ENCLOSURE 6

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNIT 1

CALCULATION MDQ0999970046
NPSH EVALUATION OF BROWNS FERRY RHR AND CS PUMPS

See attached.

QA Record

ORIGINAL

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

REV 0 EDMS/RIMS NO	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
R14981118108	calculations(nuclear)	R14 060314 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	MDQ0999970046	007	008	Entire calc ☒ Selected pages ☐
NEW	CN	NUC						

ACTION								No CCRIS Changes ☐ (For calc revision, CCRIS been reviewed and no CCRIS changes required)
	NEW ☐ REVISION ☒	DELETE ☐ RENAME ☐	SUPERSEDE ☐ DUPLICATE ☐	CCRIS UPDATE ONLY ☐ (Verifier Approval Signatures Not Required)				

UNITS	SYSTEMS	UNIDS
001, 002, 003	064 074 075	N/A

DCN,EDC,N/A	APPLICABLE DESIGN DOCUMENT(S)	CLASSIFICATION
N/A	N/A	E

QUALITY RELATED?	SAFETY RELATED? (If yes, QR = yes)	UNVERIFIED ASSUMPTION	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?	DESIGN OUTPUT ATTACHMENT?	SAR/TS and/or ISFSI SAR/CoC AFFECTED
Yes ☒ No ☐	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☒ No ☐ WJS 2/19/16

PREPARER ID	PREPARER PHONE NO	PREPARING ORG (BRANCH)	VERIFICATION METHOD	NEW METHOD OF ANALYSIS
Fady Gaied	1-312-269-6382	MEB	DESIGN REVIEW	☐ Yes ☒ No WJS 2/19/16

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
Fady Gaied	03-09-06	Chris Rennels	03-09-2006
VERIFIER SIGNATURE	DATE	APPROVAL SIGNATURE	DATE
Chris Rennels	03-09-2006		3/14/06

STATEMENT OF PROBLEM/ABSTRACT

Problem:

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:

This revision updates the calculation utilizing Multiflow and updated flow and temperatures for EPU, ATWS, Appendix R, and SBO conditions

MICROFICHE/EFICHE Yes ☒ No ☐ FICHE NUMBER(S) TVA-F-U001744, TVA-F-U001745, TVA-F-U001746

☐ LOAD INTO EDMS AND DESTROY

☒ LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY. ADDRESS:POB-1A-BFN

☐ LOAD INTO EDMS AND RETURN CALCULATION TO:

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	REV
	CN	NUC	BFN	MEB	MDQ0999970046	008

ALTERNATE CALCULATION IDENTIFICATION

BLDG	ROOM	ELEV	COORD/AZIM	FIRM	Print Report Yes ☐
01	N/A	N/A	N/A	S&L	

CATEGORIES N/A

KEY NOUNS (A-add, D-delete)

ACTION (A/D)	KEY NOUN	A/D	KEY NOUN

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

ACTION (A/C/D)	XREF CODE	XREF TYPE	XREF PLANT	XREF BRANCH	XREF NUMBER	XREF REV
A	P	DW	BFN	MEB	3-47W403-207	
A	P	DW	BFN	MEB	2-47W403-203	
A	P	DW	BFN	MEB	3-47W403-209	
A	P	DW	BFN	MEB	47W403-200	
A	P	DW	BFN	MEB	47W403-201	
A	P	DW	BFN	MEB	47W403-202	
A	P	GN	BFN	MEB	EPU TR T0611	
A	P	GN	BFN	MEB	EPU TR T0903	
A	P	DW	BFN	MEB	1-E20	
A	P	GN	BFN	MEB	EPU TR T0902	
A	P	TH	BFN	MEB	ANSI/HI 9.6.1-1998	
A	P	GN	BFN	MEB	E-mail 02/16/2006	

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. R14 060314 105		

TVAN COMPUTER INPUT FILE
STORAGE INFORMATION SHEET
Page 1 of 1

TVAN COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document MDQ0999970046	Rev. 8	Plant: BFN	

Subject:

NPSH Evaluation of Browns Ferry RHR and CS pumps For Extended Power Uprate

☐ Electronic storage of the input files for this calculation is not required. Comments:

☒ 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. 308140

☒ Microfiche/eFiche

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EDMS  reference number: TVA-F-U001744 (unit 1)
EDMS  reference number: TVA-F-U001745 (unit 2)
EDMS  reference number: TVA-F-U001746 (unit 3)
*
Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps
*
*              document type: CALCULATION OUTPUT(NUCLEAR)
*              document date: 2006-03-09
*              document identifier: mdq0999970046
*              facility : BFN Unit 0
*
*              keywords : ECCS, RHR, CS, NPSH
*              comments : Multiflow analysis
```

TVAN CALCULATION

Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps	REVISION LOG MD-Q0999-970046

Revision No.	DESCRIPTION OF REVISION	Date Approved
0	*INITIAL ISSUE.*	11-18-98
1	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. Pages added: Cover Sheet, page 1 Table 3, pages 3A and 3B Appendix 1: 2 EZFLOW file printouts (36 pages) Appendix 2: 2 EZFLOW file printouts (36 pages) Pages deleted: None Pages changed by this revision: 1A, 2, 5, 13, 14, Appendix 1 cover sheet, Appendix 2 cover sheet 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. Total pages Rev. 1: 352	04/14/99
2	Added evaluation of the potential for the ECCS strainers to ingest a steam plume/bubble from an MSRV T-quencher and its effects if ingested. This revision performed in response to BFPER 99-009146-000. Pages Added: A3-1 thru A3-3 Pages Revised: 1, 2, 6, 7, 11, 8 Pages Deleted: None Total Pages Rev 2: 355	

TVAN CALCULATION RECORD OF REVISION	
CALCULATION IDENTIFIER MD-Q0999-970046	Rev. 04
Title: NPSH EVALUATION OF BROWNS FERRY RHR AND CS PUMPS	

Revision No.	DESCRIPTION OF REVISION
3	This calculation was reviewed in light of the NRC memos granting BFN approval of containment over-pressure, 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 5500 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. 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. 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. 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. 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 ensured. 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. This calculation addresses the NPSH information obtained from the following calculations: MD-Q0075-870258 and MD-Q0074-870360. R4 This calculation supersedes the following calculations: MD-Q3999-970055, ND-Q0074-880119, ND-Q0999-880127, ND-Q2000-880135, ND-Q0999-880138, ND-Q0999-880140, ND-Q0074-880141, and ND-Q2999-940019. Pages added: 2A Pages revised: 5, 8, 13, 14, Table 3 Pages deleted: none Total Pages Rev 3: 355

005 BY DJK
CHKD: MEA

TVAN CALCULATION RECORD OF REVISION

CALCULATION IDENTIFIER MD-Q0999-970046	Rev. 04

Title

NPSH EVALUATION OF BROWNS FERRY RHR AND CS PUMPS

Revision No.	DESCRIPTION OF REVISION
04	Due to EPU, the peak suppression pool temperature has risen to 186.6° F @ 14,700 seconds. This revision assumes a over pressure of 3 psi for both short and long terms. Tables 4 & 5 were added to provide details of the calculation. Pages added: 1, 2, 4A, 5, 13 (Table 4), 14, 15 (Table 5), A-1, and A-2, B-1, B-2, & B-3 Pages revised: 4, 6, 8, and 11. Pages deleted: 1, 1A, 3, 4, and 5 Total Pages: ~~382~~ 365 NOTE THAT PAGE 4 FORMERLY CALLED PAGE 2A. 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. 6/19/02

005

TVAN CALCULATION RECORD OF REVISION

CALCULATION IDENTIFIER MDQ0999970046

Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps

Revision No.	DESCRIPTION OF REVISION
005	This revision updates the Unit 2/3 calculation to be applicable to Unit 1 for restart of Unit 1. Numbered Table 3 as Pages 15 through 29. Renumbered Table 4 from Page 13 to Page 30. Renumbered Table 5 from Pages 14 and 15 to Pages 31 and 32. Redesignated Attachment 2 as Attachment B. Pages added by this revision: 2B, 4B, Appendix 4 (8 pages), Attachment A (Pages A-3 & A-4), Attachment C (12 pages) Pages replaced by this revision: 1, 2, 5, 6 Pages deleted by this revision: None 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) Total Page Count: 390 The SAR and Tech. Spec. reviews will be performed in conjunction with the DCN package.
006	This revision adds the Unit 1 margin to the calculation. Pages added: Appendix 4 (4-9), Attachment A (Pages A-5, A-6 & A-7) Pages revised and replaced: 1, 2, 4B, 5, 6 Appendix 4 (4-2, 4-7, 4-8) Pages revised: 13 through 29 Pages deleted: 2B Total Page Count: 393 The SAR and Tech. Spec. reviews will be performed in conjunction with the DCN package.

TVAN CALCULATION RECORD OF REVISION

CALCULATION IDENTIFIER MDQ0999970046

Title NPSH Evaluation of Browns Ferry RHR and CS Pumps

Revision No.	DESCRIPTION OF REVISION
007	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) 97-04 and NRC Bulletin 96-03. Pages added: 4C, Appendix 5 (8 pages), Attachment A (Pages A-8 & A-9) Pages revised and replaced: 1, 2, & 5 *Pages revised: 8* Pages deleted: none Total Page Count: 404 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 license 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. Edward J. Rick Jr 1/12/04

TVAN CALCULATION VERIFICATION FORM

Calculation Identifier MDQ0999970046 Revision 007

Method of verification used:

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

Verifier Robert Williams Date 1/22/04

Comments:

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.

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

TVAN CALCULATION RECORD OF REVISION

CALCULATION IDENTIFIER MDQ0999970046

Title

NPSH EVALUATION OF BROWNS FERRY RHR AND CS PUMPS

Revision No.	DESCRIPTION OF REVISION
008	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. 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. 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. 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. 3/9/06 Pages added are: 2A, 5A, 5B and A10 Appendix D is added. Pages revised are: 1,2 and 7- 115 Appendices 1, 2, 4 and 5 are deleted. Attachment C is deleted. Total Page Count : 139

TVAN CALCULATION VERIFICATION FORM

Calculation Identifier MDQ0999970046 Revision 8

Method of verification used:

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

Verifier Chris Rennels Date 03-09-2006

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:	008

TABLE OF CONTENTS

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. Where necessary, suppression pool containment pressure necessary to meet the NPSH required is also determined.

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".

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 EPU Task Report T0902, "Anticipated Transient Without Scram", Rev. 2.

2.21 EPU Task Report T0611, "Appendix R Fire Protection", Rev. 0.

2.22 EPU Task Report T0903, "Station Blackout", Rev. 0.

2.23 ANSI/HI 9.6.1-1998, "American National Standard for Centrifugal and Vertical Pumps for NPSH Margin", Hydraulic Institute, 1998.

2.24 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)

2.25 STMFUNC, Steam Table Function Dynamic Link Library (DLL), Program No. 03.7.598-3.1.

See Appendix 3 for additional references.

3 DESIGN INPUT DATA

Input data required is derived from references shown above. The pump flow rates and fluid temperatures are taken from TVA correspondence (Ref. 2.24).

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 The minimum NPSHr at 10,000 gpm for the RHR pumps is 23.7 ft from Reference 2.2. Conservatively, this value is used for all RHR pumps with flow at 6500 gpm.

4.3 For bends with no angle and/or curvature information denoted on drawings, 90° short radius elbows are conservatively assumed.

4.4 HPCI and RCIC systems are assumed to not operate in a mode drawing suction from the torus ring header for all analyzed cases.

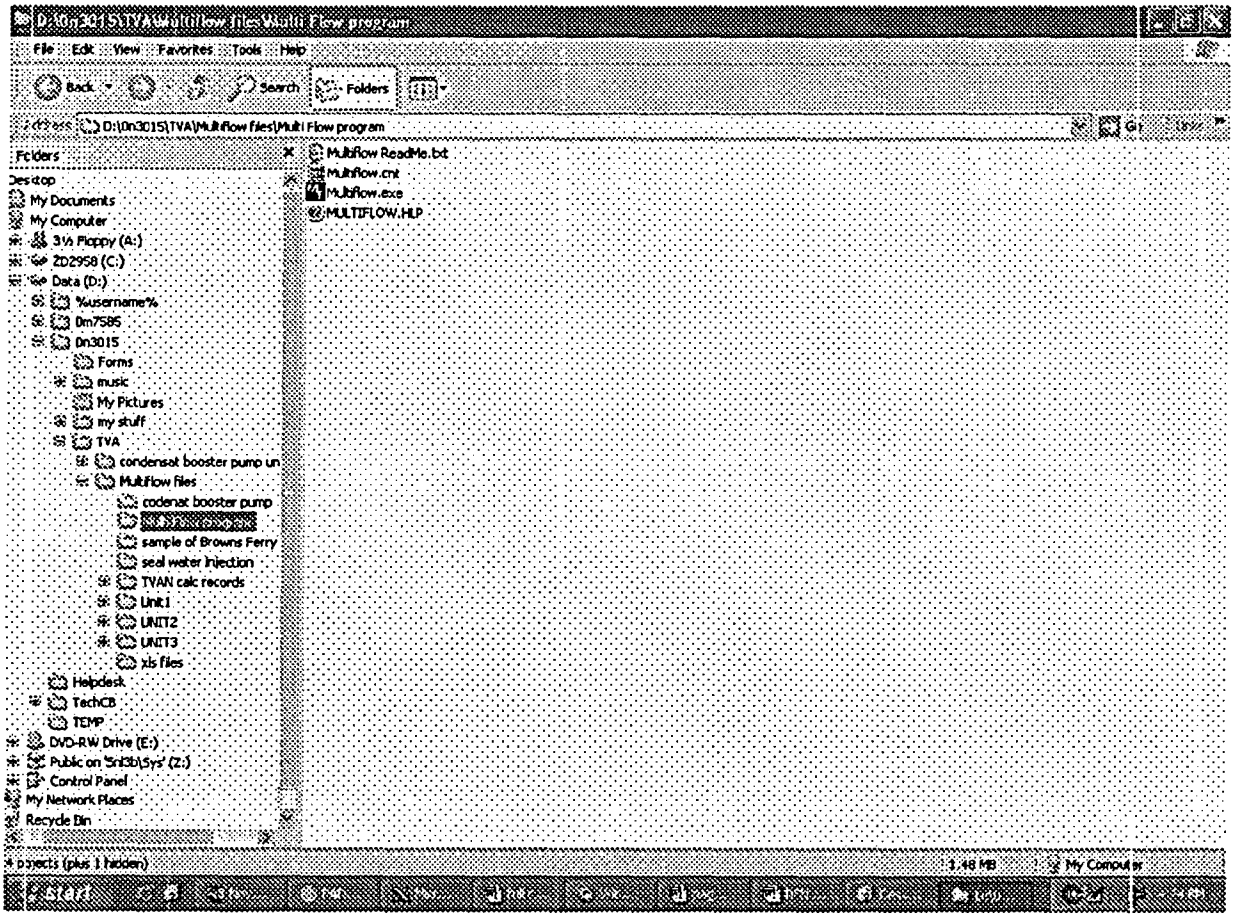
4.5 The effective strainer hydraulic loss is taken at the point of the ECCS piping flange for the strainer.

5 SPECIAL REQUIREMENTS/LIMITING CONDITIONS

None

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 E:\0N3015\TVA\Multiflow files\Multi Flow program



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.

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. NPSH margins are calculated for selected pump flow combinations and system maximum flow rates and suppression pool temperatures. The system operating conditions and modes of operations that are considered in this analysis are listed below.

Table 1: Temperature and Flow Rate Combinations

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

Per American Hydraulic Institute standards (Ref. 2.23), the required Net Positive Suction Head (NPSHr) 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. 2.23). The Net Positive Suction Head Required (NPSHr) for the RHR and CS pumps is determined from the vendor pump curves (Ref. 2.1 and 2.2). The difference between NPSHa and NPSHr is the NPSH margin.

The NPSHa is the actual fluid energy delivered to the pump impeller through the piping configuration and is calculated by the following equation (Ref. 2.3).

$NPSH_a = h_a + h_s - h_f - h_{vp}$ (Eq. 6.1)

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.

System design flow values for RHR and CS were taken from Reference 2.24. In the MultiFlow model the flow is represented in sgpm, requiring the conversion from gpm. The conversion is shown below.

$$\text{Flow (gpm)} * \frac{\text{Specific Volume of Water at standard Temp. and Pressure}}{\text{Specific Volume of Water at desired Temp. and Pressure}} = \text{Flow(sgpm)} \quad \text{(Eq 6.2)}$$

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.

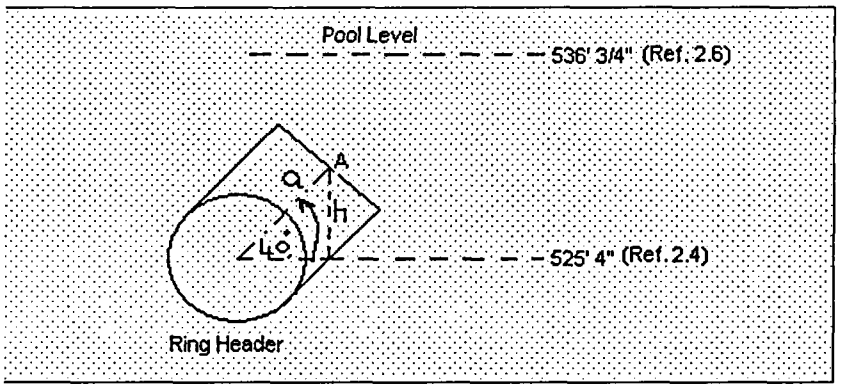
For the LOCA cases, in the MultiFlow model a pump component is used to model the strainer pressure drop as a function of the flow rate. Flows obtained from Reference 2.15 were converted to flow at standard conditions using Equation 6.2. Values of head loss at corresponding strainer flow rates taken from 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 2 depicts the head loss used to model the strainers as a function of flow. The values listed in Table 2 are linearly interpolated in Multiflow to obtain the system head loss.

Table 2: 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

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 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 Δp 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 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. 2.25).

$$\text{At } 95°\text{F},\ H_s = 8.446\,\text{ft} \times 62.05\frac{\text{lb}}{\text{ft}^3} \div 144\frac{\text{in}^2}{\text{ft}^2} = 3.639\,\text{psig} \qquad \text{(Eq. 6.2a)}$$

$$\text{At } 155.4°\text{F},\ H_s = 8.446\,\text{ft} \times 61.09\frac{\text{lb}}{\text{ft}^3} \div 144\frac{\text{in}^2}{\text{ft}^2} = 3.583\,\text{psig} \qquad \text{(Eq. 6.2b)}$$

$$\text{At } 166°\text{F},\ H_s = 8.446\,\text{ft} \times 60.88\frac{\text{lb}}{\text{ft}^3} \div 144\frac{\text{in}^2}{\text{ft}^2} = 3.570\,\text{psig} \qquad \text{(Eq. 6.2c)}$$

$$\text{At } 172°\text{F},\ H_s = 8.466\,\text{ft} \times 60.75\frac{\text{lb}}{\text{ft}^3} \div 144\frac{\text{in}^2}{\text{ft}^2} = 3.563\,\text{psig} \qquad \text{(Eq. 6.2d)}$$

$$\text{At } 187.3°\text{F},\ H_s = 8.446\,\text{ft} \times 60.42\frac{\text{lb}}{\text{ft}^3} \div 144\frac{\text{in}^2}{\text{ft}^2} = 3.544\,\text{psig} \qquad \text{(Eq. 6.2e)}$$

$$\text{At } 197.3^{\circ}\text{F}, H_s = 8.446\,\text{ft} \times 60.18\frac{\text{lb}}{\text{ft}^3} \div 144\frac{\text{in}^2}{\text{ft}^2} = 3.529\,\text{psig} \qquad \text{(Eq. 6.2f)}$$

$$\text{At } 214.6^{\circ}\text{F}, H_s = 8.446\,\text{ft} \times 59.76\frac{\text{lb}}{\text{ft}^3} \div 144\frac{\text{in}^2}{\text{ft}^2} = 3.505\,\text{psig} \qquad \text{(Eq. 6.2g)}$$

$$\text{At } 227^{\circ}\text{F}, H_s = 8.446\,\text{ft} \times 59.44\frac{\text{lb}}{\text{ft}^3} \div 144\frac{\text{in}^2}{\text{ft}^2} = 3.486\,\text{psig} \qquad \text{(Eq. 6.2h)}$$

The static elevation pressures at the ECCS piping flange points at corresponding system temperatures are summarized in Table 3.

Table 3: Strainer Pressure

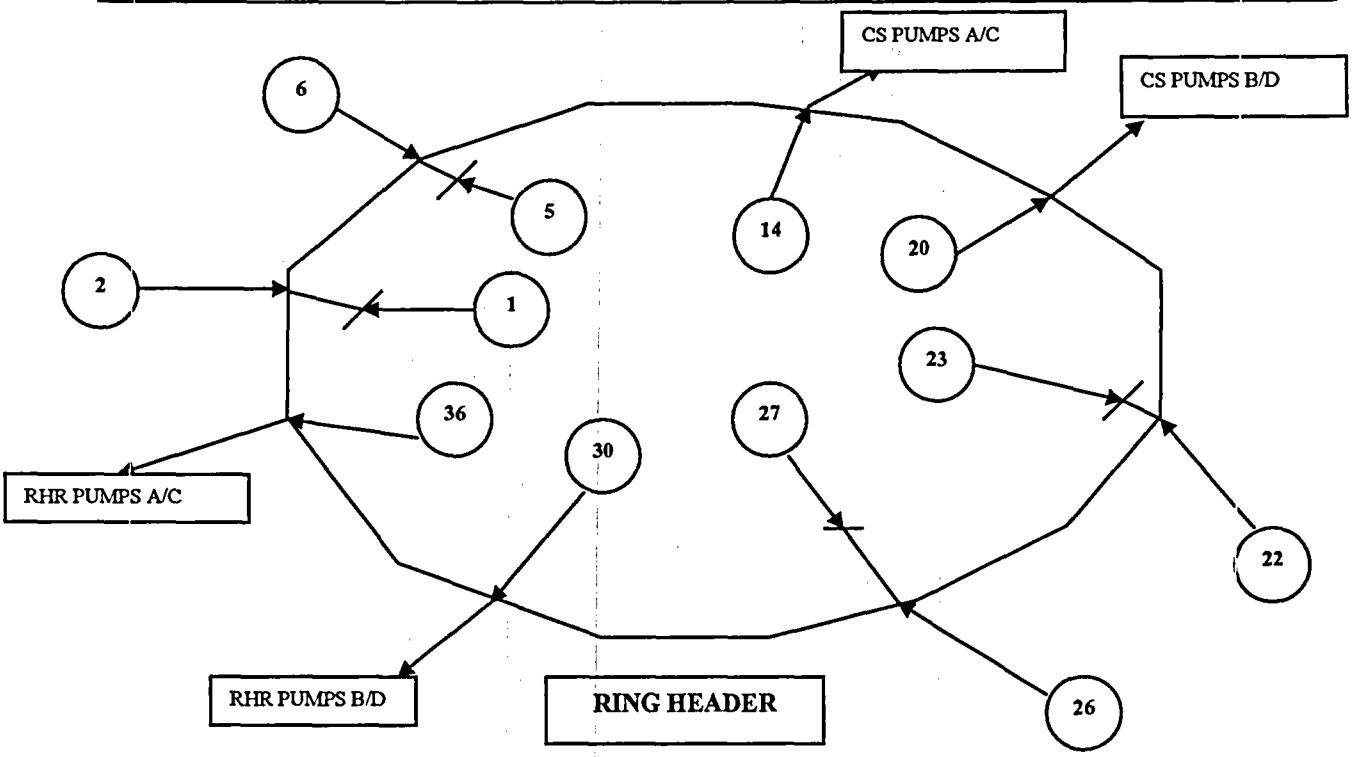
Temperature(°F)	Pressure (psig)
95.00	3.639
155.4	3.583
166.0	3.570
173.0	3.562
172.0	3.563
187.3	3.544
197.3	3.529
214.6	3.505
227.0	3.486

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. Reduction of these values by the specific pump required NPSH values from vendor pump curves (Ref. 2.1 and 2.2) results in the final NPSH margin for the pumps. [NPSHa = {H_a (value of pool pressure) + (H_s-H_f) (value of Multiflow pump suction pressure) – H_{vp} (correction for fluid vapor pressure)} X (psia to feet conversion factor)]. See Tables 7.1 through 7.24 for calculations of NPSHa and NPSH margin for Unit 1. See Tables 11.1 through 11.24 for calculations of NPSHa and NPSH margin for Unit 2. See Tables 14.1 through 14.24 for calculations of NPSHa and NPSH margin for Unit 3.

Flow conditions of the RHR and CS systems analyzed were

1) Maximum flow at a pool temperature of 95°F.
2) Maximum flow combinations at pool temperatures of 155.4°F and 166°F with no operational reduction.
3) Long term operation at the suppression pool design temperature limit of 187.3°F at design required system flow.
4) Maximum flow combinations at pool temperature where NPSHa is equal to NPSHr.
5) Flow conditions of RHR system analyzed at pool temperature of 214.6°F (ATWS, Ref. 2.20).
6) Flow conditions of RHR system analyzed at pool temperature of 227°F (Appendix R, Ref. 2.21).
7) Flow conditions of RHR system analyzed at pool temperature of 197.3°F (SBO, Ref. 2.22).

7 SUPPORTING GRAPHICS



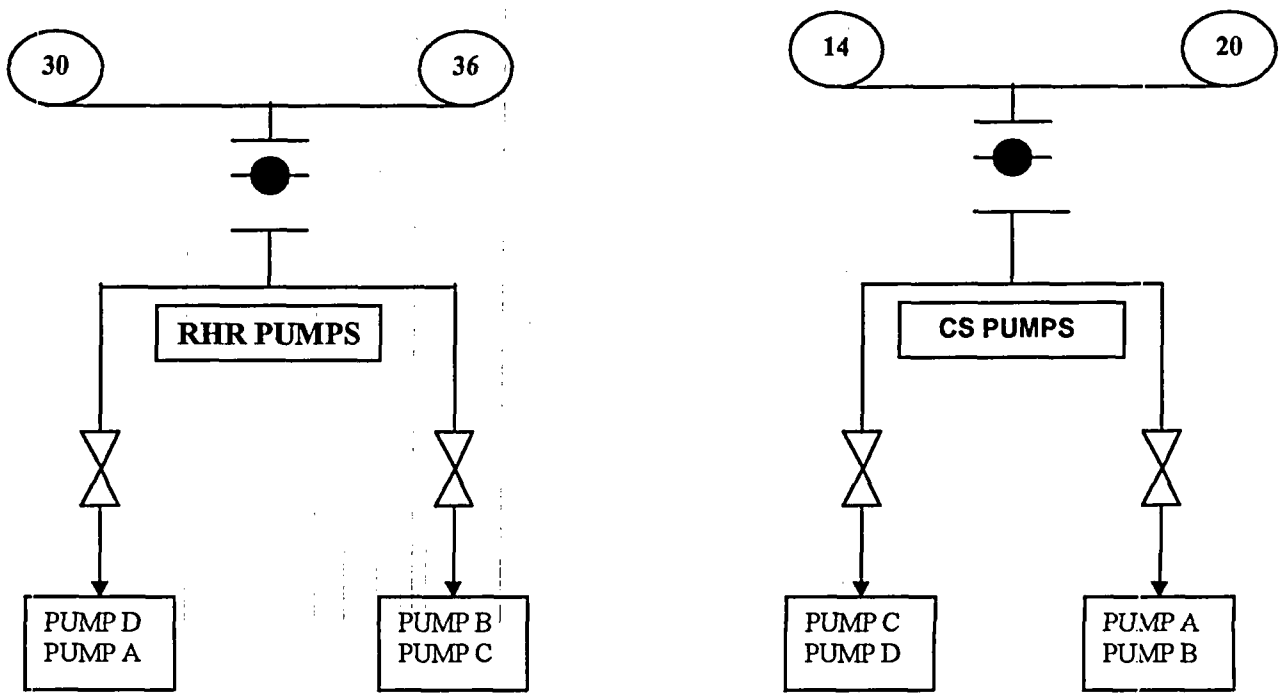


FIGURE 7.1
General MultiFlow Model

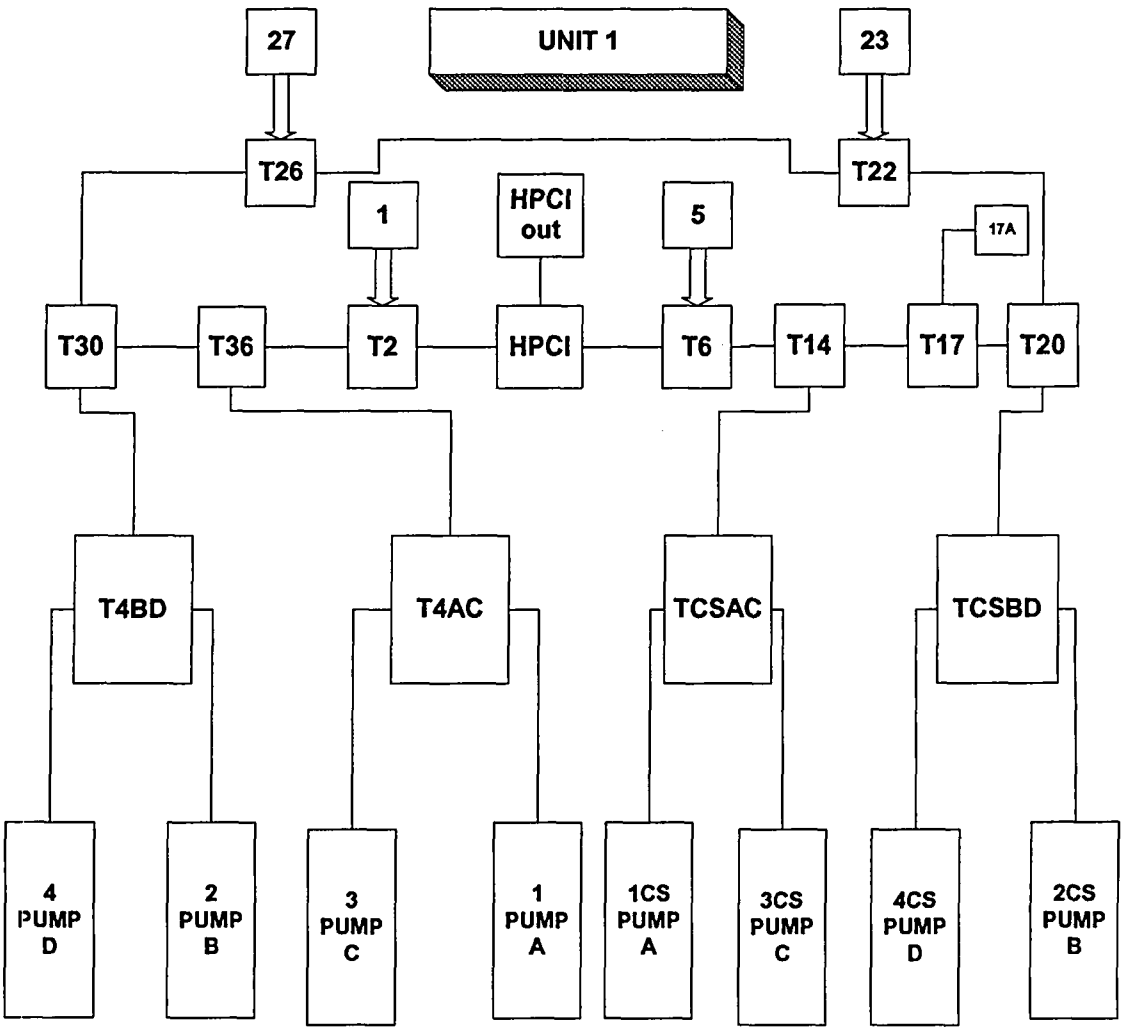


Figure 7.2 Unit 1 Nodal Diagram.

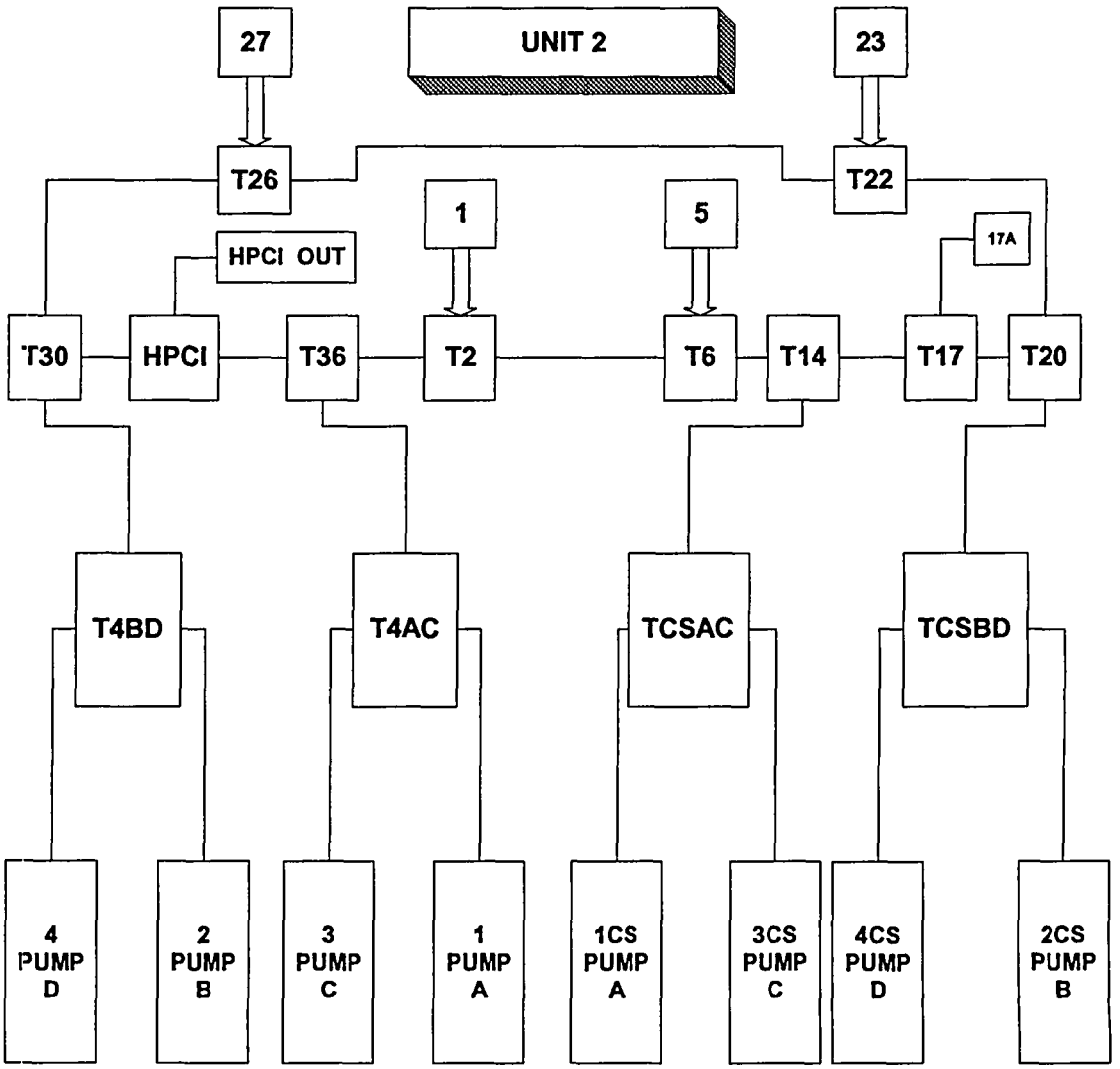


Figure 7.3 Unit 2 Nodal Diagram.

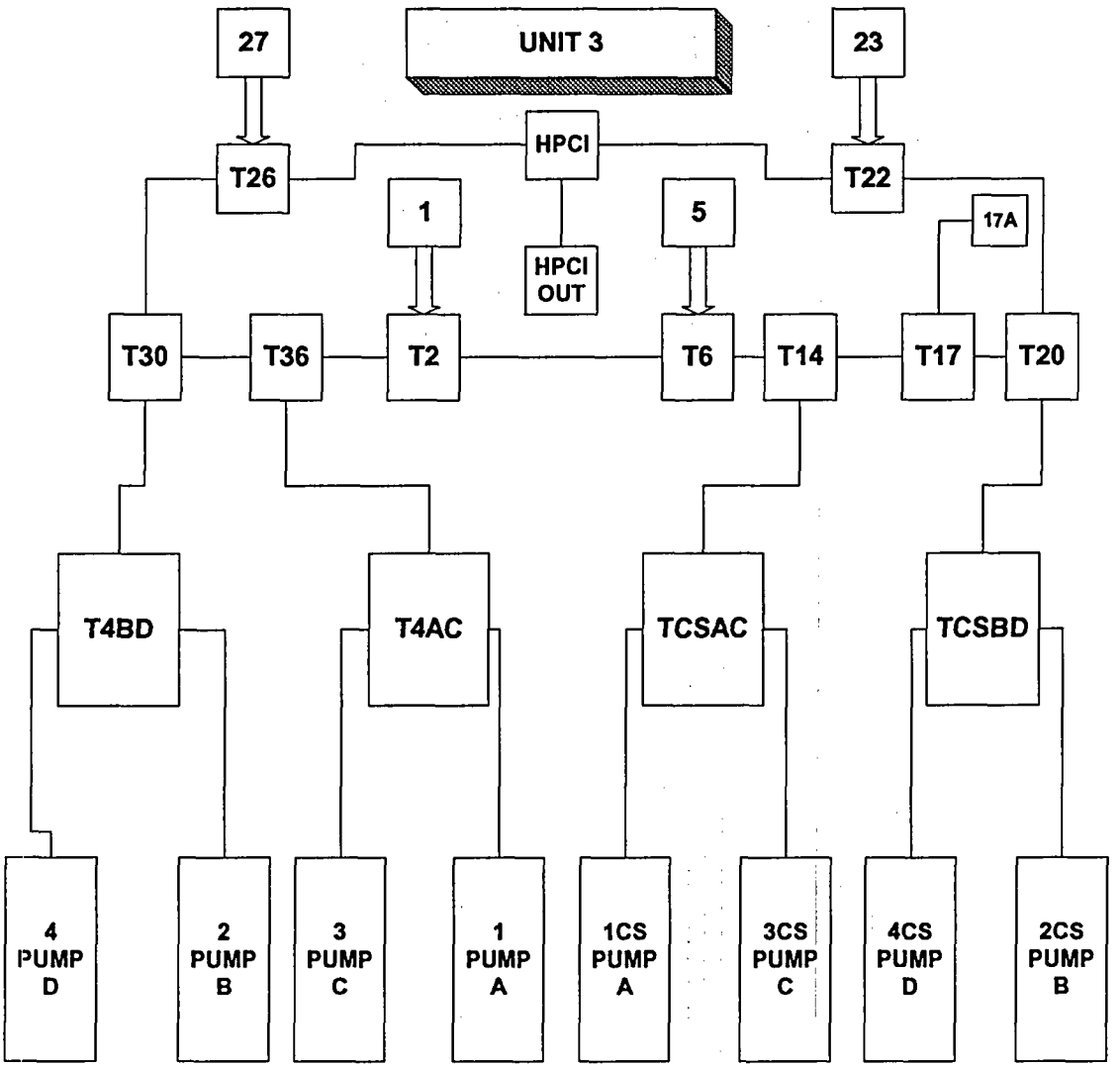
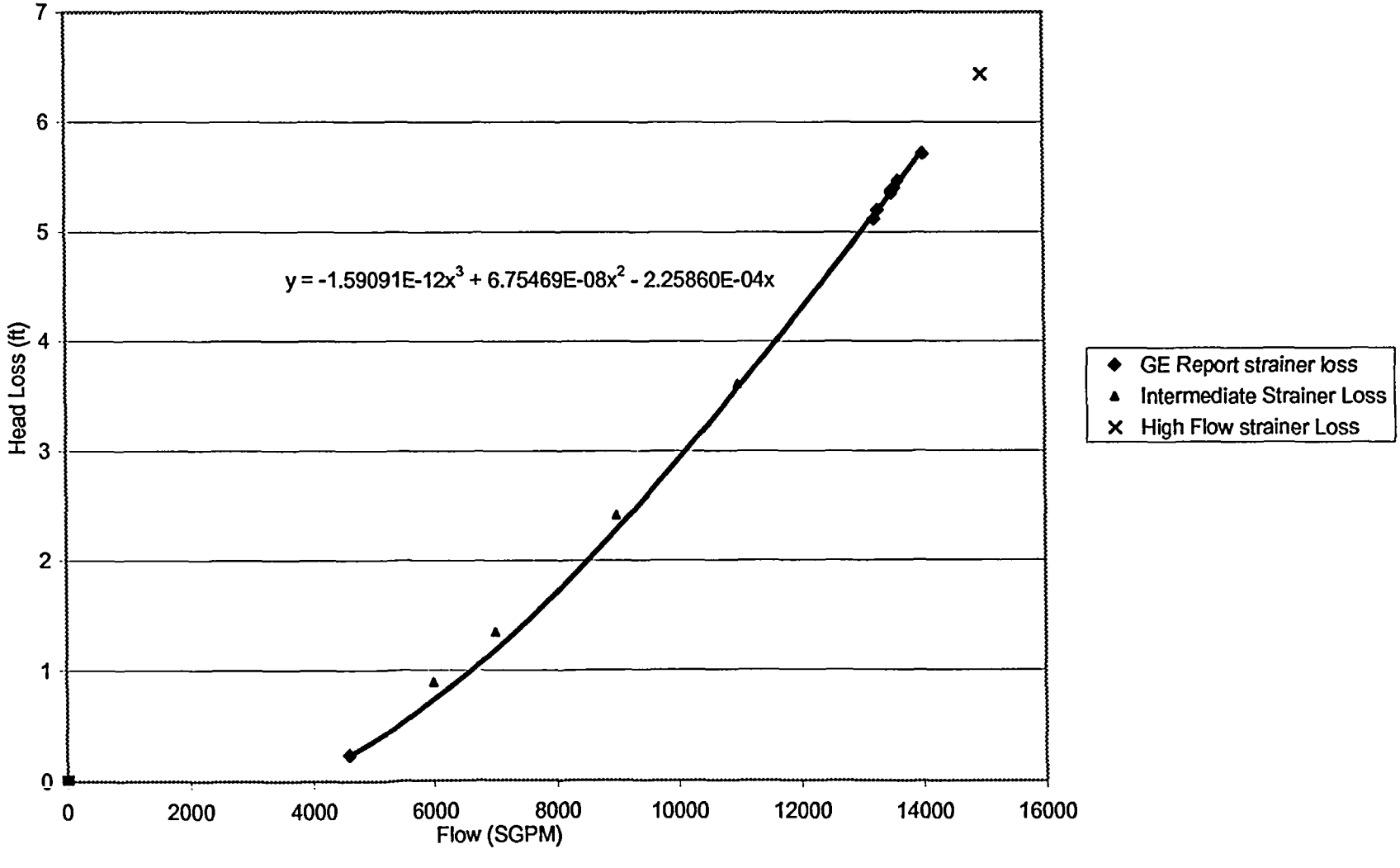


Figure 7.4 Unit 3 Nodal Diagram.

Figure 7.5: Strainer Head Loss Curve



8 RESULTS AND CONCLUSIONS

Summary values of pump NPSH margin are shown in Tables 6, 10 and 13 for Units 1, 2 and 3 respectively. In some cases overpressure is added to the normal atmospheric pool pressure (14.4 psia) to achieve the required NPSH. The pressures required to achieve BFN design basis desirable NPSH values are shown (Ref. 2.12) for each case in Tables 6, 10 and 13. The temperature determined at NPSHa = NPSHr is 172°F for all Units.

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.

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
214.6	0.01673	0.958300
227	0.01682	0.953197
197.3	0.01662	0.965060
166	0.01643	0.976166
187.3	0.01655	0.968770

Flow (gpm)	Flow (sgpm)							
	95	155.4	214.6	172	227	197.3	166	187.3
3125	3109	3061	2995	3044	2979	3016	3051	3027
4500	4478	4408	4312	4384	4289	4343	4393	4359
6500	6468	6367	6229	6332	6196	6273	6345	6297
10000	9950	9796	9583	9742	9532	9651	9762	9688
11000	10945	10775	10541	10716	10485	10616	10738	10656
14700	14627	14400	14087	14320	14012	14186	14350	14241

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(^{o}F)**	**V(ft^{3}/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			95	155.4	214.6	172	227	197.3	166	187.3
6	155.4	=vftsat_97(A6)	=B3/B6		3125	=E6*C4	=E6*C6	=E6*C7	=E6*C5	=E6*C8	=E6*C9	=E6*C10	=E6*C11
7	214.6	=vftsat_97(A7)	=B3/B7		4500	=E7*C4	=E7*C6	=E7*C7	=E7*C5	=E7*C8	=E7*C9	=E7*C10	=E7*C11
8	227	=vftsat_97(A8)	=B3/B8		6500	=E8*C4	=E8*C6	=E8*C7	=E8*C5	=E8*C8	=E8*C9	=E8*C10	=E8*C11
9	197.3	=vftsat_97(A9)	=B3/B9		10000	=E9*C4	=E9*C6	=E9*C7	=E9*C5	=E9*C8	=E9*C9	=E9*C10	=E9*C11
10	166	=vftsat_97(A10)	=B3/B10		11000	=E10*C4	=E10*C6	=E10*C7	=E10*C5	=E10*C8	=E10*C9	=E10*C10	=E10*C11
11	187.3	=vftsat_97(A11)	=B3/B11		14700	=E11*C4	=E11*C6	=E11*C7	=E11*C5	=E11*C8	=E11*C9	=E11*C10	=E11*C11
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)												

TABLE 6
Unit 1

LOCA Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
LOCA 1A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –10,000 gpm each RHR B/D Pumps –11,000 gpm each	@95°F	RHR/A	33.28	25.9	14.4	7.38
		RHR/B	32.33	30	14.4	2.33
		RHR/C	31.89	25.7	14.4	6.19
		RHR/D	33.91	29	14.4	4.91
		CS/A	34.75	27	14.4	7.75
		CS/B	36.93	27	14.4	9.93
		CS/C	36.73	27	14.4	9.73
		CS/D	35.13	27	14.4	8.13
LOCA 1B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –10,000 gpm each RHR B/D Pumps -11,000 gpm each	@155.4°F	RHR/A	31.07	25.9	16.7	5.17
		RHR/B	30.13	30	16.7	0.13
		RHR/C	29.68	25.7	16.7	3.98
		RHR/D	31.71	29	16.7	2.71
		CS/A	32.55	27	16.7	5.55
		CS/B	34.73	27	16.7	7.73
		CS/C	34.52	27	16.7	7.52
		CS/D	32.92	27	16.7	5.92
LOCA 2A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps –10,000 gpm each	@95°F	RHR/A	32.39	29	14.4	3.39
		RHR/B	33.50	26.4	14.4	7.10
		RHR/C	30.71	29	14.4	1.71
		RHR/D	34.80	25.8	14.4	9.00
		CS/A	34.72	27	14.4	7.72
		CS/B	36.90	27	14.4	9.90
		CS/C	36.70	27	14.4	9.70
		CS/D	35.10	27	14.4	8.10
LOCA 2B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps -10,000 gpm each	@155.4°F	RHR/A	31.18	29	17.0	2.18
		RHR/B	32.28	26.4	17.0	5.88
		RHR/C	29.50	29	17.0	0.50
		RHR/D	33.58	25.8	17.0	7.78
		CS/A	33.50	27	17.0	6.50
		CS/B	35.68	27	17.0	8.68
		CS/C	35.48	27	17.0	8.48
		CS/D	33.88	27	17.0	6.88
LOCA 3A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@155.4°F	RHR/A	35.92	23.7	14.4	12.22
		RHR/C	35.33	23.7	14.4	11.63
		CS/A	31.83	27	14.4	4.83
		CS/C	33.81	27	14.4	6.81

LOCA Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
LOCA 3B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	RHR/A	31.24	23.7	14.4	7.54
		RHR/C	30.65	23.7	14.4	6.95
		CS/A	27.15	27	14.4	0.15
		CS/C	29.13	27	14.4	2.13
LOCA 3C CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	RHR/A	31.25	23.7	16.9	7.55
		RHR/C	30.66	23.7	16.9	6.96
		CS/A	27.16	27	16.9	0.16
		CS/C	29.14	27	16.9	2.14
