Entergy

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CNRO-2002-00012

March 15 2002

U. S. Nuclear Regulatory Commission
Attn.: Document Control Desk
Washington, DC 20555-0001

Subject: Entergy Operations, Inc.
Use of Mechanical Nozzle Seal Assemblies

Arkansas Nuclear One – Unit 2
Docket No. 50-368
License No. NPF-6

Sir or Madam:

Pursuant to 10CFR50.55a(a)(3)(i), Entergy Operations, Inc. (Entergy) requests NRC staff authorization to use the new design of the Mechanical Nozzle Seal Assembly (MNSA-2) in temporary applications as documented in Request for Alternative ANO2-R&R-002, Rev. 0 (see Attachment 1). Entergy intends to utilize MNSA-2s on various locations in the reactor coolant system (RCS) that exhibit leakage due to Primary Water Stress Corrosion Cracking (PWSCC) at Arkansas Nuclear One – Unit 2 (ANO-2). ***The use of the MNSA-2 covered by this request will be limited to two (2) operating cycles.*** Entergy is continuing to evaluate the use of the MNSA-2 for permanent application and may seek such relief in the future.

Entergy believes use of MNSA-2s for restoring structural integrity and leak tightness to the RCS provides an acceptable level of safety and quality. The NRC staff previously authorized temporary use of the original MNSA design at Southern California Edison's San Onofre Nuclear Generating Station[1], at Waterford 3[2], and most recently at Arizona Public Service Company's Palo Verde Nuclear Generating Station[3].

[1] NRC Letter from Mr. W. H. Bateman to Mr. H. B. Ray, "Use of Mechanical Nozzle Seal Assembly for the San Onofre Nuclear Generating Station, Units 2 and 3 (TAC Nos. M99558 and M99559)," dated February 17, 1998

[2] NRC Letter from Mr. G. F. Dick to Mr. C. M. Dugger, "Use of the Mechanical Nozzle Seal Assemblies at Waterford Steam Electric Station, Unit 3 (TAC No. MA4952)," dated March 25, 1999

[3] NRC Letter from Mr. S. Dembek to Mr. G. R. Overbeck, "Palo Verde Nuclear Generating Station Units 1, 2, and 3 – Request for Code Alternative for the Use of Mechanical Nozzle Seal Assemblies – Relief Request No. 17 (TAC Nos. MB1618, MB1619, and MB1620)"

A001

During the upcoming refueling outage at ANO-2, currently scheduled to begin in April 2002, Entergy plans to inspect small-bore nozzles on the pressurizer; specifically, two (2) lower level instrument nozzles, one (1) shell side temperature nozzle, one (1) vent nozzle, four (4) upper steam space nozzles, and 96 heater sleeves for a total of 104 nozzles. Upon evidence of a leak, Entergy intends to install a MNSA-2 to restore structural integrity and leak tightness.

Currently, Entergy has no evidence of leaking pressurizer nozzles; however, we are submitting this request in order to proactively prepare for possible leaks that may be detected while performing inspections during the outage. Therefore, Entergy requests that the NRC staff approve ANO2-R&R-002, Rev. 0 by April 15, 2002, in order to support these inspection activities. ***Following NRC Staff approval, Entergy will incorporate this alternative into the ANO-2 Inservice Inspection (ISI) Plan.***

Entergy recently submitted a similar request to use MNSA-2s at the Waterford Steam Electric Station – Unit 3 (Waterford 3).[4] In that request, Entergy provided supporting technical documents to assist the staff with its review. Those documents were:

1. Westinghouse Test Report No. TR-ME-02-2, Rev. 0, "Test Report for Hydrostatic Testing of the Entergy Mechanical Nozzle Seal Assembly (MNSA-2)"

2. Westinghouse Test Report No. TR-CI-02-2, Rev. 0, "Seismic Qualification Testing of the Entergy (WSES-3, ANO Units 1 & 2) MNSA-2 Clamps for Pressurizer Heaters and Instrument Nozzles"

3. Westinghouse Test Report No. TR-CI-02-03, Rev. 0, "Test Report for Entergy MNSA-2 Clamps Thermal Cycle Test"

These documents are also applicable to ANO2-R&R-002. Rather than resubmit them, we have provided references to them throughout ANO2-R&R-002. These documents were submitted as proprietary and should still be considered as such.

In addition, Entergy will submit under a separate cover letter the revised stress report, Westinghouse Design Report No. **DAR-CI-02-2, "Addendum to CENC-1224 Analytical Report for the Arkansas Nuclear One Unit 2 Pressurizer,"** which provides the methodology used to determine acceptable application of the MNSA-2 in conformance with ASME Code requirements. Entergy will also include responses to issues raised by the staff at the January 31, 2002 meeting at which Entergy discussed the MNSA-2 application. Entergy plans to **submit this report in late March, 2002.**

This letter contains three new commitments as denoted above in bold, italicized text.

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[4] Letter CNRO-2002-00010 from Entergy to the NRC, "Use of Mechanical Nozzle Seal Assemblies," dated March 1, 2002

Should you have any questions regarding this request, please contact Guy Davant of my staff at (601) 368-5756.

Very truly yours,

John R. Hamilton
Manager, Engineering Programs

JRH/GHD/baa

Attachment:
1. Request for Alternative ANO2-R&R-002, Rev. 0

cc: Mr. C. G. Anderson (ANO) (w/o)
Mr. W. R. Campbell (ECH) (w/o)
Mr. J. K. Thayer (ECH) (w/o)

Mr. T. W. Alexion, NRR Project Manager (ANO-2)
Mr. R. L. Bywater, NRC Senior Resident Inspector (ANO)
Mr. N. Kalyanam, NRR Project Manager
Mr. E. W. Merschoff, NRC Region IV Regional Administrator

