SAFETY EVALUATION REPORT

Docket No. 71-9253
Model No. TN-FSV Package
Certificate of Compliance No. 9253
Revision No. 11

SUMMARY

By application dated December 28, 2007, supplemented on April 23, and June 11, 2009, the Department of Energy (DOE) requested an amendment to Certificate of Compliance No. 9253 for the Model No. TN-FSV package. DOE requested that the certificate be amended as follows:

- Revise the package identification number to include the “-96” designation.
- Include a third shipping configuration for the TN-FSV packaging, consisting of high burn-up pressurized water reactor (PWR) fuel rods within a PWR fuel rod shielded basket (PSB). To support this request DOE provided “Addendum B: PWR Fuel Rod Shielded Basket.”

NRC staff reviewed the application using the guidance in NUREG 1617, “Standard Review Plan for Transportation Packages for Spent Nuclear Fuel.” Based on the statements and representations in the application, the staff agrees that the changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

1.0 GENERAL INFORMATION

1.1 Packaging

The TN-FSV package is a stainless steel and lead shielded shipping cask. The TN-FSV is currently authorized to transport High Temperature Gas-Cooled Reactor fuel (Configuration 1) and the Oak Ridge Containers (Configuration 2).

This application requests the addition of up to seven high burn-up PWR spent fuel rods or PWR guide tubes as authorized contents for the TN-FSV. The PSB is used to secure and shield the PWR fuel rods within the TN-FSV cask. The PSB and a stainless steel axial spacer, placed inside the cavity of the TN-FSV cask are identified as Configuration 3. This new configuration and contents are described in Addendum B, which is prepared in accordance with the general format provisions of NRC’s Regulatory Guide 7.9, “Standard Format and Content of Part 71 Applications for Approval of Packaging of Type B, Large Quantity and Fissile Radioactive Material.” Configuration 3 for the Model No. TN-FSV is described in sufficient detail to provide an adequate basis for its evaluation.

1.2 Drawings

The applicant provided updated drawings. The TN-FSV packaging is constructed and assembled in accordance with the following Transnuclear, Inc., Drawing Nos.:

1090-SAR-1, Rev. 3	1090-SAR-8, Rev. 3
1090-SAR-2, Rev. 3	1090-SAR-9, Rev. 3
1090-SAR-6, Rev. 3	1090-SAR-10, Rev. 2
1090-SAR-7, Rev. 3	

And with the following AREVA Federal Services LLC, Drawing Nos.:

1090-SAR-3, Rev. 4
1090-SAR-4, Rev. 5
1090-SAR-5, Rev. 5

The applicant provided additional drawings specific to Configuration 3. The PSB is constructed and assembled in accordance with the following AREVA Federal Services LLC, Drawing Nos.:

P03FM108-SAR, Sheets 1-3, Rev. 2

1.3 Evaluation for the -96 Designation

The applicant requested an amendment to Certificate of Compliance No. 9253 to revise the package identification number from USA/9253/B(U)F-85 to USA/9253/B(U)F-96, as specified in 10 CFR 71.19(e). To support the request for the “-96" designation, the applicant provided a table addressing the 19 issues considered in the rulemaking process that resulted in the revised rule, which was published on January 26, 2004 (69 FR 3698). The staff evaluated the applicant’s request, as described below.

- Issue 1, Changing Part 71 to the International Systems of Units (SI) only. This proposal was not adopted in the final rule, and therefore no changes were needed in the package application or the Certificate of Compliance to conform to the new rule.

- Issue 2, Radionuclide Exemption Values. The final rule adopted radionuclide activity concentration values and consignment activity limits in TS-R-1 for the exemption from regulatory requirements for the shipment or carriage of certain radioactive low-level materials. In addition, the final rule adopted an exemption from regulatory requirements for certain natural material and ores containing naturally occurring radionuclides. The applicant stated that this revision was not applicable to the Model No. TN-FSV package. The staff agrees, based on the design purpose of the Model No. TN-FSV package and the allowed contents specified in the certificate. Thus, no changes were needed to conform to the new rule.

