

VII.C.3 Advanced Hydrogen Fueling Station Supply: Tube Trailers

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Contract Number: DE-EE0006524

Subcontractor:
Worthington Cylinder Corporation, Pomona, CA

Project Start Date: September 1, 2014
Project End Date: September 30, 2018

Overall Objectives

- Design, procure, construct, and demonstrate a U.S. Department of Transportation-approved composite tube trailer capable of 8,500 psi (586 bar) or higher delivery pressure. Increasing hydrogen delivery pressure to 8,500 psi or higher will increase the capacity of hydrogen deliveries, reduce the need for compression at hydrogen fueling stations, and reduce the overall hydrogen delivery cost.

Fiscal Year (FY) 2016 Objectives

- Develop a preliminary design for storage vessels with an operating pressure of 8,500 psi (586 bar) or higher.
- Conduct a feasibility analysis on the new storage vessel and tube trailer design.
- Pending the feasibility analysis, initiate the manufacture of prototype vessels and conduct performance testing to validate the engineering design.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan.

Hydrogen Delivery

- (A) Lack of Hydrogen/Carrier and Infrastructure Options Analysis

- (E) Gaseous Hydrogen Storage and Tube Trailer Delivery Costs

- (I) Other Fueling Site/Terminal Operations

- (K) Safety, Codes and Standards, Permitting

Technology Validation

- (D) Lack of Hydrogen Refueling Infrastructure Performance and Availability Data

Contribution to Achievement of DOE Hydrogen Delivery and Technology Validation Milestones

This project will contribute to achievement of the following DOE milestones from the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan.

Hydrogen Delivery

- Milestone 1.5: Coordinating with the H₂ Production and Storage programs, identify optimized delivery pathways that meet a H₂ delivery and dispensing cost of <\$2/gge for use in consumer vehicles. (4Q, 2020)
- Milestones 2.1 and 6.2: By 2015, reduce the cost of hydrogen delivery from the point of production to the point of use for emerging regional consumer and fleet vehicle markets to <\$4/gge. (4Q, 2015)
- Milestone 2.3: Verify 2020 targeted cost and performance for H₂ pressurization and/or containment technologies that minimize delivery pathway cost for long-term markets. (2Q, 2018)
- Milestones 2.4 and 6.3: By 2020, reduce the cost of hydrogen delivery from the point of production to the point of use in consumer vehicles to <\$2/gge. (4Q, 2020)

Technology Validation

- Milestone 3.8: Validate reduction of cost of transporting hydrogen from central production to refueling sites to <\$0.90/gge. (4Q, 2019)

FY 2016 Accomplishments

- Air Products established a tube trailer cost model to support conceptual vessel design(s) and trailer configuration(s).
- Work has begun with Worthington Cylinders in support of the project objective of increasing hydrogen delivery pressure to 8,500 psi (586 bar) or higher.

- Air Products is leveraging work outside of this project through commercialization of hydrogen distribution trailers with 7,500 psi (520 bar) operating pressure at hydrogen stations in California and Europe. This “Learning by Doing” serves as an important building block in further advancing lightweight composite tube trailers to the next level in this project.



