

## TVAN TVAN CALCULATION COVERSHEET/CCRIS UPDATE

Page 1

|  |  |  |  |   |   |         |  |   |  |
|--|--|--|--|---|---|---------|--|---|--|
| REV 0 EDMS/RIMS NO.<br>R14981118108  |  |  |  |   | EDMS TYPE:<br>calculations(nuclear)   |         | EDMS ACCESSION NO (N/A for REV. 0)   |   |  |
| Calc Title: NPSH Evaluation of Browns Ferry RHR and CS pumps   |  |  |  |   |   |         |  |   |  |
| CALC ID  | TYPE   | ORG                                    | PLANT  | BRANCH  | NUMBER  | CUR REV | NEW REV  | REVISION<br>APPLICABILITY<br>Entire calc <input checked="" type="checkbox"/><br>Selected pages <input type="checkbox"/> |  |
| CURRENT  | CN   | NUC                                    | BFN  | MEB   | MDQ0999970046   | 008     | 009  |   |  |
| NEW  | CN   | NUC                                    |  |   |   |         |  |   |  |
| ACTION   | NEW REVISION <input checked="" type="checkbox"/>   | DELETE RENAME <input type="checkbox"/> | SUPERSEDE DUPLICATE <input type="checkbox"/>   | CCRIS UPDATE ONLY <input type="checkbox"/><br>(Verifier Approval Signatures Not Required) |   |         |  | No CCRIS Changes <input type="checkbox"/><br>(For calc revision, CCRIS been reviewed and no CCRIS changes required)     |  |
| UNITS<br>001, 002, 003   |  | SYSTEMS<br>064 074 075                 |  |   | UNIDS<br>N/A  |         |  |   |  |
| DCN.EDC.N/A<br>N/A   |  |  | APPLICABLE DESIGN DOCUMENT(S) N/A  |   |   |         |  | CLASSIFICATION<br>E   |  |
| QUALITY RELATED?<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>  | SAFETY RELATED?<br>(If yes, QR = yes)<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> |  | UNVERIFIED ASSUMPTION<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |   | SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |         | DESIGN OUTPUT ATTACHMENT?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |   | SAR/TS and/or ISFSI<br>SAR/CoC AFFECTED<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> |
| PREPARER ID<br>Fady Galed  | PREPARER PHONE<br>NO<br>1-312-269-6382   |  | PREPARING ORG (BRANCH)<br>MEB  |   | VERIFICATION METHOD<br>DESIGN REVIEW  |         | NEW METHOD OF ANALYSIS<br><input type="checkbox"/> Yes <input checked="" type="checkbox"/> No    |   |  |
| PREPARER SIGNATURE<br>Fady Galed   |  |  | DATE<br>8/3/06   |   | CHECKER SIGNATURE<br>Chris Rennels  |         |  | DATE<br>8/3/06  |  |
| VERIFIER SIGNATURE<br>Chris Rennels  |  |  | DATE<br>8/3/06   |   | APPROVAL SIGNATURE<br>[Signature]   |         |  | DATE<br>8/3/06  |  |
| <b>STATEMENT OF PROBLEM/ABSTRACT</b><br>Problem:<br>The purpose of this calculation is to determine the Net Positive Suction Head (NPSH) available at various points for the Residual Heat Removal (RHR) pump and the Core Spray (CS) pumps.<br>Abstract:<br>This revision establishes and evaluates uncontrolled flows for Short-Term LOCA and Appendix R cases. This revision also determines the impact on the water level in the suppression pool due to drywell hold-up volume. |  |  |  |   |   |         |  |   |  |
| MICROFICHE/EFICHE Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> FICHE NUMBER(S) TVA-F-U001823, TVA-F-U001824, TVA-F-U001825  |  |  |  |   |   |         |  |   |  |
| <input type="checkbox"/> LOAD INTO EDMS AND DESTROY<br><input checked="" type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION ADDRESS:POB-1A-BFN<br>LIBRARY.<br><input type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO:   |  |  |  |   |   |         |  |   |  |

## TVAN CALCULATION COVERSHEET/CCRIS UPDATE

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| CALC ID | TYPE | ORG | PLANT | BRANCH | NUMBER        | REV |
|---------|------|-----|-------|--------|---------------|-----|
|         | CN   | NUC | BFN   | MEB    | MDQ0999970046 | 009 |

## ALTERNATE CALCULATION IDENTIFICATION

| BLDG | ROOM | ELEV | COORD/AZIM | FIRM | Print Report | Yes                      |  |
|------|------|------|------------|------|--------------|--------------------------|--|
| 01   | N/A  | N/A  | N/A        | S&L  |              | <input type="checkbox"/> |  |

CATEGORIES N/A

## KEY NOUNS (A-add, D-delete)

| ACTION<br>(A/D) | KEY NOUN | A/D | KEY NOUN |
|-----------------|----------|-----|----------|
|                 | ECCS     |     | RHR      |
|                 | CS       |     | NPSH     |
|                 | Flow     |     | Drywell  |
|                 |          |     |          |
|                 |          |     |          |

## CROSS-REFERENCES (A-add, C-change, D-delete)

| ACTION<br>(A/C/D) | XREF<br>CODE | XREF<br>TYPE | XREF<br>PLANT | XREF<br>BRANCH | XREF<br>NUMBER     | XREF<br>REV |
|-------------------|--------------|--------------|---------------|----------------|--------------------|-------------|
| A                 | P            | DW           | BFN           | MEB            | 1-47E818-1         |             |
| A                 | P            | IN           | BFN           | MEB            | 2/3-SSI-16         |             |
| A                 | P            | TH           | BFN           | MEB            | MACH. HDBK-26 ED.  |             |
| A                 | P            | WP           | BFN           | MEB            | WKDN. REQ. 7/25/06 |             |
| A                 | P            | DW           | BFN           | MEB            | 3-41N1001          |             |
| A                 | P            | GN           | BFN           | MEB            | EMAIL 07/28/06     |             |
| A                 | P            | TR           | BFN           | MEB            | RHR PRE-OP 8/5/74  |             |
| A                 | P            | TR           | BFN           | MEB            | CS PRE-OP 11/26/73 |             |
| A                 | P            | GN           | BFN           | MEB            | TVA CORR. 05/20/76 |             |
| A                 | 9            | GN           | BFN           | MEB            | SAMG               |             |
| A                 | P            | DW           | BFN           | MEB            | 2-47E600-601       |             |
| A                 | P            | DW           | BFN           | MEB            | 0-47W452-7         |             |
|                   |              |              |               |                |                    |             |
|                   |              |              |               |                |                    |             |
|                   |              |              |               |                |                    |             |
|                   |              |              |               |                |                    |             |
|                   |              |              |               |                |                    |             |

## CCRIS ONLY UPDATES:

Following are required only when making keyword/cross reference CCRIS updates and page 1 of form NEDP-2-1 is not included:

|                                 |                    |                   |      |
|---------------------------------|--------------------|-------------------|------|
| PREPARER SIGNATURE              | DATE               | CHECKER SIGNATURE | DATE |
| PREPARER PHONE NO. 312-269-6382 | EDMS ACCESSION NO. |                   |      |

**TVAN COMPUTER INPUT FILE  
STORAGE INFORMATION SHEET**  
Page 1 of 1

Page 2A

| <b>TVAN COMPUTER INPUT FILE<br/>STORAGE INFORMATION SHEET</b>   |        |            |  |
|---|--------|------------|--|
| Document    MDQ0999970046   | Rev. 9 | Plant: BFN |  |
| Subject:<br><br>NPSH Evaluation of Browns Ferry RHR and CS pumps  |        |            |  |
| <input type="checkbox"/> Electronic storage of the input files for this calculation is not required. Comments:  |        |            |  |
| <input checked="" type="checkbox"/> Input files for this calculation have been stored electronically and sufficient identifying information is provided below for each input file. (Any retrieved file requires re-verification of its contents before use.)  |        |            |  |
| Ref. ID No. 308632  |        |            |  |
| <input checked="" type="checkbox"/> Microfiche/eFiche   |        |            |  |
| EDMS reference number: TVA-F-U001823 (Unit 1)<br>EDMS reference number: TVA-F-U001824 (Unit 2)<br>EDMS reference number: TVA-F-U001825 (Unit 3)<br><br>Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps<br><br>document type: CALCULATION OUTPUT(NUCLEAR)<br>document date: 2006-08-03<br>document identifier: MDQ0999970046<br>facility : BFN Unit 0<br><br>keywords : ECCS, NPSH, RHR, CS<br>comments : None |        |            |  |

Page 3

## TVAN CALCULATION

| Title:<br>NPSH Evaluation of Browns Ferry RHR and CS Pumps |  | REVISION LOG<br>MD-Q0999-970046 |
|--|--|---------------------------------|
| Revision No.   | DESCRIPTION OF REVISION  | Date Approved                   |
| 0  | INITIAL ISSUE.   | 11-18-98                        |
| 1  | <p>Added case studies for one loop of RHR at runout, one at maximum design flow, all CS pumps at normal design flow, suppression pool temperature at 95°F.</p> <p>Pages added: Cover Sheet, page 1<br/>Table 3, pages 3A and 3B<br/>Appendix 1: 2 EZFLOW file printouts (36 pages)<br/>Appendix 2: 2 EZFLOW file printouts (36 pages)</p> <p>Pages deleted: None</p> <p>Pages changed by this revision: 1A, 2, 5, 13, 14, Appendix 1 cover sheet, Appendix 2 cover sheet</p> <p>SAR sections 4.8, 5.2.3.3.1 and H.4.2.1 have been reviewed by Werner Voss and this revision of the calculation does not affect the current contents of the SAR. These SAR sections will be revised based on these calculation results as part of the resolution of the Containment Overpressure issue.</p> <p>Total pages Rev. 1: <u>352</u></p> | 02/16/99                        |
| 2  | <p>Added evaluation of the potential for the ECCS streamers to ingest a steam plume / bubble from an MCRV T-accumulator and its effects if ingested. This revision performed in response to BFPER 99-009146-000.</p> <p>Pages Added: A3-1 thru A3-3</p> <p>Pages Revised: 1, 2, 6, 7, 11, 8</p> <p>Pages Deleted: None</p> <p>Total Pages Rev 2: 355</p>   |                                 |

NEP-3.1

| TVAN CALCULATION RECORD OF REVISION                              |  |
|--|--|
| CALCULATION IDENTIFIER MD-Q0999-870048                           | Rev. 04  |
| Title<br><b>NPSH EVALUATION OF BROWNS FERRY RHR AND CS PUMPS</b> |  |
| Revision No.   | DESCRIPTION OF REVISION  |
| 3  | <p>This calculation was reviewed in light of the NRC memos granting BFN approval of containment overpressure, references 3.17, 3.18, and the SAR statements in section 6.5.5, Potential Plugging of Emergency Core Cooling System Suction Strainers, (Units 2 and 3). The summary of these documents are (1) During the short term LOCA event, the first 10 minutes of a postulated LOCA event, credit is taken for 3 psi above atmospheric in the primary containment air space and (2) During the long term LOCA event, from 10 minutes to the end of the postulated LOCA event, credit is taken for 1 psi above atmospheric in the primary containment air space for a period of time from 6500 to 35000 seconds, 1.5 to 9.7 hours. Table 3 states "2 psig of containment pressure is added for all pool temperatures". The calculation summary tables (Tables 1 and 2) provide the pump NPSH margin for the various cases analyzed. The first six plant conditions are within the first 10 minutes. The last line on each table is the long term case where the suppression pool temperature is at 177°F.</p> <p>The NRC letters allow a 3 psig overpressure for the first 10 minutes compared to the calculation's assumed value of 2 psig. Therefore the results for the first six cases are conservative by 1 psig (2.31 ft water). The values for the first six plant conditions in Tables 1 and 2 have been revised accordingly. The supporting information in Table 3 has not been revised in order to maintain consistency with the actual EZFLOW calculated values; however, Table 3 has been annotated to refer to this discussion in the Revision Log.</p> <p>The NRC letters do not allow overpressure in the period of 600 seconds to 5500 seconds; however, no cases are analyzed in this time period.</p> <p>The NRC letters allow a 1 psig overpressure in the period of 5500 seconds to 35000 seconds compared to the value assumed in the calculation of 2 psig overpressure. The case of peak suppression pool temperature (177°F) occurs at approximately 19000 seconds and thus falls in this 1 psig region. The NPSH margin for the last plant condition on Tables 1 and 2 have been reduced accordingly by 1 psig difference. The resulting NPSH margin value is still positive (i.e., acceptable) for the limiting pumps. The supporting information in Table 3 has not been revised in order to maintain consistency with the actual EZFLOW calculated values; however, Table 3 has been annotated to refer to this discussion in the Revision Log.</p> <p>This calc was not revised to reflect the NRC approved over-pressure of 1 psi since the calcs show that adequate NPSH to the RHR and CS pumps is assured.</p> <p>SAR sections were reviewed via full text search for the key word "overpressure" in Curator. The SAR sections found were reviewed by the preparer and this revision of the calculation does not affect the SAR. This calculation does provide the basis for containment overpressure statements made in SAR section 6.5.5.</p> <p>This calculation addresses the NPSH information obtained from the following calculations: MD-Q0075-870258 and MD-Q0074-870380. R4</p> <p>This calculation supersedes the following calculations: MD-Q3999-870055, ND-Q0074-880110, ND-Q0999-880127, ND-Q2000-880135, ND-Q0999-880138, ND-Q0999-880140, ND-Q0074-880141, and ND-Q2999-840010.</p> <p>Pages added: 2A<br/> Pages revised: 6, 8, 13, 14, Table 3<br/> Pages deleted: none<br/> Total Pages Rev 3: 355</p> |

005 BY DJK  
CHRD: MRA

Page 4A

| TVAN CALCULATION RECORD OF REVISION              |  |
|--|--|
| CALCULATION IDENTIFIER                           | Rev. 04  |
| Title  |  |
| NPSH EVALUATION OF BROWNS FERRY RHR AND CS PUMPS |  |
| Revision No.                                     | DESCRIPTION OF REVISION  |
| 04   | <p>Due to EPU, the peak suppression pool temperature has risen to 188.6° F @ 14,700 seconds. This revision assumes a over pressure of 3 psi for both short and long terms. Tables 4 &amp; 5 were added to provide details of the calculation.</p> <p>Pages added: 1, 2, 4A, 5, 13 (Table 4), 14, 15 (Table 5), A-1, and A-2, B-1, B-2, &amp; B-3<br/>Pages revised: 4, 6, 8, and 11.<br/>Pages deleted: 1, 1A, 3, 4, and 6<br/>Total Pages: 262 265</p> <p><i>Note That Page 4 Formerly Called Page 2A.</i></p> <p>FSAR Sections 6.4, 6.5, and 14.6 and the Technical Specifications have been reviewed for changes associated with this revision. This calculation revision reflects parameters / values associated with the implementation of Extended Power Uprate (EPU). EPU requires the approval of a license amendment by the NRC and will involve revisions to multiple sections of the FSAR and Technical Specifications. Incorporation of EPU conditions into the FSAR and Technical Specifications will be accomplished as part of the implementation of the EPU license amendment following NRC approval.</p> <p><i>D. J. K. 6/19/02</i></p> |

005



| TVAN CALCULATION RECORD OF REVISION                    |   |
|--|---|
| CALCULATION IDENTIFIER MDQ0999970048                   |   |
| Title NPSH Evaluation of Browns Ferry RHR and CS Pumps |   |
| Revision No.   | DESCRIPTION OF REVISION   |
| 005  | <p>This revision updates the Unit 2/3 calculation to be applicable to Unit 1 for restart of Unit 1.</p> <p>Numbered Table 3 as Pages 15 through 29.<br/> Renumbered Table 4 from Page 13 to Page 30.<br/> Renumbered Table 5 from Pages 14 and 15 to Pages 31 and 32.<br/> Redesignated Attachment 2 as Attachment B.</p> <p>Pages added by this revision: 2B, 4B, Appendix 4 ( 8 pages), Attachment A (Pages A-3 &amp; A-4), Attachment C (12 pages)<br/> Pages replaced by this revision: 1, 2, 5, 6<br/> Pages deleted by this revision: None<br/> Pages revised by this revision: 4A, 7, 10, 11, Table 3 (pagination only), Table 4 (pagination only), Table 5 (pagination only), Attachment B (previously designated as Attachment 2)</p> <p>Total Page Count: 390</p> <p>The SAR and Tech. Spec. reviews will be performed in conjunction with the DCN package.</p> |
| 006  | <p>This revision adds the Unit 1 margin to the calculation.</p> <p>Pages added: Appendix 4 (4-9), Attachment A (Pages A-5, A-6 &amp; A-7)<br/> Pages revised and replaced: 1, 2, 4B, 5, 6 Appendix 4 (4-2, 4-7, 4-8)<br/> Pages revised: 13 through 29,<br/> Pages deleted: 2B</p> <p>Total Page Count: 393</p> <p>The SAR and Tech. Spec. reviews will be performed in conjunction with the DCN package.</p>   |
|  |   |

| TVAN CALCULATION RECORD OF REVISION                    |   |
|--|---|
| CALCULATION IDENTIFIER MDQ0999970046                   |   |
| Title NPSH Evaluation of Browns Ferry RHR and CS Pumps |   |
| Revision No.   | DESCRIPTION OF REVISION   |
| 007  | <p>This revision adds Appendix 5 to quantify, and to document the bases for, the numerical values of available NPSH and NPSH margins for U1 that are submitted to the NRC in response to both Generic Letter (GL) 87-04 and NRC Bulletin 96-03.</p> <p>Pages added: 4C, Appendix 5 (8 pages), Attachment A (Pages A-6 &amp; A-8)</p> <p>Pages revised and replaced: 1, 2, &amp; 5</p> <p>Pages revised: 6</p> <p>Pages deleted: none</p> <p>Total Page Count: <del>404</del></p> <p>FSAR sections 6.4, 6.5, and 14.6 and the Technical Specifications have been reviewed for changes associated with this change. This calculation revision reflects parameters/values associated with the implementation of Extended Power Uprate (EPU) as well as the use of 3 psi containment over-pressure credit for calculating NPSH margins for Unit 1. Both of these conditions will require licensee amendments that will revise various FSAR and Technical Specifications. Incorporation of EPU conditions for Unit 1 as well as the over-pressure credit for ECCS NPSH analysis (TS-429) into the FSAR and Technical Specifications will be accomplished as a part of the EPU license and TS-429 amendments following NRC approval. <i>Edward J. Rink Jr 11/2/04</i></p> |



| TVAN CALCULATION VERIFICATION FORM  |   |
|---|---|
| Calculation Identifier MDQ0999970046  | Revision 007                            |
| Method of verification used:<br>1. Design Review <input checked="" type="checkbox"/><br>2. Alternate Calculation <input type="checkbox"/><br>3. Qualification Test <input type="checkbox"/>   | Verifier <u>RWJ</u> Date <u>1/22/04</u> |
| Comments:<br><p>The design inputs and sources are valid for the purposes of the calculation. The results and conclusions are reasonable and correct based on the inputs and methodology. Based on this review, it is concluded that the calculation is technically correct.</p> <p>The review was conducted in accordance with the applicable requirements of TVAN NEDP-2 and NEDP-5.</p> |   |

| TVAN CALCULATION RECORD OF REVISION                              |  |
|--|--|
| CALCULATION IDENTIFIER MDQ0999970046                             |  |
| Title<br><b>NPSH EVALUATION OF BROWNS FERRY RHR AND CS PUMPS</b> |  |
| Revision No.   | DESCRIPTION OF REVISION  |
| 008  | <p>In this revision the existing EZ-flow model contained in Calculation MDQ0-999-970046 was converted to Multi-Flow 1.21 using the hardcopy files contained in the calculation. The Multiflow model was verified against current plant layout and configurations and case runs were made using the same pump configurations and flows as Rev. 007 with temperatures updated for Extended Power Uprate (EPU) conditions.</p> <p>This revision also includes evaluation of ECCS pump NPSH for the special events of Anticipated Transient Without Scram (ATWS), Appendix R, and Station Blackout (SBO) at Extended Power Uprate (EPU) conditions.</p> <p>The model results were used to perform NPSH calculations for the RHR and CS pumps for various pump combinations and rated flow demands on the suction piping at various suppression pool temperatures.</p> <p>FSAR sections 6.4, 6.5 and 6.15 and the Technical Specifications have been reviewed for changes associated with this change. This calculation revision reflects parameters/values associated with the implementation of Extended Power Uprate (EPU). This condition will require license amendments that will revise various FSAR and Technical Specifications. Incorporation of EPU conditions for ECCS analysis into the FSAR and Technical Specifications will be accomplished as a part of the EPU license and amendments following NRC approval. <u>WJH</u> 3/12/06</p> <p>Pages added are: 2A, 5A, 5B and A10<br/>           Appendix D is added.<br/>           Pages revised are: 1,2 and 7- 115<br/>           Appendices 1, 2, 4 and 5 are deleted.<br/>           Attachment C is deleted.</p> <p>Total Page Count : 139</p> |

| TVAN CALCULATION RECORD OF REVISION                    |  |
|--|--|
| CALCULATION IDENTIFIER MDQ0999970046                   |  |
| Title NPSH Evaluation of Browns Ferry RHR and CS Pumps |  |
| Revision No.   | DESCRIPTION OF REVISION  |
| 009  | <p>This revision establishes appropriate uncontrolled flows for Short-Term and Appendix R cases. This revision also evaluates the impact of "drywell hold-up volume" on water level in the suppression pool.</p> <p>FSAR sections 6.4, 6.5 and 6.15 and the Technical Specifications have been reviewed for changes associated with this change. This calculation revision reflects parameters/values associated with the Implementation of Extended Power Uprate (EPU). This condition will require license amendments that will revise various FSAR and Technical Specifications. Incorporation of EPU conditions for ECCS analysis into the FSAR and Technical Specifications will be accomplished as a part of the EPU license and amendments following NRC approval. <i>[Signature]</i> 8/31/06</p> <p>Pages Added: 5B, 5C, A-11, A-12, 116-166, Attachment E, Attachment F. <i>6/9/03</i></p> <p>Pages Deleted: none</p> <p>Pages Revised: 1, 2, 2A, 6-115</p> <p>Total pages this revision: 196</p> |

## TVAN CALCULATION VERIFICATION FORM

Calculation Identifier MDQ0999970046

Revision 009

## Method of verification used:

1. Design Review ☒
2. Alternate Calculation ☐
3. Qualification Test ☐

Verifier



Date

8-3-06

## Comments:

The design inputs and sources are valid for the purpose of the calculation. The results and conclusions are reasonable and correct based on the inputs and methodology. Based on this review, it is concluded that the calculation is technically correct.

The review was conducted in accordance with the applicable requirements of TVAN NEDP-2 and NEDP-5.

# TVAN CALCULATION TABLE OF CONTENTS

Calculation Identifier: MDQ0999970046

Revision:

009

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|                    | TVAN Calculation Record of Revision Sheet                              | 3, 4, 4A, 4B,<br>4C, 5A, 5B |
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| <b>Appendices</b>  |  |                             |
|                    | Appendix 1:  | Deleted                     |
|                    | Appendix 2:  | Deleted                     |
|                    | Appendix 3: Evaluation Of ECCS Strainer To Ingest A Steam Plume/Bubble | 3 Pages                     |
|                    | Appendix 4:  | Deleted                     |
|                    | Appendix 5:  | Deleted                     |
| <b>Attachments</b> |  |                             |
|                    | A. Previous Cover Sheets   | 11 Pages                    |
|                    | B. Memo from Tom Newton to Those Listed                                | 3 Pages                     |
|                    | C.   | Deleted                     |
|                    | D. E-mail forwarded by Donald McQueen from Thomas Newton               | 2 Pages                     |
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|                    | F. E-mail from William Eberly to Donald McQueen                        | 2 Pages                     |

|   |         |                           |                          |
|---|---------|---------------------------|--------------------------|
| Document: MD-Q0999-970046                                 | Rev.: 9 | Plant: BFN U1, 2&3        | Page: 7                  |
| Subject: NPSH Evaluation of Browns Ferry RHR and CS Pumps |         | Prepared _____ Date _____ | Checked _____ Date _____ |
| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

## 1. PURPOSE

The purpose of this revision is to revise the existing Emergency Core Cooling System (ECCS) suction piping hydraulic analysis to be based on the current accepted TVA method (Ref. 2.5) at Extended Power Uprate (EPU) conditions. Results of that analysis are then used to compute the Net Positive Suction Head (NPSH) available for pump and system flows. This revision also includes evaluation of ECCS pump NPSH for the special events of Anticipated Transient Without Scram (ATWS), Appendix R, and Station Blackout (SBO) at EPU conditions. NPSH available is determined for various ECCS pump combinations and rated flow demands on the suction piping at various suppression pool temperatures. In this revision the appropriate uncontrolled flows for the short term LOCA and Appendix R will be established. The impact of drywell hold-up volume on suppression pool level will be addressed in this revision.

## 2. REFERENCES

- 2.1 Vendor Technical Manual BFN-VTM-B260-0010 for Bingham-Willamette Pumps, Section 0020 (CS Pump Curves).
- 2.2 Vendor Technical Manual BFN-VTM-B260-0010 for Bingham-Willamette Pumps, Section 0040 (RHR Pump Curves).
- 2.3 Marks' Standard Handbook for Mechanical Engineers, 8th Edition.
- 2.4 TVA Drawings:
  - a. 47W403-204, R5
  - b. 47W403-205, R4
  - c. 47W403-206, R4
  - d. 3-47W403-207, R0
  - e. 47W403-208, R4
  - f. 2-47W403-203, R0
  - g. 3-47W403-209, R0
  - h. 47W403-200, R3
  - i. 47W403-201, R5
  - j. 47W403-202, R3
- 2.5 MULTIFLOW- Version 1.21 (S&L Program Number 03.7.749-1.21, Dated 09/25/02).
- 2.6 TVA Drawings:
  - a. 2-47E814-1, R049, "Flow Diagram- Core Spray System".
  - b. 3-47E814-1, R033, "Flow Diagram- Core Spray System".
  - c. 2-47E811-1, R064, "Flow Diagram-Residual Heat Removal System".
  - d. 3-47E811-1, R061, "Flow Diagram-Residual Heat Removal System".
  - e. 1-47E814-1, R013, "Flow Diagram- Core Spray System".
  - f. 1-47E811-1, R025, "Flow Diagram-Residual Heat Removal System".



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**2.7 Additional Drawings:**

- a. PDM Drawing 2-E20, R004, "TVA Containment Vessel"
- b. PDM Drawing 3-E20, R001, "TVA Containment Vessel"
- c. PDM Drawing 1-E20, R000, "TVA Containment Vessel"

- 2.8 TVA Design Criteria No. BFN-50-7074, "Residual Heat Removal System", Units 2 & 3, Rev. 17, to include DIM-BFN-50-7074-25.
- 2.9 TVA Design Criteria No. BFN-50-7075, "Core Spray System", Units 2 & 3, Rev. 6.
- 2.10 TVA Engineering Change Notice L1636.
- 2.11 TVA Engineering Change Notice P0602.
- 2.12 TVA Design Criteria No. BFN-50-715, "Environmental Design", Rev. 5.
- 2.13 Steam Tables, Combustion Engineering, 15th printing. Values reprinted from 1967 ASME Steam Tables.
- 2.14 GENE-E12-00148-04, "Net Positive Suction Head (NPSH) Evaluation for Browns Ferry Nuclear Plant ECCS Strainer Design", Revision 0, June, 1997.
- 2.15 GENE-E12-00148-01, "ECCS Suction Strainer Hydraulic Sizing Report", Rev. 0.
- 2.16 GENE-E12-00148-06, "Containment Pressure Report", Rev. 0.
- 2.17 NRC memo dated Nov 15, 1999, Subject: BFN Units 2 and 3, Completion of Licensing Actions for Bulletin 96-03, Potential Plugging of Emergency Core Cooling Suction Strainers By Debris In Boiling Water Reactors, Dated May 6, 1996 (TAC NOS M96135, M96136 and M96137) L449911230011.
- 2.18 NRC memo dated Sep 3, 1999, Subject: BFN Units 2 and 3, Issuance Of Amendments Regarding Crediting Of Containment Over-Pressure For Net Positive Suction Head Calculations For Emergency Cooling Pumps. I44-990913-002.
- 2.19 TVA BFN Unit 2 and 3 EPU Task 0406: ECCS Net Positive Suction Head. GE-NE-A22-00125-27-01, Rev. 0, May 2002 (W 79 020517 001).
- 2.20 ANSI/HI 9.6.1-1998, "American National Standard for Centrifugal and Vertical Pumps for NPSH Margin", Hydraulic Institute, 1998.
- 2.21 TVA Correspondence (E-Mail), Subject: "Fw: Pump/Flow Combination Cases for MULTIFLOW EPU Revision to NPSH Calculation", 02/16/2006 11:32 AM. (Attachment D)
- 2.22 STMFUNC, Steam Table Function Dynamic Link Library (DLL), Program No. 03.7.598-3.1.

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- 2.23 1-47E818-1, R024, "Flow Diagram - Condensate Storage and Supply System".
- 2.24 Safe Shutdown Instruction, 2/3-SSI-16, R 13, " Control Building Fire EL. 593 through EL. 617"..
- 2.25 Calculation MDQ-0074-880225, R07, "Total RHR System Head VS. Flow Rate for Priority 1 Mode Support".
- 2.26 Calculation MDQ-0075-870258, R06, "Core Spray Pump Performance".
- 2.27 Machinery's Handbook, 26th Edition, Industrial Pres Inc., NewYork, 2000.
- 2.28 Walkdown Request, initiated 07/25/06, collected 07/25/06 (See Attachment E).
- 2.29 3-41N1001, R0, "General Plans and Sections, Sheet 2".
- 2.30 TVA Correspondence (E-Mail), Subject: "PUMP/FLOW COMBINATIONS FOR REVISION OF MULTIFLOW NPSH CALCULATION", 07/28/2006 04:47 PM. (Attachment F).
- 2.31 Pre-Operational Test No. GE-5, Residual Heat Removal System. Dated 8-5-1974.
- 2.32 Pre-Operational Test No. GE-12, Core Spray System, Dated 11-26-1973.
- 2.33 TVA Correspondence to NRC, Subject: "Browns Ferry Nuclear Plant Unit 3 - Reportable Deficiency - Potential for RHR Pump Operation in Excess of Design Runout - IE Control No. H01172F2", 05/20/1976.
- 2.34 Technical Support for Severe Accident Management Guidelines (SAMG), R4.
- 2.35 2-47E600-601, R0, "Mechanical Instruments and Control".
- 2.36 EPU Task Report T0611, "Appendix R Fire Protection", Rev. 0.
- 2.37 0-47W452-7, R10, "Mechanical Residual Heat Removal System".

See Appendix 3 for additional references.

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### 3 DESIGN INPUT DATA

Input data required is derived from references shown above. The pump fluid temperatures are taken from TVA correspondence (Ref. 2.21 and Ref. 2.30). Case pump flow combinations are determined from information taken from References 2.25, 2.32, and 2.33.

### 4 ASSUMPTIONS

- 4.1 No pressure drop is assumed across the strainers for ATWS, SBO, and Appendix R events. These events do not result in debris entering the suppression pool and the strainers are large enough to have negligible pressure drop when clean. Check valves with minimal equivalent length are included to aid with convergence.
- 4.2 For bends with no angle and/or curvature information denoted on drawings, 90° short radius elbows are conservatively assumed.
- 4.3 HPCI and RCIC systems are assumed to not operate in a mode drawing suction from the torus ring header for all analyzed cases.
- 4.4 The effective strainer hydraulic loss is taken at the point of the ECCS piping flange for the strainer.

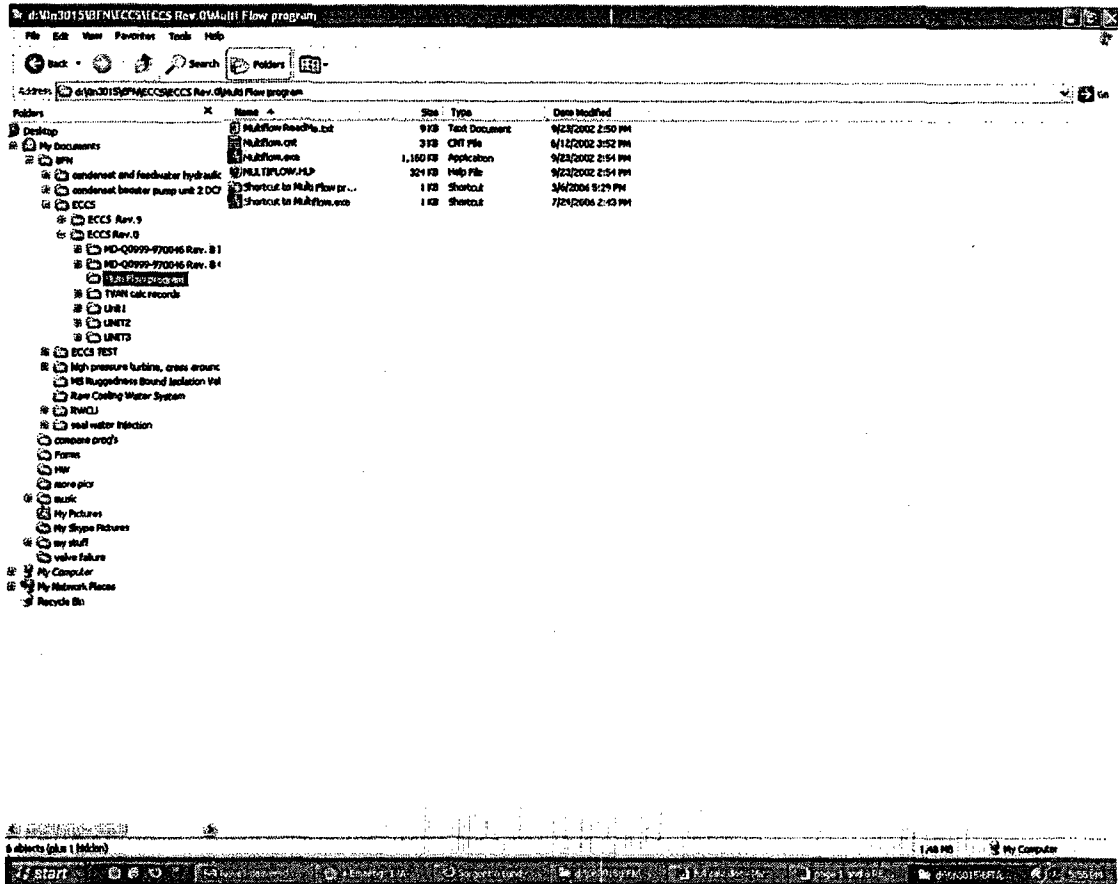
### 5 SPECIAL REQUIREMENTS/LIMITING CONDITIONS

None

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## 6 COMPUTATIONS AND ANALYSIS

The multiflow Version 1.21 runs were executed on S&L PC #ZD2958 using Windows NT Operating System. The following files are located in  
D:\0N3015\TVA\Multiflow files\Multi Flow program



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The results presented are based on the conditions specified for each of the analyzed scenario. These conditions must be met for the results of the applicable scenarios to be valid.

