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

June 30, 2020

ANO Site Vice President
Arkansas Nuclear One
Entergy Operations, Inc.
N-TSB-58
1448 S.R. 333
Russellville, AR 72802

SUBJECT: ARKANSAS NUCLEAR ONE, UNITS 1 AND 2 - ISSUANCE OF AMENDMENT NOS. 269 AND 321 RE: REQUEST TO INCORPORATE THE TORNADO MISSILE RISK EVALUATOR INTO THE LICENSING BASIS (EPID L-2019-LLA-0093)

Dear Sir or Madam:

The U.S. Nuclear Regulatory Commission (NRC or the Commission) has issued the enclosed Amendment Nos. 269 and 321 to Renewed Facility Operating License Nos. DPR-51 and NPF-6, respectively, for Arkansas Nuclear One, Units 1 and 2 (ANO-1 and ANO-2). The amendments authorize changes to the Safety Analysis Reports for ANO-1 and ANO-2 in response to your application dated April 29, 2019, as supplemented by letters dated November 14, 2019, and February 19, 2020.

The amendments incorporate the Tornado Missile Risk Evaluator methodology into the licensing basis for ANO-1 and ANO-2. The approved methodology may be used to demonstrate whether an identified structure, system, and component is required to conform to the licensing basis requirements for protection against tornado missiles at ANO-1 and ANO-2. The NRC staff notes that the Tornado Missile Risk Evaluator methodology may only be applied to discovered conditions where tornado-missile protection was required by the plant's licensing basis, but not provided. Further, the NRC's approval of this license amendment is based, in part, on the NRC staff's review of specific items included in your application. Accordingly, the methodology approved for this amendment must not be used either to remove existing tornado-missile protection, or to avoid providing tornado-missile protection during reviews done in support of the plant modification process at ANO-1 and ANO-2.

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,

/RA/

Thomas J. Wengert, Senior Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-313 and 50-368

Enclosures:
1. Amendment No. 269 to DPR-51
2. Amendment No. 321 to NPF-6
3. Safety Evaluation

cc: Listserv

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

ENTERGY OPERATIONS, INC.

DOCKET NO. 50-313

ARKANSAS NUCLEAR ONE, UNIT 1

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 269
Renewed License No. DPR-51

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

   A. The application for amendment by Entergy Operations, Inc. (the licensee), dated April 29, 2019, as supplemented by letters dated November 14, 2019, and February 19, 2020, 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 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. 269, the license is amended to authorize revision to the ANO-1 Safety Analysis Report (SAR), as set forth in the application dated April 29, 2019, as supplemented by letters dated November 14, 2019, and February 19, 2020. The licensee shall update the SAR to incorporate the changes as described in the licensee's application dated April 29, 2019, as supplemented by letters dated November 14, 2019, and February 19, 2020, consistent with the changes approved in the NRC staff's safety evaluation associated with this amendment, and shall submit the revised description authorized by this amendment with the next update of the SAR.

3. This amendment is effective as of its date of issuance and shall be implemented within 30 days from the date of issuance. The SAR changes shall be implemented in the next periodic update of the ANO-1 SAR in accordance with 10 CFR 50.71(e).

FOR THE NUCLEAR REGULATORY COMMISSION

Jennifer L.
Dixon-Herrity

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Jennifer L. Dixon-Herrity, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Date of Issuance: June 30, 2020

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

ENTERGY OPERATIONS, INC.

DOCKET NO. 50-368

ARKANSAS NUCLEAR ONE, UNIT 2

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 321
Renewed License No. NPF-6

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

   A. The application for amendment by Entergy Operations, Inc. (the licensee), dated April 29, 2019, as supplemented by letters dated November 14, 2019, and February 19, 2020, 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 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. 321, the license is amended to authorize revision to the ANO-2 Safety Analysis Report (SAR), as set forth in the application dated April 29, 2019, as supplemented by letters dated November 14, 2019, and February 19, 2020. The licensee shall update the SAR to incorporate the changes as described in the licensee's application dated April 29, 2019, as supplemented by letters dated November 14, 2019, and February 19, 2020, consistent with the changes approved in the NRC staff's safety evaluation associated with this amendment, and shall submit the revised description authorized by this amendment with the next update of the SAR.

3. This amendment is effective as of its date of issuance and shall be implemented within 30 days from the date of issuance. The SAR changes shall be implemented in the next periodic update of the ANO-2 SAR in accordance with 10 CFR 50.71(e).

FOR THE NUCLEAR REGULATORY COMMISSION

Jennifer L. Dixon-Herrity

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Jennifer L. Dixon-Herrity, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Date of Issuance: June 30, 2020

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NOS. 269 AND 321, RESPECTIVELY, TO

RENEWED FACILITY OPERATING LICENSE NOS. DPR-51 AND NPF-6

ENTERGY OPERATIONS, INC.

ARKANSAS NUCLEAR ONE, UNITS 1 AND 2

DOCKET NOS. 50-313 AND 50-368

1.0 INTRODUCTION

By letter dated April 29, 2019 (Reference 1), as supplemented by letters dated November 14, 2019 and February 19, 2020 (References 2 and 3), Entergy Operations, Inc. (Entergy, the licensee), submitted a license amendment request (LAR) to the U.S Nuclear Regulatory Commission (NRC, the Commission) for Arkansas Nuclear One, Units 1 and 2 (ANO-1 and ANO-2). The licensee requested a change to the licensing basis to use a new tornado-missile risk evaluation methodology to qualify several components that have been identified as not conforming to the existing, unit-specific licensing basis. The methodology is described in a document prepared by the Nuclear Energy Institute (NEI): NEI 17-02, "Tornado Missile Risk Evaluator (TMRE) Industry Guidance Document," Revision 1B (the TMRE methodology, included in Reference 4).[1]

The amendment request assesses external hazard frequencies, system responses, and mitigating actions to determine whether physical protection from tornado-generated missiles is warranted for certain structures, systems, and components (SSCs). The methodology would only be applicable to discovered conditions where tornado-missile protection should be present but is not currently provided. Future modifications to the facility, which need to be reviewed for tornado-missile protection, will not be evaluated using the TMRE methodology.

The supplemental letters dated November 14, 2019, and February 19, 2020, provided additional information that clarified the application, did not expand the scope of the application as originally noticed, and did not change NRC staff's original proposed no significant hazards consideration determination as published in the *Federal Register* on July 2, 2019 (84 FR 31633).

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[1] In this evaluation, all references to NEI 17-02 refer to Revision 1B unless another version is explicitly cited. "TMRE methodology" is used throughout this document to refer to the guidance in this revision, which includes options that may or may not be used in a particular LAR.

1.1 Purpose of Proposed Change

The NRC issued Regulatory Issue Summary (RIS) 2015-06, “Tornado Missile Protection,” on June 10, 2015 (Reference 5). RIS 2015-06 served to remind licensees of the need to conform to the current, site-specific licensing basis for tornado-generated missile protection at their facilities; to report examples of failure to conform with a plant’s tornado-generated missile licensing basis; and to reiterate the NRC staff’s position that the licensee’s systematic evaluation program or individual plant examination of external events results do not constitute regulatory requirements. These are not part of the plant-specific tornado-generated missile licensing basis unless the NRC or licensee acted to amend the operating license.

In response to RIS 2015-06, the licensee performed walkdowns at ANO-1 and ANO-2 to identify potential vulnerabilities with the current licensing basis for tornado-missile protection. Specifically, the licensee identified plant configurations in which SSCs should have been protected from tornado-generated missiles based on the current licensing basis but were not, resulting in noncompliance with the design and licensing bases.

2.0 REGULATORY EVALUATION

2.1 Description of Proposed License Change

In the enclosure to the LAR dated April 29, 2019, the licensee provided an evaluation of the proposed change. In Section 2.4, “Description of the Proposed Change,” the licensee states that it was requesting NRC approval of a revision to the safety analysis reports (SARs) for ANO-1 and ANO-2. The revision is to reflect those SSCs that do not require physical protection from tornado missiles. The following nonconforming conditions were identified in Table 6, “Summary of EEFPs [Exposed Equipment Failure Probabilities] Based on Tornado Category (Non-Conforming SSCs)” and Table 7, “Summary of EEFPs Based on Tornado Category (Non-Conforming SSCs)” of the evaluation:

ANO-1
- various fire damper openings
- various conduits and cable trays
- blockout FB-103-4-0008
- emergency feedwater (EFW) steam piping

ANO-2
- conduit in Room 2136
- steam supply piping to EFW from main steam header #1
- common EFW steam supply piping
- exhaust stacks 2K-4A and 2K-4B

Furthermore, the licensee proposes to modify ANO-1 SAR Section 5.1.5, “Wind and Tornado Loads,” and ANO-2 SAR Section 3.5.4, “Barrier Design Procedures” (References 6 and 7, respectively).

On September 21, 2017, NEI submitted NEI 17-02, Revision 1, in support of three proposed pilot implementations of their proposed methodology. NEI 17-02, Revision 1 was intended to provide guidance for identifying and evaluating the safety significance associated with SSCs that are exposed to potential tornado-generated missiles, and for assessing the risk posed by tornado missiles to determine whether physical protection of the noncompliant SSCs was warranted. During the pilot program, the industry guidance was updated twice. The version used at ANO is the latest, Revision 1B. All references in this evaluation to the TMRE methodology or NEI 17-02 refer to this version unless a different version is explicitly cited.

The TMRE is a risk-informed methodology, which is intended for application by ANO to resolve conditions that do not conform to requirements for protection against tornado missiles in the current licensing basis.

In Section 3.4, "Technical Evaluation Conclusions," of the enclosure to the LAR, the licensee states that the TMRE methodology could be used to resolve those issues that do not conform to deterministic design and licensing requirements for protection against tornado missiles. This would be accomplished by revising the design basis under Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.59, "Changes, tests and experiments." To make such a change without prior approval, the acceptance criteria of the TMRE must be satisfied. In addition, ANO must continue to meet the conditions stated in the LAR.

The NRC staff notes that the methodology may only be applied when legacy conditions are discovered where tornado-missile protection was not provided. The methodology cannot be used to avoid providing tornado-missile protection in the plant modification process. Therefore, future changes to the facility requiring physical tornado-missile protection would not be evaluated using the TMRE methodology. The NRC staff also notes that proposed changes that are not within the scope of the plant-specific approval described in this SE are to be reviewed consistent with the criteria in 10 CFR 50.59 and the ANO-1 and ANO-2 licensing basis.

2.2 Tornado-Missile Protection Licensing Basis

ANO-1 and ANO-2 were designed and constructed to meet the intent of the general design criteria (GDC) of the Atomic Energy Commission (AEC) as originally proposed in July 1967. Thus, ANO design and construction were initiated and proceeded to a significant extent based upon the criteria proposed in 1967.

Section 1.4, "General Design Criteria," of the ANO-1 SAR describes the manner in which the ANO-1 GDC meet the intent of the corresponding GDC published as Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," in 1971.

Section 3.1, "Conformance with AEC General Design Criteria," of the ANO-2 SAR describes the manner in which the ANO-2 GDC meet the intent of the corresponding GDC published as Appendix A to 10 CFR Part 50 in 1971.

