Department of Energy
Germantown, MD 20874-1290

SAFETY EVALUATION REPORT

Radioisotope Thermoelectric Generator Transportation System Safety Analysis Report for Packaging, Addendum No. 2

Docket 02-7-9904

Chapter 1. Introduction and General Information

Duratek Federal Services, Inc. Northwest Operations, Richland, Washington has prepared for the U.S. Department of Energy (DOE) the Radioisotope Thermoelectric Generator (RTG) Transportation System Safety Analysis Report for Packaging (SARP), Addendum No. 2 (Addendum 2). Addendum 2 provides the necessary information for two new payloads, the High Performance Generator (HPG) MOD-3 isotopic heat source (IHS) and 10 General Purpose Heat Source (GPHS) fueled clads, to be transported within the RTG packaging system. This appendix (Appendix 2) to the RTG SARP Safety Evaluation Report (SER) addresses the review of Addendum 2.

The RTG SARP provides information on two payloads: (1) a GPHS RTG payload, and (2) a Generic, Enveloping payload. Only the GPHS RTG payload was reviewed in the SER Rev. 0, at the request of DOE. The RTG SARP Rev. 0 was prepared to document compliance with the 1983 version of 10 CFR Part 71. Revision 0 of the SER consequently used 10 CFR Part 71 (1983) as the basis for review. After SER Rev. 0 was prepared, the review was extended to address areas in which the SARP had not demonstrated compliance with the April 1, 1996 version of 10 CFR Part 71 [denoted 10 CFR Part 71 (1996)], and with IAEA Safety Series 6 (1985 version, as amended 1990). Based on the extended review, it was determined that the differences were not significant, and DOE issued a Certificate of Compliance (CoC) under 10 CFR Part 71 (1996), but determined that the SARP would need to be updated to demonstrate such compliance. Areas of the RTG SARP Rev. 0 which had not been in compliance with 10 CFR Part 71 (1996), and with IAEA Safety Series 6 (1985 version, as amended 1990) have been satisfactorily revised in the 0-A and 0-B Revisions of the SARP. Rev. 1 of the SER was prepared to document the findings of this extended review. At the same time, an appendix, which will be referred to as Appendix 1, was added to document the review results of an addendum to the RTG SARP. The addendum that will be referred to as Addendum 1, was prepared by the Fluor Daniel Hanford Company, for DOE providing the necessary information for a new payload, the HPG MOD-3 RTG, to be transported within the RTG packaging system.

Following the format of Appendix 1, this appendix (Appendix 2) is broken into the same sections as the original SER, with a discussion in each section about the new payloads and their compliance with the regulations.

The review of Addendum 2 described in this appendix addresses those areas of the entire RTG Transportation System Package application that are affected by the two new payloads and that were not reviewed in the previous SER. Addendum 2 provides a comparison of the new payloads to the Generic, Enveloping payload, described in the RTG SARP Rev. 0. However, since the previous SER only addressed the GPHS payload, and not the Generic, Enveloping payload, a simple comparison was not possible for the review.

Characteristics of the HPG MOD-3 IHS and the 10 GPHS fueled clad payloads which influence the package design are summarized in Sections 1.2.3.1 and 1.2.3.2 of Addendum 2. Both payloads are variations of the currently authorized payloads, which have a minimum transport index (TI) of 50 (based on criticality safety) and contain sufficient quantities of plutonium to require the implementation of 10 CFR Part 71.63 ("Special Requirements for Plutonium Shipments").

