ATTACHMENT (10)

Non-Proprietary -- Design Report No. B-PENG-DR-005, Revision 02,

"Addendum to CENC-1179 Analytical Report for

BGE CCNPP Units 1 and 2 - Piping"

WESTINGHOUSE NON-PROPRIETARY CLASS 3

Report: 12 pages
Appendices: 153 pages
Other Attachments: none

DESIGN REPORT NO. B-PENG-DR-005, Rev. 02

Addendum to CENC-1179

Analytical Report for

Baltimore Gas & Electric Calvert Cliffs Station

Units No. I and II

Piping

WESTINGHOUSE ELECTRIC COMPANY
CE NUCLEAR POWER LLC
WINDSOR, CONNECTICUT

VERIFICATION STATUS: COMPLETE

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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: [signature]
Registration No. 16253
State of Connecticut
Date 12/21/00

Contingencies and Assumptions

Title: Addendum to CENC-1179 Analytical Report for Baltimore Gas and Electric Calvert Cliffs Station Units No. I and II Piping

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Project Manager: John. T. McGarry

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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
☒ None	There are neither Internal nor External Contingencies or Assumptions in this Design Analysis.

RECORD OF REVISIONS

Rev	Date	Pages Changed	Prepared By	Reviewed By	Approved By
00	01/05/00	Original	B. Nadgor	C. L. Mendrala	K. H. Haslinger
01	03/01/00	Pages 1 - 4, 6, A37, B13, B41, B42 Only those pages changed in this revision show Revision 01 in the header	B. Nadgor	T. D. Hammel	K. H. Haslinger
02	12/21/00	Pages 1-6, 8-11, A2, A3, A5, A8, A10-A14, A16, A17, A20, A21, A29-A36, A38-A41, B18, B40, Replaced Attachment D	B. Nadgor	C. R. Schmidt	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 Hot Leg RTD, PDT and Sampling Nozzles, 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 Hot Leg for the installation of each MNSA assembly. The impact of these holes on the design basis of the RCS Hot Leg is also examined in this design report.

These components are analyzed in accordance with:

1. Engineering Specification No. 8067-31-5, Rev. 15.
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 the internal contingencies contained in Revision 00 of this document and to incorporate the latest revisions of the drawings.

Revision 02 is performed to incorporate the design changes of the actual MNSA installed on the Hot Leg RTD nozzle. Also, one typo was corrected in the analysis of PDT/Sampling MNSA.

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B Analysis of BG&E Units I and II Hot Leg PDT/Sampling Nozzle MNSA

C ANSYS Evaluation of Top Plate

D CALCULATION A-CCNPP-9449-1230, 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 Hot Leg Piping RTD and PDT/Sampling Instrument Nozzles"

E Quality Assurance Forms

1.0 INTRODUCTION

This design report summarizes the analyses performed for the installation of Mechanical Nozzle Seal Assemblies (MNSA) on three Hot Leg nozzles. The MNSA is a mechanical device that acts as a complete replacement of the "J" weld between an Inconel 600 instrument nozzle and the Hot Leg pipe. 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 Hot Leg piping, 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. It also incorporates the latest revisions of the MNSA drawings.

Revision 02 is performed to incorporate the design changes of the actual MNSA installed on the Hot Leg RTD nozzle. Also, one typo was corrected in the analysis of PDT/Sampling MNSA.

2.0 SIGNIFICANT RESULTS

Reference 3.5 defines the current design basis documents for the RCS Piping.

The only Baltimore Gas and Electric Calvert Cliffs Station Units I and II piping design report affected by this addendum is CENC-1179. The list of design report addenda below remain applicable to the RCS Piping and are not modified by this addendum.

CENC-1515	(04/82)
604590-MPS-5DSR-006, Rev. 00	(08/90)
B-MECH-DR-001, Rev. 00	(07/92)
B-MECH-DR-004, Rev. 00	(08/93)
B-MECH-DR-005, Rev. 00	(06/93)
B-MECH-DR-008, Rev. 00	(11/93)
B-MECH-DR-009, Rev. 00	(11/93)

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 *Hot Leg RTD Nozzle MNSA*

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

2.2 *Hot Leg PDT/Sampling Nozzle MNSA*

Attachment B contains the detailed analysis of the Hot Leg PDT and Sampling Nozzle MNSA components. The following table summarizes the results for the Hot Leg PDT/Sampling Nozzle MNSA components. The existing design analysis for the Hot Leg PDT/Sampling nozzles is not affected by the addition of the MNSA.

