UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION REPORT

Docket No. 71-9235
Model No. NAC-STC
Certificate of Compliance No. 71-9235
Revision 20

Summary

By application dated June 7, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18162A167), as supplemented on August 16, 2018 (ADAMS Accession No. ML18236A684) December 18, 2018 (ADAMS Accession No. ML18354A750), and February 1, 2019, NAC International, Inc., (NAC or the applicant) requested Revision to Certificate of Compliance (CoC or the certificate) No. 9235, for the Model No. NAC-STC package.

The staff used the guidance in NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel," as well as associated ISG documents to perform the review of the proposed packaging changes. Based on the statements and representations in the application, as supplemented, and the conditions listed in the following chapters, the staff concludes that the package meets the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 71.

EVALUATION

1.0 GENERAL INFORMATION

1.1 Packaging Description

The packaging body is made of two concentric stainless steel shells. The inner shell is 1.5 inches thick and has an inside diameter of 71 inches. The outer shell is 2.65 inches thick and has an outside diameter of 86.7 inches. The annulus between the inner and outer shells is filled with lead.

The inner and outer shells are welded to steel forgings at the top and bottom ends of the packaging. The bottom end of the packaging consists of two stainless steel circular plates which are welded to the bottom end forging. The inner bottom plate is 6.2 inches thick and the outer bottom plate is 5.45 inches thick. The space between the two bottom plates is filled with a 2-inch thick disk of a synthetic polymer (NS4FR) neutron shielding material.

The packaging is closed by two steel lids which are bolted to the upper end forging. The inner lid (containment boundary) is 9 inches thick and is made of Type 304 stainless steel. The outer lid is 5.25 inches thick and is made of SA-705 Type 630, H1150 (17-4PH) stainless steel. The inner lid is fastened by forty-two, 1.5-inch diameter bolts and the outer lid is fastened by thirty-six (36), 1-inch diameter bolts. The inner lid is sealed by two O-ring seals. The outer lid is equipped with a single O-ring seal. The inner lid is fitted with a vent and drain port which are sealed by O-rings and cover plates. The containment system seals may be metallic or Viton.

Viton seals are used only for directly-loaded fuel that is to be shipped without subsequent long-term interim storage.

The packaging body is surrounded by a 1/4-inch thick jacket shell constructed of 24 stainless steel plates. The jacket shell is 99 inches in diameter and is supported by 24 longitudinal stainless steel fins which are connected to the outer shell of the packaging body. Copper plates are bonded to the fins. The space between the fins is filled with NS4FR shielding material.

Four lifting trunnions are welded to the top end forging. The package is shipped in a horizontal orientation and is supported by a cradle under the top forging and by two trunnion sockets located near the bottom end of the packaging.

The package is equipped at each end with an impact limiter made of redwood and balsa. Two impact limiter designs consisting of a combination of redwood and balsa wood, encased in Type 304 stainless steel, are provided to limit the g-loads acting on the package during an accident. The predominantly balsa wood impact limiter is designed for use with all the proposed contents. The predominately redwood impact limiters may only be used with directly loaded fuel or the Yankee-multi-purpose canister (MPC) configuration.

The package includes a stainless steel ring assembly which, when applicable, includes a top shield ring and shear ring. The stainless steel ring assembly is installed on the upper cask body, between the top impact limiter and the neutron shield shell in the upper region of the packaging. The shield ring consists of four sectors: bottom sector, top sector and two side sectors. The bottom sector of the shield ring assembly is an SA-705, Type 630, 17-4PH stainless steel forging. The top sector and side sectors are fabricated from SA-240, Type 304 stainless steel. The bolt material is SA-193, Grade B6, Type 410 stainless steel for all bolts.

The package also includes shield plates at the periphery of the top weldment assembly which, when applicable, may be added to the periphery of the top weldment to provide augmented shielding at the top region of the fuel basket for specific configurations. The shield plates are 1.25 inches thick with a same axial height as the existing support plates and the ring in basket axial direction. The shield plates are fabricated from the same material as the top weldment plates (SA 240, Type 304 stainless steel).

1.2 Contents

There were no changes to the package's approved contents.

