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DOE Hydrogen Program

Development of High Pressure Hydrogen Storage Tank for Storage and Gaseous Truck Delivery

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Project ID#
PD_40_Baldwin

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Overview

DOE Hydrogen Program

Timeline

- Phase I July 08 – June 09
  - 70% Complete
- Phase II June 09 – June 11

Budget

- Total project funding **(Phase I & II)**
  - DOE share $3M
  - Contractor share $3.34M
- Funding received in FY08 – none **($450K requested at EOY)**
- Funding for FY09 – $550K

Barriers

- Barriers addressed
  - Gaseous Hydrogen Storage and Tube Trailer Delivery Costs
  - System Weight and Volume
  - Efficiency
- Targets
  - $500/kg of H2 stored by FY2010, $300/kg by FY2015
  - Volumetric capacity 0.03 kg/liter by FY2010, >0.035 kg/liter by FY 2015
  - Tube trailer delivery capacity 700 kg by FY2010 and 1,100 kg by FY2017

Partners

- None

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Objectives

- To design and develop the most effective bulk hauling and storage solution for hydrogen in terms of cost, safety, weight, and volumetric efficiency. This will be done by developing and manufacturing a tank and corresponding ISO frame that can be used for the storage of hydrogen in a stationary or hauling application.
- The objective for the first year of this program (2009) is to design and qualify a 3600 psi tank and ISO frame that will hold 510000 in^3 (~8500L) water volume

Objectives-Technical Targets

DOE Hydrogen Program

Hydrogen delivery targets	ISO container with four 3600 psi tanks (FY 2009 Work Scope)
$500/kg of hydrogen stored by FY2010, $300/kg by FY2015	The current ISO assembly, with four tanks installed, can store about 600 kg of compressed hydrogen gas at 3600 psi with a safety factor of 2.35. It is estimated that the cost will be $675-$750 per kg of hydrogen depending on market demand.
Volumetric capacity 0.03 kg/liter by FY2010, >0.035 kg/liter by FY 2015	The baseline tank has a capacity of 150 kg hydrogen in a volume of ~8500 liters, achieving a performance of ~0.018 kg/liter. This performance measure can be increased to 0.024 kg/liter by increasing the service pressure to 5000 psi, and to 0.035 kg/liter by increasing the service pressure to 8300 psi.
Tube trailer delivery capacity 700 kg by FY2010 and 1,100 kg by FY2017	The current ISO assembly, with four tanks installed, will contain about 600 kg of hydrogen. This can be increased to about 800 kg by increasing the service pressure to 5000 psi, and to about 1150 kg by increasing the service pressure to 8300 psi.

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Milestones

Date	Milestone - Go/No-Go
Summer 2009	Milestone – successful completion of qualification test for 3600 psi tank. Test include: strength testing (such as burst and pressure cycling), environmental testing (such as exposure to environmental fluids, extreme temperatures, and high temperature creep), durability testing (flaw tolerance per ISO 11439 and penetration), and special tests (such as blow-down, accelerated stress rupture, and LBB).
Summer 2009	Successful completion of qualification of ISO frame capable of holding four tanks with a combined capacity of 600 kg of hydrogen. In addition to the structure, a system for loading, unloading, and pressure relief will be developed.
Summer 2009	Go/No-Go – Based on results of 3600 psi tank testing, a study will be completed to determine the best pressure and size of tank going forward (5000 psi Trade Study).

Approach

DOE Hydrogen Program

Task 1.0 Develop and Qualify a 3600 psi Tank

- design and qualify a tank that will hold approximately 8500 liters of water at 3600 psi
- Primary focus will be on manufacturing methods of a tank this size

Task 2.0 Develop and Qualify an ISO Frame

- ISO container assembly will be able to hold four tanks with a combined capacity of 600 kg of hydrogen

Task 3.0 5000 psi Trade Study

- A higher pressure tank will be required to meet DOE goals
- Initial review suggest a 5000 psi tank will be the most cost effective

Task 4.0 Develop and Qualify a 5000 psi Tank

- Same test will be used to qualify a higher pressure tank that was used on the 3600 psi tank

Task 5.0 Cost Reduction Studies

- Methods to reduce cost of the tank will be investigated meet DOE goal

Task 6.0 Investigate Increased Capacity

- Increased pressure will increase capacity of the tanks, but the price will also increase. Other methods to increase capacity will be researched.

