ATTACHMENT (5)

Non-Proprietary -- Design Report No. B-PENG-DR-006, Revision 02,

"Addendum to CENC-1187 Analytical Report for

BGE CCNPP Units 1 & 2 - Pressurizers"

WESTINGHOUSE NON-PROPRIETARY CLASS 3

Report: 14 pages
Appendices: 248 pages
Other Attachments: none

DESIGN REPORT NO. B-PENG-DR-006, Rev. 02

Addendum to CENC-1187
Analytical Report for
Baltimore Gas and Electric Calvert Cliffs Station
Units No. I and II
Pressurizers

ABB COMBUSTION ENGINEERING NUCLEAR POWER, INC
WINDSOR, CONNECTICUT

VERIFICATION STATUS: COMPLETE WITH CONTINGENCIES/ASSUMPTIONS

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B. Nadgor, Cognizant Engineer

Approved by: Thomas D. Hammel Date: 4/6/00
T. D. Hammel, Independent Reviewer

Approved by: C. J. Gimbrone Date: 4/6/2000
C. J. Gimbrone, Supervisor

It is hereby certified this report is in compliance with the requirements of the ASME Boiler and Pressure Vessel Code, Section III, 1989 Edition, no Addenda.

Certified by: Karl H. Haslinger
Registration No. 10990
State of Connecticut
Date April 6, 2000

Contingencies and Assumptions

Title: Addendum to CENC-1187 Analytical Report for Baltimore Gas and Electric Calvert Cliffs Station Units I and II Pressurizers

Document Number: B-PENG-DR-006 Revision Number: 02

Project Manager: John. T. McGarry

Project Number: 2009335

Instructions: A copy of this form shall be sent to the cognizant Project Manager who shall be responsible for assuring that Internal Contingencies and Assumptions are cleared and External Contingencies and Assumptions are transmitted to the customer.

Type of Contingency/Assumption	Contingency/Assumption
☒ Internal ☐ External	The analysis of the Heater Sleeve MNSA (Attachments E, F, and G) is based on the following draft (not issued) drawings: E-MNSABGE-228-003, Rev. 02, and E-MNSA-228-021, Rev. 02.

RECORD OF REVISIONS

Rev	Date	Pages Changed	Prepared By	Reviewed By	Approved By
00	01/05/99	Original	B. Nadgor	T. D. Hammel	K. H. Haslinger
01	03/01/00	Pages 1 - 4, 6, 7, A36, B13, B43, F40, F41 Added Attachment H Attachment I (was H) Only those pages changed in this revision show Revision 01 in the header	B. Nadgor	T. D. Hammel	K. H. Haslinger
02	04/06/00	Pages 1 – 5, 7, 9, 10, 13, A2, A3, A5, A10 - A14, A16 – A17, A20, A29, A30, A40, A41, Added Sections 3.3.6 and 3.4.4, B8, B15-B19, B24, B31, B32, B38 - B44 Replaced Attachment D Attachments which are not affected by this revision do not show Revision 02 in the header	B. Nadgor	T. D. Hammel	K. H. Haslinger

ABSTRACT

The Baltimore Gas and Electric Calvert Cliffs Station Units I and II, Mechanical Nozzle Seal Assemblies (MNSA), to be installed on the Pressurizer Side RTD, Upper and Bottom Nozzles, as well as the Heater Sleeves, are designed and fabricated to satisfy the requirements of the ASME Code, Section III.

The components of each MNSA replace the pressure boundary previously assumed to be the J-weld connecting the nozzle to the pipe. Four holes are required in the Pressurizer for the installation of each MNSA assembly. The impact of these holes on the design basis of the Pressurizer is also examined in this design report.

These components are analyzed in accordance with:

1. Engineering Specification No. 8067-31-4, Rev. 10.
2. Design Specification No. SP-0846, Rev. 00.
3. ASME Boiler and Pressure Vessel Code, Section III, 1989 Edition, no Addenda.

The acceptability of the design is established by the results of the detailed structural and thermal analyses contained in this report.

Revision 01 is performed to clear some internal contingencies contained in Revision 00 of this document and to incorporate the latest revisions of the drawings. Also, this revision justifies the increased installation torque on hold down bolts (see Attachment H).

Revision 02 is primarily performed to address the effect of field measurements on the Upper Pressurizer MNSA and certain design changes of the Side Pressurizer MNSA on the results of the analyses. Such evaluations are presented in Attachments A, B and D.

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LIST OF ATTACHMENTS

F	Analysis of BG&E Units I and II Heater Sleeve MNSA
G	ANSYS Evaluation of Heater Sleeve Top Plate
H	Torquing on Hold Down Bolts
I	Quality Assurance Forms

1.0 INTRODUCTION

This design report summarizes the analyses performed for the installation of Mechanical Nozzle Seal Assemblies (MNSA) on three Pressurizer nozzles, as well as Heater Sleeves. The MNSA is a mechanical device that acts as a complete replacement of the "J" weld between an Inconel 600 instrument nozzle and the Pressurizer. Its function 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. The potential for these events exists due to Primary Water Stress Corrosion Cracking.

The components of the MNSA, as well as the impact of the MNSA installation on the Pressurizer, are analyzed in accordance with the ASME Code, Section III, 1989 Edition, no Addenda (Reference 3.4).

Revision 01 is performed to clear the internal contingencies contained in Revision 00 of this document and to incorporate the latest revisions of the MNSA drawings. It also justifies the increased installation torque on hold down bolts (see Attachment H).

Revision 02 is primarily performed to address the effect of field measurements on the Upper Pressurizer MNSA and certain design changes of the Side Pressurizer MNSA on the results of the analyses.

2.0 SIGNIFICANT RESULTS

Reference 3.5 defines the current design basis documents for the Pressurizer.

The only Baltimore Gas and Electric Calvert Cliffs Station Units I and II Pressurizer design report affected by this addendum is CENC-1187. The list of design report addenda below remain applicable to the Pressurizer and are not modified by this addendum.

CENC-1235	(03/75)
CENC-1514	(03/82)
CENC-1890	(12/89)
B-MECH-DR-002, Rev. 00	(08/93)
B-PENG-DR-001, Rev. 00	(04/95)

The results of this design report are in accordance with the ASME Boiler and Pressure Vessel Code, Section III allowables (Reference 3.4).

2.1 *Side Pressurizer RTD Nozzle MNSA*

Attachment A contains the detailed analysis of the Side Pressurizer RTD Nozzle MNSA components. The following table summarizes the results for the Side Pressurizer RTD Nozzle MNSA components. The existing design analysis for the Pressurizer RTD Nozzle is not affected by the addition of the MNSA.

2.2 *Upper and Bottom Pressurizer Nozzle MNSA*

Attachment B contains the detailed analysis of the Pressurizer Upper and Bottom Nozzle MNSA components. The following table summarizes the results for the Pressurizer Upper and Bottom Nozzle MNSA components. The existing design analysis for the Pressurizer Upper and Bottom nozzles is not affected by the addition of the MNSA.

2.3 *Heater Sleeve MNSA*

Attachment F contains the detailed analysis of the Heater Sleeves MNSA components. The following table summarizes the results for the Heater Sleeves MNSA components. The existing design analysis for the Pressurizer Heater Sleeves is not affected by the addition of the MNSA.

2.4 MNSAs in Pressurizer

Attachment D contains the detailed evaluation of the attachment locations for Side RTD, Upper and Bottom Nozzle MNSAs, as well as Heater Sleeves, and stress analysis considering a modification in the Upper and Bottom nozzles on the nozzle outside surface. The results of this evaluation are shown below:

2.4.1 Maximum Allowable Bolt Load and Minimum Allowable Length of Bolt Engagement

[ ]

2.4.2 Area of Reinforcement Requirements for Nozzle Penetration

[ ]

2.4.3 Primary plus Secondary Stress Intensity Range

For the Upper and Bottom Pressurizer MNSA tapped holes:

[ ]

2.4.4 Fatigue Usage Factor

[ ]

2.4.5 Primary plus Secondary Stress Intensity Range and Fatigue Evaluation of Modified Upper, Side and Bottom Nozzles

[ ]

2.4.6 Maximum Allowable Shear Load in the Grooved Section of the Upper, Side and Bottom Nozzles

[ ]

2.4.7 Maximum Allowable Shear Load in the Heater Sleeve MNSA

[ ]

3.0 REFERENCES

3.1 "Analytical Report for Baltimore Gas & Electric Calvert Cliffs Station Units I and II Pressurizers," Report No. CENC-1187, July 1972.

