

Automotive Cryogenic Capable Pressure Vessels for Compact, High Dormancy (L)H₂ Storage

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This presentation does not contain any proprietary or confidential information

Project ID #
TV9



Overview

Timeline

- Start date: **October 2004**
- End date: **September 2011**
- Percent complete: **60%**

Budget

- Total project funding
 - DOE: **\$2500 k**
- Funding received in FY08:
 - **\$800 k**
- Funding for FY07:
 - **\$750 k**

Barriers

- **A. Volume and weight**
- **O. Hydrogen boil-off**

Targets

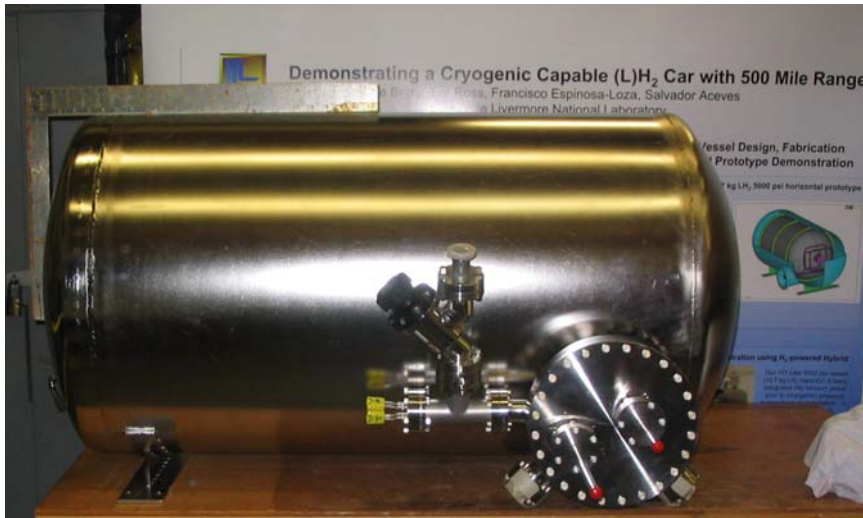
- **2010 DOE volume target**
- **2010 DOE weight target**

Partners

- Finalizing **CRADA** with major automobile manufacturer
- Negotiating **CRADA** with major pressure vessel manufacturer



Objective: Demonstrate the practical advantages of cryogenic capable pressure vessels



High energy density



No evaporative losses



Flexible refueling



safe



Milestones: We have made considerable progress toward demonstrating the practicality of cryogenic pressure vessels



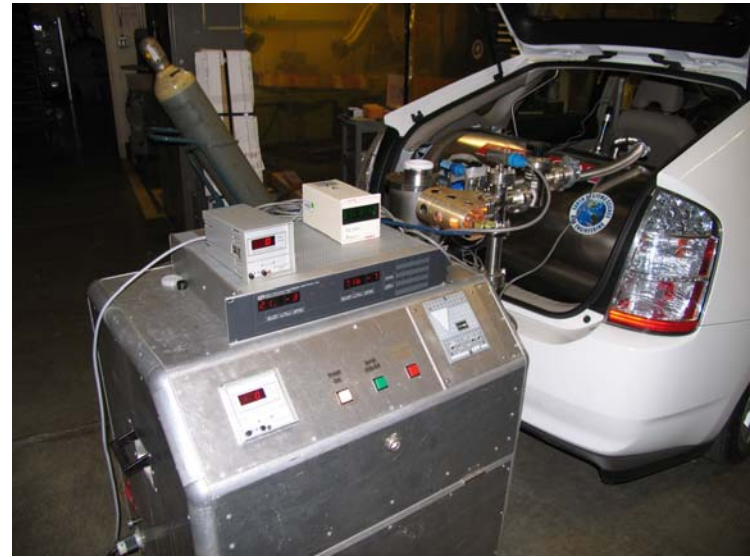
- *Install pressure vessel in experimental Prius vehicle* (November 2006)
- *Demonstrate long vehicle range:* Drove 650 miles on a single H₂ tank (January 2007)
- *Resolved technical risk of dormancy & high pressure:* Demonstrated potential for 3 weeks dormancy. Test cut short at 6 days due to valve (January 2008)
- *Demonstrating vacuum stability:* Stable vacuum measured at 10⁻⁵ torr or below as vessel warms from 30 K to ambient over ~ 1 month. Currently at 200 K (April 2008)



Approach: Study crucial aspects of cryogenic pressure vessels as onboard storage systems



dormancy



vacuum stability



outgassing



cycle test



Accomplishments: We integrated our cryogenic pressure vessel onboard an experimental hydrogen vehicle & demonstrated record unrefueled driving range (650 miles)

