ORBITER HEAT TILES



- 0. ORBITER HEAT TILES Story Preface
- 1. THE SHUTTLE
- 2. COLUMBIA'S HISTORIC FLIGHT
- 3. ABORTING THE MISSION
- 4. ORBITER HEAT TILES
- 5. EXTERNAL TANK INSULATION
- 6. COLUMBIA'S CREW
- 7. COLUMBIA'S LAST LAUNCH
- 8. THE INSULATION PROBLEM
- 9. COLUMBIA'S LAST MINUTES
- 10. COLUMBIA IS LOST



NASA's Goddard Institute for Space Studies <u>explains why</u> early shuttle missions "had problems with thermal insulation tiles. These tiles are important because vehicles reentering the atmosphere at high speed are heated by collisions with air molecules. Part of the energy from these collisions goes into heating the surface of the vehicle and the remainder goes into internal energy of the air molecules so that there is also a layer of very hot gas around the vehicle." The image depicts an artist's rendering of *Columbia's* heat tiles at work during reentry. Click on it for a closer view.

One of the most dangerous moments of any shuttle flight occurs when it reenters the Earth's atmosphere. Maximum heating occurs about twenty minutes before touchdown.

The orbiter's nose cone (including the chin panel) and the <u>leading edge</u> of its <u>wings</u> (which are coated with <u>reinforced carbon-carbon</u>) are the hottest areas during re-entry. Temperatures on these surfaces can exceed 3,000 degrees F.

Coated black ceramic $\underline{\text{tiles}}$ (known as High-Temperature Reusable Surface Insulation) cover many areas of the shuttle. They are found on its lower surface; in areas around the forward windows; on its upper body flap; at the base heat shield; on the "eyeballs" at the front of the Orbital Maneuvering System (OMS) pods; and on the leading and trailing edges of the vertical stabilizer and the $\underline{\text{rudder speed brake}}$.

Black tiles are <u>located</u> where temperatures on the outside of the shuttle are extreme.

Coated white tiles (known as Low-Temperature Reusable Surface Insulation) are designed to insulate the spacecraft from temperatures up to 1,200 degrees F. Originally used extensively, those tiles are now replaced in most areas by Flexible Insulation Blankets.

White tiles are still used, however, on the upper surface of the forward fuselage above the crew windows and on some parts of the OMS pods.

Before the shuttle's thermal protection system was incorporated into its final design, the heat tiles were put to a difficult test. In 1975, simulating extremely high temperatures the orbiters would encounter on reentry, a torch was put to the tiles. The tests were successful.

Heat tiles were <u>damaged</u>, without causing fatal problems, before <u>Columbia's STS-107</u> mission. (For example, one of the starboard pods protecting <u>Endeavour's</u> orbital maneuvering system shows <u>damage</u> on 10 October 1994.) And wreckage of the <u>Challenger</u>, retrieved from the Atlantic Ocean, still had thermal tiles <u>intact</u> despite its horrific explosion.

The small (six-by-six-inch) tiles are easily repaired or <u>replaced</u> while the shuttle is on the ground. A technician, for example, worked on <u>tiles underneath</u> *Columbia* as she was readied for her STS-28 mission. Crew members from that same mission inspected <u>those tiles</u> on 13 August 1989, after the mission was safely completed.

Repairing damaged heat tiles in space, however, is risky. Even if an orbiter is <u>docked at</u> the <u>International Space Station</u> (the linked NASA animation depicts how the ISS was "put together" over a ten-year period), astronauts would have to make repairs during a space walk.

The issue became acute during *Endeavour's* August 2007 flight (STS-118) when a baseball-sized piece of foam broke loose from the external fuel tank at 58 seconds into the mission. Falling from a bracket, the debris ultimately struck two tiles on the orbiter's underbelly.

To determine whether there was any damage to the shuttle, *Endeavour's* crew executed a <u>pitch maneuver</u> as the orbiter approached the space station. That process enabled personnel inside the space station to take pictures of the <u>shuttle's underside</u>. (Pictures of the *Earth* taken from the ISS, parenthetically, provide an <u>unbelievable sight</u> to behold - especially when viewed in time-lapse video!)

When NASA's flight managers saw an <u>apparent gash</u>, they ordered <u>Endeavour</u>'s astronauts to determine its dimensions, including <u>the depth</u>. Using a laser-tipped <u>inspection boom</u>, crew members were able to confirm <u>the gash</u> measured $3\frac{1}{2}$ by 2 inches (9 by 5 centimeters), leaving a small <u>area</u> of <u>Endeavour</u> with no heat-resisting tile protection.

The problem occurred again, during the launch of Endeavour's STS-127 mission (on the 15th of July, 2009), when numerous pieces of foam insulation (from the external tank) broke loose. Some of the debris struck the heat tiles, requiring the crew to use their robotic arm to examine the orbiter.

The key issue for NASA, to be determined before the <u>shuttle undocks</u> from the space station, is to balance the risk of a space-walking repair (if heat tiles are damaged during launch) versus the risk of a re-entry without full heat-tile protection.

In a picture which seems eerie, given the events of February 1st, 2003, a black <u>heat tile</u> floats outside *Columbia's* window as she traveled on Mission <u>61-C</u>. The photograph was taken just sixteen days before the *Challenger* disaster.

