Space Radioisotope Power Systems
Stirling Radioisotope Generator

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Why Develop a Stirling Radioisotope Generator (SRG)?

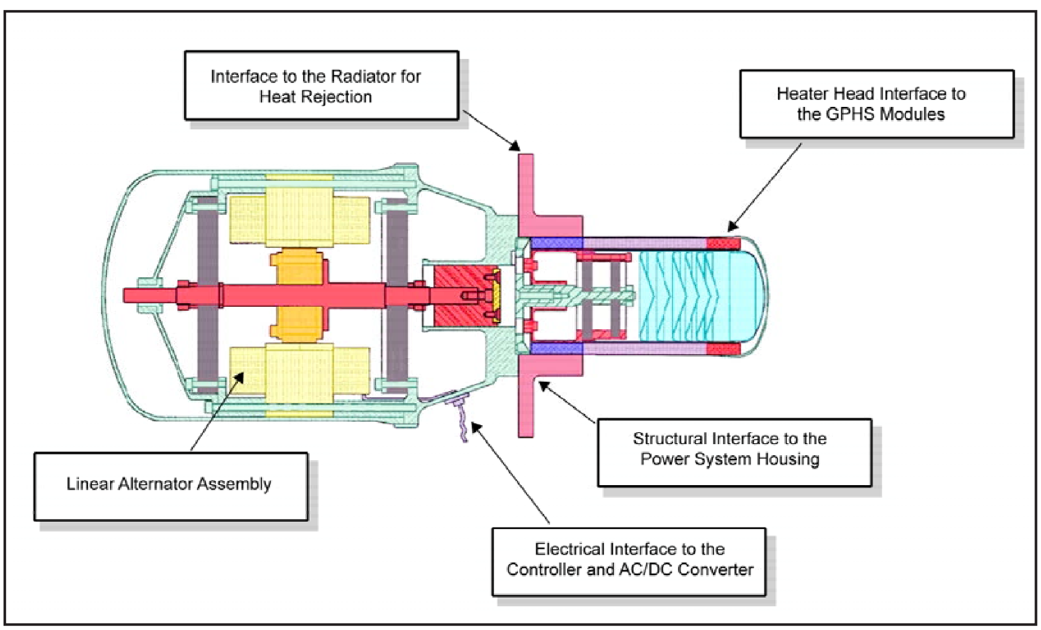
Radioisotope power systems can provide continuous power for 20-plus years, and have been used safely and reliably over the past 30 years in regions of space where the use of solar power is not feasible. To date, the United States has launched 25 missions involving 44 Radioisotope Thermoelectric Generators (RTGs). Although Stirling Radioisotope Generators have not been launched in a space exploration mission to date, they too are an application of a radioisotope technology that is well understood. To enable the next ambitious steps in exploration of our Solar System with safe, cost effective spacecraft, the U.S. Department of Energy (DOE) and National Aeronautics and Space Administration (NASA) are developing advanced, high-efficiency radioisotope power converters. The Stirling Radioisotope Generator (SRG) is one of the technologies being developed to provide spacecraft onboard electric power for potential use on future NASA missions. The development of the SRG will build upon a 55-watt-electric Stirling convertor previously developed under DOE contract with the Stirling Technology Company (STC), with NASA Glenn Research Center (GRC) assistance. The efficiency of the Stirling convertor was demonstrated to be in the mid 20 percent range. Use of the 55-watt-electric convertor in an SRG could reduce the required amount of radioisotope fuel (plutonium-238 dioxide), thereby potentially reducing the cost and amount of plutonium-238 dioxide flown on future missions.

How Does a Stirling Convertor Work?

The 55-watt Stirling convertor is a free-piston machine that operates on a Stirling thermodynamic cycle. Heat is supplied to the convertor from a DOE General Purpose Heat Source (GPHS) module, containing approximately 600 grams of Plutonium dioxide, and producing about 250 watts of thermal power. The heat input to a convertor results in a hot-end operating temperature of 650^{o}C. Heat is rejected from the cold end of the convertor at nominally 80^{o}C. The closed-cycle system converts the heat from a GPHS module into reciprocating motion with a linear alternator resulting in a AC electrical power output of 60-62 watts. An AC/DC convertor in the Stirling convertor controller converts the AC power to approximately 55 watts DC.

