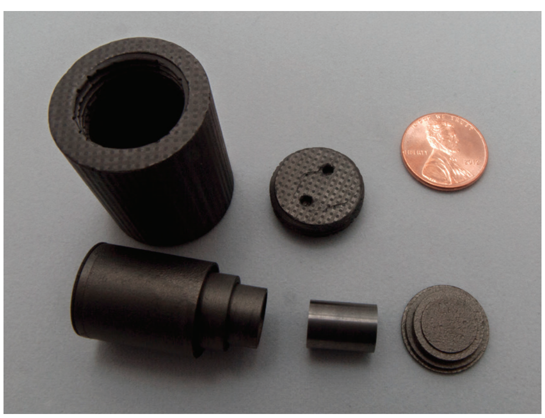
NASAfacts

Radioisotope Heater Units

Like a steady campfire that warms intrepid hikers in a remote forest, radioisotope heater units (RHUs) help bring dependable heat to wherever it's needed for missions bound for the coldest corners of the solar system.

The electronics and mechanical systems used by modern spacecraft may need assistance in maintaining their proper operating temperatures, even when toughened for space travel. For example, the temperatures on Earth's moon can swing from +250 degrees Fahrenheit in sunlight to -250 degrees in the dark within a matter of minutes, and conditions in deep space are often even colder.

An RHU generates about one watt of heat energy from the natural radioactive decay of a small pellet of plutonium dioxide (which consists mostly of plutonium-238). This heat can be transferred directly to spacecraft structures, systems, and instruments, without the need for moving parts or intervening electronic components.



The fuel pellet in an RHU, inside the small metallic cylinder at bottom center in this image, is about the size of a pencil eraser.
Image credit: Department of Energy

As with all other U.S. radioisotope power systems, RHUs are provided to NASA by the Department of Energy. More than 300 RHUs have been launched on a wide variety of historic science instruments and spacecraft systems, from Apollo 11 in 1969 through the long-lived Mars Exploration Rovers Spirit and Opportunity that landed on the Red Planet in January 2004.

Other landmark uses of RHUs include the probes sent into the atmospheres of Jupiter and Titan (and their 'parent' spacecraft, Galileo and Cassini), and the nine RHUs aboard the Voyager 1 and 2 deep space probes, each of which continues outward more than 12 billion miles from Earth.

RHUs have valuable benefits beyond their continuous emittance of heat. RHUs offer mission designers great flexibility in where a source of heat can be located, and they reduce the potential for the electromagnetic interference that can emanate from electrical heaters. RHUs are also immune to radiation effects and highly resistant to damage from micrometeorites.

An RHU is very compact, standing only 1.3 inches (3.2 centimeters) tall by one inch (2.6 centimeters) in diameter, with a total mass of about 1.4 ounces (40 grams). As of September 2014, the average thermal power of the RHUs in the DOE's inventory was approximately 0.90 watts each; this thermal power will continue to decrease by about one-hundreth of a watt per year, due to the natural decay of the radioisotope fuel (Pu-238 has a half-life of 88 years).

The design of an RHU provides a rugged, layered containment system to prevent or minimize the release of plutonium dioxide fuel even when subjected to severe accident conditions. Containment is achieved through multiple layers that are resistant to the heat and impact that might be encountered during a spacecraft accident.

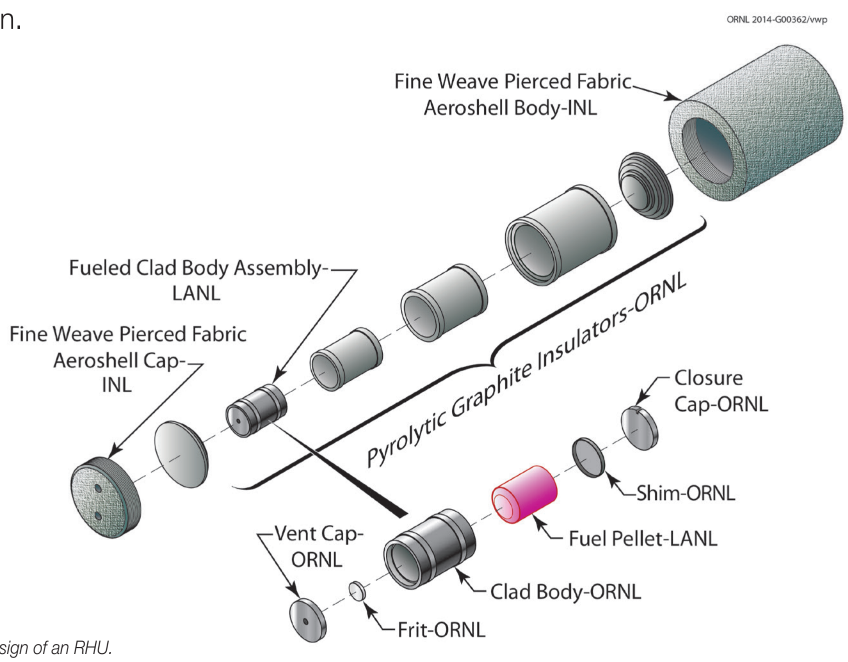
An outermost aeroshell made from extremely tough material called fine-weave pierced fabric plus a graphite-based insulator protect the fuel in an RHU from potential physical impacts, fires, and atmospheric reentry conditions. The fuel is encapsulated in a high-strength, platinum-rhodium metal shell (or "clad") that further protects and helps contain the fuel during a potential accident.

As with the plutonium dioxide fuel in a radioisotope thermoelectric generator, the fuel pellet in an RHU is in a ceramic form that offers many safety features. Similar to the materials used in coffee mugs, ceramics tend to break into large pieces rather than being vaporized into fine particles, which can become a health hazard if inhaled or ingested. Furthermore, the ceramic form is insoluble, greatly reducing the risk of ingestion by food or water contamination.

Since each RHU fuel pellet is individually encapsulated in its own aeroshell and cladding, there is less potential for a single accident to affect more than one RHU. RHUs have been subjected to a variety of detailed safety analyses and rigorous impact testing, testing which was designed purposely to be more severe than expected accident conditions.

The next possible use of RHUs on a NASA mission may be the next mission to be selected under the NASA Science Mission Directorate's New Frontiers program. Proposing teams have been offered the chance to use up to 43 RHUs from the existing U.S. inventory toward mission concepts that could explore icy comets, the atmosphere of Saturn, the surfaces of Venus or the Moon, the "Ocean Worlds" of Enceladus or Europa, or the Trojan asteroids (which circle the sun in the same orbit as Jupiter).

No matter the destination, RHUs help "bring the heat" to enable NASA mission success across the solar system.



An artist's concept of the layered design of an RHU.
Credit: Department of Energy
Oak Ridge National Laboratory (ORNL)
Idaho National Laboratory (INL)
Los Alamos National Laboratory (LANL)

Visit ***rps.nasa.gov*** for more information on NASA's use of Radioisotope Power Systems.