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

February 13, 2019

Mr. Roy G. Pratt
NAVSEA 08G
1240 Isaac Hull Ave. SE Stop 8021
Washington Navy Yard, DC 20376-8021

SUBJECT: CERTIFICATE OF COMPLIANCE NO. 9186, REVISION NO. 19, FOR THE MODEL S-6213 POWER UNIT SHIPPING CONTAINER

Dear Mr. Pratt:

As requested by your letter dated June 13, 2018, enclosed is Certificate of Compliance No. 9186, Revision No. 19, for the Model Nos. Model 1, S-6213 Power Unit Shipping Container and Model 2, S-6213 Power Unit Shipping Container. Changes to the enclosed certificate are indicated by vertical lines in the margin. The staff's safety evaluation report is also enclosed.

The approval constitutes authority to use the package for shipment of radioactive material and for the package to be shipped in accordance with the provisions of Title 49 of the *Code of Federal Regulations* 173.471.

If you have any questions regarding this certificate, please contact me or Bernard White of my staff at (301) 415-6577.

Sincerely,

/RA/

John McKirgan, Chief
Spent Fuel Licensing Branch
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9186
EPID No. L-2018-LLA-0171

Enclosures:
1. Certificate of Compliance
2. Safety Evaluation Report

cc w/encls 1 & 2: R. Boyle, Department of Transportation
J. Shuler, DOE, c/o L. F. Gelder

SUBJECT: CERTIFICATE OF COMPLIANCE NO. 9186, REVISION NO. 19, FOR THE MODEL S-6213 POWER UNIT SHIPPING CONTAINER DOCUMENT DATED: February 13, 2019

Closes EPID No. L-2018-LLA-0171

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(This closes EPID No. L-2018-LLA-0171)

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SAFETY EVALUATION REPORT
Docket No. 71-9186
Model Nos. Model 1, S-6213 Power Unit Shipping Container and
Model 2, S-6213 Power Unit Shipping Container
Certificate of Compliance No. 9186
Revision No. 19

SUMMARY

By application dated June 13, 2018, U.S. Department of Energy (DOE), Division of Naval Reactors (Naval Reactors or the applicant) requested the U.S. Nuclear Regulatory Commission (NRC) amend the Certificate of Compliance No. 9186, for the Model Nos. Model 1, S-6213 Power Unit Shipping Container (S-6213 PUSC) and Model 2, S-6213 Power Unit Shipping Container transport packages. Naval reactors requested the addition of an unirradiated Technology Demonstration Core (TDC) as authorized contents.

The staff used the guidance in NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel," as well as associated interim staff guidance documents to perform the review of the proposed package 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.

1.0 GENERAL INFORMATION REVIEW

The NRC staff reviewed Naval Reactors description of the TDC power unit. The staff concludes that the applicant has provided an adequate description of the package which was used as the basis for the evaluation of the packages against the requirements in 10 CFR Part 71.

2.0 STRUCTURAL REVIEW

The objective of the structural evaluation is to verify that the structural performance of the package is adequately demonstrated to meet the requirements of 10 CFR Part 71. The NRC staff limited the scope of the structural review to the areas of the safety analysis report (SAR) that are affected by the new contents.

2.1 Background and Discussion

The S-6213 PUSC is a transportation container to ship various submarine power reactor cores. The NRC staff previously reviewed and approved the S6W, and S9G cores (i.e., S9G, S9G/VAFF (VIRGINIA Forward Fit), etc.) as authorized contents in the S-6213 PUSC. In this application, the applicant proposed to add the TDC as authorized contents. The applicant stated that the TDC power unit is similar to the S9G/VAFF power unit.

The applicant performed structural analysis for the S8GP/TDC power unit in the S-6213 PUSC and submitted the analysis and results to demonstrate compliance with 10 CFR Part 71. The applicant stated that the analytical methodologies used for the structural analysis of the TDC power unit in the S-6213 PUSC are identical to the analytical methodologies used for the

structural analysis of the S9G/VAFF power unit in the S-6213 PUSC, which was previously reviewed and accepted by the NRC staff.