Accordingly, ANO-1 and ANO-2 were designed to meet the intent of the GDC in 10 CFR Part 50, Appendix A, including GDC 2, "Design bases for protection against natural phenomena" and GDC 4, "Environmental and dynamic effects design bases." The current GDC are repeated in Section 2.3, below. The current licensing basis for tornado-missile protection for ANO-1 is contained in Section 5.1.5 of the ANO-1 SAR. The ANO-2 current licensing basis for tornado-missile protection is contained in Section 3.5.4 of the ANO-2 SAR.

The most challenging credible missiles created by natural phenomena at ANO are those generated by tornadoes. The incidence of tornadoes at the site is described in the ANO SARs, Section 2.3, "Meteorology"; they are consistent in frequency and magnitude with NRC tornado

Region 1. ANO-1 SAR Section 5.1.5 describes the basis for tornado loading of Class 1 buildings and tornado-driven missiles at ANO-1. ANO-2 SAR Section 3.3.2, “Tornado Loadings,” provides a similar basis for missile impingement at ANO-2.

The typical method used to meet the guidelines in the GDC is physical protection by locating required equipment in structures designed to protect against damage from tornado missiles or by providing barriers designed to withstand tornado missiles.

2.3 Related Criteria in Appendix A to 10 CFR Part 50

GDC 2, “Design bases for protection against natural phenomena,” in Appendix A to 10 CFR Part 50 establishes requirements regarding the ability of SSCs important to safety to withstand the effects of natural phenomena without the loss of capability to perform their safety functions. Protection from the missile spectrum set forth in the ANO SARs provides assurance that necessary SSCs will be available to perform their safety functions during and following a tornado.

GDC 4, “Environmental and dynamic effects design bases,” establishes requirements regarding the ability of SSCs important to safety to be protected from dynamic effects, including the effects of missiles from events and conditions outside the nuclear unit. Protection from a spectrum of missiles with the critical characteristics set forth in applicable regulatory guidance provides assurance that the necessary SSCs will be available to mitigate the potential effects of extreme winds and missiles associated with such winds on plant SSCs important to safety.

2.4 Applicable Regulatory Guidance and Review Plans

The guidance in this section was used by the NRC staff to determine whether the methodology proposed in NEI 17-02, Revision 1B is acceptable for use at ANO. As the licensee has submitted the methodology to evaluate changes to the protection of SSCs from externally generated tornado missiles, the guidance applies to the acceptability of the application of that methodology at ANO-1 and ANO-2, within the constraints identified in the LAR.

NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR [Light-Water Reactor] Edition” (the SRP), includes three relevant sections:

- Section 3.5.1.4, Revision 4, “Missiles Generated by Extreme Winds” (Reference 8), and Section 3.5.2, Revision 3, “Structures, Systems, and Components to be Protected from Externally-Generated Missiles” (Reference 9), contain the current acceptance criteria governing tornado-missile protection. These criteria generally specify that SSCs that are important to safety shall be provided with sufficient, positive tornado-missile protection (i.e., barriers) to withstand the maximum credible missile hazard created by tornadoes.

- Section 19.1, Revision 3, “Determining the Technical Adequacy of Probabilistic Risk Assessment for Risk-Informed License Amendment Requests After Initial Fuel Load” (Reference 10), provides the NRC staff with guidance for evaluating the acceptability of the results of a licensee’s probabilistic risk assessment (PRA) when used to request risk-informed changes to the licensing basis.

- Section 19.2, “Review of Risk Information Used to Support Permanent Plant-Specific Changes to the Licensing Basis: General Guidance,” dated June 2007 (Reference 11), provides the NRC staff with guidance for evaluating the risk information used by a licensee to support permanent, risk-informed changes to the licensing basis.

Regulatory Guide (RG) 1.76, Revision 1, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants" (Reference 12), provides a method to define design-basis tornado and design-basis tornado-generated missiles that a nuclear power plant should be designed to withstand to prevent undue risk to the health and safety of the public. Current NRC guidance on tornado characteristics for consideration in the design of nuclear power plants is found in this guide.

RG 1.117, Revision 2, "Protection Against Extreme Wind Events and Missiles for Nuclear Power Plants," dated July 2016 (Reference 13), provides an approach for identifying those SSCs of light-water-cooled reactors that should be protected from the effects of the worst-case extreme winds (tornadoes and hurricanes) and wind-generated missiles, such that they remain functional. Appendix A, "Structures, Systems, and Components to be Protected Against Extreme Wind Events (Tornado and Hurricane)," to RG 1.117, Revision 2, lists the types of SSCs that should be protected from design-basis tornadoes. The NRC staff notes that this list is unchanged from the previous revision of the RG. In addition to physical design methods, the NRC allows the use of probabilistic analysis to demonstrate that the probability of a tornado-generated missile striking safety-related equipment is sufficiently low such that no additional protective measures are required.

RG 1.174, Revision 3, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis" (Reference 14), describes an acceptable approach for developing risk-informed applications for a licensing basis change that considers engineering issues and applies risk insights. It provides general guidance concerning analysis of the risk associated with proposed changes in plant design and operation.

RG 1.200, Revision 2, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities" (Reference 15), describes an acceptable approach for determining whether the PRA, in total or the parts that are used to support an application, is acceptable for use in regulatory decisionmaking for LWRs.

ASME International (formerly, the American Society of Mechanical Engineers (ASME)) and the American Nuclear Society (ANS) formed a Joint Committee on Nuclear Risk Management. This joint committee published ASME/ANS RA-Sa–2009, "Addenda to ASME/ANS RA-S–2008 Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," February 2009 (hereafter referred to as the PRA Standard (Reference 16)). This version is endorsed for use in RG 1.200. This industry standard sets forth requirements for PRAs used to support risk-informed decision for commercial nuclear power plants.

NUREG/CR-4461, "Tornado Climatology of the Contiguous United States," was based, in part, on a summary of information from a variety of sources collected in WASH-1300, "Technical Basis for Interim Regional Tornado Criteria," May 1974 (Reference 17). The initial version of NUREG/CR-4461 summarized data on tornadoes that occurred from January 1954 through December 1983 and were listed in a tornado database maintained by the National Severe Storms Forecast Center. Revision 1 of NUREG/CR-4461 (Reference 18) updates the 1986 report using tornado data collected from January 1, 1950, through August 2003. It contains statistics on tornado dimensions and wind speeds by region of the country and estimates of strike probabilities and design wind speeds by boxes with sides of 1 degree, 2 degrees, and 4 degrees of latitude and longitude. The guidance in NUREG/CR-4461, Revision 2 (Reference 19),[2] examines the implications of switching from the Fujita scale (F-scale) to the enhanced Fujita scale (EF-scale). This alters design wind speed estimates for tornadoes.

The TMRE methodology uses data, examples, and analysis developed by the Electric Power Research Institute (EPRI). These were presented in a topical report, EPRI NP-768, "Tornado Missile Risk Analysis," May 1978 (Reference 20), supplemented by EPRI NP-769, "Tornado Missile Risk Analysis Appendixes," May 1978 (Reference 21).

Analysts determined the number of hits per targets. These values are used to determine the missile impact parameter. From this analysis, a methodology and computer code (TORMIS) were developed and documented in EPRI NP-2005, "Tornado Missile Simulation and Design Methodology," August 1981 (Reference 22).

In a memorandum dated November 29, 1983 (Reference 23), the NRC staff concluded that the EPRI methodology based on EPRI NP-768 and EPRI NP-769 and documented in EPRI NP-2005 can be used to assess the need for positive tornado protection for specific safety-related plant features contained in EPRI NP-768 and EPRI NP-769.

3.0 TECHNICAL EVALUATION

Consistent with the design criteria above, this review is intended to demonstrate that the licensee has properly established the capability of SSCs to withstand design wind loadings so that the design reflects appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena. The ANO-2 updated SAR, Section 3.5, "Missile Protection," states that the SSCs for the bounding safety functions are those that support the following:

- no loss of containment function;
- no loss of function to systems required to shut down the reactor and maintain it in a safe shutdown condition, or mitigate the consequences of the missile damage;
- no offsite exposure exceeding the guidelines of 10 CFR Part 100, "Reactor Site Criteria"; and
- no loss of integrity of the spent fuel pool.

In RG 1.117, Revision 2, the NRC staff determined that the likelihood of a design-bases tornado occurring concurrent with a loss-of-coolant-accident is sufficiently small that the bounding safety functions are considered to be those in support of a loss of offsite power (LOOP), with protection afforded for long-term core cooling. These criteria are used by the NRC staff to assess those SSCs that should be protected from externally generated tornado missiles. In Appendix A, "Technical Basis for TMRE Methodology," to the TMRE methodology, a nonrecoverable LOOP is assumed. The NRC staff notes that, per RG 1.200, a safe and stable condition is required for a technically acceptable PRA. As such, it is assumed that long-term cooling is achieved and assured in that condition.

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[2] From this point on, all references to NUREG/CR-4461 refer to Revision 2 unless a different version is explicitly cited.

The NRC staff's review focused on (1) evaluating the acceptability of the NEI guidance process, as used by the licensee, for assessing the risk from SSCs that do not conform to the plant-specific licensing basis related to tornado-missile protection; (2) validating the acceptability of the licensee's PRA for use in the implementation of the methodology; (3) confirming that the risk associated with not physically protecting the identified nonconforming SSCs according to the tornado-missile protection licensing basis is sufficiently small; and (4) confirming that the proposed change ensures that SSCs important to safety are designed to withstand the effects of tornadoes without loss of capability to perform their safety functions, and that their design reflects the importance of the safety functions to be performed.

3.1 Tornado Missile Risk Evaluation Methodology

The TMRE methodology uses plant walkdowns to identify and quantify potential externally generated tornado missiles and evaluate the availability of protection for onsite SSCs necessary to support withstanding the effects of normal and accident conditions related to a tornado. This information is used to calculate a failure probability for onsite SSCs necessary to support safe shutdown that are not protected, which are referred to as nonconforming SSCs. The EEFP is a conditional probability that associates the failure of an exposed SSC due to an externally generated missile assuming a tornado of a given category. The failure probabilities are then incorporated into the PRA model for the facility.

The TMRE methodology outlines those aspects that are conservative in Appendix A to NEI 17-02. It indicates that the methodology is based on information derived from EPRI NP-768. Two areas were identified to be potentially nonconservative. The methodology instructs the use of sensitivity studies for these two areas. One of the nonconservatisms exists with calculations in the compliant case and the other in derivation of the missile impact parameter (MIP). The MIP is used to develop the EEFP and represents the probability of a damaging hit on a target per unit surface area, per missile, per tornado; and is sensitive to tornado intensity and the elevation of the target.

Then the methodology looks at two cases and uses the difference to determine whether the risk from not providing physical protection to the nonconforming SSCs is acceptably small. This is evaluated according to the acceptance guidelines of RG 1.174. The first case assumes that all nonconforming SSCs are protected. This is known as the compliant case. The second case is known as the degraded case and assumes that the nonconforming SSCs are considered failed as a result of the tornado and related conditions.

3.1.1 Selection of SSCs

As discussed in Section 2, "Overview of Tornado Missile Risk Evaluator Methodology," of the TMRE methodology, development of a high-winds equipment list (HWEL) comprises three major steps. The first step is the performance of walkdowns to gather information associated with those SSCs that are required to be protected. The walkdowns are used to confirm the identified nonconformances and identify any additional vulnerabilities. The concept of vulnerabilities reflects SSCs credited in the PRA that are not protected from tornadoes. Next, the information is used to create the HWEL. Finally, the HWEL is refined to ensure that the SSCs remaining are those SSCs needed to withstand design wind loadings to support safe shutdown of the facility.

