SPACE PROPULSION SYMPOSIUM (C4)
Joint session on Nuclear Propulsion and Power (7.-C3.5)

Author: Dr. Leopold Summerer
European Space Agency (ESA), The Netherlands, leopold.summerer@esa.int

Mr. Jean-Pierre Roux
Areva, *(country is not specified)*, Jean-pierre.roux@technicatome.com
Mr. Alexey Pustovalov
BIAPOS, *(country is not specified)*, *(email is not specified)*
Mr. Viacheslav Gusev
BIAPOS, Russian Federation, *(email is not specified)*
Mr. Nikolai Rybkin
BIAPOS, Russian Federation, *(email is not specified)*

TECHNOLOGY-BASED DESIGN AND SCALING LAWS FOR RTGS FOR SPACE EXPLORATION IN THE 100 W RANGE

Abstract

This paper presents the results of a study on design considerations for a 100 W radioisotope thermoelectric generator (RTG). Special emphasis has been put on the derivation of robust scaling laws covering the electric power range from 50 to 200 electric Watt. The retained concept is based on a modular block structure (unified modular structure). While taking advantage of existing Russian experience and expertise, the study reconsidered the elementary options for the full design and development process, including its safety, technical, administrative and legal parameters. The finally retained concept is based on Pu-238 (0.56 W/g, 87.6 years half-life) in form of high-temperature sintered PuO2 pellets assembled into “basic heat sources” delivering each 58.7 thermal watts. The symmetric cylindrical heat sources of 29.4x29.4 mm would have a subsystem mass of 256 g. Four of these heat sources would constitute a basic heater unit, delivering 234.8 thermal Watt with a heater unit system mass of 1.900 kg. Based on Martian surface operation assumptions and cold well temperatures of 80 or 250C, an RTG that could deliver roughly 100 W electric at end of life after 10 years would require six basic heater units, generating about 1409 thermal Watt. The state of the art of the development of reliable and long-life semiconductor thermoelectric materials that can be used for such an RTG has been analyzed. The preliminary tradeoff with emphasis on existing technology and reliability lead to the choice of two-cascade thermoelectric battery with the high-temperature cascade on the basis of SiGe alloys and the medium-temperature cascade on the basis of PbTe/GeTe alloys. Numerical analysis of a 50, 100, 150 and 200 electric Watt RTG has shown that this power range could be covered with the same modular technology and structure. Tentative dimensions, masses, and materials have been determined. According to preliminary estimates, such a 100 W RTG, based on a cold well (casing) temperature of 240C would be able to achieve roughly 7.8 Numerical investigations have been performed to determine the approximate expected equivalent dose levels of such an RTG in order to take these into account due to their impact on storage, operations and especially AIV processes and procedures. For 100 W RTGs based on the described design, the equivalent dose has been calculated to reach the maximum value in the central part of the side surface of the cylinder of about 27 mSv/h, with the values on the axial directions being roughly 30