What Are the Current Development Plans?

The need for safe, reliable, long-lived power systems for future missions includes surface exploration of planetary bodies such as Mars as well as missions in the vacuum of space beyond Earth orbit. DOE and NASA are initiating the development of a Stirling Radioisotope Generator (SRG) power system that could be used for a variety of missions. The design goals for the SRG include ensuring a high degree of safety, optimizing power levels over a minimum lifetime of 14 years, and minimizing weight. The SRG will be designed to operate on planetary bodies as well as in the



vacuum of space. In addition, it will be designed to deliver 100 to 120 watts of DC electric power. Each SRG will utilize two 55-watt Stirling convertors with about 500 watts of thermal power supplied by using two GPHS modules.

Technical Challenges of SRG Development

The development of a new advanced radioisotope power system poses several technical challenges. The SRG is a dynamic machine that produces natural vibrations and potential electromagnetic interference to scientific instruments and the spacecraft. This interference would have to be below specified levels to be acceptable for operation on a spacecraft. For potential long duration missions (3-15 years), SRG reliability and lifetime need to be assessed. The ability of an SRG to withstand and operate under launch vibration loads also has to be evaluated.

The NASA Glenn Research Center (GRC) has been conducting in-house technology projects to assist DOE in the development of the Stirling convertor to meet space qualification requirements and mission readiness for future potential NASA missions. As part of this effort, NASA GRC has characterized a 55-watt Stirling convertor for electromagnetic interference and compatibility, and conducted launch environment vibration tests at qualification levels. During those tests, the convertor operated successfully.

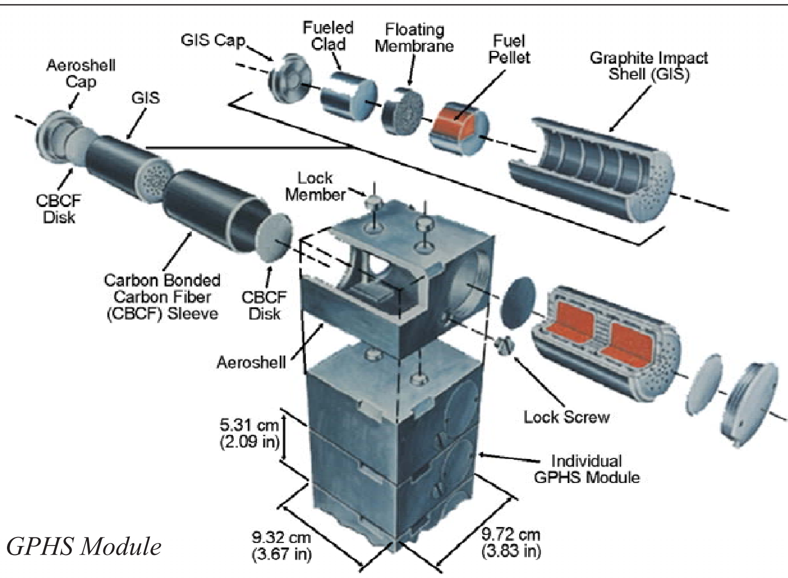
Stirling convertors will operate in an synchronous opposed pairs in a SRG configuration, which will likely help minimize vibration levels under normal operating conditions. While operation of the convertors in this configuration has shown reduced convertor vibration levels by a factor of over 100 when compared to an unbalanced single convertor, work remains to demonstrate the performance of the Stirling convertor in a flight configuration.

The design of the 55-watt Stirling convertor was based on previously successful development efforts, such as a 10-watt-electric radioisotope terrestrial convertor and a 350-watt-electric convertor aimed at commercial cogeneration and remote power applications. Testing of these convertors, for over 70,000 hours of accumulated test time with no maintenance and no degradation of performance, has indicated that the Stirling convertor may meet NASA's life and reliability goals for space applications.

Significant progress has been made in addressing these technical challenges at the component level. The development program being initiated by NASA and DOE will integrate these components into an overall system design.

Summary

DOE and NASA are currently planning a competitive procurement for the design, development, and qualification of an SRG for potential use on future NASA space exploration missions. The intent is to develop a radioisotope power system that offers the potential for a more efficient system that would use less plutonium-238 dioxide.



GPHS Module