2.2 Description of the Structural Design

The applicant used the same structural design criteria (i.e., applied loads, allowable stresses, minimum strain criterion, impact & energy absorption, vibration, failure modes, etc.) for the structural analysis of the S8GP/TDC power unit in the S-6213 PUSC, which was used for the S9G/VAFF in the S-6213 PUSC. The applicant used combinations of closed-form solutions, hand calculations, and finite element analysis methods to evaluate the S8GP/TDC power unit in the S-6213 PUSC.

2.2 Weights and Centers of Gravity

The applicant calculated the weights and centers of gravity for the S8GP/TDC power unit in the S-6213 PUSC in Section 2.2.2 of the SAR. The values of the nominal weights and the locations of the centers of gravity for various power unit components are provided in Figure 2.2-2 and Table 2.2-2 of the SAR.

2.3 Materials Evaluation

The objective of the materials evaluation is to verify that the materials performance of the package is adequately demonstrated to meet the requirements of 10 CFR Part 71. The staff limited the scope of the materials review to the areas of the safety analysis report that are affected by the new material contents.

2.3.1 Material Properties

The applicant requests the following material changes. An alloy steel adapter ring is installed in the S-6213 PUSC during shipment to accommodate the TDC power unit. For the power unit, the materials of construction are similar to those of previously approved contents. A new fuel cladding with a slightly modified chemistry, is used to increase unirradiated mechanical properties as compared to previously approved similar cladding. The staff reviewed the description of the packaging components, material properties of the adapter ring and new cladding materials and confirms that the mechanical properties of these materials are acceptable based on consensus standards and testing provided in the safety analysis.

The applicant stated that brittle fracture was evaluated by categorizing materials as not subject to brittle fracture or potentially subject to brittle fracture. Those materials (and components) that were classified as potentially subject to brittle fracture were evaluated by the applicant's analysis and testing. The applicant demonstrated that the fuel cladding will remain intact during normal conditions of transport (NCT) and hypothetical accident conditions (HAC).

The staff finds that the S-6213 PUSC is designed and fabricated from materials designated by appropriate industry or military specifications. Extensive materials data characterization, including temperature dependence of physical properties provides reasonable assurance the TDC power unit is acceptable for transport and the susceptibility of fuel cladding to brittle fracture is low. The staff also finds that the possibility for galvanic corrosion is small, as materials used in fabrication of the TDC are, in part, chosen for their ability to resist corrosion. The internal environment of the S-6213 PUSC has insufficient moisture to create a galvanic cell

and no moisture is anticipated during transportation. In addition, visual inspections of the payload cavity, performed at various intervals, provide reasonable assurance against any considerable corrosion occurring unnoticed. Finally, packages constructed of similar materials have been previously approved and successfully transported.

2.3.2 Conclusion

2.4 General Standards

The applicant stated that the general standards (i.e., minimum package size, tamper-proof features, positive closure, chemical and galvanic reactions, valves and other devices, containment and shielding effectiveness, accessible surface temperature limit, prevention of continuous venting) are similar to as the general standards previously used for the S6W and S9G power units in the S-6213 PUSC. The NRC staff reviewed the standards for the S8GP power unit and confirms that there is no change in the standards used for the TDC power unit in the S-6213 PUSC.

2.5 Lifting and Tie-down Standards

The applicant calculated the lift lug forces for the S8GP/TDC power unit and provided the calculation results along with the results of other power units in Table 2.5-1 of the SAR. The NRC staff reviewed the results and confirms that the calculation results are acceptable because the calculated lift lug forces of the S8GP/TDC power unit in the S-6213 PUSC are bounded by the largest lift lug force of all the other power units.

2.6 Normal Conditions of Transport

The applicant evaluated the package for the tests for NCT for the TDC.

<u>Heat</u>: The applicant performed structural analysis to calculate the stresses of the components and joints of the TDC power unit in the S-6213 PUSC under hot conditions for NCT, as required in 10 CFR 71.71(c)(1). The results of all stress calculations were compared with the allowable stresses. Based on the review of the comparisons between the calculated and the allowable stresses provided in Section 2.6 of the SAR, the NRC staff finds that the stress intensity values at critical components and joints under the hot condition are within the allowable limits of the materials; therefore, the calculated stresses are acceptable.

