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

Three Mile Island, Unit 1
Operating License No. DPR-50
NRC Docket No. 50-289

Subject: Request for Relief Associated with Use of the Mechanical Nozzle Seal Assembly (MNSA-2)

In accordance with 10 CFR 50.55a, "Codes and standards," paragraph (a)(3)(i), AmerGen Energy Company, LLC (AmerGen) is submitting a proposed alternative to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components." This proposed alternative would utilize the mechanical nozzle seal assembly (MNSA-2) for two (2) operating cycles.

During the upcoming refueling outage at Three Mile Island, Unit 1, currently scheduled to begin in October 2003, AmerGen plans to inspect bottom mounted incore instrumentation (BMI) nozzles on the lower reactor vessel head. If leakage is identified at the BMI nozzles, AmerGen intends to utilize the MNSA-2 clamps as the repair mechanism to restore structural integrity and leak tightness.

Currently, AmerGen has no evidence of leakage at these 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.

If you have any questions, please contact us.

Very truly yours,

Michael P. Gallagher

Michael P. Gallagher
Director, Licensing and Regulatory Affairs
AmerGen Energy Company, LLC

A047

Attachment – Relief Request

cc: H. J. Miller, Administrator, Region I, USNRC
D. M. Kern, USNRC Senior Resident Inspector, TMI-1
D. M. Skay, USNRC Senior Project Manager
File No. 01086

ENCLOSURE

REQUEST FOR ALTERNATIVE

AMERGEN ENERGY COMPANY, LLC
THREE MILE ISLAND, UNIT 1
REQUEST FOR ALTERNATIVE

I. ASME COMPONENTS AFFECTED

Component/Number: Reactor Vessel Bottom Mounted Incore Instrumentation (BMI) Nozzles (52)

Code Class: ASME Section XI, ASME Section III, Class A (Reactor Pressure Vessel)

References:

1) ASME Section III, 1989 Edition
2) ASME Section III, 1965 Edition through and including Summer 1967 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 February 21, 2002
4) Westinghouse Test Report No. TR-CI-02-4, Rev. 0, "Seismic Qualification Testing of the SONGS UNITS 2&3 MNSA-2 Clamps for Pressurizer Heaters," dated January 10, 2003
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 February 22, 2002
6) Babcock & Wilcox Design Report for TMI 1, Contract #620-0005
    a) Section III Code Sizing Analysis for Metropolitan Edison Company Reactor Vessel – Stress Analysis Report #1
    b) Reactor Vessel Instrumentation Tubes – Stress Analysis Report #9
7) Babcock & Wilcox, Drawing No. 128767E, Rev. 6, "Inst. Nozzle Detail and Assembly" (identifies nozzle location and numbers and nozzle details)
8) Babcock & Wilcox, Drawing No. 73394 B-0, Incore Monitoring Piping Typical Weld Details

9) Babcock & Wilcox, Drawing No. 128760E, Rev. 17 Arrgt. Reactor Vessel Long. Sec. (shows vessel head thickness)

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

11) "A Review of Alloy 600 Cracking in Operating Nuclear Plants: Historical Experience and Future Trends" Warren Bamford and John Hall, Westinghouse Electric Company, Proceedings of the 11th International Conference on Environmental Degradation of Materials in Nuclear Power Systems Water Reactors, Stephenson, WA Aug 11-15, 2003

12) ASME Section XI, 1995 Edition through 1996 Addenda

Unit: Three Mile Island, Unit 1

Inspection Interval: Third 10-year interval

II. APPLICABLE CODE EDITION AND ADDENDA

The applicable ASME Section XI Code Edition and Addenda for TMI, Unit 1 is the 1995 Edition through 1996 Addenda. The Third 10-year interval began on April 20, 2001.

