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

February 13, 2019

Site Vice President
Entergy Operations, Inc.
Waterford Steam Electric Station, Unit 3
17265 River Road
Killona, LA 70057-3093

SUBJECT: WATERFORD STEAM ELECTRIC STATION, UNIT 3 - ISSUANCE OF AMENDMENT TO REVISE SECTION 15.4.3.1 OF THE UPDATED FINAL SAFETY ANALYSIS REPORT TO ACCOUNT FOR FUEL MISLOAD (EPID L-2018-LLA-0058)

Dear Sir or Madam:

The U.S. Nuclear Regulatory Commission (the Commission) has issued the enclosed Amendment No. 253 to Renewed Facility Operating License No. NPF-38 for the Waterford Steam Electric Station, Unit 3 (Waterford 3). This amendment consists of changes to the Updated Final Safety Analysis Report (UFSAR) in response to your application dated March 8, 2018, as supplemented by letter dated October 18, 2018.

Specifically, the amendment revises Section 15.4.3.1 of the Waterford 3 UFSAR to incorporate the results of an updated analysis for inadvertent loading of a fuel assembly into an improper position.

A copy of the related Safety Evaluation is also enclosed. The Notice of Issuance will be included in the Commission's biweekly *Federal Register* notice.

Sincerely,

April L. Pulvirenti

April L. Pulvirenti, Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-382

Enclosures:
1. Amendment No. 253 to NPF-38
2. Safety Evaluation

cc: Listserv

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

ENTERGY OPERATIONS, INC.

DOCKET NO. 50-382

WATERFORD STEAM ELECTRIC STATION, UNIT 3

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 253
Renewed License No. NPF-38

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Entergy Operations, Inc. (EOI),dated March 8, 2018, as supplemented by letter dated October 18, 2018, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this license amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, by Amendment No. 253, Renewed Facility Operating License No. NPF-38 is hereby amended to authorize revision to the Waterford Steam Electric Station, Unit 3 (Waterford 3), Final Safety Analysis Report as set forth in the licensee's application dated March 8, 2018, as supplemented by letter dated October 18, 2018, and evaluated in the NRC staff's evaluation enclosed with this amendment.

3. This license amendment is effective as of its date of issuance and shall be implemented before the Waterford 3 restart following Refueling Outage 22.

FOR THE NUCLEAR REGULATORY COMMISSION

Robert J. Pascarelli, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Date of Issuance: February 13, 2019

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 253 TO

RENEWED FACILITY OPERATING LICENSE NO. NPF-38

ENTERGY OPERATIONS, INC.

WATERFORD STEAM ELECTRIC STATION, UNIT 3

DOCKET NO. 50-382

1.0 INTRODUCTION

By application dated March 8, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18068A705), as supplemented by letter dated October 18, 2018 (ADAMS Accession No. ML 18291B374), Entergy Operations, Inc. (Entergy, the licensee), submitted a request to update the analyzed results for the fuel assembly misload event contained in the Updated Final Safety Analysis Report (UFSAR) for Waterford Steam Electric Station, Unit 3 (Waterford 3).

The proposed changes would revise the Waterford 3 UFSAR, Section 15.4.3.1, "Inadvertent Loading of a Fuel Assembly into the Improper Position," to update the results for an inadvertent loading of a fuel assembly into the improper position with a new analysis. The new analysis accounts for the implementation of zirconium diboride (ZrBr2) integral fuel burnable absorber (IFBA) and determines an increase in the dose consequence of the worst undetectable misload event including consideration for failed incore detectors during startup and during operation.

The supplemental letter dated October 18, 2018, provided additional information that clarified the application, did not expand the scope of the application as originally noticed, and did not change the U.S. Nuclear Regulatory Commission (NRC or the Commission) staff's original proposed no significant hazards consideration determination as published in the *Federal Register* on June 19, 2018 (83 FR 28459).

2.0 REGULATORY EVALUATION

2.1 Background

The fuel assembly misload event is a limiting fault (Infrequent Event) accident and is defined in Section 15.4.3.1.1 of the Waterford 3 UFSAR as the erroneous placement or orientation of fuel assemblies in the reactor core. Misloading of one or more fuel assemblies in the reactor core may result in an unexpected loss of thermal-hydraulic operating margin. Considerable care is expended on designing a scheme for the placement of the fuel in the core to achieve the

desired core power distribution. Failing to load fuel in the proposed arrangement is a foreseeable error and requires satisfactory measures to mitigate the consequences.

