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Radioisotope Thermoelectric Generator Transport System

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Westinghouse
Hanford Company Richland, Washington

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RADIOISOTOPE THERMOELECTRIC GENERATOR TRANSPORT TRAILER SYSTEM

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Abstract

The Radioisotope Thermoelectric Generator (RTG) Transportation System, designated as System 100, comprises four major systems. The four major systems are designated as the Packaging System (System 120), Trailer System (System 140), Operations and Ancillary Equipment System (System 160), and Shipping and Receiving Facility Transport System (System 180). Packaging System (System 120), including the RTG packaging is licensed (regulatory) hardware; it is certified by the U.S. Department of Energy to be in accordance with Title 10, *Code of Federal Regulations*, Part 71 (10 CFR 71). System 140, System 160, and System 180 are nonlicensed (nonregulatory) hardware.

INTRODUCTION

The Trailer System (System 140), shown in Figure 1, consists of an exclusive-use semitrailer and on-board support systems necessary to reliably and safely transport Radioisotope Thermoelectric Generator (RTG) packages within the continental United States. Trailer System (System 140) is divided into five subsystems. These subsystems include the Semitrailer (Subsystem 141), Power Supply (Subsystem 142), Instrumentation and Data Acquisition (Subsystem 143), Package Temperature Control (Subsystem 144), and Package Mounting (Subsystem 145).

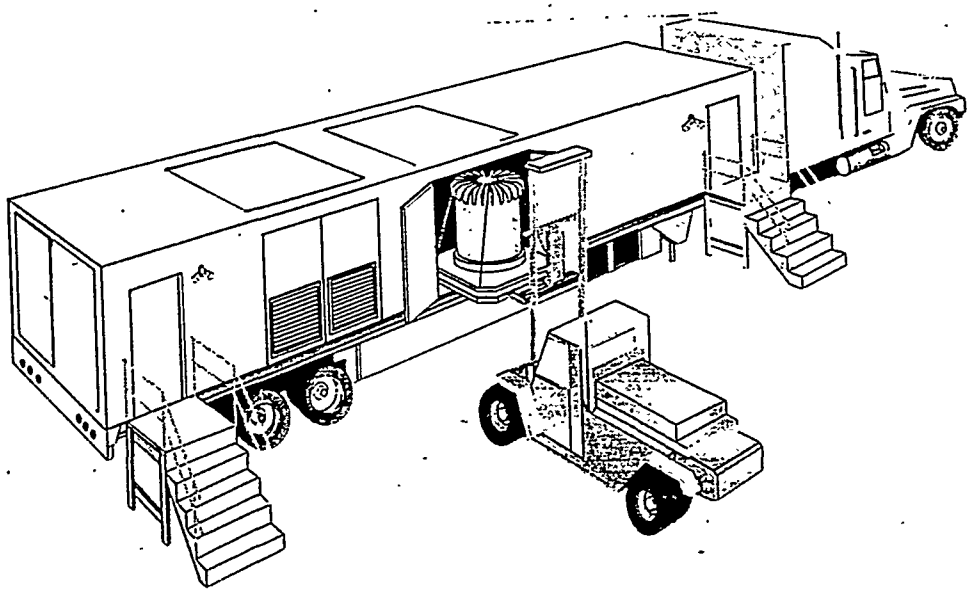

FIGURE 1. Artist's Rendering of the Radioisotope Thermoelectric Generator Transportation System.

SYSTEM DESCRIPTION

The information in the following sections is based on the functional design criteria document for RTG Transportation System, System 100. The functional design criteria document provides the general system and subsystem descriptions and the criteria on which the designs are based.

Semitrailer (Subsystem 141)

The Semitrailer (Subsystem 141) is the backbone of the Trailer System (System 140). It provides a secure, mobile, environmentally controlled enclosure, and a focal point for integrating all of the other subsystems into a complete support system for transporting RTG packages.

Semitrailer (Subsystem 141) Features

To meet the requirements for transporting Category III Special Nuclear Materials, the Semitrailer (Subsystem 141) is required to be exclusive-use and locked and sealed for security during shipment. The Semitrailer (Subsystem 141) will accommodate transport, within the continental United States, of up to two Type B, fissile RTG packages. When loaded, the Semitrailer (Subsystem 141) is required to meet U.S. Department of Transportation weight and dimensional requirements.

Two roof hatches are provided for package and equipment on-loading and off-loading using a crane. Two curbside double doors are provided for access to packages and equipment using a forktruck. Before being locked and sealed for security, personnel will have access to and from the Semitrailer (Subsystem 141) through curbside personnel doors located fore and aft.

For shock and vibration attenuation during highway transport, the Semitrailer (Subsystem 141) provides a full air-ride suspension. This includes air-ride suspension for the rear axles and an air-ride upper coupler. Heating, ventilation, and air conditioning (HVAC) are also provided for stabilizing the Semitrailer (Subsystem 141) interior at a nominal temperature range during extreme ambient temperature conditions.

