August 4, 2008

Mr. Fred Yapuncich, Project Manager
AREVA Federal Services, LLC
1102 Broadway Plaza, Suite 300
Tacoma, WA 98402

SUBJECT: MODEL NO. MIXED OXIDE FRESH FUEL PACKAGE

Dear Mr. Yapuncich:

By application dated January 19, 2007, as supplemented by letters dated August 15, 2007 and April 4, 2008, AREVA Federal Services, LLC (AREVA) requested an amendment to Certificate of Compliance No. 9295, Revision No. 1, for the Model No. MFFP (Mixed Oxide Fresh Fuel Package). AREVA requested additional payload types be authorized for transport and minor changes to the Safety Analysis Report. Changes include increase in the package weight by 130 pounds and addition of shock indicators to the outside shell. This certificate supersedes, in its entirety, Certificate of Compliance No. 9295, Revision No. 1, dated January 1, 2008. Changes made to the enclosed certificate are indicated by vertical lines in the margin. The staff's Safety Evaluation Report is also enclosed.

AREVA has been registered as the certificate holder for the package. 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 Chris Staab of my staff at (301) 492-3321.

Sincerely,

/RA/

Eric Benner, Chief
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Docket No.: 71-9295
TAC No.: L24054

Enclosures: 1. Certificate of Compliance No. 9295, Rev. 2
2. Safety Evaluation Report

cc w/encl: R. Boyle, Department of Transportation
J. Shuler, Department of Energy
Registered Users

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SAFETY EVALUATION REPORT
Docket No. 71-9295
Model No. MFFP Package
Certificate of Compliance No. 9295
Revision No. 2

SUMMARY

By application dated January 19, 2007, as supplemented by letters dated August 15, 2007 and April 4, 2008, AREVA Federal Services, LLC (AREVA) requested an amendment to Certificate of Compliance No. 9295, Revision No. 1, for the Model No. MFFP (Mixed Oxide Fresh Fuel Package). AREVA requested that additional payload types be authorized for transport. In addition, AREVA has requested approval of a number of corrections and changes to the Safety Analysis Report (SAR). They include increase in the package weight by 130 pounds and addition of shock indicators to the outside shell. Based on the statements and representations in the application, as supplemented, the staff agrees these changes do not affect the ability of the package to meet the requirements of 10 CFR 71.

1.0 GENERAL INFORMATION

1.1 Packaging

The changes made in the SAR to the packaging of the Mixed Oxide Fresh Fuel Package (MFFP) includes the cavity length from 165.25-in to 165.35-in, the body length from 171-1/4-inch to 171.33-inch, and the outside overall length to 201.33 inches. Other changes to the packaging include, revising the maximum weight from 14,130 lb. to 14,260 lb. to include the attachment channel for Fuel Control Structure, adding shock indicators to the outside shell, and placing tamper-indicating seal between holes drilled in two impact limiter bolt heads.

1.2 Drawings

PacTec revised Drawing Nos. 99008-10, 99008-20, 99008-30, 99008-32, 99008-33, 99008-34, and 99008-40 and added drawing Nos. 99008-60 and 99008-61, to reflect the changes and corrections to the packaging. These changes were evaluated and are presented in the structural section.

1.3 Contents

1.3.1 Type and Form of Material

As part of this amendment request, AREVA has requested approval of additional types of contents for transport in the MFFP packaging. The additional contents are Areva Rod Box 17 (ARB-17), AFS-B Rod Container, AFS-C Rod Container, and Excess Material Assembly (EMA).

The ARB-17 is a rod container designed to transport up to 17 MOX fuel rods. The rods type is identical to the rods comprising the standard MOX fuel assembly as described in Table 1.2-1 and Table 1.2-2 of the SAR. The rods may be either undamaged, damaged, or a combination of both (e.g., 9 undamaged and 8 damaged). Damaged fuel rods may be bent, scratched, or dented, but under no circumstances may exhibit cladding breaches. A 2-inch Schedule 40 pipe mounted with pipe clamps against one wall of the ARB-17 is used to transport both undamaged or slightly damaged fuel rods. Damaged fuel rods may be transported within this pipe only if the bending in the fuel rod is minor. The ARB-17 MOX fuel rod container has been designed with outer dimensions consistent with a standard fuel assembly so that it will interface with the strongback and clamp arms.