3.2 "Mechanical Nozzle Repair Device", BGE Design Specification No. SP-0846, Rev. 00.

3.3 "Engineering Specification for a Pressurizer Assembly for Baltimore Gas and Electric Calvert Cliffs Station", Specification No. 8067-31-4, Revision 10.

3.4 American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III, 1989 Edition (No Addenda).

3.5 ABB CENP Letter No. B-PENG-00-001, "Design Input for the MNSA Evaluations, Project No. 2009335", January 2000.

ATTACHMENT A

ANALYSIS OF BG&E UNITS I AND II SIDE PRESSURIZER RTD NOZZLE MNSA

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LIST OF FIGURES

1. INTRODUCTION

1.1 Objective

The objective of this calculation is to present the results of the evaluation of the Mechanical Nozzle Seal Assembly (MNSA) to be installed on the Pressurizer Side RTD nozzle at the Baltimore Gas & Electric Calvert Cliffs Station Units I and II.

The MNSA is a mechanical device that acts as a complete replacement of the "J" weld between an Inconel 600 instrument nozzle and the Pressurizer. Its function is to prevent leakage and restrain the nozzle from ejecting in the event of a through-wall crack or weld failure of a nozzle. The potential for these events exists due to Primary Water Stress Corrosion Cracking.

1.2 Assessment of Significant Design Changes

This report presents the detailed structural and thermal analyses required to substantiate the adequacy of the design of the BG&E, Calvert Cliffs Units I and II Mechanical Nozzle Seal Assembly as a replacement of the nozzle "J" weld. This analytical work encompasses the requirements set forth in Reference 5.1 and is performed in accordance with the requirements of the ABB CENO Quality Procedures Manual QPM-101 (Reference 5.2).

Addenda to the original Pressurizer Design Report (Reference 5.3) were reviewed and it was determined that their results have no impact on the current analysis and also that the current analysis does not impact their results.

2. DESIGN INPUTS

2.1 Selection of Design Inputs

2.1.1 Design and Operating Pressures and Temperatures

The Mechanical Nozzle Seal Assembly is considered a pressure-retaining component. The Design Pressure is 2500 psia and Design Temperature is 700°F. Operating pressure and temperature are 2250 psia and 653°F, respectively. Ambient design temperature is 140°F (Reference 5.7).

2.1.2 MNSA Materials

MNSA materials are taken from Reference 5.8.

Item	Material
Compression Collar	SA-479, Type 304
Lower Flange	SA-479, Type 304
Upper Flange	SA-479, Type 304
Top Plate	SA-479, Type 304
Clamp	SA-479, Type 304
Hex Head Bolt	SA-453, Grade 660
Hex Nut	SA-453, Grade 660
Tie Rod	SA-453, Grade 660
Hex Bolt - Clamp	SA-453, Grade 660

2.1.3 Nozzle Materials

Pressurizer Side RTD Nozzle and fitting materials are taken from References 5.5, 5.12.

Item	Material	Reference
Nozzle	SB-166	5.12
Safe End	SA-182, Type 316	5.12
Thermowell	SB-166	5.5

2.1.4 Material Properties

Material properties used in this analysis include coefficients of thermal expansion (α), moduli of elasticity (E), design stress intensity values (S_m) and Yield Strength Values (S_y). These properties are presented below and are found in the Appendices of Reference 5.9.

2.1.5 MNSA Component Dimensions

2.1.6 Nozzle and Thermowell Dimensions

2.2 Assumptions

2.2.1 Loading Conditions

2.2.2 Consideration of Seismic Loads

Because of the nature of the accelerations from seismic events, only the tie rods will be evaluated for the stress effects of the seismic event. The remaining MNSA components will not be significantly affected. Separate seismic tests on a similar MNSA configuration were performed to demonstrate an adequate seal performance (see Reference 5.16).

2.2.3 Friction Force

The effects of any impact of the nozzle against the top plate are dependent upon certain assumptions regarding the determination of the ejection force acting on the nozzle.

In an "ideal" (and worst case) break scenario, the crack would be complete, instantaneous and oriented such that no base or weld metal could interfere with the motion of the nozzle. In this case, the only resistance offered to the nozzle motion would be provided by the attached piping and by the Grafoil seal.

2.2.4 Sealing pressure

2.2.5 Preload

Nominal values of tie rod/bolt preload are used in this analysis since maximum values of preload will not significantly increase corresponding preload stresses. (A check of the results indicate that use of the maximum preload values will result in stresses which will remain below, or will be on the order of, their respective allowables. Therefore, use of the nominal values is acceptable).

2.2.6 Dimensions

3. ANALYSIS

3.1 MNSA Description

The MNSA is a mechanical device that acts as a complete replacement of the "J" weld between an Inconel 600 instrument nozzle and the Pressurizer. It replaces the sealing function of the weld using a Grafoil seal compressed at the nozzle outside diameter to the outer Pressurizer surface. The MNSA also replaces the weld structurally by means of threaded fasteners engaged in tapped holes in the outer Pressurizer vessel surface, and a restraining plate held in place by threaded tie rods. This feature prevents the nozzle from ejecting from the Pressurizer vessle, should the "J" weld fail or the nozzle develop a circumferential crack.

A sketch of the Side Pressurizer RTD MNSA is depicted in Figure 1 below.

FIGURE 1
Side Pressurizer RTD MNSA

3.2 Consideration of Impact Load

3.2.1 Relative Displacements Due to Thermal Expansion

3.2.2 Soft Spring Package Setting vs. Calculated Displacements

3.2.3 Determination of Impact Force

3.2.4 Impact Force

3.3 *Stresses in the Side RTD MNSA Components*

The Design Loads for the various MNSA components will be a function of either bolt preload, the impact load, and/or thermal expansion loads, depending upon the effects of the source load upon a particular component.

3.3.1 Tie Rod

3.3.2 Hex Head Bolt

3.3.2.1 Design Bolt Load Stresses (NB-3231 and Appendix E)

Design Bolt Load for the Design Pressure, W_{m1}

3.3.3 Top Plate

3.3.4 Compression Collar

3.3.5 Upper Flange

3.3.6 Clamp

The nozzle clamp is designed to fit tight against the nozzle and to transmit any axial load uniformly into the MNSA top plate. The load transfer between the clamp and the nozzle occurs due to contact/shear at the engaged tooth of the nozzle/clamp design and does not rely on friction.

3.3.6.1 Hex Head Bolt – Clamp

3.4 Fatigue Analysis

The fatigue analysis of the components will conservatively consider loads which may exist on the components after weld or nozzle failure has occurred. Prior to failure, components will be subjected to loads due mainly to preload and thermal expansion. After failure, and assuming that the nozzle/thermowell is free to move, certain components will be additionally stressed because of the internal pressure forcing the nozzle/thermowell up against the top plate. The load on these components would be cyclical, given the change in pressure and temperature that occurs as the plant heats up and then cools down.

The critical components for fatigue analysis purposes are the tie rod and hex head bolt, on the basis of:

- preload tensile stresses
- thermal expansion tensile stresses
- stress concentrations in the threaded sections, and
- for the levels of stresses involved, a more restrictive number of allowable cycles (versus the stainless steel MNSA components; see Table I-9.1 of Reference 5.9)

[ ]

3.4.1 Normal Operating Pressure Force

[ ]

3.4.2 Tie Rods

3.4.2.1 Peak Stress

[ ]

There are other Normal and Upset transients which are defined for the Pressurizer (per Reference 5.7), but their contribution to fatigue in the tie rod is not significant.