ATTACHMENT 1

REQUEST FOR ALTERNATIVE

ANO2-R&R-002, Rev. 0

REQUEST FOR ALTERNATIVE
ANO2-R&R-002, Rev. 0

I. Components

Components/ Numbers:	Pressurizer lower level instrument nozzles / (2) Pressurizer upper level instrument nozzles / (2) Pressurizer upper pressure instrument nozzles / (2) Pressurizer upper vent nozzle / (1) Pressurizer side shell temperature nozzle / (1) Pressurizer heater sleeves / (96)
Code Class:	ASME Section III, Class 1
References:	1) ASME Section III, 1989 Edition 2) ASME Section III, 1968 Edition through and including Summer 1970 Addenda 3) Westinghouse Test Report No. TR-ME-02-2, Rev. 0, "Test Report for Hydrostatic Testing of the Entergy Mechanical Nozzle Seal Assembly (MNSA-2)," dated 2/21/02 4) Westinghouse Test Report No. TR-CI-02-2, Rev. 0, "Seismic Qualification Testing of the Entergy (WSES-3, ANO Units 1 & 2) MNSA-2 Clamps for Pressurizer Heaters and Instrument Nozzles," dated 1/31/02 5) Westinghouse Test Report No. TR-CI-02-03, Rev. 00, "Test Report for Entergy Mechanical Nozzle Seal Assembly (MNSA-2) Thermal Cycle Test," dated 2/22/02 6) Westinghouse Design Report No. DAR-CI-02-2, "Addendum to CENC-1224 Analytical Report for Arkansas Nuclear One Unit 2 Pressurizer" 7) Entergy Operations, Inc., Letter CNRO-2002-00010 to NRC, "Use of Mechanical Nozzle Seal Assemblies," dated 3/1/02
Unit / Inspection Interval Applicability:	ANO-2 second (2^{nd}) 10-year interval

II. Code Requirements

ASME Section XI, IWA-4170 requires repairs and installation of replacements to be performed in accordance with the Owner's Design Specification and the original Construction Code of the component or system. The affected pressurizer instrument nozzles and heater sleeves were designed and constructed to the rules of ASME Section III, Subsection NB, 1968 Edition, through and including the Summer 1970

Addenda. Rules for replacing ASME Section III, Class 1 welded nozzle or heater sleeve integrity with mechanical clamping devices are not clearly defined by ASME Section III.

III. Proposed Alternative

Pursuant to 10CFR50.55a(a)(3)(i), Entergy Operations, Inc. (Entergy) requests NRC authorization to use the improved design of the Mechanical Nozzle Seal Assembly, designated MNSA-2, in applications at those nozzle locations listed in Section I, Components, above. Entergy makes this request in order to repair leaks attributed to Primary Water Stress Corrosion Cracking (PWSCC) that may be detected while performing inspections during refueling outages.

The typical repair of nozzles or heater sleeves of this type uses a half-nozzle replacement with external weld repair. These repairs would extend reactor coolant system (RCS) drain-down activities or require de-fueled conditions and significantly increase worker radiation exposure to perform extensive field machining and temper bead welding activities.

As an alternative, Entergy proposes to use the MNSA-2 as a repair to restore nozzle or heater sleeve integrity and prevent leakage for 2 operating cycles.

IV. Basis for Proposed Alternative

A. Background

The presurizer, It's nozzle assemblies and heater sleeve penetrations, were designed by Combustion Engineering (CE). The nozzles and heater sleeves are described below:

- Pressurizer lower level instrument nozzles (2)

  The pressurizer instrument nozzles were originally fabricated from Ni-Cr-Fe, SB-166 material (Inconel 600) with SA-182, F-316 stainless steel ¾-inch diameter socket weld safe ends. The nozzles are welded to the inside of the pressurizer. These nozzles were modified by cutting the nozzles off approximately 2 inches from the pressurizer shell and inserting a new SA-182, F-316 stainless steel nozzle (0.640-inch OD and 0.375-inch ID) into the original portion of the Inconel 600 nozzle. The new nozzle extends approximately 5 inches beyond the inside wall of the pressurizer. The end of the new nozzle has a ¾-inch diameter socket weld end with a 3/16-inch diameter orifice - the same as the original nozzle. The new nozzle is attached by a fillet weld on the end of the remaining portion of the Inconel 600 nozzle.

- Pressurizer upper level instrument nozzles and upper pressure instrument nozzles (4)

  The pressurizer instrument nozzles are fabricated from Ni-Cr-Fe, SB-166 material (Inconel 600) with SA-182, F-316 stainless steel ¾-inch diameter socket weld safe ends. The nozzles are welded to the inside of thepressurizer. The upper level instrument nozzles contain a 3/16-inch diameter orifice that serves as the system class break from the Class 1 system to the downstream Class 2 system. The nozzle inside bore is approximately 0.614 inch, and the outside diameter is approximately 1.062 inches. The total length of the nozzle, including the safe end, is approximately 13 1/4 inches. The J-weld uses INCO-182 filler material.

- Pressurizer upper vent nozzle (1)

  The pressurizer upper vent nozzle is fabricated from Ni-Cr-Fe, SB-166 material (Inconel 600) with a SA-182, F-316 stainless steel ¾-inch diameter socket weld safe end. The nozzle is welded to the inside of the pressurizer. The vent nozzle contains a 3/16-inch diameter orifice that serves as the system class break from the Class 1 system to the downstream Class 2 system. The nozzle inside bore is approximately 0.614 inch, and the outside diameter is approximately 1.062 inches. The total length of the nozzle, including the safe end, is approximately 11 5/8 inches. The J-weld uses INCO-182 filler material.

- Pressurizer side shell temperature element nozzle (1)

  The temperature element nozzle is fabricated from Ni-Cr-Fe, SB-166 material (Inconel 600) with a SA-182, F-316 stainless steel 1-inch diameter socket weld safe end.. The nozzle inside bore is approximately 0.815 inch, the outside diameter is approximately 1.315 inches, and overall length of the nozzle, including safe end, is approximately 14 1/8 inches. The nozzle is welded to the inside of the pressurizer. The J-weld uses INCO-182 filler material.

- Pressurizer heater sleeves (96)

  The pressurizer heater sleeves are manufactured from Ni-Cr-Fe, SB-167 material (Inconel 600). The heater sleeve assemblies are welded to the internal cladding of the vessel lower head and the heater elements are welded to the lower end of the sleeves. The heater elements are internally supported for seismic loading and vibration by two heater support plates. The outside diameter of the sleeve is approximately 1.25 inches and reduces to 1.156 inches for insertion into the pressurizer penetrations. The inside bore is approximately 0.905 inch. The length of the sleeves varies from approximately 14 3/8 inches long to approximately 18 3/4 inches long, depending on the location on the bottom head. Currently there are eighty-two (82) heaters installed and fourteen (14) heater nozzles plugged.)

