ENGINEERING REPORT

Design Evaluation of MNSA for Various Applications at Waterford Unit 3

Engineering Report Number C-NOME-ER-0120

Revision 01

ABB COMBUSTION ENGINEERING NUCLEAR POWER
Windsor, Connecticut

VERIFICATION STATUS: COMPLETE

The Safety-Related design information contained in this document has been verified to be correct by means of Design Review.

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INTRODUCTION

A Mechanical Nozzle Seal Assembly (MNSA) is a device which has been designed for use on certain primary pressure boundary nozzles in a reactor system. These nozzles are attached to the pressurizer, steam generator or RCS pipe by a partial penetration ("J") weld on the inside of the vessel or pipe. The weld joins the inconel nozzle to the carbon steel vessel or pipe. This weld, in some applications, has been found to be susceptible to Primary Water Stress Corrosion Cracking (PWSCC) creating the possibility of a primary pressure boundary leak.

A MNSA is installed onto the nozzle that has a weld or nozzle deemed susceptible to PWSCC. MNSA replaces the two functions of the weld, 1) it forms a primary pressure boundary seal and, 2) it prevents the nozzle from ejecting in the event that either the weld should fail completely or that the nozzle develop a 360° crack.

Three MNSA (Mechanical Nozzle Seal Assembly) designs have successfully completed qualification test programs which included a hydrostatic leak test (3175 ± 50 psi pressure at ambient conditions), three thermal cycle leak tests to 2500 psi at 650°F, and vibration testing which replicated the seismic spectrum for the San Onofre plants, (see References 5.1.1 and 5.1.2). Each of the MNSA designs was subjected to the seismic test conditions with the system pressurized to a minimum of 3125 psi. No leakage occurred.

The three designs qualified as described above are:

- "Bottom Pressurizer" MNSA for the pressure tap nozzle on the bottom of the pressurizer, Reference 5.2.1.
- "Side Pressurizer RTD" MNSA for the RTD nozzle on the side of the pressurizer, Reference 5.2.2.
- "Hot Leg RTD" MNSA for the RTD nozzle on the hot leg pipes, Reference 5.2.3.

All MNSA configurations are designed and fabricated to Section III requirements of the ASME Boiler and Pressure Vessel Code.

Three MNSA designs are intended for use on hot leg nozzles at Waterford 3, one for an RTD nozzle, one for a PDT nozzle and one for a sampling nozzle.

All MNSA designs have similar components, although they are sized differently for each specific application, all are fastened to the applicable vessel or pipe in a similar manner. Each design features relatively long tie rods between their Upper Flange and their Top Plate. The Upper Flange is restrained by four bolts threaded into the vessel or pipe. The Top Plate is fastened to the Upper Flange by the tie rods. See Figure 1 for a basic MNSA arrangement.

The four bolts attaching a MNSA to the vessel are the critical components which maintain its function as a primary pressure boundary. These bolts restrain the MNSA components from moving with respect to the vessel or pipe, which in turn, maintains the proper compression on MNSA's Grafoil seal.

It should be noted that this report does not evaluate the effect of the MNSA components on the nozzles or their welds. Partial penetration welds are required by the ASME to be under "substantially no load", this condition is defined in Combustion Engineering Bulletin 83-03. Satisfaction of this requirement must be verified by the Utility.

Appendix A of this report addresses some specific Waterford questions regarding the testing and qualification of MNSA.

2.0 PURPOSE

The purpose of this report is to perform an engineering evaluation of the three MNSA designs intended for use at Waterford Unit 3. A comparison of these designs will be made to other qualified MNSA designs and a determination will be made whether the new designs can be deemed qualified without additional testing.

The three Waterford MNSA designs are:

- "Hot Leg RTD" MNSA for the RTD nozzle on the hot leg pipe, Reference 5.2.4.
- "Hot Leg PDT" MNSA for the pressure tap nozzle on the hot leg pipe, Reference 5.2.5.
- "Hot Leg Sampling" MNSA for the sampling nozzle on the hot leg pipe, Reference 5.2.6.

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3.0 RESULTS

The three Waterford 3 MNSA designs have been evaluated for two operating conditions, (1) normal static operation and (2) operability during and after a seismic event.

