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

February 13, 2017

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

SUBJECT: ARKANSAS NUCLEAR ONE, UNIT 1 - REQUEST FOR ALTERNATIVE ANO1-ISI-026 FROM VOLUMETRIC/SURFACE EXAMINATION FREQUENCY REQUIREMENTS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS CODE CASE N-729-1 (CAC NO. MF8007)

Dear Sir or Madam:

By letter dated June 17, 2016, Entergy Operations, Inc. (the licensee), submitted a request to the U.S. Nuclear Regulatory Commission (NRC) for the use of an alternative to certain American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section XI requirements at Arkansas Nuclear One, Unit 1 (ANO-1).

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee requested to use the proposed alternative to the examination frequency requirements of ASME Code Case N-729-1 for the reactor vessel closure head at ANO-1, on the basis that the proposed alternative provides an acceptable level of quality and safety.

The NRC staff has completed its review of the proposed alternative and based on the enclosed safety evaluation, the staff concludes that the alternative method proposed by the licensee in Relief Request ANO1-ISI-026 will provide an acceptable level of quality and safety for the examination frequency requirements of the reactor vessel closure head. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements as set forth in 10 CFR 50.55a(z)(1) for the proposed alternative. Therefore, the NRC staff authorizes the one-time use of ANO1-ISI-026 at ANO-1 for the duration up to, and including, the refueling outage currently scheduled for April 2021, which will occur in the fifth 10-year ISI interval.

All other ASME Code, Section XI, requirements for which relief was not specifically requested and approved remain applicable, including the third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions, please contact the ANO Project Manager, Thomas Wengert, at (301) 415-4037 or by e-mail at Thomas.Wengert@nrc.gov.

Sincerely,

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

Docket No. 50-313

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

UNITED STATES
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR ALTERNATIVE ANO1-ISI-026

REGARDING THE PROPOSED ALTERNATIVE TO

ASME CODE CASE N-729-1 EXAMINATION FREQUENCY REQUIREMENTS

ENTERGY OPERATIONS, INC.

ARKANSAS NUCLEAR ONE, UNIT 1

DOCKET NO. 50-313

1.0 INTRODUCTION

By letter dated June 17, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16173A297), Entergy Operations, Inc. (Entergy or the licensee), requested relief from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code) Section XI, associated with the examination frequency requirements of Code Case N-729-1, "Alternative Examination Requirements for PWR [Pressurized Water Reactor] Reactor Vessel Upper Heads With Nozzles Having Pressure-Retaining Partial-Penetration Welds Section XI, Division 1," for Arkansas Nuclear One, Unit 1 (ANO-1).

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(z)(1), the licensee requested to use the proposed alternative in Request for Alternative ANO1-ISI-026 to the examination frequency of ASME Code Case N-729-1, on the basis that the alternative examination frequency provides an acceptable level of quality and safety.

2.0 REGULATORY EVALUATION

The inservice inspection (ISI) of ASME Code Class 1,2, and 3 components is to be performed in accordance with ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," and applicable editions and addenda as required by 10 CFR 50.55a(g), except where specific written relief has been granted by the U.S. Nuclear Regulatory Commission (NRC or the Commission).

Pursuant to 10 CFR 50.55a(g)(6)(ii), the Commission may require the licensee to follow an augmented ISI program for systems and components for which the Commission deems that added assurance of structural reliability is necessary. The regulations in 10 CFR 50.55a(g)(6)(ii)(D) require, in part, "[a]ll licensees of pressurized water reactors must augment their inservice inspection program with ASME Code Case N-729-1, subject to conditions specified in paragraphs (g)(6)(ii)(D)(2) through (6)...."

The regulations in 10 CFR 50.55a(z) state that alternatives to the requirements of paragraph (g) of 10 CFR 50.55a may be used, when authorized by the NRC, if the licensee demonstrates that (1) the proposed alternative would provide an acceptable level of quality and safety; or (2) 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.

Based on the above, and subject to the following technical evaluation, the NRC staff finds that regulatory authority exists for the licensee to request, and the Commission to authorize, the proposed alternative requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 Components Affected

The affected components are ASME Code Class 1, Reactor Vessel Closure Head (RVCH) Penetration Nozzles 0-1 through 0-69 fabricated from ASME SB-167, Alloy UNS N06690 (Alloy 690). The penetration nozzle J-groove welds are fabricated from ASME SFA-5.14, ERNiCrFe-7 (UNS N06052) and ASME SFA-5.11, ENiCrFe-7 (UNS W86152), also referred to as Alloy 52/152 weld materials. The examination requirements of these components are delineated in ASME Code Case N-729-1, Table 1, Item B4.40.