The following are some of the most common measures to minimize chances of a misloaded fuel assembly in the reactor core:

- Administrative controls in fuel manufacturing and core loading;
- Core loading to be supervised by the fuel vendor using fuel tracking software;
- Tracking neutron flux at the source-range detector location to estimate the rate at which the core is approaching a critical condition;
- Once the core is fully loaded, the placement of assemblies is verified visually before the reactor vessel head is replaced.

Nevertheless, the fuel assembly misload event is conservatively analyzed to ensure acceptable consequences.

2.2 Regulatory Review

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criterion (GDC) 13, "Instrumentation and control," states, in part, that "Instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate safety...." A fuel assembly misload event could adversely affect the fission process (power distribution), the integrity of the reactor core, and the reactor coolant pressure boundary. Meeting the requirements of GDC 13 provides assurance that a fuel assembly misload event will be detected before it can affect power distribution, core integrity, or produce unacceptable stress on the reactor coolant pressure boundary.

The NRC guidelines for meeting the requirements in GDC 13 are provided in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR [Light-Water Reactor] Edition," Section 15.4.7, "Inadvertent Loading and Operation of a Fuel Assembly in an Improper Position," Revision 2, dated March 2007 (ADAMS Accession No. ML070550013). The guidelines most relevant to this safety evaluation (SE) are as follows:

- The provisions made to search for loading errors at the beginning of each fuel cycle.
- Sufficient number of fuel loading errors should be studied by the applicant to show that the worst undetectable situation has been identified. For those reactors in which burnable poison or fuel rods are added to or removed from fuel assemblies at the plant, errors in these processes must be considered.
- Changes to the power distribution and increases in local power density should be addressed.

- The acceptable radiological consequences for the misloaded fuel bundle event should be a small fraction (interpreted as less than 10 percent) of 10 CFR Part 100, "Reactor Site Criteria," limits.

Waterford 3 was licensed to the 10 CFR 50.67, "Accident source term," limits for offsite dose consequences in Amendment No. 198 (ADAMS Accession No. ML050890248). The offsite dose consequence acceptance criteria for a limiting fault event in 10 CFR 50.67 are the same as that for 10 CFR Part 100 (i.e., a small fraction of the prescribed limits). In addition, the licensee was issued Amendment No. 210 (ADAMS Accession No. ML061930421) in order to implement ZrB_2 IFBA.

To continue to meet the requirements of GDC 13, the licensee has employed interim administrative restrictions on incore detectors. Operability of the incore detectors is administratively controlled by the Technical Requirements Manual (TRM). The licensee stated that the interim restrictions have required cycle specific analysis that could impact operations by significantly limiting the number of incore detectors that are allowed to be out of service.

The licensee has requested an amendment, pursuant to 10 CFR 50.90, "Application for amendment of license, construction permit, or early site permit," to revise Section 15.4.3.1 of the Waterford 3 UFSAR to update the fuel misload analysis to address the implementation of ZrB_2 IFBA. The licensee stated that the new misload event analysis would allow it to discontinue the interim administrative restrictions. The new misload event analysis allows fuel failure rather than imposing additional operating margin penalties. For Waterford 3, the fuel assembly misload is categorized as a limiting fault; hence, limited fuel failures that result in dose consequences within applicable limits may be incurred for this event.

The analysis results in an increase in the dose consequences of the worst undetectable misload event (UFSAR Section 15.4.3.1), including consideration for failed incore detectors during startup and during operation. However, the licensee stated that the fuel assembly misload event remains bounded by results calculated for analyzed infrequent events that have been demonstrated to be within the acceptance criteria in 10 CFR 50.67.

3.0 TECHNICAL EVALUATION

3.1 Westinghouse Nuclear Physics Code

The new analysis uses the ANC nuclear physics code. ANC is the current Westinghouse neutronics code, which was approved for application at Waterford 3 in Amendment No. 200 (ADAMS Accession No. ML051290368). ANC is a 3-dimensional two-group diffusion theory nodal code used for nuclear design analyses for determining the core design parameters. Core design parameters include critical boron concentration, control rod worths, reactivity coefficients, assembly average powers and exposures, assembly peak rod powers, peaking factors, and axial power shapes. Topical Report (TR) WCAP-11596-P-A, "Qualification of the Phoenix-P/ANC Nuclear Design System for Pressurized Water Reactor Cores" (ADAMS Accession No. ML080630391; not publicly available; proprietary information) describes the ANC nuclear design system for pressurized-water reactor (PWR) cores and provides demonstration of the qualification of the ANC nuclear analysis package. The qualification process covers an acceptable range of comparisons between the ANC calculations and the operating reactor data measured during startup tests and during normal power operations from several representative reactor cycles from three-loop and four-loop Westinghouse-designed plants.