Normal Static Operation

For a failed nozzle with an installed MNSA, the MNSA is considered the primary pressure boundary seal. As such it is exposed to the pipe or vessel's operating temperature and pressure.

For static operating conditions, the applicable qualification test involved ambient hydrostatic testing, and thermal cycle testing to design operating and pressure conditions, for an RTD MNSA. This testing is described in Reference 5.1.1.

Seismic Conditions

The primary issue is to confirm that seismic loading on the three new untested designs will not adversely effect the seal function. The function of the seal is preserved if the bolts which preload and capture the seal are not overloaded. Two approaches were used to evaluate this issue.

a) An overturning moment, resulting from the product of a unit G load, applied through the MNSA Center of Gravity, times the induced number of Gs from the seismic event, was applied to each new MNSA design. The bolt load created by this moment was compared to that experienced in a tested design. The Bottom Pressurizer MNSA was used for comparison since that design, of the three qualified through testing, produced the highest loading in the bolts.

b) The loads created by the nozzle reacting against the MNSA components during seismic testing were evaluated. Again the Bottom Pressurizer MNSA was used for comparison purposes since that design experienced the highest loads in the qualification program.

It is to be noted that the Bottom Pressurizer MNSA was subjected to vibration testing with an intensity that exceeded the San Onofre seismic spectra by a factor of five. The test was conducted with the system at a pressure of 3175 ± 50 psi, no leakage occurred. The seismic testing is described in Reference 5.1.2.

3.1 Evaluation of the three Waterford MNSA designs; the Hot Leg RTD, the Hot Leg PDT, and Hot Leg Sampling MNSA for their ability to withstand normal static loading

The critical parameter for this evaluation is the configuration of all of the components involved in restraining and compressing the Grafoil seal of each MNSA design.

From the piping and nozzle drawings, References 5.2.7 and 5.2.8, it is determined that the specified diameter, in the region where the seal will be made, is the same for the RTD, the PDT and Sampling nozzles (0.993 nominal). From the Waterford MNSA drawings, References 5.2.4-5.2.6, it is determined that the same Grafoil seal design is used for each design.

The details of the other MNSA components involved with controlling the restraint and compression of the Grafoil seal have all been designed to achieve the same seal configuration as the qualified RTD MNSA when the seal is installed. These components are the Flat Seal Retainer, the Lower Flange, and the Compression Collar.

Therefore since all of the interfacing components are the same size as the tested RTD MNSA components and the same seal compression is achieved in each design the qualification test for the RTD MNSA, Reference 5.1.1, can be extended to the Waterford 3 Hot Leg RTD, Hot Leg PDT, and Hot Leg Sampling MNSA.

Also, it should be noted that the qualified RTD MNSA design is identical to the RTD MNSA design intended for use at Waterford 3. There will be a much lower seismic load on the Waterford RTD MNSA since, as noted in Section 3.2.1, the G loading is much lower than that imposed on the qualification test specimen.

3.2 Evaluation of the three Waterford MNSA designs; the Hot Leg RTD, the Hot Leg PDT, and Hot Leg Sampling MNSA for their ability to withstand seismic loading

There are two concerns regarding seismic loading:

- Seismic loading might affect the bolts attaching MNSA to the vessel which could cause the Grafoil seal to become unloaded.
- Seismic loading would deflect the nozzle against the MNSA components and this might affect its sealing capability.

3.2.1 A calculation, Reference 5.3.1, was performed to determine the loading in the bolts created by a unit G load applied through the Center of Gravity of the MNSA design. Calculation, Reference 5.3.3 was performed to determine the G loading in the hot leg pipe region at Waterford 3.

Plant	Maximum Bolt Load P (lbs.) (1.0 G applied)	G Load at Hot Leg Pipe	Resulting Load in Bolt (lbs.) P x G
Waterford 3	46.4 (Ref.5.3.1)	0.6 (Ref.5.3.3)	27.8
San Onofre 2 & 3	37.8 (Ref.5.3.4)	2.8 (Ref.5.1.2)	105.8

The highest bolt load for Waterford 3 was found in the Sampling nozzle MNSA, of the San Onofre MNSA designs the Bottom Pressurizer MNSA had the highest bolt loads.

