



27 September 2010
E&L-098-10

Mr. Pierre Saverot
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: Response to RAI dated July 12, 2010
Re: Request for Amendment of US Nuclear Regulatory Commission
Certificate of Compliance No. 9204 for the Model 10-160B Shipping
Cask, E&L-037-10, 2 April, 2010
Docket No. 71-9204
TAC No. L24435

Dear Mr. Saverot:

Enclosed is our response to the Request for Additional Information (RAI) related to our 10-160B submittal. In addition to specific responses to the RAI items, EnergySolutions provides additional revisions (Revision 2) to Chapters 1, 5, and 7 of the SAR incorporating the information provided in our response. Please replace the previously submitted Chapters 1, 5 and 7 with the ones attached to this letter. Additionally, the Revision Control Sheet has been updated to document the current revision level of the various sections of the SAR and the SAR cover page has been revised. The attachments provided are:

- 1) Response to the RAI
- 2) Chapter 1 – The prohibited materials identified in the contents section have been revised as noted in the responses to the RAI and limitation on activity per the calculation in Chapter 5 has been added.
- 3) Chapter 5 – A calculation of gamma activity limits has been added.
- 4) Chapter 7 – A procedure for use of the gamma activity limits has been added.
- 5) Revision Control Sheet has been added as page i
- 6) The SAR cover page has been revised

Should you or members of your staff have any additional questions about the request,

please contact Mark Whittaker at (803) 758-1898.

Sincerely,

A handwritten signature in black ink that reads "Mirza I. Baig". The signature is written in a cursive style with a horizontal line underneath the name.

Mirza I. Baig
Technical Services Manager – Engineering & Licensing

Attachments:

- 1) RSI Responses
- 2) SAR Chapter 1
- 3) SAR Chapter 5
- 4) SAR Chapter 7
- 5) SAR Revision Control Sheet
- 6) SAR Cover Page

Response to Request for Additional Information on 10-160B

Chapter 1 General Information

RAI 1-1 Clarify how the powdered solids will be allocated inside the cask cavity.

Section 1.2.3.2 of the Consolidated Safety Analysis Report (SAR), Rev. 1, includes powdered solids to the list of allowable waste forms; however, no information on how the powdered solids will be accommodated in the package is provided. Staff is unable to determine whether the powdered solids will be loaded into the cask cavity inside another container or if these will be only contained by the package containment boundary.

This information is requested by the staff to determine compliance with 10 CFR 71.33.

RESPONSE:

A secondary container is required for all contents types. The Contents section of Chapter 1 is modified to include this requirement.

RAI 1-2 Include a condition on the contents of the powdered materials to prevent pyrophoric situations.

The existing Certificate of Compliance (CoC) limitations does not include metals and/or chemical forms such as hydrades. Such a condition is necessary to support the shipment of powders.

This information is requested by the staff to determine compliance with 10 CFR 71.33.

RESPONSE:

The following limitation is included in the Contents section of Chapter 1: Powdered solid radioactive material shall not include radioactive forms of combustible metal hydrides, elemental metals, i.e., magnesium, titanium, sodium, potassium, lithium, zirconium, hafnium, calcium, zinc, plutonium, uranium, and thorium, or non-metals, i.e., phosphorus.

Chapter 4 Containment Evaluation

RAI 4-1 Justify how the powdered solids will remain inside the containment boundary when evacuating the cask cavity for the leak testing.

The leak testing procedure described under Section 4.9, establishes an evacuation of the cask cavity of at least 90% vacuum prior to pressurizing the cavity with helium and then operating the helium mass spectrometer leak detector. Staff does not have reasonable assurance that the powdered solids will remain inside the containment boundary when performing this evacuation.

This information is requested by the staff to determine compliance with 10 CFR 71.41.

Response to Request for Additional Information on 10-160B

RESPONSE:

The leak testing procedure in Section 4.9 is for a periodic leak test. Periodic tests are performed without radioactive contents. Pre-shipment leak tests are performed with contents in the packaging. Additionally, contents are required to be in secondary containers.

Chapter 5 Shielding Evaluation

RAI 5-1 Provide the maximum allowable source terms loading based on satisfying the regulatory dose limits.

On page 5-2 of the Consolidated SAR, Rev. 1, the applicant states that SCALE models of the 10-160B cask were evaluated with a Co-60 source. The resulting equivalent source, approximately 13.4 Ci, gave a gamma dose rate of approximately 9.96 mrem/hr at 2m from the 8 ft wide trailer.

The staff performed confirmatory calculations using ORIGEN-ARP to calculate source terms and Mavric/Monaco as part of SCALE6 computer code for shielding analyses and found that for the ⁶⁰Co point source considered in the application, 13.4 Ci, resulted in a higher than allowed dose rate at 2 meters from the package. Staff also noted that MicroShield® may not provide conservative results.

This information is requested by the staff to determine compliance with 10 CFR 71.47.

RESPONSE:

The manual for Mavric/Monaco, Table S6.5.12, shows that Mavric/Monaco gives results for photon dose rate calculations that are as much as 20% higher than results for SAS4 (SCALE 5.1), which was used in the Consolidated SAR. In addition, correspondence from the SCALE6 code author contained the following: "Mark Whittaker of Energy Solutions recently asked why photon dose rates computed with MAVRIC were 20% higher than dose rates computed with SAS4, as shown in the MAVRIC 6.0 manual. I reran those comparisons using the latest ENDF/B-VII data from SCALE 6.1 and this is still true: MAVRIC gives photon dose rate 15-20% higher than SAS4."

Thus, it should be expected that staff's results using SCALE6 are higher than results using SCALE5. However, this difference does not mean the SAS4 results are invalid. In fact, the validation report for SAS4 (NUREG/CR-6484) states that "gamma-ray dose-rate calculations with major contributions due to active fuel show over a factor of 2 overprediction of the measured quantities". Since SAS4 overpredicts the gamma results and the SCALE6 gives results 15-20% higher than SAS4, the SCALE6 results are an overprediction by a factor of 2.3-2.4.

RAI 5-2 Provide the maximum allowable content based on calculated values for allowable external doses.

There is no analysis described in the Consolidated SAR, Rev. 1, where the applicant explains or gives details regarding the calculated dose limits. The applicant can either provide an allowable activity limit for each isotope for NCT or

Response to Request for Additional Information on 10-160B

HCT conditions (e.g., RH-72B transport package, CoC No. 71-9212) or use bounding values for the source terms (e.g., gammas/sec. and MeV/gammas).

Staff indicated the need for an additional parameter, which would complement the current $3000A_2$ and 100 watts limits, to provide a boundary for higher energy gamma emitting contents in the Certificate of Compliance contents description.

This information is requested by the staff to determine compliance with 10 CFR 71.47.

RESPONSE:

Chapter 5 has been revised to include bounding values for the source term in terms of gammas/sec and MeV/gamma. A restriction has been added to Chapter 1 and a procedure for implementing this limit has been added to Chapter 7. These revisions are attached for review.

CONSOLIDATED SAFETY ANALYSIS REPORT

FOR

MODEL 10-160B

TYPE B RADWASTE SHIPPING CASK

REVISION 2

September 2010

EnergySolutions
140 STONERIDGE DRIVE
COLUMBIA, SOUTH CAROLINA 29210

REVISION CONTROL SHEET

TITLE: Consolidated Safety
Analysis Report for 10-160B
Shipping Cask

AFFECTED PAGE(S)	DOC. REV.	HEADER DATE	REMARKS
Entire Document	0	December 2007	Consolidate Revision 0 Incorporates all previous changes to the SAR
Cover Page i 1-1 – 1-6 5-1 – 5-15 7-1 – 7-9	1 “ “ “ “	April 2010 “ “ “ “	A vertical line in the margin indicates changed text. The date in the page header reflects the date of the change. The revision status of a particular page is noted by the revision number and header date.
Cover Page i 1-1 – 1-6 5-1 – 5-18 7-1 – 7-12	2 “ “ “ “	September 2010 “ “ “ “	A vertical line in the margin indicates changed text. The date in the page header reflects the date of the change. The revision status of a particular page is noted by the revision number and header date.

1.0 GENERAL INFORMATION

1.1 Introduction

This Safety Analysis Report describes a reusable shipping package designed to protect radioactive material from both normal conditions of transport and hypothetical accident conditions as required by 10CFR71. The package is designated the Model 10-160B package.

1.2 Package Description

1.2.1 Packaging

The package consists of a steel and lead cylindrical shipping cask with a pair of cylindrical foam-filled impact limiters installed on each end. The package configuration is shown in Figure 1-1. Cask assembly drawings are included in Section 1.3. The internal cavity dimensions are 68 inches in diameter and 77 inches high. The cylindrical cask body is comprised of a 2 inch thick external steel shell and a 1 1/8 inch internal steel shell. The annular space between the shells is filled with 1 7/8 inch thickness of lead. The base of the cask consists of a 5 1/2 inch thickness of flat circular steel plates (2 1/2 and 3 inches) which are welded together. The cask primary lid also consists of a 5 1/2 inch thickness flat circular steel plates (2 1/2 and 3 inches) which are welded together. The primary lid is fastened to the cask body with twenty-four, 1 3/4 - 8 UNC bolts. There is a secondary lid in the middle of the primary lid. This secondary lid is attached to the primary lid with twelve, 1 3/4 - 8I UNC bolts. A 12 gauge stainless steel liner (0.105 inches) welded to the cask cavity and lid surface protects all accessible areas from contamination. Also, a steel thermal shield is welded to the exterior barrel of the cask and serves as protection during the fire accident.

