Procurement of a Fully Licensed Radioisotope Thermoelectric Generator Transportation System

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PROCUREMENT OF A FULLY LICENSED RADIOISOTOPE THERMOELECTRIC GENERATOR TRANSPORTATION SYSTEM

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Abstract

A fully licensed transportation system for Radioisotope Thermoelectric Generators and Light-Weight Radioisotope Heater Units is currently being designed and built. The system will comply with all applicable U.S. Department of Transportation regulations without the use of a "DOE Alternative." The U.S. Department of Transportation has special "double containment" requirements for plutonium. The system packaging uses a doubly contained "bell jar" concept. A refrigerated trailer is used for cooling the high-heat payloads. The same packaging is used for both high- and low-heat payloads. The system is scheduled to be available for use by mid-1992.

INTRODUCTION

Radioisotope Thermoelectric Generators (RTGs) and Light-Weight Radioisotope Heater Units (LWRHUs) are manufactured under the authority of the U.S. Department of Energy (DOE) and shipped to various locations in the United States. Currently, government vehicles are used to ship RTGs under the authority of a "DOE Alternative" (DOE 1986). This type of shipment does not fully comply with U.S. Department of Transportation (DOT) regulations regarding the shipment of radioactive materials (RAM); however, measures are taken to ensure adequate safety.

The shipping containers (packagings) used for the RTGs are "bird cage" devices that provide accident protection for the RTGs, but do not provide additional containment for the RAM should the RTG outer case be breached. Cryogenic material (dry ice) is shipped with the RTGs to provide free-convective air cooling.

Rather than continue relying on Manager's Alternatives to ship RTGs, the DOE Office of Special Applications (DOE-OSA) has decided to procure a fully licensed RTG Transportation System. The DOE-Richland Operations Office (DOE-RL) and the Westinghouse Hanford Company (Westinghouse Hanford) are managing the procurement of this system.

DISCUSSION OF REGULATORY ISSUES

The DOT regulates the shipment of RAM in the United States. For shipments of small amounts of RAM, a licensed Type A packaging may be used. However, for shipments of larger quantities of RAM, a much stronger Type B packaging is required. All models of RTGs and LWRHUs currently in use contain sufficient plutonium to require a Type B packaging.

An extensive licensing procedure is required for RAM packagings. The packaging designer must show by both analysis and testing that the packaging meets all of the applicable structural, thermal, radiological shielding, and criticality safety requirements. A Safety Analysis Report for Packaging (SARP) is prepared and submitted to the regulator for approval before a Certificate of Compliance (CoC) is awarded. Approval of the SARP can be a long process of design and operational changes before final approval is obtained.

In addition to the generic requirements for Type B packagings, additional measures must be taken for the shipment of plutonium. Shipments of plutonium must be doubly contained (NRC 1987), meaning that the plutonium payload must be completely sealed in an inner container that is completely sealed in an outer container. Maximum leak limits for both normal transport and accident conditions have been established and must be verified by analysis, testing, or both. Also, the shipment of plutonium by air has effectively been banned (NRC 1987).

FEDERAL PROCUREMENT PROCESS

A Commerce Business Daily announcement was published on February 27, 1989, requesting that firms interested in proposing a transportation system write a letter summarizing their qualifications. Of the firms that responded, eight were considered qualified to bid.

A purchase specification was drafted and approved by Westinghouse Hanford and DOE in July 1989 for a fixed-price procurement. The Request for Proposal (RFP) was issued in late July 1989. The contract was structured in three phases. Phase 1 covers design and certification. Phase 2 covers the fabrication and delivery of one high-heat and one low-heat transportation system. Phase 3 is a follow-on period during which DOE has the option to purchase additional units. The contract was awarded based on the lowest total cost for Phases 1 and 2.

A pre-bid conference was held August 15, 1989, in Richland, Washington, with six of the eight potential bidders attending. Four potential bidders prepared proposals, which were submitted on October 15, 1989. The proposals were reviewed by Westinghouse Hanford and DOE, and, after extensive negotiations, best and final offers were submitted on February 21, 1990. The low bidder was identified; the order was placed with Packaging Technology, Inc., of Bellevue, Washington, on March 20, 1990.

DESIGN CONSTRAINTS

The purchase specification divided the payloads into two categories--high-heat and low-heat. A separate packaging system is required for each payload category. Tables 1 and 2 summarize payload information.

A dedicated trailer was specified for the high-heat system. Active cooling was allowed for the high-heat system after extensive analysis showed passive cooling was insufficient (Becker et al. 1989). Passive cooling was required for the low-heat system.

DOE security requirements (DOE 1988) differed for the two systems. Category 3 security was required for the high-heat system, while Category 4 security was sufficient for the low-heat system. Maximum numbers of payloads per shipment of each RTG and LWRHU model were established based on cooling capacity, security requirements, and mission requirements.

CHOSEN CONCEPT

The chosen concept is a "bell jar" arrangement (Figure 1) that provides full double containment. The containment requirements are fully met by the packaging (Figure 2) so that none of the containment features of the RTGs are relied upon to achieve double containment. A commercially available refrigerated trailer (Figure 3) is used as the active cooling for the high-heat system.

A unique aspect of the winning proposal is that the same packaging is used for both high- and low-heat systems with the only difference being the use of the refrigerated trailer for high-heat shipments. This feature greatly simplifies the certification process because only one SARP document will be prepared and one CoC issued.

The "bell jar" concept also incorporates many important features that will aid in efficiently loading and handling the RTGs (Figure 4).

TABLE 1. Key High-Heat Payload Parameters and Requirements.