From the table above, it can be seen that the bolt loading in the qualified Bottom Pressurizer design is substantially higher than the Sampling nozzle MNSA at Waterford 3. Therefore, this parameter is enveloped by the qualification test performed. Furthermore, the seismic load is trivial compared to the bolt preload of approximately 3,600 pounds, Reference 5.3.5.

3.2.2 In comparing the MNSA design configurations between Waterford 3 and the qualified MNSAS it was determined that the valve attached to the PDT nozzle at Waterford weighs 25 lbs, while the one tested in the seismic qualification program of the Bottom Presurizer MNSA only weighed 20 lbs. The Table below evaluates the moment at the base of the valve pipe on the PDT MNSA at Waterford to that created at the base of the pipe of the qualified Bottom Pressurizer MNSA. Although the pipe moment is analyzed below it is only used as a method to quantify the difference in the loading of the MNSA components at Waterford 3 compared to the design tested. The loading into the MNSA components would be proportional to the pipe moment.

For simplicity the conservative assumption is made that the G loading is applied at the top of the valve rather than at the Center of Gravity. Since this is a comparative evaluation a more exact determination of the valve C.G. is not required.

Plant	Length from Surface to Top of Valve L (inches)	Valve Weight (lbs.) W	G Load Applied G	Bending Moment L x W x G (in. lbs.)
Waterford 3	13.5 (Ref. 5.2.5)	25 (Ref.5.4)	0.6 (Ref.5.3.3)	202.5
San Onofre 2 & 3	13.3 (Ref. 5.2.1)	20 (Ref.5.1.2)	2.8 (Ref.5.1.2)	744.8

As the Table shows, the loading into the qualified Bottom Pressurizer MNSA is much more severe than will be experienced by the Waterford 3 PDT MNSA.

3.2.3 Another calculation, Reference 5.3.2, was performed to determine the loading input created by seismic testing into the Bottom Pressurizer MNSA components. The loads which would be applied to each of the MNSA designs under this condition are proportional to the seismic G loading applied. As shown in the Table above, the loading into the Waterford MNSA components is only 0.6/2.8, or approximately 21% of the load, applied to the Bottom Pressurizer MNSA specimen in the qualification test.

In actuality the loads imposed during the SONGS test program were far more severe than design requirements. Due to an oil column resonance in the seismic table used for vibration testing, an unavoidable resonant frequency was encountered which inadvertently generated inertial loads approximately five times higher than required by the San Onofre seismic spectra. The MNSA maintained its structural integrity and did not leak even after this severe load.

4.0 CONCLUSION

The Waterford hot leg RTD nozzle, hot leg PDT nozzle and hot leg sampling nozzle MNSA are each considered Qualified for their intended application. The bases for this conclusion follow:

- The seal configuration is the same in each of these three designs and this configuration has successfully completed an ambient 3125 psi hydrostatic test, and three thermal cycling tests to normal operating temperature and pressure conditions, without leakage.
- The imposed stresses on the bolts of each MNSA, due to seismic loading, has been calculated and found to be less than that experienced by the Bottom Pressurizer MNSA bolts in the vibration Qualification test program.
- The imposed loads, due to seismic loading, into those MNSA components contacting the nozzles have been evaluated and found to be less than that experienced by the Bottom Pressurizer MNSA bolts in the vibration Qualification test program.

5.0 REFERENCES

5.1 ABB CENP Test Reports

5.1.1 "Test Report for MNSA Hydrostatic and Thermal Cycle Tests", Test Report Number TR-PENG-042, Revision 00.

5.1.2 "Test Report- Seismic Qualification of the San Onofre, Units 2 and 3 MNSA Clamps for Pressurizer Instrument Nozzles and RTD Hot Leg Nozzles", Test Report Number TR-PENG-033, Revision 00.