See Alignments to State and Common Core standards for this story online at:

http://www.awesomestories.com/asset/AcademicAlignment/ORBITER-HEAT-TILES-Columbia-Space-Shuttle-Explosi

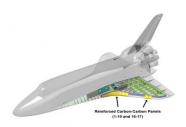
οn

n

See Learning Tasks for this story online at:

http://www.awesomestories.com/asset/AcademicActivities/ORBITER-HEAT-TILES-Columbia-Space-Shuttle-Explosio

Media Stream

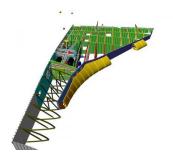


Leading Edge Carbon Reinforced Tiles

Diagram, courtesy NASA.

View this asset at:

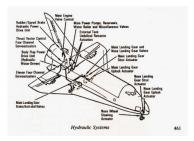
http://www.awesomestories.com/asset/view/Leading-Edge-Carbon-Reinforced-Tiles



Shuttle Wings

Drawing, courtesy NASA.

View this asset at: http://www.awesomestories.com/asset/view/Shuttle-Wings



Shuttle Hydraulic System

Drawing, NASA.

Quoted passage on hydraulic systems, HowStuffWorks.com.

View this asset at: http://www.awesomestories.com/asset/view/Shuttle-Hydraulic-System



Testing the Heat Tiles

Photo, courtesy NASA.

View this asset at: http://www.awesomestories.com/asset/view/Testing-the-Heat-Tiles



<u>View of Tiles</u>
Photo, courtesy NASA.
View this asset at: http://www.awesomestories.com/asset/view/View-of-Tiles



<u>Space Shuttle Endeavour</u> Photo, NASA.

View this asset at: http://www.awesomestories.com/asset/view/Space-Shuttle-Endeavour

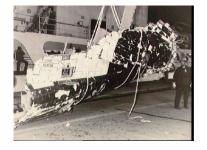


Endeavour, STS-68 - Damaged Heat Tiles

NASA photo.

View this asset at:

http://www.awesomestories.com/asset/view/Endeavour-STS-68-Damaged-Heat-Tiles



<u>Challenger - Heat Tiles Intact After Explosion</u>

NASA photo.

View this asset at:

http://www.awesomestories.com/asset/view/Challenger-Heat-Tiles-Intact-After-Explosion



Replacing Damaged or Missing Tiles

Image online, courtesy NASA.

View this asset at:

http://www.awesomestories.com/asset/view/Replacing-Damaged-or-Missing-Tiles



Columbia, STS-28 - Repairing Heat Tiles

NASA Photo.

View this asset at:

http://www.awesomestories.com/asset/view/Columbia-STS-28-Repairing-Heat-Tiles



Columbia, STS-28 - Inspecting Tiles

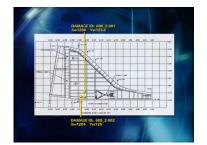
NASA photo.

View this asset at:

http://www.awesomestories.com/asset/view/Columbia-STS-28-Inspecting-Tiles



In this NASA image, we see a Mission-Status Briefing Graphic for STS-118 (a flight by the shuttle *Endeavour*).



The briefing, which took place on the 11th of August in 2007, addressed the loss of foam insulation (which coats the External Fuel Tank). The concern was whether any of the loosened foam had struck any part of the Orbiter and, if so, what damage might it have caused?

Loss of foam insulation, and the damage it could cause to the shuttle fleet, had become particularly important after *Columbia* was lost (on February 1, 2003) as a direct result of a foam-strike during that mission's launch sequence.

Click on the image for a better view.

Image online via NASA.

View this asset at:

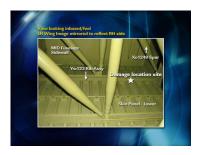
http://www.awesomestories.com/asset/view/Endeavour-Mission-STS-118-Damage-Detail



Heat Tile Floating in Space

Image online, courtesy NASA.

View this asset at: http://www.awesomestories.com/asset/view/Heat-Tile-Floating-in-Space



Endeavour, STS-118 - Inside View of Damage Area

Image online, courtesy NASA.

View this asset at:

http://www.awesomestories.com/asset/view/Endeavour-STS-118-Inside-View-of-Damage-Area



Endeavour, STS-118 Mission - Heat Tile Gash

NASA Photo - online, courtesy NASA.

View this asset at:

http://www.awesomestories.com/asset/view/Endeavour-STS-118-Mission-Heat-Tile-Gash



Endeavour, STS-118 - Heat Tiles Struck

NASA Photo.

View this asset at:

http://www.awesomestories.com/asset/view/Endeavour-STS-118-Heat-Tiles-Struck







NASA photo. Online, courtesy NASA.

View this asset at:

http://www.awesomestories.com/asset/view/Endeavour-STS-127-Picture-of-Falling-Debris

ORBITER HEAT TILES

View this asset at: http://www.awesomestories.com/asset/view/ORBITER-HEAT-TILES



Endeavour - Launch of STS-127, 15 July 2009

NASA video of Endeavour (STS-127) launch. Online, courtesy NASA.

View this asset at:

http://www.awesomestories.com/asset/view/Endeavour-Launch-of-STS-127-15-July-2009