January 19, 2011

Mr. B. K. Miles
Division of Naval Reactors
U.S. Department of Energy
Washington, DC 20585

SUBJECT: CERTIFICATE OF COMPLIANCE NO. 6386 FOR THE MODEL NO. 235R001 PACKAGE

Dear Mr. Miles:

As requested by your application dated March 31, 2010, as supplemented by correspondence dated September 30, 2010, enclosed is Certificate of Compliance No. 6386, Revision No. 20, for the Model No. 235R001 package. Changes made to the enclosed certificate are indicated by vertical lines in the margin. The staff's Safety Evaluation Report is also enclosed.

The U.S. Department of Energy is registered as user of the package under the general license provisions of 10 CFR 71.17. This 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 Jennie Rankin of my staff at (301) 492-3268.

Sincerely,

/RA/

Robert Johnson, Acting Chief
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-6386
TAC No. L24440

Enclosures:
1. Certificate of Compliance No. 6386, Rev. No. 20
2. Safety Evaluation Report

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

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Safety Evaluation Report
Model No. 235R001 Package
Docket No. 71-6386
Certificate of Compliance No. 6386
Revision 20

SUMMARY

By application dated March 31, 2010, the U.S. Department of Energy (DOE), Naval Reactors (NR) submitted an amendment request for Certificate of Compliance (CoC) for the 235R001 package. The 235R001 shipping containers are designed to ship new fuel cell assemblies to servicing facilities. The Navy has begun construction of GERALD R. FORD (CVN 78), which will be the first in a class of aircraft carriers to be powered by A1B nuclear reactors. A1B power units will be assembled at the shipyard, which means individual A1B fuel modules will have to be shipped from the Navy's core vendor to the shipyard in 235R001 shipping containers. The applicant also proposed resolution to 14 issues published by the Nuclear Regulatory Commission (NRC) in compatibility with International Atomic Energy Agency (IAEA) Transportation Safety Standards (TS-R-1) and the Transportation Safety Amendments Final Rule; Federal Register 69:16 (26 January 2004) p. 3698-3814, in order to comply with current regulations and obtain a designated certificate to "-96" for A1B fuel. The staff has evaluated the request, added A1B contents to the CoC, and designated the certificate to "-96" for A1B fuel. The staff has concluded that these changes will not affect the ability of the package to meet the requirements of 10 CFR Part 71.

1.0 GENERAL INFORMATION

The Model No. 235R001 package is designed to ship new fuel cell assemblies to servicing facilities.

1.1 Packaging

The 235R001 shipping container consists of a two-section horizontal cylindrical shell approximately 34 inches in diameter by 313 inches in length and fabricated from 0.104 inch thick carbon sheet steel. The container was originally designed to ship unirradiated fuel modules of the A1G/A4W type. Subsequently, the container has been adapted to ship standard size or partial S8G fuel modules by use of a special frame assembly and cradle clamps, S3G-3 refueling modules using cell support assemblies, rodded or unrodded D1G fuel modules, rodded or unrodded D2W fuel cells, and rodded S9G fuel cells. Revisions have been made to accommodate rodded A1B fuel cells. The loaded container maximum weight is 17,200 pounds.

1.2 Changes to Contents

The revision adds the A1B fuel cell with control rod to the 235R001 shipping container package. The maximum quantity of A1B fuel cells per package is one. The criticality safety index for the 235R001 package with A1B fuel cell is 100.0.

1.3 Changes to the Drawings:

The packaging is constructed in accordance with Container Research Corporation Drawing Nos. 235R001, Rev. BC, and Bettis Atomic Power Laboratory Drawing Nos. 6292E98, Rev. B.

1.4 Conclusions

The changes made to the General Information section were adequate and in conformance with 10 CFR Part 71,

2.0 STRUCTURAL AND MATERIALS EVALUATION

The applicant evaluated the previously approved 235R001 shipping container with A1B new fuel for compliance with the structural requirements specified in 10 CFR Part 71, under Normal Conditions of Transport and Hypothetical Accident Conditions.

2.1 Structural Design

The principal structures of the package are the 235R001 Group 18 shipping container, with A1B module support assemblies, and an unirradiated A1B fuel shipping assembly.

