January 10, 2012

Mr. Anthony Patko
Director, Licensing
Engineering
NAC International
3930 East Jones Bridge Road, Suite 200
Norcross, GA 30092

SUBJECT: AUTHORIZATION FOR A ONE-TIME SHIPMENT OF THE DOUNREAY FUEL CONTENTS IN THE MODEL NO. NAC-LWT PACKAGE (TAC NO. L24602)

Dear Mr. Patko:

As requested by your application dated November 10, 2011, pursuant to Title 10 of the Code of Federal Regulations Part 71, Certificate of Compliance (CoC) No. 9225, for Model No. NAC-LWT package, is amended with the following condition:

> A one-time shipment of five (5) special fuel assemblies in the currently certified Model No. NAC-LWT transportation package specified as follows:

- Three (3) 4x4 square EK-10 rod arrays (two with 16 rods; one with 15 rods)
    - UO_2-Mg fuel matrix/Al clad
    - Nominal 10 wt.% U-235
    - < 120 g U-235 per array
    - The maximum amount Uranium per assembly analyzed is 1400g
    - The maximum burnup analyzed is 20,000 MWd/MTU
    - The minimum cooling time is 28.3 years

- One (1) concentric tube ITR assembly (four square tubes)
    - U/Al alloy fuel/Al clad
    - Similar to DIDO assembly currently authorized, but uses four square "boxes" instead of cylindrical tubes
    - Nominal 90 wt.% U-235
    - < 170 g U-235 per assembly
    - The maximum Uranium per assembly analyzed is 220 g
    - The maximum burnup analyzed is 15,000 MWd/MTU
    - The minimum cooling time is 10 years

- One (1) hexagonal array (91 rods) TTR assembly
    - U/Al alloy fuel/Al clad
    - Nominal 90 wt.% U-235
    - < 400 g U-235 per assembly

- The maximum Uranium per assembly analyzed is 500g
- The maximum burnup analyzed is 60,000 MWd/MTU
- The minimum cooling time is 22.6 years

The assemblies will be transported in the currently certified Metal Test Reactor (MTR) basket with the center basket opening blocked to prevent misloading.

The following additional conditions apply:

- All other conditions of CoC No. 9225 shall remain the same.
- This authorization shall expire on December 31, 2013.

If you have any questions regarding this authorization, please contact me or Kim Hardin of my staff at (301) 492-3339.

Sincerely,

/RA/

Michael D. Waters, Chief
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9225

Enclosure: Safety Evaluation Report

cc: R. Boyle, Department of Transportation
J. Shuler, Department of Energy

- The maximum Uranium per assembly analyzed is 500g
- The maximum burnup analyzed is 60,000 MWd/MTU
- The minimum cooling time is 22.6 years

The assemblies will be transported in the currently certified Metal Test Reactor (MTR) basket with the center basket opening blocked to prevent misloading.

The following additional conditions apply:

- All other conditions of CoC No. 9225 shall remain the same.
- This authorization shall expire on December 31, 2013.

If you have any questions regarding this authorization, please contact me or Kim Hardin of my staff at (301) 492-3339.

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Michael D. Waters, Chief
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Enclosure: Safety Evaluation Report
cc: R. Boyle, Department of Transportation
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SAFETY EVALUATION REPORT

Docket No. 71-9225
Model No. NAC-LWT
Certificate of Compliance No. 9225

SUMMARY

By application dated November 10, 2011, NAC International (NAC or the applicant) requested an authorization to Certificate of Compliance (CoC) No. 9225 for the Model No. NAC-LWT transportation package. NAC requested a one-time authorization to ship special fuel assemblies.

This shipment is necessary to support a shipment from the Dounreay Nuclear Facility in Scotland to the Savannah River Site in the U.S. The package loading operations and the established shipment schedule will be established by the U.S. Department of Energy (DOE) National Nuclear Security Administration (NNSA) Foreign Research Reactor (FRR) program. A two-year authorization period for this one-time shipment is granted based on the fact that NNSA may not make the 2012 shipment plans, which would move the shipment date to a 2013 shipment date. This shipment is in the interest of U.S. national security.