If System 140 completely fails while located in high-heat ambient conditions, packages on board the Semitrailer (Subsystem 141) are required to be passively protected from exposure to temperatures in excess of regulatory licensing limits. This will be accomplished by a passively activated emergency ventilation feature. Thermally activated louvers will automatically open to allow outside air to flow through the interior of the Semitrailer (Subsystem 141).

The Semitrailer (Subsystem 141) will provide two independent diesel fuel storage and distribution systems to support the two electrical power generators specified by the Power Supply (Subsystem 142). A liquid collection and retention system also will be provided to collect any condensate or coolant-line leaks.

Power Supply (Subsystem 142)

The Power Supply (Subsystem 142) provides and distributes power to the Trailer System (System 140) during transport and while at shipping and receiving facilities. It supplies single- and three-phase power to the Semitrailer (Subsystem 141) HVAC, lights and receptacles, the Instrumentation and Data Acquisition (Subsystem 143), and Package Temperature Control (Subsystem 144).

Power Supply Features

The power supply consists of two diesel-powered generator sets, a docking power receptacle, a power distribution control center, and a motor control center.

Two on-board diesel generator sets provide redundancy for power generation. The units are connected to an automatic power transfer switch that senses failure of the online generator and switches power connections to the

standby generator. For reliability and seamless power transfers, both generator sets run simultaneously.

The power docking receptacle allows for connection of facility power to the Power Supply (Subsystem 142). Power from the docking receptacle is connected to a manual power transfer switch to allow the selection of on-board power or facility power.

The power distribution control center houses the power transfer switches, overload protection devices, and generator set instrumentation. Monitoring and controlling the generator sets, as well as selecting the desired power source and monitoring facility power, is performed at the power distribution control center.

Control of the Package Temperature Control (Subsystem 144) cooling pumps is performed at the motor control center. The center contains the motor starters, over-current protection, and control switches necessary to operate the cooling loops.

Instrumentation and Data Acquisition (Subsystem 143)

The Instrumentation and Data Acquisition (Subsystem 143) displays, monitors, and records critical Packaging System (System 120) and Trailer System (System 140) parameters. Instruments display temperature and flow data for the Package Temperature Control (Subsystem 144), and diesel fuel levels for the diesel fuel tanks. The data acquisition system (DAS) monitors these parameters and alarms any out-of-limits conditions. These parameters also are recorded electronically along with RTG package shock and vibration data.

Instrumentation and Data Acquisition (Subsystem 143) Features

The Instrumentation and Data Acquisition (Subsystem 143) resides in two consoles. The first console contains displays, shock and vibration recorders, and an uninterruptable power supply (UPS). Eighteen digital panel meters provide the required continuous display of critical Package Temperature Control (Subsystem 144) parameters. Two shock and vibration recorders monitor and record shock and vibration data from RTG-package-mounted accelerometers. Additionally, the UPS and its batteries provide 4 h of continuous power to the Instrumentation and Data Acquisition (Subsystem 143) if the Power Supply (Subsystem 142) fails.

The second console contains the data acquisition hardware and an alarm panel. The data acquisition hardware comprises two separate components with different operating systems - a mainframe-based data acquisition/control unit (DA/CU) and an industrial IBM-compatible computer system.

The DA/CU receives all analog inputs and provides all digital outputs for the DAS. The DA/CU can function by itself to convert input data to engineering units, log data to disk, and sound an alarm for out-of-limits conditions.

The industrial rack-mounted computer communicates with DA/CU to receive data and provide redundant data logging. The computer serves as the operator interface to display data, log data to disk, initialize instruments, and change operating parameters. The industrial computer provides a user friendly, graphics oriented operator interface.

Alarms for out-of-limits conditions are annunciated on the alarm panel. The alarm panel provides an audio and visual annunciation when operating limits are approached or exceeded. A portable remote alarm panel located in the truck-tractor cab also provides this function.

Package Temperature Control (Subsystem 144)

The Package Temperature Control (Subsystem 144) maintains an RTG device within a specified temperature range by extracting a minimum of 4.5 kW of heat from a single RTG package, or 5 kW of heat from two RTG packages. The Package Temperature Control (Subsystem 144) is an active cooling system with a required minimum reliability of 0.999 when operated continuously for a minimum duration of 360 h in dynamic

environments consistent with highway transport. Typical components and assemblies include chillers, lines, valves, fittings, circulation pumps, cold water tanks, multi-loop heat exchangers, flow sensors, and transmitters.

