August 23, 2001

Mr. Marc-André Charette
Regulatory Affairs Senior Associate
MDS Nordion
447 March Road
Kanata, Ontario, Canada K2K 1X8

SUBJECT: MODEL NO. F-423 TRANSPORTATION PACKAGE APPROVAL

Dear Mr. Charette:

As requested by your application dated June 28, 2000, as supplemented, enclosed is Certificate of Compliance No. 9299, Revision No. 0, for the Model No. F-423 Radioactive Material Transportation Package.

You have been registered as a user of the package under the general license provisions of 10 CFR 71.12. The approval constitutes authority to use the package for shipment of radioactive material and for the package to be shipped in accordance with the provisions of 49 CFR 173.471.

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

Sincerely,

/s/ /RA/

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

Docket No.: 71-9299

Enclosures:
1. Certificate of Compliance No. 9299, Rev. No. 0
2. Safety Evaluation Report

cc w/encl: R. Boyle, Department of Transportation
M. Wangler, Department of Energy

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2. PREAMBLE

a. This certificate is issued to certify that the package (packaging and contents) described in Item 5 below meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, “Packaging and Transportation of Radioactive Material.”

b. 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

a. ISSUED TO *(Name and Address)*

MDS Nordion
447 March Road
Kanata, Ontario, Canada K2K 1X8

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

MDS Nordion application dated
June 28, 2000, as supplemented.

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: F-423

(2) Description

A double-walled welded stainless steel overpack for shipping sealed sources within the Gammacell 220 (GC220) gamma irradiator. The packaging consists of concentric box-like stainless steel shells separated by an annulus of rigid polyurethane foam. The overall overpack wall thickness is eight inches on the sides, twelve inches on the front and rear, and four inches on the base. The overpack lid is constructed of a sheet of 1/2-inch thick stainless steel on top, a sheet of 1/4-inch thick cold-rolled steel on the bottom, and 4-inches of polyurethane foam in between. The package is closed by bolting the lid to the body with 40 one-inch diameter bolts.

The GC220 irradiator is positioned inside the cavity formed by the inner stainless steel shell, along with an inner steel frame and a rigid polyurethane foam bonnet and lower crush pad. Shielding is provided by the GC220 irradiator, which is a welded steel lead-filled device. The GC220 is a lead-filled shielding head mounted on a steel stand. The GC220 shielding head consists of inner and outer steel shells with lead in between. The nominal lead thickness is 10 inches. The GC220 has an irregular shape, however, the base is 60-inches long by 40-inches wide. In its shipping configuration, the GC220 is 58-inches high. The GC220 shielding plug is welded from 304 stainless steel and lead filled. The GC220 drawer is welded from 304 stainless steel and is lead filled.

5(a) (2) (continued)

The maximum package weight (including contents) is 21,000 lbs (9,530 kgs). The approximate package component dimensions and weights are as follows:

Component	Weight (lbs / kg)	Nominal Dimensions (L x W x H inches)
Overpack Lid	1,046 / 474	67.50 x 55.00 x 4.75
Inner Frame	1,038 / 470	60.50 x 48.00 x 54.13
Bonnet	846 / 384	52.00 x 41.50 x 36.75
GC220	8,575 / 3,890	60.00 x 40.00 x 58.00
Overpack Body	8,750 / 3,969	86.50 x 66.00 x 80.37
Lower Crush Pad	354 / 160	47.00 x 31.00 x 7.00

(3) Drawings

The packaging is constructed in accordance with MDS Nordion Drawing No. F642301-001:
Sheet 1, Revision D
Sheet 2, Revision C
Sheet 3, Revision B
Sheet 4, Revision A

(b) Contents

(1) Type and form of material

i. Cobalt-60 as sealed sources that meet the requirements of special form radioactive material.
ii. Cobalt-60 as sealed sources described in Condition No. 6 below.

(2) Maximum quantity of material per package

26,000 curies, a maximum of 48 sources per package, and a maximum of 5,000 curies per source.

6. Sealed sources limited to MDS Nordion sealed source capsules manufactured before February 19, 1973: C-166, C-167, and C-185. In addition, these sources must meet the following:

   (a) Sources must conform to the specifications identified in the application in Figure 4.2 for the C-166 source, Figure 4.3 for the C-167 source, and Figure 4.4 for the C-185 source;

   (b) Sources must be shown to not be leaking within six months prior to shipment; and

   (c) Sources must not have been damaged during their service life.

