August 29, 2008

Mr. Richard L. Anderson
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3277 DAEC Road
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SUBJECT: DUANE ARNOLD ENERGY CENTER – SAFETY EVALUATION FOR REQUEST FOR ALTERNATIVE TO REACTOR PRESSURE VESSEL NOZZLE TO VESSEL WELD AND INNER RADIUS EXAMINATIONS (TAC NO. MD8193)

Dear Mr. Anderson:

In a letter to the Nuclear Regulatory Commission (NRC) dated February 28, 2008, Agencywide Documents Access and Management System Accession No. ML080710428, FPL Energy Duane Arnold, LLC requested relief from American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI inspection requirements regarding examination of certain reactor pressure vessel nozzle to vessel welds and nozzle inner radii at Duane Arnold Energy Center (DAEC). Instead, an alternative in accordance with ASME Code Case N-702, "Alternative Requirements for Boiling-Water Reactor Nozzle Inner Radius and Nozzle-to-Shell Welds," was proposed. The relief was requested for the fourth 10-year interval of the Inservice Inspection (ISI) Program for DAEC, which began on November 1, 2006.

Based on the information provided in the relief request, the NRC staff concludes the licensee's proposed alternative provides an acceptable level of quality and safety. Therefore, the requested relief is authorized in accordance with 10 CFR 50.55a(a)(3)(i) for the fourth 10-Year interval of the ISI Program interval at DAEC.

If you have any questions regarding this matter, please contact Karl Feintuch at (301) 415-3079.

Sincerely,

/RA by P. Tam/

Lois James, Chief
Plant Licensing Branch III-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-331

Enclosure:
Safety Evaluation

cc w/encl: See next page

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Last revised July 2, 2008

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ALTERNATIVE TO REACTOR PRESSURE VESSEL

NOZZLE TO VESSEL WELD AND INNER RADIUS EXAMINATIONS

DUANE ARNOLD ENERGY CENTER, FPL ENERGY DUANE ARNOLD, LLC

DOCKET NO. 50-331

1.0 INTRODUCTION

By letter dated February 28, 2008, Agencywide Documents Access and Management System (ADAMS) Accession No. ML080710428, FPL Energy Duane Arnold, LLC, the licensee for Duane Arnold Energy Center (DAEC), submitted a request for relief from American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," regarding examination of reactor pressure vessel (RPV) nozzle to vessel welds and nozzle inner radii at DAEC. Instead, the licensee proposed to use an alternative in accordance with ASME Code Case N-702, "Alternative Requirements for Boiling-Water Reactor (BWR) Nozzle Inner Radius and Nozzle-to-Shell Welds." The technical basis for ASME Code Case N-702 was documented in an Electric Power Research Institute report by Boiling-Water Reactor Vessel and Internals Project (BWRVIP), "BWRVIP-108: BWR Vessel and Internals Project, Technical Basis for the Reduction of Inspection Requirements for the Boiling-Water Reactor Nozzle-to-Vessel Shell Welds and Nozzle Inner Radii," which was approved by the Nuclear Regulatory Commission (NRC) in a safety evaluation (SE) dated December 19, 2007, (ADAMS Accession No. ML073600374). This alternative will be discussed in Section 2.0 below.

The December 19, 2007, SE for BWRVIP-108 specified plant-specific requirements which must be met for applicants proposing to use this alternative. The licensee submittal intended to demonstrate that the relevant DAEC RPV nozzle-to-vessel welds and nozzle inner radii meet the plant-specific requirements so that the relief request can be granted.

2.0 REGULATORY EVALUATION

Inservice inspection (ISI) of the ASME Code Class 1, 2, and 3 components is performed in accordance with Section XI of the ASME Code and applicable addenda as required by Title 10 of the *Code of Federal Regulations* (10 CFR) 10 CFR 50.55a(g), except where specific relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). Section 50.55a(a)(3) of the 10 CFR states that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if: (i) the proposed alternatives would provide an acceptable level of quality and safety or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Section 50.55a(g)(4) of 10 CFR states further that ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except design and access provisions and preservice examination requirements, set forth in the ASME Code, Section XI, to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The applicable ISI Code of Record for the fourth 10-year ISI interval of the DAEC unit is the 2001 Edition of ASME Code, Section XI, 2003 Addenda.

For RPV nozzle-to-vessel shell welds and nozzle inner radii, ASME Code, Section XI requires 100 percent inspection during each 10-year ISI interval. However, ASME Code Case N-702 proposes an alternative which reduces the inspection of RPV nozzle-to-vessel shell welds and nozzle inner radius areas from 100 percent to 25 percent of the nozzles for each nozzle type during each 10-year interval. The NRC has approved BWRVIP-108, the underlying technical basis document for ASME Code Case N-702. The December 19, 2007, SE regarding BWRVIP-108 specified the following plant-specific requirements to be satisfied by applicants using ASME Code Case N-702:

> However, each licensee should demonstrate the plant-specific applicability of the BWRVIP-108 report to their units in the relief request by showing that all the following factors are less than 1.15:
>
> (1) the temperature factor defined as (RPV heat up and cooldown rate/100 ºF/hour),
>
> For the recirculation inlet nozzle,
>
> (2) the RPV pressure stress factor defined as [(RPV pressure)x(RPV inner radius)/(RPV thickness)]/[1000 psi x 110 inch/5.69 inch],
>
> (3) the nozzle pressure stress factor defined as (pressure/1000 psi)x{[(nozzle outer radius)^2 + (nozzle inner radius)^2]/ [(nozzle outer radius)^2 - (nozzle inner radius)^2]}/{[(13.988 inch)^2 + (6.875 inch)^2]/ [(13.988 inch)^2 - (6.875 inch)^2]},
>
> For the recirculation outlet nozzle,
>
> (4) the RPV pressure stress factor defined as [(RPV pressure)x(RPV inner radius)/(RPV thickness)]/[1000 psi x 113.2 inch/7.0 inch], and
>
> (5) the nozzle pressure stress factor defined as (pressure/1000 psi)x{[(nozzle outer radius)^2 + (nozzle inner radius)^2]/ [(nozzle outer radius)^2 - (nozzle inner radius)^2]}/{[(22.31 inch)^2 + (12.78 inch)^2]/ [(22.31 inch)^2 - (12.78 inch)^2]}.

This plant-specific information was required by the NRC staff to ensure that the probabilistic fracture mechanics (PFM) analysis documented in BWRVIP-108 applies to the RPV of the applicant's plant.

3.0 TECHNICAL EVALUATION

3.1 Licensee Evaluation (Selected direct quotes under slightly different subtitles)

ASME Code Requirement for which Relief is Requested

[The licensee requested relief from the following requirements of ASME Code, Section XI, 2001 Edition, 2003 Addenda:]

> Table IWB-2500-1 "Examination Category B-D, Full Penetration Welded Nozzle in Vessels - Inspection Program B"
>
> Class 1 nozzle-to-vessel weld and nozzle inner radii examination requirements are given in Item Number B3.90 "Nozzle-to-Vessel Welds" and B3.100 "Nozzle Inside Radius Section." The method of examination is volumetric. All nozzles with full penetration welds to the vessel shell (or head) and integrally cast nozzles are examined each interval. All of the nozzle assemblies identified in Enclosure 2[1] are full penetration welds.

Component(s) for which Relief is Requested

Code Class:	1
Component Numbers:	N1, N2, N3, N5, N6, N7, N8, N11, N12, and N16 Nozzles (see Enclosure 2[1] for specific nozzle identifications)
Examination Category:	B-D
Item Number:	B3.90 and B3.100

Licensee's Proposed Alternative to the ASME Code

> Pursuant to 10 CFR 50.55a(a)(3)(i), relief is requested from performing the required examinations on 100 percent of the identified nozzle assemblies (see Enclosure 2[1]). As an alternative for all welds and [nozzle] inner radii except for the Recirculation Outlet welds, DAEC proposes to [volumetrically] examine a minimum of 25 percent of the nozzle-to-vessel welds and inner radius sections, including at least one nozzle from each system and nominal pipe size, in accordance with [ASME] Code Case N-702.

Licensee's Bases for Alternative

> Electric Power Research Institute (EPRI) Technical Report 1003557, "BWRVIP-108: Boiling-Water Reactor Vessel and Internals Project Technical Basis for the Reduction of Inspection Requirements for the Boiling-Water Reactor Nozzle-to-Vessel Shell Welds and

[1] Refers to Enclosure 2 from the licensee's February 28, 2008, submittal. Enclosure 2 is not reproduced in this SE.

Nozzle Blend Radii," provides the basis for [ASME] Code Case N-702. The evaluation found that failure probabilities at the nozzle blend radius region and nozzle-to-vessel shell weld due to a Low Temperature Overpressure event are very low (i.e., $<1 \times 10^{-6}$ for 40 years) with or without ISI. The report concludes that inspection of 25 percent of each nozzle type is technically justified.

This EPRI report received an NRC SER dated December 19, 2007. In the SER, Section 5.0 "Plant-Specific Applicability" indicates that each licensee who plans to request relief from the ASME Code, Section XI requirements for RPV nozzle-to-vessel shell welds and nozzle inner radius sections may reference BWRVIP-108 report as the technical basis for the use of ASME Code Case N-702 as an alternative. However, each licensee should demonstrate the plant-specific applicability for the BWRVI P-1 08 report to its units in the relief request by showing that all the general and nozzle-specific criteria addressed below are satisfied (reference Enclosure 3[2]):

(1) [T]he maximum RPV heatup/cooldown rate is limited to less than 115°F per hour. The DAEC surveillance that monitors reactor vessel heatup/cooldown (Surveillance Test Procedure 3.4.9-01) limits the rate to less than or equal to 100°F/hr for Curve B and less than or equal to 20°F/hr for Curve A.

(2) For the Recirculation Inlet Nozzles the following criteria must be met:

(a) $(pr/t)/C_{RPV} < 1.15$, the calculation for the DAEC N2 Nozzle results in 0.9748 which is less than 1.15/ and

(b) $[p(ro^2 + ri^2)/(ro^2 - ri^2)]/C_{NOZZLE} < 1.15$, the calculation for the DAEC N2 Nozzle results in 1.0923 which is less than 1.15.