Parameter	GPHS RTG	HPG MOD 3 RTG	5-W RTG	DIPS Canister
Minimum number making up a trailer shipment	1	1 or 2 ³	1 to 4 ³	1
Size (per RTG or DIPS) ⁵ Diameter, cm (in.) Length, cm (in.)	42.7 ² (16.8 ²) 113.094 (44.525)	64.8 ⁸ (25.5 ⁸) 118.44 (46.63)	50.8 ¹ (20.0 ¹) 25.58 (10.07)	17.8 (7.0) 134.6 (53.0)
Weight per RTG or DIPS, kg ⁶ (lb) ⁶	56.0 (123.5)	182 (412)	36 (80)	34 (75)
PuO ₂ content per RTG or DIPS, g	11,300	6,220	314	10,700
Heat output per RTG or DIPS, W	4,500	2,500	125	4,250
Temperature limits, °C ^{4,7} (°F) ^{4,7} At fin root At fin root for 5 days At fin root for 15 days High-pressure receptacle On outer surface Surface of end caps	-- 227 (440) 216 (420) -- -- --	135 (275) -- -- 74 (165) -- --	-- -- -- 74 (165) 82 (180) --	-- -- -- -- 482 (900) 288 (550)
Shock limits, g's ⁷	15	15	5	TBD ⁹
External pressure limits, kPa ⁷ [lb/in ² (absolute) ⁷]	See note 10	-- --	-- --	172 (25)

Notes:

¹20 x 25 fin plate also exists (per Figure A.4.2 of RFP Purchase Specification).²Effective diameter of 23.4 in. must be considered to accommodate the 15-in. gas connection clearance radius (per Figure A.2.3 of Purchase Specification).³If only one HPG MOD 3 RTG is shipped, capability to also include up to four 5-W RTGs is required.⁴Reliable, active cooling allowed in satisfying these limits.⁵Dimensions do not include size of mounting plates/stands or clearance for shorting modules (if applicable).⁶Does not include stand or mounting plate weight.⁷Normal condition operational constraint only, that is, not a regulatory concern.⁸Teledyne confirms RTG and shorting module may be accommodated in a 34 in. ϕ .⁹To be determined.¹⁰The absolute pressure in the shipping container shall be at least 3 lb/in² lower than the internal absolute pressure of the GPHS-RTG at all times during shipment. The internal pressure is 25 lb/in² (absolute) at ambient conditions.

TABLE 2. Key Low-Heat Payload Parameters and Requirements.

Parameter	2-W RTG		1-W RTG	LWRHU
	Marine	Terrestrial		
Minimum number required to be shipped per package ¹	1 to 6	1 to 6	1 to 6	1 to 150
Maximum number allowed to be shipped per transport vehicle ²	19	19	45	1,237
Size (per RTG or LWRHU) ⁴ Diameter, cm (in.) Length, cm (in.) Weight per RTG or LWRHU, kg ⁵ (lb) ⁵	12.70 (5.00) 26.2 (10.3) 14 (30)	11.43 (4.50) 25.7 (10.1) 4 (9)	12.7 (5.0) 16.81 (6.62) 1.1 (2.5)	2.59 (1.02) 3.20 (1.26) 40 g
PuO ₂ content per RTG or LWRHU, g	175	175	75	2.75
Heat output per RTG or LWRHU, W ⁷	70	70	30	1.1
Temperature limits, °C ^{3,6} (°F) ^{3,6} At fin root On any surface	-- 121 (250)	-- 121 (250)	116 (240) --	-- 179 (355)
Shock limits, g's ⁶	15	15	15	300
Surface emissivity	0.65	0.90	--	--

Notes:

¹Transport vehicles capable of transporting both one and two packages per shipment are to be identified (per Section 5.2.1.1 of RFP Purchase Specification).

²The maximum number to be shipped per transport vehicle is based on DOE Order 5632.2A's 3-kg limit for plutonium-238.

³These limits must be satisfied using passive cooling only.

⁴Dimensions do not include size of mounting plates/stands or shorting modules (if applicable).

⁵Does not include stand or mounting plate weight.

⁶Normal condition operational constraint only, that is, not a regulatory concern.

⁷Design shall be capable of removing 10% more heat than specified (per Section 5.2.1.3 of Purchase Specification).

FIGURE 1. RTG Shipping Container.

FIGURE 2. Containment Assembly.

FIGURE 3. RTG Shipping Container Installed in Transport.

FIGURE 4. RTG Payload Mounting Fixtures.

CERTIFICATION AND DELIVERY SCHEDULE

The current schedule calls for the draft SARP to be complete by May 1991. The draft document will be submitted to the regulator for review and approval. It is expected that the CoC will be issued by January 1992. The RTG Transportation System will be fabricated and delivered to Westinghouse Hanford by June 1992. This delivery date will support its use for the scheduled CRAF (1995) and CASSINI (1996) missions.

FACILITY REQUIREMENTS

The proposed RTG transportation system is more complex than the shipping container currently in use. Modifications in handling equipment and procedures will be required at RTG user facilities. Equipment will need to be upgraded and high-capacity forklifts, overhead cranes, helium backfilling equipment, and other necessary equipment obtained. As the design and certification process continues, additional requirements may be identified. This process will require close communication between the RTG transportation system designer and RTG users.

FUTURE TRENDS

Government shipments of RAM are increasingly being subjected to the same level of regulatory review as private shipments. Many DOE and other government agency shipments use U.S. Nuclear Regulatory Commission approved packagings and meet all DOT shipping requirements. Exceptions to packaging and shipping requirements for government shipments are becoming increasingly difficult to obtain.

CONCLUSION

A fully licensed transportation system for RTGs is being obtained by DOE. In the future, shipments of RTGs will comply with all applicable transportation regulations.

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