As part of the review of Amendment No. 210, which approved the application of the Westinghouse ANC code package to Waterford 3, the licensee provided supplemental information to demonstrate its applicability. The supplemental information included comparisons between the predictions of the PHOENIX-P and ANC nuclear physics codes for Waterford 3 zero-power physics test measurements performed for Cycles 11 and 12. The comparisons showed that the maximum error for the potentially limiting fuel assemblies is within the uncertainty allowance on the assembly power used in the safety analysis. Therefore, the licensee may utilize ANC to determine core operating limits for Waterford 3, as described in the SE for Amendment No. 210.

3.2 Technical Evaluation of Fuel Misload Analysis

In its submittal dated March 8, 2018, the licensee stated that the new fuel assembly misload event analysis, which predicts fuel failure under the most limiting conditions, uses a similar methodology to the current analysis of record (AOR). One difference is that the new analysis determines the maximum required overpower margin (ROPM) for a given misload regardless of the azimuthal tilt observed. This is different than the method used in the current AOR, which uses azimuthal tilt in the misload analysis to help in detecting fuel assembly misloads. This change in method does not impact the operability conditions set in the technical specification related to the incore detectors and does not restrict operation of Waterford 3 if all the incore detectors are not fully operational.

Selection of Worst Misload Candidates

The Waterford 3 fuel assembly misload event analysis assumes the worst configuration of failed incore detectors permitted by the TRM in the vicinity of the two interchanged assemblies. Based on the reactivities and fissile content of the assumed misloaded assemblies and the reactivities of neighboring assemblies, several worst-case candidates are selected for the analysis.

Waterford 3 UFSAR Section 15.4.3.1, describes the worst undetectable single fuel assembly misload event (worst undetectable misload).

Each fuel assembly has a coded serial number located at its upper end fitting. Verification of this serial number is used as a means of positive identification for each assembly in the plant. During refueling outages, a visual display is provided in the main control room showing a schematic representation of the reactor core, spent fuel pool, and new fuel storage area. At the completion of core loading, all fuel assemblies in the core are confirmed and independently verified to be in the proper location. However, despite these precautions, it is assumed that an assembly is placed in a wrong core position. The worst scenario is the interchange of two assemblies of different enrichment or reactivities. The worst undetectable misload is defined as an undetectable misload that either results in the minimum overpower margin (OPM) to departure from nucleate boiling (DNB), if DNB is not predicted to occur, or results in the maximum number of rods in DNB, if DNB is predicted to occur. The Waterford 3 licensing classification of the fuel assembly misload event as a limiting fault means that the licensing analyses need not consider concurrent design basis accidents.

The licensee stated that a determination is made as to whether the misload is detectable during startup. If the misload is judged detectable, then it is eliminated from further consideration, since appropriate corrective action could be taken. Detectability of a fuel assembly misload is

determined by simulation of the beginning of cycle (BOC) and the middle of cycle (MOC) reactivity and power distribution.

In a Request for Additional Information (RAI) dated September 25, 2018 (ADAMS Accession No. ML18262A041), the NRC staff asked the licensee to explain how candidates for the worst undetectable misload may be reliably identified from the vast number of possibilities. If the specific identification methodology had not been previously approved, the NRC staff requested further justification for the identification method.

In its response to the RAI by letter dated October 18, 2018, the licensee stated that the method of screening possible adverse fuel assembly misloads is the same as that used in the Waterford 3 AOR as well as that approved by the NRC for Palo Verde Nuclear Generating Station (ADAMS Accession No. ML17319A107). The initial screening involves comparing the k-infinity differences between two possible misloaded assemblies. The BOC and MOC k-infinity differences were calculated for the proposed misloads using the ANC code. The k-infinity difference at BOC is used to identify worst case undetectable fuel assembly misloads. The k-infinity difference at MOC is used to identify fuel assembly misloads with the highest ROPM. The MOC is chosen since the ROPM limit is generally set at MOC, just after burnable absorber burnout. If a misload is undetectable at BOC but has a low ROPM at MOC it is not considered limiting. Likewise, if a misload has a high ROPM at MOC, but is highly detectable at BOC, it is also not considered limiting. Additional consideration was given for the assemblies immediately adjacent to the nominal ANC depletion peak radial peaking factor (Fr) locations throughout the cycle. For these locations, the k-infinity difference and interchange difference between the peak Fr adjacent assembly and every sub-region in the core were calculated using BOC k-infinity values. The maximum ANC Fr calculated from the base misload case is also a good indicator of the maximum ROPM, and as such was used as a screening parameter in order to ensure the worst undetectable misload would be captured.

The response to the RAI addresses the NRC staff concern by adequately explaining the method for determining the selection of the limiting misload candidates and providing adequate justification for the method; therefore, the staff finds the licensee's response acceptable.