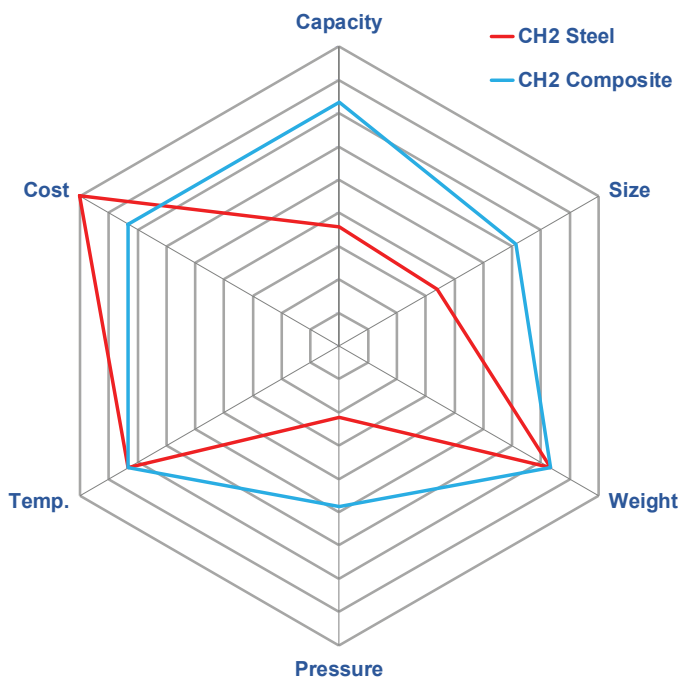
INTRODUCTION

Hydrogen delivery is a critical component to the cost, energy consumption, and environmental emissions associated with the market development of hydrogen infrastructure. Air Products and Chemicals, Inc. (Air Products) and Worthington Cylinder Corporation will develop and introduce a new composite over-wrapped pressure vessel that is safe, cost-effective, efficient, reliable, free of contaminants, and capable of being utilized for gaseous hydrogen tube trailer applications. High-pressure storage applied to hydrogen distribution can offer many advantages in serving the key hydrogen energy markets and lower hydrogen infrastructure costs. Supply systems can be deployed to provide a superior match of product supply to customer demand and growth, provide a higher level of reliability, reduce maintenance costs, and provide other business benefits.

APPROACH

To properly assess the benefits of the Advanced Hydrogen Fueling Station Supply, a preliminary techno-economics analysis of new tube trailer designs will first be conducted. The analysis will benchmark the new tube trailer design to current high-pressure hydrogen tube trailers with design criteria and constraints (Figure 1) in the areas of (1) capacity, (2) size, (3) weight, (4) pressure, (5) temperature, and (6) costs. The techno-economic analysis must prove the technical and cost viability of $\geq 8,500$ psi (586 bar) hydrogen storage tubes with the appropriate frame and chassis to proceed with detailed vessel design under the project.

Further development of a vessel suitable for hydrogen storage at pressure of 8,500 psi (586 bar) or higher will involve initial prototype vessel development and optimization of vessel design prior to manufacturing vessels for U.S. Department of Transportation certification and testing. Testing of the high-pressure vessels will be in accordance with International Organization for Standardization (ISO) 1119-2 criteria for hydrogen storage vessels. Test data will support the submission of a Special Permit application to the U.S. Department of Transportation, and after receipt of a U.S. Department of Transportation Special Permit, a new delivery trailer will be designed, fabricated, and tested. The delivery trailer unit will be deployed to supply hydrogen to hydrogen fueling stations. Also, trailer performance data will be



CH2 – compressed hydrogen

FIGURE 1. Tube trailer design constraints

collected and reported to the National Fuel Cell Technology Center at the National Renewable Energy Laboratory for independent review and analysis.

RESULTS

- This is a new project with expected official start in the third quarter of FY 2016.
- A significant amount of preliminary work and learning has been accomplished by the project team prior to official project kick-off. Air Products established a tube trailer cost model to support conceptual vessel design(s) and trailer configurations(s). Work has begun with Worthington Cylinders in support of the project objective of increasing hydrogen delivery pressure to 8,500 psi (586 bar) or higher.
- Air Products is also leveraging work outside of this project through commercialization of hydrogen distribution trailers with 7,500 psi (520 bar) operating pressure at hydrogen stations in California and Europe. The work serves as an important building block in further advancing lightweight composite tube trailers to the next level in the hydrogen energy market. The “Learning by Doing” experience helped identify and address technical challenges related to high-pressure trailer design, components, and construction, along with high-pressure trailer filling, trailer operability, and hydrogen fueling station interface. This project will benefit from the experience gained at 7,500 psi (520 bar).

CONCLUSIONS AND FUTURE DIRECTIONS

The advancement of tube trailer distribution to higher pressure under this project enables “compressionless” fueling at fill pressures greater than 5,000 psi (350 bar).

The preliminary techno-economic analysis will be performed to confirm the acceptability of the higher-pressure units as a viable storage solution. After the analysis is complete and the vessel units have been confirmed as acceptable, the design for a new $\geq 8,500$ psi (586 bar) vessel will be completed by Worthington Cylinder Corporation. Test vessels will be prepared, and the necessary testing will be performed on the vessels for U.S. Department of Transportation certification. An application will be submitted to the U.S. Department of Transportation to obtain a special permit. Upon receipt of this permit, Air Products will design the complete trailer unit for delivery of hydrogen to fueling stations.

FY 2016 PUBLICATIONS/PRESENTATIONS

1. John Aliquo, “Advanced Hydrogen Fueling Station Supply: Tube Trailers.” Poster at the DOE Hydrogen and Fuel Cells Program Annual Merit Review.