ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNITS 1, 2, AND 3

TECHNICAL SPECIFICATIONS (TS) CHANGES TS-431 AND TS-418 -
EXTENDED POWER UPRATE (EPU) - REPLACEMENT DOCUMENTATION
(TAC NOS. MC3812, MC3743, AND MC3744)

CALCULATION MDQ0999970046, REV. 10,
"NPSH EVALUATION OF BROWNS FERRY RHR AND CS PUMPS"

This enclosure provides TVA Calculation MDQ0999970046, Rev. 10, "NPSH Evaluation of Browns Ferry RHR and CS Pumps."

The revised calculation corrects the RHR pump flow rate for the evaluation of ECCS pump NPSH for the Appendix R transient. Figure 7.6, "RHR (Appendix R) pump curve and system curve," shows the corrected curves. This correction is reflected in the Appendix R results included in the calculation and used as input to TVA Calculation MDQ099920060011, Rev. 1 in Enclosure 2. Other refinements were made to the calculation which did not impact the results.

TVAN TVAN CALCULATION COVERSHEET/CCRIS UPDATE

REV 0 EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
R14981118108	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	009	010	
NEW	CN	NUC						Entire calc ☒ 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
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 ☐ MK

PREPARER ID	PREPARER PHONE NO	PREPARING ORG (BRANCH)	VERIFICATION METHOD	NEW METHOD OF ANALYSIS
Fady Galed	1-312-269-6382	MEB	DESIGN REVIEW	☐ Yes ☒ No MK

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
Fady Galed	8-11-06	Chris Rennels	8-11-06
VERIFIER SIGNATURE	**DATE**	**APPROVAL SIGNATURE**	**DATE**
Chris Rennels	8-11-06	RPC	8/21/06

STATEMENT OF PROBLEM/ABSTRACT

Problem:

The purpose of this calculation is to determine the Net Positive Suction Head (NPSH) available at various points for the Residual Heat Removal (RHR) pump and the Core Spray (CS) pumps.

Abstract:

This revision corrects the RHR pump flow for the Appendix R case.

MICROFICHE/EFICHE Yes ☒ No ☐ FICHE NUMBER(S) TVA-F-U001828, TVA-F-U001829, TVA-F-U001830

☐ 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 COMPUTER INPUT FILE
STORAGE INFORMATION SHEET**

Document MDQ0999970046	Rev. 10	Plant: BFN	

Subject:

NPSH Evaluation of Browns Ferry RHR and CS pumps

☐ 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. 308712 Units 1 and 3
Ref. ID No. 308713 Unit 2

☒ Microfiche/eFiche

EDMS reference number: TVA-F-U001828
EDMS reference number: TVA-F-U001829
EDMS reference number: TVA-F-U001830
Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps

document type: CALCULATION OUTPUT(NUCLEAR)
document date: 2006-08-11
document identifier: MDQ0999970046
facility : BFN Unit 0

keywords : ECCS, NPSH, RHR, CS
comments : None

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	06/14/99
2	Added evaluation of the potential for the ECCS strainers to ingest a steam plume/bubble from an MSRV T-quencher and the effects if ingested. This revision performed in response to BFPER 99-009145-000. 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 6500 to 35000 seconds, 1.5 to 9.7 hours. Table 3 states "2 psig of containment pressure is added for all pool temperatures". The calculation summary tables (Tables 1 and 2) provide the pump NPSH margin for the various cases analyzed. The first six plant conditions are within the first 10 minutes. The last line on each table is the long term case where the suppression pool temperature is at 177°F. 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-Q3999-870055, 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, 6, 13, 14, Table 3 Pages deleted: none Total Pages Rev 3: 355

005 BY DJK
CHRD: MRA

TVAN CALCULATION RECORD OF REVISION	
CALCULATION IDENTIFIER MD-Q0999-870048	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 185.6° 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 MDQ0999970048	
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.

R10

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: 6 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. Rich Jr 11/2/04

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 RECORD OF REVISION

CALCULATION IDENTIFIER MDQ0999970046

Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps

Revision No.	DESCRIPTION OF REVISION
009	This revision establishes appropriate uncontrolled flows for Short-Term and Appendix R cases. This revision also evaluates the impact of "drywell hold-up volume" on water level in the suppression pool. 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. 8/31/04 Pages Added: 5B, 5C, A-11, A-12, 116-166, Attachment E, Attachment F. Pages Deleted: none Pages Revised: 1, 2, 2A, 6-115 Total pages this revision: 196

TVAN CALCULATION RECORD OF REVISION

CALCULATION IDENTIFIER MDQ0999970046

Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps

Revision No.	DESCRIPTION OF REVISION
010	This revision corrects the RHR pump flow for the Appendix R case. FSAR sections 6.4, 6.5 and 6.15 and the Technical Specifications sections 3.4 and 3.5 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. Submittal to the NRC have been made for amending TS-431 and TS-418. 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. Pages Added: 5D, 5C, A-12, 167-197 Pages Deleted: 2A Pages Revised: 1, 2, 5, 5C, 6, 7-166 Total pages this revision: 227

TVAN CALCULATION VERIFICATION FORM

Calculation Identifier MDQ0999970046 Revision 010

Method of verification used:

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

Verifier [signature] Date 8-11-06

Comments:

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

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

TVAN CALCULATION TABLE OF CONTENTS

Calculation Identifier: MDQ0999970046	Revision:	010

TABLE OF CONTENTS

SECTION	TITLE	PAGE
	TVAN Calculation Coversheet/CCRIS Update	1
	TVAN Computer Input File Storage Information Sheet	2
	TVAN Calculation Record of Revision Sheet	3, 4, 4A, 4B, 5, 5A, 5B, 5C
	TVAN Calculation Verification Form	5D
	TVAN Calculation Table of Contents	6
1.0	Purpose	7
2.0	References	7
3.0	Design Input Data	10
4.0	Assumptions	10
5.0	Special Requirements/Limiting Conditions	10
6.0	Computations And Analysis	11
7.0	Supporting Graphics	32
8.0	Results and Conclusions	41

Appendices

Appendix 1:	Deleted
Appendix 2:	Deleted
Appendix 3: Evaluation Of ECCS Strainer To Ingest A Steam Plume/Bubble	3 Pages
Appendix 4:	Deleted
Appendix 5:	Deleted

Attachments

A. Previous Cover Sheets	12 Pages
B. Memo from Tom Newton to Those Listed	3 Pages
C.	Deleted
D. E-mail forwarded by Donald McQueen from Thomas Newton	2 Pages
E. Walkdown Request, initiated 07/25/06, collected 07/25/06	2 Pages
F. E-mail from William Eberly to Donald McQueen	2 Pages

1. PURPOSE

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

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

2.21 TVA Correspondence (E-Mail), Subject: "Fw: Pump/Flow Combination Cases for MULTIFLOW EPU Revision to NPSH Calculation", 02/16/2006 11:32 AM. (Attachment D)

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

2.23 1-47E818-1, R024, "Flow Diagram - Condensate Storage and Supply System".

2.24 Safe Shutdown Instruction, 2/3-SSI-16, R13, "Control Building Fire EL. 593 through EL. 617".

2.25 Calculation MDQ-0074-880225, R07, "Total RHR System Head VS. Flow Rate for Priority 1 Mode Support".

2.26 Calculation MDQ-0075-870258, R06, "Core Spray Pump Performance".

2.27 Machinery's Handbook, 26th Edition, Industrial Pres Inc., NewYork, 2000.

2.28 Walkdown Request, initiated 07/25/06, collected 07/25/06 (See Attachment E).

2.29 3-41N1001, R0, "General Plans and Sections, Sheet 2".

2.30 TVA Correspondence (E-Mail), Subject: "PUMP/FLOW COMBINATIONS FOR REVISION OF MULTIFLOW NPSH CALCULATION", 07/28/2006 04:47 PM. (Attachment F).

2.31 Pre-Operational Test No. GE-5, Residual Heat Removal System. Dated 8-5-1974.

2.32 Pre-Operational Test No. GE-12, Core Spray System, Dated 11-26-1973.

2.33 TVA Correspondence to NRC, Subject: "Browns Ferry Nuclear Plant Unit 3 - Reportable Deficiency - Potential for RHR Pump Operation in Excess of Design Runout - IE Control No. H01172F2", 05/20/1976.

2.34 Technical Support for Severe Accident Management Guidelines (SAMG), R4.

2.35 2-47E600-601, R0, "Mechanical Instruments and Control".

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

2.37 0-47W452-7, R10, "Mechanical Residual Heat Removal System".

See Appendix 3 for additional references.

3 DESIGN INPUT DATA

Input data required is derived from references shown above. The pump fluid temperatures are taken from TVA correspondence (Ref. 2.21 and Ref. 2.30). Case pump flow combinations for Appendix R and short term LOCA cases are determined from information taken from References 2.25, 2.32, and 2.33. Case pump flow combinations for Long term LOCA, SBO and ATWS cases are taken from Reference 2.21.

4 ASSUMPTIONS

4.1 No pressure drop is assumed across the strainers for ATWS, SBO, and Appendix R events. These events do not result in debris entering the suppression pool and the strainers are large enough to have negligible pressure drop when clean. Check valves with minimal equivalent length are included to aid with convergence.

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

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

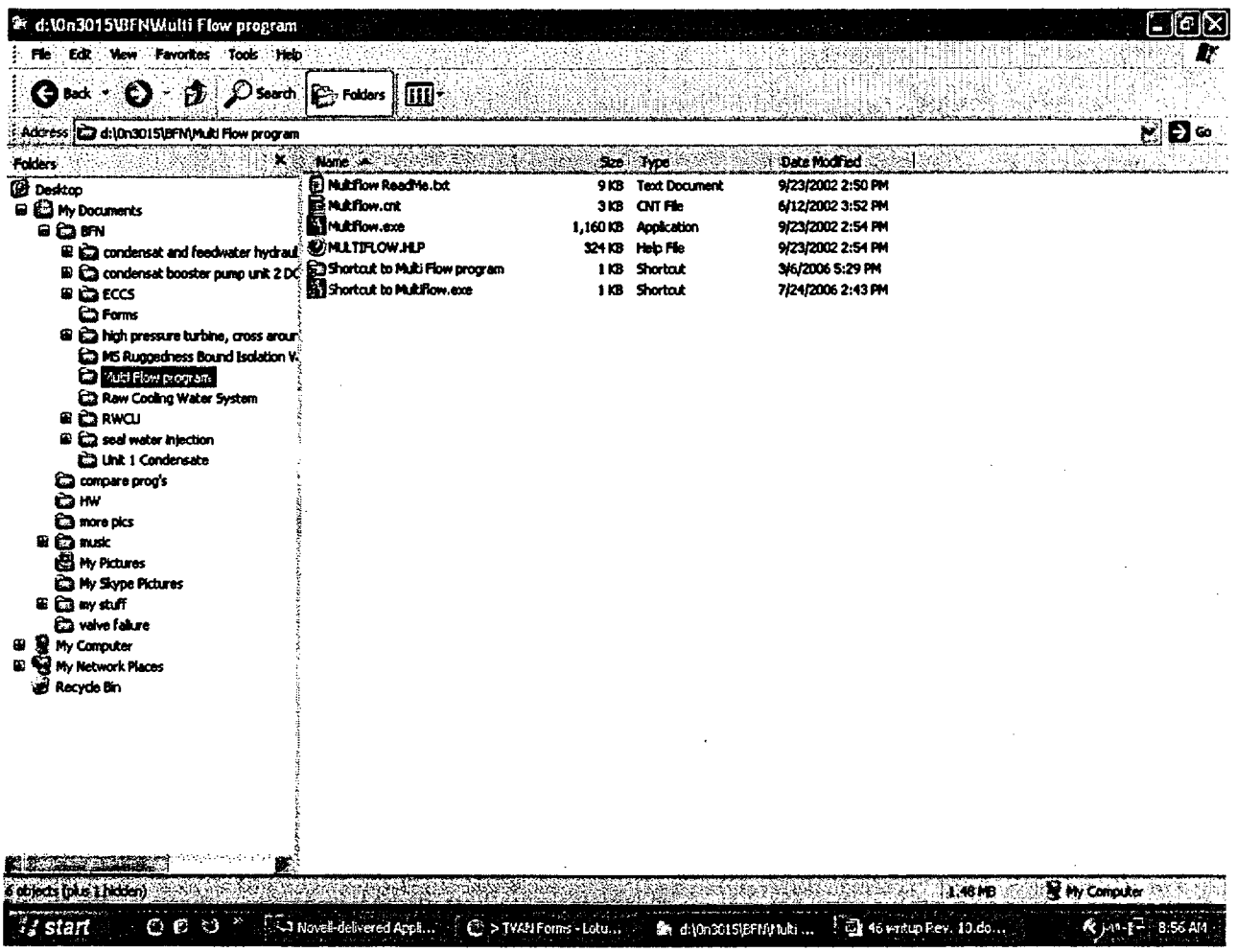
4.4 The effective strainer hydraulic loss is taken at the point of the ECCS piping flange for the strainer.

5 SPECIAL REQUIREMENTS/LIMITING CONDITIONS

None

6 COMPUTATIONS AND ANALYSIS

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



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

Utilizing Figure 7.7, Core Spray pump flow is established by finding the operating point between the pump curve and the system curve. Core Spray pump curve (Ref. 2.1) head and flow values are presented in Table 6.1.

TABLE 6.1 : CS Pump Curve

Flow (gpm)	Head (ft)
0	861
500	848
1000	825
1500	792
2000	749
2500	694
3000	626
3500	538
4070	409
4570	261

Data from Reference 2.26 is used to develop a system curve. The head (584 ft) developed by a core spray pump at 3125 gpm is used in the following equation to create a curve fit.

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

Where:
Y = Head (ft)
A = Constant
X = Flow (gpm)

584 ft (Ref. 2.26) = A (3125gpm) ^{2} (Ref. 2.26) + 326.225 ft
$A = 2.6396 \times 10^{-5}$

Table 6.2 depicts head loss obtained utilizing the above equation.

TABLE 6.2 : CS System Curve	
Flow	Head
0	325
200	326
400	329
600	335
800	342
1000	352
1200	363
1400	377
1600	393
1800	411
2000	431
2200	453
2400	477
2600	504
2800	532
3000	563
3200	596
3400	630

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

618.625 ft (Ref. 2.32) - 588 ft (Ref. 2.23) = 30.625 ft

Also, the elevation difference between the condensate storage tank (CST) water level and the torus water level had to be considered in calculating the static head.

588 ft – 536 ft (Ref. 2.32) = 52 ft

The differential pressure between the reactor pressure vessel and the suppression chamber is 105 psi (Ref. 2.26) is added to the static head. The LOCA short term condition is based on a temperature of 95°F and 155.4°F (Ref. 2.30).

For LOCA cases, 0 psi is used. By subtracting the 105 psi, the system curve shifts down giving Equation 6.1 and the new operating point is established.

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

$Y = 2.6396 \times 10^{-5}X^2 + 82.525$ ft (Eq. 6.1)

Table 6.3 depicts the system curve for the analyzed cases.

TABLE 6.3 : CS System Curve	
Flow	Head
0	83
200	84
400	87
600	92
800	100
1000	109
1200	121
1400	134
1600	150
1800	168
2000	188
2200	211
2400	235
2600	261
2800	290
3000	320
3200	353
3400	388
3600	425
3800	464
4000	505
4200	548

The operating point of the system falls between 3800 gpm and 4000 gpm. This flow is less than the flow used in the model (4125 gpm) and therefore provides conservative results.