2.3 *MNSAs in Hot Leg Piping*

Attachment D contains the detailed evaluation of the attachment locations for the RTD MNSA and the PDT/Sampling MNSA, and stress analysis considering a modification in the RTD (Rev. 02 of the report) and PDT/Sampling nozzles on the nozzle outside surface. The results of this evaluation are shown below:

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

[ ]

2.3.2 Area of Reinforcement Requirements for Nozzle Penetration

[ ]

2.3.3 Primary plus Secondary Stress Intensity Range

[ ]

2.3.4 Fatigue Usage Factor

[ ]

2.3.5 Primary plus Secondary Stress Intensity Range and Fatigue Evaluation of Modified RTD and PDT/Sampling Nozzles

[ ]

2.3.6 Maximum Allowable Shear Load in the Grooved Section of the RTD and PDT/Sampling Nozzles

[ ]

3.0 REFERENCES

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

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

3.3 "Engineering Specification for Reactor Coolant Pipe and Fittings for Baltimore Gas and Electric Company", Specification No. 8067-31-5, Revision 15.

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 HOT LEG RTD 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 Hot Leg 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 Hot Leg pipe. 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 Piping 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 650°F. Operating pressure and temperature are 2250 psia and 604°F, respectively. Ambient design temperature is 120°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

Hot Leg RTD Nozzle and fitting materials are taken from References 5.5, 5.12.

Item	Material	Reference
Nozzle	B-166	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.

2.1.4.1 Coefficient of Linear Thermal Expansion, α

The following table presents the temperature-dependent coefficients of linear thermal expansion for various materials:

temperature (°F)	SB-166 (Alloy 600)	SA-479 Type 304 (304 SS)	SA-453, Grade 660 (Alloy 660)
100	6.90	8.55	8.24
200	7.20	8.79	8.39
300	7.40	9.00	8.54
400	7.57	9.19	8.69
500	7.70	9.37	8.82
600	7.82	9.53	8.94
604	7.82*	9.54*	8.94*
650	7.88	9.61	9.00

* by interpolation

All coefficients are Coefficient B values from Table I-5.0, where Coefficient B is the mean coefficient of thermal expansion X 10^{-6} in./in./°F in going from 70°F to the indicated temperature.

2.1.4.2 Modulus of Elasticity, E

The following table presents the temperature-dependent moduli of elasticity for SA-479 Type 304 and SA-453, Grade 660:

temperature (°F)	E
70	28.3
200	27.6
300	27.0
400	26.5
500	25.8
600	25.3
604	25.3*
650	25.0*
700	24.8

* by interpolation

All moduli of elasticity values are from Table I-6.0, where E = value given X 10^6 psi.

2.1.4.3 *Design Stress Intensity Value, S_m*

The following table presents the temperature-dependent design stress intensity values for various materials:

temperature (°F)	SA-479, Type 304 S_m	SA-453, Grade 660 S_m
100	20.0	28.3
200	20.0	27.6
300	20.0	27.3
400	18.7	27.2
500	17.5	27.1
600	16.4	27.0
650	16.2	26.9*
700	16.0	26.8

* by interpolation

The design stress intensity values for SA-479 Type 304 are from Table I-1.2; and the design stress intensity values for SA-453, Grade 660 are from Table I-1.3. All S_m values are given in ksi.

2.1.4.4 *Yield Strength Value, S_y*

The following table presents the temperature-dependent yield strength values for SA-479 Type 304:

temperature (°F)	SA-479, Type 304 S_y
100	30.0
200	25.0
300	22.5
400	20.7
500	19.4
600	18.2
650	17.9
700	17.7

The yield strength values for SA-479 Type 304 are from Table I-2.2. All S_y values are given in ksi.

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 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 hot leg pipe. It replaces the sealing function of the weld using a Grafoil seal compressed at the nozzle outside diameter to the outer hot leg surface. The MNSA also replaces the weld structurally by means of threaded fasteners engaged in tapped holes in the outer hot leg surface, and a restraining plate held in place by threaded tie rods. This feature prevents the nozzle from ejecting from the hot leg, should the "J" weld fail or the nozzle develop a circumferential crack.

