Design Analysis In-Process Approvals

Title: Seismic Qualification of the Steam Generator PDT, Hot Leg PDT, and Hot Leg Sampling MNSA Hardware

Document Number: 02-NOME-CALC-0085 Revision Number: 00

1. **Assignment of Responsibility** – Management assigns the following individuals to this Design Analysis. These individuals are qualified to perform the assigned task by virtue of training and experience.

	Printed Name	**Management Approval (Initials)**
Cognizant Engineer(s)	J.G. Tursi	JMB
Mentor ☒None		
Independent Reviewer(s)	G.E. Falvo	JMB

1. The objective and method(s) have been reviewed and approved:

Independent Reviewer's initials: G.E.F.

2. Approval of deviations or modifications to approved analytical techniques:

☒ There are no deviations or modifications to approved analytical techniques.

☐ Deviations or modifications to approved analytical techniques are approved:

Management initials JMB

3. Approval of significant changes in the mode of computer program use:

☒ There are no significant changes in the mode of application of computer programs.

☐ Cognizant Program Manager concurs with the applicability of computer programs for this use:

Program Manager initials ________

4. Design inputs are appropriate and traceable to their sources:

Independent Reviewer's initials: G.E.F.

5. The Verification Plan is approved:

Management initials JMB

Verification Plan

Title: Seismic Qualification of Steam Generator PDT, Hot Leg PDT, and Hot Leg Sampling MNSA Hardware

Document Number: S2-NOME-CALC-0085 Revision Number: 00

Instructions: Describe the method(s) of verification to be employed, i.e., Design Review, Alternate Analysis, Qualification Testing, a combination of these or an alternative. The Design Analysis Verification Checklist is to be used for all Design Analyses. Other elements to consider in formulating the plan are: methods for checking calculations; comparison of results with similar analyses, etc.

Description of Verification Method:

1. Verification of Design Analysis by Design Review (per QP 3.4 of the Quality Procedures Manual).
2. Verification that an appropriate methodology is selected and correctly implemented
3. Review that the assumptions, results, conclusions, report format, ... etc. are made in accordance with Design Analysis Verification checklist.
4. Verify all design input is appropriately and correctly obtained from traceable sources.
5. Review numerical calculations for accuracy.

Verification Plan prepared by:	Approved by:
Gregor E. FALVO	JOSEPH M. BURGER
Independent Reviewer printed name and signature	Management approver printed name and signature

Design Analysis Verification Checklist

(Page 1 of 4)

Instructions: The Independent Reviewer is to complete this checklist for each analysis and it is to be incorporated into the completed analysis. If a major topic area (generally unnumbered, bold face type such as **Use of Computer Software**) is not applicable, then N/A (not applicable) next to the topic may be checked and the check boxes for all items under it may be left blank. Where there is no check box under N/A for a numbered item, such a response is generally inappropriate. If N/A is checked in such a situation, document the basis at the end of this checklist in the Comments section.

Title: Seismic Qualification of Steam Generator PDT, Hot Leg PDT, and Hot Leg Sampling MNSA Hardware

Document Number: S2-NOME-CALC-0085 **Revision Number:** 00

	Yes	N/A
Overall Assessment		
1. Are the results/conclusions correct and appropriate for their intended use?	☑	
2. Are all limitations and contingencies on the results/conclusions documented?	☑	
Assignment of Cognizant Engineers, Independent Reviewers and Mentors		
1. Have Cognizant Engineers, Independent Reviewers and Mentors, if applicable, been assigned and approved by management?	☑	
2. If there are multiple Cognizant Engineers, has their scope been documented?	☐	☑
3. If there are multiple Independent Reviewers, has their scope been documented?	☐	☑
4. If there will be multiple Management Approvers, has their scope been documented?	☐	☑
5. If an Independent Reviewer is the supervisor, has authorization as an Independent Reviewer been documented?	☐	☑
Use of Computer Software		☑
For software which has been validated under QP 3.13:		☐
1. Is the software applicable for this analysis?	☐	
2. If there are significant changes in the mode of software use, has the Program Manager(s) been consulted and have they initialed the approvals section of the Design Analysis In-Process Approvals form?	☐	☐
For software which has not been validated under QP 3.13:		☐
1. Is the computer type, program name and revision identification documented?	☐	
2. Is the documentation sufficient for the Independent Reviewer to concur that the software is appropriate for the analysis?	☐	
3. Is the documentation sufficient for the Independent Reviewer to concur that the results are correct?	☐	
4. If the documentation is incorporated by reference, is there assurance that the software actually used is identical to that in the reference?	☐	
5. If spreadsheets have been used, is the documentation sufficient for the Independent Reviewer to concur that the results are correct?	☐	

Design Analysis Verification Checklist

Document No. S2-NOME-CALC-0085, Rev. 00

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Design Analysis Contents		**Yes**	**N/A**
Objective of the Design Analysis			
1.	Has information necessary to define the task been included or referenced?	☑	
2.	Has the reason why the analysis is being performed or revised been documented?	☑	
3.	Has the applicability and intended use of the results been documented?	☑	
Assessment of Significant Design Changes			
1.	Have significant design-related changes that might impact this analysis been considered?	☑	
2.	If any such changes have been identified, have they been adequately addressed?	☐	☑
Analytical Techniques (Methods)			
1.	Are the analytical techniques (methods) described in sufficient detail to judge their appropriateness?	☑	
2.	Have analytical techniques incorporated by reference to generic analyses, lead plant analyses or previous cycle analyses been previously verified?	☐	☑
3.	For modifications or departures from previously approved analytical techniques or Conventional Engineering Analysis Procedures (QP 3.19):	☐	☑
a.	Are they documented and justified?	☐	☑
b.	Have they been approved by Management initialing the Design Analysis In-Process Approvals form?	☐	☑
4.	If superseded approved analytical techniques or Engineering Analysis Procedures are used, is their use justified and approved?	☐	☑
5.	Does the date of issue of referenced approved procedures or Engineering Analysis Procedures preclude their use in this analysis?	☐	☑
Selection of Design Inputs			
1.	Are the design inputs documented?	☑	
2.	Are the design inputs correctly selected and traceable to their source?	☑	
3.	Are references as direct as possible to the original source or documents containing collection/tabulations of inputs?	☑	
4.	Is the reference notation appropriately specific to the information utilized?	☑	
5.	Are the bases for selection of all design inputs documented?	☑	
6.	Is the verification status of design inputs transmitted from customers appropriate and documented?	☑	☐
7.	Is the verification status of design inputs transmitted from ABB CENS appropriate and documented?	☐	☑
8.	Is the use of customer-controlled sources such as Tech Specs, UFSARs, etc. authorized, and does the authorization specify amendment level, revision number, etc.?	☐	☑
Assumptions			
1.	If there are no assumptions, is this documented?	☑	☒
2.	Are all assumptions identified and justified?	☒	☑
3.	Are assumptions which must be cleared by CENO or the customer listed on a Contingencies and Assumptions form?	☐	☑
4.	Is a process in place to assure that assumptions which must be cleared by the customer will be included in transmittals to the customer?	☐	☑

Design Analysis Verification Checklist

Document No. S2-NOME-CALC-0085, Rev. 00

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Results/Conclusions	**Yes**	**N/A**
1. Are all results contained in or referenced in the Results/Conclusion section?	☑	
2. Are all limitations on the results/conclusions and their applicability documented in this section?	☑	
3. Are all contingencies on the results that must be cleared listed in the Results/Conclusion section and on a Contingencies and Assumptions form?	☐	☑
4. Is a process in place to assure that those contingencies which are the customer's responsibility to clear will be included in transmittals to the customer?	☐	☑
5. Has a comparison of the results with those of a previous cycle or similar analysis been made and significant differences explained?	☐	☑
Other Elements		
1. Have applicable Codes (e.g. ASME Code) and standards been appropriately referenced and applied?	☑	☐
2. Is the information from relevant literature searches/background data adequately documented and referenced?	☑	☐
3. Are hand calculations correct and appropriately documented?	☑	☐
4. Is all applicable computer output and input included?	☐	☑
5. Is all computer software used identified by name and revision identification?	☐	☑
6. Are all microfiche envelopes identified with the analysis number and number of sheets?	☐	☑
7. Are all files on CD-ROM identified by the path name?	☐	☑
8. Are all computer disks identified with the analysis number?	☐	☑
References		
1. Are all references used to perform the analysis listed?	☑	☐
2. Are the references as direct as possible and appropriate to the source?	☑	
3. Is the reference notation specific to the information utilized, including revision level or date of issue, and where appropriate, identification of the location of the information in the reference, such as page, table or paragraph number?	☑	
Form/Format		
1. Is the document legible, reproducible and in a form suitable for filing and retrieving as a Quality Record?	☑	
2. Are all pages identified with the document number, including revision number?	☑	
3. Do all pages have a unique page number?	☑	
4. Have all changes been authenticated by the initials and date of both the Cognizant Engineer, Independent Reviewer and, if required, by Management?	☑	
For a revision to a completed analysis:		☑
1. Where practical have changes and additions been identified by mechanisms such as vertical lines, etc.?	☐	
2. Where practical have deletions been identified by mechanisms such as strike outs, etc.?	☐	
3. Have indications of changes in previous revisions been removed?	☐	
4. Has a Record of Revision page been added or revised, and does it contain the extent of the revision?	☐	
5. Does the distribution of the revision include those on the distribution of the previous revision?	☐	

Design Analysis Verification Checklist

Document No. S2-NOME-CALC-0085, Rev. 00

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	Yes	N/A
For a "complete revision":		☑
1. Have the title and document number been preserved without change?	☐	
2. Has the revision number been incremented by one?	☐	
For a "page change package":		☑
1. Are pages numbered in accordance with the original analysis?	☐	
2. Are instructions provided for the insertion and deletion of revised pages?	☐	
3. Has a new Title Page been prepared with the Package Contents reflecting the change package?	☐	
4. Has the original Title Page been retained to preserve the approval record?	☐	
5. Has a new Design Analysis In-Process Approvals form been prepared?	☐	
6. Has the original Design Analysis In-Process Approvals form been retained to preserve the approval record?	☐	

Comments (if any)

ABB
ASEA BROWN BOVERI

Contract: SONGS 2 & 3 MNSA

Calculation: 39 Pages
Appendix: 0 Pages
Pages
Microfiche: 0

Calculation Number: S2-NOME-CALC-0085

Revision: 00

Title: Seismic Qualification of Steam Generator PDT, Hot Leg PDT, and Hot Leg Sampling MNSA Hardware

Author: J.G. Tursi, Cognizant Engineer
Date: 2/9/98

Approval: J.T. McGarry, Project Manager
Date: 2/10/98

Approval: J.M. Burger
J.M. Burger, Supervisor, Reactor Vessel Systems
Date: 2/10/98

This calculation contains safety related design information: YES ☐ NO ☒

VERIFICATION STATUS: COMPLETE

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

Name: Gregory E. Faino
Independent Reviewer
Signature:
Date: 2-10-98

Distribution: NOME File (9481-1934), Bev Boya (9485-1903)

Summary Purpose:

The purpose of this calculation is to compare the calculated values for overturning moment for the Steam Generator PDT, Hot Leg PDT, and Hot Leg Sampling MNSA to those of the previously seismically tested Bottom Pressurizer MNSA to qualify the three new designs by comparison.

Method and Results of Review:

THIS DOCUMENT WAS REVIEWED PER THE QA MANUAL AND THE ATTACHED CHECKLISTS AND VERIFICATION PLAN AND WAS FOUND TO BE ACCURATE AND ACCEPTABLE.

Record of Revisions

No.	Date	Pages Involved	Prepared By	Approved By
00		All, Original Issue	J.G. Tursi	J.T. McGarry J.M. Burger

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1.0 Scope

The scope of this calculation is to calculate the overturning moments in the Bottom Pressurizer MNSA, the Steam Generator PDT MNSA, the Hot Leg PDT MNSA, and the Hot Leg Sampling MNSA, resulting from a 1 G seismic loading applied to each design. The calculated values for the Bottom Pressurizer MNSA will be compared to the three new design's values.

