March 30, 2001

Mr. Gregg R. Overbeck
Senior Vice President, Nuclear
Arizona Public Service Company
P. O. Box 52034
Phoenix, AZ 85072-2034

SUBJECT: RELIEF REQUESTS NUMBERS 15 AND 16 FOR PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 (TAC NOS. MB1091, MB1092, AND MB1093)

Dear Mr. Overbeck:

By letter dated January 25, 2001 (102-04523), you submitted two relief requests and requested the use of alternatives to the inservice inspection requirements of 10 CFR 50.55a(g). Relief Requests Nos. 15 and 16 requested approval to use the American Society of Mechanical Engineers (ASME) Code Cases N-533-1 and N-616 as alternatives to the requirements of IWA-5242(a) of Section XI of the ASME Code, which requires insulation to be removed from pressure-retaining bolted connections to perform VT-2 visual examinations on systems which are borated for the purpose of controlling reactivity. The proposed alternatives would allow insulation to remain in place when performing the VT-2 visual examinations.

The staff has completed its review of the two relief requests and proposed alternatives, and has determined that the proposed alternatives will provide an acceptable level of quality and safety. Therefore, Relief Requests Nos. 15 and 16 are authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the remainder of the second 10-year inservice inspection interval for each unit.

Sincerely,

/RA/

Stephen Dembek, Section Chief, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

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

Enclosure: Safety Evaluation

cc w/encl: See next page

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cc:

Mr. Steve Olea
Arizona Corporation Commission
1200 W. Washington Street
Phoenix, AZ 85007

Douglas Kent Porter
Senior Counsel
Southern California Edison Company
Law Department, Generation Resources
P.O. Box 800
Rosemead, CA 91770

Senior Resident Inspector
U.S. Nuclear Regulatory Commission
P. O. Box 40
Buckeye, AZ 85326

Regional Administrator, Region IV
U.S. Nuclear Regulatory Commission
Harris Tower & Pavillion
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011-8064

Chairman
Maricopa County Board of Supervisors
301 W. Jefferson, 10th Floor
Phoenix, AZ 85003

Mr. Aubrey V. Godwin, Director
Arizona Radiation Regulatory Agency
4814 South 40 Street
Phoenix, AZ 85040

Mr. Craig K. Seaman, Director
Regulatory Affairs
Arizona Public Service Company
P.O. Box 52034
Phoenix, AZ 85072-2034

Mr. John C. Horne
Vice President, Power Generation
El Paso Electric Company
2702 N. Third Street, Suite 3040
Phoenix, AZ 85004

Mr. David Summers
Public Service Company of New Mexico
414 Silver SW, #1206
Albuquerque, NM 87102

Mr. Jarlath Curran
Southern California Edison Company
5000 Pacific Coast Hwy Bldg DIN
San Clemente, CA 92672

Mr. Robert Henry
Salt River Project
6504 East Thomas Road
Scottsdale, AZ 85251

Terry Bassham, Esq.
General Counsel
El Paso Electric Company
123 W. Mills
El Paso, TX 79901

Mr. John Schumann
Los Angeles Department of Water & Power
Southern California Public Power Authority
P.O. Box 51111, Room 1255-C
Los Angeles, CA 90051-0100

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO INSERVICE INSPECTION RELIEF REQUESTS 15 AND 16

ARIZONA PUBLIC SERVICE COMPANY

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

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

1.0 INTRODUCTION

By letter dated January 25, 2001, the Arizona Public Service Company (the licensee) submitted two requests for relief for the second 10-year inservice inspection interval of 10 CFR 50.55a(g) for Palo Verde Nuclear Generating Station, Units 1, 2, and 3 (Palo Verde). In Relief Requests Nos. 15 and 16, the licensee requested approval to use the American Society of Mechanical Engineers (ASME) Code Cases N-533-1, “Alternative Requirements for VT-2 Visual Examination of Class 1, 2, and 3 Insulated Pressure-Retaining Bolted Connections,” and N-616, “Alternative Requirements for VT-2 Visual Examination of Class 1, 2, and 3 Insulated Pressure-Retaining Bolted Connections, Section XI, Division 1,” as alternatives to the requirements of IWA-5242(a) of Section XI of the ASME Code, which requires insulation to be removed from pressure-retaining bolted connections to perform VT-2 visual examinations on systems which are borated for the purpose of controlling reactivity. The proposed alternatives would allow insulation to remain in place when performing the VT-2 visual examinations.

