UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 30, 2001

Mr. Richard W. Boyle
Radioactive Materials Branch
U.S. Department of Transportation
400 Seventh Street, S.W.
Washington, D.C. 20590

SUBJECT: CERTIFICATE OF APPROVAL NO. J/001/B(U)-85 FOR THE KATY PACKAGE

Dear Mr. Boyle:

This is in response to your letter dated January 29, 1999, as supplemented January 12 and July 10, 2000, requesting our assistance in evaluating the KATY package, authorized by Japanese Certificate of Approval No. J/001/B(U)-85, Revision 1, dated October 30, 1996.

Based upon our review, the statements and representations contained in Certificate of Approval No. J/001/B(U)-85, Revision 1, dated October 30, 1996, as supplemented, and for the reasons stated in the enclosed Safety Evaluation Report, we recommend revalidation of the package.

If you have any questions regarding this matter, please contact me or Mr. Stephen O'Connor of my staff at (301) 415-8500.

Sincerely,

/RA/

E. William Brach, Director
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-3046
TAC No. L22830

Enclosure: Safety Evaluation Report

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SAFETY EVALUATION REPORT
KATY Package
Certificate of Approval No. J/001/B(U)-85
Revision 1

SUMMARY

By letter dated January 29, 1999, as supplemented January 12 and July 10, 2000, the U.S. Department of Transportation (DOT) requested review and recommendation regarding revalidation of Japanese Certificate of Approval No. J/001/B(U)-85, Revision 1, KATY package.

Based on the statements and representations in the application, as supplemented, and on the confirmatory analyses performed by the staff, we recommend revalidation of the Japanese Certificate of Approval for the Model No. KATY package for the contents described below. The package was reviewed for compliance to the regulations of the International Atomic Energy Agency (IAEA) in Safety Series No. 6, Regulations for the Safe Transport of Radioactive Material, 1985 edition, as amended in 1990.

1. GENERAL INFORMATION

Packaging:

The package is composed of an outer container and an inner container. The outer covering of the outer container is a stainless steel drum, 480 mm in outside diameter and 520 mm in height. A lid is fastened to the drum with fastening bands and contains a rubber seal. Inside the drum is a stainless steel cylinder fitted with a tungsten alloy shield. The area between the drum and the inside cylinder contains a combination of fir-plywood impact limiters and alumina-fiber heat insulation. The impact limiters and heat insulation are divided into upper and lower sections. The upper section is removable for loading and unloading the inner container.

The inner container is also made of stainless steel. The container is 14 mm thick and has an outside diameter of 184 mm. A tungsten alloy shield is attached to its bottom. A lid is fastened on the container with four lid clamping bolts. Two chloroprene O-rings are used to ensure the lid is tightly sealed. Inside of the inner container is a stainless steel cylindrical capsule designed to contain a bottle of Mo-99. The capsule is sealed with a chloroprene O-ring and a threaded cap.

The packaging design is described in Figures I-C.1 through I-C.6 and I-D.1 of Japanese Certificate of Approval No. J/001/B(U)-85, Revision 1, KATY Package.

Contents:

The contents to be shipped in this packaging consist of a stainless steel capsule enclosing a polyethylene bottle containing 60 ml, maximum of Mo-99 solution.

2. STRUCTURAL

The structural performance of the packaging was evaluated by testing of prototypes and engineering analyses. Prior to the engineering analysis of the packaging, the applicant performed 1.2-meter and 9-meter free drop prototype tests of the normal condition of use and the hypothetical accident condition in accordance with the IAEA safety standards. The drop orientations were top-end drop, horizontal drop, and top-corner drop. The drop testing results were as follows:

	Deformation (mm)	Deceleration (m/s^2)
Normal Condition of Transport:		
- Top end orientation	4	1770
- Horizontal orientation	10	1960
- Top corner orientation	70	1080
Hypothetical Accident Conditions:		
- Top end orientation	40	3920
- Horizontal orientation	60	2750
- Top corner orientation	136	3920

The drop test results were used by the applicant in the engineering analyses with an additional margin of safety for the hypothetical accident condition results. The accelerations used in the analyses were 1960 m/s^2 and 5890 m/s^2 for the normal and the accident conditions, respectively.

The applicant performed an analysis of the inner container, lid, lid bolts, container shell, bottom plate, and capsule. The calculated stresses were within allowable limits. For the free-drop and the puncture tests, the engineering evaluations showed that the outer container will be deformed but the inner container will not be deformed nor damaged. The analysis also showed that the inner container lid and seal will remain intact and the sealing performance will not be impaired. Furthermore, the analysis showed that the capsule will maintain its integrity and will not be broken.

The applicant evaluated the package for the 15-meter immersion test. The applicant's analysis showed that the inner container and capsule will not be opened by the pressure.

The staff reviewed the applicant's analyses and evaluations and found that the design of the packaging meets the relevant requirements of IAEA Safety Series No. 6, 1985 edition, as amended in 1990.