Analysis of Fuel Failure and Peaking Factor

The amount of fuel failure that occurs as a result of DNB is determined by counting the number of fuel rods that have a power greater than the Fr that corresponds to the ROPM. The licensee stated that significant margin to fuel centerline melt is maintained for the worst undetectable misload under all operating conditions.

In the RAI dated September 25, 2018, the NRC staff asked the licensee to explain how the amount of fuel failure that occurs as a direct result of DNB is determined and to discuss "CECOR code measured values" in the context of candidate misloads that could derive from several representative and potential future loading patterns.

The licensee, in its response dated October 18, 2018, stated that the core operating limit supervisory system (COLSS) assures that the core always maintains sufficient DNB OPM during normal operation to prevent fuel failure from Condition II transients to a 95/95 confidence level. The amount of margin that must be reserved for Condition II transients (i.e., ROPM) is predetermined and is one of the COLSS setpoints. The COLSS uses the CECOR-measured planar radial peaking factor (Fxy) in its online calculation of the DNB OPM. If a fuel assembly misload were to occur, some of the effects of the misload would be seen in

the CECOR-measured Fxy. The CECOR-measured Fxy is input into COLSS, which would cause a decrease in DNB OPM. This means that only the decrease in DNB OPM associated with the unseen increase in Fxy would need to be accommodated by available margin to prevent fuel failure.

The CETOP code is used to correlate ROPM with an increase in Fxy to calculate the OPM associated with different values of Fxy. These CETOP calculations are used to determine the Fxy that would be equivalent to the current reserved ROPM value. Any fuel rod having an Fxy greater than the reserved COLSS ROPM calculated Fxy could have a departure from nucleate boiling ratio (DNBR) below the 95/95 DNBR limit. The Waterford misload analysis has assumed that the value of Fxy installed into COLSS for a core operating with a postulated misload would be the value that CECOR would measure for that core assuming that 25 percent of the incore detectors were inoperable. Thus, the analysis assumed that all fuel rods having an Fxy greater than the reserved COLSS ROPM calculated Fxy would be below the 95/95 DNBR limit. To conservatively account for postulated DNB propagation, it was assumed that all the rods in any assembly having at least one rod with an Fxy greater than the reserved COLSS ROPM calculated Fxy would be counted as failed.

The response to the RAI addresses the NRC staff concern by adequately explaining its method for conservatively determining the number of failed fuel rods; therefore, the staff found the licensee's response acceptable.

Dose Consequence

The new fuel assembly misload event analysis determined an increase in the dose consequence of the worst undetectable misload event (Waterford 3 UFSAR Section 15.4.3.1), including consideration for failed incore detectors during startup and operation. In particular, the new analysis predicts 3.2 percent fuel failure, which includes a conservative accounting for DNB propagation. The licensee stated in its submittal dated March 8, 2018, that this result is bounded by the excess load with loss of alternating current event, which predicts 8 percent fuel failure. The licensee stated that both events predict fuel failure as a result of exceeding DNB limits. The licensee further stated that the release pathway for both events is the same (i.e., release to atmosphere from secondary side via atmospheric dump valves). As described in Waterford 3 UFSAR Section 15.1.2.3, "Increased Main Steam Flow with a Concurrent Loss of Offsite Power," the excess load with loss of alternating current power event is defined as an infrequent incident.

Because the licensee's new analysis of the fuel assembly misload event was performed with an acceptable methodology and the predicted results are bounded by those of an existing, analyzed infrequent incident, the NRC staff finds the new analysis acceptable.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Louisiana State official was notified of the proposed issuance of the amendment on January 25, 2019. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has

determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration, and there has been no public comment on such finding published in the *Federal Register* on June 19, 2018 (83 FR 28459). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

6.0 CONCLUSION

The NRC staff has reviewed the licensee's license amendment request to revise Section 15.4.3.1 to update the analysis for the inadvertent loading of a fuel assembly into an improper position event for Waterford Unit 3. Based on the evaluation discussed above, the staff finds the proposed new fuel misload analysis satisfies 10 CFR 50.67 limits for dose consequences and also satisfies GDC 13, and therefore, it is acceptable.

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) there is reasonable assurance that such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

Principal Contributor: Fred Forsaty

Date: February 13, 2019

SUBJECT: WATERFORD STEAM ELECTRIC STATION, UNIT 3 - ISSUANCE OF AMENDMENT TO REVISE SECTION 15.4.3.1 OF THE UPDATED FINAL SAFETY ANALYSIS REPORT TO ACCOUNT FOR FUEL MISLOAD (EPID L-2018-LLA-0058) DATED FEBRUARY 13, 2019

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