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Acting Director
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CNRO-2004-00010

February 5, 2004

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

SUBJECT: Pre-Application Review
ASME Request for Alternative ANO1-R&R-007
Use of Mechanical Nozzle Seal Assemblies on Reactor Vessel Bottom Mounted Instrumentation Nozzles

Arkansas Nuclear One, Unit 1
Docket No. 50-313
License No. DPR-51

REFERENCES:

1. NRC Bulletin 2003-02, *Leakage from Reactor Pressure Vessel Lower Head Penetrations and Reactor Coolant Pressure Boundary Integrity*, dated August 21, 2003

2. Letter from Entergy Operations, Inc to the NRC, *Response to NRC Bulletin 2003-02 Regarding Reactor Vessel Lower Head Nozzle Integrity*, dated November 19, 2003

3. Letter to Entergy Operations, Inc. from the NRC, *Arkansas Nuclear One, Unit 2 – RE: Request for Relief from the Requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Concerning Authorization to Use New Design of Mechanical Nozzle Seal Assembly (MNSA) (TAC No. MB4517)*, dated July 3, 2002

4. Letter to Entergy Operations, Inc. from the NRC, *Waterford Steam Electric Station, Unit 3 – RE: Request for Relief from the Requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Concerning Authorization to Use New Design of Mechanical Nozzle Seal Assembly (MNSA) (TAC No. MB4272)*, dated July 3, 2002

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5. Letter to Entergy Operations, Inc. from the NRC, *Arkansas Nuclear One, Unit 1 - RE: Request for Relief from the Requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Concerning Authorization to Use New Design of Mechanical Nozzle Seal Assembly (MNSA) (TAC No. MB5861)*, dated October 1, 2002

Dear Sir or Madam:

During the upcoming spring refueling outage at Arkansas Nuclear One, Unit 1 (ANO-1), Entergy Operations, Inc. (Entergy) plans to inspect the bottom mounted instrumentation (BMI) nozzle locations on the reactor pressure vessel (RPV) bottom head in accordance with NRC Bulletin 2003-02 (Reference 1). The specifics of the ANO-1 RPV BMI inspections were provided to the NRC staff via Reference 2. If leaking BMI nozzles are discovered, Entergy plans to seek authorization from the staff to install the new design of the mechanical nozzle seal assembly (MNSA-2) to restore structural integrity and leak tightness. Such a request would be made pursuant to 10 CFR 50.55a(a)(3)(ii) and approval would be requested on an expedited basis to support return to power from the outage.

In order to provide the NRC staff with preliminary information pertaining to such a possible request and to aide in expediting approval, Entergy is submitting for pre-application review a draft of Request for Alternative ANO1-R&R-007 (see enclosure). NRC preliminary review of this draft request will expedite review of the final request, if and when formal approval is necessary. In the event the request is needed, Entergy will submit a finalized request for the staff's review and approval on an expeditious basis including any pre-application review comments received from the staff. Topics of information to be provided in the final request are denoted in brackets "[ ]" in the enclosed draft request.

The NRC staff has approved the use of the MNSA-2 on the pressurizer at ANO-2, Waterford 3, and ANO-1 (References 3, 4, and 5). As part of these approvals, the staff approved the methodology that was used to determine acceptable application of the MNSA-2 in conformance with ASME Code requirements. Entergy will use similar methodology to evaluate installation of MNSA-2s on leaking BMI nozzles at ANO-1. Prior to installation, the evaluation must indicate that Code-allowable stress values are maintained.

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

This letter contains no commitments.

Very truly yours,

FGB/GHD/ghd

Enclosure: Pre-Application Review – Draft Request for Alternative ANO1-R&R-007
cc: (see next page)

cc: Mr. W. A. Eaton (ECH)
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ENCLOSURE

CNRO-2004-00010

PRE-APPLICATION REVIEW

DRAFT
REQUEST FOR ALTERNATIVE
ANO1-R&R-007

ENTERGY OPERATIONS, INC.
ARKANSAS NUCLEAR ONE, UNIT 1

PRE-APPLICATION REVIEW

DRAFT
REQUEST FOR ALTERNATIVE
ANO1-R&R-007

I. COMPONENTS / IDENTIFICATION

Components/Numbers: Reactor Pressure Vessel (RPV) Bottom Mounted Instrumentation (BMI) Nozzles (52)

Code Class: ASME Section III, Class 1

References:

1) ASME Section III, 1989 Edition

2) ASME Section III, 1965 Edition through and including Summer 1967 Addenda

3) ASME Section XI, 1992 Edition

4) [TEST REPORT DOCUMENTING HYDROSTATIC TESTING OF MNSA-2 FOR BMI NOZZLE APPLICATION]

