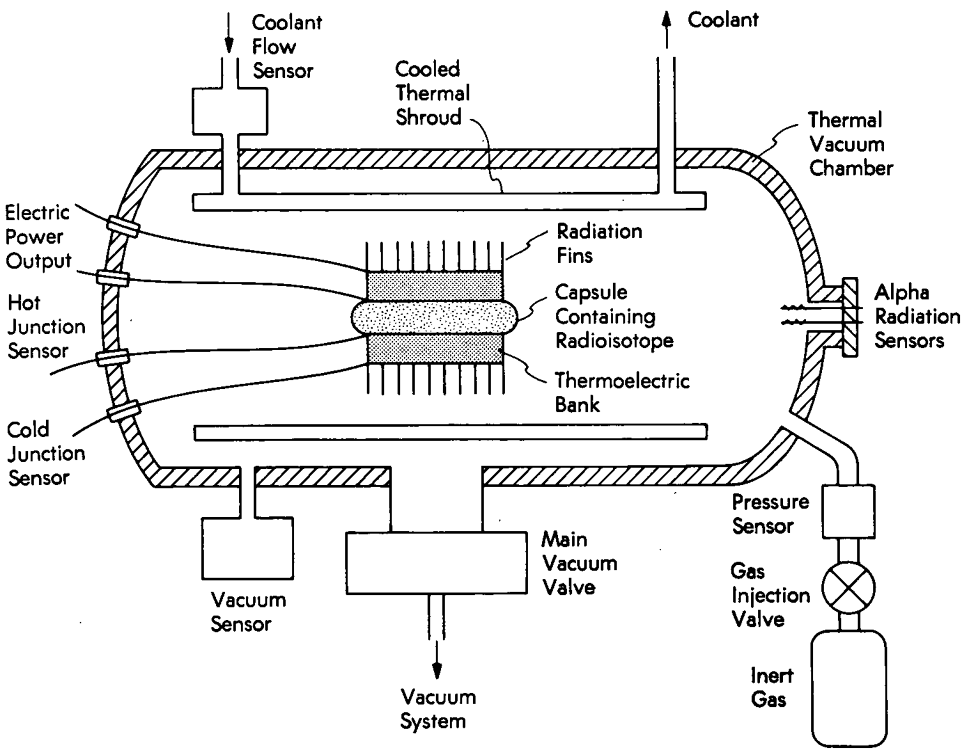
NASA TECH BRIEF

NASA Pasadena Office

Safety Monitoring System for Radioisotope Thermoelectric Generators



A comprehensive monitoring system has been developed to alert personnel of hazards which may develop while they are performing tests on a radioisotope thermoelectric generator (RTG). The monitoring system also initiates remedial action so as to minimize damage to the RTG test equipment and to protect personnel.

The diagram depicts the apparatus and monitoring system used for testing a spacecraft RTG in a thermal-vacuum environment. Thermoelectric junctions in contact with the hot surface of a capsule containing a radioisotope and with a cold surface (for example, the outer container of the RTG which radiates heat to a cold thermal shroud within the test chamber) are connected in series-parallel so as to generate electric power. Six sensors in the test system monitor five operating conditions: hot junction temperature, cold junction temperature, thermal shroud coolant flow,

(continued overleaf)

vacuum in the test chamber, and alpha radiation (two sensors). Each sensor (except one radiation sensor) is adjusted so that it triggers a malfunction signal when a specific operating condition deviates from a predetermined level. The malfunction signal activates circuitry which initiates an alarm sequence and appropriate emergency procedures which correct or minimize the malfunction. The emergency procedures and alarm sequences, which can also be initiated manually for test or in the event of unforeseen emergency, are described below.

Abnormal increase in hot junction temperature. A temperature sensor at the hot junction is connected to a temperature controller that has two adjustable signal points. The first point is set so as to generate a signal when the hot junction is at a temperature slightly above (approximately 10°C) its normal operating temperature. The signal activates audio and visual alarms in the test area and activates alarms at a continuously manned remote control center. The signal also energizes a relay which in turn short-circuits the electric power output of the RTG; short-circuiting causes an increase in Peltier cooling, which normally brings the hot junction temperature back to the normal operating range.

If the temperature continues to rise, a second signal point on the temperature controller generates a signal when the hot junction reaches a temperature approximately 25°C above the normal operating temperature of the hot junction. The second signal activates circuits which close the main vacuum valve to seal off the vacuum chamber and, after a delay of 15 seconds, cause release of an inert gas into the vacuum chamber until the chamber pressure reaches approximately 80 kN/m^2. The chamber pressure is maintained below atmospheric to avoid the possibility of escape of radioactive material. The inert gas also reduces the hot junction temperature by convective heat transfer from the outer surface of the RTG to the cool thermal shroud (and within the RTG by conductive heat transfer); a temperature drop of up to 95°C can be easily achieved. The inert gas also prevents possible oxidation or sublimation of materials in the hot generator.

Abnormal increase in cold junction temperature. A temperature sensor on the cold outer container of the RTG is connected to a second controller set to provide a signal when the temperature reaches an abnormal value (approximately 8°C above the normal outer-wall operating temperature). As described above, this signal also activates alarms and circuitry which simultaneously close the vacuum valve, and, after a delay of 15 seconds, open a gas injection valve.

Open circuit in the RTG. Any open circuit in the RTG electric-load output circuit causes an abnormal increase in the hot junction temperature. An increase in output voltage to an abnormally high value also produces the same effect. If these malfunctions occur, the hot-junction two-point controller initiates the actions first described above, and an electronic load control brings the output voltage back to a preset value.

Loss of coolant flow or loss of vacuum in the test chamber also actuate all audio and visual alarms and the circuitry which short-circuits the electric power output, closes the vacuum valve, and introduces gas to the chamber.

Release of radioactivity into the test chamber. In this instance, it is imperative to confine radioactivity to the interior of the vacuum chamber. Two alpha-radiation sensors are located within the chamber; any release of alpha particles causes the first sensor to generate a signal which activates alarms as described above and a special alarm system which signals a nuclear hazard; the main vacuum valve is closed. The second alpha sensor is used to confirm the operation of the first sensor and to record the amount of radiation within the chamber. This information is used by the test engineer to analyze the malfunction and to determine a course of corrective action.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
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NASA has decided not to apply for a patent.

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