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ARKANSAS NUCLEAR ONE, UNITS 1 AND 2 – APPROVAL OF REQUEST FOR ALTERNATIVE FROM CERTAIN REQUIREMENTS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS BOILER AND PRESSURE VESSEL CODE (EPID L-2020-LLR-0104)

LICENSEE INFORMATION

Licensee:	Entergy Operations, Inc.
Licensee Address:	ANO Site Vice President Arkansas Nuclear One Entergy Operations, Inc. N-TSB-58 1448 S.R. 333 Russellville, AR 72802
Plant Name and Units:	Arkansas Nuclear One, Units 1 and 2 (ANO-1 and ANO-2)
Docket Nos.:	50-313 and 50-368

APPLICATION INFORMATION

Submittal Date: July 15, 2020

Submittal Agencywide Documents Access and Management System (ADAMS) Accession No.: ML20218A672

Supplement Dates: February 22, 2021; July 22, 2021; and September 14, 2021

Supplement ADAMS Accession Nos.: ML21063A242; ML21203A198; and ML21257A455

Applicable Inservice Inspection (ISI) Program Interval and Interval Start/End Dates: ANO-1 is in its fifth 10-year ISI interval, which started on May 31, 2017, and is scheduled to end May 30, 2027. ANO-2 is also currently in its fifth 10-year ISI Interval, which started on March 26, 2020, and is scheduled to end March 25, 2030.

Alternative Provision: The licensee requested an alternative under Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(z)(1), “Acceptable level of quality and safety.”

Applicable Code Requirements: American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, “Rules for Inservice Inspection of Nuclear Power Plant Components,” Article IWA-4000, “Repair/Replacement Activities,” subparagraph IWA-4221(b)(1).

Applicable Code Edition and Addenda: 2007 Edition through 2008 Addenda.

Brief Description of the Proposed Alternative:

Entergy Operations, Inc. (Entergy, the licensee) requested approval to allow the use of a carbon fiber reinforced polymer (CFRP) composite system for the internal repair of the emergency cooling pond (ECP) supply piping to the service water system (SWS) at ANO-1 and ANO-2.

The licensee stated that the subject ECP supply piping is experiencing internal microbiologically influenced corrosion. ASME Code, Section XI, IWA-4221(b), requires that repair/replacement piping meet the original construction code requirements for the piping. However, the applicable construction code for the ANO units does not provide the requirements for the design, fabrication, installation, examination and testing of a CFRP composite system (also called “CFRP system”). Therefore, an alternative authorized by the U.S. Nuclear Regulatory Commission (NRC) is required for using a CFRP system for the internal repair of the ECP supply piping.

The ANO-1 supply piping (identified as HBD-12-36”) is nominally 36 inches in diameter and the ANO-2 supply piping (identified as 2HBC-88-42”) is 42 inches in diameter. The subject piping is fabricated of carbon steel with welded joints and has long straight runs with no bends and minimal elbows. The ends of the subject supply lines terminate at the ECP and intake structures wall penetrations in an embedded sluice gate thimble. The majority of the subject piping is buried. The CFRP system will also be installed in very small sections of the piping at the intake structure and ECP structure at the through-wall penetration areas, which are not considered buried piping.

The licensee stated that the repair of the existing ECP supply piping will provide the pressure boundary safety function with improved long-term system reliability because CFRP is more resistant to fouling and microbiologically influenced corrosion. Once fully implemented, the CFRP system will take the place of the host piping, assuming all design loading without reliance on the host piping structure.

The applicable 10-year ISI interval for the installation of the CFRP system is the fifth interval for each of ANO units, which is May 31, 2017, to May 30, 2027, for ANO-1 and March 26, 2020, to March 25, 2030, for ANO-2. The licensee stated that the CFRP system is to remain in service for the life of the repair. Any future repair/replacement of the repaired piping will be conducted in accordance with the applicable edition of ASME Code, Section XI, or alternative thereto, at the time of the repair/replacement or inspection.

Additional details of the licensee’s request are described in the document located at the ADAMS accession numbers identified above.