5) [TEST REPORT DOCUMENTING SEISMIC QUALIFICATION TESTING OF MNSA-2 FOR BMI NOZZLE APPLICATION]

6) [TEST REPORT DOCUMENTING THERMAL CYCLE TESTING OF MNSA-2 FOR BMI NOZZLE APPLICATION]

7) [ANO-1 RPV STRESS REPORT]

8) [ANO-1 DRAWING IDENTIFYING NOZZLE LOCATIONS AND NUMBERS]

9) Entergy Operations, Inc., Letter CNRO-2002-00010 to NRC, *Use of Mechanical Nozzle Seal Assemblies*, dated March 1, 2002

10) NRC Letter to Entergy, Operations, Inc., *Arkansas Nuclear One, Unit 2 – RE: Request for Relief from the Requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Concerning Authorization to Use New Design of Mechanical Nozzle Seal Assembly (MNSA) (TAC No. MB4517)*, dated July 3, 2002

11) NRC Letter to Entergy Operations, Inc., *Waterford Steam Electric Station, Unit 3 – RE: Request for Relief from the Requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Concerning Authorization to Use New Design of Mechanical Nozzle Seal Assembly (MNSA) (TAC No. MB4272)*, dated July 3, 2002

12) Letter to Entergy Operations, Inc. from the NRC, *Arkansas Nuclear One, Unit 1 - RE: Request for Relief from the Requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Concerning Authorization to Use New Design of Mechanical Nozzle Seal Assembly (MNSA) (TAC No. MB5861)*, dated October 1, 2002

Unit: Arkansas Nuclear One, Unit-1 (ANO-1)

Inspection Interval: Third (3^{rd}) 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 BMI nozzles were designed and constructed to the rules of ASME Section III, Subsection NB, 1965 Edition, through and including the Summer 1967 Addenda. Rules for replacing ASME Section III, Class 1 welded nozzles with mechanical clamping devices are not clearly defined by ASME Section III.

III. PROPOSED ALTERNATIVE

Pursuant to 10 CFR 50.55a(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 the BMI nozzle locations. 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 of this type uses a half-nozzle replacement with external weld repair. These repairs may extend reactor coolant system (RCS) drain-down activities 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 integrity and prevent leakage for two (2) operating cycles.

IV. BASIS FOR PROPOSED ALTERNATIVE

A. Background

The RPV and the BMI nozzles were designed by Babcock and Wilcox (B&W). B&W designed these components for a number of transient cycles believed to be adequate for a 40-year design life. Considering operating experience to date, the number of RPV transient cycles projected through the end of the ANO-1 license term (2034 following license renewal) remains less than the original number of design cycles. Since the RPV is qualified to the original number of design cycles, the qualifying analyses remain valid for the renewed license term. To maintain the validity of the analyses, Entergy will ensure the number of transient cycles during plant operation does not exceed the number of cycles assumed in the original design of the RPV and associated components.

The BMI nozzles are fabricated from Inconel Alloy 600 (Ni-Cr-Fe, SB-167) with an inside diameter (ID) and outside diameter (OD) of 0.614 inch and 1.03 inches, respectively. Each nozzle is attached to the inside of the RPV bottom head via a J-groove weld.

The Ni-Cr-Fe heat-affected zone of the J-groove 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 Combustion Engineering (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 are high circumferential stresses (hoop stresses) 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-groove 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 and consistent with the systematic measures discussed in NRC Generic Letter 88-05, *Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components In PWR plants*, are performed during each refueling outage.

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 to the RPV bottom head. 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 BMI nozzle installation.

To install the MNSA-2, four holes are drilled and tapped equally spaced around the leaking nozzle or sleeve. A counter-bore is also machined into the surface of the bottom head perpendicular to and around the leaking nozzle. Four threaded rods are threaded into the bottom head, a split Grafoil primary seal is installed in the bottom of the counter-bore, and a split compression collar is placed over the nozzle 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. To prevent seal leakage, 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 nozzle ejection in the unlikely event of a complete nozzle weld failure, an anti-ejection clamp is also installed and secured in place with the four tie rods, Belleville spring washers, and hex nuts. The anti-ejection clamp acts as a restraint only if the nozzle-to-bottom head weld completely fails.

Section B.2 contains additional specific details of the MNSA-2 design.