The AFS-B Rod Container is designed to contain up to 175 MOX fuel rods. The container has outer cross sectional dimensions of 8.4 inches square, a length from bottom to top of 159.9 inches, and an overall length (to the lift ring bolt head) of 161.2 inches. The primary material of construction of the container is ASTM 6061-T651 aluminum alloy. The two side walls, the bottom plate, and the lid are all ¾ inches thick. The side plates are attached to the bottom plate with two longitudinal, 3/8-inch groove welds. The lid is attached with twenty-two zinc-plated cap screws. The two square end pieces are made of solid aluminum alloy, and each are attached to the container with eight zinc-plated cap screws. The lower square end piece is 2.4 inches thick and the upper square end piece is 3.0 inches thick. Each bolt is secured in place using a thin stainless steel lock tab. Two of the eight bolts on each end go horizontally into the lid, in addition to the 22 cap screws on the top of the lid.

The AFS-C Rod Container is designed to contain up to 116 Exxon rods, up to 69 Pacific Northwest Laboratory (PNL) rods, or both quantities together. The container is the same as the AFS-B Rod Container except the AFS-C container has two internal 2-inch thick aluminum plates which form rod cavities to accommodate both types of rods the AFS-C Rod Container may hold.

The EMA is similar to MOX fuel assemblies described in Table 1.2-1 and Table 1.2-2 of the SAR with the exceptions that the OD of the fuel pellets may be out of tolerance (nominal pellet diameter = 0.323 inch), and the weight percent Pu-238 exceeds the 0.05 wt.% limit specified in Table 1.2-2 of the SAR (EMA fuel rods have Pu-238/Pu as high as 0.19 wt.%).

1.3.2 Maximum Quantity of Material per Package

The ARB-17 is a rod container designed to transport up to 17 MOX fuel rods. The rods are identical to MOX fuel assembly rods previously approved for transport. Figures A1.2-1 and A1.2-2 in Appendix A of the SAR provide the rod loading into the ARB-17 container. The fissile loadings for the ARB-17 rods are unchanged from those previously approved for MOX fuel assemblies. The MFFP may carry up to three ARB-17 containers. For shipping less than a total of three fuel assemblies and ARB-17 containers, non-fuel dummy fuel assemblies will be used in the unoccupied strongback locations to balance the weight. Each loaded ARB-17 weighs approximately 1,525 pounds.

The AFS-B rod container is designed to contain up to 175 MOX fuel rods. Since the AFS-B rod container loaded with up to 175 MOX fuel rods is more reactive than a MOX fuel assembly, the number of containers is restricted to only one per MFFP packaging. The remaining two slots may be loaded with either two dummy fuel assemblies or a dummy fuel assembly and an EMA.

The AFS-C rod container may contain up to 116 Exxon rods and 69 PNL rods. These limits are based upon the number of rods that will fit within the AFS-C cavity, although fewer rods may be necessary in order to meet the decay heat limit for the package. MFFP may transport up to three AFS-C rod containers, each containing up to 116 Exxon rods and 69 PNL rods. The physical parameters for the Exxon and PNL fuel rods are provided in Table 1-1 below. Data for the Exxon rods are available. However, known data for the PNL rods are limited to rod OD,rod length, average plutonium mass, and average plutonium isotopics. No records are available for a number of other PNL rod characteristics, such as pellet OD, active fuel height, and maximum plutonium mass. Data listed as “assumed” in Table 1-1 represent the most reactive estimated values determined in Chapter C 6.0, Criticality Analysis, and are considered bounding. In the criticality analysis, the Exxon rods are conservatively limited to 65 g Pu per rod, and the PNL rods are conservatively limited to 42 g Pu per rod.