- Pressurizer vessel

  The pressurizer is a low alloy steel vessel with the shell and top head internally clad with 304 austenitic stainless steel and the bottom head with a Ni-Cr-Fe cladding.

The Ni-Cr-Fe heat-affected zone of the J-weld has proven to be susceptible to PWSCC. Numerous instances of nozzle cracking have been identified in the industry in recent years. Studies performed by the CE Owner's Group (Report CE-NPSD-690-P) have found that the cracking growth is predominantly axial. The dominant conditions that promote axial growth rather than circumferential growth is high circumferential stress (hoop stress) compared to the axial stress. The hoop stress is a residual stress caused by weld shrinkage that diminishes quickly as the distance from the J-weld increases. The susceptibility to cracking is based on several factors that deal with material, stress, and environment.

Inspections required by ASME Section XI, IWB-2500 for Examination Category B-P are performed during each refueling outage. Additionally, the inspections recommended by the CE Owner's Group have been performed.

B. MNSA-2 Application, Description, and Design

1. Overview

The MNSA-2 is a mechanical device designed to replace the function of partial penetration J-groove welds that attach Alloy 600 nozzles or heater sleeves to the pressurizer. MNSA-2 provides a seal against leakage and positively captures the nozzle preventing ejection in the unlikely event of complete 360-degree weld failure. Figure 1 shows a representative drawing of the MNSA-2 for heater sleeve installation, and Figure 2 shows a representative drawing of the MNSA-2 for side shell temperature element nozzle installation. (Drawings for these nozzles plus the lower level nozzle, upper level instrument nozzle, upper pressure instrument nozzle, and upper vent nozzle designs are contained in the Addendum to the Design Report [Ref. 6].)

To install the MNSA-2, four holes are drilled and tapped (½-inch diameter x 1 ½-inch deep) equally spaced around the leaking nozzle or sleeve. A counter-bore (approximately ¼ inch wide x ¾ inch deep) is also machined into the surface of the vessel perpendicular to and around the leaking nozzle or sleeve. Four threaded rod studs are threaded into the pressurizer, a split Grafoil primary seal is installed in the bottom of the counter-bore, and a split compression collar is placed over the nozzle or sleeve to compress the Grafoil seal. The seal assembly is compressively loaded via the compression collar and the inboard and outboard flange assembly, which is in the annulus region. Hex nuts and Belleville spring washers are used to live load the Grafoil seal to accommodate small changes in load on the seal due to differential expansion or minute relaxation of the seal over time to prevent seal leakage.

To prevent nozzle or heater sleeve ejection in the unlikely event of a complete nozzle or sleeve weld failure, an anti-ejection clamp is also installed and secured in place via the tie rods, Belleville spring washers, and hex nuts. The anti-ejection clamp acts as a restraint only if the nozzle-to-RCS weld completely fails.

More specific details of the MNSA-2 design are provided in Section B.2, below.

2. MNSA-2 Design

The NRC previously authorized use of the original MNSA design at Southern California Edison's San Onofre Nuclear Generating Station, at Waterford 3, and at Arizona Public Service Company's Palo Verde Nuclear Generating Station.

The original MNSA and MNSA-2 use the same materials of construction and the same seal material. They are attached in the same fashion, and the seal is loaded by tensioning bolts or studs.

The MNSA-2 design differs from the original MNSA design in three ways:

- The counter-bore provision that contains the seal
- The manner in which the seal is live-loaded
- The means for diverting leakage, should it occur

Each is discussed in detail below.

a) Counter-Bore Provision

MNSA-2 uses nuclear grade Grafoil as the sealing material. In all cases, regardless of the angle of the surface of the pressurizer relative to the nozzle, a counter-bore is machined perpendicular to the nozzle to receive and contain the seal. The bottom of the counter-bore is perpendicular to the axis of the nozzle, so the angle of the surface of thepressurizer does not affect the leak tightness of the design. When the MNSA-2 seal is compressed, no side loads are introduced, so shoulder bolts used on the original MNSA are not required. The seal designs are simpler than the original MNSA because they involve no variable angles. Therefore, customizing MNSA components for particular slope angles, for other than bolt lengths, is not required.

b) Seal Live-Loading

MNSA-2 uses a live-loaded seal that can accommodate small changes in load on the seal due to differential expansion. The live load provision, provided via Belleville washers, also accommodates minute relaxation of the seal over time to prevent leakage. Finally, it allows for re-tightening of the studs and reloading the seal at some point in the future without disassembly, whereas the original MNSA would require a new seal and complete teardown and re-assembly to re-energize a seal. Figures 1 and 2 show the use of Belleville spring washers.

c) Leak-Off Diversion

Leakage control in the MNSA-2 design is accomplished by using a compression collar which includes a collection area (similar to a "lantern ring") positioned immediately outboard of the primary seal, as shown in

Figure 1. The compression collar has an additional Grafoil seal at the top that is lightly loaded. The seal blocks leakage from passing up along the outside of the compression collar where it could reach the threaded rods. The path of least resistance is out through the annulus between the compression collar and the nozzle, tending to divert any leakage away from the fasteners and the vessel. The presence of the collection area does not impair the primary seal in any way.

In the review of the original MNSA design, the NRC evaluated potential corrosion effects of boric acid on the MNSA and associated RCS components. The evaluation considered:

- Corrosion of the low alloy material with a MNSA installed was determined to be acceptable
- Boric acid corrosion of the materials of construction for the MNSA was determined to be acceptable based on CE Owner's Group corrosion testing
- There is no history of galvanic corrosion problems in similar applications with Grafoil contacting low alloy steel
- Potential for SCC failures of the A-286 bolts was found to be acceptable

There are no changes from the original MNSA to MNSA-2 that adversely impact the four conclusions listed above. With regard to the A-286 bolts, the NRC evaluation concluded that the bolts could be exposed to boric acid deposits or slurries if the MNSA leaks. This evaluation was appropriate because the design did not include provisions for capturing or diverting seal leakage away from bolting materials. Regardless, at the stress levels that exist in the bolts, including a stress concentration factor of four, the bolts would function satisfactorily. In contrast to the original MNSA, the MNSA-2 design includes specific provisions to divert potential seal leakage away from the low alloy steel vessel and the bolting as described below.