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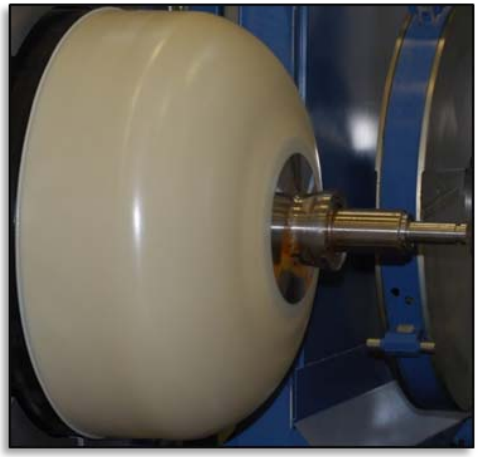
Technical Accomplishments/ Progress/Results

DOE Hydrogen Program

- **Developed the design and manufacturing procedures for 8500L tank processes**



- ✓ Large scale dome molding
- ✓ Large scale tubular welding
- ✓ Filament winding
- ✓ Cure/coating
- ✓ Proof testing

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Technical Accomplishments/ Progress/Results

DOE Hydrogen Program

- **Successful completion of several qualification tests**

  - ✓Pressure cycling (working)
  - ✓Burst
  - ✓Penetration (gunfire)

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Technical Accomplishments/ Progress/Results

DOE Hydrogen Program

- Completed the design, manufacture and assembly of ISO container (standard dimensions) capable of storing ~600 kg H_2 @ 3600 psi.
- Qualification testing is in progress

- ✓ Designed to meet industry standard transporting dimensions
- ✓ Completed stress analysis on frame
- ✓ Performed DFMEA
- ✓ Performed HazID analysis
- ✓ Developed pressure relief system for emergency situations

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Future Work

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- **FY 09**
  - **Finish qualification testing of 3600 psi tank. (Milestone)**
    - **Cycle testing (Ambient, LBB, Extreme Temperature)**
    - **Flaw tolerance per ISO 11439**
    - **Penetration**
    - **Blow-down test**
  - **Complete qualification of ISO frame that will hold four 3600 psi tanks. (Milestone)**
    - **Rail impact**
    - **Structural testing (lifting, stacking, inertia and racking)**
    - **Fire protection system**
    - **Bonfire**
  - **Complete trade study of higher pressure tank to meet DOE goals. Emphasis will be on meeting goals of efficiency and cost. (Milestone)**
- **FY 10**
  - **Complete design and qualification of higher pressure tank based on results from trade study. Initial calculation indicate this will be a 5000 psi tank**

Summary

- Hydrogen delivery and storage are key to the development for the advancement of technologies
- Developing a bulk storage unit that can be transported on an ISO frame will help to solve the current problem of hydrogen storage and delivery

Summary Table

DOE Hydrogen Program

Technical Targets	
DOE Goals	**FY 2009 Estimated Results**
$500/kg of hydrogen stored by FY2010, $300/kg by FY2015	An ISO frame with four tanks is estimated to store hydrogen at $675 - $750 per kg of hydrogen. 5000 psi tank is expected to lower this price.
Volumetric capacity 0.03 kg/liter by FY2010, >0.035 kg/liter by FY 2015	The baseline tank is estimated to have capacity of 150 kg hydrogen in a volume of 8500 liters, achieving a performance of 0.018 kg/liter.
Tube trailer delivery capacity 700 kg by FY2010 and 1,100 kg by FY2017	The baseline ISO assembly, with four 3600 psi tanks installed, will contain about 600 kg of hydrogen.
Tube trailer operating pressure goal is <10,000 psi by FY2012	Tank design for FY 2008 will be 3600 psi.

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