1.3 Drawings

NAC International revised 1 drawing:

423-872, Rev. 7	Top Weldment, Fuel Basket, PWR, 26 Element, NAC-STC Cask

2.0 STRUCTURAL EVALUATION

The objective of the structural review is to verify that the structural performance of the package has been adequately evaluated and meets the requirements of 10 CFR Part 71, including the tests and conditions for normal conditions of transport and hypothetical accident conditions.

In Revision 18C of the NAC-STC SAR, the applicant updated drawing 423-872 with the description and configuration of the shield plates. The applicant stated that the new shield plates are located in the periphery of the top weldment in order to provide additional shielding at the top region of the fuel basket. They are 1.25 inches thick with the same height and material (SA 240, Type 304 stainless steel) as the existing support plates in the basket.

Additional descriptions include a note stating that the shield plate is optional. The staff corroborated the physical characteristics of the shield plates by reviewing drawing 423-872 and by reviewing the proposed changes in the new revision of the applicant's CoC, submitted as part of this amendment. Per the applicant's proposed CoC, the staff noted that the modified shielding plates are meant to be used only when shipping HBU and LBU.

In SAR Appendix J, the applicant provided an additional calculation package to assess the structural adequacy of the basket top weldment and threaded rods with shield plates installed. The shield plates are to be attached to the ring of the top basket weldment and have the same height as the ring. The applicant noted that the shield plates are supported by the 1-inch thick plate located at the top weldment assembly and by the cask lid during bottom and top end drop condition scenarios, respectively. The applicant stated that the shield plates provide additional stiffness to the top weldment assembly. Additionally, the applicant discussed the effect of the shield plates on the threaded rods. The function of the threaded rods is to align and support the support disks in the fuel basket in the casket cavity. The applicant stated that the additional (total) weight of the optional shielding plates is 370 pounds. To account for the effect of this additional weight on the threaded rods, the applicant evaluated the following cases:

- stress evaluation of the threaded rods during a 1-foot end drop load condition and
- buckling evaluation of threaded rods during 30-foot end drop accident condition (including maximum compressive load and maximum combined axial and bending loads).

In all cases evaluated, a value of 13,500 pounds was used as the total weight transmitted to the rods. The applicant stated that this weight bounds the additional weight of the shield plates based on the acceleration experienced by the package and is therefore conservative.

Resulting margins of safety for the evaluations provided were reviewed by the staff and found to be adequate. The staff reviewed the calculation package submitted in Appendix J, focusing its review on the applicant's claim regarding the bounding weight of 13,500 pounds. The staff reviewed Revision 18C of the applicant's SAR and associated CoC and was able to confirm that the weight value used in the evaluations bounds the additional weight of the optional shielding plates. Based on the evaluations provided, the staff concludes that the calculation package provided in appendix J provides reasonable assurance of the structural adequacy of the basket due to the addition of the shield plates.

Based on the results of the evaluation, the applicant provided additional edits to applicable parts of SAR Sections 2.6 and 2.7, discussing the results of their evaluations. The staff reviewed the SAR edits and concludes that the new and revised text included in the SAR describes the new evaluations made, and further clarifies the criteria used to demonstrate the structural adequacy of the package with the optional shielding plates installed.

Based on review of the statements and representations in the application, the staff concludes that the structural design has been adequately described and evaluated and that the package will continue to meet the structural requirements of 10 CFR Part 71.

3.0 THERMAL EVALUATION

There were no changes that affected the package's thermal evaluations.

4.0 CONTAINMENT

There were no changes that affected the package's containment analysis.

5.0 SHIELDING EVALUATION

The objective of the review is to verify that the shielding of the Model NAC-STC package provides adequate protection against direct radiation from its contents and that the package design meets the external radiation requirements of 10 CFR Part 71 under NCT and HAC.

The applicant requested to modify the CoC to include a new acceptance criterion for the insulation region at the top of the lead shield. The proposed acceptance criterion applies for direct load fuel for both high burnup (HBU) and low burnup (LBU) fuel.

The staff reviewed the proposed changes and its effect on the shielding design of the NAC-STC Certificate No. 71-9235 using the guidance in Chapter 5 of NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel," March, 2000.