A sketch of the Hot Leg RTD MNSA is depicted in Figure 1 below.

FIGURE 1
Hot Leg 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.

3.2.4 Impact Force

3.3 *Stresses in the 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

3.3.3 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/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 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 Piping (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 Rosemount Drawing No. 104-852, Rev. 04, "Thermowell".

5.6 Not Used

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

5.8 ABB Drawing No.
1. E-MNSABGE-228-001, Revision 04, "Hot Leg RTD Mechanical Nozzle Seal Assembly"
2. E-MNSA-228-004, Revision 06, "Mechanical Nozzle Seal Assembly Details"
3. E-MNSA-228-020, Revision 05, "Mechanical Nozzle Seal Assy Details"
4. E-MNSA-228-023, Revision 01, "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-233-585, Rev. 6, "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 I and II", 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 HOT LEG PDT/SAMPLING 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 Hot Leg PDT and Sampling 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 Hot Leg pipe. 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 Piping 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 650°F. Operating pressure and temperature are 2,250 psia and 604°F, respectively. Ambient design temperature is 120°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

Hot Leg PDT and Sampling Nozzle materials are taken from Reference 5.6.

Item	Material
Nozzle	B-166
Safe End	A-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.

2.1.4.1 Coefficient of Linear Thermal Expansion, α

The following table presents the temperature-dependent coefficients of linear thermal expansion for various materials:

temperature (°F)	SB-166 (Alloy 600)	SA-182 316 SS	SA-479 Type 304 (304 SS)	SA-453, Grade 660 (Alloy 660)
100	6.90	8.54	8.55	8.24
200	7.20	8.76	8.79	8.39
300	7.40	8.97	9.00	8.54
400	7.57	9.21	9.19	8.69
500	7.70	9.42	9.37	8.82
600	7.82	9.60	9.53	8.94
604	7.82*	9.61*	9.54*	8.94*
650	7.88	9.69	9.61	9.00

* by interpolation

All coefficients are Coefficient B values from Table I-5.0, where Coefficient B is the mean coefficient of thermal expansion X 10^{-6} in./in./°F in going from 70°F to the indicated temperature.

2.1.4.2 Modulus of Elasticity, E

The following table presents the temperature-dependent Moduli of Elasticity for SA-479 Type 304 and SA-453, Grade 660:

temperature (°F)	E
70	28.3
200	27.6
300	27.0
400	26.5
500	25.8
600	25.3
604	25.3*
650	25.0*
700	24.8

* by interpolation

All Moduli of Elasticity values are from Table I-6.0, where E = value given X 10^6 psi.

2.1.4.3 Design Stress Intensity Value, S_m

The following table presents the temperature-dependent design stress intensity values for various materials:

temperature (°F)	SA-479, Type 304 S_m	SA-453, Grade 660 S_m
100	20.0	28.3
200	20.0	27.6
300	20.0	27.3
400	18.7	27.2
500	17.5	27.1
600	16.4	27.0
650	16.2	26.9*
700	16.0	26.8

* by interpolation

The design stress intensity values for SA-479 Type 304 are from Table I-1.2; and the design stress intensity values for SA-453, Grade 660 are from Table I-1.3. All S_m values are given in ksi.

2.1.4.4 Yield Strength Value, S_y

The following table presents the temperature-dependent yield strength values for SA-479 Type 304:

temperature (°F)	SA-479, Type 304 S_y
100	30.0
200	25.0
300	22.5
400	20.7
500	19.4
600	18.2
650	17.9
700	17.7

The yield strength values for SA-479 Type 304 are from Table I-2.2. All S_y values are given in ksi.

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 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 hot leg pipe. It replaces the sealing function of the weld using a Grafoil seal compressed at the nozzle outside diameter to the outer hot leg surface. The MNSA also replaces the weld structurally by means of threaded fasteners engaged in tapped holes in the outer hot leg surface, and a restraining plate held in place by threaded tie rods. This feature prevents the nozzle from ejecting from the hot leg, should the "J" weld fail or the nozzle develop a circumferential crack.

A sketch of the Hot Leg PDT/Sampling MNSA is presented in Figure 1 below.