LOCA 4A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 each	@155.4°F	RHR/A	35.93	23.7	14.4	12.23
		RHR/C	35.34	23.7	14.4	11.64
		CS/B	33.70	27	14.4	6.70
		CS/D	31.89	27	14.4	4.89
LOCA 4B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	RHR/A	31.25	23.7	14.4	7.55
		RHR/C	30.66	23.7	14.4	6.96
		CS/B	29.02	27	14.4	2.02
		CS/D	27.21	27	14.4	0.21
LOCA 4C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	RHR/A	31.26	23.7	16.9	7.56
		RHR/C	30.67	23.7	16.9	6.97
		CS/B	29.03	27	16.9	2.03
		CS/D	27.22	27	16.9	0.22
LOCA 5A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	RHR/B	35.64	23.7	14.4	11.94
		RHR/D	36.19	23.7	14.4	12.49
		CS/B	33.67	27	14.4	6.67
		CS/D	31.87	27	14.4	4.87
LOCA 5B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	RHR/B	30.96	23.7	14.4	7.26
		RHR/D	31.51	23.7	14.4	7.81
		CS/B	28.99	27	14.4	1.99
		CS/D	27.19	27	14.4	0.19
LOCA 5C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	RHR/B	30.97	23.7	16.9	7.27
		RHR/D	31.52	23.7	16.9	7.82
		CS/B	29.01	27	16.9	2.01
		CS/D	27.20	27	16.9	0.20
LOCA 6A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	RHR/B	35.62	23.7	14.4	11.92
		RHR/D	36.17	23.7	14.4	12.47
		CS/A	31.87	27	14.4	4.87
		CS/C	33.85	27	14.4	6.85

LOCA Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
LOCA 6B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	RHR/B	30.94	23.7	14.4	7.24
		RHR/D	31.49	23.7	14.4	7.79
		CS/A	27.19	27	14.4	0.19
		CS/C	29.17	27	14.4	2.17
LOCA 6C CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	RHR/B	30.95	23.7	16.9	7.25
		RHR/D	31.50	23.7	16.9	7.80
		CS/A	27.20	27	16.9	0.20
		CS/C	29.18	27	16.9	2.18
LOCA 7 CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C/B/D Pumps-6500 gpm each	@166°F	RHR/A	30.75	23.7	14.4	7.05
		RHR/B	30.76	23.7	14.4	7.06
		RHR/C	30.17	23.7	14.4	6.47
		RHR/D	31.31	23.7	14.4	7.61
		CS/A	27.61	27	14.4	0.61
		CS/C	29.59	27	14.4	2.59

ATWS Pump/Flow Combination	Pool Temp.	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
ATWS RHR A/C/B/D Pumps-6500 gpm each CS Pumps A/C/B/D-0 gpm each	@214.6°F	RHR/A	24.48	23.7	21.0	0.78
		RHR/B	24.53	23.7	21.0	0.83
		RHR/C	23.90	23.7	21.0	0.20
		RHR/D	25.08	23.7	21.0	1.38
Appendix R Pump/Flow Combination	**Pool Temp.**	**Pump**	**NPSHa (ft)**	**NPSHr (ft)**	**Pressure (psia)**	**NPSH margin (ft)**
App-R A RHR Pump A-6500 gpm	@227°F	A	23.93	23.7	24.1	0.23
App-R B RHR Pump B-6500 gpm	@227°F	B	23.91	23.7	24.1	0.21
App-R C RHR Pump C-6500 gpm	@227°F	C	23.81	23.7	24.1	0.11
App-R D RHR Pump D-6500 gpm	@227°F	D	23.99	23.7	24.1	0.29
SBO Pump/Flow Combination	**Pool Temp**	**Pump**	**NPSHa (ft)**	**NPSHr (ft)**	**Pressure (psia)**	**NPSH margin (ft)**
SBO 1 A/C RHR Pump A/C-6500 gpm each	@197.3°F	A	24.44	23.7	16.0	0.74
		C	23.85	23.7	16.0	0.15
SBO 2 B/D RHR Pump B/D-6500 gpm each	@197.3°F	B	23.89	23.7	16.0	0.19
		D	24.44	23.7	16.0	0.74

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	0.757222	33.28	25.9	7.38
2PUMPB	0.350229	32.33	30	2.33
3PUMPC	0.159882	31.89	25.7	6.19
4PUMPD	1.02991	33.91	29	4.91
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	1.39134	34.75	27	7.75
2CSPUMPB	2.33064	36.93	27	9.93
3CSPUMPC	2.24387	36.73	27	9.73
4CSPUMPD	1.5537	35.13	27	8.13

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	16.7

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	0.732314	31.07	25.9	5.17
2PUMPB	0.332824	30.13	30	0.13
3PUMPC	0.143287	29.68	25.7	3.98
4PUMPD	1.00271	31.71	29	2.71
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	1.35744	32.55	27	5.55
2CSPUMPB	2.28199	34.73	27	7.73
3CSPUMPC	2.19655	34.52	27	7.52
4CSPUMPD	1.51634	32.92	27	5.92

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	0.373923	32.39	29	3.39
2PUMPB	0.850622	33.50	26.4	7.10
3PUMPC	-0.34906	30.71	29	1.71
4PUMPD	1.41222	34.80	25.8	9.00
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	1.37851	34.72	27	7.72
2CSPUMPB	2.31816	36.90	27	9.90
3CSPUMPC	2.23104	36.70	27	9.70
4CSPUMPD	1.54122	35.10	27	8.10

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	17

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	0.477709	31.18	29	2.18
2PUMPB	0.94292	32.28	26.4	5.88
3PUMPC	-0.23507	29.50	29	0.50
4PUMPD	1.49653	33.58	25.8	7.78
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	1.46104	33.50	27	6.50
2CSPUMPB	2.38859	35.68	27	8.68
3CSPUMPC	2.30015	35.48	27	8.48
4CSPUMPD	1.62294	33.88	27	6.88

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.08703	35.92	23.7	12.22
2PUMPB				
3PUMPC	4.83846	35.33	23.7	11.63
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.35325	31.83	27	4.83
2CSPUMPB				
3CSPUMPC	4.19236	33.81	27	6.81
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)**	**NPSHr (ft)**	**NPSH margin (ft)**	
1PUMPA	5.05889	31.24	23.7	7.54	
3PUMPC	4.81158	30.65	23.7	6.95	
RHR	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**	
1CSPUMPA	3.33511	27.15	27	0.15	
3CSPUMPC	4.16951	29.13	27	2.13	

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	16.9
RHR	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**	
1PUMPA	5.03185	31.25	23.7	7.55	
2PUMPB					
3PUMPC	4.78583	30.66	23.7	6.96	
4PUMPD					
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**	
1CSPUMPA	3.31809	27.16	27	0.16	
2CSPUMPB					
3CSPUMPC	4.14776	29.14	27	2.14	
4CSPUMPD					

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.09288	35.93	23.7	12.23
2PUMPB				
3PUMPC	4.84431	35.34	23.7	11.64
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.14542	33.70	27	6.70
3CSPUMPC				
4CSPUMPD	3.37977	31.89	27	4.89

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.06468	31.25	23.7	7.55
2PUMPB				
3PUMPC	4.81738	30.66	23.7	6.96
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.12286	29.02	27	2.02
3CSPUMPC				
4CSPUMPD	3.36135	27.21	27	0.21

Note 1:See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	16.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.0376	31.26	23.7	7.56
2PUMPB				
3PUMPC	4.79159	30.67	23.7	6.97
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.1014	29.03	27	2.03
3CSPUMPC				
4CSPUMPD	3.34408	27.22	27	0.22

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.97132	35.64	23.7	11.94
3PUMPC				
4PUMPD	5.205	36.19	23.7	12.49
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.13602	33.67	27	6.67
3CSPUMPC				
4CSPUMPD	3.37038	31.87	27	4.87

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.94375	30.96	23.7	7.26
3PUMPC				
4PUMPD	5.17623	31.51	23.7	7.81
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.11355	28.99	27	1.99
3CSPUMPC				
4CSPUMPD	3.35204	27.19	27	0.19

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	16.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.91731	30.97	23.7	7.27
3PUMPC				
4PUMPD	5.14856	31.52	23.7	7.82
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.09216	29.01	27	2.01
3CSPUMPC				
4CSPUMPD	3.33485	27.20	27	0.20

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.96227	35.62	23.7	11.92
3PUMPC				
4PUMPD	5.19595	36.17	23.7	12.47
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.37058	31.87	27	4.87
2CSPUMPB				
3CSPUMPC	4.20969	33.85	27	6.85
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)**	**NPSHr (ft)**	**NPSH margin (ft)**	
1PUMPA					
2PUMPB	4.93475	30.94	23.7	7.24	
3PUMPC					
4PUMPD	5.16723	31.49	23.7	7.79	
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**	
1CSPUMPA	3.3523	27.19	27	0.19	
2CSPUMPB					
3CSPUMPC	4.18671	29.17	27	2.17	
4CSPUMPD					

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	16.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.90836	30.95	23.7	7.25
3PUMPC				
4PUMPD	5.13961	31.50	23.7	7.80
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.33516	27.20	27	0.20
2CSPUMPB				
3CSPUMPC	4.16483	29.18	27	2.18
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 7.17: Unit 1 NPSH Calculations Case 7 166F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	4.07008	30.75	23.7	7.05
2PUMPB	4.07366	30.76	23.7	7.06
3PUMPC	3.82229	30.17	23.7	6.47
4PUMPD	4.30658	31.31	23.7	7.61
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	2.73989	27.61	27	0.61
2CSPUMPB				
3CSPUMPC	3.57642	29.59	27	2.59
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 7.18: Unit 1 NPSH Calculations ATWS 214.6F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head		
60	0.256389624	0.016034992	2.309038802		
214.6	15.4840075	0.016732744	2.409515179	Pool Press. (psia)	21

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
PUMPA	4.64472	24.48	23.7	0.78
PUMPB	4.66355	24.53	23.7	0.83
PUMPC	4.40126	23.90	23.7	0.20
PUMPD	4.89238	25.08	23.7	1.38

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 7.19: Unit 1 NPSH Calculations App-R A 227F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head		
60	0.256389624	0.016034992	2.309038802		
227	19.65726995	0.016822324	2.422414688	Pool Press. (psia)	24.1

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.43419	23.93	23.7	0.23
2PUMPB				
3PUMPC				
4PUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 7.20: 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		
227	19.65726995	0.016822324	2.422414688	Pool Press. (psia)	24.1

RHR	Pressure (psig) (ft)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMP'A				
2PUMP'B	5.42775	23.91	23.7	0.21
3PUMP'C				
4PUMP'D				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head		
60	0.256389624	0.016034992	2.309038802		
227	19.65726995	0.016822324	2.422414688	Pool Press. (psia)	24.1

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB				
3PUMPC	5.38615	23.81	23.7	0.11
4PUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 7.22: Unit 1 NPSH Calculations App-R D 227F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head		
60	0.256389624	0.016034992	2.309038802		
227	19.65726995	0.016822324	2.422414688	Pool Press. (psia)	24.1

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB				
3PUMPC				
4PUMPD	5.46124	23.99	23.7	0.29

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 7.23: Unit 1 NPSH Calculations Case SBO A-C 197.3F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head		
60	0.256389624	0.016034992	2.309038802		
197.3	10.90873195	0.016615541	2.392637845	Pool Press. (psia)	16

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.12276	24.44	23.7	0.74
2PUMPB				
3PUMPC	4.87763	23.85	23.7	0.15
4PUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 7.24: Unit 1 NPSH Calculations Case SBO B-D 197.3F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
197.3	10.908731950	0.016615541	2.392637845	Pool Press. (psia) 15.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.99429	23.89	23.7	0.19
3PUMPC				
4PUMPD	5.22469	24.44	23.7	0.74

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

	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(ft^3/lb)**	**psia to feet of head**						
4	60	=ptsat_97(60)	=vftsat_97(A4)	=C4*144						
5	95	=ptsat_97(A5)	=vftsat_97(A5)	=C5*144	**Pool Press. (psia)**	14.4				
6										
7	**RHR**	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**					
8	1PUMPA	0.757222	=(B8-B5+F5)*D5	25.9	=C8-D8					
9	2PUMPB	0.350229	=(B9-B5+F5)*D5	30	=C9-D9					
10	3PUMPC	0.159882	=(B10-B5+F5)*D5	25.7	=C10-D10					
11	4PUMPD	1.02991	=(B11-B5+F5)*D5	29	=C11-D11					
12	**CS**	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**					
13	1CSPUMPA	1.39134	=(B13-B5+F5)*D5	27	=C13-D13					
14	2CSPUMPB	2.33064	=(B14-B5+F5)*D5	27	=C14-D14					
15	3CSPUMPC	2.24387	=(B15-B5+F5)*D5	27	=C15-D15					
16	4CSPUMPD	1.5537	=(B16-B5+F5)*D5	27	=C16-D16					
17										
18	This table depicts the calculation of NPSHa (See cells in coumn 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 cell B5 (psia)) + pool pressure (See cell F5 (psia))] X conversion factor from psia to feet (See D5)									
24										
25	NPSH margin (See cells in column E under NPSH margin heading) is obtained by subtracting NPSHr (values determined from vendor pump curves (Ref. 2.1 and 2.2)) (See column D under NPSHr heading) from NPSHa (See column C under NPSHa heading).									
26										
27	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 cells C4 and C5)									
28										
29	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. 2.25) (See cells B4 and B5)									

TABLE 9
Unit 1

LOCA Pump/Flow Combination	Pool Temp	Strainer	Flow (sgpm)	Pressure Drop (psid)
LOCA 1A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –10,000 gpm each RHR B/D Pumps –11,000 gpm each	@95°F	Strainer 1	14464.2	2.5
		Strainer 23	13122.7	2.142
		Strainer 27	13502.9	2.317
		Strainer 5	13136.2	2.159
LOCA 1B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –10,000 gpm each RHR B/D Pumps -11,000 gpm each	@155.4°F	Strainer 1	14727.2	2.489
		Strainer 23	12931.8	2.127
		Strainer 27	13238.2	2.298
		Strainer 5	12943.8	2.142
LOCA 2A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps –10,000 gpm each	@95°F	Strainer 1	14499.5	2.528
		Strainer 23	13131.8	2.154
		Strainer 27	13448.4	2.326
		Strainer 5	13146.3	2.172
LOCA 2B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps -10,000 gpm each	@155.4°F	Strainer 1	13870.5	2.399
		Strainer 23	13199.5	2.012
		Strainer 27	13225.8	2.182
		Strainer 5	13090.1	2.038
LOCA 3A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@155.4°F	Strainer 1	4923.85	0.1765
		Strainer 23	4536.97	0.1043
		Strainer 27	4621.3	0.119
		Strainer 5	4773.88	0.1472
LOCA 3B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4896.25	0.1755
		Strainer 23	4512.32	0.1038
		Strainer 27	4596.07	0.1185
		Strainer 5	4747.36	0.1464
LOCA 3C CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	Strainer 1	4868.75	0.1745
		Strainer 23	4487.58	0.1033
		Strainer 27	4570.78	0.1179
		Strainer 5	4720.89	0.1456
LOCA 4A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 each	@155.4°F	Strainer 1	4861.33	0.1641
		Strainer 23	4616.42	0.1182
		Strainer 27	4695.98	0.1326
		Strainer 5	4682.26	0.1301
LOCA 4B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4834.22	0.1632
		Strainer 23	4591.07	0.1176
		Strainer 27	4670.16	0.1319
		Strainer 5	4656.55	0.1294

LOCA Pump/Flow Combination	Pool Temp	Strainer	Flow (sgpm)	Pressure Drop (psid)
LOCA 4C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	Strainer 1	4807.19	0.1623
		Strainer 23	4565.69	0.117
		Strainer 27	4644.31	0.1312
		Strainer 5	4630.81	0.1288
LOCA 5A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	Strainer 1	4669.87	0.1278
		Strainer 23	4757.96	0.1442
		Strainer 27	4868.9	0.1656
		Strainer 5	4559.26	0.1081
LOCA 5B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4644.41	0.1272
		Strainer 23	4731.46	0.1434
		Strainer 27	4841.57	0.1647
		Strainer 5	4534.56	0.1077
LOCA 5C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	Strainer 1	4618.88	0.1266
		Strainer 23	4705.02	0.1426
		Strainer 27	4814.34	0.1637
		Strainer 5	4509.75	0.1071
LOCA 6A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	Strainer 1	4743.94	0.1415
		Strainer 23	4665.05	0.1269
		Strainer 27	4795.96	0.1514
		Strainer 5	4651.04	0.1244
LOCA 6B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4717.9	0.1408
		Strainer 23	4639.35	0.1263
		Strainer 27	4769.18	0.1506
		Strainer 5	4625.57	0.1238
LOCA 6C CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	Strainer 1	4691.82	0.1401
		Strainer 23	4613.64	0.1256
		Strainer 27	4742.47	0.1497
		Strainer 5	4600.06	0.1231
LOCA 7 CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C/B/D Pumps-6500 gpm each	@166°F	Strainer 1	8339.61	0.8902
		Strainer 23	7506.83	0.6977
		Strainer 27	7849.45	0.7709
		Strainer 5	7786.11	0.7568

ATWS Pump/Flow Combination	Pool Temp.	Strainer	Flow (sgpm)	Pressure Drop (psid)
ATWS RHR A/C/B/D Pumps-6500 gpm each CS Pumps A/C/B/D-0 gpm each	@214.6°F	Strainer 1	8911.34	0.183
		Strainer 23	4111.41	0.039
		Strainer 27	7046.99	0.1145
		Strainer 5	4846.26	0.0541
Appendix R Pump/Flow Combination	**Pool Temp.**	**Strainer**	**Flow (sgpm)**	**Pressure Drop (psid)**
App-R A RHR Pump A-6500 gpm	@227°F	Strainer 1	2352.86	0.0128
		Strainer 23	998.736	0.0023
		Strainer 27	1641.59	0.0062
		Strainer 5	1202.82	0.0034
App-R B RHR Pump B-6500 gpm	@227°F	Strainer 1	1864.65	0.0081
		Strainer 23	1202.94	0.0034
		Strainer 27	2106.25	0.0103
		Strainer 5	1022.17	0.0024
App-R C RHR Pump C-6500 gpm	@227°F	Strainer 1	2352.86	0.0128
		Strainer 23	998.736	0.0023
		Strainer 27	1641.59	0.0062
		Strainer 5	1202.82	0.0034
App-R D RHR Pump D-6500 gpm	@227°F	Strainer 1	1864.65	0.0081
		Strainer 23	1202.94	0.0034
		Strainer 27	2106.25	0.0103
		Strainer 5	1022.17	0.0024
SBO Pump/Flow Combination	**Pool Temp**	**Strainer**	**Flow (sgpm)**	**Pressure Drop (psid)**
SBO 1 A/C RHR Pump A/C-6500 gpm each	@197.3°F	Strainer 1	4754.18	0.0517
		Strainer 23	2029.55	0.0094
		Strainer 27	3320.54	0.0252
		Strainer 5	2441.73	0.0136
SBO 2 B/D RHR Pump B/D-6500 gpm each	@197.3°F	Strainer 1	3775.42	0.0326
		Strainer 23	2443.47	0.0137
		Strainer 27	4250.71	0.0414
		Strainer 5	2076.4	0.0099

TABLE 10
Unit 2

LOCA Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
LOCA 1A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –10,000 gpm each RHR B/D Pumps –11,000 gpm each	@95°F	RHR/A	33.51	25.7	14.4	7.81
		RHR/B	32.51	29.0	14.4	3.51
		RHR/C	32.21	26.0	14.4	6.21
		RHR/D	34.07	28.0	14.4	6.07
		CS/A	34.88	27.0	14.4	7.88
		CS/B	37.06	27.0	14.4	10.06
		CS/C	36.86	27.0	14.4	9.86
		CS/D	35.26	27.0	14.4	8.26
LOCA 1B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –10,000 gpm each RHR B/D Pumps –11,000 gpm each	@155.4°F	RHR/A	30.11	25.7	16.2	4.41
		RHR/B	29.12	29.0	16.2	0.12
		RHR/C	28.81	26.0	16.2	2.81
		RHR/D	30.67	28.0	16.2	2.67
		CS/A	31.49	27.0	16.2	4.49
		CS/B	33.68	27.0	16.2	6.68
		CS/C	33.47	27.0	16.2	6.47
		CS/D	31.88	27.0	16.2	4.88
LOCA 2A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps –10,000 gpm each	@95°F	RHR/A	32.54	29.0	14.4.	3.54
		RHR/B	33.60	26.0	14.4	7.60
		RHR/C	30.97	30.0	14.4	0.97
		RHR/D	34.88	24.4	14.4	10.48
		CS/A	34.77	27.0	14.4	7.77
		CS/B	36.95	27.0	14.4	9.95
		CS/C	36.75	27.0	14.4	9.75
		CS/D	35.14	27.0	14.4	8.14
LOCA 2B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps –10,000 gpm each	@155.4°F	RHR/A	31.67	29.0	17.2	2.67