REGULATORY EVALUATION

Regulatory Basis: 10 CFR 50.55a(z)(1)

The NRC regulations in 10 CFR 50.55a(g)(4), "Inservice inspection standards requirement for operating plants," state, in part, that ASME Code Class 1, 2, and 3, components including supports shall meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code Section XI.

The NRC regulations in 10 CFR 50.55a(z), "Alternative to codes and standards requirements," state that "[a]lternatives to the requirements of paragraphs (b) through (h) of [10 CFR 50.55a] or portions thereof may be used when authorized by the Director, of the Office of Nuclear Reactor Regulation. A proposed alternative must be submitted and authorized prior to implementation." The licensee must demonstrate that its request meets one of two criteria: (a) the proposed alternative would provide an acceptable level of quality and safety in accordance with paragraph (z)(1); or (b) compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety in accordance with paragraph (z)(2).

The licensee has submitted the request on the basis that the proposed alternative would provide an acceptable level of quality and safety in accordance with 10 CFR 50.55a(z)(1). Based on the above regulations, the NRC staff concludes that regulatory authority exists to authorize an alternative to ASME Code, Section XI, as requested by the licensee.

TECHNICAL EVALUATION

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In addition, the licensee described the inservice inspections of the repaired ECP supply piping. The licensee explained that any inspections or repair/replacement of the CFRP composite will be conducted in accordance with the applicable edition of the ASME Code, Section XI, or alternative thereto, at the time of the repair/replacement or inspection.

The NRC staff noted that the licensee adequately identified the important technical areas for the application of the CFRP system and provided related information, as further evaluated below.

1.0 DESIGN CRITERIA

The design criteria are described in Enclosure 5, Attachment A of the alternative request dated July 15, 2020, including the objectives, approach, methodologies, applicable standards, technical criteria, loads, load combinations, applicable design factors and effective safety factors of the design for the CFRP system design. The various aspects of the design criteria are grouped into strength, reliability, durability and design approach, as discussed in this section. The design loads and limit states (LSs) are evaluated in Section 2.0 of this safety evaluation (SE).

1.1 Strength

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1.2 Reliability

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1.3 Durability

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1.4 Design Approach

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2.0 DESIGN LOADS AND LIMIT STATES

As noted in Attachment B of Enclosure 5 of the licensee's submittal dated July 15, 2020, the CFRP system is designed to resist the effects of internal pressure, external groundwater pressure, temperature differentials, and seismic loads encountered during the design life. The licensee also considered gravity loads such as earth load, surface live load, pipe self-weight, and water weight that tend to load the buried CFRP systems through pipe ovalization in the design of the CFRP system.

The CFRP Composite System design layup, for both 36-inch diameter and 42-inch diameter pipes at ANO-1 and ANO-2, respectively, consists of **[[**

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Piping

Outside diameter and wall thickness for ANO-1: 1HBD-12-36": 36" x 0.375"
Outside diameter and wall thickness for ANO-2: 2HBC-88-42": 42" x 0.375"
Ovality: 3 percent

Pressure

Design pressure for 1HBD-12-36" piping: 15 pounds per square inch (psi)
Design Pressure for 2HBC-88-42" piping: 10 psi
Transient Pressure: zero; gravity fed.
Vacuum Pressure: zero; gravity fed.

Temperature

Normal operating temperature range of 32 degrees Fahrenheit (°F) to 101 °F
Faulted maximum temperature: 121 °F

Pressure-Induced Thrust

Bulkhead thrust force: P x A (where P is the internal pressure and A is the internal cross section area of the pipe) due to the presence of elbows within scope.

External Loads

Soil Cover:
For 1HBD-12-36" pipe:
7.5 feet (ft.) at the ECP intake structure
17 ft. (under railroad)
18 ft. (near intake structure and elbows)
7 ft. (under ditch)

For 2HBC-88-42" pipe:
7.5 ft. at the ECP intake structure
17 ft. (under railroad)
17.5 ft. (near intake structure and elbows)
7 ft. (under ditch)

Surface Live Loads
Truck and railroad design loads HS20 and E80, based on American Association of State Highway and Transportation Officials specification.

Surcharge Loads
Surcharge load at the top of the pipe used in evaluations conservatively is 363 pounds per square foot or 2.52 psi.

