May 09, 2005

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

SUBJECT: REVALIDATION OF CANADIAN CERTIFICATE OF APPROVAL NO. CDN/2081/B(U)-96 FOR THE MODEL NO. F-168 AND F-168X PACKAGES (TAC NO. L23733)

Dear Mr. Boyle:

This is in response to your letter dated April 22, 2004, requesting our assistance in evaluating the Model No. F-168 and F-168X transportation packages, authorized by Canadian Certificate of Approval No. CDN/2081/B(U)-96, dated December 9, 2002. Your letter forwarded MDS Nordion's F-168 and F-168X Safety Analysis Report. You also provided supplemental information by letter dated December 6, 2004.

Based upon our review, the statements, and representations in the Safety Analysis Report, and for the reasons stated in the enclosed Safety Evaluation Report, we recommend revalidation of Canadian Certificate of Approval No. CDN/2081/B(U)-96, dated December 9, 2002, for the Model No. F-168 and F-168X packages, with the following additional conditions:

For F-168 and F-168X sealed source contents which were not qualified as special form on their respective drawings:

1. Sources must conform to the following specifications:

Source	Atomic Energy of Canada Limited, Drawing No.
C-146	C-146, Rev. K
C-151	C-151, Rev. 0
C-185	C-185, Rev. A
C-189	C-189, Rev. A
C-190	C-190, dated July 11, 1967
C-199	C-199, Rev. A
C-200	C-200, Rev. A
C-232	C-232, dated December 9, 1969
C-238	C-238, dated October 15, 1969
C-247	C-247, dated May 26, 1970
C-252	C-252, dated May 11, 1970
XC-325	XC-325, Rev. A

Source	MDS Nordion, Drawing No.
C-132	C-132, Issue 6
C-133	C-133, Issue 9
C-177	C-177, Issue 4
AC-191	AC-191, Issue 6
AC-195	AC-195, Issue 7
TC-239	TC-239, Rev. B
C-246	C-246, Issue 5
C-306	C-306, Issue 2
AC-339	AC-339, Issue 3
AC-345	AC-345, Issue 3
C-348	C-348, Issue 2

2. Sources must have been shown to not be leaking within six months prior to shipment.

3. Sources must not have been damaged during their service lives.

We received no supporting information for the following sources: C-248, C-335, XC-318, C-350, and C-351.

If you have any questions regarding this matter, please contact me or Julia M. Barto of my staff at (301) 415-8500.

Sincerely,

/RA/

Robert J. Lewis, Chief
Licensing Section
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Docket No.: 71-3070
TAC No.: L23733

Enclosure: Safety Evaluation Report

Source	MDS Nordion, Drawing No.
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OFC	SFPO		SFPO		SFPO		SFPO		SFPO	
NAME	J Barto		M DeBose		H Lee		A Barto		R Parkhill	
DATE	04/27 /05		04/29/05		05 /01/05		05/ 03/05		05/ 03/05	

OFC	SFPO		SFPO		SFPO		SFPO			
NAME	G Gundersen		G Bjorkman		L Campbell		R Lewis			
DATE	04/ 29/05		04/ 30/05		05/03/05		05/09/05			

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SAFETY EVALUATION REPORT
Model No. F-168 and F-168X Packages
Canadian Certificate of Approval CDN/2081/B(U)-96
Docket No. 71-3070

SUMMARY

By letter dated April 22, 2004, the U.S. Department of Transportation (DOT) requested Nuclear Regulatory Commission (NRC, or the staff) assistance in evaluating the Model No. F-168 and F-168X transportation packages, authorized by Canadian Certificate of Approval No. CDN/2081/B(U)-96, dated December 9, 2002, for U.S. revalidation. DOT's letter also forwarded MDS Nordion's F-168 and F-168X Safety Analysis Report (SAR). Supplemental information was provided by DOT's letter dated December 6, 2004.

Based upon our review, the statements and representations in the SAR, and for the reasons stated in this Safety Evaluation Report, the staff finds that the Model No. F-168 and F-168X transportation packages, authorized by Canadian Certificate of Approval No. CDN/2081/B(U)-96, dated December 9, 2002, meets the requirements of International Atomic Energy Agency (IAEA) Safety Standards Series No. TS-R-1 (ST-1, Revised), "Regulations for the Safe Transport of Radioactive Material," 1996 Edition (Revised) (IAEA Safety Standards Series TS-R-1). The staff recommends that Canadian Certificate of Approval No. CDN/2081/B(U)-96 be revalidated, with the following conditions:

For F-168 and F-168X sealed source contents not qualified as special form:

1. Sources must conform to the following specifications:

Source	Atomic Energy of Canada Limited, Drawing No.
C-146	C-146, Rev. K
C-151	C-151, Rev. 0
C-185	C-185, Rev. A
C-189	C-189, Rev. A
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C-246	C-246, Issue 5
C-306	C-306, Issue 2
AC-339	AC-339, Issue 3
AC-345	AC-345, Issue 3
C-348	C-348, Issue 2

2. Sources must have been shown to not be leaking within six months prior to shipment.

3. Sources must not have been damaged during their service lives.

The staff received no supporting information for the following sources listed in the certificate contents: C-248, C-335, XC-318, C-350, and C-351.