2.2 Materials Evaluation

The Model 235R001 shipping and storage container ships and stores various types of un-irradiated fuel by essentially changing/modifying internal hardware responsible for securing the payload. Except for specific hardware for the new internal payload the container, in effect, remains the same. Section 1.2 of the application provides the Model 235R001 packaging description and major components consist of the following:

- Base Assembly: Near cylindrical half that's flanged for bolting (1/2-inch, stainless steel); and forms a hollow cylinder when bolted to the cover assembly for accommodating the A1B fuel cell. A silicon rubber seal is located in a machined groove at the inner edge of the flange. The base is fabricated from American Iron and Steel Institute-AISI or American Society for Testing and Materials-ASTM low-carbon steel. The shell is welded closed by reinforced steel domes. Steel stiffening plates are welded to the outside for rollover protection. Welded steel plates between the stiffening plates are used for lifting, rigging, towing, and tie down. Of note are four H-beam skid assemblies (steel) bolted to the outside of the base assembly.

- Cover Assembly: Similar to the base assembly in design and fabricated from low carbon steel. Differences include steel roll-formed angles for stiffening, and steel stacking brackets (also for rigging) closed with welded steel guard plates for protection are located at each end of the cover and various accessories such as a pressure gage, pressure relief valves, manual relief valve humidity indicator two ports for optional indicators and a filling valve (nitrogen).

- Shear Mounts: Are responsible for isolating the module support assemblies (MSA) (8 per MSA) from the base assembly and are manufactured from silicone elastomer inserted between two steel plates. The mounts are bolted (stainless steel) to both the container via welded shear mount brackets, and the MSA side rails.

- MSA (Upper and Lower): The upper MSA supports the manifold of the A1B and the lower MSA supports the fuel cluster end of the A1B fuel cell. The upper and lower MSA's each consists of the following components:

    - Side Rail Assembly: High strength low alloy steel plate provides attachment locations used together with a U-shaped stainless steel side rail brace and a stiffening stainless steel end plate. Besides the braces and end plates the side rails attach to shear mounts, module clamps and axial restraint assembly. Also, stainless steel pivot fixture side plates are attached in the lower MSA.
    - Module Clamp: Stainless steel module consists of one clamp assembly (welded or bolted) and three top clamp plates responsible for restricting the A1B fuel cell from moving vertically.
    - Lateral Restraint System: Stainless steel shim plates held together by fixture (shim support and trap plates) prevent lateral movement of the A1B fuel cell, inserted between the A1B and side rails.
    - Axial Restraint (Upper MSA only): Stainless steel assembly consisting of upper bearing bar, a lower bearing plate and four adjustable axial restraints.

- Fuel Shipping Assembly: For shipping one unirradiated A1B fuel shipping assembly. The assembly consists of a fuel assembly with a control rod, a translating assembly, and a control rod hold down device.

Specifications and temperature dependent mechanical properties, including yield strength, tensile strength, allowable strength, modulus of elasticity, and coefficient of thermal expansion are presented in Section 2 tables of the application. Section 2 of the application also provides temperatures, density, and Poisson's ratio values. The staff reviewed the materials selected and found them to be acceptable.

2.2.1 Chemical or Galvanic Reactions

Section 2 of the application discusses reactions due to chemical, galvanic, or other reactions. The applicant provides information that direct contact between the payload and the packaging components is prevented by lining surfaces with rubber pads and wrapping A1B fuel cell assembly with two layers of polyethylene and then wrapping with a cloth-backed aluminized polyethylene.

Prior to shipment the loaded container will be purged with dry nitrogen to a dew point of -40°F and then pressurized. In addition, the materials prohibited for internal use in shipping containers or their compounds and alloys with other materials are not used in the packaging design. These measures ensure that there will be no significant chemical, galvanic, or other reactions among the packaging components, or between the packaging components and the package contents.

The staff concludes during normal operation the internals will not be subject to continuous or frequent exposure to moisture or that water intrusion is not likely to occur in great quantities. A neoprene gasket seals the base and cover assemblies. The number of galvanic potential between the different metals used in fabrication is low. Both the container exterior and interior surfaces are covered with primer and enamel, though stainless steel and bronze parts used internally are not painted. Therefore, the conditions required to create the possibility for galvanic corrosion is small. Further, visual inspections to be performed of the payload cavity at

various timed intervals provide reasonable assurance against any significant corrosion occurring unnoticed.

2.2.2 Brittle Fracture

Section 2 of the application discusses material brittle fracture. The applicant provides the information that unirradiated Zircaloy, Alloy 625, and wrought hafnium used are not fracture sensitive materials. The Alloy A-286 is loaded in the compression only and therefore is also exempt from brittle fracture. In addition, austenitic stainless steel is not a fracture sensitive material.