5.2 ABB CENP Drawings

5.2.1 E-MNSA-228-001, Revision 02, "Bottom Pressurizer Mechanical Nozzle Seal Assembly".

5.2.2 E-MNSA-228-002, Revision 02, "Side Pressurizer RTD Mechanical Nozzle Seal Assembly".

5.2.3 E-MNSA-228-003, Revision 05, "Hot Leg RTD Sampling MNSA".

5.2.4 E-MNSAWFD-228-001, Revision 02, "Hot Leg RTD Mechanical Nozzle Seal Assembly".

5.2.5 E-MNSAWFD-228-002, Revision 02, "Hot Leg PDT MNSA".

5.2.6 E-MNSAWFD-228-003, Revision 02, "Hot Leg Sampling MNSA"

5.2.7 E-74470-771-003, Revision 02, "Primary Pipe Assembly"

5.2.8 D-74470-772-001, Revision 04, "Instrument Nozzles, Waterford III Piping"

5.3 <u>ABB CENP Calculations</u>

5.3.1 "Seismic Qualification of Hot Leg RTD, Hot Leg PDT and Hot Leg Sampling MNSA Hardware", Calculation Number C-NOME-CALC-0107, Revision 00.

5.3.2 "Nozzle Loads for which SONGS Bottom Mounted PZR MNSA was Qualified", Calculation Number S-PENG-CALC-008, Revision 00.

5.3.3 "Analysis of Waterford 3 Hot Leg Seismic Response Spectra and Accelerations", Calculation Number C-PENG-CALC-021, Revision 00.

5.3.4 "Seismic Qualification of the Steam Generator PDT, Hot Leg PDT and Hot Leg Sampling MNSA Hardware", Calculation Number S2-NOME-CALC-0085, Revision 00.

5.3.5 "Analysis of Waterford Unit 3 Hot Leg Sampling MNSA", Calculation Number C-PENG-CALC-018, Revision 00.

5.4 Waterford Drawing 1564-1539 P33. "1/4-2" Bonnetless-Inclined Valve", Velan Engineering Co., Dwg. P1-4562-N-1. Note: Applicable Part is a 1" Valve Size.