LLNL Cryotank

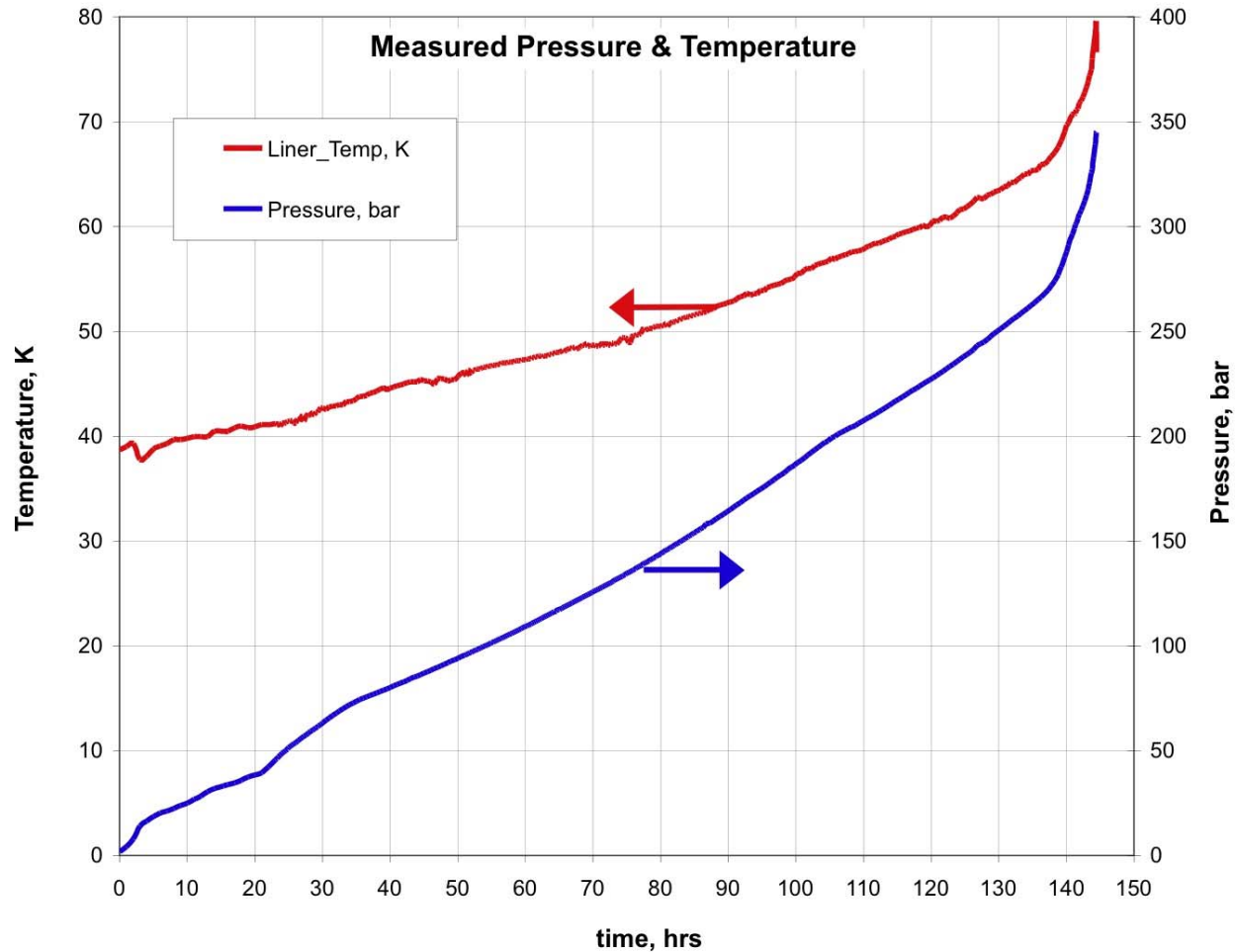
- Within 10% of DOE 2007 volume using LH₂ and including all system components
- Meets DOE 2007 weight goal
- stores 10.7 kg LH₂ (151 L capacity)
- stores 3.5 kg H₂ at 300 K, 5000 psi

