NASA Facts

National Aeronautics and
Space Administration

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Return to Flight Focus Area

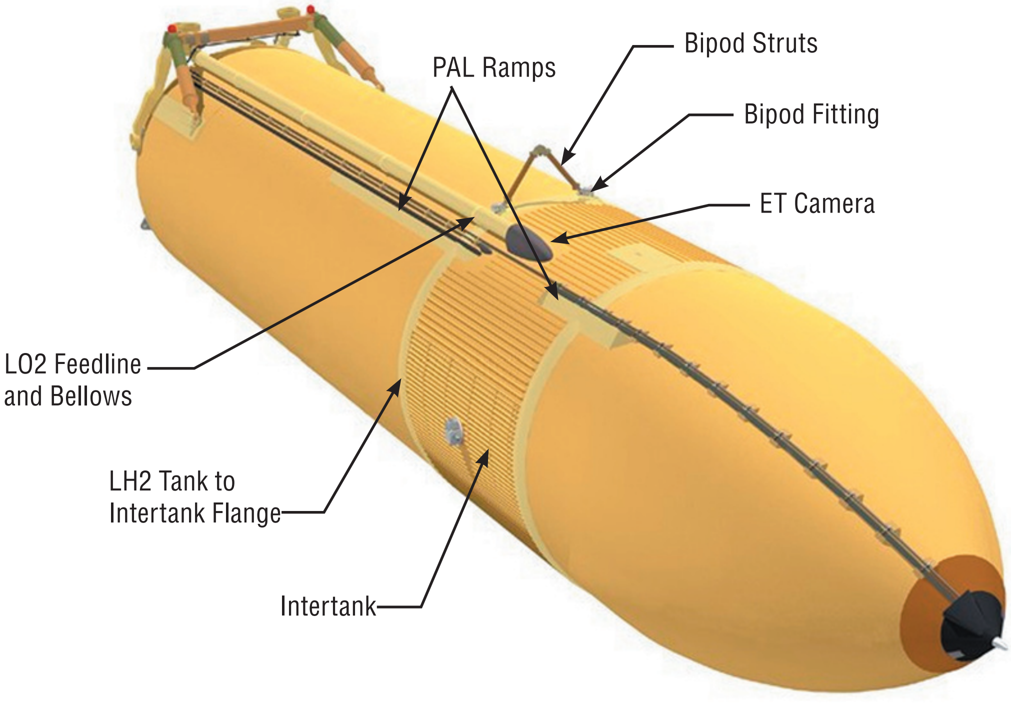
Improvements to the Space Shuttle's External Tank

NASA fuels discoveries that make the world smarter, healthier and safer. The Space Shuttle will be used to complete assembly of the International Space Station, a vital research platform for human endurance in space and a test bed for technologies and techniques that will enable longer journeys to the Moon, Mars and beyond.

As part of its work to return the Shuttle to flight safely, the Space Shuttle Program performed a top-to-bottom assessment of the External Tank's Thermal Protection System, or TPS, and made several modifications and improvements to minimize any debris the tank and its Thermal Protection System could potentially generate during launch and ascent.

The External Tank is the "fuel tank" for the Shuttle's Orbiter and holds the propellants used by the Shuttle's Main Engines. It is also the only component of the Space Shuttle that is not reused: Approximately 8.5 minutes into a Shuttle flight, the tank—its propellant used—is jettisoned and disintegrates over a remote part of the ocean.

Improvements have been made to the tank's forward bipod fitting area, the liquid hydrogen tank to intertank flange area, and the liquid oxygen feedline bellows. The External Tank Project Office also reviewed the existing design of the tank's protuberance air load ramps—known as PAL ramps.



The ramps consist of thick, manually sprayed layers of foam that could, if liberated, become a source of debris. In addition, the project examined how the thermal protection system is applied to the tank and is continuing to analyze techniques that will allow the foam to be tested without damaging it.

Forward Bipod

The tank's new forward bipod design eliminates the insulating foam ramps of the original design in favor of electric heaters. In the original design, the ramps helped to prevent ice buildup—a potential debris source—on the tank's bipod fittings. Each External Tank has two bipod fittings that connect the tank to the Orbiter through the Shuttle's two forward attachment struts. The bipod redesign will allow the tank to fly with the fittings exposed—minus the insulating foam ramps.

The fittings themselves are the same basic design as before. However, to prevent ice from forming while the Shuttle sits on the launch pad loaded with extremely cold cryogenic liquid hydrogen fuel, the redesign adds four rod heaters placed below each fitting in a new copper plate.

The new bipod design also requires additional cabling to operate the heating system and adds a smaller end cover on the bipod spindle that connects the fitting to the bipod strut.

NASA technicians fit the new forward bipod to the external tank.

Liquid Hydrogen Tank/ Intertank Flange

The liquid hydrogen tank flange is at the bottom of the intertank and provides a joining mechanism for the tank and intertank. The intertank is the ribbed, cylinder structure that joins the liquid hydrogen tank and the liquid oxygen tank. After the two tanks are joined to the intertank, the flanges at both ends are insulated with foam. During assessment of the tank, it was discovered that voids, or spaces, sometimes develop in the foam sprayed on the liquid hydrogen tank flange.

To reduce the number of voids, an enhanced close-out, or finishing, procedure has been implemented that includes improved foam application to the stringer area, or intertank ribbing, and to the upper and lower area of the flange. The foam, which is sprayed by hand, requires four technicians, a new mold-injection procedure on the intertank's ribbing and real-time videotaped observation of the process.

