



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

November 7, 2017

Mr. Robert S. Bement
Executive Vice President Nuclear/
Chief Nuclear Officer
Mail Station 7602
Arizona Public Service Company
P.O. Box 52034
Phoenix, AZ 85072-2034

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 –
RELIEF REQUEST NO. 55 TO APPROVE AN ALTERNATE FREQUENCY FOR
THE REACTOR PRESSURE VESSEL HEAD NOZZLES VOLUMETRIC
EXAMINATION IN LIEU OF FREQUENCY REQUIREMENTS IN
CODE CASE N-729-1 (CAC NOS. MF9592, MF9593, AND MF9594;
EPID L-2017-LLR-0022)

Dear Mr. Bement:

By letter dated April 7, 2017 (Agencywide Documents Access and Management System Accession No. ML17101A678), Arizona Public Service Company (APS, the licensee) submitted Relief Request No. 55 (RR-55) for Palo Verde Nuclear Generating Station (PVNGS), Units 1, 2, and 3. This relief request proposes relief from the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 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."

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(z)(1), the licensee requested to use the proposed alternative in RR-55 in lieu of the volumetric examination frequency for the reactor vessel closure head (RVCH) nozzles of Table 1 in ASME Code Case N-729-1, on the basis that the alternative examination frequency provides an acceptable level of quality and safety.

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed the licensee's submittal and determined that the alternate method proposed by APS in RR-55 will provide an acceptable level of quality and safety for the examination frequency requirements of the PVNGS, Units 1, 2, and 3 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 RR-55 at PVNGS, Units 1, 2, and 3 for the duration of the fourth 10-year inservice inspection interval as stated in Table 1 of the enclosed safety evaluation.

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 Project Manager, Siva P. Lingam, at 301-415-1564 or via e-mail at Siva.Lingam@nrc.gov.

Sincerely,



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

Docket Nos. STN 50-528, STN 50-529,
and STN 50-530

Enclosure:
Safety Evaluation

cc: Listserv



UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST NO. 55 REGARDING PROPOSED ALTERNATE FREQUENCY

FOR VOLUMETRIC EXAMINATION OF REACTOR

VESSEL CLOSURE HEAD NOZZLES

ARIZONA PUBLIC SERVICE COMPANY

PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3

DOCKET NOS. 50-528, 50-529, AND 50-530

1.0 INTRODUCTION

By letter dated April 7, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17101A678), Arizona Public Service Company (APS, the licensee) submitted Relief Request No. 55 (RR-55) for Palo Verde Nuclear Generating Station (PVNGS), Units 1, 2, and 3. This relief request proposes relief from the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 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."

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(z)(1), the licensee requested to use the proposed alternative in RR-55 in lieu of the volumetric examination frequency for the reactor vessel closure head (RVCH) nozzles of Table 1 in 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, and applicable editions and addenda as required by 10 CFR 50.55a(g), "Preservice and inservice inspection requirements," except where specific written relief has been granted by the U.S. Nuclear Regulatory Commission (NRC).

Pursuant to 10 CFR 50.55a(g)(6)(ii), "Augmented ISI program," the NRC may require the licensee to follow an augmented ISI program for systems and components for which the NRC deems that added assurance of structural reliability is necessary. The regulations in 10 CFR 50.55a(g)(6)(ii)(D), "Augmented ISI requirements: Reactor vessel head inspections," require, in part, "[h]olders of operating licenses...for pressurized-water reactors as of or after

August 17, 2017 shall implement the requirements of ASME BPV Code Case N-729-4 instead of ASME BPV Code Case N-729-1, subject to conditions specified in paragraphs (g)(6)(ii)(D)(2) through (4)....” However Code Case N-729-1 has been used as explained in Section 3.3 of this safety evaluation.