Table 1-1 – Exxon and PNL Fuel Rod Data for AFS-C Rod Container

Parameter	Exxon	PNL
Cladding Material	Zircaloy	Zircaloy
Overall Length	196.24 cm (77.26 in)	92.96 cm (36.6 in)
Active Fuel Length	177.8 cm (70 in)	71.12 cm (28 in) assumed
Cladding OD	1.1455 cm (0.451 in)	1.4351 cm (0.565 in)
Cladding ID	0.9677 cm (0.381 in)	1.3208 cm (0.520 in) assumed
Pellet OD	0.9439 cm (0.3716 in)	1.3043 cm (0.5133 in) assumed
Effective pellet Density	10.85 g/cm^3 assumed	10.85 (assumed)
Average Pu mass	58.3 g	37.4 g
Maximum Pu mass	65 g assumed	42 g assumed

Table 1-2 Average Fuel Rod Isotopics

Isotope	Exxon	PNL
U-235	0.71	0.71
U-238	99.29	99.29
Total U	100	100
Pu-238	0.745	0.28
Pu-239	75.13	75.38
Pu-240	17.26	18.10
Pu-241	5.23	5.08
Pu-242	1.55	1.15
Total Pu	100	100

As mentioned in the previous section, EMA is similar to MOX assemblies except the pellet OD and the Pu-238 weight. With respect to loading, the EMA is similar.

1.3.3 Criticality Safety Index

Criticality Safety Index (CSI): 0.0

Based on the statements and representations in the application, as supplemented, the staff concludes that AREVA has provided information on the MFFP in sufficient detail to provide an adequate basis for its evaluation against 10 CFR Part 71.

2.0 STRUCTURAL EVALUATION

2.1 Structural Design Criteria

The structural design criteria do not change for this amendment. The stress acceptance criteria are based on ASME Boiler & Pressure Vessel (B&PV) Code, Section III, NB and NG for the containment and criticality control structural components, respectively. The containment boundaries were required to be leaktight under NCT and HAC. Structural failure such as brittle fracture, fatigue and buckling were evaluated in accordance with NUREG guidelines or applicable industrial codes and standards.

2.1.2 Fatigue Assessment on Normal Operating Cycles

The MFFP has a service life of 20 years, and the maximum number of shipments is increased from 25 to 65 per year. Therefore, the package will undergo 1300 atmosphere-to-operating pressure cycles in its life. According to ASME B&PV Code, the stainless steel Type XM-19 can withstand 2000 cycles at 160°F. Since 2000>1300, staff agrees that first criterion is satisfied.

The normal Service Pressure Fluctuation (SPF) due to temperature extremes between -40°F and 166°F is calculated as 7.2 psig which is less than SPF of 22.4 psig. Thus, the second criterion is also satisfied.

Other criteria concerning temperature difference due to normal service, startup and shutdown, and dissimilar materials are all satisfied.

Staff reviewed the fatigue resistance ability of Type XM-19 stainless steel containment boundary subjected to 2,600 cycles of repeating mechanical loads of lifting and handling, and agreed that there is a large margin of safety to satisfy the sixth criterion. So as the closure bolts made of ASTM A564 Type 630 material.

2.2 Weights and Centers of Gravity

The maximum payload weight remains at 4,740 lbs. However, the empty packaging weighs at 9,520 lbs increasing the total weight to 14,260 lbs from 14,130 lbs. The axial location of the c.g. remains the same at 103.7 inches from the outer surface of the bottom-end impact limiter. Table 2.1-3 of the SAR summarizes the weights and their corresponding c.g.s of major MFFP structural components.

2.4 Lifting and Tie-down Standards for All Packages

The doubler plates are part of the tie-down devices: there are two doubler plates, one bearing against the forward cradle, and the other bearing against the rear cradle. However, the entire axial load is carried by only one doubler plate which is ½-inch thick and 5 inches wide. To aid fabrication, the plate is made from two or more pieces jointed with full penetration welds. The structural performance of the weldment should be the same or better than that of a solid doubler plate, if the welding is performed according to the approved QA program. Staff reviewed the weld shear stress and bearing stress induced by the increased weight of 14,260 lbs, and found there still have sufficient margins of safety (+0.66 and +2.71 respectively).

2.6 Normal Conditions of Transport

2.6.1 Heat

Since the overall length of the strongback was increased to 164.90 inches, the axial gaps due to differential thermal expansion were recalculated as 0.15 inch at room temperature and 0.10 inch at hot NCT temperature. The radial gap between the strongback top-end plate and the inner surface of the containment body at room temperature was recalculated as 0.25 inch. Thus, clearance is maintained and there will be no interferences between the strongback and the cask under NCT.

The stresses in the shell due to internal design pressure of 25 psig were reanalyzed due to dimensional changes. Staff verified the calculations, and confirmed that a large margin of safety is maintained.

