Form NRC-618
(12-73)
10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE

For Radioactive Materials Packages

1.(a) Certificate Number	1.(b) Revision No.	1.(c) Package Identification No.	1.(d) Pages No.	1.(e) Total No. Pages
9153	0	USA/9153/B( )	1	2

2. PREAMBLE

2.(a) This certificate is issued to satisfy Sections 173.393a, 173.394, 173.395, and 173.396 of the Department of Transportation Hazardous Materials Regulations (49 CFR 170-189 and 14 CFR 103) and Sections 146-19-10a and 146-19-100 of the Department of Transportation Dangerous Cargoes Regulations (46 CFR 146-149), as amended.

2.(b) The packaging and contents described in item 5 below, meets the safety standards set forth in Subpart C of Title 10, Code of Federal Regulations, Part 71, "Packaging of Radioactive Materials for Transport and Transportation of Radioactive Material Under Certain Conditions."

2.(c) This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. This certificate is issued on the basis of a safety analysis report of the package design or application-

3.(a) Prepared by (Name and address):
Teledyne Energy Systems
110 West Timonium Road
Timonium, MD 21093

3.(b) Title and identification of report or application:
Teledyne Energy Systems application
dated October 5, 1981, as supplemented.

3.(c) Docket No. 71-9153

4. CONDITIONS

This certificate is conditional upon the fulfilling of the requirements of Subpart D of 10 CFR 71, as applicable, and the conditions specified in item 5 below.

5. Description of Packaging and Authorized Contents, Model Number, Fissile Class, Other Conditions, and References:

(a) Packaging

(1) Model No.: SENTINEL 1S

(2) Description

The packaging contains a thermoelectric generator with 10,100 Ci of strontium 90 fluoride. The dimensions are 32.2 inches in height by 37.53 inches in diameter. The package is welded to a 39.5 inch square, steel pallet, which is 4 inches high.

The contents are housed in a Hastelloy C-276 liner. The liner, with its pressed cap, is contained within a fuel capsule (1.871" OD x 4.194"). The capsule lid is threaded for strength and welded (minimum weld penetration of 0.055" is specified) to give a positive seal. The wall thickness of the capsule is a minimum of 0.198 inches. The fuel capsule is constructed of Hastelloy C-276. The capsule is inserted into the stainless steel canned depleted uranium biological shield (1.898" ID x 4.320" OD x 5.885" or 5.978"), and the shield plug is bolted into place using three steel bolts, equally spaced on a 3.25-inch bolt circle.

The biological shield is held in a horizontal position within the generator's aluminum housing by the sized Min-K-1301 thermal insulation. Min-K and load bearing plates are used to support the shield base. Spring washers are used to preload the Min-K supporting the biological shield.

(2) Description (continued)

The finned (13" OD x 14.5") aluminum housing (7" OD x 8.97") forms the outer protective shell of the generator (70 lbs). The generator is held in place within the cask by a hold down assembly with a rubber pad on top and a 2-inch thick (1/8"-0.001" core) aluminum honeycomb with a 97 square inch effective area, on the bottom. The total system weight is approximately 7,190 pounds.

(3) Drawings

The packaging is constructed in accordance with Teledyne Energy Systems Drawing Nos.: 013-01000, Rev. 0; 013-01001, Rev. 0; 013-01002, Sheets 1 and 2, Rev. 0; and assembled in accordance with Figure 2.7-1, p 3-17 of the application.

(b) Contents

(1) Type and form of material

Strontium fluoride ($^{90}SrF_2$) doubly encapsulated in a Hastelloy C-276 fuel capsule, with a Hastelloy C-276 liner which meets the requirements of special form as defined in 10 CFR §71.4(o).

(2) Maximum quantity of material per package

10,100 curies.

6. The lifting rings must be either removed, securely covered, or locked during transport to prevent their use as tie-down devices.

7. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12(b).

8. Expiration date: October 31, 1986.

REFERENCES

Teledyne Energy Systems application dated October 5, 1981.

Supplement dated: October 21, 1981.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald, Chief
Transportation Certification Branch
Division of Fuel Cycle and
Material Safety, NMSS

Date: NOV 01 1981

U.S. Nuclear Regulatory Commission
Transportation Certification Branch
Safety Evaluation Report
Model No. SENTINEL 1S
Docket No. 71-9153

SUMMARY

By application dated October 5, 1981, Teledyne Energy Systems requested design approval of the Model No. SENTINEL 1S package for the shipment of a thermal electric generator. Shielding of the 10,100 Ci of strontium 90 fluoride is provided by 5.7 inches of carbon steel and 1.181 inches of depleted uranium. Containment is provided by the source capsule meeting the requirements of special form.