2.0 BACKGROUND

Inservice inspection of the ASME Code Class 1, 2, and 3 components is to be performed in accordance with Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," of the ASME Boiler and Pressure Vessel (B&PV) Code and applicable addenda as required by 10 CFR 50.55a(g), except where specific written relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). Paragraph 50.55a(a)(3) of 10 CFR Part 50 states in part that alternatives to the requirements of paragraph (g) may be used, when authorized by the Nuclear Regulatory Commission (NRC), if the licensee demonstrates that: (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.

Pursuant to 10 CFR 50.55a(g)(4), 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 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 10-year interval, subject to the limitations and modifications listed therein. The applicable edition of Section XI of the ASME Code for Palo Verde for the second 10-year inservice inspection interval is the 1989 Edition.

3.0 EVALUATION OF RELIEF REQUESTS

3.1 Request for Relief No. 15, Visual Examination of Insulated Pressure-Retaining Bolted Connections on Class 2 and 3 Systems Borated for the Purpose of Controlling Reactivity

ASME Code Class:	2 and 3
Code Reference:	IWA-5242(a), 1992 Edition, 1992 Addenda
Examination Category:	C-H and D-B
Item Numbers:	All
Components:	Insulated, pressure-retaining bolted connections on systems borated for the purpose of controlling reactivity.
Inservice Inspection Interval:	Second 10-year interval

Applicable Code Requirement from which relief is requested:

Tables IWC-2500-1 and IWD-2500-1 require that Class 2 and 3 connections be VT-2 visually examined each 40-month inspection period.

ASME Section XI, paragraph IWA-5242(a) requires that “For systems borated for the purpose of controlling reactivity, insulation shall be removed from pressure-retaining bolted connections for visual examination VT-2.”

Licensee’s Proposed Alternative

The licensee will implement ASME Code Case N-533-1 for the portions of Class 2 and 3 systems identified above with the inspection frequency being the Code-required frequency of every inservice inspection period. If the licensee does not remove the insulation from the bolted connection, the licensee proposes to perform a system pressure test to pressurize the connection and a VT-2 visual examination of the subject bolted connections each inservice inspection period. The licensee stated that this alternative is consistent with ASME Code Case N-533-1. If the licensee removes the insulation for the subject bolted connection, it will perform a VT-2 visual examination as required, but will not perform the system pressure test.

If the licensee detects evidence of leakage, the licensee stated that the bolted connections would be evaluated in accordance with the corrective measures of ASME Section XI, Sub-Article IWA-5250, as modified by Relief Request No. 12, which was approved by the staff in its letter dated April 26, 1999.

The corrective measures approved for the licensee in the safety evaluation dated April 26, 1999, for Relief Request No. 12, are the following alternative methodology for leakage at a Code Class 1, 2, and 3 pressure-retaining bolted connection:

1. The leakage shall be stopped, and the bolting and component material shall be evaluated for joint integrity as described in 3. below.

2. If the leakage is not stopped, the joint shall be evaluated in accordance with IWA-3142 for joint integrity. The evaluation shall include the considerations in 3. below.

3. The evaluation for 1. and 2. above is to determine the susceptibility of the bolting to corrosion and failure. The evaluation will, at a minimum, consider the following factors:

    a. The number and service age of bolts,
    b. Bolt and component material,
    c. Corrosiveness of the process fluid,
    d. Leakage location and system function,
    e. Leakage history at connection or other system components, and
    f. Visual evidence of corrosion at connection (while connection is assembled).