2.6.2 Cold

The minimum torque applied to tighten the closure bolts was reduced from 180 ft-lbs to 175 ft-lbs. The preload at a temperature of -40°F was recalculated to be 13,779 lbs, considering the differential thermal expansion between the closure lid and closure bolt materials. This shows that adequate preload is maintained.

2.7 Hypothetical Accident Conditions (10 CFR 71.73)
2.7.1 30-foot Free Drop (No Change)
2.7.2 Crush (No Change)
2.7.3 Puncture (10 CFR 71.73(c)(3))

The ability of the MFFP to adequately withstand the 1 m drop puncture accident was demonstrated by full-scale testing of CTU. The applicant selected six worst case scenarios for the puncture tests, each preceded by at least one 30-ft free drop, as listed in Table 2.7.3 of the application. It is particularly noteworthy that Test No. 3, Series 3 on the horizontal puncture drop to challenge the containment shell leaktight integrity needs reanalysis because of gross weight increase. The applicant performed such a calculation in Section 2.12.8.2.3, Test Series 3. The analysis considered the effect of total weight increase of 7.3% (1043 lbs) from 13,217 lbs to 14,260 lbs on the HAC horizontal puncture drop. For a package weighted 13,217 lbs, the test showed damage in the form of an indention of approximately 2.13 inches deep. Additional available puncture energy of 7.3% could produce additional deformation of 0.073 x 2.13 = 0.16 inch, if the indention is linearly dependent on the mass or puncture energy. The small amount of increase in indention should also be acceptable. However, it is not clear whether this linear assumption is valid or not. Nevertheless, staff investigated this issue and found that in this case (i.e., horizontal puncture drop of a 14,260 lbs shell made of a material with ultimate strength of 85 ksi) a minimum thickness of 0.3 inch is adequate to withstand the punching action. (See Figure 2.2 of ORNL Report NSIC-68, Page 18). Since the thickness of the shell is 9/16 inch which exceeds the perforation thickness, the containment leaktight integrity is assured. Therefore, the MFFP with the increased mass meets the containment requirements of 10 CFR 71.73(c)(3).

2.7.4 Thermal (See Chapter 3)
2.7.5 Immersion-Fissile (No Change)
2.7.6 Immersion-All Packages (No Change)
2.7.7 Deep Water immersion Test (No Change)
2.7.8 Summary of Damage (No Change)

2.8 Fuel Rods

The 3D Monte-Carlo computer code, MCNP5 was used to perform criticality calculations for the MFFP. The fuel rods are assumed to arrange themselves in the most reactive configuration in the cavity between the strongback and the FCS. Three fuel rod arrangements are considered in the evaluation: (1) Exxon rods, (2) PNL rods, and (3) both rod types combined. In the case of (3), the AFS-C may fit 116 Exxon rods and 69 PNL rods in a close-packed hexagonal array as sketched in Figure C6.6-1 (for HAC array geometry). For loading purposes, axial separation of the rods is maintained by a spacer. The excess volume is filled with stainless steel dunnage rods if less than the maximum number of rods is placed in an AFS-C.

3.0 THERMAL

The MFFP has been approved for transporting up to 3 fresh MOX 17x17 PWR fuel assemblies. An amendment has been applied for to carry the following additional contents:

Areva Rod Box 17 (ARB-17) containers (replacing up to three (3) standard fuel assemblies, and in any combination with standard fuel assemblies and/or dummy fuel assemblies). Each ARB-17 may contain up to 17 standard MOX fuel rods. The fuel rods may be undamaged or slightly damaged.

Contents of up to one (1) AFS-B rod container, and one (1) Excess Material Assembly (EMA). The AFS-B may contain up to 175 standard MOX fuel rods. For transportation purposes, the EMA is equivalent to a MOX fuel assembly.

Contents of up to three (3) AFS-C rod containers containing two types of rods currently stored at Los Alamos Technical Area 18 (TA-18), Exxon rods and Pacific Northwest Laboratory (PNL) rods. TA-18 rods are MOX rods but are not the same as standard MOX rods. Each AFS-C may contain up to 116 Exxon rods and 69 PNL rods.

