ENCLOSURE 4

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North Anna Unit 3 Site-Specific GE14E Fuel Assembly Mechanical Design Report

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1.0 INTRODUCTION AND SUMMARY

This report provides the results of the North Anna Unit 3 site-specific analysis for GE14E fuel assemblies that are designed for use in GE ESBWR reactors. Report NEDC-33240P-A, Revision 1 (Reference 1), is incorporated by reference into the ESBWR Design Control Document (DCD) and in the FSAR, as Reference 4.2-4. Report NEDE-33240P-A includes both (1) the Global Nuclear Fuel report and (2) the associated NRC Safety Evaluation (Attachment 1 to the report) that describes the basis for approval of the GE14E fuel design for the ESBWR standard design and, in Section 5 of Attachment 1, sets forth the conditions and limitations for licensees referencing the report. The site-specific analyses presented in Reference 5 and described in this report demonstrate that the GE14E design is acceptable for use at North Anna 3.

The purpose of this report is to describe the analyses performed and to provide the results of these analyses using the North Anna Unit 3 site-specific seismic demands. In addition, this report describes the approach that will be used to complete the associated ITAAC (i.e., DCD Tier 1, Table 2.1.1-3, ITAAC 15) for verifying that the GE14E fuel design is adequate to withstand the seismic and dynamic loads to which it may be subjected.

2.0 FUEL ASSEMBLY DESCRIPTION

The fuel assembly is as described in Reference 1.

3.0 FUEL ASSEMBLY ANALYSIS

The site-specific seismic response spectra are higher than the Certified Seismic Design Response Spectra (CSDRS) in some frequencies. This section describes how the GE14E fuel assembly is evaluated for North Anna Unit 3, considering the site-specific seismic demands.

3.1 Fuel Lift

The GE14E fuel lift is to be analyzed using the methods stipulated in Reference 2. The acceptance criteria limit, as given in Reference 2, is that the fuel bundle lift-out of the fuel support piece does not exceed [[ ]]. This limit is established by the fitup between the lower tie plate and the fuel support piece. The fitup for the ESBWR is identical to that for earlier fuel and reactor designs.

Confirmation that the fuel lift values are below the acceptance limit will be performed using Reference 2 analysis methods prior to initial fuel load as required by DCD Tier 1 ITAAC 15 in Table 2.1.1-3, "ITAAC for the Reactor Pressure Vessel and Internals."

3.2 Structural Adequacy of Fuel for Combined Seismic and Dynamic Loads

The GE14E fuel has been designed to comply with the loading envelope and methods requirements stipulated in Reference 2, Section II. The acceptance criteria, as given in Reference 2, are that the primary stresses in the fuel are less than 70 percent of the material ultimate strength. This is demonstrated by ensuring the combined seismic and dynamic accelerations of the fuel remain below the horizontal and vertical acceleration limits.

As described in Reference 1, Attachment 1, GE14 fuel assemblies for BWR/4-6 have been demonstrated to be acceptable for the following peak seismic and dynamic accelerations: [[

]]. Due to the similarities between GE14E and GE14, and due to the shorter ESBWR fuel assembly length, the GE14E fuel assemblies are capable of withstanding accelerations greater than those for GE14 fuel assemblies.

3.2.1 Standard Design Evaluation

The standard design evaluation described in Reference 1 compares the peak seismic accelerations of the GE14E fuel from the standard design Reactor/Fuel Building Complex seismic soil-structure interaction analysis to the acceptable horizontal and vertical acceleration limits provided in Section 3.2. For the standard plant evaluation, only the seismic accelerations were considered and the peak horizontal acceleration in a single direction was used as opposed to the more limiting resultant peak horizontal acceleration. This comparison showed that there is significant margin in standard plant peak accelerations to the acceleration limits. Because there was sufficient margin, the GE14E fuel was determined to be adequate to withstand the seismic and dynamic demands expected for the standard design of the ESBWR.