III. APPLICABLE CODE REQUIREMENTS

A. Mechanical Repair

ASME Section XI, IWA-4221, items to be used for repair and replacement activities shall meet the owner's requirements and the applicable construction code to which the original item was constructed. The affected reactor vessel instrument 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 A vessel welded nozzles with mechanical clamping devices are not clearly defined by ASME Section III.

B. Flaw Removal

In accordance with ASME Code Section XI, 1995 Edition, through 1996 Addenda, paragraphs IWB-3132 and IWB-3142 require that existing flaws in ASME Code Class components which are unacceptable for continued service, be corrected by repair/replacement activity or analytical evaluation, to the extent necessary to meet the acceptance standards in ASME Code Section XI, Article IWB-3000. Additionally, IWA-4000 describes the repair/replacement activities to correct an unacceptable flaw. Detection of leaks in the structural portion of an ASME Code Class 1, 2, or 3 component is direct evidence of a flaw in the component.

IV. REASON FOR REQUEST

A. Mechanical Repair

Pursuant to 10 CFR 50.55a(a)(3)(i), AmerGen Energy Company, LLC (AmerGen) 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 above. AmerGen makes this request in order to repair leaks that may be detected while performing inspections during refueling outages.

The welded repair of nozzles using a half-nozzle replacement technique would extend reactor coolant system (RCS) drain-down activities and significantly increase worker radiation exposure to perform extensive field machining and welding activities. These repairs take approximately 3 times longer to perform than the proposed alternative. We expect the dose to be approximately 4 Rem per nozzle for the proposed alternative. The dose expected is approximately 12 Rem per nozzle for the welded repair. In addition, the half nozzle replacement is intrusive to the RCS and the proposed alternative is not. The overall impact with the welded repair on the outage schedule is an additional 9 days.

As an alternative, AmerGen proposes to use the MNSA-2 as a repair to restore nozzle integrity and prevent leakage for two (2) operating cycles.

B. Flaw Evaluation

The proposed MNSA-2 repair will relocate the pressure boundary away from the current nozzle weld such that the original crack will remain in place. Therefore, it must be demonstrated that a postulated crack and any potential future growth of that crack does not impact the structural integrity of the vessel. This is accomplished via an ASME Code Section XI, Appendix K, elastic-plastic evaluation of the as-left flaw. The evaluation postulates a double-sided crack that has propagated through the J-groove weld and is beginning to encroach on the carbon steel material that comprises the pressure boundary. The assumed flaw configuration is evaluated to determine its growth rate and stability for plant operation in order to demonstrate structural integrity of the pressure boundary for the remaining life of the plant, even though this request is for only two (2) additional operating cycles.

A satisfactory analysis of the as-left behind flaw configuration provides an alternative to mechanical removal of the flaw.

ASME Section XI, Appendix K provides guidance on performing an elastic-plastic failure mechanism evaluation to demonstrate flaw stability. The criterion specifies that a flaw in a component is acceptable for continued service when the criteria of K-2200, K-2300 and K-2400 are satisfied.

In this evaluation, rather than utilizing the various safety factors specified for different load types in these criteria, a conservative safety factor of 3.0 is applied to the calculated combined plastic-zone adjusted stress intensity factor used to calculate J-Applied. As is demonstrated later in this evaluation, the principal criteria that a flaw is considered acceptable and stable for continued service if the applied J-integral curve for the crack falls below thematerial resistance J-value, the J-R curve, continues to be satisfied.

The Appendix K methodology was developed for application to the beltline regions of a Reactor Vessel and the elastic-plastic fracture mechanics evaluation is consistent with Appendix K but is tailored to the application and conditions evaluated. The methodology is actually based on Regulatory Guide (RG) 1.161, which is very similar to the non-mandatory rules given in Appendix K of Section XI of the1992 ASME Code Edition. Specific aspects of Appendix K unique to reactor vessel beltline were, therefore, not applicable and, not used. Both Appendix K and RG 1.161 represent industry-accepted methodologies for evaluating crack stability, and were used as guidance for establishing the methodology used in this calculation.