CoC No. 9225 has been amended by letter based on the statements and representations in the application, and 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

By application dated November 10, 2011, NAC requested a one-time authorization to ship the following five special fuel assemblies in up to six cells in the currently certified Model No. NAC-LWT transportation package specified as follows:

- Three (3) 4x4 square EK-10 rod arrays (two with 16 rods; one with 15 rods)
    - UO_2-Mg fuel matrix/Al clad
    - Nominal 10 wt.% U-235
    - < 120 g U-235 per array
    - The maximum amount Uranium per assembly analyzed is 1,400g
    - The maximum burnup analyzed is 20,000 MWd/MTU
    - The minimum cooling time is 28.3 years

- One (1) concentric tube ITR assembly (four square tubes)
    - U/Al alloy fuel/Al clad
    - Similar to DIDO assembly currently authorized, but uses four square "boxes" instead of cylindrical tubes

- Nominal 90 wt.% U-235
- < 170 g U-235 per assembly
- The maximum Uranium per assembly analyzed is 220 g
- The maximum burnup analyzed is 15,000 MWd/MTU
- The minimum cooling time is 10 years

- One (1) hexagonal array (91 rods) TTR assembly

  - U/Al alloy fuel/Al clad
  - Nominal 90 wt.% U-235
  - < 400 g U-235 per assembly
  - The maximum Uranium per assembly analyzed is 500g
  - The maximum burnup analyzed is 60,000 MWd/MTU
  - The minimum cooling time is 22.6 years

The assemblies will be transported in the currently certified Metal Test Reactor (MTR) basket with the center basket opening blocked to prevent misloading.

2.0 Structural Review

As summarized in Attachment one to the request, NAC also performed an evaluation of the structural integrity of the Dounreay fuel for the NCT and HAC of the transport. The evaluation includes side and end drops of the fuel in the package using the design basis decelerations for the Model No. NAC-LWT. The heaviest assembly weighs less than 11 pounds, which is bounded by the currently certified 80 pound per cell content weight limit.

Based on the evaluation summary, the staff has reasonable assurance that the package will continue to meet the structural requirements of 10 CFR Part 71.

3.0 Thermal Review

The total heat load for the contents is calculated to be less than 3 watts (1998 data).

Based on the statements and representations in the application, there are no changes that affect the currently approved thermal evaluation of the payload during the shipment and there continues to be reasonable assurance that the package will meet the thermal requirements of 10 CFR Part 71.

4.0 Containment Review

The package is approved as leaktight, which does not change with this approval.

Based on the statements and representations in the application, as supplemented, there are no changes that affect the currently approved containment evaluation of the payload during the shipment, and there continues to be reasonable assurance that the package will meet the containment requirements of 10 CFR Part 71.

5.0 Shielding Review

This section presents the findings of the shielding review for a request for authorization to approve shipment of the Dounreay fuel material under the CoC No. 71-9225 for the Model No. NAC-LWT transportation package. The staff reviewed the source term calculation analysis of the package presented in the calculation package, in which the applicant provided an updated source terms analysis for the licensing of EK-10, IRT-2M, and TTR fuel in the Model No. NAC-LWT.

5.1 Description of the Shielding Design

5.1.1 Packaging Design Features

The shielding design for this authorization is based on source term calculations. The source term calculations are performed for five special fuel assemblies to be transported in the Model No. NAC-LWT package using the currently approved MTR fuel basket. The Model No. NAC-LWT is an approved package that allows transport of seven 30-watt element (554,700 MWd/MTU / 1,200 days cooled) assemblies in the MTR basket. The five special fuel assemblies consist of three different types of fuel assemblies, EK-10 (3 assemblies), IRT-2M (1 assembly), and TTR (1 assembly). Detailed descriptions of these assemblies are shown in Table 6-1 of the Calculation Package.

5.1.2 Codes and Standards

The codes and standards applied to this amendment are the same as established in the currently certified MTR basket.