The regulations in 10 CFR 50.55a(z), “Alternatives to codes and standards requirements,” 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 NRC to authorize, the proposed alternative requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 Components Affected

The affected components are 97 control element drive mechanisms and one vent ASME Code Class 1, RVCH penetration nozzles fabricated from ASME SB-166, Alloy UNS N06690 (Alloy 690). The penetration nozzle J-groove welds are fabricated from ERNiCrFe-7, ERNiCrFe-7A, and ENiCrFe-7, also referred to as Alloy 52/152 weld materials. Each of these nozzles and associated welds are categorized as Item B4.40 in ASME Code Case N-729-1, Table 1, to identify the volumetric inspection frequency requirement for these components.

3.2 Inservice Inspection Interval

PVNGS, Units 1, 2, and 3 is currently in its fourth 10-year ISI interval.

3.3 Code Requirement for Which Relief is Requested

Paragraph 50.55a(g)(6)(ii)(D) of 10 CFR requires 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 primary water stress corrosion cracking (PWSCC) resistant nozzles and weld materials.

On July 18, 2017, the *Federal Register* (82 FR 32934) published an NRC final rule updating the latest NRC approved version of the ASME Code for use for inservice inspection in 10 CFR 50.55a. As part of this rulemaking activity, paragraph 50.55a(g)(6)(ii)(D) of 10 CFR was updated to require all licensees of PWRs to use ASME Code Case N-729-4 in lieu of N-729-1, with changes to the previous NRC conditions. The volumetric inspection requirements from which the licensee is requesting relief have not changed due to this update.

Because the volumetric inspection requirements from which the licensee is requesting relief remain the same between ASME Code Cases N-729-1 and N-729-4, and in an effort to reduce unnecessary regulatory burden, the NRC will not request the licensee to revise its relief request to ASME Code Case N-729-4 with conditions as specified in 10 CFR 50.55a(g)(6)(ii)(D). As

such, the current licensee's technical basis may continuously be based on, in part, ASME Code Case N-729-1 as conditioned in 10 CFR 50.55a(g)(6)(ii)(D). However, the NRC staff recognizes that ASME Code Case N-729-4, as conditioned in 10 CFR 50.55a(g)(6)(ii)(D), is applicable to the licensee's relief request by the first refueling outage starting after August 17, 2017, as specified in the rule.

3.4 Proposed Alternative

APS is requesting relief from the examination frequency requirements of ASME Code Case N-729-1, Item B4.40 for performing volumetric and/or surface examinations of the PVNGS, Units 1, 2, and 3 RVCH penetrations. Specifically, the proposed alternative would allow volumetric or surface examinations to be extended as listed in the table below:

Table 1: Licensee's Proposed Alternative

Unit	Startup from RVCH Replacement	Current Exam Outage per Code Case N 729-1	Exam Outage of Proposed Alternative
1	May 2010 (from U1R15)	U1R21 (currently scheduled for spring 2019)	U1R25 (currently scheduled for spring 2025)
2	December 2009 (from U2R15)	U2R21 (currently scheduled for fall 2018)	U2R25 (currently scheduled for fall 2024)
3	November 2010 (from U3R15)	U3R21 (currently scheduled for fall 2019)	U3R25 (currently scheduled for fall 2025)

NOTE: U1R15 refers to Unit 1's fifteenth refueling outage. This nomenclature is similar for other units.

3.5 Licensee's Basis for Proposed Alternative

The licensee stated that the Electric Power Research Institute published topical report, "Materials Reliability Program [MRP]: Technical Basis for Reexamination Interval Extension for Alloy 690 PWR Reactor Vessel Top Head Penetration Nozzles (MRP-375)," dated February 2014 (ADAMS Accession No. ML14283A046), and that it provides a technical justification to extend the volumetric/surface examination interval of the RVCH nozzle penetrations from 10 years to 20 years. In summary, the licensee proposed to extend the inspection intervals from once each interval (nominally 10 calendar years) to once every 15 calendar years based on plant service experience and factor of improvement (FOI) studies using laboratory data.