3.4.3 Hex Head Bolt

3.4.4 Hex Head Bolt - Clamp

3.5 Consideration of Hydrostatic Test Pressure Conditions

3.6 Consideration of Faulted Conditions

4. SUMMARY OF RESULTS

The results presented below were determined using the assumptions defined and justified in Section 2.0. There are no additional contingencies or assumptions that are applicable to these results.

All stresses are satisfactory and meet the appropriate allowable limits set forth in Section III of the ASME Boiler and Pressure Vessel Code (Reference 5.9).

5. REFERENCES

5.1 ABB Project Plan No. B-NOME-IPQP-0287 Rev. 0, "Mechanical Nozzle Repair Devices (MNRD) for PZR Bottom Nozzles, PZR Side Nozzles, PZR Upper Nozzles, Hot Leg RTD Nozzles, Hot Leg PDT/Sampling Nozzles, PZR Heater Sleeves", September 1999.

5.2 ABB Combustion Engineering Nuclear Power Quality Procedures Manual QPM-101, Revision 03.

5.3 "Analytical Report for Baltimore Gas and Electric Calvert Cliffs Station Units I and II Pressurizers," Report No. CENC-1187, July 1972.

5.4 Dedication Reports No.
1. 9481-99-140-1A, Rev. 0, January 2000
2. 9481-99-152-1A, Rev. 0, January 2000.

5.5 Rosemount Drawing No. 104-852, Rev. 04, "Thermowell".

5.6 ABB CE Drawing No. E-232-634, Rev. 10, "Nozzle Details"

5.7 BGE Design Specification No. SP-0846, Rev. 00, "Mechanical Nozzle Repair Device".

5.8 ABB Drawing No.
1. E-MNSABGE-228-006, Revision 05, "Side Pressurizer RTD Mechanical Nozzle Seal Assembly"
2. E-MNSA-228-004, Revision 06, "Mechanical Nozzle Seal Assembly Details"
3. E-MNSA-228-020, Revision 06, "Mechanical Nozzle Seal Assy Details"

5.9 American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III, 1989 Edition (No Addenda).

5.10 "Test Report for MNSA Hydrostatic and Thermal Cycle Tests," Test Report No. TR-PENG-042, Rev.00.

5.11 "Roark's Formulas for Stress and Strain," Warren C. Young, Sixth Edition, 1989, McGraw-Hill.

5.12 ABB CE Drawing No. E-232-634, Rev. 10, "Nozzle Details".

5.13 American National Standard, Unified Inch Screw Threads, ANSI B1.1 - 1982.

5.14 "Engineering Mechanics: Statics and Dynamics", F. L. Singer, Third Edition, Harper & Row, New York, 1975.

5.15 "How to Calculate and Design for Stress in Preloaded Bolts", A. G. Hopper and G. V. Thompson, Product Engineering, 1964.

5.16 Engineering Report No. B-NOME-ER-0133, Revision 00, "Design Evaluation of MNSA for Various Applications at BG&E Units 1, and 2", January 2000.

5.17 "Mechanical Engineers' Handbook", M. Kutz, ed., John Wiley & Sons, Inc., 1986.

5.18 "Strength of Materials", F. L. Singer, Second Edition, Harper & Row, New York, 1962

5.19 Union Carbide Grafoil, "Engineering Design Manual, " Volume One, Sheet and Laminated Products, by R. A. Howard, 1987.

5.20 ABB CENP Calculation No. B-PENG-CALC-022, Revision 00, "Analysis of BG&E Hot Leg and Pressurizer MNSAs Seismic Accelerations", November 1999.

ATTACHMENT B

ANALYSIS OF BG&E UNITS I AND II UPPER AND BOTTOM PRESSURIZER NOZZLE MNSA

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1. INTRODUCTION

1.1 Objective

The objective of this calculation is to present the results of the evaluation of the Mechanical Nozzle Seal Assembly (MNSA) to be installed on the Pressurizer Upper and Bottom nozzles at the Baltimore Gas & Electric Calvert Cliffs Station Unit I and II.

The MNSA is a mechanical device that acts as a complete replacement of the "J" weld between an Inconel 600 instrument nozzle and the Pressurizer. Its function is to prevent leakage and restrain the nozzle from ejecting in the event of a through-wall crack or weld failure of a nozzle. The potential for these events exists due to Primary Water Stress Corrosion Cracking.

1.2 Assessment of Significant Design Changes

This report presents the detailed structural and thermal analyses required to substantiate the adequacy of the design of the BG&E, Calvert Cliffs Units I and II Mechanical Nozzle Seal Assembly as a replacement of the nozzle "J" weld. This analytical work encompasses the requirements set forth in Reference 5.1 and is performed in accordance with the requirements of the ABB CENO Quality Procedures Manual QPM-101 (Reference 5.2).

Addenda to the original Pressurizer Design Report (Reference 5.3) were reviewed and it was determined that their results have no impact on the current analysis and also that the current analysis does not impact their results.

2. DESIGN INPUTS

2.1 Selection of Design Inputs

2.1.1 Design and Operating Pressures and Temperatures

The Mechanical Nozzle Seal Assembly is considered a pressure-retaining component. The Design Pressure is 2,500 psia and Design Temperature is 700°F. Operating pressure and temperature are 2,250 psia and 653°F, respectively. Ambient design temperature is 140°F (Reference 5.7).

2.1.2 MNSA Materials

MNSA materials are taken from Reference 5.8.

Item	Material
Compression Collar	SA-479, Type 304
Lower Flange	SA-479, Type 304
Upper Flange	SA-479, Type 304
Top Plate	SA-479, Type 304
Clamp	SA-479, Type 304
Hex Head Bolt	SA-453, Grade 660
Hex Nut	SA-453, Grade 660
Tie Rod	SA-453, Grade 660
Hex Bolt - Clamp	SA-453, Grade 660
Socket Head Shoulder Screw	SA-453, Grade 660

2.1.3 Nozzle Materials

Pressurizer Upper and Bottom Nozzle materials are taken from Reference 5.6.

Item	Material
Nozzle	SB-166
Safe End	SA-182, Type 316

2.1.4 Material Properties

Material properties used in this analysis include coefficients of thermal expansion (α), Moduli of Elasticity (E), design stress intensity values (S_m), and Yield Strength Values (S_y). These properties are presented below and are found in the Appendices of Reference 5.9.

2.1.5 MNSA Component Dimensions

[ ]

2.1.6 Nozzle Dimensions

[ ]

2.2 *Assumptions*

2.2.1 Loading Conditions

2.2.2 Consideration of Seismic Loads

Because of the nature of the accelerations from seismic events, only the tie rods will be evaluated for the stress effects of the seismic event. The remaining MNSA components will not be significantly affected. Separate seismic tests on a similar MNSA configuration were performed to demonstrate an adequate seal performance (see Reference 5.16).

2.2.3 Friction Force

The effects of any impact of the nozzle against the top plate are dependent upon certain assumptions regarding the determination of the ejection force acting on the nozzle.

In an "ideal" (and worst case) break scenario, the crack would be complete, instantaneous and oriented such that no base or weld metal could interfere with the motion of the nozzle. In this case, the only resistance offered to the nozzle motion would be provided by the attached piping and by the Grafoil seal.

2.2.4 Sealing pressure

2.2.5 Preload

Nominal values of tie rod/bolt preload are used in this analysis since maximum values of preload will not significantly increase corresponding preload stresses. (A check of the results indicate that use of the maximum preload values will result in stresses which will remain below, or will be on the order of, their respective allowables. Therefore, use of the nominal values is acceptable).

2.2.6 Dimensions

Nominal design dimensions of the parts were used for the calculations of the relative displacement and for the stress analysis, except when noted.