The impact limiters are 102 inches in the outside diameter and extend about 12 inches beyond the outside wall of the cask. There is a 47 1/2 inch diameter void at each end. Each limiter has an external shell, fabricated from stainless steel which cans the foam and allows it to withstand large plastic deformation without fracturing. The volume inside the shell is filled with a crushable, shock and thermal insulating polyurethane foam. The polyurethane is sprayed into the shell and allowed to expand until the void is completely filled. The foam bonds to the shell, which creates a unitized construction for the impact limiters. The upper and lower impact limiters are held together with eight circumferentially located ratchet binders which secure the limiters to the cask. A general arrangement drawing of the package is included in Appendix 1.3. It shows the package dimensions as well as all materials of construction.

1.2.1.1 Containment Vessel

The containment vessel is defined as the inner steel shell of the cask body together with closure features comprised of the lower surface of the cask lid and the primary and secondary lid bolts.

1.2.1.2 Neutron Absorbers

There are no materials used as neutron absorbers or moderators in the package.

1.2.1.3 Package Weight

Maximum gross weight for the package is 72,000 lbs. including a maximum payload weight of 14,500 lbs.

1.2.1.4 Receptacles

There are no receptacles on this package.

1.2.1.5 Vent, Drain, Test Ports and Pressure Relief Systems

Pressure test ports with manual venting features exist between the twin O-ring seals for both the primary and secondary lids. This facilitate leak testing the package in accordance with ANSI N14.5.

The drain and vent ports are provided with same venting features for venting pressures within the containment cavity, which may be generated during transport, prior to lid removal. Each port is sealed with an elastomer gasket. Specification information for all seals and gaskets is contained in Chapter 3.

1.2.1.6 Lifting Devices

Lifting devices are a structural part of the package. The General Arrangement Drawing in Appendix 1.3 shows two lifting lugs provided for removal and handling of the cask. Three lid lifting lugs are used for removal and handling of the secondary and primary lid. Refer to Section 2.4.3 for a detailed analysis of the structural integrity of the lifting devices.

1.2.1.7 Tie-downs

From the General Arrangement Drawing shown in Appendix 1.3, it can be seen that the tie-down arms are an integral part of the external cask shell. Consequently, tie-down arms are considered a structural part of the package. Refer to Section 2.4.4 for a detailed analysis of the structural integrity of the tie-down arms.

1.2.1.8 Heat Dissipation

There are no special devices used for the transfer or dissipation of heat.

1.2.1.9 Coolants

There are no coolants involved.

1.2.1.10 Protrusions

There are no outer or inner protrusions except for the tie-down arms described above.

1.2.1.11 Shielding

Cask walls provide a shield thickness of 1 7/8 inches of lead and 3 inches of steel. Cask ends provide a minimum of 5 inches of steel. The contents will be limited such that the radiological shielding provided (nominally 3¼ inches lead equivalent based on Co-60) will assure compliance with DOT and IAEA regulatory requirements.

An optional, removable steel insert may be installed inside the cask to provide additional shoring and shielding for the cask contents. The insert fits closely to the inside walls of the cask, but is not attached to the cask nor the contents. It may vary in thickness between ½ inch and

1½ inch on the sides, and is open on the top and bottom. It is approximately ½ inch shorter than the cask cavity.

1.2.2 Operational Features

Refer to the General Arrangement Drawing of the package in Appendix 1.3. There are no complex operational requirements associated with this package.

1.2.3 Contents of Packaging

1.2.3.1 Cask Contents

The contents of the cask will consist of:

- 1) Greater than Type A quantities (up to a maximum of 3000 A₂) of radioactive material in the form of solids or dewatered materials in secondary containers.
- 2) Greater than Type A quantities (up to a maximum of 3000 A₂) of radioactive material in the form of activated reactor components or segments of components of waste from a nuclear power plant.
- 3) That quantity of any radioactive material which does not exceed 3000 A₂ and which does not generate spontaneously more than 200 thermal watts of radioactive decay heat.
- 4) The weight of the contents in the cask cavity will be limited to 14,500 lbs. If an insert is installed in the cavity, the maximum payload is reduced by the weight of the insert.
- 5) Transuranic Waste (TRU) with not more than 325 fissile gram equivalents (FGE) of fissile radioactive material up to a maximum of 3000 A₂.
- 6) The activity of gamma emitting radionuclides shall not exceed the limitation discussed in Chapter 5 and the limit determined per the procedure in Chapter 7 Attachment 1.

1.2.3.2 Waste Forms

The type and form of waste material will include:

- 1) By-product, source, or special nuclear material consisting of process solids or resins, either dewatered, solid, or solidified in secondary containers. (See Section 4.2.1 for specific limitations). Contents containing greater than 20 Ci of plutonium must be in solid form.
- 2) Neutron activated metals or metal oxides in solid form in secondary containers.
- 3) Miscellaneous radioactive solid waste materials, including special form materials and powdered solids in secondary containers. Powdered solids shipments shall be performed only when the most recent periodic leak test meets the requirements of Chapter 4, Section 4.9. Powdered solid radioactive material shall not include radioactive forms of combustible metal hydrides, combustible elemental metals, i.e., magnesium, titanium, sodium, potassium, lithium, zirconium, hafnium, calcium, zinc, plutonium, uranium, and thorium, or combustible non-metals, i.e., phosphorus.
- 4) TRU wastes are limited as described in Appendix 4.10.2, Transuranic (TRU) Waste Compliance Methodology for Hydrogen Gas Generation. TRU exceeding the fissile limits of 10 CFR 71.15 must not be machine compacted and must have no more than 1% by weight of special reflectors and no more than 25% by volume of hydrogenous material.
- 5) Explosives, corrosives, non-radioactive pyrophorics, and compressed gases are prohibited. Pyrophoric radionuclides may be present only in residual amounts less than 1 weight percent. The total amount of potentially volatile organic compounds present in the headspace of a secondary container is restricted to 500 parts per million.

10-160B GENERAL ARRANGEMENT

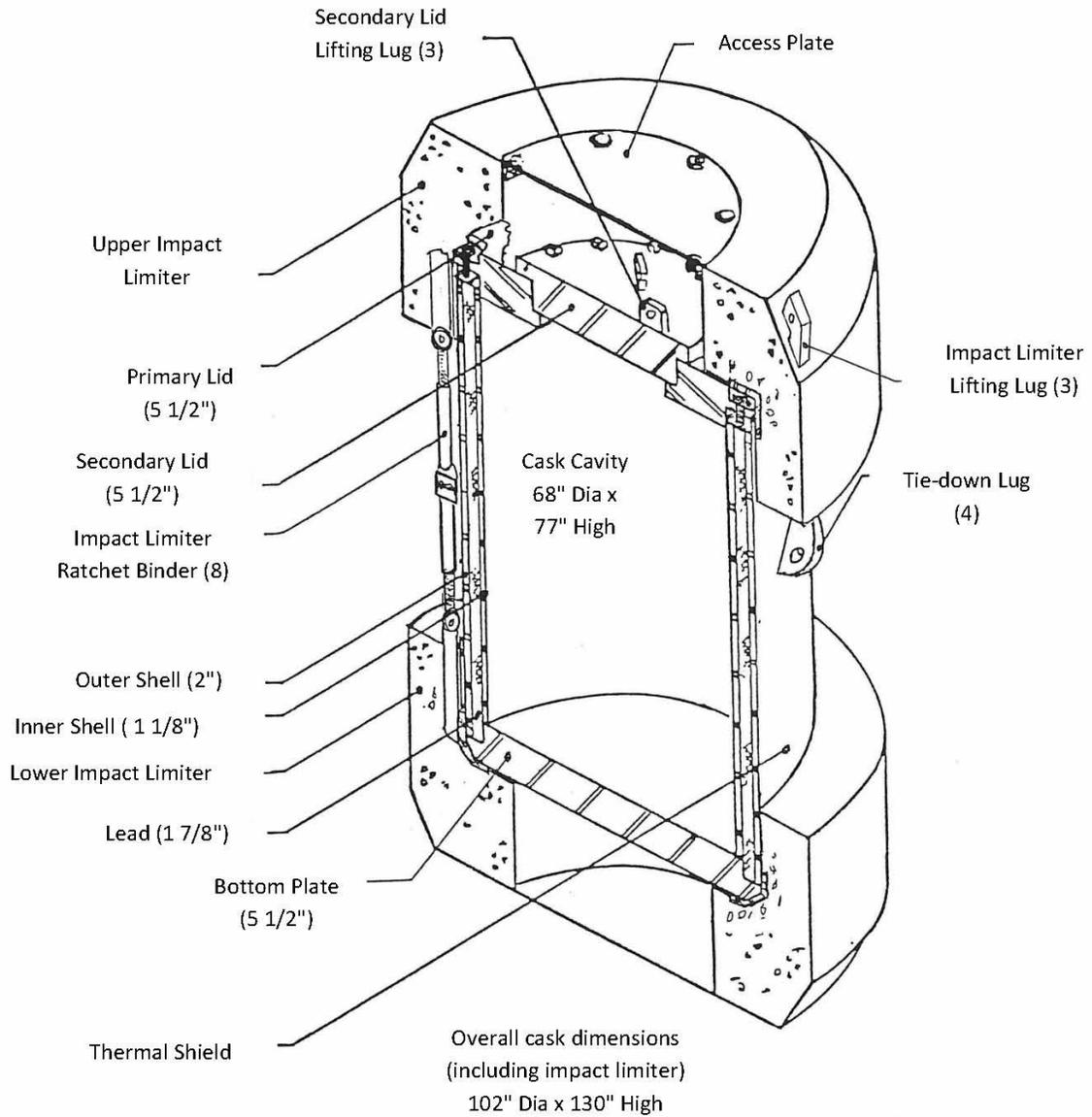


Figure 1-1

1.3 Appendix

10-160B Shipping Cask Drawing

(withheld as security-related sensitive information)

5. SHIELDING EVALUATION

5.1 Discussion and Results

5.1.1 Operating Design

The Model 10-160B packaging consists of a lead and steel containment vessel which provides the necessary shielding for the various radioactive materials to be shipped within the package. (Refer to Section 1.2.3 for packaging contents.) Tests and analysis performed under chapters 2.0 and 3.0 have demonstrated the ability of the containment vessel to maintain its shielding integrity under normal conditions of transport. Prior to each shipment, radiation readings will be taken based on individual loadings to assure compliance with applicable regulations as determined in 10CFR71.47 (see Section 7.1, step 13c).