3.1 Description of Thermal Design

3.1.1 Design Features

The MFFP has an internal strongback structure that provides support for the fuel assemblies, or alternate contents. The stainless steel cylindrical package body provides a leaktight containment. Impact limiters (on each end of the cylindrical package body) are used for impact energy absorption as well as for thermal protection of the O-ring seals. Even though the package qualifies as nonexclusive shipment per 10 CFR §71.43(g), each loaded MFFP will be transported individually, in a horizontal position, and in a single closed conveyance (tarpaulined vehicle, shipping container, canopy, etc.) due to its width, length, and weight.

3.1.2 Content's Decay Heat

The currently approved contents, the 17x17 PWR (MOX) fuel assembly, holds 264 fuel rods. The maximum allowed decay heat is 80 watts per fuel assembly, evenly distributed over the 144 inch active fuel length. This is the basis for the thermal analyses previously conducted for this design. All of the additional proposed contents have a maximum decay heat of 80 watts (per assembly) or less. The specific values of decay heat for the additional proposed contents are detailed below.

Areva Rod Box 17 (ARB-17) containers - 5.15 Watts
AFS-B rod container - 53 Watts Actual (80 Assumed for Analysis)
Excess Material Assembly (EMA) - 80 Watts - assumed for Analysis
AFS-C rod containers w/ Exxon or PNL rods - 80 Watts - assumed for Analysis

3.1.3 Summary of Temperatures

The tables below provide summaries of component temperatures both the normal conditions of transport (NCT) in Table 3.1 and hypothetical accident conditions (HAC) analyses, in Table 3.2, conducted by the applicant.

Table 3.1 - NCT Component Temperatures				
Component		Temperature (°F)		
		NCT Hot	NCT Hot w/o Solar	Maximum Allowable
Fuel Cladding		221	179	392
Poison	Strongback	178	134	850
	Fuel Box	177	133	850
Body Shell		159	110	800
Closure Lid		147	109	800
Impact Limiter	Foam (max)	159	110	225
	Skin	146	108	225
Seals	Closure	159	110	225
	Vent/Sample Port	146	108	225
Bulk Fill Gas (avg)		166	121	--

Table 3.2 - HAC Component Temperatures					
Component		Temperature (°F)			
		Pre-Fire Steady-State	End of Fire (30 Mins)	HAC Peak	Maximum Allowable
Fuel Cladding		179	436	518	1,337
Poison	Strongback	134	408	494	1,000
	Fuel Box	133	652	652	1,000
Body Shell		110	1,361	1,361	2,500
Closure Lid		109	179	301	1,000
Impact Limiter	Foam (max)	107	n/a	n/a	n/a
	Skin	107	1,429	1,429	2,500
Seals	Closure	110	200	339	400
	Vent/Sample Port	108	148	295	400

Bulk Fill Gas (avg)	121	770	770	--

3.2 Thermal Evaluation for Normal Conditions of Transport

In the previously approved analysis of record, the applicant considers an isolated horizontal package in a closed conveyance (covered vehicle), in order to analyze the thermal performance of the MFFP package design under Normal Conditions of Transportation. The internal heat generation per MFFP is assumed to be uniformly distributed and amounting to 240 (= 3 x 80) watts.

The applicant provides temperature-dependent material properties for all major components of the MFFP package as well as acceptable temperature ranges of operation (minimum and maximum allowable values) in Section 3.2 of the SAR. Anisotropic thermal conductivities (radial & axial) for the fuel region are separately derived using a "k effective" approach, described in Section 3.6.2.2 of the SAR. The approach is based on a detailed model of the individual fuel pins within the strongback walls and allows a simplification of the loaded MFFP model to be used, where the fuel region is treated as a homogeneous material with an effective conductivity.

Using the Thermal Desktop and SINDA/FLUINT computer programs, the applicant constructed a 1/4 symmetry model of a loaded MFFP, using appropriate detail to represent the strongback structure with the boral neutron absorber sheets, and the overpack structure with the attached impact limiters. The 240 watts are assumed to be uniformly distributed among the three fuel regions. Inside the MFFP, both conduction and radiation are allowable means of heat transfer. The MFFP exchanges heat with the surrounding environment through convection and radiation.

For the additional proposed contents, the applicant uses simple conduction hand calculations to establish that the thermal performance of the package with any of the additional proposed contents in place is bounded by the originally approved thermal analysis for 3 standard fuel assemblies.