7. In addition to the requirements of Subpart G of 10 CFR Part 71:

   (a) The package must be prepared for shipment and operated in accordance with the Operating Procedures in Chapter 7 of the application.

   (b) Each packaging must be acceptance tested and maintained in accordance with the Acceptance Tests and Maintenance Program in Chapter 8 of the application.

8. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 71.12.

9. Expiration date: August 31, 2006.

<u>REFERENCES</u>

MDS Nordion application dated June 28, 2000.

Supplements dated: May 11 and June 28, 2001

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

/s/ /RA/

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

Date <u>August 23, 2001</u>

SAFETY EVALUATION REPORT

Docket No. 71-9299
Model No. F-423 Package
Certificate of Compliance No. 9299
Revision No. 0

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SAFETY EVALUATION REPORT

Docket No. 71-9299
Model No. F-423 Package
Certificate of Compliance No. 9299
Revision No. 0

SUMMARY

By application dated June 28, 2000, as supplemented May 11 and June 28, 2001, MDS Nordion requested that the U.S. Nuclear Regulatory Commission approve the Model No. F-423 transportation package as a Type B(U)-85 package. Based on the statements and representations in the application, as supplemented, and the conditions listed below, the staff concludes that the package meets the requirements of 10 CFR Part 71.

1.0 GENERAL INFORMATION

1.2 Packaging

The Model No. F-423 is a double-walled welded stainless steel overpack for shipping sealed sources within the Gammacell 220 (GC220) gamma irradiator. The packaging consists of concentric box-like stainless steel shells separated by an annulus of rigid polyurethane foam. The overall overpack wall thickness is eight inches on the sides, twelve inches on the front and rear, and four inches on the base. The overpack lid is constructed of a sheet of 1/2-inch thick stainless steel on top, a sheet of 1/4-inch thick cold-rolled steel on the bottom, and 4-inches of polyurethane foam in between. The package is closed by bolting the lid to the body with 40 one-inch diameter bolts.

The GC220 irradiator is positioned inside the cavity formed by the inner stainless steel shell, along with an inner steel frame and a rigid polyurethane foam bonnet and lower crush pad. Shielding is provided by the GC220 irradiator, which is a welded steel lead-filled device. The GC220 is a lead-filled shielding head mounted on a steel stand. The GC220 shielding head consists of inner and outer steel shells with lead in between. The nominal lead thickness is 10 inches. The GC220 has an irregular shape, however, the base is 60-inches long by 40-inches wide. In its shipping configuration, the GC220 is
58-inches high. The GC220 shielding plug is welded from 304 stainless steel and lead filled. The GC220 drawer is welded from 304 stainless steel and is lead filled.

The maximum package weight (including contents) is 21,000 lbs (9,530 kgs). The approximate package component dimensions and weights are as follows:

Component	Weight (lbs / kg)	Nominal Dimensions (L x W x H inches)
Overpack Lid	1,046 / 474	67.50 x 55.00 x 4.75
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1.2 Drawings

The packaging is constructed in accordance with MDS Nordion Drawing No. F642301-001:

Sheet 1, Revision D
Sheet 2, Revision C
Sheet 3, Revision B
Sheet 4, Revision A

1.3 Contents

The contents of the Model No. F-423 consist of the GC220 irradiator with up to 26,000 curies of ^{60}Co in up to 48 special form capsules, and a maximum of 5,000 curies per source. The special form capsules are sealed sources that meet the requirements of special form radioactive material. or meet the following conditions:

Sealed sources limited to MDS Nordion sealed source capsules manufactured before February 19, 1973: C-166, C-167, and C-185. These sources must meet the following:

- Sources must conform to the specifications identified in the application in Figure 4.2 for the C-166 source, Figure 4.3 for the C-167 source, and Figure 4.4 for the C-185 source;
- Sources must be shown to not be leaking within six months prior to shipment; and
- Sources must not have been damaged during their service life.

