NASA Facts

National Aeronautics and
Space Administration

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Return to Flight Focus Area

External Tank Forward Bipod Fitting

When the Space Shuttle returns to flight, the External Tank will have a redesigned forward bipod fitting—a design that meets the recommendation of the Columbia Accident Investigation Board to minimize potential debris by eliminating the large insulating foam bipod ramps.

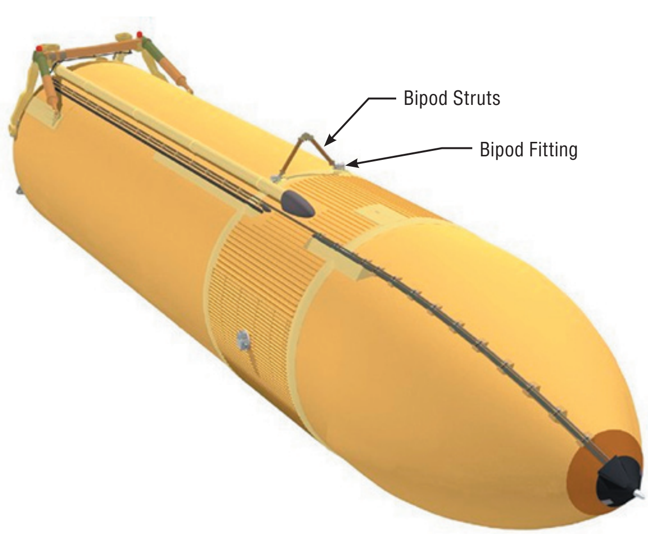
Returning the Space Shuttle to flight is the first step in realizing the Vision for Space Exploration, which calls for a stepping stone strategy of human and robotic missions to achieve new exploration goals. NASA fuels discoveries that make the world smarter, healthier and safer. The Shuttle will be 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.

The tank's new bipod design eliminates the insulating foam ramps in favor of electric heaters. In the original design, the ramps helped to prevent ice buildup—another 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.

History

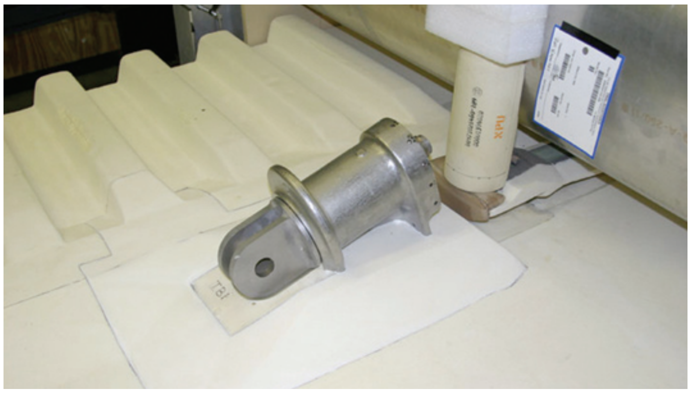
The External Tank Project Office began developing bipod redesign concepts after insulating foam from the left bipod ramp area came off during the October 2002 launch of Space Shuttle Atlantis on the STS-112 mission. During the launch of Columbia on its STS-107 mission in January 2003, a similar loss prompted NASA's Office of Space Flight to mandate a redesign of the bipod ramp before the Shuttle fleet could return to flight.

The bipod ramps were wedge-shaped foam structures, approximately 30 inches long, 14 inches wide and 12 inches tall. The ramps were applied by hand spraying BX250/265 foam over the bipod fittings during the final stages of the tank's preparation. The final ramp shapes were then created by hand carving the foam to required dimensions. During the STS-107 investigation, dissection of existing bipod ramps on tanks in inventory indicated that hand spraying over the complex geometry of the fittings was prone to produce internal voids and defects in the foam. Internal voids and defects have been shown to contribute to foam loss during ascent.



Design Changes

The bipod redesign will allow the tank to fly with the fittings mainly 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 cryogenic (subzero) liquid hydrogen fuel, the redesign adds four rod heaters placed below each fitting in a new copper plate. The copper plate with heaters is sandwiched between the fitting and an existing phenolic thermal isolating pad. This thermal isolator helps to reduce heat loss from the copper plate into the extremely cold liquid hydrogen tank.



Redesigned bipod fitting.

The heaters are cartridge-type heaters with a wire coil inserted into a tube filled with magnesium oxide. They are 0.25 inches in diameter and five inches in length. Each heater can produce up to 300 watts of power when operated at 120 volts AC. The heaters will only function pre-launch, and will be powered and monitored through connections in the Ground Umbilical Carrier Plate, which separates when the Shuttle is launched. The heaters will be controlled through ground-based Programmable Logic Controllers that will vary the heater power based on temperature sensors located with the heaters at the copper plates. Additional temperature sensors on the bipod fittings will monitor the fitting temperatures to ensure they stay well above freezing. To minimize the potential for a launch scrub, the heaters and temperature sensors have built-in redundancy to permit successful operation even in the presence of certain hardware failures.

Other Fitting Modifications

Although the original bipod fittings were covered with insulating foam ramps, the bipod spindles, which connected the fittings to the struts, remained exposed. These spindles were required to rotate to accommodate the shrinkage of the tank that occurs when it becomes extremely cold. These spindles each contained a heater element that will no longer be required because of the addition of the rod heaters. Once the spindle heater was eliminated, a smaller end cover was placed on the fitting.

Since the fittings will now fly exposed to the aerodynamic heating environment, the end covers will get much hotter during flight. The new smaller end covers are made from Inconel 718 to withstand higher temperatures. The fittings themselves are made from Titanium and are already capable of withstanding aerodynamic temperatures.

The new bipod design also requires additional cabling to operate the heating system. It includes eight circuits—four for each bipod—that run from the External Tank Ground Umbilical Carrier Plate to the heaters under the bipod fitting.

Testing

Testing is an important factor in any redesign or modification because it validates the integrity of the design. Though testing cannot duplicate actual flight, it can significantly reduce risk because it allows for careful observation and precise control over the test article. The new bipod fitting design has undergone wind tunnel tests, structural tests, and thermal tests, during both its design and implementation phases, to certify it is ready for flight. These tests ensure the new design does not affect the current External Tank loads and stresses.

Structural testing performed at NASA's Michoud Assembly Facility in New Orleans demonstrated the load capability—its ability to withstand external forces acting on the structure—of the redesigned fitting. The structural testing included both the effects of cryogenic temperatures at the fitting mounting area and the high temperature effects of aerodynamic heating of the fitting itself.

Thermal testing performed at Eglin Air Force Base, Fla., demonstrated the capability of the heater system to prevent ice or frost formation on the launch pad. These thermal tests encompassed all tanking, or fueling, and de-tanking scenarios. The environmental chamber at Eglin permitted all possible environmental conditions—extreme combinations of temperatures, humidity, and winds—to be examined.

Wind tunnel testing performed at Arnold Engineering Development Center at Arnold Air Force Base, Tenn., demonstrated the design's aerodynamic capabilities and its ability to resist aerodynamic loads and high temperatures generated during ascent.

Although most of the foam that covered the bipod area has been eliminated with the redesign, the base area must still be covered with hand-sprayed foam. To ensure this foam is free from internal defects that could cause foam loss during flight, the foam application techniques for this area have been refined and thoroughly tested through a process verification and validation program.

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

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