5.1.3 Summary Table of Maximum Radiation Levels

The information on the special fuel assemblies was provided by the applicant and the staff used them to compare with the design basis shielding source terms for the Model No. NAC-LWT package in the MTR fuel configuration. Dose rate calculations were not provided by the applicant due to the source term comparison. Comparison between the five special fuel assemblies and the MTR design basis fuel assemblies demonstrate that the gamma source strength for the five special fuels assemblies is two orders of magnitude lower than the design basis (MTR) for gammas and three or more orders of magnitude below that for neutrons.

5.2 Source Specifications

5.2.1 Gamma Source

Gamma source strength for the five special fuel assemblies is shown in Table 1-1 of the Calculation Package. For the five special fuel assemblies, the total gamma source term is 1.47×10^{13} gamma/sec and 5.55×10^{12} MeV/sec. The design basis gamma source term is 1.25×10^{15} gamma/sec and 5.38×10^{14} MeV/sec. Comparing these gamma source terms, the five special fuel assemblies are lower in magnitude in comparison with the design basis (MTR fuel assemblies).

5.2.2 Neutron Source

The neutron source strength for the five special fuel assemblies is shown in Table 1-2 of the Calculation Package. For the five special fuel assemblies, the total neutron source term is 2.51×10^{3} neutron/sec. The design basis neutron source term is 6.47×10^{6} neutron/sec. Comparing these neutron source terms, the five special fuel assemblies are lower in magnitude in comparison with the design basis (MTR fuel assemblies).

Table 1-3 shows the fission product gases and some of the particulate isotopes. In terms of activity, there is a significant difference between the five special fuel assemblies and the MTR design basis. For example, for Cs-137, the amount of activity is 232 Ci for the five special fuel assemblies, while this is 50,000 Ci for the design basis.

5.3 Model Specification

5.3.1 Configuration of Source and Shielding

The five special fuel assemblies are loaded into the MTR basket. These fuel assemblies include three EK-10 assembly, one ITR-2M assembly, and one TTR fuel assembly. A total of five MTR baskets are permitted for transport, while only one basket of the special fuel assemblies is going to be used in the Model No. NAC-LWT.

5.3.2 Material Properties

The special fuel design basis input is shown in Table 4.1 of the Calculation Package. This information was provided by DOE.

For the EK-10 fuel assembly, the Uranium per assembly is 1288 g, maximum burnup is 14,800 MWD/MTU, and the cooling time is 10,349 days.

For the IRT-2M fuel assembly, the Uranium per assembly is 189.8 g, maximum burnup is 9,180 MWD/MTU, and the cooling time of 3,653 days.

For the TTR fuel assembly, the Uranium per assembly is 455 g, maximum burnup is 48,600 MWD/MTU, and the cooling time of 8,281 days.

5.4 Evaluation

The applicant performed source term analyses for the five fuel assemblies to be transported in the Model No. NAC-LWT package using the MTR fuel basket. The fuel assemblies mentioned above are going to be loaded into the MTR basket.

The method of analysis used by the applicant included a review of previously performed analyses and updating of fuel source term models where necessary. Also, some evaluations of the payloads were performed using various updated code and cross section sets. Comparison between the special fuel and the MTR design payloads in the evaluation were identified in the Calculation Package.

The applicant stated that all previous results were generated using SCALE 4.3 SAS2H with the 27-group ENDF/B-IV cross section library. The applicant stated that this code/library set has been superseded by both updated code version and cross section libraries. Table 6-7 shows a summary of code/library comparison, which includes SAS2H, T-DEPL from SCALE 4.3, SCALE 5.1, and SCALE 6. The code/libraries used in the evaluations were 27-group (SCALE 4.3), 44-group (SCALE4.3), 238-group (SCALE 4.3), 44-group (SCALE 5.1), 238-group (SCALE 5.1), 44-group (SCALE 6), and 238-group (ENDF/VII) (SCALE 6).