Under seismic conditions, the increase in loading acts to offset the preload in the Hex Head Bolts, which would result in no sealing or anti-ejection capability. By showing that the overturning moment of the Bottom Pressurizer MNSA, subjected to the seismic load, is equal or greater than either the overturning moment values of the Steam Generator PDT, Hot Leg PDT, or Hot Leg Sampling MNSA, we can conclude that seismically testing the three new MNSA assemblies is unnecessary because the loadings in the three new designs will be less than the loadings the Bottom Pressurizer MNSA was subjected to during qualification testing (Reference 3.1)

2.0 Method

The method used to calculate the overturning moments is hand calculations, utilizing the principles of mechanical design. Once calculated, a direct comparison of the overturning moments will be made for the Bottom Pressurizer and Steam Generator PDT MNSA's since there geometry is very similar and the bolt circles for the Hex Head Bolts are identical.

Further calculations will be performed to determine the force acting to offset the Preload in the four Hex Head Bolts, created by the overturning moments, for the Bottom Pressurizer, Hot Leg PDT, and Hot Leg Sampling MNSA's. The unloading force values for the Bottom Pressurizer MNSA will be compared to both the Hot Leg PDT MNSA and Hot Leg Sampling MNSA values, since there geometry and bolt circles are different.

3.0 References

3.1 ABB Report No. TR-PENG-033, Rev. 00, "Test Report, Seismic Qualification of the San Onofre Units 2 & 3 MNSA Clamps for Pressurizer Instrument Nozzles and RTD Hot Leg Nozzles".

3.2 ABB Report No. S-PENG-DR-005, Rev. 00, "Design Report, Addendum to CENC-1365 and CENC-1507 Analytical Reports for Southern California Edison San Onofre Units 2 & 3 Piping".

3.3 ABB CENO Drawing No. E-MNSA-228-001, Rev. 02, "Bottom Pressurizer Mechanical Nozzle Seal Assembly".

3.4 ABB CENO Drawing No. E-MNSA-228-014, Rev. 02, "Steam Generator PDT Mechanical Nozzle Seal Assembly".

3.5 ABB CENO Drawing No. E-MNSA-228-015, Rev. 01, "Hot Leg PDT MNSA".

3.6 ABB CENO Drawing No. E-MNSA-228-016, Rev. 03, "Hot Leg Sampling MNSA".

3.7 ABB CENO Drawing No. E-MNSA-228-004, Rev. 05, "Mechanical Nozzle Seal Assembly Details".

3.8 ABB CENO Drawing No. E-MNSA-228-013, Rev. 04, "Mechanical Nozzle Seal Assembly Details".

4.0 CALCULATION OF BOTTOM PRESSURIZER (BP) MNSA OVERTURNING MOMENT

- THE WEIGHT OF THE ENTIRE BP MNSA IS TABULATED AND CALCULATED IN TABLE 1.
- FOR CALCULATION PURPOSES, THE ASSEMBLY WILL BE SPLIT INTO TWO PARTS; 1.) THE UPPER ASSY, AND 2.) THE LOWER ASSY.

4.1 THE UPPER ASSY PARTS & WEIGHTS ARE: (FROM TABLE 1)

DESCRIPTION	QTY	TOTAL WEIGHT (LBS)
a.) TOP PLATE	1	3.63
b.) TIE RODS	4	1.56
c.) HEX NUTS	12	0.27
d.) 7/8" RETAINER WASHERS	12	+ 0.22

W_{BPUP} = UPPER ASSY WEIGHT = $\boxed{5.68 \text{ LBS}}$.

4.2 OVERTURNING MOMENT OF BP MNSA UPPER ASSY –

MOMENTS ABOUT PIVOT POINT, FIGURE 1

4.2.1 OVERTURNING MOMENT DUE TO TOP PLATE – ⊛ ASSUMING A 1g SEISMIC LOAD.

$$M_{BPTP} = W_{BPTP}(D)$$

$$M_{BPTP} = 3.63\text{ LBS}\left(.375\text{ IN} + 0.037\text{ IN} + 13.28\text{ IN} + 0.63\text{ IN}\right)$$

$$M_{BPTP} = 3.63\text{ LBS}\left(14.322\text{ IN}\right) = \boxed{51.9 \text{ IN-LBS}} \circledast$$

4.2.2 OVERTURNING MOMENT DUE TO REMAINDER OF UPPER ASSY -

- WEIGHT (TIE RODS):

$$W_{BPTR} = W_{BPUP} - W_{BPTP}$$

$$W_{BPTR} = 5.68 \text{ LBS} - 3.63 \text{ LBS} = \underline{\underline{2.05 \text{ LBS}}}$$

- FORCE ACTS THROUGH THE CG OF THE TIE RODS;

  - LOCATION (DIMENSIONS FROM FIGURE 1)

$$CG_{BP} = \left[\frac{(.630 + 13.28 + .037) - (.700 + .500 + .282 + 2.035)}{2}\right] + (.700 + .500 + .282 + 2.035)$$

$$CG_{BP} = \left[\frac{(13.947) - (3.517)}{2}\right] + 3.517 = \underline{8.732 \text{ IN}}$$

4.2.3 MOMENT - ⊛ ASSUMING A 1g SEISMIC LOAD

$$M_{BPTR} = W_{BPTR}\left(CG_{BP}\right)$$

$$M_{BPTR} = 2.05 \text{ LBS}\left(8.732 \text{ IN}\right)$$

$$M_{BPTR} = \boxed{\underline{17.9 \text{ IN-LBS}}} \quad ⊛$$

4.3 THE LOWER ASSY PARTS & WEIGHTS ARE:- (FROM TABLE 1)

DESCRIPTION	QTY	TOTAL WEIGHT (LBS)
a.) LOWER FLANGE	1	24.64
b.) SEAL RETAINER	1	0.74
c.) COMPRESSION COLLAR	1	0.82
d.) UPPER FLANGE (BOTTOM)	1	7.10
e.) UPPER FLANGE (TOP)	1	6.96
f.) HEX BOLT (SHORT)	2	0.44
g.) HEX BOLT (LONG)	2	0.72
h.) $\frac{1}{2}$" RETAINER WASHER	4	+ 0.11

W_{BPLW} = LOWER ASSY WEIGHT = $\boxed{41.53 \text{ LBS}}$

4.3.1 FOR CALCULATION PURPOSES, THE BP MNSA LOWER ASSY IS DIVIDED INTO TWO SECTIONS:

- SECTION ① ; WITH A TRIANGULAR CROSS-SECTION
- SECTION ② ; WITH A SQUARE CROSS-SECTION

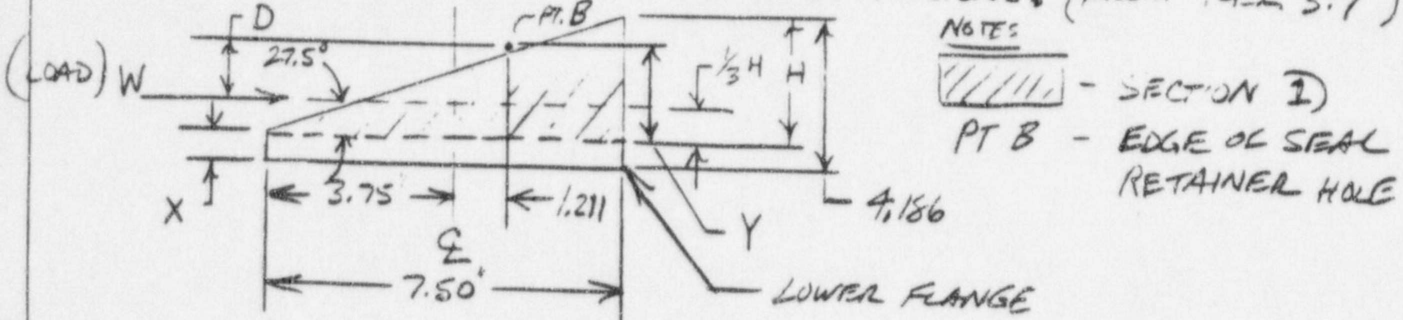
THE ASSUMPTION IS MADE THAT $\frac{1}{2}$ OF THE LOWER ASSY WEIGHT IS ACCOUNTED FOR BY SECTION ①, & THE REMAINING HALF BY SECTION ②.

$\Rightarrow$ OR $41.53 \text{ LBS}/2 = \boxed{20.765 \text{ LBS}}$ EA. SECTION

4.4 OVERTURNING MOMENT OF 3P MNSA LOWER ASSY

4.4.1 MOMENT ARM OF LOWER ASSY, SECTION ① –

TRIANGULAR SECTION WITH DIMENSIONS: (FROM REF 3.7)



- DETERMINE "H" – $\tan(27.5^\circ) = \dfrac{H}{7.50''}$

$$\Rightarrow \quad H = \tan(27.5^\circ)\left[7.50''\right]$$

$$\underline{H = 3.904''}$$

- DETERMINE "X" – $X = 4.186'' - H$

$$X = 4.186'' - 3.904''$$

$$\underline{X = 0.282}$$

- DETERMINE "1/3 H" – $\frac{1}{3}H = 0.333(3.904'')$

$$\underline{\tfrac{1}{3}H = 1.301}$$

4.4.1 (CON.)

- DETERMINE "Y" – $\tan(27.5^\circ) = \frac{Y}{(3.75' - 1.211'')}$

  $Y = \tan(27.5')[4.961'']$

  $\underline{Y = 2.583''}$

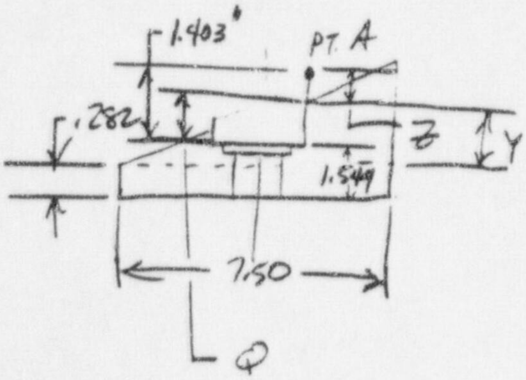
- DETERMINE "D" – $D = Y - \frac{1}{3}H$

  $D = 2.583'' - 1.301''$

  $\underline{D = 1.282''}$

- ADDITIONAL STICKOUT OF SEAL RETAINER BELOW LOWER FLANGE "Z"

NOTE: – PT A IS PIVOT POINT FOR OVERTURNING MOMENT.



- DETERMINE "Q" –

  $Q = Y - [1.544'' - .282'']$

  $Q = 2.583'' - [1.262]$

  $\underline{Q = 1.321''}$

- FINALLY "Z" – $Z = 1.403'' - Q$

  $Z = 1.403'' - 1.321''$

  $\underline{Z = 0.082''}$

4.4.1 (CON.)

⇒ MOMENT ARM: $D' = D + Z$

$D' = 1.282'' + 0.082''$

$\boxed{D' = \underline{1.364}''}$

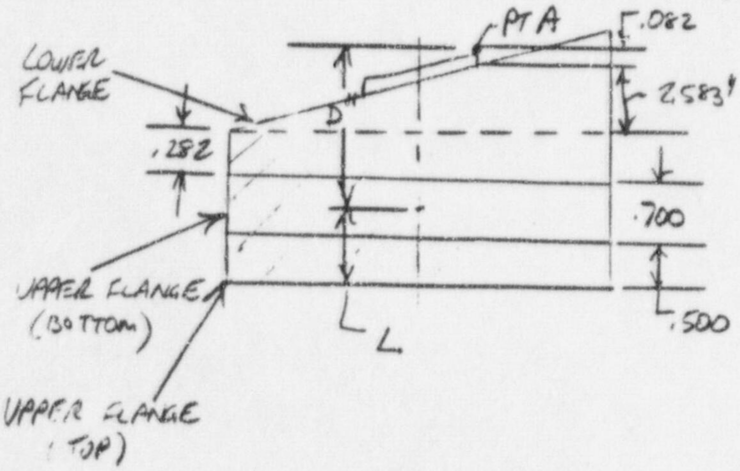
4.4.2 SECTION ① MOMENT — ⊛ ASSUMING A 2g SEISMIC LOAD.