The vehicle

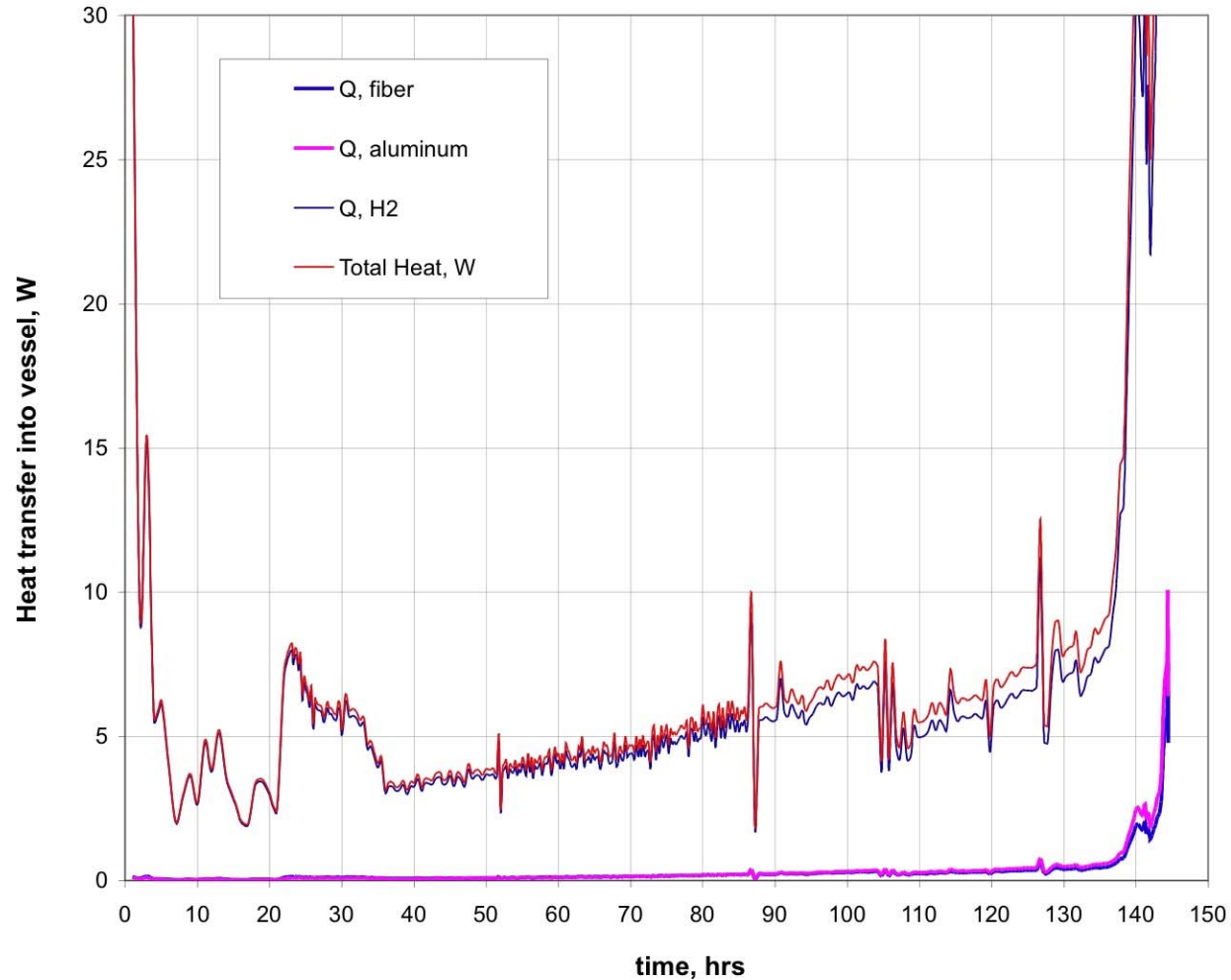
- Toyota Prius converted to H₂ fuel by Quantum Technologies.
- Originally equipped with 5000 psi 68 L pressure vessels (1.6 kg H₂)
- Increased capacity to a single 151 liter vessel (3.5-10.7 kg)



We demonstrated longest LH₂ dormancy onboard a vehicle (6 days) and potential for 3 weeks at ~3.5 Watts heat transfer rate