Differential Settlement: Negligible (< 0.002")

Seismic Accelerations

Operating Basis Earthquake (OBE):
Horizontal: 0.1g
Vertical: 0.067g
Design Basis Earthquake (DBE)
Horizontal: 0.2g
Vertical: 0.133g

Seismic Anchor Movement: Negligible (< 0.002")

Groundwater height above pipe crown at ECP Intake structure = 6 ft.
Groundwater height above pipe crown at Intake structure = 3 ft.
Installation temperature = 71 °F to 82 °F
Surrounding soil temperature = 50 °F to 70 °F
Ambient temperature inside the pipeline during installation and curing of CFRP: 60 °F to 110 °F
Minimum temperature range relative to installation temperature: ΔT = 32 - 82 = -50 °F
Maximum temperature range relative to installation temperature: ΔT = 121 - 71 = +50 °F

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2.1 Load Combinations for Design Limit States

As discussed in Enclosure 5, Attachment C of the alternative request dated July 15, 2020,
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2.2 Limit States

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Load Designation Symbols

Pw	Internal working pressure, with thrust as applicable
Pt	Internal transient pressure, with thrust as applicable
Pv	Internal negative pressure (vacuum)
ΔT	Temperature differential between CFRP average installation temperature and maximum/minimum operating temperature
We	Earth load
We*	Earth load in submerged condition when groundwater is present
Wp	Pipe weight
Wp*	Pipe weight in submerged condition when groundwater is present
Pgw	External groundwater pressure
Wt	Surface live load

Wf	Fluid weight
E	Seismic loads

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The NRC staff reviewed the loads, load combinations, and the design LSs used by the licensee in its design evaluation of the buried service water piping internally lined with CFRP. The NRC staff finds that the design methodology used by the licensee in CFRP design evaluations is

sound and adequate. The licensee considered the applicable loads and load combinations appropriately per the plant design specifications noted in the ANO-1 and ANO-2 SARs.

2.3 Design

As noted in Enclosure 1 of the alternative request dated July 15, 2020, the design analysis code for ANO-1 HBD-12-36” piping fabricated of carbon steel is American National Standards Institute (ANSI) B31.1.0, 1967 Edition, except for the following: moments, section modulus, stress limits, flexibility factors, stress intensification factors, and design loading combinations using the summer Addenda (ANSI B31.1.b – 1973) to ANSI B31.1 – 1973.

The design analysis code for ANO-2 “2HBC-88-42” piping fabricated of carbon steel material is the ASME Section III, 1971 Edition with Addenda through Summer 1971 and Code Case 1606-1, except for the following:

a) ASME Code, Section III, 1971 Edition, Winter 1972 Addenda Sections NC-3611.1(b)(4)(c) and NC-3650 with Code Case 1606-1, are used for moments, section modulus, design loading combinations, and stress limits.

b) ASME Code, Section III, 1974 Edition, Section NC-3673.2 is used for the flexibility factors and stress intensification factors.

The NRC staff reviewed the licensee’s plant-specific stress calculation summaries for repairs proposed in the alternative request. **[[**

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In the request for additional information (RAI) response letter dated July 22, 2021, regarding glass transition temperature (Tg) affected by cure temperature, the licensee provided information that V-Wrap™ 770 epoxy remains in the glassy phase at ANO using the criterion Tg

Field > Tmax (121 °F) **[[ ]].** This ensures that the CFRP repair will not become rubbery at the maximum operating temperature of 121 °F, and therefore, will maintain load carrying capability and structural integrity. **[[**

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The NRC staff finds that the licensee's calculations have considered the appropriate load combinations in analyzing the repaired 36-inch diameter piping. The NRC staff also notes that the licensee used results from the Water Research Foundation's research program, which is primarily developed for nonsafety-related applications. These included full-scale field experiments of prestressed concrete cylinder pipe (PCCP) subjected to the combined effects of internal pressure and external loads to study modes and loads at failure; laboratory scale experiments to determine shear bond strength; and development of simplified and reliable design formulas.