The licensee noted that the resistance of Alloy 690 and corresponding weld metals Alloy 52 and 152 is demonstrated by the lack of any PWSCC indications reported in these materials, in up to 24 consecutive years of service for thousands of Alloy 690 steam generator tubes, and more than 22 consecutive years of service for thick-wall and thin-wall Alloy 690 applications. The licensee noted that this substantial operating experience includes service at pressurizer and hot-leg temperatures, includes Alloy 690 wrought base metal and Alloy 52/152 weld metal, and ISI volumetric or surface examinations performed in accordance with ASME Code Case N-729-1 on 13 of the 41 replacement RVCHs currently operating in the U.S. fleet.

Beyond the service history addressing crack detection FOI, the licensee further used the parameters of crack growth rate defined by ASME Code Case N-729-1 and calculated the FOI needed to support the proposed alternative, based on crack growth rate alone. The licensee found that a FOI of 6.1 was necessary for its replacement RVCH with Alloy 690/52/152 materials to support extending the inspection interval to 15 calendar years. The licensee noted 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. Therefore, in order to show that the inspection interval extension provides reasonable assurance of structural integrity, the licensee showed that a crack growth rate FOI of 6.1 was acceptable by comparing the available crack growth rate curves of Alloy 600 materials to the available crack growth rate data for Alloy 690 materials. The licensee provided this comparison with additional analysis and calculations by Dominion Engineering, Inc., as noted in the attachment to the submittal entitled, "Technical Note, Assessment of Laboratory PWSCC Crack Growth Rate Data Compiled for Alloys 690, 52 and 152 with Regard to Factors of Improvement (FOI) versus Alloys 600 and 182," TN-5696-00-02, Revision 0, dated March 2015.

The TN-5696-00-02 utilizes laboratory crack growth rate test data for Alloy 690/52/152 presented in MRP-375 and data from the summary report prepared by two NRC contractors, Pacific Northwest National Laboratory (PNNL) and Argonne National Laboratory (ANL) (ADAMS Accession No. ML14322A587). TN-5696-00-02 concludes that the resistance to PWSCC by the materials used for the nozzles and associated welds in the replacement RVCH at PVNGS, Units 1, 2, and 3 support an improvement factor greater than 12 based on crack growth rate alone. The licensee's conclusion is that this 12 FOI is twice the 6.1 FOI necessary for an extension of the volumetric inspection frequency to 15 calendar years. Therefore, the licensee explained 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).

3.6 NRC Staff Evaluation

In evaluating the technical sufficiency of the licensee's proposed alternative to defer the PVNGS, Units 1, 2, and 3 RVCH nozzle and J-groove weld volumetric/surface examination interval to 15 calendar years, the NRC staff considered the licensee's basis for use of the proposed alternative in accordance with 10 CFR 50.55a(z)(1), on the basis that the alternative examination frequency provides an acceptable level of quality and safety.

Due to issues with PWSCC, many PWR plants in the United States and overseas have replaced RVCHs, containing Alloy 600/82/182 nozzles and welds, with RVCHs utilizing nozzle and welds made of Alloy 690/52/152 materials, which are less susceptible to PWSCC than Alloy 600/82/182. The inspection frequencies developed in ASME Code Case N-729-1 for RVCH penetration nozzles made of Alloy 690/52/152 were developed based, in part, on a conservative assessments of the limited crack growth rate data and operating experience of these materials. The licensee's primary technical basis is that the available crack growth rate data is now sufficient to justify a longer inspection interval, and demonstrate a large FOI of these materials as compared to the 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. The licensee determined that it needed an FOI of 6.1. The NRC staff independently verified that the licensee's requested alternate inspection interval of 15 calendar years is bounded by the licensee's calculated FOI

of 6.1, by using the parameters defined by ASME Code Case N-729-1 and using PVNGS, Units 1, 2, and 3 upper head operating temperature of 596.3 degrees Fahrenheit.