Similar to the case of the two RTG payloads, a shipping rack is placed under the new payloads as a spacer between the payload and the inner containment vessel (ICV) base. The shipping rack is fastened to the ICV base and is designed to remain in place and un-deformed under all conditions including the hypothetical accident condition (HAC) drop. The payload is also bolted to the ICV base through openings in the shipping rack. However, the payload attachment bolts and payload itself are not expected to survive the HAC. In this case, the shipping rack serves as a barrier to protect the containment seals and electrical feed-through connector from the radiation and heat of the broken payload pieces. The shipping rack used for the two new payloads is identical to the one used for the HPG MOD-3 RTG payload. The shipping rack is a circular platform structure, which consists of a 33-inch-diameter, 3/8-inch-thick 304 stainless steel top plate and an eccentric circular cylindrical leg about 5 inches high and made of a 3/8-inch-thick 304 stainless steel plate. Addendum 1 (Document WHC-SD-RTG-SARP-002), page 1.3.2-3 provides details of the shipping rack design. Up to two packages may be carried in a single, exclusive use trailer when loaded with the new payloads.

The HPG MOD-3 IHS payload is essentially the radioactive heat source of the HPG MOD-3 RTG contained in a Storage Protective Container (SPC). Drawings provided by the applicant show details of the IHS and SPC. The HPG MOD-3 IHS consists of 24 fuel sphere assemblies. Each assembly contains sintered PuO_2, which is clad and in the form of a 3.721 cm diameter sphere, that itself is enclosed inside a graphite impact shell having an outer diameter of 6.48 cm. The 24 fuel sphere assemblies are contained within an IHS protection can. The can is in turn housed inside the SPC. The fuel sphere assemblies are positioned in six layers stacked on top of one another with each layer consisting of four assemblies. The maximum amount of PuO_2 per package is 6.22 kg, which produces a maximum of 2,500 W of power. The SPC is a circular cylindrical container with a curved top dome and flat bottom. It is about 10 inches in diameter and 30 inches long and is made of 304 stainless steel plate with a thickness varying from 1/4 to 1/2 inch. The SPC has an analog pressure gage and a shut off valve. The SPC containing the IHS

weighs about 200 lb. The SPC with the IHS payload is placed within the ICV on top of the HPG MOD-3 RTG stand assembly with a special adapter made of 6061-T6 aluminum alloy. The maximum heat load of the payload is 2,500 W, and the activity is 78,400 Ci.

The 10 GPHS fueled clads payload consists of 10 GPHS fueled clads stored in four containers. Four of the clads in an aero-shell are sealed in a delta seal container. Two and three of the clads are stored in two separate EP-61 containers which are currently welded closed. The remaining one clad is placed inside a product can, which is also a welded container. The delta seal container is about 6 inches in outer diameter and 8 inches high. The EP-61 is about 3.5 inches in diameter and 17 inches high. The product can is about 3 inches in diameter and 4 inches high. The four containers are bolted to a 1-inch-thick, 28-inch-diameter 6061-T651 aluminum alloy circular plate. The centers of the four containers are located approximately 11 inches from the center of the circular base plate. The delta seal and the product can containers with their contents weigh about 40 lb and 12 lb, respectively. The two EP-61 containers with payloads weigh less than 22 lb. The maximum heat load of the 10 GPHS fueled clads payload is 625 W, and the activity is 19,900 Ci.

Engineering drawings in Addendum 2 and its supplements provide sufficient information for an adequate evaluation of the compliance of the RTG package containing the new payloads.

Chapter 2. Structural Evaluation

The structural evaluation presented in the RTG SARP Addendum No. 2 for the HPG MOD-3 IHS and the 10 GPHS fueled clads payloads has been reviewed. The review found the evaluation to be adequate and acceptable.

Specifically, the review accepts the following assessments presented in Addendum 2:

(1) Using the maximum acceleration value obtained from the certification drop test program, analyses presented in Addendum 2 show that the downward impact force of the two payloads during a 30-ft bottom end drop of the package cannot permanently deform the shipping rack. Thus the ability of the shipping rack to perform its barrier function under all conditions of transport is assured, although the shipping rack appears weaker than the one that was tested for the GPHS RTG payload. This conclusion holds unless the temperature of the aluminum alloy components of the payload support structure exceeds the conservative estimate of 250F. As the applicant's thermal analysis is extremely conservative, the actual temperature should be considerably lower than the estimate.