- Issue 3, Revision of A_1 and A_2. The final rule adopted changes in the A_1 and A_2 values from TS-R-1, with the exception of two radionuclides. The A_1 and A_2 values were modified in TS-R-1 based on refined modeling of possible doses from radionuclides, and the NRC agreed that incorporating the latest in dosimetric modeling would improve transportation regulations. The applicant stated that this change was not applicable to the Model No. TN-FSV, since for configuration 1, the A_2 value for krypton-85 did not change, and for configurations 2 and 3, the package is shown to be leak tight and the containment analysis was not based on the A_2 values in Part 71. Thus, no changes were needed to conform to the new rule.

- Issue 4, Uranium Hexafluoride (UF_6) Package Requirements. The Model No. TN-FSV is not authorized for the transport of uranium hexafluoride. Therefore, no changes were needed to conform to the new rule.

- Issue 5, Criticality Safety Index (CSI). The final rule adopted the new term Criticality Safety Index from TS-R-1. The applicant revised the main Safety Analysis Report Chapter 1, and Addendum B, of the application to incorporate the CSI nomenclature. The Certificate of Compliance has been revised to delete reference to the Transport Index for criticality control.

- Issue 6, Type C Packages and Low Dispersible Material. This proposal was not adopted for the final rule. Thus, no changes were needed.

- Issue 7, Deep Immersion Test. The final rule adopted an extension of the previous version of 10 CFR 71.61 from packages for irradiated fuel to any Type B package containing activity greater than 10^5 A_2. The applicant stated that the package was previously evaluated in Section 2.7.5.1 of the main Safety Analysis Report. Thus, no changes were needed to conform to the new rule.

- Issue 8, Grandfathering Previously Approved Packages. The final rule adopted a process for allowing continued use, for specific periods of time, of previously approved package designs without demonstrating compliance to the final rule. The applicant has decided in accordance with 10 CFR 71.19(e) to submit information demonstrating compliance with the final rule. Thus, grandfathering the design of the Model No. TN-FSV package is not necessary.

- Issue 9, Changes to Various Definitions. The final rule adopted several revised and new definitions. These changes were adopted to provide clarity to Part 71. Thus, no changes were needed to conform to the new rule.

- Issue 10, Crush Test for Fissile Material Packages. The revised 10 CFR 71.73 expanded the applicability of the crush test to fissile material packages. The crush test is required for packages with a mass not greater than 500 kilograms (1100 pounds). Since the Model No. TN-FSV package has a mass greater than this, the crush test is not applicable. Therefore no changes were needed to conform to the new rule.

- Issue 11, Fissile Material Package Design for Transport by Aircraft. The final rule adopted a new section, Section 71.55(f), which addresses design requirements for packages transporting fissile material by air. The applicant stated that this requirement is not applicable to the Model No. TN-FSV, since fissile materials will not be transported by air. Therefore, for clarity, the Certificate of Compliance has been conditioned to specify that air transport is not authorized for fissile material.

- Issue 12, Special Package Authorization. The final rule adopted provisions for special package authorization that will apply only in limited circumstances and only to one-time shipments of large components. This provision is not applicable to the Model No. TN-FSV package. Thus, no changes were needed to conform to the new rule.

- Issue 13, Expansion of Part 71 Quality Assurance (QA) Requirements to Certificate Holders. The Department of Energy is the holder for Certificate of Compliance No. 9253. No changes are needed to conform to the new rule.

- Issue 14, Adoption of the American Society of Mechanical Engineers (ASME) code. This proposal was not adopted in the final rule. Thus, no changes were needed to conform to the new rule.

- Issue 15, Change Authority for Dual-Purpose Package Certificate Holders. This proposal was not adopted for the final rule. Thus, no changes were needed to conform to the new rule.

- Issue 16, Fissile Material Exemptions and General License Provisions. The final rule adopted various revisions to the fissile material exemptions and the general license provisions in Part 71 to facilitate effective and efficient regulation of the transport of small quantities of fissile material. The criticality safety of the Model No. TN-FSV package does not rely on limiting fissile materials to exempt or generally licensed quantities. Therefore, no changes were needed to conform to the new rule.