Two NASA technicians inspect the flange that joins the liquid hydrogen tank and intertank on the external tank.

Liquid Oxygen Feedline Bellows

The liquid oxygen feedline bellows is part of the liquid oxygen feedline assembly. The feedline assembly extends externally along the right side of the liquid hydrogen tank, up to and within the intertank, and then to the aft dome, or tail, of the liquid oxygen tank. It is approximately 70 feet long and about 17 inches in diameter. The liquid oxygen feedline bellows are joints that allow the feedline to move, or flex, when the feedline is installed and when the tank is assembled. The bellows also allow the lines to adjust as the liquid hydrogen tank is filled and permit the line to adapt to the forces generated at liftoff.

The feedline is insulated with foam. However, because the bellows must allow for movement, they are not insulated. The original configuration of the bellows allowed ice to form during pre-launch tanking, or filling, of the External Tank when moisture in the outside air contacted the cold surface of the bellows; the surface is cold because of the near minus 297 degree liquid oxygen.

The lack of insulation on the bellows means the moisture can turn to ice. Though no losses of foam insulation on the feedline have been reported, if ice forms on the bellows and is dislodged during liftoff, it could potentially damage the Shuttle system.

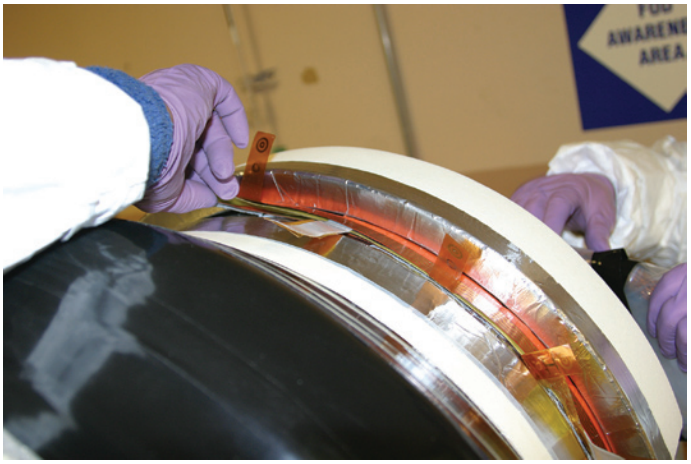
To prevent ice from forming, the bellows thermal protection system is being reshaped to include a “drip-lip” that allows condensate—moisture—to run off. The new “lip” is squared at its bottom end—it has a slight 10 degree angle—so that the condensate drips off the cover; the original design was angled toward the tip of the rain-shield, which allowed the water to contact the shield and freeze.

In addition to the drip lip, a strip heater has been added on the bellows to further reduce the amount of ice and frost formed. The heater is a copper-nickel alloy metal strip heater, similar to heaters used on the Solid Rocket Motor joints, which will keep the bellows area slightly warmer than freezing, about 40 degrees Fahrenheit. The heater strips are about 53 inches long—the circumference of the bellows—and about 0.5 inches wide. The two heater strips are covered and joined by a silicone gasket that allows the heater to be bonded between the bellows rain shield and end shield. Tabs placed at intervals on the heater assist in its placement on the bellows and allow pull tests to verify the strength of the adhesive bond.

The heater, which is connected to the ground support equipment that operates prior to launch, will be turned on shortly after the liquid oxygen tank begins fast fill approximately 5 hours and 10 minutes before launch, and turned off 1 minute and 52 seconds before launch.

Protuberance Airload Ramps, or PAL Ramps

The External Tank’s protuberance airload ramps, known as PAL ramps, are foam ramps that were designed to reduce adverse aerodynamic loading, or forces, on the tank’s cable trays and its pressurization lines during launch. One of those ramps is near the top of the liquid oxygen tank, close to the nose cone; the other is below the intertank, near the top of the liquid hydrogen tank.



A heater has been added by NASA engineers to the topmost bellows on the Space Shuttle External Tank’s liquid oxygen feedline to further reduce the amount of ice and frost formed prior to launch of the Shuttle.

Based on material analysis, testing and flight data, NASA is satisfied that the current design configuration of the PAL ramps is safe to fly and has approved plans to fly the next tank, ET 120,with that configuration. The forward 10 feet of the PAL ramp was removed on ET 120 to allow access to the tank’s liquid oxygen/intertank flange area and later replaced.

Nondestructive Inspection of Foam

NASA is continuing to pursue the development of nondestructive inspection techniques on the tank’s Thermal Protection System. The initial focus is on manually sprayed closeout, or final, foam applications. The project office is surveying state-of-the-art technologies and evaluating their capabilities.

Two technologies that show promise are terahertz imaging and backscatter radiography. The main advantage of a terahertz imager is that it does not emit any radiation, capturing pictures of the natural terahertz rays emitted by almost all objects. Occupying a portion of the spectrum between infrared and microwaves, from 10^{11} to 10^{13} Hertz, terahertz waves can pass easily through some solid materials, like walls and clothes, and can also be focused as light to create images of objects. The terahertz imaging is being developed in conjunction with NASA’s Langley Research Center in Langley, Va.

The backscatter technique uses X-ray photons that bounce off the electrons of materials.

The External Tank Project Office is conducting more comprehensive testing on these technologies.

For more information, visit **http://www.nasa.gov.**

The first modified tank for Return to Flight, ET120, rolls out at Michoud Assembly Facility in New Orleans on Dec. 31, 2004.

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