<u>Cold</u>: The applicant performed structural analysis to calculate the stresses of the components and joints of the S8GP/TDC power unit under cold conditions, as required in 10 CFR 71.71(c)(2). The results of all stress calculations were compared with the allowable stresses. Based on the review of the results provided in the SAR, the NRC staff finds that the stress intensity values at critical components and joints under the cold condition are within the allowable limits of the materials; therefore, the calculated stresses are acceptable.

<u>Reduced External Pressure</u>: This condition requires the package to be assessed for the effects of reduced external pressure equal to 3.5 psia, as required in 10 CFR 71.71(c)(3). The applicant stated that, from the previous calculations for the S6W power unit in the S-6213 PUSC, which is similar to the S8GP power unit in the S-6213 PUSC, a critical bolted joint is capable of taking a differential pressure of about 36.0 psia. Since it is greater than the 11.2 psia differential pressure the package would be subjected to with reduced external pressure equal to

3.5 psia, the TDC power unit design is acceptable for the requirement of the reduced external pressure. The NRC staff reviewed the statement and determines that the reduced external pressure requirement is satisfied.

Increased External Pressure: This condition requires the package to be assessed for the effects of increased external pressure equal to 20.0 psia, as required in 10 CFR 71.71(c)(4). The applicant stated that, from the previous calculations for the S6W power unit in the S-6213 PUSC, which is similar to the S8GP power unit, all regions of the container have an allowable external pressure, which is much greater than the specified 20.0 psia pressure. The NRC staff reviewed the statement and determines that the increased external pressure requirement is satisfied.

Vibration: The applicant stated that the calculated natural frequency of the TDC power unit is lower than the excitation forcing frequency at the same railcar speed of 50 mph. Since the natural frequency of the TDC power unit is lower than the maximum excitation forcing frequency, the TDC power unit package may expect to have some effects due to a resonance condition; however, the applicant stated that a resonance condition is not detrimental to shipment of the TDC power unit in the S-6213 package due to sufficient damping in the system based on the study in Reference 2.4.1. The results of the study show that the worst case maximum g-load induced by railcar vibration at the natural frequency is less than 1/20th of 1g due to sufficient damping of the system. The NRC staff reviewed the statement and determined that the vibration requirement, in 10 CFR 71.71(c)(5) is satisfied based on the sufficient damping available in the package, and a minimum effect of less than 1/20th of 1g due to a resonance condition, as demonstrated by the study in Reference 2.4.1.

Water Spray: The S-6213 PUSCs are designed to withstand positive and negative pressures. In addition, no external surfaces are absorbent or reactive to water. Due to the construction materials of the S-6213 PUSC, the NRC staff determines that water spray, as required in 10 CFR 71.71(c)(5) is not a significant challenge to the structural design of this package.

Free Drop: The applicant evaluated the performance of the TDC power unit under 1-foot free drop with a side drop orientation for NCT, as required in 10 CFR 71.71(c)(7). The detailed evaluations of the power unit are provided in Section 2.6.7 of the SAR. The NRC staff reviewed the evaluations in Section 2.6.7 of the SAR and finds that the evaluations are acceptable because the stresses in the main flange, which is the most critical component of the shipping container, due to the 1-foot drop are less than that which would be required to cause yielding of the main flange stud, which indicates that the power unit will remain firmly clamped between the flanges of the shipping container. Therefore, the NRC staff determines that shipment of the TDC power unit in the S-6213 PUSC has been adequately evaluated for NCT tests in 10 CFR 71.71.

2.7 Hypothetical Accident Conditions

The applicant performed the structural analysis for the S-6213 PUSC containing a TDC core under HAC. The results of the analysis are provided in Section 2.7 of the SAR.