3.2.2 Site-Specific Evaluations

A site-specific analysis, using approved DCD methods, has been performed to demonstrate the capability of the GE14E fuel to meet the NA3 site-specific combined loads. The limiting, site-specific, fuel seismic and dynamic accelerations have been calculated in Reference 5, which considers the combined effect of SSE, LOCA and SRV accelerations combined by Square-Root-of-Sum-of-Squares (SRSS) methodology (which is an approved DCD methodology for combining loads) for both the horizontal and vertical accelerations. In addition, in Reference 5, the horizontal seismic and dynamic demands considered the resultant acceleration in the horizontal direction, which provides the maximum acceleration in an arbitrary direction and is made up of component accelerations in the E-W and N-S directions. For the peak seismic horizontal acceleration, time consistent resultants were calculated and generated to combine the components of horizontal motion at each time step of the evaluation and the maximum over all time was selected. The horizontal dynamic accelerations (LOCA and SRV) were generated conservatively by combining the peak N-S and E-W accelerations by SRSS (using approved DCD methods), which ignore that maximum acceleration in the E-W and N-S may not occur at the same time. This evaluation methodology is consistent with the methodology that will be used to evaluate DCD Tier 1 ITAAC 15 in Table 2.1.1-3.

The limiting fuel accelerations resulting from combined seismic and dynamic loads in Reference 5 at any fuel assembly node are [[ ]], which are both below the acceleration limits given in Reference 1 of [[ ]].

These evaluations demonstrate that the GE14E fuel design is adequate for use at the North Anna Unit 3 site.

3.3 Verification Through ITAAC

In addition to these analyses, FSAR Section 4.2.3.1.3, "Fuel Lift and Seismic and Dynamic Load Analysis," explains that the fuel lift and seismic and dynamic load analyses will be completed prior to fuel release. DCD Tier 1 ITAAC 15 in Table 2.1.1-3, "ITAAC for the Reactor Pressure Vessel and Internals," sets forth the requirements for these analyses for the initial fuel to be loaded into the core.

The acceptance criteria, as stated in the ITAAC, are that the initial fuel will have primary stresses and maximum fuel bundle lift out of the fuel support piece that do not exceed the values in the approved "Fuel Assembly Mechanical Design Report." The approach that will be used for North Anna Unit 3 to verify that these acceptance criteria are met for the GE14E fuel assemblies is identified in Reference 1, which refers to the loading envelope and methods in Reference 2. Specifically, the acceptance criteria, as given in Reference 2 and as described above, are that the primary stresses in the fuel are less than 70 percent of the material ultimate strength and that the fuel bundle lift-out of the fuel support piece does not exceed [[ ]].

The generation of the bounding seismic and dynamic accelerations will be performed using the limiting combination of seismic and dynamic loads, final as-built information, DCD approved methodologies considering resultant horizontal accelerations at any fuel assembly node as discussed in Section 3.2.2 above and in Reference 5, and the GE14 acceleration limits given in Section 3.2 above. For the fuel lift, the fuel lift procedure and the applicable loads to consider are described in Reference 1, Section 3.4.1.11.

4.0 FUEL CHANNEL AND CHANNEL FASTENER

The fuel channel and channel fastener are as described in Reference 1.

5.0 REFERENCES

1. NEDC-33240P-A, "GE14E Fuel Assembly Mechanical Design Report," Revision 1, Global Nuclear Fuel, Class III (Proprietary), and NEDO-33240-A, Revision 1, Class 1 (Non-proprietary), September 2010.
2. NEDC-21175-3-P-A, BWR Fuel Assembly Evaluation of Combined Safe Shutdown (SSE) and Loss-of-Coolant Accident (LOCA) Loadings (Amendment No. 3), October 1984. NOTE: This is Reference 2 in NEDC-33240P-A.
3. SER-DMN-019, Shimizu Engineering Report, "GE Hitachi Nuclear Energy, Dominion NA3 ESBWR Project, RB/FB Seismic Analyses Bounding Results and In-Structure Response Spectra," Revision 1, March 2016.
4. ESBWR Design Control Document, Rev. 10, Tier 1 and Tier 2.
5. GE Hitachi Nuclear Energy, Report 003N5344, "North Anna 3 Fuel Qualification Bounding Accelerations," Rev. 0, April 2016.