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

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

TABLE 6.4 : RHR Single Pump curve

Flow (gpm)	Head (ft)
0	825
2000	810
3000	800
4000	787
5000	775
6000	755
7000	716
8000	675
9000	625
10000	575
10950	527
12000	475

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

The system head that must be overcome is calculated by revising the results of Reference 2.25 for the case being examined using the following equation:

$$H = H_f + H_s - P_j + P_R \qquad \text{(Eq. 6.2)}$$

H = Total Head (ft)
H_f = Friction Loss (ft)
H_s = Total Static Head (ft)
P_j = Jet Pump Pressure (ft) (removed as the recirculation loop discharge valve remains open during the Appendix R event – Ref. 2.36)
P_R = Reactor Pressure (Ref. 2.24)

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

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

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

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

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

For Appendix R, the total static head (H_s) is determined based on a reactor water level at the bottom of the Main Steam Line nozzle, normal torus water level, reactor pressure of 100 psig (Ref. 2.24), and no losses through the jet pumps since the recirculation loop discharge valve remains open during the Appendix R event (Ref. 2.36). The reactor pressure is controlled based on reading PI-3-79 (Ref. 2.36). The reactor pressure of 100 psig is corrected to the bottom of the MSL from the location of the tap.

Total Static Head (H_s) = (632.04'-536')-(632.04'-628.17') = 92.17 ft

Water level at Main Steam Line (MSL) = 632.04 ft
Water level in the torus = 536 ft
PI-3-79 elevation = 628.17 ft (Ref. 2.35)
Pressure Indicator elevation is subtracted to account for the 100 psi (Ref. 2.24) reactor pressure that has to be maintained by the operator to ensure MSRVs continue operation.

Jet Pump Pressure is neglected since the recirculation loop discharge valve remains open during Appendix R event (Ref. 2.36), which eliminates jet pressure.
Jet pressure = 123 psi at 30,000 gpm, (Ref. 2.25) adjusted to percentage of flow in the system.

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

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

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

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

The reactor pressure is required to be 100 psig or greater based on Ref. 2.24. The system operating point requires adjustment for the reactor vessel pressure. The Appendix R condition is based on a temperature of 223°F (Ref. 2.30). Utilizing the conversion factor at that temperature, 100 psig is converted to 241.82 feet.

$$\text{H at } 2500\,\text{gpm} = 24.6\text{ft} + 92.17\text{ft} - 0.854\text{psi} * (0.016\frac{\text{ft}^3}{\text{lb}} * 144\frac{\text{in}^2}{\text{ft}^2}) + 241.82\text{ft} = 356.6\text{ft}$$

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

TABLE 6.5 :
Single pump system curve

Flow (gpm)	Head (ft)
2500	356.6
5000	424.9
7500	538.2
10800	757.2

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

TABLE 6.6: Single pump system curve

Flow (gpm)	Head (ft)
0	334
2000	349
3000	367
4000	392
5000	425
6000	465
7000	512
8000	566
8975	626
9975	695
10950	769
11950	852

Based on Figure 7.6, the system operating point for the RHR pumps for the Appendix R cases is at 8,975 gpm with a corresponding head of 626 ft. This flow is less than the flow used in the model (9,100 gpm) and therefore the model provides conservative results.

To determine the required pressure in the reactor pressure vessel to allow Appendix R cases to run at 7200gpm or less, a new system curve is developed by adding a head loss to the existing system curve, which shifts the operating point below 7200 gpm (See Table 6.7).

TABLE 6.7 : Single pump system curve

Flow (gpm)	Head (ft)
2500	548.7
5000	616.9
7500	730.2
10800	949.2

A plot of system head loss at corresponding flows is developed using a third degree polynomial curve fit. The system head loss curve is presented with the pump curve in Fig. 7.6. Table 6.8 depicts the system head loss at various flows.

TABLE 6.8: Single Pump system curve

Flow (gpm)	Head (ft)
0	526
2000	541
3000	559
4000	584
5000	617
6000	657
7150	712
7500	730
8500	788
9500	854
10950	961
11950	1044

From Figure 7.6 the operating point is found to be 7150 gpm at 183.3 psig reactor pressure. The Appendix R condition is based on a temperature of 223°F (Ref. 2.30). Utilizing the conversion factor at that temperature, 192 ft is converted to 83.3 psi.

For the LOCA-short term scenarios, a dual pump curve is obtained by utilizing the data from the single pump curve and doubling the flow at constant head values (Ref. 2.2), Table 6.9 shows dual pump curve data.

TABLE 6.9 : Dual Pumps

Flow (gpm)	Head (ft)
0	825
4000	810
6000	800
8000	787
10000	775
12000	755
14000	716
16000	675
18000	625
20000	575
22000	525
24000	475

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

$$H = H_f + H_s - P_j$$

H = Total Head (ft)
H_f = Friction Loss (ft)
H_s = Total Static Head (ft)
P_j = Jet Pump Pressure (ft) (removed as this case considers a broken recirculation loop)

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

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

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

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

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

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

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

Total Static Head (H_s) = (577.17 ft – 536 ft) = 41.17 ft

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

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

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

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

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

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

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

$$H \text{ at } 5000\,\text{gpm} = 33\,\text{ft} + 41.17\,\text{ft} - 3.42\,\text{psi} * (0.016\frac{\text{ft}^3}{lb} * 144\frac{\text{in}^2}{\text{lb}^2}) = 66.3\text{ft}$$

Similarly the rest of the flows are calculated in the same manner. Table 6.10 summarizes head at the corresponding flow for the system without jet pumps.

TABLE 6.10 : System curve

Flow (gpm)	Head (ft)
5000	66.3
10000	141.7
15000	266.3
20000	441.2

A plot of head at the corresponding flows is developed for the system without jet pumps. A third degree polynomial curve fit at the corresponding flow is plotted in order to obtain values between points (See Fig. 7.8). Table 6.11 depicts the developed head at the corresponding flow to model the system curve.

TABLE 6.11 : System Curve without jet pumps

Flow (gpm)	Head (ft)
0	39
2000	44
4000	57
6000	77
8000	106
10000	142
12000	186
14000	237
16000	297
18000	365
20000	441
22000	525
23500	594
25500	693

Analyzing data in the table above the system operating point is at 22,000 gpm with a corresponding head of 525 ft (See Figure 7.8). This flow is less than the flow used in the model (23,000 gpm) and therefore provides conservative results.

For the LOCA-short term with the unbroken recirculation loop, Table 6.12 summarizes the system head at the corresponding flow for the system with jet pump losses included taken from Reference 2.25.

TABLE 6.12 : System Curve

Flow (gpm)	Head (ft)
5000	101
10000	200
15000	364
20000	594

A plot of developed head at the corresponding flows is developed for the system with jet pumps. A third degree polynomial curve fit at the corresponding flow is plotted in order to obtain values between points (See Fig. 7.8). Table 6.13 depicts the system head loss at the corresponding flows.

TABLE 6.13: System Curve with jet pumps

Flow (gpm)	Head (ft)
0	66
2000	72
4000	89
6000	116
8000	153
10000	200
12000	258
14000	326
16000	405
18000	494
19750	581
21750	690

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

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

Table 6.14: Temperature and Flow Rate Combinations

LOCA Pump/Flow Combinations	Suppression Pool Temperature
CS Pumps A/B/C/D – 4125 gpm each RHR A/C Pumps – 10,500 gpm each RHR B/D Pumps – 11,500 gpm each	Temperature @ 95°F Temperature @ 10 minutes EPU (155.4°F)
CS Pumps A/B/C/D – 4125 gpm each RHR A/C Loop – 11,500 gpm each RHR B/D Loop – 10,500 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 @ 172°F 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 @ 172°F 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 @ 172°F 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 @ 172°F 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 @ 177°F
RHR A/B/C/D Pumps – 6500 gpm each	Temperature @ 192°F
RHR A/B/C/D Pumps – 6500 gpm each	Temperature @ 211°F
Appendix R Pump/Flow Combinations	
One RHR Pump (non specific) – 7200 gpm	Temperature @ 191°F
One RHR Pump (non specific) – 9100 gpm	Temperature @ 191°F
One RHR Pump (non specific) – 7200 gpm	Temperature @ 223°F
One RHR Pump (non specific) – 9100 gpm	Temperature @ 223°F
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 @ 157°F
Two RHR Pump (A/C) – 6500 gpm, B/D -0 Two RHR Pump (B/D) – 6500 gpm, A/C -0	Temperature @ 200°F

Per American Hydraulic Institute standards (Ref. 2.20), 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. 2.20).

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. 6.3)

where:

h_a = Atmospheric head = Suppression Pool airspace pressure converted to feet of water (ft).
h_s = Static pressure head = Elevation difference between the centerline of the pump inlet and the suppression pool water level (ft).
h_f = Total friction head loss (ft).
h_{vp} = Vapor pressure of water at system temperature (ft).

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

Since the ECCS ring header and the connecting piping to the ECCS strainers is common to the suction of all of the ECCS pumps, the flow and pressure distribution for the ring header and strainers is different for varying system demands. Therefore, to determine individual ECCS pump suction pressures for various plant states, a model of the suction piping configuration was created from TVA drawings (Ref. 2.4 and 2.6) for analysis with the Multiflow computer program (Ref. 2.5). A simplified layout of the Multiflow model for the ECCS ring header and suction piping to the RHR and CS pumps is shown in Figure 7.1 (See Section 7.0). 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 7.0).

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.

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

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

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

For the LOCA cases, in the MultiFlow model, a pump component is used to model the strainer pressure drop as a function of the flow rate. Reference 2.15 provides strainer head loss for two different time periods. For short term (less than 10 minutes), head losses are provided for three flows. For long term (greater than 10 minutes), head loss is provided for one flow rate. Flows obtained from Reference 2.15 were converted to flow at standard conditions using Equation 6.4. Values of head loss at corresponding strainer flow rates, taken from Reference 2.15, are converted to head loss at standard conditions. A curve was developed and input into MultiFlow representing the head loss at the strainer addressing the variation in strainer head loss for the two time periods. Based on a review of Reference 2.15, the strainer head loss varies linearly with flow through strainer. The curve developed provides conservative losses at the strainers in comparison to the head loss values in Reference 2.15. (See Fig. 7.5). Table 6.13 provides the head loss data points used to model the strainers as a function of flow.

Table 6.13: Strainer Loss

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

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

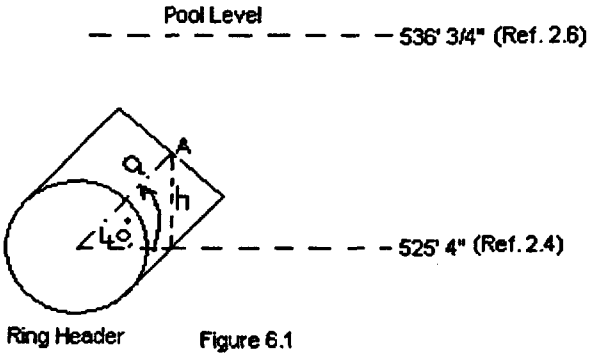


Figure 6.1

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

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

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

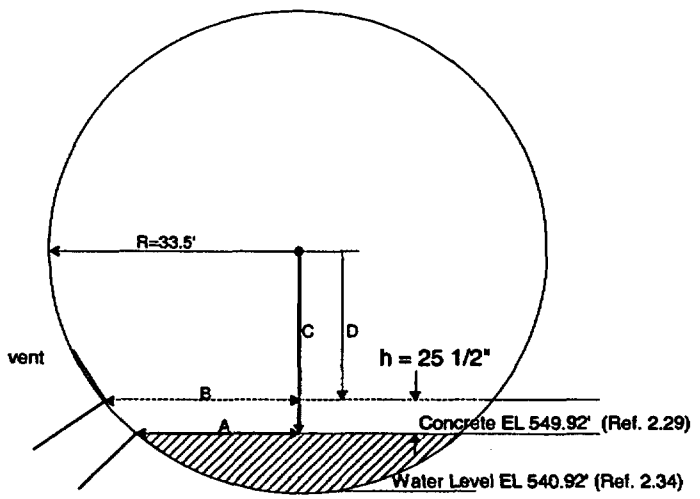


Figure 6.2

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

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

$C = 33.5' - 9' = 24.5$ ft
$D = 33.5' - 9' - 2.125'$ (Ref. 2.28) $= 22.375$ ft

$A^2 = 33.5^2 - 24.5^2 = 522.0$ ft
$A = 22.85$ ft
$B^2 = 33.5^2 - 22.375^2 = 621.61$ ft
$B = 24.93$ ft

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

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

$$Vc = \pi \cdot hc^2 \cdot \left(R - \frac{hc}{3}\right) = \pi \cdot 9^2 \cdot \left(33.5 - \frac{9}{3}\right) = 7761.3\,ft^3$$

The volume of the concrete and water is found by:

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

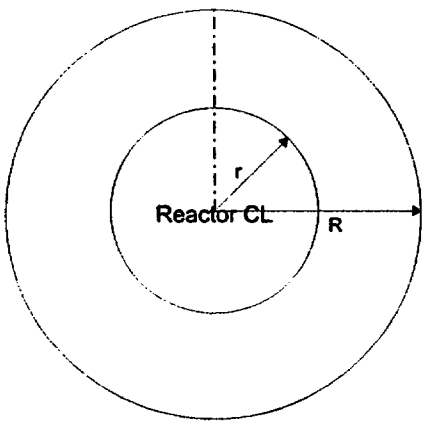
Therefore, the amount of water holdup in the drywell is

$$V_W = V_{C+W} - V_C = 11583.63 - 7761.3 = 3822.33\,ft^3$$

Where:

V_C= Volume of concrete
V_{C+W} = Volume of concrete and water
h_c = height of concrete
h_{c+w} = height of concrete and water
V_W= Volume of standing water in drywell

Water Level decrease in Torus:



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

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

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

where:

A_T= Surface area of water in torus

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

From TVA drawings (Ref. 2.6), the low water level of the suppression pool is 536' 1 3/4" with Δp and 536' 3/4" with zero delta P, which will be considered here.
The water level in the torus for LOCA and SBO is:
536' 3/4"- 0.352'= 535.711'
and the static head of Pt. A = 535.711 - 527.616 = 8.049'

The pressure at the strainer flange points (nodes 1, 5, 23, and 27) at the specified temperatures for the cases where the core spray pumps are running are adjusted to account for the water holdup in the drywell. The densities as a function of temperature in the following equations are taken from STMFUNC (Ref. 2.22).