If the evaluation of the above variables indicates the need for further evaluation, then a bolt closest to the source of the leakage shall be removed. The bolt will receive a VT-1 examination and be evaluated and dispositioned in accordance with IWB-3517 of the ASME Code, Section XI. If the removed bolting shows evidence of rejectable degradation, all remaining bolts shall be removed and receive a VT-1 examination in accordance with IWB-3140. If the leakage is identified when the bolted connection is in service and the information in the engineering evaluation is supportive, the removal of the bolt for the VT-1 examination may be deferred until the next refueling outage.

Licensee's Justification for Granting Relief

The licensee stated that Code Class 2 and 3 systems are extensive, covering many areas and elevations of the plant. Many of the bolted connections for these systems are located in difficult to access areas requiring scaffolding to be erected to provide access to the bolted connections. With high operating temperatures of these systems in Mode 3, at normal operating temperature and pressure, removing insulation presents personnel safety hazards.

The licensee stated that the use of Code Case N-533-1 is an acceptable approach to ensure leaktight integrity of systems borated for the purpose of controlling reactivity. The licensee explained that the approach is a system pressure test and a VT-2 visual examination performed each inservice inspection period for Class 2 and 3 systems. The pressure test will use the four-hour hold time for insulated bolted connections to allow any leakage to penetrate the insulation to provide a means for detecting any significant leakage with the insulation in place. The licensee concluded that this two-step approach will provide an acceptable level of quality and safety for these bolted connections.

Staff Evaluation

The ASME Code requires the removal of all insulation from pressure-retaining bolted connections in systems borated for the purpose of controlling reactivity when performing VT-2 visual examinations during system pressure tests. For Class 1 systems, the Code requires this examination during each refueling outage, while Class 2 and 3 systems are required to receive this examination each inservice inspection period. As an alternative to the Code requirements,

the licensee has proposed to use Code Case N-533-1 for borated Class 2 and 3 systems at Palo Verde. This code case was originally written for Class 1 systems (Code Case N-533). The licensee has been authorized to implement an alternative examination equivalent to Code Case N-533 for bolted connections on Class 1 borated systems used for reactivity control in the safety evaluation dated April 26, 1999, which is discussed above. The alternative approved for the Class 1 borated systems is the same alternative the licensee is now proposing for bolted connections on Class 2 and 3 systems.

The staff finds for Class 2 and 3 systems, that the alternative in Code Case N-533-1 provides an acceptable approach for ensuring the leak-tight integrity of systems borated for the purpose of controlling reactivity. The approach in the code case is that a system pressure test and VT-2 visual examination will be performed on the bolted connections each inservice inspection period. The licensee committed to a minimum four-hour pressure hold time for the system pressure test. The four-hour time will allow leakage to penetrate the insulation, thus providing a means of detecting any significant leakage with the insulation in place. The staff concludes that this two-step approach provides an acceptable level of quality and safety for bolted connections in Class 2 and 3 borated systems and the licensee has agreed to this approach in its letter of January 25, 2001.

3.2 Request for Relief No. 16, Insulation Removal During IWA-5000 Pressure Tests on Pressure-Retaining Bolted Connections on Class 1, 2, and 3 Systems Borated for the Purpose of Controlling Reactivity

ASME Code Class:	1, 2, and 3
Code Reference:	IWA-5242(a), 1992 Edition, 1992 Addenda
Examination Category:	B-P, C-H, and D-B
Item Numbers:	All
Components:	Insulated, pressure-retaining bolted connections on systems borated for the purpose of controlling reactivity.
Inservice Inspection Interval:	Second 10-year interval

Applicable Code Requirement from which relief is requested:

Table IWB-2500-1 requires that bolted connections in Class 1 systems be VT-2 visually examined each refueling outage. Tables IWC-2500-1 and IWD-2500-1 require that bolted connections in Class 2 and 3 systems be VT-2 examined each inservice inspection period.