Utilizing Figure 7.7, Core Spray pump flow is established by finding the operating point between the pump curve and the system curve. The system curve is determined by modifying the Pre-operational report data (Ref. 2.32). The Pre-operational report data accounts for the difference of elevation between the torus and the condensate storage tank.

Core Spray pump curve head and flow values are presented in Table 6.1.

| TABLE 6.1 : CS<br>Pump Curve |              |
|------------------------------|--------------|
| Flow<br>(gpm)                | Head<br>(ft) |
| 0                            | 861          |
| 500                          | 848          |
| 1000                         | 825          |
| 1500                         | 792          |
| 2000                         | 749          |
| 2500                         | 694          |
| 3000                         | 626          |
| 3500                         | 538          |
| 4070                         | 409          |
| 4570                         | 261          |

Data from the Pre-Operation report is used to develop a system curve (Ref. 2.32). Flow for the CS pump is taken and the corresponding head is taken from the pump curve (Ref. 2.2). The following equation is used to create a curve fit,

$$Y = AX^2 + \text{Static head (ft)}$$

Where:

Y = Head (ft)

A = Constant

X = Flow (gpm)

$$380 \text{ ft (Ref. 2.2)} = A(4213 \text{ gpm})^2 \text{ (Ref. 2.32)} + 30.625 \text{ ft}$$

$$A = 1.971906 \times 10^{-5}$$

Static head is equal to the difference between the water level elevation in the condensate storage tank and the vessel inlet nozzle.

$$618.625 \text{ ft (Ref. 2.32)} - 588 \text{ ft (Ref. 2.23)} = 30.625 \text{ ft}$$

Utilizing the calculated constant, the system curve is developed using the following equation:

$$Y = 1.97190 \times 10^{-5} X^2 + 30.625 \text{ ft} \quad (\text{Eq. 6.1})$$

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Table 6.2 presents data obtained from Equation 6.1.

| TABLE 6.2 : System Curve<br>(Pre-operational data) |              |
|--|--------------|
| Flow<br>(gpm)                                      | Head<br>(ft) |
| 0  | 31           |
| 250  | 32           |
| 500  | 36           |
| 750  | 42           |
| 1000   | 50           |
| 1250   | 61           |
| 1500   | 75           |
| 1750   | 91           |
| 2000   | 109          |
| 2250   | 130          |
| 2500   | 154          |
| 2750   | 179          |
| 3000   | 208          |
| 3250   | 239          |
| 3500   | 272          |
| 3750   | 307          |
| 4000   | 346          |
| 4250   | 386          |



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The established data is modified to include the elevation difference between the condensate storage tank (CST) water level and the torus water level.

$$588 \text{ ft} - 536.0625 \text{ ft (Ref. 2.32)} = 51.9 \text{ ft}$$

and adding this addition of elevation to Equation 6.1 develops the desirable system curve.

$$Y = 1.97190 \times 10^{-5} X^2 + 30.625 + 51.9 \text{ ft}$$

Table 6.3 presents the modified values used to get the system curve.

| TABLE 6.3 :<br>System Curve<br>Vessel to Torus |              |
|--|--------------|
| Flow<br>(gpm)                                  | Head<br>(ft) |
| 0  | 83           |
| 250  | 84           |
| 500  | 87           |
| 750  | 94           |
| 1000   | 102          |
| 1250   | 113          |
| 1500   | 127          |
| 1750   | 143          |
| 2000   | 161          |
| 2250   | 182          |
| 2500   | 206          |
| 2750   | 231          |
| 3000   | 260          |
| 3250   | 290          |
| 3500   | 324          |
| 3750   | 359          |
| 4070   | 409          |
| 4320   | 450          |

The intersection of the modified system curve and the pump curve is the operating point for the core spray pumps. This value is determined to be at a flow of 4070 gpm and a head of 409 ft. This flow is less than the flow used in the model (4125 gpm) and therefore provides conservative results.

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RHR Pump flow for LOCA-ST and Appendix R conditions are identified using the RHR pump curve (Ref. 2.2) and developed system head curves.

For the Appendix R condition a single pump curve is developed by utilizing points from the pump curve (Ref. 2.2), Table 6.4 shows points taken from Ref. 2.2 pump curve data. These points are used to develop the pump curve shown in Figure 7.6.

| TABLE 6.4 : RHR<br>Single Pump curve |              |
|--------------------------------------|--------------|
| Flow<br>(gpm)                        | Head<br>(ft) |
| 0                                    | 825          |
| 2000                                 | 810          |
| 3000                                 | 800          |
| 4000                                 | 787          |
| 5000                                 | 775          |
| 6000                                 | 755          |
| 7000                                 | 716          |
| 8000                                 | 675          |
| 9000                                 | 625          |
| 10000                                | 575          |
| 10950                                | 527          |
| 12000                                | 475          |

Reference 2.25 determines the system head loss curve based on a water elevation in the reactor vessel of 604'-0" (top of jet pump riser). This curve is also based on flow through the jet pumps. The results of Ref. 2.25 will be modified to develop the system head loss curve for the Appendix R case.

The total head is developed by revising the results of Calculation Reference 2.25 for the case being examined using the following equation:

$$H = H_f + H_s - P_j$$

H = Total Head

H<sub>f</sub> = Friction Loss

H<sub>s</sub> = Total Static Head

P<sub>j</sub> = Jet Pump Pressure (removed as the recirculation loop discharge gate valve remains open during the Appendix R event – Ref. 2.36)

The friction loss of 460 ft, determined in Ref. 2.25, is adjusted as shown below, for the multiple flows in the system used to develop the system head loss curve.

$$H_f \text{ at } 2500\text{gpm} = \left( \frac{2500}{10800} \right)^2 * 460 = 24.6\text{ft}$$

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$$H_r \text{ at } 5000\text{gpm} = \left(\frac{5000}{10800}\right)^2 * 460 = 98.59\text{ft}$$

$$H_r \text{ at } 7500\text{gpm} = \left(\frac{7500}{10800}\right)^2 * 460 = 221.8\text{ft}$$

$$H_r \text{ at } 10800\text{gpm} = \left(\frac{10800}{10800}\right)^2 * 460 = 460\text{ft}$$

For Appendix R, the total static head ( $H_s$ ) is determined based on a reactor water level at the bottom of the Main Steam Line nozzle, normal torus water level, reactor pressure equal to or greater than 100 psig (Ref. 2.34), and no losses through the jet pumps since the recirculation loop discharge gate valve remains open during the Appendix R event (Ref. 2.36). The reactor pressure is controlled by the operator based on reading PI-3-79 (Ref. 2.36). The reactor pressure of 100 psig is corrected to the bottom of the MSL from the location of the tap.

Total Static Head ( $H_s$ ) = Water level at the bottom of Main Steam Line (MSL) reactor vessel nozzle (Ref. 2.34) - Water level in the torus (Ref. 2.25).

Water level at Main Steam Line (MSL) = 632.04 ft

Water level in the torus = 536 ft

PI-3-79 elevation = 628.17 ft (Ref. 2.35)

Pressure Indicator elevation is subtracted to account for the 100 psi (Ref. 2.34) reactor pressure that has to be maintained by the operator to ensure MSR's continues operation.

$$\text{Total Static Head } (H_s) = (632.04' - 536') - (632.04 - 628.17) = 92.17 \text{ ft}$$

Jet Pump Pressure is neglected since the recirculation loop discharge gate valve remains open during Appendix R event (Ref. 2.36), which eliminates jet pressure.

Jet pressure = 123 psi, (Ref. 2.25) adjusted to percentage of flow in the system.

$$P_j = 123 * \left(\frac{2500}{30000}\right)^2 = 0.854\text{psi}$$

$$P_j = 123 * \left(\frac{5000}{30000}\right)^2 = 3.417\text{psi}$$

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$$P_j = 123 * \left( \frac{7500}{30000} \right)^2 = 7.688 \text{ psi}$$

$$P_j = 123 * \left( \frac{10800}{30000} \right)^2 = 16 \text{ psi}$$

$$H \text{ at } 2500 \text{ gpm} = 24.6' + 92.17' - 0.854 \text{ psi} * (0.016 \frac{\text{ft}^3}{\text{lb}} * 144 \text{ ft}) = 114.8 \text{ ft}$$

Similarly the rest of the flows are calculated in the same manner, Table 6.5 summarizes head at the corresponding flow:

| TABLE 6.5 :<br>Pump system curve |              |
|----------------------------------|--------------|
| Flow<br>(gpm)                    | Head<br>(ft) |
| 2500                             | 114.8        |
| 5000                             | 182.9        |
| 7500                             | 296.2        |
| 10800                            | 515.2        |

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A plot of system head at the corresponding flows is developed using a third degree polynomial curve fit. The system head loss curve is presented with the pump curve in Fig. 7.6. Table 6.6 depicts the system head at various flows.

| TABLE 6.6:<br>Pump system curve |              |
|---------------------------------|--------------|
| Flow<br>(gpm)                   | Head<br>(ft) |
| 0                               | 92           |
| 1000                            | 96           |
| 2000                            | 107          |
| 3000                            | 125          |
| 4000                            | 150          |
| 5000                            | 183          |
| 6000                            | 223          |
| 7000                            | 270          |
| 8000                            | 324          |
| 9000                            | 386          |
| 10000                           | 455          |
| 10950                           | 527          |
| 11950                           | 610          |
| 12950                           | 700          |

Based on Figure 7.6, the system operating point is at 10,950 gpm with a corresponding head of 527 ft.

The reactor pressure is required to be 100 psig or greater based on Ref. 2.34. The system operating point requires adjustment for the reactor vessel pressure. The Appendix R condition is based on a temperature of 223°F (Ref. 2.30). Utilizing the conversion factor at that temperature (Ref. 2.13), 100 psig is converted to 241.82 feet. Adjusting for the elevation difference between the bottom of the MSL and the PI tap (241.82 ft – (632.04 ft – 628.17 ft) gives an additional 237.95 ft of head. Adding 237.95 ft to the static head of 529 feet, a new system head is established. This head is used to find the flow for the RHR pumps for the Appendix R case. From Figure 7.7, the corresponding flow for a head of 767 ft is approximately 5,250 gpm. This flow is less than the flow used in the NPSH model (7,200 gpm) and the NPSH model therefore provides conservative results.

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For the LOCA-short term scenarios, a dual pump curve is obtained by utilizing the data from the single pump curve and doubling the flow at constant head values (Ref. 2.2), Table 6.7 shows dual pump curve data.

| TABLE 6.7 :<br>Dual Pumps |              |
|---------------------------|--------------|
| Flow<br>(gpm)             | Head<br>(ft) |
| 0                         | 825          |
| 4000                      | 810          |
| 6000                      | 800          |
| 8000                      | 787          |
| 10000                     | 775          |
| 12000                     | 755          |
| 14000                     | 716          |
| 16000                     | 675          |
| 18000                     | 625          |
| 20000                     | 575          |
| 22000                     | 525          |
| 24000                     | 475          |

As in the Appendix R case, the head loss curve is developed by revising the results of Reference 2.25 for the case being examined using the following equation:

$$H = H_f + H_s - P_j$$

H = Total Head

H<sub>f</sub> = Friction Loss

H<sub>s</sub> = Total Static Head

P<sub>j</sub> = Jet Pump Pressure (removed as this case considers a broken recirculation loop)

Friction Loss = 526 ft (Ref. 2.25), adjusted based on the ratio of flow in the system.

$$H_f \text{ at } 5000\text{gpm} = \left( \frac{5000}{20000} \right)^2 * 526 = 33\text{ft}$$

$$H_f \text{ at } 10000\text{gpm} = \left( \frac{10000}{20000} \right)^2 * 526 = 132\text{ft}$$

$$H_f \text{ at } 15000\text{gpm} = \left( \frac{15000}{20000} \right)^2 * 526 = 296\text{ft}$$

$$H_f \text{ at } 20000\text{gpm} = \left( \frac{20000}{20000} \right)^2 * 526 = 526\text{ft}$$



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Total Static Head ( $H_s$ ) = RHR discharge elevation at connection to Recirculation loop (Ref. 2.37) - Water level in the torus (Ref. 2.25)

RHR discharge elevation at connection to Recirculation loop = 577.17 ft  
Water level in the torus = 536 ft

Total Static Head ( $H_s$ ) = (577.17 ft - 536 ft) = 41.17 ft

Since the Jet Pump pressure loss needs to be subtracted out since it was included in Reference 2.25 analyses. In the analyses in this calculation, the recirculation loop discharge broken, the pressure loss for the jet pump must be removed from the system head loss.

From Reference 2.25, the Jet Pump pressure loss at 30,000 gpm = 123 psi.

As system head will be developed for multiple flows, the losses through the jet pump need to be determined at those flow rates. The loss at 30,000 gpm is adjusted based on flow consistent with the methodology in Ref. 2.25:

$$P_j = 123 * \left( \frac{5000}{30000} \right)^2 = 3.42 \text{ psi}$$

$$P_j = 123 * \left( \frac{10000}{30000} \right)^2 = 13.67 \text{ psi}$$

$$P_j = 123 * \left( \frac{15000}{30000} \right)^2 = 30.75 \text{ psi}$$

$$P_j = 123 * \left( \frac{20000}{30000} \right)^2 = 54.67 \text{ psi}$$

$$H \text{ at } 5000 \text{ gpm} = 33 \text{ ft} + 41.17 \text{ ft} - 3.42 \text{ psi} * (0.016 \frac{\text{ft}^3}{\text{lb}} * 144 \text{ ft}) = 66.3 \text{ ft}$$

Similarly the rest of the flows are calculated in the same manner, Table 6.8 summarizes head at the corresponding flow for the system without jet pumps:

|   |         |                           |                          |
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| TABLE 6.8 :<br>System curve |              |
|-----------------------------|--------------|
| Flow<br>(gpm)               | Head<br>(ft) |
| 5000                        | 66.3         |
| 10000                       | 142.7        |
| 15000                       | 266.3        |
| 20000                       | 441.2        |

A plot of developed head at the corresponding flows is developed for the system without jet pumps. A third degree polynomial curve fit at the corresponding flow is plotted in order to obtain values between points (See Fig. 7.8). Table 6.9 depicts the developed head at the corresponding flow to model the system curve.

| TABLE 6.9 :<br>System Curve<br>without jet<br>pumps |              |
|---|--------------|
| Flow<br>(gpm)                                       | Head<br>(ft) |
| 0   | 39           |
| 2000  | 44           |
| 4000  | 57           |
| 6000  | 77           |
| 8000  | 106          |
| 10000   | 142          |
| 12000   | 185          |
| 14000   | 237          |
| 16000   | 297          |
| 18000   | 365          |
| 20000   | 441          |
| 22000   | 525          |
| 23500   | 594          |
| 25500   | 692          |

Analyzing data in the table above the system operating point is at 22,000 gpm with a corresponding head of 525 ft. This flow is less than the flow used in the model (23,000 gpm) and therefore provides conservative results.

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For the LOCA-ST with the unbroken recirculation loop, Table 6.10 summarizes the system head at the corresponding flow for the system with jet pump losses included:

| TABLE 6.10 :<br>System Curve |              |
|------------------------------|--------------|
| Flow<br>(gpm)                | Head<br>(ft) |
| 5000                         | 101          |
| 10000                        | 200          |
| 15000                        | 364          |
| 20000                        | 594          |

A plot of developed head at the corresponding flows is developed for the system with jet pumps. A third degree polynomial curve fit at the corresponding flow is plotted in order to obtain head between points (See Fig. 7.8). Table 6.11 depicts the developed head at the corresponding flow to model the system curve.

| TABLE 6.11:<br>System Curve<br>with jet pumps |              |
|---|--------------|
| Flow<br>(gpm)                                 | Head<br>(ft) |
| 0   | 66           |
| 2000  | 72           |
| 4000  | 89           |
| 6000  | 116          |
| 8000  | 153          |
| 10000   | 200          |
| 12000   | 258          |
| 14000   | 326          |
| 16000   | 405          |
| 18000   | 494          |
| 19750   | 581          |
| 21750   | 690          |

Analyzing the values from Figure 7.8 the system operating point is 19,750 gpm with a corresponding head of 581 ft. This flow is less than the flow used in the model (21,000 gpm) and therefore the model provides conservative results.

|   |         |                           |                          |
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This calculation documents the results of analysis to determine the NPSH available for the pipe routing and configuration from the ECCS suction strainer to the pump suction for both the RHR and CS piping systems. The system operating conditions and modes of operations that are considered in this analysis are listed below.

| Table 6.12: Temperature and Flow Rate Combinations   |   |
|--|---|
| LOCA Pump/Flow Combinations  | Suppression Pool Temperature  |
| CS Pumps A/B/C/D – 4125 gpm each<br>RHR A/C Pumps – 10,500 gpm each<br>RHR B/D Pumps – 11,500 gpm each | Temperature @ 95°F<br>Temperature @ 10 minutes EPU (155.4°F)  |
| CS Pumps A/B/C/D – 4125 gpm each<br>RHR A/C Loop – 11,500 gpm each<br>RHR B/D Loop – 10,500 gpm each   | Temperature @ 95°F<br>Temperature @ 10 minutes EPU (155.4°F)  |
| CS Pumps A/C – 3125 gpm each, B/D - 0<br>RHR A/C Pumps – 6500 gpm each, B/D - 0                        | Temperature @ 10 minutes EPU (155.4°F)<br>Temperature @ 172°F<br>Temperature @ T <sub>max</sub> EPU (187.3°F) |
| CS Pumps B/D – 3125 gpm each, A/C – 0<br>RHR A/C Pumps – 6500 gpm each, B/D – 0                        | Temperature @ 10 minutes EPU (155.4°F)<br>Temperature @ 172°F<br>Temperature @ T <sub>max</sub> EPU (187.3°F) |
| CS Pumps B/D – 3125 gpm each, A/C – 0<br>RHR B/D Pumps – 6500 gpm each, A/C - 0                        | Temperature @ 10 minutes EPU (155.4°F)<br>Temperature @ 172°F<br>Temperature @ T <sub>max</sub> EPU (187.3°F) |
| CS Pumps A/C – 3125 gpm each, B/D – 0<br>RHR B/D Pumps – 6500 gpm each, A/C - 0                        | Temperature @ 10 minutes EPU (155.4°F)<br>Temperature @ 172°F<br>Temperature @ T <sub>max</sub> EPU (187.3°F) |
| CS Pumps A/C – 3125 gpm each, B/D – 0<br>RHR A/B/C/D Pumps – 6500 gpm each                             | Temperature @ 166°F   |
| ATWS Pump/Flow Combinations  |   |
| RHR A/B/C/D Pumps – 6500 gpm each  | Temperature @ 177°F   |
| RHR A/B/C/D Pumps – 6500 gpm each  | Temperature @ 192°F   |
| RHR A/B/C/D Pumps – 6500 gpm each  | Temperature @ 211°F   |
| Appendix R Pump/Flow Combinations  |   |
| One RHR Pump (non specific) – 7200 gpm   | Temperature @ 191°F   |
| One RHR Pump (non specific) – 7200 gpm   | Temperature @ 223°F   |
| SBO Pump/Flow Combinations   |   |
| Two RHR Pump (A/C) – 6500 gpm, B/D -0<br>Two RHR Pump (B/D) – 6500 gpm, A/C -0                         | Temperature @ 157°F   |
| Two RHR Pump (A/C) – 6500 gpm, B/D -0<br>Two RHR Pump (B/D) – 6500 gpm, A/C -0                         | Temperature @ 200°F   |

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Per American Hydraulic Institute standards (Ref. 2.20), the required Net Positive Suction Head (NPSH<sub>r</sub>) of a pump is the NPSH that will cause the total head to be reduced by 3%, due to flow blockage from cavitation vapor in the impeller vanes (Ref. 2.20).

The NPSH<sub>a</sub> is the actual fluid energy delivered to the pump impeller through the piping configuration and is calculated by the following equation (Ref. 2.3).

$$\text{NPSH}_a = h_a + h_s - h_f - h_{vp} \quad (\text{Eq. 6.3})$$

where:

$h_a$  = Atmospheric head = Suppression Pool airspace pressure converted to feet of water (ft).

$h_s$  = Static pressure head = Elevation difference between the centerline of the pump inlet and the suppression pool water level (ft).

$h_f$  = Total friction head loss (ft).

$h_{vp}$  = Vapor pressure of water at system temperature (ft).

The Browns Ferry Plant ECCS configuration includes an ECCS ring header circumscribing the suppression chamber with connecting piping to four inlet penetrations through the torus wall into the suppression pool. Inside the suppression pool, each connecting line is fitted with a flanged surface for mating to the ECCS strainer flanges. The ECCS ring header supplies the suction piping of the RHR, CS, High Pressure Core Injection (HPCI) and Reactor Core Isolation Cooling (RCIC) systems.

Since the ECCS ring header and the connecting piping to the ECCS strainers is common to the suction of all of the ECCS pumps, the flow and pressure distribution for the ring header and strainers is different for varying system demands. Therefore, to determine individual ECCS pump suction pressures for various plant states, a model of the suction piping configuration was created from TVA drawings (Ref. 2.4 and 2.6) for analysis with the Multiflow computer program (Ref. 2.5). A simplified layout of the Multiflow model for the ECCS ring header and suction piping to the RHR and CS pumps is shown in Figure 7.1 (See Section 8.0). All model link input dimensions and components were taken from TVA drawings (Ref. 2.4 and 2.6) which contained systems configuration and dimensions. Nodal diagrams for Units 1, 2 and 3 ECCS hydraulic models are shown in Figures 7.2, 7.3 and 7.4, respectively (See Section 8.0).

For piping links in the model, piping lengths included the total piping isometric dimension. When drawings did not specify whether a piping elbow was short or long radius, the conservative case, e.g. short radius was chosen. The types of valves used in the models were taken from Reference 2.6. For all form losses (elbows, valves, etc.), the Multiflow default values of equivalent length, resistance, etc. were selected. The piping roughness value of 0.00015 ft was selected, which is acceptable for a condensate quality system and would not be expected to change with the system age.

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In the MultiFlow, model the flow is represented in sgpm, requiring the conversion from gpm. The conversion is shown below.

$$\text{Flow (gpm)} * \frac{\text{Specific Volume of Water at standard Temp. and Pressure}}{\text{Specific Volume of Water at desired Temp. and Pressure}} = \text{Flow (sgpm)} \quad (\text{Eq 6.4})$$

The standard temperature and pressure used in Multiflow is 60°F at 14.7 psia. All flows are converted to sgpm at the corresponding temperature for all cases. All sgpm conversions are shown in Tables 4 and 5.

For the LOCA cases, in the MultiFlow model a pump component is used to model the strainer pressure drop as a function of the flow rate. Flows obtained from Reference 2.15 were converted to flow at standard conditions using Equation 6.4. Values of head loss at corresponding strainer flow rates taken from Reference 2.15 are converted to head loss at standard conditions. A plot of head loss at standard conditions was developed. A third order polynomial equation of head loss at standard conditions was developed in order to obtain head loss values between data points (See Fig. 7.5). Table 6.13 depicts the head loss used to model the strainers as a function of flow. The values listed in Table 6.13 are linearly interpolated in Multiflow to obtain the system head loss.

| Table 6.13: Strainer Loss |           |
|---------------------------|-----------|
| Flow (sgpm)               | Loss (ft) |
| 0                         | 0         |
| 4592                      | -0.230    |
| 6000                      | -0.890    |
| 7000                      | -1.340    |
| 9000                      | -2.410    |
| 11000                     | -3.610    |
| 13239                     | -5.118    |
| 13288                     | -5.201    |
| 13514                     | -5.354    |
| 13515                     | -5.377    |
| 13565                     | -5.403    |
| 13624                     | -5.466    |
| 14033                     | -5.711    |
| 15000                     | -6.440    |
| 16000                     | -7.162    |

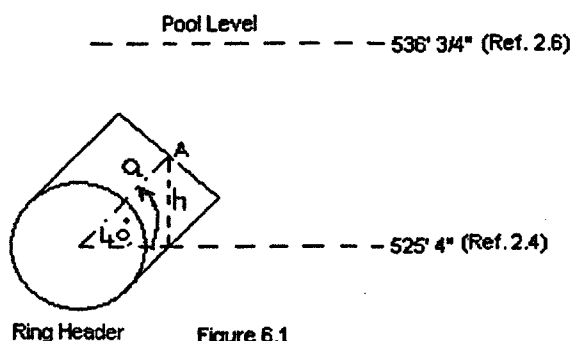
In order to assist analysis convergence in the ATWS, Appendix R and SBO cases, "dummy" check valves with a minimum equivalent length to model strainer loss were installed in the piping links



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from the strainer flanges to the ECCS ring header tees. For these special cases, the strainer pressure drop is assumed to be zero since there is no debris in the strainer.

Pump static suction head is equal to the available water level above pump suction centerline. In the Multiflow model, the static head at the strainer flange node is needed for calculation purposes. It is necessary to establish this value in psig in the Multiflow model at the strainer flanges. From TVA drawings (Ref. 2.6), the low water level of the suppression pool is 536' 1 3/4" with  $\Delta p$  and 536' 3/4" with zero delta P, which will be considered here.



Angle = 40° (Ref. 2.7 a, b and c)  
h is the vertical distance from point A to the Ring Header centerline.  
h = 2.283 (Ref. 2.7 a, b and c)  
Point A is the strainer piping flange.  
Point A elevation = 525.333 + 2.283 = 527.616'  
and static head of Pt. A = 536.062 - 527.616 = 8.446'

These pressures are valid for cases where water is routed directly to the suppression pool (Appendix R and ATWS). These values were established at the strainer flange points (nodes 1, 5, 23, and 27) for the specified temperatures. The densities as a function of temperature in the following equations are taken from STMFUNC (Ref. 2.22).

|   |         |                           |                          |
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For cases where the water is routed through the drywell (All LOCA and SBO cases), holdup in the drywell must be taken into account. This will reduce the suppression pool level that can be considered in NPSH calculations. The volume of water holdup in the drywell is calculated as follows. (See Figure 6.2)

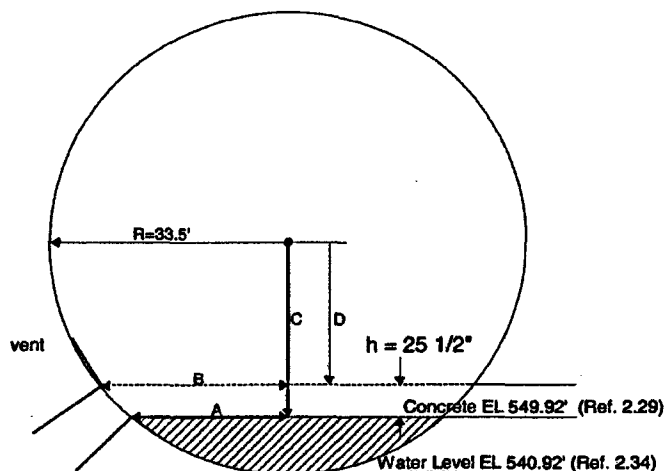


Figure 6.2

From Figure 6.2 (Ref. 2.28) the volume of the standing water in the drywell beneath the level of the vent is calculated by finding the volume of two spherical segments, the concrete portion and the concrete and water portion, and subtracting to obtain the volume of the water:

To find the radii of the water and concrete surfaces, basic geometry is used:

$$C = 33.5' - 9' = 24.5 \text{ ft}$$

$$D = 33.5' - 9' - 2.125' \text{ (Ref. 2.28)} = 22.375 \text{ ft}$$

$$A^2 = 33.5^2 - 24.5^2 = 522.0 \text{ ft}$$

$$A = 22.85 \text{ ft}$$

$$B^2 = 33.5^2 - 22.375^2 = 621.61 \text{ ft}$$

$$B = 24.93 \text{ ft}$$

Where A, B, C, and D are segments defined on Figure 6.2.

The volume of the concrete is found by using the equations in Reference 2.27:

$$V_c = \pi \cdot h_c^2 \cdot \left( R - \frac{h_c}{3} \right) = \pi \cdot 9^2 \cdot \left( 33.5 - \frac{9}{3} \right) = 7761.3 \text{ ft}^3$$

|   |         |                                 |                          |
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The volume of the concretet and water is found by:

$$V_{C+w} = \pi \cdot h_{c+w}^2 \cdot \left( R - \frac{h_{c+w}}{3} \right) = \pi \cdot 11.125^2 \cdot \left( 33.5 - \frac{11.125}{3} \right) = 11583.63 \text{ ft}^3$$

Therefore, the amount of water holdup in the drywell is

$$V_w = V_{C+w} - V_c = 11583.63 - 7761.3 = 3822.33 \text{ ft}^3$$

Where:

$V_c$  = Volume of concrete

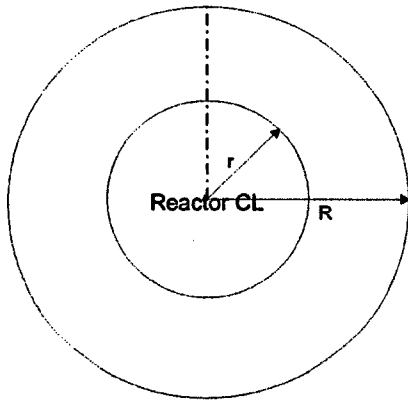
$V_{C+w}$  = Volume of concrete and water

$h_c$  = height of concrete

$h_{c+w}$  = height of concrete and water

$V_w$  = Volume of standing water in drywell

Water Level decrease in Torus:



To find the surface area of the water in the torus, equations from Reference 2.27 are used. This method is accurate for water levels within 1 foot of mid level of torus.

$$A_T = \pi(R^2 - r^2) = \pi(71.25^2 - 40.25^2) = 10,858 \text{ ft}^2$$

$$\Delta H = \frac{V_w}{A_T} = \frac{3822.33 \text{ ft}^3}{10858 \text{ ft}^2} = 0.352 \text{ ft}$$

where:

$A_T$  = Surface area of water in torus

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R = Outer radius of torus  
r = inner radius of torus  
ΔH = Decrease in water level

From TVA drawings (Ref. 2.6), the low water level of the suppression pool is 536' 1 3/4" with Δp and 536' 3/4" with zero delta P, which will be considered here.

The water level in the tours for LOCA and SBO is:

$$536' \frac{3}{4} - 0.352' = 535.711'$$

$$\text{and the static head of Pt. A} = 535.711 - 527.616 = 8.049'$$

The pressure at the strainer flange points (nodes 1, 5, 23, and 27) at the specified temperatures for the cases where the core spray pumps are running are adjusted to account for the water holdup in the drywell. The densities as a function of temperature in the following equations are taken from STMFUNC (Ref. 2.25).

$$\text{At } 95^{\circ}\text{F}, H_s = 8.094 \text{ ft} \times 62.05 \frac{\text{lb}}{\text{ft}^3} \div 144 \frac{\text{in}^2}{\text{ft}^2} = 3.488 \text{ psig} \quad (\text{Eq. 6.5a})$$

$$\text{At } 155.4^{\circ}\text{F}, H_s = 8.094 \text{ ft} \times 61.09 \frac{\text{lb}}{\text{ft}^3} \div 144 \frac{\text{in}^2}{\text{ft}^2} = 3.434 \text{ psig} \quad (\text{Eq. 6.5b})$$

$$\text{At } 157^{\circ}\text{F}, H_s = 8.094 \text{ ft} \times 61.06 \frac{\text{lb}}{\text{ft}^3} \div 144 \frac{\text{in}^2}{\text{ft}^2} = 3.432 \text{ psig} \quad (\text{Eq. 6.5c})$$

$$\text{At } 166^{\circ}\text{F}, H_s = 8.094 \text{ ft} \times 60.88 \frac{\text{lb}}{\text{ft}^3} \div 144 \frac{\text{in}^2}{\text{ft}^2} = 3.422 \text{ psig} \quad (\text{Eq. 6.5d})$$

$$\text{At } 172^{\circ}\text{F}, H_s = 8.094 \text{ ft} \times 60.75 \frac{\text{lb}}{\text{ft}^3} \div 144 \frac{\text{in}^2}{\text{ft}^2} = 3.415 \text{ psig} \quad (\text{Eq. 6.5e})$$

$$\text{At } 177^{\circ}\text{F}, H_s = 8.446 \text{ ft} \times 60.64 \frac{\text{lb}}{\text{ft}^3} \div 144 \frac{\text{in}^2}{\text{ft}^2} = 3.557 \text{ psig} \quad (\text{Eq. 6.5f})$$

$$\text{At } 187.3^{\circ}\text{F}, H_s = 8.094 \text{ ft} \times 60.42 \frac{\text{lb}}{\text{ft}^3} \div 144 \frac{\text{in}^2}{\text{ft}^2} = 3.396 \text{ psig} \quad (\text{Eq. 6.5g})$$

$$\text{At } 191^{\circ}\text{F}, H_s = 8.446 \text{ ft} \times 60.33 \frac{\text{lb}}{\text{ft}^3} \div 144 \frac{\text{in}^2}{\text{ft}^2} = 3.539 \text{ psig} \quad (\text{Eq. 6.5h})$$

$$\text{At } 192^{\circ}\text{F}, H_s = 8.446 \text{ ft} \times 60.31 \frac{\text{lb}}{\text{ft}^3} \div 144 \frac{\text{in}^2}{\text{ft}^2} = 3.537 \text{ psig} \quad (\text{Eq. 6.5i})$$

$$\text{At } 200^{\circ}\text{F}, H_s = 8.094 \text{ ft} \times 60.12 \frac{\text{lb}}{\text{ft}^3} \div 144 \frac{\text{in}^2}{\text{ft}^2} = 3.379 \text{ psig} \quad (\text{Eq. 6.5j})$$

|   |         |                           |                          |
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$$\text{At } 211^{\circ}\text{F, } H_s = 8.446 \text{ ft} \times 59.85 \frac{\text{lb}}{\text{ft}^3} + 144 \frac{\text{in}^2}{\text{ft}^2} = 3.510 \text{ psig} \quad (\text{Eq. 6.5k})$$

$$\text{At } 223^{\circ}\text{F, } H_s = 8.446 \text{ ft} \times 59.55 \frac{\text{lb}}{\text{ft}^3} + 144 \frac{\text{in}^2}{\text{ft}^2} = 3.493 \text{ psig} \quad (\text{Eq. 6.5l})$$

The static elevation pressures at the ECCS piping flange points at corresponding system temperatures are summarized in Table 6.14.

| Table 6.14 : Strainer Pressure    |                 |
|-----------------------------------|-----------------|
| Temperature( $^{\circ}\text{F}$ ) | Pressure (psig) |
| 95.00                             | 3.488           |
| 155.4                             | 3.434           |
| 157.0                             | 3.432           |
| 166.0                             | 3.422           |
| 172.0                             | 3.415           |
| 177.0                             | 3.557           |
| 187.3                             | 3.396           |
| 191.0                             | 3.539           |
| 192.0                             | 3.537           |
| 200.0                             | 3.379           |
| 211.0                             | 3.510           |
| 223.0                             | 3.493           |

The Multiflow model calculation accounted for system static head and piping friction losses. To obtain the NPSH available, it was necessary to subtract fluid vapor pressure  $h_{vp}$  (at the analyzed suppression pool temperature) and take into account the suppression pool absolute pressure. Utilizing Equation 6.1, the available NPSH is determined. See Tables 7.1 through 7.24 for calculations of NPSHa for Unit 1. See Tables 11.1 through 11.24 for calculations of NPSHa for Unit 2. See Tables 14.1 through 14.24 for calculations of NPSHa for Unit 3.