		RHR/B	32.72	26.0	17.2	6.72
		RHR/C	30.09	30.0	17.2	0.09
		RHR/D	34.01	24.4	17.2	9.61
		CS/A	33.89	27.0	17.2	6.89
		CS/B	36.07	27.0	17.2	9.07
		CS/C	35.87	27.0	17.2	8.87
		CS/D	34.27	27.0	17.2	7.27
LOCA 3A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@155.4°F	RHR/A	35.93	23.7	14.4	12.23
		RHR/C	35.38	23.7	14.4	11.68
		CS/A	31.83	27.0	14.4	4.83
		CS/C	33.81	27.0	14.4	6.81

LOCA Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
LOCA 3B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	RHR/A	31.25	23.7	14.4	7.55
		RHR/C	30.70	23.7	14.4	7.00
		CS/A	27.15	27.0	14.4	0.15
		CS/C	29.13	27.0	14.4	2.13
LOCA 3C CS Pumps A/C-3125gpm each, B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	RHR/A	31.26	23.7	16.9	7.56
		RHR/C	30.71	23.7	16.9	7.01
		CS/A	27.16	27.0	16.9	0.16
		CS/C	29.14	27.0	16.9	2.14
LOCA 4A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 each	@155.4°F	RHR/A	35.94	23.7	14.4	12.24
		RHR/C	35.39	23.7	14.4	11.69
		CS/B	33.70	27.0	14.4	6.70
		CS/D	31.90	27.0	14.4	4.90
LOCA 4B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	RHR/A	31.26	23.7	14.4	7.56
		RHR/C	30.71	23.7	14.4	7.01
		CS/B	29.02	27.0	14.4	2.02
		CS/D	27.22	27.0	14.4	0.22
LOCA 4C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	RHR/A	31.27	23.7	16.9	7.57
		RHR/C	30.72	23.7	16.9	7.02
		CS/B	29.03	27.0	16.9	2.03
		CS/D	27.23	27.0	16.9	0.23
LOCA 5A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	RHR/B	35.65	23.7	14.4	11.95
		RHR/D	36.20	23.7	14.4	12.50
		CS/B	33.68	27.0	14.4	6.68
		CS/D	31.87	27.0	14.4	4.87
LOCA 5B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	RHR/B	30.97	23.7	14.4	7.27
		RHR/D	31.52	23.7	14.4	7.82
		CS/B	29.00	27.0	14.4	2.00
		CS/D	27.19	27.0	14.4	0.19
LOCA 5C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	RHR/B	30.98	23.7	16.9	7.28
		RHR/D	31.53	23.7	16.9	7.83
		CS/B	29.01	27.0	16.9	2.01
		CS/D	27.20	27.0	16.9	0.20
LOCA 6A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	RHR/B	35.63	23.7	14.4	11.93
		RHR/D	36.18	23.7	14.4	12.48
		CS/A	31.87	27.0	14.4	4.87
		CS/C	33.85	27.0	14.4	6.85

LOCA Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
LOCA 6B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	RHR/B	30.95	23.7	14.4	7.25
		RHR/D	31.49	23.7	14.4	7.79
		CS/A	27.19	27.0	14.4	0.19
		CS/C	29.17	27.0	14.4	2.17
LOCA 6C CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	RHR/B	30.96	23.7	16.9	7.26
		RHR/D	31.51	23.7	16.9	7.81
		CS/A	27.20	27.0	16.9	0.20
		CS/C	29.18	27.0	16.9	2.18
LOCA 7 CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C/B/D Pumps-6500 gpm each	@166°F	RHR/A	30.81	23.7	14.4	7.11
		RHR/B	30.80	23.7	14.4	7.10
		RHR/C	30.26	23.7	14.4	6.56
		RHR/D	31.35	23.7	14.4	7.65
		CS/A	27.61	27.0	14.4	0.61
		CS/C	29.59	27.0	14.4	2.59

ATWS Pump/Flow Combination	Pool Temp.	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
ATWS RHR A/C/B/D Pumps-6500 gpm each CS Pumps A/C/B/D-0 gpm each	@214.6°F	RHR/A	24.55	23.7	21.0	0.85
		RHR/B	24.57	23.7	21.0	0.87
		RHR/C	24.00	23.7	21.0	0 30
		RHR/D	25.11	23.7	21.0	1.41
Appendix R Pump/Flow Combination	**Pool Temp.**	**Pump**	**NPSHa (ft)**	**NPSHr (ft)**	**Pressure (psia)**	**NPSH margin (ft)**
App-R A RHR Pump A-6500 gpm	@227°F	A	23.93	23.7	24.1	0.23
App-R B RHR Pump B-6500 gpm	@227°F	B	23.91	23.7	24.1	0.21
App-R C RHR Pump C-6500 gpm	@227°F	C	23.85	23.7	24.1	0.15
App-R D RHR Pump D-6500 gpm	@227°F	D	23.99	23.7	24.1	0.29
SBO Pump/Flow Combination	**Pool Temp**	**Pump**	**NPSHa (ft)**	**NPSHr (ft)**	**Pressure (psia)**	**NPSH margin (ft)**
SBO 1 A/C RHR Pump A/C-6500 gpm each	@197.3°F	A	24.45	23.7	16.0	0.75
		C	23.90	23.7	16.0	0.20
SBO 2 B/D RHR Pump B/D-6500 gpm each	@197.3°F	B	23.90	23.7	15.9	0.20
		D	24.44	23.7	15.9	0.74

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	0.8557	33.51	25.7	7.81
2PUMPB	0.4278	32.51	29	3.51
3PUMPC	0.2945	32.21	26	6.21
4PUMPD	1.0980	34.07	28	6.07
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	1.4476	34.88	27	7.88
2CSPUMPB	2.3860	37.06	27	10.06
3CSPUMPC	2.3008	36.86	27	9.86
4CSPUMPD	1.6090	35.26	27	8.26

Note 1:See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	16.2
RHR	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**	
1PUMPA	0.8239	30.11	25.7	4.41	
2PUMPB	0.4022	29.12	29	0.12	
3PUMPC	0.2707	28.81	26	2.81	
4PUMPD	1.0630	30.67	28	2.67	
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**	
1CSPUMPA	1.4106	31.49	27	4.49	
2CSPUMPB	2.3385	33.68	27	6.68	
3CSPUMPC	2.2503	33.47	27	6.47	
4CSPUMPD	1.5728	31.88	27	4.88	

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	0.4393	32.54	29	3.54
2PUMPB	0.8944	33.60	26	7.60
3PUMPC	-0.2399	30.97	30	0.97
4PUMPD	1.4481	34.88	24.4	10.48
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	1.3999	34.77	27	7.77
2CSPUMPB	2.3371	36.95	27	9.95
3CSPUMPC	2.2531	36.75	27	9.75
4CSPUMPD	1.5602	35.14	27	8.14

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	17.2

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	0.4860	31.67	29	2.67
2PUMPB	0.9305	32.72	26	6.72
3PUMPC	-0.1834	30.09	30	0.09
4PUMPD	1.4766	34.01	24.4	9.61
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	1.4290	33.89	27	6.89
2CSPUMPB	2.3531	36.07	27	9.07
3CSPUMPC	2.2687	35.87	27	8.87
4CSPUMPD	1.5875	34.27	27	7.27

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.0929	35.93	23.7	12.23
2PUMPB				
3PUMPC	4.8594	35.38	23.7	11.68
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.3527	31.83	27	4.83
2CSPUMPB				
3CSPUMPC	4.1924	33.81	27	6.81
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.0647	31.25	23.7	7.55
2PUMPB				
3PUMPC	4.8324	30.70	23.7	7.00
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.3346	27.15	27	0.15
2CSPUMPB				
3CSPUMPC	4.1696	29.13	27	2.13
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	16.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.0376	31.26	23.7	7.56
2PUMPB				
3PUMPC	4.8065	30.71	23.7	7.01
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.3175	27.16	27	0.16
2CSPUMPB				
3CSPUMPC	4.1478	29.14	27	2.14
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.0991	35.94	23.7	12.24
2PUMPB				
3PUMPC	4.8656	35.39	23.7	11.69
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.1471	33.70	27	6.70
3CSPUMPC				
4CSPUMPD	3.38145	31.90	27	4.90

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.0708	31.26	23.7	7.56
2PUMPB				
3PUMPC	4.8385	30.71	23.7	7.01
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.1245	29.02	27	2.02
3CSPUMPC				
4CSPUMPD	3.36302	27.22	27	0.22

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	16.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.0437	31.27	23.7	7.57
2PUMPB				
3PUMPC	4.8126	30.72	23.7	7.02
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.1031	29.03	27	2.03
3CSPUMPC				
4CSPUMPD	3.34574	27.23	27	0.23

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.9760	35.65	23.7	11.95
3PUMPC				
4PUMPD	5.2064	36.20	23.7	12.50
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.1375	33.68	27	6.68
3CSPUMPC				
4CSPUMPD	3.37187	31.87	27	4.87

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.9484	30.97	23.7	7.27
3PUMPC				
4PUMPD	5.1777	31.52	23.7	7.82
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.1150	29.00	27	2.00
3CSPUMPC				
4CSPUMPD	3.35352	27.19	27	0.19

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	16.9

CS	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.9220	30.98	23.7	7.28
3PUMPC				
4PUMPD	5.1500	31.53	23.7	7.83
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.0936	29.01	27	2.01
3CSPUMPC				
4CSPUMPD	3.33632	27.20	27	0.20

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.9665	35.63	23.7	11.93
3PUMPC				
4PUMPD	5.1969	36.18	23.7	12.48
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.3714	31.87	27	4.87
2CSPUMPB				
3CSPUMPC	4.2111	33.85	27	6.85
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.9390	30.95	23.7	7.25
3PUMPC				
4PUMPD	5.1682	31.49	23.7	7.79
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.3531	27.19	27	0.19
2CSPUMPB				
3CSPUMPC	4.1881	29.17	27	2.17
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)** 16.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.9126	30.96	23.7	7.26
3PUMPC				
4PUMPD	5.1406	31.51	23.7	7.81
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.3360	27.20	27	0.20
2CSPUMPB				
3CSPUMPC	4.1662	29.18	27	2.18
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 11.17: Unit 2 NPSH Calculations Case 7 166F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	4.0924	30.81	23.7	7.11
2PUMPB	4.0911	30.80	23.7	7.10
3PUMPC	3.8597	30.26	23.7	6.56
4PUMPD	4.3208	31.35	23.7	7.65
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	2.7421	27.61	27	0.61
2CSPUMPB				
3CSPUMPC	3.5792	29.59	27	2.59
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 11.18: Unit 2 NPSH Calculations ATWS 214.6F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head		
60	0.256389624	0.016034992	2.309038802		
214.6	15.4840075	0.016732744	2.409515179	Pool Press. (psia)	21

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
PUMPA	4.6737	24.55	23.7	0.85
PUMPB	4.6813	24.57	23.7	0.87
PUMPC	4.4451	24.00	23.7	0.30
PUMPD	4.9070	25.11	23.7	1.41

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 11.19: Unit 2 NPSH Calculations App-R A 227F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head		
60	0.256389624	0.016034992	2.309038802		
227	19.65726995	0.016822324	2.422414688	Pool Press. (psia)	24.1

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.4375	23.93	23.7	0.23
2PUMPB				
3PUMPC				
4PUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 11.20: Unit 2 NPSH Calculations App-R B 227F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
227	19.65726995	0.016822324	2.422414688	Pool Press. (psia) 24.1

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	5.4287	23.91	23.7	0.21
3PUMPC				
4PUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 11.21: Unit 2 NPSH Calculations App-R C 227F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
227	19.65726995	0.016822324	2.422414688	Pool Press. (psia) 24.1

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB				
3PUMPC	5.4042	23.85	23.7	0.15
4PUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 11.22: Unit 2 NPSH Calculations App-R D 227F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
227	19.65726995	0.016822324	2.422414688	**Pool Press. (psia)** 24.1

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB				
3PUMPC				
4PUMPD	5.4591	23.99	23.7	0.29

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 11.23: Unit 2 NPSH Calculations SBO A-C 197.3F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
197.3	10.90873195	0.016615541	2.392637845	Pool Press. (psia) 16

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.1289	24.45	23.7	0.75
2PUMPB				
3PUMPC	4.8986	23.90	23.7	0.20
4PUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 11.24: Unit 2 NPSH Calculations SBO B-D 197.3F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
197.3	10.90873195	0.016615541	2.392637845	Pool Press. (psia) 15.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.9975	23.90	23.7	0.20
3PUMPC				
4PUMPD	5.2248	24.44	23.7	0.74

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

TABLE 12
Unit 2

LOCA Pump/Flow Combination	Pool Temp	Strainer	Flow (sgpm)	Pressure Drop (psid)
LOCA 1A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –10,000 gpm each RHR B/D Pumps –11,000 gpm each	@95°F	Strainer 1	14272.5	2.451
		Strainer 23	13418.6	2.089
		Strainer 27	13444.5	2.289
		Strainer 5	13090.4	2.104
LOCA 1B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –10,000 gpm each RHR B/D Pumps -11,000 gpm each	@155.4°F	Strainer 1	14131	2.434
		Strainer 23	12895.5	2.083
		Strainer 27	13290.3	2.276
		Strainer 5	13069.3	2.099
LOCA 2A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps –10,000 gpm each	@95°F	Strainer 1	14428.6	2.498
		Strainer 23	13122	2.142
		Strainer 27	13545	2.336
		Strainer 5	13130.4	2.152
LOCA 2B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps -10,000 gpm each	@155.4°F	Strainer 1	13734	2.426
		Strainer 23	13208	2.057
		Strainer 27	13233	2.25
		Strainer 5	13210.6	2.072
LOCA 3A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@155.4°F	Strainer 1	4906.49	0.173
		Strainer 23	4554.8	0.1073
		Strainer 27	4642.08	0.1228
		Strainer 5	4752.64	0.1432
LOCA 3B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4878.95	0.1721
		Strainer 23	4530.07	0.1069
		Strainer 27	4616.77	0.1222
		Strainer 5	4726.21	0.1424
LOCA 3C CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	Strainer 1	4851.52	0.1711
		Strainer 23	4505.26	0.1064
		Strainer 27	4591.39	0.1216
		Strainer 5	4699.83	0.1416
LOCA 4A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 each	@155.4°F	Strainer 1	4834.86	0.159
		Strainer 23	4649.62	0.1241
		Strainer 27	4730.9	0.1391
		Strainer 5	4640.62	0.1225
LOCA 4B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4807.85	0.1581
		Strainer 23	4624.13	0.1235
		Strainer 27	4704.94	0.1384
		Strainer 5	4615.09	0.1219

LOCA Pump/Flow Combination	Pool Temp	Strainer	Flow (sgpm)	Pressure Drop (psid)
LOCA 4C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	Strainer 1	4780.92	0.1572
		Strainer 23	4598.6	0.1229
		Strainer 27	4678.94	0.1377
		Strainer 5	4589.54	0.1212
LOCA 5A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	Strainer 1	4641.86	0.1227
		Strainer 23	4785.4	0.1494
		Strainer 27	4901.46	0.172
		Strainer 5	4527.29	0.1026
LOCA 5B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4616.51	0.1221
		Strainer 23	4758.78	0.1486
		Strainer 27	4873.98	0.1711
		Strainer 5	4502.73	0.1022
LOCA 5C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	Strainer 1	4591.11	0.1215
		Strainer 23	4732.21	0.1478
		Strainer 27	4846.6	0.1701
		Strainer 5	4478.08	0.1017
LOCA 6A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	Strainer 1	4723.27	0.1377
		Strainer 23	4678.05	0.1293
		Strainer 27	4823.48	0.1567
		Strainer 5	4631.2	0.1208
LOCA 6B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4697.33	0.137
		Strainer 23	4652.29	0.1287
		Strainer 27	4796.54	0.1559
		Strainer 5	4605.83	0.1202
LOCA 6C CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	Strainer 1	4671.37	0.1363
		Strainer 23	4626.52	0.128
		Strainer 27	4769.68	0.155
		Strainer 5	4580.42	0.1196
LOCA 7 CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C/B/D Pumps-6500 gpm each	@166°F	Strainer 1	8281.33	0.8749
		Strainer 23	7547.79	0.7061
		Strainer 27	7931.33	0.7895
		Strainer 5	7721.55	0.7428

ATWS Pump/Flow Combination	Pool Temp.	Strainer	Flow (sgpm)	Pressure Drop (psid)
ATWS RHR A/C/B/D Pumps-6500 gpm each CS Pumps A/C/B/D-0 gpm each	@214.6°F	Strainer 1	8741.02	0.1761
		Strainer 23	4051.77	0.0378
		Strainer 27	7351.21	0.1246
		Strainer 5	4771.99	0.0525
Appendix R Pump/Flow Combination	**Pool Temp.**	**Strainer**	**Flow (sgpm)**	**Pressure Drop (psid)**
App-R A RHR Pump A-6500 gpm	@227°F	Strainer 1	2331.73	0.0126
		Strainer 23	984.885	0.0022
		Strainer 27	1691.65	0.0066
		Strainer 5	1187.74	0.0033
App-R B RHR Pump B-6500 gpm	@227°F	Strainer 1	1818.73	0.0077
		Strainer 23	1178.54	0.0032
		Strainer 27	2198.02	0.0112
		Strainer 5	1000.71	0.0023
App-R C RHR Pump C-6500 gpm	@227°F	Strainer 1	2331.73	0.0126
		Strainer 23	984.885	0.0022
		Strainer 27	1691.65	0.0066
		Strainer 5	1187.74	0.0033
App-R D RHR Pump D-6500 gpm	@227°F	Strainer 1	1818.73	0.0077
		Strainer 23	1178.54	0.0032
		Strainer 27	2198.02	0.0112
		Strainer 5	1000.71	0.0023
SBO Pump/Flow Combination	**Pool Temp**	**Strainer**	**Flow (sgpm)**	**Pressure Drop (psid)**
SBO 1 A/C RHR Pump A/C-6500 gpm each	@197.3°F	Strainer 1	4710.92	0.0508
		Strainer 23	2001.19	0.0092
		Strainer 27	3423.1	0.0268
		Strainer 5	2410.79	0.0133
SBO 2 B/D RHR Pump B/D-6500 gpm each	@197.3°F	Strainer 1	3681.88	0.031
		Strainer 23	2393.53	0.0131
		Strainer 27	4437.98	0.0451
		Strainer 5	2032.61	0.0095

TABLE 13
Unit 3

LOCA Pump/Flow Combination	Pool Temp.	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
LOCA 1A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps -10,000 gpm each RHR B/D Pumps -11,000 gpm each	@95°F	RHR/A	33.38	23.9	14.4	9.48
		RHR/B	32.40	27.0	14.4	5.40
		RHR/C	31.98	23.7	14.4	8.28
		RHR/D	33.96	30.0	14.4	3.96
		CS/A	34.86	27.0	14.4	7.86
		CS/B	37.02	27.0	14.4	10.02
		CS/C	36.84	27.0	14.4	9.84
		CS/D	35.22	27.0	14.4	8.22
LOCA 1B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps -10,000 gpm each RHR B/D Pumps -11,000 gpm each	@155.4°F	RHR/A	29.65	23.9	16.0	5.75
		RHR/B	28.67	27.0	16.0	1.67
		RHR/C	28.25	23.7	16.0	4.55
		RHR/D	30.23	30.0	16.0	0.23
		CS/A	31.12	27.0	16.0	4.12
		CS/B	33.29	27.0	16.0	6.29
		CS/C	33.10	27.0	16.0	6.10
		CS/D	31.48	27.0	16.0	4.48
LOCA 2A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps –10,000 gpm each	@95°F	RHR/A	32.61	27.0	14.4	5.61
		RHR/B	33.71	24.8	14.4	8.91
		RHR/C	30.91	27.0	14.4	3.91
		RHR/D	35.00	26.0	14.4	9.00
		CS/A	34.99	27.0	14.4	7.99
		CS/B	37.17	27.0	14.4	10.17
		CS/C	36.97	27.0	14.4	9.97
		CS/D	35.37	27.0	14.4	8.37
LOCA 2B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps -10,000 gpm each	@155.4°F	RHR/A	28.79	27.0	16.08	1.79
		RHR/B	29.87	24.8	16.08	5.07
		RHR/C	27.09	27.0	16.08	0.09
		RHR/D	31.16	26.0	16.08	5.16
		CS/A	31.12	27.0	16.08	4.12
		CS/B	33.28	27.0	16.08	6.28
		CS/C	33.09	27.0	16.08	6.09
		CS/D	31.48	27.0	16.08	4.48
LOCA 3A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@155.4°F	RHR/A	35.93	23.7	14.4	12.23
		RHR/C	35.33	23.7	14.4	11.63
		CS/A	31.84	27.0	14.4	4.84
		CS/C	33.82	27.0	14.4	6.82
LOCA 3B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	RHR/A	31.25	23.7	14.4	7.55
		RHR/C	30.65	23.7	14.4	6.95
		CS/A	27.16	27.0	14.4	0.16
		CS/C	29.14	27.0	14.4	2.14

LOCA Pump/Flow Combination	Pool Temp.	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
LOCA 3C CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	RHR/A	31.26	23.7	16.9	7.56
		RHR/C	30.66	23.7	16.9	6.96
		CS/A	27.17	27.0	16.9	0.17
		CS/C	29.15	27.0	16.9	2.15