In conjunction with the above discussion, Table 11 of NUREG CR5729 provides a J-R curve meeting the K-3300(b) requirements for the Reactor Vessel lower shell material. This reference provides an industry-accepted source for this data.

V. PROPOSED ALTERNATIVE AND BASIS FOR PROPOSED ALTERNATIVE

As discussed in the previous section, as an alternative, AmerGen proposes to use the MNSA-2 as a repair to restore nozzle integrity and prevent leakage for two (2) operating cycles.

A. Background

The reactor vessel and its BMI nozzle assemblies were designed by Babcock and Wilcox (B&W). B&W designed these components for a number of transient cycles that are adequate for a 40-year design life. Considering operating experience to date, the number of reactor vessel transient cycles projected through the end of the TMI, Unit 1 license term 2014, remains less than the original number of design cycles. Since the reactor vessel is qualified to the original number of design cycles, the qualifying analyses remain valid for the license term. To maintain the validity of the analyses, AmerGen will ensure the number of transient cycles during plant operation does not exceed the number of cycles assumed in the original design of the reactor vessel and associated components.

The candidate nozzles are described below:

- Reactor Vessel Bottom Mounted Incore Instrumentation (BMI) Nozzle (52)

The BMI nozzle is fabricated from Inconel alloy (Ni-Cr-Fe, SB-167). The outside diameter (OD) of the nozzle is 1.03". The nozzle has an inside diameter (ID) of 0.614". The nozzle is welded to the inside of the reactor vessel.

Numerous instances of Alloy 600 nozzle cracking have been identified in the industry in recent years. The cracking growth is predominantly axial (Reference 11). 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 are performed prior to plant startup following 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 Reactor Vessel lower head. MNSA-2 provides a seal against leakage and positively captures the nozzle preventing ejection in the unlikely event of complete 360-degree J-groove 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. A counter-bore is also machined into the surface of the vessel perpendicular to and around the leaking nozzle. Four threaded rods are threaded into the reactor vessel, 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, which is in the annulus region, is compressively loaded via the compression collar and the inboard and outboard flange assembly. 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 J-groove weld failure, an anti-ejection plate is also installed and secured in place with the four tie rods, Belleville spring washers, and hex nuts. A clamp around the nozzle is used as a reaction point for the anti-ejection plate. The clamp has grooves on its inner surface which mate with grooves that are machined on the nozzle OD during installation. The anti-ejection plate acts as a restraint only if the nozzle-to-reactor vessel J-groove weld completely fails.

Section B.2, below 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), Calvert Cliffs, Millstone 2 and at Arizona Public Service Company's Palo Verde Nuclear Generating Station. More recently, the NRC authorized use of the MNSA-2 design at Arkansas Nuclear One, Unit 2 (ANO-2) and Waterford 3.

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 pressure vessel relative to the nozzle, a counter-bore is machined at 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 vessel head 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 contact the reactor vessel or the threaded rods.

In the unlikely event of leakage past the primary Grafoil seal, fluid enters the annulus region between the compression collar 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 reactor vessel head surface. Failure of the inner or outer seal is unlikely since neither is pressurized. The annulus region inside the compression collar does not impair the primary seal in any way.

The NRC evaluated potential corrosion effects of boric acid on the original 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 corrosion testing performed by Westinghouse.
- 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.

The sealing qualities of MNSA-2 are enhanced 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 Combustion Engineering (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. <u>MNSA-2 Installation</u>

The MNSA-2 installation process is non-intrusive on the existing nozzle pressure boundary, and it does not require draining the reactor vessel to install. In addition to the counter-bore, a series of grooves is machined in the nozzle to mate with the anti-ejection clamp. 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 reactor vessel bottom head will be performed at temperatures above RT_{NDT} (40°F) to ensure the bolting stress does not create a potential for brittle failure.