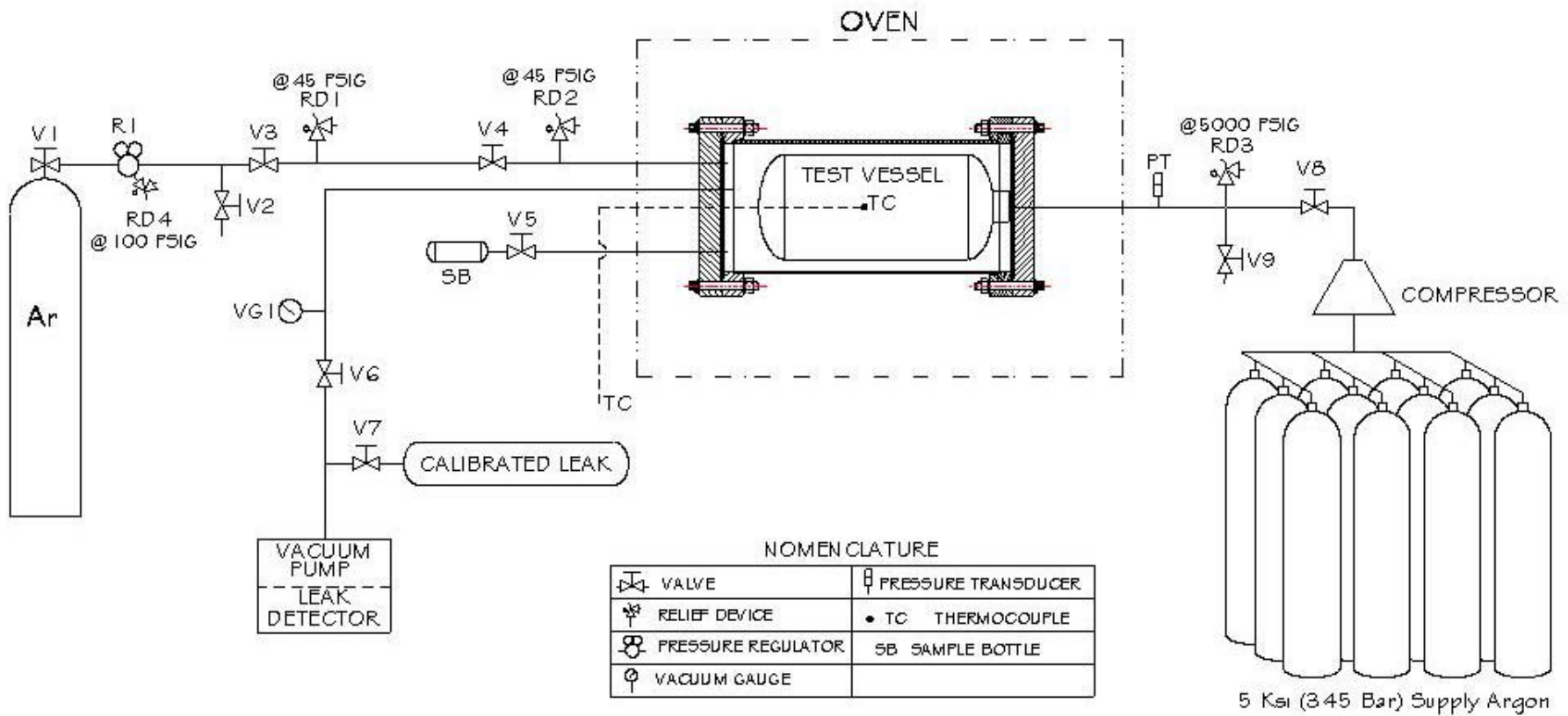


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Vacuum stability is a key issue for cryogenic vessels.

We are measuring outgassing from the surface of vessels with multiple surface treatments



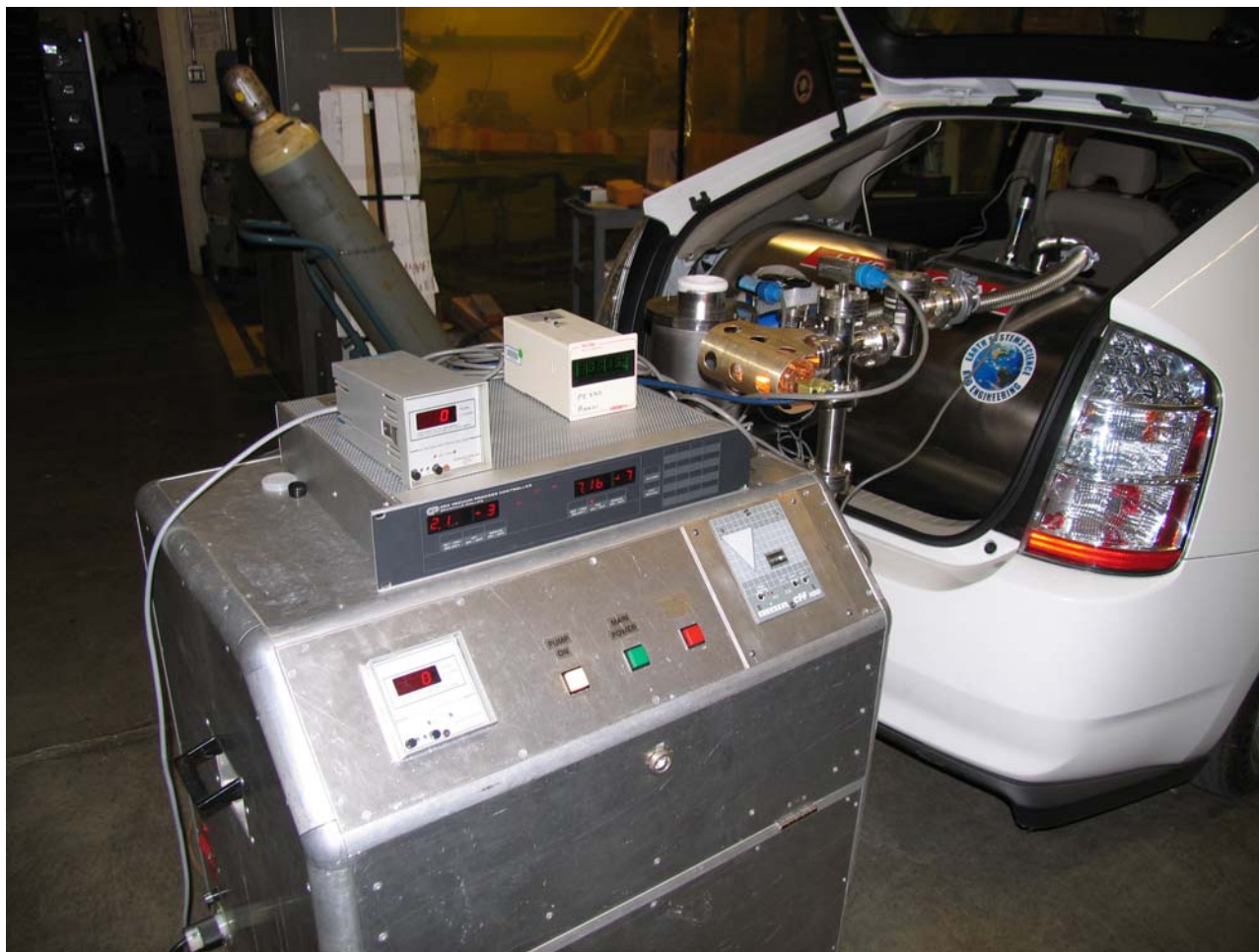
We are conducting outgassing experiments inside an oven installed within a high pressure cell