The research program also included an investigation using finite element analysis of CFRP-lined buried PCCP to analyze the combined effects of gravity loads and pressures to validate the accuracy and conservatism of simplified design formulas for LSs including pressure, bending, and stability (buckling). In such analyses, stresses in the CFRP system and its buckling load resulting from interaction of the CFRP system, host pipe, and surrounding soil were calculated as the host pipe continues to degrade during its service life.

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]] Based on the additional layers provided at the discontinuities, the NRC staff concludes that there is additional margin of safety in the design.

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The NRC staff concludes that the licensee has performed an acceptable failure modes and effects analysis (FMEA) because the licensee has considered significant potential failure modes and demonstrated that the CFRP system is designed to mitigate or prevent the potential failures.

The NRC staff notes that CFRP has been used in aerospace, automotive, marine, and sports industries because of its advantage of high strength combined with low weight. The NRC staff also notes that the NRC regulations do not address the AWWA guidance. The NRC staff evaluated the proposed alternative based on the merits of its technical basis in lieu of the AWWA guidance or the proposed ASME Code Case N-871 under development.

Terminations

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2.4 Factor of Safety (Allowable Stress Design versus Load and Resistance Factor Design)

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Allowable Stress Design Methodology in ASME Code, Subsection NC/ND Classes 2 and 3

References used for the following discussion include the 2017 Editions of: (1) ASME Code, Section III, Subsection ND; (2) ASME Code, Section II, Part D, Mandatory Appendices 1 and 3; and (3) ASME Code, Section VIII, Division 1, Non-mandatory Appendix P.

In the ASME Code, the FS for ductile materials (metallic) was 4 until 1999, when it was reduced to 3.5. This is primarily used to determine the minimum required wall thickness, based on hoop-stress considerations under internal pressure. The FS is applied to the minimum tensile strength at temperature (Su) to obtain allowable stress (= Su/4 or Su/3.5). Further, there are k factors (1.0, 1.2, 1.8, and 2.4) applied to increase the allowable stress for other load combinations (Design-normal, Upset, Emergency, and Faulted, or Service Levels A, B, C, and D). In 1981, the k factors were changed to 1.5, 1.65, 2.25, and 3 (with other limitations). For secondary stresses such as thermal expansion, the k factor is approximately 1.5 (i.e., 1.25 applied to Sc + 0.25 applied to Sh, where Sc and Sh are allowable stresses at cold and hot conditions, respectively). Thus, k factors effectively lower the FS in the ASME allowable stress design **(**ASD) methodology. In the ASME Code, the FS for brittle metals (e.g., cast iron) is 10.

For buckling, the FS values are as follows: FS=3; k = 4/3. The FS_{eff} is the effective factor of safety for buckling value is calculated as follows: FS_{eff} = 3/(4/3) = 2.25.

The following table is a summary of the calculated ASD methodology values:

ASD Methodology Summary:
Computed/Allowable ≤ 1 or Allowable/Computed ≥ 1

Values Through 1981	**Codes Prior to 1999 With FS = 4 (Ductile)**	**Codes After 1999 With FS = 3.5 (Ductile)**	**With FS = 10 (Brittle)**
Longitudinal (Rows 3-7)	FS_{eff}	FS_{eff}	FS_{eff}
Normal (Level-A) k=1	4	3.5	10
Upset (Level-B) k=1.2	3.33	2.92	8.33

ValuesThrough 1981	**Codes Prior to 1999 With FS = 4 (Ductile)**	**Codes After 1999 With FS = 3.5 (Ductile)**	**With FS = 10 (Brittle)**
Emergency (Level-C) k=1.8	2.22	1.94	5.56
Faulted (Level-D) k=2.4	1.67	1.46	4.17
Thermal Stresses (if 7000 cycles) 1.5 Sh approximately ((1.25 Sc + 0.25 Sh)	2.67	2.33	6.67
Hoop Direction	4	3.5	10

Values After 1981	With FS = 4 (Ductile)	With FS = 3.5 (Ductile)	With FS = 10 (Brittle)
Longitudinal (Rows 3-7)	FS_{eff}	FS_{eff}	FS_{eff}
Normal (Level-A) k=1.5	2.67	2.33	6.67
Upset (Level-B) k=1.8	2.22	1.94	5.56
Emergency (Level-C) k=2.25	1.78	1.56	4.44
Faulted (Level-D) k=3	1.33	1.17	3.33
Thermal Stresses (if 7000 cycles) 1.5 Sh	2.67	2.33	6.67
Hoop Direction	4	3.5	10

2.5 LRFD Methodology Used for Repair of ECP Piping Using CFRP

For the load and resistance factor design (LRFD) methodology acceptability, the Load must be less than or equal to (≤) the Resistance; (or) the Demand ≤ the Capacity; (or) the Demand ≤ the Strength.