Free Drop: The applicant performed analyses for three free drop orientations for the TDC power unit in the S-6213 PUSC: (i) 30-foot top and bottom drop, (ii) 30-foot side drop, and (iii) 30-foot corner and oblique drop. The applicant used combinations of hand calculations and finite element computer analyses to evaluate the performance of the TDC power unit in the S-6213

PUSC. The results of the drop analyses are provided in Appendices 2.10.1 through 2.10.3 of the SAR. The NRC staff reviewed the results of the analyses of the drop test, and found that there was: (i) no loss of primary containment, (ii) no contact of the closure head and the containment cover, (iii) no contact between top impact limiter and the power unit, (iv) no top impact limiter breach, (v) no failure of attachment components, and (vi) elastic behavior of the packaging cover and fasteners. Based on the results, the NRC staff confirms that the applicant demonstrated that the TDC power unit in the S-6213 PUSC is adequately designed to perform its intended functions and maintain the structural integrity of the package under HAC tests required 10 CFR 71.73(c)(1).

<u>Pin Puncture</u>: The applicant evaluated the TDC power unit in the S-6213 PUSC for the 40-inch puncture drop, as required by 10 CFR 71.73(c)(3), and provided the analysis results in Table 2.10.4-6 of Appendix 2.10.4 of the SAR. The results show that the TDC core basket lower region was not punctured during the hypothetical puncture accident test. Based on the results, the staff confirms that the applicant demonstrated that the package function is not impaired due to the puncture impact.

<u>Thermal</u>: The applicant's thermal evaluation is provided in Chapter 3, "Thermal Evaluation" of the SAR, and the NRC staff's safety evaluation is presented in Section 3 of this safety evaluation report (SER).

<u>Immersion – Fissile Materials</u>: The criticality analysis of Chapter 6 of this safety evaluation report shows that the immersed core remains subcritical. Therefore, there is no damage to the package by immersion.

The NRC staff reviewed the structural evaluation of the TDC power unit in the S-6213 PUSC under HAC, and determines that shipment of the TDC power unit has been adequately evaluated, as required by 10 CFR Part 71.73.

2.3 Evaluation Findings

The NRC staff reviewed the structural evaluation of the TDC power unit in the S-6213 PUSC under HAC, and determines that shipment of the TDC power unit has been adequately evaluated, as required by 10 CFR Part 71.73.

The NRC staff reviewed Naval Reactors description of the TDC power unit material changes. The staff finds that the TDC material changes meet the regulatory requirements of 10 CFR Part 71 for NCT and HAC, for mitigating galvanic or chemical reactions, and is constructed with materials and processes in accordance with acceptable industry/military codes and standards.

2.4 Reference

2.4.1 RSO-84220-00-21, "KAPL Evaluation of Rail Shipment at 50 MPH for KAPL Cognizant Cargoes in M-130, M-140, PWR-2, Model 1, D2G PUSC, and S-6213 PUSC, for Information", dated December 20, 2000.

3.0 THERMAL REVIEW

The applicant submitted this amendment to propose the TDC power unit as authorized contents in the S-6213 PUSC . The S-6213 PUSC is currently certified as a Type B package and TDC is fresh, un-irradiated fuel.

The objective of the thermal review is to verify that the S-6213 PUSC, loaded with the TDC, satisfies the requirements of 10 CFR Part 71 after evaluation of the thermal tests for NCT and HAC.

3.1 Thermal Design and Decay Heat

The applicant stated, in SAR Chapter 3.0, that S-6213 PUSC is a closed vessel equipped with two pressure relief valves discharging to the ambient. The power unit assembly is shipped dry in the PUSC, with the PUSC pressurized with the dry nitrogen gas. The TDC power unit is unexposed to irradiation and does not generate decay heat. The only heat sources are external to the container.

The staff has reviewed the package description and thermal design/mechanism in SAR Chapter 3.0 for the S-6213 PUSC loaded with the TDC and concludes that the description of the thermal design and heat load remain unchanged as in the previous applications and has been adequately described.

3.2 Material Properties and Component Specifications

The applicant tabulated the thermal properties of the materials, used to fabricate the barrel of the PUSC in SAR Chapter 3.0. The staff reviewed the thermal properties of the materials used in the fabrication of the PUSC and the TDC and accepts the thermal properties used in NCT and HAC thermal evaluations.

3.3 Thermal Evaluation under Normal Conditions of Transport

<u>Thermal Model</u>

The applicant described the thermal model in SAR Chapter 3.0 for the following conditions:(a) a constant peak insolation for a 12-hour period at an ambient temperature of 100°F in still air for the heat condition and (b) an ambient temperature of -40°F in still air and shade for the cold condition.

