

# Cryogenic Propellant Storage and Transfer Engineering Development Unit Hydrogen Tank

## Project Manager(s)/Lead(s)

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## Sponsoring Program(s)

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Space Technology Mission Directorate  
Technology Demonstration Missions

## Project Description

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The Cryogenic Propellant Storage and Transfer (CPST) project has been a long-running program in the Space Technology Mission Directorate to enhance the knowledge and technology related to handling cryogenic propellants, specifically liquid hydrogen. This particular effort, the CPST engineering development unit (EDU), was a proof of manufacturability effort in support of a flight article. The EDU was built to find and overcome issues related to manufacturability and collect data to anchor the thermal models for use on the flight design.

The EDU is a 1,000-gallon, flight-like, liquid hydrogen storage tank with built-in features, such as four tank fill level sensors, channel-based liquid acquisition devices (LADs), a thermodynamic vent system, and a comprehensive insulation/heat intercept system. (See fig. 1 for its 'as tested' configuration.) The tank body is comprised of 2219 thin-wall aluminum with about an inch of spray-on foam insulation (SOFI). The SOFI is only useful in atmospheric conditions and is in fact required in the presence of any gas other than helium in order to prevent damaging 'liquid air.' Over the SOFI is a 60-layer insulation blanket that is only effective in a vacuum to intercept heat in the form of radiation from entering the tank. The EDU was tested in a large vacuum chamber on site at NASA Marshall Space Flight Center, test stand 300 (fig. 2). The EDU was filled in a simulated launch environment (gaseous nitrogen) and then subjected to vacuum conditions to simulate launch

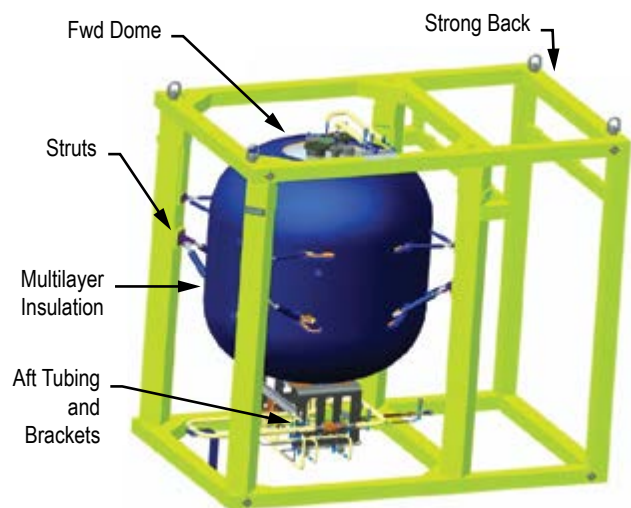
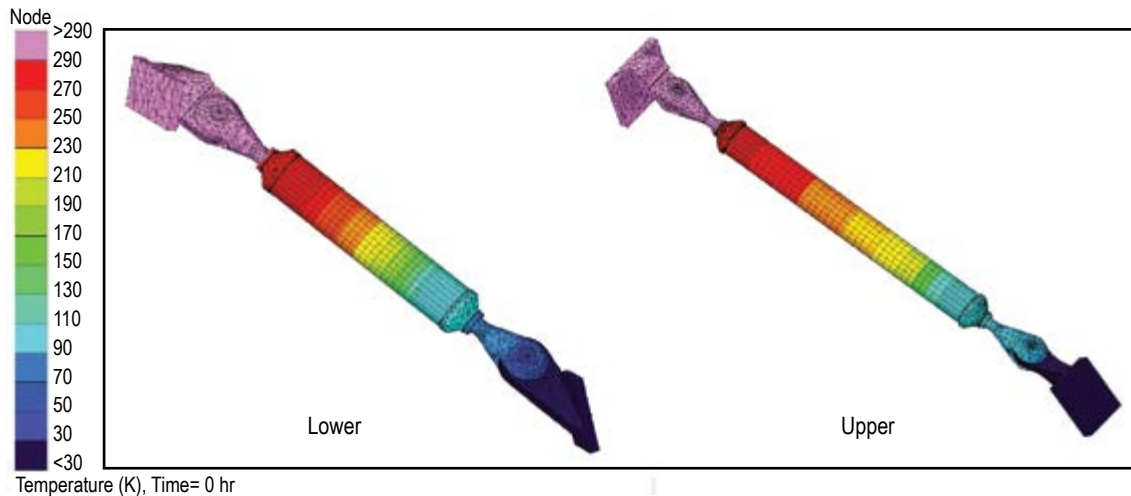


Figure 1: EDU tank.



Figure 2: Tank in vacuum chamber.



**Figure 3: Thermal analysis of tank struts.**

and space flight. The testing was conducted in June 2014 and was successful.

The testing was a 20-day test to determine the boil-off rate for the system at the launch pad conditions and the on-orbit conditions. The testing also was to gather data on the pressurization system for the EDU. There were two ways to pressurize the tank, one diffuser at the top (in the ullage or dry conditions) and a submerged diffuser in the bottom of the tank. Several pressure tests were conducted at different pressure levels and fill levels. (See fig. 3 for thermal analysis of tank struts.)

One other technology that was tested was the LADs. The LADs are a way to collect fuel without collecting gases. Since LADs work better in low gravity conditions, the only method to test them is to see how long they can support a column of liquid. We were able to support a column of liquid for 61 minutes during the testing. There was an ice blockage that prevented full testing of the thermodynamic vent system, but all other systems performed well. There is more testing planned for FY 2016 using the EDU and test stand 300.

### ***Anticipated Benefits***

A body of data now exists to refine thermal models with a flight-like tank and data set. EDU has also provided a better understanding of the physics of submerged pressurization.

### ***Potential Applications***

Potential applications include improved manufacturing techniques for propellant tanks and improved thermal modeling of cryogenic systems.

### **Notable Accomplishments**

Notable accomplishments include the creation of manufacturing techniques to construct LADs, support struts, and shaping SOFI; supported a column of liquid in a LAD for 61 minutes; and proved that the radio frequency measuring gauge was accurate to within 1.5% of all other methods.