5.1 Description of the Shielding Design

The applicant requested to add a fabrication acceptance criterion in Section 8.1.5.1.1 of the application, which states that for a direct load cask the effectiveness of the upper 10.18 inches of the cask radial lead shield may be reduced by an equivalent of 0.65 inches of radial lead to accommodate the Fiberfrax lead insulation. The Fiberfrax insulation is present as part of the current NAC-STC design and is shown in drawing 423-802 Rev. 22 on page 5 of 7 in detail G-G. The applicant stated during a teleconference with the staff that the presence of the Fiberfrax insulation can cause the lead shield, due to the pouring of the lead, to have a slightly lower thickness or higher porosity reducing its effectiveness in this region. The lead shield itself is not fabricated with a smaller radius and the alternate acceptance criteria is only needed for the cases where the count rate in this region is higher than the original acceptance criteria by an amount equivalent to what would be seen with a lead shield reduction of 0.65 inches.

When the package is fabricated, gamma scans are performed per the acceptance criteria in Section 8.1.5.1 of the application, "Gamma Shield Test," to demonstrate that the shielding is functional. If the count rate of the fabricated cask exceeds that of a mock-up that is designed to be at the minimum allowable shielding dimensions per the cask drawings, then corrective action must be taken. The applicant requested an alternative acceptance criterion if the region of the Fiberfrax insulation does not meet the acceptance criteria by including the basket top weldment as detailed in drawing 423-782. This is only allowed if the count rate of the fabricated cask in the region of the Fiberfrax insulation shows to be lower than that of the mockup by what would be equivalent to 0.65 inches of lead.

To accommodate this acceptance criteria, the applicant requested to include a CoC condition that states that the cask shall use the shield plate for the basket top weldment as detailed in license drawing 423-872 when a cask is adhering to the gamma shielding integrity acceptance criteria described in Section 8.1.5.1.1 of the application.

The staff reviewed drawing 423-872 of the basket top weldment shield plate and drawing 823-802, Rev. 22 where the area of insulation is shown and determined that the drawings include dimensions and tolerances in sufficient detail to support its safety function.

5.2 Source Specification

In the direct load configuration, the NAC-STC is currently authorized to ship HBU and LBU fuel. As defined by the CoC, HBU fuel is fuel that experiences burnup exceeding 45 GWd/MTU.

The NAC-STC can accommodate up to 26 assemblies in the LBU configuration. For HBU fuel the number and configuration of assemblies is specified by SAR drawing 423-800 which allows loading patterns for 14, 16 and 20 assemblies, empty basket cells are loaded with thermal shunts.

Assemblies must meet the fuel specifications in Table 1 of the CoC. For LBU assemblies, the allowable burnup, enrichment and cooling time combinations are specified in Table 2 of the CoC. For Framatome-Cogema 17x17 fuel, additional allowable burnup, enrichment and cooling time combinations are specified in Table 6 of the CoC; however, use of these combinations require use of the shield ring assembly as specified in drawing 423-927. HBU fuel is only allowed for shipment for the Framatome-Cogema 17x17 fuel listed in Table 1 of the CoC. The allowable cooling times for specified burnup and enrichment combinations are given in Tables 3 through 5 of the CoC and are divided into three maximum cobalt impurity levels (0.4, 0.8 and 1.2 g/kg). When using the shield ring assembly, the allowable cooling times for specified burnup and enrichment combinations are given in Tables 7 through 9 of the CoC.

5.3 Model Specification

To justify the requested change does not adversely affect the package's compliance with regulatory dose rate limits, the applicant performed dose rate evaluations in SAR Sections 5.9 and 5.10 with the reduced lead thickness and including top weldment configuration based on the design basis analyses for HBU and LBU fuel, respectively, and compared these evaluations to the design basis analyses without the reduced lead configuration.

5.3.1 HBU Fuel

For HBU fuel the applicant used the same methodology discussed in its design basis calculations in SAR Sections 5.8.6, 5.8.7, and 5.8.8, however it included the reduction in lead thickness by replacing the outer 0.65 inches of the top 10.18 inches of the radial lead shield with void, and added the top weldment as detailed in drawing 423-782. The applicant modeled the partial loadings of configurations A, B, and C per SAR drawing 423-800 for the 3 different cobalt impurity levels specified within the CoC, 0.4, 0.8 and 1.2 g/kg. The applicant calculated the minimum cooling time required to meet regulatory dose rate limits. This package with HBU fuel contents is limited by the surface dose rate limit of 200 mrem/hr, as shown in SAR Tables 5.8.6-1, 5.8.7-1 and 5.8.8-1.