Flow conditions of the RHR and CS systems analyzed were

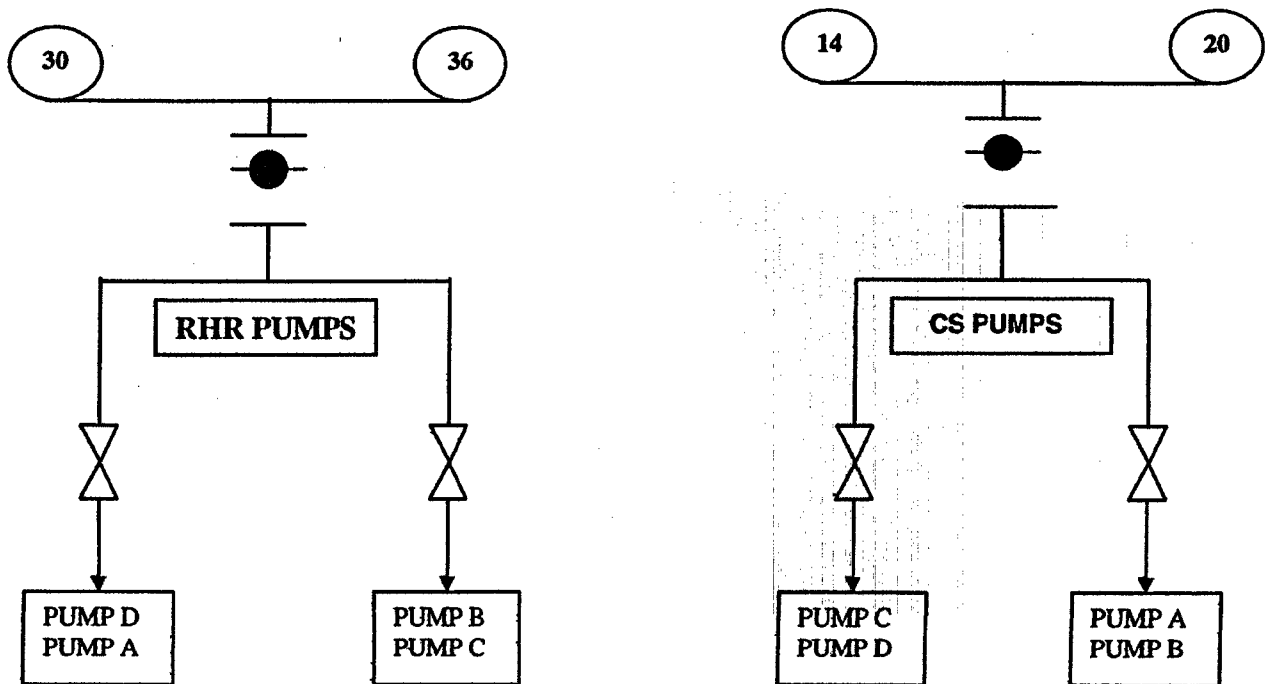
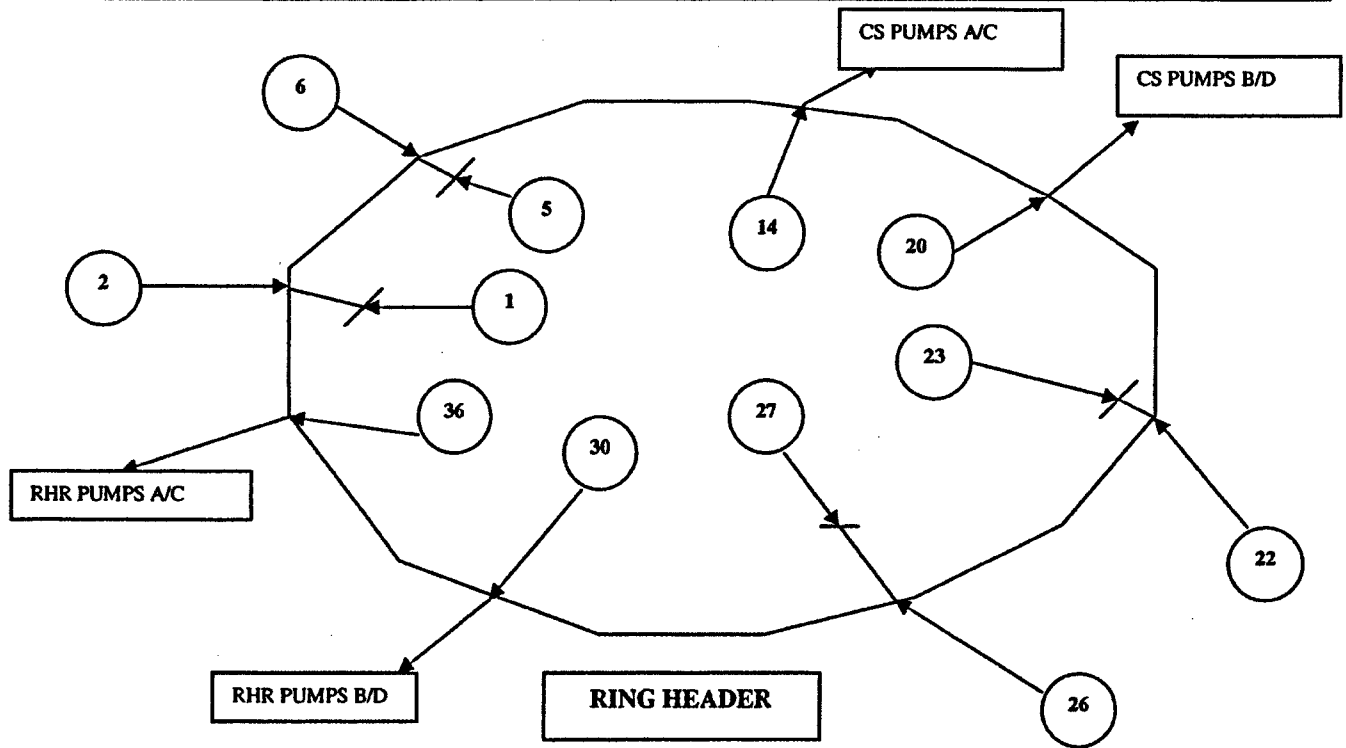
- 1) Maximum flow at a pool temperature of 95°F. (LOCA)
- 2) Maximum flow combinations at pool temperatures of 155.4°F and 166°F with no operational reduction. (LOCA)
- 3) Long term operation at the suppression pool design temperature limit of 187.3°F at design required system flow. (LOCA)
- 4) Maximum flow combinations at pool temperature 172°F at the end of overpressure requirement. (LOCA)
- 5) Flow conditions of RHR system analyzed at pool temperature of 177°F, 192°F and 211°F (ATWS).
- 6) Flow conditions of RHR system analyzed at pool temperature of 191°F and 223°F (Appendix R).
- 7) Flow conditions of RHR system analyzed at pool temperature of 157°F and 200°F (SBO).

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## 7 SUPPORTING GRAPHICS

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**FIGURE 7.1**  
**General MultiFlow Model**

|   |         |                           |                          |
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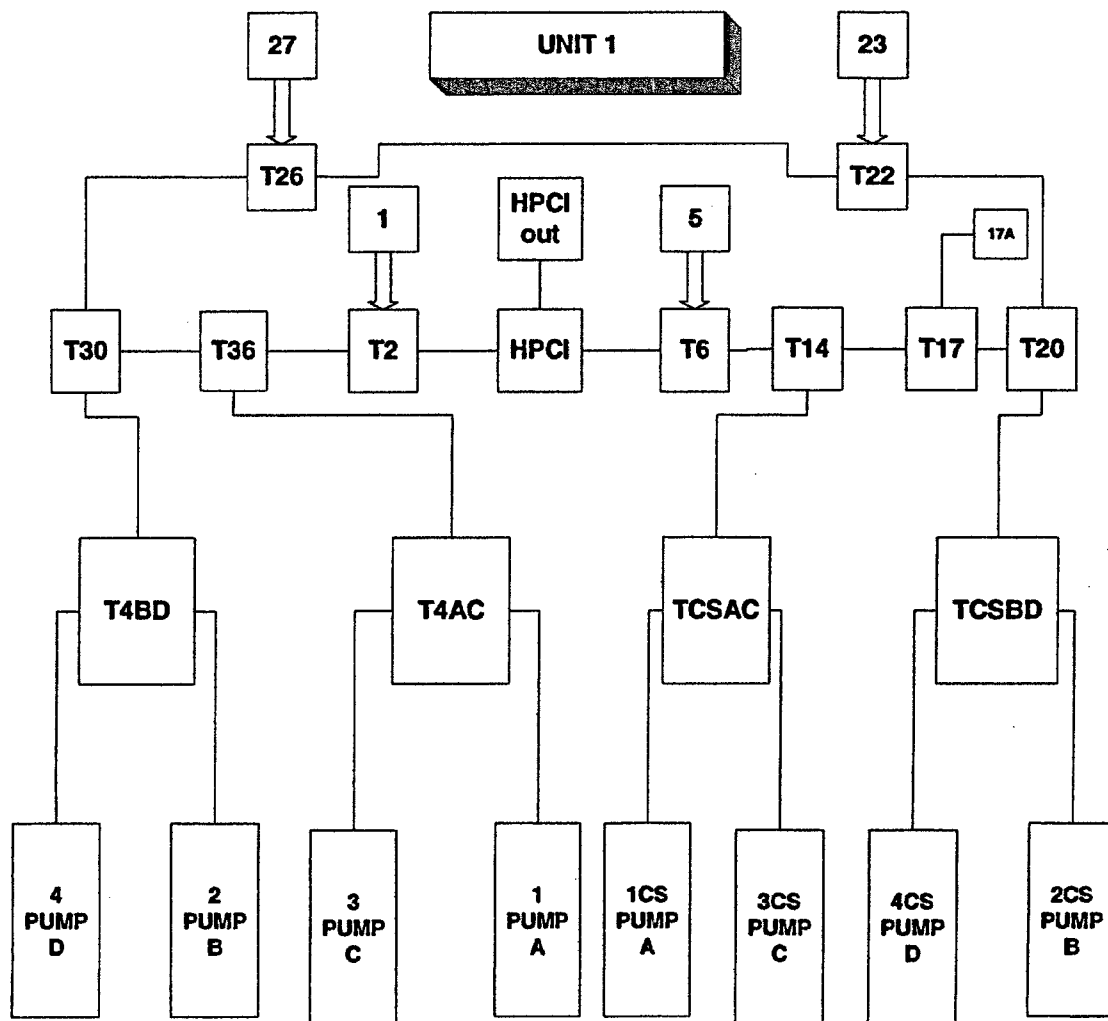


Figure 7.2 Unit 1 Nodal Diagram.



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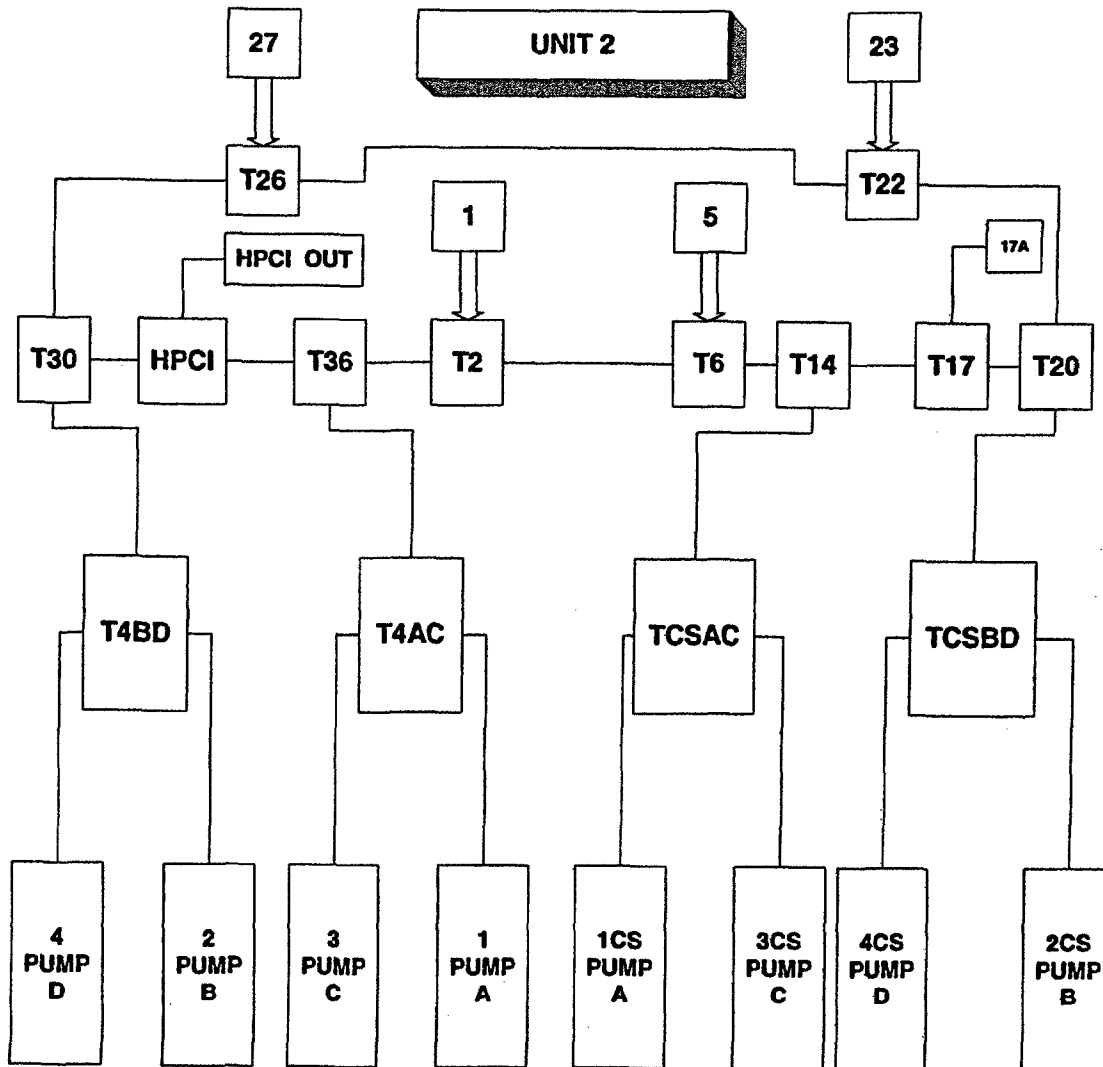


Figure 7.3 Unit 2 Nodal Diagram.

|   |         |   |          |
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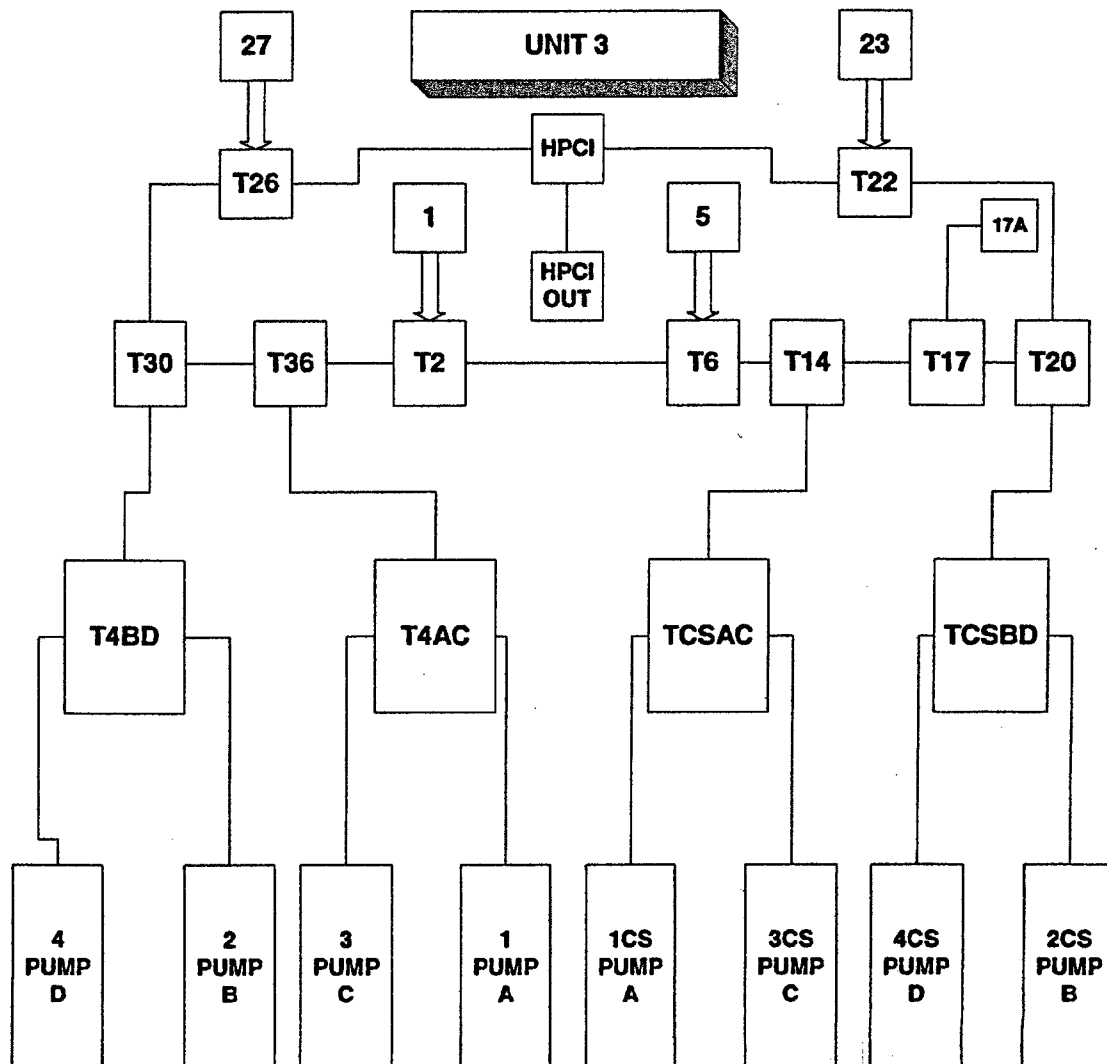
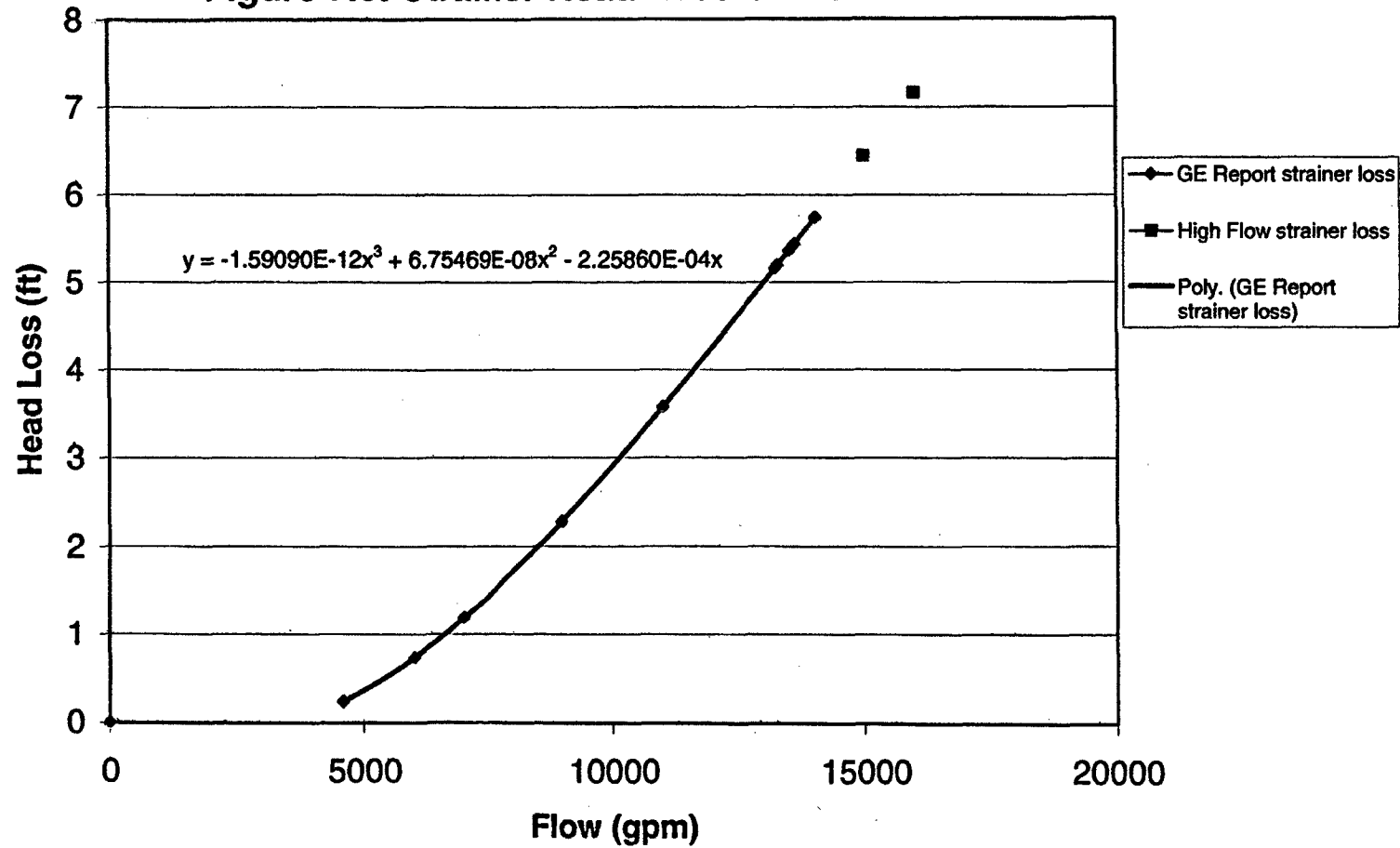


Figure 7.4 Unit 3 Nodal Diagram.

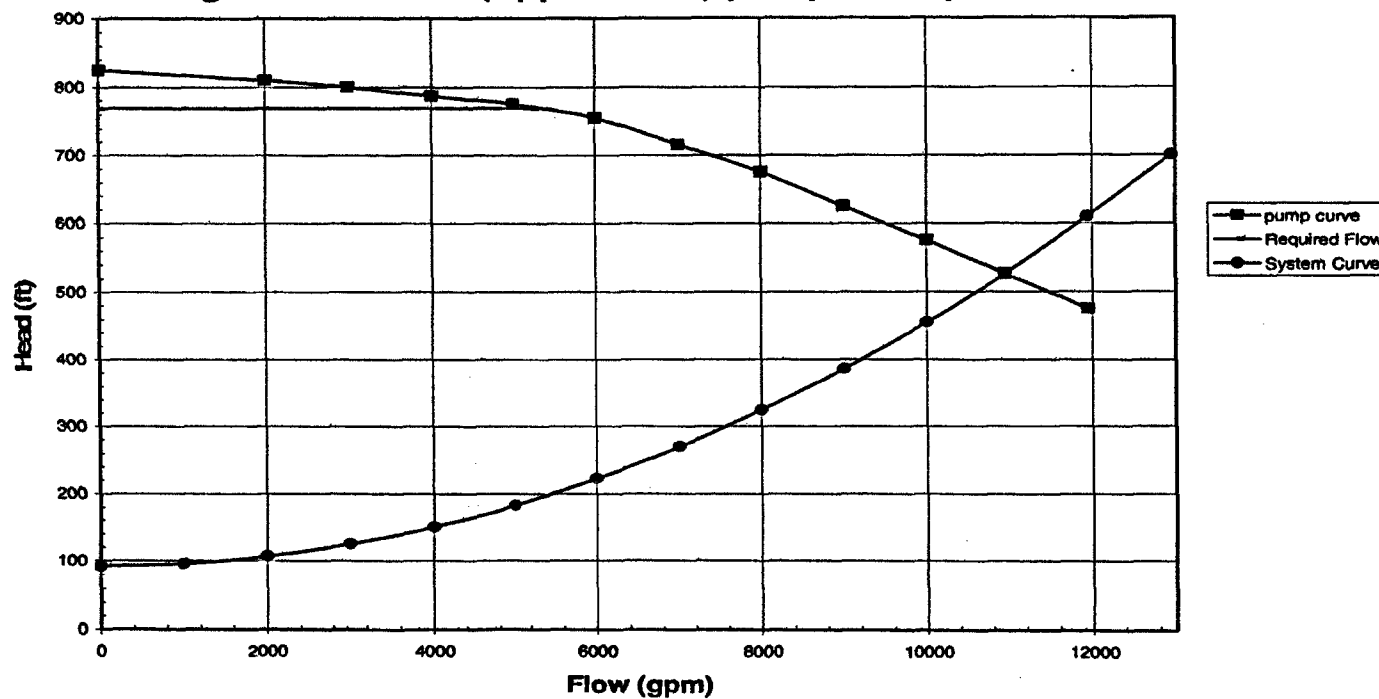
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**Figure 7.5: Strainer Head Loss Curve**



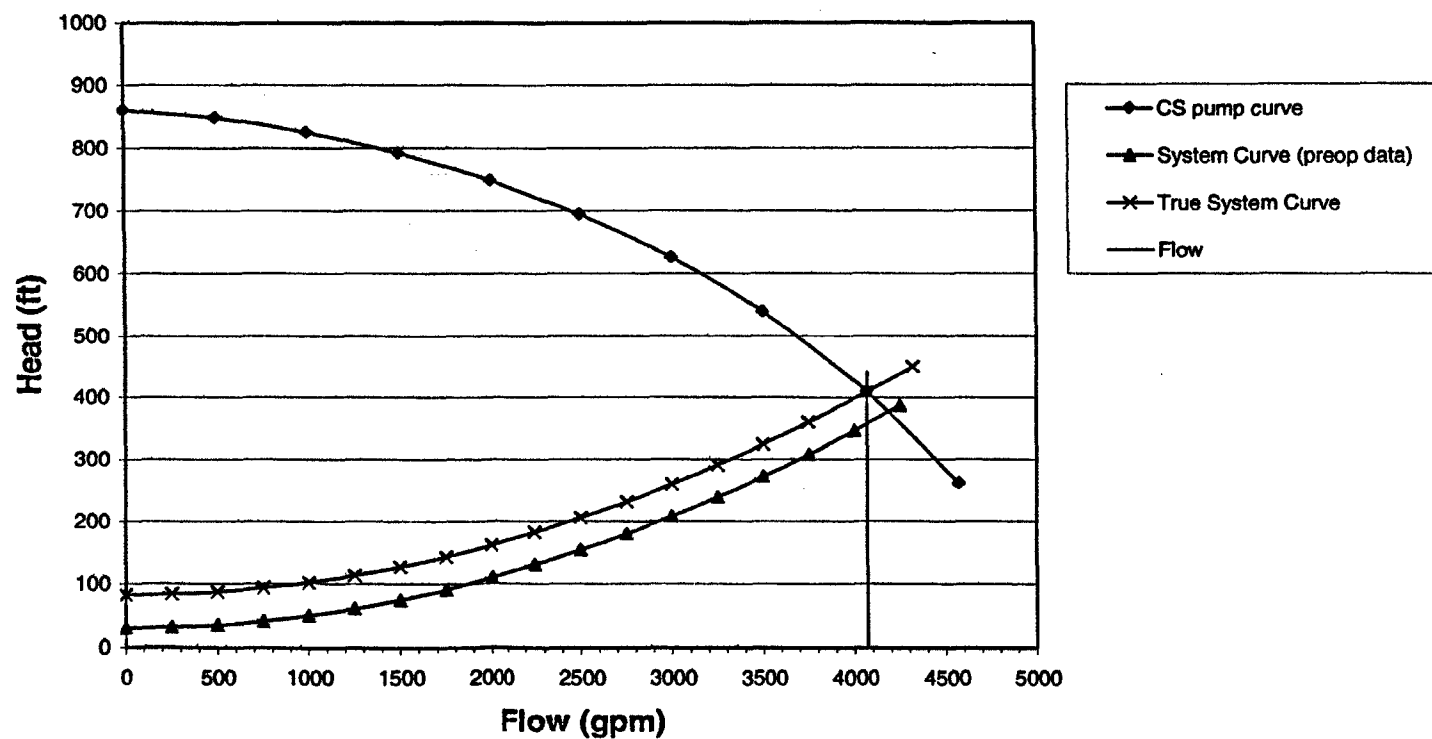
|   |         |                           |                          |
|---|---------|---------------------------|--------------------------|
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Figure 7.6 : RHR (Appendix R) pump and system curve



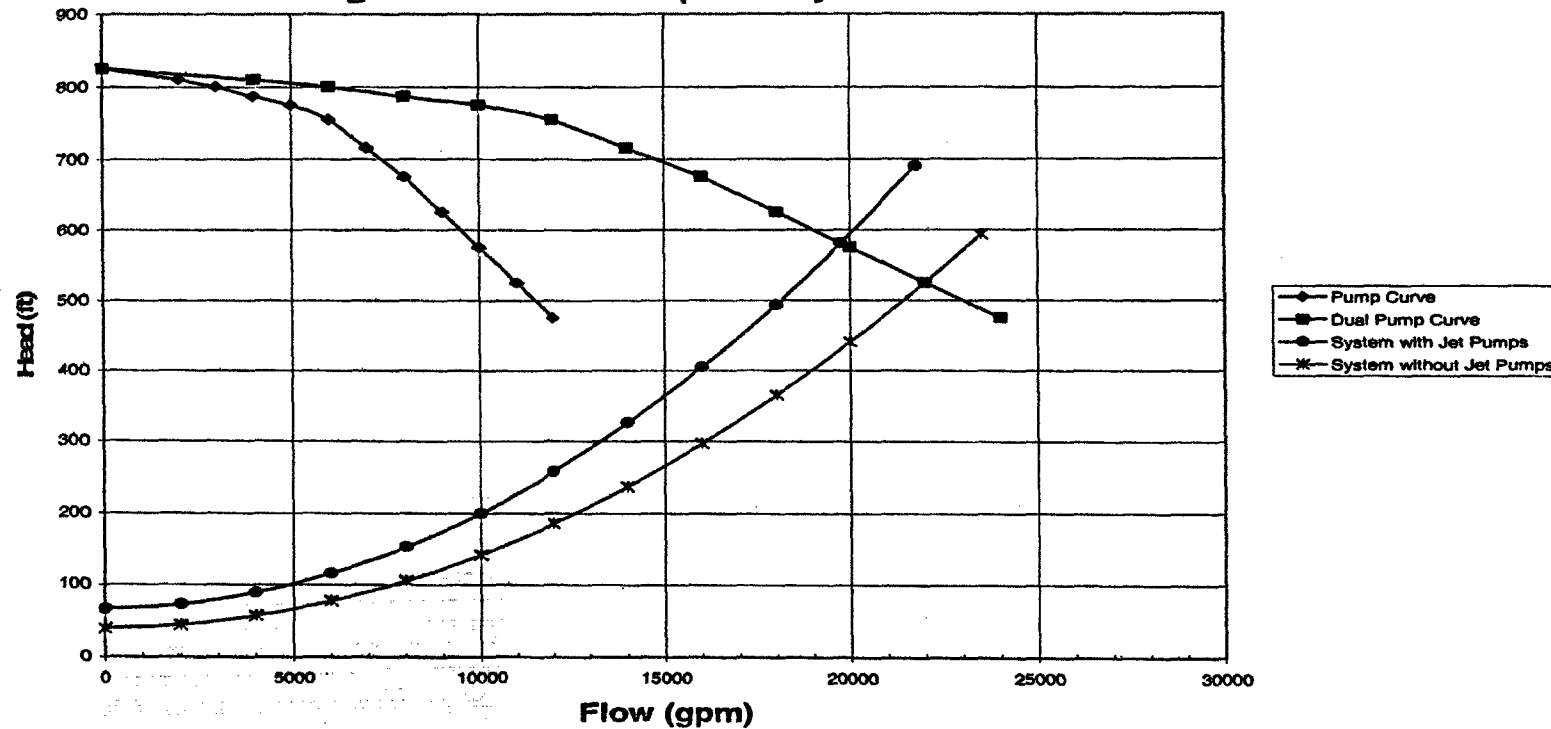
|   |         |                           |                          |
|---|---------|---------------------------|--------------------------|
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Figure 7.7: Core Spray Pump and System Curves



|   |         |                           |          |
|---|---------|---------------------------|----------|
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Figure 7.8: RHR Pump and System curves



|   |         |                           |                          |
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## 8 RESULTS AND CONCLUSIONS

Summary values of pump NPSH available are shown in Tables 6, 10 and 13 for Units 1, 2 and 3 respectively. These values are based on zero credit for containment overpressure as indicated in column five of tables 6, 10, and 13.

Flows used in Multiflow cases are conservatively higher than flows identified in this calculation.

All steps taken to calculate NPSHa are shown in Tables 7.1 through 7.24 for Unit 1, Tables 11.1 through 11.24 for Unit 2, and Tables 14.1 through 14.24 for Unit 3. The pump pressures are obtained from Multiflow output files. The equations used in these tables are shown in Table 8.