The CFRP material is a non-isotropic, linearly elastic, high-strength composite with very low rupture strain of approximately 1 percent (brittle) compared to 15 to 20 percent for ductile metals like steel. An ASME Code Case currently under development for CFRP, as well as in a few published papers using CFRP, utilize a FS of 10 for the ASD methodology, while it varies for the LRFD methodology. The LRFD methodology applies four types of factors, namely: load factor (LF), resistance factor (Φ) for material strength variability, material adjustment factor (C) for environmental exposure, and a time effect factor (λ) that depends on short-term or long-term use.

The LF is greater than (>) 1 and is applied to the left-hand side of the LRFD evaluations (i.e., Load or Demand) to increase the load for uncertainties, while factors Φ, C, and λ < 1 are applied to the right-hand side of the LRFD evaluations (i.e., Resistance or Strength) to reduce allowable strength. The following table summarizes the load factors, resistance factors, material adjustment factor, and time effect factors used by the licensee in the ANO evaluations.

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These correspond to the current ASME Code FS of 3.5 for stresses and 3.0 for buckling and are considered reasonable for ANO conditions and water environments. It is also noted that those portions of ANO's ECP pipes to be repaired using CFRP are buried and experience gravity load, internal and external pressure and thermal loading, ground water load, soil overburden loads, and seismic loads. The following table shows the minimum acceptable FS_{eff} for the LRFD methodology for different load combinations or LSs:

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The licensee's evaluations are based on characteristic strength values corresponding to 80 percent confidence on the 5th percentile. It is noted that typically a 16 percent drop in characteristic tensile strength when A-Basis (95 percent confidence on 1st percentile) is used.

2.6 Results of Effective Factors of Safety for End Use and Their Acceptability

For degraded carbon steel piping, the ECP system safety-related buried 36-inch diameter piping at ANO-1 and Class 3 buried 42-inch diameter piping at ANO-2 will be repaired using CFRP composite. The following tables summarize the results of FS_{eff}. **[[**

]]—for 4 critical locations (identified as index 1 through 4) for ANO-1, and 4 critical locations (identified as index 5 through 8) for ANO-2, as listed below.

Index	Piping Class	Pipe	Repair Location
1	ANO-1 HBD-12-36”	36-Steel	Near Intake
2	ANO-1 HBD-12-36”	36-Steel	Under Railroad
3	ANO-1 HBD-12-36”	36-Steel	Near Elbows
4	ANO-1 HBD-12-36”	36-Steel	Under Ditch
5	ANO-2 2HBC-88-42”	42-Steel	Near Intake
6	ANO-2 2HBC-88-42”	42-Steel	Under Railroad
7	ANO-2 2HBC-88-42”	42-Steel	Near Elbows
8	ANO-2 2HBC-88-42”	42-Steel	Under Ditch

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FS_{eff} Limit	3.5	2.33	2.33	2.25	2.33	2.33	2,33	2.25	1.75

In its letter dated February 22, 2021, regarding the effect of cure temperature on CFRP strength and the computed effective factors of safety (FS_{eff}), the licensee provided the recomputed
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]] The assumed adjustment factors used to illustrate the effect of cure temperature are not acceptance limits. Actual adjustment factors will be calculated by the licensee based on actual test results, which will be based on the results of actual cure temperatures. The acceptance limit is a safety factor limit and not the cure temperature or cure temperature adjustment factor.

Since CFRP is non-metallic and non-isotropic, the material properties as well as the analytical methods may have some uncertainties that are unknown or cannot be directly accounted in the evaluations. Therefore, the licensee was requested to compute FS_{eff} values using A-basis (1st percentile with 95 percent confidence for CFRP Strength), which were provided in licensee's letter dated February 22, 2021.