LOCA 4A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@155.4°F	RHR/A	35.94	23.7	14.4	12.24
		RHR/C	35.35	23.7	14.4	11.65
		CS/B	33.70	27.0	14.4	6.70
		CS/D	31.89	27.0	14.4	4.89
LOCA 4B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	RHR/A	31.26	23.7	14.4	7.56
		RHR/C	30.67	23.7	14.4	6.97
		CS/B	29.02	27.0	14.4	2.02
		CS/D	27.21	27.0	14.4	0.21
LOCA 4C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	RHR/A	31.27	23.7	16.9	7.57
		RHR/C	30.68	23.7	16.9	6.98
		CS/B	29.03	27.0	16.9	2.03
		CS/D	27.22	27.0	16.9	0.22
LOCA 5A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	RHR/B	35.65	23.7	14.4	11.95
		RHR/D	36.19	23.7	14.4	12.49
		CS/B	33.68	27.0	14.4	6.68
		CS/D	31.87	27.0	14.4	4.87
LOCA 5B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	RHR/B	30.97	23.7	14.4	7.27
		RHR/D	31.51	23.7	14.4	7.81
		CS/B	29.00	27.0	14.4	2.00
		CS/D	27.19	27.0	14.4	0.19
LOCA 5C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	RHR/B	30.98	23.7	16.9	7.28
		RHR/D	31.52	23.7	16.9	7.82
		CS/B	29.01	27.0	16.9	2.01
		CS/D	27.20	27.0	16.9	0.20
LOCA 6A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	RHR/B	35.63	23.7	14.4	11.93
		RHR/D	36.17	23.7	14.4	12.47
		CS/A	31.88	27.0	14.4	4.88
		CS/C	33.86	27.0	14.4	6.86
LOCA 6B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	RHR/B	30.95	23.7	14.4	7.25
		RHR/D	31.49	23.7	14.4	7.79
		CS/A	27.20	27.0	14.4	0.20
		CS/C	29.18	27.0	14.4	2.18

LOCA Pump/Flow Combination	Pool Temp.	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
LOCA 6C CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	RHR/B	30.96	23.7	16.9	7.26
		RHR/D	31.50	23.7	16.9	7.80
		CS/A	27.21	27.0	16.9	0.21
		CS/C	29.19	27.0	16.9	2.19
LOCA 7 CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C/B/D Pumps-6500 gpm each	@166°F	RHR/A	30.77	23.7	14.4	7.07
		RHR/B	30.78	23.7	14.4	7.08
		RHR/C	30.18	23.7	14.4	6.48
		RHR/D	31.32	23.7	14.4	7.62
		CS/A	27.63	27.0	14.4	0.63
		CS/C	29.61	27.0	14.4	2.61

ATWS Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	NPSHr (ft)	Pressure (psia)	NPSH margin (ft)
ATWS RHR A/C/B/D Pumps-6500 gpm each CS Pumps A/C/B/D-0 gpm each	@214.6°F	RHR/A	24.52	23.7	21.0	0.82
		RHR/B	24.55	23.7	21.0	0.85
		RHR/C	23.93	23.7	21.0	0.23
		RHR/D	25.09	23.7	21.0	1.39
Appendix R Pump/Flow Combination	**Pool Temp**	**Pump**	**NPSHa (ft)**	**NPSHr (ft)**	**Pressure (psia)**	**NPSH margin (ft)**
App-R A RHR Pump A-6500 gpm	@227°F	A	23.93	23.7	24.1	0.23
App-R B RHR Pump B-6500 gpm	@227°F	B	23.90	23.7	24.1	0.20
App-R C RHR Pump C-6500 gpm	@227°F	C	23.81	23.7	24.1	0.11
App-R D RHR Pump D-6500 gpm	@227°F	D	23.98	23.7	24.1	0.28
SBO Pump/Flow Combination	**Pool Temp**	**Pump**	**NPSHa (ft)**	**NPSHr (ft)**	**Pressure (psia)**	**NPSH margin (ft)**
SBO 1 A/C RHR Pump A/C-6500 gpm each	@197.3°F	A	24.45	23.7	16.0	0.75
		C	23.85	23.7	16.0	0.15
SBO 2 B/D RHR Pump B/D-6500 gpm each	@197.3°F	B	23.85	23.7	15.9	0.15
		D	24.40	23.7	15.9	0.70

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)**	**NPSHr (ft)**	**NPSH margin (ft)**	
1PUMPA	0.80107	33.38	23.9	9.48	
2PUMPB	0.378837	32.40	27	5.40	
3PUMPC	0.196499	31.98	23.7	8.28	
4PUMPD	1.04947	33.96	30	3.96	
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**	
1CSPUMPA	1.43727	34.86	27	7.86	
2CSPUMPB	2.3699	37.02	27	10.02	
3CSPUMPC	2.29033	36.84	27	9.84	
4CSPUMPD	1.59296	35.22	27	8.22	

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)**	16

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	0.828492	29.65	23.9	5.75
2PUMPB	0.414702	28.67	27	1.67
3PUMPC	0.232564	28.25	23.7	4.55
4PUMPD	1.07595	30.23	30	0.23
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	1.45158	31.12	27	4.12
2CSPUMPB	2.37214	33.29	27	6.29
3CSPUMPC	2.29119	33.10	27	6.10
4CSPUMPD	1.60649	31.48	27	4.48

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	0.469288	32.61	27	5.61
2PUMPB	0.944092	33.71	24.8	8.91
3PUMPC	-0.26239	30.91	27	3.91
4PUMPD	1.49817	35.00	26	9.00
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	1.49582	34.99	27	7.99
2CSPUMPB	2.43307	37.17	27	10.17
3CSPUMPC	2.34888	36.97	27	9.97
4CSPUMPD	1.65613	35.37	27	8.37

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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) 16.08

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	0.383607	28.79	27	1.79
2PUMPB	0.84087	29.87	24.8	5.07
3PUMPC	-0.33748	27.09	27	0.09
4PUMPD	1.3873	31.16	26	5.16
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	1.37023	31.12	27	4.12
2CSPUMPB	2.28972	33.28	27	6.28
3CSPUMPC	2.20984	33.09	27	6.09
4CSPUMPD	1.52407	31.48	27	4.48

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)**	**NPSHr (ft)**	**NPSH margin (ft)**
1PUMPA	5.09137	35.93	23.7	12.23
2PUMPB				
3PUMPC	4.83981	35.33	23.7	11.63
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.35622	31.84	27	4.84
2CSPUMPB				
3CSPUMPC	4.19583	33.82	27	6.82
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)**	**NPSHr (ft)**	**NPSH margin (ft)**
1PUMPA	5.06319	31.25	23.7	7.55
2PUMPB				
3PUMPC	4.81293	30.65	23.7	6.95
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.33804	27.16	27	0.16
2CSPUMPB				
3CSPUMPC	4.17294	29.14	27	2.14
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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) 16.9
RHR	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1PUMPA	5.03611	31.26	23.7	7.56
2PUMPB				
3PUMPC	4.78719	30.66	23.7	6.96
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.321	27.17	27	0.17
2CSPUMPB				
3CSPUMPC	4.15116	29.15	27	2.15
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.0976	35.94	23.7	12.24
2PUMPB				
3PUMPC	4.84605	35.35	23.7	11.65
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.14542	33.70	27	6.70
3CSPUMPC				
4CSPUMPD	3.37977	31.89	27	4.89

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.06937	31.26	23.7	7.56
2PUMPB				
3PUMPC	4.81912	30.67	23.7	6.97
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.12286	29.02	27	2.02
3CSPUMPC				
4CSPUMPD	3.36135	27.21	27	0.21

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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) 16.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.04225	31.27	23.7	7.57
2PUMPB				
3PUMPC	4.79333	30.68	23.7	6.98
4PUMPD				
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.1014	29.03	27	2.03
3CSPUMPC				
4CSPUMPD	3.34409	27.22	27	0.22

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.97346	35.65	23.7	11.95
3PUMPC				
4PUMPD	5.20404	36.19	23.7	12.49
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.13718	33.68	27	6.68
3CSPUMPC				
4CSPUMPD	3.37154	31.87	27	4.87

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.94591	30.97	23.7	7.27
3PUMPC				
4PUMPD	5.17532	31.51	23.7	7.81
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.11471	29.00	27	2.00
3CSPUMPC				
4CSPUMPD	3.3532	27.19	27	0.19

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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) 16.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.91948	30.98	23.7	7.28
3PUMPC				
4PUMPD	5.14769	31.52	23.7	7.82
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA				
2CSPUMPB	4.09332	29.01	27	2.01
3CSPUMPC				
4CSPUMPD	3.33601	27.20	27	0.20

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.96393	35.63	23.7	11.93
3PUMPC				
4PUMPD	5.19451	36.17	23.7	12.47
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.37547	31.88	27	4.88
2CSPUMPB				
3CSPUMPC	4.21507	33.86	27	6.86
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.93642	30.95	23.7	7.25
3PUMPC				
4PUMPD	5.16583	31.49	23.7	7.79
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.35715	27.20	27	0.20
2CSPUMPB				
3CSPUMPC	4.19204	29.18	27	2.18
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)** 16.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.91004	30.96	23.7	7.26
3PUMPC				
4PUMPD	5.13825	31.50	23.7	7.80
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	3.33996	27.21	27	0.21
2CSPUMPB				
3CSPUMPC	4.17012	29.19	27	2.19
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 14.17: Unit 3 NPSH Calculations Case 7 166F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/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)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	4.0793	30.77	23.7	7.07
2PUMPB	4.08192	30.78	23.7	7.08
3PUMPC	3.82856	30.18	23.7	6.48
4PUMPD	4.31176	31.32	23.7	7.62
CS	**Pressure (psig)**	**NPSHa (ft)**	**NPSHr (ft)**	**NPSH margin (ft)**
1CSPUMPA	2.74921	27.63	27	0.63
2CSPUMPB				
3CSPUMPC	3.58624	29.61	27	2.61
4CSPUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 14.18: Unit 3 NPSH Calculations Case ATWS 214.6F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
214.6	15.4840075	0.016732744	2.409515179	Pool Press. (psia) 21

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
PUMPA	4.66078	24.52	23.7	0.82
PUMPB	4.67186	24.55	23.7	0.85
PUMPC	4.41446	23.93	23.7	0.23
PUMPD	4.89771	25.09	23.7	1.39

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 14.19: Unit 3 NPSH Calculations Case App-R A 227F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
227	19.65726995	0.016822324	2.422414688	Pool Press. (psia) 24.1

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.43696	23.93	23.7	0.23
2PUMPB				
3PUMPC				
4PUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 14.20: Unit 3 NPSH Calculations Case App-R B 227F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
227	19.65726995	0.016822324	2.422414688	Pool Press. (psia) 24.1

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	5.42391	23.90	23.7	0.20
3PUMPC				
4PUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
227	19.65726995	0.016822324	2.422414688	Pool Press. (psia) 24.1

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB				
3PUMPC	5.38608	23.81	23.7	0.11
4PUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
227	19.65726995	0.016822324	2.422414688	Pool Press. (psia) 24.1

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB				
3PUMPC				
4PUMPD	5.45444	23.98	23.7	0.28

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 14.23: Unit 3 NPSH Calculations SBO A-C 197.3F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head	
60	0.256389624	0.016034992	2.309038802	
197.3	10.90873195	0.016615541	2.392637845	Pool Press. (psia) 16

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA	5.12658	24.45	23.7	0.75
2PUMPB				
3PUMPC	4.87856	23.85	23.7	0.15
4PUMPD				

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

Table 14.24: Unit 3 NPSH Calculations SBO B-D 197.3F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^3/lb)	Conversion Factor psia to feet of head		
60	0.256389624	0.016034992	2.309038802		
197.3	10.90873195	0.016615541	2.392637845	Pool Press. (psia)	15.9

RHR	Pressure (psig)	NPSHa (ft)	NPSHr (ft)	NPSH margin (ft)
1PUMPA				
2PUMPB	4.97858	23.85	23.7	0.15
3PUMPC				
4PUMPD	5.20597	24.40	23.7	0.70

Note 1: See Table 8 for steps taken in calculating NPSHa and NPSH margin.

TABLE 15
Unit 3

LOCA Pump/Flow Combination	Pool Temp	Strainer	Flow (sgpm)	Pressure Drop (psid)
LOCA 1A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –10,000 gpm each RHR B/D Pumps –11,000 gpm each	@95°F	Strainer 1	14354.6	2.469
		Strainer 23	13421.3	2.101
		Strainer 27	13167.1	2.365
		Strainer 5	13283.1	2.116
LOCA 1B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –10,000 gpm each RHR B/D Pumps -11,000 gpm each	@155.4°F	Strainer 1	13772.1	2.415
		Strainer 23	13093	2.029
		Strainer 27	13313.7	2.274
		Strainer 5	13207.2	2.052
LOCA 2A CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps –10,000 gpm each	@95°F	Strainer 1	14264.8	2.442
		Strainer 23	13309.3	2.039
		Strainer 27	13237	2.286
		Strainer 5	13414.9	2.063
LOCA 2B CS Pumps A/B/C/D-3125gpm each RHR A/C Pumps –11,000 gpm each RHR B/D Pumps -10,000 gpm each	@155.4°F	Strainer 1	14262.7	2.485
		Strainer 23	12921.5	2.115
		Strainer 27	13265.2	2.354
		Strainer 5	12936.6	2.133
LOCA 3A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@155.4°F	Strainer 1	4905.66	0.1729
		Strainer 23	4551.66	0.1068
		Strainer 27	4648.25	0.1239
		Strainer 5	4750.43	0.1428
LOCA 3B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4878.12	0.1719
		Strainer 23	4526.95	0.1063
		Strainer 27	4622.91	0.1233
		Strainer 5	4724.01	0.142
LOCA 3C CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	Strainer 1	4850.69	0.1709
		Strainer 23	4502.16	0.1058
		Strainer 27	4597.51	0.1227
		Strainer 5	4697.64	0.1412
LOCA 4A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 each	@155.4°F	Strainer 1	4835.65	0.1591
		Strainer 23	4647.75	0.1238
		Strainer 27	4731.51	0.1392
		Strainer 5	4641.08	0.1226
LOCA 4B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4808.63	0.1582
		Strainer 23	4622.27	0.1232
		Strainer 27	4705.55	0.1385
		Strainer 5	4615.54	0.122

LOCA Pump/Flow Combination	Pool Temp	Strainer	Flow (sgpm)	Pressure Drop (psid)
LOCA 4C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR A/C Pumps-6500 gpm each B/D-0 gpm each	@187.3°F	Strainer 1	4781.69	0.1573
		Strainer 23	4596.76	0.1225
		Strainer 27	4679.56	0.1378
		Strainer 5	4589.99	0.1213
LOCA 5A CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	Strainer 1	4642.35	0.1228
		Strainer 23	4773.43	0.1471
		Strainer 27	4913.97	0.1745
		Strainer 5	4526.25	0.1024
LOCA 5B CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4617	0.1222
		Strainer 23	4746.88	0.1463
		Strainer 27	4886.42	0.1735
		Strainer 5	4501.7	0.102
LOCA 5C CS Pumps B/D-3125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	Strainer 1	4591.6	0.1216
		Strainer 23	4720.38	0.1455
		Strainer 27	4858.97	0.1725
		Strainer 5	4477.05	0.1015
LOCA 6A CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	Strainer 1	4720.96	0.1372
		Strainer 23	4661.24	0.1262
		Strainer 27	4846.9	0.1613
		Strainer 5	4626.89	0.12
LOCA 6B CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@172°F NPSHa=NPSHr	Strainer 1	4695.03	0.1366
		Strainer 23	4635.59	0.1256
		Strainer 27	4819.83	0.1604
		Strainer 5	4601.55	0.1195
LOCA 6C CS Pumps A/C-3125gpm each B/D-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@187.3°F	Strainer 1	4669.07	0.1358
		Strainer 23	4609.93	0.1249
		Strainer 27	4792.84	0.1595
		Strainer 5	4576.16	0.1188
LOCA 7 CS Pumps A/C-3125gpm each B/D-0 gpm each RHR A/C/B/D Pumps-6500 gpm each	@166°F	Strainer 1	8289.24	0.877
		Strainer 23	7500.75	0.6964
		Strainer 27	7988.88	0.8029
		Strainer 5	7703.14	0.7388

ATWS Pump/Flow Combination	Pool Temp.	Strainer	Flow (sgpm)	Pressure Drop (psid)
ATWS RHR A/C/B/D Pumps-6500 gpm each CS Pumps A/C/B/D-0 gpm each	@214.6°F	Strainer 1	8797.52	0.1784
		Strainer 23	3842.31	0.034
		Strainer 27	7688.36	0.0017
		Strainer 5	4587.81	0.0485
Appendix R Pump/Flow Combination	**Pool Temp.**	**Strainer**	**Flow (sgpm)**	**Pressure Drop (psid)**
App-R A RHR Pump A-6500 gpm	@227°F	Strainer 1	2336.37	0.0126
		Strainer 23	936.046	0.002
		Strainer 27	1767.64	0.0072
		Strainer 5	1155.95	0.0031
App-R B RHR Pump B-6500 gpm	@227°F	Strainer 1	1707.37	0.0118
		Strainer 23	1252.23	0.0064
		Strainer 27	2088.01	0.0177
		Strainer 5	1148.39	0.0053
App-R C RHR Pump C-6500 gpm	@227°F	Strainer 1	2336.37	0.0126
		Strainer 23	936.046	0.002
		Strainer 27	1767.64	0.0072
		Strainer 5	1155.95	0.0031
App-R D RHR Pump D-6500 gpm	@227°F	Strainer 1	1707.37	0.0118
		Strainer 23	1252.23	0.0064
		Strainer 27	2088.01	0.0177
		Strainer 5	1148.39	0.0053
SBO Pump/Flow Combination	**Pool Temp**	**Strainer**	**Flow (sgpm)**	**Pressure Drop (psid)**
SBO 1 A/C RHR Pump A/C-6500 gpm each	@197.3°F	Strainer 1	4720.36	0.051
		Strainer 23	1901.72	0.0083
		Strainer 27	3578.79	0.0293
		Strainer 5	2345.14	0.0126
SBO 2 B/D RHR Pump B/D-6500 gpm each	@197.3°F	Strainer 1	3456.45	0.0478
		Strainer 23	2540.8	0.0259
		Strainer 27	4218.78	0.0713
		Strainer 5	2329.97	0.0217

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 or 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") * COSINE 40.14° = 70.0"

X_2 = 22.5 * SINE 40.14° = 14.50"

Appendix 3 (Cont'd)

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

Horizontal Separation = S_H = 13' 10" - X_1 - X_2 + 15" - 6" = 13' 10" - 70.0" - 14.50" + 15" - 6" = 90.5" = 7.54 feet
= 2.3 meters

Z_1 = (1' 10" + 8.5" + 11 5/16" + 49.8") * SINE 40.14° = 59.1"

Z_2 = 22.5 * COSINE 40.14° = 17.2"

E = 59.1" - 17.2" = 41.9" ~ 42"

Elevation of tip of strainer = Centerline of ring header + E = 525' 4" + 42" = 528' 10"

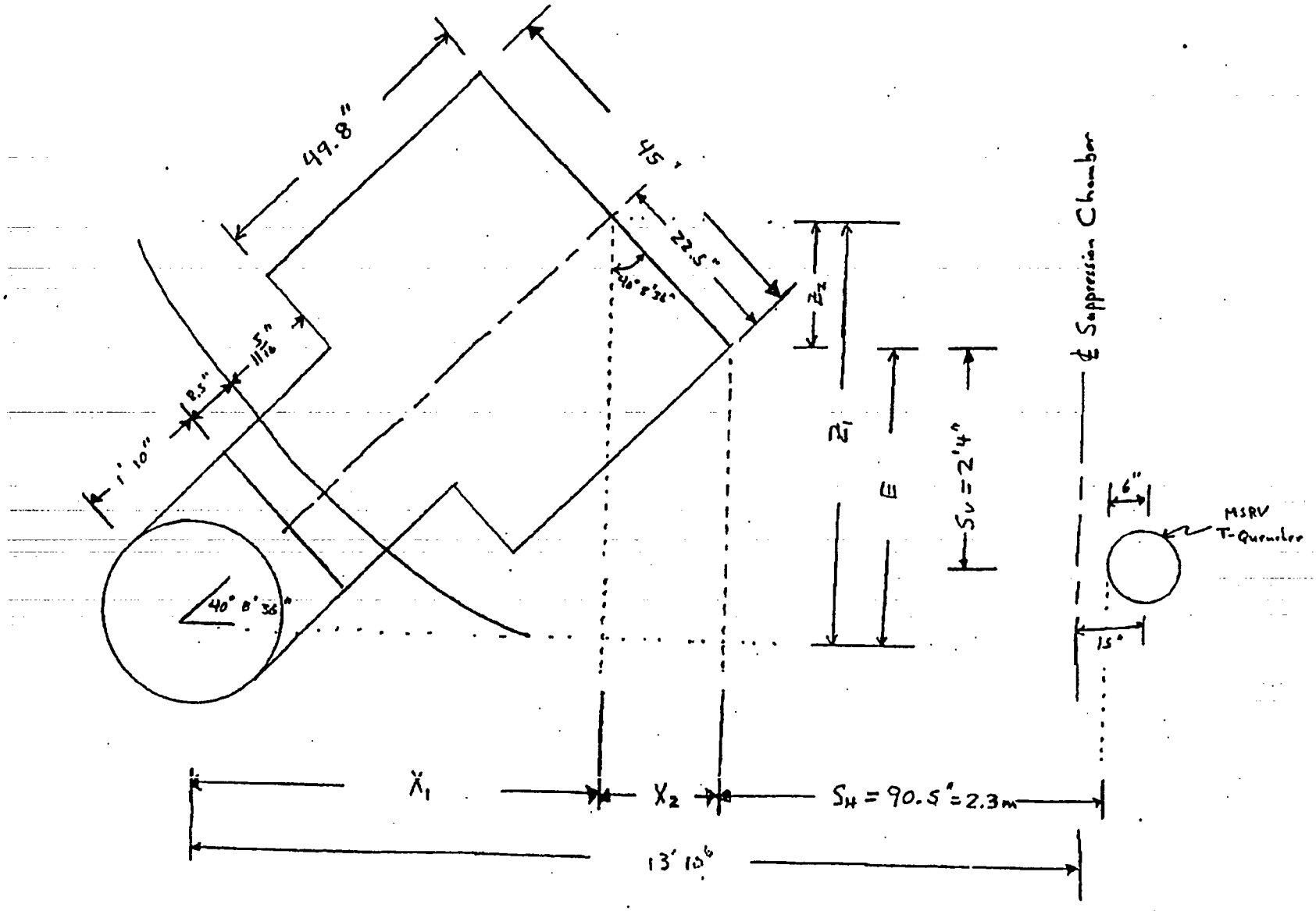
Vertical Separation = Elevation of tip of strainer - Elevation of MSRV T-Quencher
= 528' 10" - 526' 6" = 2' 4"

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.

Figure A3-1

ECCS Strainer and MSRV T-Quencher Relationship



Page 1
Attachment A
Page A-1

QA Record

TVAN CALCULATION

TITLE: NPSH Evaluation of Browns Ferry RHR and CS Pumps	PLANT/UNIT: *BFN / Unit 2 & 3*
PREPARING ORGANIZATION: Site Engineering-Mechanical / Nuclear	KEY NOUNS (Consult CCRIS LIST)
BRANCH/PROJECT IDENTIFIERS: *MD-Q0999-970046*	Each time these calculations are issued, preparers must ensure that the original (R0) RIMS accession number is filled in.
APPLICABLE DESIGN DOCUMENT(S): *Design Criteria No. BFN-50-7074 & BFN-50-7075*	SAR SECTION(S): *N/A* — UNID SYSTEM(S): *074 & 075*

Rev	(for RIMS use)	RIMS accession number
R0	219	R14 981118 108
R1		
R2		
R3		

	Revision 0	R1	R2	R3
DCN No. (or indicate Not Applicable)		N/A		
Prepared	Thomas F. Newton	W.W. Vogt		
Checked	Mark Byrd	6-11-98		
Reviewed	Mark Byrd	6-11-98		
Approved	[illegible]	[illegible]		
Date	9/2/97	11-18-98		
Use form TVA 10534 if more space required	List all pages added by this revision	SEE		
	List all pages deleted by this revision	REV		
	List all pages changed by this revision	LOG		
Calculation Revision (A) Entire Calc; (P) Selected pages		P		

Safety-related? Yes ■ No ☐

Statement of Problem

NRC IE Bulletin 96-03 and Regulatory Guide 1.82, Revision 2 in May 1996 required measures to insure adequate NPSH for ECCS pumps during post LOCA conditions

It is necessary to determine the pump NPSH available is adequate and that margin is available for ECCS strainer design.

