

Pyroshock Testing of the Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)

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Abstract. The Mars Science Laboratory (MSL) Multi-Mission Radioisotope Thermoelectric Generator, or MMRTG, was developed by the Department Of Energy to a set of requirements from multiple NASA mission concepts. Those concepts included deep space missions to the outer planets as well as missions to Mars. The synthesis of that diverse set of requirements addressed functional as well as environmental requirements.

The MSL mission was fortuitous in that the multi-mission environmental requirements largely encompassed the MSL environmental requirements. This was true in the case of pyroshock, and for MSL, the worst case shocks were predicted during Entry, Descent, and Landing (EDL) when 86 pyros would be fired at approximately 8 months after launch. An early version of the generator, called the Engineering Unit, or EU, was assigned to be the test article for the pyroshock tests at multi-mission levels. The test was conducted, but due to the "weakly-controlled" nature of the test equipment, the MMRTG experienced severe "overtest" conditions. The EU survived the test extremely well though, and has since gone on to operate for several years.

During the test, current and voltage measurements were made at a high-enough frequency to observe a slight dip in electrical power output at the time each shock was applied. The power recovered after each shock.

Subsequent testing on another “never-before-shocked” generator found a similar behavior during more moderate shock testing, exhibiting a slight, temporary decrease in power output; this phenomenon was proved to be repeatable and a small team of engineers was formed to review possible causes and recommend further action if any. All of this work was preparatory for a late 2009 launch.

MSL's MMRTG was placed into storage awaiting a November 2011 launch after the mission postponed launch. This added approximately two years of age to the generator and so the MMRTG flight unit would have operated continuously for approximately 3.25 years when it was actually exposed to the shocks during Entry, Descent, and Landing. The EU had been tested in the spirit of Test-As-You-Fly, but now, due to the launch delay, the credibility of the earlier testing was questioned. No one could conclusively assert the MSL MMRTG would not be harmed by applying pyro-shocks so far into its operating life.

After careful review with the DOE and its contractors and experts, a test plan was formulated to test an aged generator at JPL in a flight-like configuration and witness how it performed in the face of worst case shock testing. This paper elaborates on the above observations, discusses potential root causes, and describes the resultant testing at JPL and the outcome.