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 Entergy's Waterford Steam Electric Station, Unit 3 (Waterford 3), and at Arizona Public Service Company's Palo Verde Nuclear Generating Station. More recently, the NRC authorized use of the MNSA-2 design on the pressurizer at Arkansas Nuclear One, Units 1 and 2 (ANO-1 and ANO-2) and Waterford 3 as documented in References 10, 11, and 12, respectively.

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 improves upon 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 sealing surface is machined to a 125 finish.) The bottom of the counter-bore is perpendicular to the axis of the nozzle, so the angle of the surface of the pressurizer 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-2 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 tear-down and re-assembly to re-energize a seal. Figure 1 shows 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 MNSA-2 Grafoil seal, as shown in Figure 1. The compression collar has additional Grafoil seals at both ends (inner and outer) that are maintained under constant load using the Belleville washer stacks as a preloading mechanism to accommodate differential expansion between the bolts and compression collar. The seals limit leakage from escaping outside the compression collar where it could reach the threaded rods.

In the unlikely event of leakage past the primary Grafoil seal, fluid enters the annulus region between the sleeve and the nozzle. From there, the fluid escapes through a tube fitting into a leak-off line that diverts any leakage away from the fasteners and pressurizer surface. Failure of the inner or outer seal is unlikely since neither is pressurized, except in the case of completely clogged leak-off channels with a failure of the primary Grafoil seal. The annulus region inside the compression collar 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 concluded:

- Corrosion of the low alloy material with a MNSA installed is acceptable.
- Boric acid corrosion of the materials of construction for the MNSA is 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 is acceptable.

No changes from the original MNSA to MNSA-2 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.

3. MNSA-2 Installation

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

Torquing the MNSA threaded rods into the bottom head will be performed at temperatures above RT_{NDT} (50°F) to ensure the bolting stress does not create a potential for brittle failure.

Prior to installing a MNSA-2, Entergy will perform stress calculations to ensure Code-allowable stress values are maintained. Entergy will use methodology to evaluate installation of MNSA-2s on the ANO-1 bottom head similar to that used to install them on the pressurizers at ANO-1, ANO-2, and Waterford 3. The NRC staff previously reviewed and approved this methodology via References 10, 11, and 12. [ANY DIFFERENCES WILL BE IDENTIFIED AND DISCUSSED.]

4. 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 is contained in Appendix 1 of this request. There are no corrosion problems associated with the application of the MNSA-2 to Alloy 600 small diameter nozzles.

The stainless steel portions of the MNSA-2 performing a reactor coolant system (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 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 BMI nozzles.

5. MNSA-2 Structural Evaluation

The component parts of the MNSA-2 for BMI nozzle installations are being analyzed, designed, and manufactured in accordance with ASME Section III, Subsection NB, 1989 Edition, which is approved in 10CFR50.55a. The ANO-1 original construction code for the RPV is ASME Section III, 1965 Edition, through and including the Summer 1967 Addenda. As required by ASME Section XI, Entergy will amend the ANO-1 RPV stress report (Reference 7) and will include in the amendment a reconciliation for use of the 1989 Edition of ASME Section III as it applies to the MNSA-2 and its interface with the RPV bottom head.

The analysis for the MNSA-2 components 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) for any component.

The stress analysis will consider 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 nozzle ejection in the unlikely event of a complete failure of the ID J-groove 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 will consider RPV 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 the RPV design life.]

6. RPV Bottom Head Modification and Structural Evaluation

The MNSA-2 is attached to the bottom head with SA-453 Grade 660 threaded rods and hex nuts. To accommodate the threaded rods, four holes are drilled and tapped into the bottom head in a circular pattern around the nozzle. To provide a seating surface for the Grafoil seal, a counter-bore is machined into the bottom head extending out approximately ¼ inch from the existing nozzle bore and to a maximum depth of ¾ inch. The addition of the holes and the counter-bore in the bottom head will be analyzed and documented in the ANO-1 stress report (Reference 7). The analysis will be performed to the requirements of ASME Section III, 1965 Edition through and including the Summer 1967 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 (N-415.2) at any location.
- Adequate reinforcement in the wall of the bottom head for the tapped holes and counter-bore exists (N-452 and N-454).

The methodology to be used in the stress analysis will consider 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-groove weld at operating and shutdown conditions. The applied stresses will be evaluated at the counter-bore region and at the tapped holes for compliance with Code allowables. The applied stresses on the bottom head will be modified by the appropriate geometry factors and by additional factors to take into account stress interaction between the tapped holes and the counter-bore. The results of the stress analysis, considering the tapped holes and counter-bore in the bottom head, must demonstrate applied stresses are below ASME Code allowables and provide assurance of vessel structural integrity.