The following table summarizes the calculated effective FSs for end-use conditions with the acceptance limit, as provided by the licensee in Enclosure 1 to its RAI response letter dated February 22, 2021.

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In summary, all LSs are satisfied with a minimum cure temperature of 90 °F. The FS for LLS2, shear bond failure check in the end or termination zones, remains unchanged as end zones can be cured at a minimum of 121 °F, which corresponds to the maximum operating temperature used in the design.

Based on a review of licensee's design check, the results of FS_{eff} remain acceptable, even though there is a 16 percent drop in the FS for some LSs for the 36-inch and 42-inch diameter pipes, when A-Basis allowable values are used, and also when adjustment factors for cure temperature effect are also considered. A few deviations are acceptable as explained.

The NRC staff finds that the effective FS_{eff} for short-term use will be higher compared to long-term (end-use) because time effect factor λ is 1.0 for short term use. Therefore, effective FS_{eff} for short-term use are acceptable. This is because the time effect factor for short-term strength is 1.0, while it is a reduction factor of 0.6 for the long-term end use condition

Based on the NRC staff review and evaluation described above, the staff concludes that CFRP repair is structurally adequate because the evaluations for the various LSs demonstrated that the effective FSs meet the minimum acceptable values providing reasonable assurance regarding the structural integrity of the proposed repair.

The NRC staff's review of licensee's calculations, as described above, indicates that the CFRP system design provided in the alternative request satisfies the acceptance criteria for the applicable LSs. Therefore, the NRC staff finds that there is reasonable assurance that the proposed repair of degraded ECP system using CFRP composite, including the terminations overlapping with the host carbon steel piping, will maintain structural integrity. The design evaluations are acceptable because the FS_{eff} meet the limiting values for all LSs, thus meeting the acceptance criteria. The NRC staff concludes that the CFRP design used for the repair of degraded ECP supply piping at ANO-1 and ANO-2 is acceptable.

2.7 Failure Modes and Effects Analysis

The NRC staff concludes that the licensee has performed an adequate FMEA, because the licensee has considered potential credible failure modes of the installed CFRP layers, discussed the basis of why the failure mode is not possible, and provided solutions to either prevent or minimize the failure modes. Therefore, the NRC staff finds that the licensee's FMEA is acceptable.

The NRC staff finds that the proposed CFRP composite satisfies the design criteria of the subject piping such that the CFRP layers will be able to support the existing pipe loads without considering the host pipe base metal, except at the terminations. The CFRP terminations act as interfaces to transfer loads from the repaired sections to the host pipe. The NRC staff concludes that the terminations are adequately designed to maintain their structural integrity.

3.0 MATERIAL CONTROLS

Enclosure 4, Attachments A, B, and C of the alternative request of the letter dated July 15, 2020, discuss material manufacturing, material qualification and testing, and watertightness testing, respectively. The NRC staff's evaluations on these matters are described below.

3.1 Material Manufacturing

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3.2 Material Qualification and Testing

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4.0 INSTALLATION CONTROLS

Enclosure 6 of the alternative request dated July 15, 2020, provides the sample procedures and associated installation controls, which include pre-installation preparation, installation, in-process inspection, and in-process repair. Related information is also provided in Enclosures 1 and 5, Attachment D of the alternative request. The NRC staff's evaluation of the installation controls is documented below.

4.1 Pre-Installation Preparation

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4.2 Installation

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The licensee's supplemental letter dated July 22, 2021, addressed in more detail the glass transition temperature (Tg) of the epoxy material used in the CFRP system. **[[**

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These Tg values are determined in accordance with the American Society for Testing and Materials (ASTM) E1640, "Standard Test Method for Assignment of the Glass Transition Temperature By Dynamic Mechanical Analysis," which addressed dynamic mechanical analysis testing **[[**

]] Relevant Tg criteria are used to ensure that the epoxy does not behave in a rubbery manner as further discussed below.