5.3.2 LBU Fuel

For LBU fuel the applicant used the same methodology discussed in its design basis calculations in SAR Sections 5.1 through 5.5. As with the HBU model it included the reduction in lead thickness by replacing the outer 0.65 inches of the top 10.18 inches of the radial lead shield with void, and added the top weldment as detailed in drawing 423-782.

The applicant modeled the LEU fuel (burnup equal to or less than 45 GWd/MTU) using a Cobalt impurity at 1.2 g/kg. The applicant calculates the minimum cooling time required to meet regulatory dose rate limits.

5.3.3 HAC

For HAC, the applicant modeled the proposed configuration C loading with 0.4 g/kg cobalt impurity. This is the most limiting (has the highest calculated dose rate) configuration for HAC based on the SAR Tables 5.8.6-2, 5.8.7-2 and 5.8.8-2. The applicant incorporated the reduced lead volume in modeling the lead slump which increases the lead void.

5.4 Evaluation

For the proposed configuration, the applicant shows in SAR Tables 5.9-1, 5.9-2, and 5.9-3 that the change in cooling times required to meet the regulatory dose rates for HBU fuel are within the uncertainty of the calculation. For LBU, SAR Table 5.10-1 shows that the cooling times required to meet the regulatory dose rates are either the same or lower (more conservative). For HBU HAC the applicant shows that even with the increased lead slump void space that the package still meets the 10 CFR 71.51(a)(2) dose rate limit at 1 meter.

The staff found that the applicant's results are expected. Based on SAR Figures 5.8.6-5, 5.8.7-5, and 5.8.8-5, the limiting dose rate is on the side just above the lead shield. This is due to the streaming path between the top of the lead shield and the lid. Reducing the lead thickness would show an increase in radial calculated dose rates, however the top shield weldment is providing enough shielding to the streaming pathways so that at the limiting location the dose rate not increase above regulatory limits and therefore the staff finds that the applicant's results, which show that there is very little change, are reasonable.

There are several allowable LBU assembly types (14x14, 15x15, etc.) that have separate loading tables and the applicant only evaluated the 17x17. The staff finds that the applicant has provided enough information to demonstrate with reasonable assurance that the proposed lead reduction and addition of the top shielding weldment configuration would not cause dose rates to exceed regulatory limits for any of the other approved LBU configurations. The staff is basing its finding on the applicant's LBU and HBU analyses. The staff finds that the HBU axial burnup profile would be more limiting at the top of the fuel assembly. The longer an assembly is burned the burnup profile flattens out and becomes less peaked by increasing burnup at the ends. This is reflected in the axial burnup profiles used by the applicant for both LBU and HBU fuel in SAR Figures 5.2-1 and 5.8.2-1, respectively. The LBU axial burnup profile in SAR Figure 5.2-1 shows less relative burnup at the top of the fuel than that of the HBU axial profile in SAR Figure 5.8.2-1 and therefore the source term for the HBU fuel at the top of the fuel assembly where the reduction in lead is would bound that of the LBU fuel. This effect is also reflected in the dose rate maps shown by the applicant in SAR Figures 5.8.6-5, 5.8.6-6, 5.8.7-5, 5.8.7-6, 5.8.8-5, and 5.8.8-6. Therefore, the HBU analysis would bound that of the LBU, and the staff finds the analysis of the single LBU analysis further demonstrates this and provides additional confirmation that the alternative configuration would not adversely affect the cask's capability of meeting regulatory dose rates.

Under NCT, for the part of the cask where the lead thickness would be reduced, the calculated dose rates are about a factor of 10 below the peak dose rate just above the lead shield as shown in SAR Figures 5.8.6-5, 5.8.7-5 and 5.8.8-5. The staff performed a confirmatory evaluation using MICROSHIELD. It compared the dose rate at the surface using a point source for both Co-60 and the spent fuel gamma source from SAR Tables 5.2-6 and 5.2-22. The staff evaluated the change for the gamma source only since the purpose of the lead is as a gamma shield. The results of the staff's evaluation show that the 0.65-inch reduction in lead shielding results in an increase in dose rate by a factor of about 2.6. This is within the margin to the limiting dose rate for this location as mentioned above.