Section 2.3, "Evaluate Target and Missile Characteristics," Section 5, "Evaluate Target and Missile Characteristics," and Section 6.5, "Target Failures and Secondary Effects," of the TMRE methodology, state that "Tornado missile failures do not need to be considered for SSCs protected by 18" [inch] reinforced concrete walls, 12" reinforced concrete roofs, and/or 1" steel plate." The guidance does not require analysis for evaluating the risk of nonconforming conditions that are protected as described in TMRE methodology Section 2.3.

Nonconforming SSCs Screened from the TMRE analysis

The ANO-1 TMRE analysis excluded the following two nonconforming SSCs:

- conduit EC 1493 (includes the reactor head vent solenoid valve that operates the high point vent valves), and
- small bore service water piping (HCD-65-2" and HCD-66-2" to electrical switchgear cooling pumps VCH-4A and VCH-4B).

The high point vents can be used by the emergency operating procedures during the plant transient response to a tornado event. However, the high point vents will be used after a loss of primary-to-secondary cooling (e.g., EFW and high-pressure injection cooling). The NRC staff assessed that the increase in risk if the high point vents were included in the TMRE PRA model would not affect the conclusion of the LAR.

The licensee provided clarification in its supplement to the LAR dated February 19, 2020, that the electrical switchgear room did not require chilled water cooling in any accident scenario based on plant analysis.

Conduct of the Walkdowns

Section 3, "Perform Plant TMRE Walkdown," of the TMRE methodology, describes the process for preparing, conducting, assessing, and documenting the performance of a walkdown of a site to gather sufficient information about the number and types of missiles on site as well as confirmation and identification of SSCs that should be protected from externally generated missiles. The licensee used walkdowns to gather physical data associated with known vulnerable and nonconforming SSCs and to identify other SSCs modeled in the internal events PRA that are not protected from tornadoes and tornado missiles. From this, the licensee developed an HWEL.

In Section 3.3.3, "Missile Walkdowns," of the enclosure to the LAR, the licensee indicated that the guidance in the TMRE methodology was followed. Section 3.4, "Tornado Missile Identification and Classification," of the TMRE methodology provides guidance on the expertise needed to perform tornado-missile walkdown, verifying total number of missiles through TMRE walkdown for nonstructural missiles, structural missiles, and considering nonpermanent missiles. The personnel recommendations for the tornado-missile walkdown are discussed in Section 3.4.1, "Perform Plant TMRE Walkdown," of the TMRE methodology, which states:

> Personnel performing the Tornado Missile Walkdown do not require PRA expertise or knowledge, and structural engineering experience is not required. The personnel only need to be trained on the methods for identifying and counting potential missiles. This section and Section 4.3 of EPRI 3002008092 ["Process for High Winds Walkdown and Vulnerability Assessments at Nuclear Power Plants"] provide adequate information to support training Tornado Missile Walkdown personnel.

The NRC staff reviewed the approval of another risk-informed tornado protection methodology known as TORMIS (from the name of the EPRI computer code used to implement the methodology, which was evaluated in Reference 24). Given that no specific expectations are required in the conduct of walkdowns for that methodology and the expectation for the personnel involved to be familiar with plant layout and drawings (allowing personnel to properly define the missiles and classify/group missiles accordingly), the NRC staff finds the means used by the licensee to qualify walkdown personnel to be acceptable.

Determination of Applicable Missiles

As discussed above, RG 1.76, Revision 1, provides a method to define design-basis tornado and design-basis tornado-generated missiles. It defines tornado-generated missiles as objects moving under the action of the aerodynamic forces induced by the tornado wind. Wind velocities in excess of 75 miles per hour are capable of generating missiles from objects lying within the path of the tornado wind and from the debris of nearby damaged structures. The ANO-1 SAR, Table 5-2, "Typical Missiles," identifies wood plank, steel pipe, and automobile as missiles generated by tornado and used for the design basis. The same missiles were identified for ANO-2 in Section 3.3.2.1, "Applicable Design Parameters," of the ANO-2 SAR.

TMRE methodology Section 3.4.4, "Structural Missiles," and Section C.4, "Debris from Damaged Structures," of Appendix C, "Bases for Target Robustness and Missile Characteristics," contain guidance, including lists showing the type and size of a few structures, for determining the number of missiles generated by building deconstruction. The guidance for building deconstruction was based on typical construction practices and an assumption of a moderately stacked warehouse, which was confirmed by a walkdown of a typical warehouse at a nuclear power plant.

The NRC staff finds the approach for determining the missile inventory from building deconstruction in the TMRE methodology to be acceptable because (1) it considers different building types, (2) it is based on typical construction practices and representative warehouse inventory, and (3) the approach conservatively assumes that the entire building deconstructs, resulting in its construction constituents, as well as the inventory within, being available as missiles. Section C.4 of the TMRE methodology also includes an example evaluation of the guidance to determine the number of missiles from building deconstruction. Because of the availability of guidance as well as an example for the implementation of the guidance to determine missile inventory from building deconstruction, the NRC staff finds that extensive structural engineering experience is not necessary for personnel performing the tornado-missile inventory walkdown.

Section 3.4.2, "Non-Structural Missile Inventory," of the TMRE methodology, provides guidance on the process for counting nonstructural missile inventory to verify bounding values of plant nonstructural missiles. Due to the large diversity of objects to consider in the missile count, the TMRE methodology recommends grouping missiles of similar size and type into various zones around the plant. While not all-inclusive, Table 3-2, "Potential Tornado Missile Type," of the TMRE methodology, provides examples of missiles to consider while performing a walkdown. Missile inventory was counted from the missile survey out to 2,500 ft from the reference point. The NRC staff noted that the 2,500-ft. missile source distance is a typical value used to support site-specific tornado-missile count for applications and was derived from a case study discussed in Section 2.3.3, "Off Site Missile Assessment," of EPRI NP-769. For nonstructural missile count, the NRC staff finds counting missiles to a distance of approximately 2,500 ft is acceptable, because it is consistent with typical counting practice and the EPRI studies used as the basis for the TMRE methodology. The TMRE guidance also states that in the case of targets greater than 1,500 ft from the reference point, a qualitative evaluation of the missile inventory within 2,500 ft of the outlying targets should be performed. However, the licensee did not specify whether all target SSCs were within 1,500 ft of this reference point which, if not, would require an additional qualitative assessment. In the supplement to the LAR dated November 14, 2019, the licensee confirmed that all SSCs including the turbine building, auxiliary buildings, intake structures, tank areas, and the alternate alternating current power diesel generator were within 1500 ft of the reference point. The NRC staff finds the licensee's approach for considering missiles around targets that are further from the reference point acceptable because the insights from EPRI NP-768 data, which is used to support the TMRE methodology, suggest that the majority of the hits would occur from tornado missiles within 600 ft of the target.

Section 3.4.3, "Non-Permanent Missiles," of the TMRE methodology, provides guidance on the consideration of nonpermanent missiles, such as those present during outages and construction periods. This section of the NEI guidance states that it is not necessary to explicitly account for the additional outage-related missiles in the TMRE missile inventory. The guidance further states that outages are of relatively short duration compared to the operational time at a nuclear power plant. The NRC staff notes that duration of outages, or other temporary activities that involve bringing additional equipment to the sites, may be relatively long, specifically for a multi-unit site.

For ANO, the NRC staff notes that the generic missile count from the TMRE methodology (240,000) was used for its TMRE analysis. The NRC staff also notes that the licensee's actual missile count (196,498) was lower than the TMRE methodology generic missile count. Given that the licensee has margin in the missile count to account for potential increases in missile counts during outage preparation and staging, the NRC staff finds the licensee's approach consistent with the NEI guidance. In the future, should the result of a proposed change exceed those assumptions and the risk metric thresholds in the TMRE methodology, NRC approval would be required before staging material that would create a missile count in excess of 240,000 missiles.

In summary, the NRC staff finds the licensee's approach for characterizing tornado missiles in TMRE acceptable because (1) the licensee's process for performing missile counts considered structural and nonstructural missiles, (2) the licensee's process is based on the relevant industry guidance, and (3) the methodology includes the externally generated missiles identified in the ANO-1 and ANO-2 SARs, as updated.

High-Winds Equipment List

The guidance in Sections 3.1, "Vulnerable SSC Walkdown Preparation," and 3.2, "Vulnerable SSC Walkdown," of the TMRE methodology was used to review previously identified nonconforming SSCs, collect and verify any data needed for the TMRE model via the development of HWEL, and locate and evaluate unprotected SSCs included in the TMRE PRA model via walkdowns. Sections 3.3.1, "High Wind Equipment List," and 3.3.2, "Target Walkdowns," of the enclosure to the LAR describe the licensee's process for SSC (target) identification. Consistent with the TMRE methodology, specific configurations of interest observed during the walkdowns include:

- active (e.g., pumps or compressors) or passive (e.g., tanks, piping) components that were directly exposed to tornado winds whether inside or outside,
- components inside non-Category I structures,
- components adjacent to non-Category I structures, and
- components subject to failure, due to secondary effects.

The enclosure to the LAR also provides details about the development of its site-specific HWEL. The NEI guidance recommends refinement of the HWEL using certain screening criteria including:

- screening out SSCs that were located inside Category I structures and that were located away from vulnerable openings or features such as ventilation louvers and roll-up doors, and

- screening SSCs that were dependent on offsite power, because the TMRE methodology assumed there would be a nonrecoverable LOOP due to the tornado event.

Given that the licensee's TMRE PRA and corresponding results do not screen out any SSCs based on the area of the penetrations, and that Category I structures were required to be designed to withstand the effects of tornado missiles, the NRC staff finds that the licensee's approach for screening SSCs in Category I structures acceptable.

3.1.1.1 Missile Impact Parameter

The NRC staff's evaluation of the MIP values in the TMRE methodology examined the dependencies of MIP values and the appropriateness of the area scaling approach. The dependencies that were examined included the tornado region (tornado frequency), building configurations in EPRI NP-768, tornado intensity, missile location, and target height.

As discussed in Section 2.4 of this SE, the TMRE methodology uses the NRC-approved data in EPRI NP-768 to derive the generic MIP values. Multiple scenarios of tornadoes striking a site were considered as part of the NRC reviewed and approved information provided in EPRI NP-768. Tornadoes were considered to take multiple alternative paths and be of different intensity. To explore the effect on missile-hit frequencies of sites located in different places in the country, average tornado frequency of three NRC tornado regions (Regions I, II, and III, numbered in decreasing order of tornado occurrence frequencies) were used as input to the calculations in EPRI NP-768. The calculations also explored effects of different missile types, different initial missile insertion heights, different initial locations of missiles through the site, and different configurations of buildings in the nuclear power plant. To study the different alternatives, the EPRI NP-768 analysis uses a Monte Carlo approach that sampled and addressed uncertainties of parameters such as wind speeds, initial missile locations, and insertion heights. The EPRI NP-768 report examined statistical convergence on target hit frequencies to select a sufficiently large sample of tornado paths and intensities (measured in the Fujita-prime scale (F'-scale)), as well as missile trajectories.