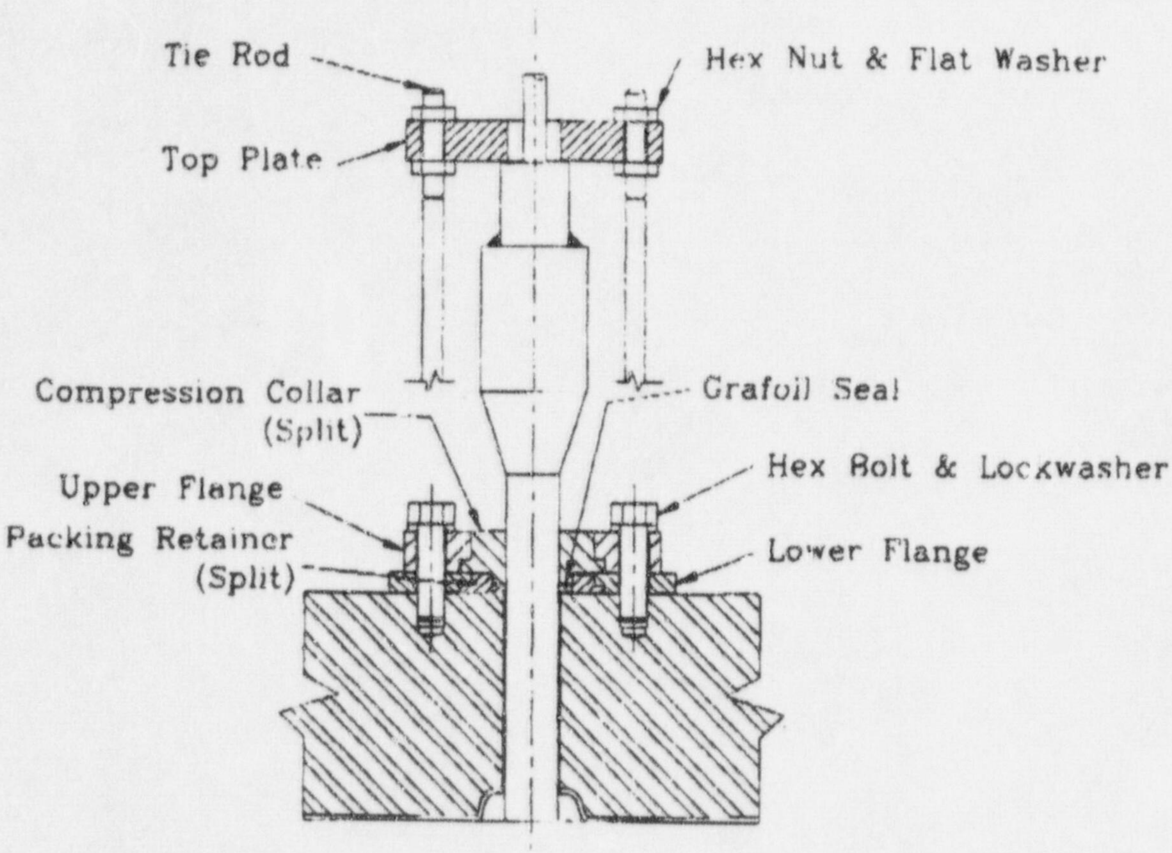

Figure 1

Basic MNSA Configuration

APPENDIX A

ABB CENP Inter Office Correspondence, C-PENG-99-004, Dated 3/13/99, K.H. Haslinger to J.T. McGarry.

ABB

Inter-Office Correspondence

To: John McGarry

cc: Rhonda Doney KHH
Edward Siegel
Ken Margotta
Boris Nadgor
Cheryl Mendrala

C-PENG-99-004
K.H. Haslinger K.H. Haslinger
March 13, 1999

Subject: Documentation of MNSA Clamp Seismic Qualification for WSES-3 MNSAs

References:

1. ABB CENP Test Report TR-ESE-033, Rev. 00 "Seismic Qualification of the SONGS Units 2&3 MNSA Clamps for Pressurizer Instrument Nozzles and Hot Leg Nozzles."
2. ABB CENP Calculation S-PENG-CALC-008, Rev. 01, "Nozzle Loads for which SONGS Bottom Mounted PZR MNSA was Qualified."
3. ABB CENP Test Report TR-PENG-042, Rev. 00, "Test Report for MNSA Hydrostatic Test and Thermal Cycle Test."
4. ABB CENP Calculation C-PENG-CALC-018, Rev. 00, "Analysis of Waterford Unit 3 Hot Leg Sampling MNSA."
5. ABB CENP Calculation C-PENG-CALC-019, Rev. 00, "Analysis of Waterford Unit 3 Hot Leg PDT MNSA."
6. ABB CENP Calculation C-PENG-CALC-020, Rev. 00, "Analysis of Waterford Unit 3 Hot Leg RTD MNSA."
7. ABB CENP Information Bulletin 83-03, "Instrumentation Nozzle Welds."
8. ABB CENP Calculation C-PENG-CALC-021, Rev. 00, "Determination of Waterford 3 Hot Leg Seismic Response Spectra & Accelerations for Use in the Analyses of MNSAs."

This document has been prepared in response to questions from Mr. Ken P. Wilson of WSES to Karl H. Haslinger of ABB CENP. The questions regarding the documentation of MNSA Clamp Seismic Qualification had been sent to ABB CENP Windsor electronically on 3/12/99.

This document is provided as general information to the WSES-3 MNSA project.

General Responses:

As stated in the various ABB CENP documents "*The MNSA is a mechanical device that acts as a complete replacement of the 'J' weld between the Inconel 600 instrument nozzles and either the Hot Leg pipe, the Pressurizer vessel, or Steam Generator shell. The function of the MNSA is to prevent leakage and to restrain the nozzle from ejecting in the event of a through-wall crack or weld failure of a nozzle.*"

It should be noted that in the following discussions the term "ejection" refers to a small outward movement of the nozzle in a direction axial to the nozzle until it contacts the MNSA anti-ejection plate.