The 10-160B will be operated under “exclusive use” such that the contents in the cask will not create a dose rate exceeding 200 mrem/hr on the cask surface, or 10 mrem/hr at two meters from the outer lateral surfaces of the vehicle. The package shielding must be sufficient to satisfy the dose rate limit of 10CFR71.51(a) (2) which states that any shielding loss resulting from the hypothetical accident will not increase the external dose rate to more than 1000 mrem/hr at one meter from the external surface of the cask.

5.1.2 Shielding Design Features

The cask side wall consists of an outer 2-inch thick steel shell surrounding 1 7/8 inches of lead and an inner containment shell wall of 1 1/8-inch thick steel.

The primary cask lid consists of two steel layers with a total thickness of 5½ inches. The lid closure is made in a stepped configuration to eliminate radiation streaming at the lid/cask body interface.

A secondary lid is located at the center of the main lid, covering a 31-inch opening. The secondary lid is constructed of steel plates with a total thickness of 5½ inches with multiple steps machined in its periphery. These steps match those in the primary lid, eliminating radiation streaming pathways.

The cask bottom has an identical shielding effectiveness to the cask lids. It also consists of two layers of steel with a total thickness of 5 ½ inches.

Foam filled impact limiters cover the top and bottom of the vertically oriented cask. The impact limiters are conservatively ignored for the purpose of the shielding evaluation.

5.1.3 Maximum Dose Rate Calculations

Table 5.1 gives both Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC) dose rates resulting from the maximum point sources (neutron and gamma) which may be in contact with either the side wall or the top (or bottom) of the cask. Maximum allowable dose rates given in 10CFR71 are shown in Table 5.1 for comparison. The following assumptions were used to develop the values shown in the table.

5.1.3.1 Normal Conditions

- ° The source is conservatively modeled as a point source centered in the cask cavity.

5.1.3.2 Accident Conditions

- The source is modeled as a point source on the inner liner adjacent to the location of the lead slump and in contact with the lid.
- Lead slump (see Section 2.7.1.1) considers the effect of loss of lead shielding from the slumped region in the side wall.

Table 5.1
Summary of Maximum Dose Rates (mrem/hr)

<u>Condition</u>	<u>Package Surface</u>		<u>1 m from Surface</u>		<u>2m from</u> <u>8' trailer</u>
	<u>Side</u>	<u>Top/Bottom</u>	<u>Side</u>	<u>Top/Bottom</u>	<u>Side</u>
NCT					
Neutron Source	114	86.3	N.A.	N.A.	9.44
Gamma Source	126	179	N.A.	N.A.	9.96
Allowable	200	200	N.A.	N.A.	10.0
HAC					
Neutron Source	N.A.	N.A.	82.7	39.5	N.A.
Gamma Source	N.A.	N.A.	144	99.9	N.A.
Allowable	N.A.	N.A.	1000.0	1000.0	N.A.

5.2 Source Specification

5.2.1 Methodology

A unit point source is placed at the cask center. A neutron source and a gamma source are evaluated independently. The dose rate from the unit source is determined at the cask outer surface and at 2m from the 8' wide trailer. The ratio between the dose limit and the calculated value is determined. An equivalent source is set equal to the activity of the unit source times the smallest ratio of the surface limit to the calculated dose rate from the unit source. This equivalent source, which is the largest activity source that meets the cask NCT dose limits, is then used to evaluate the effects of the hypothetical accident. If the HAC limits are met for the maximum activity source, the cask complies with the requirements of 10 CFR 71. A mixed gamma and neutron source will also comply as the sum of the gamma and neutron dose rates must be less than the NCT dose limit and thus, as shown for the independently evaluated sources, the HAC limits will be met.

5.2.2 Gamma Source

SCALE models of the 10-160B cask are evaluated with a Co-60 source. The resulting equivalent source, approximately 13.4 Ci, gives a gamma dose rate of approximately 9.96 mrem/hr at 2m from the 8' wide trailer.

5.2.3 Neutron Source

SCALE models of the 10-160B cask are evaluated with a Pu-Be neutron source. A ^{239}Pu -Be source produces neutrons at a rate of approximately $1.4\text{E}+06$ n/sec per Ci (Ref. 5.6.3). A 325 FGE (approximately 20 Ci) ^{239}Pu -Be source will produce approximately $2.8\text{E}+07$ n/sec. The equivalent

neutron source, which produces a dose rate of 9.4 mrem/hr at 2m from the 8' wide trailer, has an emission rate of $1.1 \text{ E}+08$ n/sec. Thus, the equivalent source used for the dose rate calculation is larger than the fissile gram limit imposed by the criticality evaluation of Chapter 6 and gives a conservative dose rate result. The neutron energy spectrum for a Pu-Be source is shown below.

Neutron Energy Spectrum for a Pu-Be Source (Ref. 5.6.3)

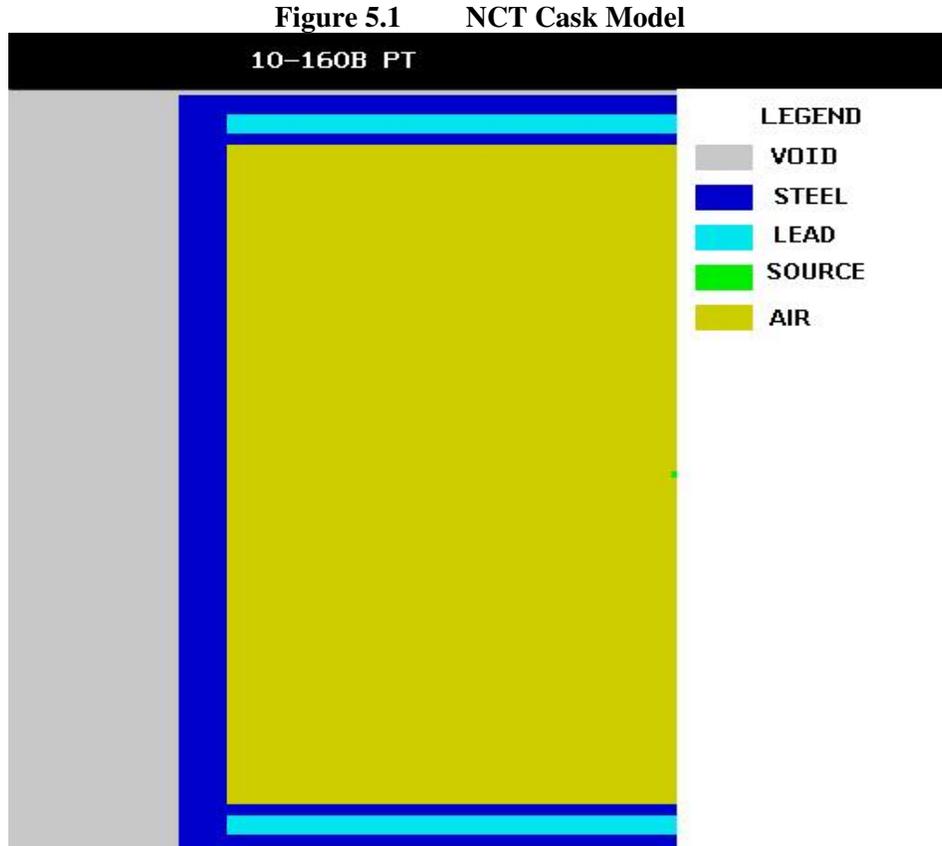
Energy Interval, E_i (MeV)	Fraction of neutrons in E_i
0-0.5	0.038
0.5-1	0.049
1-1.5	0.045
1.5-2	0.042
2-2.5	0.046
2.5-3	0.062
3-6.5	0.459
6.5-10.5	0.259
Total	1.000

5.3 Model Specification

5.3.1 Description of Radial and Axial Shielding Configuration

Normal Conditions of Transport (NCT)

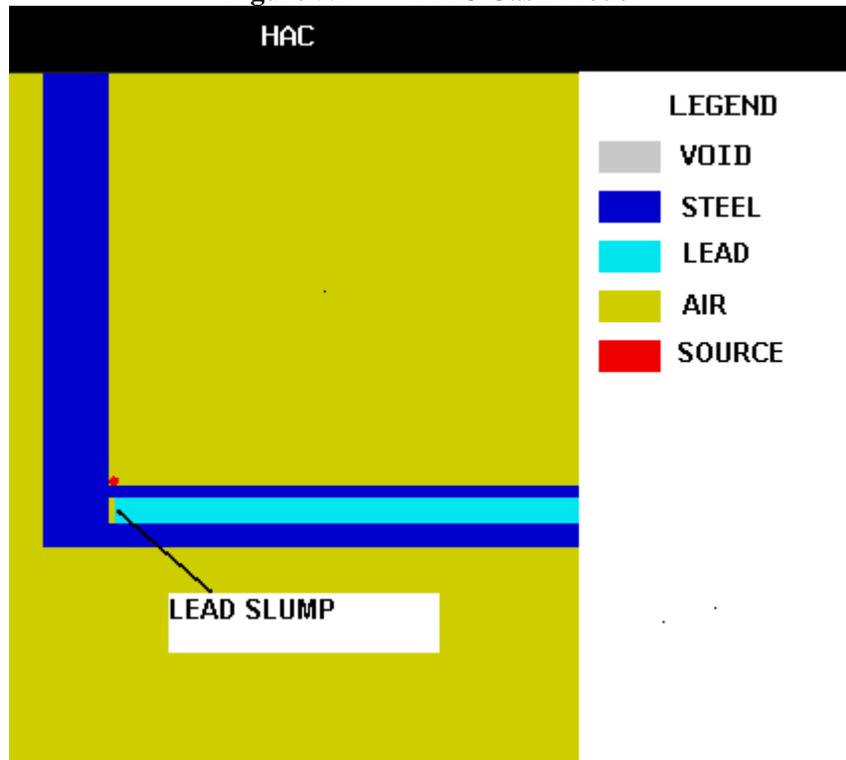
The walls of the 10-160B cask, 1.125" inner and 2" outer steel walls with a 1.875" lead layer between, are modeled as cylindrical shells around the cavity cylinder. The base and lid of the cask is a 5.5" steel plate. Impact limiters are conservatively ignored. This geometry is shown in Figure 5.1. In terms of shielding, the cask lid and bottom are the same so only one end is modeled. The cask is transported upright, i.e., with the axis of the cylinder vertical. Doses are evaluated at contact with the cask sidewall, with the cask lid, and at 2m from the 8' wide trailer.