- Issue 17, Double Containment of Plutonium. The final rule removed the requirement that packages with plutonium in excess of 0.74 terabecquerel (20 curies) have a second, separate inner container. The application does not refer to the double containment of plutonium, and no revisions were needed to conform to the new rule.

- Issue 18, Contamination Limits as Applied to Spent Fuel and High Level Waste Packages. This proposal was not adopted for the final rule. Thus, no changes were needed to conform to the new rule.

- Issue 19, Modification of Events Reporting Requirements. The final rule adopted modified reporting requirements. While the final rule is applicable to the package, no changes were needed to conform to the new rule.

The staff concluded that the design has been adequately described and meets the requirements of the revised regulations in 10 CFR Part 71. The Certificate of Compliance has been revised to include the “-96” designation in the package identification number. To allow time to modify the packaging markings to include the “-96” designation, the certificate has been conditioned to allow use of packages marked with the “-85” designation for a period of approximately one year. After June 30, 2010, the packaging must be marked with the package identification number including the “-96” designation.

2.0 STRUCTURAL

Addendum B to the Safety Analysis Report for the TN-FSV Packaging (Addendum B), Configuration 3, provides a structural evaluation of the PSB used to transport up to seven (7) rods of PWR fuel in the TN-FSV cask. Structural integrity and reasonable assurance of safety is demonstrated by way of calculation or similarity with previously approved payloads.

2.1 Structural Design

2.1.1 Design Criteria

The PSB provides no containment function and by the nature of its robust construction, provides some auxiliary gamma shielding through retention of the contents within the PSB body. The design of the PSB is such that its effect on the TN-FSV package performance is bounded by two previously approved configurations.

The applicant noted that the PSB design criteria relate to limiting the potential damage to the inner surface of the TN-FSV cask. The design criteria presented are as follows:

- Total payload weight of the PSB and spacer must not exceed 5000 lbs.
- Heat load must remain below 360 W.
- Shielding components must not be subject to brittle fracture.
- The shielding body and spacer must not buckle during an end drop.
- The radial support disks must not load the TN-FSV inner shell beyond what was previously evaluated.
- The lid must not separate from the PSB.

2.1.2 Fabrication and Examination

Welder and weld qualifications will be performed in accordance with Section IX of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) code. Welding of the PSB will be conducted in accordance with Section III, Division 1, Subsection NG, Article NG-4400, of the ASME B&PVC. All welds will be examined by visual inspection per American Welding Society (AWS) Structural Welding Code D1.6. Selected welds will be examined using liquid penetrant testing after the final pass in accordance with Section III, Division 1, Subsection NG, Article NG-5000 and Section V, Article 6. The staff finds the use of these codes acceptable for the fabrication of the PSB.

2.1.3 Codes and Standards

To ensure the PSB or attached spacer do not buckle, ASME B&PV code case N-284-1, “Metal Containment Shell Buckling Design Methods,” is used to verify structural performance. Lid bolts are evaluated using the guidance of NUREG/CR-6007 “Stress Analysis of Closure Bolts for Shipping Casks.” Staff has reviewed the codes used in the package design and finds them acceptable.

2.2 Weights and Centers of Gravity

The maximum weight of the PSB is 5000 lb, consistent with the design criteria set forth by the applicant. The center of gravity of the PSB alone and the combined TN-FSV/PSB package center of gravity are calculated and presented in Addendum B. Based on the calculations provided, the applicant determined that the overall center of gravity of the package shifts 2 inches axially. The applicant concluded that this change is minimal and will cause negligible changes in the structural response during Normal Conditions of Transport (NCT) as well as Hypothetical Accident Conditions (HAC). Based on the geometry of the package, the staff concurs with this assessment.

2.3 Materials Properties and Specifications

The body of the PSB is made of ASTM 304 stainless steel, which is immune to low-temperature embrittlement. The PSB lid bolts are made of low alloy ASTM 574 steel. The PSB lid bolts cannot be removed, even in the case of a failure of all four of the lid attachment bolts. Since the lid cannot be removed from the PSB, the spent fuel rods cannot move into a position in which they are unshielded by the PSB. Therefore, the integrity of the lid attachment bolts during NCT or HAC is not critical to safety, and the fracture behavior of the bolts is not of concern.