Tables 9, 12 and 15 list the strainer pressure drop and flow rates for Units 1, 2 and 3 respectively.

|   |         |   |          |
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Table 4: sgpm calculations

| Temp(°F) | V(ft³/lb) | Ratio Vs/Vr |
|----------|-----------|-------------|
| 60       | 0.01603   | 1.000000    |
| 95       | 0.01612   | 0.995022    |
| 172      | 0.01646   | 0.974154    |
| 155.4    | 0.01637   | 0.979577    |
| 187.3    | 0.01655   | 0.968770    |
| 177      | 0.01649   | 0.972434    |
| 192      | 0.01658   | 0.967045    |
| 211      | 0.01671   | 0.959742    |
| 191      | 0.01658   | 0.967414    |
| 223      | 0.01679   | 0.954866    |
| 157      | 0.01638   | 0.979074    |
| 200      | 0.01663   | 0.964033    |

| Flow (gpm) | Flow (sgpm) |       |       |       |       |       |       |       |       |       |       |
|------------|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|            |             |       |       |       |       |       |       |       |       |       |       |
|            | 95          | 155.4 | 187.3 | 172   | 177   | 192   | 211   | 191   | 223   | 157   | 200   |
|            | 0           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| 4125       | 4104        | 4041  | 3996  | 4018  | 4011  | 3989  | 3959  | 3991  | 3939  | 4039  | 3977  |
| 7200       | 7164        | 7053  | 6975  | 7014  | 7002  | 6963  | 6910  | 6965  | 6875  | 7049  | 6941  |
| 10500      | 10448       | 10286 | 10172 | 10229 | 10211 | 10154 | 10077 | 10158 | 10026 | 10280 | 10122 |
| 11500      | 11443       | 11265 | 11141 | 11203 | 11183 | 11121 | 11037 | 11125 | 10981 | 11259 | 11086 |
| 6500       | 6468        | 6367  | 6297  | 6332  | 6321  | 6286  | 6238  | 6288  | 6207  | 6364  | 6266  |

Note 1: See Table 5 for steps of conversion of flow from gpm to sgpm.



|    | A  | B               | C           | D | E          | F           | G | H | I | J | K | L | M |
|----|--|-----------------|-------------|---|------------|-------------|---|---|---|---|---|---|---|
| 1  | Table 5: sgpm calculations   |                 |             |   |            |             |   |   |   |   |   |   |   |
| 2  | Temp(°F)   | V(ft³/lb)       | Ratio Vs/Vr |   | Flow (gpm) | Flow (sgpm) |   |   |   |   |   |   |   |
| 3  | 60   | =vftsat_97(60)  | 1           |   |            |             |   |   |   |   |   |   |   |
| 4  | 95   | =vftsat_97(A4)  | =B3/B4      |   |            |             |   |   |   |   |   |   |   |
| 5  | 172  | =vftsat_97(A5)  | =B3/B5      |   |            |             |   |   |   |   |   |   |   |
| 6  | 155.4  | =vftsat_97(A6)  | =B3/B6      |   |            |             |   |   |   |   |   |   |   |
| 7  | 214.6  | =vftsat_97(A7)  | =B3/B7      |   |            |             |   |   |   |   |   |   |   |
| 8  | 227  | =vftsat_97(A8)  | =B3/B8      |   |            |             |   |   |   |   |   |   |   |
| 9  | 197.3  | =vftsat_97(A9)  | =B3/B9      |   |            |             |   |   |   |   |   |   |   |
| 10 | 166  | =vftsat_97(A10) | =B3/B10     |   |            |             |   |   |   |   |   |   |   |
| 11 | 187.3  | =vftsat_97(A11) | =B3/B11     |   |            |             |   |   |   |   |   |   |   |
| 12 |  |                 |             |   |            |             |   |   |   |   |   |   |   |
| 13 | This table depicts flow conversion to flow at standard conditions utilizing the ratio of specific volume of water at standard temperature and pressure (See cell B3) to the specific volume of water at desired temperature and pressure (See cells B4 through B11), the resulting ratios are displayed in cells C3 through C11. |                 |             |   |            |             |   |   |   |   |   |   |   |
| 14 | All flows (gpm) (See cells E6 through E11) are multiplied by the ratio Vs/Vr at the desired temperature resulting in flows at standard conditions (See cells F6 through M11) used in Multiflow.  |                 |             |   |            |             |   |   |   |   |   |   |   |
| 15 | vftsat_97(Temperature) is the specific volume of water at a specific temperature, it is a thermodynamic property of water obtained from STMFUNC excel add-in program (Ref. 2.25) (See cell B3 through B11)   |                 |             |   |            |             |   |   |   |   |   |   |   |

|   |         |                           |                          |
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**TABLE 6**  
**Unit 1**

| LOCA Pump/Flow Combination  | Pool Temp | Pump  | NPSHa (ft) | Pressure (psia) |
|---|-----------|-------|------------|-----------------|
| <b>LOCA 1A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @95°F     | RHR/A | 31.04      | 14.4            |
|   |           | RHR/B | 30.03      | 14.4            |
|   |           | RHR/C | 29.51      | 14.4            |
|   |           | RHR/D | 31.76      | 14.4            |
|   |           | CS/A  | 28.39      | 14.4            |
|   |           | CS/B  | 32.21      | 14.4            |
|   |           | CS/C  | 31.84      | 14.4            |
|   |           | CS/D  | 29.07      | 14.4            |
| <b>LOCA 1B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @155.4°F  | RHR/A | 23.46      | 14.4            |
|   |           | RHR/B | 22.45      | 14.4            |
|   |           | RHR/C | 21.92      | 14.4            |
|   |           | RHR/D | 24.17      | 14.4            |
|   |           | CS/A  | 20.80      | 14.4            |
|   |           | CS/B  | 24.62      | 14.4            |
|   |           | CS/C  | 24.25      | 14.4            |
|   |           | CS/D  | 21.48      | 14.4            |
| <b>LOCA 2A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @95°F     | RHR/A | 30.13      | 14.4            |
|   |           | RHR/B | 31.29      | 14.4            |
|   |           | RHR/C | 28.30      | 14.4            |
|   |           | RHR/D | 32.72      | 14.4            |
|   |           | CS/A  | 28.37      | 14.4            |
|   |           | CS/B  | 32.16      | 14.4            |
|   |           | CS/C  | 31.82      | 14.4            |
|   |           | CS/D  | 29.02      | 14.4            |
| <b>LOCA 2B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @155.4°F  | RHR/A | 22.55      | 14.4            |
|   |           | RHR/B | 23.70      | 14.4            |
|   |           | RHR/C | 20.71      | 14.4            |
|   |           | RHR/D | 25.14      | 14.4            |
|   |           | CS/A  | 20.79      | 14.4            |
|   |           | CS/B  | 24.57      | 14.4            |
|   |           | CS/C  | 24.23      | 14.4            |
|   |           | CS/D  | 21.43      | 14.4            |
| <b>LOCA 3A</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each                        | @155.4°F  | RHR/A | 35.57      | 14.4            |
|   |           | RHR/C | 34.98      | 14.4            |
|   |           | CS/A  | 31.48      | 14.4            |

|   |         |                           |                          |
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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

| LOCA Pump/Flow Combination  | Pool Temp | Pump  | NPSHa (ft) | Pressure (psia) |
|---|-----------|-------|------------|-----------------|
| B/D-0 gpm each  |           | CS/C  | 33.46      | 14.4            |
| <b>LOCA 3B</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each  | @172°F    | RHR/A | 30.88      | 14.4            |
|   |           | RHR/C | 30.30      | 14.4            |
|   |           | CS/A  | 26.80      | 14.4            |
|   |           | CS/C  | 28.78      | 14.4            |
| <b>LOCA 3C</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each  | @187.3°F  | RHR/A | 24.94      | 14.4            |
|   |           | RHR/C | 24.35      | 14.4            |
|   |           | CS/A  | 20.85      | 14.4            |
|   |           | CS/C  | 22.83      | 14.4            |
| <b>LOCA 4A</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 each      | @155.4°F  | RHR/A | 35.58      | 14.4            |
|   |           | RHR/C | 34.99      | 14.4            |
|   |           | CS/B  | 33.34      | 14.4            |
|   |           | CS/D  | 31.54      | 14.4            |
| <b>LOCA 4B</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each  | @172°F    | RHR/A | 30.90      | 14.4            |
|   |           | RHR/C | 30.31      | 14.4            |
|   |           | CS/B  | 28.67      | 14.4            |
|   |           | CS/D  | 26.86      | 14.4            |
| <b>LOCA 4C</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each  | @187.3°F  | RHR/A | 24.95      | 14.4            |
|   |           | RHR/C | 24.36      | 14.4            |
|   |           | CS/B  | 22.72      | 14.4            |
|   |           | CS/D  | 20.91      | 14.4            |
| <b>LOCA 5A</b><br>CS Pumps B/D-43125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @155.4°F  | RHR/B | 35.29      | 14.4            |
|   |           | RHR/D | 35.84      | 14.4            |
|   |           | CS/B  | 33.32      | 14.4            |
|   |           | CS/D  | 31.52      | 14.4            |
| <b>LOCA 5B</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each  | @172°F    | RHR/B | 30.61      | 14.4            |
|   |           | RHR/D | 31.16      | 14.4            |
|   |           | CS/B  | 28.64      | 14.4            |
|   |           | CS/D  | 26.84      | 14.4            |
| <b>LOCA 5C</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each  | @187.3°F  | RHR/B | 24.66      | 14.4            |
|   |           | RHR/D | 25.21      | 14.4            |
|   |           | CS/B  | 22.69      | 14.4            |
|   |           | CS/D  | 20.89      | 14.4            |
| <b>LOCA 6A</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each                    | @155.4°F  | RHR/B | 35.27      | 14.4            |
|   |           | RHR/D | 35.82      | 14.4            |
|   |           | CS/A  | 31.52      | 14.4            |

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| LOCA Pump/Flow Combination   | Pool Temp | Pump  | NPSHa (ft) | Pressure (psia) |
|--|-----------|-------|------------|-----------------|
| A/C-0 gpm each   |           | CS/C  | 33.50      | 14.4            |
| <b>LOCA 6B</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @172°F    | RHR/B | 30.59      | 14.4            |
|  |           | RHR/D | 31.14      | 14.4            |
|  |           | CS/A  | 26.84      | 14.4            |
|  |           | CS/C  | 28.82      | 14.4            |
| <b>LOCA 6C</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @187.3°F  | RHR/B | 24.64      | 14.4            |
|  |           | RHR/D | 25.19      | 14.4            |
|  |           | CS/A  | 20.89      | 14.4            |
|  |           | CS/C  | 22.87      | 14.4            |
| <b>LOCA 7</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C/B/D Pumps-6500 gpm each                | @166°F    | RHR/A | 30.40      | 14.4            |
|  |           | RHR/B | 30.41      | 14.4            |
|  |           | RHR/C | 29.82      | 14.4            |
|  |           | RHR/D | 30.96      | 14.4            |
|  |           | CS/A  | 27.26      | 14.4            |
|  |           | CS/C  | 29.23      | 14.4            |

| ATWS Pump/Flow Combination  | Pool Temp.        | Pump        | NPSHa (ft)        | Pressure (psia)        |
|---|-------------------|-------------|-------------------|------------------------|
| <b>ATWS</b><br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @177°F            | RHR/A       | 28.68             | 14.4                   |
|   |                   | RHR/B       | 28.73             | 14.4                   |
|   |                   | RHR/C       | 28.10             | 14.4                   |
|   |                   | RHR/D       | 29.28             | 14.4                   |
| <b>ATWS</b><br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @192°F            | RHR/A       | 22.28             | 14.4                   |
|   |                   | RHR/B       | 22.32             | 14.4                   |
|   |                   | RHR/C       | 21.69             | 14.4                   |
|   |                   | RHR/D       | 22.87             | 14.4                   |
| <b>ATWS</b><br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @211°F            | RHR/A       | 11.14             | 14.4                   |
|   |                   | RHR/B       | 11.19             | 14.4                   |
|   |                   | RHR/C       | 10.56             | 14.4                   |
|   |                   | RHR/D       | 11.74             | 14.4                   |
| <b>Appendix R Pump/Flow Combination</b>                                       | <b>Pool Temp.</b> | <b>Pump</b> | <b>NPSHa (ft)</b> | <b>Pressure (psia)</b> |
| App-R A<br>RHR Pump A-7200 gpm  | @191°F            | A           | 24.44             | 14.4                   |
| App-R B<br>RHR Pump B-7200 gpm  | @191°F            | B           | 24.43             | 14.4                   |
| App-R C<br>RHR Pump C-7200 gpm  | @191°F            | C           | 24.30             | 14.4                   |
| App-R D<br>RHR Pump D-7200 gpm  | @191°F            | D           | 24.52             | 14.4                   |

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| Appendix R Pump/Flow Combination        | Pool Temp. | Pump | NPSHa (ft) | Pressure (psia) |
|---|------------|------|------------|-----------------|
| App-R A<br>RHR Pump A-7200 gpm          | @223°F     | A    | 4.48       | 14.75           |
| App-R B<br>RHR Pump B-7200 gpm          | @223°F     | B    | 4.46       | 14.75           |
| App-R C<br>RHR Pump C-7200 gpm          | @223°F     | C    | 4.34       | 14.75           |
| App-R D<br>RHR Pump D-7200 gpm          | @223°F     | D    | 4.56       | 14.75           |
| SBO Pump/Flow Combination               | Pool Temp  | Pump | NPSHa (ft) | Pressure (psia) |
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @157°F     | A    | 35.45      | 14.4            |
|   |            | C    | 34.86      | 14.4            |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @157°F     | B    | 35.14      | 14.4            |
|   |            | D    | 35.69      | 14.4            |
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @200°F     | A    | 18.76      | 14.4            |
|   |            | C    | 18.18      | 14.4            |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @200°F     | B    | 18.46      | 14.4            |
|   |            | D    | 19.01      | 14.4            |

## CALCULATION SHEET

Table 7.1: Unit 1 NPSH Calculations Case 1A 95F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 95       | 0.816362332           | 0.016115213               | 2.320590685                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | -0.2071         | 31.04      |
| 2PUMPB   | -0.641          | 30.03      |
| 3PUMPC   | -0.866          | 29.51      |
| 4PUMPD   | 0.102           | 31.76      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | -1.348          | 28.39      |
| 2CSPUMPB | 0.297           | 32.21      |
| 3CSPUMPC | 0.137           | 31.84      |
| 4CSPUMPD | -1.058          | 29.07      |

|    | A   | B               | C               | D                    | E                  | F    | G | H | I | J |
|----|---|-----------------|-----------------|----------------------|--------------------|------|---|---|---|---|
| 1  | Table 8: Unit 1 NPSH Calculations Case 1A 95F   |                 |                 |                      |                    |      |   |   |   |   |
| 2  |   | Vapor Pressure  | Specific Volume | Conversion Factor    |                    |      |   |   |   |   |
| 3  | Temp(°F)  | (psia)          | V(ft³/lb)       | psia to feet of head |                    |      |   |   |   |   |
| 4  | 60  | =ptsat_97(60)   | =vfsat_97(A4)   | =C4*144              |                    |      |   |   |   |   |
| 5  | 95  | =ptsat_97(A5)   | =vfsat_97(A5)   | =C5*144              | Pool Press. (psia) | 14.4 |   |   |   |   |
| 6  |   |                 |                 |                      |                    |      |   |   |   |   |
| 7  | RHR   | Pressure (psig) | NPSHa (ft)      |                      |                    |      |   |   |   |   |
| 8  | 1PUMPA  | 0.757222        | =(B8-B5+F5)*D5  |                      |                    |      |   |   |   |   |
| 9  | 2PUMPB  | 0.350229        | =(B9-B5+F5)*D5  |                      |                    |      |   |   |   |   |
| 10 | 3PUMPC  | 0.159882        | =(B10-B5+F5)*D5 |                      |                    |      |   |   |   |   |
| 11 | 4PUMPD  | 1.02991         | =(B11-B5+F5)*D5 |                      |                    |      |   |   |   |   |
| 12 | CS  | Pressure (psig) | NPSHa (ft)      |                      |                    |      |   |   |   |   |
| 13 | 1CSPUMPA  | 1.39134         | =(B13-B5+F5)*D5 |                      |                    |      |   |   |   |   |
| 14 | 2CSPUMPB  | 2.33084         | =(B14-B5+F5)*D5 |                      |                    |      |   |   |   |   |
| 15 | 3CSPUMPC  | 2.24387         | =(B15-B5+F5)*D5 |                      |                    |      |   |   |   |   |
| 16 | 4CSPUMPD  | 1.5537          | =(B16-B5+F5)*D5 |                      |                    |      |   |   |   |   |
| 17 |   |                 |                 |                      |                    |      |   |   |   |   |
| 18 | This table depicts the calculation of NPSHa (See cells in column C under NPSHa heading)   |                 |                 |                      |                    |      |   |   |   |   |
| 19 |   |                 |                 |                      |                    |      |   |   |   |   |
| 20 | All pressures are in psi, which requires the conversion at the desired temperature (Cell D5 ) to obtain NPSHa in feet. The conversion factor (See cell D5) is obtained by   |                 |                 |                      |                    |      |   |   |   |   |
| 21 | multiplying specific volume of water at the desired temperature (See cell C5) by 144.   |                 |                 |                      |                    |      |   |   |   |   |
| 22 |   |                 |                 |                      |                    |      |   |   |   |   |
| 23 | [NPSHa = { suction pressure (pressure at pump inlet nodes obtained from Multiflow output files) (See cells in column B under Pressure heading (psig)) – vapor pressure (See |                 |                 |                      |                    |      |   |   |   |   |
| 24 | cell B5 (psia)) + pool pressure (See cell F5 (psia))] X conversion factor from psia to feet (See D5)  |                 |                 |                      |                    |      |   |   |   |   |
| 25 | vfsat_97(Temperature) is the specific volume of water at a specific temperature, it is a thermodynamic property of water obtained from STMFUNC excel add-in program (Ref.   |                 |                 |                      |                    |      |   |   |   |   |
| 26 | 2.25) (See cells C4 and C5)   |                 |                 |                      |                    |      |   |   |   |   |
| 27 | ptsat_97(Temperature) is the vapor pressure of water at a specific temperature, it is a thermodynamic property of water obtained from STMFUNC excel add-in program (Ref.    |                 |                 |                      |                    |      |   |   |   |   |
| 28 | 2.25) (See cells B4 and B5)   |                 |                 |                      |                    |      |   |   |   |   |

## CALCULATION SHEET

Table 7.2: Unit 1 NPSH Calculations Case 1B 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309               | 2.357180486                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | -0.199          | 23.46      |
| 2PUMPB   | -0.627          | 22.45      |
| 3PUMPC   | -0.849          | 21.92      |
| 4PUMPD   | 0.105           | 24.17      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | -1.324          | 20.80      |
| 2CSPUMPB | 0.296           | 24.62      |
| 3CSPUMPC | 0.138           | 24.25      |
| 4CSPUMPD | -1.039          | 21.48      |



Table 7.3: Unit 1 NPSH Calculations Case 2A 95F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 95       | 0.816362332           | 0.016115213               | 2.320590685                            | Pool Press. (psia) | 14.4 |
|          |                       |                           |  |                    |      |
| RHR      | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1PUMPA   | -0.599                | 30.13                     |  |                    |      |
| 2PUMPB   | -0.102                | 31.29                     |  |                    |      |
| 3PUMPC   | -1.389                | 28.30                     |  |                    |      |
| 4PUMPD   | 0.518                 | 32.72                     |  |                    |      |
| CS       | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1CSPUMPA | -1.357                | 28.37                     |  |                    |      |
| 2CSPUMPB | 0.276                 | 32.16                     |  |                    |      |
| 3CSPUMPC | 0.128                 | 31.82                     |  |                    |      |
| 4CSPUMPD | -1.078                | 29.02                     |  |                    |      |

## CALCULATION SHEET

Table 7.4: Unit 1 NPSH Calculations Case 2B 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309               | 2.357180486                            | Pool Press. (psia) | 14.4 |
|          |                       |                           |  |                    |      |
| RHR      | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1PUMPA   | -0.585                | 22.55                     |  |                    |      |
| 2PUMPB   | -0.097                | 23.70                     |  |                    |      |
| 3PUMPC   | -1.364                | 20.71                     |  |                    |      |
| 4PUMPD   | 0.514                 | 25.14                     |  |                    |      |
| CS       | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1CSPUMPA | -1.332                | 20.79                     |  |                    |      |
| 2CSPUMPB | 0.275                 | 24.57                     |  |                    |      |
| 3CSPUMPC | 0.129                 | 24.23                     |  |                    |      |
| 4CSPUMPD | -1.059                | 21.43                     |  |                    |      |

## CALCULATION SHEET

Table 7.5: Unit 1 NPSH Calculations Case 3A 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309               | 2.357180486                            | Pool Press. (psia) | 14.4 |
|          |                       |                           |  |                    |      |
| RHR      | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1PUMPA   | 4.938                 | 35.57                     |  |                    |      |
| 2PUMPB   |                       |                           |  |                    |      |
| 3PUMPC   | 4.689                 | 34.98                     |  |                    |      |
| 4PUMPD   |                       |                           |  |                    |      |
| CS       | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1CSPUMPA | 3.204                 | 31.48                     |  |                    |      |
| 2CSPUMPB |                       |                           |  |                    |      |
| 3CSPUMPC | 4.043                 | 33.46                     |  |                    |      |
| 4CSPUMPD |                       |                           |  |                    |      |

## CALCULATION SHEET

Table 7.6: Unit 1 NPSH Calculations Case 3B 172F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft³/lb) | Conversion Factor<br>psia to feet of head |                    |      |
|----------|--------------------------|------------------------------|---|--------------------|------|
| 60       | 0.256389624              | 0.016034992                  | 2.309038802                               |                    |      |
| 172      | 6.281035863              | 0.016460423                  | 2.370300872                               | Pool Press. (psia) | 14.4 |
|          |                          |                              |   |                    |      |
| RHR      | Pressure (psig)          | NPSHa (ft)                   |   |                    |      |
| 1PUMPA   | 4.911                    | 30.88                        |   |                    |      |
|          |                          |                              |   |                    |      |
| 3PUMPC   | 4.664                    | 30.30                        |   |                    |      |
|          |                          |                              |   |                    |      |
| RHR      | Pressure (psig)          | NPSHa (ft)                   |   |                    |      |
| 1CSPUMPA | 3.187                    | 26.80                        |   |                    |      |
|          |                          |                              |   |                    |      |
| 3CSPUMPC | 4.021                    | 28.78                        |   |                    |      |
|          |                          |                              |   |                    |      |

## CALCULATION SHEET

Table 7.7: Unit 1 NPSH Calculations Case 3C 187.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 187.3    | 8.822339971           | 0.01655191                | 2.383475045                            | Pool Press. (psia) | 14.4 |
|          |                       |                           |  |                    |      |
| RHR      | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1PUMPA   | 4.884                 | 24.94                     |  |                    |      |
| 2PUMPB   |                       |                           |  |                    |      |
| 3PUMPC   | 4.638                 | 24.35                     |  |                    |      |
| 4PUMPD   |                       |                           |  |                    |      |
| CS       | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1CSPUMPA | 3.17                  | 20.85                     |  |                    |      |
| 2CSPUMPB |                       |                           |  |                    |      |
| 3CSPUMPC | 3.999                 | 22.83                     |  |                    |      |
| 4CSPUMPD |                       |                           |  |                    |      |

## CALCULATION SHEET

Table 7.8: Unit 1 NPSH Calculations Case 4A 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309                            | 2.357180486                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.944           | 35.58      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.695           | 34.99      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.996           | 33.34      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.231           | 31.54      |

## CALCULATION SHEET

Table 7.9: Unit 1 NPSH Calculations Case 4B 172F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 172      | 6.281035863           | 0.016460423               | 2.370300872                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.917           | 30.90      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.669           | 30.31      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.975           | 28.67      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.213           | 26.86      |

## CALCULATION SHEET

Table 7.10: Unit 1 NPSH Calculations Case 4C 187.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 187.3    | 8.822339971           | 0.01655191                | 2.383475045                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.889           | 24.95      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.644           | 24.36      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.953           | 22.72      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.196           | 20.91      |



## CALCULATION SHEET

Table 7.11: Unit 1 NPSH Calculations Case 5A 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309               | 2.357180486                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.822           | 35.29      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.056           | 35.84      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.987           | 33.32      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.221           | 31.52      |

## CALCULATION SHEET

Table 7.12: Unit 1 NPSH Calculations Case 5B 172F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 172      | 6.281035863           | 0.016460423                            | 2.370300872                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.796           | 30.61      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.028           | 31.16      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.965           | 28.64      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.204           | 26.84      |

## CALCULATION SHEET

Table 7.13: Unit 1 NPSH Calculations Case 5C 187.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 187.3    | 8.822339971           | 0.01655191                | 2.383475045                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.769           | 24.66      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5               | 25.21      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.944           | 22.69      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.187           | 20.89      |

## CALCULATION SHEET

Table 7.14: Unit 1 NPSH Calculations Case 6A 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309               | 2.357180486                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.813           | 35.27      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.047           | 35.82      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.222           | 31.52      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 4.061           | 33.50      |
| 4CSPUMPD |                 |            |

## CALCULATION SHEET

Table 7.15: Unit 1 NPSH Calculations Case 6B 172F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 172      | 6.281035863           | 0.016460423                            | 2.370300872                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.787           | 30.59      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.019           | 31.14      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.204           | 26.84      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 4.039           | 28.82      |
| 4CSPUMPD |                 |            |

## CALCULATION SHEET

Table 7.16: Unit 1 NPSH Calculations Case 6C 187.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 187.3    | 8.822339971           | 0.01655191                | 2.383475045                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.76            | 24.64      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 4.992           | 25.19      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.187           | 20.89      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 4.017           | 22.87      |
| 4CSPUMPD |                 |            |

## CALCULATION SHEET

Table 7.17: Unit 1 NPSH Calculations Case 7 166F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 166      | 5.468938413           | 0.016426501               | 2.365416198                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 3.922           | 30.40      |
| 2PUMPB   | 3.926           | 30.41      |
| 3PUMPC   | 3.674           | 29.82      |
| 4PUMPD   | 4.159           | 30.96      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 2.592           | 27.26      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 3.428           | 29.23      |
| 4CSPUMPD |                 |            |

**Table 7.18: Unit 1 NPSH Calculations ATWS 177F**

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 177      | 7.033092437           | 0.016489536                            | 2.374493143                            | Pool Press. (psia) | 14.4 |

| RHR   | Pressure (psig) | NPSHa (ft) |
|-------|-----------------|------------|
| PUMPA | 4.713           | 28.68      |
| PUMPB | 4.732           | 28.73      |
| PUMPC | 4.466           | 28.10      |
| PUMPD | 4.964           | 29.28      |



## CALCULATION SHEET

Table 7.19: Unit 1 NPSH Calculations ATWS 192F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head | 60.30839169        |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 192      | 9.757027807           | 0.01658144                | 2.387727412                            | Pool Press. (psia) | 14.4 |

| RHR   | Pressure (pslg) | NPSHa (ft) |
|-------|-----------------|------------|
| PUMPA | 4.687           | 22.28      |
| PUMPB | 4.706           | 22.32      |
| PUMPC | 4.441           | 21.69      |
| PUMPD | 4.937           | 22.87      |

## CALCULATION SHEET

Table 7.20: Unit 1 NPSH Calculations ATWS 214.6F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 211      | 14.42019545           | 0.016707611                            | 2.405895953                            | Pool Press. (psia) | 14.4 |

| RHR   | Pressure (psig) | NPSHa (ft) |
|-------|-----------------|------------|
| PUMPA | 4.652           | 11.14      |
| PUMPB | 4.67            | 11.19      |
| PUMPC | 4.408           | 10.56      |
| PUMPD | 4.899           | 11.74      |

Table 7.21: Unit 1 NPSH Calculations App-R A 227F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft³/lb) | Conversion Factor<br>psia to feet of head |                    |      |
|----------|--------------------------|------------------------------|---|--------------------|------|
| 60       | 0.256389624              | 0.016034992                  | 2.309038802                               |                    |      |
| 191      | 9.551535023              | 0.016575101                  | 2.386814603                               | Pool Press. (psia) | 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 5.393           | 24.44      |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 7.22: Unit 1 NPSH Calculations App-R B 191F

|          | Vapor Pressure | Specific Volume        | Conversion Factor    |                    |      |
|----------|----------------|------------------------|----------------------|--------------------|------|
| Temp(°F) | (psia)         | V(ft <sup>3</sup> /lb) | psia to feet of head |                    |      |
| 60       | 0.256389624    | 0.016034992            | 2.309038802          |                    |      |
| 191      | 9.551535023    | 0.016575101            | 2.386814603          | Pool Press. (psia) | 14.4 |

| RHR    | Pressure (psig) (ft) | NPSHa (ft) |
|--------|----------------------|------------|
| 1PUMPA |                      |            |
| 2PUMPB | 5.385                | 24.43      |
| 3PUMPC |                      |            |
| 4PUMPD |                      |            |

## CALCULATION SHEET

Table 7.23: Unit 1 NPSH Calculations App-R C 227F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 191      | 9.551535023           | 0.016575101                            | 2.386814603                            | Pool Press. (psia) | 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC | 5.333           | 24.30      |
| 4PUMPD |                 |            |

**Table 7.24: Unit 1 NPSH Calculations App-R D 227F**

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 191      | 9.551535023           | 0.016575101                            | 2.386814603                            | Pool Press. (psia) | 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD | 5.426           | 24.52      |

## CALCULATION SHEET

Table 7.25: Unit 1 NPSH Calculations App-R A 227F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft³/lb) | Conversion Factor<br>psia to feet of head | 59.54891812        |       |
|----------|--------------------------|------------------------------|---|--------------------|-------|
| 60       | 0.256389624              | 0.016034992                  | 2.309038802                               |                    |       |
| 223      | 18.22056282              | 0.016792916                  | 2.418179953                               | Pool Press. (psia) | 14.75 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 5.323           | 4.48       |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 7.26: Unit 1 NPSH Calculations App-R B 227F

|          | Vapor Pressure | Specific Volume | Conversion Factor    |                    |       |
|----------|----------------|-----------------|----------------------|--------------------|-------|
| Temp(°F) | (psia)         | V(ft³/lb)       | psia to feet of head |                    |       |
| 60       | 0.256389624    | 0.016034992     | 2.309038802          |                    |       |
| 223      | 18.22056282    | 0.016792916     | 2.418179953          | Pool Press. (psia) | 14.75 |

| RHR    | Pressure (psig) (ft) | NPSHa (ft) |
|--------|----------------------|------------|
| 1PUMPA |                      |            |
| 2PUMPB | 5.315                | 4.46       |
| 3PUMPC |                      |            |
| 4PUMPD |                      |            |



## CALCULATION SHEET

Table 7.27: Unit 1 NPSH Calculations App-R C 227F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft <sup>3</sup> /lb) | Conversion Factor<br>psia to feet of head |                    |      |
|----------|--------------------------|---|---|--------------------|------|
| 60       | 0.256389624              | 0.016034992                               | 2.309038802                               |                    |      |
| 223      | 18.22056282              | 0.016792916                               | 2.418179953                               | Pool Press. (psia) | 14.8 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC | 5.264           | 4.34       |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 7.28: Unit 1 NPSH Calculations App-R D 227F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |       |
|----------|-----------------------|--|--|--------------------|-------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |       |
| 223      | 18.22056282           | 0.016792916                            | 2.418179953                            | Pool Press. (psia) | 14.75 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD | 5.356           | 4.56       |

## CALCULATION SHEET

Table 7.29: Unit 1 NPSH Calculations Case SBO A-C 197.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 157      | 4.417636119           | 0.016377716               | 2.358391077                            | Pool Press. (psia) | 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 5.048           | 35.45      |
| 2PUMPB |                 |            |
| 3PUMPC | 4.799           | 34.86      |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 7.30: Unit 1 NPSH Calculations Case SBO B-D 197.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 157      | 4.417636119           | 0.016377716               | 2.358391077                            | Pool Press. (psia) | 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB | 4.918           | 35.14      |
| 3PUMPC |                 |            |
| 4PUMPD | 5.152           | 35.69      |

## CALCULATION SHEET

Table 7.31: Unit 1 NPSH Calculations Case SBO A-C 197.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 200      | 11.53763273           | 0.016633238               | 2.395186284                            | Pool Press. (psia) | 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 4.971           | 18.76      |
| 2PUMPB |                 |            |
| 3PUMPC | 4.726           | 18.18      |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 7.32: Unit 1 NPSH Calculations Case SBO B-D 197.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head | Pool Press. (psia) 14.4 |
|----------|-----------------------|--|--|-------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                         |
| 200      | 11.537632733          | 0.016633238                            | 2.395186284                            |                         |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB | 4.843           | 18.46      |
| 3PUMPC |                 |            |
| 4PUMPD | 5.073           | 19.01      |

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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

**TABLE 9**  
**Unit 1**

| LOCA Pump/Flow Combination  | Pool Temp | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|---|-----------|-------------|-------------|----------------------|
| <b>LOCA 1A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @95°F     | Strainer 1  | 15713.7     | 3.04                 |
|   |           | Strainer 23 | 14682.4     | 2.645                |
|   |           | Strainer 27 | 15042.5     | 2.83                 |
|   |           | Strainer 5  | 14759.5     | 2.688                |
| <b>LOCA 1B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @155.4°F  | Strainer 1  | 15470.3     | 2.993                |
|   |           | Strainer 23 | 14455.5     | 2.606                |
|   |           | Strainer 27 | 14808.3     | 2.787                |
|   |           | Strainer 5  | 14531.9     | 2.648                |
| <b>LOCA 2A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @95°F     | Strainer 1  | 15969.4     | 3.036                |
|   |           | Strainer 23 | 14701.6     | 2.656                |
|   |           | Strainer 27 | 15063.3     | 2.839                |
|   |           | Strainer 5  | 14736.8     | 2.675                |
| <b>LOCA 2B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @155.4°F  | Strainer 1  | 15452.5     | 2.989                |
|   |           | Strainer 23 | 14474.8     | 2.616                |
|   |           | Strainer 27 | 14829.5     | 2.796                |
|   |           | Strainer 5  | 14509.2     | 2.635                |
| <b>LOCA 3A</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @155.4°F  | Strainer 1  | 4923.85     | 0.177                |
|   |           | Strainer 23 | 4536.97     | 0.104                |
|   |           | Strainer 27 | 4621.3      | 0.119                |
|   |           | Strainer 5  | 4773.88     | 0.147                |
| <b>LOCA 3B</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @172°F    | Strainer 1  | 4896.25     | 0.176                |
|   |           | Strainer 23 | 4512.32     | 0.104                |
|   |           | Strainer 27 | 4596.07     | 0.119                |
|   |           | Strainer 5  | 4747.36     | 0.146                |
| <b>LOCA 3C</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @187.3°F  | Strainer 1  | 4868.75     | 0.175                |
|   |           | Strainer 23 | 4487.58     | 0.103                |
|   |           | Strainer 27 | 4570.78     | 0.118                |
|   |           | Strainer 5  | 4720.89     | 0.146                |
| <b>LOCA 4A</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 each          | @155.4°F  | Strainer 1  | 4861.33     | 0.164                |
|   |           | Strainer 23 | 4616.42     | 0.118                |
|   |           | Strainer 27 | 4695.98     | 0.133                |
|   |           | Strainer 5  | 4682.26     | 0.130                |
| <b>LOCA 4B</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @172°F    | Strainer 1  | 4834.22     | 0.163                |
|   |           | Strainer 23 | 4591.07     | 0.118                |
|   |           | Strainer 27 | 4670.16     | 0.132                |
|   |           | Strainer 5  | 4656.55     | 0.129                |