Hypothetical Accident Conditions (HAC)

As discussed in Section 2, the hypothetical accident conditions do not affect the geometry of the steel shells or the base or lid (see Section 5.3.1, above). The HAC model is shown in Figure 5.3. The lead slump resulting from the 30' drop (< 0.02") discussed in Section 2.7.1.1, is included in the HAC model as a void 0.05 cm high at the top of the lead shell. Doses are determined at 1 m from the sidewall and the lid.

Figure 5.2 HAC Cask Model



5.3.2 Material Properties

The properties of the cask materials are shown in Table 5.2

Table 5.2 Material Properties

Material	Composition	Density (g/cm ³)
Source	beryllium / cobalt	1.85 / 8.9
Cask inner wall	Steel	7.82
Cask outer wall	Steel	7.82
Cask shield layer	Lead	11.34

5.4. Shielding Evaluation

5.4.1. Methods

The gamma and neutron dose rates were calculated using SCALE, Module SAS4 (Ref.3), using the geometry described in Section 5.3. The dose locations are surface or point detectors at the cask surface or at 2m from the trailer for NCT and at 1m from the cask surface for HAC.

5.4.2. Input and Output Data

The SCALE input and output files are provided in 5.8. The input file lists the inputs that define the source dimensions, shield dimensions, materials and density, and source spectrum.

5.4.3. Flux-to-Dose-Rate Conversion

The flux to exposure rate conversion factors are listed in Table 5.3 and Table 5.4 (Ref. 5.6.2). These are the default conversion factors in SCALE.

Table 5.3 Gamma-Ray-Flux-To-Dose-Rate Conversion Factors

Photon Energy-E (MeV)	DF _g (E) Rem/hr)/(photons/cm ² -s)
0.01	3.96-06
0.03	5.82-07
0.05	2.90-07
0.07	2.58-07
0.1	2.83-07
0.15	3.79-07
0.2	5.01-07
0.25	6.31-07
0.3	7.59-07
0.35	8.78-07
0.4	9.85-07
0.45	1.08-06
0.5	1.17-06
0.55	1.27-06
0.6	1.36-06
0.65	1.44-06
0.7	1.52-06
0.8	1.68-06
1.0	1.98-06
1.4	2.51-06
1.8	2.99-06
2.2	3.42-06
2.6	3.82-06
2.8	4.01-06
3.25	4.41-06
3.75	4.83-06
4.25	5.23-06
4.75	5.60-06
5.0	5.80-06
5.25	6.01-06
5.75	6.37-06
6.25	6.74-06
6.75	7.11-06
7.5	7.66-06
9.0	8.77-06
11.0	1.03-05
13.0	1.18-05
15.0	1.33-05

Table 5.4 Neutron Flux-To-Dose-Rate Conversion Factors And Mean Quality Factors (\bar{QF})

Neutron Energy-E (MeV)	\bar{QF}^*	$DF_n(E)$ (rem/hr) (n/cm ² -s)
2.5-08	2	3.67-06
1.0-07	2	3.67-06
1.0-06	2	4.46-06
10.-05	2	4.54-06
1.0-04	2	4.18-06
1.0-03	2	3.76-06
1.0-02	2.5	3.56-06
1.0-01	7.5	2.17-05
5.0-01	11	9.26-05
1.0	11	1.32-04
2.5	9	1.25-04
5.0	8	1.56-04
7.0	7	1.47-04
10.0	6.5	1.47-04
14.0	75	2.08-04
20.0	8	2.27-04

*Maximum value of QF in a 30-cm phantom.

#Read as 2.5 x 10⁻⁸

5.4.4. External Radiation Levels

The SCALE model used to determine external radiation levels uses point or surface detectors to calculate the dose rates at various distances from the cask surface either radially or axially. The point detectors are aligned with the point sources, thus normally giving the maximum dose rates. The highest dose rate from the point or surface detectors is reported. Table 5.5 contains the maximum neutron and gamma dose rates found for each of the four cases, i.e., NCT radial, NCT axial, HAC radial, and HAC axial for each of the sources, neutron and gamma.

Table 5.5 Maximum External Radiation Levels

Normal Conditions of Transport	Package Surface (mrem/h)			2 Meters from Trailer (mrem/h)
	Top	Side	Bottom	
Radiation				Side
Neutron Source	86.3	114	86.3	9.44
Gamma Source	179	126	179	9.96
10 CFR 71.47 Limit ¹	200	200	200	10

1. shipped as “exclusive use”

Hypothetical Accident Conditions	1 Meter from Package Surface mSv/h (mrem/h)
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Radiation	Top	Side	Bottom
Neutron Source	39.5	82.7	39.5
Gamma Source	99.9	143.6	99.9
10 CFR 71.51(a)(2) Limit	1000	1000	1000

5.5 Gamma Activity Limits

Using the cask model described in 5.3, additional calculations were performed to determine the maximum activity that can be contained in the 10-160B and meet the dose rate limits of 10 CFR 71.47. Since the results in Table 5.5 show that contents meeting NCT limits will meet HAC limits, maximum activity was determined only for NCT.

Two contents configurations were evaluated:

Point source – activity in a right circular cylinder; OD = 1 cm and height = 1 cm, centered in the cask cavity. The required secondary container is ignored for the shielding calculation.

Distributed source – activity homogeneously distributed in a right circular cylinder centered in the cask cavity with $H=2r$ (approximately the geometry of the cask cavity) and $V\rho=14,500$ lbs (maximum allowed weight of contents); with a maximum r and H of 86cm and 194 cm, respectively (the cask cavity size is $r=86.4$ cm and $H=195.6$ cm). The required secondary container is ignored for the shielding calculation. Density (ρ) ranged from 1 to 8 g/cc. The material of the source was selected as Zr ($z=40$); multiple calculations with various materials showed a material selection of Zr was conservative.

Dose rates were calculated at 2m from the edge of the 8' wide cask trailer with a single energy gamma for each calculation varying from 350 keV to 1.83 MeV (the mid-points of the SCALE gamma energy groups) and an activity of 1×10^{12} gammas/sec. Five point detectors were placed at 322cm from the centerline ($x=322$) at the midpoint ($z=0$) and at 5 cm intervals in the $+z$ direction ($z=5,10,15,&20$). The maximum point detector value was used. The flux to exposure rate conversion factors are the same as used previously and are listed in Table 5.4 (Ref. 5.6.2).

As stated in the SAS4 validation report (NUREG/CR-6484, Reference 5.7.4) "gamma-ray dose-rate calculations with major contributions due to active fuel show over a factor of 2 overprediction of the measured quantities". An overprediction factor of 2 is included in the calculation of maximum activity. The maximum allowed gamma activity in gammas/sec for each gamma energy was determined by multiplying the modeled source activity (1×10^{12} gammas/sec) by the ratio of the dose rate limit (10 mrem/hr) to the calculated dose rate and then multiplying by the overprediction correction factor of 2. The distributed source results are for contents with a density of 1 g/cc (unit density). Results of the maximum activity calculations for the point source are given in Table 5.6

Table 5.6 Point Source Activity Limits

Gamma Energy (MeV)	SAS4 result at 2m (Rem/hr)	Activity equivalent to 10 mrem/hr (γ/s)
0.35	3.32E-07	6.02E+16
0.5	7.94E-06	2.52E+15
0.7	2.44E-04	8.20E+13
0.9	1.62E-03	1.23E+13
1.17	6.71E-03	2.98E+12
1.5	1.83E-02	1.09E+12