FIGURE 1
Hot Leg PDT/Sampling 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 PDT and Sampling 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

3.3.6 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/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 Piping (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-233-586, Rev. 7, "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-228-002, Revision 03, "Hot Leg PDT/Sampling MMSA"
2. E-MNSA-228-013, Revision 10, "Mechanical Nozzle Seal Assembly Details"
3. E-MNSA-228-020, Revision 05, "Mechanical Nozzle Seal Assy Details"
4. E-MNSA-228-004, Revision 06, "Mechanical Nozzle Seal Assembly Details"

5.9 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.

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

ANSYS OUTPUT FILE

```
        AA AA          BBB BBB      BBB BBB
       AAA AAA         BBB BBBB     BBB BBBB
      AAAA AAAA        BBB BBB      BBB BBB
     AAAAA AAAAA       BBB BBBB     BBB BBBB

    AAAAAA AAAAAA      BBB BBBBB    BBB BBBBB
   AAAAAAA AAAAAAA     BBB BBBBBB   BBB BBBBBB
  AAAAAA     AAAAAA    BBB BBBBB    BBB BBBBB
 AAAAAA       AAAAAA   BBB BBB      BBB BBB

      A S E A    B R O W N    B O V E R I


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 C O M B U S T I O N    ****  E N G I N E E R I N G
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N U C L E A R   P O W E R   W O R K S T A T I O N   E N V I R O N M E N T
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          Date/Time       : Thu Sep 30 15:45:49 EDT 1999

          User            : mendrala
          Group           : v9421me
          Project,Task    : default_charge

          Job Id          : 0u9d79en
          Job Name        : 0u9d79en

          Node Name       : twister
          Cpu Type        : HP-UX

          Process ID      : 4138
          Priority        : 8

          Submit Node     : tornado
          Directory       : twister:/PS/mendrala/bn
1

 Job Stream Commands From the File:  twister:/PS/mendrala/bn/sub

1 Executing /ansys53/bin/hp700/ansys.e53

 *-------------------------------------------------------------*
 |                                                             |
 |   W E L C O M E   T O   T H E   A N S Y S   P R O G R A M   |
 |                                                             |
 *-------------------------------------------------------------*
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CPU Time (Total) = [illegible]

ATTACHMENT D

CALCULATION No. A-CCNPP-9449-1230, 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 Hot Leg Piping RTD and PDT/Sampling Instrument Nozzles"

(41 pages including cover)

WESTINGHOUSE NON-PROPRIETARY CLASS 3

SUMMARY OF CONTENTS	
Calculation	34 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 HOT LEG PIPING RTD AND PDT/SAMPLING INSTRUMENT NOZZLES

A-CCNPP-9449-1230, 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 RTD and PDT/Sampling Instrument Nozzles in the hot leg piping.

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

PREPARED BY: B. A. Bell [signature] DATE: 12/13/2000

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 [signature] Date: 12/15/2000
Independent Reviewer

APPROVED BY: D. P. Siska [signature] DATE: 12-15-2000

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	J. D. Key	D. P. Siska
1	12/13/00	Section 1.0, 3.0, 5.0, 6.0, 7.0, & 8.0. Add Section 6.8	B. A. Bell B a Bell 12/13/2000	J. G. Thakkar J G Thakkar 12/15/2000	D. P. Siska DP Siska 12-15-2000

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Attachment 1: Design Analysis Verification Checklist & Reviewer's Comment Form (For QA Record only)

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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 Hot Leg Piping RTD and PDT/Sampling nozzles. The MNRDs are described in Reference 1 along with the Project Plan (Reference 2). A MNRD is attached to the outside surface of a pipe by four 1/2-inch bolts. The eight objectives of this analysis relate to the machined tapped holes made in the pipe to receive the attachment bolts as well as the grooved portion on the PDT/Sampling and RTD nozzles where the MNRD clamp is attached. The objectives are as follows:

[ ]

The results of this analysis will demonstrate that the use of a MNRD in the hot leg piping 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.

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2.0 ASSESSMENT OF SIGNIFICANT DESIGN CHANGES