$M_{BPLW_{①}} = 20.765 \text{ LBS} (1.364 \text{ IN})$

$M_{BPLW_{①}} = \boxed{28.3 \text{ IN-LBS}}$ ⊛

4.4.3 MOMENT OF LOWER ASSY, SECTION ② -

SQUARE CROSS-SECTION WITH DIMENSIONS: (FROM REF 3.7)



▨ - SECTION ②

- DETERMINE L -

$$L = \frac{(.282 + .700 + .500)}{2}$$

$\underline{L = 0.741 \text{ IN}}$

⇒ MOMENT ARM: $D'' = [.082'' + 2.583'' + .282'' + .700 + .500] - L$

$\boxed{D'' = [4.147''] - 0.741 \text{ IN} = \underline{3.406 \text{ IN}}}$

4.4.4 SECTION ② MOMENT – ⊛ ASSUMING A 1g SEISMIC LOAD.

$$M_{BPLW②} = 20.765 \text{ LBS} \left(3.406 \text{ IN}\right)$$

$$M_{BPLW②} = \boxed{70.7 \text{ IN-LBS}} \; ⊛$$

4.5 TOTAL OVERTURNING MOMENT (BP):

$$M_{BP} = M_{BPTP} + M_{BPTR} + M_{BPLW①} + M_{BPLW②}$$

$$M_{BP} = 51.9 \text{ IN-LBS} + 17.9 \text{ IN-LBS} + 28.3 \text{ IN-LBS} + 70.7 \text{ IN-LBS}$$

$$\boxed{M_{BP} = 168.8 \text{ IN-LBS} \quad \text{OR} \quad 14.1 \text{ FT-LBS}}$$

5.0 CALCULATION OF STEAM GENERATOR PDT. (SG) MNSA OVERTURNING MOMENT

- THE WEIGHT OF THE ENTIRE SG MNSA IS TABULATED AND CALCULATED IN TABLE 2.
- FOR CALCULATION PURPOSES, THE ASSEMBLY WILL BE SPLIT INTO TWO PARTS; 1.) THE UPPER ASSY, AND 2.) THE LOWER ASSY.

5.1 THE UPPER ASSY PARTS + WEIGHTS ARE: (FROM TABLE 2)

	DESCRIPTION	QTY	TOTAL WEIGHT (LBS)
a.)	TOP PLATE	1	3.59
b.)	TIE RODS	4	1.66
c.)	HEX NUTS	12	0.27
d.)	3/8" RETAINER WASHERS	12	+ 0.22

$W_{SG\,UP}$ = UPPER ASSY WEIGHT = $\boxed{5.74 \text{ LBS}}$

5.2 OVERTURNING MOMENT OF SG MNSA UPPER ASSY - MOMENTS ABOUT PIVOT PT, FIGURE 2

5.2.1. OVERTURNING MOMENT DUE TO TOP PLATE -
(*) ASSUMING A 1g SEISMIC LOAD

$$M_{SG\,TP} = W_{SG\,TP}\left(D_{SG\,TP}\right)$$

$$M_{SG\,TP} = 3.59 \text{ LBS}\left(.375'' + .015'' + 12.73'' + 0.176''\right)$$

$$M_{SG\,TP} = 3.59 \text{ LBS}\left(13.296 \text{ IN}\right) = \boxed{47.7 \text{ IN-LBS}}\ (*)$$

5.2.2 OVERTURNING MOMENT DUE TO REMAINDER OF UPPER ASSY –

- WEIGHT: (TIE RODS) $W_{SGTR} = W_{SGUP} - W_{SGTP}$

$$W_{SGTR} = 5.74 \text{ LBS} - 3.59 \text{ LBS} = \underline{2.15 \text{ LBS}}$$

- FORCE ACTS THROUGH THE CG OF THE TIE RODS;

– LOCATION (DIMENSIONS FROM FIGURE 2)

$$CG_{SG} = \left[\frac{(.176 + 12.73 + .015) - (.700 + .500 + .371 + .754)}{2}\right] + (.700 + .500 + .371 + .754)$$

$$CG_{SG} = \left[\frac{(12.921) - (2.325)}{2}\right] + (2.325) = \underline{7.623 \text{ IN}}$$

5.2.3 MOMENT – ⊛ ASSUMING A 1g SEISMIC LOAD.

$$M_{SGTR} = W_{SGTR}\,(CG_{SG})$$

$$M_{SGTR} = 2.15 \text{ LBS}\,(7.623 \text{ IN})$$

$$M_{SGTR} = \boxed{16.4 \text{ IN-LBS}} \; ⊛$$

5.3 THE LOWER ASSY PARTS & WEIGHTS ARE :- (FROM TABLE 2)

	DESCRIPTION	QTY	TOTAL WEIGHT (LBS)
a.)	LOWER FLANGE	1	10.09
b.)	SEAL RETAINER	1	0.32
c.)	COMPRESSION COLLAR	1	0.58
d.)	UPPER FLANGE (BOTTOM)	1	7.08
e.)	UPPER FLANGE (TOP)	1	6.95
f.)	HEX BOLT (SHORT)	2	0.38
g.)	HEX BOLT (LONG)	2	0.45
h.)	1/2" RETAINER WASHERS	4	+ 0.11

W_{SGLW} = LOWER ASSY WEIGHT = $\boxed{25.96 \text{ LBS}}$

5.3.1 FOR CALCULATION PURPOSES, THE SG MNSA LOWER ASSY IS DIVIDED INTO TWO SECTIONS;

- SECTION ①; WITH A TRIANGULAR CROSS-SECTION
- SECTION ②; WITH A SQUARE CROSS-SECTION

THE ASSUMPTION IS MADE THAT 1/4 OF THE LOWER ASSY WEIGHT IS ACCOUNTED FOR BY SECTION ①, & THE REMAINING 3/4 OF THE WEIGHT BY SECTION ②.

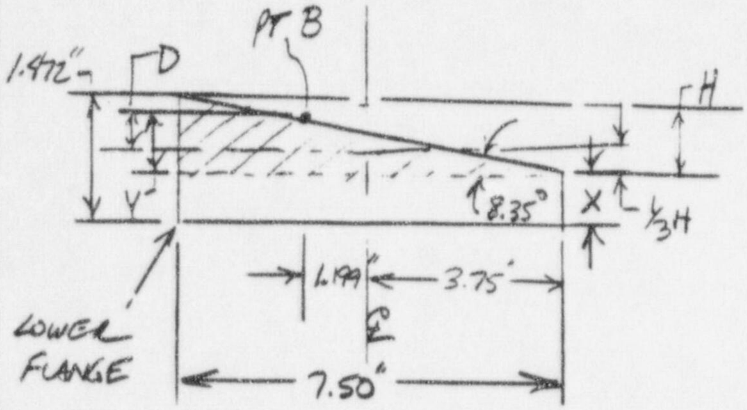
⇒ OR ; SECTION ① = $\frac{1}{4}(25.96)$ = 6.49 LBS

SECTION ② = $\frac{3}{4}(25.96)$ = 19.47 LBS

5.4 OVERTURNING MOMENT OF SG MNSA LOWER ASSY.

5.4.1 MOMENT ARM OF LOWER ASSY, SECTION ① –

TRIANGULAR CROSS-SECTION WITH DIMENSIONS: (FROM REF 3.8)



NOTES

▨ – SECTION ①

PT B – EDGE OF SEAL RETAINER HOLE

- DETERMINE "H" – $\tan(8.35^\circ) = \frac{H}{7.50''}$

$$\Rightarrow H = \tan(8.35^\circ)[7.50'']$$

$$\underline{H = 1.101''}$$

- DETERMINE "X" – $X = 1.472'' - H$

$$X = 1.472'' - 1.101''$$

$$\underline{X = 0.371''}$$

- DETERMINE "$\frac{1}{3}H$" – $\frac{1}{3}H = 0.333\,(1.101'')$

$$\underline{\tfrac{1}{3}H = 0.367''}$$

5.4.1 (CON.)

- DETERMINE "Y" – $\tan(8.35^\circ) = \dfrac{Y}{(3.75'' + 1.199'')}$

$$Y = \tan(8.35^\circ)\left[4.949''\right]$$

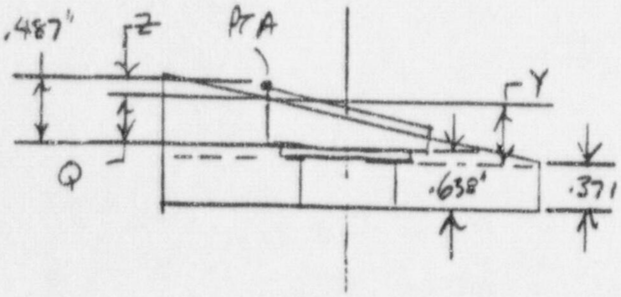
$$\underline{Y = 0.726''}$$

- DETERMINE "D" – $D = Y - \frac{1}{3}H$

$$D = 0.726'' - 0.367''$$

$$\underline{D = 0.359''}$$

- ADDITIONAL STICKOUT, OF SEAL RETAINER BELOW LOWER FLANGE – "Z"



NOTE: – PT A IS PIVOT POINT FOR OVERTURNING MOMENT.

- DETERMINE Q

$$Q = Y - [.638'' - .371'']$$

$$Q = 0.726'' - [.267'']$$

$$\underline{Q = 0.459}$$

- FINALLY "Z" – $Z = 0.487 - Q$

$$Z = 0.487 - 0.459$$

$$\underline{Z = 0.028''}$$

5.4.1 (CON.)

⇒ MOMENT ARM: $D' = D + Z$

$D' = 0.359'' + 0.028''$

$\underline{D' = 0.387''}$

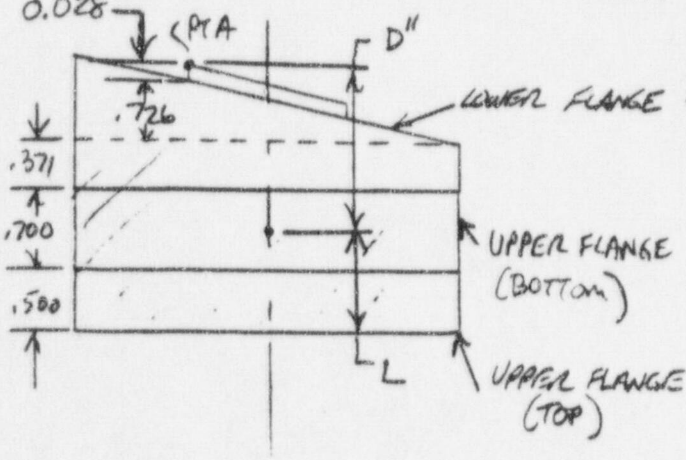
5.4.2 SECTION ① MOMENT — ⊛ ASSUMING A 1g SEISMIC LOAD

$M_{SG LW ①} = 6.49 \text{ LBS } (.387 \text{ IN})$

$M_{SG LW ①} = \boxed{2.5 \text{ IN-LBS}}$ ⊛

5.4.3 MOMENT OF LOWER ASSY, SECTION ② -

- SQUARE CROSS-SECTION WITH DIMENSIONS: (FROM REF. 3.8)



▨ - SECTION ②

- DETERMINE L -

$$L = \frac{(.371 + .700 + .500)}{2}$$

$\underline{L = 0.786 \text{ IN}}$

⇒ MOMENT ARM: $D'' = [.028'' + .726'' + .371'' + .700'' + .500''] - L$

$$\boxed{D'' = [2.325 \text{ IN}] - 0.786 \text{ IN} = \underline{1.539 \text{ IN}}}$$

5.4.4 SECTION ② MOMENT – ⊛ ASSUMING A 1g SEISMIC LOAD

$M_{SGLW\textcircled{2}} = 19.47 \text{ LBS} (1.539 \text{ IN})$

$M_{SGLW\textcircled{2}} = \boxed{30.0 \text{ IN-LBS}}$ ⊛

5.5 TOTAL OVERTURNING MOMENT (SG):

$M_{SG} = M_{SGTP} + M_{SGTR} + M_{SGLW\textcircled{1}} + M_{SGLW\textcircled{2}}$

$M_{SG} = 47.7 \text{ IN-LBS} + 16.4 \text{ IN-LBS} + 2.5 \text{ IN-LBS} + 30.0 \text{ IN-LBS}$

$\boxed{M_{SG} = \underline{96.6 \text{ IN-LBS}} \text{ OR } \underline{8.1 \text{ FT-LBS}}}$

6.0 CALCULATION OF HOT LEG POT (HLP) MNSA OVERTURNING MOMENT

- THE WEIGHT OF THE ENTIRE HLP MNSA IS TABULATED & CALCULATED IN TABLE 3.
- FOR CALCULATION PURPOSES, THE ASSEMBLY WILL BE SPLIT INTO TWO PARTS; 1) THE UPPER ASSY. AND 2.) THE LOWER ASSY.