1.83	3.35E-02	5.97E+11
2.25	5.39E-02	3.71E+11

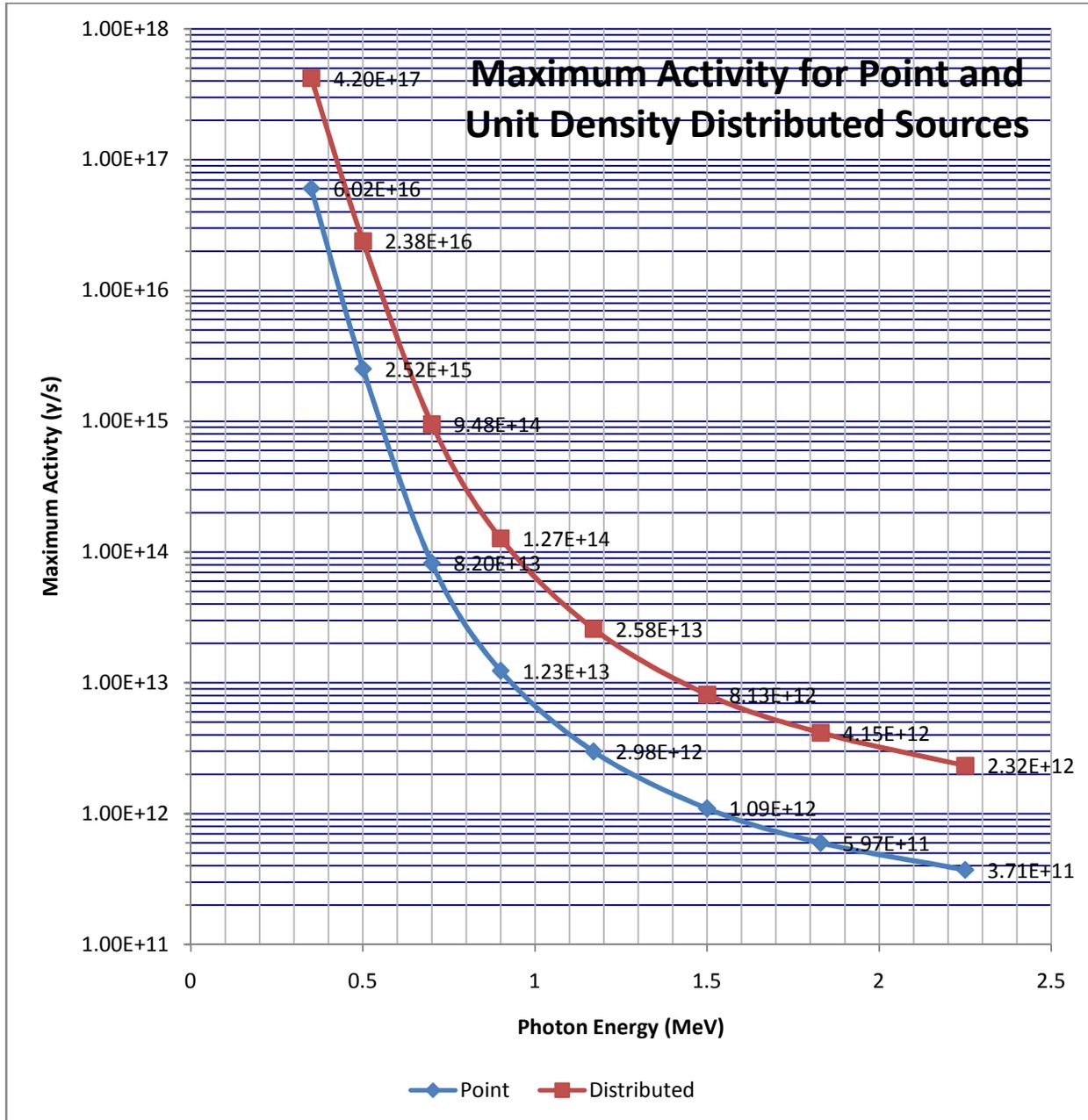
Results of the maximum activity calculations for the distributed unit density source are given in Table 5.7

Table 5.7 Distributed Unit Density Source Activity Limits

Gamma Energy (MeV)	SAS4 result at 2m (Rem/hr)	Activity equivalent to 10 mrem/hr (γ/s)
0.35	4.76E-08	4.20E+17
0.5	8.41E-07	2.38E+16
0.7	2.11E-05	9.48E+14
0.9	1.57E-04	1.27E+14
1.17	7.74E-04	2.58E+13
1.5	2.46E-03	8.13E+12
1.83	4.82E-03	4.15E+12
2.25	8.62E-03	2.32E+12

The cask activity limits for a point source and a unit density distributed source are plotted in Figure 5.3.

Figure 5.3 Maximum Activity for Point and Unit Density Distributed Sources



Due to self absorption and geometry (radius and height change with density), the dose rates from distributed sources will change with density, decreasing as density increases, resulting in a maximum activity that increases with density. A correction factor for the actual source density is applied to the distributed unit source results to give the source specific gamma activity limit. Maximum activity results for the same gamma energy (0.9 MeV) with source density varying from 1 to 8 g/cc (with a corresponding change in source geometry) were used to determine the density correction factor (DCF). The DCF is the ratio of the maximum activity at a density greater than 1 to the maximum activity for the unit activity source. The DCFs were plotted versus density and a curve was fitted to the results. The equation of the curve is used to determine the DCF for the any density of contents. Results of the density correction factor (DCF) calculations are given in Table 5.8.

Table 5.8 Density Correction Factor

Source Density (g/cc)	SAS4 result at 2m (Rem/hr)	Activity equivalent to 10 mrem/hr (γ/s)	Density Correction Factor
1	1.57E-04	1.27E+14	1.00E+00
2	9.82E-05	2.04E+14	1.60E+00
4	7.84E-05	2.55E+14	2.00E+00
6	6.38E-05	3.14E+14	2.46E+00
8	5.75E-05	3.48E+14	2.73E+00

The equation for the fitted curve is:

$$DCF = 0.8109\ln(\rho)+0.9929$$

The maximum activity plot and the DCF, if applicable, are used to determine the maximum activity for any contents. A procedure for determining the maximum activity is provided in Chapter 7.

5.6 Conclusion

The cask shielding must be able to limit the dose rate to 1000 mrem/hr at 1 meter from any surface of the cask after the cask goes through the hypothetical accident. This section demonstrates compliance with this requirement. Structural analysis (Section 2.0) demonstrates that the cask wall will not fail during the hypothetical accident. However, lead slump may occur during a drop giving an isolated region in the sidewall without lead. Lead slump cannot occur in the lid or bottom of the cask since lead is not present in these parts of the cask. The dose rate at 1 meter from the cask in the slumped region (assuming a localized lead void) was determined to be less than the 1000 mrem/hr limit for a source at the NCT dose rate limit. With application of the gamma activity limits from Section 5.5, the contents will meet the dose rate limits.

5.7 References

- 5.7.1 SCALE: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluations, NUREG/CR-0200, Rev.6 (ORNL/NUREG/CSD-2/R6), Vols. I, II, III, May 2000
- 5.7.2 ANSI/ANS 6.1.1-1977, "Neutron and Gamma-Ray Flux-to-Dose-Rate Factors."
- 5.7.3 Cember, H, *Introduction to Health Physics*, Pergamon Press, New York, 1987
- 5.7.4 Guide to Verification and Validation of the SCALE-4 Radiation Shielding Software, NUREG/CR-6484, November 1996

5.8 SCALE Input Files for 10-160B Consolidated SAR Rev. 0

5.8.1 10-160b-pt-axial-HAC.inp

```
'Input generated by Espn 89 Compiled on 06-07-2002
=sas4      parm=size=500000
10-160B pt axial
27n-18couple infhommedium
  carbonsteel 1 1 293 end
  lead 2 1 293 end
  beryllium 3 1 293 end
  arbm-air 0.0002 2 0 0 0 7014 82 8016 18 4 1 293 end
  cobalt 5 1 293 end
end comp
idr=0 ity=2 izm=5 isn=8 irf=9504 ifs=1 mhw=5 frd=86.36 szf=1 end
86.36 89.218 93.98 99.06 199.06 end
4 1 2 1 4 end
xend
ran=000000091807 tim=120 nst=1000 nmt=4000 nit=1000 nco=4 ist=0 ipr=0
iso=0 nod=16 sfa=1e+12 igo=4 inb=0 ine=0 mfu=5 isp=0 ipf=0 isd=4
nda=1000 end
soe 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 22 78 0 0 0 0 0 0 0 0 0 0 end
det 199.06 0 76.79 199.06 0 81.79 199.06 0 86.79 199.06 0 91.79 199.06
0 96.79 199.06 0 101.79 199.06 0 106.79 199.06 0 111.79 199.06 0
116.79 199.06 0 121.79 199.06 0 126.79 199.06 0 131.79 199.06 0
136.79 199.06 0 141.79 199.06 0 146.79 199.06 0 151.79 end
sdl 99.06 199.06 299.06 399.06 end
sdr 70 120 70 140 70 90 70 90 end
sds 10 0 14 36 0 0 0 0 end
sxy 5 84.36 86.36 -1 1 95.79 97.79 86.36 97.79 99.06 111.76 end
gend
10-160b pt hac
0 0 0 0
sph 85.36 0 96.79 1
rcc 0 0 -97.79 0 0 195.58 86.36
rcc 0 0 -98.79 0 0 197.58 89.218
rcc 0 0 -97.79 0 0 195.53 93.98
rcc 0 0 -111.76 0 0 223.52 99.06
sph 0 0 0 300
sph 0 0 0 500
rcc 0 0 -97.79 0 0 195.58 93.98
rcc 0 0 -211.76 0 0 423.52 199.06
end
src +1
cav +2 -1
inn +3 -2
shd +4 -3
our +5 -8
inv +6 -9
exv +7 -6
slp +8 -3 -4
det +9 -5
end
1 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0
5 4 1 2 1 1000 0 4 4
0
```

end

5.8.2 10-160b-pt-axial-igo0.inp

```
'Input generated by Espn 89 Compiled on 06-07-2002
=sas4      parm=size=500000
10-160B pt
27n-18couple infhommedium
  carbonsteel 1 1 293 end
  lead 2 1 293 end
  beryllium 3 1 293 end
  arbm-air 0.0002 2 0 0 0 7014 82 8016 18 4 1 293 end
  cobalt 5 1 293 end
end comp
idr=1 ity=2 izm=3 isn=8 irf=9504 ifs=1 mhw=4 frd=1 szf=1  end
1 97.79 111.76  end
5 4 1  end
xend
ran=000000111507 tim=120 nst=1000 nmt=4000 nit=1500 nco=4 ist=0 ipr=0
iso=0 nod=0 sfa=1e+12 igo=0 inb=0 ine=0 mfu=5 isp=0 ipf=0 isd=4
nda=1000  end
soe 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 22 78 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
sds 10 0 18 0 10 0 10 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
gend
point source
  fue 1 97.78 end
fend
inn 1 89.218 98.79 end
rs1 2 93.98 97.79 end
our 1 99.06 111.76 end
as1 1 89.218 99.79 end
hol 1 end
cav 4 86.36 97.79 end
cend
end
```