This calculation determines the RHR and CS pump NPSH margin available with a ECCS replacement strainer design.

ORIGINAL

These calculations contain unverified assumption(s) that must be verified later. Yes ☐ No ■

Abstract

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.

☐ Microfilm and store calculations in RIMS Service Center
■ Microfilm and return calculations to: POB TIC - BFN

Microfilm and destroy. ☐
Address:

QA Record

TVAN CALCULATION COVERSHEET

Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps		Plant: BFN Unit: 2/3	Page: 1
Preparing Organization: SE-DE/MNUC	Key Nouns (For EDM):		
Calculation Identifier: 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): BFN-50-7074 & BFN-50-7075 BFN-50-7064A	Rev: R0	(for EDM use):	EDM Accession Number: R14 981118 108
	Rev: R1 (354) (352)		R14 990616 105 |R2
UNID System(s): SYS 074 & 075 + 064A	Rev: R2		R14 991118 101
	Rev: R3		R14 000706 101 |R2

	R0	R1	R2	R3			
					Quality Related?	Yes ☒	No ☐
DCN, EDC, NA	N/A	N/A	N/A	N/A	Safety related? If yes, mark Quality Related yes	Yes ☒	No ☐
Prepared	TFN	WW. Vass	Willie D. Crouch	Glenn D. Henry	Glenn D. Henry (x 2911)		
Checked	MB	Eugene Sanders	MD Brown	Willie D. Crouch	These calculations contain unverified assumption(s) that must be verified later?	Yes ☐	No ☒
Design Verified	MB	Eugene Sanders	MD Brown	Willie D. Crouch	These calculations contain special requirements and/or limiting conditions?	Yes ☐	No ☒
Approved	KTG	EDC			These calculations contain a design output attachment?	Yes ☐	No ☒
Approval Date	11-18-98	06/16/1999	11/16/1999	7/1/2000	Calculation Classification	E	
SAR Affected?	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☐	Yes ☐ No ☒	Microfiche generated	Yes ☐	No ☒
Revision applicability	Entire calc ☒	Entire calc ☒ Selected pgs ☐	Entire calc ☐ Selected pgs ☐	Entire calc ☐ Selected pgs ☐	Number		

Statement of Problem:
(SEE REV. 0 COVER SHEET, PAGE 1A)

This calculation also evaluates the potential for the ECCS strainers to ingest a steam plume/bubble from an MSRV T-quencher and its effects if ingested. |R2

ORIGINAL

Abstract
(SEE REV. 0 COVER SHEET, PAGE 1A)

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.

☐ Microfilm and return calculation to Calculation Library. Address:
☐ Microfilm and return calculation to:
☐ Microfilm and destroy.

ATTACHMENT A
PAGE A-3

QA Record

ORIGINAL

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

REV 0 EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
R14 981118 108	calculations(nuclear)	R14 020731 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 ☐ Selected pages ☒

ACTION: NEW ☐ REVISION ☒ | DELETE ☐ RENAME ☐ | SUPERSEDE ☐ DUPLICATE ☐ | CCRIS UPDATE ONLY ☐ (Verifier Approval Signatures Not Required) | No CCRIS Changes ☐ (For calc revision, CCRIS been reviewed and no CCRIS changes required)

UNITS	SYSTEMS	UNIDS
002/003	074 075 064A	Various

DCN EDC N/A	APPLICABLE DESIGN DOCUMENT(S)	CLASSIFICATION
N/A	N/A	E

QUALITY RELATED?	SAFETY RELATED? (If yes, QR = yes)	UNVERIFIED ASSUMPTION	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?	DESIGN OUTPUT ATTACHMENT?	SAR/TS AFFECTED
Yes ☒ No ☐	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☒ No ☐

PREPARER ID	PREPARER PHONE NO.	PREPARING ORG (BRANCH)	VERIFICATION METHOD	NEW METHOD OF ANALYSIS
KGSeuthe	729-4874	MEB	Design Review	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
KGSeuthman	06-19-02	TELantz	06/19/02
VERIFIER SIGNATURE	**DATE**	**APPROVAL SIGNATURE**	**DATE**
TELantz	06/19/02		07/30/02

STATEMENT OF PROBLEM/ABSTRACT

See previous cover sheets (Attachment A, pages A-1 & A-2) for the earlier statements of the problem / abstracts.

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/EFICHE Yes ☐ No ☒ FICHE NUMBER(S)

☐ LOAD INTO EDMS AND DESTROY
☒ LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY. ADDRESS:
☐ LOAD INTO EDMS AND RETURN CALCULATION TO:

ATTACHMENT A
PAGE A-4

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	REV
	CN	NUC	BFN	MEB	MD-Q0999-970046	04

ALTERNATE CALCULATION IDENTIFICATION

BLDG	ROOM	ELEV	COORD/AZIM	FIRM	Print Report Yes ☐

CATEGORIES

KEY NOUNS (A-add, D-delete)

ACTION (A/D)	KEY NOUN	A/D	KEY NOUN
A	3952	A	CPPU
A	EPU	A	CS SYS
A	RHR	A	NPSH
A	PUMP	A	HEAD
A	STRAINER	A	ECCS

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

ACTION (A/C/D)	XREF CODE	XREF TYPE	XREF PLANT	XREF BRANCH	XREF NUMBER	XREF REV
A	P	VD	BFN	MEB	W79 020517 001	00

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.	R14 020731 105	

ATTACHMENT A
PAGE A-5

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

REV 0 EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
R14981116106	calculations(nuclear)	

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	MDQ0999970046	004		
NEW	CN	NUC					005	Entire calc ☒ Selected pages ☐

ACTION						No CCRIS Changes ☐
	NEW ☐ REVISION ☒	DELETE ☐ RENAME ☐	SUPERSEDE ☐ DUPLICATE ☐	CCRIS UPDATE ONLY ☐ (Verifier Approval Signatures Not Required)		(For calc revision, CCRIS been reviewed and no CCRIS changes required)

UNITS	SYSTEMS	UNIDS
001, 002, 003	064 074 075	N/A

DCN EDC N/A	APPLICABLE DESIGN DOCUMENT(S)	CLASSIFICATION
DCN 51200	N/A	E

QUALITY RELATED?	SAFETY RELATED?	UNVERIFIED ASSUMPTION	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?	DESIGN OUTPUT ATTACHMENT?	SARTS AFFECTED
Yes ☒ No ☐	(If yes, QR = yes) Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒

PREPARER ID	PREPARER PHONE	PREPARING ORG (BRANCH)	VERIFICATION METHOD	NEW METHOD OF ANALYSIS
DJKAROL	NO 301-228-6720	MECH/NUC	DESIGN REVIEW	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
DENNIS KAROL	6-25-03	M. ANGIOLILLO	25 JUN 03
VERIFIER SIGNATURE	DATE	APPROVAL SIGNATURE	DATE
M. ANGIOLILLO	25 JUN 03	W. D. CROUCH	

STATEMENT OF PROBLEM/ABSTRACT

Problem:

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:

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.

This revision makes the calculation applicable to Units 1, 2 and 3.

MICROFICHE/EFICHE Yes ☐ No ☒ FICHE NUMBER(S)

☐ LOAD INTO EDMS AND DESTROY
☐ LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY.
☐ LOAD INTO EDMS AND RETURN CALCULATION TO:

ADDRESS:

ATTACHMENT A
PAGE A-6

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

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

ALTERNATE CALCULATION IDENTIFICATION

BLDG	ROOM	ELEV	COORD/AZIM	FIRM	Print Report
01	N/A	N/A	N/A	Bechtel	Yes ☐

CATEGORIES

KEY NOUNS (A-add, D-delete)

ACTION (A/D)	KEY NOUN	A/D	KEY NOUN
A	LOCA		

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

ACTION (A/C/D)	XREF CODE	XREF TYPE	XREF PLANT	XREF BRANCH	XREF NUMBER	XREF REV
A	P	CN	BFN	NTB	NDQ199920020016	
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	DW	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.		

ATTACHMENT A
PAGE A-7

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

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

ALTERNATE CALCULATION IDENTIFICATION

BLDG	ROOM	ELEV	COORD/AZIM	FIRM	Print Report
01	N/A	N/A	N/A	Bechtel	Yes ☐

CATEGORIES

KEY NOUNS (A-add, D-delete)

ACTION (A/D)	KEY NOUN	A/D	KEY NOUN

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

ACTION (A/C/D)	XREF CODE	XREF TYPE	XREF PLANT	XREF BRANCH	XREF NUMBER	XREF REV
A	P	DN	BFN	MEB	DCN 51200	
A	P	VD	BFN	MEB	GENE-0000-00028716SE	
D	P	DW	BFN	NTB	47W814-1	
D	P	DW	BFN	NTB	47W458-3	
D	P	DW	BFN	MEB	3-47W401-5	

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

ORIGINAL

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

REV 0 EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
R14981118108	calculations(nuclear)	W78 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 APPLICABILITY
CURRENT	CN	NUC	BFN	MEB	MDQ0999970046	005		Entire calc ☒
NEW	CN	NUC					006	Selected pages ☐

ACTION										No CCRIS Changes ☒ (For calc revision, CCRIS been reviewed and no CCRIS changes required)
	NEW ☐ REVISION ☒		DELETE ☐ RENAME ☐		SUPERSEDE ☐ DUPLICATE ☐		CCRIS UPDATE ONLY ☐ (Verifier Approval Signatures Not Required)			

UNITS	SYSTEMS	UNIDS
0(1, 002, 003	064 074 075	N/A

DCN,EDC,N/A	APPLICABLE DESIGN DOCUMENT(S)	CLASSIFICATION
DCN 51200	N/A	E

QUALITY RELATED?	SAFETY RELATED? (If yes, QR = yes)	UNVERIFIED ASSUMPTION	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?	DESIGN OUTPUT ATTACHMENT?	SAR/TS AFFECTED
Yes ☒ No ☐	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒

PREPARER ID	PREPARER PHONE	PREPARING ORG (BRANCH)	VERIFICATION METHOD	NEW METHOD OF ANALYSIS
DJKAROL	NO 301-228-6720	MECH/NUC	DESIGN REVIEW	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
DJKAROL	9-12-03	LDEDGE	9-12-03
VERIFIER SIGNATURE	**DATE**	**APPROVAL SIGNATURE**	**DATE**
LDEDGE	9-12-03	WDCROUCH	9/22/03

STATEMENT OF PROBLEM/ABSTRACT

Problem:

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:

This revision adds the Unit 1 margin to the calculation.

MICROFICHE/EFICHE Yes ☐ No ☒ FICHE NUMBER(S)

☐ LOAD INTO EDMS AND DESTROY
☐ LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY. ADDRESS:
☐ LOAD INTO EDMS AND RETURN CALCULATION TO:

ATTACHMENT A PAGE A-9

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	REV
	CN	NUC	BFN	MEB	MDQ0999970046	006

ALTERNATE CALCULATION IDENTIFICATION

BLDG	ROOM	ELEV	COORD/AZIM	FIRM	Print Report
01	N/A	N/A	N/A	Bechtel	Yes ☐

CATEGORIES

KEY NOUNS (A-add, D-delete)

ACTION (A/D)	KEY NOUN	A/D	KEY NOUN

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

ACTION (A/C/D)	XREF CODE	XREF TYPE	XREF PLANT	XREF BRANCH	XREF NUMBER	XREF REV

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. W78 030924 016		

ATTACHMENT A PAGE A-10

QA Record

ORIGINAL

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

REV 0 EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
R14981118108	calculations(nuclear)	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	MDQ0999970046	006		Entire calc ☒ Selected pages ☐
NEW	CN	NUC					007	

ACTION: NEW ☐ REVISION ☒ | DELETE ☐ RENAME ☐ | SUPERSEDE ☐ DUPLICATE ☐ | CCRIS UPDATE ONLY ☐ (Verifier Approval Signatures Not Required) | No CCRIS Changes ☒ (For calc revision, CCRIS been reviewed and no CCRIS changes required)

UNITS	SYSTEMS	UNIDS
001, 002, 003	064 074 075	N/A

DCN, EDC, N/A	APPLICABLE DESIGN DOCUMENT(S)	CLASSIFICATION
N/A	N/A	E

QUALITY RELATED?	SAFETY RELATED? (If yes, QR = yes)	UNVERIFIED ASSUMPTION	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?	DESIGN OUTPUT ATTACHMENT?	SAR/TS AFFECTED
Yes ☒ No ☐	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒

PREPARER ID	PREPARER PHONE NO	PREPARING ORG (BRANCH)	VERIFICATION METHOD	NEW METHOD OF ANALYSIS
Ed Rink	256 729 7000 x 16393	Mech/Nuc	Design Review	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
Edward J. Rink Jr	1/12/04	James W Gronek	1/14/04
VERIFIER SIGNATURE	**DATE**	**APPROVAL SIGNATURE**	**DATE**
Robert J. Wallace	1/22/04	For William D. Crouch	2/11/04

STATEMENT OF PROBLEM/ABSTRACT

Problem:

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:

This revision adds Appendix E 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) 97-04 and NRC Bulletin 96-03.

MICROFICHE/EFICHE Yes ☐ No ☒ FICHE NUMBER(S)

- ☐ LOAD INTO EDMS AND DESTROY
- ☐ LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY. ADDRESS:
- ☐ LOAD INTO EDMS AND RETURN CALCULATION TO:

005 BY DJK
CHKD. MDA

To: Those Listed

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, same 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 T0400 Report, Reference 2)

	RHR Flow (gpm)	CS Flow (gpm)	Pre-EPU Pool Temp (°F)	Vapor Pressure (psi)	Time after LOCA	EPU Pool Temp (°F)	Vapor Pressure (psi)	Vapor pressure difference	Conversion factor (ft/psi)	Pre-EPU NPSH Margin (ft) without credit	EPU NPSH Margin (ft) without credit	containment overpressure credit (psi)	EPU NPSH Margin (ft) with credit
RHR													
Short Term LOCA (0-600 sec)	42,000	12,500	140	2.889	600	155.4	4.251	1.362	2.357	-2.52 -2.59	-5.73 -5.80	3	1.34 1.32
Long Term LOCA	13,000	6,250	177	7.026	601	152.0	3.963	-3.063	2.355	5.87 5.74	13.08 12.95	0	13.08 12.95
				7.026	4150	175.83	6.837	-0.189	2.374	5.87 5.74	6.32 6.19	0	6.32 6.19
				7.026	4580	177	7.026	0.000	2.375	5.87	5.87	1	8.24
				7.026	5500	179.1	7.354	0.328	2.377	5.87	5.09	1	7.47
				7.026	7090	181.85	7.837	0.811	2.379	5.87	3.94 3.81	1	6.32 6.19
				7.026	7100	181.9	7.846	0.820	2.379	5.87	3.92	2	8.68
				7.026	14,700	186.6	8.684	1.658	2.383	5.87	1.92 1.79	2	6.69 6.56
				7.026	35,000	182.8	7.995	0.969	2.380	5.87	3.56	2	8.32
				7.026	37,500	181.85	7.837	0.811	2.379	5.87 5.74	3.94 3.81	1	6.32 6.19
				7.026	52,300	175.83	6.837	-0.189	2.374	5.87	6.32	0	6.32
CS													
Short Term LOCA			140	2.889	600	155.4		1.362	2.357	4.23 4.16	1.02 0.95	3	8.09 8.02
Long Term LOCA			177	7.026	601	152.0 Begin of 0 psi		-3.063	2.355	-0.45 0.58	6.76 6.48	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
				↓	4580	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
				↓	7090	181.85 End of 1 psi		0.811	2.379	-0.45	-2.38 -2.73	1	0.00 -0.35
				↓	7100	181.9 Begin of 2 psi		0.820	2.379	-0.45	-2.40	2	2.36
				↓	14700	186.6		1.658	2.383	-0.45	-4.40 -4.53	2	0.37 0.24
				↓	35000	182.75		0.969	2.380	-0.45	-2.76	2	2.00
				↓	37500	181.85 End of 2 psi		0.811	2.379	-0.45	-2.38 -2.44	1	0.00 -0.13
				↓	52300	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 C of T0400 Report, Reference 7)

RHR	CS	Pre-EPU	Vapor	Time after	EPU Pool	Vapor	Vapor	Conversion	Pre-EPU NPSH	EPU NPSH	containment	EPU NPSH

06/18, [illegible]

Attachment-2 B Page B-2

005 By DJK
Chkd: MA

Table 4-4

CPPU DBA-LOCA NPSH Margins and Containment Overpressure Credit

Time After LOCA (sec)	Suppression Pool Temperature (°F)	Containment Overpressure Required (psi)	RHR pump NPSH margin (ft)	CS pump NPSH margin (ft)	Description/Basis
600	155.4	~~2.1~~ 2.46	0	6.75	Short-term analysis. Overpressure required to meet RHR NPSH requirements
601	152.4	0	12.95 ~~13.08~~	6.55 ~~6.76~~	Long-term analysis
4,150	175.83	0	6.32	0	Greater than 0 psi of overpressure required for long-term for CS pumps
7,000	181.85	1	6.32	0	Greater than 1 psi of overpressure required for long-term for CS pumps
14,700	186.6	~~1.84~~ 1.90	6.32	0	Peak Suppression Pool temperature
37,500	181.85	1	6.32	0	Less than 1 psi of overpressure required for long-term for CS pumps

Attachment 2, Page B-3
DCS BY DSK
CHKD: MDA

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." <tfnewton@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

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

ENCLOSURE 7

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNIT 1

CONTAINMENT CALCULATION FOR NPSH EVALUATIONS

Following are the inputs, assumptions, methodology, and results for the containment calculations performed for input into the NPSH evaluations. The calculations are performed with assumptions which maximize the suppression pool temperature. This calculation however differs from the EPU DBA LOCA containment calculation described in PUSAR Section 4.1, "Containment System Performance," in that this calculation uses inputs, which minimize the resultant containment (wetwell airspace) pressure.

Key Analysis Inputs

TABLE 7-1

ITEM	PARAMETER	VALUE
1.	Reactor Power 102% of EPU power	4031 MWt
2.	Reactor Steam Dome Pressure	1055 psia
3.	Decay Heat	ANS 5.1 - 1979 +2σ
4.	Initial Suppression Pool volume corresponding to minimum suppression pool level	121,500 ft^3
5.	Drywell Volume	159,000 ft^3
6.	Initial Wetwell Airspace Volume	129,300 ft^3
7.	Initial Drywell Pressure	15.5 psia
8.	Initial Drywell Temperature	150°F
9.	Initial Wetwell Airspace Temperature	95°F
10.	Initial Wetwell Airspace Pressure	14.4 psia
11.	Initial Suppression Pool Temperature	95°F

TABLE 7-1

ITEM	PARAMETER	VALUE
12.	Initial Drywell Relative Humidity	100%
13.	Initial Wetwell Relative Humidity	100%
14.	Ultimate Heat Sink/RHR Service Water Temperature	95°F
15.	RHR Heat Exchanger K value	223 Btu/sec-°F
16.	Pump Heat Per RHR/LPCI Pump	2000 hp
17.	Pump Heat Per LPCS	600 hp

Analysis Method

The GE SHEX code is used to calculate the containment response, including suppression pool temperature and wetwell airspace pressure.

Analysis Description

The DBA LOCA for NPSH is analyzed for two time periods: up to 600 seconds (no containment sprays) called "short-term" DBA LOCA for NPSH and after 600 seconds (containment sprays on) called "long-term" DBA LOCA for NPSH. For the short-term, all ECCS pumps are assumed to be operating, as the worst assumption, whereas the long-term analysis assumes that only one RHR loop (2 RHR pumps and 2 SW pumps) is operating.

Assumptions for DBA LOCA Short-Term NPSH Evaluation

TABLE 7-2

ITEM	ASSUMPTION	BASIS
1.	The break is modeled as an instantaneous double-ended guillotine break of a recirculation discharge line (1.94 ft^2).	This assumption would produce a peak suppression pool temperature and a minimum containment pressure.
2.	Containment heat sinks are included in the model.	Heat transfer to the wetwell and drywell heat structures decreases the containment pressure, which is worse for NPSH calculations
3.	The four LPCI pumps operate during the event, with the flow from two pumps injected into the broken loop (going directly to the drywell through the break) at 11,000 gpm/pump. The other two pumps inject into the intact loop at 10,000 gpm/pump.	Minimize the pressure response.
4.	The four LPCS pumps operate during the event injecting 3125 gpm/pump.	Minimize the pressure response.
5.	Initial drywell and wetwell pressures are at their minimum expected values of 15.5 psia and 14.4 psia, respectively.	Minimize the pressure response.
6.	Initial drywell relative humidity is at its maximum expected value of 100%.	Minimize the mass of non-condensable gas to minimize the pressure response.

TABLE 7-2

ITEM	ASSUMPTION	BASIS
7.	Heat transfer between the wetwell airspace and suppression pool is mechanistically calculated.	This is a conservative approach for determination of wetwell temperature and pressure for NPSH.