2.0 STRUCTURAL EVALUATION

2.1 General Description

The staff reviewed the Model No. F-423 application for compliance with the general standards for transportation packages as specified in 10 CFR 71.43 and found that the package met the applicable requirements: Minimum size, tamper-proof feature, positive closure, and chemical and galvanic reactions. The GC220 provides the containment for the package. The containment system includes the inner shell of the GC220 shielding head, head plug, drawer, source cage, sealed sources, shipping cover, and the lower shipping bracket. Positive closure is provided by securing the GC220 shipping cover with four 3/4-inch nominal diameter socket-head bolts. In addition, the GC220 is installed under the inner frame and bonnet assembly, which are then secured in the
F-423 overpack. This prevents inadvertent opening of the GC220. A lock wire between two adjacent bolts on the overpack lid acts as a tamper-proof feature during a loaded shipment.

The materials used in fabrication of the package are stainless steel, lead, carbon steel, and polyurethane foam. There will be no significant chemical or galvanic reaction between any of these materials, or the stainless steel sources containing the ^{60}Co material.

2.2 Lifting and Tie-Down Features

The staff reviewed the Model No. F-423 application for compliance with the lifting and tie-down standards for transportation packages as specified in 10 CFR 71.45 and found that the package met the applicable requirements. For lifting, the package is equipped with four lift lugs welded to the top of the package. The four lift lugs were shown by analyses to be capable of lifting three times the maximum package weight without yielding.

Four rings are used for tie-down, two located at each end of the package. The applicant evaluated the integrity of the tie-down components under 2g (vertical), 10g (horizontal) and 5g (horizontal transverse) loads acting concurrently on the package. Evaluation of the stresses in the tie-down rings for the concurrent 2g, 10g and 5g tie-down loads specified in 10 CFR 71.45 showed that the stresses did not exceed yield.

2.3 Normal Condition of Transport

The staff reviewed the Model No. F-423 application for compliance with the normal conditions of transport as specified in 10 CFR 71.71 and found that the package met the applicable requirements: resistance to heat and cold, reduced and increased external pressure, vibration, water spray, free drop, and penetration. The package will not be affected by ambient temperatures in the range of -40°F to 100°F. The applicant's analysis showed that the Model No. F-423 lid can withstand an external pressure of 25 psig without yielding. The analysis also showed that an increased external pressure of 20 psia or a reduced external pressure of 3.5 psia would have no effect on the package.

The applicant's shock and vibration analysis and operational experience with a similar package shows that the package will maintain its structural integrity under normal transport vibration conditions. The applicant demonstrated that the water spray test would have no significant effect on the package's integrity.

The applicant performed a 3-foot bottom end drop on a full-scale test package. The test results demonstrated that the containment, shielding and impact protection were maintained. The feet on the Model No. F-423 package showed some minor buckling. However, this damage would not result in any reduction in the effectiveness of the packaging. The packaging maintained its structural integrity under the normal condition free-drop test.

The exterior of the Model No. F-423 overpack is completely covered by 0.5 inches thick of 304L stainless steel. The applicant demonstrated through analysis that a 13-pound steel cylinder dropped through a distance of 40-inches onto the most vulnerable section of the package would not affect the integrity of the package.

2.4 Hypothetical Accident Conditions

The applicant combined full-scale testing, engineering analysis, and a comparison with similar packages to evaluate the structural integrity of the package under hypothetical accident conditions in accordance with 10 CFR 71.73. The applicant demonstrated by engineering analysis that an end-drop onto the top left or right edge, with the center-of-gravity located directly over the point of impact, would be the worst-case scenario by potentially causing the lid of the package to be dislodged.

The applicant physically tested a single full-scale model package in the following sequence:

(1) A 3-foot bottom end drop;
(2) A 30-foot center-of-gravity over the top left corner oblique-drop to attempt to dislodge the overpack lid;
(3) A 40-inch oblique puncture-test impact on the edge of the lid near the left corner to further attempt to dislodge the lid;
(4) A puncture-test drop onto the left side through the center-of-gravity to attempt to breach the overpack skin;
(5) A puncture-test impact on the left front corner at mid-height through the center-of-gravity to further attempt to breach the overpack skin; and
(6) A puncture-test impact on the front end to further attempt to breach the overpack skin.

The results of the physical testing were as follows: (1) there were no cracks or breaches in the GC220 shielding head; (2) the C-198 capsules were not damaged and they passed the post-drop helium test; (3) the Model No. F-423 lid remained in place, retained by 14 of 26 bolts. There were several dents in the overpack, but only a minor breach in the skin.