Package Temperature Control (Subsystem 144) Features

An RTG package has a cooling jacket with two independent coolant circulation channels. Each coolant circulation channel is required to receive a minimum coolant flow rate of 0.3 L/s (5 gal/min). This provides a minimum of 0.6 L/s (10 gal/min) coolant flow rate to the RTG package. If one of the coolant circulation loops fails, a flow rate of 0.3 L/s (5 gal/min) is more than adequate to remove the maximum 4.5 kW thermal energy given off by the RTG device inside of the RTG package. The Package Temperature Control (Subsystem 144) obtains power from the Power Supply (Subsystem 142). Two refrigeration units on the cold side of the Package Temperature Control (Subsystem 144) independently circulate cold water through their own cold water tanks. Multi-loop heat exchangers on each of the cold water tanks cool each of five independent loops on the hot side of the Package Temperature Control (Subsystem 144). Each of the five loops is connected through both multi-loop heat exchangers on each of the cold water tanks. Should any one of the cold water loops fail as a result of a malfunctioning refrigeration unit or a ruptured line, the other cold water loop has the capacity to handle the heat load of up to 5 kW thermal. Four of the five chilled water loops are primary loops that carry chilled water to two RTG packages. The fifth loop is a spare loop with 61 m (200 ft) of hose. The hose can be extended to an RTG package that is located up to a maximum of 30.5 m (100 ft) away from the Semitrailer (Subsystem 141), or it may be used as a backup loop if one of the four primary loops is required to be taken out of service.

Package Mounting (Subsystem 145)

The Package Mounting (Subsystem 145) provides tie down points for attaching the RTG package to the Semitrailer (Subsystem 141), features for handling an RTG package with a forktruck, additional shock and vibration attenuation for the RTG device during highway transport, and shock protection for the RTG device during on-loading and off-loading of the RTG package to and from the Semitrailer (Subsystem 141).

Package Mounting (Subsystem 145) Features

The Package Mounting (Subsystem 145) consists of a top plate, bottom plate, and eight helical springs. The top plate provides four shackle points, one at each corner of the top plate. The shackle points allow the RTG package to be anchored to the Package Mounting (Subsystem 145) using shackles, straps, and turnbuckles. The shackle points also can be used with lifting slings for moving the Package Mounting (Subsystem 145) as a single component.

Heavy reinforcements to the top plate are required to counteract bending forces from the extreme weight of an RTG package. Stiffening of the top plate was accomplished by adding I-beam sections to the underside of the top plate. Additionally, L-angle sections were added to the perimeter to prevent twisting the Package Mounting (Subsystem 145) during the 0.46-m (18-in.) edge drop testing defined in MIL STD 810E.

The bottom plate provides the means for securing the package mounting to the Semitrailer (Subsystem 141) floor with six 3/4-in. bolts. The bottom plate also incorporates the fork pockets for a 4,536- to 11,340-kg (10,000- to 25,000-lb) capacity forktruck, and a 20,412- to 24,948-kg (45,000- to 55,000-lb) capacity forktruck.

The package mounting relies on eight helical springs to supply the required shock and vibration protection to the RTG device. The helical springs will limit the shock input to the package to 11.2 *g* during an 0.46-m (18-in.) flat bottom drop. The springs have a 15 percent critical damping ratio, and will allow the RTG package and Package Mounting (Subsystem 145) to bounce when dropped. The RTG package will not experience forces greater than the initial impact for any successive bounce. The 2.03-m (80-in.) wide, bottom plate ensures that the RTG package and Package Mounting (Subsystem 145) assembly will not overturn when rebounding after the 0.46-m (18-in.) edge drop.

The engineering analysis for the Package Mounting (Subsystem 145) confirms that the eight helical springs will

provide adéquate shock and vibration attenuation to the RTG package during highway transport. Several input scenarios were chosen to simulate possible highway transport conditions. These inputs were data from MIL-STD-810E (DOD 1989), vendor testing of the air ride upper coupler, and the draft American National Standards Institute Standard N14.23 (ANSI 1980). The response of the RTG package for all inputs was well below the limits established by RTG manufacturers and users.

Other design considerations were regulated by system interfaces. The overall height of the Package Mounting (Subsystem 145) is limited to 0.41 m (16 in.) for the RTG package and Package Mounting (Subsystem 145) assembly to fit through the Semitrailer (Subsystem 141) cargo doors. The maximum width of the Package Mounting (Subsystem 145) is limited by the 2.29-m (90-in.) width of the cargo doors, and the minimum width is limited by the need to have the distance between the helical springs be approximately three times the distance between the plane of the helical springs and the center of gravity. The Package Mounting (Subsystem 145) is constructed of American Standard of Testing and Materials A36 (ANSI 1993) structural steel and finished with a protective paint coating.

Acknowledgments

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References

10 CFR 71 (1989) "Packaging and Transportation of Radioactive Material", *Code of Federal Regulations*, as amended, Office of the Federal Register, National Archive and Records Administration, Washington, D.C.

ANSI (1980) *Draft American National Standard Design Basis for Resistance to Shock and Vibration of Radioactive Material Packages Greater Than One Ton In Truck Transport*, N14.23, American National Standards Institute, New York, NY.

ASTM (1993) *Standard Specification for Structural Steel*, A-36, American Society for Testing and Materials, Philadelphia, PA, 01.04: 107.

DOD (1989) *Military Standard*, "Environmental Test Methods and Engineering Guidelines," MIL-STD-810E, U.S. Department of Defense, Washington, D.C., 516.4-12.

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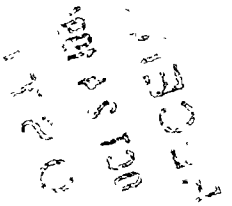

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