8.	No RHR heat exchanger operation for the short-term analysis time period of 600 seconds.	No operator action before 600 seconds.
9.	Containment mass leakage of 2%/day was used to evaluate the impact on the wetwell pressure.	Minimize the containment pressure.

Assumptions for DBA LOCA Long-Term NPSH Evaluation

TABLE 7-3

ITEM	ASSUMPTION	BASIS
1.	The break is modeled as an instantaneous double-ended guillotine break of a recirculation suction line (4.2 ft^2).	This assumption would produce a peak suppression pool temperature and a minimum containment pressure.
2.	RHR cooling is initiated for containment spray with 2 RHR pumps (5,850 gpm/pump), 2 SW pumps, 95°F SW temperature, and a heat exchanger K-value of 223 BTU/sec-°F. The RHR pump flow is split 95%/5% between drywell and wetwell spray.	Minimize the pressure response.
3.	Two LPCI pumps actuate and provide 9,000 gpm/pump to control RPV level for the first 600 seconds of the event.	Minimize the pressure response.

TABLE 7-3

ITEM	ASSUMPTION	BASIS
4.	Two LPCS pumps actuate and provide 3,550 gpm/pump to control RPV level throughout the event.	Minimize the pressure response.
5.	Initial drywell and wetwell pressures are at their minimum expected values of 15.5 psia and 14.4 psia, respectively.	Minimize the pressure response.
6.	Initial drywell relative humidity is at its maximum expected value of 100%	Minimize the mass of non-condensable gas to minimize the pressure response.
7.	Heat transfer between the wetwell airspace and suppression pool is mechanistically calculated.	This is a conservative approach for determination of wetwell temperature and pressure for NPSH.
8.	Containment mass leakage of 2%/day was used to evaluate the impact on the wetwell pressure.	Minimize the containment pressure.

Analysis Results

The results of the SHEX short-term and long-term containment analyses for evaluating NPSH, including suppression pool temperature and wetwell airspace pressure, are provided in Attachment A to this enclosure.

ATTACHMENT A:

DBA LOCA SHORT-TERM AND LONG-TERM CONTAINMENT ANALYSIS
SUPPRESSION POOL TEMPERATURE AND WETWELL PRESSURE
FOR NPSH EVALUATIONS

Note:

1. Adjusted wetwell airspace pressure including 2% leakage per day.

A.1: Short-Term Results for Input to NPSH Evaluation

TABLE 7-A.1

Time (sec)	P_{ww} (psia)	T_{sp} (°F)	P_{ww} Leak[1] (psia)
0.00	14.40	95.00	14.40
0.25	14.86	95.02	14.86
0.87	17.72	95.16	17.72
1.50	20.45	95.37	20.45
2.59	24.07	95.83	24.07
4.15	27.46	96.61	27.46
6.65	30.58	98.07	30.58
11.40	33.09	101.20	33.09
16.90	34.10	105.00	34.10
26.90	34.96	111.70	34.96
36.40	35.61	117.20	35.61
47.65	36.34	123.00	36.34
54.34	36.73	125.90	36.73
66.59	37.35	130.30	37.35
73.59	37.65	132.30	37.65
79.09	37.86	133.60	37.86
84.21	38.04	134.70	38.04
88.06	38.17	135.40	38.16
91.34	38.14	135.90	38.14
93.25	38.12	136.20	38.12
94.66	38.10	136.30	38.09
95.53	38.08	136.40	38.08

TABLE 7-A.1

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
96.22	38.07	136.40	38.07
96.94	38.06	136.40	38.06
97.81	38.04	136.40	38.04
98.91	38.02	136.40	38.02
101.31	37.98	136.40	37.98
103.81	37.95	136.40	37.95
106.31	37.92	136.40	37.91
108.87	37.89	136.40	37.89
111.47	37.56	136.40	37.56
113.97	37.03	136.50	37.03
116.47	36.54	136.60	36.54
118.97	36.01	136.80	36.01
121.47	35.48	136.90	35.48
123.97	34.95	137.00	34.95
126.47	34.42	137.20	34.42
128.97	33.91	137.30	33.91
131.47	33.40	137.50	33.40
133.97	32.88	137.60	32.88
136.47	32.41	137.80	32.41
138.97	31.92	138.00	31.91
141.47	31.42	138.20	31.42
143.97	30.99	138.40	30.99
146.47	30.56	138.60	30.56
148.97	30.11	138.80	30.11
151.47	29.67	139.00	29.67
153.97	29.27	139.20	29.27
156.47	28.87	139.40	28.87
158.97	28.49	139.60	28.48
161.47	28.11	139.70	28.11
163.97	27.74	139.90	27.74
166.47	27.38	140.20	27.38
168.97	27.02	140.40	27.02

TABLE 7-A.1

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
171.47	26.66	140.60	26.66
173.97	26.32	140.80	26.32
176.47	25.98	141.00	25.98
178.97	25.65	141.20	25.65
181.47	25.33	141.40	25.33
183.97	25.02	141.60	25.02
186.47	24.70	141.80	24.69
188.97	24.39	142.00	24.39
191.47	24.06	142.30	24.06
193.97	23.73	142.50	23.73
196.47	23.41	142.70	23.41
198.97	23.10	142.90	23.10
201.84	22.73	143.10	22.72
204.72	22.39	143.30	22.39
207.72	22.03	143.50	22.03
210.59	21.71	143.70	21.71
213.34	21.40	143.90	21.40
215.97	21.13	144.10	21.13
218.72	20.86	144.30	20.85
221.22	20.60	144.50	20.59
223.72	20.35	144.60	20.34
226.28	20.10	144.80	20.10
229.09	19.89	144.90	19.89
231.97	19.63	145.10	19.63
234.84	19.43	145.30	19.42
237.91	19.20	145.40	19.20
240.50	19.02	145.50	19.02
243.00	18.85	145.70	18.85
245.62	18.68	145.80	18.67
248.34	18.53	145.90	18.53
251.97	18.34	146.10	18.34
254.94	18.18	146.20	18.18

TABLE 7-A.1

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
257.44	18.07	146.30	18.07
259.66	17.99	146.40	17.99
264.12	17.95	146.60	17.94
274.25	17.98	147.10	17.98
281.62	18.00	147.50	18.00
287.12	18.02	147.70	18.02
292.00	18.03	147.90	18.03
296.94	18.04	148.00	18.04
301.19	18.02	148.20	18.02
304.94	17.95	148.30	17.94
309.00	17.86	148.50	17.86
313.06	17.79	148.60	17.79
316.81	17.71	148.80	17.71
320.81	17.64	148.90	17.64
325.06	17.56	149.10	17.56
329.25	17.51	149.20	17.51
333.44	17.44	149.40	17.44
337.87	17.39	149.50	17.39
342.31	17.33	149.70	17.33
347.19	17.28	149.80	17.28
351.75	17.23	149.90	17.23
356.25	17.17	150.10	17.16
360.87	17.14	150.20	17.14
365.62	17.10	150.30	17.10
370.00	17.07	150.50	17.06
374.87	17.04	150.60	17.04
379.62	17.02	150.70	17.01
385.06	16.97	150.90	16.96
389.87	16.96	151.00	16.96
394.87	16.93	151.10	16.92
399.94	16.92	151.20	16.92
404.87	16.90	151.30	16.90

TABLE 7-A.1

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
409.75	16.87	151.50	16.87
414.75	16.87	151.60	16.87
419.62	16.87	151.70	16.87
424.50	16.84	151.80	16.84
429.50	16.84	151.90	16.84
434.50	16.84	152.00	16.83
439.87	16.83	152.10	16.83
445.25	16.83	152.20	16.83
450.50	16.83	152.30	16.83
455.87	16.83	152.40	16.83
461.37	16.83	152.60	16.82
467.00	16.82	152.70	16.82
472.56	16.82	152.80	16.82
478.25	16.82	152.90	16.82
483.75	16.82	153.00	16.82
489.50	16.82	153.10	16.81
495.06	16.82	153.30	16.81
500.87	16.81	153.40	16.81
506.62	16.81	153.50	16.81
512.62	16.81	153.60	16.81
518.37	16.81	153.70	16.81
524.25	16.81	153.90	16.81
530.06	16.81	154.00	16.81
535.81	16.81	154.10	16.81
541.81	16.81	154.20	16.81
547.69	16.81	154.40	16.81
553.69	16.81	154.50	16.81
559.69	16.81	154.60	16.81
565.69	16.81	154.70	16.81
571.69	16.81	154.80	16.81
577.62	16.81	155.00	16.81
583.62	16.81	155.10	16.81

TABLE 7-A.1

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
589.62	16.81	155.20	16.81
595.62	16.81	155.30	16.81
600.12	16.81	155.40	16.81

A.2: Long-Term Results for Input to NPSH Evaluation

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
0.00	14.40	95.00	14.40
0.52	17.16	95.20	17.16
1.52	23.84	96.11	23.84
4.96	32.32	100.60	32.32
12.21	34.96	111.00	34.96
23.83	36.84	125.90	36.84
32.33	37.24	131.90	37.24
36.57	37.33	133.30	37.33
37.29	37.35	133.40	37.35
40.91	37.47	134.40	37.47
43.98	37.56	135.10	37.56
46.48	37.64	135.60	37.64
48.98	37.70	136.10	37.70
52.60	37.81	136.80	37.81
56.48	37.93	137.40	37.93
60.16	38.05	138.00	38.05
64.10	38.17	138.50	38.17
67.48	38.26	138.90	38.26
70.85	38.32	139.30	38.32
73.51	38.34	139.60	38.34
76.10	38.36	139.80	38.35
78.79	38.37	140.00	38.37
81.54	38.38	140.30	38.38

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
84.01	38.39	140.50	38.39
85.91	38.40	140.60	38.40
87.41	38.40	140.70	38.40
88.66	38.41	140.70	38.41
89.91	38.42	140.80	38.42
91.19	38.42	140.80	38.42
92.54	38.42	140.80	38.42
93.88	38.43	140.90	38.42
95.29	38.43	140.90	38.43
96.73	38.44	140.90	38.44
98.13	38.44	141.00	38.44
99.63	38.45	141.00	38.45
110.79	38.56	141.30	38.56
123.19	38.38	141.40	38.38
135.69	38.06	141.50	38.06
148.19	37.74	141.60	37.74
160.19	37.50	141.80	37.50
172.91	37.44	142.00	37.43
185.32	37.04	142.30	37.04
197.82	36.64	142.60	36.64
210.32	36.34	142.80	36.33
222.82	36.04	143.00	36.04
235.32	35.73	143.10	35.73
247.82	35.43	143.30	35.43
260.26	35.13	143.40	35.13
272.76	34.83	143.50	34.83
285.26	34.55	143.60	34.54
297.76	34.35	143.70	34.35
310.01	34.19	143.80	34.19
322.51	33.75	144.00	33.75
335.01	33.39	144.20	33.39
347.23	32.94	144.50	32.94

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{GP} (°F)	P_{WW} Leak[1] (psia)
359.41	32.55	144.80	32.55
371.63	32.14	145.10	32.14
383.63	31.78	145.50	31.78
395.79	31.40	145.80	31.40
408.10	31.00	146.20	30.99
420.23	30.66	146.60	30.66
432.16	30.26	147.00	30.26
444.10	29.94	147.40	29.93
456.13	29.59	147.80	29.58
468.16	29.25	148.20	29.24
480.38	28.92	148.60	28.91
492.79	28.53	149.10	28.52
505.29	28.24	149.50	28.24
517.79	27.90	149.90	27.90
530.29	27.56	150.30	27.56
542.79	27.30	150.70	27.29
555.60	26.96	151.10	26.96
568.54	26.68	151.50	26.68
582.79	26.35	152.00	26.35
596.23	26.02	152.40	26.02
607.18	24.43	152.80	24.43
618.52	22.64	153.30	22.63
630.43	21.94	153.80	21.94
642.18	21.16	154.40	21.15
654.08	20.49	154.90	20.49
667.40	19.96	155.50	19.95
681.12	19.57	156.00	19.57
695.49	19.28	156.40	19.28
711.08	19.04	156.90	19.04
726.52	18.82	157.30	18.82
742.71	18.67	157.70	18.67
760.62	18.59	158.10	18.59

TABLE 7-A.2

Time (sec)	P_{WM} (psia)	T_{SP} (°F)	P_{WM} Leak[1] (psia)
780.77	18.67	158.60	18.67
802.55	18.75	159.00	18.74
821.49	18.58	159.30	18.58
844.58	18.68	159.70	18.68
867.08	18.76	159.90	18.75
886.77	18.80	160.10	18.80
903.90	18.84	160.20	18.84
919.52	18.87	160.40	18.87
942.33	18.91	160.50	18.91
966.08	18.94	160.70	18.94
990.33	18.98	160.90	18.97
1014.96	19.01	161.10	19.00
1039.27	19.04	161.30	19.04
1063.46	19.08	161.50	19.07
1087.59	19.10	161.60	19.10
1111.59	19.13	161.80	19.12
1135.27	19.15	162.00	19.14
1159.84	19.17	162.20	19.17
1183.96	19.20	162.30	19.19
1208.27	19.22	162.50	19.22
1232.59	19.25	162.70	19.25
1257.02	19.28	162.80	19.27
1281.55	19.28	163.00	19.27
1306.15	19.28	163.20	19.27
1330.68	19.28	163.30	19.27
1355.71	19.28	163.50	19.28
1380.55	19.29	163.70	19.28
1404.90	19.29	163.80	19.29
1429.43	19.30	164.00	19.29
1455.02	19.30	164.10	19.30
1478.80	19.31	164.30	19.30
1503.27	19.31	164.40	19.31

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{EP} (°F)	P_{WW} Leak[1] (psia)
1527.87	19.32	164.60	19.31
1552.40	19.32	164.80	19.31
1577.30	19.32	164.90	19.31
1600.90	19.32	165.10	19.31
1624.74	19.32	165.20	19.31
1647.68	19.29	165.30	19.28
1671.99	19.32	165.50	19.31
1695.40	19.31	165.60	19.31
1718.46	19.28	165.80	19.28
1741.65	19.32	165.90	19.31
1765.30	19.31	166.00	19.31
1789.59	19.31	166.20	19.31
1814.74	19.32	166.30	19.31
1839.34	19.32	166.50	19.31
1864.93	19.32	166.60	19.32
1889.02	19.32	166.70	19.32
1914.80	19.32	166.90	19.32
1941.15	19.33	167.00	19.32
1966.37	19.33	167.20	19.32
1992.71	19.33	167.30	19.33
2037.93	19.31	167.50	19.30
2090.24	19.32	167.80	19.31
2142.21	19.35	168.10	19.34
2193.77	19.36	168.30	19.35
2245.62	19.39	168.60	19.38
2297.49	19.39	168.80	19.38
2347.46	19.42	169.10	19.41
2398.74	19.45	169.30	19.44
2448.74	19.44	169.50	19.44
2498.84	19.47	169.80	19.46
2548.74	19.50	170.00	19.49
2597.55	19.50	170.20	19.49

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
2647.15	19.53	170.40	19.52
2695.90	19.53	170.70	19.52
2745.74	19.56	170.90	19.55
2794.99	19.56	171.10	19.55
2844.52	19.60	171.30	19.59
2893.46	19.61	171.50	19.59
2942.99	19.64	171.70	19.63
2992.30	19.65	171.90	19.64
3041.55	19.66	172.10	19.65
3091.40	19.69	172.30	19.68
3140.52	19.69	172.50	19.68
3189.59	19.69	172.70	19.68
3239.43	19.73	172.80	19.72
3288.49	19.73	173.00	19.71
3338.09	19.75	173.20	19.74
3387.40	19.74	173.40	19.73
3436.99	19.76	173.60	19.75
3486.96	19.78	173.70	19.77
3536.55	19.80	173.90	19.78
3585.99	19.79	174.10	19.77
3635.84	19.81	174.20	19.79
3685.09	19.80	174.40	19.78
3735.18	19.82	174.60	19.80
3785.77	19.84	174.70	19.82
3835.59	19.83	174.90	19.82
3885.43	19.85	175.00	19.84
3934.74	19.84	175.20	19.83
3985.09	19.86	175.30	19.85
4034.77	19.85	175.50	19.84
4084.18	19.88	175.60	19.86
4134.27	19.90	175.80	19.88
4183.99	19.92	175.90	19.90

TABLE 7-A.2

Time (sec)	P_{WM} (psia)	T_{SP} (°F)	P_{WM} Leak[1] (psia)
4234.21	19.93	176.10	19.92
4284.30	19.95	176.20	19.93
4334.24	19.94	176.30	19.92
4383.90	19.95	176.50	19.94
4431.74	19.97	176.60	19.95
4481.02	19.98	176.70	19.97
4530.99	20.00	176.80	19.98
4580.46	20.02	177.00	20.00
4630.43	20.04	177.10	20.02
4681.02	20.05	177.20	20.04
4731.37	20.07	177.40	20.06
4781.59	20.09	177.50	20.07
4831.68	20.11	177.60	20.09
4882.09	20.13	177.70	20.11
4931.93	20.14	177.80	20.13
4981.96	20.16	178.00	20.14
5031.71	20.14	178.10	20.13
5081.68	20.16	178.20	20.14
5131.77	20.18	178.30	20.16
5182.49	20.20	178.40	20.18
5230.27	20.21	178.50	20.19
5277.87	20.23	178.60	20.21
5323.15	20.26	178.70	20.24
5368.52	20.25	178.80	20.23
5411.12	20.23	178.90	20.21
5457.09	20.26	179.00	20.24
5506.99	20.29	179.10	20.27
5557.02	20.32	179.20	20.30
5607.90	20.36	179.30	20.34
5658.90	20.41	179.40	20.39
5709.77	20.40	179.50	20.38
5760.49	20.42	179.60	20.40

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{EP} (°F)	P_{WW} Leak[1] (psia)
5810.87	20.41	179.70	20.39
5857.21	20.42	179.80	20.40
5907.21	20.42	179.90	20.40
5957.24	20.44	180.00	20.41
6006.87	20.43	180.10	20.41
6057.02	20.45	180.20	20.43
6106.80	20.47	180.30	20.44
6155.93	20.46	180.40	20.44
6205.59	20.48	180.50	20.45
6252.99	20.49	180.50	20.47
6303.27	20.51	180.60	20.48
6352.93	20.52	180.70	20.50
6402.46	20.54	180.80	20.52
6452.62	20.55	180.90	20.53
6481.46	20.56	180.90	20.54
6506.46	20.58	181.00	20.55
6550.77	20.56	181.00	20.53
6601.40	20.59	181.10	20.57
6636.30	20.59	181.20	20.57
6661.30	20.61	181.20	20.59
6686.30	20.62	181.30	20.60
6732.43	20.60	181.30	20.58
6782.43	20.63	181.40	20.61
6825.34	20.63	181.50	20.61
6850.34	20.64	181.50	20.62
6875.34	20.66	181.50	20.63
6900.34	20.67	181.60	20.64
6944.09	20.64	181.60	20.61
6994.46	20.66	181.70	20.64
7045.09	20.69	181.80	20.66
7080.05	20.68	181.80	20.65
7105.05	20.69	181.90	20.66

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
7130.05	20.70	181.90	20.67
7155.05	20.70	182.00	20.68
7180.05	20.71	182.00	20.68
7228.68	20.68	182.10	20.65
7279.55	20.70	182.10	20.68
7329.68	20.72	182.20	20.69
7369.96	20.71	182.30	20.68
7394.96	20.72	182.30	20.69
7419.96	20.73	182.30	20.70
7444.96	20.73	182.40	20.71
7469.96	20.74	182.40	20.71
7494.96	20.75	182.40	20.72
7519.96	20.75	182.40	20.72
7567.46	20.72	182.50	20.70
7617.46	20.74	182.60	20.71
7667.71	20.76	182.60	20.73
7718.21	20.78	182.70	20.75
7743.24	20.76	182.70	20.73
7768.24	20.77	182.80	20.74
7793.24	20.77	182.80	20.75
7818.24	20.78	182.80	20.75
7843.24	20.78	182.90	20.75
7868.24	20.79	182.90	20.76
7893.24	20.79	182.90	20.76
7930.62	20.75	183.00	20.72
7980.74	20.77	183.00	20.74
8030.74	20.78	183.10	20.75
8081.37	20.80	183.10	20.77
8131.37	20.81	183.20	20.78
8158.46	20.80	183.20	20.77
8183.46	20.80	183.30	20.77
8208.46	20.81	183.30	20.78

TABLE 7-A.2

Time (sec)	P_{WM} (psia)	T_{GP} (°F)	P_{WM} Leak[1] (psia)
8233.46	20.81	183.30	20.78
8258.46	20.82	183.30	20.79
8283.46	20.82	183.40	20.79
8308.46	20.82	183.40	20.79
8333.46	20.83	183.40	20.80
8358.46	20.83	183.40	20.80
8383.46	20.83	183.50	20.80
8408.46	20.83	183.50	20.80
8433.46	20.83	183.50	20.80
8458.46	20.83	183.50	20.80
8483.46	20.84	183.60	20.81
8508.46	20.84	183.60	20.81
8533.46	20.84	183.60	20.81
8558.46	20.84	183.60	20.81
8583.46	20.84	183.70	20.81
8608.46	20.84	183.70	20.81
8633.46	20.84	183.70	20.81
8658.46	20.84	183.70	20.81
8683.46	20.85	183.80	20.82
8708.46	20.85	183.80	20.82
8733.46	20.85	183.80	20.82
8758.46	20.85	183.80	20.82
8783.46	20.85	183.90	20.82
8808.46	20.85	183.90	20.82
8833.46	20.85	183.90	20.82
8858.46	20.85	183.90	20.82
8883.46	20.85	184.00	20.82
8916.77	20.81	184.00	20.78
8966.77	20.83	184.00	20.80
9016.77	20.85	184.10	20.82
9066.77	20.87	184.10	20.84
9102.49	20.86	184.20	20.83

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{GP} (°F)	P_{WW} Leak[1] (psia)
9127.49	20.87	184.20	20.83
9152.49	20.87	184.20	20.84
9177.49	20.88	184.20	20.85
9202.49	20.88	184.30	20.85
9227.49	20.89	184.30	20.86
9266.93	20.85	184.30	20.81
9316.93	20.86	184.40	20.83
9366.93	20.88	184.40	20.85
9416.93	20.89	184.40	20.86
9466.93	20.91	184.50	20.87
9494.21	20.89	184.50	20.86
9519.21	20.90	184.50	20.86
9544.21	20.90	184.50	20.87
9569.21	20.91	184.60	20.87
9594.21	20.91	184.60	20.88
9619.21	20.91	184.60	20.88
9644.21	20.92	184.60	20.88
9669.21	20.92	184.60	20.88
9705.27	20.87	184.70	20.84
9755.27	20.89	184.70	20.85
9805.27	20.90	184.70	20.86
9855.27	20.91	184.80	20.88
9905.27	20.92	184.80	20.89
9952.62	20.91	184.90	20.87
9977.62	20.92	184.90	20.88
10027.62	20.93	184.90	20.89
10152.62	20.94	185.00	20.90
10277.62	20.95	185.10	20.91
10402.62	20.95	185.20	20.91
10527.62	20.95	185.20	20.91
10652.62	20.95	185.30	20.91
10842.43	20.94	185.40	20.90

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
11048.02	20.96	185.60	20.92
11173.02	20.98	185.60	20.94
11298.02	20.98	185.70	20.94
11423.02	20.98	185.70	20.94
11548.02	20.97	185.80	20.93
11673.02	20.97	185.80	20.93
11798.02	20.97	185.90	20.93
11923.02	20.96	185.90	20.92
12048.02	20.96	186.00	20.92
12173.02	20.96	186.00	20.91
12298.02	20.95	186.10	20.91
12423.02	20.95	186.10	20.90
12548.02	20.94	186.20	20.90
12673.02	20.94	186.20	20.89
12798.02	20.93	186.20	20.89
12932.40	20.93	186.30	20.89
13182.40	20.99	186.30	20.94
13432.05	20.99	186.40	20.94
13682.05	21.00	186.40	20.96
13932.05	21.01	186.50	20.96
14182.05	21.00	186.50	20.95
14432.05	21.00	186.50	20.95
14682.05	20.99	186.60	20.94
14932.05	20.98	186.60	20.93
15182.05	20.97	186.60	20.92
15432.05	20.96	186.60	20.91
15682.05	20.96	186.60	20.91
15932.05	20.95	186.60	20.89
16182.05	20.93	186.60	20.88
16432.06	20.92	186.60	20.87
16682.06	20.91	186.60	20.86
16932.06	20.90	186.60	20.84

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
17182.06	20.89	186.60	20.83
17432.06	20.88	186.60	20.82
17682.06	20.87	186.60	20.81
17932.06	20.86	186.60	20.80
18182.06	20.85	186.60	20.78