3. ANALYSIS

3.1 MNSA Description

The MNSA is a mechanical device that acts as a complete replacement of the "J" weld between an Inconel 600 instrument nozzle and the Pressurizer. It replaces the sealing function of the weld using a Grafoil seal compressed at the nozzle outside diameter to the outer Pressurizer surface. The MNSA also replaces the weld structurally by means of threaded fasteners engaged in tapped holes in the Pressurizer surface, and a restraining plate held in place by threaded tie rods. This feature prevents the nozzle from ejecting from the Pressurizer, should the "J" weld fail or the nozzle develop a circumferential crack.

A sketch of the Pressurizer Upper and Bottom MNSA is depicted in Figures 1 below.

FIGURE 1
Pressurizer Upper and Bottom MNSA

3.2 Consideration of Impact Load

3.2.1 Relative Displacements Due to Thermal Expansion

3.2.2 Soft Spring Deflection Setting vs. Calculated Displacements

3.2.3 Determination of Impact Force

3.2.4 Impact Force

3.3 *Stresses in the Upper and Bottom MNSA Components*

The Design Loads for the various MNSA components will be a function of either bolt preload, the impact load, and/or thermal expansion loads, depending upon the effects of the source load upon a particular component.

3.3.1 Tie Rod

3.3.2 Hex Head Bolt

3.3.3 Top Plate

3.3.4 Compression Collar

3.3.5 Upper Flange

3.3.6 Socket Head Shoulder Screw

3.3.7 Clamp

The nozzle clamp is designed to fit tight against the nozzle and to transmit any axial load uniformly into the MNSA top plate. The load transfer between the clamp and the nozzle occurs due to contact/shear at the engaged tooth of the nozzle/clamp design and does not rely on friction.

3.3.7.1 Hex Head Bolt - Clamp

3.4 *Fatigue Analysis*

The fatigue analysis of the components will conservatively consider loads which may exist on the components after weld or nozzle failure has occurred. Prior to failure, components will be subjected to loads due mainly to preload and thermal expansion. After failure, and assuming that the nozzle/clamp is free to move, certain components will be additionally stressed because of the internal pressure forcing the nozzle/clamp up against the top plate. The load on these components would be cyclical, given the change in pressure and temperature that occurs as the plant heats up and then cools down.

The critical components for fatigue analysis purposes are the tie rod and hex head bolts, on the basis of:

- preload tensile stresses
- thermal expansion tensile stresses
- stress concentrations in the threaded sections, and
- for the levels of stresses involved, a more restrictive number of allowable cycles (versus the stainless steel MNSA components; see Table I-9.1 of Reference 5.9)

3.4.1 Normal Operating Pressure Force

3.4.2 Tie Rods

3.4.2.1 Peak Stress

There are other Normal and Upset transients which are defined for the Pressurizer (per Reference 5.7), but their contribution to fatigue in the tie rod is not significant.

3.4.3 Hex Head Bolt

3.4.4 Hex Head Bolt - Clamp

[ ]

3.5 Consideration of Hydrostatic Test Pressure Conditions

[ ]

3.6 Consideration of Faulted Conditions

[ ]

4. SUMMARY OF RESULTS

The results presented below were determined using the assumptions defined and justified in Section 2.0. There are no additional contingencies or assumptions that are applicable to these results.

All stresses are satisfactory and meet the appropriate allowable limits set forth in Section III of the ASME Boiler and Pressure Vessel Code (Reference 5.9).

5. REFERENCES

5.1 ABB Project Plan No. B-NOME-IPQP-0287 Rev. 0, "Mechanical Nozzle Repair Devices (MNRD) for PZR Bottom Nozzles, PZR Side Nozzles, PZR Upper Nozzles, Hot Leg RTD Nozzles, Hot Leg PDT/Sampling Nozzles, PZR Heater Sleeves", September 1999.

5.2 ABB Combustion Engineering Nuclear Power Quality Procedures Manual QPM-101, Revision 03.

5.3 "Analytical Report for Baltimore Gas & Electric Calvert Cliffs Station Units I and II Piping," Report No. CENC-1179, March 1972.

5.4 Dedication Reports No.
1. 9481-99-140-1A, Rev. 0, January 2000
2. 9481-99-152-1A, Rev. 0, January 2000.

5.5 Union Carbide Grafoil, "Engineering Design Manual, " Volume One, Sheet and Laminated Products, by R. A. Howard, 1987.

5.6 ABB CE Drawing No. E-232-634, Rev. 10, "Nozzle Details". |

5.7 BGE Design Specification No. SP-0846, Rev. 00, "Mechanical Nozzle Repair Device".

5.8 ABB CE Drawing No.
1. E-MNSABGE-228-005, Revision 04, "Upper Pressurizer Mechanical Nozzle Seal Assembly" |
2. E-MNSABGE-228-007, Revision 03, "Bottom Pressurizer Mechanical Nozzle Seal Assembly"
3. E-MNSA-228-020, Revision 06, "Mechanical Nozzle Seal Assy Details" |
4. E-MNSA-228-004, Revision 06, "Mechanical Nozzle Seal Assembly Details"

5.9 American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III, 1989 Edition (No Addenda).

5.10 "Test Report for MNSA Hydrostatic and Thermal Cycle Tests," Test Report No. TR-PENG-042, Rev.00.

5.11 "Roark's Formulas for Stress and Strain," Warren C. Young, Sixth Edition, 1989, McGraw-Hill.

5.12 ANSI Standards for Threads, Appendix B, B1.1, 1982.

5.13 "Engineering Mechanics: Statics and Dynamics", F. L. Singer, Third Edition, Harper & Row, New York, 1975.

5.14 "Mechanical Engineers' Handbook", M. Kutz, ed., John Wiley & Sons, Inc., 1986.

5.15 "How to Calculate and Design for Stress in Preloaded Bolts", A. G. Hopper and G. V. Thompson, Product Engineering, 1964.

5.16 Engineering Report No. B-NOME-ER-0133, Revision 00, "Design Evaluation of MNSA for Various Applications at BG&E Units I and II", January 2000.

5.17 "Strength of Materials", F. L. Singer, Second Edition, Harper & Row, New York, 1962

5.18 ABB CENP Report No. MISC-ME-C-230, Revision 02, "Software Verification and Validation Report - ANSYS Version 5.3 on HP9000/800 Series Machines with the HP-UX 10.20 Operating System", December 1998.

5.19 ABB CENP Calculation No. B-PENG-CALC-022, Revision 00, "Analysis of BG&E Hot Leg and Pressurizer MNSAs Seismic Accelerations", November 1999.

5.20 BG&E Drawing No. E-9343-C090-024, Rev. 1, "Upper Instrument Nozzle 96 I.D. Pressurizer".

5.21 ABB Letter No. NOME-00-B1-0106, from J. T. McGarry to Joe Richards, "Mechanical Nozzle Repair Devices (MNRD), BGE Purchase Order 42874, Upper Pressurizer Nozzles on Unit 1", March 27, 2000.