The staff reviewed the NCT thermal model and confirmed that the applicant's thermal methodology remains unchanged from what was previously reviewed for approval by the NRC and is, therefore, acceptable for this application.

<u>Temperatures and Thermal Stress</u>

The applicant stated, in SAR Chapter 3.0, that the TDC power unit does not generate decay heat and the only heat sources are external to the PUSC; therefore, the S-6213 PUSC loaded with the TDC power unit will exhibit the following characteristics under NCT:

(a) The maximum temperature of each package component, including the gaskets, will not exceed the corresponding limits,

(b) The container surface temperature remains below 185°F in the shade, as required by 10 CFR 71.43 for an exclusive use shipment,
(c) All component thermal stresses are below the required limits of the materials, and
(d) The minimum temperatures will be equal to the minimum ambient temperature specified as -40°F, with no adverse effect to the package components.

The staff reviewed the thermal evaluation provided in SAR Chapter 3.0 and confirmed that (a) the thermal evaluation demonstrates that the maximum component temperatures and maximum thermal stresses are below the corresponding limits under NCT hot conditions and (b) there is no adverse operational effect under the NCT cold conditions of -40° in still and shade.

Maximum Internal Pressure

The applicant stated, in SAR Chapter 3.0, that the S-6213 PUSC has pressure relief valves to limit the internal pressure below the PUSC design pressure as established in SAR Chapter 2.0. The applicant stated, in SAR Chapter 3.0, that even in the event of a relief valve failure, the calculated maximum internal pressure is still below the design pressure.

The staff reviewed the description of the pressure relief valve and the pressure calculation for relief valve failure and confirmed that the package internal pressure will not exceed the design pressure.

The staff determined that the applicant's NCT thermal evaluation is acceptable because the methodology has remained unchanged as the conditions reviewed by NRC in the previous application still apply and the calculated component temperatures remain below the limits.

The staff, therefore, concludes that the package contents of the TDC power unit in the S-6213 PUSC meets the NCT thermal requirements, in compliance with 10 CFR 71.71.

3.4 Thermal Evaluation under Hypothetical Accident Conditions

The applicant stated, in SAR 3.0, that the principal modification to the thermal evaluation for the TDC power unit in the S-6213 PUSC is the change in PUSC weight. The applicant stated, in SAR Chapter 3.0, that the thermal methodology used for the HAC evaluation is the same as the one used in a previous application approved by the NRC. In the thermal model, the heat absorbed by the PUSC is calculated based on convection and radiation with an emissivity of 0.9 between a 1475°F fire source and the PUSC shell. The applicant stated in the SAR that the calculated temperatures of PUSC shell and the PUSC packaging and contents are below their temperatures of concern and therefore the components of the PUSC and its contents will remain intact, but the gasket material will melt before the maximum temperature of the shell is reached and therefore allow for a release from the package.

The staff reviewed the applicant's calculated temperatures and noted that the HAC thermal analysis demonstrated that the temperatures of both PUSC packaging and contents are below their corresponding melting points because of the presence of insulating air gaps within PUSC. The staff also noted that in the event of relief valve failure, the O-ring gaskets would become unseated allowing venting for the S-6213 PUSC. The staff confirmed that a release from the package due to venting is not a significant safety issue because TDC is fresh, un-irradiated fuel.

The applicant performed a calculation of the internal PUSC pressure assuming the relief valves fail to operate and the O-ring gaskets remain intact. The calculated internal pressure is greater than the PUSC joint capability which will potentially cause the O-ring gaskets to be unseated allowing venting of the package interior to occur.

The staff determined that the applicant's HAC thermal evaluation is acceptable because the model predicted that temperatures remained unchanged from the conditions reviewed by NRC in a previous application, the calculated component temperatures are below their melting points and the PUSC internal pressure is not a safety issue with the potential for venting of the internal package cavity. The staff confirmed that the contents of the TDC power unit in the S-6213 PUSC meets the HAC thermal requirements, in compliance with 10 CFR 71.73.