The applicant predicts that all component temperatures are within operational limits for normal conditions of transport. The applicant also demonstrates that the accessible external surface temperature remains below the regulatory limit in 10 CFR § 71.43 (g) of 50^{o}C (122^{o}F) without insolation, required for packages under nonexclusive use.

3.3 Thermal Evaluation for Hypothetical Accident Conditions

The SINDA/FLUINT 1/4-symmetry thermal model used for the fire simulation is very similar to the one developed for the NCT except that the impact limit region is modified in order to account for possible drop damages and the degradation of the foam when exposed to elevated temperatures. Seven inches are subtracted from the outer layer of the polyurethane foam in order to represent the crushing effects. The possibility of developing a 'chimney flow' of hot gases is simulated by a void semi-circular shaped region in the vicinity of the side impact damage. As a result, a localized region of the impact limiter is left with approximately 1 inch of foam remaining. All voided spaces within the impact limiter are assumed to be filled with air.

The fire is simulated by exposing the package to a forced convection environment with ambient temperature of 800^{o}C (1475^{o}F) for 30 minutes. The applicant proposes combustion gas velocities and appropriate correlations for the different outer surfaces. The insulating and fire extinguishing properties of the polyurethane foam support the proposed modeling approach and the results that follow. The butyl-rubber O-ring seal is estimated to reach a temperature of approximately 340°F, which is 60°F below that material allowable limit (400°F for exposures of 8 hours or less). All components remain within their operational limits.

3.4 Confirmatory Analysis

For the original application, the staff independently modeled the transportation package overpack, confirming that the package design provides sufficient thermal safety margins for all its components. Given the minimal impact on the thermal performance of the package from the additional proposed contents, a confirmatory analysis was not conducted for this amendment request.

The applicant provided the staff with information related to the validation of the SINDA/FLUINT code, which was reviewed by the staff. The staff found that use of the SINDA/FLUINT code for the specific package design and contents sought in this application was acceptable, based on the validation information provided; however, the staff did not conduct an in-depth review of the validation documentation, and, therefore, does not make a generic finding on the validity of the use of the SINDA/FLUINT code for other design configurations or future applications.

3.5 Internal Pressure

The Maximum Normal Operating Pressure (MNOP) is calculated at 10 psig, after conservatively assuming failure of 3% of the fuel rods. This value is considerably smaller than the proposed 25 psig design pressure with which the applicant estimated stresses upon the MFFP walls. For the accident (fire) scenario, the applicant conservatively assumes all fuel rods to have failed as well as the gassing (volatization) of all internal rubber/plastic pads. The resulting internal pressure reaches up to 124 psig, approximately. The applicant uses the stress values calculated from the 25 psig NCT condition to linearly extrapolate the maximum stress values encountered during the fire event. Based on allowable stress limits provided by ASME B&PV Code, Section III, Subsection NH, there is still a considerable margin of safety. Even after considering the extreme range of stress (per Regulatory Guide 7.6, Paragraph C.7), the performance of the containment cask during the fire event is still within an acceptable margin of safety.

3.6 Conclusion

Based on the documentation and information supplied by the applicant, and the review performed by staff, there is reasonable assurance that the package design, as amended to include additional contents discussed above, meets the requirements of 10 CFR Part 71 for thermal performance.

4.0 CONTAINMENT

No containments are provided by ARB-17, AFS-B, or AFS-C containers. Therefore, MFFP is relied upon for containment for the additional content. The containment design of the MFFP has been previously reviewed and approved by the staff. No changes have been made to containment design of the MFFP by the applicant.

5.0 SHIELDING

The ARB-17, AFS-B, and AFS-C containers are loaded with MOX fresh fuel rods and are not a significant source of radiation. Shielding materials are not specifically provided by the MFFP package, and none are permitted within the package. Measurements shall be performed prior to shipment to demonstrated compliance with the external allowable dose rates under 10 CFR 71.47 and determination of transport index per 49 CFR 173.403.

6.0 CRITICALITY

The purpose of the criticality review is to ensure that the contents will remain subcritical under all credible normal, off-normal, and accident conditions encountered during handling, packaging, transfer, and storage. These objectives include a review of the criticality design criteria, features and fuel specifications, verification and review of the configuration and material properties for the MFFP, and a review of the criticality analyses including computer programs, benchmark comparisons, and multiplication factors calculated in this request.