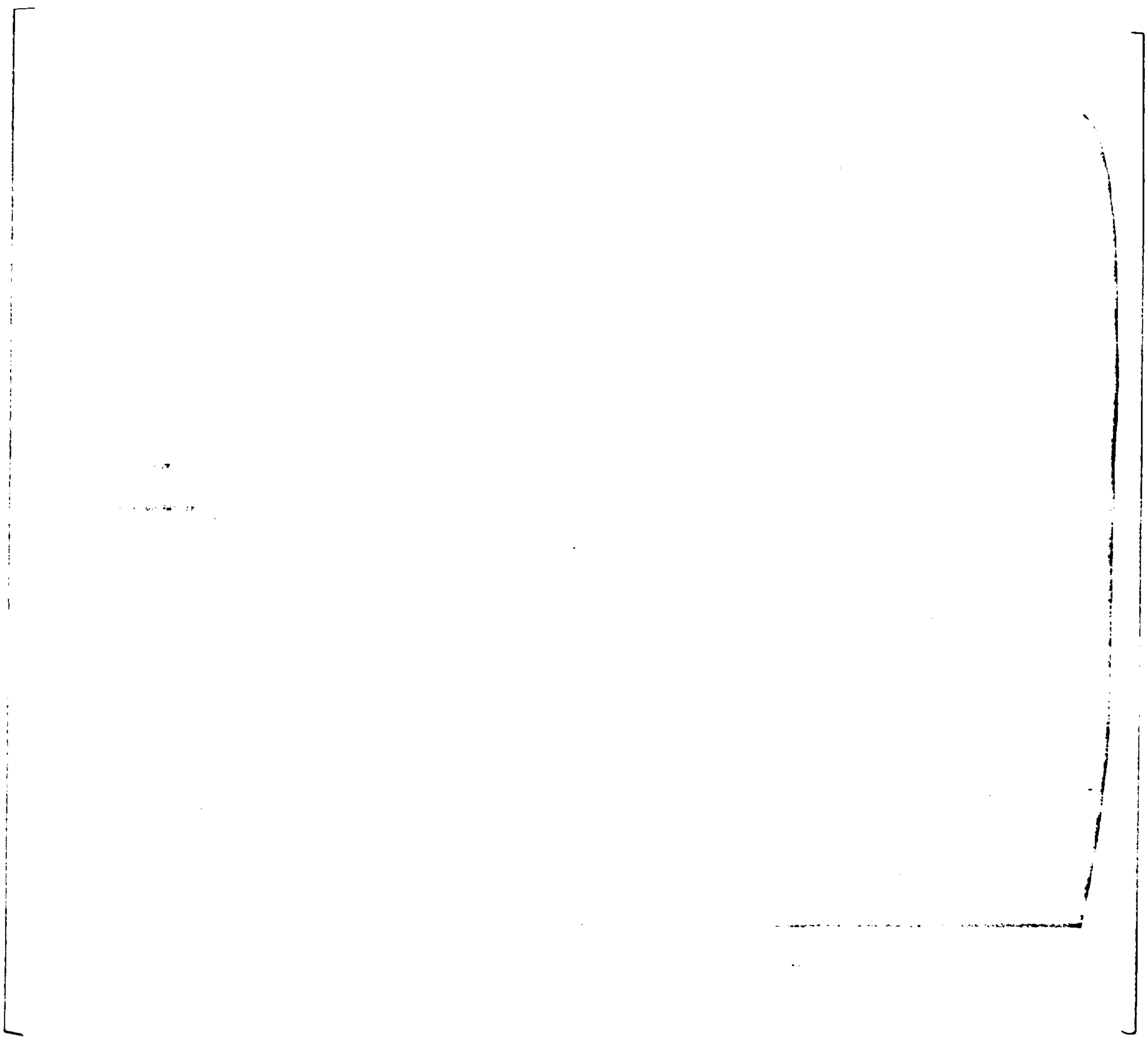
ATTACHMENT C

ANSYS EVALUATION OF TOP PLATE

This Attachment contains the figure of the ANSYS model used to obtain the stiffness and the stresses of the MNSA top plate, as well as the resulting output file from the computer run. The output file printed here contains an echo print of the input file used.

FIGURE C1.

Element Plot of ANSYS Top Plate Model



ATTACHMENT D

CALCULATION No. A-CCNPP-9449-1229, Rev. 01
"Evaluation of Attachment Locations for Mechanical Nozzle Repair Devices on Baltimore Gas and Electric Company Calvert Cliffs Nuclear Power Plant Units 1 and 2 Pressurizer Top Head, Shell, and Bottom Head Instrument Nozzles and Heater Sleeves"

(56 pages including cover)

SUMMARY OF CONTENTS	
Calculation	49 Pages
Appendices	0 Pages
Attachments	6 Pages
Diskette Attached	_ Yes X No

EVALUATION OF ATTACHMENT LOCATIONS FOR MECHANICAL NOZZLE REPAIR DEVICES ON BALTIMORE GAS AND ELECTRIC COMPANY CALVERT CLIFFS NUCLEAR POWER PLANT UNITS 1 AND 2 PRESSURIZER TOP HEAD, SHELL, AND BOTTOM HEAD INSTRUMENT NOZZLES AND HEATER SLEEVES

A-CCNPP-9449-1229, REV. 01

Quality Class: QC-1 (Safety-Related)

Contingencies: None

PURPOSE: To evaluate the structural integrity of the attachment locations for the mechanical nozzle repair devices about the pressurizer top head, shell, and bottom head instrument nozzles as well as the heater sleeves.

This Design Analysis is complete and verified. Management authorizes the use of its results.

PREPARED BY: B. A. Bell *Bruce A. Bell* DATE: 4/05/00

VERIFICATION STATUS: COMPLETE

The Safety-Related design information contained in this document has been verified to be correct by means of Design Review using the Checklist in QP-3.4 of QPM-101.

Name J. G. Thakkar Signature *J. G. Thakkar* Date 04/05/2000
Independent Reviewer

APPROVED BY: D. P. Siska *DP Siska* DATE: 4-5-2000

ABB COMBUSTION ENGINEERING
CHATTANOOGA, TENNESSEE

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RECORD OF REVISIONS

NUMBER	DATE	PARAGRAPH(s) INVOLVED	PREPARED BY	INDEPENDENT REVIEWER	APPROVED BY
0	11/12/99	Original Issue	B. A. Bell 11/12/99	J. D. Key 12/01/99	D. P. Siska 12/01/99
1	4/05/00	Sections 1.0, 3.0, 5.0, 6.0 (pages 7, 8, 38 – 44), 7.0, & 8.0	B. A. Bell B. A. Bell 4/05/00	J. G. Thakkar J. G. Thakkar 04/05/2000	D. P. Siska D. P. Siska 4-5-2000

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TABLE OF CONTENTS

1.0 OBJECTIVE OF THE DESIGN ANALYSIS

This report investigates the structural integrity of the attachment locations for the Mechanical Nozzle Repair Devices (MNRD) on Baltimore Gas and Electric Company (BGE) Calvert Cliffs Nuclear Power Plant Units 1 and 2 pressurizer top head, shell, and bottom head instrument nozzles as well as the heater sleeves. The MNRDs are described in Reference 3 along with the Project Plan (Reference 13). A MNRD is attached to the outside surface of the pressurizer by four or six ½-inch bolts, depending upon the application. The eight objectives of this analysis relate to the machined tapped holes made in the pressurizer top head, shell, and bottom head to receive the MNRD attachment bolts as well as the grooved section on the top and bottom head and shell nozzles and the heater sleeves where the MNRD clamp is attached. The objectives are:

The results of this analysis will demonstrate that the use of a MNRD on the pressurizer top head, side, bottom head nozzles, and heater sleeves will comply with the ASME Code requirements. This analysis can be used for future repair work on any other leaking partial penetration nozzles provided their criteria are the same as those used in this report.

2.0 ASSESSMENT OF SIGNIFICANT DESIGN CHANGES

The "as-designed" configurations for the pressurizer top head, shell, and bottom head walls and partial penetration nozzles defined in References 12A through 12F are considered. The design conditions and operating transients (TNS) as presented in References 1 and 8 are not changed by the results of this analysis.

3.0 ANALYTICAL TECHNIQUES

4.0 SELECTION OF DESIGN INPUTS

The operating conditions for the BGE Calvert Cliffs Nuclear Power Plant Units 1 and 2 pressurizer at 100% power along with the design conditions from References 1 and 8 are as follows:

Normal Operating Pressure:	2250 psia
Normal Operating Temperature:	653 °F
Design Pressure:	2500 psia
Design Temperature:	700 °F

The transient conditions for the Units 1 and 2 pressurizer are from Reference 1, page 4, and detailed in Sections 6.2 through 6.5.