3.5 Evaluation Findings

Based on review of statements and thermal evaluations in this proposed amendment, the staff determined that (a) the thermal design features of the S-6213 PUSC remain unchanged from the package design previously approved by the NRC and (b) the thermal analyses are discussed in sufficient detail for verification of the performance of the package during NCT and HAC. The staff concludes that the S-6213 PUSC with the TDC power unit as contents meets the thermal requirements in 10 CFR Part 71.

4.0 CONTAINMENT REVIEW

The applicant submitted this amendment to propose the TDC power unit as contents for the S-6213 PUSC. The S-6213 PUSC is currently certified as a Type B package and TDC is fresh, un-irradiated fuel which contains no fission product gases.

The objective of the containment review is to verify that the S-6213 PUSC, loaded with the TDC power unit satisfies the containment requirements in 10 CFR Part 71.

4.1 Description of Containment System

4.1.1 Containment Boundary/System

The applicant stated, in SAR Chapter 4A.0, that for the TDC power unit, (a) the containment boundary for the power unit is formed by the fuel cladding and its weldments, and (b) that the S-6213 PUSC packaging provides no containment function.

The staff reviewed the fuel containment boundary shown in SAR Figure 4A.1-1 for the TDC power unit and confirmed that the containment boundary remains unchanged from those reviewed and accepted by NRC in previous applications.

4.1.2 Containment Penetrations

The applicant stated, in SAR Chapter 4A.0, that there are no penetrations into the fuel cladding of the TDC power unit.

The staff reviewed the fuel containment boundary configuration and confirmed that there are no penetrations into the fuel cladding of the TDC power unit.

4.1.3 Seals and Welds

The applicant described, in SAR Chapter 4A.0, that the containment boundary of the TDC power units which is unchanged for this amendment, as shown in SAR Figure 4A.1-1.

The staff reviewed SAR Chapter 4A.0 and Figure 4A.1-1 and confirmed the process would yield the necessary containment function for the TDC.

4.2 Containment under Normal Conditions of Transport

The applicant stated, in SAR Chapter 4A.0, that based on thermal and structural evaluations, there will be no release of radioactive material from the S-6213 PUSC and that the containment requirements are met.

The staff reviewed SAR Table 4A.2-1 for structural and thermal performance of the containment system under NCT and accepts that containment function of the fuel cladding is maintained because stresses and package temperatures do not reduce the containment effectiveness and external pressure has no effect on the containment boundary.

4.3 Containment under Hypothetical Accident Conditions

The applicant stated, in SAR Chapter 4A.0, that based on thermal and structural evaluations, there is no reduction in the sealing capability or effectiveness of the fuel cladding and there will be no release of radioactive material from the S-6213 PUSC under HAC.

The staff reviewed SAR Table 4A.3-1 for structural and thermal performance of the containment system under HAC and accepts that containment function of the fuel cladding is maintained, and the containment requirements are met because the fuel cladding remains below its melting point with a significant margin and therefore there is no reduction in containment effectiveness.

4.4 Calculation of Allowable Leakage Rate

The applicant stated, in SAR Chapter 4A.0, that leakage rate tests of the fuel cladding are neither practical nor are they considered necessary. This is because (a) fabrication and inspection processes are highly controlled, (b) visual, ultrasonic, and radiographic tests are performed to ensure there are no cracks associated with the containment boundary, (c) operational monitoring of reactor coolant indicates no evidence of fuel cladding failure, (d) the containment boundary is enclosed within the S-6213 PUSC, which includes bolted-closed steel sections and impact limiters, and (e) the S-6213 PUSC is pressurized with an inert gas and that a pressure drop leakage test is performed.

The staff reviewed SAR Chapter 4A.0 and confirmed that the fuel element design and the quality control practices, described above by the applicant for the fuel element design, and the quality control practices employed for S-6213 PUSC, provide adequate assurance that the fuel cladding will prevent release of radioactive material from the fresh, un-irradiated fuel which contains no fission product gases.

4.5 Findings

Based on review of the statements and representations in the application, the staff concludes that the containment design of the S-6213 PUSC un-irradiated fuel package, loaded with the TDC power unit, has been adequately described and evaluated and that the package design meets the containment requirements of 10 CFR Part 71.