5.8.3 10-160b-pt-HAC.inp

```
'Input generated by Espn 89 Compiled on 06-07-2002
=sas4      parm=size=500000
10-160B pt axial
27n-18couple infhommedium
  carbonsteel 1 1 293 end
  lead 2 1 293 end
  beryllium 3 1 293 end
  arbm-air 0.0002 2 0 0 0 7014 82 8016 18 4 1 293 end
  cobalt 5 1 293 end
end comp
idr=0 ity=2 izm=5 isn=8 irf=9504 ifs=1 mhw=5 frd=86.36 szf=1  end
86.36 89.218 93.98 99.06 199.06  end
4 1 2 1 4  end
xend
ran=000000091807 tim=120 nst=1000 nmt=4000 nit=1000 nco=4 ist=0 ipr=0
iso=0 nod=16 sfa=1e+12 igo=4 inb=0 ine=0 mfu=5 isp=0 ipf=0 isd=4
nda=1000  end
soe 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 22 78 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

```

det 199.06 0 76.79 199.06 0 81.79 199.06 0 86.79 199.06 0 91.79 199.06
0 96.79 199.06 0 101.79 199.06 0 106.79 199.06 0 111.79 199.06 0
116.79 199.06 0 121.79 199.06 0 126.79 199.06 0 131.79 199.06 0
136.79 199.06 0 141.79 199.06 0 146.79 199.06 0 151.79 end
sdl 99.06 199.06 299.06 399.06 end
sdr 70 120 70 140 70 90 70 90 end
sds 10 0 14 36 0 0 0 0 end
sxy 5 84.36 86.36 -1 1 95.79 97.79 86.36 97.79 99.06 111.76 end
gend
10-160b pt hac
0 0 0 0
sph 85.36 0 96.79 1
rcc 0 0 -97.79 0 0 195.58 86.36
rcc 0 0 -98.79 0 0 197.58 89.218
rcc 0 0 -97.79 0 0 195.53 93.98
rcc 0 0 -111.76 0 0 223.52 99.06
sph 0 0 0 300
sph 0 0 0 500
rcc 0 0 -97.79 0 0 195.58 93.98
rcc 0 0 -211.76 0 0 423.52 199.06
end
src +1
cav +2 -1
inn +3 -2
shd +4 -3
our +5 -8
inv +6 -9
exv +7 -6
slp +8 -3 -4
det +9 -5
end
1 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0
5 4 1 2 1 1000 0 4 4
0

end

```

5.8.4 10-160b-pt-igo0.inp

```

'Input generated by Espn 89 Compiled on 06-07-2002
=sas4 parm=size=500000
10-160B pt
27n-18couple infhommedium
carbonsteel 1 1 293 end
lead 2 1 293 end
beryllium 3 1 293 end
arbm-air 0.0002 2 0 0 0 7014 82 8016 18 4 1 293 end
cobalt 5 1 293 end
end comp
idr=0 ity=2 izm=5 isn=8 irf=9504 ifs=1 mhw=4 frd=1 szf=1 end
1 86.36 89.218 93.98 99.06 end
5 4 1 2 1 end
xend
ran=000000111207 tim=120 nst=1000 nmt=4000 nit=10000 nco=4 ist=0 ipr=0
iso=0 nod=0 sfa=1e+12 igo=0 inb=0 ine=0 mfu=5 isp=0 ipf=0 isd=4
nda=1000 end
soe 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

```

```

0 0 22 78 0 0 0 0 0 0 0 0 end
sdl 99.06 199.06 322 344 end
sdr 0 20 0 100 0 100 0 10 end
sds 5 1 10 1 10 1 1 1 end
gend
point source
  fue 1 97.78 end
fend
  inn 1 89.218 98.79 end
  rs1 2 93.98 97.79 end
  our 1 99.06 111.76 end
  as1 1 89.218 99.79 end
  hol 1 end
  cav 4 86.36 97.79 end
cend
end

```

5.8.5 10-160b-pt-n-axial-HAC.inp

```

'Input generated by Espn 89 Compiled on 06-07-2002
=sas4      parm=size=500000
10-160B pt neutron
27n-18couple infhommedium
  carbonsteel 1 1 293 end
  lead 2 1 293 end
  beryllium 3 1 293 end
  arbm-air 0.0002 2 0 0 0 7014 82 8016 18 4 1 293 end
  cobalt 5 1 293 end
end comp
  idr=1 ity=1 izm=4 isn=8 irf=9029 ifs=1 mhw=3 frd=86.36 szf=1 end
  97.79 98.79 111.76 211.76 end
  4 1 1 4 end
xend
  ran=000000111607 tim=120 nst=1000 nmt=4000 nit=500 nco=4 ist=0 ipr=0
  iso=0 nod=9 sfa=1.1e+08 igo=4 inb=0 ine=0 mfu=3 isp=0 ipf=0 isd=4
  nda=1000 end
  soe 0.259 0.459 0.108 0.042 0.045 0.049 0.038 0 0 0 0 0 0 0 0 0 0 0
  0 0 0 0 0 0 0 0 end
  det 45.36 0 211.76 55.36 0 211.76 65.36 0 211.76 75.36 0 211.76 85.36
  0 211.76 95.36 0 211.76 105.36 0 211.76 115.36 0 211.76 125.36 0
  211.76 end
  sdl 111.76 211.76 311.76 411.76 end
  sdr 80 90 0 150 80 90 80 90 end
  sds 0 0 15 36 0 0 0 0 end
  sxy 3 84.36 86.36 -1 1 95.79 97.79 86.36 97.79 99.06 111.76 end
gend
10-160b pt hac
  0 0 0 0
  sph 85.36 0 96.79 1
  rcc 0 0 -97.79 0 0 195.58 86.36
  rcc 0 0 -98.79 0 0 197.58 89.218
  rcc 0 0 -97.79 0 0 195.53 93.98
  rcc 0 0 -111.76 0 0 223.52 99.06
  sph 0 0 0 400
  sph 0 0 0 500
  rcc 0 0 -97.79 0 0 195.58 93.98
  rcc 0 0 -211.76 0 0 423.52 199.06
  end

```



```

arbm-air 0.0002 2 0 0 0 7014 82 8016 18 4 1 293 end
cobalt 5 1 293 end
end comp
idr=0 ity=1 izm=5 isn=8 irf=9029 ifs=1 mhw=3 frd=86.36 szf=1 end
86.36 89.218 93.98 99.06 199.06 end
4 1 2 1 4 end
xend
ran=000000091807 tim=120 nst=1000 nmt=4000 nit=1000 nco=4 ist=0 ipr=0
iso=0 nod=10 sfa=1.1e+08 igo=4 inb=0 ine=0 mfu=3 isp=0 ipf=0 isd=4
nda=1000 end
soe 0.259 0.459 0.108 0.042 0.045 0.049 0.038 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 end
det 199.06 0 57.79 199.06 0 67.79 199.06 0 77.79 199.06 0 87.79 199.06
0 97.79 199.06 0 107.79 199.06 0 117.79 199.06 0 127.79 199.06 0
137.79 199.06 0 147.79 end
sdl 99.06 199.06 322 344 end
sdr 70 120 0 140 80 100 80 100 end
sds 10 0 14 36 10 0 10 0 end
sxy 3 84.36 86.36 -1 1 95.79 97.79 86.36 97.79 99.06 111.76 end
gend
10-160b pt hac
0 0 0 0
sph 85.36 0 96.79 1
rcc 0 0 -97.79 0 0 195.58 86.36
rcc 0 0 -98.79 0 0 197.58 89.218
rcc 0 0 -97.79 0 0 195.53 93.98
rcc 0 0 -111.76 0 0 223.52 99.06
sph 0 0 0 400
sph 0 0 0 500
rcc 0 0 -97.79 0 0 195.58 93.98
rcc 0 0 -211.76 0 0 423.52 199.06
end
src +1
cav +2 -1
inn +3 -2
shd +4 -3
our +5 -8
inv +6 -9
exv +7 -6
slp +8 -3 -4
det +9 -5
end
1 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0
3 4 1 2 1 1000 0 4 4
0
end

```

5.8.8 10-160b-pt-n-igo0.inp