6.1 THE UPPER ASSY PARTS & WEIGHTS ARE: (FROM TABLE 3)

DESCRIPTION	QTY	TOTAL WEIGHT (LBS)
a.) TOP PLATE	1	3.59
b.) TIE RODS	4	2.00
c.) HEX NUTS	12	0.27
d.) 3/8" RETAINER WASHERS	8	+ 0.15

$W_{HLP_{UP}}$ = UPPER ASSY WEIGHT = $\boxed{6.01 \text{ LBS}}$

6.2 OVERTURNING MOMENT OF HLP MNSA UPPER ASSY. – MOMENTS ABOUT PIVOT PT. FIGURE 3

6.2.1. OVERTURNING MOMENT DUE TO TOP PLATE –

Ⓧ ASSUMING A 1g SEISMIC LOAD.

$$M_{HLP_{TP}} = W_{HLP_{TP}} (D_{HLP_{TP}})$$

$$M_{HLP_{TP}} = 3.59\text{ LBS} (15.11" + 0.020" - 0.375")$$

$$M_{HLP_{TP}} = 3.59\text{ LBS} (15.505\text{ IN}) = \boxed{55.7 \text{ IN-LBS}} \quad Ⓧ$$

6.2.2 OVERTURNING MOMENT DUE TO REMAINDER OF UPPER ASSY -

- WEIGHT (TIE RODS) : $W_{HLP_{TR}} = W_{HLP_{UP}} - W_{HLP_{TP}}$

$$W_{HLP_{TR}} = 6.01 \text{ LBS} - 3.59 \text{ LBS} = \underline{\underline{2.42 \text{ LBS}}}$$

- FORCE ACTS THROUGH THE CG OF THE TIE RODS;

— LOCATION (DIMENSIONS FROM FIGURE 3)

$$CG_{HLP} = \left[\frac{(15.11 + .020) - (1.500 + .135 + .380)}{2}\right] + (1.500 + .135 + .380)$$

$$CG_{HLP} = \left[\frac{(15.13) - (2.015)}{2}\right] + (2.015) = \underline{8.573 \text{ IN}}$$

6.2.3. MOMENT - ⊛ ASSUMING A 1g SEISMIC LOAD

$$M_{HLP_{TR}} = W_{HLP_{TR}} \left(CG_{HLP} \right)$$

$$M_{HLP_{TR}} = 2.42 \text{ LBS} \left(8.573 \text{ IN} \right)$$

$$M_{HLP_{TR}} = \boxed{\underline{20.7 \text{ IN-LBS}}} \; ⊛$$

6.3 THE LOWER ASSY PARTS : WEIGHTS ARE : (FROM TABLE 3)

DESCRIPTION	QTY	TOTAL WEIGHT (LBS)
a.) LOWER FLANGE	1	2.68
b.) SEAL RETAINER	1	0.18
c.) COMPRESSION COLLAR	1	0.53
d.) UPPER FLANGE (BOTTOM)	1	3.66
e.) UPPER FLANGE (TOP)	1	4.24
f.) HEX BOLT	4	0.79
g.) RETAINER PLATES	4	+ 0.06

W_{HLPLW} = LOWER ASSY WEIGHT = $\boxed{12.14 \text{ LBS}}$

6.4 OVERTURNING MOMENT OF HL MNSA LOWER ASSY.

HLP MNSA LOWER ASSY MOMENT; MOMENTS ABOUT PIVOT PT ON FIGURE 3 :

→ ⊕ ASSUMING A 1g SEISMIC LOAD.

$$M_{HLPLW} = W_{HLPLW}(CG_{HLPLW})$$

$$M_{HLPLW} = 12.14 \text{ LBS}\left(\frac{0.135'' + 0.380'' + 1.50''}{2}\right)$$

$$M_{HLPLW} = 12.14 \text{ LBS}\,(1.008 \text{ IN})$$

$$M_{HLPLW} = \boxed{12.2 \text{ IN-LBS}} \ ⊕$$

6.5 TOTAL OVERTURNING MOMENT (HLP):

$$M_{HLP} = M_{HLP_{TP}} + M_{HLP_{TR}} + M_{HLP_{LW}}$$

$$M_{HLP} = 55.7 \text{ IN-LBS} + 20.7 \text{ IN-LBS} + 12.\text{[illegible] IN-LBS}$$

$$\boxed{M_{HLP} = \underline{88.6 \text{ IN-LBS}} \quad \text{OR} \quad \underline{7.4 \text{ FT-LBS}}}$$

7.0 CALCULATION OF HOT LEG SAMPLING (HLS) MNSA OVERTURNING MOMENT

- THE WEIGHT OF THE ENTIRE HLS MNSA IS TABULATED AND CALCULATED IN TABLE 4.
- FOR CALCULATION PURPOSES THE ASSEMBLY WILL BE SPLIT INTO TWO PARTS; 1.) THE UPPER ASSY, AND 2.) THE LOWER ASSY.

7.1 THE UPPER ASSY PARTS & WEIGHTS ARE: (FROM TABLE 4)

DESCRIPTION	QTY	TOTAL WEIGHT (LBS)
a.) TOP PLATE	1	4.93
b.) TIE RODS	4	1.00
c.) HEX NUTS	12	0.27
d.) 7/8" RETAINER WASHERS	8	+ 0.15

$W_{HLS_{UP}}$ = UPPER ASSY WEIGHT = $\boxed{6.35 \text{ LBS}}$

7.2 OVERTURNING MOMENT OF HLS MNSA UPPER ASSY. –

MOMENT ABOUT PIVOT PT., FIGURE 4

7.2.1 OVERTURNING MOMENT DUE TO TOP PLATE –

⊛ ASSUMING A 1g SEISMIC LOAD

$$M_{HLS_{TP}} = W_{HLS_{TP}} \left(D_{HLS_{TP}} \right)$$

$$M_{HLS_{TP}} = 4.93 \text{ LBS} \left(.375'' + 7.25'' \right)$$

$$M_{HLS_{TP}} = 4.93 \text{ LBS} \left(7.625 \text{ IN} \right) = \boxed{37.6 \text{ IN-LBS}} \; ⊛$$

7.2.2 OVERTURNING MOMENT DUE TO REMAINDER OF UPPER ASSY -

- WEIGHT (TIE RODS): $W_{HLS_{TR}} = W_{HLS_{UP}} - W_{HLS_{TP}}$

$$W_{HLS_{TR}} = 6.35 \text{ LBS} - 4.93 \text{ LBS}$$

$$W_{HLS_{TR}} = \underline{\underline{1.42 \text{ LBS}}}$$

- FORCE ACTS THROUGH THE CG OF THE TIE RODS;

∴ LOCATION (DIMENSIONS FROM FIGURE 4)

$$CG_{HLS} = \left[\frac{(7.25) - (1.500 + .135 + .380)}{2}\right] + (1.500 + .135 + .380)$$

$$CG_{HLS} = \left[\frac{(7.25) - (2.015)}{2}\right] + (2.015) = \underline{4.633 \text{ IN}}$$

7.2.3 MOMENT - ⊛ ASSUMING A 1g SEISMIC LOAD

$$M_{HLS_{TR}} = W_{HLS_{TR}} \left(CG_{HLS}\right)$$

$$M_{HLS_{TR}} = 1.42 \text{ LBS} \left(4.633 \text{ IN}\right)$$

$$M_{HLS_{TR}} = \boxed{6.1 \text{ IN-LBS}} \; ⊛$$

7.3 THE LOWER ASSY PARTS & WEIGHTS ARE: (FROM TABLE 4)

	DESCRIPTION	QTY	TOTAL WEIGHT (LBS)
a.)	LOWER FLANGE	1	2.68
b.)	SEAL RETAINER	1	0.18
c.)	COMPRESSION COLLAR	1	0.49
d.)	UPPER FLANGE (BOTTOM)	1	3.66
e.)	UPPER FLANGE (TOP)	1	4.24
f.)	HEX BOLT	4	0.79
g.)	RETAINER PLATES	4	+ 0.06

$W_{HLS_{LW}}$ = LOWER ASSY. WEIGHT = $\boxed{12.10 \text{ LBS}}$

7.4 OVERTURNING MOMENT OF HLS MNSA LOWER ASSY.

HLS MNSA LOWER ASSY MOMENT; MOMENTS ABOUT PIVOT PT. ON FIGURE 4: ⊛ ASSUMING A 1g SEISMIC LOAD.

$$M_{HLS_{LW}} = W_{HLS_{LW}} \left(D_{HLS_{LW}} \right)$$

$$M_{HLS_{LW}} = 12.10 \text{ LBS} \left(3.135'' + 0.380'' - 1.500'' \right)$$

$$M_{HLS_{LW}} = 12.10 \text{ LBS} \left(2.015 \text{ IN} \right)$$

$$M_{HLS_{LW}} = \boxed{24.4 \text{ IN-LBS}} \; ⊛$$

7.5 TOTAL OVERTURNING MOMENT (HCS):

$$M_{HCS} = M_{HCS_{TP}} + M_{HCS_{TR}} + M_{HCS_{LW}}$$

$$M_{HCS} = 37.6 \text{ IN-LBS} + 6.1 \text{ IN-LBS} + 24.4 \text{ IN-LBS}$$

$$\boxed{M_{HCS} = 68.1 \text{ IN-LBS OR } \underline{5.7 \text{ FT-LBS}}}$$

8.0 COMPARISON BETWEEN BP MNSA & SG MNSA

- THE BP MNSA & SG MNSA HAVE ESSENTIALLY THE SAME DESIGN. IF WE COMPARE THE OVERTURNING MOMENTS FOR THESE TWO DESIGNS AND THE SG MNSA MOMENT IS LESS THAN OR EQUAL TO THAT OF THE BP MNSA, THEN WE CAN CONCLUDE THAT THE SG MNSA DESIGN IS QUALIFIED TO WITHSTAND THE SAME SEISMIC CONDITIONS THAT THE BP MNSA WAS SUBJECTED TO DURING TESTING (REF. 3.1).

⇒ COMPARE

IS THIS TRUE?:

$$M_{BP} \geq M_{SG}$$

$$\boxed{\text{(FROM 4.5) } \underline{\underline{19.1 \text{ FT-LBS}}} \geq \text{ (FROM 5.5) } \underline{\underline{8.1 \text{ FT-LBS}}}}$$

(*) THIS STATEMENT IS TRUE / SG MNSA IS SEISMICALLY QUALIFIED

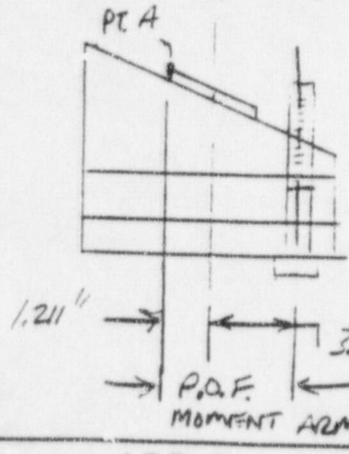
9.0 COMPARISON OF BP MNSA TO HLP MNSA

- THE DESIGNS OF THE BP MNSA & HLP MNSA HAVE DIFFERENCES, SO THAT A ONE-FOR-ONE COMPARISON CANNOT BE MADE (AS WAS DONE FOR THE SG MNSA). IN ORDER TO COMPARE THE TWO DESIGNS, WE MUST LOOK AT THE LOAD CREATED BY THAT OVERTURNING MOMENT THAT WOULD TEND TO OFFSET THE HEX BOLTS PRELOAD.

- THEREFORE, THE PRELOAD OFFSETTING FORCE (P.O.F.) WILL BE CALCULATED FOR EACH DESIGN. IF THE P.O.F. FOR THE HLP MNSA IS LESS THAN OR EQUAL TO THAT FOR THE BP MNSA, THE HLP MNSA WILL BE CONSIDERED SEISMICALLY QUALIFIED TO WITHSTAND SEISMIC CONDITIONS FOR THE BP MNSA (REF. 3.1).