Staff also reviewed the qualification of wood used in the impact limiter. Changes proposed to the description of wood properties and methodology for acceptance testing of the wood for the impact limiters did not conclusively demonstrate future construction would meet the crush strength requirements specified in Drawing No. 1090-SAR-9, Rev. 3. The certificate was conditioned to specify that fabrication of additional impact limiters (balsa and redwood encased in stainless steel shells) is no longer authorized.

2.4 General Standard for All Packages (10 CFR 71.43)

2.4.1 Minimum Package Size

This does not apply to the PSB as it is considered payload and not the actual packaging.

2.4.2 Tamper-Indicating Features

This does not apply to the PSB as it is considered payload and not the actual packaging.

2.4.3 Positive Closure

This does not apply to the PSB as it is considered payload and not the actual packaging.

2.4.4 Chemical and Galvanic Reactions

The PSB is constructed from austenitic stainless steel, which is immune to corrosion in the spent fuel environment. The PSB lid bolts are plated with a 25 micron thick layer electroless nickel that is sufficient to protect the bolts from corrosion. The staff finds no corrosion issues that will influence the safety of the package.

2.4.5 Effects of Radiation on Materials

The radiation of the package contents is not sufficient to change the properties of stainless or alloyed steel. The safety performance of the PSB will be not be affected by radiation.

2.5 Lifting and Tie-Down Standards for All Packages (10 CFR 71.45)

2.5.1 Lifting Devices

This does not apply to the PSB as it is considered payload and not the actual packaging.

2.5.2 Tie-Down Devices

This does not apply to the PSB as it is considered payload and not the actual packaging.

2.6 Normal Conditions of Transport (10 CFR 71.71)

2.6.1 Heat

The applicant evaluated the effect of heat and a subsequent increase in internal pressure and determined that the stress on the cask was bounded by a previously approved configuration. Based on the large margin between the 3.6 psig Maximum Normal Operating Pressure (MNOP) used in the Addendum B configuration and the 30 psig MNOP in a previously approved configuration, the staff agrees with this conclusion.

With respect to differential thermal expansion, the staff reviewed the applicant's differential thermal expansion evaluation. Based on the calculated maximum expansion of 0.129 inch and package normal clearance of 1 inch, staff concurs that no geometric interference will occur.

2.6.2 Cold

The applicant determined that an ambient temperature of -40 degrees C has no detrimental effect on the package or contents. Based on the material properties of austenitic steel, staff agrees with this assessment.

2.6.3 Reduced External Pressure

The PSB is an internal component to the package; therefore this requirement does not apply.

2.6.4 Increased External Pressure

The PSB is an internal component to the package; therefore this requirement does not apply.

2.6.5 Vibration

The applicant demonstrated that due to the geometry of the PSB, vibrations due to transport will have a negligible effect on the basket. Based on the geometry of the PSB and its fit inside the cask, staff agrees with this conclusion.

2.6.6 Water Spray

The PSB is an internal component to the package; therefore this requirement does not apply.

2.6.7 1.2-Meter Free Drop

The applicant noted that the effect of the PSB on the TN-FSV is bounded by previously approved contents based on maximum payload weight. The PSB was evaluated for buckling in both the axial direction (PSB and spacer) due to an end drop and a side drop orientation (support disks). Based on results generated using ASME Code Case N-284-1, no buckling was predicted for the end drop for the PSB and spacer. The support disks were evaluated using plate theory and it was determined that buckling would not occur based on a bounding calculation performed for HAC. Based on the weight limit in Addendum B for Configuration 3, staff agrees that the structural effects are bound by a previous configuration. Confirmatory analysis by staff indicated a large margin of safety against buckling of the support disks.

2.6.8 Corner Drop

The TN-FSV package exceeds 220 lb; therefore this evaluation does not apply.

2.6.9 Compression

The PSB is an internal component to the package; therefore this requirement does not apply.

2.6.10 Penetration

The PSB is an internal component to the package; therefore this requirement does not apply.