The sealing qualities of MNSA-2 are enhanced beyond that of the original MNSA by virtue of the controlled geometry (counter-bore), and by maintaining a live load on the seal. The counter-bore design has been used routinely in hundreds of similar applications for sealing fixed in-core detectors to flanges on the reactor head in CE units. A variety of other repairs and permanent flange upgrades have been installed on both CE and Westinghouse units using both static and live-loaded Grafoil seal technology. Therefore, the possibility of a leak past the primary seal is very small. Nevertheless, in the unlikely event of such a leak, MNSA-2 is designed to limit exposure of the SA-453 (A-286) bolting material and the carbon steel vessel by providing a leak-off path.

d) Installation

The MNSA-2 installation process is non-intrusive on the existing heater sleeve or instrument nozzle pressure boundary, and it does not require draining of the pressurizer to install. In addition to the counter-bore, a small groove is machined in the end of the instrument nozzle to receive the anti-ejection plate as shown on Figure 2. The tooling is designed to machine the counter-bore and groove without disconnecting the pressure boundary heater element, instrument tubing or thermowell.

Torquing the MNSA threaded rods into the pressurizer will be performed at temperatures above RT_{NDT} *(30°F)* to ensure the bolting stress does not create a potential for brittle failure.

3. MNSA-2 Materials

The MNSA-2 assembly is fabricated from the same materials as the original MNSA, though with different application of some of the components. A detailed assessment of the MNSA-2 metallic components as related to general corrosion, stress corrosion cracking of nozzles and fasteners, galvanic effects, crevice corrosion, and surface pitting of the constituent components is contained in Appendix 1 of this relief request. There are no potential corrosion problems associated with the application of the MNSA-2 to Alloy 600 small diameter nozzles and heater sleeves.

The stainless steel portions of the MNSA-2 performing an RCS pressure boundary function are manufactured in accordance with material specifications provided in ASME Section III, Subsection NB and Appendix I. Additionally, the material meets the requirements contained in NB-2000 including examination and testing. Materials are supplied to the provisions of ASME Section III, NCA-3800 by suppliers maintaining a valid Quality System Certificate or a Certificate of Authorization with the scope of Material Supply. Metallic pressure boundary material is certified in accordance with ASME Section III, NCA-3800.

The primary Grafoil seal material is Grade GTJ (used in nuclear applications) composed of 99.5% graphite, with the remaining 0.5% made up of ash, halides, and sulfur. The Grafoil seal itself is chemically resistant to attack from organic and inorganic fluids, and is very resistant to borated water. Similar Grafoil material is used as valve packing in valves installed in the RCS with acceptable results. The Grafoil material is provided under the provisions of a Quality Assurance Program meeting 10CFR50 Appendix B that has been approved by Entergy. Material testing and certification is provided with the material to verify compliance with the engineered features that are required to ensure functionality and compatibility with the pressure boundary materials and environment.

In summary, there are no potential corrosion or material stress issues associated with applying the MNSA-2 to the pressurizer heater sleeves or nozzles.

4. <u>MNSA-2 Structural Evaluation</u>

The component parts of the MNSA-2 for heater sleeve, side shell, upper pressure instrument, upper level instrument, upper vent, and lower level nozzle installations are being analyzed, designed, and manufactured in accordance with ASME Section III, Subsection NB, 1989 Edition, which is approved in 10 CFR 50.55a. The ANO-2 original Construction Code for the pressurizer is ASME Section III, 1968 Edition, through and including the Summer 1970 Addenda. As required by ASME Section XI, an amendment to the ANO-2 Pressurizer Stress Report CENC-1224 [Ref. 6] will be completed and will include a reconciliation (see Attachment D of Ref. 6) for use of the 1989 Edition of ASME Section III as it applies to the MNSA-2 and its interface with the pressurizer.

The analysis for the MNSA-2 components will ensure that:

- Stresses not to exceed the allowables as stated in the Code
- The Code-prescribed cumulative fatigue usage factor of 1.0 is not exceeded (NB-3222.4) for any component

The stress analysis considers the loads transmitted to the components of the MNSA-2 due to installation pre-load, normal and upset loads at pressure and temperature, and impact loads due to the ejection of the heater sleeve or nozzle in the unlikely event of a complete failure of the ID J-weld. The results of the stress analysis will ensure that the applied stresses on each load-bearing component (tie rods, threaded rods, and top plate) are below the applicable Code allowables, thereby providing assurance of structural integrity for the MNSA-2.

Fatigue evaluations of the MNSA-2 clamp components consider a forty-year design life and ensure fatigue usage factors are less than 1.0 for all components of the MNSA-2. However, for two cycles of operation, the expected number of heat-up and cooldown cycles is substantially less than those accounted for in the stress analysis for a 40-year design life.

5. <u>Pressurizer Modification and Structural Evaluation</u>

The MNSA-2 is attached to the pressurizer with SA-453 Grade 660 threaded rods and hex nuts. To accommodate the threaded rods, four holes are drilled and tapped into the pressurizer in a circular pattern around the nozzle. To provide a seating surface for the Grafoil seal, a counter-bore is machined into the pressurizer extending out approximately ¼ inch from the existing nozzle bore and to a maximum depth of ¾ inch. The addition of the holes in the pressurizer will be analyzed and documented in an attachment to the addendum to Stress Report CENC-1224 [Ref. 6] for the heater sleeve, side shell temperature nozzle, upper level instrument nozzle, upper pressure nozzle, upper vent nozzle, and lower level instrument nozzle locations. The analysis is performed to the requirements of ASME Section III, 1968 Edition through and including the Summer 1970 Addenda. The analysis will ensure that:

- Stresses do not exceed the allowables as stated in the Code
- The Code-prescribed cumulative fatigue usage factor of 1.0 is not exceeded (NB-3222.4) at any location
- Adequate reinforcement in the wall of the pressurizer for the tapped holes and counter-bore exists (NB-3332.1 and NB-3332.2)

The stress analysis will consider all loads evaluated in the original design stress report, including all pressure and temperature transients, the differential thermal expansion loads due to the threaded rods in the tapped holes, compression collar loads, and the loads on the existing J-weld at operating and during shutdown conditions. The applied stresses and stress ranges will be evaluated at the counter-bore region and at the tapped holes for compliance with Code allowables. The applied stresses on the pressurizer will be modified by the appropriate geometry factors for non-radial effects (where applicable) and by additional factors to take into account stress interaction between the tapped holes and the counter-bore as determined by finite element analysis (FEA). The results of the stress analysis, considering the tapped holes and counter-bore in the pressurizer shell, will demonstrate applied stresses are below ASME Code allowables and provide assurance of vessel structural integrity.

Fatigue evaluations of the pressurizer shell in the vicinity of the tapped holes and counter-bores consider a forty-year design life and ensure fatigue usage factors are less than 1.0. However, for two cycles of operation, the expected number of heat-up and cooldown cycles is substantially less than those accounted for in the stress analysis for a 40-year design life

The area reinforcement calculations performed in the original design stress report in accordance with ASME Code Section III NB-3332.1 and 3332.2 will be updated to evaluate the removal of pressurizer metal area by machining the tapped holes and counter-bores. The results of the analysis in Reference 6 will ensure that for each pressurizer nozzle or heater sleeve location evaluated for possible MNSA-2 installation, the area available for reinforcement is greater than the area required as a result of metal removal.

C. <u>MNSA-2 Design Requirements</u>

In accordance with ASME Section XI, IWA-4170, replacements shall meet the requirements of the Owner's Design Specifications and the original Construction Code. Alternatively, replacements may meet later editions of the original Construction Code provided:

- The requirements affecting the design, fabrication, and examination of the item to be used for replacement are reconciled with the Owner's Specification through the Stress Analysis Report, Design Report, or other suitable method that demonstrates the item is satisfactory for the specified design and operating conditions.

- Mechanical interfaces, fits, and tolerances that provide satisfactory performance are compatible with the system and component requirements.

- Materials are compatible with installation and system requirements.

ASME Section III NB-3200 rules are followed for designing and manufacturing the MNSA-2. Specifically, the joints will be designed to meet the following criteria:

(1) Provisions must be made to prevent separation of the joint under all service loading conditions.

(2) The joint must be designed to be accessible for maintenance, removal, and replacement activities.

(3) The joint must either be designed in accordance with the rules of ASME Section III, Subarticle NB-3200, or be evaluated using a prototype of the joint that will be subjected to additional performance tests in order to determine the safety of the joint under simulated service conditions.

These topics are discussed below.

1. <u>Joint Integrity</u>

   In addition to the prototype testing discussed below, the MNSA-2 is analyzed to meet the requirements of NB-3200. The MNSA-2 is designed as an ASME Section III, Class 1, safety-related primary pressure boundary in accordance with the rules of NB-3200 to prevent joint separation under service loads. An amendment to Pressurizer Stress Report CENC-1224 for ANO-2 [Ref. 6] demonstrates that stresses under all service conditions do not exceed the Code allowables as stated within Section III and that fatigue limits are not exceeded using the conditions contained in the Design Specification.

2. <u>Maintenance, Removal, and Replacement</u>

   Typical for mechanical connections, the MNSA-2 will be accessible for maintenance, removal, and replacement after service. The MNSA-2 is manufactured without welding and is bolted in place, so disassembly is a mechanical evolution that requires de-tensioning the installation bolting.

3. Prototype Testing

The original MNSA design was qualified by a series of tests and analyses. With each specific, new application, a Design Specification and a Design Report were prepared. For MNSA-2 applications on the ANO-2 pressurizer, a single set of tests was performed for an outer heater sleeve MNSA-2, the most conservative configuration.

In addition to the integrity and functional characteristics demonstrated by design and analysis in accordance with ASME NB-3200, significant prototype testing was performed to demonstrate the functionality, structural integrity, and the sealing capability using conservative, bounding service loadings. Detailed descriptions of the prototype testing procedures and results (References 3, 4, 5) were provided to the NRC Staff as Enclosures to Reference 7.

The objective of the prototype testing was to use the most conservative penetration based on size and geometry to envelop all pressurizer penetration locations at Waterford 3 and ANO-2 for hydrostatic, thermal cycling, and seismic tests. The heater sleeve on the upper hillside of the pressurizer bottom head for Waterford 3 was chosen as this bounding penetration. The prototype testing verified leak tightness and structural integrity of the MNSA-2.

- Hydrostatic Test

  The heater sleeve fixture was clamped with a MNSA-2 with the heater sleeve filled with demineralized water. The nozzle was not welded to the mounting fixtures. As discussed in Reference 3, the hydrostatic test consisted of pressurizing the seal assembly fixture to 3,250 psig ± 50 psig at ambient temperature conditions and holding the pressure for 10 minutes. Several tests were performed on the pressurizer MNSA-2. No leakage or seal damage was detected after the test.

- Thermal Cycling Test

  After completion of the hydrostatic test, the MNSA-2 prototype was subjected to a thermal cycling test (as described in Reference 5) consisting of 3 heatup and cooldown cycles. The test fixture was filled with demineralized water. Each cycle consisted of heating the autoclave from ambient temperature (less than 200°F) to 650°F and raising the pressure to between 2,250 psig and 2,500 psig. The elevated temperature/pressure condition was held for at least 60 minutes, after which the MNSA-2 test fixture was cooled down to ambient conditions (less than 200°F). The remaining thermal cycling tests started from where the original test fixture cooled. No leakage was observed during these tests. At the conclusion of the tests, the MNSA-2 fixture was disassembled, and visual examinations were performed on both the internal surfaces of the flange and on the Grafoil gaskets to look for evidence of any steam wisps, residual fluid deposits, or liquid stains that would indicate a leak. None were detected.