9.1 P.O.F. FOR BP MNSA

- OVERTURNING MOMENT (FROM 4.5) = 168.8 IN-LBS
- WORST CASE IS THAT ONLY ONE BOLT WILL BE RESISTING THIS OVERTURNING MOMENT



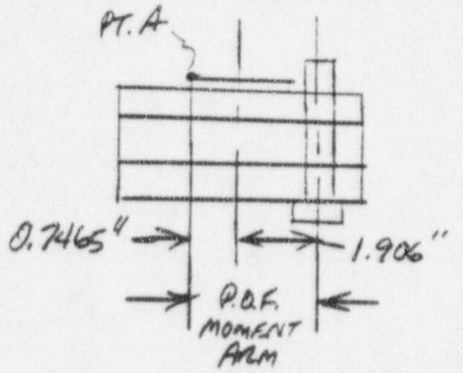
$$P.O.F._{BP} = \frac{M_{BP}}{\text{MOMENT ARM}_{P.O.F.}}$$

$$P.O.F._{BP} = \frac{168.8 \text{ IN-LBS}}{(1.211'' + 3.25'')} = \frac{168.8 \text{ IN-LBS}}{4.461 \text{ IN}}$$

$$\boxed{P.O.F._{BP} = \underline{\underline{37.8 \text{ LBS}}}}$$ ⊛

9.2 P.O.F FOR HLP MNSA

- OVERTURNING MOMENT (FROM 6.5) = 88.6 IN-LBS
- WORST CASE IS FOR ONE BOLT RESISTING THE ENTIRE OVERTURNING MOMENT.



$$P.O.F._{HLP} = \frac{M_{HLP}}{\text{MOMENT ARM}_{P.O.F.}}$$

$$P.O.F._{HLP} = \frac{88.6 \text{ IN-LBS}}{(1.906" + 0.7465")} = \frac{88.6 \text{ IN-LBS}}{(2.6525 \text{ IN})}$$

$$\boxed{P.O.F_{HLP} = \underline{\underline{33.4 \text{ LBS}}}}$$

9.3 COMPARISON OF BP TO HLP

- COMPARE P.O.F.'s OF TWO DESIGNS:

IS THIS TRUE? $P.O.F_{HLP} \leq P.O.F_{BP}$

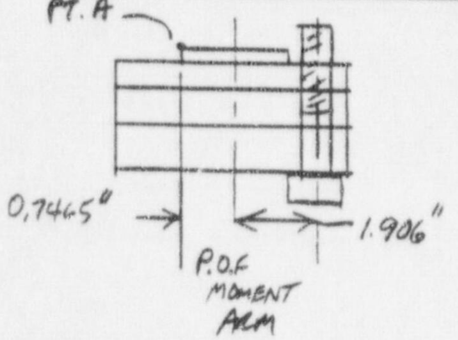
$$\boxed{(\text{FROM } 9.2)\ \underline{\underline{33.4 \text{ LBS}}} \leq (\text{FROM } 9.1)\ \underline{\underline{37.8 \text{ LBS}}}}$$ ✓

THE STATEMENT IS TRUE & THEREFORE THE HLP IS SEISMICALLY QUALIFIED.

10.0 COMPARISON OF 3P MNSA TO HLS MNSA

- THE DESIGNS OF THE 3P MNSA AND HLS MNSA HAVE EVEN GREATER GEOMETRICAL DIFFERENCES. THEREFORE, AS IS SECTION 9.0, THE ONLY MEANINGFUL COMPARISON IS TO COMPARE THE PRELOAD OFFSETTING FORCE (P.O.F.) FOR EACH DESIGN. IF THE P.O.F. FOR THE HLS MNSA IS LESS THAN OR EQUAL TO THAT OF THE 3P MNSA, THE HLS MNSA IS CONSIDERED SEISMICALLY QUALIFIED.

10.1 P.O.F FOR HLS MNSA



- OVERTURNING MOMENT (FROM 7.5)

$$M_{HLS} = 68.1 \text{ IN-LBS}$$

- WORST CASE IS FOR ONE BOLT RESISTING THE ENTIRE OVERTURNING MOMENT.

$$P.O.F._{HLS} = \frac{M_{HLS}}{\text{MOMENT ARM}_{P.O.F.}} = \frac{68.1 \text{ IN-LBS}}{(2.6525 \text{ IN})}$$

$$\boxed{P.O.F._{HLS} = 25.7 \text{ LBS}}$$ ⊛

10.2 COMPARISON OF BP TO HLS

- COMPARE P.O.Fs OF TWO DESIGNS:

IS THIS TRUE? $P.O.F._{HLS} \le P.O.F._{BP}$

$\boxed{\text{(FROM 10.1) } \underline{\underline{25.7\text{ LBS}}} \le \text{ (FROM 9.1) } \underline{\underline{37.8\text{ LBS}}}}$ ✓

THE STATEMENT IS TRUE & THEREFORE THE HLS IS SEISMICALLY QUALIFIED.

11.0 CONCLUSION

UNDER A REPRESENTATIVE 1g. LOADING, THE OFFSETTING LOADS CREATED IN THE S.G. PDT, HOT LEG PDT, AND HOT LEG SAMPLING MNSAs ARE LESS THAN THE LOADS CREATED IN THE BP MNSA.

THEREFORE, THE STATEMENT CAN BE MADE THAT THE THREE NEW DESIGNS ARE "SEISMICALLY QUALIFIED" SINCE THEY WOULD BE TESTED TO THE SAME SONGS RESPONSE SPECTRUM AS THE BP MNSA IN REFERENCE 3.1.

ADDITIONALLY, THE BP MNSA WAS ACTUALLY SUBJECTED TO SEISMIC LOADS THAT EXCEEDED THE SONGS RESPONSE SPECTRUM BY A FACTOR OF (5) FIVE, WHILE MAINTAINING THE HYDROSTATIC TEST PRESSURE (REF. 3.1).

FIGURE 1

Bottom Pressurizer Mechanical Nozzle Seal Assembly
(from References 3.3 & 3.7)

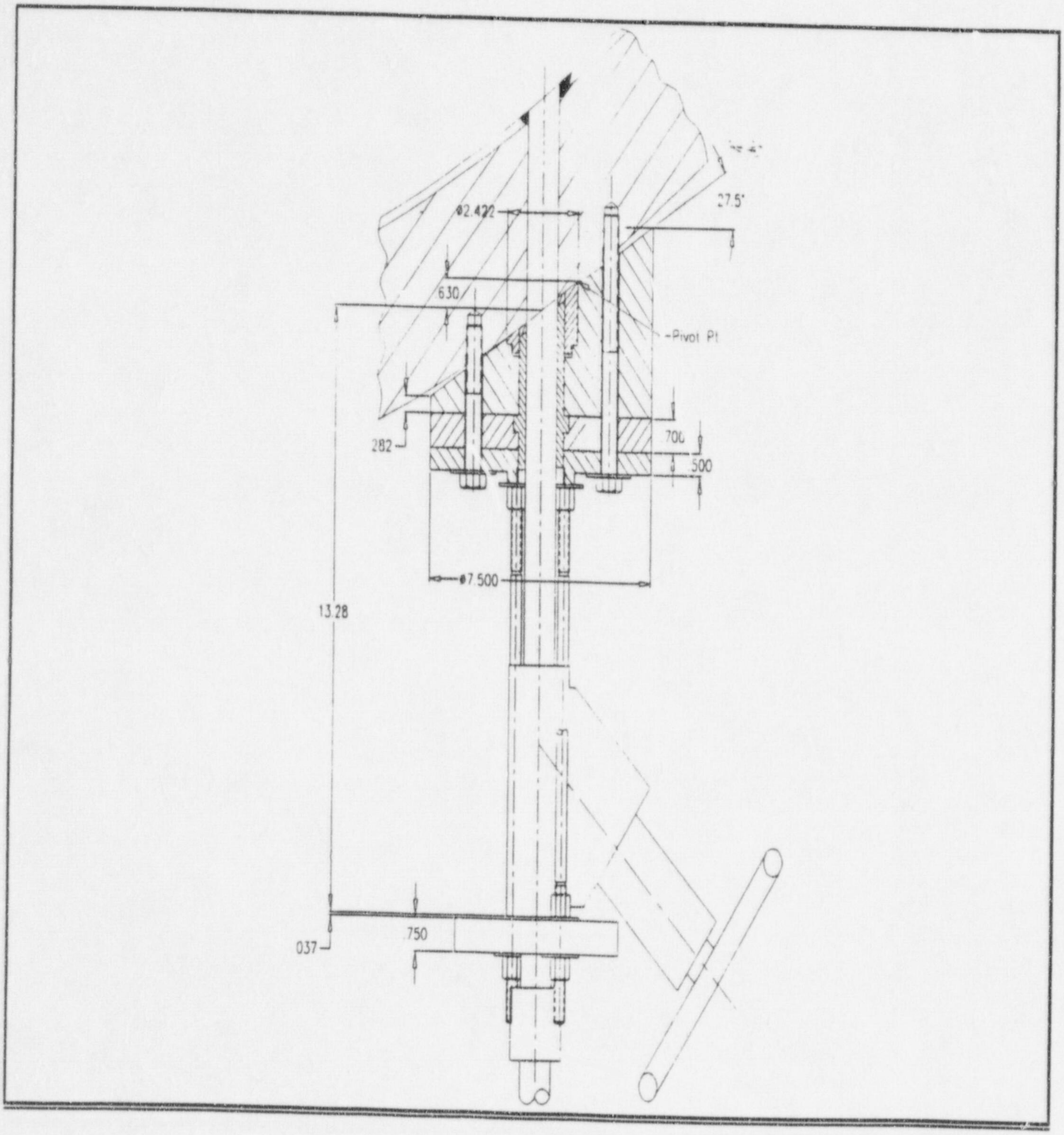


FIGURE 2

Steam Generator PDT Mechanical Nozzle Seal Assembly

(from References 3.4, 3.7, & 3.8)

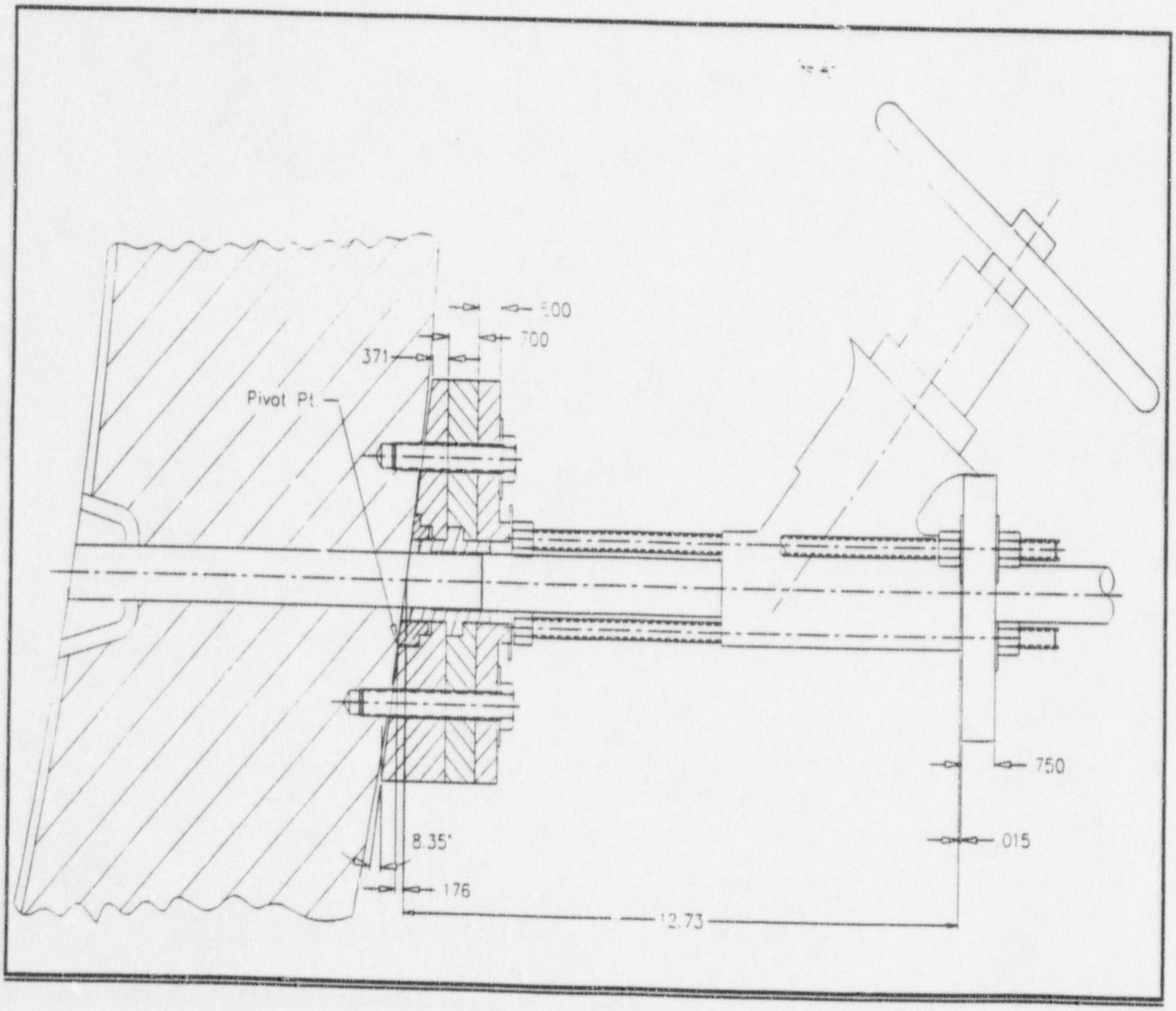


FIGURE 3

Hot Leg PDT Mechanical Nozzle Seal Assembly

(from References 3.5, 3.7, & 3.8)