Based on the statements and representations contained in the application, as amended, we have concluded that the Model No. SENTINEL 1S package meets the performance requirements of 10 CFR Part 71.

REFERENCES 1. Teledyne Energy Systems application dated October 5, 1981.

2. Supplement dated October 21, 1981.

DRAWINGS

The packaging is constructed in accordance with Teledyne Energy Systems Drawing Nos.: 013-01000, Rev. 0; 013-01001, Rev. 0; 013-01002, Sheets 1 and 2, Rev. 0; and assembled in accordance with Figure 2.7-1, p 3-17 of the application.

PACKAGING DESCRIPTION

The packaging contains a thermoelectric generator with 10,100 Ci of strontium 90 fluoride. The dimensions are 32.2 inches in height by 37.53 inches in diameter. The package is welded to a 39.5 inch square, steel pallet, which is 4 inches high.

The contents are housed in a Hastelloy C-276 liner. The liner, with its pressed cap, is contained within a fuel capsule (1.871" OD x 4.194"). The capsule lid is threaded for strength and welded (minimum weld penetration of 0.055" is specified) to give a positive seal. The wall thickness of the capsule is a minimum of 0.193 inches. The fuel capsule is constructed of Hastelloy C-276. The capsule is inserted into the stainless steel canned depleted uranium biological shield (1.898" ID x 4.320" OD x 5.885" or 5.978"), and the shield plug is bolted into place using three steel bolts, equally spaced on a 3.25-inch bolt circle.

The finned (13" OD x 14.5") aluminum housing (7" OD x 8.97") forms the outer protective shell of the generator (70 lbs). The generator is held in place within the cask by a hold down assembly with a rubber pad on top and a 2-inch thick (1/8"-0.001" core) aluminum honeycomb with a 97 square inch effective area, on the bottom. The total system weight is approximately 7,190 pounds.

CONTENTS

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(2) Maximum quantity of material per package

10,100 curies.

CONTAINMENT

The stronium fluoride ($^{90}SrF_2$) is doubly encapsulated in a liner and fuel capsule constructed from Hastelloy C-276 which meets the requirements of special form as defined in 10 CFR §71.4(o).

STRUCTURAL

The Model No. SENTINEL 1S package consists of four structural components. These components are the fuel capsule assembly, the shield assembly, the generator housing and the shipping cask.

The shipping cask forms the primary structure for lifting and general handling. It also provides radiation shielding during transit.

The generator housing and the shipping cask provide structural protection to the shield assembly for both normal transportation and hypothetical accidents. However, to add additional conservatism, the housing and the cask have been ignored in the evaluation of the package integrity for the hypothetical accident conditions as specified in Appendix B of 10 CFR 71. Thus, the ability of the package to meet the requirements of 10 CFR 71 for the accident conditions has been conservatively based on the structural integrity of the shield assembly alone.

The fuel capsule meets the requirements of special form as demonstrated by analysis and test.

A. General Standards for all Packaging

Chemical and Galvanic Reaction

There is no significant chemical, galvanic, or other reaction among the packaging components, or between the packaging components and the package contents.

Positive Closure

Inadvertent opening of the package is prevented by means of positive closure devices.

Lifting Devices

Three lifting rings are shown by analysis to be capable of lifting three times the maximum package weight without exceeding material yield stress in any material of the packaging.

The requirements of covering the lifting rings are met by imposing a licensing condition in the certificate.

The staff agrees with the applicant's conclusion that failure of lifting devices under excessive loads would not result in any loss of packaging effectiveness or release of radioactive materials.

Tie-Down Devices

Applicant has shown by analysis that the tie-down devices which are structural parts of the package are adequately designed to meet the regulatory requirements of 10 CFR §71.31(d).

B. Structural Standards for Type B and Large Quantity Packaging

Load Resistance

The package is shown by analysis to be capable of withstanding statically five times of its fully loaded weight uniformly distributed along its length without generating stress in any material of the packaging in excess of its yield strength.

External Pressure

Applicant has shown by analysis that the packaging design meets the regulatory requirements.

C. Normal Conditions of Transport

Heat

The pertinent temperatures, pressures, thermal expansions and the resulting stresses are considered insignificant for the normal conditions of transport when compared to the same parameters under the hypothetical accident conditions.

Cold

The stresses caused by thermal contraction under the cold (-40°F) environment are judged not to reduce packaging effectiveness substantially. The cask body is machined from a solid steel forged billet meeting ASTM-A181 Grade 2 specifications. The cask lid is hot rolled A36 steel plate. For brittle fracture considerations, the cask has been conservatively ignored in the evaluation of the ability of the package to meet regulatory requirements under the hypothetical accident conditions.

