VIII.9 Hydrogen Contaminant Detector

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Overall Objectives

Ensure high quality fuel is dispensed to fuel cell electric vehicle (FCEV) customers for optimal fuel cell operation by testing for critical contaminants in the fuel before it is dispensed

Fiscal Year (FY) 2015 Objectives

- Define engineering requirements for an in-line hydrogen contaminant detector (HCD)
- Conduct a market survey of the current state of applicable technologies
- Provide a gap analysis that compares requirements to status of current technology

Technical Barriers

This project addresses the following technical barriers from the Safety Codes and Standards section of the Fuel Cell Technologies Office (FCTO) Multi-Year Research, Development, and Demonstration (MYRDD) Plan:

(A) Safety Data and Information: Limited Access and Availability

Contribution to Achievement of DOE Safety, Codes and Standards

This project contributes to achievement of the following DOE milestones from the Safety, Codes and Standards section of the FCTO MYRDD Plan:

- Milestone 3.2: Publish hydrogen quality testing protocols (4Q, 2015)

FY 2015 Accomplishments

- Completed set of engineering requirements for in-line HCD
- Completed market survey of potential HCD technologies
- Published report with engineering requirements, market survey, and gap analysis.

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INTRODUCTION

It is critical that stations deliver high purity hydrogen to FCEV customers to prevent negative impacts on the vehicles. The equipment along the production and dispensing pathway can affect the purity of automotive fuel cell-grade hydrogen. Potential contaminant sources include production equipment, transportation equipment, storage tanks, compressors, chillers, station piping, and dispensing hoses. Each of these sources can introduce different contaminants into the fuel stream. Each station may be subject to different contaminant sources, depending on the configuration and fuel source. Different types and concentrations of contaminants in the dispensed hydrogen have drastically different effects on fuel cell performance. While there may be individual contracts between gas suppliers and station owners, there is no overall agreement on who is responsible for fuel quality along the production-to-dispensing pathway. This combination of factors makes it challenging to guarantee high purity fuel will be dispensed to customers.

An in-line HCD would make it possible to detect contaminants in the fuel stream as or before they are dispensed to an FCEV customer, therefore limiting contamination to at most one FCEV. Currently there is no immediate solution available. Work from this task will be used to inform future efforts on the best path forward for developing and implementing an in-line HCD at commercial hydrogen stations in the near-term.

APPROACH

The list of contaminants and required levels of detection from SAE International (SAE) J2719 make the likelihood of a one size fits all solution infeasible. The first part of this task, which defined a reduced set of engineering requirements for an in-line HCD, considered common station configurations based on input from vehicle original equipment manufacturers, station operators, industrial gas companies, and government officials. The second part posed a survey to multiple gas analysis technology manufacturers inquiring about current technology and planned development. The final part of this task analyzed the gaps between what is needed for an in-line HCD and the current state of the market. A House of Quality diagram is provided comparing the most promising technologies with customer requests and engineering requirements.

RESULTS

The near-term engineering requirements, developed with input from a wide array of stakeholders, specify a device with capital and operating expenditures that amount to less than 1% of total station costs and are capable of detecting carbon monoxide, water, ammonia, and sulfur at one order of magnitude above SAE J2719 levels (ppbv–ppmv range). (It is impractical to expect a near-term HCD to be able to detect all contaminants listed in SAE J2719.) Device capital cost should be less than $5,000 at high volumes (>1,000 units), and annual operating costs should be less than $1,000. The device should be integrated just upstream of the dispenser to include the greatest possible number of contaminant sources. Because the pressure used in stations is as much as 900 bar, the HCD must employ a pressure reducer and slip stream for sampling. Gas analysis and reporting should occur within the time of a fill, and the results should indicate to a station operator whether the gas meets quality requirements. Routine maintenance and operation of the device should not require a highly specialized technician, and routine maintenance should not be required more frequently than every six months.