The data for the special fuel design basis was presented in Table 4-1 of the calculation package. The applicant provided SAS2H input files for all the analyses. For this authorization, revisions of the SAS2H model involved changing dimension and depletion parameters to account for the updated and bounding data. To provide a bounding fuel assembly description, the applicant modified each fuel type by increasing the uranium mass and decreasing the weight percent of U-235 in Uranium. Burnup was increased, and the cooling time was decreased to increase the source term. On Page 18 of 37 of the Calculation Package, the applicant provided a table describing the design basis fuel.

The staff reviewed the applicant's source term calculations used in the analyses. Also, the staff checked the code input in the calculation packages and confirmed that the proper material properties and boundary conditions were used. The staff performed source term calculations using SCALE 6 to compare photon and neutron sources. The staff concludes that the source term calculations for the special fuel are a small fraction of the design basis source terms and will not exceed the regulatory limits.

5.5 Conclusions

The staff evaluated the shielding safety analysis for the packages that are loaded with the five special fuel assemblies. The staff found that the applicant has correctly modeled and analyzed the shielding safety of these packages. Based upon the information provided by the applicant, the staff has reasonable assurance that the applicant's shielding analyses demonstrate that the package design meets external radiation standards in 10 CFR Part 71.47 and 10 CFR Part 71.51(a)(2).

6.0 Criticality Evaluation

NAC submitted a request for authorization for shipment of the Dounreay fuel material under NRC regulations in 10 CFR Part 71 in the Model No. NAC-LWT transportation package. The Model No. NAC-LWT is a Type B(U)F-96 radioactive material transportation package. Its current CoC (Revision 55 dated March 23, 2010) allows shipment of Light Water Reactor (LWR) and research reactor fuel. This authorization will allow a one-time shipment of five special fuel assemblies in the MTR fuel basket. NAC performed a criticality evaluation of the shipment and submitted it with the request (Reference 1). The staff reviewed this calculation as well as the pertinent information from the NAC-LWT Safety Analysis Report (SAR) (Reference 2).

6.1 Description of Criticality Design

The applicant controls criticality by limiting the amount of fissile material that will be contained within the package. The neutron multiplication factor (k-effective, or k-eff) will be less than 0.95 during all Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC).

The applicant stated in Reference 3 that this is a single shipment using a single package. The staff finds that by specifying the allowable number of packages that may be transported in a single shipment, that the applicant meets the requirements of 10 CFR 71.35(b).

The staff found that the description of the packaging was described in sufficient detail to provide an adequate basis for its evaluation and that the description included types and dimensions of materials of construction. The staff found that the applicant met the requirements of 10 CFR 71.31(a)(1) and 10 CFR 71.33(a)(5). The staff examined the sketches of the model used for the criticality calculations and verified that the dimensions and materials were consistent with those in the drawings of the actual package.

The staff verified that the applicant provided sufficient information for all materials used in the models of the packaging and contents. There are no materials in the package that need to be adjusted to be consistent with accident conditions, i.e. there are no materials used in the model that change form, such as a neutron shield or neutron absorbers that could melt, as assumed in the calculations needed to maintain sub-criticality. The applicant did not take credit for any kind of neutron absorber material. The applicant did not request credit for burnable poisons in the fuel.

The applicant provided a summary table of the criticality evaluations in Table 1-1 in Reference 1 of the application. The staff verified that the table included the maximum value of k-eff. For the limiting conditions for the Model No. NAC-LWT with the Dounreay fuel, the applicant's analysis gave a maximum k-eff of 0.58. It was not clear to the staff if these values included the code standard deviation or bias. However, in Reference 2 the applicant showed that typical code bias for NAC validations are less than 2% Δk-eff for applications involving Low Enriched Uranium (LEU), High Enriched Uranium (HEU), fast fission, and Mixed Oxide (MOX) materials. Considering the low value of k-eff, the staff found that the summary table showed that the package meets the sub-criticality criterion.