ASME Section XI, paragraph IWA-5242(a) requires that “For systems borated for the purpose of controlling reactivity, insulation shall be removed from pressure-retaining bolted connections for visual examination VT-2.”

Licensee’s Proposed Alternative

The licensee stated that, in insulated systems borated for the purpose of controlling reactivity, a VT-2 visual examination during the system pressure tests of IWB-5000, IWC-5000, and IWD-5000 will be performed in accordance with ASME Code Case N-616 with the insulation remaining installed when the bolting is made of the following material:

- SA-564 Grade 630, H1100
- SA-193 Grade B6 tempered at 1100 ^{o}F minimum
- SA-453 Grade 660 preloaded below 100 KSI (originally SA-286 Grade 660, but corrected in an email to the staff, which is discussed in the staff's evaluation on the next page)
- Nut material - SA-194 Grade 8 or 8M

The licensee further stated (1) that the hold time for the system pressure test will meet ASME Code Section XI requirements (i.e., 4 hours for insulated components), (2) the use of Code Case N-616 will only apply to bolted connections where the associated valve bodies, pump casings, and piping contain a minimum of 10 percent chromium and are in the proper heat treatment condition, and (3) if evidence of leakage is detected, either by discovery of active leakage or evidence of boric acid crystals, the insulation shall be removed and the bolted connection shall be re-examined and, if necessary, evaluated in accordance with the corrective measures of Section XI, Sub-Article IWA-5250, as modified by Relief Request No. 12, which was approved by the staff in its letter dated April 26, 1999.

The corrective measures approved for the licensee in the safety evaluation dated April 26, 1999, for Relief Request No. 12, are the following alternative methodology for leakage at a Code Class 1, 2, and 3 pressure-retaining bolted connection:

1. The leakage shall be stopped, and the bolting and component material shall be evaluated for joint integrity as described in 3. below.

2. If the leakage is not stopped, the joint shall be evaluated in accordance with IWA-3142 for joint integrity. The evaluation shall include the considerations in 3. below.

3. The evaluation for 1. and 2. above is to determine the susceptibility of the bolting to corrosion and failure. The evaluation will, at a minimum, consider the following factors:

    a. The number and service age of bolts,
    b. Bolt and component material,
    c. Corrosiveness of the process fluid,
    d. Leakage location and system function,
    e. Leakage history at connection or other system components, and
    f. Visual evidence of corrosion at connection (while connection is assembled).

If the evaluation of the above variables indicates the need for further evaluation, then a bolt closest to the source of the leakage shall be removed. The bolt will receive a VT-1 examination and be evaluated and dispositioned in accordance with IWB-3517 of the ASME Code, Section XI. If the removed bolting shows evidence of rejectable degradation, all remaining bolts shall be removed and receive a VT-1 examination in accordance with IWB-3140. If the leakage is identified when the bolted connection is in service and the information in the engineering evaluation is supportive, the removal of the bolt for the VT-1 examination may be deferred until the next refueling outage.

Licensee's Justification for Granting Relief

The licensee stated that, in lieu of removing insulation at bolted connections for the sole purpose of performing VT-2 visual examinations, when the bolting is made from the corrosion-resistant materials listed above, the use of ASME Code Case N-616 provides an acceptable level of quality and safety. The licensee explained that corrosion-resistant bolted connections on borated systems consists of materials with chromium content greater than or equal to 10 percent because these materials are resistant to boric acid corrosion, which is established in ASME Code Case N-616.

The licensee stated that, during previous refueling outages at Palo Verde, Class 1 bolted connections have been inspected with the insulation removed in accordance with IWA-5242(a) and ASME Code Case N-533 and the bolted connections did not exhibit any evidence of degradation due to boric acid corrosion. The licensee explained that, where boric acid residues were discovered and corrosion-resistant bolting removed, no corrosion was evident in the bolting material.