5.0 SHIELDING REVIEW

The contents consist of an unirradiated power unit. Shielding is not needed for the package to meet the external radiation standards in 10 CFR 71.47.

6.0 CRITICALITY REVIEW

The applicant requested an amendment to the certificate of compliance for the S-6213 PUSC that would include the TDC as an allowable content. The objective of this review is to verify that the S-6213 PUSC continues to meet the criticality safety requirements of 10 CFR Part 71 under NCT and HAC with the requested changes.

6.1 Description of Criticality Design

The S-6213 PUSC is designed to transport fresh fuel modules. The S-6213 PUSC is designed to contain different types of fuel modules in various positions within the package, as well as control rods, with the fuel and poison loadings varying based on module type. This evaluation focuses on the S-6213 PUSC loaded with the S8G prototype power unit containing the TDC. The NRC previously approved the S6W and S9G/VAFF fuel for transport in the S-6213 PUSC. The features important to criticality for the proposed TDC power unit are very similar to the S9G/VAFF power unit. The S-6213 PUSC is designed to transport only one power unit at a time. The power unit consists of the fuel assemblies surrounded by a core basket and bottom support structures, with the general physical parameters described in Table 6B.1-1 of the SAR. Neutron poison materials are used within the S-6213 PUSC loaded with the TDC to control reactivity. The package internals maintain spacing between the fuel modules to control neutron interaction between modules, and the thickness of the S-6213 PUSC reduces neutron communication between packages in arrays.

6.2 Fissile Material Contents

The applicant analyzed the new fuel and poison configurations using multiple conservatisms to maximize the reactivity of the TDC, including parametric studies of control rod position, cladding thicknesses, poison element materials and configuration, and manufacturing tolerances. Based on staff review of the parametric studies performed by the applicant for the various assembly types, conservative core manufacturing tolerances, optimal assembly fuel variations, and optimal poison material variations, NRC staff verified that the applicant used the most reactive fuel module types with the most reactive core in their subsequent calculations.

6.3 General Considerations for Criticality Evaluations

The applicant performed calculations using the Monte Carlo neutron transport theory computer program MC21 to model both two and three dimensional geometries. MC21 is the standard neutron transport Monte Carlo tool used by the applicant, and has been qualified for the k_{eff}

evaluations performed in this amendment. The program is a continuous energy Monte Carlo neutron transport solver that uses highly detailed explicit geometry and compositions, represents the entire applicable energy spectrum, and uses statistical analysis of a large number of neutron histories. These histories track each neutron from birth in a fission event to their death in capture, leakage, or fission. To run the MC21 code, the applicant utilizes the Reference Data Set 2011 (RDS-2011) of supporting neutron cross section data for their computer code calculations. Staff reviewed the applicant's description of the MC21 code and the RDS-2011 neutron cross section data, and has travelled to the Bettis Atomic Laboratory to examine in detail the codes and methodologies used by the applicant in performing their calculations, and finds that MC21 and RDS-2011 are appropriate for performing the criticality analyses presented in this amendment.

The applicant based the construction of the S-6213 PUSC loaded with the TDC contents to represent an accurate geometry model, with special importance given to aspects of the model that are important to criticality safety. The applicant used material data in the evaluation from American Society of Mechanical Engineers, American Society for Testing and Materials, and Naval Nuclear Propulsion Program documents. The models described by the applicant for this amendment accurately represent the features of the fuel modules in complete geometric detail, including the fuel, poisons, cladding, coolant channels, control rods and channels, and the structural material of the module.

The applicant demonstrated the maximum reactivity of the S-6213 PUSC loaded with the TDC contents by evaluating various sensitivities and assumptions for the single package evaluation under flooding conditions, a single package under NCT, a single package under HAC, and packages in arrays under both NCT and HAC. Based on the application, the applicant calculated the criticality safety index (CSI) for a close packed infinite array of S-6213 PUSCs loaded with the TDC contents would yield a CSI of 100 in accordance with 10 CFR 71.59(a)(1) and 10 CFR 71.59(a)(2).