```

'Input generated by Espn 89 Compiled on 06-07-2002
=sas4 parm=size=500000
10-160B pt
27n-18couple infhommedium
carbonsteel 1 1 293 end
lead 2 1 293 end
beryllium 3 1 293 end

```


7.0 OPERATING PROCEDURE

This chapter describes the general procedure for loading and unloading of the 10-160B cask.

An optional steel insert may be used to shield the contents of the cask. The appropriate thickness of insert that should be used is determined from calculations and experience with previous, similar shipments. However, the insert must be thick enough so that dose rates on the exterior of the cask do not exceed the limits of 10 CFR 71.47, but must be no thicker than the maximum permissible size described in section 1.0.

The maximum permissible activity is 3000 A₂ or the maximum activity in gammas/sec, determined per Attachment 1, whichever is less.

The maximum permissible payload of the cask is 14,500 pounds, including contents, secondary containers, shoring, and optional steel insert (if used).

For contents that could radiolytically generate combustible gases, the criteria of Section 4.8 must be addressed. For DOE TRU waste, compliance with the 5% hydrogen concentration limit shall be demonstrated by the methods discussed in Appendix 4.10.2. For other contents, which exceed the 5% concentration limit, the procedures in Section 7.4 can be used to satisfy the criteria of Section 4.8.

Powdered solids shipments require the cask to be leaktight. The most recent periodic leak test must meet the requirements of Chapter 4, Section 4.9, Periodic Verification Leak Rate Determination for Leaktight Status.

7.1 Procedure for Loading the Package

7.1.1 Determine if cask must be removed from trailer for loading purposes. To remove cask from trailer:

7.1.1.1 Loosen and disconnect ratchet binders from upper impact limiter.

7.1.1.2 Using suitable lifting equipment, remove upper impact limiter. Care should be taken to prevent damage to impact limiter during handling and storage.

7.1.1.3 Disconnect cask to trailer tie-down equipment.

7.1.1.4 Attach cask lifting ears and torque bolts to 200 ft-lbs ± 20 ft-lbs lubricated.

7.1.1.5 Using suitable lifting equipment, remove cask from trailer and lower impact limiter and place cask in level loading position.

NOTE **THE CABLES USED FOR LIFTING THE CASK MUST HAVE A TRUE ANGLE, WITH RESPECT TO THE HORIZONTAL OF NOT LESS THAN 60°.**

- 7.1.2 Loosen and remove the twenty-four bolts (24, 1 $\frac{3}{4}$ " – 8 UN) which secure the primary lid to cask body.
- 7.1.3 Remove primary lid from cask body using suitable lifting equipment and the three lifting lugs on the secondary lid. Care should be taken during lid handling operations to prevent damage to cask or lid seal surfaces.

NOTE THE CABLES USED FOR LIFTING THE LID MUST HAVE A TRUE ANGLE, WITH RESPECT TO THE HORIZONTAL OF NOT LESS THAN 45°.

NOTE IN CERTAIN CIRCUMSTANCES, LOADING MAY BE ACCOMPLISHED THROUGH THE SECONDARY LID AND THE PRIMARY LID WILL REMAIN ON. IN THIS CASE, THE FOLLOWING ALTERNATE (A) STEPS WILL BE USED:

- 7.1.1.A (ALTERNATE) REMOVE THE IMPACT LIMITER CENTER COVER PLATE. THIS WILL PROVIDE ACCESS TO THE SECONDARY LID AND LIFTING LUGS.
- 7.1.2.A (ALTERNATE) WORKING THROUGH THE CENTER HOLE IN THE UPPER IMPACT LIMITER, LOOSEN AND REMOVE THE 12 1 $\frac{3}{4}$ " – 8 UN LID BOLTS WHICH SECURE THE SECONDARY LID TO THE PRIMARY LID.
- 7.1.3.A (ALTERNATE) REMOVE THE SECONDARY LID USING SUITABLE LIFTING EQUIPMENT AND THE THREE LUGS ON THE LID. CARE SHOULD BE TAKEN DURING LID HANDLING

OPERATIONS TO PREVENT DAMAGES TO SEAL
SURFACES OR THE LID

- 7.1.4 Visually inspect accessible areas of the cask interior for damage, loose materials, or moisture. Clean and inspect seal surfaces. Replace seals when defects or damage is noted which may preclude proper sealing.

NOTE RADIOACTIVELY CONTAMINATED LIQUIDS MAY BE PUMPED OUT, REMOVED BY USE OF AN ABSORBENT MATERIAL, OR VIA DRAIN LINE. REMOVAL OF ANY MATERIAL FLOW INSIDE THE CASK SHALL BE PERFORMED UNDER THE SUPERVISION OF QUALIFIED HEALTH PHYSICS (HP) PERSONNEL WITH THE NECESSARY HP MONITORING AND RADIOLOGICAL HEALTH SAFETY PRECAUTIONS AND SAFEGUARDS.

NOTE WHEN SEALS ARE REPLACED (INCLUDING SEALS ON THE OPTIONAL VENT AND DRAIN PORTS), LEAK TESTING IS REQUIRED AS SPECIFIED IN SECTION 8.2.2.1.

- 7.1.5 Check the torques on the cavity vent and drain line cap screws to determine that the cap screws are properly installed using O-rings. This step is not required if the cask does not have the optional vent and drain lines, or if the tamper seals on the vent or drain lines have not been removed. Torque the cap screws to 20 ± 2 ft-lbs.
- 7.1.6 Place radwaste material, disposable liners, drums, or other containers into cask and install shoring or bracing, if necessary to restrict movement of contents during transport.
- 7.1.7 Clean and inspect lid seal surfaces.

- 7.1.8 Replace the primary lid and secure the lid to the cask body by installing the 24 lid bolts. Ensure that the lid orientation stripe is in alignment with the cask stripe. Torque bolts to 300 ± 30 ft-lbs.
- 7.1.8.A (Alternate) Replace secondary lid (if removed) and secure to the primary lid with 12 bolts. Ensure that the lid orientation stripe is in alignment with the stripe on the primary lid. Torque the bolts to 300 ± 30 ft-lbs.
- NOTE** **PERFORM PRESSURE DROP LEAK TEST OF THE CASK PRIMARY LID, SECONDARY LID, VENT LINE, OR DRAIN LINE (AS APPLICABLE) IN ACCORDANCE WITH SECTION 8.2.2.2 PRIOR TO SHIPMENT OF PACKAGE LOADED WITH LARGE QUANTITIES OF LSA MATERIALS OR TYPE B QUANTITIES OF NON-LSA MATERIAL.**
- 7.1.9 Install anti-tamper seals to the designated lid bolts, or to vent and/or drain line plugs (if applicable).
- 7.1.10 If cask has been removed from trailer, proceed as follows to return cask to trailer:
- 7.1.10.1 Using suitable lifting equipment, lift and position cask into lower impact limiter on trailer in the same orientation as removed.
- 7.1.10.2 Unbolt and remove cask lifting ears.

- 7.1.10.3 Reconnect cask to trailer using tie-down equipment.
- 7.1.11 Using suitable lifting equipment, lift, inspect for damage and install upper impact limiter on cask in the same orientation as removed.
- 7.1.12 Attach and hand tighten ratchet binders between upper and lower impact limiters.
- 7.1.13 Cover lift lugs as required.
- 7.1.14 Install anti-tamper seals to the designated ratchet binder.
- 7.1.15 Replace center plate on the upper impact limiter.
- 7.1.16 Inspect package for proper placards and labeling.
- 7.1.17 Complete required shipping documentation.
- 7.1.18 Prior to shipment of a loaded package the following shall be confirmed:
 - (a) That the licensee who expects to receive the package containing materials in excess of Type A quantities specified in 10 CFR 20.1906(b) meets and follows the requirements of 10 CFR 20.1906 as applicable.
 - (b) That trailer placarding and cask labeling meet DOT specifications (49 CFR 172).
 - (c) That the external radiation dose rates of the 10-160B are less than or equal to 200 millirem per hour (mrem/hr) at the surface and less than or equal to 10 mrem/hr at 2 meters in accordance with 10 CFR 71.47.
 - (d) That all anti-tamper seals are properly installed.

- (e) For powdered solids shipments, the most recent periodic leak test demonstrated the cask was leaktight.

7.2 Procedure for Unloading Package

In addition to the following sequence of events for unloading a package, packages containing quantities of radioactive material in excess of Type A quantities specified in 10 CFR 20.1906(b) shall be received, monitored, and handled by the licensee receiving the package in accordance with the requirements of 10 CFR 20.1906 as applicable.

- 7.2.1 Move the unopened package to an appropriate level unloading area.