GENERAL INFORMATION

The package is comprised of a vertical right cylindrical assembly consisting of a steel encased lead shield body, and a steel encased lead shielded closure plug assembly. The outer cylindrical jacket on the body is 3/8 inch thick ASTM A-36 plate, and filled with a minimum thickness of 10 1/4 inch ASTM B-29 lead. The closure plug is secured to the body by eight 7/8-9 threaded fasteners manufactured from ASTM A-320, Grade B, which clamp a neoprene gasket under the plug flange around the top of the cavity. The vertical assembly also consists of an external cylindrical fireshield, a top shield cap, an optional heat screen, a permanent steel skid and an optional load spreader skid.

The F-168 and F-168X packagings are identical, with the exception that the ventline and drainline of the F-168X packaging at the cavity end are permanently sealed by a stainless steel plug. The F-168X is only used for dry, in-cell loading and unloading operations.

The package has the following approximate dimensions and weights, with the heat screen and fireshield installed:

Overall height with skid (mm)	1750
Diameter of the packaging (mm)	1140
Width of the skid (mm)	1372
Length of the skid (mm)	1372
Total weight of package (kg)	5445

The Model No. F-168 and F-168X package is designed to transport up to 50,000 Curies of ^{124}Sb, 100,000 Curies of ^{137}Cs, or 200,000 Curies of ^{60}Co in either special form sealed sources, or in sealed sources meeting the requirements in the “Conditions” section of this SER. The contents are further specified in the Canadian Certificate.

The staff reviewed MDS Nordion Drawing No. F116801-021, Issue B, Sheets 1 through 5. This drawing is not referenced in the Canadian Certificate; however, the drawing provided to the staff is consistent with the general description and sketch in the certificate.

STRUCTURAL

The structural assessment, was based on the conclusions and results described in an MDS Nordion International Inc. report: “Engineering Assessment of the Ability of the F-168 and F-168-X to Meet the Requirements of IAEA Safety Series No. 6, 1985 Edition (Supplement 1988), IE.0004.R90.22, Rev. 0, July 1991." The application described the mechanical and thermal tests performed to demonstrate the ability of the packaging to withstand hypothetical accident conditions in transport. Two 1.0 m pin puncture drops and a total of five 9.0 m free drops were conducted. After the drop tests, the packaging was visually inspected. Damages to the packaging included a crushed top flame deflector; the external fins were flattened onto the body; and cracks in the weld in the lifting lug and lead shielding regions. The cylindrical fire shield remained attached, the lead shielding was intact and the package was found to meet the requirements of Paragraph 656 of the IAEA Standard.

The F-168 packaging was subjected to a physical thermal test and thermal analyses. After the physical fire test, some lead shielding was found to have melted. But radiation surveys showed that there was no substantial increase in radiation levels. This confirms that, despite the fact there was some melting of the lead shield, the radiation levels would still meet the requirements of Paragraph 656 of the IAEA Standard. The applicant stated that the currently used fire shield for F-168 and F-168X transport packages is better than the ones used for the thermal test simulation. In the thermal test simulation the insulted fire shield was only 34 inches high. Currently, the fire shield is 38-7/8 inches high. This will lower the lead temperature during a fire and thus preclude melting. The applicant submitted ANSYS finite element analysis to show that the lead shielding in the package will not melt and the structural integrity of the F-168 or F-168X package is assured.

Based on the test results provided in the application and also considering that the contents of the F-168 or F-168X package are either special form sealed sources, or sealed sources meeting the requirements in the “Conditions” section of this SER, it is concluded that further structural evaluation is not necessary. The staff finds that Model No. F-168 or F-168X package design has the ability to meet the requirements of IAEA Safety Standards Series No. TS-R-1.

THERMAL

This package is designed for the transport of sources with a maximum heat load of 3.3 kW associated with a 200,000 Ci loading of ^{60}Co. The stainless steel canister containing the sealed sources is surrounded by lead shielding contained by a finned carbon steel cylinder. The carbon steel cylinder is permanently mounted to a structural steel base which is surrounded by a fire shield on the sides and top. Internal to the carbon steel cylinder on its top and bottom is insulation material between it and the lead. An optional heat screen is provided over the upper fire shield. The thermal issues of concern in this submittal include the maximum package surface temperature for normal conditions of transport and whether the lead melts under the hypothetical accident condition fire.

