FLUKE®

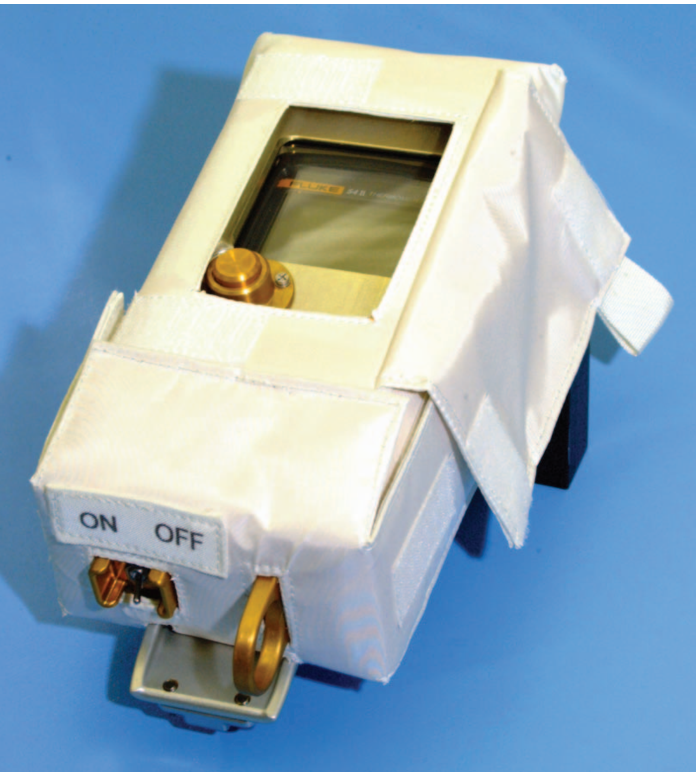
Fluke in Space

Digital thermometers test Thermal Protection System tiles

Technology at Work

When the U.S. space shuttle Discovery thundered into the skies in the summer of 2005, Fluke was suited up for the ride into the ozone.

It wasn't Fluke's first space visit. Fluke tools have frequently been called on to work beyond the pull of gravity. But this time, the mission was truly critical.



The Fluke 54-2 in its NASA suit of aluminum, mylar and fiberglass. Engineers reduced the conrols to just one button.

Painstakingly adapted for work in space, a Fluke 54 Series II digital thermometer and 80PK-27 surface contact probe played a key role in proving that the Thermal Protection System (TPS) tiles that save the shuttle from the fierce heat of atmospheric friction can be repaired, even in the chill vacuum of space.

Discovery's "Return to Flight" voyage in the summer of 2005 was the first Shuttle flight since the tragic loss of the Shuttle Columbia. In addition to delivering supplies and equipment to the International Space Station, the 12-day mission tested inspection and repair techniques in space that had never been done before. Dressed in a protective space suit of aluminum, Mylar and fabric, the Fluke 54 accompanied astronauts on their Day Five space walk.

Perfecting space-based repairs became a top priority after the loss of the last Shuttle, Columbia, which disintegrated over Texas as it re-entered the atmosphere on Feb. 1, 2003. For more than two years the Shuttle program was grounded as investigators sought a cause and developed fixes.

The Columbia Accident Investigation Board concluded that a piece of insulating foam that broke off Columbia's external fuel tank during lift off had hit and damaged the protective tiles at the leading edge of the Shuttle's left wing.

In the wake of the Columbia accident, hindsight became crystal clear. The foam problem had occurred before, yet Columbia astronauts had no way, short of a space walk, to inspect the TPS system while in flight—and no proven method to fix any problems they might find. Even if Columbia's crew had confirmed the damage during flight, there was almost nothing they could do to repair it.

The Accident Investigation Board recommended changes to the fuel tank that would prevent Shuttles from shedding their fuel tank insulation during takeoff. But insulation is not the only threat spacecraft face from foreign object debris. "Space junk" and micrometeoroids can also cause surface damage. So the board also recommended that the U.S. National Aeronautics and Space Administration (NASA) "develop a practical capability to inspect and effect emergency repairs to the widest possible range of damage to the Thermal Protection System."

By 2005 those repair capabilities were ready for testing. In their first space walk, on day five of the Discovery mission, crew members Steve Robinson and Soichi Noguchi ventured outside the Shuttle to demonstrate repair techniques on sample tiles in the cargo bay.