- 7.2.2 Perform an external examination of the unopened package. Record any significant observations.
- 7.2.3 Remove anti-tamper seals.
- 7.2.4 Loosen and disconnect ratchet binders from the upper overpack assembly.
- 7.2.5 Remove upper overpack assembly using caution not to damage the cask or overpack assembly.
- 7.2.6 If cask must be removed from trailer, refer to Step 7.1.1.

- 7.2.7 (Optional if vent port installed). Vent cask cavity removing plugs from the vent line.
- 7.2.8 Loosen and remove the twenty-four (24) 1¾" – 8 UN primary lid bolts.
- 7.2.9 Using suitable lifting equipment, lift lid from cask using care during handling operations to prevent damage to cask and lid seal surfaces.

NOTE: THE CABLES USED FOR LIFTING THE LID MUST HAVE A TRUE ANGLE WITH RESPECT TO THE HORIZONTAL OF NOT LESS THAN 45°.

- 7.2.10 Remove contents to disposal area.

NOTE: RADIOACTIVELY CONTAMINATED LIQUIDS MAY BE PUMPED OUT, REMOVED BY USE OF AN ABSORBENT MATERIAL, OR VIA DRAIN LINE. REMOVAL OF ANY MATERIAL FROM INSIDE THE CASK SHALL BE PERFORMED UNDER THE SUPERVISION OF QUALIFIED HEALTH PHYSICS (HP) PERSONNEL WITH THE NECESSARY HP MONITORING AND RADIOLOGICAL HEALTH SAFETY PRECAUTIONS AND SAFEGUARDS.

- 7.2.11 Assemble package in accordance with loading procedure (7.1.7 through 7.1.17).

7.3 Preparation of Empty Packages for Transport

The Model 10-160B cask requires no special transport preparation when empty. Loading and unloading procedures outlined in this chapter shall be followed as applicable for empty packages. The requirements of 49 CFR 173.428 shall be complied with.

NOTE: EACH PACKAGE USER WILL BE SUPPLIED WITH A COMPLETE DETAILED OPERATING PROCEDURE FOR USE WITH THE PACKAGE.

7.4 Procedures for Shipment of Packages Which Generate Combustible Gases

Procedures for preparing packages for shipment which radiolytically generate combustible gases are outlined below. These procedures are divided into two categories:

- a. Combustible gas control by inerting, and
- b. Combustible gas suppression.

7.4.1 Combustible Gas Control by Inerting

7.4.1.1 Dewater the secondary container. The bulk of the free water is removed from the secondary container by displacing the water with nitrogen gas.

7.4.1.2 Inert the secondary container (and, if necessary, the cask). The inerting operation is done at the dewatering station just before the cask is loaded. Inerting is performed if the hydrogen generated will be greater than 5% in any portion of the package for a time period that is twice the expected shipping time. Inerting is intended to limit the oxygen concentration to less than 5% including any oxygen that is radiolytically generated over the same period considered for hydrogen generation. If a leak path can develop

between the secondary container and the cask, the cask will also be inerted.

7.4.1.3 Inerting of the secondary container and / or the cask cavity, to achieve an oxygen concentration of less than 5%, can be performed per the following:

- Connect a nitrogen supply.
- Pressurize with nitrogen to 15 ± 1 psig. for fifteen minutes.
- Depressurize to ~ 0 psig.
- Repeat this pressurization / depressurization cycle two more times

7.4.2 Combustible Gas Suppression

7.4.2.1 Dewater the secondary container. See paragraph 7.4.1.1.

7.4.2.2 Install the previously qualified* combustible gas suppression system (e.g., a vapor pressure catalytic recombiner).

*Previous qualification means that the catalytic recombiner design to be used has been tested for a period of twice the expected shipping time under conditions expected in transport and has proven satisfactory.

7.4.2.3 Sample the gas in the secondary container and measure static pressure. This will assure that the combustible gas control method is working properly and that the combustible gas criteria specified in Section 4.4 will be met.

7.4.2.4 Load the secondary container.

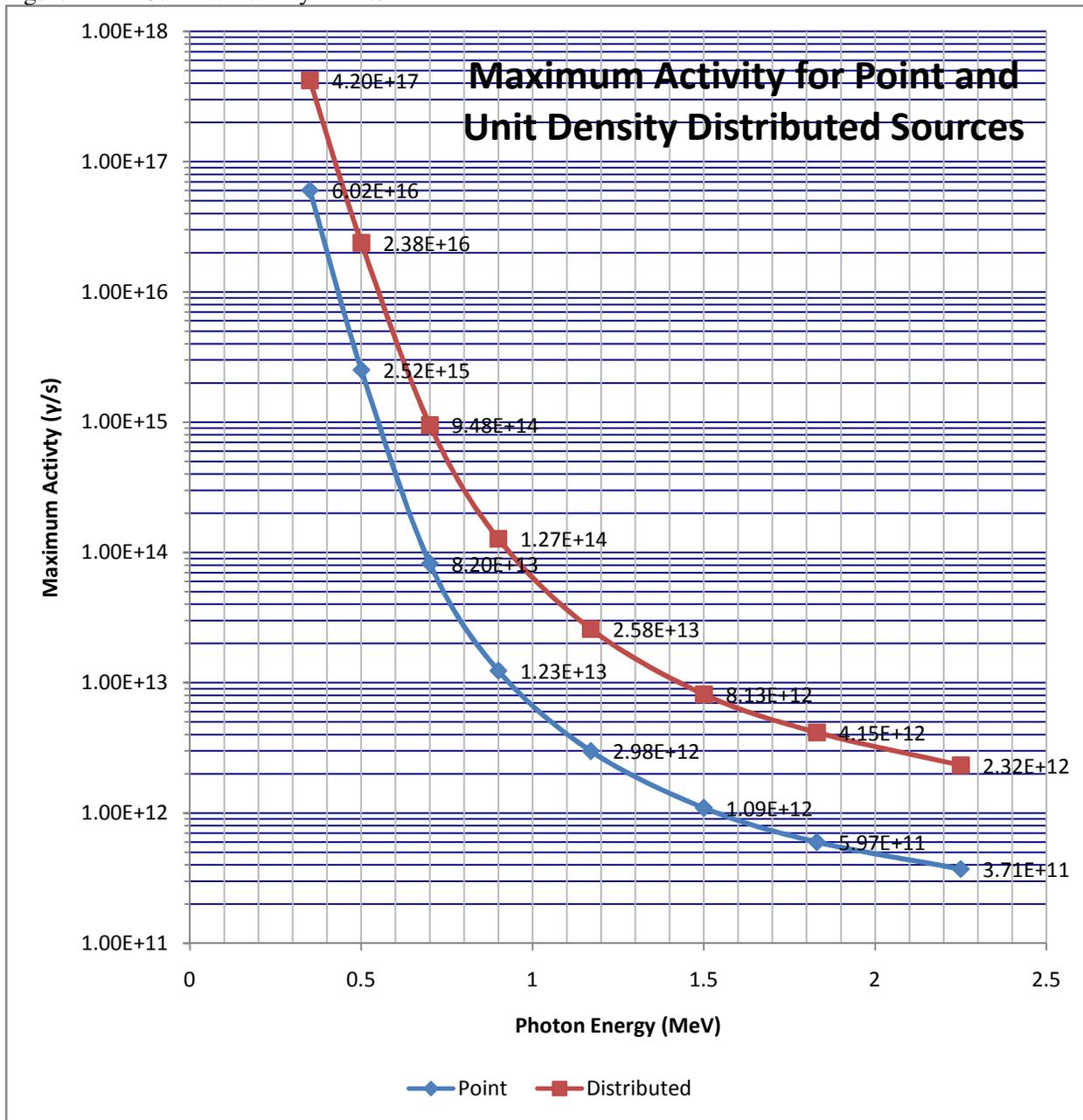
Attachment 1
Determination of Acceptable Activity
(see Chapter 5 for the derivation of the gamma activity limits)

1. Determine the total activity in the contents.
2. Determine if the content should be considered a distributed source. A distributed source is one that meets the definition of “distributed throughout” from NUREG-1608 and has a volume of at least 7.5 ft³. If the content is a distributed source, determine the density (ρ) of the content, in g/cm³.
3. Calculate the A₂ value of the contents per Appendix A to 10 CFR 71
4. Calculate the total gamma/sec for the contents by photon energy. Sum the photons per second by energy group, ignoring photon energies below 0.3 MeV and including any photons with energies above 2.25 MeV in the highest energy group. Typical energy groupings (in MeV) are: 0.3-0.4, 0.4-0.6, 0.6-0.8, 0.8-1.0, 1.0-1.33, 1.33-1.66, 1.66-2.0, and 2.0-2.5. For contents with only a few energies, the actual photon energies may be used.
5. Determine the unit density gamma activity limit for the mid-point of each photon group (or for each photon energy) from Step 4 using the plot in Figure A-1. Use the point source or the distributed source limit as appropriate from Step 2.
6. If the content is a distributed source, calculate the Density Correction Factor (DCF) and multiply the unit density gamma limit by the DCF to determine the specific density gamma limit.

$$DCF = 0.8109\ln(\rho)+0.9929$$

7. Calculate the sum of fractions, i.e., divide the gamma/sec for each photon group (or for each photon energy) by the limit for that energy (or group) and sum the fractions.
8. If the sum is less than 1.0 and the A₂ value is less than 3000, the contents meet the activity limits of the CoC.

Figure A-1 – Gamma Activity Limits



Example 1 - Determine the acceptability of a 50 Ci Cs-137 source. The source is a metal capsule 2 cm in diameter and 10 cm long.

- Step 1 The activity is 50 Ci
- Step 2 The content is not a distributed source
- Step 3 The A_2 value of Cs-137 is 16 Ci. The A_2 of the content is $50/16 = 3.125 A_2$
- Step 4 Cs-137 produces 0.85 gammas per decay with an energy of 0.66 MeV. The total gamma/sec is $3.7E+10$ d/sec per Ci x 0.85 gamma/d x 50Ci = $1.57E+12$ gamma/sec. All the gamma would be in energy group 0.6-0.8MeV.
- Step 5 The limit for energy group 0.6-0.8 (mid-point energy = 0.7MeV) for a point source is $8.20E+13$.
- Step 6 NA

- Step 7 Sum = $1.57E+12 / 8.20E+13 = 0.02$
- Step 8 Sum is less than 1 and A_2 is less than 3000. The content meets the activity limits.

Example 2 – Determine the acceptability of a secondary container containing 100 ft³ of solidified process waste. The activity is homogeneously distributed. The measured weight of the waste is 13,100 lbs. The isotopic activity, determined by analysis of samples of the waste, is: Co-60-5 Ci, Cs-137-10 Ci, Fe-55-50 Ci, Mn-54-4 Ci, Sr-90-8 Ci

- Step 1 The activity is 77 Ci
- Step 2 The contents are a distributed source. The calculated density is 2.1 g/cm³.
- Step 3

Radionuclide	Activity (Ci)	A2	# of A2
Co-60	5	11	0.45
Cs-137	10	16	0.63
Fe-55	50	1100	0.05
Mn-54	4	27	0.15
Sr-90	8	8.1	0.99
sum	77		2.26

- Step 4 See Table below
- Step 5 See Table below
- Step 6 DCF = $0.8109 \ln(\rho) + 0.9929$
DCF = 1.59
- Step 7

Group No.	Energy (MeV)	Activity (photons/sec)	Unit Density Limit (photons/sec)	Specific Density Limit (photons/sec)	F
1	0.35	0.00E+00	4.20E+17	6.68E+17	0.00E+00
2	0.50	0.00E+00	2.38E+16	3.78E+16	0.00E+00
3	0.70	3.15E+11	9.48E+14	1.51E+15	2.09E-04
4	0.90	1.48E+11	1.27E+14	2.02E+14	7.33E-04
5	1.17	1.85E+11	2.58E+13	4.10E+13	4.51E-03
6	1.50	1.85E+11	8.13E+12	1.29E+13	1.43E-02
7	1.83	0.00E+00	4.15E+12	6.60E+12	0.00E+00
8	2.25	0.00E+00	2.32E+12	3.69E+12	0.00E+00
sum					1.98E-02

- Step 8 F is less than 1 and A_2 is less than 3000, thus, the contents meet the activity limits.