(3) For the Recirculation Outlet Nozzles the following criteria must be met:

(a) $(pr/t)/C_{RPV} < 1.15$, the calculation for the DAEC N1 Nozzle results in 1.17 which is higher than 1.15, and

(b) $[p(ro^2 + ri^2)/(ro^2 - ri^2)]/C_{NOZZLE} < 1.15$, the calculation for the DAEC N1 Nozzle results in 0.87 which is less than 1.15.

Based upon the above information, all RPV nozzle-to-vessel shell welds and nozzle inner radii sections, with the exception of the recirculation outlet nozzles, meet the criteria and therefore [ASME] Code Case N-702 is applicable. However, the recirculation outlet nozzles do not meet all of the criteria and [ASME] Code Case N-702 would not be applied. See Enclosure 3[2] for details.

Therefore, use of [ASME] Code Case N-702 provides an acceptable level of quality and safety pursuant to 10 CFR 50.55a(a)(3)(i) for all RPV nozzle-to-vessel shell welds and nozzle inner radii sections, with the exception of the recirculation outlet nozzles.

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[2] Refers to Enclosure 3 from the licensee's February 28, 2008, submittal. Enclosure 3 is not reproduced in this SE.

3.2 Staff Evaluation

The December 19, 2007, NRC SE on the BWRVIP-108 report specified five plant-specific criteria that licensees shall meet to demonstrate that the BWRVIP-108 report results apply to their plants. The five criteria are related to the driving force of the PFM analyses for the recirculation inlet and outlet nozzles. It was stated in the December 19, 2007, SE, that the nozzle material fracture toughness-related RT_{NDT} values used in the PFM analyses were based on data from the entire fleet of BWR RPVs. Therefore, the BWRVIP-108 PFM analyses are bounding with respect to fracture resistance, and only the driving force of the underlying PFM analyses needs to be evaluated. It was also stated in the December 19, 2007, SE that, except for the RPV heatup/cooldown rate, the plant-specific criteria are for the recirculation inlet and outlet nozzles only because the probabilities of failure, P(F|E)s, for other nozzles are an order of magnitude lower.

The licensee provided in the submittal, DAEC's plant-specific data and its evaluation of the five driving force factors, or ratios, against the criteria established in the December 19, 2007, SE. The licensee's evaluation indicated that the fourth criterion (related to recirculation outlet nozzles) was not satisfied. As a result, the reduced inspection requirements in accordance with ASME Code Case N-702 do not apply to DAEC RPV recirculation outlet nozzles. The NRC staff agrees with the licensee's decision to exclude the DAEC RPV recirculation outlet nozzles from the scope of this request based upon the licensee's evaluation. However, considering that the driving force factor for the recirculation outlet nozzles (1.17) is very close to the plant-specific criterion (1.15) and the P(F|E)s for other RPV nozzles are an order of magnitude lower than the recirculation outlet nozzles, the NRC staff determined that ASME Code Case N-702 applies to all other requested DAEC RPV nozzles. It should be noted that RPV feedwater nozzles and control rod drive return line nozzles are outside the scope of ASME Code Case N-702 and are, accordingly, outside the scope of this application.

It should be noted also that ASME Code Case N-702 permits a VT-1 visual examination of the nozzle inner radius without performing a sensitivity demonstration of detecting a 1-mil width wire or crack. This is not consistent with the NRC position established in Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," regarding ASME Code Case N-648-1, "Alternative Requirements for Inner Radius Examinations of Class 1 Reactor Vessel Nozzles." However, since the licensee stated in the submittal that DAEC has no plans of using Code Case N-648-1 and volumetric examinations of all nozzle inner radii will be completed, the inconsistency between ASME Code Case N-702 and the NRC position regarding VT-1 is not an issue in this application.

4.0 CONCLUSION

The NRC staff has reviewed the submittal and finds that the DAEC RPV meets four of the five plant-specific criteria specified in the December 19, 2007, SE on the BWRVIP-108 report, which provides technical bases for use of ASME Code Case N-702. The only plant-specific criterion that was not met regarded the evaluation of the DAEC recirculation outlet nozzles, which were excluded from the scope of this request. Consequently, pursuant to 10 CFR 50.55a(a)(3)(i), relief is granted through the end of the fourth 10-year ISI interval from the requirements of Table IWB-2500-1 (inspection Program B) of ASME Code, Section XI, pertaining to inspection of the RPV nozzle-to-vessel shell welds and inner radii for nozzles specified in the licensee's submittal, and an alternative of using ASME Code Case N-702 is authorized because an

acceptable level of quality and safety can be maintained. This determination has considered the licensee's intention to perform volumetric examinations for all the affected nozzle inner radii.

This relief from the ASME Code requirements and request for an alternative are authorized by law and will not endanger life or property or the common defense and security, and is otherwise in the public interest. All other requirements of the ASME Code, Sections III and XI, for which relief has not been specifically requested and approved, remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: Simon Sheng

Date: August 29, 2008