The primary containment boundary of the Model 235R001 package is the fuel cladding. The packaging internals are not containment boundary components. Fracture toughness requirements are conservatively applied to the fracture sensitive carbon steel internal components. Any carbon steel material with welds connecting components having a minimum thickness or greater required by the application are required to have Charpy V-notch impact energy of 15 ft-lb or greater at a maximum temperature of 10°F. These test specimens are taken from component material during fabrication.

The staff finds that to comply with 10 CFR 71.71(b), the package was performance tested at -20ºF to assure that no brittle fracture of important to safety components occurs. No observable differences in test results (e.g., drop test results) were noted for the low temperature test versus the normal ambient temperature test. Therefore, the staff finds low temperature has no effect on the Model 235R001 packaging material performance.

2.2.3 Materials and Material Testing

Section 8 of the application discusses acceptance and maintenance testing.

Conclusion

The staff finds that the Model 235R001 shipping and storage container meets the regulatory requirements for preventing or mitigating galvanic or chemical reactions, is unaffected by cold temperatures and is constructed with materials and processes in accordance with acceptable codes and standards.

2.3 Fabrication and Examination

This package is fabricated and examined according to previously reviewed Quality Assurance Program which is outlined in Chapter 9 of the Safety Analysis Report (SAR).

2.4 General Standards for All Packages

The applicant evaluated this package for compliance with Part 71 Regulations including Minimum Package Size, Inclusion of a Tamper Indicating Feature, Positive Closure, Chemical, Galvanic, or Other Reactions, Protection of Valves Against Unauthorized Operation, Radiation Release, Ambient Surface Temperature, and Continuous Venting.

Staff reviewed the evaluations presented by the applicant and found them credible, therefore the requirements of 10 CFR 71.43 are satisfied.

2.5 Lifting and Tiedown Standards

2.5.1 Lifting

The applicant described two methods of lifting the package and demonstrated a factor of safety of 3 for lifting.

2.5.2 Tiedown

The applicant demonstrated that the standard tie down method could reasonably resist the required 2G, 5G, and 10G vertical, lateral, and longitudinal loadings as prescribed by 10 CFR 71.45(b). The applicant also showed that inadvertent tiedown points could be rendered inoperable, however, the applicant also demonstrated that these tiedown points were sufficiently robust to withstand the required loadings.

Staff reviewed the evaluation and calculations provided in the SAR and determined that the requirements of 10 CFR 71.45 are met.

2.6 Normal Conditions of Transport

For normal conditions of transport, the applicant evaluated the package for heat and associated pressures as well as differential thermal expansion, cold and associated pressures as well as differential thermal contraction, reduced and increased external pressure, vibration, water spray, free drop, brittle fracture, and penetration. Methods of evaluation were by means of classical engineering mechanics. Staff reviewed these calculations and found them acceptable to demonstrate a reasonable assurance of safety, therefore the requirements of 10 CFR 71.71 are satisfied.

2.7 Hypothetical Accident Conditions

The A1B fuel shipping assembly was evaluated for various hypothetical accident conditions including a 9 m free drop with multiple orientations, a 1 m puncture drop, thermal effects and associated pressures, and water immersion. This package carries no plutonium by air, no fissile material by air, and no special form material.

Evaluations of the 9 m free drop were performed for end and end oblique drops, side and side oblique drops, and slapdown drops. These evaluations were done with classical energy balance methods that produce conservative results with respect to gross damage assessment since no credit was taken for the outer Model 235R001, Group 18, shipping container. The reported damage for all of the free drop cases was consistent with the assumptions used in the thermal and criticality evaluations and staff investigations of the calculations presented by the applicant confirmed that the methodology used was conservative with respect to overall structural performance.

With respect to water immersion for fissile material and all packages, the Group 18 Model 235R001 assumes a flooded condition for all cases in the criticality evaluation, therefore the potential for buckling due to pressure of a 50 foot immersion is bounded by the initial conditions assumed for criticality.

The requirements of 10 CFR 71.73 are satisfied.

2.8 Conclusions

Based on the statements and representations in the application, the staff concludes that there is reasonable assurance that this package meets the structural requirements in 10 CFR Part 71 under normal conditions of transport and the hypothetical accident conditions, where applicable.

3.0 THERMAL EVALUATION

In this section, the applicant evaluated the shipping container Model 235R001 to incorporate new and unirradiated A1B fuel assembly as allowable contents, in order to demonstrate compliance with the thermal requirements specified under 10 CFR Part 71, under Normal Conditions of Transport and Hypothetical Accident Conditions.