Targets

The EPRI NP-768 report analyzed effects of different configurations of buildings and missiles at nuclear power plants by considering two hypothetical nuclear power plants, referred to as Plants A and B. The targets selected for the computation of hit frequencies were the buildings of Plants A and B. Plant A was a single-unit plant with seven buildings. Plant B was a two-unit plant with 16 buildings. Plant B was analyzed in two configurations: configuration B1 postulated that all Unit 2 buildings were under construction when the tornado struck (with construction material providing a source of missiles); configuration B2 postulated both units as being operational at the time of the tornado strike. The types of missiles considered included wood beams, pipes, steel rods, utility poles, plates, and automobile vehicles (cars and trucks). At Plant A, the missiles were assumed to be distributed uniformly over an enclosed area, while for Plant B, the distribution of missiles was nonuniform in the B1 and B2 configurations, which included different assumptions on insertion heights and the initial location of missile types (e.g., vehicles were predominantly located in parking lots).

Missile trajectories were simulated and the characteristics of the hits on the different buildings or targets were recorded (such as impact speeds and scabbing damage) using the EPRI methodology. The EPRI methodology employs Monte Carlo techniques in order to propagate the transport of tornado-generated missiles and to assess the probability of missile strikes causing damage to unprotected SSCs. Statistics were derived to quantify the number of hits per target, the number of hits per missile, the number of hits with specific features (including whether a threshold velocity was exceeded or whether a given amount of damage was caused by the hit) and associated hit frequencies.

The TMRE methodology notes that the majority of the tornado-generated missile hits in the EPRI NP-768 analysis affected the vertical walls, with few hits on the building roofs. Based on that observation, the guidance selected the vertical wall exposed area only to define the MIP for near-ground targets for use in the TMRE methodology. The exception in the selection of areas was for the target referred to as Target 6 (service water intake structure), which was 20 ft in height. For Target 6, the total building area (walls and roof) was selected for estimating MIP values for both near-ground and elevated targets, on the basis that it was a short building with expected missile hits to the roof. In the TMRE methodology, Table B-3, “Plant ‘A’ Tornado Missile Impact Parameters for Near Ground Targets,” of Appendix B, “Bases for MIP and Missile Inventories,” revised average MIP values over all building targets for the three NRC tornado regions are provided. The average value for each tornado intensity interval was computed as a weighted average using the target areas as the weights (based on building wall areas with the previously stated exception of Target 6). This area-weighted average is equivalent to adding missile-hit frequencies for all targets, and then dividing by the total reference area, as well as the tornado frequency, for the F’ tornado intensity category under consideration.

Section B.3.2, “Selection of Conservative Tornado Region MIP,” of Appendix B to the TMRE methodology asserts that differences in MIP values between the NRC tornado regions were unexpected and that no specific discussion is provided in EPRI NP-768 to explain those differences. To address the possible uncertainty, the maximum average of the three NRC tornado regions for each F’ tornado intensity category was selected to define reference MIP values. The TMRE methodology further states that lack of convergence might have caused the numerical differences in the NRC tornado regions and postulates a transition height between near-ground and elevated targets as 30 ft above the reference. Depending on the location of the target (the location was measured with respect to the target center), the guidance provides different MIP values.

The NRC staff examined the TMRE methodology's approach for computing the MIP values from EPRI NP-768 data. The NRC staff determined that the MIP values were appropriately calculated MIP values for the seven targets in Plant A studied in EPRI NP-768 and that the MIP average values in Tables B-3 and B-5 of NEI 17-02, Revision 1B, were acceptable. The NRC staff also compared the MIP values for each target in EPRI NP-768 to the average MIP values in the TMRE methodology, which would be used generically. The targets in the EPRI NP-768 analysis were buildings that shielded each other against tornado-generated missiles. The reference MIP values in the TMRE methodology were averages from multiple targets (each target had a different level of exposure to tornado missiles). In an as-built, as-operated nuclear power plant, specific targets may be more exposed and have higher MIP values than the generic MIP values proposed in the TMRE methodology. Section A.5, "Benchmark Results," of Appendix A to the TMRE methodology, presented the results of a benchmark analysis, comparing results from using the average MIP values to site-specific high-winds PRA results, and concluded that the average MIP values and the associated EEFP tended to overestimate (in several cases, depending on the F' tornado category, by orders of magnitude) SSC failure probabilities. The TMRE methodology states that the technical acceptability of high-winds PRA models used to benchmark the TMRE methodology were consistent with the guidance in RG 1.200. As the NRC staff used the results of those high winds PRA models to provide an order of magnitude estimation of SSC failure probabilities for this application, primarily for benchmarking purposes, the staff concluded that there was no need to review the technical acceptability of the high winds PRA models.

The TMRE methodology does not include the containment building for the near-ground MIP calculations. The licensee also applied the robust missile fractions from the TMRE methodology (discussed in Section 3.3 of this SE). The NRC staff has determined that the net result of these changes is not significant and did not affect the licensee's conclusions.

The NRC staff concludes that the licensee's approach of excluding the containment building in the computation of the reference MIP values for near-ground structures in its TMRE methodology is acceptable, because it eliminates the impact of the containment building on the near-ground MIP values.

Section B.4, "MIP Values for Use in the TMRE," of Appendix B to the TMRE methodology, provides two sets of MIP values: one for elevated targets and one for near-ground targets. As previously noted, the demarcation between near-ground and elevated targets was 30 ft above the primary missile source for a target. The EPRI NP-768 data supported the assumption of decrease in hit frequency with target height. For example, the MIP value of Target 1, which was only impacted at heights above 60 ft, was one order of magnitude less than the MIP value of other targets. As noted in Table B-2a, "Elevated and Near Ground Missile Impact Parameter Comparisons," of Appendix B to the TMRE methodology, the guidance proposed an MIP (elevated ground) = 0.43 × MIP (near-ground).

Conservatism in MIP Calculation

Section B.3.4, "Basis for Target Elevation Demarcation," of Appendix B to the TMRE methodology, provides the bases for the 30 ft demarcation. Section B.3.4 states that the demarcation elevation of 30 ft was decoupled from the EPRI NP-768 data because the EPRI NP-768 data did not provide quantifiable insights into missile hit probability at different elevations. The TMRE guidance further states that an assumed demarcation elevation was qualitatively justified based on regulatory documents associated with tornado missiles (i.e., RG 1.76, Revision 1, and SRP Section 3.5.1.4). Those regulatory documents included the 30 ft demarcation for heavier missiles, such as automobiles.

The NRC staff considered insights from the target elevation sensitivity study in Appendix E, "TMRE Methodology Sensitivity Studies," to the TMRE methodology, to examine the appropriateness of the change in MIP values for elevated targets and the transition elevation of 30 ft. The NRC staff concludes that assuming 30 ft as a transition distance to consider a lower value of the MIP is acceptable for this application, because it is generally consistent with insights obtained from the EPRI NP-768 data and the Appendix E sensitivity analyses. The NRC staff emphasizes that any use of such transition distances or reduction factors outside the scope of the TMRE methodology is not approved through the granting of this amendment request.

The NRC staff concludes that selection of only the exposed vertical wall area to calculate MIP values for near-ground targets is justified because the majority of the missile hits in the EPRI NP-768 analysis occurred near the ground and on the vertical walls. The EPRI NP-768 data and the TMRE methodology sensitivity analyses consistently showed that elevated targets have fewer hits and, therefore, using smaller MIP values for elevated targets is acceptable. Using different MIP values for each tornado intensity is acceptable and supported by EPRI NP-768 data. The airborne missile paths are longer and cause more target hits for more intense tornadoes and, therefore, the average MIP values monotonically increase with increasing tornado intensity.

The reference MIP values derived in the TMRE methodology were averaged over all examined targets (weighted by the exposed vertical wall area) with the exception of the containment building. The NRC staff concludes that computing the MIP values as an average of the examined targets is reasonable. The average value takes credit for mutual shielding of the buildings (i.e., the average MIP values correspond to a target that is neither the most exposed nor the least exposed) and mutual shielding is a more realistic representation of actual nuclear power plant configurations. The TMRE methodology guidance includes a benchmark comparison supporting the conclusion that use of average MIP values do not underestimate, in general, the EEFP with respect to site-specific failure probability of SSCs calculated using high winds PRA models. In summary, the NRC staff concludes that the use of average MIP values in the TMRE methodology, which do not include the containment building of the EPRI NP-768 Plant A, are acceptable for this application.

3.2 Determination of Site Tornado Frequency

The licensee developed site-specific tornado frequencies for each category of tornadoes, which it classified using the F'-scale. Section 4, "Determine Site Tornado Hazard Frequency," of the TMRE methodology provides guidance on the development of site-specific tornado initiator frequencies.

The TMRE methodology uses the tornado data found in NUREG/CR-4461 to develop the site-specific tornado frequencies to be used in the TMRE PRA model. NUREG/CR-4461 provides, for each U.S. nuclear plant site, tornado wind speeds associated with 10^{-5}/year, 10^{-6}/year, and 10^{-7}/year occurrence frequencies for a tornado strike. Additionally, the total tornado strike frequency is provided for all locations in the continental United States. Using data from NUREG/CR-4461, Revision 2, and the approach detailed in Section 4 of the TMRE methodology, the licensee developed a site-specific tornado frequency curve (hazard curve) for the licensee's site. The site-specific hazard curve was then used to derive the frequency of all tornadoes considered in the TMRE methodology (F'-2 through F'-6).

For the purposes of the TMRE methodology, NEI used the F'-scale to classify tornado wind speed. This scale is different from the original F-scale and the enhanced Fujita scale (EF-scale) that is typically used. Section 4.2, "Background," of the TMRE methodology states that for the TMRE application, the F'-scale was chosen because the MIP values were derived based on simulations that used the F'-scale to categorize the tornadoes. Because F'-scale occurrence frequencies were not directly available from NUREG/CR-4461, Revision 2, those frequencies were derived from the site-specific F'-scale data. As noted in Section 4.2 of the TMRE methodology, using the F'-scale data instead of the EF-scale data resulted in higher and, therefore, more conservative strike frequencies. Although the TMRE methodology uses the F'-scale for consistency in MIP derivation, RG 1.76, Revision 1, uses the EF-scale and, therefore, the use of the F'-scale is limited to this application.

The licensee described its process for determining tornado-initiating event frequencies in Section 3.3.4, "Tornado Hazard Frequency," of the enclosure to the LAR. As stated in that section, the TMRE methodology and data from NUREG/CR-4461, Revision 2, were used to determine the tornado initiating event frequencies for the ANO TMRE PRA model. Site-specific tornado frequencies for applicable tornadoes were developed as a result of this effort. Using guidance in the TMRE methodology and plotting the ANO data points in an XY scatter chart with a logarithmic trend line, the licensee derived the hazard curve used to calculate tornado initiating event frequencies for each tornado intensity.

The NRC staff finds that the licensee's process for generating tornado initiator frequency is consistent with guidance in the TMRE methodology and is technically acceptable for this application. The NRC staff's finding is based on the licensee's: (1) use of the most recent data from NUREG/CR-4461, Revision 2, which has been endorsed by the NRC staff and includes tornadoes reported in the contiguous United States from January 1950 through August 2003, (2) demonstration of acceptable results in the derivation of a site-specific tornado frequency curve (hazard curve), and (3) use of a technically sound approach to determine the frequency of each tornado category for use in the TMRE PRA model.