Pressure

The cask containment vessels have been shown to withstand atmospheric pressure considerably greater than 0.5 times standard atmospheric pressure.

Vibration

The vibration loading is judged not to have significant effects on packaging safety.

Water Spray

Water spray will have no effect on the package.

Free Drop

The package can safely withstand the free drop requirement of 10 CFR 71 Appendix A as demonstrated by meeting the more stringent requirements specified in Appendix B of 10 CFR 71 for the hypothetical accident conditions.

Corner Drop

Not applicable for this design case.

Penetration

The staff agrees with the applicant's judgement that this regulatory loading has insignificant adverse effects on the package design.

Compression

Not applicable to the present design case.

D. Hypothetical Accident Conditions

Free Drop

For added conservatism, the steel cask and the aluminum housing have been neglected in the analysis. The applicant has shown that the shield assembly can safely withstand the impact load resulted by the 30-foot free drop for the top and side impact attitudes. Equivalent g-load has been conservatively determined as 1366g's. For the bottom drop condition, the shield assembly is protected by a 2-inch thick, 1/8"-0.001" core aluminum hexagonal honeycomb pad. The honehcomb pad has been shown to have the capability to absorb almost all the impact energy inflicted upon the shield assembly.

Puncture

The staff agrees with the applicant's conclusion that since the shield assembly is less than 6 inches in any direction (i.e., length, diameter, etc.), puncture is not possible.

Thermal

The staff agrees with the applicant's conclusion that stresses induced by differential thermal expansion and temperature increases have no significant effects on packaging safety.

Immersion

Not applicable, fissile packages only.

THERMAL

The applicant performed a computer analysis on the generator and cask for normal conditions of transport and hypothetical accident conditions. For normal conditions a 130°F ambient, solar heating and 82.9 watts thermal internal heat was assumed for an intact generator/cask system. For the hypothetical fire accident, the generator is assumed to come out of the cask and be directly exposed to the fire test.

For normal conditions, the 82.9 watts internal heat must be dissipated from the cask. Most cask components are found to remain below 300°F; the inner most regions (capsule walls) reach as high as 823°F which is well below the maximum temperatures allowed (2320°F).

For the hypothetical accident, the generator is assumed to be ejected from the cask and exposed directly to the fire; as a result of the fire, the generator's aluminum housing and insulation is lost. The remaining encased depleted uranium shield and fuel capsule are not damaged by the fire. The maximum predicted temperatures are compared to the critical temperatures in the table shown below:

Comparison of critical and predicted maximum temperatures (fire accident)

	Critical Temperature	Predicted Maximum Temperatures
Liner, Hastelloy C-276	2320°F*	1430°F
Capsule, Hastelloy C-276	2320°F	1390°F
Biological Shield, Uranium (depleted) - 0.75% Titanium Alloy	2075°F	1380°F
Shield Clad, (304 Stainless Steel)	2550°F	1377°F

*Long-term compatibility with fuel to 800°C (1472°F).

The staff has reviewed the applicant's thermal analysis. The staff concludes that the analysis satisfies the requirements of 10 CFR Part 71 for normal and accident conditions. We agree with the applicant's conclusion that the Hastelloy liner and capsule, and the stainless steel clad, depleted uranium shield will remain intact following the fire accident.

SHIELDING

Table 5.1, p 5-2 of the application, presents dose rates assuming 12,000 Ci strontium 90 source. The maximum calculated gamma dose rate for normal conditions of transport is given as 23 mrem/hr on the bottom of the package surface as packaged for shipment. The maximum calculated gamma dose rate for accident conditions of transport is given as 360 mrem/hr, 3-feet from the surface of the depleted uranium shield. These dose rates are well within the 200 mrem/hr (surfaces and 1,000 mrem/hr (at 3 feet) requirements for normal and accident conditions, respectfully, The staff is in general agreement with the calculated values.

CRITICALITY

Not applicable, no fissile material.

OPERATING, ACCEPTANCE, AND MAINTENANCE

General operating, acceptance, and maintenance procedures and controls are given in Sections 7 and 8 of the application in addition to the requirements of 10 CFR §§71.53, 71.54, and 71.55.

CONCLUSION

Based on our review, the statements and representations contained in the application, we find that the Model No. SENTINEL 1S package meets the requirements of 10 CFR Part 71.

Charles E. MacDonald, Chief
Transportation Certification Branch
Division of Fuel Cycle and
Material Safety, NMSS

Date: NOV 01 1981