In conjunction with the Tg values, Tmax is defined as the faulted maximum achievable ECP supply system piping water temperature of 121 °F, which bounds all of the design basis and severe accident conditions. The licensee explained that the typical operating temperature range of the ECP supply piping is 32 °F to 101 °F and that the maximum faulted temperature peak is above 120 °F for a short duration of less than 24 hours during the postulated design-basis accident, as indicated in ANO-1 SAR Figure 9-22 (ADAMS Accession No. ML20133J853).

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4.3 <u>In-Process Testing and Inspections</u>

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4.4 In-Process Repair

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4.5 Acceptance Examination

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4.6 Pressure Testing

In its supplemental letter dated February 22, 2021, the licensee explained that the ANO-1 ECP supply piping (line number HBD-12-36) is a non-class line designed in accordance with the ANSI B31.1 code. Therefore, the licensee stated that this piping line is not subject to the rules of ASME Code, Section XI, IWA-1320, which specify the component and piping classifications for ASME Code inservice inspection requirements. The licensee also clarified that it performs an SWS flow test on this piping each refueling outage in accordance with station procedures.

The licensee also clarified that the ANO-2 ECP supply piping (line number 2HBC-88-42) is an ASME Class 3 line and is subject to the rules of ASME Code, Section XI, Subsection IWD per IWA-1320. The licensee indicated that this piping is addressed in the ANO-2 ISI program and is exempt from pressure testing per IWD-5222(c)(3). The NRC staff notes that the provision in IWD-5222(c)(3) allows exemption from pressure testing for open-ended discharge piping that is not periodically pressurized to the conditions described in IWD-5221. The licensee also stated that it performs an SWS flow test for this piping each refueling outage in accordance with station procedures.

With respect to the system pressure testing, the licensee stated that the performance of a system pressure test prior to returning the system to service is not required according to ASME Code, Section XI IWD-5222(c)(3) of the 2007 Edition with 2008 Addenda. However, as part of a return to service post-modification testing, the licensee will conduct an SWS flow test for the ECP supply piping in accordance with station procedures.

The NRC staff finds the licensee's clarification of the pressure tests acceptable because the licensee confirmed the following: (1) the ANO-1 ECP supply piping is not ASME Code Class piping and, therefore, is not subject to the pressure test requirements in ASME Code, Section XI, IWD-5000; (2) the ANO-2 ECP supply piping is ASME Code Class 3 piping, but the piping is exempt from pressure testing per IWD-5222(c)(3), based on the configuration of open-ended discharge piping; and (3) even though the ASME Code requirements for pressure testing are not applicable to the ECP supply piping, a flow test is performed on the subject piping each refueling outage in accordance with station procedures to ensure that the intended function of the piping (i.e., piping integrity for water transport) is maintained.

5.0 PRESERVICE AND INSERVICE INSPECTIONS

The licensee provided additional clarification on the preservice and inservice inspections in its supplemental letter dated February 22, 2021. As previously addressed in Section 4.1 of this SE, the licensee stated that preservice examinations will be performed prior to the installation of the CFRP system to verify that the base metal of the host piping at the termination ends meet

the minimum wall thickness necessary to bear the conditions specified in the design-basis documents. The licensee indicated that these measurements will be performed in accordance with ASME Code, Sections V and XI.

As discussed in Section 4.3 of this SE, the licensee stated that visual examination will be performed on the CFRP system to ensure the absence of defects (e.g., cuts, folds, end curls, raised edges, bubbles, blisters, air pockets, broken fibers, clustered porosity, wrinkles, foreign objects) and similar anomalies prior to the return to service. Volumetric examination (acoustic tap testing) will be also performed to supplement the visual examination to confirm the integrity of the composite.

As described in Section 4.6 of this SE, the licensee stated that the performance of a system pressure test prior to returning the system to service is not required in accordance with ASME Code, Section XI, IWD-5222(c)(3), which is based on the open-ended discharge configuration of the piping. However, as part of a return to service post-modification testing, the licensee will conduct an SWS flow test for the ECP supply piping lines in accordance with station procedures.

Prior to placing the ECP supply piping back into service, the licensee will also perform a baseline visual examination of 100 percent of the accessible area of the CFRP system, including the expansion ring assemblies and termination ends, by using a remote crawler with a high-resolution camera. The licensee identified these inspections as a regulatory commitment in Enclosure 13 of the alternative request.