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5.0 ASSUMPTIONS

The assumptions included in this design analysis are:

6.0 DETAILED ANALYSIS

This section contains the structural evaluation of the attachment locations for the mechanical nozzle repair devices (MNRD) on the Calvert Cliffs Units 1 and 2 pressurizer top head, shell, and bottom head instrument nozzles as well as the heater sleeves. The evaluation includes comparing the revised available area of reinforcement to the required area, as well as performing a fatigue evaluation on the pressurizer top head, shell, and bottom head outside surfaces with the stress concentration factor due to the attachment stud holes. This section also contains the structural evaluation of the grooved portion of the top, side, and bottom pressurizer nozzles including a fatigue evaluation. The following figures from References 3A, 3B, 3C, and 3E show the configuration for the MNRDs and their attachment to the pressurizer top head, shell, and bottom head. Stresses due to loads in the stud are concentrated at the upper threads and are negligible at the bottom of the hole.

Top Pressurizer Mechanical Nozzle Repair Device
(See References 3A and 3D for details.)

6.0 DETAILED ANALYSIS

Side Pressurizer RTD Mechanical Nozzle Repair Device
(See References 3B and 3D for details.)

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6.0 DETAILED ANALYSIS

Bottom Pressurizer Mechanical Nozzle Repair Device
(See References 3C and 3D for details.)

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6.0 DETAILED ANALYSIS

Heater Sleeve Mechanical Nozzle Repair Device
(See References 3E and 3F for details.)

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6.0 DETAILED ANALYSIS

6.1 Seal Assembly Bolted Connection to Pressurizer Evaluation

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6.0 DETAILED ANALYSIS

6.1 Seal Assembly Bolted Connection to Pressurizer Evaluation

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6.0 DETAILED ANALYSIS

6.2 Top Pressurizer Mechanical Nozzle Repair Device

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"Mathcad 6.0" (Reference 4).

6.0 DETAILED ANALYSIS

6.2 Top Pressurizer Mechanical Nozzle Repair Device

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6.0 DETAILED ANALYSIS

6.2 Top Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.2 Top Pressurizer Mechanical Nozzle Repair Device

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6.0 DETAILED ANALYSIS

6.2 Top Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.2 Top Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.2 Top Pressurizer Mechanical Nozzle Repair Device

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6.0 DETAILED ANALYSIS

6.3 Side Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.3 Side Pressurizer Mechanical Nozzle Repair Device

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6.0 DETAILED ANALYSIS

6.3 Side Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.3 Side Pressurizer Mechanical Nozzle Repair Device

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6.0 DETAILED ANALYSIS

6.3 Side Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.3 Side Pressurizer Mechanical Nozzle Repair Device

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6.0 DETAILED ANALYSIS

6.3 Side Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.3 Side Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.3 Side Pressurizer Mechanical Nozzle Repair Device

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6.0 DETAILED ANALYSIS

6.4 Bottom Pressurizer Mechanical Nozzle Repair Device

ABB - CENP

6.0 DETAILED ANALYSIS

6.4 Bottom Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.4 Bottom Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.4 Bottom Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.4 Bottom Pressurizer Mechanical Nozzle Repair Device

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6.0 DETAILED ANALYSIS

6.4 Bottom Pressurizer Mechanical Nozzle Repair Device

ABB - CENP

6.0 DETAILED ANALYSIS

6.4 Bottom Pressurizer Mechanical Nozzle Repair Device

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6.0 DETAILED ANALYSIS

6.4 Bottom Pressurizer Mechanical Nozzle Repair Device

6.0 DETAILED ANALYSIS

6.4 Bottom Pressurizer Mechanical Nozzle Repair Device

ABB - CENP

6.0 DETAILED ANALYSIS

6.5 Seal Assembly Connection to Top, Side, and Bottom Pressurizer Nozzles

ABB - CENP

6.0 DETAILED ANALYSIS

6.5 Seal Assembly Connection to Top, Side, and Bottom Pressurizer Nozzles

ABB - CENP

6.0 DETAILED ANALYSIS

6.5 Seal Assembly Connection to Top, Side, and Bottom Pressurizer Nozzles

ABB - CENP

6.0 DETAILED ANALYSIS

6.5 Seal Assembly Connection to Top, Side, and Bottom Pressurizer Nozzles

ABB - CENP

6.0 DETAILED ANALYSIS

6.5 Seal Assembly Connection to Top, Side, and Bottom Pressurizer Nozzles

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6.0 DETAILED ANALYSIS

6.5 Seal Assembly Connection to Top, Side, and Bottom Pressurizer Nozzles

ABB - CENP

6.0 DETAILED ANALYSIS

6.5 Seal Assembly Connection to Top, Side, and Bottom Pressurizer Nozzles

ABB - CENP

6.0 DETAILED ANALYSIS

6.6 Seal Assembly Connection to Heater Sleeve

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6.0 DETAILED ANALYSIS

6.6 Seal Assembly Connection to Heater Sleeve

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7.0 RESULTS/CONCLUSIONS

7.1 RESULTS

The objectives and their resolutions are presented below.

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7.0 RESULTS / CONCLUSIONS

7.1 RESULTS (continued)

7.2 CONCLUSION

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8.0 REFERENCES

1. ABB CENP Report No. CENC-1187, "Analytical Report for Baltimore Gas and Electric Calvert Cliffs Station Units No. 1 and 2 Pressurizers", July 1972.

2. ASME Boiler and Pressure Vessel Code, Section III for Nuclear Power Plant Components, 1989 Edition, No Addendum.

3. ABB CENP Drawings:
   A. E-MNSABGE-228-005, Rev. 04, "Upper Pressurizer Mechanical Nozzle Seal Assembly".
   B. E-MNSABGE-228-006, Rev. 05, "Side Pressurizer RTD Mechanical Nozzle Seal Assembly".
   C. E-MNSABGE-228-007, Rev. 03, "Bottom Pressurizer Mechanical Nozzle Seal Assembly".
   D. E-MNSA-228-020, Rev. 06, "Mechanical Nozzle Seal Assembly Details (4 sheets)".
   E. E-MNSABGE-228-003, Rev.01, "Heater Sleeve Mechanical Nozzle Seal Assembly (2 sheets)".
   F. E-MNSABGE-228-021, Rev. 01, "Mechanical Nozzle Seal Details (2 sheets)".

4. Mathcad 6.0, by Mathsoft, Inc., Cambridge, MA.

5. "Stress Concentration Factors", by R. E. Peterson, John Wiley & Sons, New York, 1974.

6. USA Standard ASA-B1.1-1974, "Unified Screw Threads", 1974.

7. "Preloading of Bolts", by Bernie J. Cobb; Product Engineering, August 19, 1963.

8. BGE Design Specification No. SP-0846, Rev. 00, "Mechanical Nozzle Repair Device", April 1999.

9. ABB/CE Calculation Report No. A-SONGS-9416-1175, Rev. 02, "Evaluation of Attachment Locations for Mechanical Nozzle Seal Assembly on SONGS Units 2 and 3 Partial Penetration Welded Nozzles in the Hot Leg Piping", December 1997.

10. ABB/CE Report No. CR-9448-CSE91-1101, Rev. 1, "Acceptance Criteria for Florida Power and Light St. Lucie #1 and #2 Manway and Handhole Stud Hole Threads", Appendix C - "Good Bolting Practices", Volume 1 issued by EPRI - 3412 Hillview Avenue, Palo Alto, California 94304.

11. ABB/CE Report No. TR-PENG-012, Rev. 00, "Test Report for Verification Testing of RTD Nozzle Seal Assembly", February 1, 1995.

12. ABB CENP Drawings:
   A. E-232-630, Rev. 8, "Pressurizer Outline for 96" I.D. Pressurizer".
   B. E-232-632, Rev. 1, "Top Head Welding and Machining, 96 " I.D. Pressurizer".
   C. E-232-631, Rev. 4, "Vessel Welding and Machining for 96" I.D. Pressurizer".
   D. E-232-633, Rev. 4, "Bottom Head Welding and Machining for 96" I.D. Pressurizer".
   E. E-232-634, Rev. 10, "Nozzle Details for 96" I.D. Pressurizer".
   F. E-233-479, Rev. 5, "Heater Arrangement and Details".
   G. E-232-637, Rev. 7, "Internal Details for 96" I.D. Pressurizer".
   H. A-246-007, Rev. 1, "Heater Locking Bushing for Pressurizer".
   I. A-246-006, Rev. 1, "Heater Locking Collar for Pressurizer".