The applicant evaluated the maximum stresses that would be produced in the package under the fire test conditions and determined that the stresses were within acceptable limits.

The applicant demonstrated that the effect of 21 psig external pressure due to the package being immersed under 50-feet of water would not affect the integrity of the package.

Based on a review of the test results and analysis in the application, the staff concludes that the structural design of the packaging meets the requirements of 10 CFR Part 71.

3.0 THERMAL EVALUATION

3.1 Description of Thermal Design

The Model No. F-423 overpack for the GC220 irradiator consists of concentric box-like stainless steel shells separated by an annulus of rigid polyurethane foam. Foam thickness is eight inches on the sides, twelve inches on the ends, and four inches in the bottom and lid. The irradiator itself is positioned inside the cavity formed by the inner stainless steel shell, along with an inner steel frame and a rigid polyurethane foam bonnet and lower crush pad. The rigid polyurethane foam in the overpack shell and internal components acts to protect the GC220 during the drop tests and also to insulate the lead shielding and contents during the thermal tests. The rigid polyurethane foam will char at the surface when exposed to a high heat environment such as that encountered under hypothetical accident conditions. This char prevents direct combustion of the foam at its surface and will expand to seal any cracks or punctures in the stainless steel shell. During a fire, polyethylene vent hole plugs will melt to allow smoke and gases from the charring foam to be released.

The contents of the Model No. F-423 consist of the GC220 irradiator with up to 26,000 curies of ^{60}Co in special form capsules, or in sealed source capsules meeting the requirements discussed in Section 4 of this SER. The GC220 consists of a lead-filled shielding head mounted on a steel stand. The shielding head is formed by a mild steel outer shell, consisting of a middle cylindrical section and top and bottom conical sections, a central cylindrical steel shell of varying diameter which forms the source cavity, an annular stainless steel, lead-filled shielding plug, and a cylindrical stainless steel, lead-filled drawer with a stainless steel drain tube through its entire length. The volume between the outer and inner mild steel shells of the shielding head is filled with lead, forming a nominal shielding thickness of ten inches. A ring of up to 48 source capsules is centered within the shielded cavity. The annular shielding plug is directly on top of the source ring, with the cylindrical drawer taking up the volume inside the source ring and the shielding plug.

3.2 Material Properties and Component Specifications

Material properties for all package materials which affect the thermal evaluation are shown in Tables 3.1 and 3.2 of the application. The steel, lead, and neoprene used in the package design are commercially available and meet the specifications given in Table 3.3 of the application. The specification for the foam used in the package is shown in Appendix 3.1 of the application, Attachment F, "Polyurethane Foam Material Property Information." The foam fire retardance is specified to be tested according to 14 CFR 25, or an equivalent method.

3.3 Thermal Evaluation Under Normal Conditions of Transport

3.3.1 Analytical Model

The package was modeled using the ANSYS finite element code version 5.5.3 to simulate the thermal requirements under normal conditions of transport. The model consisted of a three-dimensional eighth-section of the package. The bottom eighth-section was used for the model, since this represented the shortest conduction path into the overpack. The solar load intended for the top of the package was conservatively applied to the bottom in the analytical model. Material properties used in the analytical model are listed in Tables 1 and 2 of Appendix 3.1 of the application, "Thermal Simulation of IAEA Fire Test on the F-423 Overpack, MDS Nordion Report No. IN/TR 1644 F423."

Radiation heat transfer across the internal air space of the package is modeled by a radiation enclosure, with the GC220 surface having an emissivity of 0.8 and the surfaces of the inner frame and floor of the overpack having an emissivity of 0.5. The symmetry surfaces of the enclosure are assumed to have an emissivity of 0.01 to act as a mirrored surface and effectively reflect radiation back into the enclosure. This radiation model is conservative since the blocking effects of the package internal structure are neglected. For radiation on the external surfaces of the package, the applicant assumed an ambient temperature of 38°C with a stainless steel surface emissivity of 0.5.

