The Multi-Mission Radioisotope Thermoelectric Generator for Science Exploration

Presented by: David Woerner | RTG Integration Manager | NASA Jet Propulsion Laboratory | David.F.Woerner@jpl.nasa.gov | (626) 497-8451

The Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) was developed to serve as a power source for a variety of space missions, from planetary surface to deep space interplanetary missions. Its special capability to handle the harsh surface environment of Mars makes it unique among recent RTGs, which could not survive on the surface of Mars. The special design characteristic of an isolated and hermetically sealed thermoelectric converter compartment enables long term performance in a multitude of environments.

The MMRTG converts thermal energy, supplied by the Department of Energy's General Purpose Heat Source (GPHS) modules, to electrical energy. The MMRTG produces electrical power when heat generated from the decay of the radioisotope fuel in the GPHS modules flows through the thermoelectric couples located around the heat source. The resulting temperature gradient across the thermoelectric couples generates a voltage via the Seebeck effect. The generator produces power when a load is placed across the thermoelectric string, allowing current to flow. Waste heat is rejected to the environment via radiator fins attached to the housing.[1]

Thermoelectrics [2]
The MMRTG thermocouple is based on the proven design heritage of the Pioneer and Viking RTGs. The thermoelectric materials (PbSnTe, TAGS, and PtTe) have demonstrated extended lifetime and performance capabilities, and are based upon those used for the two Viking spacecraft that landed on Mars in 1976.

The MMRTG has 16 thermoelectric modules connected in series. Each module contains 48 thermoelectric couples in an electrical series/parallel ladder arrangement for reliability.

Two module box tests are underway at Teledyne Energy Systems, to measure the long-term performance of MMRTG thermoelectric couples. The boxes are being operated at two different temperatures to envelop potential mission operating conditions of the MMRTG.

Mission Performance: Mars Science Laboratory

The Mars Science Laboratory (MSL) mission successfully landed on Mars on August 6, 2012, when it began science operations for its primary mission. MSL's MMRTG is operating very well on the surface of Mars, providing power above predictions and operating within its flight allowable temperature limits. The MSL mission produced approximately 114 W, at the beginning of the surface mission [8].

The MSL mission provided the first experience with integrated design and operation of a thermoelectric power source, a solar array, and rechargeable Lithium-ion batteries on an interplanetary mission. Given the internal fault protection measures of the MMRTG, MSL interfaced the MMRTG directly with the power bus [7].

Extended Operation Testing of MMRTG Engineering and Qualification Units [5]
The MMRTG Engineering Unit (EU) is currently under life assessment testing at the University of Dayton Research Institute in Dayton, Ohio. Life assessment testing began with an electrical heat source simulator in 2007, and so the EU has accumulated more than approximately 8.85 years on test, as of 2013 [4].

The EU was previously tested to demonstrate the MMRTG flight design could meet the extreme Multi-Mission qualification requirements. The test program was divided into five major segments: electrical performance, thermal vacuum, vibration, pyro-shock, and magnets.

Future EU tests under consideration include: both long-term and accelerated simulation of Curiosity's diurnal thermal cycling; transient power output analysis; helium leak testing; and possible chassis short characterization.

The MMRTG Qualification Unit will begin life assessment this summer, and subsequent tests will evaluate performance parameters against original QU data for baseline performance validation. The assessment will simulate as deep space cruise as opposed to MSL's thermal cycling on Mars.

COMING SOON: Get Access to More MMRTG Information

Interested in Proposing a mission using an MMRTG? U.S. Citizens who are U.S. NASA affiliates may request approval to access MMRTG Technical Data located in the RPS User’s Library. The RPS User’s Library is expected to be made available at http://rps.nasa.gov in Fiscal Year 2016. For more details email the RPS Program at rps@nasa.gov.

Literature cited

www.nasa.gov