Prior to installing a MNSA-2, AmerGen will perform stress calculations to ensure Code-allowable stress values are maintained. A certified Design Report will be prepared to address the MNSA-2 installation and the changes to the reactor vessel head. AmerGen will use more rigorous methodology at TMI to evaluate installation of MNSA-2s than was used at ANO-2 and Waterford 3.

4. <u>MNSA-2 Materials</u>

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 issues associated with the application of the MNSA-2 to Alloy 600 small diameter nozzles.

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 AmerGen. 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 reactor vessel head BMI nozzles.

5. MNSA-2 Structural Evaluation

The component parts of the MNSA-2 for reactor vessel bottom mounted instrument nozzle installations are being analyzed, designed, and manufactured in accordance with ASME Section III, Subsection NB, 1989 Edition. The TMI, Unit 1 original construction code for the reactor vessel is ASME Section III, 1965 Edition, through and including the Summer 1967 Addenda (Reference 2). As required by ASME Section XI, a reconciliation for use of the 1989 Edition of ASME Section III, as it applies to the MNSA-2 and its interface with the reactor vessel will be performed (see Section C, "MNSA-2 Design Requirements").

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

- Stresses do not exceed the allowable criteria 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 all the design transients analyzed in the Reactor Vessel Design Report, Reference 6. The stress analysis also considers the MNSA-2 installation preload 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 allowable criteria, thereby providing assurance of structural integrity for the MNSA-2.

Fatigue evaluations of the MNSA-2 clamp components consider reactor vessel 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 reactor vessel design life.

6. Reactor Vessel Modification and Structural Evaluation

The MNSA-2 is attached to the reactor vessel with SA-453 Grade 660 threaded rods and hex nuts. To accommodate the threaded rods, four blind holes are drilled and tapped into the reactor vessel in a circular pattern around the nozzle. To provide a seating surface for the Grafoil seal, a counter-bore is machined into the reactor vessel extending out approximately ¼ inch from the existing nozzle bore and to a maximum depth of ¾ inch on the short side of the counterbore for all nozzles. The depth will be greater on the opposite side of the nozzle depending on its location. The outermost nozzles will have the greatest counterbore depth on the "downhill" side of the nozzle. The addition of the blind holes and the counter-bore in the reactor vessel will be analyzed and documented in the TMI, Unit 1 stress report for the outermost and center bottom-mounted instrument nozzle locations. The outermost and center bottom-mounted instrument nozzle locations are bounding. The analysis is performed to the requirements of ASME Section III, 1989 Edition, and reconciled to the 1965 Edition through and including the Summer 1967 Addenda. The analysis of the reactor pressure vessel ensures that:

- Stresses do not exceed the allowable criteria as stated in the Code.
- The Code-prescribed cumulative fatigue usage factor of 1.0 is not exceeded (N-415.2) at any location.

The methodology used in the stress analysis considers 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 blind tapped holes, compression collar loads, and the loads on the existing J-groove weld at operating and shutdown conditions. A 3-

dimensional Finite Element Analysis of one-quarter of the bottom head of the reactor vessel with the MNSA-2 related modifications at the outermost and center bottom mounted instrument nozzles is used to calculate stress. This includes structural effects from the support skirt. The model includes the blind tapped holes, the counter-bore and an increase in the nozzle penetration diameter due to corrosion. The results of the stress analysis, considering the blind tapped holes and counter-bore in the reactor vessel bottom head, must demonstrate calculated stresses are below ASME Code allowable stress criteria and provide assurance of vessel structural integrity.

Fatigue evaluations of the reactor vessel bottom head and instrument nozzles near the blind tapped holes and counter-bores consider reactor vessel design life and ensure fatigue usage factors must be less than 1.0. 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 reactor vessel design life.