6.4 Single Package Evaluation

For the single package evaluation, staff confirmed that the applicant adhered to the applicable conditions of 10 CFR 71.55 and evaluated various flooded conditions as well as residual water left in the package in order to determine the maximum reactivity of the S-6213 PUSC loaded with the TDC contents. In all instances, the applicant found the package to remain subcritical and the resulting calculated k_{eff} to be less than 0.95, including all biases and uncertainties for both NCT and HAC.

6.5 Evaluation of Package Arrays Under Normal Conditions of Transport

For the array of packages under NCT, the applicant modeled a close packed triangular array to minimize spacing with the S-6213 PUSC loaded with the TDC contents with varying degrees of moderation in compliance with the applicable portions of 10 CFR 71.59. The applicant also utilized full water reflection around the packages. The applicant included numerous calculations in their SAR to determine the maximum reactivity of the TDC by utilizing parametric studies for all of the NCT scenarios evaluated, including conservatively modeling manufacturing tolerances in order to increase the k_{eff} of the packages. Staff evaluated the sensitivity studies performed by the applicant for the various parameters and found that in all instances conservatisms were appropriately applied to increase the overall multiplication factor for the

packages. The applicant identified the packages remain subcritical and the resulting calculated k_{eff} to be less than 0.95, including all biases and uncertainties for all modeled scenarios.

6.6 Evaluation of Package Arrays Under Hypothetical Accident Conditions

For HAC, the applicant modeled a single S-6213 PUSC loaded with the TDC contents with varying degrees of moderation in compliance with the applicable portions of 10 CFR 71.59, similar to the approach used for NCT. The applicant demonstrated maximum reactivity utilizing numerous parametric studies for all of the scenarios evaluated, including control rod and poison movements, preferential flooding, payload shifting within the S-6213, and manufacturing tolerances. Staff evaluated the sensitivity studies performed by the applicant for the various parameters and found that in all instances conservatisms were appropriately applied to increase the overall multiplication factor for the packages. In all instances, the packages remain subcritical and the resulting calculated k_{eff} that was identified by the applicant was found to be less than 0.95, including all biases and uncertainties.

6.7 Benchmark Evaluations

The benchmarking methodology for the TDC is the same as that used for the previous NRC approval of the S-6213 package, and NRC staff determined that it remains applicable for the contents of the TDC. The method utilized by the applicant is a set of models from the International Criticality Safety Benchmark Evaluation Project to generate calculational-over-experimental (C/E) eigenvalues, which are used to generate a benchmark bias and 2σ uncertainty for a wide range of Above Thermal Leakage Fractions. The analysis performed by the applicant is used to determine a 95% confidence interval to apply uniformly to the uncertainty in the MC21 benchmark bias. The method employed continues to comply with the requirements of 10 CFR 71.31(a)(2) and 10 CFR 71.35.

6.8 Evaluation Finding

NRC staff finds that the S-6213 PUSC loaded with the TDC contents under the assumptions analyzed by the applicant, and the conditions listed in the certificate of compliance, continues to meet the criticality safety requirements of 10 CFR Part 71. This determination was made through NRC staff review of the applicant's FSAR, and evaluation of the modeling parameters, conservatisms utilized, and verification of the resulting k_{eff}s for the evaluated system under both NCT and HAC demonstrated by the applicant's analysis continued to be less than 0.95.

7.0 OPERATING PROCEDURES

Minor changes were made to the operating procedures to include the TDC power unit and ensure clarity. The changes to the operating procedures do not affect the ability of the package to meet the requirements in 10 CFR Part 71.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

Minor changes were made to the acceptance tests and maintenance program to include the TDC power unit and ensure clarity. The changes to the acceptance tests and maintenance program do not affect the ability of the package to meet the requirements in 10 CFR Part 71.

CONDITIONS

The following changes have been made to the certificate:

Condition 5.(b)(1)(iii) and (2) has been added to specify the new contents.

The references section has been updated to include the supplement dated June 13, 2018.

CONCLUSION

Certificate of Compliance No. 9186 has been revised to add an unirradiated TDC power unit as authorized contents in the Model No. Model 2, S-6213 Power Unit Shipping Container. Based on the statements and representations in the application, and with the conditions listed above, the staff agrees that this amendment does not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9186, Revision No. 19.