- Seismic Testing

  Seismic qualification was performed in accordance with the guidelines in IEEE-344. A test specimen representative of an outer heater sleeve MNSA-2 design for Waterford 3 was attached to an adapter plate and mounted to a shaker table. The heater sleeve test specimen was not welded to the mounting fixtures. The MNSA-2 components were assembled and installed onto the simulated heater sleeve mock-up. The seismic testing consisted of subjecting the MNSA-2 test rig to five operating basis earthquake events and one safe shutdown earthquake event. The mounting fixture permitted pressurization to 3,175 psig ± 50 psig at ambient temperature during the seismic test. This elevated pressure was conservatively used to account for the fact that the seismic testing was performed at ambient temperatures rather than operating temperatures. The test results indicate that no mechanical damage occurred and no leakage was present. Information contained in Reference 4 provides a basis for performing the seismic testing using ambient temperatures and concludes that the test results were applicable to hot conditions.

The test program and test results described in References 3, 4, and 5 have been reviewed and found to adequately represent or bound the conditions for which Entergy proposes to install the MNSA-2 at ANO-2. The test data along with the analysis will provide assurance that the MNSA-2 is capable of performing as the pressure boundary and preventing leakage during all modes of operation and all accident conditions.

The MNSA-2s to be installed at ANO-2 will be subjected to the conditions described below which are obtained from the Design Specification and form part of the basis for analysis. As evidenced by the prototype test summaries, the prototype test conditions equal or exceed the operating conditions for which the clamps will be exposed.

	ANO-2 Conditions	MNSA-2 Design
Design Pressure	2500 psia	2500 psia
Design Temperature (Pressurizer)	700°F	700°F
Nominal Operating Pressure	2250 psia	
Normal Temperature (Pressurizer)	653°F	

D. Inservice Testing and Inspection

1. ASME Section XI Preservice

The bolting and tie rods of the MNSA-2 are considered ASME Section XI, Examination Category B-G-2, Item No. B7.50 bolting. As required by IWA-4820, a VT-1 pre-service inspection will be performed in accordance with IWB-2200.

2. ASME Section XI Pressure Tests

In accordance with ASME Section XI, IWA-4710(c) and the alternatives of Code Case N-416, mechanical joints made in the installation of pressure retaining replacements shall be pressure tested. The test will be performed and a VT-2 inspection performed as part of plant re-start and will be conducted at normal operating pressure with the test temperature determined in accordance with the ANO-2 Pressure and Temperature Limits as stated in the ANO-2 Technical Specifications.

3. ASME Section XI Inservice Inspection

The VT-1 inservice inspections required by ASME Section XI for Examination Category B-G-2 are required by "period" over the 10-year interval and would not be performed more frequently than during refueling cycles. The VT-2 inspection required by ASME Section XI for Examination Category B-P is required to be performed prior to plant startup following each refueling outage.

V. Conclusion

10CFR50.55a(a)(3) states:

"Proposed alternatives to the requirements of (c), (d), (e), (f), (g), and (h) of this section or portions thereof may be used when authorized by the Director of the Office of Nuclear Reactor Regulation. The applicant shall demonstrate that:

(i) The proposed alternatives would provide an acceptable level of quality and safety, or

(ii) 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."

Entergy believes that the proposed alternative provides an acceptable level of quality and safety because:

- The design of the MNSA-2 is in accordance with ASME Section III, 1989 Edition, NB-3200. The analysis will include provisions for fatigue and assurances that stresses do not exceed Code allowables. Additionally, significant prototype testing (seismic, hydrostatic, and thermal cycling) has been completed that demonstrates functionality and leak tightness during conditions of operations that are representative of ANO-2.

- Modification of the Pressurizer will be analyzed in accordance with the original Construction Code (ASME Section III, 1968 Edition through and including the Summer 1970 Addenda). Analysis will include fatigue, reinforcement requirements for the tapped holes and counter-bores, and assurance that stresses do not exceed Code allowables.

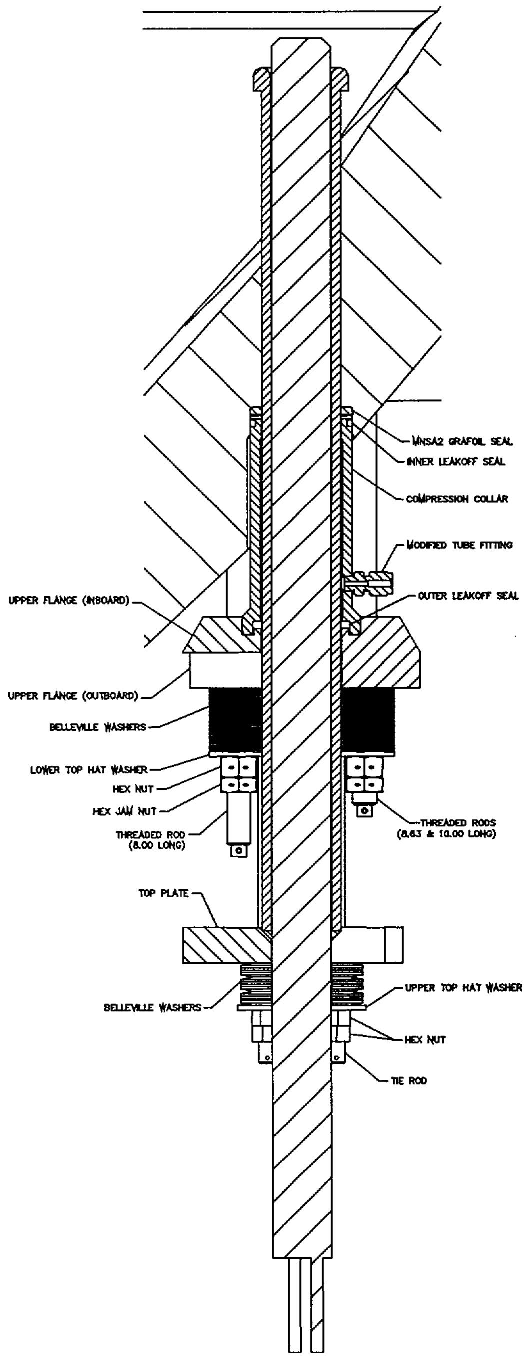
- Methods of analysis, materials, and fabrication meet ASME Section III, Subsection NB. This is comparable to the original methods of analysis, materials and fabrication used for the Pressurizer.