The staff reviewed the MFFP criticality safety analysis to ensure that all credible normal, off-normal, and accident conditions have been identified and their potential consequences on criticality considered such that the MFFP with the payloads found in Appendices A, B, and C meets the following regulatory requirements: 10 CFR 71.31, 71.33, 71.35, and 71.59. The staff's review also involved a determination on whether the cask system fulfills the acceptance criteria listed in Section 6 of NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel."

6.1 Description of Criticality Design

The MFFP is a steel cylinder containment body and closure lid that provides containment for the MOX fuel assemblies. The MFFP primary design features include neutron poison plates (boral) with a minimum B-10 areal density of 0.035 cm^3 to ensure criticality safety. The poison plates surround each fuel assembly on all four sides. Criticality is ensured by the structural design of the MFFP. The strongback structure provides support by firmly keeping the fuel assemblies in place. A stainless steel shell provides separation between assemblies being stored in the MFFP.

6.1.2 Spent Nuclear Fuel Contents

The MFFP has been approved for transporting up to 3 fresh MOX 17x17 PWR fuel assemblies. An amendment has been applied for to carry the following additional contents:

> Areva Rod Box 17 (ARB-17) containers (replacing up to three (3) standard fuel assemblies, and in any combination with standard fuel assemblies and/or dummy fuel assemblies). Each ARB-17 may contain up to 17 standard MOX fuel rods. The fuel rods may be undamaged or slightly damaged.
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6.1.3 General Considerations for Criticality Evaluations

The applicant performed analyses for a single package under conditions of 10 CFR 71.55(b), (d), and (e), and for undamaged and damaged arrays of packages under their respective conditions specified in 10 CFR 71.59(a)(1) and (2). The results of these analyses were presented in tables that showed the calculated k-effectives and their standard errors. The upper subcritical limit (USL) for the MFFP (package or package array) is determined by the applicant to be 0.9288. The package is considered to be subcritical if k_{safe} (k_s) for the cases is less than the USL. The computed k_{safe} is equated as $k_s = k_{eff} + 2\sigma < USL$. Staff reviewed these tables and found that the most reactive cases are clearly indicated, and were demonstrated to be less than the USL.

Appendix A:
No structural credit is taken for the ARB-17 in the criticality evaluation of Appendix A contents so it is not modeled. The fuel rods are assumed to arrange in the most reactive configuration within the cavity formed between the strongback and FCS. An added conservatism is the modeling of 25 rods in a 5 x 5 square array instead of 17 rods. Each of the rods is placed into a plastic sleeve to prevent scratching during transportation. The amount of plastic is considered insignificant and is not modeled in MCNP.

Appendix B:
The AFS-B is not modeled in the criticality evaluation so the rods are assumed to arrange into the most reactive configuration within the cavity formed by the strongback and the FCS. The AFS-B is credited with being able to maintain the structural integrity of the rods and confine the rods to the rod container during all normal conditions and hypothetical accident conditions. A variety of square arrangements were modeled from 10x10 to 14x14.

Appendix C:
No structural credit is taken for the AFS-C in this criticality evaluation. The rods are assumed to arrange in the most reactive configuration within the cavity formed between the strongback and the FCS. Three models were developed: (1) only Exxon rods, (2) only PNL rods, and (3) both rods types combined. A number of square arrangements were modeled from 7x7 to 11x11.

6.2.1 Single Package Evaluation

6.2.2.1.1 Criticality Evaluation for Appendix A Payload Under NCT

No MCNP models were developed for the ARB-17 payload under NCT configuration. In the absence of moderation, the ARB-17 is bounded by three standard fuel assemblies since the reactivity in a dry condition is based primarily on fissile mass content.

6.2.2.1.2 Criticality Evaluation for Appendix A Payload Under HAC

Explicit models were developed with flooding to determine optimum moderation. The rods are assumed to move into the most reactive configuration. 25 rods were modeled instead of 17 rods for conservatism. The 25 rods were modeled in a 5x5 square pitch array. The pitch between rods was varied. The poison plates included in the MFFP packaging were neglected in the criticality analysis.