2.7 Hypothetical Accident Conditions (10 CFR 71.73)

2.7.1 9-Meter Free Drop

The applicant noted that the effect of the PSB on the TN-FSV is bounded by previously approved contents based on maximum payload weight. The PSB was evaluated for buckling in both the axial direction (PSB and spacer) due to an end drop and a side drop orientation (support disks). Based on results generated using ASME Code Case N-284-1, buckling was not predicted for the end drop for the PSB and spacer. The support disks were evaluated using plate theory and it was determined that buckling would not occur based on the fact that the applied load was approximately 1% of the critical buckling load. Based on the weight limit for Configuration 3, staff agrees that the structural effects are bound by a previous configuration. Confirmatory analysis by staff indicated a large margin of safety against buckling of the support disks.

2.7.2 Crush

The TN-FSV cask exceeds 1100 lb; therefore this evaluation does not apply.

2.7.3 Puncture

The PSB is an internal component to the package; therefore this requirement does not apply.

2.7.4 Thermal

The thermal evaluation demonstrated that the temperatures and associated pressures within the TN-FSV were bounded by previously approved contents with respect to the effects on the package. The applicant concluded that the effects of pressure due the thermal effects of fire would not impact the structural performance of the PSB since it does not have any sealed cavities. With respect to the spacer, it was concluded that a pressure of 6.4 psig would have a negligible effect. Staff reviewed the summary of temperatures and pressures and agrees that they are bound by a previously approved configuration.

2.7.5 Immersion - Fissile Material

The PSB is an internal component to the package; therefore this requirement does not apply.

2.7.6 Immersion - All Packages

The PSB is an internal component to the package; therefore this requirement does not apply.

2.7.7 Deep Water Immersion Test

The PSB is an internal component to the package; therefore this requirement does not apply.

2.8 Evaluation Findings

On the basis of the review of the statements and representations in the application, the staff concludes that the package has been adequately described and that its structural capabilities meet the requirements of 10 CFR Part 71.

3.0 THERMAL

The staff reviewed the PSB thermal design and evaluation to assess whether the package and fuel material temperatures will remain within their allowable values or criteria for NCT and HAC as required in 10 CFR Part 71 “Packaging and Transportation of Radioactive Materials.” The application was also reviewed to determine whether the package fulfills the acceptance criteria listed in Section 3 of NUREG-1617, as well as associated Interim Staff Guidance (ISG) documents.

3.1 Description of Changes

Addendum B documents the thermal safety of the PSB, Configuration 3, for NCT and HAC when transported within the TN-FSV packaging.

3.2 Description of the Thermal Design

The PSB and its spacer are designed to passively dissipate the decay heat of up to seven spent fuel rods and/or guide tubes. The PSB has a 166-in overall length. The PSB consists of a lid, seven fuel tubes, and a basket body. The PSB outer diameter is 17.5 inches. It does not provide any containment function and, as such, it is designed with bottom drain holes to permit water draining. Since the PSB overall length is smaller than the TN-FSV cask cavity, a stainless steel spacer is used to position the PSB inside the cask to facilitate loading and unloading. The spacer also ensures the fuel rods active region lies between the impact limiters which minimizes thermal resistance. The PSB contents are up to seven PWR fuel rods or guide tubes of any PWR fuel rod type with a maximum heat load of 360 watts. The maximum temperatures for the PSB under NCT and HAC within the TN-FSV packaging are summarized in Tables B3.3-1 and B3.4-1 of Addendum B, respectively.

3.3 Normal Conditions of Transport

Since the PSB is designed to fit within the TN-FSV packaging and since the PSB maximum decay heat is equal to or less than the TN-FSV currently licensed total decay heat (360 watts), the developed PSB thermal model uses the maximum inner shell temperature reported in Table 3-4 of the Safety Analysis Report for the TN-FSV Packaging for Configuration 1. The applicant developed a three-dimensional (3-D) thermal model that represents a 60 degree section of the lower half of the PSB plus the spacer. This thermal model was built using the Thermal Deskop and SINDA/FLUINT software. SINDA/FLUINT is a general purpose code based on either finite difference and/or finite element approach and can be used to compute the steady-state and transient response of a given problem. The decay heat of the fuel rods is modeled using a surface heat flux on the cylindrical elements representing the fuel cladding. This heat flux is modified by the use of a peaking factor to account for axial variation in the decay heat profile. Heat transfer by conduction, convection, and radiation across an air-filled void between the exterior of the PSB and the TN-FSV inner shell is included in the thermal model. To take credit for convection, the thermal conductivity of air is multiplied by a Nusselt number obtained from a correlation applicable to this geometry. The TN-FSV cask inner shell is modeled as a zero-thickness wall with an 18-inch diameter. A uniform temperature of 167°F is applied across this surface area. This temperature corresponds to the peak temperature obtained from Table 3-4, as previously determined for NCT of the TN-FSV.