The original ANO-1 RVCH penetration nozzles were manufactured from ASME SB-167, Alloy N06600 (Alloy 600) and used J-groove welds fabricated from ASME SFA-5.14, ERNiCr-3 (UNS N06082) and ASME SFA-5.11, ENiCrFe-3 (UNS W86182), also referred as Alloy 82/182 weld materials. The new RVCH with primary water stress corrosion cracking (PWSCC) resistant materials (Alloy 690 nozzles and Alloy 52/152 weld materials) was placed in operation in December 2005.

3.2 Inservice Inspection Interval

ANO-1 is currently in its fourth 10-year ISI interval, which started on May 31, 2008, and will end on May 30, 2017. The proposed alternative would defer the required examinations currently scheduled to occur during ANO-1's 27th refueling outage in April 2018, to the fifth 10-year ISI interval. The licensee proposes to defer the scheduled examination by an additional 3 years and complete the required examinations during ANO-1's April 2021 refueling outage. The ASME Code of Record for the current ISI interval is the 2007 Edition with the 2008 Addenda of Section XI. The ANO-1 Code of Record for the fifth 10-year ISI interval will be the Edition and Addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(a) 12 months prior to the start of the plant's fifth 10-year ISI interval, which is currently scheduled to begin on May 31, 2017, and end on May 30, 2027.

3.3 Regulatory Requirements

Section 50.55a(g)(6)(ii)(D) of 10 CFR requires, in part, that licensees augment their ISI program in accordance with ASME Code Case N-729-1, subject to the conditions specified in paragraphs (2) through (6) of 10 CFR 50.55a(g)(6)(ii)(D). ASME Code Case N-729-1, Table 1, Inspection Item B4.40, requires volumetric or surface examinations be performed within one inspection interval (nominally 10 calendar years) of its inservice date for a replaced RVCH with PWSCC resistant nozzles and weld materials. Therefore, the required volumetric or surface examinations for ANO-1 replacement RVCH nozzles and welds were required to be completed

by December of 2015. However, by letter dated April 28, 2014 (ADAMS Accession No. ML14118A477) and as supplemented by letter dated October 2, 2014 (ADAMS Accession No. ML14275A460), Entergy requested to defer the volumetric or surface examinations to the 27th refueling outage (April 2018). By letter dated December 23, 2014, the NRC staff approved licensee's request (ADAMS Accession No. ML14330A207).

3.4 Proposed Alternative

In its June 17, 2016, submittal, the licensee proposes to further defer the required volumetric or surface examinations by an additional 3 calendar years, for a total deferral of approximately 5.5 calendar years. Entergy proposes to complete the required inspections during the refueling outage, currently scheduled for April 2021.

3.5 Licensee's Basis for Proposed Alternative

The licensee stated that when it requested the one-time deferral of 2.5 calendar years for the inspection of its replacement RVCH in 2014, it was based on the expectation that an industry initiative, underway to support extension of the required examinations, would receive NRC approval. Entergy stated that, as part of this initiative, Electric Power Research Institute (EPRI) published "[Materials Reliability Program] MRP-375, Technical Basis for Reexamination Interval Extension for Alloy 690 PWR Reactor Vessel Top Head Penetration Nozzles," dated February 2014 (ADAMS Accession No. ML14283A046), which provided the technical justification to extend the volumetric/surface examination interval from 10 years to 20 years. Entergy also stated that the ASME Code Case Committee adopted the revised volumetric/surface examination of two inspection intervals (20 years) in ASME Code Case N-729-5. The licensee stated that it is now seeking to further defer the required inspections by an additional 3 years to support its outage schedule, and to allow the NRC an opportunity to have all the information needed to consider the conclusions reached in MRP-375.

The licensee's basis for the proposed alternative is based on several topics, including the following: (1) the inspection interval in ASME Code Case N-729-1 is based on PWSCC crack growth rates for Alloy 600/82/182, which are conservative compared to the lower crack growth rates for Alloy 690/52/152; (2) bare metal visual examinations; and (3) available data from similar operating plants with similar RVCHs, where volumetric and surface examinations have been satisfactorily completed in accordance with ASME Code Case N-729-1.

In addressing the first basis for use of the proposed alternative, the licensee asserts that the inspection intervals contained in ASME Code Case N-729-1 for heads with Alloy 690/52/152 materials are based in part, on data from Alloy 600/82/182 materials. The volumetric or surface inspection interval of RVCH penetrations fabricated from PWSCC resistant materials was conservatively established as once each inspection interval (10 calendar years). This inspection interval was partly based on PWSCC crack growth rates and data contained in "Materials Reliability Program: Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick-Wall Alloy 600 Materials (MRP-55)," dated July 18, 2002, and "Materials Reliability Program: Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Alloy 82, 182, and 132 Welds (MRP-115)," dated November 2004 (both documents are available to the public at www.epri.com).