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

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

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

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

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

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

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

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

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

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

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

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

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

Table 6.14 : Strainer Pressure

Temperature(°F)	Pressure (psig)
95.00	3.488
155.4	3.434
157.0	3.432
166.0	3.422
172.0	3.415
177.0	3.557
187.3	3.396
191.0	3.539
192.0	3.537
200.0	3.379
211.0	3.510
223.0	3.493

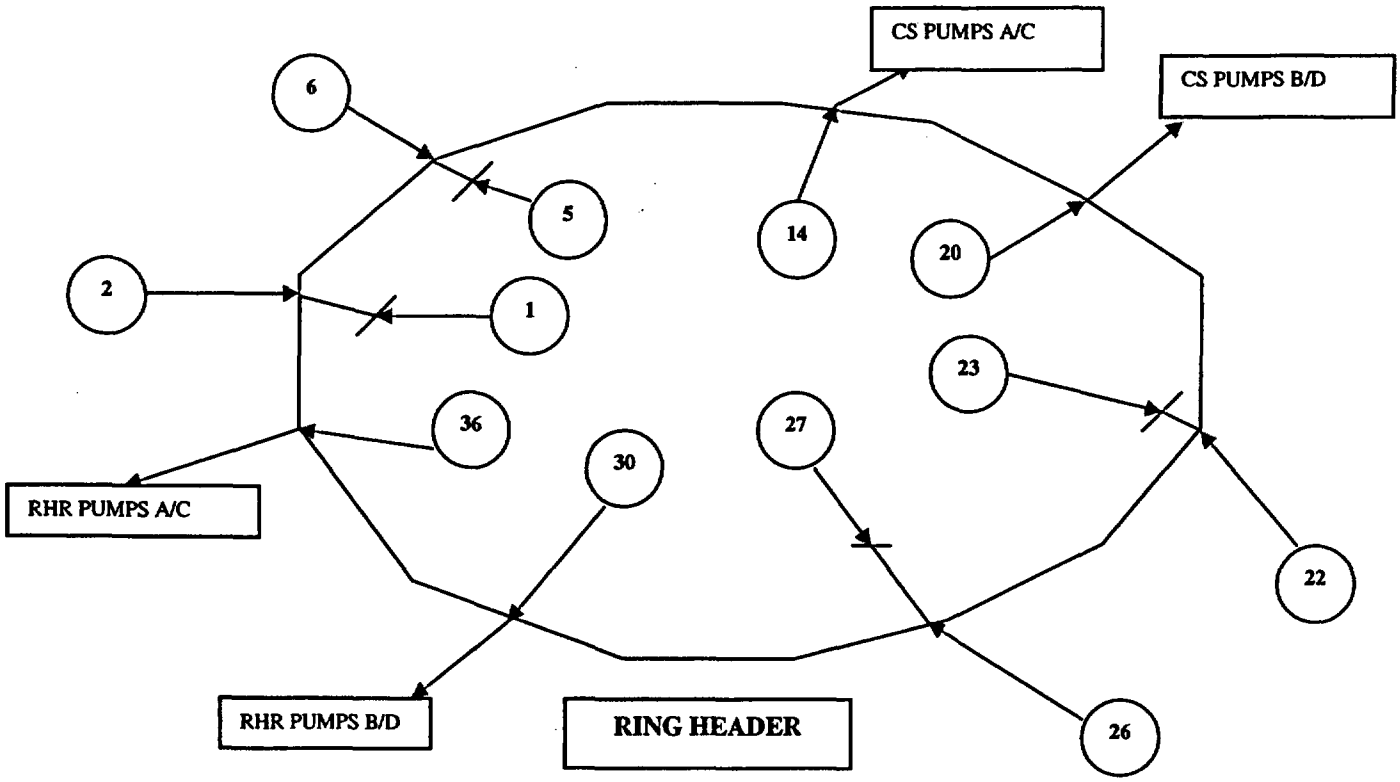
The Multiflow model calculation accounted for system static head and piping friction losses. To obtain the NPSH available, it was necessary to subtract fluid vapor pressure h_{vp} (at the analyzed suppression pool temperature) and take into account the suppression pool absolute pressure. Utilizing Equation 6.1, the available NPSH is determined. See Tables 7.1 through 7.40 for calculations of NPSHa for Unit 1. See Tables 11.1 through 11.40 for calculations of NPSHa for Unit 2. See Tables 14.1 through 14.40 for calculations of NPSHa for Unit 3.

Flow conditions of the RHR and CS systems analyzed were

1) Maximum flow at a pool temperature of 95°F. (LOCA)
2) Maximum flow combinations at pool temperatures of 155.4°F and 166°F with no operational reduction. (LOCA)
3) Long term operation at the suppression pool design temperature limit of 187.3°F at design required system flow. (LOCA)
4) Maximum flow combinations at pool temperature 172°F at the end of overpressure requirement. (LOCA)
5) Flow conditions of RHR system analyzed at pool temperature of 177°F, 192°F and 211°F (ATWS).
6) Flow conditions of RHR system analyzed at pool temperature of 191°F and 223°F at 7200gpm and 9100 gpm (Appendix R).
7) Flow conditions of RHR system analyzed at pool temperature of 157°F and 200°F (SBO).

7 SUPPORTING GRAPHICS

Figure No.	Title	Page
Figure 7.1	General multiflow Model	33
Figure 7.2	Unit 1 nodal diagram	34
Figure 7.3	Unit 2 nodal diagram	35
Figure 7.4	Unit 3 nodal diagram	36
Figure 7.5	Strainer Loss Curve Fit	37
Figure 7.6	RHR (Appendix R) pump and system curve	38
Figure 7.7	Core Spray pump and System Curves	39
Figure 7.8	RHR pump and System Curves	40



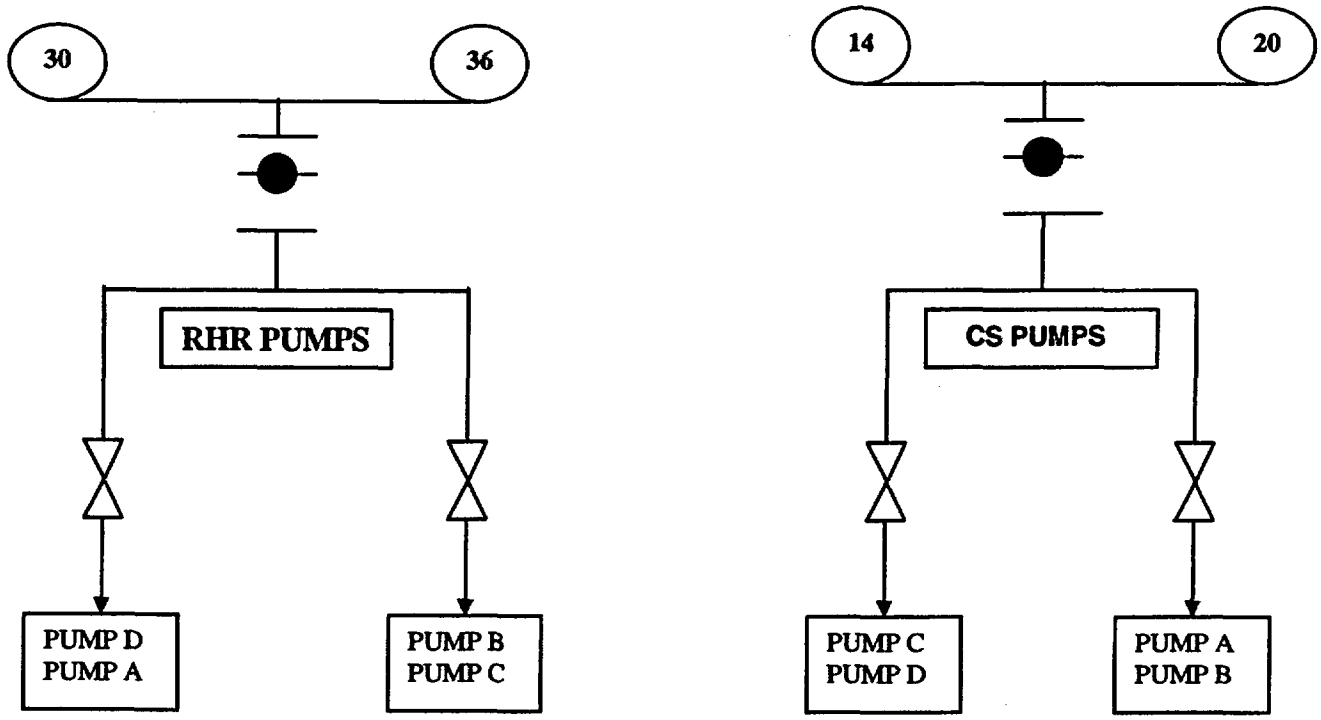


FIGURE 7.1
General MultiFlow Model

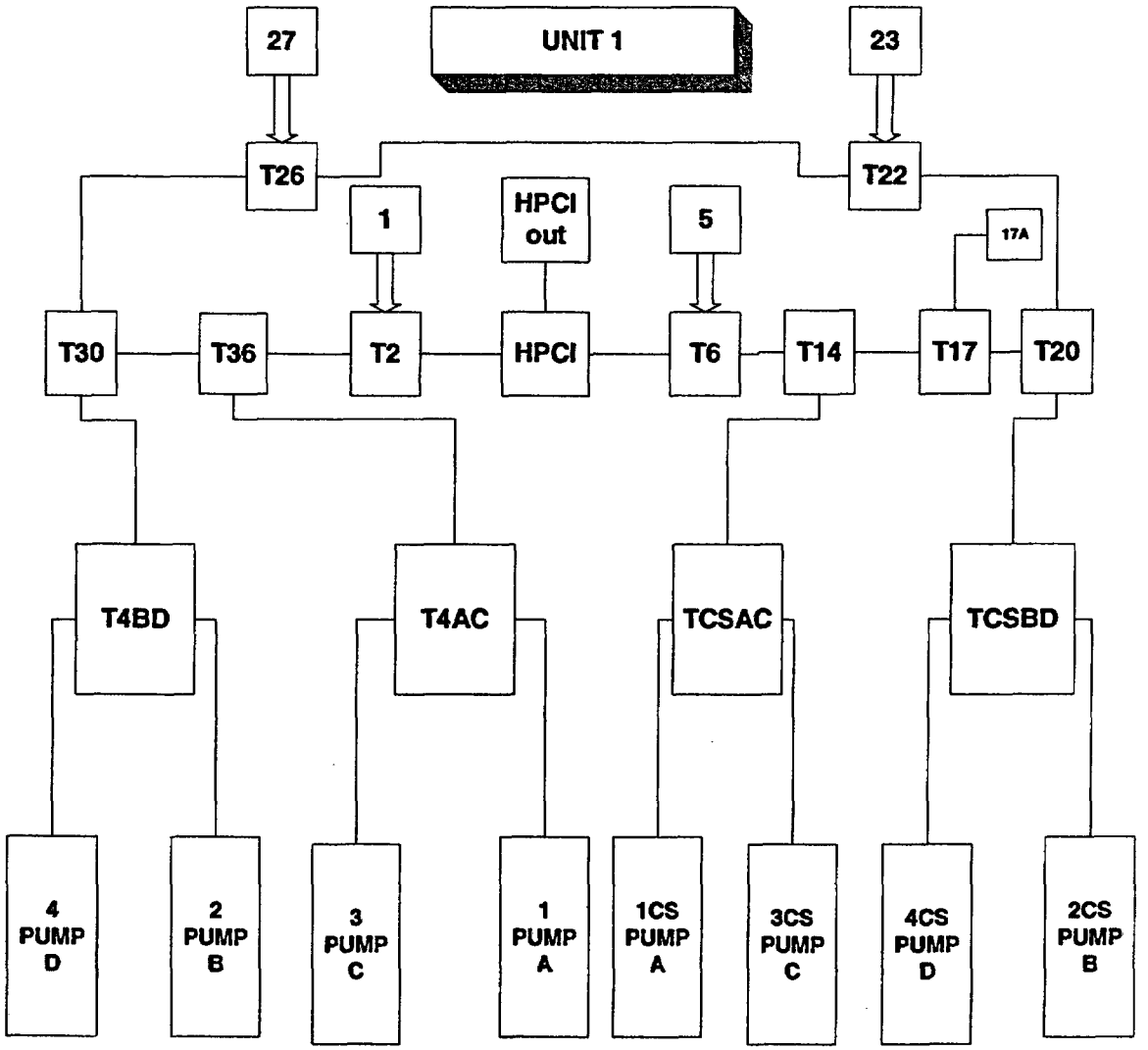


Figure 7.2 Unit 1 Nodal Diagram.

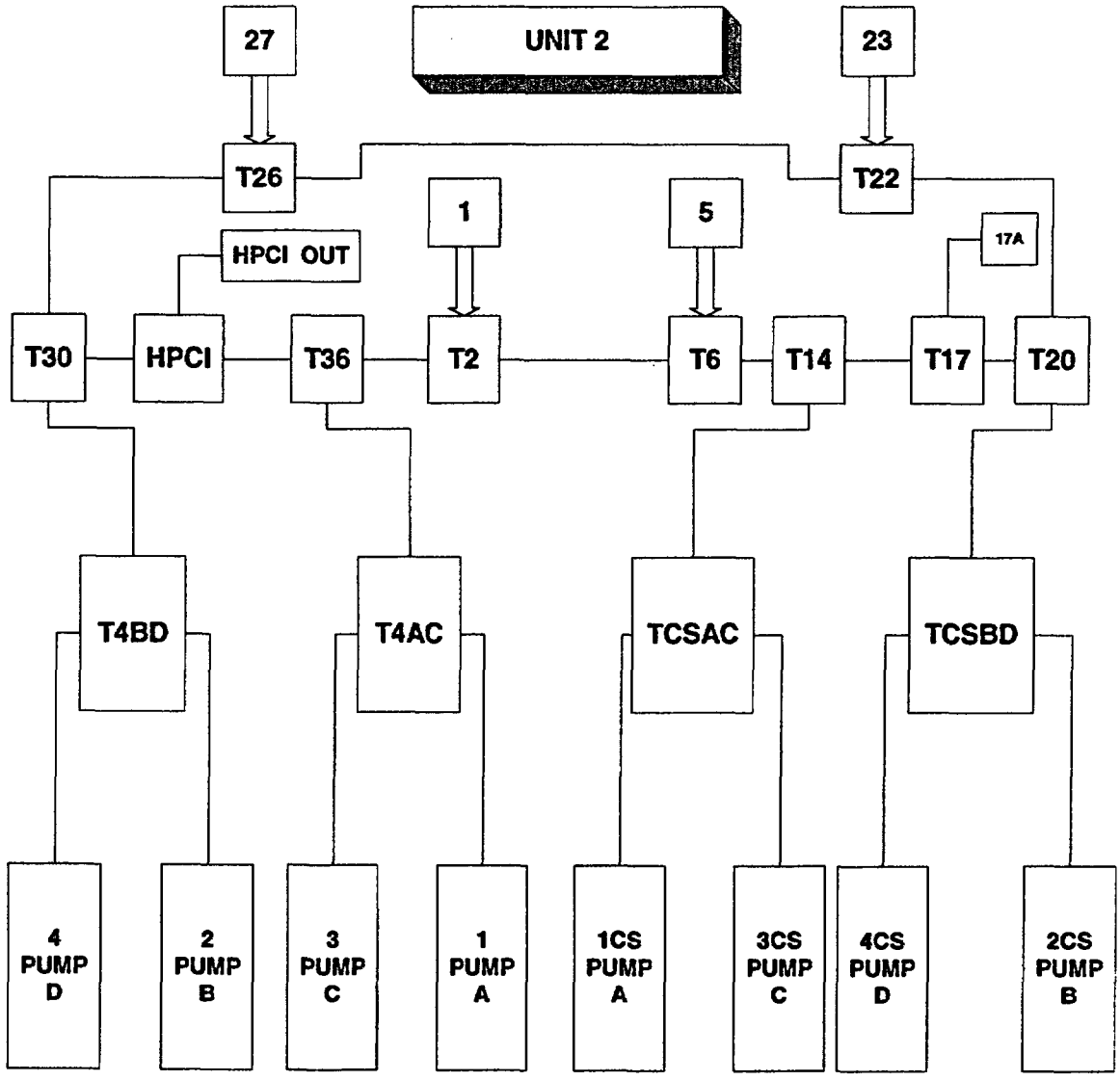


Figure 7.3 Unit 2 Nodal Diagram.