Convection and conduction across the internal airspace is accounted for by an effective thermal conductivity. This effective thermal conductivity (k_{eff}) is the thermal conductivity that a stationary fluid must have to transfer the same amount of heat as a moving fluid. The k_{eff} is calculated using correlations, given in Attachment C of Appendix 3.1 of the application, which approximate internal convection in the package as that between long concentric cylinders or concentric spheres. The k_{eff} calculated in this way represents 99% of the conduction area between the GC220 and the inside of the overpack. The other 1% is represented by conduction through the steel package internal structure (see Attachment C of Appendix 3.1). Of the total package conductivity, 1% is attributed to the steel and is combined with the k_{eff} for the air in the void between the exterior of the GC220 and the interior of the overpack.

Internal heat generation for the sources inside the GC220 is assumed to be 400 W, which is slightly higher than the decay heat for the maximum allowed 26,000 curies of ^{60}Co. The decay heat was modeled as a heat flux on the inside surface of the inner cavity shell, with 60% of the flux in the radial direction, 30% to the top of the cavity, and 10% to the bottom. Since only the bottom of the package is present in the eighth-section model, the bottom of the inner cavity is conservatively modeled to receive 40% of the heat flux. The lead-to-steel contact resistance at the outside of the GC220 shielding head was modeled by adding the thermal resistance of a 0.02-inch air gap to the conductivity of the outer steel.

For convection on the exterior of the package, the applicant assumed a 38°C bulk-fluid temperature with a surface convection coefficient as calculated in Attachment D of Appendix 3.1. The heat transfer coefficient was calculated using a correlation for a square in the cross flow of air at 1.0 m/s (3.3 ft/s). Insolation on the exterior of the package was assumed to be 400 W/m^2 on the sides of the package and 800 W/m^2 on the flat bottom surface. This is conservative with respect to the insolation requirements of 10 CFR 71.71(c)(1). The applicant evaluated package temperatures at the end of a twelve-hour insolation cycle, and compared these temperatures to those calculated at steady state with constant insolation.

3.3.2 Test Model

In addition to the analytical model, the applicant tested a full scale prototype for steady state temperatures under normal conditions of transport. The test was performed at an ambient temperature of 21°C with 22,000 curies of ^{60}Co loaded in the GC220. Temperatures were recorded at several key locations in the GC220 and the Model No. F-423 overpack. The applicant compared the results of this test to the results of an ANSYS run of the analytical model using the ambient temperature and decay heat of the actual test.

3.3.3 Maximum Temperatures

The following table presents the maximum measured temperatures for key locations in the test model, along with the temperatures evaluated using the analytical model at actual test conditions, regulatory conditions with a twelve-hour insolation cycle, and regulatory conditions with constant insolation:

Table 1
Maximum Measured Temperatures for Test and Analytical Models

Temperature Location:	Test: 21°C ambient, 22kCi, No Solar Load	Analytical: 21°C ambient, 22kCi, No Solar Load	Analytical: 38°C ambient, 26kCi, 12-hr. Insolation	Analytical: 38°C ambient, 26kCi, Const. Insolation
Source	109°C	125°C	<177°C*	<177°C*
GC220 Inner Cavity Wall	68°C	77°C	104°C	154°C
GC220 Shielding Head, Outside	59°C	65°C	97°C	145°C
F-423 Inner Frame, Inside Wall	46°C	51°C	96°C	138°C
F-423 Inner Frame, Outside Wall	32°C	34°C	83°C	115°C
F-423 Exterior	23°C	23°C	88°C	95°C
F-423 Lid, Underside	40°C	43°C	110°C	136°C
F-423 Lid, Topside	29°C	30°C	115°C	137°C

Note:
* - 177°C is the source temperature calculated under hypothetical accident conditions. Temperatures under normal conditions of transport will be less than 177°C.

The applicant also evaluated the analytical model of the package with the maximum decay heat, a 38°C ambient temperature, and no insolation. The results of this evaluation showed that no accessible surface of the Model No. F-423 package will exceed 50°C, as required by 10 CFR 71.43(g) for non-exclusive use shipments.

3.3.4 Maximum Normal Operating Pressure

Since the GC220 inner cavity is not sealed, the containment system will only experience the increase in pressure associated with that of the neoprene-sealed overpack cavity, which is at a lower average air temperature. The applicant has calculated the maximum normal operating pressure of the package to be 4 psig. The applicant demonstrated in Section 2 of the application that the package can withstand an internal pressure of 25 psig. The source capsules are sealed at atmospheric pressure and room temperature. The applicant calculated the pressure rise in the capsules to be 8 psig under hypothetical accident conditions. The pressure rise under normal conditions of transport will be less than 8 psig. Stresses in the capsule due to this pressurization are negligible.