C. MNSA-2 Design Requirements

In accordance with ASME Section XI, IWA-4221, items to be used for repair and replacement activities shall meet the owner's requirements and the applicable construction code to which the original item was constructed. Alternatively, later editions and addenda of the original Construction Code may be used provided the following requirements are met, as applicable:

- Reconciliation of Code and Owner's requirements.
- Reconciliation of components.
- Reconciliation of material.
- Reconciliation of parts and appurtenances.
- Reconciliation of design 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 will be designed in accordance with the rules of ASME Section III, Subarticle NB-3200, and 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. A design report 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. Design Analysis and Prototype Testing

   The MNSA-2 design was qualified by a series of tests and analyses. Because this request reflects a specific, new application of the MNSA-2, AmerGen will prepare a design specification and a revised stress report for TMI, Unit 1.

   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. Entergy provided detailed descriptions of the prototype hydrostatic and thermal cycle testing procedures and results (References 3 and 5) to the NRC staff as enclosures to Reference 10. Reference 4 is the Test Report of the seismic testing performed by Westinghouse for the SONGS pressurizer heater sleeve MNSA-2s.

   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, ANO-1, and ANO-2 for hydrostatic and thermal cycling. The seismic testing performed for the SONGS pressurizer was basically the same as had been performed for the Entergy pressurizer except that higher seismic levels were used to accommodate the SONGS seismic requirements. The heater sleeve on the upper hillside of the pressurizer bottom head for Waterford 3 was chosen as the bounding penetration. The SONGS heater sleeve configuration is identical to Waterford 3. The prototype testing verified leak tightness and structural integrity of the MNSA-2. There is nothing in the test apparatus that would restrict its applicability to the pressurizer. The MNSA-2 configuration used on the pressurizer is for a larger diameter nozzle than the reactor vessel BMI nozzles and the results are conservative relative to the reactor vessel BMI application.

Provided below are summaries of each test. Please refer to References 3, 4, and 5 for more specific details of the tests.

- 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 pressure 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 three (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 and SONGS 2 & 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 (SSE) 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 will be reviewed to ensure the tests bound the conditions for which AmerGen proposes to install the MNSA-2 at TMI, Unit 1. 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 TMI, Unit 1 will be subjected to the conditions stated below which are obtained from the design specification and form part of the basis for analysis.

Parameters	TMI, UNIT 1 Conditions	MNSA-2 Design
Design Pressure	2,500 psig	2,500 psig
Design Temperature (Reactor Vessel)	650°F	700°F
Nominal Operating Pressure	2,185 psig	
Normal Inlet Temperature (Reactor Vessel)	550°F	

D. Inservice Testing and Inspection

1. ASME Section XI Preservice

The bolting and tie rods of the MNSA-2 shall have a VT-1 pre-service inspection performed.

2. ASME Section XI Repair Pressure Tests

In accordance with ASME Section XI, IWA-4540(c), which specifies examination and testing requirements for repair and replacement activities, mechanical joints made in the installation of pressure retaining items shall be pressure tested in accordance with IWA-5211(a). Following the installation of the MNSA-2 clamp, a system leakage test during operation at nominal operating pressure, followed by a VT-2 examination, shall be performed.

3. ASME Section XI Inservice Inspection

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. This visual inspection for leakage will be supplemented by additional examinations during the refueling outage in the event that a MNSA-2 clamp is installed. Additionally, the insulation beneath the reactor vessel shall be removed to expose the MNSA-2 clamp and a VT-2 examination shall be conducted with the system depressurized.

E. 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."

AmerGen 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 TMI, Unit 1.

- Modification of the reactor vessel will be analyzed in accordance with ASME Section III, 1989 Edition, NB-3200, and reconciled 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 blind 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 reactor vessel.

