

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



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Project ID#

PD021

Overview

Timeline

- Phase I July 08 – June 09
 - 100% 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 – \$445K
- Funding received in FY09 – \$600K
- Funding for FY10 - \$610K

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

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. **Complete 4Q 2009.**
- 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 in³ (~8500L) water volume. **Complete 4Q 2009.**
- **The objective for the second year of this program (2010) will be to perform trade studies for a 5000 psi vessel. Based on the results of the trade studies, move forward on the design, manufacture and the qualification of a 5000 psi vessel/system.**

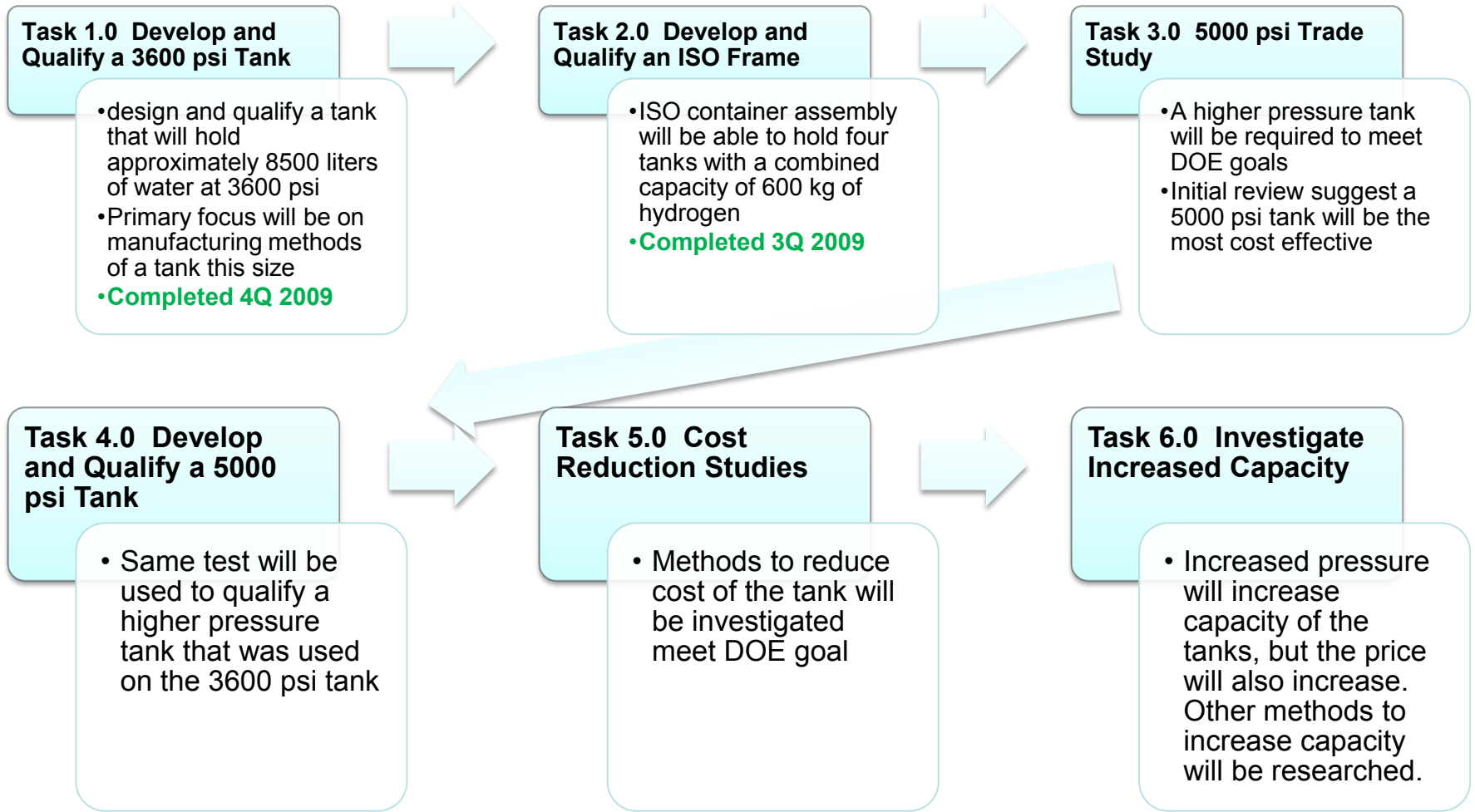
Objectives-Technical Targets

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	<p>The baseline tank has a capacity of 150 kg hydrogen in a volume of ~8500 liters, achieving a performance of ~0.018 kg/liter.</p> <p>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.</p>
Tube trailer delivery capacity 700 kg by FY2010 and 1,100 kg by FY2017	<p>The current ISO assembly, with four tanks installed, will contain about 600 kg of hydrogen.</p> <p>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.</p>

Milestones

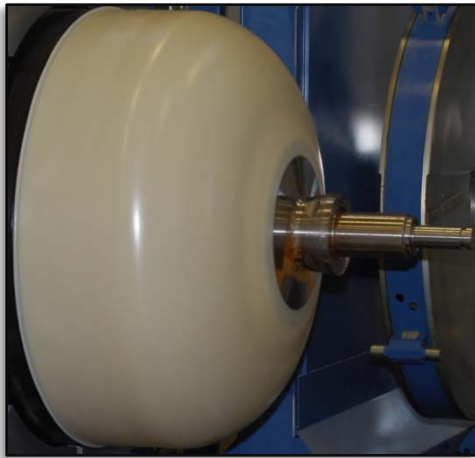
Date	Milestone - Go/No-Go
Summer 2009	Milestone – successful completion of qualification test for 3600 psi tank. Test include: strength testing (such as burst and pressure cycling), environmental testing (such as exposure to environmental fluids, extreme temperatures, and high temperature creep), durability testing (flaw tolerance per ISO 11439 and penetration), and special tests (such as blow-down, accelerated stress rupture, and LBB).
Fall 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 2010	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



Technical Accomplishments/ Progress/Results

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



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



Technical Accomplishments/ Progress/Results

- **Successful completion of all qualification of 3600 pressure vessel**
 - ✓ Hydrostatic Burst Test
 - ✓ Ambient Pressure Cycle Test
 - ✓ LBB (Leak Before Burst) Test
 - ✓ Penetration (Gunfire)
 - ✓ Environmental Test
 - ✓ Flaw Tolerance Test
 - ✓ High Temperature Creep Test
 - ✓ Accelerated Stress Rupture Test
 - ✓ Extreme Temperature Cycle Test
 - ✓ Natural Gas Cycle Test with Blowdown



Technical Accomplishments/ Progress/Results



Completed the design, manufacture and assembly of ISO container (standard dimensions) capable of storing ~600 kg H₂ @ 3600 psi.



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

Completed Testing of ISO Container

- ✓ Dimensional
- ✓ Stacking
- ✓ Lifting – Top and bottom
- ✓ Inertia Test
- ✓ Impact Test
- ✓ Bonfire

Future Work

- **FY 10**
 - Complete trade study of higher pressure tank to meet DOE goals. Emphasis will be on meeting goals of efficiency and cost. **(Milestone)**
 - 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

Technical Targets

DOE Goals	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.