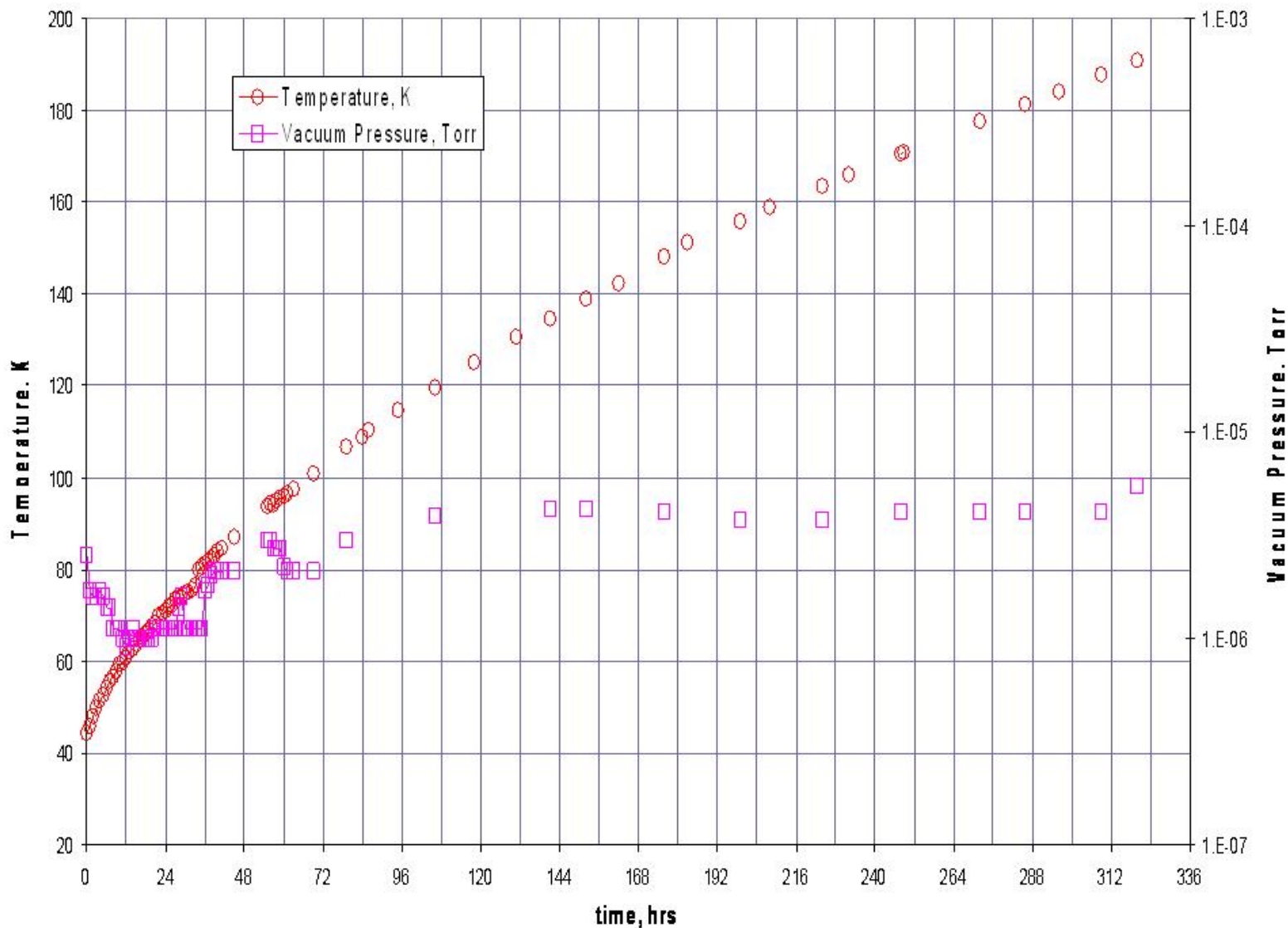
**System was fully built, tested and baked.
Three sets of experiments have been run.**