3.4 Evaluation Under Hypothetical Accident Conditions

3.4.1 Thermal Model

The thermal model for hypothetical accident conditions is the same as the analytical model for normal conditions of transport, with several different assumptions and modified heat loads. The resulting temperatures for the normal conditions evaluation of the package with 26,000 curies ^{60}Co, 38°C ambient temperature, at steady state, were used as the initial conditions for the hypothetical accident conditions thermal transient. The 30 minute, 800°C fire temperature applied to the exterior surfaces of the package was followed by a 1 minute ramp-down to normal conditions of transport ambient temperatures, followed by a 14.5 hour cool-down period, including a 12 hour period of insolation at the level applied under normal conditions of transport.

The lead-to-steel contact resistance used in the normal conditions model was conservatively removed during hypothetical accident conditions to allow more heat to the interior of the package. Any polyurethane foam elements that reached 465°C were given the conductivity of air at that point to account for the charring of the foam that occurs at that temperature. The emissivity of the exterior steel surfaces was set to 1.0. The convection coefficient calculated in Attachment D of Appendix 3.1 for hypothetical accident conditions was applied to the exterior surfaces of the cask model.

3.4.2 Maximum Temperatures

The following table presents the maximum evaluated temperatures for several key locations for the Model No. F-423 package under the hypothetical accident conditions fire transient:

Table 2
Maximum Evaluated Temperatures Under Hypothetical Accident Conditions

Temperature Location:	Hypothetical Accident Conditions Temperature	Time after Start of Fire (hrs)
Source	177°C	7
GC220 Inner Cavity Wall	129°C	7
GC220 Shielding Head, Outside	132°C	1.7
F-423 Inner Frame, Inside Wall	143°C	1.7
F-423 Inner Frame, Outside Wall	152°C	1.7
F-423 Exterior	785°C	0.5
F-423 Lid, Underside	341°C	0.7
F-423 Lid, Topside	757°C	0.5

The maximum temperature reached by the lead due to the fire transient (129°C) was 198°C below its melting temperature. Therefore, the shielding provided by the GC220 inside the Model No. F-423 will be maintained under hypothetical accident conditions.

3.4.3 Maximum Pressure

Since the GC220 inner cavity is not sealed, and the neoprene seal on the overpack cavity will no longer be functioning due to the fire, the containment system will not experience a pressure rise under hypothetical accident conditions. The source capsules are sealed at atmospheric pressure and room temperature. The applicant has calculated the pressure rise in the capsules to be 8 psig under hypothetical accident conditions.

3.5 Evaluation Findings

Based on a review of the statements and representations in the application, the staff concludes that the thermal design of the Model No. F-423 package has been adequately described and evaluated, and that the thermal performance of the package meets the thermal requirements of 10 CFR Part 71.

4.0 Containment Evaluation

The containment boundary of the Model No. F-423 package is defined as the enclosure formed by the lower shipping bracket, the inner shell of the GC220 shielding head, and the shipping cover, surrounding the drawer and head plug assemblies. The shipping cover is secured by four 0.75-inch socket cap screws. The lower bolted closure consists of either the bottom shipping cap secured by ten 0.75-inch socket cap screws, or the bottom shipping bracket secured by four 0.75-inch socket cap screws. Section 2 of the application showed that there was no damage to the containment system as a result of the hypothetical accident conditions free drop or puncture tests.

The contents of the package are ^{60}Co sealed sources. The containment system is not sealed and depends on the sealed sources to meet the requirements of 10 CFR 71.51(a). The sealed sources consist of either C-198 special form capsules, or the following MDS Nordion sealed source capsules manufactured before February 19, 1973: C-166, C-167, and C-185.

Additional shipping requirements for the C-166, C-167, and C-185 sealed source contents will be as follows:

- Sources must conform to the specifications identified in the application in Figure 4.2 for the C-166 source, Figure 4.3 for the C-167 source, and Figure 4.4 for the C-185 source
- Sources must be shown to not be leaking within six months prior to shipment
- Sources must not have been damaged during their service life.

The applicant has shown that the sources remain inside the containment boundary under both normal conditions of transport and hypothetical accident conditions.