The NRC staff finds that the preservice inspections, which will be performed prior to the return to service, are acceptable because: (1) the inspections include the thickness measurements for the substrate piping to ensure the structural integrity of the metallic substrate near the termination end regions; (2) the visual examination, including the examination by using a remote crawler, is sufficient to ensure the absence of defects in the CFRP system that may affect the integrity of the composite; (3) the volumetric examination using acoustic tap testing will be also used to confirm the integrity of the composite system along with the visual examination; and (4) the preservice flow testing will ensure the intended function of the ECP supply piping to reliably provide the ECP water to the SWS intake structure.

In addition to the pre-service visual inspection using a crawler, a second remote crawler visual inspection will be performed on the accessible areas of the CFRP system during the third refueling outage (i.e., within 5 years) after the CFRP system installation. In addition, volumetric examination by using acoustic testing will be performed at selected termination ends prior to startup from the third refueling outage following CFRP system installation to ensure the continued integrity of the CFRP system. The licensee identified these visual and volumetric inspections as regulatory commitments in Enclosure 13 of the alternative request.

The licensee further stated that, based on the results of these inspections, the scope of future inspections and the respective frequency, if necessary, will be determined under the licensee's preventative maintenance program. To support the adequacy of the licensee's inspection approach, the licensee explained that the subject piping has an exterior coal-tar enamel coating and cathodic protection to prevent corrosion. Based on the coating and cathodic protection, the licensee stated that there is no expectation that the exterior piping surfaces will have any corrosion.

The NRC staff finds that the licensee's proposed ISI are acceptable for the proposed duration of the alternative request (i.e., fifth ISI interval of ANO-1 and ANO-2) because: (1) the visual examination using a high-resolution camera crawler and volumetric examination using acoustic tap testing will be performed during the third refueling outage (i.e., within 5 years) following the CFRP installation, and these inspections are sufficient to reveal any defects or degradation indications of the CFRP system; (2) these visual and volumetric inspections are identified as regulatory commitments as described in Enclosure 13 of the request; (3) even though pressure testing is not required for the subject piping per the ASME Code provisions based on the open discharge configuration of the piping, the licensee will continue to perform flow tests on the subject piping every refueling outage to ensure the intended function of the piping is maintained (i.e., pressure boundary and flow supply); (4) the subject piping has an external protective coating and cathodic protection, which provides reasonable assurance that the substrate metal piping is not subject to significant degradation or failure; and (5) the results of the visual and volumetric examinations will be used to determine the scope and frequency of the subsequent inspections.

6.0 QUALITY CONTROLS

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The NRC staff finds that the design controls, material controls, installation, and quality assurance and quality control of the proposed CFRP composite system satisfy the requirements of 10 CFR Part 50, Appendix B and are, therefore, acceptable.

CONCLUSION

As set forth above, the NRC staff determines that proposed alternative, as described in the licensee's letter dated July 15, 2020, as supplemented by letters dated February 22, 2021, July 22, 2021, and September 14, 2021, for the use of a CFRP composite system to repair the internal surface of the ECP supply piping is acceptable on the basis that the proposed alternative provides an acceptable level of quality and safety. The NRC staff finds that the proposed alternative will provide reasonable assurance of the structural integrity and leak tightness of the piping. Accordingly, the NRC staff concludes that the licensee has adequately addressed the regulatory requirements in 10 CFR 50.55a(z)(1). Therefore, the NRC staff authorizes the use of the proposed alternative for the fifth 10-year inservice inspection interval at ANO-1 and ANO-2.

All other requirements in ASME Code, Section XI for which relief or an alternative was not specifically requested and approved as part of this subject request remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

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Date: September 30, 2021

/RA/

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ARKANSAS NUCLEAR ONE, UNITS 1 AND 2 – APPROVAL OF REQUEST FOR ALTERNATIVE FROM CERTAIN REQUIREMENTS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS BOILER AND PRESSURE VESSEL CODE (EPID L-2020-LLR-0104) DATED SEPTEMBER 30, 2021

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