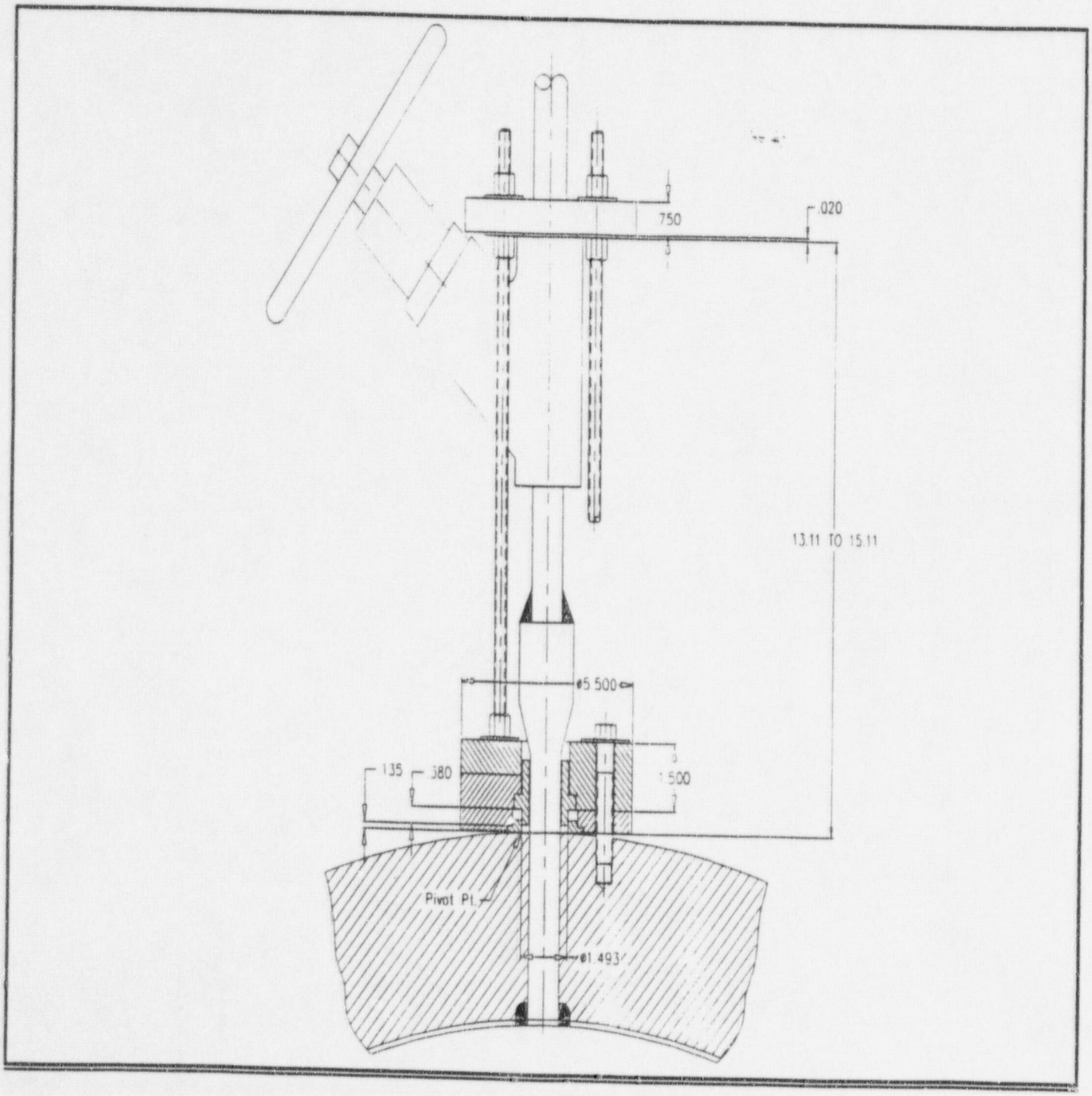


FIGURE 4

Hot Leg Sampling Mechanical Nozzle Seal Assembly

(from References 3.6, 3.7, & 3.8)

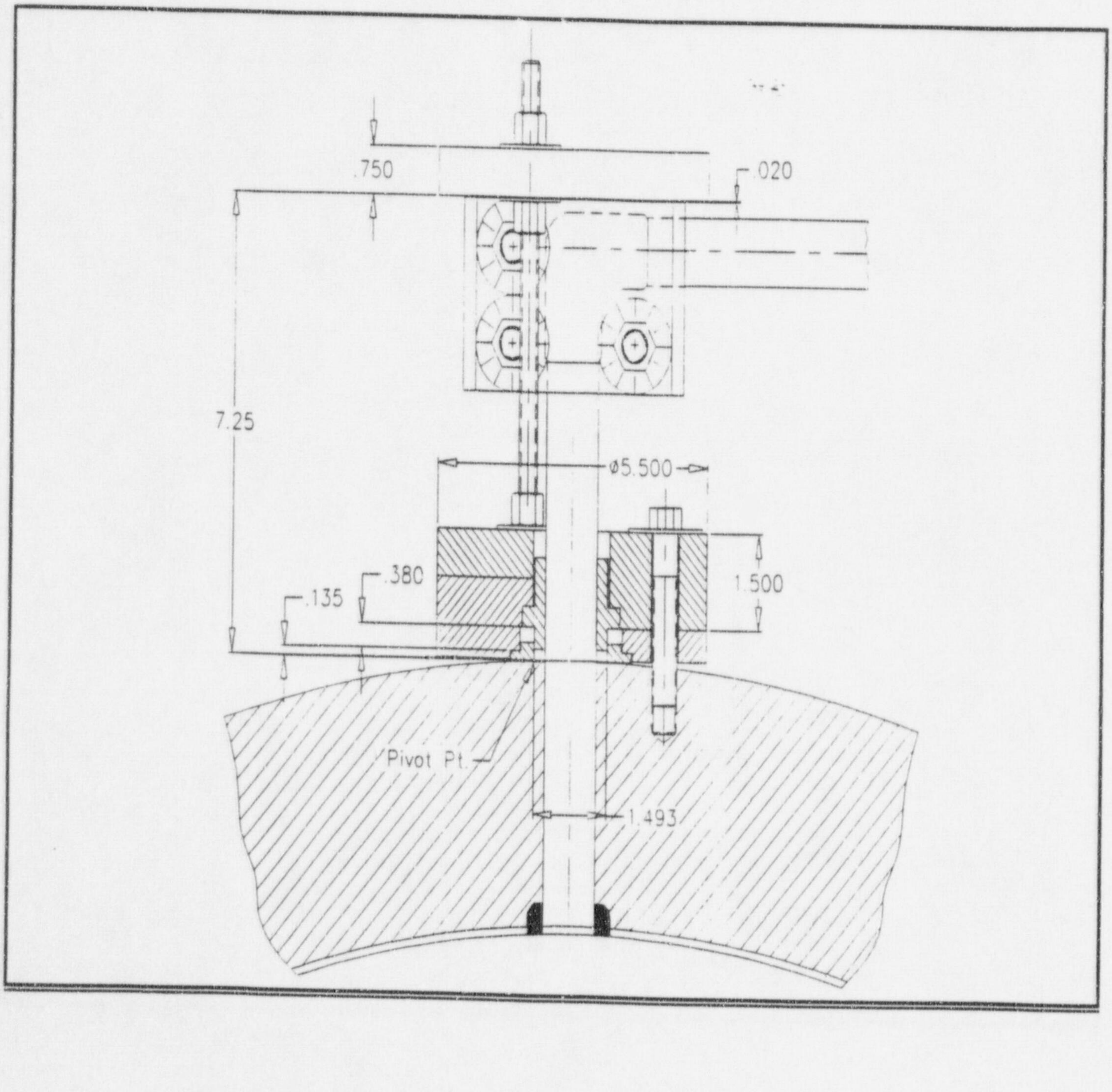


TABLE 1

Bottom Pressurizer MNSA (E-MNSA-228-001-1, Assembly) Weight

Name	Detail Part No.	Volume (cu.in.)	Density (lb/cu.in.)	Weight/Piece (lbs)	Quantity	Total Weight (lbs)
Lower Flange	E-MNSA-228-004-1	87.057	0.283	24.64	1	24.64
Seal Retainer	-004-2	2.614	0.283	0.74	1	0.74
Compression Collar	-004-3	2.899	0.283	0.82	1	0.82
Upper Flange (Bottom)	-004-29	25.100	0.283	7.10	1	7.10
Upper Flange (Top)	-004-5	24.593	0.283	6.96	1	6.96
Top Plate	-004-6	12.826	0.283	3.63	1	3.63
Hex Bolt (Short)	-004-25	0.773	0.283	0.22	2	0.44
Hex Bolt (Long)	-004-24	1.266	0.283	0.36	2	0.72
Tie Rod	-004-15	1.381	0.283	0.39	4	1.56
Hex Nut	-004-27	0.081	0.283	0.02	12	0.27
1/2" Retainer Washer	-004-22	0.093	0.283	0.03	4	0.11
3/8" Retainer Washer	-004-21	0.066	0.283	0.02	12	0.22
					Total:	*47.21*

Notes:

1. Weight of Grafoil Seal is negligible.

TABLE 2

Steam Generator MNSA (E-MNSA-228-014-1, Assembly) Weight

Name	Detail Part No.	Volume (cu.in.)	Density (lb/cu.in.)	Weight/Piece (lbs)	Quantity	Total Weight (lbs)
Lower Flange	E-MNSA-228-013-2	35.655	0.283	10.09	1	10.09
Seal Retainer	-013-3	1.138	0.283	0.32	1	0.32
Compression Collar	-013-4	2.042	0.283	0.58	1	0.58
Upper Flange (Bottom)	-013-10	25.007	0.283	7.08	1	7.08
Upper Flange (Top)	-013-11	24.561	0.283	6.95	1	6.95
Top Plate	-013-6	12.670	0.283	3.59	1	3.59
Hex Bolt (Short)	-013-9	0.663	0.283	0.19	2	0.38
Hex Bolt (Long)	-013-8	0.799	0.283	0.23	2	0.45
Tie Rod	-013-1	1.463	0.283	0.41	4	1.66
Hex Nut	-004-27	0.081	0.283	0.02	12	0.27
1/2" Retainer Washer	-004-22	0.093	0.283	0.03	4	0.11
3/8" Retainer Washer	-004-21	0.066	0.283	0.02	12	0.22
					Total:	***31.69***

Notes:

1. Weight of Grafoil Seal is negligible.

TABLE 3

Hot Leg PDT MNSA (E-MNSA-228-015-1, Assembly) Weight

Name	Detail Part No.	Volume (cu.in.)	Density (lb/cu.in.)	Weight/Piece (lbs)	Quantity	Total Weight (lbs)
Lower Flange	E-MNSA-228-013-13	9.477	0.283	2.68	1	2.68
Seal Retainer	-004-32	0.628	0.283	0.18	1	0.18
Compression Collar	-013-16	1.865	0.283	0.53	1	0.53
Upper Flange (Bottom)	-013-12	12.925	0.283	3.66	1	3.66
Upper Flange (Top)	-013-14	14.973	0.283	4.24	1	4.24
Top Plate	-013-06	12.670	0.283	3.59	1	3.59
Hex Bolt	-013-21	0.701	0.283	0.20	4	0.79
Tie Rod	-013-18	1.767	0.283	0.50	4	2.00
Hex Nut	-004-27	0.081	0.283	0.02	12	0.27
Retainer Plate	-013-20	0.054	0.283	0.02	4	0.06
3/8" Retainer Washer	-004-21	0.066	0.283	0.02	8	0.15
					Total:	*18.15*

Notes:

1. Weight of Grafoil Seal is negligible.

TABLE 4

Hot Leg Sampling MNSA (E-MNSA-228-016-1, Assembly) Weight

Name	Detail Part No.	Volume (cu.in.)	Density (lb/cu.in.)	Weight/Piece (lbs)	Quantity	Total Weight (lbs)
Lower Flange	E-MNSA-228-013-13	9.477	0.283	2.68	1	2.68
Seal Retainer	-004-32	0.628	0.283	0.18	1	0.18
Compression Collar	-013-17	1.735	0.283	0.49	1	0.49
Upper Flange (Bottom)	-013-12	12.925	0.283	3.66	1	3.66
Upper Flange (Top)	-013-14	14.973	0.283	4.24	1	4.24
Top Plate	-013-15	17.430	0.283	4.93	1	4.93
Hex Bolt	-013-21	0.701	0.283	0.20	4	0.79
Tie Rod	-013-19	0.884	0.283	0.25	4	1.00
Hex Nut	-004-27	0.081	0.283	0.02	12	0.27
Retainer Plate	-013-20	0.054	0.283	0.02	4	0.06
3/8" Retainer Washer	-004-21	0.066	0.283	0.02	8	0.15
					Total:	***18.46***

Notes:

1. Weight of Grafoil Seal is negligible.
2. Seismic effect of the weight of Clamp (Detail -013-22), Hex Hd Bolts (Detail -016-15), and 1/2" Retainer Washers (Detail -004-22) is addressed in the Design Report, **Ref. 3.2**

ABB

March 18, 1999
NOME-99-C-0123

Mr. Bruce N. Proctor
Entergy Operations, Inc.
Waterford Steam Electric Station Unit 3
P.O. Box B
Killona, LA 70066

SUBJECT: Mechanical Nozzle Seal Assemblies (MNSA)
Entergy Contract No. NWC00385
Volumes and Surface Area

Dear Mr. Proctor:

Paragraph 4.4.9 of the Technical and Quality Requirements of the subject contract requests volume and surface areas of the steel parts of the MNSAs. The requested information is as follows:

MNSA	Surface Area – sq in	Volume – cu in
RTD Nozzle MNSA	135	42
PDT Nozzle MNSA	174	63
Sampling Nozzle MNSA	286	89
Total	595	194

If there are any questions please call me at (860) 285-2030.

Sincerely,

John T. McGarry
Project Manager

xc: G. Bundick

ABB Combustion Engineering Nuclear Operations

Combustion Engineering, Inc.
P.O. Box 500
2000 Day Hill Road
Windsor, CT 06095-0500
Telephone (860) 688-1911
Fax (860) 285-9521
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ABB

March 18,1999
NOME-99-C-0124

(REVISION 2)
March 22, 1999

Mr. Bruce N. Proctor
Entergy Operations, Inc.
Waterford Steam Electric Station Unit 3
P.O. Box B
Killona LA 70066

SUBJECT: **Mechanical Nozzle Seal Assemblies**
Entergy Contract No.NWC00385
Corrosion Issues

Dear Mr. Proctor:

The attached discussion addresses corrosion issues associated with the MNSAs. Included is a section that discusses fatigue crack growth in carbon steel. This was one of the topics ABB was asked to address.

If there are any questions please call the author, John Hall at (860)285-4762 or me at (860)285-2030.

Sincerely,

John T. McGarry
Project Manager

xc: G. Bundick

ABB Combustion Engineering Nuclear Operations

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Corrosion Issues Associated with the Installation of Mechanical Nozzle Seal Assemblies (MNSAs) on Leaking Hot Leg Nozzles at Waterford-3

The purpose of this discussion is to summarize the available industry and ABB CENP information on various corrosion related issues associated with the use of mechanical nozzle seal assemblies such as the ones currently being installed at Waterford-3.

Background

Entergy Operations is installing mechanical nozzle seal assemblies (MNSAs) on three Alloy 600 hot leg nozzles (two RTD and one sampling) at Waterford-3. Visual inspection of these nozzles during the current refueling outage indicated that they were leaking, as were two pressurizer instrumentation nozzles.

Leaking or cracked small diameter Alloy 600 nozzles are not unique to Waterford-3. All Combustion Engineering (CE) supplied PWRs have numerous Alloy 600 nozzles in the pressurizers (instrumentation nozzles and heater sleeves), hot and cold leg piping (RTD and sampling nozzles), reactor vessel heads (CEDM, ICI and vent line nozzles) and steam generators (instrument nozzles). Most of these were procured as hot-worked and annealed bar stock to the requirements of ASME SB-166. They were machined and welded to the ID of the components with partial penetration welds. Reference 1 describes the fabrication sequence and material properties for all Alloy 600 nozzles in CE supplied PWRs.

Commencing about 1986, primary water stress corrosion cracking (PWSCC) began to occur in Alloy 600 nozzles in CE supplied units. The first failures were in pressurizer instrumentation nozzles, which was to be expected since PWSCC is temperature dependent and temperatures in the pressurizers are higher (653°F) than elsewhere in the primary system. More recently, cracks have occurred in the hot leg nozzles in several CE supplied units including Palo Verde-2, SONGS-2 and 3, and St Lucie-2. Reference 2 summarizes Alloy 600 nozzle cracking experience through about 1995 and there have been several additional occurrences since, including Waterford-3 during the current outage.

Most leaking or cracked Alloy 600 nozzles have been repaired by replacing them with Alloy 690 (more corrosion resistant) nozzles. The Waterford-3 pressurizer nozzles were replaced in this way. Another repair technique is the mechanical nozzle seal assembly (MNSA) which eliminates leakage by mechanically sealing without removing the nozzles. This technique will be used for the three leaking Waterford-3 hot leg nozzles.

With the MNSA approach, the defective nozzles are left in place. As a result, borated water from the primary system will fill the crevice between the nozzle and carbon steel piping. Carbon and low alloy steel used in PWR primary systems are clad with stainless steel to isolate these materials from the primary coolant and minimize corrosion and corrosion product release to the primary coolant. Nozzle hole ID surfaces are not clad because in the as-built condition they are not exposed to primary coolant. Under certain conditions, accelerated corrosion of carbon and low alloy steels will occur if they are exposed to primary coolant and, even under normal operating conditions, some corrosion will occur. Although this corrosion is expected to be minor, there is frequently concern that it could be significant relative to long term service of the repaired nozzle.

A second MNSA concern related to propagation of cracks in the Alloy 600 nozzles through the weld metal and into the carbon steel. If this occurs, continued propagation of the cracks through the carbon steel by a stress corrosion mechanism or a fatigue mechanism from cyclic loads during service may result.

In addition, questions have been raised about potential corrosion specific to the MNSA. These questions have been in three areas: boric acid corrosion of the pipe OD surface if the MNSA develops a leak; galvanic corrosion of the carbon steel as a result of the presence of a grafoil seal, Alloy 600 nozzle, stainless steel MNSA parts, carbon steel and an aqueous environment; and stress corrosion cracking of the stainless steel fasteners that attach the MNSA to the pipe and apply the loads that seal the leaks.

The balance of this letter addresses the various corrosion issues described above.

Boric Acid Corrosion of Nozzle Holes

If a repaired nozzle has a through-wall crack, the crevice between the nozzle and pipe will fill with aerated borated water when the RCS is re-filled. If the MNSA device itself does not leak, the crevice environment will be a stagnant solution that cannot be replenished except perhaps at shutdown when the RCS is drained. Thus, the level of boric acid will not exceed that of the primary coolant at the beginning of a cycle. Although the crevice solution is initially aerated, corrosion of the carbon steel, and to a lesser extent the Alloy 600, will consume the dissolved oxygen, thereby establishing a deaerated condition for most of an operating cycle. During shutdown, the crevice solution may become aerated again.

The corrosion of carbon and low alloy steels in aerated and deaerated borated water at ambient, intermediate and elevated temperatures has been studied in laboratory tests and there have been a number of instances in operating plants where areas of unclad carbon or low alloy steels have been exposed to the primary coolant for significant numbers of years. These data have been used by ABB CENP to develop a corrosion rate that can be used to estimate the amount of corrosion that will occur in crevice regions (Reference 3). The analysis assumed that a plant would operate for 88 percent of the time, be in a shutdown condition for 10 percent of the time and be in a start-up condition for 2 percent of the time. Corrosion rates for carbon and low alloy steels in borated water are highest at low temperature aerated conditions and intermediate temperature aerated conditions (start-up). Because of the characteristics of boric acid and the deaerated condition, corrosion at operating conditions is minimal. The laboratory data also indicated that the corrosion will be uniform, significant pitting will not occur, there will not be a galvanic effect and there is not a potential for hydrogen embrittlement of the carbon or low alloy steel. Using the available data, ABB CENP has estimated an overall corrosion rate for these materials in primary coolant of 1.51 mils per year (0.00151 in/yr).

A specific analysis to determine how much carbon steel could be corroded in the crevice region has not been conducted for the MNSA application. Analysis for weld repairs in pressurizers and piping for weld repairs indicate that the bore holes could be enlarged by several tenths of an inch and still meet ASME code requirements. Assuming this to be the case for a MNSA repair as well, the crevice corrosion lifetime of the MNSA should exceed the remaining plant lifetime, including a 20 year lifetime extension.

Welded nozzle repairs have also been used for leaking Alloy 600 nozzles. Some of these result in the crevice region being filled with borated water or steam. The repair with the longest service time is at ANO-1 where a repaired pressurizer vapor space nozzle has been in service since 1991. After approximately 8 years of service, there has not been any detectable degradation of the low alloy steel based on periodic UT inspection.

A similar repair was made to a SONGS-3 leaking hot leg nozzle in 1993. After 4 years, the repaired nozzle was removed for inspection which indicated only minor pitting corrosion (depths of pits were 0.005 to 0.008 in.) of the carbon steel on the ID of the nozzle hole. St Lucie –2 has had three similar repairs of pressurizer water space nozzles in service since 1994, without indications of corrosion problems.

Other plants have operated for prolonged periods with areas of unclad carbon or low alloy steels exposed to primary coolant. The longest of these was at Yankee Rowe which had sections of the reactor vessel unclad from 1965 until end of life without any apparent degradation. Palo Verde-1 has always operated with a small section of a carbon steel pump body without cladding. Since 1994, another CE plant has had a pressurizer heater hole exposed to primary coolant and has operated for approximately 5 years without any indication of problems.

In summary, available laboratory corrosion data and service experience indicate that any corrosion of the carbon steel in the hot leg Alloy 600 nozzle holes will be minor and will not affect the lifetime of the MNSA repair.

Stress Corrosion Cracking of Carbon Steel Pipe

With the MNSA repair, the Alloy 600 nozzle, which has a through-wall crack, will remain in-place. The residual stresses from the original partial-penetration welds will also remain. CEOG, EPRI and other industry studies (Reference 4) indicate that residual stresses from the welding process are the major driving force for SCC initiation and propagation in Alloy 600 nozzles. Cracks in the nozzle and weld metal may continue to grow because of these residual stresses through the weld and weld butter to the carbon steel pipe. Propagating the cracks through the nozzle and weld metals will relieve most of these residual stresses but not before the cracks reach the carbon steel pipe. Stresses in the pipe may be sufficient to propagate the cracks by a stress corrosion cracking or fatigue mechanism.