18432.06	20.84	186.60	20.78
18682.06	20.83	186.50	20.77
18932.06	20.82	186.50	20.76
19182.06	20.82	186.50	20.75
19432.06	20.81	186.50	20.74
19682.06	20.80	186.40	20.73
19932.06	20.80	186.40	20.73
20182.06	20.79	186.40	20.72
20432.06	20.78	186.30	20.71
20682.06	20.79	186.30	20.72
20932.06	20.80	186.30	20.73
21182.06	20.85	186.20	20.77
21431.77	20.89	186.20	20.82
21680.81	20.93	186.10	20.86
21929.18	20.95	186.10	20.87
22177.37	21.00	186.00	20.92
22426.49	20.99	186.00	20.92
22676.49	20.98	185.90	20.91
22926.49	20.94	185.90	20.86
23176.49	20.89	185.90	20.81
23426.49	20.83	185.80	20.75
23676.49	20.79	185.80	20.71
23926.49	20.77	185.80	20.69
24176.49	20.76	185.70	20.67
24426.49	20.74	185.70	20.66
24676.49	20.74	185.70	20.65
24926.49	20.73	185.60	20.65

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
25176.49	20.73	185.60	20.64
25426.49	20.72	185.60	20.63
25676.49	20.72	185.50	20.63
25926.49	20.72	185.50	20.63
26176.49	20.71	185.50	20.62
26426.49	20.70	185.50	20.61
26676.49	20.68	185.40	20.59
26926.49	20.66	185.30	20.57
27176.49	20.65	185.30	20.55
27426.49	20.63	185.20	20.54
27676.49	20.62	185.20	20.53
27926.49	20.61	185.10	20.51
28176.49	20.60	185.00	20.50
28426.49	20.58	185.00	20.49
28676.43	20.57	184.90	20.47
28926.43	20.56	184.80	20.46
29176.43	20.54	184.70	20.44
29426.43	20.53	184.70	20.43
29676.43	20.51	184.60	20.41
29926.43	20.51	184.50	20.40
30176.43	20.49	184.50	20.39
30426.43	20.47	184.40	20.37
30676.43	20.46	184.30	20.36
30926.43	20.44	184.20	20.34
31176.43	20.43	184.10	20.32
31426.43	20.41	184.10	20.31
31676.43	20.40	184.00	20.29
31926.43	20.38	183.90	20.28
32176.43	20.37	183.80	20.26
32426.43	20.36	183.70	20.25
32676.43	20.34	183.60	20.23
32926.43	20.33	183.60	20.21

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
33176.43	20.31	183.50	20.20
33426.43	20.30	183.40	20.18
33676.43	20.28	183.30	20.17
33926.43	20.27	183.20	20.15
34176.43	20.25	183.10	20.14
34426.43	20.24	183.00	20.12
34676.43	20.22	182.90	20.11
34926.43	20.21	182.80	20.09
35176.43	20.19	182.70	20.07
35426.43	20.17	182.70	20.05
35676.43	20.16	182.60	20.04
35926.43	20.14	182.50	20.02
36176.43	20.12	182.40	20.00
36426.43	20.11	182.30	19.99
36676.43	20.10	182.20	19.97
36926.43	20.08	182.10	19.96
37176.43	20.07	182.00	19.94
37426.43	20.05	181.90	19.93
37676.43	20.03	181.80	19.91
37926.43	20.02	181.70	19.89
38176.43	20.00	181.60	19.87
38426.43	19.98	181.50	19.85
38676.43	19.97	181.40	19.84
38926.43	19.95	181.30	19.82
39176.43	19.93	181.20	19.80
39426.43	19.91	181.10	19.78
39676.43	19.90	180.90	19.76
39926.43	19.88	180.80	19.75
40176.43	19.86	180.70	19.73
40426.43	19.85	180.60	19.71
40678.81	19.83	180.50	19.69
40929.93	19.81	180.40	19.68

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
41179.93	19.79	180.30	19.66
41429.93	19.78	180.20	19.64
41679.93	19.77	180.10	19.63
41929.93	19.75	180.00	19.61
42179.93	19.74	179.90	19.60
42429.93	19.72	179.80	19.58
42679.93	19.70	179.70	19.56
42929.93	19.69	179.60	19.54
43179.93	19.67	179.50	19.53
43429.93	19.66	179.40	19.51
43679.93	19.64	179.30	19.49
43929.93	19.62	179.20	19.48
44179.93	19.61	179.10	19.46
44429.93	19.59	179.00	19.44
44679.93	19.58	178.90	19.43
44929.93	19.56	178.80	19.41
45179.93	19.55	178.70	19.40
45429.93	19.53	178.60	19.38
45679.93	19.52	178.50	19.36
45929.93	19.50	178.40	19.35
46179.93	19.49	178.30	19.33
46429.93	19.47	178.20	19.32
46679.93	19.46	178.10	19.30
46929.93	19.44	178.00	19.29
47179.93	19.43	177.90	19.27
47429.93	19.41	177.80	19.26
47679.93	19.40	177.70	19.24
47929.93	19.39	177.60	19.23
48179.93	19.38	177.50	19.22
48429.93	19.36	177.40	19.20
48679.93	19.35	177.30	19.19
48929.93	19.33	177.20	19.17

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{GP} (°F)	P_{WW} Leak[1] (psia)
49179.93	19.32	177.10	19.16
49429.93	19.31	177.00	19.14
49679.93	19.29	176.90	19.13
49929.93	19.28	176.80	19.11
50179.93	19.27	176.70	19.10
50429.93	19.25	176.60	19.09
50679.93	19.24	176.50	19.07
50929.93	19.23	176.40	19.06
51179.93	19.21	176.30	19.04
51429.93	19.20	176.20	19.03
51679.93	19.19	176.10	19.02
51929.93	19.18	176.00	19.01
52179.93	19.16	175.90	18.99
52429.93	19.15	175.80	18.98
52679.93	19.14	175.70	18.96
52929.93	19.12	175.60	18.95
53179.93	19.11	175.60	18.94
53429.93	19.10	175.50	18.92
53679.93	19.08	175.40	18.91
53929.93	19.07	175.30	18.89
54179.93	19.06	175.20	18.88
54429.93	19.05	175.10	18.87
54679.93	19.03	175.00	18.85
54929.93	19.02	174.90	18.84
55179.93	19.01	174.80	18.83
55429.93	18.99	174.70	18.81
55679.93	18.98	174.60	18.80
55929.93	18.97	174.50	18.79
56179.93	18.96	174.40	18.77
56429.93	18.94	174.40	18.76
56679.93	18.93	174.30	18.75
56929.93	18.92	174.20	18.73

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
57179.93	18.91	174.10	18.72
57429.93	18.89	174.00	18.71
57679.93	18.88	173.90	18.69
57929.93	18.87	173.80	18.68
58179.93	18.86	173.70	18.67
58429.93	18.84	173.60	18.65
58679.93	18.83	173.50	18.64
58929.93	18.82	173.50	18.63
59179.93	18.81	173.40	18.62
59429.93	18.80	173.30	18.60
59679.93	18.78	173.20	18.59
59929.93	18.77	173.10	18.58
60179.93	18.76	173.00	18.56
60429.93	18.75	172.90	18.55
60679.93	18.74	172.80	18.54
60929.93	18.73	172.70	18.53
61179.93	18.72	172.70	18.52
61429.93	18.71	172.60	18.51
61679.93	18.69	172.50	18.49
61929.93	18.68	172.40	18.48
62179.93	18.67	172.30	18.47
62429.93	18.66	172.20	18.46
62679.93	18.65	172.10	18.45
62929.93	18.64	172.10	18.44
63179.93	18.63	172.00	18.43
63429.93	18.62	171.90	18.41
63679.93	18.61	171.80	18.40
63929.93	18.60	171.70	18.39
64179.93	18.59	171.60	18.38
64429.93	18.58	171.60	18.37
64679.93	18.57	171.50	18.36
64929.93	18.56	171.40	18.35

TABLE 7-A.2

Time (sec)	P_{WM} (psia)	T_{SP} (°F)	P_{WM} Leak[1] (psia)
65179.93	18.55	171.30	18.34
65429.93	18.54	171.20	18.33
65679.93	18.53	171.20	18.31
65929.93	18.52	171.10	18.30
66179.93	18.51	171.00	18.29
66429.93	18.50	170.90	18.28
66679.93	18.49	170.80	18.27
66929.93	18.48	170.80	18.26
67179.93	18.47	170.70	18.25
67429.93	18.46	170.60	18.24
67679.93	18.45	170.50	18.23
67929.93	18.44	170.50	18.22
68179.93	18.43	170.40	18.21
68429.93	18.42	170.30	18.20
68679.93	18.41	170.20	18.19
68929.93	18.40	170.10	18.18
69179.93	18.39	170.10	18.17
69429.93	18.38	170.00	18.16
69679.93	18.37	169.90	18.15
69929.93	18.36	169.80	18.14
70179.93	18.35	169.80	18.13
70429.93	18.34	169.70	18.12
70679.93	18.33	169.60	18.11
70929.93	18.33	169.60	18.10
71179.93	18.32	169.50	18.09
71429.93	18.31	169.40	18.08
71679.93	18.30	169.30	18.07
71929.93	18.29	169.30	18.06
72179.93	18.28	169.20	18.05
72429.93	18.27	169.10	18.04
72679.93	18.26	169.00	18.03
72929.93	18.25	169.00	18.02

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SP} (°F)	P_{WW} Leak[1] (psia)
73179.93	18.24	168.90	18.01
73429.93	18.24	168.80	18.00
73679.93	18.23	168.80	17.99
73929.93	18.22	168.70	17.98
74179.93	18.21	168.60	17.97
74429.93	18.20	168.50	17.96
74679.93	18.19	168.50	17.95
74929.93	18.18	168.40	17.94
75179.93	18.17	168.30	17.93
75429.93	18.16	168.30	17.92
75679.93	18.16	168.20	17.91
75929.93	18.15	168.10	17.90
76179.93	18.14	168.10	17.89
76429.93	18.13	168.00	17.88
76679.93	18.12	167.90	17.87
76929.93	18.11	167.90	17.87
77179.93	18.10	167.80	17.86
77429.93	18.10	167.70	17.85
77679.93	18.09	167.60	17.84
77929.93	18.08	167.60	17.83
78179.93	18.07	167.50	17.82
78429.93	18.06	167.40	17.81
78679.93	18.05	167.40	17.80
78929.93	18.05	167.30	17.79
79179.93	18.04	167.20	17.78
79429.93	18.03	167.20	17.77
79679.93	18.02	167.10	17.77
79929.93	18.01	167.00	17.76
80179.93	18.00	167.00	17.75
80429.93	18.00	166.90	17.74
80679.93	17.99	166.80	17.73
80929.93	17.98	166.80	17.72

TABLE 7-A.2

Time (sec)	P_{WW} (psia)	T_{SS} (°F)	P_{WW} Leak[1] (psia)
81179.93	17.97	166.70	17.71
81429.93	17.97	166.70	17.70
81679.93	17.96	166.60	17.70
81929.93	17.95	166.50	17.69
82179.93	17.94	166.50	17.68
82429.93	17.93	166.40	17.67
82679.93	17.93	166.30	17.66
82929.93	17.92	166.30	17.65
83179.93	17.91	166.20	17.64
83429.93	17.90	166.10	17.64
83679.93	17.90	166.10	17.63
83929.93	17.89	166.00	17.62
84179.93	17.88	166.00	17.61
84429.93	17.87	165.90	17.60
84679.93	17.87	165.80	17.59
84929.93	17.86	165.80	17.59
85179.93	17.85	165.70	17.58
85429.93	17.84	165.60	17.57
85679.93	17.84	165.60	17.56
85929.93	17.83	165.50	17.56
86179.93	17.82	165.50	17.55
86400.06	17.82	165.40	17.54

ENCLOSURE 8

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNIT 1

MARKUP OF PUSAR SECTION 4.2.5 INDICATING CHANGES ASSOCIATED WITH REVISED NPSH CALCULATION

This enclosure provides a markup of the text previously provided in the PUSAR regarding Emergency Core Cooling System (ECCS) net positive suction head (NPSH). The marked changes indicate the impact resulting from the revision to the NPSH calculation as described in the cover letter.

Changes are shown as follows:

- Deleted material is bold and is struck through. (**~~deleted~~**)
- New material is bold and double underlined. (**new item**)

PUSAR MARKUP

4.2.5 ECCS Net Positive Suction Head

Following a LOCA, the RHR and CS pumps operate to provide the required core and containment cooling. Adequate margin (NPSH available minus NPSH required) is required during this period to ensure the essential pump operation. The limiting NPSH conditions occur during either short-term or long-term post-LCCA pump operation and depend on the total pump flow rates, debris loading on the suction strainers, and suppression pool temperature.

TVA previously requested containment overpressure credit for Browns Ferry Units 2 and 3 (Reference 20). In that submittal, TVA indicated that the need for containment overpressure in the short term was based on RHR requirements, and in the long term was based on CS requirements. The pre-EPU analysis indicates that up to 3 psi of overpressure credit (considering whole number value) is required for the short-term case for RHR pump operation to maintain adequate NPSH. One (1) psi of overpressure credit is required pre-EPU for the long-term case for CS pump adequate NPSH.

For the pre-EPU and the EPU analyses, the assumptions used maximized suppression pool temperature and minimized containment pressure. EPU RTP operation increases the reactor decay heat,

which increases the heat addition to the suppression pool following a LOCA. Therefore, changes in vapor pressure corresponding to the increase in suppression pool temperatures affect the NPSH margin. After 10 minutes, operation of the RHR pumps for containment cooling in the containment spray mode with continued operation of a CS loop for ECCS injection is also assumed.

The NPSH margins were calculated based on conservatively assuming RHR maximum flow rates and CS design flow rates during the short-term, and RHR and CS design flow rates during the long-term. The system flow rates for the short-term case are 42,000 gpm total RHR flow and 12,500 gpm total CS flow. The system flow rates for the long-term case are 13,000 gpm total RHR flow and 6,250 gpm total CS flow. The methodology used to determine the amount of debris generated and transported to the ECCS strainers is generally based on NEDO-32686, the BWROG Utility Resolution Guidance for ECCS Suction Strainer Blockage. The minimum quantity of paint chips recommended by this guidance is 85 lbs. BFN has identified a maximum surface area allowable of 157 ft^2 for unqualified coatings within the primary containment, which represents an additional 18 lbs of debris; therefore, 103 lbs of paint debris were assumed in sizing the strainers. This quantity did not change with EPU. Because the ECCS pump flow rates were unchanged for EPU, strainer approach velocities were not affected. Therefore, the debris loading on the suction strainers for EPU is the same as the pre-EPU condition. The assumptions used in the Browns Ferry Unit 1 ECCS NPSH calculations for friction loss, static head, strainer loss, flow, and NPSH required have not changed since the responses to NRC GL 97-04 (Reference 15) and NRC Bulletin 96-03 (Reference 21).

The short-term EPU NPSH analysis (0 to 600 seconds) indicates that with a containment overpressure (suppression chamber air space pressure) credit of 3 psi the RHR pumps have adequate NPSH margin. The short-term analysis also indicates that greater than 3 psi of overpressure is available from the beginning of the event until approximately 350 seconds. From 350 seconds to 600 seconds, the short-term analysis (using inputs that conservatively maximized suppression pool temperature and minimized containment pressure) indicates an available overpressure of less than 3 psig. ~~For the brief time that the short-term analysis indicates that less than 3 psi is available, the RHR pumps only require 2.5 psig.~~ **Adequate margin exists between the COP required and the containment pressure except for the RHR pumps injecting into the broken recirculation system piping during the latter portion of the DBA LOCA Short-Term**

analysis. Operation of the RHR pumps with a small negative NPSH margin (approximately 0.3 psi) for a short period of time (≤ 10 minutes) will not cause significant damage to the RHR pumps injecting into the broken recirculation system piping. ~~In addition, historical~~ Historical plant testing has demonstrated that the RHR pumps are capable of operating for short periods of time at NPSH values less than (approximately 9 feet) the manufacturer's required NPSH without degradation or substantial loss of flow. Therefore, RHR pump operation is not adversely affected by containment pressure less than 3 psi. This was previously presented for pre-EPU conditions and approved by the NRC in Reference 16. In the SER accompanying Reference 16, the NRC stated that "the use of 3 psi of containment overpressure above the initial airspace pressure is acceptable for the first 10 minutes after a LOCA." Reference 16 also concludes that CS pump operation is not affected by this lower containment overpressure during the short term.

The long-term EPU NPSH analysis (0 until the end of the event) indicates that up to ~~2~~ 2.5 psi ~~(considering whole number value)~~ containment overpressure credit is required. Containment overpressure credit is required when the suppression pool temperature exceeds ~~181~~ 171°F to obtain adequate NPSH margin for the long-term operation of the CS pumps. This is an increase from the 1 psi of overpressure credit currently approved for pre-EPU conditions. The long-term analysis demonstrates that greater than 4 psi of containment overpressure is available during this period.

Tables 4-2 and 4-3 provide the results of the short-term and long-term containment response. Table 4-4 provides the suppression pool temperature and required containment overpressure required to maintain NPSH margins during the DBA LOCA for EPU conditions.

Based on the above, Browns Ferry is requesting approval of 3 psi of overpressure credit to meet both the short-term and long-term NPSH requirements. A single containment overpressure credit value is requested both to account for potential future contingencies and to provide consistency between the inputs to the short- and long-term analyses. Other means to increase the NPSH margin were found to not be feasible.

~~One RHR pump is required to operate during either the SBO or an Appendix R fire event.~~ Operation of RHR pumps is analyzed for NPSH considerations during the SBO, ATWS, and Appendix R fire event. EPU RTP operation increases the reactor decay heat, which increases the heat addition to the suppression pool following these events (see Sections 6.7.1, 9.3.1, and 9.3.2).

As a result, the long-term peak suppression pool water temperature and peak containment pressure increase. The NPSH evaluation at these peak pool temperatures shows adequate NPSH margins during the SBO, ~~ATWS,~~ and Appendix R events with containment overpressures of ~~1~~ 2 psi, ~~7 psi,~~ and 10 psi, respectively.

The HPCI system primary function is to provide reactor inventory makeup water and assist in depressurizing the reactor during an intermediate or small break LOCA. The HPCI system can operate with suction from the suppression pool at a temperature below 140°F during the first 10 minutes after initiation of the event. EPU has an insignificant effect on the time for the suppression pool temperature to reach 140°F. If the HPCI pump operates beyond the first 10 minutes following the event, the reactor operator may terminate HPCI pump operation when the suppression pool temperature reaches 140°F. The HPCI pump NPSH margin remains adequate as long as the suppression pool temperature does not exceed 140°F during HPCI operation.

HPCI system operation is credited during ATWS~~, Appendix R,~~ and SBO events. The suppression pool temperature does not affect the NPSH margin, because the HPCI pump takes suction from the CST during these events.

Table 4-4

Browns Ferry EPU DBA LOCA NPSH Margins and Containment Overpressure Credit

Time After LOCA (sec)	Suppression Pool Temperature (°F)	Containment Overpressure Required (psi)	Minimum RHR pump NPSH margin (ft)*	Minimum CS pump NPSH margin (ft)*	Description/Basis
600	155.4	~~2.46~~ 2.8	~~0~~ 0.09	~~6.75~~ 4.12	Short-term analysis. Overpressure required to meet RHR NPSH requirements.
601	~~152.4~~ 155.4	0	~~12.95~~ 11.63	~~6.55~~ 4.83	Long-term analysis
~~4,150~~ 2,600	~~175.83~~ 172 (171 is used to provide margin)	0	~~6.32~~ 6.95	~~0~~ 0.15	Greater than 0 psi of overpressure required for long-term for CS pumps.
~~7,090~~	~~181.85~~	~~1~~	~~6.32~~	~~0~~	~~Greater than 1 psi of overpressure required for long term for CS pumps~~
14,700	~~186.6~~ 187.3	~~1.90~~ 2.5	~~6.32~~ 6.96	~~0~~ 0.16	Peak Suppression Pool temperature
~~37,500~~ 64,000	~~181.85~~ 172 (171 is used to provide margin)	~~1~~ 0	~~6.32~~ 6.95	~~0~~ 0.15	Less than ~~1~~ 0 psi of overpressure required for long-term for CS pumps.

* Based on Units 1, 2, and 3 limiting pump, and crediting COP.