6.2.2.2.1 Criticality Evaluation for Appendix B Payload Under NCT

No MCNP models were developed for the NCT configuration with a payload of 1 EMA and 1 AFS-B. In the absence of moderation, the AFS-B is bounded by three standard fuel assemblies since the reactivity in a dry condition is based primarily on fissile mass content.

6.2.2.2.2 Criticality Evaluation for Appendix B Payload Under HAC

Explicit models were developed with flooding to determine optimum moderation. The rods are assumed to be free to move into the most reactive configuration, so cases were models with varying pitches. The poison plates included in the MFFP packaging were neglected in the criticality analysis.

6.2.2.3.1 Criticality Evaluation for Appendix C Payload Under NCT

Under NCT conditions, the internals of the package are assumed to be dry. In the absence of moderation, reactivity is based primarily on fissile mass content. The total number of rods are bounded by a 11x11 array of Exxon rods and a 9x9 array of PNL rods within each AFS-C.

Parametric runs are performed on the PNL rods to determine the optimum values for the active fuel height, pellet OD, and cladding ID. The results are used in the NCT models for PNL rods.

6.2.2.3.2 Criticality Evaluation for Appendix C Payload Under HAC

Explicit models were developed with flooding to determine optimum moderation. The rods are assumed to be free to move into the most reactive configuration, so cases were models with varying pitches. The poison plates included in the MFFP packaging were neglected in the criticality analysis.

6.2.3 Criticality Evaluation Under NCT

Because the MFFP is considered to be leaktight under NCT conditions, the NCT cases assumed no moderation within the MFFP. The model consisted of an infinite close-packed hexagonal array. Reactivity as a function of water density was evaluated over a range of 0 to 1.0 g/cm^3. Neutron poison plates have minimum B-10 areal density of 0.035 g/cm^3. Only 75% credit is taken for the B-10 number density.

6.2.4 Criticality Evaluation Under HAC

The HAC array was modeled as being in a close-packed hexagonal array. The worst-case pitch for the single package HAC case was assumed for the array models. For the initial cases, the small steel components (i.e., the clamp arms and strongback angles) were ignored. The most reactive cases involved full-density water internal moderation with no external moderation. Any external water would act to isolate the fuel assemblies from each other. Therefore, inclusion of the small steel components would not provide a significant increase in reactivity.

6.1.3 Transport Index

An infinite number of MFFPs are evaluated in a close-packed hexagonal array for the NCT and HAC, making "N" infinite. In accordance with 10 CFR 71.59, the criticality safety index (CSI) is 50/N = 0

6.1.4 Confirmatory Analysis

Staff performed confirmatory calculations for certain portions of the criticality analysis during its review of the proposed package using information presented in the application. Staff reviews of the criticality analysis confirm that the most reactive conditions were properly identified and that k-effective for these conditions meet the subcriticality requirements of 10 CFR 71 for both the damaged and undamaged package arrays.

6.1.5 Conclusion

Based on the review of the information and representations made by the applicant in the SAR, the staff finds reasonable assurance that the package design with the proposed contents meets the criticality requirements of 10 CFR Part 71.

7.0 OPERATING PROCEDURES

The package loading and unloading operations for the ARB-17 container is the same as the operations for fuel assembly loading and unloading described in Sections 7.1 and 7.2 of the MFFP SAR. However, the applicant has added options for horizontal or vertical loading/unloading of the MFFP package. In addition, other minor changes have been made to Sections 7.1 and 7.2 of the MFFP SAR. The package loading and unloading operations for the AFS-B and AFS-C containers are described in Sections 7.1 and 7.2 of Appendices B and C of the SAR.

Based on the statements and representations in the application, the staff concludes that the operating procedures have been adequately described and evaluated and that the package meets the requirements of 10 CFR Part 71.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

ARB-17, AFS-B, and AFS-C acceptance tests are provided in Section 8 of the appendices.

CONDITIONS

The final rule adopted a new section, Section 71.55(f), which addresses packaging design requirements for packages transporting fissile material by air. This requirement is not applicable to the MFFP package. Therefore, for clarity, the Certificate of Compliance has been revised to specify that air transport is not authorized. The following condition was added to the Certificate of Compliance.

- Transport by air of fissile material is not authorized.

CONCLUSION

Based on 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 the package meets the requirements of 10 CFR Part 71.

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