3. CONTAINMENT

The inner container represents the containment boundary. It consists of a cylindrical stainless steel body with a bottom plate, flange, and mating lid with two concentric chloroprene O-ring seals with a test port between the seals. The lid is fastened with four closure bolts.

The applicant demonstrated the inner container's acceptability as a containment boundary by both analysis and the physical testing of three prototype models. The drop tests resulted in no visible damage to the inner container and its seals. Two of the prototypes were thermally tested per paragraph 628 of IAEA Safety Series No. 6, 1985 edition, as amended in 1990. Following the thermal tests, the prototypes were visually examined. No damage to the inner container and its components was found. Also, the highest temperature measured by thermocouple was 86.4°C at the side center of the inner container of prototype No. 1, which is substantially less than the manufacturer's recommended maximum service temperature of 149°C for the chloroprene O-rings. Because of the thermocouple installed on the capsule inside the inner container, the applicant could not perform a post thermal test leak check, but made conclusions based on: (1) the visual examination of the seals and flange, (2) the observed maximum temperature attained by the inner container, and (3) the results of thermal stress analyses on the inner container components. The applicant concluded that there was reasonable assurance that the container's integrity had not degraded and that the seals would perform as designed. The staff concurs with the applicant's conclusion.

With regard to leakage from the inner container of the Mo-99 contents, the applicant conservatively neglected the containment properties of the bottle of Mo-99 in their analysis. The applicant had provided supplemental information regarding liquid leakage rates. These calculations, performed in accordance with the methodologies described in ANSI N14.5 - 1997, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," indicated that for normal conditions of transport, the calculated leakage rate was less than the $10^{-6}A_2$ value for Mo-99, and less than the A_2 value for Mo-99 for the hypothetical accident conditions. The Mo-99 A_2 values were obtained from Table 1 of IAEA Safety Series No. 6, 1985 edition, as amended in 1990.

The applicant's operating and maintenance procedure requires a "go/no-go" pressure test prior to each shipment of Mo-99. Additionally, the package is inspected visually for any evidence of scratching, dirt, or other abnormalities. For shipping, the package must be restrained to prevent tipping, rollover, or sliding. Maintenance actions include replacing the inner container O-rings annually and whenever the inner container fails the pre-shipment pressure test, and replacing the inner container lid bolts every 10 years. An independent visual inspection and pressure test is required if the package is used more than 10 times in a year (one inspection per 10 uses).

Based on the applicant's analyses and tests, the staff concludes that the inner container meets the requirements for containment as described in IAEA Safety Series No. 6, 1985 edition, as amended in 1990.

4. SHIELDING

Radiation Source and Design Features:

The contents to be shipped in the packaging is a mixed solution of Mo-99. The solution consists of aqueous $NaNO_3$ with aqueous NaOH containing Na_2MoO_4. There are two types of the mixed solution:

1. A solution prepared by mixing $NaNO_3$ at 1 mol/l into a 0.2N aqueous NaOH containing Na_2MoO_4.

2. A solution prepared by mixing $NaNO_3$ at 1 mol/l into a 2N aqueous NaOH containing Na_2MoO_4.

The solution is contained in a polyethylene bottle having a maximum capacity of $3.7x10^{13}$ Bq. The maximum quantity of solution to be shipped will be 60 ml.

The Mo-99 solution is a beta/gamma emitter. The total radiation source strength includes energies from the radioactive decay of Mo-99 to Tc-99m and also from the decay of Tc-99m to Tc-99. There is no neutron contribution from the decay of Mo-99. The energies and emission rates of the main radiations and intensities of the Mo-99 source are listed in Safety Analysis Report Table II-D.2.

The Mo-99 solution will be contained in a polyethylene bottle which will be enclosed in a stainless steel capsule. The dimensions of the polyethylene bottle are approximately 36 mm maximum outer diameter by 80 mm maximum height. The dimensions of the capsule are 73 mm outer diameter by 149 mm maximum height. The capsule lid is also stainless steel and is fitted with an O-ring. The lid screws into the threaded capsule opening. Both the lid and the main capsule have a tungsten alloy shield. The cap has a handle for opening and closing and the cap is made of martensite stainless steel to also permit magnetic hoisting.

The capsule is contained within the inner container. The main body of the inner container is tungsten alloy shield covered with stainless steel. The maximum outer diameter of the container is 184 mm and 260 mm in height. The inner diameter of the inner container is 77 mm. The lid of the container is stainless steel with a tungsten alloy shield attached to the bottom of the lid. The lid is secured to the container by four stainless steel lid clamping bolts.

The outer container is a stainless steel drum with a maximum outer diameter of 480 mm and height of 520 mm. An impact limiter made of fir-plywood and heat insulation of alumina-fiber are interposed between the drum and the inner cylinder. The impact limiter is provided to protect the packaging and its contents from damage in the event of an accidental drop. The heat insulation is provided to prevent excessive heat from entering the packages in the event of an accidental fire. The impact limiter and heat insulation are considered to be air in the shielding evaluation.