13. ABB CENP Project Plan, B-NOME-IPQP-0287, Rev. 0, "Mechanical Nozzle Repair Devices (MNRD) for PZR Bottom Nozzles, PZR Side Nozzles, PZR Upper Nozzles, Hot Leg RTD Nozzles, Hot Leg PDT/Sampling Nozzles, PZR Heater Sleeves".

ATTACHMENT 1

1. Design Analysis Verification Checklist (4 pages).
2. Reviewer's Comment Form (1 page).

(Copies in Q.A. Records)

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ATTACHMENT E

CALCULATION OF THE TIE ROD AVERAGE TEMPERATURE

Calculation of average temperature due to axial conduction for Heater Sleeve MNSA

ATTACHMENT F

ANALYSIS OF BG&E UNITS I AND II HEATER SLEEVE MNSA

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

1.1 Objective

The objective of this calculation is to present the results of the evaluation of the Mechanical Nozzle Seal Assembly (MNSA) to be installed on the Heater Sleeve at the Baltimore Gas & Electric Calvert Cliffs Station Unit I and II.

The MNSA is a mechanical device that acts as a complete replacement of the "J" weld between an Inconel 600 Heater Sleeve and the Pressurizer. Its function is to prevent leakage and restrain the sleeve from ejecting in the event of a through-wall crack or weld failure of a sleeve. The potential for these events exists due to Primary Water Stress Corrosion Cracking.

1.2 Assessment of Significant Design Changes

This report presents the detailed structural and thermal analyses required to substantiate the adequacy of the design of the BG&E, Calvert Cliffs Units I and II Mechanical Nozzle Seal Assembly as a replacement of the sleeve "J" weld. This analytical work encompasses the requirements set forth in Reference 5.1 and is performed in accordance with the requirements of the ABB CENO Quality Procedures Manual QPM-101 (Reference 5.2).

Addenda to the original Pressurizer Design Report (Reference 5.3) were reviewed and it was determined that their results have no impact on the current analysis and also that the current analysis does not impact their results.

2. DESIGN INPUTS

2.1 Selection of Design Inputs

2.1.1 Design and Operating Pressures and Temperatures

The Mechanical Nozzle Seal Assembly is considered a pressure-retaining component. The Design Pressure is 2,500 psia and Design Temperature is 700°F. Operating pressure and temperature are 2,250 psia and 653°F, respectively. Ambient design temperature is 140°F (Reference 5.7).

2.1.2 MNSA Materials

MNSA materials are taken from Reference 5.8.

Item	Material
Compression Collar	SA-479, Type 304
Lower Flange	SA-479, Type 304
Upper Flange	SA-479, Type 304
Top Plate	SA-479, Type 304
Hex Head Bolt	SA-453, Grade 660
Hex Nut	SA-453, Grade 660
Tie Rod	SA-453, Grade 660
Socket Head Shoulder Screw	SB-637, Alloy No. N07718

2.1.3 Heater Sleeve Materials

Heater Sleeve assembly materials are taken from References 5.6, 5.20 and 5.21.

Item	Material
Sleeve	SB-167
Bushing	SA-182, Type 316
Collar	SA-182, Type 316

2.1.4 Material Properties

Material properties used in this analysis include coefficients of thermal expansion (α), Moduli of Elasticity (E), design stress intensity values (S_m), and Yield Strength Values (S_y). These properties are presented below and are found in the Appendices of Reference 5.9.

2.1.5 MNSA Component Dimensions

2.1.6 Heater Sleeve Dimensions

2.2 Assumptions

2.2.1 Loading Conditions

2.2.2 Consideration of Seismic Loads

Because of the nature of the accelerations from seismic events, only the tie rods will be evaluated for the stress effects of the seismic event. The remaining MNSA components will not be significantly affected. Separate seismic tests on similar MNSA configurations were performed to demonstrate an adequate seal performance (see Reference 5.16).

2.2.3 Friction Force

The effects of any impact of the sleeve against the top plate are dependent upon certain assumptions regarding the determination of the ejection force acting on the sleeve.

In an "ideal" (and worst case) break scenario, the crack would be complete, instantaneous and oriented such that no base or weld metal could interfere with the motion of the sleeve. In this case, the only resistance offered to the sleeve motion would be provided by the attached piping and by the Grafoil seal.

2.2.4 Sealing pressure

2.2.5 Preload

Nominal values of tie rod/bolt preload are used in this analysis since maximum values of preload will not significantly increase corresponding preload stresses. (A check of the results indicate that use of the maximum preload values will result in stresses which will remain below, or will be on the order of, their respective allowables. Therefore, use of the nominal values is acceptable).

2.2.6 Dimensions

Nominal design dimensions of the parts were used for the calculations of the relative displacement and for the stress analysis, except when noted.

3. ANALYSIS

3.1 MNSA Description

The MNSA is a mechanical device that acts as a complete replacement of the "J" weld between an Inconel 600 sleeve and the Pressurizer. It replaces the sealing function of the weld using a Grafoil seal compressed at the sleeve outside diameter to the outer Pressurizer surface. The MNSA also replaces the weld structurally by means of threaded fasteners engaged in tapped holes in the outer Pressurizer surface, and a restraining plate held in place by threaded tie rods. This feature prevents the sleeve from ejecting from the Pressurizer, should the "J" weld fail or the sleeve develop a circumferential crack.

A general sketch of the Heater Sleeve MNSA is presented in Figure 1 below.

FIGURE 1
Heater Sleeve MNSA

3.2 Consideration of Impact Load

3.2.1 Relative Displacements Due to Thermal Expansion

3.2.2 Soft Spring Package Setting vs. Calculated Displacements

3.2.3 Determination of Impact Force

3.2.4 Impact Force

3.3 Stresses in the Heater Sleeve MNSA Components

The Design Loads for the various MNSA components will be a function of either bolt preload, the impact load, and/or thermal expansion loads, depending upon the effects of the source load upon a particular component.

3.3.1 Tie Rod

3.3.2 Hex Head Bolt

3.3.3 Top Plate

3.3.4 Compression Collar

Dimensions from Reference 5.8.2 (Items 3).

3.3.5 Upper Flange

3.3.6 Socket Head Shoulder Screw

3.3.6.2 *Bearing Stress,* σ_b

3.4 Fatigue Analysis

The fatigue analysis of the components will conservatively consider loads which may exist on the components after weld or sleeve failure has occurred. Prior to failure, components will be subjected to loads due mainly to preload and thermal expansion. After failure, and assuming that the sleeve/clamp is free to move, certain components will be additionally stressed because of the internal pressure forcing the sleeve/clamp up against the top plate. The load on these components would be cyclical, given the change in pressure and temperature that occurs as the plant heats up and then cools down.

The critical components for fatigue analysis purposes are the tie rod and hex head bolts, on the basis of:

- preload tensile stresses
- thermal expansion tensile stresses
- stress concentrations in the threaded sections, and
- for the levels of stresses involved, a more restrictive number of allowable cycles (versus the stainless steel MNSA components; see Table I-9.1 of Reference 5.9)

3.4.1 Normal Operating Pressure Force

3.4.2 Tie Rods

3.4.2.1 Peak Stress

There are other Normal and Upset transients which are defined for the Pressurizer (per Reference 5.7), but their contribution to fatigue in the tie rod is not significant.

3.4.3 Hex Head Bolt

[ ]

3.5 Consideration of Hydrostatic Test Pressure Conditions

[ ]

3.6 Consideration of Faulted Conditions

Reference 5.7 lists the Faulted Conditions which are identical to the Design Condition except that they also include a Loss of Secondary Pressure, Safe Shutdown Earthquake and Pipe Rupture events. The Loss of Secondary Pressure and the Pipe Rupture events have no effect on the MNSA components.

[ ]

4. SUMMARY OF RESULTS

The results presented below were determined using the assumptions defined and justified in Section 2.0. There are no additional contingencies or assumptions that are applicable to these results.