6.2 Fissile Material Contents

The applicant provided the physical characteristics of the five special assemblies. There will be three EK-10 assemblies, one IRT-2M assembly, and one TTR assembly. The EK-10 has a square rod array with 15 or 16 rods. It has a UO_2-Mg fuel matrix with Al cladding. It is 10% enriched with less than 120g U-235 per assembly. The IRT-2M is a concentric tube assembly with four square tubes. It is U-Al fuel with Al cladding and it is 90% enriched with less than 170g U-235. The TTR fuel is also U-Al with Al cladding. It is a hexagonal array of 91 rods with less than 400g U-235. Bounding fuel specifications were in Table 6-1 of Reference 1.

The applicant referenced some calculations from the NAC-LWT SAR (Reference 2) for showing the possible effect of geometric tolerance and mechanical perturbations. The staff found that any increase in reactivity due to these factors would be small in comparison to the safety margin in the low k-eff value.

The staff found that the applicant described the contents in sufficient detail to provide an adequate basis for this evaluation. The staff found that the applicant adequately defined the type, maximum quantity, and chemical and physical form of the fissile material. The staff found that this application met the requirements of 10 CFR 71.31(a)(1), 10 CFR 71.33(b)(1), 10 CFR 71.33(b)(2) and 10 CFR 71.33(b)(3).

6.3 General Considerations for Criticality Evaluations

The applicant performed criticality evaluations for an infinite array (i.e., used infinite reflective boundary conditions) of packages in the damaged and undamaged condition, optimally moderated with water, and in the most reactive form of the fissile material. The applicant did not assume close reflection[1] of the containment system on all sides. The applicant found that voiding the exterior increases the reactivity because it allows more neutron interaction between the packages. The staff found this assumption acceptable. The applicant performed analyses to determine the optimum internal moderation. The applicant showed in Section 6.4 of Reference 1 that the most reactive configuration was with 100% water density for internal moderation. The staff found that the applicant met the requirements of 10 CFR 71.55(b).

The applicant did not perform a calculation for a single package; however, the applicant showed a large margin to criticality in their calculations. Therefore, the staff found that the reflective boundary condition would be representative enough of the single evaluation. If there were any

[1] "Close reflection by water" is defined in 10 CFR 71.4 as immediate contact by water of sufficient thickness for maximum reflection of neutrons.

differences, it would be bounded by the conservatism in the calculation assumptions and results.

In Section 5 of Reference 1, the applicant calculated the Criticality Safety Index (CSI) to have a value of 0. This was based on the analysis performed that used a value of N equal to infinity (i.e., an infinite array of packages). The staff found that the CSI was appropriately determined per 10 CFR 71.59(b). The staff determined that the applicant met the requirements of 10 CFR 71.59(a)(3) because the value of N is not less than 0.5. The staff concluded that the applicant met the requirements of 10 CFR 71.59(a)(1) by demonstrating that an array of at least 5N packages (infinite array in this case) with nothing between the packages is subcritical.

The applicant did not provide a calculation for HAC; however, in Reference 3 the applicant stated that the fuel remains intact during NCT and HAC. The staff performed scoping calculations with MCNP5 using the maximum amount of fissile material allowed within the shipment and determined that it would be nearly impossible for the fuel to reconfigure to a critical configuration under any credible circumstances. The staff found that it would require the U-235 to reconfigure to an optimally moderated homogenous sphere of U-235 and water (at least 95% water by mass). The staff concluded that this gave reasonable assurance that the shipment will be subcritical under all NCT and HAC. The staff determined that this met the requirements in 10 CFR 71.55(e), which requires that a package and its contents be subcritical under HAC. The staff concluded that the applicant met the requirements of 10 CFR 71.59(a)(2) by demonstrating that an array of at least 2N packages under HAC is subcritical.

Since k-eff is less than 0.95 under the tests specified in 10 CFR 71.71 for NCT, the staff verified that this met the requirements of 10 CFR 71.55(d)(1), which requires that the contents be subcritical. The staff verified that the geometric form of the package contents would not be altered in such a way to affect criticality. The staff found that the applicant met the intent of 10 CFR 71.55(d)(2). The staff verified that there was no reduction in the effectiveness of the packaging for criticality prevention under NCT. Therefore, the staff found that the applicant met the requirements in 10 CFR 71.55(d)(4).