(2) The review also focused on the mounting or tie-down designs for the two payloads. The review determined that the designs are adequate for preventing dislocation or large displacements of the payloads during the normal conditions of transport (NCT). Thus the shielding evaluation presented in Addendum 2 for the NCT is adequate without considering possible dislocation of the payloads.

(3) The review also paid special attention to the evaluation presented in Addendum 2 concerning the possible pressure build-up and resulting stress rise in the welded containers (the EP-61 and the product can) of the 10 GPHS fueled clads payload due to helium release from the fueled clads. The review determined the evaluation to be adequate and its favorable conclusion to be acceptable. Nevertheless, the review also concludes that the condition, even if not mitigated, would not lead to a sudden, large rupture of the containers. The ductility of the materials used for the containers would guarantee a leak-before-break mode of failure. Thus, the condition is only a potential safety concern for workers performing the loading and unloading operations.

Chapter 3. Thermal Evaluation

The thermal evaluation presented in the RTG SARP Addendum 2 for the HPG MOD-3 isotopic heat source and the 10 GPHS fueled clads as payloads for the RTG Transportation System Package has been reviewed. The review found the evaluation to be adequate and acceptable.

The GPHS RTG described in the RTG SARP (WHC-SD-SARP-001, Docket 94-6-9904) was reviewed and a Certificate of Compliance was issued by DOE on May 31, 1996. The heat source was contained in 11.3 kg of PuO_2 and produced a maximum of 4,500 W of power. Addendum 1 to the WHC-SD-SARP-001 Revision 0, Docket 95-16-9904, was reviewed and a Certificate of Compliance was issued by DOE on May 27, 1999. The heat source contained in the HPG MOD-3 RTG consists of 6.2 kg of PuO_2 and produces a maximum of 2,500 W of power. The design changes from what had been approved in Addendum 1 are described in Addendum 2, Chapter 1. These changes will not greatly affect the thermal response of the HPG MOD-3 IHS from those of the HPG MOD-3 RTG to NCT or HAC conditions.

The staff agrees that since the worst case heat load for the HPG MOD-3 IHS under NCT conditions is the same as for the HPG MOD-3 RTG presented in Addendum 1, the temperature results for the HPG MOD-3 RTG will bound those for the HPG MOD-3 IHS as well as the much lower decay rate (625 watts) of the GPHS fueled clads.

A description of the HAC analysis for the HPG MOD-3 RTG is given in Addendum 2 to the SARP. The results of this analysis were justified to be applicable to the HPG MOD-3 IHS. The staff agrees with the justification of the use of the results from the HPG MOD-3 RTG applied to the HPG MOD-3 IHS. Thus the staff agrees that since the worst case heat load for the HPG MOD-3 IHS under HAC conditions is the same as for the HPG MOD-3 RTG presented in Addendum 1, the temperature results for the HPG MOD-3 RTG will bound those for the HPG MOD-3 IHS as well as the much lower decay rate (625 watts) of the GPHS fueled clads.

Chapter 4. Containment

The description of the Containment System for the RTG package, as described in WHC-SD-RTG-SARP-001, Rev. 0-B was reviewed and found to meet the requirements of 10 CFR Part 71 (1983), as outlined in Section 4.2 (Acceptance Criteria) of the original RTG SER. The

Containment System review also demonstrated compliance with the requirements of 10 CFR Part 71 (1996) and IAEA Safety Series No. 6 (1985 Version, as amended 1990). Since the original evaluation of the Containment System, as described in the previously referenced documents, was bounding for both NCT and HAC, the addition of the HPG MOD-3 isotopic heat source and the 10 GPHS fueled clads as authorized contents required no additional changes or modifications to the Containment System review.

Chapter 5. Shielding Evaluation

Since Addendum 2 states that up to two packages may be carried in a single, exclusive-use trailer when loaded with the two new payloads, the review has examined all possible combinations of two packages with the two new payloads. The review found the case of two packages with the HPG MOD-3 IHS payloads to be the most limiting case. Thus the following describes only the review of this limiting case.