ABB-CENP has addressed the MNSA both with the nozzle J-Weld either fully and/or partially intact and after full ejection (due to a hypothetical 360-Degree crack). Prior to ejection, the MNSA and the nozzle represent dynamically two separate structures and the seismic evaluations for the MNSA (as included in References 4 through 6) are applicable. The presence of the MNSA does not alter the original nozzle analyses, as amended by the requirements imposed by Reference 7. This is because after full ejection the MNSA provides the axial restraint to the nozzle while the full-length engagement inside the hot leg pipe bore provides the complete lateral restraint of the original configuration. Since Reference 7 may have necessitated installation of shims between nozzle and bore to reduce stresses into the J-weld, and since installation of the MNSA now allows complete removal of these shims, the nozzle design now can be credited with the supporting function from the closely fitting Grafoil seal compression collar. This new design feature more than compensates for the removal of the shims. On the hot leg ID end of the nozzle the narrow clearance, plus the resulting complex fracture contours will continue to provide a lateral restraint similar to that of the original J-weld.

Therefore it is established that, with exception of the rotational restraint provided by the original J-Weld, the presence of the MNSA plus the remaining nozzle engagement after nozzle ejection maintains the original nozzle supporting characteristics such as strength, rigidity and boundary conditions with respect to the attached piping. The MNSA itself pairs up with the nozzle and because of its own stiffness provides added support to the nozzle without detrimentally affecting its natural frequency response behavior.

The ability of the MNSA to perform as a complete replacement of the J-weld was largely demonstrated by test. This was accomplished for the SONGS design by the hydrostatic and thermal cycle testing documented in Reference 3 and the severe seismic qualification testing of Reference 1 as augmented by the discussion of Reference 2. These references are now used to demonstrate seismic qualification of the WSES-3 MNSA designs by comparison to the much lower WSES-3 seismic pipe motions documented in Reference 8.

Specific WSES Questions are addressed as follows:

ABB CENP calculation S-[illegible]IG-CALC-008 and Waterford-3 document ER-W3-99-0198-00-00 state that CE ABB Test Report TR-PENG-033 prepared for San Onofre Units 2 & 3 states that a crack was simulated by seal welding the socket for the test specimen along only a 180° arc instead of the entire 360°.

Question 1. What is the basis for using 180°?

Response: *ABB CENP had proposed to do the SONGS testing using a 360° crack, because it tended to represent an idealized, worst break scenario for the nozzle itself. SONGS rationale for specifying a 180° crack was the notion that it not only better represented the most likely break scenario, but that it also would tend to impose an additional side loading into the Grafoil seal region.*

ABB CENP concurred with the SONGS request, primarily because we did not expect any real impact on the outcome of the seismic test (please note that earlier MNSA clamps had been tested).

Question 2: Does the TR-PENG-033 test report envelop the as-found crack conditions identified at Waterford SES Unit-3?

Response: *The Waterford leakage behavior and observations suggest the presence of minor axial cracks. One can, therefore, conclude that the remaining J-weld at WSES-3 is stronger than that simulated with a 180° crack. Nevertheless, as discussed above, ABB CENP does not believe that the length of the actual crack affects the primary conclusion of the testing which was designed to confirm that the MNSA seal provides its sealing function for nozzle loads above yield and thus well above the external nozzle limit loads implied via Reference 7 or any nozzle loads ever imparted due to seismic inertial loading which would be less than 50 lbs. for WSES-3 in either vertical or horizontal directions. The 50 lbs. is based on a conservatively assumed nozzle weight of 80 lbs. times a maximum spatial OBE acceleration of 0.6 Gs (per Reference 8)..*

Question 3. Would test report TR-PENG-033 envelop a complete through wall crack and/or weld failure?

Response: *Yes. In case the nozzle ejects and is in contact with the anti-ejection plate, the nozzle continues to be held firmly supported in the direction lateral to its axis inside the hot leg piping bore. In the axial direction the anti-ejection plate has been sized adequately to resist both initial impact loads and subsequent pressure loading of nearly 1,800 lbs. at operating conditions. Any imposed seismic load (maximum acceleration of 0.6 Gs for WSES, per Reference 8) remains small, and thus almost negligible, compared with impact, pressure and any external pipe loads permitted by Reference 7.*

Question 4. What is the basis for stating that "The MNSA is a mechanical device that acts as a complete replacement " (i.e. 360° crack – no weld) ...when the seismic test report (TR-PENG-033) which is the only documented leakage testing during a Design Basis Earthquake used a test specimen that was welded along a 180° to simulate a cracked weld condition?