The following table is a summary of the maximum radiation levels at various locations on and around the package for normal, off-normal, and hypothetical accident conditions:

Maximum Radiation Levels, in µSv/hr (mrem/hr)							
		On Package Surface			One Meter from Surface		
		Top	Side	Bottom	Top	Side	Bottom
Normal Transportation Conditions	Dose Equivalent	1310 (131)	809 (81)	848 (85)	42.2 (4.2)	29.6 (3)	14.7 (1.5)
	Standard Value	2000 (200)			100 (10)		
Off-Normal Conditions	Dose Equivalent	1310 (131)	873 (87)	848 (84)			
	Standard Value	2000 (200)					
Hypothetical Accident Conditions	Dose Equivalent				44.3 (4.4)	32.7 (3.2)	15.7 (1.6)
	Standard Value				10000 (1000)		

<u>Shielding Model:</u>

The applicant used a two dimensional transportation code for the shielding evaluation, DOT3.5. This code was developed by Oak Ridge National Laboratory and is commonly used in the industry. Two-dimensional models were prepared for the shielding evaluations for normal transportation conditions, off-normal conditions, and hypothetical accident conditions. For normal transportation conditions, only the tungsten alloy and stainless steel of the inner container and the capsule were considered. The impact limiters and heat insulation were replaced with air. The outer container was not considered as part of the shield but only as an outer boundary of the package surface.

For off-normal transportation conditions, the deformation of the outer container in the 1.2-meter drop test was taken into account. The top and bottom corners of the outer container are chamfered all around due to the consequences of a corner drop test. The inner container is not damaged and the effect of the dose equivalent is negligible.

For the hypothetical accidental conditions, the outer container was modeled to demonstrate the deformation caused by the 9-meter drop test. In the accident condition model, the top and bottom were reduced by 20 mm to simulate the deformation caused by the vertical drop and the diameter was reduced by 60 mm to simulate the deformation caused by the horizontal drop. The top and bottom corners were chamfered to simulate the deformation of the corner drop test. The effects of the deformations had a negligible effect on the dose equivalent.

Evaluation:

The staff performed confirmatory calculations of the dose equivalent using the information in the application. The results of the confirmatory calculations were in close agreement with those in the application. Based on the review of the statements and representations in the application, the staff finds that the shielding design is adequate. The package meets the external radiation requirements of IAEA Safety Series No. 6, 1985 edition, as amended in 1990.

5. MATERIALS

Type 304 stainless steel is used for the capsule liner and the shipping drum. Type 416 stainless steel is used for the capsule lid and lid bolts. The lid uses a chloroprene O-ring for a seal. These grades of stainless steel and the O-ring are resistant to the corrosive effects of the sodium hydroxide solution for a duration well in excess of one year, which is the maximum interval between package inspections. Therefore, the applicant determined, and the staff agrees, that the secondary containment boundary and shipping drum materials are resistant to the solution and capable of maintaining confinement of the isotope.

The shipping drum is filled with an alumina-fiber insulation to provide thermal insulation and impact cushioning for the capsule. The alumina fiber is tested to verify that it does not contain potentially harmful levels of leachable chlorides or other corrosive agents detrimental to the isotope container or drum should the insulation become wet.

6. ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The capsule and drum are inspected prior to every shipment and at annual intervals. The capsule lid O-rings and bolts are replaced during the annual maintenance inspections.

CONCLUSION

Based on the statements and representations contained in the application, as supplemented, the staff concludes that the Model No. KATY package meets the requirements of IAEA Safety Series No. 6, 1985 edition, as amended in 1990.

Issued with letter to R. Boyle, Department of Transportation,
on January 30, 2001.

ROUTING AND TRANSMITTAL SLIP

Date: February 5, 2001

NAME	INITIALS	DATE
SO'Connor		
EZiegler		
EKeegan		
KLathrop		
LYang		
GHornseth		
EEaston		
RHall		
WHodges		
SShankman		
EWBrach		

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ACTION: _____ APPROVAL: __X___ FOR YOUR INFO: _____
NOTE & RETURN: _____ PREPARE REPLY: ______ COORDINATION: _____

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EDO/NMSS TICKET NO(s).: NA
DUE TO DIVISION:
DUE TO NMSS:
DUE TO EDO:

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MEMORANDUM/LETTER TO: Richard W. Boyle, Department of Transportation

FROM: EWBrach

SUBJECT: CERTIFICATE OF APPROVAL NO. J/001/B(U)-85 FOR THE KATY PACKAGE

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REMARKS:

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ORIGINATOR: Steve O'Connor PHONE: 415-8561
SECRETARY: Debbie Damiano HONE: 415-2385

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