- The non-Code portions of the MNSA-2 that perform a safety-related function are provided under a program meeting 10CFR50 Appendix B.

- After installation, the MNSA-2 will be pressure tested and inspected (uninsulated) for leakage to ensure quality of installation and leak tightness.

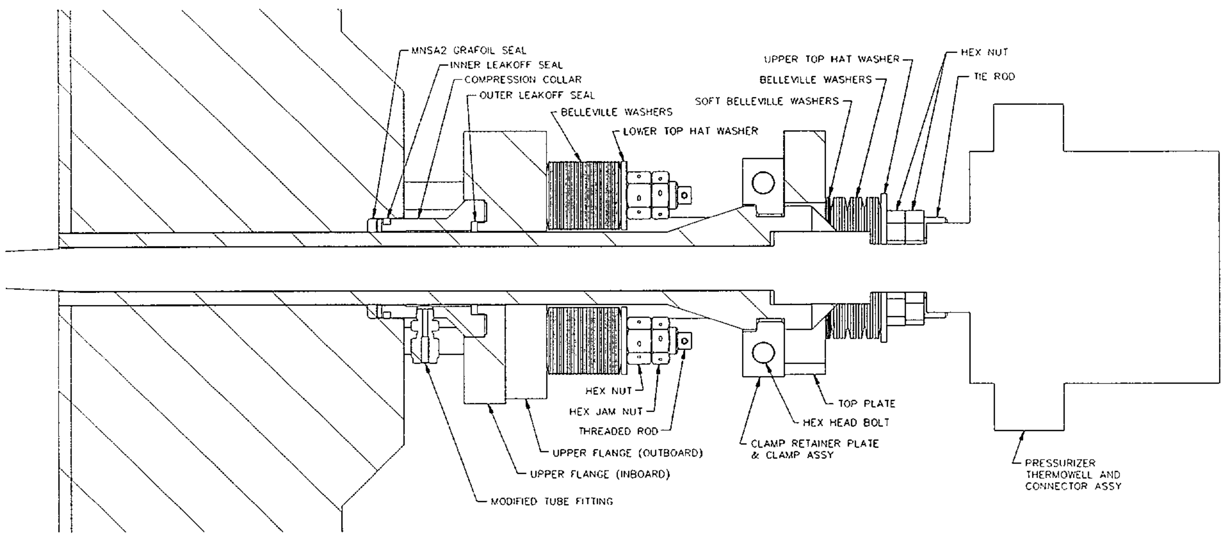
- The request for the alternative is limited to 2 operating cycles.

Therefore, we request authorization to perform the requested alternative to the Code requirement pursuant to 10CFR50.55a(a)(3)(i).



Heater Sleeve MNSA-2

FIGURE 1



<u>Side Shell MNSA-2</u>

FIGURE 2

ANO2-R&R-002, Rev. 0

APPENDIX 1

CORROSION ISSUES WITH MNSA-2 MATERIALS

REQUEST FOR ALTERNATIVE
ANO2-R&R-002

Appendix 1

CORROSION ISSUES WITH MNSA-2 MATERIALS

This appendix summarizes the several corrosion issues associated with the application of MNSA-2 for small diameter Alloy 600 nozzle repair. The materials of interest are the carbon or low alloy steel used in the components with the defective nozzles, the stainless steels used for the MNSA-2, the fastener material used to attach the MNSA-2 to the component, and the Alloy 600 nozzles that may be repaired.

Corrosion of Carbon/Low Alloy Steel. Assuming a repaired nozzle has a through-wall crack, the crevice between the Alloy 600 nozzle and the pipe/pressurizer will, under worst-case conditions, fill with aerated borated water. The crevice environment will be a stagnant solution that cannot be replenished except perhaps during shutdowns when the RCS is drained. Thus, the level of boric acid will not exceed that of the primary coolant at the beginning of a fuel cycle. The corrosion of carbon and low alloy steels in this situation has been previously addressed, most notably by Reference 1, which estimated an overall corrosion rate for these materials using available laboratory corrosion data from tests in aerated and deaerated solution at 100 to over 600°F assuming plants operated for 88% of the time, were in outages for 10% of the time and were in start-up conditions for 2% of the time. Reference 1 analyses estimated, for small diameter Alloy 600 nozzles and heater sleeves in CEOG plants, the amount of material that could be lost by corrosion before ASME Code limits would be exceeded. Corrosion rate data and the bounding allowable material loss calculations were used to estimate repair lifetimes for hot leg pipe nozzles of 76 years, for pressurizer nozzles of 56 years and for heater sleeves of 196 years. Thus, the Reference 1 calculations support a conclusion that carbon and low alloy steel corrosion in the crevice region is not an issue.

Stress Corrosion Cracking of Carbon and Low Alloy Steels. The repaired nozzles will have cracks in the Alloy 600 nozzles or the partial penetration weld metals that will remain in place after the repair is completed. Since residual stresses from the welding will remain, these cracks may continue to propagate through the nozzle/weld metal by a stress corrosion mechanism to the carbon or low alloy steel base metal. Reference 1 indicated that further growth into the base metals by SCC is not likely because the low primary side oxygen levels in PWRs will result in corrosion potentials below the critical cracking potentials for these materials in high temperature water.