All stresses are satisfactory and meet the appropriate allowable limits set forth in Section III of the ASME Boiler and Pressure Vessel Code (Reference 5.9).

5. REFERENCES

5.1 ABB Project Plan No. B-NOME-IPQP-0287 Rev. 0, "Mechanical Nozzle Repair Devices (MNRD) for PZR Bottom Sleeves, PZR Side Sleeves, PZR Upper Sleeves, Hot Leg RTD Nozzles, Hot Leg PDT/Sampling Nozzles, PZR Heater Sleeves", September 1999.

5.2 ABB Combustion Engineering Nuclear Power Quality Procedures Manual QPM-101, Revision 03.

5.3 "Analytical Report for Baltimore Gas & Electric Calvert Cliffs Station Units I and II Piping," Report No. CENC-1179, March 1972.

5.4 Dedication Reports No.
1. 9481-99-140-1A, Rev. 0, January 2000
2. 9481-99-152-1A, Rev. 0, January 2000.

5.5 Union Carbide Grafoil, "Engineering Design Manual, " Volume One, Sheet and Laminated Products, by R. A. Howard, 1987.

5.6 ABB CE Drawing No. E-232-637, Rev. 2, "Internal Details".

5.7 BGE Design Specification No. SP-0846, Rev. 00, "Mechanical Nozzle Repair Device".

5.8 ABB CE Drawing No.
1. E-MNSABGE-228-003, Revision 02, "Heater Sleeve Mechanical Nozzle Seal Assembly" (see Contingencies and Assumptions sheet)
2. E-MNSABGE-228-021, Revision 02, "Mechanical Nozzle Seal Assembly Details" (see Contingencies and Assumptions sheet)
3. E-MNSA-228-020, Revision 05, "Mechanical Nozzle Seal Assy Details"
4. E-MNSA-228-004, Revision 06, "Mechanical Nozzle Seal Assembly Details"
5. E-MNSA-228-013, Revision 10, "Mechanical Nozzle Seal Assembly Details"

5.9 American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III, 1989 Edition (No Addenda).

5.10 "Test Report for MNSA Hydrostatic and Thermal Cycle Tests," Test Report No. TR-PENG-042, Rev.00.

5.11 "Roark's Formulas for Stress and Strain," Warren C. Young, Sixth Edition, 1989, McGraw-Hill.

5.12 ANSI Standards for Threads, Appendix B, B1.1, 1982.

5.13 "Engineering Mechanics: Statics and Dynamics", F. L. Singer, Third Edition, Harper & Row, New York, 1975.

5.14 "Mechanical Engineers' Handbook", M. Kutz, ed., John Wiley & Sons, Inc., 1986.

5.15 "How to Calculate and Design for Stress in Preloaded Bolts", A. G. Hopper and G. V. Thompson, Product Engineering, 1964.

5.16 Engineering Report No. B-NOME-ER-0133, Revision 00, "Design Evaluation of MNSA for Various Applications at BG&E Units I and II", January 2000.

5.17 "Strength of Materials", F. L. Singer, Second Edition, Harper & Row, New York, 1962

5.18 ABB CENP Report No. MISC-ME-C-230, Revision 02, "Software Verification and Validation Report - ANSYS Version 5.3 on HP9000/800 Series Machines with the HP-UX 10.20 Operating System", December 1998.

5.19 ABB CENP Calculation No. B-PENG-CALC-022, Revision 00, "Analysis of BG&E Hot Leg and Pressurizer MNSAs Seismic Accelerations", November 1999.

5.20 ABB CE Drawing No. A-246-006, Rev. 1, "Heater Locking Collar".

5.21 ABB CE Drawing No. A-246-007, Rev. 1, "Heater Locking Bushing".

ATTACHMENT G

ANSYS EVALUATION OF THE HEATER SLEEVE TOP PLATE

This Attachment contains the figure of the ANSYS model used to obtain the stiffness and the stresses of the Heater Sleeve MNSA top plate, as well as the resulting output file from the computer run. The output file printed here contains an echo print of the input file used.

FIGURE G1.

Element Plot of ANSYS Heater Sleeve Top Plate Model

***** ANSYS - ENGINEERING ANALYSIS SYSTEM RELEASE [illegible]

DX,DY,DZ= 0.000E+00 0.000E+00 0.000E+00 CSYS= 0

ACTUAL NO. OF ACTIVE DEGREES OF FREEDOM = 12741

***** POST1 NODAL DEGREE OF FREEDOM LISTING *****

1978	-0.20596E-03
1979	-0.20674E-03

```
ALL SELECT    FOR ITEM=AREA COMPONENT=
 IN RANGE        1 TO        17 STEP        1
```

MINIMUM VALUES

NODE	1768	1768	1500	1768	1768

TOTAL VALUES
VALUE 500.00

ATTACHMENT H

TORQUING OF HOLD DOWN BOLTS
(Letter No. CSE-00-011)

(11 pages including cover)

ABB
ASEA BROWN BOVERI

Inter-Office Correspondence

To: J. T. McGarry

cc: D. P. Siska

January 28, 2000
Southeast Nuclear Service Center
CSE-00-011 / Page 1 of 4

SUBJECT: **TORQUING OF HOLD DOWN BOLTS FOR HEATER SLEEVE MNSAs**

REFERENCES:

(1) ABB CENP Report No. A-CCNPP-9449-1229, Rev. 00, "Evaluation of Attachment Locations for Mechanical Nozzle Repair Devices on Baltimore Gas and Electric Company Calvert Cliffs Nuclear Power Plant Units 1 and 2 Pressurizer Top Head, Shell, and Bottom Head Instrument Nozzles and Heater Sleeves", December 1999.

(2) ASME Boiler and Pressure Vessel Code, Section III for Nuclear Power Plant Components, 1989 Edition, No Addenda.

(3) Inter-Office Correspondence from J. T. McGarry to Bruce Bell on, "Torquing of MNSA Bolts", January 14, 2000.

(4) ABB CENP Report No. CENC-1187, "Analytical Report for Baltimore Gas and Electric Calvert Cliffs Station Units No. 1 and 2 Pressurizers", July 1972.

(5) "Preloading of Bolts", by Bernie J. Cobb, Product Engineering, August 19, 1963.

(6) ABB CENP Report No. TR-PENG-012, Rev. 00, "Test Report for Verification Testing of RTD Nozzle Seal Assembly", February 1, 1995.

(7) ABB CENP Report No. CR-9448-CSE91-1101, Rev. 1, "Acceptance Criteria for Florida Power and Light St. Lucie #1 and #2 Manway and Handhole Stud Hole Threads", Appendix C – "Good Bolting Practices". Volume 1 issued by EPRI – 3412 Hillview Avenue, Palo Alto, California 94304.

(8) USA Standard ASA-B1.1-1974, "Unified Screw Threads", 1974.

(9) E-MNSABGE-228-003, Rev. 01, "Heater Sleeve Mechanical Nozzle Seal Assembly (2 sheets)".

(10) E-MNSA-228-021, Rev. 01, "Mechanical Nozzle Seal Assembly Details (2 sheets)".

(11) "Design of Machine Elements", 3rd Edition, by M. F. Spotts, 1961, Prentice-Hall, Inc.

1.0 INTRODUCTION

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2.0 ANALYTICAL TECHNIQUES

3.0 ANALYSIS

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ATTACHMENT 1

REFERENCES

(3) Inter-Office Correspondence from J. T. McGarry to Bruce Bell on, "Torquing of MNSA Bolts", January 12, 2000 (1 page).

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Inter-Office Correspondence

January 14, 2000

To: Bruce Bell

From: J. T. McGarry

xc: J. Burger
K. Haslinger
K. Margotta
B. Nadgor

SUBJECT: Torquing of MNSA Bolts

ATTACHMENT 2

Other Design Document Checklist (3 pages).

(For Q. A. Records only)

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ABB CENP

ATTACHMENT I

QUALITY ASSURANCE FORMS

ATTACHMENT I

QUALITY ASSURANCE FORMS