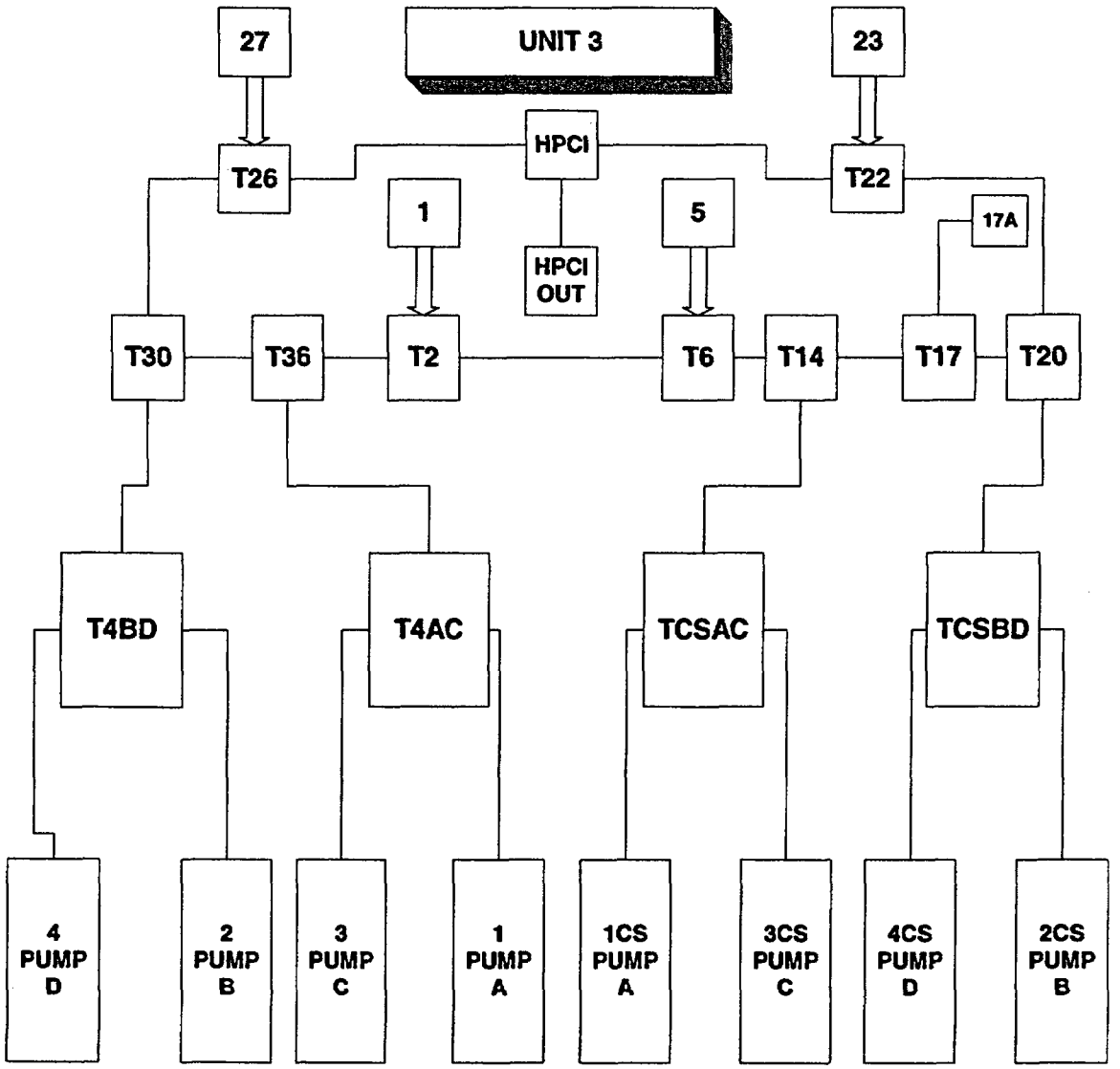


Figure 7.4 Unit 3 Nodal Diagram.

Figure 7.5: Strainer Head Loss Curve

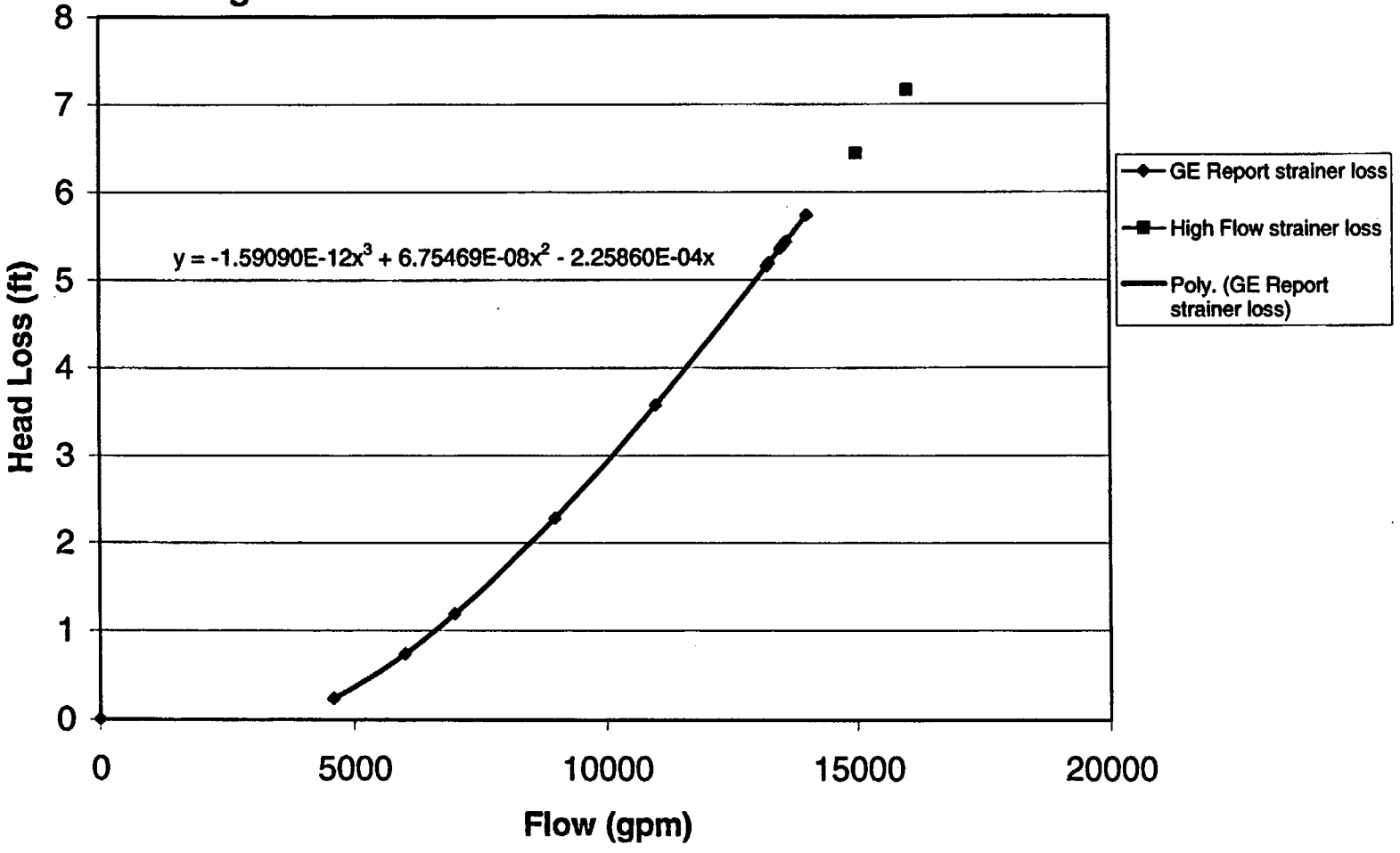


Figure 7.6 : RHR (Appendix R) pump curve and system curve

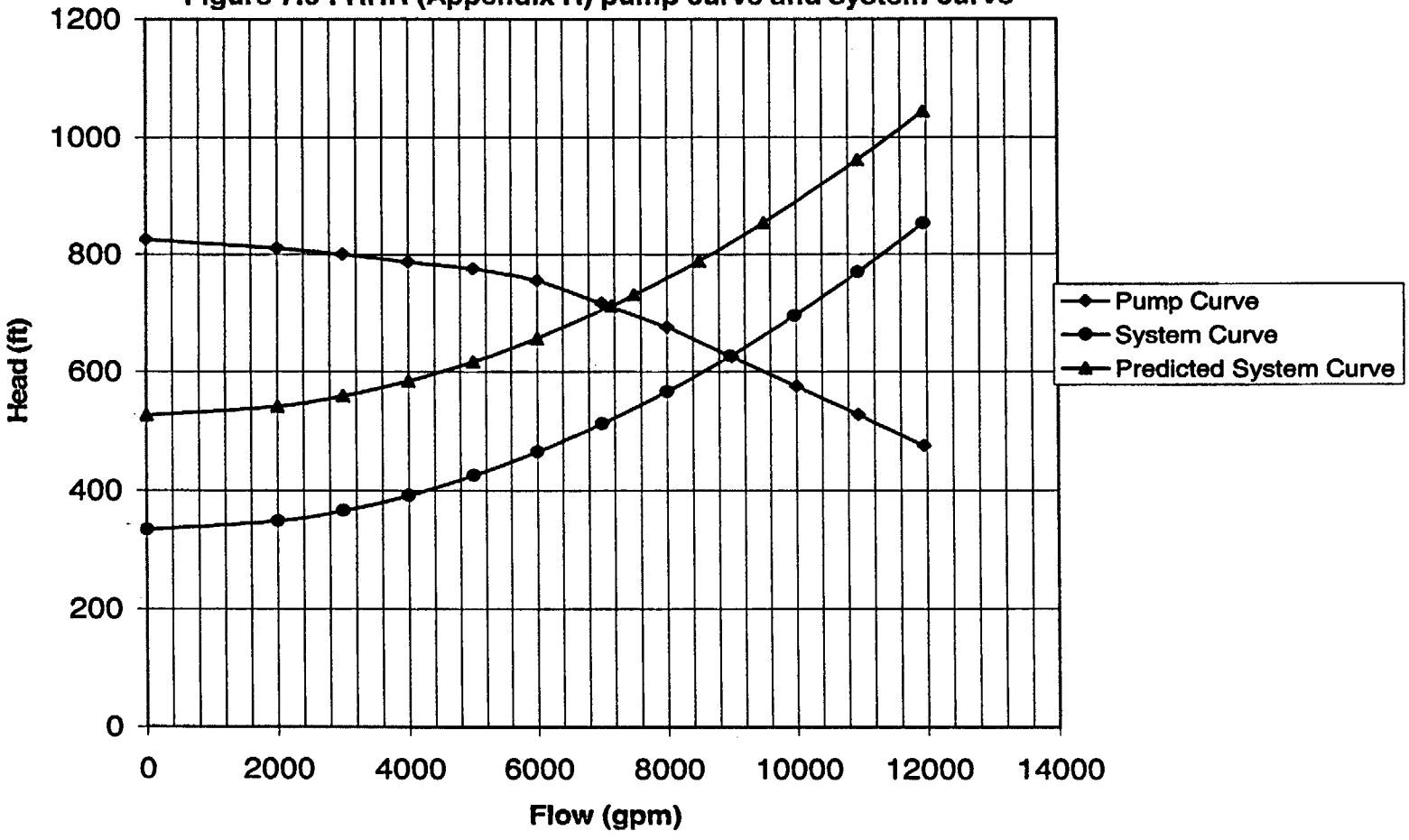


Figure 7.7: Core Spray Pump and System Curves

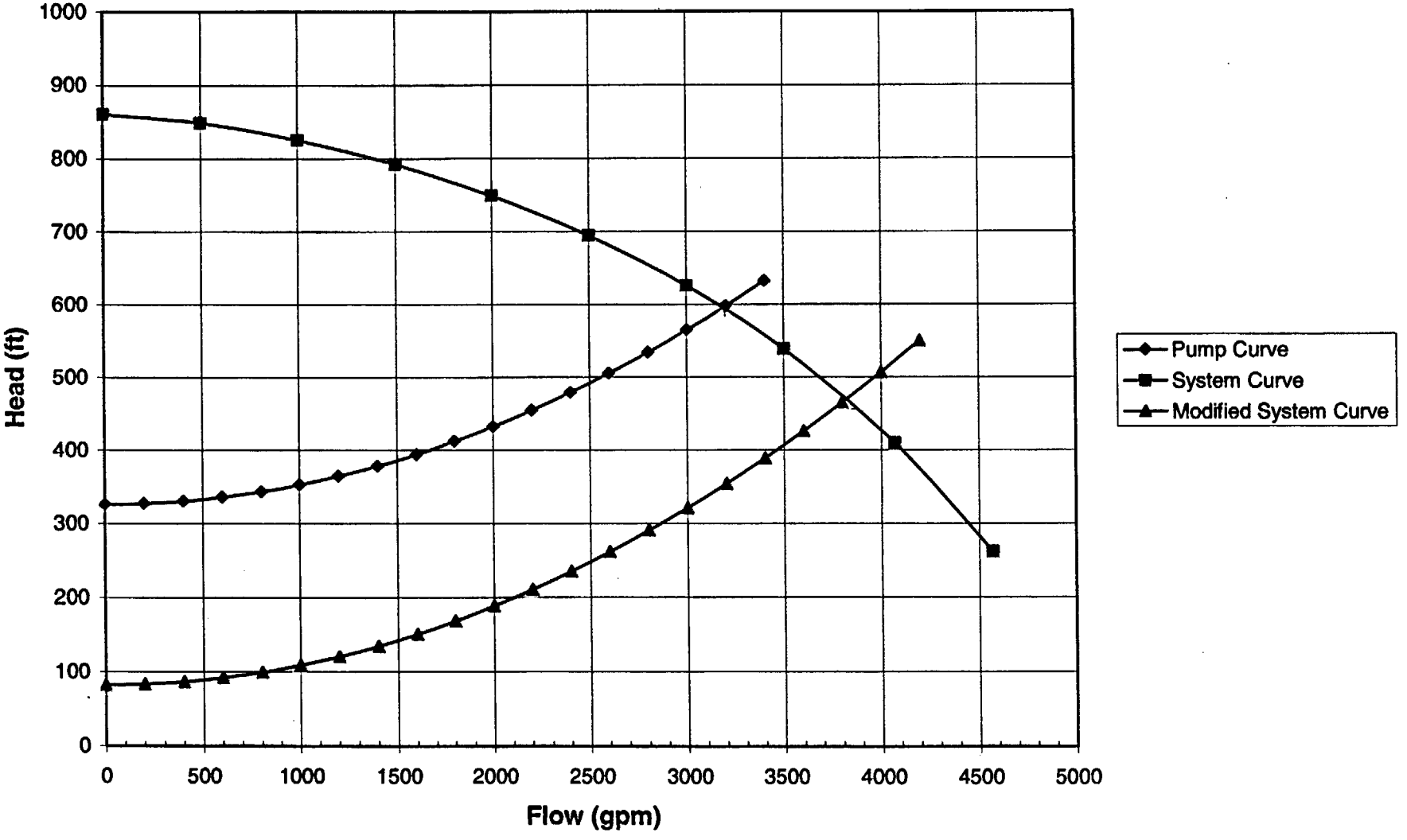
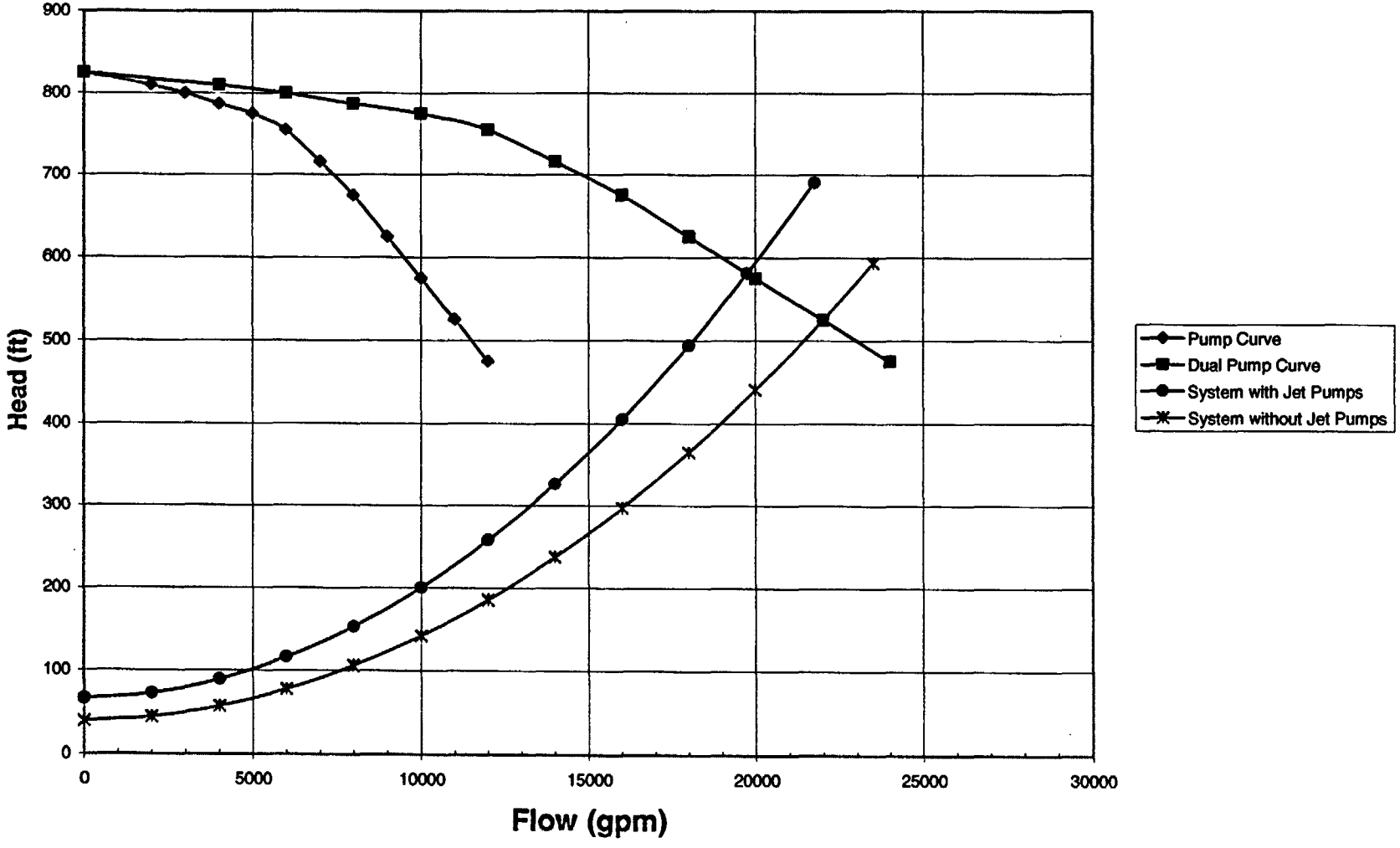