3.1 Discussion

The 235R001 shipping container is used for the shipment of one new, unirradiated, A1B fuel shipping assembly. It is a closed container with two pressure relief valves, initially pressurized to 5-7 psig using nitrogen. The new fuel shipping assembly is shipped dry.

3.2 Summary of Properties of Material

A thorough description of the materials employed in this package can be found in Section 2.2, Materials Evaluation, of this Safety Evaluation Report. In addition, the shipping container is painted according to the references established in Section 3.6 of the SAR.

The melting temperatures for relevant materials are presented in Table 3-1 of the SAR.

3.3 Technical Specification of Components

The relief valves are designed for an opening pressure of 7 to 9.5 psig with a minimum reseat pressure of 5 psig, to keep the container pressurized at 7 psig or less.

3.4 Normal Conditions of Transport

The evaluation for normal conditions of transport was performed analytically and no test model was used. Since the evaluated package's content is a new fuel shipping assembly, it does not generate decay heat. For the calculation of maximum temperatures the total heat absorbed by the container is represented as the sum of the heat radiated to the environment and the respective convected heat. The applicant used 10 CFR 71.71(c)(1) to calculate the absorbed heat, and the proper correlations for determining to corresponding convective heat transfer coefficient. After completing the heat balance equation, the maximum temperature value is 154.8°F, which complies with the requirements 10 CFR 71.43(g) for exclusive use shipments. The calculated maximum internal pressure is 10.5 psig, and the minimum temperature and pressure of the package are -40°F and -2.3 psig, respectively.

After reviewing this evaluation, the staff determined that the materials temperatures and internal pressures are acceptable. These demonstrate compliance with 10 CFR 71.71.

3.5 Hypothetical Accident Conditions

For the hypothetical accident conditions evaluation, the applicant assumed the container to be

exposed to a fire with a flame temperature of 1,475°F for 30 minutes. The accident scenario does not represent an additional loss of containment since the melting temperature of the containment boundary is considerably higher than the flame temperature. The applicant also analyzed the thermal expansion phenomena regarding the fuel assembly volume. The resulting increase in volume is 1.77%, as addressed in the criticality evaluation.

The staff determined that this evaluation satisfies 10 CFR 71.73 requirements, because the materials temperature limits are not exceeded and the moderator material remains able to perform its function.

4.0 CONTAINMENT EVALUATION

In this section, the applicant evaluated the shipping container Model 235R001 to incorporate new and unirradiated A1B fuel assembly as allowable contents, in order to demonstrate compliance with the containment requirements specified under 10 CFR Part 71, under Normal Conditions of Transport and Hypothetical Accident Conditions.

4.1 Containment Boundary

The containment boundary is formed by Zircaloy-4 cladding metallurgically bonded to the fuel bearing region. The cladding requires a dimensional inspection, ultrasonic test inspection, and different examinations to maintain a level of conformity to the specifications as presented in Sections 4.1.3.2 and 4.1.3.3 of the SAR.

4.3 Requirements for Normal Conditions of Transport

For the normal conditions of transport, the applicant demonstrated that no radioactive material is released from the fuel elements as consequence of the analysis performed in Chapters 2 and 3. The applicant also noted that the fuel elements are capable to withstand the calculated maximum internal pressure of 10.5 psig, in case the relief valves failed to open.

After reviewing this evaluation, the staff determined compliance with 10 CFR 71.51 and 71.71, because no radioactive material is released under normal conditions of transport.

4.4 Containment Requirements for Hypothetical Accident Conditions

In the hypothetical accident conditions evaluation, the applicant based the analysis in the most limiting module. The worst combination of damage from the 30 foot drop and puncture accident, from the structural evaluation, is used to calculate the postulated release of radioactive material. The values of radionuclide content and composite A_2 fraction of one A1B fuel module used for the release calculations are presented in Table 4.5-1. The calculated quantity of A_2 released in the hypothetical accident conditions is 4.9% of an A_2, which satisfies the requirements of 10 CFR 71.51 (a)(2). The applicant also demonstrated no fissile material release as consequence of the thermal accident and the water immersion of the package.

The staff determined that this evaluation satisfies 10 CFR 71.55(a) and 71.73 requirements, because no unacceptable quantity of radioactive material is released under hypothetical accident conditions.