Response: *The lateral nozzle fixity is basically the same for any of the following conditions: an original J-Weld condition with shim, a slightly cracked J-weld condition with shim, a 180° cracked J-weld condition with shim, a simulation of a 180° cracked J-weld condition with MNSA, and also a simulation of a 360° cracked J-weld condition with MNSA. This conclusion is based on the fact that a completely severed nozzle continues to be tightly held at both the bottom of the nozzle (because of tight clearances and rough crack contours) and at the Hot Leg OD (by the tightly fitting compression collar).*

Question 5: In addition to deflections of the nozzles resulting from a DBE, the nozzles are also subjected to external loads defined by ASME as "substantially no [illegible]" which are considered acceptable even as high as 10% of nozzle yield strength. Woul[illegible]rity of the MNSA's Grafoil seal be maintained?

Response: *The seismic test produced cyclical nozzle loads resulting in stresses in excess of 30,000 psi, approximately one order of magnitude higher than those permitted by Reference 7 as external loads. Since in all likelihood the external loads are principally caused by plant heat-up or cool-down, the total number of cycles is 500. During the seismic test the number of total event simulations exceeded 30, all of which must have imposed hundreds of significant loading cycles into both MNSA and nozzle in the seal region. Also taking credit for the sine sweep testing it is easily demonstrated that not only did the test exceed loads in the seal region by an order of magnitude, it also exceeded the number of cycles for which the MNSA has been qualified.*

Question 6: **ASME Section III, NB-3671.7(c) states that..."1. A prototype must be subjected to performance test to determine that safety of the joint under simulated service conditions. .... The mechanical joints shall be sufficiently leak tight to satisfy the requirements of the Design Specifications. or 2. Joints are designed in accordance with the rules of NB-3200. Based upon the comments above, what section of the ASME Code is applicable for the intended use of the MNSA Clamp at Waterford-3?**

Response: *The metal components of the MNSA are demonstrated to meet the ASME Code NB-3200 criteria. The Grafoil seal itself has been designed to fit into a controlled volume space which after compression during installation provides adequate pressure to seal against the primary fluid at hot leg operating conditions. Since the sealing performance cannot be demonstrated by analysis, the testing of References 1 and 3 was performed to qualify that aspect of the MNSA. Furthermore, all testing conditions were selected such that they would tend to envelope in a conservative fashion even the very unlikely assumption of a complete 360°, instantaneous crack occurrence.*

ABB

Inter-Office Correspondence

To: John McGarry

cc: Rhonda Doney KHH

Edward Siegel

Ken Margotta

Boris Nadgor

Cheryl Mendrala

C-PENG-99-004

K.H. Haslinger K.H. Haslinger

March 13, 1999

Subject: Documentation of MNSA Clamp Seismic Qualification for WSES-3 MNSAs

References:

1. ABB CENP Test Report TR-ESE-033, Rev. 00 "Seismic Qualification of the SONGS Units 2&3 MNSA Clamps for Pressurizer Instrument Nozzles and Hot Leg Nozzles."
2. ABB CENP Calculation S-PENG-CALC-008, Rev. 01, "Nozzle Loads for which SONGS Bottom Mounted PZR MNSA was Qualified."
3. ABB CENP Test Report TR-PENG-042, Rev. 00, "Test Report for MNSA Hydrostatic Test and Thermal Cycle Test."
4. ABB CENP Calculation C-PENG-CALC-018, Rev. 00, "Analysis of Waterford Unit 3 Hot Leg Sampling MNSA."
5. ABB CENP Calculation C-PENG-CALC-019, Rev. 00, "Analysis of Waterford Unit 3 Hot Leg PDT MNSA."
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Response: *ABB CENP had proposed to do the SONGS testing using a 360° crack, because it tended to represent an idealized, worst break scenario for the nozzle itself. SONGS rationale for specifying a 180° crack was the notion that it not only better represented the most likely break scenario, but that it also would tend to impose an additional side loading into the Grafoil seal region.*

ABB CENP concurred with the SONGS request, primarily because we did not expect any real impact on the outcome of the seismic test (please note that earlier MNSA clamps had been tested).