Addendum B, Table B3.3-1, presents the predicted component temperatures. It can be seen from this Table that a substantial thermal margin is predicted for all components. For Configuration 1, the Safety Analysis Report for the TN-FSV Packaging states that the maximum TN-FSV cask seal temperature under NCT is 166°F which is well within the long term allowable temperature of 225°F for the butyl rubber seals. Using the predicted thermal results, the applicant calculated a maximum normal operating pressure of 3.6 psig for NCT.

3.4 Hypothetical Accident Conditions

The applicant used the same approach and models from NCT to evaluate the HAC. The maximum temperature obtained during the HAC transient for the TN-FSV cask inner shell (per Table 3-7 of the Safety Analysis Report for the TN-FSV Packaging) is used as a boundary condition for the 3-D thermal model of the PSB. The HAC evaluation of the PSB is based on a steady state calculation using this maximum temperature, as previously determined for HAC of the TN-FSV cask. The TN-FSV fire test conditions fulfill 10 CFR 71.73(c) requirements. PSB components maximum temperatures under these conditions are presented in Table B3.4-1. It can be seen from this Table that all temperatures for the PSB components remain well below the allowable values. Using the predicted thermal results, the applicant calculated a maximum normal operating pressure of 6.4 psig for HAC.

3.5 Confirmatory Analysis

The staff reviewed the applicant's models and calculation options to determine the adequacy of the proposed PSB thermal design. Additionally, the staff performed selected confirmatory analyses using the FLUENT finite volume computational fluid dynamics (CFD) code, as an independent evaluation of the thermal analysis and modeling options presented in the application. Specifically the staff developed a 3-D FLUENT model of the PSB including all the components. The main purpose of this confirmatory analysis model was to verify the adequacy of the applicant's modeling options and assumptions. The staff's confirmatory calculation for NCT resulted in temperature values that were on the same order of magnitude as compared to the applicant's calculated results. Therefore, the staff finds the applicant's calculated temperatures and associated modeling approach acceptable.

The staff also performed a confirmatory analysis of the PSB thermal evaluation using ANSYS engineering simulation software. A 60-degree section of the PSB, its components, and the inner wall of the TN-FSV cask were developed. This 3-D model is similar to the one provided by the applicant in Figure B3.3-1 of Addendum B. Appropriate material attribution was done to each part using the materials and properties specified in Section B3.2 of Addendum B. For the NCT evaluation, a cask's inner wall temperature of 167°F was used along with radiation, conduction and convection as described by the applicant in Section B3.3. Heat generation was applied to the fuel rods to model the decay heat dissipated by these cylindrical elements, in a similar manner as the surface heat flux used by the applicant. For the HAC, a steady-state model was developed using a similar approach, but varying the temperatures of the ambient and the cask's inner wall as described in Section B3.4. For both conditions, the confirmatory analysis resulted in temperature values that were similar to the ones obtained by the applicant. The outcome of this confirmatory analysis supports the applicant's calculated temperatures and corroborates the acceptability of the used thermal modeling approach.

3.6 Evaluation Findings

The staff has reviewed the package thermal design and concludes that the package material and component temperatures will not extend beyond the specified allowable limits during normal conditions of transport or hypothetical accident conditions consistent with the tests specified in 10 CFR 71.71 and 71.73.

4.0 CONTAINMENT

The staff reviewed the application for the TN-FSV package to verify that the containment performance of the package design has been adequately evaluated under normal conditions of transport and hypothetical accident conditions, and that the package design meets the containment performance requirements of 10 CFR Part 71. The application was also reviewed to determine whether the package fulfills the acceptance criteria listed in Section 4 of NUREG-1617, as well as associated ISG documents.