An extensive body of literature data exists on the SCC of carbon and low alloy steels in water environments, including those typical of PWRs and BWRs (Reference 5). These data indicate that the key factor affecting SCC initiation and growth in these materials is the oxidizing potential (primarily dissolved oxygen content) of the environment. Dissolved oxygen significantly affects the electrochemical potential (corrosion potential) of the materials. In a typical PWR, dissolved oxygen levels in the primary coolant are less than 10 ppb.

At temperatures of about 600°F, the corrosion potential of carbon steels in a PWR environment is about –600 mV versus the standard hydrogen electrode, as a result of the hydrogen overpressure in PWR primary systems. Numerous laboratory corrosion tests of carbon and low alloy steels indicate that there is a critical corrosion potential of approximately –200 mV below which crack initiation and propagation will not occur. This corresponds to a dissolved oxygen level of approximately 100 ppb which is about an order of magnitude higher than in a PWR. At 200 ppb oxygen (with a sufficiently high stress level and sulfur content in the steel), these steels readily crack. The laboratory data are supported by field experience (i.e., there have not been any documented instances of SCC of carbon steels in PWR primary system components but there have been occurrences in BWRs where oxygen levels are on the order of 200 ppb).

In summary, the extensive collection of laboratory data indicates that, at normal operating conditions, propagation of cracks from the Alloy 600 nozzles and weld metals into the carbon steel pipe material by a stress corrosion mechanism will not occur because of the low corrosion potential resulting from the PWR environment.

Fatigue Crack Growth into the Carbon Steel

A Section XI flaw evaluation has not been conducted for the Waterford-3 hot leg nozzles. However, this case is similar to the situation for SCC in that a crack could propagate through the nozzle and weld metals to the carbon steel and then be propagated by a fatigue mechanism as a result of cyclic loads caused by plant operations.

ABB CENP has conducted an approximation type calculation (Reference 6) for another plant as part of an engineering evaluation of the longevity of a half-nozzle repair. This evaluation assumed that part of the Alloy 600 nozzle and the J-groove partial penetration weld between the nozzle and the carbon steel pipe remained in place. Further, the evaluation assumed that a stress corrosion crack had propagated through the nozzle, weld metal and weld butter to the carbon steel. The crack was assumed to have the geometry of the weld prep; i.e., it was a quarter circle crack with a depth of 0.75 inch. The resulting K_I for this crack geometry and size and normal plant conditions (design pressure of 2500 psi was used) was 37.6 KSI $in^{1/2}$. The amount of fatigue crack growth for 500 heat-up and shutdown cycles was then calculated using the relationship provided by Figure A-4300-1 from the 1974 ASME Code. The calculation indicated a total of 0.14 inch of growth of the assumed flaw, which was considered relatively minor. Given the similarity in operating conditions and pipe geometry, a similar value for crack growth would be probable for the Waterford-3 piping.

A section XI evaluation of a similar crack in an instrumentation nozzle in the Waterford-3 pressurizer has been performed . Although the crack size and stress conditions are different, the calculated crack growth over the remaining plant lifetime for the pressurizer indicates that only minor crack growth could occur over the next several cycles in a cracked pipe nozzle.

As indicated in the discussions of boric acid corrosion of the nozzle holes and stress corrosion cracking of the carbon steel pipe, there are a number of cases where cracked nozzles have been left in service. At ANO-1, the section of a pressurizer nozzle containing a crack has been in service since 1991. At San Onofre-3, a similarly cracked nozzle in the hot leg piping has been in service since 1993 and several additional similarly cracked nozzles have been in service for lesser times. At St Lucie-2 and at Calvert Cliffs-1, three repaired pressurizer nozzles and three repaired heater sleeves, with cracks left in-place, have been in service for 1 to 5 years.

Considering the service experience from the significant number of nozzles with known cracks currently in-service and the fatigue crack growth calculations for the Waterford-3 pressurizer and the hot leg cracked nozzles at another plant, ABB CENP is confident that fatigue crack growth in the Waterford-3 hot leg nozzles will be minor. Accordingly, ABB CENP recommends that no further evaluations be conducted for these nozzles for the next cycle of operations. If Entergy Operations decides to leave the MNSA devices in-place for additional cycles or elects to repair with a half-nozzle technique, a more rigorous evaluation should be conducted that will demonstrate that fatigue crack growth into the carbon steel pipe over the plant lifetime, including a 20-year life extension, will not be significant.

Boric Acid Corrosion of the Pipe OD Surface

If the MNSA also leaks, a mixture of borated water and steam will escape the nozzle and may impinge on the A-286 bolts, and 304 stainless steel parts. A buildup of boric acid deposits will make such a leak evident during the boric acid walk-down inspections required by GL 88-05. Thus, any significant leakage should exist for only one fuel cycle.

The tests described in Reference 7 included impingment of a borated water-steam mixture onto corrosion resistant materials similar to A-286. After 2500 hours there was no observable corrosion confirming the corrosion resistance of these type materials.

However, low alloy steels exposed to borated water under conditions promoting the development of wet boric acid deposits, slurries or concentrated solutions will experience significant corrosion (References 7 and 8). The available laboratory data did not adequately represent the geometry of a cracked nozzle in a low alloy steel shell which prompted the Combustion Engineering Owners Group (CEOG) to fund a test program to evaluate low alloy steel corrosion resulting from leakage through a stress corrosion crack near the J-groove weld in a nozzle. The test included blocks of SA 533 Grade B steel heated to 600-650°F, water from a high temperature test loop with nominal primary side chemical conditions and leakage from laboratory induced stress corrosion cracks in Alloy 600 tubes welded into the blocks. Post-test examinations indicated high (up to 2.15 inches per year) corrosion rates in localized areas, overall metal loss rates that were relatively low (1.07 cubic inch/year or less), and that the maximum metal loss occurred where the leakage left the annulus with most of the ID surfaces of the low alloy steel having no corrosion (Reference 9).

The above results were then used to develop and justify inspection recommendations. The approach was to calculate the maximum amount (volume) of material that could be removed at pressurizer heater or nozzle holes without violating the ASME Code shell reinforcement requirements. Two adjacent holes were assumed to suffer corrosion damage such that the remaining undamaged ligament was at a minimum. The resulting volume of material was divided by the maximum observed corrosion rate to determine the time required to violate the reinforcement requirements. This conservative value was then reduced by an additional 50% to provide additional conservatism. For the most limiting nozzle configuration in a CEOG plant, the time required was 7.5 years of operation and for the most limiting heater sleeve configuration, the time was 3.2 years or 1175 days. This type analysis has not been completed for RCS piping nozzles but the pressurizer results should approximate the conditions for the piping application.

In summary, boric acid corrosion of the materials of construction for the MNSA and the OD surfaces have been addressed by CEOG sponsored and other testing and analysis. With the inspections currently required, a leaking MNSA should be detected before significant corrosion of the piping occurs.

Galvanic Corrosion

Galvanic corrosion occurs because of the difference in electrochemical potential (ECP) between the different parts of a cell (in this case, the MNSA materials, Grafoil seal, Alloy 600 nozzle and carbon steel of the piping) in a conductive solution (electrolyte). The part with the highest ECP (least noble) will corrode preferentially. Specific tests to evaluate galvanic corrosion of the MNSA cell have not been conducted but it is obvious that the carbon steel will be the most limiting member of this cell and will corrode preferentially.

The major concern centers on the corrosion occurring in the carbon steel in contact with the grafoil seal. This particular combination is used in other applications where the low alloy (or carbon steel) is frequently inspected (for example, steam generator secondary side manway and hand hole applications) and there is no history of corrosion problems in these applications. The MNSA application is similar and for these reasons significant galvanic corrosion is not expected. Tests in simulated reactor coolant (Reference 9) with low alloy steel coupled to a more noble corrosion resistant alloy (Type 304 stainless steel) did not show a significant galvanic effect. These results provide additional confidence that galvanic corrosion will not be a concern.

It should be noted that the Grafoil used in the MNSA is Grade GTJ which has been treated with ammonium phosphate to inhibit corrosion. The corrosion protection provided by this inhibitor is comparable to sacrificial inhibitors such as zinc or aluminum. Union Carbide ran a seven-month corrosion test with Grafoil Grade GTJ placed against Grade 420 stainless steel, which is vulnerable to corrosion, in deionized water. A second sample using uninhibited Grafoil was also tested under the same conditions. For the sample with the GTJ Grafoil, there was minimal visible pitting with a maximum pit depth of .0007 inches. For the sample with the uninhibited Grafoil there was considerable pitting with a maximum pit depth of .0053 inches. While the carbon steel in piping may have a somewhat higher ECP than the 420 stainless steel, it is apparent that the GTJ Grafoil significantly reduces the galvanic corrosion process. It should also be noted that, in the absence of leakage past the Grafoil seal, the annulus will become stagnant and will not allow replenishment of the boric acid or oxygen.

Stress Corrosion Cracking of the MNSA Fasteners

The bolts attaching the MNSA to the piping are SA453 grade 660 (A-286), a precipitation hardening austenitic iron-nickel-chromium alloy. The alloy was developed for high temperature applications requiring good corrosion resistance and high strength. In PWR applications, A-286 is typically used where corrosion resistance similar to that of types 304 and 316 stainless steel is required along with higher strength and fatigue resistance. A-286 has been used for reactor vessel internals bolts, CRDM parts, reactor coolant pump shafts and fasteners and for external bolting applications. In many applications, A-286 has performed satisfactorily but there have been some stress corrosion cracking failures of fasteners immersed in primary coolant. These failures have resulted in concerns about potential SCC failures of all A-286 applications.

Stress corrosion cracking requires the simultaneous presence of three elements:

a) a susceptible material condition
b) an aggressive environment
c) a tensile stress above some threshold level.

A-286 has been proven in the laboratory and in field service, to be susceptible to SCC in a PWR environment when highly stressed (References 11 and 12). The Reference 11 investigation indicated that bolts that were hot headed had increased susceptibility to SCC. Most of the A-286 field failures have occurred in hot headed bolts. The bolts for the MNSA application were machined from heat treated bar stock and are expected to be less susceptible than hot headed bolts to SCC.

Primary coolant is sufficient to cause SCC in highly stressed A-286. The MNSA bolts are external to the reactor coolant system pressure boundary and not exposed under normal conditions to reactor coolant. Under these conditions, A-286 bolts have been in service for more than 10 years in high stress level application without any reported failures. If the MNSA develops a leak, the bolts may be sprayed with a mixture of borated water and steam. Since the bolts are hot, conditions for wetting and drying will exist and thus the accumulation of wet deposition or a slurry of boric acid on the bolts may occur. Laboratory tests (Reference 13) have indicated that A-286 is resistant to SCC at 482°F in highly concentrated (40%) boric acid solutions. Since leakage is a condition that will require repair and, that condition will be obvious by the buildup of boric acid deposits, the bolts are not expected to remain in service for more than one fuel cycle (24 months) before the leaking MNSA will be repaired.

In summary, testing in PWR environments and concentrated boric acid solutions and service experience indicate that A-286 bolts in the MNSA application will operate indefinitely without SCC failures under normal conditions. If the MNSA device leaks, the bolts may be exposed to borated water or steam under conditions in which deposits or slurries will develop. At stress levels present in the MNSA application, these bolts will operate satisfactorily for more than one fuel cycle but the leaking MNSA will be discovered and repaired as part of the GL 88-05 walkdown inspections, limiting the service life for these conditions to a cycle or less.

Summary

In summary, there are not any potential corrosion problems associated with the application of the mechanical nozzle seal assemblies to hot leg piping at Waterford-3. The available data indicate that corrosion of the nozzle hole will be acceptable over the expected lifetime. Cracks present in the nozzle or weld metal will not propagate by a stress corrosion cracking mechanism into the carbon steel pipe from such cracks. Boric acid corrosion of the pipe OD surface will be detected by required inspections before it becomes significant. There will not be significant galvanic corrosion associated with the use of a Grafoil seal nor will the other MNSA materials be affected if a leak should develop in a MNSA.

Significant plant experience with repairs in which cracked nozzles have been left in-service and crack growth calculations for the Waterford-3 pressurizer nozzles and the hot leg pipes at another plant indicate that fatigue crack growth into the carbon steel pipe should not be a problem. Accordingly, ABB CENP recommends that additional evaluations of the hot leg nozzles not be conducted for the next cycle of operations. If the MNSA devices continue in-service for additional cycles or if a half-nozzle repair is considered, a more rigorous evaluation should be completed to demonstrate acceptability for remaining plant life.

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