Figure 7.8: RHR Pump and System curves



8 RESULTS AND CONCLUSIONS

Summary values of pump NPSH available are shown in Tables 6, 10 and 13 for Units 1, 2 and 3 respectively. These values are based on zero credit for containment overpressure as indicated in column five of tables 6, 10, and 13.
Flows used in Multiflow cases are conservatively higher than flows identified in this calculation.

All steps taken to calculate NPSHa are shown in Tables 7.1 through 7.40 for Unit 1, Tables 11.1 through 11.40 for Unit 2, and Tables 14.1 through 14.40 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
187.3	0.01655	0.968770
177	0.01649	0.972434
192	0.01658	0.967045
211	0.01671	0.959742
191	0.01658	0.967414
223	0.01679	0.954866
157	0.01638	0.979074
200	0.01663	0.964033

Flow (gpm)	Flow (sgpm)										
	95	155.4	187.3	172	177	192	211	191	223	157	200
4125	4104	4041	3996	4018	4011	3989	3959	3991	3939	4039	3977
6500	6468	6367	6297	6332	6321	6286	6238	6288	6207	6364	6266
7200	7164	7053	6975	7014	7002	6963	6910	6965	6875	7049	6941
10500	10448	10286	10172	10229	10211	10154	10077	10158	10026	10280	10122
11500	11443	11265	11141	11203	11183	11121	11037	11125	10981	11259	11086
9100	9055	8914	8816	8865	8849	8800	8734	8803	8689	8910	8773

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

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Table 5: sgpm calculations**												
2	**Temp(°F)**	**V(ft³/lb)**	**Ratio Vs/Vr**		**Flow (gpm)**	**Flow (sgpm)**							
3	60	=vftsat_97(60)	1										
4	95	=vftsat_97(A4)	=B3/B4										
5	172	=vftsat_97(A5)	=B3/B5			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		10500	=E9*C4	=E9*C6	=E9*C7	=E9*C5	=E9*C8	=E9*C9	=E9*C10	=E9*C11
10	166	=vftsat_97(A10)	=B3/B10		11500	=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. 2.22) (See cell B3 through B11)												

TABLE 6
Unit 1

LOCA Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	Pressure (psia)
LOCA 1A CS Pumps A/B/C/D-4125gpm each RHR A/C Pumps –10,500 gpm each RHR B/D Pumps –11,500 gpm each	@95°F	RHR/A	31.04	14.4
		RHR/B	30.03	14.4
		RHR/C	29.51	14.4
		RHR/D	31.76	14.4
		CS/A	28.39	14.4
		CS/B	32.21	14.4
		CS/C	31.84	14.4
		CS/D	29.07	14.4
LOCA 1B CS Pumps A/B/C/D-4125gpm each RHR A/C Pumps –10,500 gpm each RHR B/D Pumps -11,500 gpm each	@155.4°F	RHR/A	23.46	14.4
		RHR/B	22.45	14.4
		RHR/C	21.92	14.4
		RHR/D	24.17	14.4
		CS/A	20.80	14.4
		CS/B	24.62	14.4
		CS/C	24.25	14.4
		CS/D	21.48	14.4
LOCA 2A CS Pumps A/B/C/D-4125gpm each RHR A/C Pumps –11,500 gpm each RHR B/D Pumps –10,500 gpm each	@95°F	RHR/A	30.13	14.4
		RHR/B	31.29	14.4
		RHR/C	28.30	14.4
		RHR/D	32.72	14.4
		CS/A	28.37	14.4
		CS/B	32.16	14.4
		CS/C	31.82	14.4
		CS/D	29.02	14.4
LOCA 2B CS Pumps A/B/C/D-4125gpm each RHR A/C Pumps –11,500 gpm each RHR B/D Pumps -10,500 gpm each	@155.4°F	RHR/A	22.55	14.4
		RHR/B	23.70	14.4
		RHR/C	20.71	14.4
		RHR/D	25.14	14.4
		CS/A	20.79	14.4
		CS/B	24.57	14.4
		CS/C	24.23	14.4
		CS/D	21.43	14.4
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	35.57	14.4
		RHR/C	34.98	14.4
		CS/A	31.48	14.4
		CS/C	33.46	14.4

LOCA Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	Pressure (psia)
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	RHR/A	30.88	14.4
		RHR/C	30.30	14.4
		CS/A	26.80	14.4
		CS/C	28.78	14.4
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	24.94	14.4
		RHR/C	24.35	14.4
		CS/A	20.85	14.4
		CS/C	22.83	14.4
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	35.58	14.4
		RHR/C	34.99	14.4
		CS/B	33.34	14.4
		CS/D	31.54	14.4
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	RHR/A	30.90	14.4
		RHR/C	30.31	14.4
		CS/B	28.67	14.4
		CS/D	26.86	14.4
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	24.95	14.4
		RHR/C	24.36	14.4
		CS/B	22.72	14.4
		CS/D	20.91	14.4
LOCA 5A CS Pumps B/D-43125gpm each A/C-0 gpm each RHR B/D Pumps-6500 gpm each A/C-0 gpm each	@155.4°F	RHR/B	35.29	14.4
		RHR/D	35.84	14.4
		CS/B	33.32	14.4
		CS/D	31.52	14.4
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	RHR/B	30.61	14.4
		RHR/D	31.16	14.4
		CS/B	28.64	14.4
		CS/D	26.84	14.4
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	24.66	14.4
		RHR/D	25.21	14.4
		CS/B	22.69	14.4
		CS/D	20.89	14.4
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	35.27	14.4
		RHR/D	35.82	14.4
		CS/A	31.52	14.4
		CS/C	33.50	14.4

LOCA Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	Pressure (psia)
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	RHR/B	30.59	14.4
		RHR/D	31.14	14.4
		CS/A	26.84	14.4
		CS/C	28.82	14.4
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	24.64	14.4
		RHR/D	25.19	14.4
		CS/A	20.89	14.4
		CS/C	22.87	14.4
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	30.40	14.4
		RHR/B	30.41	14.4
		RHR/C	29.82	14.4
		RHR/D	30.96	14.4
		CS/A	27.26	14.4
		CS/C	29.23	14.4

ATWS Pump/Flow Combination	Pool Temp.	Pump	NPSHa (ft)	Pressure (psia)
ATWS RHR A/C/B/D Pumps-6500 gpm each CS Pumps A/C/B/D-0 gpm each	@177°F	RHR/A	28.68	14.4
		RHR/B	28.73	14.4
		RHR/C	28.10	14.4
		RHR/D	29.28	14.4
ATWS RHR A/C/B/D Pumps-6500 gpm each CS Pumps A/C/B/D-0 gpm each	@192°F	RHR/A	22.28	14.4
		RHR/B	22.32	14.4
		RHR/C	21.69	14.4
		RHR/D	22.87	14.4
ATWS RHR A/C/B/D Pumps-6500 gpm each CS Pumps A/C/B/D-0 gpm each	@211°F	RHR/A	11.14	14.4
		RHR/B	11.19	14.4
		RHR/C	10.56	14.4
		RHR/D	11.74	14.4
Appendix R Pump/Flow Combination	**Pool Temp.**	**Pump**	**NPSHa (ft)**	**Pressure (psia)**
App-R A RHR Pump A-7200 gpm	@191°F	A	24.44	14.4
App-R B RHR Pump B-7200 gpm	@191°F	B	24.43	14.4
App-R C RHR Pump C-7200 gpm	@191°F	C	24.30	14.4
App-R D RHR Pump D-7200 gpm	@191°F	D	24.52	14.4
App-R A RHR Pump A-9100 gpm	@191°F	A	23.5	14.4
App-R B RHR Pump B-9100 gpm	@191°F	B	23.47	14.4
App-R C RHR Pump C-9100 gpm	@191°F	C	23.27	14.4
App-R D RHR Pump D-9100 gpm	@191°F	D	23.63	14.4

Appendix R Pump/Flow Combination	Pool Temp.	Pump	NPSHa (ft)	Pressure (psia)
App-R A RHR Pump A-7200 gpm	@223°F	A	4.48	14.75
App-R B RHR Pump B-7200 gpm	@223°F	B	4.46	14.75
App-R C RHR Pump C-7200 gpm	@223°F	C	4.34	14.75
App-R D RHR Pump D-7200 gpm	@223°F	D	4.56	14.75
App-R A RHR Pump A-9100 gpm	@223°F	A	3.56	14.76
App-R B RHR Pump B-9100 gpm	@223°F	B	3.50	14.75
App-R C RHR Pump C-9100 gpm	@223°F	C	3.33	14.76
App-R D RHR Pump D-9100 gpm	@223°F	D	3.66	14.75
SBO Pump/Flow Combination	**Pool Temp**	**Pump**	**NPSHa (ft)**	**Pressure (psia)**
SBO 1 A/C RHR Pump A/C-6500 gpm each	@157°F	A	35.45	14.4
		C	34.86	14.4
SBO 2 B/D RHR Pump B/D-6500 gpm each	@157°F	B	35.14	14.4
		D	35.69	14.4
SBO 1 A/C RHR Pump A/C-6500 gpm each	@200°F	A	18.76	14.4
		C	18.18	14.4
SBO 2 B/D RHR Pump B/D-6500 gpm each	@200°F	B	18.46	14.4
		D	19.01	14.4

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

	A	B	C	D	E	F	G	H	I	J
1	**Table 8: Unit 1 NPSH Calculations Case 1A 95F**									
2		**Vapor Pressure**	**Specific Volume**	**Conversion Factor**						
3	**Temp(°F)**	**(psia)**	**V(ft³/lb)**	**psia to feet of head**						
4	60	=ptsat_97(60)	=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)**							
8	1PUMPA	-0.2071	=(B8-B5+F5)*D5							
9	2PUMPB	-0.641	=(B9-B5+F5)*D5							
10	3PUMPC	-0.866	=(B10-B5+F5)*D5							
11	4PUMPD	0.102	=(B11-B5+F5)*D5							
12	**CS**	**Pressure (psig)**	**NPSHa (ft)**							
13	1CSPUMPA	-1.348	=(B13-B5+F5)*D5							
14	2CSPUMPB	0.297	=(B14-B5+F5)*D5							
15	3CSPUMPC	0.137	=(B15-B5+F5)*D5							
16	4CSPUMPD	-1.058	=(B16-B5+F5)*D5							
17										
18	This table depicts the calculation of NPSHa (See cells in column C under NPSHa heading)									
19										
20	All pressures are in psi, which requires the conversion at the desired temperature (Cell D5) to obtain NPSHa in feet. The conversion factor (See cell D5) is obtained by									
21	multiplying specific volume of water at the desired temperature (See cell C5) by 144.									
22										
23	[NPSHa = [suction pressure (pressure at pump inlet nodes obtained from Multiflow output files) (See cells in column B under Pressure heading (psig)) – vapor pressure (See cell B5 (psia)) + pool pressure (See cell F5 (psia))] X conversion factor from psia to feet (See D5)									
24										
25	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. 2.22) (See cells C4 and C5)									
26										
27	ptsat_97(Temperature) is the vapor pressure of water at a specific temperature, it is a thermodynamic property of water obtained from STMFUNC excel add-in program (Ref. 2.22) (See cells B4 and B5)									

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)	14.4

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

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(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)
1PUMPA	-0.599	30.13
2PUMPB	-0.102	31.29
3PUMPC	-1.389	28.30
4PUMPD	0.518	32.72
CS	**Pressure (psig)**	**NPSHa (ft)**
1CSPUMPA	-1.357	28.37
2CSPUMPB	0.276	32.16
3CSPUMPC	0.128	31.82
4CSPUMPD	-1.078	29.02

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)	14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	-0.585	22.55
2PUMPB	-0.097	23.70
3PUMPC	-1.364	20.71
4PUMPD	0.514	25.14
CS	**Pressure (psig)**	**NPSHa (ft)**
1CSPUMPA	-1.332	20.79
2CSPUMPB	0.275	24.57
3CSPUMPC	0.129	24.23
4CSPUMPD	-1.059	21.43

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)
1PUMPA	4.938	35.57
2PUMPB		
3PUMPC	4.689	34.98
4PUMPD		
CS	**Pressure (psig)**	**NPSHa (ft)**
1CSPUMPA	3.204	31.48
2CSPUMPB		
3CSPUMPC	4.043	33.46
4CSPUMPD		

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)
1PUMPA	4.911	30.88
3PUMPC	4.664	30.30
RHR	Pressure (psig)	NPSHa (ft)
1CSPUMPA	3.187	26.80
3CSPUMPC	4.021	28.78

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)	14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	4.884	24.94
2PUMPB		
3PUMPC	4.638	24.35
4PUMPD		
CS	**Pressure (psig)**	**NPSHa (ft)**
1CSPUMPA	3.17	20.85
2CSPUMPB		
3CSPUMPC	3.999	22.83
4CSPUMPD		

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

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

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)	14.4

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

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

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

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)	14.4

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

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

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

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)	14.4

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

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

Table 7.18: Unit 1 NPSH Calculations ATWS 177F

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

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

Table 7.19: Unit 1 NPSH Calculations ATWS 192F

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		
192	9.757027807	0.01658144	2.387727412	Pool Press. (psia)	14.4