The licensee stated that (1) Code Class systems borated for the purpose of controlling reactivity are extensive and consist of large systems covering many areas inside the containment bioshield and many elevations of the plant, (2) access to the bolted connections for these systems requires scaffolding to be erected, and (3) many of the bolted connections are located in medium to high radiation areas. The licensee stated that insulation removal combined with scaffolding requirements is burdensome due to the increased outage resource requirements, increased costs associated with implementation of the ASME Code requirements and extended outage duration, and increased radiation exposure. The licensee explained that these same costs will be incurred when the licensee uses the relief provided by ASME Code Cases N-533 and N-533-1, and the relief provided by Code Case N-616 will also reduce these costs associated with Code Case N-533 and N-533-1.

Staff Evaluation

It should be noted that the licensee stated SA-286 Grade 660 instead of SA-453 Grade 660 in its January 25, 2001, application for relief request (RR) No. 16. In the e-mail dated February 28, 2001 (ADAMS Accession No. ML010680004), the licensee explained that the reference to SA-286 presented in the application for RR No. 16 was a typographical error. The material specification should have been "A-286" which is equivalent to SA-453, Grade 660. There is no material designated SA-286.

The ASME Code requires the removal of all insulation from pressure-retaining bolted connections in systems borated for the purpose of controlling reactivity when performing VT-2 visual examinations during system pressure tests. The Code requires this examination to be performed each refueling outage for Class 1 systems, and each inservice inspection period for Class 2 and 3 systems. The licensee has requested relief from the ASME Code to use Code Case N-616.

The staff has developed a position over the years on the use of American Iron and Steel Institute (AISI) Type 17-4 PH stainless steel (SA-564 Grade 630, H1100), AISI Type 410 stainless steel (SA-193 grade B6), and A-286 stainless steel (SA-453 Grade 660) fasteners. The AISI Type 17-4 PH and 410 stainless steels are suitable for use in contact with primary

reactor coolant system borated water if they are aged at a temperature of 1100 ^{o}F or higher. If they are aged at a lower temperature, the stainless steels become susceptible to primary water stress corrosion cracking. The hardness of these alloys should be below R_c 30 if they are properly heat treated.

For A-286 stainless steel, the material is susceptible to stress corrosion cracking, particularly if preloaded above 100 ksi. NUREG/CR-3604, "Bolting Applications," dated May 1984, states that A-286 stainless steel is not suitable for use as a reactor structural material because much safer materials are available. However, there are a large number of A-286 stainless steel bolting in nuclear service, both in boiling water reactors (BWRs) and pressurized water reactors (PWRs). Bengtsson and Korhonen of ASEA-ATOM, Vasteras, Sweden, examined the behavior of A-286 stainless steel in a BWR environment as reported in the Proceedings of the International Symposium on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors, August 22-25, 1983, Myrtle Beach, South Carolina, sponsored by the National Association of Corrosion Engineers, the Metallurgical Society of the American Institute of Metallurgical Engineers, and the American Nuclear Society. They found the A-286 stainless steel, in comparison to other tested materials, to be the most susceptible material that was tested to intergranular stress corrosion cracking in BWR water. They also found that A-286 stainless steel is less likely to crack as the applied stress is reduced. Piascik and Moore from Babcock & Wilcox reported a number of vessel internals bolt failures of A-286 stainless steel bolts in Nuclear Technology, Volume 75, dated December 1986, in PWR water. They correlated the failures with bolt fillet peak stress and found that bolts preloaded below 100 ksi showed no failures.