The "as-designed" configurations for the hot leg pipes defined in Reference 3 are considered. The design conditions and operating transients (TNS) as presented in References 4 and 13 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 hot leg piping along with the design conditions from References 4 and 13 are as follows:

Design Pressure:	2500 psia
Design Temperature:	650 °F (42" & 30" I.D. Pipe)
Operating Pressure:	2250 psia
Operating Temperature:	604 °F (Hot Leg)

The transient conditions for the hot leg piping are also from Reference 4, pages 4, A-79, and B-20. The bending moments are determined from the external loads given in Reference 5, Figure 10, Sheet 4, Section C for the tapped holes evaluation.

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5.0 ASSUMPTIONS

The assumptions included in this design analysis are as follows:

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5.0 ASSUMPTIONS

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 RTD and PDT/Sampling nozzles in the hot leg piping. The evaluation includes comparing the revised available area of reinforcement to the required area, as well as performing a fatigue evaluation on the hot leg piping 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 PDT/Sampling and RTD nozzles including a fatigue evaluation. The following figures from References 1A and 1B show the configuration for the MNRDs and their attachment to the hot leg piping. Stresses due to loads in the stud are concentrated at the upper threads and are negligible at the bottom of the hole.

PDT/Sampling Mechanical Nozzle Repair Device
(See References 1A and 1C for details.)

NOTE: The bottom end of the stud holes in this figure are rounded and do not come to a point as shown.

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6.0 DETAILED ANALYSIS

RTD Mechanical Nozzle Repair Device
(See References 1B and 1C for details.)

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6.0 DETAILED ANALYSIS

6.1 SEAL ASSEMBLY BOLTED CONNECTION TO PIPING EVALUATION

6.1.1 DETERMINATION MAXIMUM ALLOWABLE LOAD BASED ON THREAD SHEAR

Reference 6; Paragraph NB- 3227.2(a) and Reference 7, page 81

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6.0 DETAILED ANALYSIS

6.1 SEAL ASSEMBLY BOLTED CONNECTION TO PIPING EVALUATION (Cont'd)

6.1.1 DETERMINATION MAXIMUM ALLOWABLE LOAD BASED ON THREAD SHEAR

6.1.2 EVALUATION OF INSTALLATION TORQUE (PRELOAD)

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6.0 DETAILED ANALYSIS

6.2 EVALUATION OF RTD AND PDT/SAMPLING PENETRATION REINFORCEMENT AREAS FOR STANDARD MNRD

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6.0 DETAILED ANALYSIS

6.2 EVALUATION OF RTD AND PDT/SAMPLING PENETRATION REINFORCEMENT AREAS FOR STANDARD MNRD (continued)

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6.0 DETAILED ANALYSIS

6.2 EVALUATION OF RTD AND PDT/SAMPLING PENETRATION REINFORCEMENT AREAS FOR STANDARD MNRD (continued)

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6.0 DETAILED ANALYSIS

6.2 EVALUATION OF RTD AND PDT/SAMPLING PENETRATION REINFORCEMENT AREAS FOR STANDARD MNRD (continued)

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6.0 DETAILED ANALYSIS

6.2 EVALUATION OF RTD AND PDT/SAMPLING PENETRATION REINFORCEMENT AREAS FOR STANDARD MNRD (continued)

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6.0 DETAILED ANALYSIS

6.3 RANGE OF STRESS INTENSITY EVALUATION OF 1/2" TAPPED HOLES

The stresses at the location of the tapped holes for attachment of the MNRD to the hot leg pipe are calculated by classical methods of strength of materials. In order to address the specific location of these holes (i.e. the outside surface of the pipe), the stress calculations are performed according to the provisions of Subsection NB-3200 of ASME Section III, Reference 6. The drilled holes are considered to be local structural discontinuities that effect the peak stresses and fatigue usage factor

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6.0 DETAILED ANALYSIS

6.3 RANGE OF STRESS INTENSITY EVALUATION OF 1/2" TAPPED HOLES (cont'd)

6.0 DETAILED ANALYSIS

6.3 RANGE OF STRESS INTENSITY EVALUATION OF 1/2" TAPPED HOLES (cont'd)

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6.0 DETAILED ANALYSIS

6.3 RANGE OF STRESS INTENSITY EVALUATION OF 1/2" TAPPED HOLES (cont'd)

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6.0 DETAILED ANALYSIS

6.4 FATIGUE EVALUATION OF TAPPED HOLES (Reference 6: Paragraph NB-3222.4)