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

Table 7.20: Unit 1 NPSH Calculations ATWS 211F

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		
211	14.42019545	0.016707611	2.405895953	Pool Press. (psia)	14.4

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

Table 7.21: Unit 1 NPSH Calculations App-R A 191F 7200gpm

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		
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia)	14.4

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

Table 7.22: Unit 1 NPSH Calculations App-R B 191F 7200gpm

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

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

Table 7.23: Unit 1 NPSH Calculations App-R C 191F 7200gpm

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		
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia)	14.4

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

Table 7.24: Unit 1 NPSH Calculations App-R D 191F 7200gpm

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		
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia)	14.4

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

Table 7.25: Unit 1 NPSH Calculations App-R A 223F 7200gpm

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		
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia)	14.75

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

Table 7.26: Unit 1 NPSH Calculations App-R B 223F 7200gpm

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

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

Table 7.27: Unit 1 NPSH Calculations App-R C 223F 7200gpm

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		
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia)	14.75

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

Table 7.28: Unit 1 NPSH Calculations App-R D 223F 7200gpm

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		
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia)	14.75

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

Table 7.29: Unit 1 NPSH Calculations App-R A 191F 9100gpm

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		
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia)	14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	4.996	23.50
2PUMPB		
3PUMPC		
4PUMPD		

Table 7.30: Unit 1 NPSH Calculations App-R B 191F 9100gpm

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		
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia)	14.4

RHR	Pressure (psig) (ft)	NPSHa (ft)
1PUMPA		
2PUMPB	4.983	23.47
3PUMPC		
4PUMPD		

Table 7.31: Unit 1 NPSH Calculations App-R C 191F 9100gpm

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		
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia)	14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC	4.9	23.27
4PUMPD		

Table 7.32: Unit 1 NPSH Calculations App-R D 191F 9100gpm

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		
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia)	14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC		
4PUMPD	5.05	23.63

Table 7.33: Unit 1 NPSH Calculations App-R A 223F 9100gpm

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		
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia)	14.76

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	4.932	3.56
2PUMPB		
3PUMPC		
4PUMPD		

Table 7.34: Unit 1 NPSH Calculations App-R B 223F 9100gpm

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

RHR	Pressure (psig) (ft)	NPSHa (ft)
1PUMPA		
2PUMPB	4.919	3.50
3PUMPC		
4PUMPD		

Table 7.35: Unit 1 NPSH Calculations App-R C 223F 9100gpm

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		
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia)	14.76

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC	4.836	3.33
4PUMPD		

Table 7.36: Unit 1 NPSH Calculations App-R D 223F 9100gpm

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		
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia)	14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC		
4PUMPD	4.985	3.66

Table 7.37: Unit 1 NPSH Calculations Case SBO A-C 157F

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		
157	4.417636119	0.016377716	2.358391077	Pool Press. (psia)	14.4

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

Table 7.38: Unit 1 NPSH Calculations Case SBO B-D 157F

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	
157	4.417636119	0.016377716	2.358391077	Pool Press. (psia) 14.4

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

Table 7.39: Unit 1 NPSH Calculations Case SBO A-C 200F

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		
200	11.53763273	0.016633238	2.395186284	Pool Press. (psia)	14.4

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

Table 7.40: Unit 1 NPSH Calculations Case SBO B-D 200F

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	
200	11.537632733	0.016633238	2.395186284	Pool Press. (psia) 14.4

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

TABLE 9
Unit 1

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

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	0.162
		Strainer 23	4565.69	0.117
		Strainer 27	4644.31	0.131
		Strainer 5	4630.81	0.129
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	0.128
		Strainer 23	4757.96	0.144
		Strainer 27	4868.9	0.166
		Strainer 5	4559.26	0.108
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	Strainer 1	4644.41	0.127
		Strainer 23	4731.46	0.143
		Strainer 27	4841.57	0.165
		Strainer 5	4534.56	0.108
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	0.127
		Strainer 23	4705.02	0.143
		Strainer 27	4814.34	0.164
		Strainer 5	4509.75	0.107
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	0.142
		Strainer 23	4665.05	0.127
		Strainer 27	4795.96	0.151
		Strainer 5	4651.04	0.124
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	Strainer 1	4717.9	0.141
		Strainer 23	4639.35	0.126
		Strainer 27	4769.18	0.151
		Strainer 5	4625.57	0.124
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	0.140
		Strainer 23	4613.64	0.126
		Strainer 27	4742.47	0.149
		Strainer 5	4600.06	0.123
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	0.890
		Strainer 23	7506.83	0.698
		Strainer 27	7849.45	0.771
		Strainer 5	7786.11	0.757

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

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

Appendix R Pump/Flow Combination	Pool Temp.	Strainer	Flow (sgpm)	Pressure Drop (psid)
App-R A RHR Pump A-9100 gpm	@191°F	Strainer 1	3340.85	0.0255
		Strainer 23	1420.38	0.0046
		Strainer 27	2331.64	0.0124
		Strainer 5	1710.13	0.0067
App-R B RHR Pump B-9100 gpm	@191°F	Strainer 1	2649.2	0.016
		Strainer 23	1710.59	0.0067
		Strainer 27	2989.65	0.0204
		Strainer 5	1453.56	0.0048
App-R C RHR Pump C-9100 gpm	@191°F	Strainer 1	3340.85	0.0255
		Strainer 23	1420.38	0.0046
		Strainer 27	2331.64	0.0124
		Strainer 5	1710.13	0.0067
App-R D RHR Pump D-9100 gpm	@191°F	Strainer 1	2649.2	0.016
		Strainer 23	1710.59	0.0067
		Strainer 27	2989.65	0.0204
		Strainer 5	1453.56	0.0048
Appendix R Pump/Flow Combination	**Pool Temp.**	**Strainer**	**Flow (sgpm)**	**Pressure Drop (psid)**
App-R A RHR Pump A-9100 gpm	@223°F	Strainer 1	3259.2	0.0251
		Strainer 23	1403.71	0.0046
		Strainer 27	2300.63	0.0122
		Strainer 5	1689.46	0.0066
App-R B RHR Pump B-9100 gpm	@223°F	Strainer 1	2614.85	0.0158
		Strainer 23	1690.27	0.0066
		Strainer 27	2947.57	0.0201
		Strainer 5	1436.32	0.0048
App-R C RHR Pump C-9100 gpm	@223°F	Strainer 1	3295.2	0.0251
		Strainer 23	1403.71	0.0046
		Strainer 27	2300.63	0.0122
		Strainer 5	1689.46	0.0066
App-R D RHR Pump D-9100 gpm	@223°F	Strainer 1	2614.85	0.0158
		Strainer 23	1690.27	0.0066
		Strainer 27	2947.57	0.0201
		Strainer 5	1436.32	0.0048

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

TABLE 10
Unit 2

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

LOCA Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	Pressure (psia)
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	RHR/A	30.90	14.4
		RHR/C	30.35	14.4
		CS/A	26.80	14.4
		CS/C	28.78	14.4
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	24.95	14.4
		RHR/C	24.40	14.4
		CS/A	20.85	14.4
		CS/C	22.83	14.4
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	35.59	14.4
		RHR/C	35.04	14.4
		CS/B	33.35	14.4
		CS/D	31.54	14.4
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	RHR/A	30.91	14.4
		RHR/C	30.36	14.4
		CS/B	28.67	14.4
		CS/D	26.86	14.4
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	24.96	14.4
		RHR/C	24.41	14.4
		CS/B	22.72	14.4
		CS/D	20.92	14.4
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	35.30	14.4
		RHR/D	35.85	14.4
		CS/B	33.33	14.4
		CS/D	31.52	14.4
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	RHR/B	30.62	14.4
		RHR/D	31.16	14.4
		CS/B	28.65	14.4
		CS/D	26.84	14.4
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	24.67	14.4
		RHR/D	25.22	14.4
		CS/B	22.70	14.4
		CS/D	20.89	14.4
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	35.28	14.4
		RHR/D	35.82	14.4
		CS/A	31.52	14.4
		CS/C	33.50	14.4

LOCA Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	Pressure (psia)
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	RHR/B	30.60	14.4
		RHR/D	31.14	14.4
		CS/A	26.84	14.4
		CS/C	28.82	14.4
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	24.65	14.4
		RHR/D	25.19	14.4
		CS/A	20.89	14.4
		CS/C	22.87	14.4
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	30.45	14.4
		RHR/B	30.45	14.4
		RHR/C	29.91	14.4
		RHR/D	31.00	14.4
		CS/A	27.26	14.4
		CS/C	29.24	14.4

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

Appendix R Pump/Flow Combination	Pool Temp.	Pump	NPSHa (ft)	Pressure (psia)
App-R A RHR Pump A-7200 gpm	@191°F	A	24.45	14.4
App-R B RHR Pump B-7200 gpm	@191°F	B	24.43	14.4
App-R C RHR Pump C-7200 gpm	@191°F	C	24.36	14.4
App-R D RHR Pump D-7200 gpm	@191°F	D	24.52	14.4
App-R A RHR Pump A-9100gpm	@191°F	A	23.51	14.4
App-R B RHR Pump B-9100gpm	@191°F	B	23.47	14.4
App-R C RHR Pump C-9100 gpm	@191°F	C	23.36	14.4
App-R D RHR Pump D-9100 gpm	@191°F	D	23.62	14.4
App-R A RHR Pump A-7200 gpm	@223°F	A	4.49	14.75
App-R B RHR Pump B-7200 gpm	@223°F	B	4.46	14.75
App-R C RHR Pump C-7200 gpm	@223°F	C	4.39	14.75
App-R D RHR Pump D-7200 gpm	@223°F	D	4.55	14.75
App-R A RHR Pump A-9100 gpm	@223°F	A	3.55	14.75
App-R B RHR Pump B-9100 gpm	@223°F	B	3.51	14.75
App-R C RHR Pump C-9100 gpm	@223°F	C	3.39	14.75
App-R D RHR Pump D-9100 gpm	@223°F	D	3.65	14.75

SBO Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	Pressure (psia)
SBO 1 A/C RHR Pump A/C-6500 gpm each	@157°F	A	35.46	14.4
		C	34.91	14.4
SBO 2 B/D RHR Pump B/D-6500 gpm each	@157°F	B	35.15	14.4
		D	35.69	14.4
SBO 1 A/C RHR Pump A/C-6500 gpm each	@200°F	A	18.78	14.4
		C	18.23	14.4
SBO 2 B/D RHR Pump B/D-6500 gpm each	@200°F	B	18.46	14.4
		D	19.01	14.4

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

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)	14.4
RHR	**Pressure (psig)**	**NPSHa (ft)**			
1PUMPA	-0.1690	23.53			
2PUMPB	-0.6070	22.49			
3PUMPC	-0.7790	22.09			
4PUMPD	0.1150	24.20			
CS	**Pressure (psig)**	**NPSHa (ft)**			
1CSPUMPA	-1.3270	20.80			
2CSPUMPB	0.2770	24.58			
3CSPUMPC	0.1360	24.25			
4CSPUMPD	-1.0580	21.43			

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

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

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

Table 11.4: Unit 2 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)	14.4

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

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

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

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)	14.4

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

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

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

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)	14.4

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

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

CALCULATION SHEET

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

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^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)	14.4

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

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

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

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

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

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

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

Table 11.18: Unit 2 NPSH Calculations ATWS 177F

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		
177	7.033092437	0.016489536	2.374493143	Pool Press. (psia)	14.4

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

Table 11.19: Unit 2 NPSH Calculations ATWS 192F

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		
192	9.757027807	0.01658144	2.387727412	Pool Press. (psia)	14.4

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

Table 11.20: Unit 2 NPSH Calculations ATWS 211F

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		
211	14.42019545	0.016707611	2.405895953	Pool Press. (psia)	14.4

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

Table 11.21: Unit 2 NPSH Calculations App-R A 191F 7200gpm

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		
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia)	14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	5.397	24.45
2PUMPB		
3PUMPC		
4PUMPD		

Table 11.22: Unit 2 NPSH Calculations App-R B 191F 7200gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB	5.386	24.43
3PUMPC		
4PUMPD		

Table 11.23: Unit 2 NPSH Calculations App-R C 191F 7200gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC	5.356	24.36
4PUMPD		

Table 11.24: Unit 2 NPSH Calculations App-R D 191F 7200gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC		
4PUMPD	5.424	24.52

Table 11.25: Unit 2 NPSH Calculations App-R A 223F 7200gpm

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		
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia)	14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	5.327	4.49
2PUMPB		
3PUMPC		
4PUMPD		

Table 11.26: Unit 2 NPSH Calculations App-R B 223F 7200gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB	5.316	4.46
3PUMPC		
4PUMPD		

Table 11.27: Unit 2 NPSH Calculations App-R C 223F 7200gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC	5.286	4.39
4PUMPD		

CALCULATION SHEET

Table 11.28: Unit 2 NPSH Calculations App-R D 223F 7200gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC		
4PUMPD	5.354	4.55

Table 11.29: Unit 2 NPSH Calculations App-R A 191F 9100gpm

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		
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia)	14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	5.003	23.51
2PUMPB		
3PUMPC		
4PUMPD		

Table 11.30: Unit 2 NPSH Calculations App-R B 191F 9100gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB	4.985	23.47
3PUMPC		
4PUMPD		

Table 11.31: Unit 2 NPSH Calculations App-R C 191F 9100gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC	4.937	23.36
4PUMPD		

Table 11.32: Unit 2 NPSH Calculations App-R D 191F 9100gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC		
4PUMPD	5.046	23.62

Table 11.33: Unit 2 NPSH Calculations App-R A 223F 9100gpm

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		
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia)	14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	4.938	3.55
2PUMPB		
3PUMPC		
4PUMPD		

Table 11.34: Unit 2 NPSH Calculations App-R B 223F 9100gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB	4.921	3.51
3PUMPC		
4PUMPD		

Table 11.35: Unit 2 NPSH Calculations App-R C 223F 9100gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC	4.872	3.39
4PUMPD		

Table 11.36: Unit 2 NPSH Calculations App-R D 223F 9100gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC		
4PUMPD	4.981	3.65

Table 11.37: Unit 2 NPSH Calculations SBO A-C 157F

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	
157	4.417636119	0.016377716	2.358391077	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	5.055	35.46
2PUMPB		
3PUMPC	4.821	34.91
4PUMPD		

Table 11.38: Unit 2 NPSH Calculations SBO B-D 157F

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	
157	4.417636119	0.016377716	2.358391077	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB	4.921	35.15
3PUMPC		
4PUMPD	5.152	35.69

CALCULATION SHEET

Table 11.39: Unit 2 NPSH Calculations SBO A-C 200F

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	
200	11.53763273	0.016633238	2.395186284	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	4.977	18.78
2PUMPB		
3PUMPC	4.747	18.23
4PUMPD		

Table 11.40: Unit 2 NPSH Calculations SBO B-D 200F

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		
200	11.53763273	0.016633238	2.395186284	Pool Press. (psia)	14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB	4.846	18.46
3PUMPC		
4PUMPD	5.073	19.01