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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

| LOCA Pump/Flow Combination   | Pool Temp | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|--|-----------|-------------|-------------|----------------------|
| <b>LOCA 4C</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each | @187.3°F  | Strainer 1  | 4807.19     | 0.162                |
|  |           | Strainer 23 | 4565.69     | 0.117                |
|  |           | Strainer 27 | 4644.31     | 0.131                |
|  |           | Strainer 5  | 4630.81     | 0.129                |
| <b>LOCA 5A</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @155.4°F  | Strainer 1  | 4669.87     | 0.128                |
|  |           | Strainer 23 | 4757.96     | 0.144                |
|  |           | Strainer 27 | 4868.9      | 0.166                |
|  |           | Strainer 5  | 4559.26     | 0.108                |
| <b>LOCA 5B</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @172°F    | Strainer 1  | 4644.41     | 0.127                |
|  |           | Strainer 23 | 4731.46     | 0.143                |
|  |           | Strainer 27 | 4841.57     | 0.165                |
|  |           | Strainer 5  | 4534.56     | 0.108                |
| <b>LOCA 5C</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @187.3°F  | Strainer 1  | 4618.88     | 0.127                |
|  |           | Strainer 23 | 4705.02     | 0.143                |
|  |           | Strainer 27 | 4814.34     | 0.164                |
|  |           | Strainer 5  | 4509.75     | 0.107                |
| <b>LOCA 6A</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @155.4°F  | Strainer 1  | 4743.94     | 0.142                |
|  |           | Strainer 23 | 4665.05     | 0.127                |
|  |           | Strainer 27 | 4795.96     | 0.151                |
|  |           | Strainer 5  | 4651.04     | 0.124                |
| <b>LOCA 6B</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @172°F    | Strainer 1  | 4717.9      | 0.141                |
|  |           | Strainer 23 | 4639.35     | 0.126                |
|  |           | Strainer 27 | 4769.18     | 0.151                |
|  |           | Strainer 5  | 4625.57     | 0.124                |
| <b>LOCA 6C</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @187.3°F  | Strainer 1  | 4691.82     | 0.140                |
|  |           | Strainer 23 | 4613.64     | 0.126                |
|  |           | Strainer 27 | 4742.47     | 0.149                |
|  |           | Strainer 5  | 4600.06     | 0.123                |
| <b>LOCA 7</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C/B/D Pumps-6500 gpm each                | @166°F    | Strainer 1  | 8339.61     | 0.890                |
|  |           | Strainer 23 | 7506.83     | 0.698                |
|  |           | Strainer 27 | 7849.45     | 0.771                |
|  |           | Strainer 5  | 7786.11     | 0.757                |



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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

| ATWS Pump/Flow Combination   | Pool Temp. | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|--|------------|-------------|-------------|----------------------|
| ATWS<br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @177°F     | Strainer 1  | 9045.39     | 0.186                |
|  |            | Strainer 23 | 4168.86     | 0.039                |
|  |            | Strainer 27 | 7155.71     | 0.116                |
|  |            | Strainer 5  | 4914.04     | 0.055                |
| ATWS<br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @192°F     | Strainer 1  | 8994.24     | 0.185                |
|  |            | Strainer 23 | 4147.2      | 0.039                |
|  |            | Strainer 27 | 7114.06     | 0.116                |
|  |            | Strainer 5  | 4888.49     | 0.055                |
| ATWS<br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @211°F     | Strainer 1  | 8924.42     | 0.183                |
|  |            | Strainer 23 | 4117.08     | 0.039                |
|  |            | Strainer 27 | 7057.55     | 0.115                |
|  |            | Strainer 5  | 4852.95     | 0.054                |
| Appendix R Pump/Flow Combination                                       | Pool Temp. | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
| App-R A<br>RHR Pump A-7200 gpm   | @191°F     | Strainer 1  | 2646.06     | 0.016                |
|  |            | Strainer 23 | 1121.85     | 0.003                |
|  |            | Strainer 27 | 1845.71     | 0.008                |
|  |            | Strainer 5  | 1351.38     | 0.004                |
| App-R B<br>RHR Pump B-7200 gpm   | @191°F     | Strainer 1  | 2096.07     | 0.010                |
|  |            | Strainer 23 | 1351.34     | 0.004                |
|  |            | Strainer 27 | 2369.33     | 0.013                |
|  |            | Strainer 5  | 1148.26     | 0.003                |
| App-R C<br>RHR Pump C-7200 gpm   | @191°F     | Strainer 1  | 2646.06     | 0.016                |
|  |            | Strainer 23 | 1121.85     | 0.003                |
|  |            | Strainer 27 | 1845.71     | 0.008                |
|  |            | Strainer 5  | 1351.38     | 0.004                |
| App-R D<br>RHR Pump D-7200 gpm   | @191°F     | Strainer 1  | 2096.07     | 0.010                |
|  |            | Strainer 23 | 1351.34     | 0.004                |
|  |            | Strainer 27 | 2369.33     | 0.013                |
|  |            | Strainer 5  | 1148.26     | 0.003                |

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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

| Appendix R Pump/Flow Combination | Pool Temp. | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|----------------------------------|------------|-------------|-------------|----------------------|
| App-R A<br>RHR Pump A-7200 gpm   | @223°F     | Strainer 1  | 2609.76     | 0.016                |
|                                  |            | Strainer 23 | 1108.86     | 0.003                |
|                                  |            | Strainer 27 | 1821.18     | 0.008                |
|                                  |            | Strainer 5  | 1335.21     | 0.004                |
| App-R B<br>RHR Pump B-7200 gpm   | @223°F     | Strainer 1  | 2068.99     | 0.009                |
|                                  |            | Strainer 23 | 1335.48     | 0.004                |
|                                  |            | Strainer 27 | 2335.73     | 0.013                |
|                                  |            | Strainer 5  | 1134.8      | 0.003                |
| App-R C<br>RHR Pump C-7200 gpm   | @223°F     | Strainer 1  | 2609.76     | 0.016                |
|                                  |            | Strainer 23 | 1108.86     | 0.003                |
|                                  |            | Strainer 27 | 1821.18     | 0.008                |
|                                  |            | Strainer 5  | 1335.21     | 0.004                |
| App-R D<br>RHR Pump D-7200 gpm   | @223°F     | Strainer 1  | 2068.99     | 0.009                |
|                                  |            | Strainer 23 | 1335.48     | 0.004                |
|                                  |            | Strainer 27 | 2335.73     | 0.013                |
|                                  |            | Strainer 5  | 1134.8      | 0.003                |

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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

| SBO Pump/Flow Combination               | Pool Temp | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|---|-----------|-------------|-------------|----------------------|
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @157°F    | Strainer 1  | 4827.87     | 0.053                |
|   |           | Strainer 23 | 2055.54     | 0.009                |
|   |           | Strainer 27 | 3370.38     | 0.026                |
|   |           | Strainer 5  | 2474.21     | 0.014                |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @157°F    | Strainer 1  | 3830.36     | 0.003                |
|   |           | Strainer 23 | 2475.26     | 0.014                |
|   |           | Strainer 27 | 4319.02     | 0.042                |
|   |           | Strainer 5  | 2103.36     | 0.010                |
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @200°F    | Strainer 1  | 4748.62     | 0.052                |
|   |           | Strainer 23 | 2027.47     | 0.009                |
|   |           | Strainer 27 | 3316.74     | 0.025                |
|   |           | Strainer 5  | 2439.17     | 0.014                |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @200°F    | Strainer 1  | 3771.2      | 0.033                |
|   |           | Strainer 23 | 2440.95     | 0.014                |
|   |           | Strainer 27 | 4245.61     | 0.041                |
|   |           | Strainer 5  | 2074.25     | 0.009                |

|   |         |                           |                          |
|---|---------|---------------------------|--------------------------|
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**TABLE 10**  
**Unit 2**

| LOCA Pump/Flow Combination  | Pool Temp | Pump  | NPSHa (ft) | Pressure (psia) |
|---|-----------|-------|------------|-----------------|
| <b>LOCA 1A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @95°F     | RHR/A | 31.11      | 14.4            |
|   |           | RHR/B | 30.08      | 14.4            |
|   |           | RHR/C | 29.68      | 14.4            |
|   |           | RHR/D | 31.78      | 14.4            |
|   |           | CS/A  | 28.39      | 14.4            |
|   |           | CS/B  | 32.17      | 14.4            |
|   |           | CS/C  | 31.84      | 14.4            |
|   |           | CS/D  | 29.02      | 14.4            |
| <b>LOCA 1B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @155.4°F  | RHR/A | 23.53      | 14.4            |
|   |           | RHR/B | 22.49      | 14.4            |
|   |           | RHR/C | 22.09      | 14.4            |
|   |           | RHR/D | 24.20      | 14.4            |
|   |           | CS/A  | 20.80      | 14.4            |
|   |           | CS/B  | 24.58      | 14.4            |
|   |           | CS/C  | 24.25      | 14.4            |
|   |           | CS/D  | 21.43      | 14.4            |
| <b>LOCA 2A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @95°F     | RHR/A | 30.22      | 14.4            |
|   |           | RHR/B | 31.33      | 14.4            |
|   |           | RHR/C | 28.50      | 14.4            |
|   |           | RHR/D | 32.75      | 14.4            |
|   |           | CS/A  | 28.38      | 14.4            |
|   |           | CS/B  | 32.16      | 14.4            |
|   |           | CS/C  | 31.83      | 14.4            |
|   |           | CS/D  | 29.02      | 14.4            |
| <b>LOCA 2B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @155.4°F  | RHR/A | 22.64      | 14.4            |
|   |           | RHR/B | 23.75      | 14.4            |
|   |           | RHR/C | 20.91      | 14.4            |
|   |           | RHR/D | 25.17      | 14.4            |
|   |           | CS/A  | 20.80      | 14.4            |
|   |           | CS/B  | 24.58      | 14.4            |
|   |           | CS/C  | 24.24      | 14.4            |
|   |           | CS/D  | 21.43      | 14.4            |
| <b>LOCA 3A</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @155.4°F  | RHR/A | 35.58      | 14.4            |
|   |           | RHR/C | 35.03      | 14.4            |
|   |           | CS/A  | 31.48      | 14.4            |
|   |           | CS/C  | 33.46      | 14.4            |

|   |         |                           |                          |
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| LOCA Pump/Flow Combination  | Pool Temp | Pump  | NPSHa (ft) | Pressure (psia) |
|---|-----------|-------|------------|-----------------|
| <b>LOCA 3B</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each  | @172°F    | RHR/A | 30.90      | 14.4            |
|   |           | RHR/C | 30.35      | 14.4            |
|   |           | CS/A  | 26.80      | 14.4            |
|   |           | CS/C  | 28.78      | 14.4            |
| <b>LOCA 3C</b><br>CS Pumps A/C-3125gpm each,<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each | @187.3°F  | RHR/A | 24.95      | 14.4            |
|   |           | RHR/C | 24.40      | 14.4            |
|   |           | CS/A  | 20.85      | 14.4            |
|   |           | CS/C  | 22.83      | 14.4            |
| <b>LOCA 4A</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 each      | @155.4°F  | RHR/A | 35.59      | 14.4            |
|   |           | RHR/C | 35.04      | 14.4            |
|   |           | CS/B  | 33.35      | 14.4            |
|   |           | CS/D  | 31.54      | 14.4            |
| <b>LOCA 4B</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each  | @172°F    | RHR/A | 30.91      | 14.4            |
|   |           | RHR/C | 30.36      | 14.4            |
|   |           | CS/B  | 28.67      | 14.4            |
|   |           | CS/D  | 26.86      | 14.4            |
| <b>LOCA 4C</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each  | @187.3°F  | RHR/A | 24.96      | 14.4            |
|   |           | RHR/C | 24.41      | 14.4            |
|   |           | CS/B  | 22.72      | 14.4            |
|   |           | CS/D  | 20.92      | 14.4            |
| <b>LOCA 5A</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each  | @155.4°F  | RHR/B | 35.30      | 14.4            |
|   |           | RHR/D | 35.85      | 14.4            |
|   |           | CS/B  | 33.33      | 14.4            |
|   |           | CS/D  | 31.52      | 14.4            |
| <b>LOCA 5B</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each  | @172°F    | RHR/B | 30.62      | 14.4            |
|   |           | RHR/D | 31.16      | 14.4            |
|   |           | CS/B  | 28.65      | 14.4            |
|   |           | CS/D  | 26.84      | 14.4            |
| <b>LOCA 5C</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each  | @187.3°F  | RHR/B | 24.67      | 14.4            |
|   |           | RHR/D | 25.22      | 14.4            |
|   |           | CS/B  | 22.70      | 14.4            |
|   |           | CS/D  | 20.89      | 14.4            |
| <b>LOCA 6A</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each  | @155.4°F  | RHR/B | 35.28      | 14.4            |
|   |           | RHR/D | 35.82      | 14.4            |
|   |           | CS/A  | 31.52      | 14.4            |
|   |           | CS/C  | 33.50      | 14.4            |

|   |         |                           |                          |
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| LOCA Pump/Flow Combination   | Pool Temp | Pump  | NPSHa (ft) | Pressure (psia) |
|--|-----------|-------|------------|-----------------|
| <b>LOCA 6B</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @172°F    | RHR/B | 30.60      | 14.4            |
|  |           | RHR/D | 31.14      | 14.4            |
|  |           | CS/A  | 26.84      | 14.4            |
|  |           | CS/C  | 28.82      | 14.4            |
| <b>LOCA 6C</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @187.3°F  | RHR/B | 24.65      | 14.4            |
|  |           | RHR/D | 25.19      | 14.4            |
|  |           | CS/A  | 20.89      | 14.4            |
|  |           | CS/C  | 22.87      | 14.4            |
| <b>LOCA 7</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C/B/D Pumps-6500 gpm each                | @166°F    | RHR/A | 30.45      | 14.4            |
|  |           | RHR/B | 30.45      | 14.4            |
|  |           | RHR/C | 29.91      | 14.4            |
|  |           | RHR/D | 31.00      | 14.4            |
|  |           | CS/A  | 27.26      | 14.4            |
|  |           | CS/C  | 29.24      | 14.4            |

| ATWS Pump/Flow Combination  | Pool Temp. | Pump  | NPSHa (ft) | Pressure (psia) |
|---|------------|-------|------------|-----------------|
| <b>ATWS</b><br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @177°F     | RHR/A | 28.75      | 14.4            |
|   |            | RHR/B | 28.77      | 14.4            |
|   |            | RHR/C | 28.20      | 14.4            |
|   |            | RHR/D | 29.32      | 14.4            |
| <b>ATWS</b><br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @192°F     | RHR/A | 22.35      | 14.4            |
|   |            | RHR/B | 22.37      | 14.4            |
|   |            | RHR/C | 21.80      | 14.4            |
|   |            | RHR/D | 22.91      | 14.4            |
| <b>ATWS</b><br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @211°F     | RHR/A | 11.21      | 14.4            |
|   |            | RHR/B | 11.23      | 14.4            |
|   |            | RHR/C | 10.66      | 14.4            |
|   |            | RHR/D | 11.77      | 14.4            |

|   |         |                           |                          |
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| Appendix R Pump/Flow Combination        | Pool Temp. | Pump | NPSHa (ft) | Pressure (psia) |
|---|------------|------|------------|-----------------|
| App-R A<br>RHR Pump A-7200 gpm          | @191°F     | A    | 24.45      | 14.4            |
| App-R B<br>RHR Pump B-7200 gpm          | @191°F     | B    | 24.43      | 14.4            |
| App-R C<br>RHR Pump C-7200 gpm          | @191°F     | C    | 24.36      | 14.4            |
| App-R D<br>RHR Pump D-7200 gpm          | @191°F     | D    | 24.52      | 14.4            |
| App-R A<br>RHR Pump A-7200 gpm          | @223°F     | A    | 4.49       | 14.75           |
| App-R B<br>RHR Pump B-7200 gpm          | @223°F     | B    | 4.46       | 14.75           |
| App-R C<br>RHR Pump C-7200 gpm          | @223°F     | C    | 4.39       | 14.75           |
| App-R D<br>RHR Pump D-7200 gpm          | @223°F     | D    | 4.55       | 14.75           |
| SBO Pump/Flow Combination               | Pool Temp  | Pump | NPSHa (ft) | Pressure (psia) |
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @157°F     | A    | 35.46      | 14.4            |
|   |            | C    | 34.91      | 14.4            |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @157°F     | B    | 35.15      | 14.4            |
|   |            | D    | 35.69      | 14.4            |
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @200°F     | A    | 18.78      | 14.4            |
|   |            | C    | 18.23      | 14.4            |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @200°F     | B    | 18.46      | 14.4            |
|   |            | D    | 19.01      | 14.4            |

## CALCULATION SHEET

Table 11.1: Unit 2 NPSH Calculations Case 1A 95F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 95       | 0.816362332           | 0.016115213               | 2.320590685                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | -0.1760         | 31.11      |
| 2PUMPB   | -0.6210         | 30.08      |
| 3PUMPC   | -0.7950         | 29.68      |
| 4PUMPD   | 0.1120          | 31.78      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | -1.3510         | 28.39      |
| 2CSPUMPB | 0.2780          | 32.17      |
| 3CSPUMPC | 0.1350          | 31.84      |
| 4CSPUMPD | -1.0770         | 29.02      |



## CALCULATION SHEET

Table 11.2: Unit 2 NPSH Calculations Case 1B 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309               | 2.357180486                            | Pool Press. (psia) | 14.4 |
|          |                       |                           |  |                    |      |
| RHR      | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1PUMPA   | -0.1690               | 23.53                     |  |                    |      |
| 2PUMPB   | -0.6070               | 22.49                     |  |                    |      |
| 3PUMPC   | -0.7790               | 22.09                     |  |                    |      |
| 4PUMPD   | 0.1150                | 24.20                     |  |                    |      |
| CS       | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1CSPUMPA | -1.3270               | 20.80                     |  |                    |      |
| 2CSPUMPB | 0.2770                | 24.58                     |  |                    |      |
| 3CSPUMPC | 0.1360                | 24.25                     |  |                    |      |
| 4CSPUMPD | -1.0580               | 21.43                     |  |                    |      |

## CALCULATION SHEET

Table 11.3: Unit 2 NPSH Calculations Case 2A 95F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 95       | 0.816362332           | 0.016115213               | 2.320590685                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | -0.5590         | 30.22      |
| 2PUMPB   | -0.0810         | 31.33      |
| 3PUMPC   | -1.3020         | 28.50      |
| 4PUMPD   | 0.5290          | 32.75      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | -1.3520         | 28.38      |
| 2CSPUMPB | 0.2760          | 32.16      |
| 3CSPUMPC | 0.1340          | 31.83      |
| 4CSPUMPD | -1.0780         | 29.02      |

## CALCULATION SHEET

Table 11.4: Unit 2 NPSH Calculations Case 2B 95F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309               | 2.357180486                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | -0.5470         | 22.64      |
| 2PUMPB   | -0.0760         | 23.75      |
| 3PUMPC   | -1.2780         | 20.91      |
| 4PUMPD   | 0.5260          | 25.17      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | -1.3280         | 20.80      |
| 2CSPUMPB | 0.2760          | 24.58      |
| 3CSPUMPC | 0.1350          | 24.24      |
| 4CSPUMPD | -1.0590         | 21.43      |

## CALCULATION SHEET

Table 11.5: Unit 2 NPSH Calculations Case 3A 155.4F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft <sup>3</sup> /lb) | Conversion Factor<br>psia to feet of head |                    |      |
|----------|--------------------------|---|---|--------------------|------|
| 60       | 0.256389624              | 0.016034992                               | 2.309038802                               |                    |      |
| 155.4    | 4.249928506              | 0.016369309                               | 2.357180486                               | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.9440          | 35.58      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.7100          | 35.03      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.2040          | 31.48      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 4.0430          | 33.46      |
| 4CSPUMPD |                 |            |

## CALCULATION SHEET

Table 11.6: Unit 2 NPSH Calculations Case 3B 172F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 172      | 6.281035863           | 0.016460423                            | 2.370300872                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.9170          | 30.90      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.6840          | 30.35      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.1870          | 26.80      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 4.0210          | 28.78      |
| 4CSPUMPD |                 |            |

## CALCULATION SHEET

Table 11.7: Unit 2 NPSH Calculations Case 3C 187.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 187.3    | 8.822339971           | 0.01655191                | 2.383475045                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.8890          | 24.95      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.6580          | 24.40      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.1690          | 20.85      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 3.9990          | 22.83      |
| 4CSPUMPD |                 |            |

## CALCULATION SHEET

Table 11.8: Unit 2 NPSH Calculations Case 4A 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309                            | 2.357180486                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.9500          | 35.59      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.7170          | 35.04      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.9980          | 33.35      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.232           | 31.54      |

## CALCULATION SHEET

Table 11.9: Unit 2 NPSH Calculations Case 4B 172F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 172      | 6.281035863           | 0.016460423                            | 2.370300872                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.9230          | 30.91      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.6900          | 30.36      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.9770          | 28.67      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.215           | 26.86      |



## CALCULATION SHEET

Table 11.10: Unit 2 NPSH Calculations Case 4C 187.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 187.3    | 8.822339971           | 0.01655191                | 2.383475045                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.8960          | 24.96      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.6650          | 24.41      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.9550          | 22.72      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.198           | 20.92      |

## CALCULATION SHEET

Table 11.11: Unit 2 NPSH Calculations Case 5A 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309               | 2.357180486                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.8270          | 35.30      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.0570          | 35.85      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.9880          | 33.33      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.223           | 31.52      |

Table 11.12: Unit 2 NPSH Calculations Case 5B 172F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 172      | 6.281035863           | 0.016460423                            | 2.370300872                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.8000          | 30.62      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.0290          | 31.16      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.9670          | 28.65      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.206           | 26.84      |

Table 11.13: Unit 2 NPSH Calculations Case 5C 187.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 187.3    | 8.822339971           | 0.01655191                             | 2.383475045                            | Pool Press. (psia) | 14.4 |

| CS       | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.7740          | 24.67      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.0020          | 25.22      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.9460          | 22.70      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.188           | 20.89      |

## CALCULATION SHEET

Table 11.14: Unit 2 NPSH Calculations Case 6A 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309                            | 2.357180486                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.8170          | 35.28      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.0480          | 35.82      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.2220          | 31.52      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 4.0620          | 33.50      |
| 4CSPUMPD |                 |            |

## CALCULATION SHEET

Table 11.15: Unit 2 NPSH Calculations Case 6B 172F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 172      | 6.281035863           | 0.016460423                            | 2.370300872                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.7910          | 30.60      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.0200          | 31.14      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.205           | 26.84      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 4.04            | 28.82      |
| 4CSPUMPD |                 |            |

## CALCULATION SHEET

Table 11.16: Unit 2 NPSH Calculations Case 6C 187.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|--|--|-------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                         |
| 187.3    | 8.822339971           | 0.01655191                             | 2.383475045                            | Pool Press. (psia) 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.7650          | 24.65      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 4.9930          | 25.19      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.1880          | 20.89      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 4.0180          | 22.87      |
| 4CSPUMPD |                 |            |

## CALCULATION SHEET

Table 11.17: Unit 2 NPSH Calculations Case 7 166F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 166      | 5.468938413           | 0.016426501                            | 2.365416198                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 3.9440          | 30.45      |
| 2PUMPB   | 3.9430          | 30.45      |
| 3PUMPC   | 3.7120          | 29.91      |
| 4PUMPD   | 4.1730          | 31.00      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 2.5940          | 27.26      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 3.4310          | 29.24      |
| 4CSPUMPD |                 |            |



## CALCULATION SHEET

Table 11.18: Unit 2 NPSH Calculations ATWS 214.6F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft <sup>3</sup> /lb) | Conversion Factor<br>psia to feet of head |                    |      |
|----------|--------------------------|---|---|--------------------|------|
| 60       | 0.256389624              | 0.016034992                               | 2.309038802                               |                    |      |
| 177      | 7.033092437              | 0.016489536                               | 2.374493143                               | Pool Press. (psia) | 14.4 |

| RHR   | Pressure (psig) | NPSHa (ft) |
|-------|-----------------|------------|
| PUMPA | 4.7420          | 28.75      |
| PUMPB | 4.7500          | 28.77      |
| PUMPC | 4.5100          | 28.20      |
| PUMPD | 4.9790          | 29.32      |

**Table 11.19: Unit 2 NPSH Calculations ATWS 214.6F**

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 192      | 9.757027807           | 0.01658144                             | 2.387727412                            | Pool Press. (psia) | 14.4 |

| RHR   | Pressure (psig) | NPSHa (ft) |
|-------|-----------------|------------|
| PUMPA | 4.7160          | 22.35      |
| PUMPB | 4.7240          | 22.37      |
| PUMPC | 4.4850          | 21.80      |
| PUMPD | 4.9510          | 22.91      |

## CALCULATION SHEET

Table 11.20: Unit 2 NPSH Calculations ATWS 214.6F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 211      | 14.42019545           | 0.016707611                            | 2.405895953                            | Pool Press. (psia) | 14.4 |

| RHR   | Pressure (psig) | NPSHa (ft) |
|-------|-----------------|------------|
| PUMPA | 4.6810          | 11.21      |
| PUMPB | 4.6880          | 11.23      |
| PUMPC | 4.4520          | 10.66      |
| PUMPD | 4.9140          | 11.77      |

## CALCULATION SHEET

Table 11.21: Unit 2 NPSH Calculations App-R A 191F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 191      | 9.551535023           | 0.016575101                            | 2.386814603                            | Pool Press. (psia) | 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 5.3970          | 24.45      |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD |                 |            |

Table 11.22: Unit 2 NPSH Calculations App-R B 191F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 191      | 9.551535023           | 0.016575101               | 2.386814603                            | Pool Press. (psia) 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB | 5.3860          | 24.43      |
| 3PUMPC |                 |            |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 11.23: Unit 2 NPSH Calculations App-R C 227F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft <sup>3</sup> /lb) | Conversion Factor<br>psia to feet of head | Pool Press. (psia) 14.4 |
|----------|--------------------------|---|---|-------------------------|
| 60       | 0.256389624              | 0.016034992                               | 2.309038802                               |                         |
| 191      | 9.551535023              | 0.016575101                               | 2.386814603                               |                         |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC | 5.3560          | 24.36      |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 11.24: Unit 2 NPSH Calculations App-R D 191F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|--|--|-------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                         |
| 191      | 9.551535023           | 0.016575101                            | 2.386814603                            | Pool Press. (psia) 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD | 5.4240          | 24.52      |

## CALCULATION SHEET

Table 11.25: Unit 2 NPSH Calculations App-R A 223F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft <sup>3</sup> /lb) | Conversion Factor<br>psia to feet of head |                    |       |
|----------|--------------------------|---|---|--------------------|-------|
| 60       | 0.256389624              | 0.016034992                               | 2.309038802                               |                    |       |
| 223      | 18.22056282              | 0.016792916                               | 2.418179953                               | Pool Press. (psia) | 14.75 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 5.3270          | 4.49       |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD |                 |            |



## CALCULATION SHEET

Table 11.26: Unit 2 NPSH Calculations App-R B 227F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft³/lb) | Conversion Factor<br>psia to feet of head | Pool Press. (psia) 14.75 |
|----------|--------------------------|------------------------------|---|--------------------------|
| 60       | 0.256389624              | 0.016034992                  | 2.309038802                               |                          |
| 223      | 18.22056282              | 0.016792916                  | 2.418179953                               |                          |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB | 5.3160          | 4.46       |
| 3PUMPC |                 |            |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 11.27: Unit 2 NPSH Calculations App-R C 227F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                          |
|----------|-----------------------|---------------------------|--|--------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                          |
| 223      | 18.22056282           | 0.016792916               | 2.418179953                            | Pool Press. (psia) 14.75 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC | 5.2860          | 4.39       |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 11.28: Unit 2 NPSH Calculations App-R D 227F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                          |
|----------|-----------------------|--|--|--------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                          |
| 223      | 18.22056282           | 0.016792916                            | 2.418179953                            | Pool Press. (psia) 14.75 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD | 5.3540          | 4.55       |

## CALCULATION SHEET

Table 11.29: Unit 2 NPSH Calculations SBO A-C 157F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head | Pool Press. (psia) 14.4 |
|----------|-----------------------|--|--|-------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                         |
| 157      | 4.417636119           | 0.016377716                            | 2.358391077                            |                         |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 5.0550          | 35.46      |
| 2PUMPB |                 |            |
| 3PUMPC | 4.8210          | 34.91      |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 11.30: Unit 2 NPSH Calculations SBO B-D 157F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head | Pool Press. (psia) 14.4 |
|----------|-----------------------|--|--|-------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                         |
| 157      | 4.417636119           | 0.016377716                            | 2.358391077                            |                         |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB | 4.9210          | 35.15      |
| 3PUMPC |                 |            |
| 4PUMPD | 5.1520          | 35.69      |

**Table 11.31: Unit 2 NPSH Calculations SBO A-C 200F**

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|--|--|-------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                         |
| 200      | 11.53763273           | 0.016633238                            | 2.395186284                            | Pool Press. (psia) 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 4.9770          | 18.78      |
| 2PUMPB |                 |            |
| 3PUMPC | 4.7470          | 18.23      |
| 4PUMPD |                 |            |

**Table 11.32: Unit 2 NPSH Calculations SBO B-D 200F**

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head | Pool Press. (psia) 14.4 |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 200      | 11.53763273           | 0.016633238               | 2.395186284                            |                         |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB | 4.8460          | 18.46      |
| 3PUMPC |                 |            |
| 4PUMPD | 5.0730          | 19.01      |

|   |         |                           |                          |
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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

**TABLE 12**  
**Unit 2**

| LOCA Pump/Flow Combination  | Pool Temp | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|---|-----------|-------------|-------------|----------------------|
| <b>LOCA 1A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @95°F     | Strainer 1  | 15634.5     | 3.022                |
|   |           | Strainer 23 | 14713.8     | 2.663                |
|   |           | Strainer 27 | 15123       | 2.864                |
|   |           | Strainer 5  | 14726.7     | 2.670                |
| <b>LOCA 1B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @155.4°F  | Strainer 1  | 15392       | 2.975                |
|   |           | Strainer 23 | 14486.6     | 2.623                |
|   |           | Strainer 27 | 14888       | 2.820                |
|   |           | Strainer 5  | 14499.4     | 2.630                |
| <b>LOCA 2A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @95°F     | Strainer 1  | 15646.1     | 3.024                |
|   |           | Strainer 23 | 14710.7     | 2.661                |
|   |           | Strainer 27 | 15114.8     | 2.861                |
|   |           | Strainer 5  | 14726.5     | 2.669                |
| <b>LOCA 2B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @155.4°F  | Strainer 1  | 15403.2     | 2.978                |
|   |           | Strainer 23 | 14483.7     | 2.621                |
|   |           | Strainer 27 | 14880       | 2.817                |
|   |           | Strainer 5  | 14499.1     | 2.630                |
| <b>LOCA 3A</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @155.4°F  | Strainer 1  | 4906.49     | 0.173                |
|   |           | Strainer 23 | 4554.8      | 0.107                |
|   |           | Strainer 27 | 4642.08     | 0.123                |
|   |           | Strainer 5  | 4752.64     | 0.143                |
| <b>LOCA 3B</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @172°F    | Strainer 1  | 4878.95     | 0.172                |
|   |           | Strainer 23 | 4530.07     | 0.107                |
|   |           | Strainer 27 | 4616.77     | 0.122                |
|   |           | Strainer 5  | 4726.21     | 0.142                |
| <b>LOCA 3C</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @187.3°F  | Strainer 1  | 4851.52     | 0.171                |
|   |           | Strainer 23 | 4505.26     | 0.106                |
|   |           | Strainer 27 | 4591.39     | 0.122                |
|   |           | Strainer 5  | 4699.83     | 0.142                |
| <b>LOCA 4A</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 each          | @155.4°F  | Strainer 1  | 4834.86     | 0.159                |
|   |           | Strainer 23 | 4649.62     | 0.124                |
|   |           | Strainer 27 | 4730.9      | 0.139                |
|   |           | Strainer 5  | 4640.62     | 0.123                |
| <b>LOCA 4B</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each   | @172°F    | Strainer 1  | 4807.85     | 0.158                |
|   |           | Strainer 23 | 4624.13     | 0.124                |
|   |           | Strainer 27 | 4704.94     | 0.138                |



|   |         |                           |                          |
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| LOCA Pump/Flow Combination  | Pool Temp | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|---|-----------|-------------|-------------|----------------------|
| RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each   |           | Strainer 5  | 4615.09     | 0.122                |
| LOCA 4C<br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each | @187.3°F  | Strainer 1  | 4780.92     | 0.157                |
|   |           | Strainer 23 | 4598.6      | 0.123                |
|   |           | Strainer 27 | 4678.94     | 0.138                |
|   |           | Strainer 5  | 4589.54     | 0.121                |
| LOCA 5A<br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @155.4°F  | Strainer 1  | 4641.86     | 0.123                |
|   |           | Strainer 23 | 4785.4      | 0.149                |
|   |           | Strainer 27 | 4901.46     | 0.172                |
|   |           | Strainer 5  | 4527.29     | 0.103                |
| LOCA 5B<br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @172°F    | Strainer 1  | 4616.51     | 0.122                |
|   |           | Strainer 23 | 4758.78     | 0.149                |
|   |           | Strainer 27 | 4873.98     | 0.171                |
|   |           | Strainer 5  | 4502.73     | 0.102                |
| LOCA 5C<br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @187.3°F  | Strainer 1  | 4591.11     | 0.122                |
|   |           | Strainer 23 | 4732.21     | 0.148                |
|   |           | Strainer 27 | 4846.6      | 0.170                |
|   |           | Strainer 5  | 4478.08     | 0.102                |
| LOCA 6A<br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @155.4°F  | Strainer 1  | 4723.27     | 0.138                |
|   |           | Strainer 23 | 4678.05     | 0.129                |
|   |           | Strainer 27 | 4823.48     | 0.157                |
|   |           | Strainer 5  | 4631.2      | 0.121                |
| LOCA 6B<br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @172°F    | Strainer 1  | 4697.33     | 0.137                |
|   |           | Strainer 23 | 4652.29     | 0.129                |
|   |           | Strainer 27 | 4796.54     | 0.156                |
|   |           | Strainer 5  | 4605.83     | 0.120                |
| LOCA 6C<br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @187.3°F  | Strainer 1  | 4671.37     | 0.136                |
|   |           | Strainer 23 | 4626.52     | 0.128                |
|   |           | Strainer 27 | 4769.68     | 0.155                |
|   |           | Strainer 5  | 4580.42     | 0.119                |
| LOCA 7<br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C/B/D Pumps-6500 gpm each                | @166°F    | Strainer 1  | 8281.33     | 0.875                |
|   |           | Strainer 23 | 7547.79     | 0.706                |
|   |           | Strainer 27 | 7931.33     | 0.789                |
|   |           | Strainer 5  | 7721.55     | 0.743                |