For the normal conditions of transport the applicant has stated that the F-168 and F-168X are always shipped exclusive use, except when transported by air as stated in their response to RAI letter dated December 6, 2004. This statement resolves the staff's concern that the top center of the heat screen slightly exceeds the limit of Paragraph 652 of the IAEA Standard for non-exclusive use and is within the 85EC limit for exclusive use. When transported by air the maximum activity of the content is reduced by approximately 1/6 th (refer to Paragraph 416 of the IAEA Standard), therefore the 50EC limit of Paragraph 617 of the IAEA Standard (without the heat screen in place) was demonstrated to be in compliance with a maximum surface temperature of 46EC. The basis of the package temperatures was determined by direct measurement of a F168 S/N 96 package loaded with more than 200,000 Ci of ^{60}Co conducted in 1990.

The staff requested the applicant to define what special stowage provisions would be used if the package exceeded 15 W/m^2. The applicant stated that these special instructions would include keeping the package uncovered, open to the air, and if transported in a freight container, the freight container should be left uncovered. Additionally, the applicant stated the packages would be labeled as high heat emitters and instructions would be provided not to store them in insulated spaces, nor place other cargo within 1.52 meters of each container.

For the hypothetical accident condition, the applicant performed a fire test of a F-168 S/N 40 package in 1978. The package had been dropped and its fire shields were uninsulated. As a consequence of this fire test, some lead melted and escaped through the damaged carbon steel shell. However, even with the loss of lead the radiation levels were found to be acceptable. Modifications were made to the package design which principally included insulation of the fire shields and lengthening of the cylindrical fire shield.

Subsequent to the fire test, a thermal simulation using AECL-FA3 program was performed including a validation of the software program and a simulation of the actual fire test with an uninsulated fire shield and then insulated cylindrical fire shield only. Finally, an ANSYS model was performed on the current F168 package design with insulated fire shields and the results confirm that the lead will not melt. The staff reviewed the calculations provided and noted that the casks were conservatively analyzed in the undamaged configuration since that would convey more heat to the lead. The ANSYS analysis concluded that the maximum temperature of the lead was 277EC, which is below 327EC, the melting point of lead.

The staff finds that an adequate basis exists to support the conclusion that the Model No. F-168 and F-168X transportation packages meet the requirements of IAEA Safety Standards Series No. TS-R-1.

CONTAINMENT

The containment system is defined as the outermost envelope of the encapsulated ^{124}Sb, ^{137}Cs, or ^{60}Co source. The applicant stated that all of the sealed sources used for transport are subject to ANSI/ISO or special form testing, or are similar in design to those that have been tested. The applicant also stated that all of the sources listed in Appendix 12 of their SAR are leak tight and meet the requirements defined in Paragraph 656 of the IAEA Standard. The Staff notes that not all of the sources requested for shipment in the Canadian Certificate are listed in Appendix 12 of the SAR.

The applicant also provided drawings for most of the source contents listed in the Canadian Certificate (in Appendix 3 of the SAR). The Staff reviewed those drawings and noted that all of the source encapsulations had welded enclosures. Therefore, the staff recommends the following conditions:

For F-168 and F-168X sealed source contents which were not qualified as special form on their respective drawings:

1. Sources must conform to the following specifications:

Source	Atomic Energy of Canada Limited, Drawing No.
C-146	C-146, Rev. K
C-151	C-151, Rev. 0
C-185	C-185, Rev. A
C-189	C-189, Rev. A
C-190	C-190, dated July 11, 1967
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C-246	C-246, Issue 5
C-306	C-306, Issue 2
AC-339	AC-339, Issue 3
AC-345	AC-345, Issue 3
C-348	C-348, Issue 2

2. Sources must have been shown to not be leaking within six months prior to shipment.

3. Sources must not have been damaged during their service lives.

The staff received no supporting information for the following sources: C-248, C-335, XC-318, C-350, and C-351.

Based on the information provided in the application and also considering that the contents of the F-168 or F-168X package are either special form sealed sources, or sealed sources meeting the requirements in the “Conditions” section of this SER, the staff finds that Model No. F-168 or F168X package design has the ability to meet the requirements of IAEA Safety

Standards Series No. TS-R-1.