3.3 Failure Probability

The second part of the methodology is the calculation of the failure probability of the SSCs due to externally generated tornado missiles. The failure probability of all SSCs impacted by tornado missiles that are part of the TMRE model (i.e., nonconformances and vulnerabilities) is determined through the EEFP. As described in Section 5 of the TMRE methodology, the EEFP represents "conditional probability that an exposed SSC is hit and failed by a tornado missile, given a tornado of a certain magnitude." An EEFP is calculated for each nonconformance and vulnerability at each of the tornado categories from F'2 through F'6. For buildings above 30 ft, a summation of EEFPs is used due to the MIP component of the EEFP being driven in part by elevation.

The EEFP is fundamental to the TMRE, because it provides the likelihood of an SSC being failed by a tornado missile. The NRC staff reviewed the EEFP, the derivation of the term, and its sensitivities. The TMRE methodology indicates that the EEFP was developed to be a conservative estimate. As such, deviations from the methodology can result in nonconservative probabilities and are not permitted by the methodology.

Robustness

The fragility factor used in the EEFP determination is the conditional probability of the SSC failing to perform its function given that it is hit by a tornado missile. For the purposes of the TMRE methodology, the SSCs were assumed to always fail if hit by a tornado missile (i.e., the factor is assumed to be 1). However, as discussed previously, the TMRE methodology defines adjustment factors on the missile inventory to account for levels of target robustness to withstand missile impacts. Section 5 of the TMRE methodology includes guidance for the consideration of robust targets. Robust targets (e.g., steel pipes and tanks) are those that can only be damaged by certain types of missiles. Robust targets are subdivided into categories based on their characteristics such as the thickness of the steel or concrete used for the construction of the specific SSCs. To account for target robustness, the TMRE methodology assigns a certain fraction of the total missile inventory to be used in calculation of the EEFP for that target.

Nine categories of robust targets are defined in Table 5-2, "Missile Inventories for EEFP Calculations," of the TMRE methodology, to adjust missile counts from 1 percent (very robust target, such as a reinforced concrete roof of at least 8 inches in thickness) to 55 percent (less robust target, such as a steel pipe of at least 16 inches in diameter and less than 3/8-inch thickness). Other targets not belonging to any of those nine categories were considered to be not robust, and any missile hit was assumed to fail the target (i.e., the missile count is 100 percent for these targets). An example of missile inventory adjustments to account for target robustness is presented in Table 5-3, "Example Missile Inventories for Different Targets (For F'6 Tornado EEFP Calculations)," of the TMRE methodology The basis for the identification of certain SSCs as robust, and the determination of the fraction of missile inventory that can damage each such SSC was provided in Appendix C, Section C.3, "Approach," of the TMRE methodology. The NRC staff finds the approach for the identification of certain SSCs as robust to be acceptable for this application because the characterization appropriately captures the varying level of damage that may be caused by a tornado missile hit.

Section B.6, "Missiles Affecting Robust Targets," of Appendix B to the TMRE methodology, states that the number of missiles used in the EEFP calculation could be adjusted to account for the population of missiles that could damage an SSC and provided the percentage of the total missile inventory for each type of robust target. These percentages depended on specific missile type counts taken from two plant missile inventories as shown in Tables B-15, "Unrestrained Missile Inventories," B-16, "Restrained Missile Inventories," and B-17, "Average Missile Type Inventory," of Appendix B to the TMRE methodology. In accordance with Table 5-2 of the TMRE methodology, the ANO licensee has appropriately incorporated robustness values in EEFP calculations.

The NRC staff concludes that the licensee's approach for adjusting the number of missiles for robust targets by using the robust missile data in Table 5-2 of the TMRE methodology is acceptable for this application. It has been reviewed and determined to develop conservative robust missile adjustment factors. The NRC staff further concludes that additional comparison of site-specific missile type inventories is not necessary for this application.

Failure Modes

As discussed above, Section 6.5 of the TMRE methodology was added to provide guidance on the consideration and treatment of additional tornado and tornado-missile-induced failure modes for all nonconforming SSCs in the TMRE PRA model. Guidance was provided on functional failures of SSCs as well as the impact of secondary effects. The NRC staff finds that the guidance in TMRE methodology Section 6.5 adequately captures the important tornado and tornado-missile-induced failure modes for SSCs as well as their treatment in the TMRE PRA model. The NRC staff further finds that the direct impact on exposed SSCs is the dominant failure mode for this application compared to more complex failure modes (e.g., spurious closure or opening).

The TMRE methodology includes consideration of secondary failure modes in Section 3.2.3, "SSC Failure Modes." It states that flooding and combustion motor intake effects caused by tornado-missile-induced failures of fluid-filled tanks and pipes should be considered as viable secondary failure modes considered in the development of the TMRE PRA.

The NRC staff reviewed the licensee's approach for considering primary and secondary failure modes in the LAR, as supplemented, and finds it to be acceptable for this application because (1) the approach captures the most important secondary failure modes, (2) the licensee considered these secondary failure modes for SSCs in its TMRE PRA development, and (3) the licensee either included identified secondary failure modes in the TMRE PRA or dispositioned them appropriately.

The NRC staff also finds that the licensee's process for determination of the impact of tornado missiles on targets by determining EEFPs is acceptable (i.e., evaluating the risk associated with the lack of tornado-missile protection for nonconforming SSCs), because (1) the approach is consistent with the derivation of the MIP values and, therefore, uses the MIP values appropriately; (2) the approach to defining missile inventories based on a reference radius (2,500 ft) or the target area is consistent with the original analysis in EPRI NP 768; (3) adjusting inventories to account for robustness levels is adequately justified and an acceptable first order approximation in lieu of detailed fragility analyses for this application, as targets are expected to have different levels of resilience to missile hits; and (4) the approach to estimating exposed areas, in general, tends to overestimate the area in the path of missiles, and therefore, it is appropriate for the risk evaluations performed to support this application. The NRC staff's conclusion on acceptability of using EEFPs in risk evaluations is limited only to address the tornado-missile protection nonconforming conditions within the scope of the TMRE methodology as described in other sections of this SE.

3.4 Risk Results Review

3.4.1 Key Principle 1: Compliance with Current Regulations

As a key principle of risk-informed integrated decisionmaking, Regulatory Position 1, in RG 1.174, Revision 3, states, in part, that "The licensee should affirm that the proposed licensing basis change meets the current regulations unless the proposed change is explicitly related to [a requested] exemption (i.e., a specific exemption under 10 CFR 50.12)."

The licensee states, in part, in Section 4.1, "Applicable Regulatory Requirements/Criteria," of the enclosure to the LAR that RG 1.174 establishes criteria to quantify the "sufficiently small" frequency of damage discussed in SRP Section 3.5.1.4, which allows for a probabilistic basis for relaxation of deterministic criteria for tornado-missile protection of SSCs. However, the cited SRP sections discuss the probability of occurrence of events and not the change in core damage frequency (CDF) and large early release frequency (LERF). The probabilistic criteria in SRP Section 3.5.1.4 (i.e., the probability of damage to unprotected safety-related features) is not directly comparable to RG 1.174 acceptance guidelines. In Item 14 of Attachment 3, "ANO's

Review of Pilot Plant RAIs [Requests for Additional Information],” of the enclosure to the LAR, the licensee states that the safety analysis acceptance criteria are not affected by the change, as those events do not assume a tornado coincident with a design-basis accident (except to the extent that the tornado has the potential to initiate a design-basis accident). Use of the TMRE methodology does not alter accident analysis input assumptions, acceptance criteria, or results. The licensee further states that the types of accidents, accident precursors, failure mechanisms, and accident initiators already evaluated in the SAR remained unaltered.

Based on its review of the LAR and its supplements, the NRC staff finds that the proposed change continues to meet the regulations, because the design basis for the SSCs impacted by the proposed change will reflect the importance of the safety functions to be performed by those SSCs in accordance with the licensing basis, and, therefore, there is reasonable assurance that, subsequent to the proposed change, necessary safety-related SSCs will continue to be available to perform their safety functions during and following a tornado event at ANO.

The NRC staff notes that exemption from the applicable regulations was neither requested by the licensee in the application, nor is granted by the NRC staff. All applicable design requirements remain. Therefore, Key Principle 1 in risk-informed decisionmaking is satisfied.

3.4.2 Key Principle 2: Evaluation of Defense-in-Depth

Defense-in-depth is an approach to designing and operating nuclear facilities involving multiple independent and redundant layers of defense to compensate for human and system failures. Regulatory Position 2.1.1 in RG 1.174, Revision 3, states that defense-in-depth consists of a number of elements and consistency with the defense-in-depth philosophy is maintained if the following occurs:

- A reasonable balance is preserved among prevention of core damage, prevention of containment failure, and consequence mitigation.
- Overreliance on programmatic activities as compensatory measures associated with the change in the licensing basis is avoided.
- System redundancy, independence, and diversity are preserved commensurate with the expected frequency, consequences of challenges to the system, and uncertainties.
- Defenses against potential common-cause failures are preserved, and the potential for the introduction of new common-cause failure mechanisms is assessed.
- Independence of barriers is not degraded.
- Defenses against human errors are preserved.
- The intent of the plant’s design criteria is maintained.

In Section 3.2, “Traditional Engineering Considerations,” of the enclosure to the LAR, the licensee provided a discussion of how its risk-informed assessment was consistent with the defense-in-depth philosophy. The following sections provide an evaluation of each of the seven considerations.

A reasonable balance is preserved among prevention of core damage, prevention of containment failure, and consequence mitigation.

In Item 1 of Section 3.2, the licensee states that the proposed change does not introduce new accidents or transients as compared to those present in the licensee's internal events PRA and those analyzed during the safety analyses. In Section 2.3, "Reason for the Proposed Change," of the enclosure to the LAR, the licensee identified six nonconforming conditions for ANO-1 (two excluded from the TMRE analysis) and four nonconforming conditions for ANO-2 (one is described in a note to the table). Moreover, most of each system that is important to safety is protected from tornado missiles. The licensee also explained that no conditions were discovered within the scope of the proposed change that would affect containment integrity during a tornado event and that the containment would continue to provide its function as a key fission product barrier.

In Section 3.3.9, "Sensitivities," of the enclosure to the LAR, the licensee reported the results of a sensitivity study, "ANO-1 Single Event Cutset Sensitivity." Though not required by the TMRE methodology, the study identified several single-order cutsets (i.e., initiating event and one basic event leading to core damage). These single-order cutsets were related to Room 97 (cable spreading room), Room 98 (corridor), and Room 129 (control room). The NRC staff notes that RG 1.174, Revision 3, states that a licensing change should neither significantly increase the challenge to multiple radioactive barriers simultaneously nor introduce a new event that simultaneously affects multiple barriers. The NRC staff noted that on a single room basis the SSCs impacted were critical to event mitigation (e.g., both diesel generators, service water, engineered safeguards actuations, emergency feedwater, etc.). In the supplement to the LAR dated November 14, 2019, the licensee states that if a single tornado-induced missile enters any of these three rooms, all of the SSCs in the respective room are impacted in the TMRE analysis. However, most of the SSCs in these rooms required several plant modifications in response to RIS 2015-06. The modifications were to ensure compliance with the ANO-1 licensing basis.