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| ATWS Pump/Flow Combination   | Pool Temp. | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|--|------------|-------------|-------------|----------------------|
| ATWS<br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @177°F     | Strainer 1  | 8872.92     | 0.179                |
|  |            | Strainer 23 | 4108.5      | 0.038                |
|  |            | Strainer 27 | 7463.75     | 0.127                |
|  |            | Strainer 5  | 4838.83     | 0.053                |
| ATWS<br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @192°F     | Strainer 1  | 8822.57     | 0.178                |
|  |            | Strainer 23 | 4087.11     | 0.038                |
|  |            | Strainer 27 | 7420.69     | 0.126                |
|  |            | Strainer 5  | 4813.63     | 0.053                |
| ATWS<br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @211°F     | Strainer 1  | 8753.88     | 0.176                |
|  |            | Strainer 23 | 4057.37     | 0.038                |
|  |            | Strainer 27 | 7362.16     | 0.125                |
|  |            | Strainer 5  | 4778.59     | 0.053                |
| Appendix R Pump/Flow Combination                                       | Pool Temp. | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
| App-R A<br>RHR Pump A-7200 gpm   | @191°F     | Strainer 1  | 2622.36     | 0.016                |
|  |            | Strainer 23 | 1106.32     | 0.003                |
|  |            | Strainer 27 | 1901.84     | 0.008                |
|  |            | Strainer 5  | 1334.48     | 0.004                |
| App-R B<br>RHR Pump B-7200 gpm   | @191°F     | Strainer 1  | 2044.51     | 0.009                |
|  |            | Strainer 23 | 1323.98     | 0.004                |
|  |            | Strainer 27 | 2472.33     | 0.014                |
|  |            | Strainer 5  | 1124.17     | 0.003                |
| App-R C<br>RHR Pump C-7200 gpm   | @191°F     | Strainer 1  | 2622.36     | 0.016                |
|  |            | Strainer 23 | 1106.32     | 0.003                |
|  |            | Strainer 27 | 1901.84     | 0.008                |
|  |            | Strainer 5  | 1334.48     | 0.004                |
| App-R D<br>RHR Pump D-7200 gpm   | @191°F     | Strainer 1  | 2044.51     | 0.009                |
|  |            | Strainer 23 | 1323.98     | 0.004                |
|  |            | Strainer 27 | 2472.33     | 0.014                |
|  |            | Strainer 5  | 1124.17     | 0.003                |

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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

| Appendix R Pump/Flow Combination | Pool Temp. | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|----------------------------------|------------|-------------|-------------|----------------------|
| App-R A<br>RHR Pump A-7200 gpm   | @223°F     | Strainer 1  | 2586.27     | 0.016                |
|                                  |            | Strainer 23 | 1093.46     | 0.003                |
|                                  |            | Strainer 27 | 1876.84     | 0.008                |
|                                  |            | Strainer 5  | 1318.44     | 0.004                |
| App-R B<br>RHR Pump B-7200 gpm   | @223°F     | Strainer 1  | 2017.98     | 0.009                |
|                                  |            | Strainer 23 | 1308.36     | 0.004                |
|                                  |            | Strainer 27 | 2437.7      | 0.014                |
|                                  |            | Strainer 5  | 1110.96     | 0.003                |
| App-R C<br>RHR Pump C-7200 gpm   | @223°F     | Strainer 1  | 2586.27     | 0.016                |
|                                  |            | Strainer 23 | 1093.46     | 0.003                |
|                                  |            | Strainer 27 | 1876.84     | 0.008                |
|                                  |            | Strainer 5  | 1318.44     | 0.004                |
| App-R D<br>RHR Pump D-7200 gpm   | @223°F     | Strainer 1  | 2017.98     | 0.009                |
|                                  |            | Strainer 23 | 1308.36     | 0.004                |
|                                  |            | Strainer 27 | 2437.7      | 0.014                |
|                                  |            | Strainer 5  | 1110.96     | 0.003                |

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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

| SBO Pump/Flow Combination               | Pool Temp | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|---|-----------|-------------|-------------|----------------------|
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @157°F    | Strainer 1  | 4784.2      | 0.052                |
|   |           | Strainer 23 | 2026.92     | 0.009                |
|   |           | Strainer 27 | 3473.87     | 0.027                |
|   |           | Strainer 5  | 2443.02     | 0.014                |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @157°F    | Strainer 1  | 3735.72     | 0.032                |
|   |           | Strainer 23 | 2424.85     | 0.013                |
|   |           | Strainer 27 | 4508.33     | 0.046                |
|   |           | Strainer 5  | 2059.1      | 0.009                |
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @200°F    | Strainer 1  | 4705.39     | 0.051                |
|   |           | Strainer 23 | 1999.14     | 0.009                |
|   |           | Strainer 27 | 3419.22     | 0.027                |
|   |           | Strainer 5  | 2408.25     | 0.013                |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @200°F    | Strainer 1  | 3677.74     | 0.031                |
|   |           | Strainer 23 | 2391.04     | 0.013                |
|   |           | Strainer 27 | 4432.71     | 0.045                |
|   |           | Strainer 5  | 2030.51     | 0.009                |

|   |         |                    |            |
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| <b>CALCULATION SHEET</b>                                  |         |                    |            |

**TABLE 13**  
**Unit 3**

| LOCA Pump/Flow Combination  | Pool Temp.                | Pump  | NPSHa<br>(ft) | Pressure<br>(psia) |
|---|---------------------------|-------|---------------|--------------------|
| <b>LOCA 1A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @95°F                     | RHR/A | 31.07         | 14.4               |
|   |                           | RHR/B | 30.05         | 14.4               |
|   |                           | RHR/C | 29.52         | 14.4               |
|   |                           | RHR/D | 31.75         | 14.4               |
|   |                           | CS/A  | 28.42         | 14.4               |
|   |                           | CS/B  | 32.18         | 14.4               |
|   |                           | CS/C  | 31.87         | 14.4               |
|   |                           | CS/D  | 29.04         | 14.4               |
| <b>LOCA 1B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @155.4°F                  | RHR/A | 23.49         | 14.4               |
|   |                           | RHR/B | 22.46         | 14.4               |
|   |                           | RHR/C | 21.94         | 14.4               |
|   |                           | RHR/D | 24.17         | 14.4               |
|   |                           | CS/A  | 20.83         | 14.4               |
|   |                           | CS/B  | 24.59         | 14.4               |
|   |                           | CS/C  | 24.28         | 14.4               |
|   |                           | CS/D  | 21.45         | 14.4               |
| <b>LOCA 2A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @95°F                     | RHR/A | 30.18         | 14.4               |
|   |                           | RHR/B | 31.30         | 14.4               |
|   |                           | RHR/C | 28.32         | 14.4               |
|   |                           | RHR/D | 32.72         | 14.4               |
|   |                           | CS/A  | 28.42         | 14.4               |
|   |                           | CS/B  | 32.18         | 14.4               |
|   |                           | CS/C  | 31.86         | 14.4               |
|   |                           | CS/D  | 29.03         | 14.4               |
| <b>LOCA 2B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @155.4°F                  | RHR/A | 22.59         | 14.4               |
|   |                           | RHR/B | 23.72         | 14.4               |
|   |                           | RHR/C | 20.73         | 14.4               |
|   |                           | RHR/D | 25.14         | 14.4               |
|   |                           | CS/A  | 20.83         | 14.4               |
|   |                           | CS/B  | 24.59         | 14.4               |
|   |                           | CS/C  | 24.27         | 14.4               |
|   |                           | CS/D  | 21.44         | 14.4               |
| <b>LOCA 3A</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @155.4°F                  | RHR/A | 35.57         | 14.4               |
|   |                           | RHR/C | 34.98         | 14.4               |
|   |                           | CS/A  | 31.49         | 14.4               |
|   |                           | CS/C  | 33.46         | 14.4               |
| <b>LOCA 3B</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @172°F<br><br>NPSHa=NPSHr | RHR/A | 30.89         | 14.4               |
|   |                           | RHR/C | 30.30         | 14.4               |
|   |                           | CS/A  | 26.81         | 14.4               |
|   |                           | CS/C  | 28.78         | 14.4               |

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| LOCA Pump/Flow Combination   | Pool Temp.                | Pump  | NPSHa (ft) | Pressure (psia) |
|--|---------------------------|-------|------------|-----------------|
| <b>LOCA 3C</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each | @187.3°F                  | RHR/A | 24.94      | 14.4            |
|  |                           | RHR/C | 24.35      | 14.4            |
|  |                           | CS/A  | 20.86      | 14.4            |
|  |                           | CS/C  | 22.84      | 14.4            |
| <b>LOCA 4A</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each | @155.4°F                  | RHR/A | 35.59      | 14.4            |
|  |                           | RHR/C | 35.00      | 14.4            |
|  |                           | CS/B  | 33.34      | 14.4            |
|  |                           | CS/D  | 31.54      | 14.4            |
| <b>LOCA 4B</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each | @172°F<br><br>NPSHa=NPSHr | RHR/A | 30.91      | 14.4            |
|  |                           | RHR/C | 30.32      | 14.4            |
|  |                           | CS/B  | 28.67      | 14.4            |
|  |                           | CS/D  | 26.86      | 14.4            |
| <b>LOCA 4C</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each | @187.3°F                  | RHR/A | 24.96      | 14.4            |
|  |                           | RHR/C | 24.37      | 14.4            |
|  |                           | CS/B  | 22.72      | 14.4            |
|  |                           | CS/D  | 20.91      | 14.4            |
| <b>LOCA 5A</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @155.4°F                  | RHR/B | 35.30      | 14.4            |
|  |                           | RHR/D | 35.84      | 14.4            |
|  |                           | CS/B  | 33.33      | 14.4            |
|  |                           | CS/D  | 31.52      | 14.4            |
| <b>LOCA 5B</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @172°F<br><br>NPSHa=NPSHr | RHR/B | 30.61      | 14.4            |
|  |                           | RHR/D | 31.16      | 14.4            |
|  |                           | CS/B  | 28.65      | 14.4            |
|  |                           | CS/D  | 26.84      | 14.4            |
| <b>LOCA 5C</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @187.3°F                  | RHR/B | 24.67      | 14.4            |
|  |                           | RHR/D | 25.21      | 14.4            |
|  |                           | CS/B  | 22.70      | 14.4            |
|  |                           | CS/D  | 20.89      | 14.4            |
| <b>LOCA 6A</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @155.4°F                  | RHR/B | 35.28      | 14.4            |
|  |                           | RHR/D | 35.82      | 14.4            |
|  |                           | CS/A  | 31.53      | 14.4            |
|  |                           | CS/C  | 33.51      | 14.4            |
| <b>LOCA 6B</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @172°F<br><br>NPSHa=NPSHr | RHR/B | 30.59      | 14.4            |
|  |                           | RHR/D | 31.14      | 14.4            |
|  |                           | CS/A  | 26.85      | 14.4            |
|  |                           | CS/C  | 28.83      | 14.4            |

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| LOCA Pump/Flow Combination   | Pool Temp. | Pump  | NPSHa (ft) | Pressure (psia) |
|--|------------|-------|------------|-----------------|
| <b>LOCA 6C</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @187.3°F   | RHR/B | 24.64      | 14.4            |
|  |            | RHR/D | 25.19      | 14.4            |
|  |            | CS/A  | 20.90      | 14.4            |
|  |            | CS/C  | 22.88      | 14.4            |
| <b>LOCA 7</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C/B/D Pumps-6500 gpm each                | @166°F     | RHR/A | 30.42      | 14.4            |
|  |            | RHR/B | 30.43      | 14.4            |
|  |            | RHR/C | 29.83      | 14.4            |
|  |            | RHR/D | 30.97      | 14.4            |
|  |            | CS/A  | 27.28      | 14.4            |
|  |            | CS/C  | 29.26      | 14.4            |

| ATWS Pump/Flow Combination  | Pool Temp | Pump  | NPSHa (ft) | Pressure (psia) |
|---|-----------|-------|------------|-----------------|
| <b>ATWS</b><br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @177°F    | RHR/A | 28.72      | 14.4            |
|   |           | RHR/B | 28.75      | 14.4            |
|   |           | RHR/C | 28.13      | 14.4            |
|   |           | RHR/D | 29.29      | 14.4            |
| <b>ATWS</b><br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @192°F    | RHR/A | 22.32      | 14.4            |
|   |           | RHR/B | 22.34      | 14.4            |
|   |           | RHR/C | 21.72      | 14.4            |
|   |           | RHR/D | 22.89      | 14.4            |
| <b>ATWS</b><br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @211°F    | RHR/A | 11.18      | 14.4            |
|   |           | RHR/B | 11.21      | 14.4            |
|   |           | RHR/C | 10.59      | 14.4            |
|   |           | RHR/D | 11.75      | 14.4            |

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| Appendix R Pump/Flow Combination        | Pool Temp | Pump | NPSHa (ft) | Pressure (psia) |
|---|-----------|------|------------|-----------------|
| App-R A<br>RHR Pump A-7200 gpm          | @191°F    | A    | 24.45      | 14.4            |
| App-R B<br>RHR Pump B-7200 gpm          | @191°F    | B    | 24.41      | 14.4            |
| App-R C<br>RHR Pump C-7200 gpm          | @191°F    | C    | 24.30      | 14.4            |
| App-R D<br>RHR Pump D-7200 gpm          | @191°F    | D    | 24.50      | 14.4            |
| App-R A<br>RHR Pump A-7200 gpm          | @223°F    | A    | 4.49       | 14.75           |
| App-R B<br>RHR Pump B-7200 gpm          | @223°F    | B    | 4.45       | 14.75           |
| App-R C<br>RHR Pump C-7200 gpm          | @223°F    | C    | 4.34       | 14.75           |
| App-R D<br>RHR Pump D-7200 gpm          | @223°F    | D    | 4.54       | 14.75           |
| SBO Pump/Flow Combination               | Pool Temp | Pump | NPSHa (ft) | Pressure (psia) |
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @157°F    | A    | 35.46      | 14.4            |
|   |           | C    | 34.86      | 14.4            |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @157°F    | B    | 35.10      | 14.4            |
|   |           | D    | 35.65      | 14.4            |
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @200°F    | A    | 18.77      | 14.4            |
|   |           | C    | 18.18      | 14.4            |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @200°F    | B    | 18.42      | 14.4            |
|   |           | D    | 18.96      | 14.4            |



Table 14.1: Unit 3 NPSH Calculations Case 1A 95F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 95       | 0.816362332           | 0.016115213               | 2.320590685                            | Pool Press. (psia) | 14.4 |
|          |                       |                           |  |                    |      |
| RHR      | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1PUMPA   | -0.194                | 31.07                     |  |                    |      |
| 2PUMPB   | -0.635                | 30.05                     |  |                    |      |
| 3PUMPC   | -0.861                | 29.52                     |  |                    |      |
| 4PUMPD   | 0.0983                | 31.75                     |  |                    |      |
| CS       | Pressure (psig)       | NPSHa (ft)                |  |                    |      |
| 1CSPUMPA | -1.338                | 28.42                     |  |                    |      |
| 2CSPUMPB | 0.2827                | 32.18                     |  |                    |      |
| 3CSPUMPC | 0.1479                | 31.87                     |  |                    |      |
| 4CSPUMPD | -1.0716               | 29.04                     |  |                    |      |

## CALCULATION SHEET

Table 14.2: Unit 3 NPSH Calculations Case 1B 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|--|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                    |      |
| 155.4    | 4.249928506           | 0.016369309                            | 2.357180486                            | Pool Press. (psia) | 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | -0.1866         | 23.49      |
| 2PUMPB   | -0.6197         | 22.46      |
| 3PUMPC   | -0.8437         | 21.94      |
| 4PUMPD   | 0.1031          | 24.17      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | -1.3136         | 20.83      |
| 2CSPUMPB | 0.2827          | 24.59      |
| 3CSPUMPC | 0.1494          | 24.28      |
| 4CSPUMPD | -1.052          | 21.45      |

## CALCULATION SHEET

Table 14.3: Unit 3 NPSH Calculations Case 2A 95F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head | Pool Press. (psia) 14.4 |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 95       | 0.816362332           | 0.016115213               | 2.320590685                            |                         |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | -0.5788         | 30.18      |
| 2PUMPB   | -0.0943         | 31.30      |
| 3PUMPC   | -1.3787         | 28.32      |
| 4PUMPD   | 0.5166          | 32.72      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | -1.338          | 28.42      |
| 2CSPUMPB | 0.2823          | 32.18      |
| 3CSPUMPC | 0.1476          | 31.86      |
| 4CSPUMPD | -1.072          | 29.03      |

**Table 14.4: Unit 3 NPSH Calculations Case 2B 155.4F**

| Temp(°F)   | Vapor Pressure (psia)  | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                          |
|------------|------------------------|--|--|--------------------------|
| 60         | 0.256389624            | 0.016034992                            | 2.309038802                            |                          |
| 155.4      | 4.249928506            | 0.016369309                            | 2.357180486                            | Pool Press. (psia) 14.40 |
|            |                        |  |  |                          |
| <b>RHR</b> | <b>Pressure (psig)</b> | <b>NPSHa (ft)</b>                      |  |                          |
| 1PUMPA     | -0.5654                | 22.59                                  |  |                          |
| 2PUMPB     | -0.0892                | 23.72                                  |  |                          |
| 3PUMPC     | -1.3536                | 20.73                                  |  |                          |
| 4PUMPD     | 0.5133                 | 25.14                                  |  |                          |
| <b>CS</b>  | <b>Pressure (psig)</b> | <b>NPSHa (ft)</b>                      |  |                          |
| 1CSPUMPA   | -1.3148                | 20.83                                  |  |                          |
| 2CSPUMPB   | 0.2815                 | 24.59                                  |  |                          |
| 3CSPUMPC   | 0.1482                 | 24.27                                  |  |                          |
| 4CSPUMPD   | -1.053                 | 21.44                                  |  |                          |

## CALCULATION SHEET

Table 14.5: Unit 3 NPSH Calculations Case 3A 155.4F

| Temp(°F)   | Vapor Pressure (psia)  | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                         |
|------------|------------------------|--|--|-------------------------|
| 60         | 0.256389624            | 0.016034992                            | 2.309038802                            |                         |
| 155.4      | 4.249928506            | 0.016369309                            | 2.357180486                            | Pool Press. (psia) 14.4 |
|            |                        |  |  |                         |
| <b>RHR</b> | <b>Pressure (psig)</b> | <b>NPSHa (ft)</b>                      |  |                         |
| 1PUMPA     | 4.942                  | 35.57                                  |  |                         |
| 2PUMPB     |                        |  |  |                         |
| 3PUMPC     | 4.6908                 | 34.98                                  |  |                         |
| 4PUMPD     |                        |  |  |                         |
| <b>CS</b>  | <b>Pressure (psig)</b> | <b>NPSHa (ft)</b>                      |  |                         |
| 1CSPUMPA   | 3.2072                 | 31.49                                  |  |                         |
| 2CSPUMPB   |                        |  |  |                         |
| 3CSPUMPC   | 4.0468                 | 33.46                                  |  |                         |
| 4CSPUMPD   |                        |  |  |                         |

## CALCULATION SHEET

Table 14.6: Unit 3 NPSH Calculations Case 3B 172F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft³/lb) | Conversion Factor<br>psia to feet of head | Pool Press. (psia) 14.4 |
|----------|--------------------------|------------------------------|---|-------------------------|
| 60       | 0.256389624              | 0.016034992                  | 2.309038802                               |                         |
| 172      | 6.281035863              | 0.016460423                  | 2.370300872                               |                         |
|          |                          |                              |   |                         |
| RHR      | Pressure (psig)          | NPSHa (ft)                   |   |                         |
| 1PUMPA   | 4.9151                   | 30.89                        |   |                         |
| 2PUMPB   |                          |                              |   |                         |
| 3PUMPC   | 4.665                    | 30.30                        |   |                         |
| 4PUMPD   |                          |                              |   |                         |
| CS       | Pressure (psig)          | NPSHa (ft)                   |   |                         |
| 1CSPUMPA | 3.19                     | 26.81                        |   |                         |
| 2CSPUMPB |                          |                              |   |                         |
| 3CSPUMPC | 4.0249                   | 28.78                        |   |                         |
| 4CSPUMPD |                          |                              |   |                         |

Table 14.7: Unit 3 NPSH Calculations Case 3C 187.3F

| Temp(°F)   | Vapor Pressure (psia)  | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                         |
|------------|------------------------|---------------------------|--|-------------------------|
| 60         | 0.256389624            | 0.016034992               | 2.309038802                            |                         |
| 187.3      | 8.822339971            | 0.01655191                | 2.383475045                            | Pool Press. (psia) 14.4 |
|            |                        |                           |  |                         |
| <b>RHR</b> | <b>Pressure (psig)</b> | <b>NPSHa (ft)</b>         |  |                         |
| 1PUMPA     | 4.888                  | 24.94                     |  |                         |
| 2PUMPB     |                        |                           |  |                         |
| 3PUMPC     | 4.6392                 | 24.35                     |  |                         |
| 4PUMPD     |                        |                           |  |                         |
| <b>CS</b>  | <b>Pressure (psig)</b> | <b>NPSHa (ft)</b>         |  |                         |
| 1CSPUMPA   | 3.173                  | 20.86                     |  |                         |
| 2CSPUMPB   |                        |                           |  |                         |
| 3CSPUMPC   | 4.003                  | 22.84                     |  |                         |
| 4CSPUMPD   |                        |                           |  |                         |

## CALCULATION SHEET

Table 14.8: Unit 3 NPSH Calculations Case 4A 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 155.4    | 4.249928506           | 0.016369309               | 2.357180486                            | Pool Press. (psia) 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.948           | 35.59      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.697           | 35.00      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.996           | 33.34      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.231           | 31.54      |



Table 14.9: Unit 3 NPSH Calculations Case 4B 172F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 172      | 6.281035863           | 0.016460423               | 2.370300872                            | Pool Press. (psia) 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.921           | 30.91      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.671           | 30.32      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.9748          | 28.67      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.2133          | 26.86      |

## CALCULATION SHEET

Table 14.10: Unit 3 NPSH Calculations Case 4C 187.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 187.3    | 8.822339971           | 0.01655191                | 2.383475045                            | Pool Press. (psia) 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 4.894           | 24.96      |
| 2PUMPB   |                 |            |
| 3PUMPC   | 4.645           | 24.37      |
| 4PUMPD   |                 |            |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.953           | 22.72      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.196           | 20.91      |

## CALCULATION SHEET

Table 14.11: Unit 3 NPSH Calculations Case 5A 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|--|--|-------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                         |
| 155.4    | 4.249928506           | 0.016369309                            | 2.357180486                            | Pool Press. (psia) 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.824           | 35.30      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.055           | 35.84      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.988           | 33.33      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.222           | 31.52      |

## CALCULATION SHEET

Table 14.12: Unit 3 NPSH Calculations Case 5B 172F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|--|--|-------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                         |
| 172      | 6.281035863           | 0.016460423                            | 2.370300872                            | Pool Press. (psia) 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.797           | 30.61      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.027           | 31.16      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.966           | 28.65      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.205           | 26.84      |

## CALCULATION SHEET

Table 14.13: Unit 3 NPSH Calculations Case 5C 187.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 187.3    | 8.822339971           | 0.01655191                | 2.383475045                            | Pool Press. (psia) 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.771           | 24.67      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 4.999           | 25.21      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA |                 |            |
| 2CSPUMPB | 3.945           | 22.70      |
| 3CSPUMPC |                 |            |
| 4CSPUMPD | 3.188           | 20.89      |

Table 14.14: Unit 3 NPSH Calculations Case 6A 155.4F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 155.4    | 4.249928506           | 0.016369309               | 2.357180486                            | Pool Press. (psia) 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.8149          | 35.28      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.0455          | 35.82      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.2265          | 31.53      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 4.066           | 33.51      |
| 4CSPUMPD |                 |            |

Table 14.15: Unit 3 NPSH Calculations Case 6B 172F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 172      | 6.281035863           | 0.016460423               | 2.370300872                            | Pool Press. (psia) 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.788           | 30.59      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 5.0178          | 31.14      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.209           | 26.85      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 4.044           | 28.83      |
| 4CSPUMPD |                 |            |

## CALCULATION SHEET

Table 14.16: Unit 3 NPSH Calculations Case 6C 187.3F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|--|--|-------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                         |
| 187.3    | 8.822339971           | 0.01655191                             | 2.383475045                            | Pool Press. (psia) 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   |                 |            |
| 2PUMPB   | 4.762           | 24.64      |
| 3PUMPC   |                 |            |
| 4PUMPD   | 4.99            | 25.19      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 3.1919          | 20.90      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 4.022           | 22.88      |
| 4CSPUMPD |                 |            |



**Table 14.17: Unit 3 NPSH Calculations Case 7 166F**

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|--|--|-------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                         |
| 166      | 5.468938413           | 0.016426501                            | 2.365416198                            | Pool Press. (psia) 14.4 |

| RHR      | Pressure (psig) | NPSHa (ft) |
|----------|-----------------|------------|
| 1PUMPA   | 3.9313          | 30.42      |
| 2PUMPB   | 3.933           | 30.43      |
| 3PUMPC   | 3.6805          | 29.83      |
| 4PUMPD   | 4.1637          | 30.97      |
| CS       | Pressure (psig) | NPSHa (ft) |
| 1CSPUMPA | 2.6012          | 27.28      |
| 2CSPUMPB |                 |            |
| 3CSPUMPC | 3.438           | 29.26      |
| 4CSPUMPD |                 |            |

## CALCULATION SHEET

Table 14.18: Unit 3 NPSH Calculations Case ATWS 177F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft³/lb) | Conversion Factor<br>psia to feet of head | Pool Press. (psia) 14.4 |
|----------|--------------------------|------------------------------|---|-------------------------|
| 60       | 0.256389624              | 0.016034992                  | 2.309038802                               |                         |
| 177      | 7.033092437              | 0.016489536                  | 2.374493143                               |                         |

| RHR   | Pressure (psig) | NPSHa (ft) |
|-------|-----------------|------------|
| PUMPA | 4.7293          | 28.72      |
| PUMPB | 4.7405          | 28.75      |
| PUMPC | 4.4794          | 28.13      |
| PUMPD | 4.9695          | 29.29      |

Table 14.19: Unit 3 NPSH Calculations Case ATWS 192F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 192      | 9.757027807           | 0.01658144                | 2.387727412                            | Pool Press. (psia) 14.4 |

| RHR   | Pressure (psig) | NPSHa (ft) |
|-------|-----------------|------------|
| PUMPA | 4.703           | 22.32      |
| PUMPB | 4.714           | 22.34      |
| PUMPC | 4.4544          | 21.72      |
| PUMPD | 4.942           | 22.89      |

Table 14.20: Unit 3 NPSH Calculations Case ATWS 211F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft <sup>3</sup> /lb) | Conversion Factor<br>psia to feet of head | Pool Press. (psia) 14.4 |
|----------|--------------------------|---|---|-------------------------|
| 60       | 0.256389624              | 0.016034992                               | 2.309038802                               |                         |
| 211      | 14.42019545              | 0.016707611                               | 2.405895953                               |                         |

| RHR   | Pressure (psig) | NPSHa (ft) |
|-------|-----------------|------------|
| PUMPA | 4.667           | 11.18      |
| PUMPB | 4.678           | 11.21      |
| PUMPC | 4.42            | 10.59      |
| PUMPD | 4.905           | 11.75      |

## CALCULATION SHEET

Table 14.21: Unit 3 NPSH Calculations Case App-R A 227F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft <sup>3</sup> /lb) | Conversion Factor<br>psia to feet of head |                         |
|----------|--------------------------|---|---|-------------------------|
| 60       | 0.256389624              | 0.016034992                               | 2.309038802                               |                         |
| 191      | 9.551535023              | 0.016575101                               | 2.386814603                               | Pool Press. (psia) 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 5.3966          | 24.45      |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 14.22: Unit 3 NPSH Calculations Case App-R B 227F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft³/lb) | Conversion Factor<br>psia to feet of head |                    |      |
|----------|--------------------------|------------------------------|---|--------------------|------|
| 60       | 0.256389624              | 0.016034992                  | 2.309038802                               |                    |      |
| 191      | 9.551535023              | 0.016575101                  | 2.386814603                               | Pool Press. (psia) | 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB | 5.38            | 24.41      |
| 3PUMPC |                 |            |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 14.23: Unit 3 NPSH Calculations Case App-R C 227F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft³/lb) | Conversion Factor<br>psia to feet of head |                         |
|----------|--------------------------|------------------------------|---|-------------------------|
| 60       | 0.256389624              | 0.016034992                  | 2.309038802                               |                         |
| 191      | 9.551535023              | 0.016575101                  | 2.386814603                               | Pool Press. (psia) 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC | 5.333           | 24.30      |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 14.24: Unit 3 NPSH Calculations Case App-R D 227F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 191      | 9.551535023           | 0.016575101               | 2.386814603                            | Pool Press. (psia) 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD | 5.4183          | 24.50      |



## CALCULATION SHEET

Table 14.25: Unit 3 NPSH Calculations Case App-R A 223F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft <sup>3</sup> /lb) | Conversion Factor<br>psia to feet of head |                          |
|----------|--------------------------|---|---|--------------------------|
| 60       | 0.256389624              | 0.016034992                               | 2.309038802                               |                          |
| 223      | 18.22056282              | 0.016792916                               | 2.418179953                               | Pool Press. (psia) 14.75 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 5.3266          | 4.49       |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD |                 |            |

Table 14.26: Unit 3 NPSH Calculations Case App-R B 227F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft <sup>3</sup> /lb) | Conversion Factor<br>psia to feet of head | Pool Press. (psia) 14.75 |
|----------|--------------------------|---|---|--------------------------|
| 60       | 0.256389624              | 0.016034992                               | 2.309038802                               |                          |
| 223      | 18.22056282              | 0.016792916                               | 2.418179953                               |                          |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB | 5.3105          | 4.45       |
| 3PUMPC |                 |            |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 14.27: Unit 3 NPSH Calculations Case App-R C 227F

| Temp(°F) | Vapor Pressure<br>(psia) | Specific Volume<br>V(ft <sup>3</sup> /lb) | Conversion Factor<br>psia to feet of head | Pool Press. (psia) 14.75 |
|----------|--------------------------|---|---|--------------------------|
| 60       | 0.256389624              | 0.016034992                               | 2.309038802                               |                          |
| 223      | 18.22056282              | 0.016792916                               | 2.418179953                               |                          |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC | 5.264           | 4.34       |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 14.28: Unit 3 NPSH Calculations Case App-R D 227F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                          |
|----------|-----------------------|---------------------------|--|--------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                          |
| 223      | 18.22056282           | 0.016792916               | 2.418179953                            | Pool Press. (psia) 14.75 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB |                 |            |
| 3PUMPC |                 |            |
| 4PUMPD | 5.348           | 4.54       |

Table 14.29: Unit 3 NPSH Calculations SBO A-C 157F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft <sup>3</sup> /lb) | Conversion Factor psia to feet of head |                         |
|----------|-----------------------|--|--|-------------------------|
| 60       | 0.256389624           | 0.016034992                            | 2.309038802                            |                         |
| 157      | 4.417636119           | 0.016377716                            | 2.358391077                            | Pool Press. (psia) 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 5.052           | 35.46      |
| 2PUMPB |                 |            |
| 3PUMPC | 4.8             | 34.86      |
| 4PUMPD |                 |            |

Table 14.30: Unit 3 NPSH Calculations SBO B-D 157F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 157      | 4.417636119           | 0.016377716               | 2.358391077                            | Pool Press. (psia) | 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB | 4.902           | 35.10      |
| 3PUMPC |                 |            |
| 4PUMPD | 5.132           | 35.65      |

Table 14.31: Unit 3 NPSH Calculations SBO A-C 200F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head | Pool Press. (psia) 14.4 |
|----------|-----------------------|---------------------------|--|-------------------------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                         |
| 200      | 11.53763273           | 0.016633238               | 2.395186284                            |                         |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA | 4.975           | 18.77      |
| 2PUMPB |                 |            |
| 3PUMPC | 4.727           | 18.18      |
| 4PUMPD |                 |            |

## CALCULATION SHEET

Table 14.32: Unit 3 NPSH Calculations SBO B-D 200F

| Temp(°F) | Vapor Pressure (psia) | Specific Volume V(ft³/lb) | Conversion Factor psia to feet of head |                    |      |
|----------|-----------------------|---------------------------|--|--------------------|------|
| 60       | 0.256389624           | 0.016034992               | 2.309038802                            |                    |      |
| 200      | 11.53763273           | 0.016633238               | 2.395186284                            | Pool Press. (psia) | 14.4 |

| RHR    | Pressure (psig) | NPSHa (ft) |
|--------|-----------------|------------|
| 1PUMPA |                 |            |
| 2PUMPB | 4.827           | 18.42      |
| 3PUMPC |                 |            |
| 4PUMPD | 5.054           | 18.96      |



|   |         |                           |                          |
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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

**TABLE 15**  
**Unit 3**

| LOCA Pump/Flow Combination  | Pool Temp | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|---|-----------|-------------|-------------|----------------------|
| <b>LOCA 1A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @95°F     | Strainer 1  | 15628.6     | 3.022                |
|   |           | Strainer 23 | 14681.1     | 2.645                |
|   |           | Strainer 27 | 15176.1     | 2.884                |
|   |           | Strainer 5  | 14712.2     | 2.662                |
| <b>LOCA 1B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each | @155.4°F  | Strainer 1  | 15390.6     | 2.975                |
|   |           | Strainer 23 | 14453.3     | 2.604                |
|   |           | Strainer 27 | 14938.4     | 2.839                |
|   |           | Strainer 5  | 14483.6     | 2.621                |
| <b>LOCA 2A</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @95°F     | Strainer 1  | 15646.5     | 3.025                |
|   |           | Strainer 23 | 14677       | 2.642                |
|   |           | Strainer 27 | 15163.5     | 2.880                |
|   |           | Strainer 5  | 14711       | 2.661                |
| <b>LOCA 2B</b><br>CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each | @155.4°F  | Strainer 1  | 15403.4     | 2.978                |
|   |           | Strainer 23 | 14450.6     | 2.603                |
|   |           | Strainer 27 | 14928       | 2.835                |
|   |           | Strainer 5  | 14483.9     | 2.621                |
| <b>LOCA 3A</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @155.4°F  | Strainer 1  | 4905.66     | 0.173                |
|   |           | Strainer 23 | 4551.66     | 0.107                |
|   |           | Strainer 27 | 4648.25     | 0.124                |
|   |           | Strainer 5  | 4750.43     | 0.143                |
| <b>LOCA 3B</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @172°F    | Strainer 1  | 4878.12     | 0.172                |
|   |           | Strainer 23 | 4526.95     | 0.106                |
|   |           | Strainer 27 | 4622.91     | 0.123                |
|   |           | Strainer 5  | 4724.01     | 0.142                |
| <b>LOCA 3C</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @187.3°F  | Strainer 1  | 4850.69     | 0.171                |
|   |           | Strainer 23 | 4502.16     | 0.106                |
|   |           | Strainer 27 | 4597.51     | 0.123                |
|   |           | Strainer 5  | 4697.64     | 0.141                |
| <b>LOCA 4A</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 each          | @155.4°F  | Strainer 1  | 4835.65     | 0.159                |
|   |           | Strainer 23 | 4647.75     | 0.124                |
|   |           | Strainer 27 | 4731.51     | 0.139                |
|   |           | Strainer 5  | 4641.08     | 0.123                |
| <b>LOCA 4B</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each      | @172°F    | Strainer 1  | 4808.63     | 0.158                |
|   |           | Strainer 23 | 4622.27     | 0.123                |
|   |           | Strainer 27 | 4705.55     | 0.139                |
|   |           | Strainer 5  | 4615.54     | 0.122                |

|   |         |                           |                          |
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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

| LOCA Pump/Flow Combination   | Pool Temp | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|--|-----------|-------------|-------------|----------------------|
| <b>LOCA 4C</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR A/C Pumps-6500 gpm each<br>B/D-0 gpm each | @187.3°F  | Strainer 1  | 4781.69     | 0.157                |
|  |           | Strainer 23 | 4596.76     | 0.123                |
|  |           | Strainer 27 | 4679.56     | 0.138                |
|  |           | Strainer 5  | 4589.99     | 0.121                |
| <b>LOCA 5A</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @155.4°F  | Strainer 1  | 4642.35     | 0.123                |
|  |           | Strainer 23 | 4773.43     | 0.147                |
|  |           | Strainer 27 | 4913.97     | 0.175                |
|  |           | Strainer 5  | 4526.25     | 0.102                |
| <b>LOCA 5B</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @172°F    | Strainer 1  | 4617        | 0.122                |
|  |           | Strainer 23 | 4746.88     | 0.146                |
|  |           | Strainer 27 | 4886.42     | 0.174                |
|  |           | Strainer 5  | 4501.7      | 0.102                |
| <b>LOCA 5C</b><br>CS Pumps B/D-3125gpm each<br>A/C-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @187.3°F  | Strainer 1  | 4591.6      | 0.122                |
|  |           | Strainer 23 | 4720.38     | 0.146                |
|  |           | Strainer 27 | 4858.97     | 0.173                |
|  |           | Strainer 5  | 4477.05     | 0.102                |
| <b>LOCA 6A</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @155.4°F  | Strainer 1  | 4720.96     | 0.137                |
|  |           | Strainer 23 | 4661.24     | 0.126                |
|  |           | Strainer 27 | 4846.9      | 0.161                |
|  |           | Strainer 5  | 4626.89     | 0.120                |
| <b>LOCA 6B</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @172°F    | Strainer 1  | 4695.03     | 0.137                |
|  |           | Strainer 23 | 4635.59     | 0.126                |
|  |           | Strainer 27 | 4819.83     | 0.160                |
|  |           | Strainer 5  | 4601.55     | 0.119                |
| <b>LOCA 6C</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR B/D Pumps-6500 gpm each<br>A/C-0 gpm each | @187.3°F  | Strainer 1  | 4669.07     | 0.136                |
|  |           | Strainer 23 | 4609.93     | 0.125                |
|  |           | Strainer 27 | 4792.84     | 0.159                |
|  |           | Strainer 5  | 4576.16     | 0.119                |
| <b>LOCA 7</b><br>CS Pumps A/C-3125gpm each<br>B/D-0 gpm each<br>RHR A/C/B/D Pumps-6500 gpm each                | @166°F    | Strainer 1  | 8289.24     | 0.877                |
|  |           | Strainer 23 | 7500.75     | 0.696                |
|  |           | Strainer 27 | 7988.88     | 0.803                |
|  |           | Strainer 5  | 7703.14     | 0.739                |