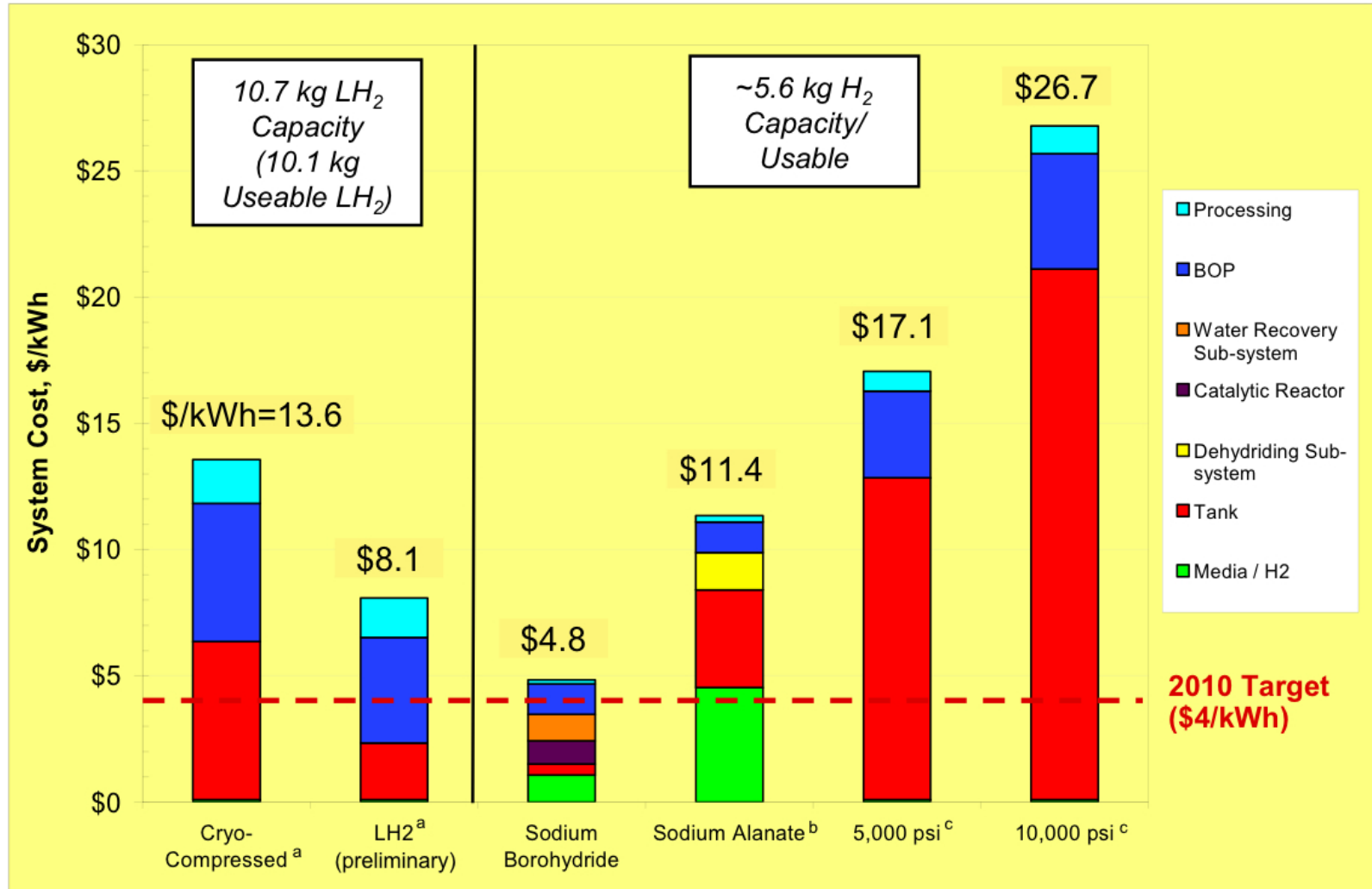
**At the request of our industrial partner,
we have monitored vacuum quality over a month
as our vessel warmed up from cryogenic to ambient temperature**