4.1 Description of Containment System

The applicant requested several changes to the authorized contents of the TN-FSV. However, no changes were made to the containment system design, and the package will remain tested to leaktight standards of ANSI N14.5. The new contents do not affect the integrity of the containment system under NCT or HAC. Therefore, the staff finds that the requested changes do not impact the performance of the previously approved TN-FSV containment system, and are acceptable.

4.2 Evaluation Findings

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

5.0 SHIELDING

5.1 Description of Shielding Design

The TN-FSV transportation cask is designed to allow transport of up to seven PWR rods of varying designs within the PSB. Shielding of the TN-FSV is provided by both the cask and the PSB. The main components of the shielding design are the stainless steel and lead shielding, with aluminum and balsa also credited. All exclusive use dose rates are generated using a design basis source that bounds all fuel rods allowed for transportation.

The applicant provided an analysis to demonstrate that the package meets the external radiation standards of 10 CFR Part 71.47 and 71.51. The source term was assumed to be up to seven 15x15 PWR assembly fuel rods since they contain a bounding fuel loading of 2.36 kg/rod, at burnups of 60, 72, and 80 GWD/MTU at an initial ^{235}U enrichment of 4%. The decay heat is still limited to 360 watts per the original SAR license. For a burnup of 60 GWD/MTU the minimum decay time is 180 days, while for 72 and 80 GWD/MTU, the minimum decay time is 365 days. Three irradiation cycles were assumed with conservatively short cycle lengths.

Gamma and neutron source terms were computed using the SAS2 module of the SCALE5.0 code system with the fuel burnup and decay analysis performed by the ORIGEN-S code. Based on this analysis, the design basis source was found to be seven 15x15 fuel rods with a burnup of 72 GWD/MTU and a cooling time of 450 days. This bounding source resulted in a SAS2 surface dose rate of 135 mrem/hr and 8.4 mrem/hr at 2 meters from the transport vehicle and bounds all other fuel types defined in the fuel qualification table. The normal conditions analyses at the package surface were used to show that the one meter accident conditions dose rate limit would be met. The applicant calculated the maximum dose rates shown below using MCNP5 v1.40 using a similar methodology to the previous Configurations 1 and 2 for the TN-FSV.

		Dose Rate (mrem/hr)			
Normal Conditions		**Gamma**	**Neutron**	**Total**	**Limit**
Package Surface	Top	0.211	0.146	0.357	200
	Side	42	147	189	200
	Bottom	1.86	0.162	2.022	200
2 m from Surface	Top	0.572	0.426	0.998	10
	Side	3.34	6.35	9.69	10
	Bottom	0.0596	0.416	0.4756	10
Driver	Top	0.0104	0.0807	0.0911	2
HAC					
1 m from Surface	Top	2.78	0.517	3.297	1000
	Side	14.7	40.1	54.8	1000
	Bottom	0.126	0.06	0.186	1000

5.2 Evaluation Findings

The staff performed independent source term and dose rate calculations for normal conditions of transport, focusing on the NCT Side dose rate at the package surface since this rate approached the limits of 10 CFR 71.47. In all instances, the calculated dose rates were in agreement with those performed by the applicant. Therefore, staff agrees that the TN-FSV transportation package meets the external radiation standards of 10 CFR Part 71.

6.0 CRITICALITY EVALUATION

6.1 Description of Criticality Design

The TN-FSV package is designed to ship up to seven PWR rods of various designs. The applicant utilized very conservative assumptions in modeling the cask, and all fuel is modeled as fresh fuel. The system was modeled for both NCT and HAC using MCNP5 v1.40 and used the ENDF/B-VI cross section set. In all instances, the resultant k_{eff} values were significantly below the Upper Safety Limit of 0.9349.

NRC staff reviewed the submitted addendum and found that the applicant's analysis was very conservative and thorough. Although only two of the fuel rod types were examined in the analysis, staff agrees with the applicant that the reactivity of the system is so small as to adequately encompass the other PWR fuel rod types that are permitted for transportation.

6.2 Evaluation Findings

Based on NRC staff verification of adequate system modeling and that the acceptance standard of a maximum k_{eff} of 0.95 was maintained for all analyzed scenarios, the TN-FSV transportation package was considered acceptable for transportation under 10 CFR Part 71.