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6.0 DETAILED ANALYSIS

6.4 FATIGUE EVALUATION OF TAPPED HOLES (continued)

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6.0 DETAILED ANALYSIS

6.4 FATIGUE EVALUATION OF TAPPED HOLES (continued)

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6.0 DETAILED ANALYSIS

6.5 RANGE OF STRESS INTENSITY EVALUATION OF GROOVED SECTION IN PDT/SAMPLING AND RTD NOZZLES

The stresses at the grooved section of the PDT/Sampling and RTD nozzles for attachment of the MNRD clamp are calculated by classical methods of strength of materials. In order to address the specific location of the grooved section (i.e. the outside surface of the nozzle), the stress calculations are performed according to the provisions of Subsection NB-3200 of ASME Section III, Reference 6. The grooved sections of the nozzles are considered to be local structural discontinuities that effect the

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6.0 DETAILED ANALYSIS

6.5 RANGE OF STRESS INTENSITY EVALUATION OF GROOVED SECTION IN PDT/SAMPLING AND RTD NOZZLES (continued)

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6.0 DETAILED ANALYSIS

6.5 RANGE OF STRESS INTENSITY EVALUATION OF GROOVED SECTION IN PDT/SAMPLING AND RTD NOZZLES (continued)

6.0 DETAILED ANALYSIS

6.5 RANGE OF STRESS INTENSITY EVALUATION OF GROOVED SECTION IN PDT/ SAMPLING AND RTD NOZZLES (continued)

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6.0 DETAILED ANALYSIS

6.6 FATIGUE EVALUATION OF GROOVED SECTION IN PDT/SAMPLING AND RTD NOZZLES

(Reference 6: Paragraph NB-3222.4)

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6.0 DETAILED ANALYSIS

6.6 FATIGUE EVALUATION OF GROOVED SECTION IN PDT/SAMPLING AND RTD NOZZLES (cont'd)

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6.0 DETAILED ANALYSIS

6.7 SEAL ASSEMBLY CONNECTION TO PDT/SAMPLING NOZZLES

In the seal assembly connection to the PDT/Sampling nozzles, the maximum permissible shear load in the grooved section of these nozzles is calculated using the minimum shear area per the dimensions from View E in Reference 1A and nozzle dimensions in Reference 12B.

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6.0 DETAILED ANALYSIS

6.8 SEAL ASSEMBLY CONNECTION TO RTD NOZZLES

In the seal assembly connection to the RTD nozzles. the maximum permissible shear load in the grooved section of these nozzles is calculated using the minimum shear area per the dimensions from View E in Reference 1B and nozzle dimensions in Reference 12A.

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7.0 RESULTS / CONCLUSIONS

7.1 RESULTS

The objectives and their resolutions are presented below.

7.0 RESULTS / CONCLUSIONS

7.1 RESULTS (continued)

7.2 CONCLUSION

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8.0 REFERENCES

1. ABB CENP Drawings
   A. E-MNSABGE-228-002, Rev. 01, "Hot Leg PDT & Sampling MNSA".
   B. E-MNSABGE-228-001, Rev. 04, "Hot Leg RTD Mechanical Nozzle Seal Assembly".
   C. E-MNSA-228-020, Rev. 01, "Mechanical Nozzle Seal Assembly Details (4 sheets)".

2. 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".

3. ABB CENP Drawings
   A. E-233-580, Rev. 03, "General Arrangement Plan".
   B. E-233-582, Rev. 09, Piping Details and Assembly".

4. ABB/CE Report No. CENC-1179, "Analytical Report for Baltimore Gas & Electric Calvert Cliffs Station Units 1 and 2 Piping", March 1972.

5. Project Specification for Reactor Coolant Pipe and Fittings for Baltimore Gas & Electric Atomic Power Plant, Specification No. 8067-31-5, Revision 11.

6. ASME Boiler and Pressure Vessel Code, Section III, Division 1 - Subsection NB, "Rules for Construction of Nuclear Power Plant Components", 1989 edition, No Addenda.

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

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

9. 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.

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

11. ABB CENP Letter No. NOME-99-VI-0244, "Palo Verde PDT & Sampling Nozzle MNSA Drawing Transmittal", June 7, 1999.

12. ABB CENP Drawings
    A. E-233-585, Rev. 06, "Nozzle Details Piping".
    B. E-233-586, Rev. 07, "Nozzle Details Piping".
    C. E-233-587, Rev. 06, "Nozzle Details Piping".

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

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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

QUALITY ASSURANCE FORMS