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

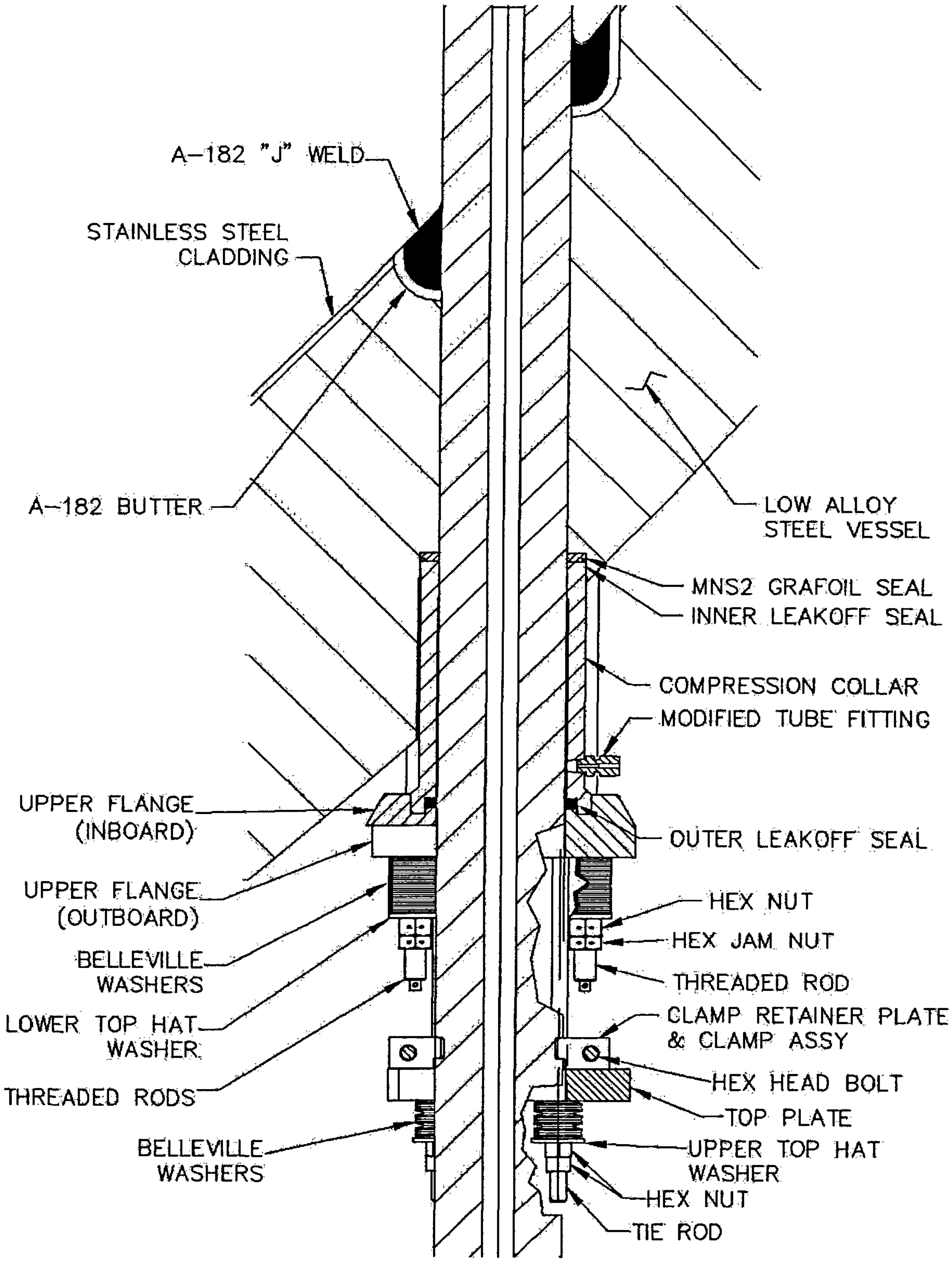
- After installation, the MNSA-2 will be pressure tested and inspected (uninsulated) for leakage to ensure quality of installation and leak tightness.

- This relief request for use of the alternative repair criteria is for two (2) operating cycles.

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

VI. Duration of Proposed Alternative

AmerGen proposes to use the MNSA-2 as a repair to restore nozzle integrity and prevent leakage for two (2) operating cycles.