TABLE 12
Unit 2

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

LOCA Pump/Flow Combination	Pool Temp	Strainer	Flow (sgpm)	Pressure Drop (psid)
RHR A/C Pumps-6500 gpm each B/D-0 gpm each		Strainer 5	4615.09	0.122
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	0.157
		Strainer 23	4598.6	0.123
		Strainer 27	4678.94	0.138
		Strainer 5	4589.54	0.121
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	0.123
		Strainer 23	4785.4	0.149
		Strainer 27	4901.46	0.172
		Strainer 5	4527.29	0.103
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	Strainer 1	4616.51	0.122
		Strainer 23	4758.78	0.149
		Strainer 27	4873.98	0.171
		Strainer 5	4502.73	0.102
LOCA 5C 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	0.122
		Strainer 23	4732.21	0.148
		Strainer 27	4846.6	0.170
		Strainer 5	4478.08	0.102
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	0.138
		Strainer 23	4678.05	0.129
		Strainer 27	4823.48	0.157
		Strainer 5	4631.2	0.121
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	Strainer 1	4697.33	0.137
		Strainer 23	4652.29	0.129
		Strainer 27	4796.54	0.156
		Strainer 5	4605.83	0.120
LOCA 6C 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	0.136
		Strainer 23	4626.52	0.128
		Strainer 27	4769.68	0.155
		Strainer 5	4580.42	0.119
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	0.875
		Strainer 23	7547.79	0.706
		Strainer 27	7931.33	0.789
		Strainer 5	7721.55	0.743

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

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

Appendix R Pump/Flow Combination	Pool Temp.	Strainer	Flow (sgpm)	Pressure Drop (psid)
App-R A RHR Pump A-9100 gpm	@191°F	Strainer 1	3310.73	0.025
		Strainer 23	1400.64	0.0045
		Strainer 27	2403	0.0132
		Strainer 5	1688.63	0.0065
App-R B RHR Pump B-9100 gpm	@191°F	Strainer 1	2583.85	0.0152
		Strainer 23	1675.82	0.0064
		Strainer 27	3120.33	0.0222
		Strainer 5	1423.01	0.0046
App-R C RHR Pump C-9100 gpm	@191°F	Strainer 1	3310.73	0.025
		Strainer 23	1400.64	0.0045
		Strainer 27	2403	0.0132
		Strainer 5	1688.63	0.0065
App-R D RHR Pump D-9100 gpm	@191°F	Strainer 1	2583.85	0.0152
		Strainer 23	1675.82	0.0064
		Strainer 27	3120.33	0.0222
		Strainer 5	1423.01	0.0046
Appendix R Pump/Flow Combination	**Pool Temp.**	**Strainer**	**Flow (sgpm)**	**Pressure Drop (psid)**
App-R A RHR Pump A-9100 gpm	@223°F	Strainer 1	3265.36	0.0247
		Strainer 23	1384.15	0.0044
		Strainer 27	2371.35	0.013
		Strainer 5	1668.13	0.0064
App-R B RHR Pump B-9100 gpm	@223°F	Strainer 1	2550.21	0.015
		Strainer 23	1655.82	0.0063
		Strainer 27	3076.9	0.0219
		Strainer 5	1406.08	0.0046
App-R C RHR Pump C-9100 gpm	@223°F	Strainer 1	3265.36	0.0247
		Strainer 23	1384.15	0.0044
		Strainer 27	2371.35	0.013
		Strainer 5	1668.13	0.0064
App-R D RHR Pump D-9100 gpm	@223°F	Strainer 1	2550.21	0.015
		Strainer 23	1655.82	0.0063
		Strainer 27	3076.9	0.0219
		Strainer 5	1406.08	0.0046

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

TABLE 13
Unit 3

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

LOCA Pump/Flow Combination	Pool Temp.	Pump	NPSHa (ft)	Pressure (psia)
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	24.94	14.4
		RHR/C	24.35	14.4
		CS/A	20.86	14.4
		CS/C	22.84	14.4
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	35.59	14.4
		RHR/C	35.00	14.4
		CS/B	33.34	14.4
		CS/D	31.54	14.4
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	RHR/A	30.91	14.4
		RHR/C	30.32	14.4
		CS/B	28.67	14.4
		CS/D	26.86	14.4
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	24.96	14.4
		RHR/C	24.37	14.4
		CS/B	22.72	14.4
		CS/D	20.91	14.4
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	35.30	14.4
		RHR/D	35.84	14.4
		CS/B	33.33	14.4
		CS/D	31.52	14.4
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	RHR/B	30.61	14.4
		RHR/D	31.16	14.4
		CS/B	28.65	14.4
		CS/D	26.84	14.4
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	24.67	14.4
		RHR/D	25.21	14.4
		CS/B	22.70	14.4
		CS/D	20.89	14.4
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	35.28	14.4
		RHR/D	35.82	14.4
		CS/A	31.53	14.4
		CS/C	33.51	14.4
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	RHR/B	30.59	14.4
		RHR/D	31.14	14.4
		CS/A	26.85	14.4
		CS/C	28.83	14.4

LOCA Pump/Flow Combination	Pool Temp.	Pump	NPSHa (ft)	Pressure (psia)
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	24.64	14.4
		RHR/D	25.19	14.4
		CS/A	20.90	14.4
		CS/C	22.88	14.4
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	30.42	14.4
		RHR/B	30.43	14.4
		RHR/C	29.83	14.4
		RHR/D	30.97	14.4
		CS/A	27.28	14.4
		CS/C	29.26	14.4

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

Appendix R Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	Pressure (psia)
App-R A RHR Pump A-7200 gpm	@191°F	A	24.45	14.4
App-R B RHR Pump B-7200 gpm	@191°F	B	24.41	14.4
App-R C RHR Pump C-7200 gpm	@191°F	C	24.30	14.4
App-R D RHR Pump D-7200 gpm	@191°F	D	24.50	14.4
App-R A RHR Pump A-9100 gpm	@191°F	A	23.51	14.4
App-R B RHR Pump B-9100 gpm	@191°F	B	23.45	14.4
App-R C RHR Pump C-9100 gpm	@191°F	C	23.27	14.4
App-R D RHR Pump D-9100 gpm	@191°F	D	23.59	14.4
App-R A RHR Pump A-7200 gpm	@223°F	A	4.49	14.75
App-R B RHR Pump B-7200 gpm	@223°F	B	4.45	14.75
App-R C RHR Pump C-7200 gpm	@223°F	C	4.34	14.75
App-R D RHR Pump D-7200 gpm	@223°F	D	4.54	14.75
App-R A RHR Pump A-9100 gpm	@223°F	A	3.55	14.75
App-R B RHR Pump B-9100 gpm	@223°F	B	3.48	14.75
App-R C RHR Pump C-9100 gpm	@223°F	C	3.30	14.75
App-R D RHR Pump D-9100 gpm	@223°F	D	3.63	14.75

SBO Pump/Flow Combination	Pool Temp	Pump	NPSHa (ft)	Pressure (psia)
SBO 1 A/C RHR Pump A/C-6500 gpm each	@157°F	A	35.46	14.4
		C	34.86	14.4
SBO 2 B/D RHR Pump B/D-6500 gpm each	@157°F	B	35.10	14.4
		D	35.65	14.4
SBO 1 A/C RHR Pump A/C-6500 gpm each	@200°F	A	18.77	14.4
		C	18.18	14.4
SBO 2 B/D RHR Pump B/D-6500 gpm each	@200°F	B	18.42	14.4
		D	18.96	14.4

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(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)			
1PUMPA	-0.194	31.07			
2PUMPB	-0.635	30.05			
3PUMPC	-0.861	29.52			
4PUMPD	0.0983	31.75			
CS	Pressure (psig)	NPSHa (ft)			
1CSPUMPA	-1.338	28.42			
2CSPUMPB	0.2827	32.18			
3CSPUMPC	0.1479	31.87			
4CSPUMPD	-1.0716	29.04			

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)	14.4

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

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

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^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) 14.40

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	-0.5654	22.59
2PUMPB	-0.0892	23.72
3PUMPC	-1.3536	20.73
4PUMPD	0.5133	25.14
CS	**Pressure (psig)**	**NPSHa (ft)**
1CSPUMPA	-1.3148	20.83
2CSPUMPB	0.2815	24.59
3CSPUMPC	0.1482	24.27
4CSPUMPD	-1.053	21.44

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)		
1PUMPA	4.942	35.57		
2PUMPB				
3PUMPC	4.6908	34.98		
4PUMPD				
CS	Pressure (psig)	NPSHa (ft)		
1CSPUMPA	3.2072	31.49		
2CSPUMPB				
3CSPUMPC	4.0468	33.46		
4CSPUMPD				

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)
1PUMPA	4.9151	30.89
2PUMPB		
3PUMPC	4.665	30.30
4PUMPD		
CS	**Pressure (psig)**	**NPSHa (ft)**
1CSPUMPA	3.19	26.81
2CSPUMPB		
3CSPUMPC	4.0249	28.78
4CSPUMPD		

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(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) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	4.888	24.94
2PUMPB		
3PUMPC	4.6392	24.35
4PUMPD		
CS	**Pressure (psig)**	**NPSHa (ft)**
1CSPUMPA	3.173	20.86
2CSPUMPB		
3CSPUMPC	4.003	22.84
4CSPUMPD		

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

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(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)
1PUMPA	4.921	30.91
2PUMPB		
3PUMPC	4.671	30.32
4PUMPD		
CS	**Pressure (psig)**	**NPSHa (ft)**
1CSPUMPA		
2CSPUMPB	3.9748	28.67
3CSPUMPC		
4CSPUMPD	3.2133	26.86

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) 14.4

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

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

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

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) 14.4

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

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(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)
1PUMPA		
2PUMPB	4.8149	35.28
3PUMPC		
4PUMPD	5.0455	35.82
CS	**Pressure (psig)**	**NPSHa (ft)**
1CSPUMPA	3.2265	31.53
2CSPUMPB		
3CSPUMPC	4.066	33.51
4CSPUMPD		

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

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(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)
1PUMPA		
2PUMPB	4.788	30.59
3PUMPC		
4PUMPD	5.0178	31.14
CS	**Pressure (psig)**	**NPSHa (ft)**
1CSPUMPA	3.209	26.85
2CSPUMPB		
3CSPUMPC	4.044	28.83
4CSPUMPD		

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) 14.4

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

Table 14.17: Unit 3 NPSH Calculations Case 7 166F

Temp(°F)	Vapor Pressure (psia)	Specific Volume V(ft^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)
1PUMPA	3.9313	30.42
2PUMPB	3.933	30.43
3PUMPC	3.6805	29.83
4PUMPD	4.1637	30.97
CS	**Pressure (psig)**	**NPSHa (ft)**
1CSPUMPA	2.6012	27.28
2CSPUMPB		
3CSPUMPC	3.438	29.26
4CSPUMPD		

Table 14.18: Unit 3 NPSH Calculations Case ATWS 177F

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	
177	7.033092437	0.016489536	2.374493143	Pool Press. (psia) 14.4

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

Table 14.19: Unit 3 NPSH Calculations Case ATWS 192F

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

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

Table 14.20: Unit 3 NPSH Calculations Case ATWS 211F

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

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

Table 14.21: Unit 3 NPSH Calculations Case App-R A 191F 7200gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

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

Table 14.22: Unit 3 NPSH Calculations Case App-R B 191F 7200gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

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

Table 14.23: Unit 3 NPSH Calculations Case App-R C 191F 7200gpm

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	
191	9.551535023	0.016575101	2.386814603	**Pool Press. (psia)** 14.4

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

Table 14.24: Unit 3 NPSH Calculations Case App-R D 191F 7200gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC		
4PUMPD	5.418	24.50

Table 14.25: Unit 3 NPSH Calculations Case App-R A 223F 7200gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	5.327	4.49
2PUMPB		
3PUMPC		
4PUMPD		

Table 14.26: Unit 3 NPSH Calculations Case App-R B 223F 7200gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB	5.311	4.45
3PUMPC		
4PUMPD		

Table 14.27: Unit 3 NPSH Calculations Case App-R C 223F 7200gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

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

Table 14.28: Unit 3 NPSH Calculations Case App-R D 223F 7200gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

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

Table 14.29: Unit 3 NPSH Calculations Case App-R A 191F 9100gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	5.002	23.51
2PUMPB		
3PUMPC		
4PUMPD		

Table 14.30: Unit 3 NPSH Calculations Case App-R B 191F 9100gpm

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		
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia)	14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB	4.976	23.45
3PUMPC		
4PUMPD		

Table 14.31: Unit 3 NPSH Calculations Case App-R C 191F 9100gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC	4.9	23.27
4PUMPD		

Table 14.32: Unit 3 NPSH Calculations Case App-R D 191F 9100gpm

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	
191	9.551535023	0.016575101	2.386814603	Pool Press. (psia) 14.4

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC		
4PUMPD	5.037	23.59

Table 14.33: Unit 3 NPSH Calculations Case App-R A 223F 9100gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA	4.937	3.55
2PUMPB		
3PUMPC		
4PUMPD		

Table 14.34: Unit 3 NPSH Calculations Case App-R B 223F 9100gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB	4.911	3.48
3PUMPC		
4PUMPD		

Table 14.35: Unit 3 NPSH Calculations Case App-R C 223F 9100gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC	4.837	3.30
4PUMPD		

Table 14.36: Unit 3 NPSH Calculations Case App-R D 223F 9100gpm

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	
223	18.22056282	0.016792916	2.418179953	Pool Press. (psia) 14.75

RHR	Pressure (psig)	NPSHa (ft)
1PUMPA		
2PUMPB		
3PUMPC		
4PUMPD	4.971	3.63

Table 14.37: Unit 3 NPSH Calculations SBO A-C 157F

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	
157	4.417636119	0.016377716	2.358391077	Pool Press. (psia) 14.4

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

Table 14.38: Unit 3 NPSH Calculations SBO B-D 157F

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		
157	4.417636119	0.016377716	2.358391077	Pool Press. (psia)	14.4

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

Table 14.39: Unit 3 NPSH Calculations SBO A-C 200F

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	
200	11.53763273	0.016633238	2.395186284	Pool Press. (psia) 14.4

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

Table 14.40: Unit 3 NPSH Calculations SBO B-D 200F

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		
200	11.53763273	0.016633238	2.395186284	Pool Press. (psia)	14.4

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

TABLE 15
Unit 3

LOCA Pump/Flow Combination	Pool Temp	Strainer	Flow (sgpm)	Pressure Drop (psid)
LOCA 1A CS Pumps A/B/C/D-4125gpm each RHR A/C Pumps –10,500 gpm each RHR B/D Pumps –11,500 gpm each	@95°F	Strainer 1	15628.6	3.022
		Strainer 23	14681.1	2.645
		Strainer 27	15176.1	2.884
		Strainer 5	14712.2	2.662
LOCA 1B CS Pumps A/B/C/D-4125gpm each RHR A/C Pumps –10,500 gpm each RHR B/D Pumps -11,500 gpm each	@155.4°F	Strainer 1	15390.6	2.975
		Strainer 23	14453.3	2.604
		Strainer 27	14938.4	2.839
		Strainer 5	14483.6	2.621
LOCA 2A CS Pumps A/B/C/D-4125gpm each RHR A/C Pumps –11,500 gpm each RHR B/D Pumps –10,500 gpm each	@95°F	Strainer 1	15646.5	3.025
		Strainer 23	14677	2.642
		Strainer 27	15163.5	2.880
		Strainer 5	14711	2.661
LOCA 2B CS Pumps A/B/C/D-4125gpm each RHR A/C Pumps –11,500 gpm each RHR B/D Pumps -10,500 gpm each	@155.4°F	Strainer 1	15403.4	2.978
		Strainer 23	14450.6	2.603
		Strainer 27	14928	2.835
		Strainer 5	14483.9	2.621
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	0.173
		Strainer 23	4551.66	0.107
		Strainer 27	4648.25	0.124
		Strainer 5	4750.43	0.143
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	Strainer 1	4878.12	0.172
		Strainer 23	4526.95	0.106
		Strainer 27	4622.91	0.123
		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	0.171
		Strainer 23	4502.16	0.106
		Strainer 27	4597.51	0.123
		Strainer 5	4697.64	0.141
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	0.159
		Strainer 23	4647.75	0.124
		Strainer 27	4731.51	0.139
		Strainer 5	4641.08	0.123
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	Strainer 1	4808.63	0.158
		Strainer 23	4622.27	0.123
		Strainer 27	4705.55	0.139
		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	0.157
		Strainer 23	4596.76	0.123
		Strainer 27	4679.56	0.138
		Strainer 5	4589.99	0.121
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	0.123
		Strainer 23	4773.43	0.147
		Strainer 27	4913.97	0.175
		Strainer 5	4526.25	0.102
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	Strainer 1	4617	0.122
		Strainer 23	4746.88	0.146
		Strainer 27	4886.42	0.174
		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	0.122
		Strainer 23	4720.38	0.146
		Strainer 27	4858.97	0.173
		Strainer 5	4477.05	0.102
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	0.137
		Strainer 23	4661.24	0.126
		Strainer 27	4846.9	0.161
		Strainer 5	4626.89	0.120
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	Strainer 1	4695.03	0.137
		Strainer 23	4635.59	0.126
		Strainer 27	4819.83	0.160
		Strainer 5	4601.55	0.119
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	0.136
		Strainer 23	4609.93	0.125
		Strainer 27	4792.84	0.159
		Strainer 5	4576.16	0.119
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	0.696
		Strainer 27	7988.88	0.803
		Strainer 5	7703.14	0.739