Fatigue evaluations of the bottom head near the tapped holes and counter-bores will consider bottom head design life and ensure fatigue usage factors must be less than 1.0. [PERFORM ANALYSIS TO ENSURE THAT FOR 2 OPERATING CYCLES, THE EXPECTED NUMBER OF HEAT-UP AND COOLDOWN CYCLES ARE SUBSTANTIALLY LESS THAN THOSE ACCOUNTED FOR THE STRESS ANALYSIS FOR THE BOTTOM HEAD DESIGN LIFE.]

The area reinforcement calculations performed in the original design stress report in accordance with ASME Code Section III N-452 will be updated to evaluate the removal of bottom head metal by machining the tapped holes and counter-bores. The results of the analysis in Reference 6 ensure that for each BMI nozzle location evaluated for possible MNSA-2 installation, the area available for reinforcement is greater than the area required as a result of metal removal.

Revised stress calculations contained in the amended stress report will address reinforcement requirements for modification to the bottom head to account for the additional area removed by machining the tapped holes and the counter-bore.

The updated reinforcement calculations will use the minimum vessel tolerances on design thickness (the same as was performed in the original stress report) and the maximum tolerances on the machined tapped holes and counter-bore. The minimum required thickness of the bottom head will be used in the calculations in accordance with the ASME Section III N-452 and the original RPV stress report.

In order to support MNSA-2 installation, the resulting calculations must show that substantial margin exists between the areas available for reinforcement compared to the area required for reinforcement. These calculations take into account material removal due to the introduction of the tapped holes and counter-bore required for MNSA-2 installation.

C. MNSA-2 Design Requirements

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. Joint Integrity

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 the ANO-1 stress report (Reference 7) will demonstrate 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. Maintenance, Removal, and Replacement

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

[PROVIDE DESCRIPTIONS OF TESTING TO SUPPORT BMI NOZZLE APPLICATION.]

The MNSA-2s to be installed at ANO-1 will be subjected to the conditions stated below which are obtained from the design specification and from part of the basis for analysis.

Parameters	ANO-1 Conditions	MNSA-2 Design
Design Pressure	2,500 psig	2,500 psig
Design Temperature	650°F	[TO BE DETERMINED]
Operating Pressure	2,155 psig	

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 is 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. During plant startup, the test will be performed and a VT-2 inspection performed at normal operating pressure with the test temperature determined in accordance with the pressure and temperature limits as stated in the ANO-1 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. The VT-2 activity involves visually inspecting for leakage the counter-bore/annulus region of each installed MNSA-2 during each refueling outage. Upon discovering leakage that occurred during the operating cycle, we will remove the MNSA-2 and inspect it and the surrounding pressurizer surface for corrosion.

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:

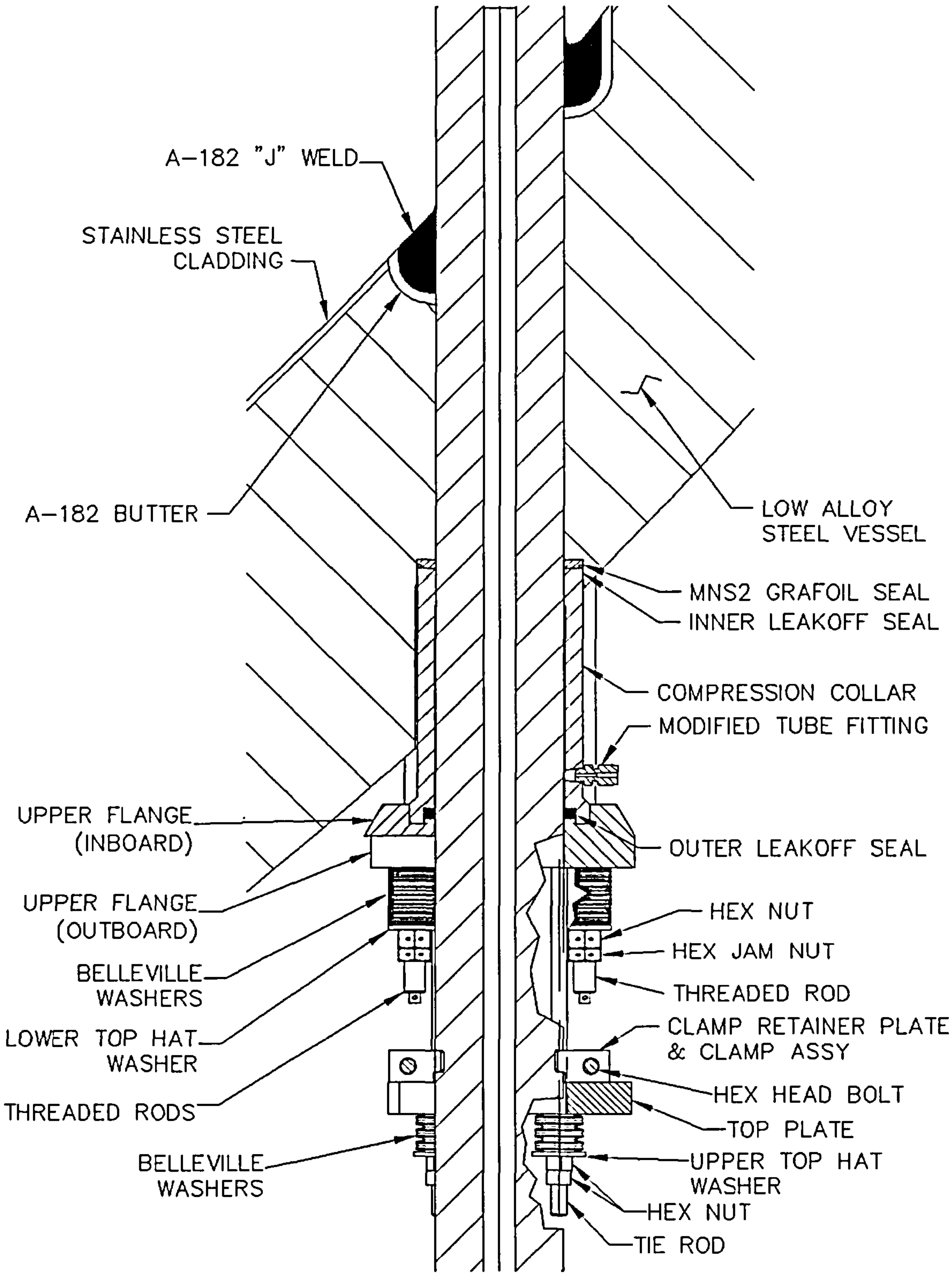
- The design of the MNSA-2 is in accordance with ASME Section III, 1989 Edition, NB-3200. The analysis will include provisions for fatigue and assurances that stresses do not exceed Code allowables. Additionally, significant prototype testing (seismic, hydrostatic, and thermal cycling) has been completed that demonstrates functionality and leak tightness during conditions of operations that are representative of ANO-1.

- Modification of the RPV bottom head will be analyzed in accordance with the original Construction Code (ASME Section III, 1965 Edition through and including the Summer 1967 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 RPV bottom head.

- 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 two (2) operating cycles.

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



Typical Side Shell MNSA-2

FIGURE 1

ANO1-R&R-007

APPENDIX 1

CORROSION ISSUES WITH MNSA-2 MATERIALS

REQUEST FOR ALTERNATIVE
ANO1-R&R-007

Appendix 1

CORROSION ISSUES WITH MNSA-2 MATERIALS

This appendix summarizes 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/RPV bottom head 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 reactor coolant system (RCS) is drained. Thus, the concentration 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°F 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 Combustion Engineering (CE) 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 stress corrosion cracking (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 hardened 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 Grafoil seal were to leak (unlikely since it will be live-loaded during service), the secondary inner and outer seals divert leakage away from the fasteners and prevent exposure to borated water and steam. If the leakage is not channeled away from the fasteners, a wetting and drying condition could result in concentration 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 environments comparable to these. Thus, concern about anodic polarization is not warranted. Leakage is a condition that will require repair and will be apparent from 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 an issue for the MNSA-2 application.

<u>Corrosion Near the Component OD Surface</u>: 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 and low alloy steel component material. The 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 leak-off line will force oxygen from the line and oxygen in the crevice will be consumed by corrosion of the carbon or 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 leak-off line 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 leak-off 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.

<u>Galvanic Corrosion</u>: 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 is not 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 after the machining, residual tensile 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 BMI nozzle 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 RPV bottom head 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 bottom head 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 no corrosion problems associated with the application of the MNSA-2 to Alloy 600 small diameter nozzles. This assessment considered potential corrosion issues associated with the component base metal, the MNSA-2 materials of construction and galvanic effects.

References [THESE TO BE CONFIRMED AND UPDATED, AS REQUIRED.]

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3. D. E. Powell and J. F. Hall, "Stress Corrosion Cracking of A-286 Stainless Steel in High temperature Water", Improved Technology for Critical Bolting Applications, PMC – Vol. 26, pp15-22, 1986

4. J. Gorman, "Materials Handbook for Nuclear plant Pressure Boundary Applications", EPRI TR-199668-S1, December 1997 (Draft)

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