In evaluating the licensee's technical basis for the proposed alternative, the NRC staff notes that the licensee uses MRP-375. MRP-375, 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, "Materials Reliability Program (MRP), Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick-Wall Alloy 600 Material (MRP-55)," dated July 18, 2002 (ADAMS Accession No. ML023010510), and MRP-115, "Materials Reliability Program, Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Alloy 82, 182, and 132 Welds (MRP-115NP)," dated November 2004 (ADAMS Accession No. ML051450555). 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 NRC staff does not consider it appropriate to use all of the data from MRP-375 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 2018.

In the interim, the NRC staff's review of the proposed alternative 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 6.1. However, the only PNNL and ANL data that was not bound by the licensee's FOI was that associated with weld dilution specimens. This means that certain crack growth rate tests of weld dilution samples would have a FOI of less than 6.1 versus the crack growth rate curves for Alloy 600 weld materials. Therefore, this data would not support the licensee's requested inspection frequency extension. The NRC staff considered the impact of this limitation.

The NRC staff considered the PNNL and ANL weld dilution crack growth rate data and its significance to address the licensee's requested inspection frequency extension. It should be noted, that the PNNL and ANL data summary report includes very limited weld dilution testing and no general conclusions had been reached regarding the use or applicability of the weld dilution crack growth rate data. This was because there was a high variability in the data, including results of low or no growth in some cases, and in the cases of fast growth, only over limited distances of at most one millimeter. However, the weld dilution crack growth rate data was included in the report, as the report provides a summary of all data collected, to be assessed by the NRC staff.

Ultimately, the NRC staff chose to exclude the weld dilution zone crack growth rate data from its independent analysis due to: (1) the limited number of data points available, (2) the variability in the results, and (3) 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 at the interface between the J-groove weld and the low alloy steel RVCH. Since any such flaw would have been required to grow through a region of typically PWSCC-resistant stainless steel, non-diluted Alloy 52/152, or a dilution of Alloy 52/152 and stainless steel (a condition for which dilution testing has shown limited or no growth), it is not apparent to the NRC staff how accelerated crack growth in this 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. Therefore, the NRC staff

considers the impact of these weld dilution zone crack growth rates to be not relevant for this specific relief request.

The NRC staff does note that crack growth rate testing for Alloy 690/52/152 material is ongoing. Exclusion of the crack growth rate data in the weld dilution zone 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.

By excluding the crack growth rate in the weld dilution zone from the PNNL and ANL data, the NRC staff finds that the licensee's needed FOI of 6.1 is acceptable based on the crack growth data from the PNNL and ANL summary report. Therefore, the NRC staff finds that the licensee's proposed alternative is justified and bounded by the relevant available data included in the PNNL and ANL data summary report, and provides an equivalent or acceptable level of quality and safety.

In evaluating the licensee's 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. Therefore, 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 PVNGS, Units 1, 2, and 3 replacement RVCH nozzles and associated J-groove welds.

The NRC staff finds that the licensee's analyses provided sufficient technical justification. The NRC staff finds that the licensee's analyses support the concept that extending the volumetric/surface inspection interval for PVNGS, Units 1, 2, and 3 replacement RVCH with Alloy 690 materials to 15 calendar years, because of the NRC staff agreed upon enhanced resistance to PWSCC of the Alloy 690 materials, does not pose a higher risk than that associated with a RVCH with Alloy 600/82/182 nozzles and associated J-groove welds that are 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 APS in request for alternative RR-55 will provide an acceptable level of quality and safety for the examination frequency requirements of the PVNGS, Units 1, 2, and 3 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 RR-55 at PVNGS, Units 1, 2, and 3 for the duration of the fourth 10-year ISI interval as stated in Table 1 of this safety evaluation.

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: J. Collins

Date: November 7, 2017

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 – RELIEF REQUEST NO. 55 TO APPROVE AN ALTERNATE FREQUENCY FOR THE REACTOR PRESSURE VESSEL HEAD NOZZLES VOLUMETRIC EXAMINATION IN LIEU OF FREQUENCY REQUIREMENTS IN CODE CASE N-729-1 (CAC NOS. MF9592, MF9593, AND MF9594; EPID L-2017-LLR-0022) DATED NOVEMBER 7, 2017

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