NASA developed two kinds of repair techniques: mechanical and chemical. Mechanical methods for fastening patches to the Shuttle's protective skin can be accurately tested on earth. But chemical systems—in essence, high tech glues and fillers—could be affected by the vacuum of space, and by temperatures that can swing from 250 below zero up to 258 degrees Fahrenheit as the Shuttle orbits from the earth's shadow into the sunlight. It is space where these systems must be proven.

So space is where the modified Fluke 54 earned its airfare, testing repairs on the reinforced carbon-carbon (RCC) material that covers the critical leading surfaces of the Shuttle's nose and wings. During Shuttle descents, these surfaces glow at temperatures hot enough to melt steel. Damage here brought down Columbia.

NASA assigned Swales Aerospace, an employee-owned engineering firm headquartered in Beltsville, Maryland, to prepare the Fluke 54 for space duty. Surprisingly few changes were needed, according to Swales testing engineer George Tansill.

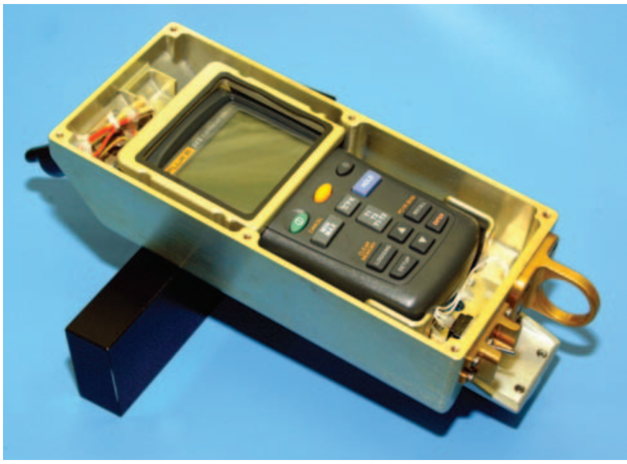
The first change you see is the meter's new case, or space suit. The gray plastic Fluke 54 lives in a three and a half-pound protective aluminum chassis that's wrapped in turn in a multi-layer blanket of reflective Mylar plastic. The outside is a layer of white beta cloth, a woven fiberglass material impregnated with Teflon. It's the same material astronauts wear for space walks. A plastic window covers the Fluke 54's screen. Crew members can place a flap of the insulating blanket over the window to further slow heat loss.

Temperatures in space vary tremendously. Objects in the sun can quickly heat up, while those in shadow grow cold. Crew members carry the Fluke 54 to work in a secondary bag, then clip the insulated chassis to their space suit or the work site. With the added mass of its aluminum chassis, protected by its insulating blanket of Mylar, the Fluke stays within its operating range outside the Shuttle for up to eight hours.

The harsh environment of space mandated other modifications. Concerned that a strike by a cosmic particle might affect the unit's software, Swales engineers installed an outside switch to positively disconnect the Fluke 54 battery. If that happens, switching the battery off and on resets the software.

Other changes help achieve a basic engineering goal: KISS (keep it simple, stupid). The space thermometer has just one button, for one temperature test. At the business end of the device is a Fluke 80PK-27 Industrial Surface probe, shortened and attached rigidly to the aluminum chassis.

Though simple to use, the space thermometer has a vital mission. Robinson and Noguchi used it to check surface temperatures as they test a kind of "space spackle" for patching cracks up to four inches long and .02 inches wide in the RCC panels. Called NOAX (short for Non-Oxide Adhesive eXperimental), this pre-ceramic polymer sealant is impregnated with carbon-silicon carbide powder. It's designed to fix the kind of damage possible if, in spite of improvements, small pieces of foam fall from the external fuel tank.



NASA engineers dissassembled 10 Fluke 54-2 thermometers to create their custom space-models. In the process, they investigated every safety aspect imaginable, especially shatter-proof impact resistance and extreme temperature tolerance.

Crew members use hand tools similar to putty knives to work the material into the crack and smooth the repair, and then they heat the repair area as necessary. And Tansill points out that the Shuttle commander can control worksite temperatures by positioning the vehicle and establishing an orbit that provides optimal exposure to the sun.

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