The licensee had previously used the parameters defined by ASME Code Case N-729-1 and calculated the factor of improvement (FOI) required for its replacement RVCH with Alloy 690/52/152 materials needed to support extending the inspection interval to 12.5 calendar

years to correspond to a value of 7.7. Entergy determined that a FOI value of 9.5 is needed to support the requested inspection interval of 15.5 calendar years, by applying a factor of 1.24 (i.e., 15.5/12.5) to the prior calculated FOI value of 7.7, which yielded the new FOI value of 9.5 (i.e., 1.24x7.7). The licensee stated that the PWSCC crack growth rates for Alloy 690/52/152 materials are significantly lower than those of Alloy 600/82/182 materials, and therefore, merit a much longer inspection interval than required by ASME Code Case N-729-1. The licensee bases this assertion on laboratory test data for Alloy 690/52/152 data presented in MRP-375. The licensee asserted that the FOI value of 9.5 is supported by its analyses of Alloy 690/152/52 material crack growth rate data presented in MRP-375, and in data from the summary report prepared by two NRC contractors, Pacific Northwest National Laboratory (PNNL) and Argonne National Laboratory (ANL) (ADAMS Accession No. ML14322A587).

In addressing the second basis for its use of the proposed alternative, the licensee stated that preservice volumetric examinations of the replacement RVCH partial penetration nozzles were performed prior to the installation of the new RVCH, and that no recordable indications were observed in the examination volumes/areas of interest. Additionally, inservice bare metal visual examinations were performed in accordance with ASME Code Case N-729-1, Table 1, Item B4.30, in spring 2010 and spring 2015. These examinations were performed, using qualified examiners, by visual testing (VT-2) on the outer surface of the RVCH including the annulus area of the penetration nozzles. The VT-2 examinations did not reveal any indications of nozzle leakage (i.e., boric acid deposits) on RVCH surfaces or nozzles.

In addressing the third basis for its use of the proposed alternative, the licensee stated that four RVCHs for units similar in design and materials of fabrication to ANO-1, have received ISI volumetric examinations of replacement RVCHs in accordance with ASME Code Case N-729-1. Entergy stated that these examinations did not reveal any recordable indications. Entergy also stated that because the four units tested were similar in design and materials of fabrication to that of ANO-1, it believes that these examination results provide additional assurance of the low likelihood for the potential to experience PWSCC for the ANO-1 replacement RVCH for the proposed extension period.

Entergy concluded that its analyses demonstrates that the proposed alternative inspection interval provides a substantially reduced effect on nuclear safety when comparing its replacement RVCH with the PWSCC resistant materials to a RVCH fabricated with Alloy 600/82/182 materials examined to the current requirements. Entergy further concluded that the available laboratory data supports the FOI implied by the requested extension period. The licensee concluded that the proposed alternative revised volumetric/surface examination interval provides an acceptable level of quality and safety as conditioned by 10 CFR 50.55a(z)(1).

3.7 NRC Staff Evaluation

In evaluating the technical sufficiency of the licensee's proposed alternative of further deferral of the ANO-1 RVCH nozzle and J-groove weld volumetric/surface examination interval to 15.5 calendar years, the NRC staff considered each of the aspects of the licensee's basis for use of the proposed alternative. The NRC staff found that the technical basis included by the licensee provided sufficient information for the NRC staff to review the proposed alternative. Due to issues with PWSCC, many PWR plants in the United States and overseas have replaced RVCHs with Alloy 600/82/182 nozzles and welds with RVCHs containing PWSCC resistant Alloy 690/52/152 nozzles and welds. The inspection frequencies developed in Code Case N-729-1 for RVCH penetration nozzles using Alloy 690/52/152 were developed based, in part, on crack growth rate equations documented in MRP-55 and MRP-115 for Alloy 600/82/182. The

licensee's primary technical basis is that the available crack growth rate data for the new, more crack-resistant, materials (i.e., Alloy 690/52/152) justify a longer inspection interval, and demonstrate a large FOI of these materials as compared to the older Alloy 600/82/182 materials. This FOI would then provide the basis for the extension of the ISI frequency requested by the licensee in its proposed alternative. Based on its proposed inspection interval of 15.5 calendar years, the licensee determined that it needed an FOI of 9.5. The NRC staff independently verified that the licensee's requested alternate inspection interval of 15.5 calendar years is bounded by the licensee's calculated FOI of 9.5, by using the parameters defined by ASME Code Case N-729-1 and calculated the FOI by using ANO-1's implied upper head operating temperature 613 degrees Fahrenheit.