Our experimental results to date indicate good vacuum stability as the vessel warms up from 30 K to 200 K



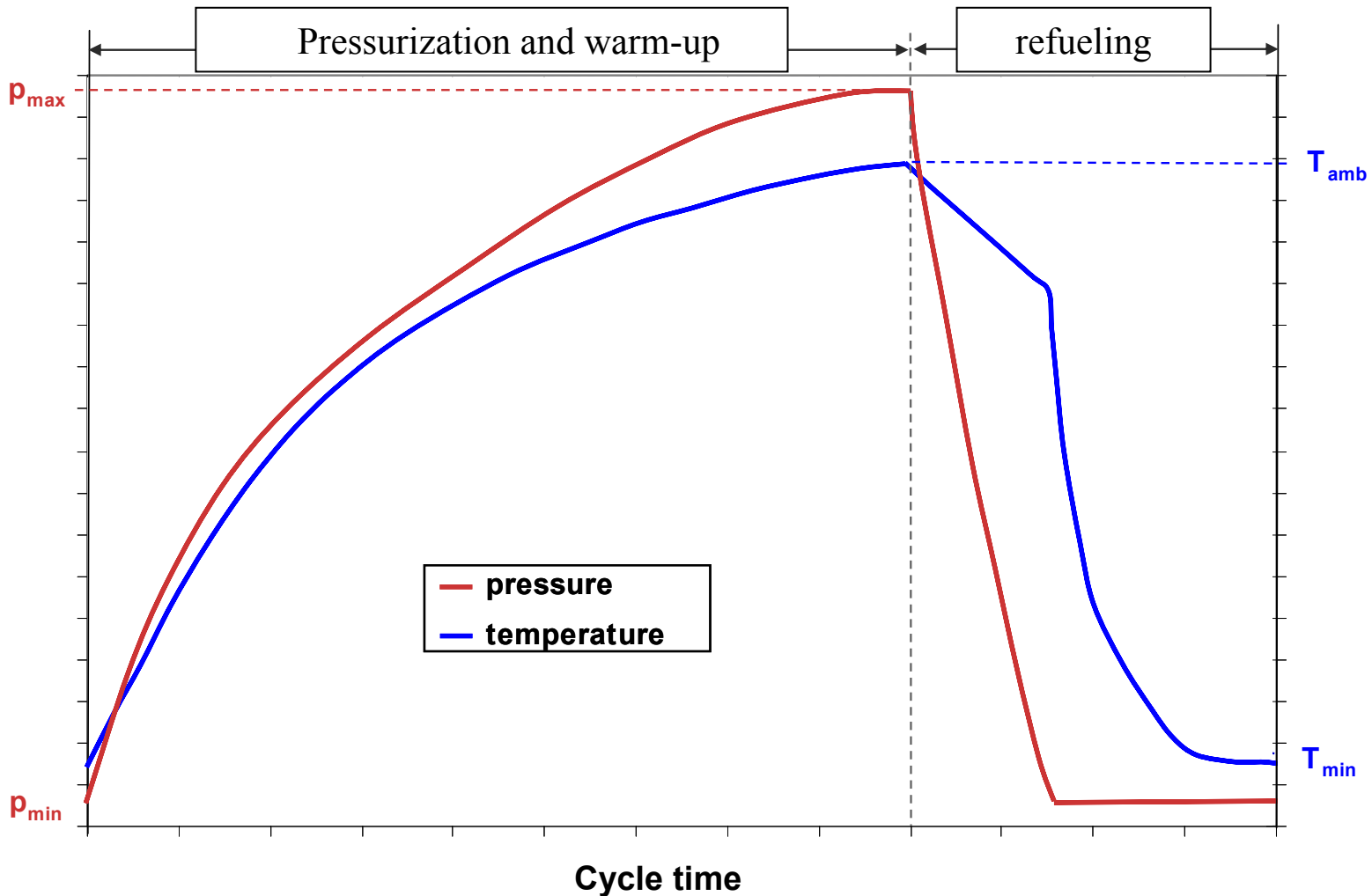
Our cryogenic capable pressure vessels are projected to be less expensive than compressed hydrogen vessels



