AWESOME stories

ORBITER HEAT TILES

NASA's Goddard Institute for Space Studies explains why 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 leading edge of its wings (which are coated with reinforced carbon-carbon) are the hottest areas during re-entry. Temperatures on these surfaces can exceed 3,000 degrees F.

Coated black ceramic 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 rudder speed brake.

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

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

Repairing damaged heat tiles in space, however, is risky. Even if an orbiter is docked at the International Space Station (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 pitch maneuver as the orbiter approached the space station. That process enabled personnel inside the space station to take pictures of the shuttle's underside. (Pictures of *the Earth* taken from the ISS, parenthetically, provide an *unbelievable sight* to behold - especially when viewed in time-lapse video!)

When NASA's flight managers saw an apparent gash, they ordered *Endeavour's* astronauts to determine its dimensions, including the depth. Using a laser-tipped inspection boom, crew members were able to confirm the gash measured 3½ by 2 inches (9 by 5 centimeters), leaving a small area of *Endeavour* 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 shuttle undocks 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 heat tile floats outside *Columbia's* window as she traveled on Mission 61-C. 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-Explosion

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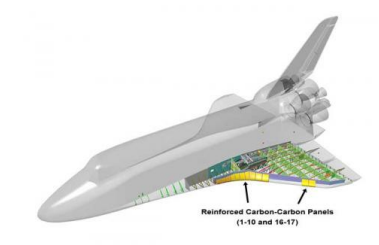
http://www.awesomestories.com/asset/AcademicActivities/ORBITER-HEAT-TILES-Columbia-Space-Shuttle-Explosion

Media Stream



Leading Edge Carbon Reinforced Tiles
Diagram, courtesy NASA.
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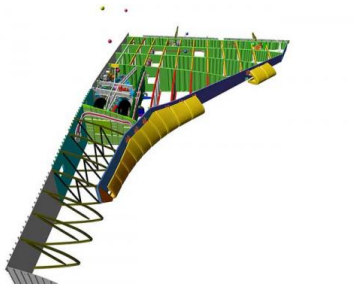

Shuttle Wings
Drawing, courtesy NASA.
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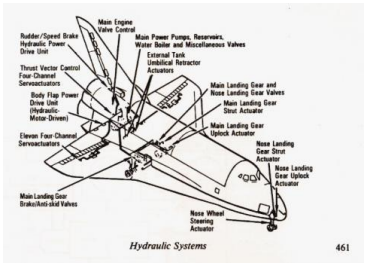

Shuttle Hydraulic System
Drawing, NASA.
Quoted passage on hydraulic systems, *HowStuffWorks.com*.
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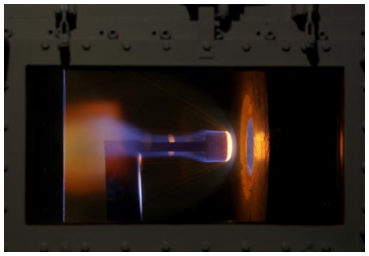

Testing the Heat Tiles
Photo, courtesy NASA.
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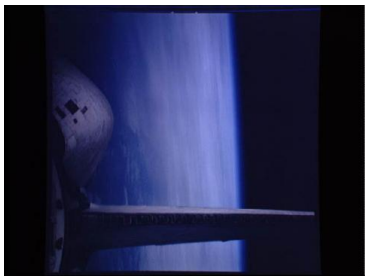

View of Tiles

Photo, courtesy NASA.

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Space Shuttle Endeavour

Photo, NASA.

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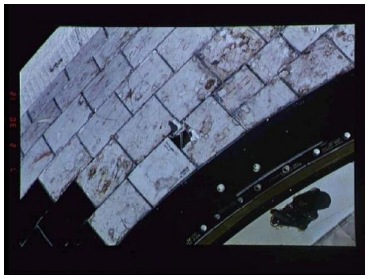

Endeavour, STS-68 - Damaged Heat Tiles

NASA photo.

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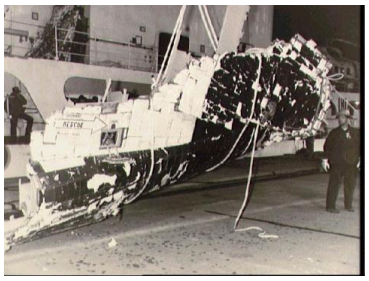

Challenger - Heat Tiles Intact After Explosion

NASA photo.

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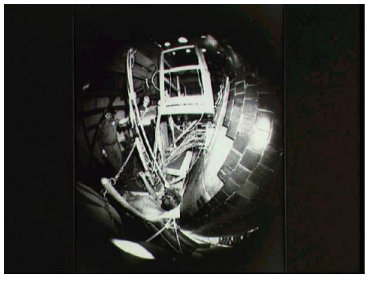

Replacing Damaged or Missing Tiles

Image online, courtesy NASA.

View this asset at:
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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.
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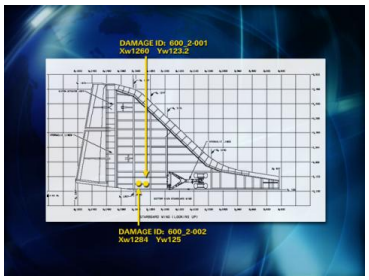
Endeavour, Mission STS-118 - Damage Detail

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.
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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.
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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.
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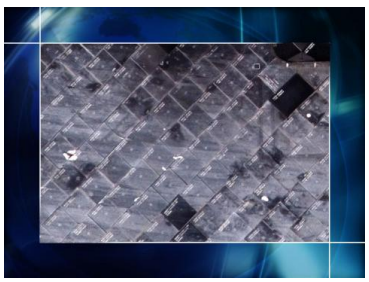

Endeavour, STS-118 - Heat Tiles Struck

NASA Photo.
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Endeavour, STS-127 - Picture of Falling Debris

NASA photo. Online, courtesy NASA.

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ORBITER HEAT TILES

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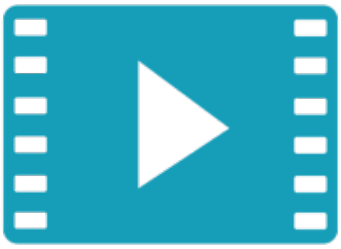

Endeavour - Launch of STS-127, 15 July 2009

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

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