Under HAC the applicant shows that there is an increase in the maximum calculated dose rate but that it is still below the regulatory limit. There is more margin to the regulatory limit than there is for NCT and the HAC dose rates are dominated by the neutron source due to the loss of the neutron shielding from the fire accident and the HAC accident dose rates are peaked at the center of the cask as shown in SAR Figures 5.8.6-6, 5.8.7-6 and 5.8.8-6. Therefore, the staff finds that the changes to the lead gamma shield toward the top of the cask would be less prominent under HAC and it finds the applicant's results to be expected.

5.5 Conclusion

Based on the evaluations and statements discussed in this SER, the staff found that the reduction in lead by 0.65 inches for the top 10.18 inches of the radial lead shield when using the top shield plate weldment will not cause the package to exceed regulatory dose rate limits.

Based upon the information provided by the applicant and the staff's confirmatory calculations the staff has reasonable assurance that the applicant's shielding analyses demonstrate that the package design meets the requirements of 10 CFR Part 71. However, a condition was added to the CoC to clarify when the shield plate is required during transportation, since it compensates for the reduction of the lead thickness for both high burnup fuel and low burnup fuel.

6.0 CRITICALITY EVALUATION

There were no changes that affected the package's criticality evaluations.

7.0 PACKAGE OPERATIONS

There were no changes that affected package operations.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM REVIEW

SAR Chapter 8 identifies the acceptance tests and maintenance programs to be conducted on the Model No. NAC-STC package and verifies their compliance with the requirements of 10 CFR Part 71.

The applicant requested to add an alternate acceptance criterion for the region of the lead shield where the Fiberfrax insulation exists. The changes to the acceptance criteria are discussed in Section 5.1 of this SER. When performing gamma scans of the fabricated cask, the applicant determines the allowable change in count rate which it translates to lead thickness. This is acceptable to the staff because for a known source and detector, in this case the source is specified as a Co-60 source in SAR Section 8.1.5.1, a reproducible relationship can be developed to determine the measured count rate as a function of lead thickness (i.e., increase in lead thickness would reduce the count rate and vice versa).

The staff reviewed the proposed language and found that it is clear and provides sufficient detail to ensure that the changes have no adverse impact on safety. Based on the statements and representations in the application, the staff concluded that the revised acceptance criteria meet the requirements of 10 CFR Part 71, and that they are adequate to assure the package will be constructed in a manner consistent with its evaluation for approval. Further, the certificate is conditioned to specify that the package must be prepared for shipment and operated in accordance with the Acceptance Tests and Maintenance Procedures in SAR Chapter 8, as amended.

9.0 CONDITIONS

The staff made editorial changes to improve the readability of the CoC. The CoC includes the following condition(s) of approval:

The following drawing was revised and incorporated into the certificate of compliance:

423-872, Rev. 7 Top Weldment, Fuel Basket, PWR, 26 Element, NAC-STC Cask

5.(b)(2)(4) was revised to make use of the shield ring required for packages containing high burnup fuel assemblies, as described in 5.(b)(1)(i)(4). In addition, at NAC's request, the second paragraph of this condition was also removed as low burnup fuel assemblies described in Item 5.(b)(1)(i)(1) will no longer be comingled with high burnup fuel assemblies described in 5.(b)(1)(i)(4).

Condition 13 was added to clarify when the shield plate is required during transportation, since it compensates for the reduction of the lead thickness for both high burnup fuel and low burnup fuel. For packages fabricated with the reduced lead content in the Fiberfrax region, use of the shield plate, as configured in NAC International Drawing No. 423-872, is required. Packages in this configuration are accepted using the gamma shielding integrity acceptance criteria described in SAR Section 8.1.5.1.1.

Conditions 13 and 14 were renumbered to account for the addition of a new Condition 13.

The references section was updated to include the application for this amendment dated June 7, 2018, as supplemented on August 16, 2018, December 18, 2018, and February 1, 2019.

10.0 CONCLUSIONS

Based on the statements and representations contained in the application, as supplemented, and the conditions listed above, the staff concludes that the design has been adequately described and evaluated, and the Model No. NAC-STC package meets the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. NAC-STC, Revision No. 20.