The results of the sensitivity demonstrate the impact of the TMRE conservatism of correlation of all SSCs and their assumed failure (e.g., treatment as nonrobust) in the impacted room. Defense-in-depth is maintained because the licensing basis allows for tornado protection from a combination of barriers. (The NEI 17-02 process allows only a single barrier.) Therefore, the results of this sensitivity study do not provide a realistic assessment of tornado-induced missile protection for these rooms. Although the NEI 17-02 guidance does not allow for barrier combination protection, based on the information provided in the LAR supplement dated November 14, 2019, the NRC staff concludes that a reasonable balance among the layers of defense is preserved.

The NRC staff notes that none of the identified nonconforming conditions impacted by the proposed change affects only LERF, which is an indication that there was no significant impact on prevention of containment failure. Furthermore, the proposed change does not significantly affect the availability and reliability of SSCs that mitigate accident conditions nor significantly reduce the effectiveness of the licensee's emergency preparedness program. Therefore, the NRC staff finds that the proposed change continues to preserve a reasonable balance between prevention of core damage, prevention of containment failure, and consequence mitigation.

Over-reliance on programmatic activities as compensatory measures associated with the change in the licensing basis is avoided.

In Item 2 of Section 3.2, the licensee states that the implementation of the proposed change does not require compensatory measures and does not change the licensee's existing operating procedures. The licensee further states that the proposed change does not rely upon proceduralized operator actions within an hour of a tornado passing that would require operators to travel into areas that are not protected from the effects of the tornado or tornado missiles. The NRC staff notes that no new operator actions developed specifically in response to the proposed change were included in the licensee's risk assessment supporting the proposed change. Therefore, the NRC staff finds that the proposed change avoids an over-reliance on programmatic activities because the proposed change does not result in human actions or compensatory measures.

System redundancy, independence, and diversity are preserved commensurate with the expected frequency, consequences of challenges to the system, and uncertainties.

In Item 3 of Section 3.2, the licensee explained that the redundancy, independence, and diversity associated with the functions of the nonconforming SSCs are unchanged. The licensee also states that the proposed change had no impact on the availability and reliability of SSCs that could either initiate or mitigate events, except for the tornado-missile protection of the identified nonconforming SSCs, which was evaluated in the application. The licensee further states that the expected frequency of tornado strikes remains low. Additional equipment is available to mitigate the effect of tornado-missile impact, stored in protective structures. Based on the review of the LAR, as supplemented, the NRC staff finds that system redundancy, independence, and diversity are preserved commensurate with the expected frequency, consequences of challenges to the system, and uncertainties.

Defenses against potential common-cause failures are preserved, and the potential for the introduction of new common-cause failure mechanisms is assessed.

In Item 4 of Section 3.2, the licensee states that tornado events and missiles generated by such events represent a common-cause initiating event, which can affect multiple SSCs. The licensee's risk assessment supporting the proposed change captures such impacts. In the LAR, the licensee explained that the nonconforming conditions included in the proposed change were physically distributed about the licensee's site. However, with regards to ANO-1, the licensee states in the LAR that the service water and EFW systems could be impacted related to nonconforming conduits in the demineralizer area.

The NRC staff requested additional information to understand how these systems remain functional following an impact of a tornado-induced missile. In the supplement to the LAR dated November 14, 2019, the licensee reported that a single missile could not have an impact on both the service water and EFW systems. The licensee also clarified the meaning of entries in the LAR enclosure Table 1, "ANO-1 Nonconforming (Safety-Related) SSC Vulnerabilities." Specifically, the EFW SSCs impacted are associated with nonconformance #3, whereas the demineralizer area was only associated with nonconformance #2. The licensee provided further clarification by showing that the worst-case scenario for the EFW system occurs when the turbine-driven pump loses one of its two steam admission lines and the motor-driven pump loses starting actuation redundancy.

With regards to the service water system, the worst-case scenario is the loss of one of two service water loops, which can be recovered in approximately 30 minutes.

The NRC staff determined that none of these scenarios qualify as a common-cause failure. Therefore, the NRC staff concludes that the licensee has adequately assessed the potential for the introduction of new common-cause failure mechanisms. The proposed change is acceptable because it does not degrade defenses against potential common-cause failures and considers the impact of the potential common-cause initiator.

Independence of barriers is not degraded.

In Item 5 of Section 3.2, the licensee states that in both units, neither the reactor fuel cladding nor any part of the reactor coolant pressure boundary is directly exposed to tornado missiles, and the containment structure is a robust tornado-missile barrier. However, with regards to ANO-1, the results of the licensee's TMRE "Missile Distribution Sensitivity," show a substantial increase in LERF risk when compared to CDF. In the supplement to the LAR dated November 14, 2019, the licensee states that the increase in LERF risk was associated with the CDF cutsets related to Rooms 97, 98, and 129, which resulted in a loss of secondary heat removal and a dry steam generator (SG). The combination of a dry SG and a core melt was considered to lead to a thermally-induced SG tube rupture and containment bypass with no LERF mitigation.

Based on the information provided in the LAR supplement dated November 14, 2019, the NRC staff determined that thermally-induced SG tube rupture is unlikely for a plant with an elevated hot leg like ANO-1. Other significant conservatisms were introduced in assessing multiple failures from a missile reaching interior spaces. Consequently, it is the NRC staff's assessment that there is no significant degradation of barriers for ANO-1. The NRC staff notes that the proposed change does not significantly increase the likelihood or consequence of an event that challenges multiple barriers, and does not introduce a new event, which would challenge multiple barriers. The NRC staff finds that the proposed change does not affect the independence of the fission product barriers and therefore, the independence of those barriers is not degraded.

Defenses against human errors are preserved.

In Item 6 of Section 3.2, the licensee states that ANO has procedures that prescribe actions to be taken in the event of a tornado watch or tornado warning and after a tornado has passed. Abnormal and emergency procedures include alternative actions if equipment is damaged by tornadoes. The proposed changes do not appear to create new human actions that are important to preserving the layers of defense or significantly increase mental or physical demand on individuals responding to a tornado. Therefore, the NRC staff concludes that the proposed change preserves defenses against human error and does not introduce new human error mechanisms.

The intent of the plant's design criteria is maintained.

In Item 7 of Section 3.2, the licensee states that the proposed change only affected a very small fraction of the potential target area of the system. The licensee explained that in lieu of protection for the identified nonconforming SSCs, it had analyzed the actual exposure of the SSCs, the potential for impact by damaging tornado missiles, and the consequent effect on CDF and LERF. While there is some slight reduction in protection from a defense-in-depth perspective, the impact is known, and it was determined by the licensee to be negligible. The licensee concluded that the intent of the plant's design criteria is maintained. The licensee also states that the methodology utilized to support the proposed change could not be used in the modification process for a future plant change to avoid providing tornado-missile protection. Therefore, the NRC staff finds that the intent of the plant's design criteria is maintained by the proposed change.

In summary, the NRC staff finds that the proposed change does not significantly affect the seven considerations for defense-in-depth and the proposed change preserves defense-in-depth commensurate with the expected frequency and consequence of challenges to the system resulting from the proposed change.

3.4.3 Key Principle 3: Evaluation of Safety Margins

Regulatory Position 2.1.2 in RG 1.174, Revision 3, discusses two specific criteria that should be addressed when considering the impact of the proposed changes on safety margin, as follows:

- the codes and standards or their alternatives approved for use by the NRC are met, and

- safety analyses acceptance criteria in the licensing basis (e.g., FSAR supporting analyses) are met or proposed revisions provide sufficient margin to account for uncertainty in the analysis and data.

Section 3.2 of the enclosure to the LAR discusses the impact of the proposed change on the safety margin. The licensee states that consensus codes and standards (e.g., ASME, Institute of Electrical and Electronic Engineers, or alternatives approved by the NRC) continue to be met and that the proposed change was not in conflict with approved codes and standards relevant to the SSCs impacted by the change. In the enclosure to the LAR, the licensee states that the safety analysis acceptance criteria were not impacted by the proposed change. The licensee states that special considerations such as single-failure criteria were not considered. The LAR documents that only a very small fraction of available SSCs that could be used to accomplish the objective are not protected from the effects of tornado missiles, and the remaining unaffected components provide reasonable assurance the objective would be achieved. In the event exposed components of one train of safety-related equipment is affected by a tornado missile, there is reasonable assurance that opposite train equipment would be available to provide the safety function. Finally, the licensee states that in addition to the equipment credited in the safety analysis described in the ANO-1 and ANO-2 SARs, onsite and near-site FLEX equipment is expected to be available, which the licensee asserts should provide further assurance that the objective would be achieved.

The NRC staff concludes that the proposed change maintains sufficient safety margin because codes and standards or their alternatives accepted for use by the NRC will continue to be met and the safety analysis acceptance criteria remain unaffected by the proposed change.

3.4.4 Key Principle 4: Change in Risk Consistent with the Commission's Safety Goal Policy Statement

3.4.4.1 PRA Acceptability

The objective of the PRA acceptability review is to determine whether the plant-specific PRA used in evaluating the LAR, as supplemented, is of sufficient scope, level of detail, and technical elements for the application. The NRC staff evaluated the PRA acceptability information provided by the licensee in its tornado-missile risk evaluation LAR and supplements, including industry peer-review results against the criteria discussed in RG 1.200, Revision 2.

3.4.4.2 Internal Events PRA Model

For each supporting requirement (SR) in the PRA Standard, there are three possible degrees of "satisfaction" referred to as capability categories (CC) (i.e., CC-I, CC-II, and CC-III), with CC-I being the minimum, CC-II considered widely acceptable, and CC-III indicating the maximum achievable level of detail, plant-specificity, and realism. For many SRs, the CCs are combined (e.g., the requirement for meeting CC-I is combined with CC-II) or the requirement is the same across all CCs so that the requirement is simply met or not met. For each SR, the peer review team designates one of the CCs or indicates that the SR is met or not met. According to Section 2.1, "Consensus PRA Standards," of RG 1.200, Revision 2, CC-II is the level of detail that is adequate for the majority of risk-informed applications. Therefore, in general, a fact and observation (F&O) is written for any SR that is determined not to be met or does not fully satisfy CC-II of the ASME standard, consistent with RG 1.200, Revision 2.

ANO-1 did not list open F&Os (for which resolutions were incorporated in the TMRE PRA model). The NRC staff relied on the ANO-1 National Fire Protection Association (NFPA) 805 and Technical Specifications Task Force-425 LARs, dated January 29, 2014, and March 12, 2018 (References 25 and 26, respectively).

Attachments 1 and 2 of the enclosure to the LAR provides details on ANO-1 and ANO-2 PRA technical adequacy. Section 4.2 of both attachments states that the internal events PRA model was peer reviewed using RG 1.200, Revision 1, which endorses the use of the ASME/ANS-RA-Sb-2005, an earlier version of the PRA Standard. Revision 2 of RG 1.200 endorses the use of the 2009 addendum to the 2008 version of the PRA Standard. For ANO-2, the licensee had responded to an NRC staff RAI about the NFPA 805 submittal that SRs of ASME/ANS RA-Sb–2005 and ASME/ANS RA-Sa–2009 had been compared and no new analysis was required (Reference 27). In ANO-2 Amendment No. 300, the NRC staff found this to be satisfactory (Reference 28). For ANO-1, in response to an RAI related to the NFPA 805 submittal (Reference 29), the licensee stated that the internal events PRA peer review utilized Revision 2 of RG 1.200. In the letter dated November 14, 2019, the licensee states that the 2009 peer review was conducted in accordance with Revision 2 of RG 1.200.