7.0 PACKAGE OPERATIONS

The staff reviewed the instructions for package operation in Chapter B7 of Addendum B. The procedures include preparation of the TN-FSV and PSB for loading, including visual inspection of the package components prior to loading. Procedures for both wet and dry loading of PWR fuel rods in the PSB, including procedures for maintaining an inert atmosphere are provided. The pre-shipment leak tests for the TN-FSV are specified. Additionally, Chapter B7 includes procedures for unloading the package and preparing an empty package for transport. It is noted that the package will be prepared for transport and operated according to site-specific written procedures which will be consistent with the procedures in Addendum B. The certificate has been conditioned to specify that the package in Configuration 3 is operated and prepared for shipment in accordance with Chapter B7.

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

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The staff reviewed Chapter B8 of Addendum B for the acceptance tests and maintenance program for Configuration 3. Section B8.1 provides the acceptance tests for the PSB. Additionally, the leakage test requirements for the TN-FSV to be used in Configuration 3 are included, since the TN-FSV cask, not the PSB, provides the containment boundary.

Section B8.2 describes the maintenance program for Configuration 3. Maintenance of the PSB includes periodic replacement of the lid socket head cap screws. Periodic leakage rate tests are performed on the TN-FSV cask, which provides the containment boundary for Configuration 3.

The certificate has been conditioned to specify that the TN-FSV package in Configuration 3 is acceptance tested and maintained in accordance with Chapter B8 of Addendum B.

Based on review of the statements and representations in the application, the staff concludes that the acceptance tests for the packaging meet the requirements of 10 CFR Part 71 and that the maintenance program is adequate to assure packaging performance during its service life.

CONDITIONS

The conditions specified in the Certificate of Compliance have been revised to include provisions for Configuration 3 and incorporate changes to designate the certificate as "-96." These conditions are listed below:

1. For Configuration 3:

   (1) In the 12-month period prior to shipment and after seal replacement, each containment seal of the outer cask must be tested to show a leak rate no greater than 1×10^{-7} ref-cm^3/sec. The leak test must have a sensitivity of at least 5×10^{-8} ref-cm^3/sec.

   (2) Prior to each shipment, the outer cask containment seals (main seal and vent seal) must be leak tested in accordance with Section B7.1.2 of Addendum B. The seals must show no leakage greater than 1×10^{-7} ref-cm^3/sec or no leakage when tested to a sensitivity of at least 1×10^{-3} ref-cm^3/sec. The drain seal of the outer cask must also be tested if the drain port cover has been removed since the seal was last leak tested.

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

   (a) The package must be prepared for shipment and operated in accordance with Chapter 7 of the Safety Analysis Report for Configuration 1; Chapter 7 of Addendum A for Configuration 2; and Chapter B7 of Addendum B for Configuration 3.

   (b) Each packaging must meet the acceptance tests and must be maintained in accordance with Chapter 8 of the Safety Analysis Report for Configuration 1; Chapter 8 of Addendum A for Configuration 2; and Chapter B8 of Addendum B for Configuration 3.

   (c) Prior to each shipment for Configurations 1, 2, and 3, the cask main closure seal and vent seal must be inspected. The drain seal must be inspected if the drain port cover has been removed during preparation for shipment. In addition, prior to each shipment for Configuration 2, the Oak Ridge Container main closure seal and vent seal must be inspected. For Configurations 1, 2, and 3, all seals must be replaced within the 12-month period prior to shipment, or earlier if inspection shows any defect.

3. Transport of fissile material by air is not authorized.

4. Fabrication of additional impact limiters (balsa and redwood encased in stainless steel shells) is not authorized.

5. Packagings may be marked with Package Identification Number USA/9253/B(U)F-85 until June 30, 2010, and must be marked with Package Identification Number USA/9253/B(U)F-96 after June 30, 2010.

CONCLUSION

Based on the statements and representations in the application, as supplemented, and the conditions listed above, the staff concludes that the Model No. TN-FSV package design has been adequately described and evaluated and that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9253, Revision No. 11, on June 30, 2009.