5.0 SHIELDING EVALUATION

The package contains non-irradiated fuel; shielding is not required.

6.0 CRITICALITY EVALUATION

The applicant requested an amendment to the certificate for the 235R001 Group 18 shipping and storage container. The major change related to the criticality evaluation was the addition of a new fuel assembly design as authorized contents, with an associated change in the internal configuration. The applicant supplied a description of the analysis to support this change.

6.1 Package Loading

The package is designed to contain one single, fresh, un-irradiated fuel assembly. The assemblies will be shipped with control components (CCs) in place. A fresh fuel material composition was used throughout the criticality analysis, and the most reactive assembly type was selected. The applicant modeled an infinite array of two-dimensional (axially infinite) assemblies, conservatively ignoring the neutron absorption by the container.

6.2 Normal Conditions of Transport

The applicant's analysis showed the requirement that the package will remain subcritical for the normal conditions of transport in 10 CFR Part 71 is met. Normal conditions of transport include poison elements and a control rod withdrawn to the maximum extent possible due to mechanical restraints and manufacturing tolerances. Conservative adjustments are made for the manufacturing uncertainty maximizing the possible fuel load and minimizing the poison mass. The assembly is assumed to be flooded with close, full reflection on all sides. The packaging is conservatively ignored to eliminate neutron absorption from the analysis. The limiting case is presented.

6.3 Hypothetical Accident Conditions

A hypothetical accident condition also assumes optimum flooding. Structural analysis conservatively assumes that the control rod will not remain in the module during accident conditions. The analysis is performed without any control components in the assembly. The applicant varied the flooded assembly water density from 0% to 100% at a fixed temperature to optimize reactivity. Any manufacturing tolerances are modeled to maximize effective fuel and moderator volume while minimizing poison content. The model is fully moderated on all sides with 12 inches of water with an escape boundary beyond the reflector. The applicant successfully demonstrated the case of maximum reactivity remains below the upper subcritical limit.

6.4 Assessment

The applicant's analysis utilized a Monte Carlo method to determine k_{eff}. All fuel and poison elements are modeled explicitly. The cross-section libraries used in the analyses are the same as those used to develop the benchmark cases.

The applicant provided a list of applicable benchmarks to determine bias and uncertainty of the software used. Benchmark problems were chosen due to similarities in fissile and structural materials as well as assembly configuration.

Staff conducted confirmatory analyses with the KENO-VI module in SCALE. Due to the sensitive nature of the contents, limited material and geometric information is modeled. Staff analysis used estimated material properties and homogenized fuel zones with discretely modeled poison elements of approximate, conservative dimensions. Interspersed poison was ignored. Since the staff did not explicitly reproduce the model and verify the actual value for k_{eff}, confirmatory analysis focused on verifying the conservative adjustments made by the applicant. Still, staff criticality estimates were in reasonable agreement with those of the applicant. Based on its review of the methods and calculations to confirm that approximations and analyses are indeed conservative, staff agrees with the applicant's conclusion that the package meets the criticality requirements of 10 CFR 71.55.

7.0 PACKAGE OPERATIONS EVALUATION

Operating procedures such as procedures for loading the package with A1B fuel assemblies, procedures to unload the package, and preparation of an empty package for transport remain adequate and conform to the requirements of 10 CFR Part 71.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM EVALUATION

Acceptance and maintenance testing such as visual inspection, material testing, structural and pressure testing, leak testing, and component testing remain adequate and conform to the requirements of 10 CFR Part 71 .

CONDITIONS

The following conditions in CoC No. 6386, Revision No. 20 have been revised as follows:

Condition 5(a)(2), “Description,” revised to include rodded A1B fuel cells and revise the maximum loaded container weight .

Condition 5(b)(1), “Type and form of material,” was revised to include A1B fuel as contents.

Condition 5(b)(2) “Maximum quantity of material per package” was revised to include A1B contents.

Condition 5(c), “Criticality Safety Index,” was revised to provide a CSI for A1B fuel of 100. The condition was also revised to remove reference to the Transport Index for Criticality Control. This terminology was replaced by the Criticality Safety Index as defined in the 10 CFR 71.4.

CONCLUSION

As requested by the application, CoC No. 6386 for the 235R001 package has been amended to include A1B fuel as contents and designated to “-96” for A1B fuel.

Based on the staff’s review, the statements and representation in the application and for the reasons stated in the SER, and with the conditions listed above, we conclude that these changes will not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 6386, Revision No. 20,
on 1/19/2011.