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| <b>CALCULATION SHEET</b>                                  |         |                           |                          |

| ATWS Pump/Flow Combination   | Pool Temp. | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|--|------------|-------------|-------------|----------------------|
| ATWS<br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @177°F     | Strainer 1  | 8930.1      | 0.181                |
|  |            | Strainer 23 | 3896.18     | 0.035                |
|  |            | Strainer 27 | 7805.12     | 0.138                |
|  |            | Strainer 5  | 4652.6      | 0.049                |
| ATWS<br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @192°F     | Strainer 1  | 8879.5      | 0.180                |
|  |            | Strainer 23 | 3875.86     | 0.034                |
|  |            | Strainer 27 | 7760.5      | 0.138                |
|  |            | Strainer 5  | 4628.14     | 0.049                |
| ATWS<br>RHR A/C/B/D Pumps-6500 gpm each<br>CS Pumps A/C/B/D-0 gpm each | @211°F     | Strainer 1  | 8810.45     | 0.179                |
|  |            | Strainer 23 | 3847.63     | 0.034                |
|  |            | Strainer 27 | 7699.73     | 0.136                |
|  |            | Strainer 5  | 4594.2      | 0.049                |
| Appendix R Pump/Flow Combination                                       | Pool Temp. | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
| App-R A<br>RHR Pump A-6500 gpm   | @191°F     | Strainer 1  | 2627.57     | 0.016                |
|  |            | Strainer 23 | 1051.49     | 0.003                |
|  |            | Strainer 27 | 1987.05     | 0.009                |
|  |            | Strainer 5  | 1298.89     | 0.004                |
| App-R B<br>RHR Pump B-6500 gpm   | @191°F     | Strainer 1  | 1919.34     | 0.015                |
|  |            | Strainer 23 | 1407.03     | 0.008                |
|  |            | Strainer 27 | 2348.25     | 0.022                |
|  |            | Strainer 5  | 1290.38     | 0.007                |
| App-R C<br>RHR Pump C-6500 gpm   | @191°F     | Strainer 1  | 2627.57     | 0.016                |
|  |            | Strainer 23 | 1051.49     | 0.003                |
|  |            | Strainer 27 | 1987.05     | 0.009                |
|  |            | Strainer 5  | 1298.89     | 0.004                |
| App-R D<br>RHR Pump D-6500 gpm   | @191°F     | Strainer 1  | 1919.34     | 0.015                |
|  |            | Strainer 23 | 1407.03     | 0.008                |
|  |            | Strainer 27 | 2348.25     | 0.022                |
|  |            | Strainer 5  | 1290.38     | 0.007                |

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| Appendix R Pump/Flow Combination | Pool Temp. | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|----------------------------------|------------|-------------|-------------|----------------------|
| App-R A<br>RHR Pump A-6500 gpm   | @223°F     | Strainer 1  | 2591.43     | 0.016                |
|                                  |            | Strainer 23 | 1039.21     | 0.003                |
|                                  |            | Strainer 27 | 1961.32     | 0.009                |
|                                  |            | Strainer 5  | 1283.05     | 0.004                |
| App-R B<br>RHR Pump B-6500 gpm   | @223°F     | Strainer 1  | 1894.42     | 0.015                |
|                                  |            | Strainer 23 | 1389.94     | 0.008                |
|                                  |            | Strainer 27 | 2315.96     | 0.022                |
|                                  |            | Strainer 5  | 1274.67     | 0.007                |
| App-R C<br>RHR Pump C-6500 gpm   | @223°F     | Strainer 1  | 2591.43     | 0.016                |
|                                  |            | Strainer 23 | 1039.21     | 0.003                |
|                                  |            | Strainer 27 | 1961.32     | 0.009                |
|                                  |            | Strainer 5  | 1283.05     | 0.004                |
| App-R D<br>RHR Pump D-6500 gpm   | @223°F     | Strainer 1  | 1894.42     | 0.015                |
|                                  |            | Strainer 23 | 1389.94     | 0.008                |
|                                  |            | Strainer 27 | 2315.96     | 0.022                |
|                                  |            | Strainer 5  | 1274.64     | 0.007                |

|  |                |   |  |
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| <b>CALCULATION SHEET</b>   |                |   |  |

| SBO Pump/Flow Combination               | Pool Temp | Strainer    | Flow (sgpm) | Pressure Drop (psid) |
|---|-----------|-------------|-------------|----------------------|
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @157°F    | Strainer 1  | 4793.76     | 0.052                |
|   |           | Strainer 23 | 1926.27     | 0.008                |
|   |           | Strainer 27 | 3630.94     | 0.029                |
|   |           | Strainer 5  | 2377.02     | 0.013                |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @157°F    | Strainer 1  | 3506.98     | 0.049                |
|   |           | Strainer 23 | 2575.18     | 0.026                |
|   |           | Strainer 27 | 4284.26     | 0.072                |
|   |           | Strainer 5  | 2361.58     | 0.022                |
| SBO 1 A/C<br>RHR Pump A/C-6500 gpm each | @200°F    | Strainer 1  | 4714.82     | 0.051                |
|   |           | Strainer 23 | 1899.77     | 0.008                |
|   |           | Strainer 27 | 3574.78     | 0.029                |
|   |           | Strainer 5  | 2342.63     | 0.013                |
| SBO 2 B/D<br>RHR Pump B/D-6500 gpm each | @200°F    | Strainer 1  | 3452.57     | 0.048                |
|   |           | Strainer 23 | 2538.1      | 0.026                |
|   |           | Strainer 27 | 4213.84     | 0.071                |
|   |           | Strainer 5  | 2327.49     | 0.022                |

## Appendix 3

## Evaluation of the ECCS Strainer to Ingest a Steam Plume/Bubble

This appendix determines the vertical and horizontal distances between the MSRV T-quenchers and various points on the ECCS suction strainers. The horizontal distance is compared to the MSRV T-Quencher to ECCS separation criteria contained in the Brookhaven National Laboratory attached to the NRC Safety Evaluation Report for NEDO- 30832-A, "Elimination of Limit on BWR Suppression Pool Temperature Limit for SRV Discharge with Quenchers"

## Assumptions:

None

## References:

1. Drawing 2/3-E20, "TVA Containment Vessel", Pittsburgh-Des Moines Steel Co.
2. Drawing 2/3-47W401-5, "Mechanical Main Steam Relief Valve Vent Piping".
3. General Electric Drawing 105E2202 Rev 1, "Suction Strainer"

## Design Input Data:

1. Distance from ring header centerline to weld on penetration X-204A-D = 1' 10" (Ref. 1)
2. Distance from weld on penetration X-204A-D to exterior of suppression chamber shell = 8.5" (based on field measurement)
3. Distance from exterior of suppression chamber shell to strainer flange = 0' 11 5/16" (Ref. 1)
4. Length of suction strainer = 49.8" (Scaled from Ref. 3)
5. Hydraulic Diameter of suction strainer = 45" (Ref. 3)
6. Angle of suction strainer to horizontal = 40° 08' 36" = 40.14° (Ref. 1)
7. Distance from centerline of ring header to centerline of suppression chamber = 13' 10" (Ref. 1)
8. Distance from centerline of suppression chamber to centerline of MSRV T-Quencher = 15" (Ref. 2)
9. Diameter of MSRV T-Quencher = 12" (Ref. 2)
10. Elevation of ring header = 525' 4" (Ref. 1)
11. Elevation of MSRV T-Quencher = 526' 6" (Ref. 2)

## Computations and Results:

The following calculation is based on the sketch shown in Figure A3-1. The figure is based on the above design input data.

$$X_1 = (1' 10" + 8.5" + 11 5/16" + 49.8") * \text{COSINE } 40.14^\circ = 70.0"$$

$$X_2 = 22.5 * \text{SINE } 40.14^\circ = 14.50"$$

## Appendix 3 (Cont'd)

## Evaluation of the ECCS Strainer to Ingest a Steam Plume/Bubble

$$\text{Horizontal Separation} = S_H = 13' 10'' - X_1 - X_2 + 15'' - 6'' = 13' 10'' - 70.0'' - 14.50'' + 15'' - 6'' = 90.5'' = 7.54 \text{ feet} \\ = 2.3 \text{ meters}$$

$$Z_1 = (1' 10'' + 8.5'' + 11 \frac{5}{16}'' + 49.8'') \cdot \text{SINE } 40.14^\circ = 59.1''$$

$$Z_2 = 22.5' \cdot \text{COSINE } 40.14^\circ = 17.2''$$

$$E = 59.1'' - 17.2'' = 41.9'' \sim 42''$$

$$\text{Elevation of tip of strainer} = \text{Centerline of ring header} + E = 525' 4'' + 42'' = 528' 10''$$

$$\text{Vertical Separation} = \text{Elevation of tip of strainer} - \text{Elevation of MSRV T-Quencher} \\ = 528' 10'' - 526' 6'' = 2' 4''$$

**Conclusion:**

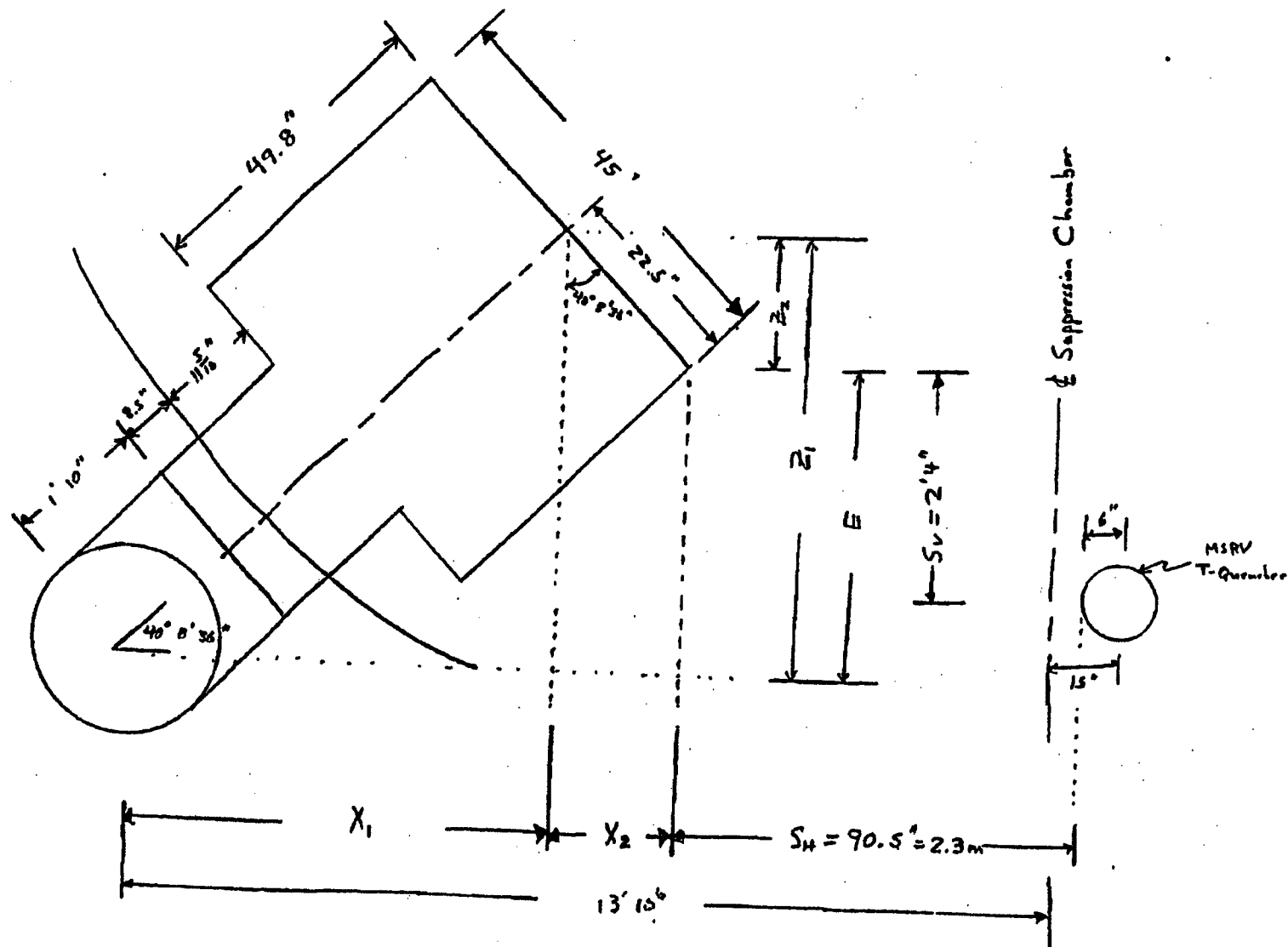
The horizontal separation distance from the Brookhaven report is 1.5 meters. Since the BFN separation (2.3 meters) exceeds the Brookhaven criteria, it is not expected that the steam/thermal plume from an MSRV would be ingested by an ECCS suction strainer.

Calculation MD-Q0999-970046

Figure A3-1

Page A3 of 3

ECCS Strainer and MSRV T-Quencher Relationship





# QA Record

## TVAN CALCULATION

Page 1  
Attachment A  
Page A-1

|  |   |   |  |
|--|---|---|--|
| TITLE<br><b>NPSH Evaluation of Browns Ferry RHR and CS Pumps</b>   |   | PLANT/UNIT<br><b>BFN / Unit 2 &amp; 3</b>   |  |
| PREPARING ORGANIZATION<br>Site Engineering-Mechanical / Nuclear  |   | KEY NOUNS (Consult CCRIS LIST)  |  |
| BRANCH/PROJECT IDENTIFIERS<br><b>MD-Q0999-970046</b>   |   | Each time these calculations are issued, preparers must ensure that the original (R0) RIMS accession number is filled in. |  |
|  |   | Rev   | (for RIMS use) RIMS accession number   |
|  |   | R0  | <b>279 R14 981118 108</b>              |
| APPLICABLE DESIGN DOCUMENT(S)<br><b>Design Criteria No. BFN-50-7074 &amp; BFN-50-7075</b>  |   | R1  |  |
|  |   | R2  |  |
| SAR SECTION(S)<br><b>N/A</b>   | UNIT SYSTEM(S)<br><b>074 &amp; 075</b>  | R3  |  |
| Revision 0   |   | R1  | R2 R3                                  |
| DCN No. (or indicate Not Applicable)   |   | <b>N/A</b>  |  |
| Prepared<br><i>Thomas F. Newton</i>  | <i>W. V. 02</i>                         |   |  |
| Checked<br><i>Michael Byrd</i>   | <i>5/11/97</i>                          |   |  |
| Reviewed<br><i>Michael Byrd</i>  | <i>11-18-98</i>                         |   |  |
| Approved<br><i>Michael Byrd</i>  |   |   |  |
| Date<br><i>7/2/97</i>  |   |   |  |
| Use form<br>TVA  | List all pages added by this revision   | <b>SEE</b>  |  |
| 10534<br>if more   | List all pages deleted by this revision | <b>REV</b>  |  |
| space<br>required  | List all pages changed by this revision | <b>LOG</b>  |  |
| Calculation Revision<br>(A) Entire Calc; (P) Selected pages  |   | <b>P</b>  |  |
| These calculations contain unverified assumption(s) that must be verified later.   |   | Yes <input type="checkbox"/>  | No <input checked="" type="checkbox"/> |
| <p><b>Abstract</b></p> <p>Pump Net Positive Suction Head Required (NPSHR) is defined as the minimum head required to prevent pump cavitation. The Net Positive Suction Head Available (NPSHA) must be greater than the NPSHR to prevent pump cavitation. The difference between NPSHA and NPSHR is the remaining head margin and is referred to in this calculation as the NPSH margin. This evaluation encompasses both Unit 2 and Unit 3 RHR and CS pumps.</p> |   |   |  |
| <input type="checkbox"/> Microfilm and store calculations in RIMS Service Center<br><input checked="" type="checkbox"/> Microfilm and return calculations to: POB TIC - BFN  |   | Microfilm and destroy. <input type="checkbox"/><br>Address:   |  |

**ORIGINAL**

# QA Record

Attachment A  
Page A-2

| TVAN CALCULATION COVERSHEET  |   |  |   |   |  |   |
|--|---|--|---|---|--|---|
| Title NPSH Evaluation of Browns Ferry RHR and CS Pumps   |   |  | Plant BFN   |   | Page 1   |   |
|  |   |  | Unit 2/3  |   |  |   |
| Preparing Organization<br>SE-DE/MNUC   |   | Key Nouns (For EDM)  |   |   |  |   |
| Calculation Identifier<br>MD-Q0999-970046  |   | Each time these calculations are issued, preparer must ensure that the original (R0) RIMS/EDM accession number is filled in. |   |   |  |   |
| Applicable Design Document(s)<br>BFN-50-7074 & BFN-50-7075<br>BFN-50-7064A   |   | Rev  | (for EDM use)   | EDM Accession Number  |  |   |
|  |   | R0   |   | R14 981118 103  |  |   |
|  |   | R1   |   | R14 990616 105  |  |   |
|  |   | R2   |   | R14 991118 101  |  |   |
|  |   | R3   |   | R14 000708 101  |  |   |
| UNID System(s)<br>SYS 074 & 075 + 064A   |   |  |   |   |  |   |
|  | R0  | R1   | R2  | R3  | Quality Related?   | Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> |
| DCN, EDC, NA   | N/A   | N/A  | N/A   | N/A   | Safety related? If yes, mark Quality Related yes                                 | Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> |
| Prepared   | TFN   | Wm. Varr   | William V. Carr   | James P. Berry  | Gen. D. Henry, 2/11/1  |   |
| Checked  | MB  | Engel & Smith  | W. B. Carr  | William V. Carr   | These calculations contain unverified assumption(s) that must be verified later? | Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |
| Design Verified  | MB  | Engel & Smith  | W. B. Carr  | William V. Carr   | These calculations contain special requirements and/or limiting conditions?      | Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |
| Approved   | KTG   | W. B. Carr   | W. B. Carr  | W. B. Carr  | These calculations contain a design output attachment?                           | Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |
| Approval Date  | 11-18-98  | 04/16/1999   | 11/16/1999  | 7/1/2000  | Calculation Classification   | E   |
| SAR Affected?  | Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> | Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>  | Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> | Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> | Microfiche generated   | Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |
| Revision applicability   | Entire calc <input checked="" type="checkbox"/>                     | Entire calc <input checked="" type="checkbox"/>  | Entire calc <input type="checkbox"/>                                | Entire calc <input type="checkbox"/>                                | Number   |   |
| <p>Statement of Problem:<br/>(SEE REV. 0 COVER SHEET, PAGE 1A)</p> <p>This calculation also evaluates the potential for the ECCS strainers to ingest a steam plant/bubble from a MSEV T-governor and its effect if ingested.</p>   |   |  |   |   |  |   |
| <p>Abstract<br/>(SEE REV. 0 COVER SHEET, PAGE 1A)</p> <p>Rev. 1 performs additional EZFLOW case runs for one loop of RHR with two pumps in run-out at 11,000 gpm each, one loop of RHR with two pumps at maximum design flow of 10,000 gpm each, and four CS pumps operating at normal design flow, 3125 gpm, with the suppression pool temperature at 95 degrees F.</p> |   |  |   |   |  |   |
| <input type="checkbox"/> Microfilm and return calculation to Calculation Library. Address:   |   |  |   | <input type="checkbox"/> Microfilm and destroy.                     |  |   |
| <input type="checkbox"/> Microfilm and return calculation to:  |   |  |   |   |  |   |

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QA Record

ATTACHMENT A  
PAGE A-3

ORIGINAL

## TVAN CALCULATION COVERSHEET/CCRIS UPDATE

Page 1

|   |  |  |   |   |  |  |   |  |
|---|--|--|---|---|--|--|---|--|
| KEY EDMS/EDMS NO.<br>R14 981118 108   |  | EDMS TYPE<br>calculations(nuclear)   |   | EDMS ACCESSION NO (N/A for REV. 0)<br>R14 020781 105                                    |  |  |   |  |
| Calc Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps  |  |  |   |   |  |  |   |  |
| CALC ID   | TYPE   | ORG  | PLANT   | BRANCH  | NUMBER   | CUR REV  | NEW REV   | REVISION APPLICABILITY   |
| CURRENT   | CN   | NUC  | BFN   | MEB   | MD-Q0999-970046  | 03   | 04  | Entire calc <input type="checkbox"/><br>Selected pages <input checked="" type="checkbox"/> |
| ACTION  | NEW REVISION <input checked="" type="checkbox"/>   | DELETE RENAME <input type="checkbox"/>   | SUPERSEDE DUPLICATE <input type="checkbox"/>  | CCRIS UPDATE ONLY <input type="checkbox"/><br>(Verify Approval Signatures Not Required) |  |  | No CCRIS Changes <input type="checkbox"/><br>(For calc revision, CCRIS been reviewed and no CCRIS changes required) |  |
| UNITS<br>002003   | SYSTEMS<br>074 075 064A  |  | UNITS<br>Various  |   |  | CLASSIFICATION<br>E  |   |  |
| DCN EDC N/A   |  | APPLICABLE DESIGN DOCUMENT(S)<br>N/A   |   |   | CLASSIFICATION<br>E  |  |   |  |
| QUALITY RELATED?<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>   | SAFETY RELATED?<br>(If yes, CR = yes)<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> | UNVERIFIED ASSUMPTION<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> | SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |   | DESIGN OUTPUT ATTACHMENT?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> | SAR/TS AFFECTED<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |   |  |
| PREPARED BY<br>KGG  | PREPARED PHONE NO.<br>729-4874   | PREPARING ORG/BRANCH<br>MEB  | VERIFICATION METHOD<br>Design Review  |   | NEW METHOD OF ANALYSIS<br><input checked="" type="checkbox"/> Yes <input type="checkbox"/> No    |  |   |  |
| PREPARED SIGNATURE<br>KGG   | DATE<br>06-19-02   | CHECKER SIGNATURE<br>TELENTZ   | DATE<br>06-19-02  |   | DATE<br>06-19-02   |  |   |  |
| VERIFIER SIGNATURE<br>TELENTZ   | DATE<br>06-19-02   | APPROVAL SIGNATURE<br>[Signature]  | DATE<br>06-19-02  |   | DATE<br>07/30/02   |  |   |  |
| STATEMENT OF PROBLEM/ABSTRACT<br>See previous cover sheets (Attachment A, pages A-1 & A-2) for the earlier statements of the problem / abstracts.<br><br>Due to EPU, the peak suppression pool temperature has risen to 186.6° F @ 14,700 seconds (Ref. 3.19). This calculation assumes a over pressure of 3 psi for both the short and long terms and concluded that there is adequate NPSH margin for the worst case after allowing for the increase in vapor pressure due to the higher temperature. |  |  |   |   |  |  |   |  |
| MICROFICHE/FICHE Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> FICHE NUMBER(S)  |  |  |   |   |  |  |   |  |
| <input type="checkbox"/> LOAD INTO EDMS AND DESTROY<br><input checked="" type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY. ADDRESS:<br><input type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO:   |  |  |   |   |  |  |   |  |

**TVAN CALCULATION COVERSHEET/CCRS UPDATE**

| CALC ID | TYPE | ORG | PLANT | BRANCH | NUMBER          | REV |
|---------|------|-----|-------|--------|-----------------|-----|
|         | CN   | NUC | BFN   | MEB    | MD-Q0899-870046 | 04  |

| ALTERNATE CALCULATION IDENTIFICATION |      |      |            |      |              |                              |
|--------------------------------------|------|------|------------|------|--------------|------------------------------|
|                                      |      |      |            |      |              |                              |
| BLDG                                 | ROOM | ELEV | COORD/AZIM | FIRM | Print Report | Yes <input type="checkbox"/> |
| CATEGORIES                           |      |      |            |      |              |                              |

| ACTION | KEY NOUN | AD | KEY NOUN |
|--------|----------|----|----------|
| A      | 3962     | A  | CPPU     |
| A      | EPU      | A  | CS SYS   |
| A      | RHR      | A  | NPSH     |
| A      | PUMP     | A  | HEAD     |
| A      | STRAINER | A  | ECCS     |

[illegible]

|                     |                    |                     |      |
|---------------------|--------------------|---------------------|------|
| PREPARER SIGNATURE  | DATE               | CHECKER SIGNATURE   | DATE |
| PREPARER PHONE NO.  | EDMS ACCESSION NO. | R14 020731 105      |      |
| TVA 40532 (07-2001) | Page 2 of 2        | NEOP-2-1437-09-2001 |      |

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NEOP-1407-09-2001

# ATTACHMENT A PAGE A-5

## TVAN CALCULATION COVERSHEET/CCRIS UPDATE

Page 1

|   |  |  |  |                                     |   |                                    |  |   |  |  |
|---|--|--|--|-------------------------------------|---|------------------------------------|--|---|--|--|
| REV 0 EDMS/RIMS NO.<br>R14981118108   |  |  |  | EDMS TYPE:<br>calculations(nuclear) |   | EDMS ACCESSION NO (N/A for REV. 0) |  |   |  |  |
| Calc Title: NPSH Evaluation Of Browns Ferry RHR And CS Pumps  |  |  |  |                                     |   |                                    |  |   |  |  |
| CALC ID   | TYPE   | ORG                                    | PLANT  | BRANCH                              | NUMBER  | CUR REV                            | NEW REV  | REVISION<br>APPLICABILITY<br>Entire calc <input checked="" type="checkbox"/><br>Selected pages <input type="checkbox"/> |  |  |
| CURRENT   | CN   | NUC                                    | BFN  | MEB                                 | MDQ0999970046   | 004                                |  |   |  |  |
| NEW   | CN   | NUC                                    |  |                                     |   |                                    | 005  |   |  |  |
| ACTION  | NEW REVISION <input type="checkbox"/>  | DELETE RENAME <input type="checkbox"/> | SUPERSEDE DUPLICATE <input type="checkbox"/>   |                                     | CCRIS UPDATE ONLY <input type="checkbox"/><br>(Verifier Approval Signatures Not Required)                               |                                    |  | No CCRIS Changes <input type="checkbox"/><br>(For calc revision, CCRIS been reviewed and no CCRIS changes required)     |  |  |
| UNITS:<br>001, 002, 003   |  | SYSTEMS:<br>064 074 075                |  |                                     | UNIDS:<br>N/A   |                                    |  |   |  |  |
| DCN.EDC.N/A<br>DCN 51200  |  | APPLICABLE DESIGN DOCUMENT(S)<br>N/A   |  |                                     |   |                                    | CLASSIFICATION<br>E  |   |  |  |
| QUALITY RELATED?<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>   | SAFETY RELATED?<br>(If yes, OR = yes)<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> |  | UNVERIFIED ASSUMPTION<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |                                     | SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |                                    | DESIGN OUTPUT ATTACHMENT?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |   | SAR/TS AFFECTED<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |  |
| PREPARER ID<br>DJKAROL  | PREPARER PHONE<br>NO 301-228-6720  |  | PREPARING ORG (BRANCH)<br>MECH/NUC   |                                     | VERIFICATION METHOD<br>DESIGN REVIEW  |                                    | NEW METHOD OF ANALYSIS<br><input type="checkbox"/> Yes <input checked="" type="checkbox"/> No    |   |  |  |
| PREPARER SIGNATURE<br>DENNIS KAROL <i>[Signature]</i>   |  |  | DATE<br>6-15-03  |                                     | CHECKER SIGNATURE<br>M. ANGIOLLO <i>[Signature]</i>   |                                    |  | DATE<br>25 JUN 03   |  |  |
| VERIFIER SIGNATURE<br>M. ANGIOLLO <i>[Signature]</i>  |  |  | DATE<br>25 JUN 03  |                                     | APPROVAL SIGNATURE<br>W. D. CROUCH  |                                    |  | DATE<br><i>[Signature]</i>  |  |  |
| STATEMENT OF PROBLEM/ABSTRACT   |  |  |  |                                     |   |                                    |  |   |  |  |
| <p><b>Problem:</b></p> <p>The purpose of this calculation is to determine that the Residual Heat Removal (RHR) pump and the Core Spray (CS) pump Net Positive Suction Head (NPSH) is adequate and that margin is available for the Emergency Core Cooling System (ECCS) replacement strainer design.</p> <p><b>Abstract:</b></p> <p>Revision 5 has determined that the values calculated in Revision 4 of the main calculation for Units 2 and 3 operations at Extended Power Uprate (EPU) conditions is also applicable to Unit 1 operations at EPU conditions.</p> <p>This revision makes the calculation applicable to Units 1, 2 and 3.</p> |  |  |  |                                     |   |                                    |  |   |  |  |
| MICROFICHE/EFICHE Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> FICHE NUMBER(S)<br><input type="checkbox"/> LOAD INTO EDMS AND DESTROY<br><input type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION ADDRESS:<br>LIBRARY.<br><input type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO:<br>  |  |  |  |                                     |   |                                    |  |   |  |  |

# ATTACHMENT A PAGE A-6

## TVAN CALCULATION COVERSHEET/CCRIS UPDATE

Page 2

|                                      |             |             |                   |                 |               |                              |
|--------------------------------------|-------------|-------------|-------------------|-----------------|---------------|------------------------------|
| CALC ID                              | TYPE        | ORG         | PLANT             | BRANCH          | NUMBER        | REV                          |
|                                      | CN          | NUC         | BFN               | MEB             | MDQ0999970048 | 005                          |
| ALTERNATE CALCULATION IDENTIFICATION |             |             |                   |                 |               |                              |
|                                      |             |             |                   |                 |               |                              |
| BLDG<br>01                           | ROOM<br>N/A | ELEV<br>N/A | COORD/AZIM<br>N/A | FIRM<br>Bechtel | Print Report  | Yes <input type="checkbox"/> |
| CATEGORIES                           |             |             |                   |                 |               |                              |

### KEY NOUNS (A-add, D-delete)

| ACTION<br>(A/D) | KEY NOUN | A/D | KEY NOUN |
|-----------------|----------|-----|----------|
| A               | LOCA     |     |          |
|                 |          |     |          |
|                 |          |     |          |
|                 |          |     |          |
|                 |          |     |          |

### CROSS-REFERENCES (A-add, C-change, D-delete)

| ACTION<br>(A/C/D) | XREF<br>CODE | XREF<br>TYPE | XREF<br>PLANT | XREF<br>BRANCH | XREF<br>NUMBER  | XREF<br>REV |
|-------------------|--------------|--------------|---------------|----------------|-----------------|-------------|
| A                 | P            | CN           | BFN           | NTB            | NDQ199920020018 |             |
| A                 | P            | DW           | BFN           | MEB            | 1-47E811-1      |             |
| A                 | P            | DW           | BFN           | MEB            | 2-47E811-1      |             |
| A                 | P            | DW           | BFN           | MEB            | 3-47E811-1      |             |
| A                 | P            | DW           | BFN           | MEB            | 1-47E814-1      |             |
| A                 | P            | DW           | BFN           | MEB            | 0-47E452-1      |             |
| A                 | P            | DW           | BFN           | MEB            | 2-47W2452-1     |             |
| A                 | P            | DW           | BFN           | MEB            | 0-47W458-2      |             |
| A                 | P            | DW           | BFN           | MEB            | 1-47W458-3      |             |
| A                 | P            | DW           | BFN           | MEB            | 2-47W458-3      |             |
| A                 | P            | DW           | BFN           | MEB            | 2-47W458-4      |             |
| A                 | P            | DW           | BFN           | MEB            | 2-47W458-5      |             |
| A                 | P            | OW           | BFN           | MEB            | 47W401-5        |             |
| A                 | P            | VD           | BFN           | MEB            | 103 (UNIT 1)    |             |
| A                 | P            | VD           | BFN           | MEB            | 103 (UNIT 2)    |             |
| A                 | P            | VD           | BFN           | MEB            | E19             |             |
| A                 | P            | VD           | BFN           | MEB            | 2-E19           |             |
| A                 | P            | VD           | BFN           | MEB            | 3-E19           |             |
| A                 | P            | DN           | BFN           | MEB            | DCN T-40210A    |             |
| A                 | P            | DN           | BFN           | MEB            | DCN T-40211A    |             |

#### CCRIS ONLY UPDATES:

Following are required only when making keyword/cross reference CCRIS updates and page 1 of form NEDP-2-1 is not included:

|                    |                    |                   |      |
|--------------------|--------------------|-------------------|------|
| PREPARER SIGNATURE | DATE               | CHECKER SIGNATURE | DATE |
| PREPARER PHONE NO. | EDMS ACCESSION NO. |                   |      |