Based on a review of the statements and representations in the application, the staff concludes that the containment design has been adequately described and evaluated and that the package design meets the containment requirements of 10 CFR Part 71.

5.0 Shielding Evaluation

Shielding in the Model No. F-423 package is provided primarily by the GC220 irradiator. The GC220 irradiator is designed to reduce dose rates on its exterior to less than 200 mrem/hr. When loaded in the overpack, dose rates will be much lower due to the shielding provided by the steel shells and the distance provided by the dimensions of the package.

The contents of the package are up to 26,000 curies of ^{60}Co. Shielding in the GC220 is provided by a nominal lead thickness of 10 inches between the steel shells of the shielding head. The top of the GC220 is shielded by the annular steel, lead filled head plug and the cylindrical steel, lead filled drawer. The structural evaluation in Section 2 of the application shows there will be no lead slump in any component of the GC220, and the thermal evaluation in Section 3 of the application shows there will be no melting of the lead.

Surveys of a full scale Model No. F-423 package were performed before and after the drop tests using a source of approximately 22,000 curies of ^{60}Co. Actual source values for each of the surveys are given in Table 5.1 of the application. The measurements were normalized to the maximum 26,000 curies of ^{60}Co. The maximum normalized surface and 1-meter dose rates for the Model No. F-423 package before and after the drop tests are given in the following table:

Table 3
Maximum Normalized Surface and 1-Meter Dose Rates Before and After Drop Tests

Location	Surface Measurement (mR/hr)		1 m Measurement (mR/hr)	
	Before Drop	After Drop	Before Drop	After Drop
Side	1.6	1.5	0.33	0.29
Top	0.8	1.2	0.5	1.2
Bottom	12	12	1.2	1.2

The change in dose rates after the drop tests was due to the relocation of the GC220 shielding head inside the package overpack. The dose rate listed above for the top of the package neglects a localized "hot spot" with a significantly higher dose rate. This hot spot was due to the removal of a tungsten shield plug from the source loading tube in the head plug, which resulted in a direct streaming path to the contents. This shield plug was removed to insert test instrumentation into the inner cavity, and is impossible to remove during transportation due to the presence of the shipping cover.

Based on a review of the statements and representations in the application, the staff concludes that the shielding design has been adequately described and evaluated and that the package meets the external radiation requirements of 10 CFR Part 71.

6.0 Operating Procedures

Operating Procedures for the package are specified in Chapter 7 of the application. The chapter includes sections on (1) loading ^{60}Co sources into the GC220, (2) loading the GC220 into the Model No. F-423 overpack and preparation for shipment, (3) securing the Model No. F-423 package on road vehicles, (4) unloading the Model No. F-423 package, (5) unloading ^{60}Co sources from the GC220, and (6) preparing an empty package for transport.

Based on the review of statements and representations in the application, the staff concludes that the operating procedures meet the requirements of 10 CFR Part 71 and that these procedures are adequate to assure that the package will be operated in a manner consistent with its evaluation for approval.

7.0 Acceptance Tests and Maintenance Program

Package acceptance tests and maintenance program are specified in Chapter 8 of the application. The acceptance tests prior to first use include visual examinations, structural and pressure tests, leak tests, component tests, shielding integrity tests, and thermal acceptance tests.

The maintenance program includes structural and pressure tests prior to shipment, inspections of certain structural components (inner frame, bonnet assembly, lower crush pad, and hoist ring screws) either annually or prior to shipment, inspection of gaskets and sealing surfaces prior to each shipment, and radiation surveys prior to each shipment.

Based on the review of the statements and representations in the application, the staff concludes that the operating procedures meet the requirements of 10 CFR Part 71 and that these procedures are adequate to assure that the package will be acceptance tested and maintained in a manner consistent with its evaluation for approval.

CONDITIONS

In addition to the requirements of Subpart G of 10 CFR Part 71:

(a) The package must be prepared for shipment and operated in accordance with the Operating Procedures in Chapter 7 of the application.

(b) Each packaging must be acceptance tested and maintained in accordance with the Acceptance Tests and Maintenance Program in Chapter 8 of the application.

CONCLUSION

Based on the review of the statements and representations in the application, as supplemented, and the conditions listed above, the staff concludes that the design has been adequately described and evaluated and that the package meets the requirements of 10 CFR Part 71.

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