Model key scenarios
  - Create modeling meshes for critical geometries
  - Perform CFD simulations of various release scenarios in appropriate geometries, including ventilation
- Prepare codes and standards proposals
  - Identify requirements in NFPA 2, IFC, and NFPA 30A that should be modified, prepare proposals to do so (QAI lead)
- Prepare final report
- Potential future work
  - Perform similar analysis for parking garages, individual houses

Any proposed future work is subject to change based on funding levels

Summary

- **Relevance:**
  - Provide risk- and technical-basis for improvements to safety codes and standards requirements
- **Approach:**
  - Risk analysis will identify critical scenarios of concern, detailed modeling will characterize these scenarios and mitigations, which in turn will be used in proposals safety codes and standards improvements
- **Future Work**:
  - Define key scenarios and risk analysis
  - Model key scenarios
  - Prepare codes and standards proposals
  - Prepare final report