In evaluating the licensee's first technical basis for use of the proposed alternative, the NRC staff notes that the licensee uses MRP-375. This document, in part, summarizes numerous Alloy 690/52/152 crack growth rate data from various sources to develop FOIs for the crack growth rate equations provided in MRP-55 and MRP-115. While the NRC staff finds the licensee's assertions and/or interpretations to be reasonable, MRP-375 is not an NRC-approved document. Additionally, the NRC staff has not validated all of the data reported in MRP-375. Therefore, the staff does not consider it appropriate to use all of the data from this document in its review of the licensee's relief request. A more detailed review of the data provided in MRP-375 will be performed by an international group of experts as part of an Alloy 690 Expert Panel. It is expected that this group will complete its review sometime in 2017.

In the interim, the NRC staff's reviews will rely upon Alloy 690/52/152 crack growth rate data from two NRC contractors, PNNL and ANL. The data is documented in the PNNL and ANL summary report. The majority of the data from PNNL and ANL for Alloy 690 test samples were generally consistent with the overall data presented in MRP-375, and also support the licensee's use of an FOI value of 9.5. The PNNL and ANL data summary report also includes crack growth rate data up to approximately 20 percent cold work based on the observation of local strains in welds and weld dilution zone data. However, the NRC staff did not consider the weld dilution zone data in its assessment. This is because the limited weld dilution zone data that is currently available has shown higher crack growth rates than are commonly observed for Alloy 690/52/152 material. The high crack growth rates in weld dilution zones may be due to the reduced chromium present in these areas.

The NRC staff chose to exclude the weld dilution zone data from this analysis due to the limited number of data points available, the variability in the results, and the limited area of continuous weld dilution for potential flaws to grow through. For example, in the case of the highest measured crack growth rates, a flaw would have to travel in the heat affected zone of a J-groove weld along the low alloy steel head interface. It is not fully apparent to the NRC staff how accelerated crack growth in a very small area of weld dilution zone would result in a significantly increased probability of leakage or component failure as a result of the requested extension of the required inspection interval. Exclusion of this data may be reevaluated as additional data becomes available, a better understanding of the existing data is obtained, or if a longer extension of the inspection interval is requested in the future. The NRC staff considers the impact of these weld dilution zone crack growth rates to be not relevant for this specific relief request. Therefore, the staff finds that the licensee's use of an FOI value of 9.5 is justified and bounded by the relevant available data included in the PNNL and ANL data summary report.

In evaluating the licensee's second basis for use of the proposed alternative, the NRC staff finds that past inservice bare metal visual examinations of the replacement RVCH provide a reasonable means to demonstrate the absence of through-wall degradation at these locations

by the absence of leakage through the nozzles or J-groove welds, prior to the time these examinations were conducted. The NRC staff finds that the proposed alternative frequency for the volumetric/surface examinations, in conjunction with the required bare metal visual examinations will provide reasonable assurance of the continued structural integrity of the ANO-1 replacement RVCH nozzles and associated J-groove welds.

In evaluating the licensee's third basis for use of the proposed alternative, the NRC staff noted the successful completion of ISI (with no indications of PWSCC) by volumetric examinations of four similar replacement RVCHs fabricated from similar PWSCC resistant alloys. The staff finds that the absence of service-induced PWSCC on similar RVCHs provides relevant industry operating experience, and supports the licensee's assertion of low probability for PWSCC-induced failure occurring on ANO-1's replacement RVCH during the deferred inspection interval.

NRC staff finds that the licensee's analyses provided sufficient technical justification and supports the concept that deferring the volumetric/surface inspection interval for ANO-1 replacement RVCH by an additional 3 years, for a total deferral of 5.5 calendar years, does not pose a higher risk than that associated with a RVCH with Alloy 600/82/182 nozzles and associated J-groove welds inspected at intervals as specified in 10 CFR 50.55a(g)(6)(ii)(D). Hence, the NRC staff finds the licensee's technical basis to be acceptable. Therefore, based on the above evaluation, the NRC staff finds that the proposed alternative provides an acceptable level of quality and safety as required by 10 CFR 50.55a(z)(1).

4.0 CONCLUSION

As set forth above, the NRC staff has determined that the alternative method proposed by Entergy in Request for Alternative ANO1-ISI-026 will provide an acceptable level of quality and safety for the examination frequency requirements of the ANO-1 replacement RVCH. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC staff authorizes the one-time use of ANO1-ISI-026 at ANO-1 for the duration up to and including the refueling outage currently scheduled for April 2021, which will occur in the fifth 10-year ISI interval.

All other ASME Code, Section XI, requirements for which relief was not specifically requested and approved remain applicable, including the third-party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: Roger Kalikian

Date: February 13, 2017.

SUBJECT: ARKANSAS NUCLEAR ONE, UNIT 1 - REQUEST FOR ALTERNATIVE ANO1-ISI-026 FROM VOLUMETRIC/SURFACE EXAMINATION FREQUENCY REQUIREMENTS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS CODE CASE N-729-1 (CAC NO. MF8007), DATED FEBRUARY 13, 2017

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