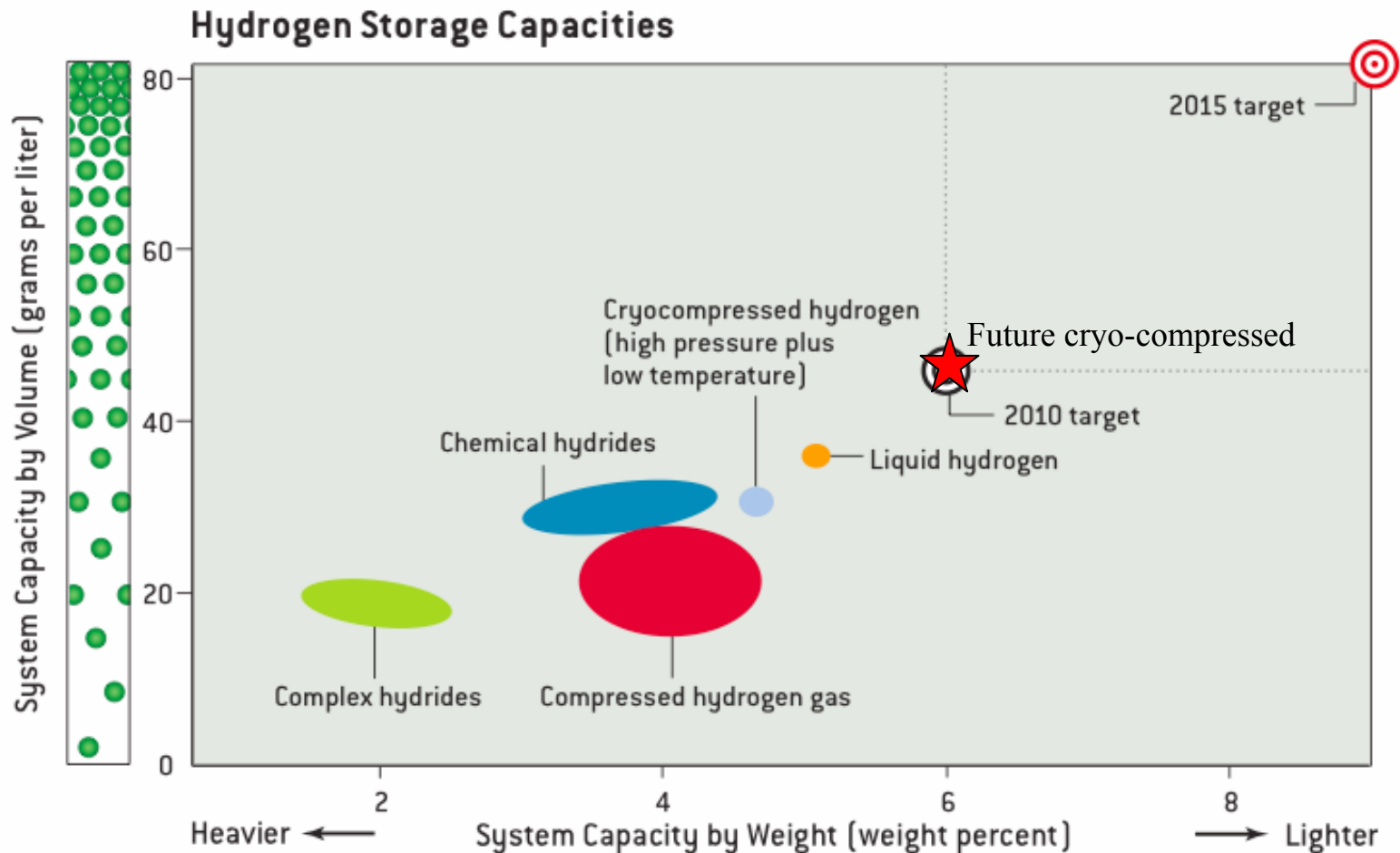
Source: TIAX



Future plans: In collaboration with our industrial partners, design and manufacture a new cryogenic pressure vessel for full cycle testing



Future plans: we will build and demonstrate a cryogenic capable onboard storage system meeting 2010 weight & volume targets



Summary: We will demonstrate the most compact and we believe ultimately practical hydrogen storage technology



- *The high capacity of liquid hydrogen vessels without the evaporative losses:* ~10X longer thermal endurance than low pressure LH₂ tanks essentially eliminates boil-off.
- *Less expensive than compressed hydrogen vessels:* LH₂ capable vessels use 2-3x less carbon fiber than conventional compressed H₂ vessels.
- *Refueling flexibility yields infrastructure and driver advantages:* Meets real time driver priorities (range, cost, ease, energy) and increases fuel availability