The market survey incorporated responses to an HCD survey developed for this project from 10 companies that manufacture analytical equipment with information from previous studies and international workshops related to hydrogen quality. Gas chromatography, mass spectrometry, Fourier transform infrared spectroscopy, non-dispersive infrared spectroscopy, laser absorption, continuous wave cavity ring-down spectroscopy, and concentrator technologies were investigated for detection abilities, cost, availability, and ambient and sampling requirements. Survey responses indicated that current technology is capable of detecting contaminants at lower levels than the requirements specified in SAE J2719. Capital costs ranged from $10,000 to $90,000, while operating costs ranged from $0 to $4,000. The required maintenance schedule varied from annual maintenance for the cavity ring-down technology to daily maintenance for the Fourier transform infrared technology. The cavity ring-down technology specified a sampling and analysis time of one second, which was the fastest response time identified in this survey. The concentrator coupled with mass spectrometry specified the longest response time at 15 minutes.

The gaps between what is currently available and what is required have been identified. As observed, no current technology meets all of the requirements defined here for an HCD. The largest gaps are costs, robustness, skill level needed to operate HCDs, and field validation. This is expected, as the need for such a device is evolving, and existing gas analysis technologies are generally designed for a laboratory setting that requires specially trained operators. Figure 1 gives a visual representation of the gap analysis.

Research into a promising nontraditional gas analysis technology is currently underway at Los Alamos National Laboratory, where an HCD based on a surrogate fuel cell is being developed. This device has the potential to indicate the presence of impurities in a hydrogen stream, but it is not yet ready for commercial deployment.

CONCLUSIONS AND FUTURE DIRECTIONS

- The market survey indicates that there is currently no commercial HCD solution that meets all of the engineering requirements.

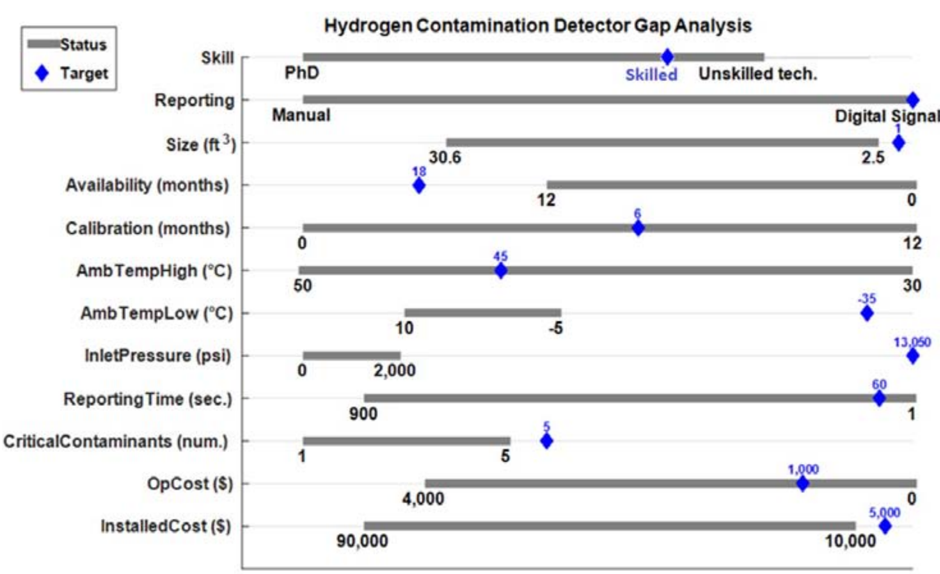

FIGURE 1. Hydrogen contaminant gap analysis with gray bars indicating the current state of the market and blue diamonds indicating engineering requirements

- The capital and operational costs of available analyzers are too high.
- Operation of the current technology is too sophisticated for operators of commercial hydrogen stations and not robust enough to handle the environment.

Hydrogen contaminant detection continues to be an issue of high importance. Plans for continuation of this task will likely involve the installation of new HCD technology in commercial hydrogen stations with the intent of gathering performance and cost data.

FY 2015 PUBLICATIONS/PRESENTATIONS

1. D. Terlip, S. McWhorter, B. Buttner and C. Ainscough, "H2FIRST –Hydrogen Contaminant Detector Task Project Deliverable 1," NREL TP 5400-64063, April 2015.

2. D. Terlip, S. McWhorter, B. Buttner and C. Ainscough, "Hydrogen Contaminant Detector," Presented at the Bi-Annual H2FIRST Coordination Panel Meeting, March 18, 2015.

3. D. Terlip, "Hydrogen Contaminant Detector Project Overview," presented at the California Fuel Cell Partnership Working Group Meeting, 18 September 2014.