TVA 40532 [07-2001]

Page 2 of 2

NEDP-2-1 [07-09-2001]

**TVAN CALCULATION COVERSHEET/CCRIS UPDATE**

Page 2B

| CALC ID | TYPE | ORG | PLANT | BRANCH | NUMBER        | REV |
|---------|------|-----|-------|--------|---------------|-----|
|         | CN   | NUC | BFN   | MEB    | MDQ0999970046 | 005 |

### ALTERNATE CALCULATION IDENTIFICATION

|                   |                    |                    |                          |                        |  |
|-------------------|--------------------|--------------------|--------------------------|------------------------|--|
| <u>BLDG</u><br>01 | <u>ROOM</u><br>N/A | <u>ELEV</u><br>N/A | <u>COORD/AZIM</u><br>N/A | <u>FIRM</u><br>Bechtel | <u>Print Report</u> Yes <input type="checkbox"/> |
|-------------------|--------------------|--------------------|--------------------------|------------------------|--|

## CATEGORIES

**KEY NOUNS (A-add, D-delete)**

| <u>ACTION</u> | <u>KEY NOUN</u> | <u>A/D</u> | <u>KEY NOUN</u> |
|---------------|-----------------|------------|-----------------|
| (A/D)         |                 |            |                 |
|               |                 |            |                 |
|               |                 |            |                 |
|               |                 |            |                 |
|               |                 |            |                 |

**CROSS-REFERENCES (A-add, C-change, D-delete)**

[illegible]

**CCRIS ONLY UPDATES:**

**Following are required only when making keyword/cross reference CCRIS updates and page 1 of form NEDP-2-1 is not included:**

|                    |                    |                   |      |
|--------------------|--------------------|-------------------|------|
| PREPARER SIGNATURE | DATE               | CHECKER SIGNATURE | DATE |
| PREPARER PHONE NO. | EDMS ACCESSION NO. |                   |      |

QA Record

## ATTACHMENT A PAGE A-8

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

ORIGINAL

Page 1

|  |  |  |  |                                     |   |   |  |   |  |
|--|--|--|--|-------------------------------------|---|---|--|---|--|
| REV. 0 EDMS/RIMS NO.<br>R14981118108   |  |  |  | EDMS TYPE:<br>calculations(nuclear) |   | EDMS ACCESSION NO (N/A for REV. 0)<br>W 78 030924 016 |  |   |  |
| Calc Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps   |  |  |  |                                     |   |   |  |   |  |
| CALC ID  | TYPE   | ORG                                    | PLANT  | BRANCH                              | NUMBER  | CUR REV   | NEW REV  | REVISION<br>APPLICABILITY<br>Entire calc <input checked="" type="checkbox"/><br>Selected pages <input type="checkbox"/>             |  |
| CURRENT  | CN   | NUC                                    | BFN  | MEB                                 | MDQ099970046  | 005   |  |   |  |
| NEW  | CN   | NUC                                    |  |                                     |   |   | 006  |   |  |
| ACTION   | NEW REVISION <input checked="" type="checkbox"/>   | DELETE RENAME <input type="checkbox"/> | SUPERSEDE DUPLICATE <input type="checkbox"/>   |                                     | CCRIS UPDATE ONLY <input type="checkbox"/><br>(Verifier Approval Signatures Not Required)                               |   |  | No CCRIS Changes <input checked="" type="checkbox"/><br>(For calc revision, CCRIS been reviewed and no CCRIS changes required) 9/14 |  |
| UNITS<br>001, 002, 003   |  | SYSTEMS<br>064 074 075                 |  |                                     | UNIDS<br>N/A  |   |  |   |  |
| DCN/EDC/N/A<br>DCN 51200   |  | APPLICABLE DESIGN DOCUMENT(S)<br>N/A   |  |                                     |   |   | CLASSIFICATION<br>E  |   |  |
| QUALITY RELATED?<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>  | SAFETY RELATED?<br>(If yes, OR = yes)<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> |  | UNVERIFIED ASSUMPTION<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |                                     | SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |   | DESIGN OUTPUT ATTACHMENT?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |   | SAR/TS AFFECTED<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |
| PREPARER ID<br>DJKAROL   | PREPARER PHONE<br>NO 301-228-6720  |  | PREPARING ORG (BRANCH)<br>MECH/NUC   |                                     | VERIFICATION METHOD<br>DESIGN REVIEW  |   | NEW METHOD OF ANALYSIS<br><input type="checkbox"/> Yes <input checked="" type="checkbox"/> No    |   |  |
| PREPARER SIGNATURE<br>DJKAROL <i>Dennis Karol</i>  |  |  | DATE<br>9-12-03  |                                     | CHECKER SIGNATURE<br>LDEGEL <i>L. Degel</i>   |   |  | DATE<br>9-12-03   |  |
| VERIFIER SIGNATURE<br>LDEGEL <i>L. Degel</i>   |  |  | DATE<br>9-12-03  |                                     | APPROVAL SIGNATURE<br>WDCROUCH <i>W. Crouch</i>   |   |  | DATE<br>9/22/03   |  |
| STATEMENT OF PROBLEM/ABSTRACT  |  |  |  |                                     |   |   |  |   |  |
| Problem:<br><br>The purpose of this calculation is to determine that the Residual Heat Removal (RHR) pump and the Core Spray (CS) pump Net Positive Suction Head (NPSH) is adequate and that margin is available for the Emergency Core Cooling System (ECCS) replacement strainer design. |  |  |  |                                     |   |   |  |   |  |
| Abstract:<br><br>This revision adds the Unit 1 margin to the calculation.  |  |  |  |                                     |   |   |  |   |  |
| MICROFICHE/FICHE Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> FICHE NUMBER(S)   |  |  |  |                                     |   |   |  |   |  |
| <input type="checkbox"/> LOAD INTO EDMS AND DESTROY<br><input type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION ADDRESS:<br>LIBRARY.<br><input type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO:  |  |  |  |                                     |   |   |  |   |  |





QA Record

## ATTACHMENT A PAGE A-10

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

ORIGINAL

Page 1

|  |  |  |  |  |               |   |  |  |  |
|--|--|--|--|--|---------------|---|--|--|--|
| REV 0 EDMS/RIMS NO.<br>R14981118108  |  |  |  | EDMS TYPE<br>calculations(nuclear)   |               | EDMS ACCESSION NO (N/A for REV. 0)<br>W78 040219 001  |  |  |  |
| Calc Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps   |  |  |  |  |               |   |  |  |  |
| CALC ID  | TYPE   | ORG  | PLANT  | BRANCH   | NUMBER        | CUR REV   | NEW REV  | REVISION APPLICABILITY   |  |
| CURRENT  | CN   | NUC  | BFN  | MEB  | MDC0999970046 | 006   |  | Entire calc <input checked="" type="checkbox"/><br>Selected pages <input type="checkbox"/>       |  |
| NEW  | CN   | NUC  |  |  |               |   | 007  |  |  |
| ACTION   | NEW REVISION <input checked="" type="checkbox"/> | DELETE RENAME <input type="checkbox"/>   | SUPERSEDE DUPLICATE <input type="checkbox"/> | CCRIS UPDATE ONLY <input type="checkbox"/><br>(Verifier Approval Signatures Not Required)    |               |   | No CCRIS Changes <input checked="" type="checkbox"/><br>(For calc revision, CCRIS been reviewed and no CCRIS changes required) |  |  |
| UNITS<br>001, 002, 003   |  | SYSTEMS<br>064 074 075   |  |  | UNIDS<br>N/A  |   |  |  |  |
| DCN.EDC.N/A<br>N/A   |  | APPLICABLE DESIGN DOCUMENT(S) N/A  |  |  |               |   |  | CLASSIFICATION<br>E  |  |
| QUALITY RELATED?<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>  |  | SAFETY RELATED?<br>(If yes, QR = yes)<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> |  | UNVERIFIED ASSUMPTION<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |               | SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |  | DESIGN OUTPUT ATTACHMENT?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |  |
| PREPARER ID<br>Ed Rink   |  | PREPARER PHONE NO<br>255 729 7000 x 18393  |  | PREPARING ORG (BRANCH)<br>Mech/Nuc   |               | VERIFICATION METHOD<br>Design Review  |  | NEW METHOD OF ANALYSIS<br><input type="checkbox"/> Yes <input checked="" type="checkbox"/> No    |  |
| PREPARER SIGNATURE<br><i>Edward J. Rink Jr</i>   |  |  |  | DATE<br>11/12/04   |               | CHECKER SIGNATURE<br><i>James W. Gronck</i>   |  |  |  |
| VERIFIER SIGNATURE<br><i>Robert J. Wolf</i>  |  |  |  | DATE<br>1/22/05  |               | APPROVAL SIGNATURE<br><i>William J. Lamb</i>  |  |  |  |
| STATEMENT OF PROBLEM/ABSTRACT  |  |  |  |  |               |   |  |  |  |
| Problem:<br><br>The purpose of this calculation is to determine that the Residual Heat Removal (RHR) pump and the Core Spray (CS) pump Net Positive Suction Head (NPSH) is adequate and that margin is available for the Emergency Core Cooling System (ECCS) replacement strainer design. |  |  |  |  |               |   |  |  |  |
| Abstract:<br><br>This revision adds Appendix 6 to quantify, and to document the basis for, the numerical values of available NPSH and NPSH margins for U1 that are submitted to the NRC in response to both Generic Letter (GL) 97-04 and NRC Bulletin 96-03.                              |  |  |  |  |               |   |  |  |  |
| MICROFICHE/EFICHE Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> FICHE NUMBER(S)  |  |  |  |  |               |   |  |  |  |
| <input type="checkbox"/> LOAD INTO EDMS AND DESTROY  |  |  |  |  |               |   |  |  |  |
| <input type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY. ADDRESS:  |  |  |  |  |               |   |  |  |  |
| <input type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO:   |  |  |  |  |               |   |  |  |  |

# ATTACHMENT A PAGE A-11

## TVAN CALCULATION COVERSHEET/CCRIS UPDATE

Page 1

|  |  |   |  |  |   |   |  |   |  |  |
|--|--|---|--|--|---|---|--|---|--|--|
| REV 0 EDMS/RIMS NO.<br>R14981118108  |  |   |  | EDMS TYPE:<br>calculations(nuclear)  |   | EDMS ACCESSION NO (N/A for REV. 0)  |  |   |  |  |
| Calc Title: NPSH Evaluation of Browns Ferry RHR and CS pumps   |  |   |  |  |   |   |  |   |  |  |
| CALC ID  | TYPE   | ORG   | PLANT  | BRANCH   | NUMBER  | CUR REV   | NEW REV  | REVISION<br>APPLICABILITY<br>Entire calc <input checked="" type="checkbox"/><br>Selected pages <input type="checkbox"/> |  |  |
| CURRENT  | CN   | NUC   | BFN  | MEB  | MDQ0999970046   | 007   | 008  |   |  |  |
| NEW  | CN   | NUC   |  |  |   |   |  |   |  |  |
| ACTION   | NEW REVISION <input checked="" type="checkbox"/> | DELETE RENAME <input type="checkbox"/>  | SUPERSEDE DUPLICATE <input type="checkbox"/> |  | CCRIS UPDATE ONLY <input type="checkbox"/><br>(Verifier Approval Signatures Not Required) |   |  | No CCRIS Changes <input type="checkbox"/><br>(For calc revision, CCRIS been reviewed and no CCRIS changes required)     |  |  |
| UNITS<br>001, 002, 003   |  | SYSTEMS<br>064 074 075  |  |  | UNIDS<br>N/A  |   |  |   |  |  |
| DCN.EDC.N/A<br>N/A   |  | APPLICABLE DESIGN DOCUMENT(S) N/A   |  |  |   |   |  | CLASSIFICATION<br>E   |  |  |
| QUALITY RELATED?<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>  |  | SAFETY RELATED? (If yes, QR = yes)<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> |  | UNVERIFIED ASSUMPTION<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |   | SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> |  | DESIGN OUTPUT ATTACHMENT?<br>Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>                        |  | SAR/TS and/or ISFSI SAR/CoC AFFECTED<br>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> <i>YSS 2/19/14</i> |
| PREPARER ID<br>Fady Galed  | PREPARER PHONE<br>NO<br>1-312-269-6382           |   | PREPARING ORG (BRANCH)<br>MEB                |  | VERIFICATION METHOD<br>DESIGN REVIEW  |   | NEW METHOD OF ANALYSIS<br><input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <i>W 3/19/06</i> |   |  |  |
| PREPARER SIGNATURE<br>Fady Galed <i>Fady Galed</i>   |  |   | DATE<br>03-09-06                             |  | CHECKER SIGNATURE<br>Chris Rennels <i>Chris Rennels</i>                                   |   |  | DATE<br>03-09-2006  |  |  |
| VERIFIER SIGNATURE<br>Chris Rennels <i>Chris Rennels</i>   |  |   | DATE<br>03-09-2006                           |  | APPROVAL SIGNATURE<br><i>[Signature]</i>  |   |  | DATE  |  |  |
| STATEMENT OF PROBLEM/ABSTRACT<br>Problem:<br><br>The purpose of this calculation is to determine that the Residual Heat Removal (RHR) pump and the Core Spray (CS) pump Net Positive Suction Head (NPSH) is adequate and that margin is available for the Emergency Core Cooling System (ECCS) replacement strainer design.<br><br>Abstract:<br><br>This revision updates the calculation utilizing Multiflow and updated flow and temperatures for EPU, ATWS, Appendix R, and SBO conditions. |  |   |  |  |   |   |  |   |  |  |
| MICROFICHE/EFICHE Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> FICHE NUMBER(S) TVA-F-U001744, TVA-F-U001745, TVA-F-U001746  |  |   |  |  |   |   |  |   |  |  |
| <input type="checkbox"/> LOAD INTO EDMS AND DESTROY<br><input checked="" type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION ADDRESS:POB-1A-BFN<br>LIBRARY.<br><input type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO:   |  |   |  |  |   |   |  |   |  |  |

To: Those Listed

005 BY DJK  
CRED. NDA

From: Thomas Newton, BFN EPU Project

Subject: ECCS NPSH Calculation Revision Differences from EPU Task Report T0406

Date: 7/16/02

BFN Calculation MD-Q0999-970046 was revised at Revision 3 to incorporate the approved license value of containment overpressure credit. This meant adding 1 psi to the short term results for RHR and subtracting 1 psi from the long term results for CS in Tables 1 and 2 since the calculation already considered 2 psi in its original deterministic results. Revision 3 modified the calculation results per the NRC SER of approved overpressure for NPSH. The conversion factor for 1 psi used in performing this calculation was 2.31 ft/psi. The original results of the calculation utilized the conversion factor corresponding to the suppression pool temperature as listed in Table 3 of the calculation.

In Extended Power Uprate analysis, General Electric made the following statement in Final Task Report T0406, "ECCS Net Positive Suction Head", Section 3.3.2, Item 2, primary bullet 3, "CLTP NPSH margins from previous NPSH calculation (MD-Q0999-970046) were obtained. Since these margins include containment overpressure credits, NPSH margins without the credits (baseline values) were calculated. This calculation uses a fixed conversion factor of 2.31 ft/psi, as is as that used in (MD-Q0999-970046) to convert psi to feet of water. The remaining NPSH calculations uses conversion factors calculated based on the water temperature."

Therefore, GE's analyses used a conversion factor of 2.31 ft/psi to establish the baseline NPSH margin from the TVA calculation and then used a vapor head conversion factor correctly based on the suppression pool water temperature for the additive effect of increased suppression pool temperature (and vapor pressure) on NPSH margin.

GE utilized a spreadsheet and table (attached with marked changes per the TVA calculation) to support or report Task Report T0406 results which reflected the deterministic attributes above. If one utilizes conversion factors based on suppression pool temperature, the values for NPSH margin in Task Report T0406, Section 3.3.1.1, are slightly different. Revision 4 of MD-Q0999-970046 was performed using conversion factors based on the suppression pool water temperature and a containment overpressure of 3 psi. Results are reflected in Case 1 (NPSH margin for the worst case RHR pump), Case 2 (NPSH margin for the worst case CS pump), and Table 4 and some values are slightly different from the content of Task Report T0406 per this explanation

*Thomas F. Newton*

cc: T. Taylor

J. Wright

H. Jones

Calculating NPSH Margins at the Suppression Pool Temperature calculated for NPSH (Appendix E of T9400 Report, Reference 2)

|  | RHR<br>Flow<br>(gpm) | CS<br>Flow<br>(gpm) | Pre-<br>EPU<br>Pool<br>Temp<br>(°F) | Vapor<br>Pressure<br>(psf) | Time after<br>LOCA<br>Temp (°F) | Vapor<br>Pool<br>Temp (°F) | Vapor<br>Pressure<br>(psf) | Vapor<br>Pressure<br>Differences<br>(psf) | Conversion<br>factor<br>(N/psf) | Pre-EPU<br>NPSH<br>Margin (ft)<br>without<br>credit | EPU<br>NPSH<br>Margin (ft)<br>without<br>credit | containment<br>overpressure<br>credit (psf) | EPU<br>NPSH<br>Margin (ft)<br>with credit |
|--|----------------------|---------------------|-------------------------------------|----------------------------|---------------------------------|----------------------------|----------------------------|---|---------------------------------|---|---|---|---|
| RHR<br>Short Term<br>LOCA (0-600<br>sec) | 42,000               | 12,500              | 140                                 | 2,889                      | 600                             | 155.4                      | 4,231                      | 1,382                                     | 2,357                           | -2.62   | -5.73   | -5.20                                       | 3 1.34 1.32                               |
| Long Term<br>LOCA                        | 13,000               | 8,250               | 177                                 | 7,026                      | 001                             | 152.0                      | 3,963                      | -3,063                                    | 2,355                           | -5.87   | -13.08  | -12.45                                      | 0 13.08 12.45                             |
|  |                      |                     |                                     | 7,026                      | 4150                            | 175.83                     | 6,637                      | -0.189                                    | 2,374                           | -5.87   | -6.32   | -6.19                                       | 0 6.32 6.19                               |
|  |                      |                     |                                     | 7,026                      | 4500                            | 177                        | 7,026                      | 0.000                                     | 2,375                           | -5.87   | -5.87   |   | 1 5.87 5.87                               |
|  |                      |                     |                                     | 7,026                      | 5500                            | 179.1                      | 7,354                      | 0.328                                     | 2,377                           | -5.87   | -5.09   |   | 1 7.47                                    |
|  |                      |                     |                                     | 7,026                      | 7000                            | 181.85                     | 7,837                      | 0.811                                     | 2,379                           | -5.87   | -3.94   | -3.91                                       | 1 6.32 6.19                               |
|  |                      |                     |                                     | 7,026                      | 7100                            | 181.9                      | 7,840                      | 0.820                                     | 2,379                           | -5.87   | -3.92   |   | 2 5.64                                    |
|  |                      |                     |                                     | 7,026                      | 14,700                          | 186.8                      | 8,804                      | 1.858                                     | 2,383                           | -5.87   | -1.82   | -1.71                                       | 2 6.64 6.56                               |
|  |                      |                     |                                     | 7,026                      | 35,000                          | 182.8                      | 7,995                      | 0.889                                     | 2,380                           | -5.87   | -3.56   |   | 2 7.32                                    |
|  |                      |                     |                                     | 7,026                      | 37,500                          | 181.85                     | 7,895                      | 0.811                                     | 2,379                           | -5.87   | -3.94   | -3.91                                       | 1 6.32 6.19                               |
|  |                      |                     |                                     | 7,026                      | 52,300                          | 175.83                     | 6,637                      | -0.189                                    | 2,374                           | -5.87   | -8.32   |   | 0 6.32                                    |
| CS<br>Short Term<br>LOCA                 |                      |                     | 140                                 | 2,889                      | 600                             | 155.4                      |                            | 1,382                                     | 2,357                           | 4.23  | 4.16  | 1.02  | 3 8.09 8.02                               |
| Long Term<br>LOCA                        |                      |                     | 177                                 | 7,026                      | 001                             | 152.0                      |                            | -3,063                                    | 2,355                           | -0.45   | -0.58   | -6.76                                       | 0 6.76 6.48                               |
|  |                      |                     |                                     |                            | 4150                            | 175.83                     | End of 0 psi               | -0.189                                    | 2,374                           | -0.45   | 0.00  | -0.13                                       | 0 0.00 -0.13                              |
|  |                      |                     |                                     |                            | 4500                            | 177                        |                            | 0.000                                     | 2,375                           | -0.45   | -0.45   |   | 1 1.72                                    |
|  |                      |                     |                                     |                            | 5500                            | 179.1                      |                            | 0.328                                     | 2,377                           | -0.45   | -1.23   |   | 1 1.15                                    |
|  |                      |                     |                                     |                            | 7000                            | 181.85                     | End of 1 psi               | 0.811                                     | 2,379                           | -0.45   | -2.38   | -2.73                                       | 1 0.00 -0.35                              |
|  |                      |                     |                                     |                            | 7100                            | 181.9                      | End of 2 psi               | 0.820                                     | 2,379                           | -0.45   | -2.40   |   | 2 2.36                                    |
|  |                      |                     |                                     |                            | 14,700                          | 186.8                      |                            | 1.858                                     | 2,383                           | -0.45   | -4.40   | -4.53                                       | 2 0.37 0.24                               |
|  |                      |                     |                                     |                            | 35,000                          | 182.75                     |                            | 0.889                                     | 2,380                           | -0.45   | -2.76   |   | 2 2.00                                    |
|  |                      |                     |                                     |                            | 37,500                          | 181.85                     | End of 2 psi               | 0.811                                     | 2,379                           | -0.45   | -2.38   | -2.74                                       | 1 0.00 -0.13                              |
|  |                      |                     |                                     |                            | 52,300                          | 175.83                     | End of 1 psi               | -0.189                                    | 2,374                           | -0.45   | 0.00  |   | 0 0.00                                    |

Calculating NPSH Margins at the Peak Suppression Pool Temperature following a DBA LOCA (Appendix G of T9400 Report, Reference 2)

| RHR | CS | Pre-<br>EPU | Vapor | Time after<br>EPU Pool | Vapor | Vapor | Conversion | NPSH | EPU<br>NPSH | containment<br>NPSH |
|-----|----|-------------|-------|------------------------|-------|-------|------------|------|-------------|---------------------|
|-----|----|-------------|-------|------------------------|-------|-------|------------|------|-------------|---------------------|

06/18/11

005 BY DAK  
CRED: MOK

Attachment - 2 Page B-2

NMDC-33017P - Issue Revision A  
GE PROPRIETARY INFORMATION

Table 4-1

CIPU DBA-LOCA NPSH Margins and Containment Overpressure Credit

| Time After<br>LOCA (sec) | Suppression Pool<br>Temperature (°F) | Containment<br>Overpressure<br>Required (psf) | RHR pump NPSH<br>margin (ft) | CS pump NPSH<br>margin (ft) | Description/Basis  |
|--------------------------|--------------------------------------|---|------------------------------|-----------------------------|--|
| 600                      | 155.1                                | <del>2.1</del><br>2.46                        | 0                            | 6.75                        | Short-term analysis. Overpressure<br>required to meet RHR NPSH<br>requirements |
| 601                      | 152.4                                | 0   | 12.75 13.08                  | 6.55 6.76                   | Long-term analysis   |
| 4,150                    | 175.83                               | 0   | 6.32                         | 0                           | Greater than 0 psi of overpressure<br>required for long-term for CS<br>pumps   |
| 7,090                    | 181.85                               | 1   | 6.32                         | 0                           | Greater than 1 psi of overpressure<br>required for long-term for CS<br>pumps   |
| 14,700                   | 186.6                                | <del>1.84</del><br>1.90                       | 6.32                         | 0                           | Peak Suppression Pool<br>temperature   |
| 37,500                   | 181.85                               | 1   | 6.32                         | 0                           | Less than 1 psi of overpressure<br>required for long-term for CS<br>pumps      |

Attachment -2. Page B-3

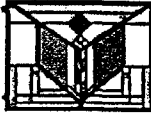
005 BY DK  
CRED: W04

Attachment D

Page D-1

MDQ0999970046

REV-008



DONALD L  
MCQUEEN/Sargentlundy  
02/16/2006 11:32 AM

To FADY S GAIED/Sargentlundy@Sargentlundy

cc

bcc

Subject Fw: Pump/Flow Combination Cases for MULTIFLOW EPU  
Revision to NPSH Calculation

— Forwarded by DONALD L MCQUEEN/Sargentlundy on 02/16/2006 11:32 AM —



"Newton, Thomas F."  
<tnewton@tva.gov>  
01/23/2006 10:39 AM

To <donald.L.mcqueen@sargentlundy.com>

cc "Housley, Denzel A." <dahousley@tva.gov>, "Jones, Henry  
L." <hljones@tva.gov>, "Wolcott, J. D." <jdwolcott@tva.gov>

Subject Pump/Flow Combination Cases for MULTIFLOW EPU  
Revision to NPSH Calculation

Don,

The attached is a listing of the cases we have agreed upon. The number of cases is very similar to that of the existing calculation. It doesn't take long to modify the input and run each case - the largest effect is formatting and presenting the results. I am leaving the office for the day, but will be here most of the day tomorrow. I will call you when I get in so that we can discuss any questions on the cases listed.

Tom Newton



LOCA Cases for MULTIFLOW Revision to NPSH Calculation.doc

**Pump/Flow Combinations for MULTIFLOW Revision to NPSH Calculation**

Note 1 - All cases to be run at 0 containment overpressure conditions

Note 2 - LOCA strainer resistance to be developed as a function of strainer flow and input as a resistance element in MULTIFLOW model, special event strainer resistance taken as zero.

Note 3 - All cases at EPU conditions only

Note 4 - Cases at which  $NPSH_a = NPSH_r$  will require iteration on pool temperature to determine final pool temperature

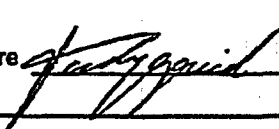
| <b>LOCA Pump/Flow Combinations</b>   | <b>Suppression Pool Temperature</b>  |
|--|--|
| CS Pumps A/B/C/D - 3125 gpm each<br>RHR A/C Pumps - 10,000 gpm each<br>RHR B/D Pumps - 11,000 gpm each | Temperature @ 95°F<br>Temperature @ 10 minutes EPU   |
| CS Pumps A/B/C/D - 3125 gpm each<br>RHR A/C Loop - 11,000 gpm each<br>RHR B/D Loop - 10,000 gpm each   | Same as above  |
| CS Pumps A/C - 3125 gpm each, B/D - 0<br>RHR A/C Pumps - 6500 gpm each, B/D - 0                        | Temperature @ 10 minutes EPU (155.4°F)<br>Temperature where $NPSH_a = NPSH_r$<br>Temperature @ $T_{max}$ EPU (187.3°F) |
| CS Pumps B/D - 3125 gpm each, A/C - 0<br>RHR A/C Pumps - 6500 gpm each, B/D - 0                        | Temperature @ 10 minutes EPU (155.4°F)<br>Temperature where $NPSH_a = NPSH_r$<br>Temperature @ $T_{max}$ EPU (187.3°F) |
| CS Pumps B/D - 3125 gpm each, A/C - 0<br>RHR B/D Pumps - 6500 gpm each, A/C - 0                        | Temperature @ 10 minutes EPU (155.4°F)<br>Temperature where $NPSH_a = NPSH_r$<br>Temperature @ $T_{max}$ EPU (187.3°F) |
| CS Pumps A/C - 3125 gpm each, B/D - 0<br>RHR B/D Pumps - 6500 gpm each, A/C - 0                        | Temperature @ 10 minutes EPU (155.4°F)<br>Temperature where $NPSH_a = NPSH_r$<br>Temperature @ $T_{max}$ EPU (187.3°F) |
| CS Pumps A/C - 3125 gpm each, B/D - 0<br>RHR A/B/C/D Pumps - 6500 gpm each                             | Temperature @ 166°F  |
| <b>ATWS Pump/Flow Combinations</b>   |  |
| HPCI Pump Flow - 4500 gpm<br>RHR A/B/C/D Pumps - 6500 gpm each   | Temperature @ 214.6°F (EPU Task Report T0902)  |
| <b>Appendix R Pump/Flow Combinations</b>   |  |
| One RHR Pump (non specific) - 6500 gpm   | Temperature @ 227°F (EPU Task Report T0611)  |
| <b>SBO Pump/Flow Combinations</b>  |  |
| One RHR Pump (non specific) - 6500 gpm   | Temperature @ 197.3°F (EPU Task Report T0903)  |



MD-Q0999-970046

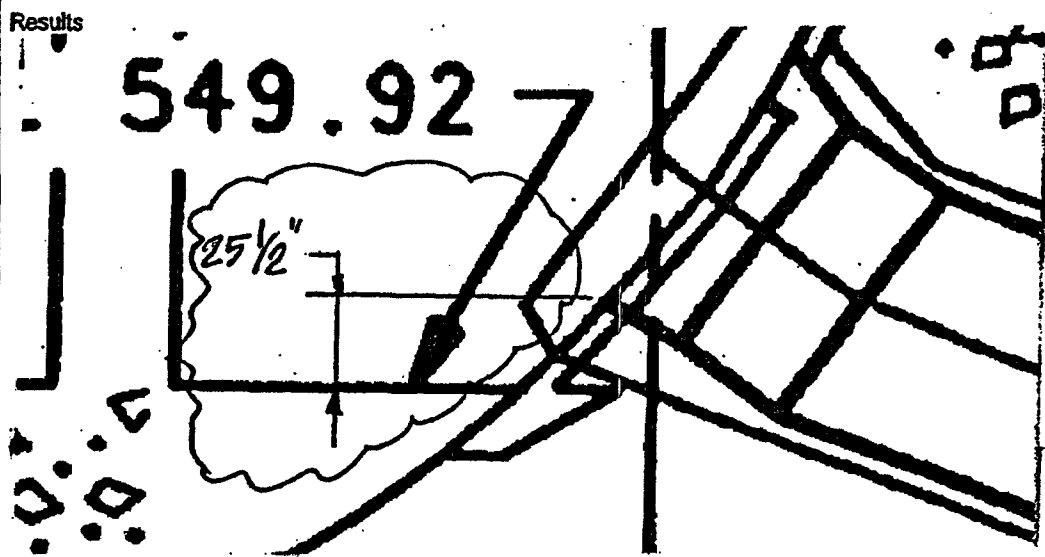
Attachment E  
Rev. - 009

1

| LIMITED WALKDOWN REQUEST AND DATA COLLECTING FORM   |                                |  |
|---|--------------------------------|--|
| Requesting Organization   | <u>Sargent &amp; Lundy LLC</u> | Date <u>07/25/06</u>   |
| Initiating Document   | <u>ECCS</u>                    |  |
| Walkdown Location (Unit/Bldg/Elev/Room/Column Lines)<br><u>Unit 1 / Reactor Building / Drywell</u>  |                                |  |
| Scope<br>Walkdown:<br><br>Please identify the elevation of point A see detail D-D on the attached drawing or the vertical distance between Point A and Point C. |                                |  |
| Name  | <u>Fady S. Galed</u>           | Signature <u></u> Date <u>07/25/06</u> |

MD-Q 0999-970046

Attachment E 2  
Rev.-009

| LIMITED WALKDOWN REQUEST AND DATA COLLECTING FORM |   |                 |
|---|---|-----------------|
| Performing Organization                           | Sargent & Lundy LLC   |                 |
| Date  |   |                 |
| Results   |  |                 |
| DIM. TAKEN @ 42.30° REF DWG O-47E200-9            |   |                 |
| <u>ROMAN KARPINSKI</u>                            | <u>R. Karpinski</u>   | <u>7-25-06</u>  |
| Data Taker Name                                   | Signature   | Date            |
| <u>K. G. Gauthaman</u>                            | <u>K. Gauthaman</u>   | <u>07.25.06</u> |
| Data Verifier Name                                | Signature   | Date            |

MD-Q0999-970046

Attachment F 1  
Rev. 009



"Eberly, William A"  
<waeberly@tva.gov>  
07/28/2006 04:47 PM

To <donaId.I.mcqueen@sargentlundy.com>

cc <FADY.S.GAIED@sargentlundy.com>, "Wolcott, James D"  
<jdwolcott@tva.gov>

bcc

Subject PUMP/FLOW COMBINATIONS FOR REVISION OF  
MULTIFLOW NPSH CALCULATION

Don,

Attached is a table specifying the revised analysis case conditions which we need to be addressed in your revision of calculation MDQ0999970046.

**Bill Eberly, PE**

Program Manager, Heat Cycle & BOP  
TVAN E&TS Staff  
423-751-8222  
Pager 40796



S&L Revised Pump Flow Cases.doc

**Pump/Flow Combinations for Revision to NPSH (MultiFlow) Calculation****Note 1 - All cases to be run at 0 containment overpressure condition**

| <b>LOCA Pump/Flow Combination</b>  | <b>Pool Temperature</b>     | <b>Event/Basis</b>  |
|--|-----------------------------|---|
| <b>LOCA-ST</b>   |                             |   |
| CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -10,500 gpm each<br>RHR B/D Pumps -11,500 gpm each                        | 95°F<br>155.4°F             | initial pool condition<br>10 minute ST peak   |
| CS Pumps A/B/C/D-4125gpm each<br>RHR A/C Pumps -11,500 gpm each<br>RHR B/D Pumps -10,500 gpm each                        | 95°F<br>155.4°F             | initial pool condition<br>10 minute ST peak   |
| <b>LOCA-LT</b>   |                             |   |
| Analyze the Same Pump/Flow<br>Combinations as Previous Revision<br>CS Pumps - 3125 gpm each<br>RHR Pumps - 6500 gpm each | 155.4°F<br>187.3°F<br>172°F | 10 minute ST peak, start LT<br>peak pool temperature<br>end of overpressure requirement           |
| <b>ATWS Pump/Flow Combination</b>  |                             |   |
| HPCI Pump Flow - 4500 gpm<br>RHR A/B/C/D Pumps - 6500 gpm  | 211°F<br>192°F<br>177°F     | peak pool temperature, no DW clrs<br>end of overpressure requirement<br>peak with DW clrs & TRACG |
| <b>Appendix R Pump/Flow Combination</b>  |                             |   |
| RHR Pump A-7200 gpm  | 223°F<br>191°F              | peak pool temperature, with DW clrs<br>end of overpressure requirement                            |
| RHR Pump B-7200 gpm  | 223°F<br>191°F              | peak pool temperature, with DW clrs<br>end of overpressure requirement                            |
| RHR Pump C-7200 gpm  | 223°F<br>191°F              | peak pool temperature, with DW clrs<br>end of overpressure requirement                            |
| RHR Pump D-7200 gpm  | 223°F<br>191°F              | peak pool temperature, with DW clrs<br>end of overpressure requirement                            |
| <b>SBO Pump/Flow Combination</b>   |                             |   |
| One RHR Pump (non-specific) - 6500 gpm   | 200°F<br>157°F              | peak pool temperature<br>overpressure is approximately 0 psig                                     |