The enclosure to the LAR describes the peer review process for ANO internal events PRAs. The licensee states that all upgrades to the internal events PRAs have been peer reviewed. In addition, the licensee performed a systematic review of the SRs related to development of the TMRE PRA model and determined that changes made in interim updates have not affected it.

Based on its review of the LAR, as supplemented, the NRC staff finds that the internal events finding-level F&Os related to this application have been satisfactorily dispositioned. No F&Os that remain open are significant to this application. The NRC staff also finds that that the licensee has demonstrated that the internal events PRA meets the guidance in RG 1.200, Revision 2. Specifically, internal events PRA for both ANO-1 and ANO-2 have been reviewed against the applicable SRs in the PRA Standard. The NRC staff concludes that the internal events PRA model is technically acceptable for this application. Accordingly, the NRC staff finds that the licensee's internal events PRA model provides an adequate basis for the development of its TMRE PRA model.

3.4.4.3 Tornado-Missile PRA Model

In addition to the internal events technical elements, the details of the conversion process from the internal events PRA to the TMRE PRA was reviewed to determine that it followed industry guidance in the TMRE methodology, and to determine whether the conversion process was acceptable for this application.

Appendix D, "Technical Bases for TMRE Methodology," to the TMRE methodology includes SRs at CC-II from Part 2 (internal events PRA) of the PRA Standard that have been selected specifically by the NRC staff for the application of the TMRE PRA model in assessing tornado-missile protection nonconformance risk. The selected SRs required specific consideration during the development of the TMRE model from the internal events model. The licensee listed how it conformed with the SRs in Appendix D of the TMRE methodology in Table 9 of Attachments 1 and 2 of the enclosure to the LAR.

Section 6.2, "Tornado Initiating Events," of the TMRE methodology, states that for multi-unit sites, the tornado event should be assumed to result in a multi-unit LOOP used in the TMRE PRA model. The licensee's LAR did not address the ANO multi-unit aspect, IE-A10 and IE-B5 entries in Table 9 of Attachment 1 and 2 of the LAR. The licensee confirmed in its supplement to the LAR dated November 14, 2019, that the ANO TMRE PRA models did incorporate multi-unit LOOP events.

The NRC staff finds that the licensee has conformed to the above-mentioned SRs, because it has adequately considered them in the development of the TMRE PRA model from the internal events model.

Section 3.3.2, "Assessment of Assumptions and Approximations," of RG 1.200, Revision 2, states that for each application that calls upon the guide, the applicant identifies the key assumptions and approximations relevant to that application. Those assumptions and approximation were used to identify sensitivity studies as input to the decisionmaking associated with the application. RG 1.200, Revision 2, defines the terms "key assumption" and "key source of uncertainty" in the same section of the guidance. In its supplement to the LAR dated November 14, 2019, the licensee provided a list of key sources of uncertainty and assumptions for both ANO-1 and ANO-2. None of these sources affected the TMRE application. However, the NRC staff notes that one of the ANO-1 sources of uncertainty is related to thermally-induced steam generator tube rupture (SGTR). ANO-1 is a Babcock & Wilcox (B&W) plant with an elevated hot leg, which is not susceptible to this mode of failure. In the supplement to the LAR dated February 19, 2020, the licensee provided the insights of the consequential SGTR study (NUREG-1570, Risk Assessment of Severe Accident-Induced Steam Generator Tube Rupture," dated March 1998 (Reference 30)), where it states that because flows of superheated gas are not expected to reach SG tube bundles in the B&W SG design, it was excluded from the study. The NRC staff determined that the modeling of Westinghouse and Combustion Engineering thermally-induced SGTR phenomena in a B&W

plant is conservative and does not impact the conclusion reached by the licensee in its assessment for this LAR.

The NRC staff concludes that the licensee has identified key assumptions and sources of uncertainty consistent with the guidance in RG 1.200, Revision 2, and has adequately addressed them for this application, demonstrating that those assumptions either do not impact the decision or are addressed via the sensitivity analyses in the TMRE methodology.

As a result of its review of the LAR, as supplemented, the NRC staff concludes that the ANO TMRE PRA is acceptable for this application because (1) the internal events model which is the base for the TMRE PRA is technically acceptable, (2) the licensee has appropriately considered specific SRs that were identified as being important to the TMRE PRA development, and (3) the licensee has appropriately identified key assumptions and sources of uncertainty and has adequately dispositioned them for this application. Therefore, quantitative results obtained from the ANO TMRE PRA models along with appropriate sensitivity studies can be used to demonstrate that the incremental risk due to those SSCs that are not protected from tornado-generated missiles per the licensee's current licensing basis meets the acceptance guidelines in RG 1.174, Revision 3.

3.4.4.4 Comparison Against Acceptance Guidelines Including Uncertainty and Sensitivity Analyses

Compliant and Degraded Cases

Section 6.3, "Compliant Case and Degraded Case," of the TMRE methodology provides the guidance for creating two configurations, referred to as compliant and degraded cases, which were to be used to evaluate the change in risk associated with not providing tornado-missile protection for the nonconforming SSCs. As described in Section 6.3 of the TMRE methodology:

- The Compliant Case represents the plant in full compliance with its tornado missile protection current licensing basis. Therefore, all nonconforming SSCs that were required to be protected against missiles are assumed to be so protected, even when reality determines the SSCs are not protected. In the Compliant Case, nonconforming SSCs are assumed to have no additional failure modes beyond those normally considered in the internal events PRA.

- The Degraded Case represents the current configuration of the plant (i.e., configuration with nonconforming conditions with respect to the tornado missile protection current licensing basis). As such, the TMRE PRA model will include additional tornado induced failure modes for all nonconforming SSCs. The failure probabilities for those additional tornado induced failure modes were based on EEFP calculations. . . .

Therefore, the primary difference between the compliant and degraded cases is the treatment of the nonconforming SSCs. The NRC staff finds that the licensee's approach is acceptable because it appropriately modifies the failure probabilities of affected SSCs for estimating the risk associated with the proposed change.

Section 3.3.5, "Target Evaluation," of the enclosure to the LAR describes the EEFP determined and used for vulnerable SSCs for both compliant and degraded cases. These EEFP values are listed in Tables 6 and 7 of the enclosure to the LAR. The submittal identified SSCs for which EEFPs were not calculated individually, but the components were included as a portion of a larger correlated target. The NRC staff finds the licensee's approach for developing compliant and degraded cases acceptable, because it appropriately modifies the failure probabilities of affected SSCs associated with the proposed change and captures the residual risk from the nonconforming conditions and vulnerabilities, as well as the change in risk from the identified nonconforming conditions.

Comparison of PRA Results with Acceptance Guidelines

The licensee presented the change in risk between the degraded case (i.e., current plant) in which nonconforming SSCs are modeled as vulnerable to a tornado missile and the compliant plant case in which the plant is in full compliance with its design-basis tornado-generated missile protection requirements. The approach for calculation of the change in risk captures the incremental risk from leaving the nonconforming SSCs unprotected (i.e. in the current as is condition).

ANO-1

Based on the information in Table 8, "ANO-1 Quantification Results," in Section 3.3.7, "Model Quantification Results," of the enclosure to the LAR, the compliant-case CDF and LERF were 9.19×10^{-6}/year and 2.41×10^{-6}/year, respectively. The corresponding metrics for the degraded case were 9.78×10^{-6}/year and 2.46×10^{-6}/year, respectively. Consequently, the licensee reported the change in risk from the tornado-missile nonconformances as 5.9×10^{-7}/year for CDF and 5.1×10^{-8}/year for LERF.

ANO-2

Based on the information in Table 9, "ANO-2 Quantification Results," in Section 3.3.7 of the enclosure to the LAR , the compliant-case CDF and LERF were 1.11×10^{-5}/year and 6.18×10^{-7}/year, respectively. The corresponding metrics for the degraded case were 1.12×10^{-5}/year and 6.24×10^{-7}/year, respectively. Consequently, the licensee reported the change in risk from the tornado-missile nonconformances as 1.0×10^{-7}/year for CDF and 6.0×10^{-9}/year for LERF.

Those results meet the guidelines for "very small" change in risk in RG 1.174 (e.g., Region III). Per the guidance in RG 1.174, the total base CDF and LERF need not be reported for "very small" increases in risk.

Uncertainty and Sensitivity Analyses

Regulatory Position 2, "Element 2: Perform Engineering Analysis," in RG 1.174, Revision 3, states, in part, that the "licensee should appropriately consider uncertainty in the analysis and interpretation of findings." Regulatory Position 3, "Element 3: Define Implementation and Monitoring Program," states, in part, that decisions concerning "the implementation of licensing basis changes should be made after considering the uncertainty associated with the results of the traditional and probabilistic engineering evaluations." The NRC staff had a variety of concerns regarding uncertainty and the conservatism of some parts of the methodology. Those concerns and the licensee's resolution were reviewed by the NRC staff.

Section 7.2, “Sensitivity Analysis,” of the TMRE methodology identifies certain sensitivity studies and provides guidance on their performance. In Section 3.3.9 of the enclosure to the LAR, the licensee included the specified sensitivities and several others. The NRC staff noted that some of the sensitivities reported compliant CDF and LERF values that were greater than the degraded cases. In response to PRA RAI 06 in its letter dated November 14, 2019, the licensee states that the values were correct but transposed and provided a corrected copy. The NRC determined that the amended response was acceptable.

Section 7.2.1, “TMRE Missile Distribution Sensitivity,” of the TMRE methodology provides guidance for performing sensitivities to address uncertainties associated with highly exposed and risk-significant target with a large concentration of nearby missiles that may be underestimated. The sensitivity would be performed by applying either the generic MIP multiplier of 2.75 or the target-specific MIP multiplier to the appropriate basic events, recalculating the delta-CDF and delta-LERF and comparing the results to the RG 1.174 acceptance criteria. The results of this sensitivity for ANO-2 was below the acceptance criteria; however, both the delta-CDF and delta-LERF results for ANO-1 exceeded the RG 1.174 acceptance criteria. The licensee provided an updated ANO-1 TMRE Missile Distribution Sensitivity in its supplement to the LAR dated February 19, 2020, which addressed three conservatisms, as follows:

- With regards to the TMRE methodology Section 5 classification of SSCs for nonconforming conduits, correlation groups 73-A, 73-B, 73-C, and 73-D were recategorized from nonrobust (100 percent of missiles can impact the SSC) to semi-robust (50 percent of the missiles can impact the SSC). This change was based on reclassifying all conduits as steel pipe.

- The second conservatism is in two parts. The first part is related to the correlation of main steam safety valves (MSSVs). A single missile was regarded as having the potential to impact both SG MSSVs. Realistically, the correlation should be reduced from 100 percent to 50 percent. The second part is that missile impact was assumed to fail both the fail-to-open and fail-to-close function of an MSSV. The licensee stipulated that only one failure mode could occur and, therefore, 50 percent of the MSSVs could fail-to-open and the remaining MSSVs fail-to-close. The licensee only removed the impact of one of the parts.