Question 2: Does the TR-PENG-033 test report envelop the as-found crack conditions identified at Waterford SES Unit-3?

Response: *The Waterford leakage behavior and observations suggest the presence of minor axial cracks. One can, therefore, conclude that the remaining J-weld at WSES-3 is stronger than that simulated with a 180° crack. Nevertheless, as discussed above, ABB CENP does not believe that the length of the actual crack affects the primary conclusion of the testing which was designed to confirm that the MNSA seal provides its sealing function for nozzle loads above yield and thus well above the external nozzle limit loads implied via Reference 7 or any nozzle loads ever imparted due to seismic inertial loading which would be less than 50 lbs. for WSES-3 in either vertical or horizontal directions. The 50 lbs. is based on a conservatively assumed nozzle weight of 80 lb. times a maximum spatial OBE acceleration of 0.6 Gs (per Reference 8)..*

Question 3. Would test report TR-PENG-033 envelop a complete through wall crack and/or weld failure?

Response: *Yes. In case the nozzle ejects and is in contact with the anti-ejection plate, the nozzle continues to be held firmly supported in the direction lateral to its axis inside the hot leg piping bore. In the axial direction the anti-ejection plate has been sized adequately to resist both initial impact loads and subsequent pressure loading of nearly 1,800 lbs. at operating conditions. Any imposed seismic load (maximum acceleration of 0.6 Gs for WSES, per Reference 8) remains small, and thus almost negligible, compared with impact, pressure and any external pipe loads permitted by Reference 7.*

Question 4. What is the basis for stating that "The MNSA is a mechanical device that acts as a complete replacement " (i.e. 360° crack – no weld) ...when the seismic test report (TR-PENG-033) which is the only documented leakage testing during a Design Basis Earthquake used a test specimen that was welded along a 180° to simulate a cracked weld condition?

Response: *The lateral nozzle fixity is basically the same for any of the following conditions: an original J-Weld condition with shim, a slightly cracked J-weld condition with shim, a 180° cracked J-weld condition with shim, a simulation of a 180° cracked J-weld condition with MNSA, and also a simulation of a 360° cracked J-weld condition with MNSA. This conclusion is based on the fact that a completely severed nozzle continues to be tightly held at both the bottom of the nozzle (because of tight clearances and rough crack contours) and at the Hot Leg OD (by the tightly fitting compression collar).*

Question 5: In addition to deflections of the nozzles resulting from a DBE, the nozzles are also subjected to external loads defined by ASME as "substantially no load" which are considered acceptable even as high as 10% of nozzle yield strength. Would the integrity of the MNSA's Grafoil seal be maintained?

Response: *The seismic test produced cyclical nozzle loads resulting in stresses in excess of 30,000 psi, approximately one order of magnitude higher than those permitted by Reference 7 as external loads. Since in all likelihood the external loads are principally caused by plant heat-up or cool-down, the total number of cycles is 500. During the seismic test the number of total event simulations exceeded 30, all of which must have imposed hundreds of significant loading cycles into both MNSA and nozzle in the seal region. Also taking credit for the sine sweep testing it is easily demonstrated that not only did the test exceed loads in the seal region by an order of magnitude, it also exceeded the number of cycles for which the MNSA has been qualified.*

Question 6: ASME Section III, NB-3671.7(c) states that..."1. A prototype must be subjected to performance test to determine that safety of the joint under simulated service conditions. .... The mechanical joints shall be sufficiently leak tight to satisfy the requirements of the Design Specifications. or 2. Joints are designed in accordance with the rules of NB-3200. Based upon the comments above, what section of the ASME Code is applicable for the intended use of the MNSA Clamp at Waterford-3?

Response: The metal components of the MNSA are demonstrated to meet the ASME Code NB-3200 criteria. The Grafoil seal itself has been designed to fit into a controlled volume space which after compression during installation provides adequate pressure to seal against the primary fluid at hot leg operating conditions. Since the sealing performance cannot be demonstrated by analysis, the testing of References 1 and 3 was performed to qualify that aspect of the MNSA. Furthermore, all testing conditions were selected such that they would tend to envelope in a conservative fashion even the very unlikely assumption of a complete 360°, instantaneous crack occurrence.