SHIELDING

The Model No. F-168 package is designed to transport up to 50,000 Curies of ^{124}Sb, 100,000 Curies of ^{137}Cs, or 200,000 Curies of ^{60}Co in either special form sealed sources, or in sealed sources meeting the requirements in the "Conditions" section of this SER. The radiation shielding design of the Model No. F-168 consists primarily of the steel inner cavity shell, over ten inches of lead on the side, top, and bottom of the cavity, and the steel outer shell. Some additional shielding is provided by the fire shields on the sides and top of the package, as well as by a shield plate covering the top shield plug-to-body interface to reduce streaming around the plug.

The shielding analysis for the F-168 consists of actual external dose rate measurements of the package containing 200,000 Curies of ^{60}Co, which is the most limiting content for the package. Appendix 10 of the F-168 SAR contains the radiation survey data taken before and after the accident conditions of transport tests performed to satisfy the requirements of IAEA TS-R-1 Paragraphs 726-729. The resulting dose rates are presented in Appendix 10, and are summarized in the following table:

Table 1: Maximum External Dose Rates for F-168 Package (mrem/hr)

Position on Cask	Before Regulatory Accident Tests		After Regulatory Accident Tests
	Surface	1 m	1 m
Top Center	35.1	4.6	15.2
Top Over Shield Plug-to-Body Interface	58.5	4.6	58.4
Top Corner	29.2	4.6	23.3
Side Top	8.8	4.6	5.3
Side Center	52.6	6.4	7.0
Side Bottom	8.2	4.6	4.6
Bottom Center	70.2	3.5	23.3
Side at Drain Port	4.6	2.9	2.9

The measured external dose rates are all within the dose rate limits of IAEA TS-R-1 Paragraphs 530, 531 for normal conditions of transport, and Paragraph 656(b) for accident conditions of transport.

The staff performed confirmatory radiation dose rate calculations using the MicroShield 5 point kernel gamma dose rate code. Using conservative material and geometry approximations, the staff calculated external gamma dose rates that confirmed those measured by the applicant.

Based on the statements and representations made in the shielding analysis in the applicant's

SAR, and on the staff's own analysis, the staff has reasonable assurance that the Model No. F-168 meets the external dose rate requirements of IAEA Safety Standards Series No. TS-R-1, when limited to the contents described as authorized radioactive contents in the Canadian Certificate.

PACKAGE OPERATIONS

The operating instructions for the package were provided in Appendix 2 of the SAR, Specification No. IN/DS 1811 F168 (2), "Design, Manufacturing and Operating Specification for the F-168 and F-168X Transport Packages." The document included procedures for how to prepare the package for shipment. Prior to shipment of the package the radiation and contamination surveys are performed, and a tamper-indicating seal is installed. The Canadian Certificate states that the package operations must be in accordance with this procedure.

ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The acceptance and maintenance program for the package were provided in Appendix 2 of the SAR, Specification No. IN/DS 1811 F168 (2), "Design, Manufacturing and Operating Specification for the F-168 and F-168X Transport Packages." Package acceptance tests include review of quality assurance records, visual examinations, leakage testing of welds, and other operational tests. The maintenance program includes visual examinations, leak testing of the radiation shield cavity, leak testing of the vermiculite zones, and leak testing of the fireshield. The Canadian Certificate states that both the acceptance tests and the maintenance program must be in accordance with this procedure.

The applicant provided MDS Nordion Specification No. IN/QA 0224 Z000(5), "Radioactive Material Transport Package Quality Plan," and MDS Nordion Specification No. IN/QA 0562 A000(2), "Sealed Source Quality Plan." These documents are referenced in the Canadian Certificate.

CONDITIONS

Consistent with the conclusions of our review, the staff recommends that the following provisions be included as conditions of approval for the F-168 and F-168X packages. For F-168 and F-168X sealed source contents not qualified as special form:

1. Sources must conform to the following specifications:

Source	Atomic Energy of Canada Limited, Drawing No.
C-146	C-146, Rev. K
C-151	C-151, Rev. 0
C-185	C-185, Rev. A
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AC-339	AC-339, Issue 3
AC-345	AC-345, Issue 3
C-348	C-348, Issue 2

2. Sources must have been shown to not be leaking within six months prior to shipment.

3. Sources must not have been damaged during their service lives.

CONCLUSIONS

Based upon our review, the statements and representations in the SAR, and for the reasons stated in this Safety Evaluation Report, the staff finds that the Model No. F-168 and F-168X packages, authorized by Candian Certificate of Approval No. CDN/2081/B(U)-96 dated December 9, 2002, with the conditions listed above, meets the requirements of IAEA Safety Standards Series No. TS-R-1.

Issued with letter to R. Boyle, Department of Transportation,
on May 09, 2005.