- Based on NUREG-1570, the thermally-induced SGTR consequence was removed from the ANO-1 TMRE model.

With regards to the first conservatism, Table 6 of the submittal states these cables are located in conduits and cable trays, as determined by the ANO TMRE walkdown team. Conduit can refer to solid steel piping, to flexible metal tubing, or to cabling placed in metal vaults. It was not clear why the original analysis classified the conduits as nonrobust if they were in solid steel piping. In a telephone call, the licensee clarified the basis for the claim that the conduit is robust. The NRC staff relied on licensee positions docketed in previous LARs (References 25-27 and 29) to confirm this and accepts the applicability of this conservatism.

Regarding the second conservatism, the NRC staff notes that regarding Issue 126, “Reliability of PWR [Pressurized Water Reactor] Main Steam Safety Valves,” in NUREG-0933, “Resolution of Generic Safety Issues,” states that MSSV instability (valve chatter) can result in both an inadequate opening to relieve pressure that may degrade secondary heat removal and closure to avoid loss of secondary inventory. However, the NRC staff agrees that a single missile strike impacting all MSSVs is sufficiently conservative as to offset this case.

For the third conservatism, though the NUREG-1570 study excluded B&W plants, the NRC staff notes that consequential SGTRs can still occur as noted in a letter from the Advisory Committee on Reactor Safeguards dated May 19, 2017 (Reference 31). This states that B&W plants are less susceptible to consequential SGTR. However, the NRC staff has determined that the dominant mode of consequential SGTR for the B&W design is vibration, not thermal effects that could be a consequence of tornado missile impacts.

Section 7.2.2, "Compliant Case Conservatisms," of the TMRE methodology provides guidance for performing sensitivities to address the impact of potential compliant-case conservatisms. This section states that the licensee would identify modeling conservatisms (accident sequence, system, and large early release SRs identified in TMRE methodology Appendix D, "Technical Basis for TMRE Methodology") related to equipment failures only. The guidance further states that sensitivity analyses will be performed. The licensee stated that it would follow TMRE methodology for addressing compliant-case conservatisms.

In its supplement to the LAR dated February 19, 2020, the licensee described the process of determining the conservatisms to be addressed in this sensitivity. However, the licensee identified no conservatisms related to the accident sequence, system, and large early release modeling. Instead, the licensee conservatively assumed that a 25 percent reduction in tornado-missile impact might be possible, computed a Fussell-Vesely (F-V) importance value for relevant SSCs, and used that to determine an adjusted compliant case risk value (multiplying compliant case risk by the F-V value, then by 25 percent). The result was added to the delta-risk value provided in the LAR. The NRC staff does not view this as equivalent to the sensitivity comparing quantified case results. However, the NRC staff considers it an acceptable way to address sensitivity when other conservatisms cannot be identified.

Because the licensee's approach addresses relevant SRs in the endorsed PRA Standard for performing this sensitivity analysis, the NRC staff concludes that the licensee's approach for considering conservatism associated with modeling equipment failures in future implementation of the TMRE methodology is acceptable.

The NRC staff finds the licensee's approach for addressing cases where change in risk estimates from sensitivity analyses exceed the RG 1.174 acceptance guidelines for "very small" change in risk in future implementation of its TMRE methodology to be acceptable because (1) it relies on refinements that are within the scope of the TMRE methodology as well as the licensee's PRA model configuration control process, and (2) the relevant TMRE methodology guidance that will be followed by the licensee will require prior NRC staff approval for cases where the refinements are not sufficient to meet the acceptance guidelines of RG 1.174.

The sensitivities performed by the licensee demonstrate that the incremental risk from deciding not to protect the nonconforming SSCs against tornado-missile damage continues to remain "very small" per the acceptance guidelines in RG 1.174. Therefore, the NRC staff finds that the results are robust relative to the uncertainties involved because sensitivity studies have demonstrated that the NRC staff's decision would not be changed due to the uncertainties.

Based on the results from the base and sensitivity cases using the TMRE PRA, the NRC staff concludes that Key Principle 4 of risk-informed decisionmaking is met.

3.4.5 Key Principle 5: Performance Measurement Strategies – Implementation and Monitoring Program

Regulatory Position 3 in RG 1.174, Revision 3, states, in part, that “Careful consideration should be given to implementation of the proposed change and the associated performance-monitoring strategies.” This regulatory position further states that “an implementation and monitoring plan should be developed to ensure that the engineering evaluation conducted to examine the impact of the proposed changes continue to reflect the actual reliability and availability of the SSCs evaluated. This will ensure that the conclusions that have been drawn from the evaluation remain valid.”

In Attachment 2 of the enclosure to the LAR, the licensee states that administrative controls are in place to ensure that the PRA models support the application. Procedures address control of the model and associated computer files. PRA models will reflect the as-built, as-operated plant over time. The process includes provisions for monitoring issues affecting the PRA models (e.g., due to changes in the plant, errors or limitations identified in the model, industry operational experience). Risk associated with unincorporated changes will be assessed. The tornado-missile risk of nonconforming SSCs will be reevaluated when relevant factors change to ensure the continued validity of the results.

ANO design control programs meet 10 CFR Part 50 Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.” Section 8.1, “Plant Configuration Changes,” of the TMRE methodology states that Appendix B design controls will ensure that subsequent plant configuration changes are evaluated. This will include assessment of their impact on the risk basis for accepting the identified nonconforming conditions using TMRE. This section also states that licensees shall ensure that plant changes that increase the site missile burden are evaluated.

The enclosure to LAR Section 4.1, “Applicable Regulatory Requirements/Criteria,” states that the licensee has confirmed that the risk-informed change process assures that any significant permanent changes to site missile sources, such as a new building, warehouse, or laydown area, will be evaluated for impact to the TMRE basis, even if such a change is not in the purview of the site design control program.

The NRC staff concludes that the cumulative risk associated with previous nonconforming conditions that remain unprotected against tornado missile need to be considered in future decisionmaking. Further, the NRC staff concludes that the licensee’s PRA maintenance and monitoring programs are sufficient to track the as-built, as-operated condition of the plant and the performance of equipment that, when degraded, can affect the conclusions of the licensee’s risk evaluation and integrated decisionmaking that support the change to the licensing basis.

3.5 Methodology Conclusion

The NRC staff has reviewed the licensee's evaluation of the risk from tornado missiles to identified nonconforming SSCs. The licensee's process is consistent with the guidance in the TMRE methodology. The licensee's results for tornado-missile risk from nonconforming SSCs meet the risk acceptance guidelines of RG 1.174. Therefore, the NRC staff finds that the identified SSCs that do not conform to the tornado-missile protection licensing can remain in the current condition. Specifically, the NRC staff has found that the licensee's risk evaluation—

- is based on an acceptable internal events PRA which has been subjected to a peer review process assessed against the PRA Standard and is based on a TMRE PRA that has been acceptably developed;

- determines tornado-missile risk of nonconforming SSCs that results in an integrated, systematic process that reasonably reflects the current plant configuration and operating practices, and applicable plant and industry operational experience;

- maintains defense-in-depth and safety margin;

- includes evaluations that provide reasonable confidence that the risk of nonconforming tornado-missile protection is maintained and that any potential increases in CDF and LERF resulting from uncertainty in treatment are small; and

- includes provisions for future sensitivity studies and the periodic reviews of the tornado-missile risk of nonconforming SSCs to ensure the risk remains acceptably low.

The licensee's results for tornado-missile risk include the contribution of nonconforming SSCs. On that basis and for the reasons stated above, the NRC staff concludes that the licensee's process and evaluation demonstrate that the tornado-missile risk from nonconforming SSCs is acceptably low as it meets the risk acceptance guidelines of RG 1.174, Revision 3.

3.6 Deviations from the TMRE Methodology

The ANO LAR requested the inclusion of two nonconforming SSCs in the revised licensing basis for ANO-1 without including them in the TMRE analysis. Based on the licensee's letter dated February 19, 2020, the NRC staff found these to be consistent with the RG 1.174 risk thresholds for acceptance. The NRC staff found that the licensee's implementation of the TMRE methodology, as updated, was acceptable for use to support this determination and that not providing physical tornado-missile protection to legacy nonconforming SSCs (i.e., SSCs that should have such protection according to the plant-specific licensing basis but, in reality, do not) is acceptable.

3.7 Scope and Limitations of Application of the TMRE Methodology

The methodology can only be applied to conditions where it has been discovered that tornado-missile protection consistent with the original licensing basis was not provided. The methodology cannot be used either to remove existing tornado-missile protection or to avoid providing tornado-missile protection in the plant modification process.

Section 3.4 of the enclosure to the LAR, states, in part, that the TMRE methodology could be used to resolve those nonconforming conditions by revising the current licensing basis under 10 CFR 50.59, provided "… the acceptance criteria are satisfied and conditions stipulated by the [NRC] staff in the safety evaluation approving the requested amendment are met." The TMRE methodology would only be applied when legacy conditions are discovered where tornado-missile protection was required and not provided. It cannot be used to avoid providing tornado-missile protection in the plant modification process. Therefore, future changes to the facility requiring physical tornado-missile protection must not be evaluated using the TMRE methodology.

The licensee will need prior NRC approval should the delta-CDF or delta-LERF values during subsequent implementation by the licensee for legacy nonconforming SSCs, or any of the required sensitivity studies in the TMRE methodology exceed the acceptance guidelines for Region III ("very small change") of RG 1.174, if the apparent change in risk cannot be reduced with refinements within the scope of the licensee's approved TMRE methodology.

The NRC staff notes that all proposed changes not within the scope of the TMRE methodology as described in this SE are expected to be reviewed consistent with the criteria in 10 CFR 50.59, another governing change process identified in 10 CFR, or the plant's licensing basis. Legacy nonconforming conditions within the scope of this approval may be evaluated using the licensee's TMRE methodology and if the results meet the defined TMRE acceptance criteria, NRC approval need not be sought. However, such changes are still required to be reported under the requirements of 10 CFR Part 50.

3.8 Technical Conclusion

Based on its review summarized in this SE, the NRC staff finds the SSCs identified in the LAR that do not conform to the current tornado-missile protection licensing basis can remain in the as-built condition. The licensee has demonstrated that these nonconforming conditions should not prevent mitigation of the potential effects of extreme winds and missiles associated with such winds. Further, the licensee has demonstrated that the proposed change ensures SSCs important to safety are designed to perform their safety functions during and following a tornado at ANO, where their design reflects the importance of the safety functions to be performed.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Arkansas State official was notified of the proposed issuance of the amendment on May 1, 2020. 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, as published in the *Federal Register* on July 2, 2019 (84 FR 31633) and there has been no public comment on such finding. 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 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 amendments will not be inimical to the common defense and security or to the health and safety of the public.

7.0 REFERENCES

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Date: June 30, 2020

SUBJECT: ARKANSAS NUCLEAR ONE, UNITS 1 AND 2 - ISSUANCE OF AMENDMENT NOS. 269 AND 321 RE: REQUEST TO INCORPORATE THE TORNADO MISSILE RISK EVALUATOR INTO THE LICENSING BASIS (EPID L-2019-LLA-0093) DATED JUNE 30, 2020

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ADAMS Accession No. ML20135H141 *By memorandum ** By e-mail

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