In the most limiting case, each package with the HPG MOD-3 IHS payloads contains the payload in a storage protection container (SPC) inside the inner and outer containment vessels (ICV & OCV). The two packages, which are to be transported in a semi-trailer truck, have the same radioisotope activity as the two HPG MOD-3 RTG packages approved for shipment in the RTG Transportation System SARP Addendum 1.

Reviewing the engineering drawings of the SPC indicated that the HPG MOD-3 IHS is securely mounted inside the SPC. The distances from the IHS to various dose points at the surface of the package and semi-trailer are expected to be the same as if the IHS is inside the MOD-3 RTG package. Hence, the radiation dose rates are expected to be the same as those evaluated in the RTG Transportation System SARP Addendum 1. Based on this evaluation, this review determined that the transportation configuration of the two HPG MOD-3 IHS packages inside the semi-trailer established in the previous Addendum should be maintained. In addition, the two HPG MOD-3 IHS packages must be separated by at least 2.90 m (9.5 feet) center-to-center in a single shipment.

Therefore, the claims made in the SARP Addendum 2 are confirmed. Two packages with the new payloads in an exclusive-use shipment are expected to yield radiation dose rate measurements satisfying the requirements of 10 CFR 71.43 and 71.47.

Chapter 6. Criticality Evaluation

The two HPG MOD-3 IHS package case of this Addendum (RTG Transportation System SARP Addendum 2) involves the same isotopic sources and package configuration in the semi-trailer as those of the previous Addendum. Evaluation of the calculational models and NCT and HAC array criticality conditions indicated that the criticality potential is expected to be the same as that established for shipment approved in Addendum 1.

The 10 GPHS fueled clads shipment involves isotopic sources 7.2 times less than the GPHS RTG. Its criticality potential is expected to be bounded by that established for shipment approved in the RTG SARP.

The staff concludes that the criticality Transportation Index (TI) established for the RTG SARP of 50 is appropriate for this Addendum 2 shipment.

Chapter 7. Operating Procedures

The description of the Operating Procedures for the RTG package, as described in WHC-SD-RTG-SARP-001, Rev. 0-B, was reviewed and found to meet the requirements of 10 CFR Part 71 (1983), as outlined in Section 7.2 (Acceptance Criteria) of the original RTG SER. The Operating Procedures review also demonstrated compliance with the requirements of 10 CFR Part 71 (1996) and IAEA Safety Series No. 6 (1985 Version, as amended 1990). Since the original description of the Operating Procedures, as described in the previously referenced documents, was bounding, the addition of the HPG MOD-3 isotopic heat source and the 10 GPHS fueled clads as authorized contents required only the inclusion of contents-specific steps for loading and unloading the new payloads.

Chapter 8. Acceptance Tests and Maintenance Program

The description of the Acceptance Tests and Maintenance Program for the RTG package, as described in WHC-SD-RTG-SARP-001, Rev. 0, dated 04/15/96, and Rev. 0-A, dated 09/26/96, was reviewed and found to meet the requirements of 10 CFR Part 71 (1983), as outlined in Section 8.2 (Acceptance Criteria) of the original RTG SER. The Acceptance Tests and Maintenance Program review also demonstrated compliance with the requirements of 10 CFR Part 71 (1996) and IAEA Safety Series No. 6 (1985 Version, as amended 1990). Since the earlier evaluations of the Acceptance Tests and Maintenance Program, as described in the previously referenced documents, was bounding, the addition of the HPG MOD-3 isotopic heat source and the 10 GPHS fueled clads as authorized contents required no additional changes or modifications to the review of the Acceptance Tests and Maintenance Program Chapter.

There are no changes requiring further review of Chapter 9 of the SARP. Chapter 9 of the SARP provides sufficient information to confirm that regulatory requirements will be met when the described quality assurance program is implemented for transport of the new payloads.

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