Typical BMI MNSA-2

FIGURE 1

APPENDIX 1

CORROSION ISSUES WITH MNSA-2 MATERIALS

CORROSION ISSUES WITH MNSA-2 MATERIALS

This appendix summarizes issues associated with the application of MNSA-2 for small diameter Alloy 600 nozzle repair (which bounded the incore monitoring instrumentation). The materials of interest are the carbon or low alloy steel used in the component 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 Low Alloy Steel: Assuming that a repaired nozzle has a through-wall crack, the annulus between the Alloy 600 nozzle and the reactor vessel bottom head (or other component) will fill with primary coolant. Prior experience, including the recent South Texas-1 BMI nozzle event, indicates that primary water stress corrosion cracks are very tight, and, thus, there will be little communication between the annulus environment and the bulk primary coolant. Furthermore, there are not any concentrating mechanisms that would tend to increase the boric acid level in this essentially stagnant environment. Thus, boric acid concentration in the annulus will not exceed that of the primary coolant at the beginning of a fuel cycle. The water that initially fills the annulus may be aerated, but the dissolved oxygen will quickly be consumed by corrosion of the low alloy steel as the plant returns to service. As a result, a low oxygen condition will exist during operation. During refuelings, when the primary system is aerated, there will be only limited potential for increases in the dissolved oxygen level of the annulus environment. Reference 1 estimates that corrosion of low alloy steel at operating conditions will be very low (less than 0.0003 inch/year). The corrosion rate at shutdown conditions (low temperature (100°F) and fully aerated) was significantly higher, being approximately 0.008 inch/year. A very conservative, overall corrosion rate based on an 88% capacity factor, fully aerated shutdown conditions, and a short time at intermediate conditions would be about 0.0015 inch/year. At this low rate, corrosion of the low alloy steel in the annulus region will not be a significant concern. The data of Reference 1 also indicate that coupling the low alloy steel with stainless steel did not produce significant galvanic corrosion nor did the presence of a crevice in the test specimens result in localized, pitting type corrosion. The available data indicate that low alloy steel corrosion in the crevice region is not a significant concern.

Stress Corrosion Cracking of Low Alloy Steel: The nozzles that have a MNSA-2 installed will have cracks in the nozzle material or in the partial penetration weld metal that will remain after MNSA-2 installation. Since residual stresses from the welding will remain, these cracks may continue to propagate through the nozzle/weld metal by a stress corrosion cracking (SCC) mechanism to the low alloy steel base metal. Under certain conditions, continued growth of these cracks by a SCC mechanism into the low alloy steel is possible. The available laboratory and field data were reviewed to address this potential issue. Reference 2, which presented the results of a detailed review of the potential for SCC of low alloy steels, concluded that SCC of low alloy steels in PWR environments is unlikely. The principal reason for this is the low oxygen, reducing conditions resulting from hydrazine (oxygen scavenger) additions during start-up and hydrogen overpressure during operations. At coolant temperatures of about 600°F, the corrosion potential for carbon and low alloy steels in typical PWR environments is approximately –600 mV. Corrosion data for carbon and low alloy steels cited in Reference 2 indicates that there is a critical cracking potential of about –200mV below which SCC initiation or growth does not occur. As long as nominal PWR primary coolant chemistry conditions are maintained, SCC of low alloy steels is not a concern.

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 is 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 3 and 4). 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 5). 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 MNSA2 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 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 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 low alloy steel corrosion 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.

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 6 and 7). 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 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 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 vessel ID will not be present and SCC initiation is unlikely.

(3) The temperature near the vessel 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 17-7 PH Stainless Steel: 17-7 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-MNSA2-228-002 indicates that the washers are in contact only with Type 304 or A-286 stainless steels which 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. 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 reactor vessel steel and compression collar will receive primary coolant. Primary coolant will escape by the leak off tube into the containment environment or by the crevice between the compression collar and reactor vessel 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 potential 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.

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