The staff's position is that any AISI Types 17-4 PH or 410 stainless steel studs or bolts aged at a temperature below 1100 ^{o}F or with a hardness above R_c 30 must have the thermal insulation removed for VT-2 visual examinations during the system pressure test. For A-286 stainless steel studs or bolts, the preload must be verified to be below 100 ksi or the thermal insulation removed and the joint visually inspected. For nuts conforming to SA-194, experience indicates it would not be necessary to remove the thermal insulation for visual inspections.

The licensee has proposed to implement ASME Code Case N-616 for the performance of the VT-2 visual examination at locations where corrosion-resistant bolting is installed without removal of the insulation. The following restrictions will apply:

1. A four-hour hold time at system operating pressure will be used prior to the visual examination.

2. This relief will not apply to the following:

    a. A-286 stainless steel (SA-453 Grade 660) bolting with a preload stress above 100 ksi.
    b. Bolts made from grade 410 stainless steel (SA-193 Grade B6) tempered at a temperature below 1100 ^{o}F or with a hardness above R_c 30.

If evidence of leakage is detected at locations where corrosion-resistant bolting material is used, either by discovery of active leakage or evidence of boric acid crystals, the insulation shall be removed and the bolted connection re-examined. If necessary, the bolted connection will be evaluated in accordance with the corrective actions of IWA-5250.

The bolting materials SA-194 Grade B8, SA-194 Grade B8M, SA-564 Grade 630 H1100 that are proposed by the licensee and listed in the above section on the licensee's proposed alternative for Relief Request No. 16 in this safety evaluation have a chromium content of greater than 10 percent and meet the requirements of Code Case N-616 for VT-2 visual examination without insulation removal. Therefore, the relief request will apply to these bolting materials.

In summary, the licensee proposed alternative to IWA-5242(a) is to perform the system pressure tests in accordance with the hold time requirements specified in IWA-5213(a) and the VT-2 visual examination will be performed as required by IWA-5242(a), except that the insulation will not be removed. If leakage is detected during testing, the insulation will be removed for examination, and the effects of the leakage will be evaluated in accordance with the previously NRC-approved corrective actions that are given in the above section on the licensee's proposed alternative for the relief request.

The staff finds that, once the Code-specified hold time requirement during the system pressure tests are followed, significant leakage, if any, will penetrate the insulation and be detected. In addition, for those bolted connections in borated systems with bolting composed of less than 10 percent chromium, or other bolting to which the relief does not apply, periodic removal of the insulation for the VT-2 visual examination, even under cold and non-pressurized conditions, should allow for detection of even minor leakage in a timely manner via the presence of boric acid crystals or residue. Also, if leakage is detected during the system pressure testing, the insulation will be removed for examination, and the effects of the leakage will be evaluated in accordance with the previously NRC-approved corrective actions that are given in the above section on the licensee's proposed alternative for the relief request. Thus, the two-phased approach of the licensee's proposed alternative provides an acceptable level of quality and safety for bolted connections in borated systems.

Therefore, the staff concludes that Relief Request No. 16 is acceptable for corrosion-resistant bolted connections in systems borated for the purpose of reactivity control, where the bolting material is the material proposed by the licensee and listed in the above section on the licensee's proposed alternative for the relief request.

4.0 CONCLUSION

The staff concludes that the use of ASME Code Cases N-533-1 and N-616 for Class 1, 2, and 3 systems that are borated for the purposes of reactivity control are acceptable because the code cases provide an acceptable level of quality and safety for the VT-2 visual examination of bolted connections without removing insulation. Therefore, the licensee's proposed alternatives are authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the second 10-year inservice inspection interval, or until such time Code Cases N-533-1 and N-616 are referenced in a future revision of Regulatory Guide 1.147 or 10 CFR 50.55a. At that time, if the licensee intends to continue to implement Code Cases N-533-1 and N-616, the licensee should follow all provisions in the subsequent code cases with limitations (if any) referenced in Regulatory Guide 1.147 or 10 CFR 50.55a.

Principal Contributors: Tom McLellan
Jim Davis

Date: March 30, 2001