The staff did not verify that there would be no leakage of water into the containment system per 10 CFR 71.55(d)(3) because the applicant assumed full in-leakage of water at its most reactive extent for NCT and HAC. The staff found that the applicant met the requirements of 10 CFR 71.55(d)(3).

6.4 Benchmark Evaluation

The applicant performed the criticality evaluation using SCALE 4.3 CSAS25 using KENO-Va with the 27-group ENDF/B-IV cross section library. This code and cross section set were validated by the applicant for high enriched research reactor fuel in Section 6.5.2 of Reference 2. Since this code and cross section set have since been superseded with newer versions, the applicant performed calculations using SCALE 6 with ENDF/B-V cross sections and MCNP with ENDF/B-VI cross sections, and the results from these codes also show a large safety margin. The staff notes that it is difficult to perform validation calculations for UO_2-Mg fuel given the lack of available benchmarking experiments for this fuel material. However, given the large safety margin shown in the applicant's calculations, the staff determined that their current benchmarking is adequate for this calculation and that any increase in calculation uncertainty for UO_2-Mg could not cause the shipment to exceed any regulatory limits.

6.5 References

1. Calculation 65008000-6001, "Updated Criticality Analysis for the Licensing of EK-10, IRT-2M, and TTR Fuel in the NAC-LWT," November 10, 2011 (ADAMS Accession No. ML11333A051)

2. Safety Analysis Report (SAR) for the NAC Legal Weight Truck Cask, Revision 41, NAC International, April 2010 (ADAMS Accession No. ML101750226)

3. Letter from A. L. Patko to the U.S. Nuclear Regulatory Commission, "Submission of a Request for Authorization for the NAC-LWT Cask to Allow Shipment of the Dounreay Fuel Contents Supplementing the Certificate of Compliance (CoC) No. 9225," November 10, 2011 (ADAMS Accession No. ML11333A049)

7.0 Packaging Operations

There are no changes to the packaging operations requirements currently approved for this authorization.

8.0 Fabrication and Maintenance

There are no changes to the fabrication and maintenance requirements currently approved for this authorization.

CONDITIONS

The authorization is limited to the following condition:

A one-time authorization to ship the following special fuel assemblies:

- Three (3) 4x4 square EK-10 rod arrays (two with 16 rods; one with 15 rods)
  - UO_2-Mg fuel matrix/Al clad
  - Nominal 10 wt.% U-235
  - < 120 g U-235 per array
  - The maximum amount Uranium per assembly analyzed is 1400g
  - The maximum burnup analyzed is 20,000 MWd/MTU
  - The minimum cooling time is 28.3 years
- One (1) concentric tube ITR assembly (four square tubes)
  - U/Al alloy fuel/Al clad
  - Similar to DIDO assembly currently authorized, but uses four square "boxes" instead of cylindrical tubes
  - Nominal 90 wt.% U-235
  - < 170 g U-235 per assembly
  - The maximum Uranium per assembly analyzed is 220 g
  - The maximum burnup analyzed is 15,000 MWd/MTU
  - The minimum cooling time is 10 years
- One (1) hexagonal array (91 rods) TTR assembly
  - U/Al alloy fuel/Al clad

- Nominal 90 wt.% U-235
- < 400 g U-235 per assembly
- The maximum Uranium per assembly analyzed is 500g
- The maximum burnup analyzed is 60,000 MWd/MTU
- The minimum cooling time is 22.6 years

The assemblies will be transported in the currently certified MTR basket with the center basket opening blocked to prevent misloading.

The following additional conditions apply:

- All other conditions of CoC No. 9225 shall remain the same.
- This authorization shall expire on December 31, 2013.

CONCLUSION

CoC No. 9225 has been amended by letter for a one-time authorization to ship special fuel assemblies as specified above in a currently authorized MTR basket in the Model No. NAC-LWT package. This authorization expires December 31, 2013. Based on the statements and representations in the application, and with the conditions listed above, the staff agrees that this authorization does not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued on January 10, 2012.