Stress Corrosion Cracking of MNSA-2 Fasteners. The fasteners attaching the MNSA-2 to the components are SA-453 grade 660 (A-286 stainless steel) which is a precipitation hardening alloy used in applications where corrosion resistance comparable to 300 series stainless steels but higher strength is required. Laboratory tests and field experience have shown A-286 to be susceptible to SCC in a PWR environment when highly stressed References 2 and 3). Hot headed bolts are more susceptible to SCC than bolts machined from heat-treated bar stock. The MNSA-2 fasteners will be machined from bar stock and thus will be less susceptible to SCC. More importantly, the MNSA-2 fasteners will be external to the RCS and thus not exposed to primary coolant. SCC does not occur in the absence of an aggressive environment. If the primary seal were to leak (unlikely since they will receive a live load during service), the secondary seals divert any leakage away from the fasteners and prevent exposure of borated water and steam. If the leakage is not channeled away from the fasteners, and due to the fasteners being hot, a wetting and drying condition could result in an accumulation of boric acid. Laboratory tests indicate that A-286 is resistant to SCC in highly concentrated boric acid solutions (Reference 4). The Aerospace Structural Metals Handbook indicates A-286 is susceptible to SCC in saturated lithium chloride solutions and that anodic polarization further reduces times to cracking in these solutions. The alloy is also susceptible to cracking in boiling sodium chloride solutions and is also susceptible to intergranular corrosion in strong acid solutions such as nitric-hydrofluoric. In the MNSA-2 application, the A-286 will not experience any environments comparable to these. Thus concern about anodic polarization is not warranted. Leakage is a condition that will require repair and will be obvious by boric acid accumulation. This condition will not persist for more than one fuel cycle (24 months maximum) before the leak will be repaired. Thus, SCC of the A-286 is not a corrosion issue for the MNSA-2 application.

Corrosion Near the Component OD Surface. If the MNSA-2 primary seal leaks, leakage into the crevice formed by the MNSA-2 and the component could wet the stainless steel MNSA-2 and the carbon/low alloy steel component material. The telltale leak off connection may permit the ingress of oxygen into the crevice between the seals resulting in an aerated environment. A more likely scenario is that water/steam escaping via the telltale line will force oxygen from the line and that oxygen in the crevice will be consumed by corrosion of the carbon/low alloy steel. The environment in such a situation will probably be similar to that resulting from primary coolant leakage into CRDM crevices. An expert's panel formed to address the issue of SCC growth in CRDM materials has concluded that the environment in such a crevice will be either hydrogenated superheated steam or normal PWR primary water. Further the panel, on the basis of MULTEQ calculations of the concentration process, concluded that there would not be a significant shift in crevice pH from that of primary water. The telltale will indicate leakage, thus leakage should not persist for more than one cycle. A minor amount (several mils maximum) of carbon/low alloy steel corrosion, as described above, may occur. General corrosion of the SS will be negligible. Since the SS in the crevice region will be in compression, SCC will not occur. The Grafoil seal material has low leachable chlorides (< 50 ppm), and because of leakage via the telltale line, the level of chlorides will not accumulate to the level where significant pitting will occur. Thus, corrosion near the component OD surface is not an issue.

Galvanic Corrosion. Galvanic corrosion occurs as the result of differences in electrochemical potential (ECP) between the different parts of a cell in a conductive solution (electrolyte). In this case, the cell parts are the MNSA-2 materials. The material with the highest electrochemical potential corrodes preferentially. In this case, the carbon or low alloy steel would preferentially corrode. Similar combinations of materials have been used in applications requiring periodic inspections and there has not been a history of corrosion. In tests in simulated reactor coolant, low alloy steel specimens coupled to more noble material

(Type 304 SS) did not show a significant galvanic effect. The available data do not indicate that galvanic corrosion will be an issue.

Outside Diameter Initiated Stress Corrosion Cracking of the Alloy 600 Nozzles. The outside diameter of the nozzles will be machined by the machining operation that cuts the counter-bore. Any machining operation (cutting with a single point tool, grinding, reaming, etc) will result in a layer of cold-worked (higher strength) material and a change in surface residual stresses (References 5 and 6). The residual stresses may be tensile or compressive. The layer of cold-work material will be several thousandths of an inch thick. If the part is welded subsequent to the machining, tensile residual stresses will result. Because the cold-worked layer has higher strength than the bulk of the material in the nozzle, the surface residual stresses will be higher than if an annealed material had been welded. The higher stresses could result in early initiation of SCC. However, the additional machining associated with MNSA-2 installation is not expected to have an adverse effect on the SCC susceptibility of the nozzles for the following reasons:

(1) The nozzle OD surfaces were previously machined during original fabrication and the additional machining will not significantly alter residual stresses already present.

(2) The nozzles will not be welded. Thus residual stresses such as associated with the partial penetration weld at the pressurizer ID will not be present and SCC initiation is unlikely.

(3) The temperature near the pressurizer OD, the location of the machining, is lower than at the ID surface. Since the temperature is lower and PWSCC is a thermally activated process, the time to initiate and propagate cracks at the machining location will be significantly longer than the time to initiate the cracks that caused the nozzle to need repair.

SCC of 17-4 PH Stainless Steel. 17-7 PH (not 17-4 PH) stainless steel is used for the inner and outer Belleville washers in the MNSA-2 design. A concern was expressed that the material may be susceptible to SCC when coupled to non 17-7 PH materials based on data in the Aerospace Structural Metals Handbook. A review of drawing E-MNSA-2-228-002 indicates that the washers are in contact only with Type 304 or A-286 stainless steels that are very similar in composition to 17-7 PH. The differences in composition are not sufficient to cause a significant galvanic effect. Further, the washers are normally exposed to the containment environment and only when there is a leak is there any potential for exposure to an aqueous environment, in this case steam. Additionally, the leak-channeling feature of the MNSA-2s should divert leakage away from the Belleville washers. The temperatures of the washers (< 350°F) is sufficiently low that SCC is not a concern nor, at this temperature, is the loss of toughness resulting from the 885°F embrittlement phenomenon an issue.

Gross Failure of the Inner Seal. If a major failure of the inner seal occurs, the crevice between the MNSA-2 compression collar and the Alloy 600 nozzle or the crevice between the pressurizer steel and compression collar will receive primary coolant. Primary coolant will escape through the leak off tube into the containment environment, or if the secondary seals were to fail, reactor coolant would leak by the crevice between the compression collar and pressurizer shell. No additional material will be exposed to the steam or steam water mixtures other than those described above and thus, there are no other corrosion issues resulting from this type event.

Summary

In summary, there are not any potential corrosion problems associated with the application of the MNSA-2 to Alloy 600 small diameter nozzles and heater sleeves. This assessment considered potential corrosion issues associated with the component base metal, the MNSA-2 materials of construction and galvanic effects.

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