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	@177°F	Strainer 1	8930.1	0.181
		Strainer 23	3896.18	0.035
		Strainer 27	7805.12	0.138
		Strainer 5	4652.6	0.049
ATWS RHR A/C/B/D Pumps-6500 gpm each CS Pumps A/C/B/D-0 gpm each	@192°F	Strainer 1	8879.5	0.180
		Strainer 23	3875.86	0.034
		Strainer 27	7760.5	0.138
		Strainer 5	4628.14	0.049
ATWS RHR A/C/B/D Pumps-6500 gpm each CS Pumps A/C/B/D-0 gpm each	@211°F	Strainer 1	8810.45	0.179
		Strainer 23	3847.63	0.034
		Strainer 27	7699.73	0.136
		Strainer 5	4594.2	0.049
Appendix R Pump/Flow Combination	**Pool Temp.**	**Strainer**	**Flow (sgpm)**	**Pressure Drop (psid)**
App-R A RHR Pump A-7200 gpm	@191°F	Strainer 1	2627.57	0.016
		Strainer 23	1051.49	0.003
		Strainer 27	1987.05	0.009
		Strainer 5	1298.89	0.004
App-R B RHR Pump B-7200 gpm	@191°F	Strainer 1	1919.34	0.015
		Strainer 23	1407.03	0.008
		Strainer 27	2348.25	0.022
		Strainer 5	1290.38	0.007
App-R C RHR Pump C-7200 gpm	@191°F	Strainer 1	2627.57	0.016
		Strainer 23	1051.49	0.003
		Strainer 27	1987.05	0.009
		Strainer 5	1298.89	0.004
App-R D RHR Pump D-7200 gpm	@191°F	Strainer 1	1919.34	0.015
		Strainer 23	1407.03	0.008
		Strainer 27	2348.25	0.022
		Strainer 5	1290.38	0.007

Appendix R Pump/Flow Combination	Pool Temp.	Strainer	Flow (sgpm)	Pressure Drop (psid)
App-R A RHR Pump A-7200 gpm	@223°F	Strainer 1	2591.43	0.016
		Strainer 23	1039.21	0.003
		Strainer 27	1961.32	0.009
		Strainer 5	1283.05	0.004
App-R B RHR Pump B-7200 gpm	@223°F	Strainer 1	1894.42	0.015
		Strainer 23	1389.94	0.008
		Strainer 27	2315.96	0.022
		Strainer 5	1274.67	0.007
App-R C RHR Pump C-7200 gpm	@223°F	Strainer 1	2591.43	0.016
		Strainer 23	1039.21	0.003
		Strainer 27	1961.32	0.009
		Strainer 5	1283.05	0.004
App-R D RHR Pump D-7200 gpm	@223°F	Strainer 1	1894.42	0.015
		Strainer 23	1389.94	0.008
		Strainer 27	2315.96	0.022
		Strainer 5	1274.64	0.007

Appendix R Pump/Flow Combination	Pool Temp.	Strainer	Flow (sgpm)	Pressure Drop (psid)
App-R A RHR Pump A-9100 gpm	@191°F	Strainer 1	3317.34	0.0251
		Strainer 23	1331.14	0.004
		Strainer 27	2511.32	0.0144
		Strainer 5	1643.21	0.0062
App-R B RHR Pump B-9100 gpm	@191°F	Strainer 1	2425.64	0.0235
		Strainer 23	1780.14	0.0127
		Strainer 27	2964.72	0.0351
		Strainer 5	1632.5	0.0106
App-R C RHR Pump C-9100 gpm	@191°F	Strainer 1	3317.34	0.0251
		Strainer 23	1331.14	0.004
		Strainer 27	2511.32	0.0144
		Strainer 5	1643.21	0.0062
App-R D RHR Pump D-9100 gpm	@191°F	Strainer 1	2425.64	0.0235
		Strainer 23	1780.14	0.0127
		Strainer 27	2964.72	0.0351
		Strainer 5	1632.5	0.0106
Appendix R Pump/Flow Combination	**Pool Temp.**	**Strainer**	**Flow (sgpm)**	**Pressure Drop (psid)**
App-R A RHR Pump A-9100 gpm	@223°F	Strainer 1	3271.89	0.0248
		Strainer 23	1315.41	0.004
		Strainer 27	2478.7	0.0142
		Strainer 5	1623	0.0061
App-R B RHR Pump B-9100 gpm	@223°F	Strainer 1	2394.05	0.0232
		Strainer 23	1758.32	0.0125
		Strainer 27	2924.15	0.0346
		Strainer 5	1612.47	0.0105
App-R C RHR Pump C-9100 gpm	@223°F	Strainer 1	3271.89	0.0248
		Strainer 23	1315.41	0.004
		Strainer 27	2478.7	0.0142
		Strainer 5	1623	0.0061
App-R D RHR Pump D-9100 gpm	@223°F	Strainer 1	2394.05	0.0232
		Strainer 23	1758.32	0.0125
		Strainer 27	2924.15	0.0346
		Strainer 5	1612.47	0.0105

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

Appendix 3

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

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

Assumptions:

None

References:

1. Drawing 2/3-E20, "TVA Containment Vessel", Pittsburgh-Des Moines Steel Co.

2. Drawing 2/3-47W401-5, "Mechanical Main Steam Relief Valve Vent Piping".

3. General Electric Drawing 105E2202 Rev 1, "Suction Strainer"

Design Input Data:

1. Distance from ring header centerline to weld on penetration X-204A-D = 1' 10" (Ref. 1)

2. Distance from weld on penetration X-204A-D to exterior 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"

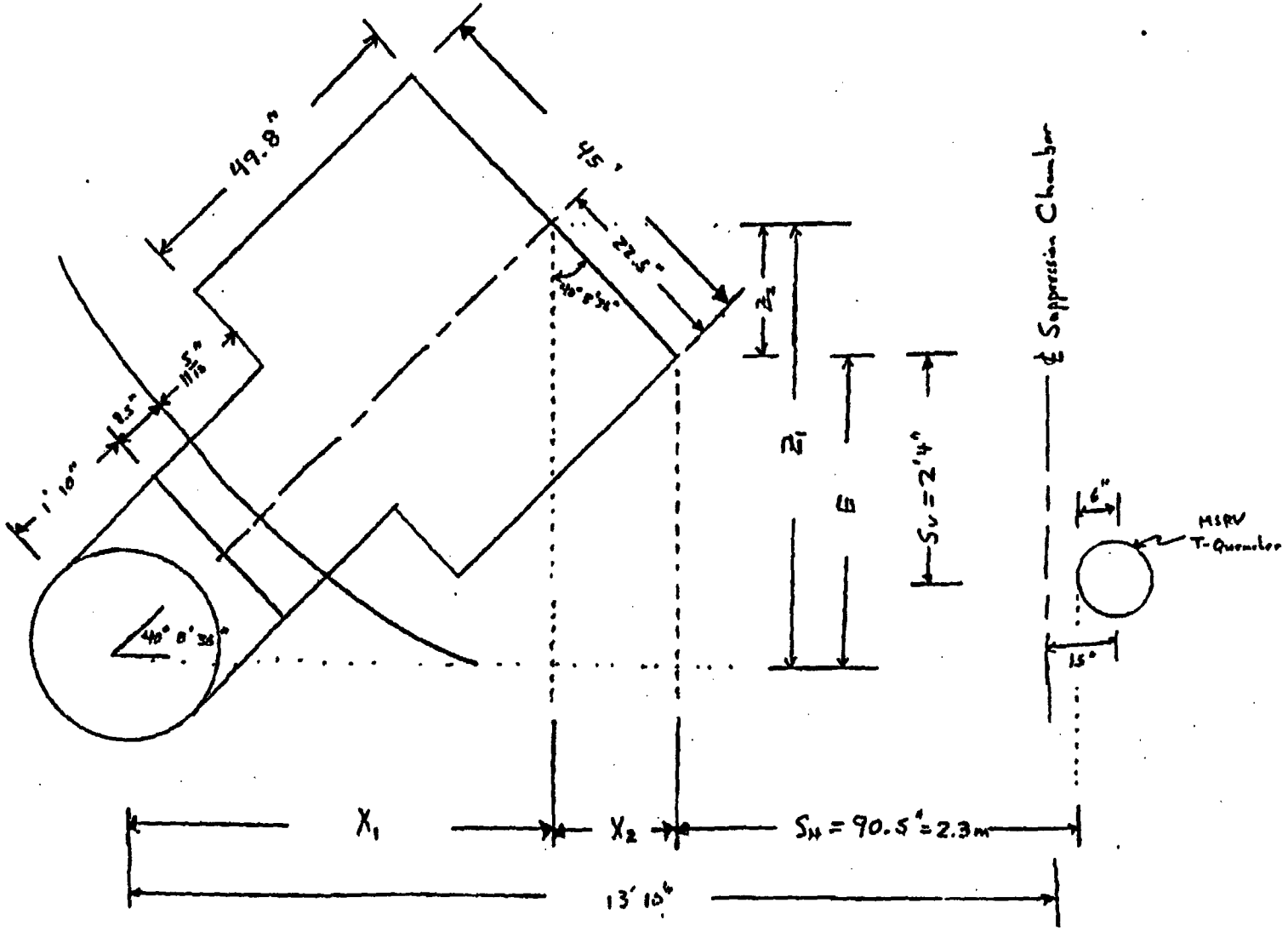
Vertical Separation = Elevation of tip of strainer - Elevation of MSRV T-Quencher
= 528' 10" - 526' 6 " = 2' 4"

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



QA Record

TVAN CALCULATION

TITLE	NPSH Evaluation of Browns Ferry RHR and CS Pumps	PLANT/UNIT	BFN / Unit 2 & 3

PREPARING ORGANIZATION	KEY NOUNS (Consult CCRIS LIST)
Site Engineering-Mechanical / Nuclear	

BRANCH/PROJECT IDENTIFIERS	Each time these calculations are issued, preparers must ensure that the original (R0) RIMS accession number is filled in.		
MD-Q0999-970046	Rev	(for RIMS use)	RIMS accession number
	R0	219	R14 981118 10
APPLICABLE DESIGN DOCUMENT(S)	R1		
Design Criteria No. BFN-50-7074 & BFN-50-7075	R2		
SAR SECTION(S): N/A; UNID SYSTEM(S): 074 & 075	R3		

	Revision 0	R1	R2	R3
DCN No. (or Indicate Not Applicable)		N/A		
Prepared	Thomas F. Newton	Thomas F. Newton		
Checked	Michael Boyd	Michael Boyd 11-18-98		
Reviewed	Mark Lloyd	Mark Lloyd 11-18-98		
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:

Attachment A
Page A-2

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.		
	Rev	(for EDM use)	EDM Accession Number
Applicable Design Document(s) BFN-50-7074 & BFN-50-7075 BFN-50-7064A	R0		R14 981118 103
	R1	354 352	R14 990616 105 |R2
UNID System(s) SYS 074 & 075 + 064A	R2		R14 991118 101
	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	[signature]	[signature]	[signature]	[handwritten name]		
Checked	MH	[signature]	[signature]	[signature]	These calculations contain unverified assumption(s) that must be verified later?	Yes ☐	No ☒
Design Verified	MB	[signature]	[signature]	[signature]	These calculations contain special requirements and/or limiting conditions?	Yes ☐	No ☒
Approved	KTO	[signature]	[signature]	[signature]	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)

ORIGINAL

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

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 11,600 gpm each, one loop of RHR with two pumps at maximum design flow of 10,800 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 destroy.

☐ Microfilm and return calculation to:

261

ATTACHMENT A
PAGE A-3

QA Record

ORIGINAL

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

Page 1

REV'D EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
R14 981118 106	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										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
002003	074 075 054A	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?	EAR/TE 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
KGGauthier	729-3074	MEB	Design Review	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
KGGauthier	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/FICHE 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	VU	BFN	MEB	W29 020517 001	00

CCRIS ONLY UPDATER:
Following are required only when making keyword/cross reference CCRIS updates and page 1 of form NEDP-3-1 is not included:

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE

PREPARER PHONE NO. | EDMS ACCESSION NO. B14 020781 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)
R1493111610S	calculations(nuclear)	

Calc Title: NPSH Evaluation Of Browns Ferry RHR And CS Pumps

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	CUR REV	NEW REV	
CURRENT	CN	NUC	BFN	MEB	MDQ0999970046	004		REVISION APPLICABILITY
NEW	CN	NUC					005	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
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? (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
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. ADDRESS:
☐ LOAD INTO EDMS AND RETURN CALCULATION TO:

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 Yes ☐
01	N/A	N/A	N/A	Bechtel	

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	NDQ199920020018	
A	P	DW	BFN	MEB	1-47E811-1	
A	P	DW	BFN	MEB	2-47E811-1	
A	P	DW	BFN	MEB	3-47E811-1	
A	P	DW	BFN	MEB	1-47E814-1	
A	P	DW	BFN	MEB	0-47E452-1	
A	P	DW	BFN	MEB	2-47W2452-1	
A	P	DW	BFN	MEB	0-47W458-2	
A	P	DW	BFN	MEB	1-47W458-3	
A	P	DW	BFN	MEB	2-47W458-3	
A	P	DW	BFN	MEB	2-47W458-4	
A	P	DW	BFN	MEB	2-47W458-5	
A	P	DW	BFN	MEB	47W401-6	
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 Yes ☐
01	N/A	N/A	N/A	Bechtel	

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)
R14981116108	calculations(nuclear)	W 78 030924 016

Calc Title: NPSH Evaluation of Browns Ferry RHR and CS Pumps

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	CUR REV	NEW REV	
CURRENT	CN	NUC	BFN	MEB	MDQ0999970046	005		REVISION APPLICABILITY
NEW	CN	NUC					006	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 has 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? (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 801-228-6720	MECH/NUC	DESIGN REVIEW	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
DJKAROL Donna Karol	9-12-03	LDEDGELL Lisa Edgell	9-12-03
VERIFIER SIGNATURE	DATE	APPROVAL SIGNATURE	DATE
LDEDGELL Lisa Edgell	9-12-03	WDCROUCH W. D. Crouch	9/12/03

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	MDO0999970046	006

ALTERNATE CALCULATION IDENTIFICATION

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

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)
R14981118106	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	MDO0999970046	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 L Wallace	1/22/04	for William J. Lyon	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 6 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:

ATTACHMENT A PAGE A-11

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

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

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 and/or ISFSI SAR/CoC 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
Fady Gaied	1-312-269-6382	MEB	DESIGN REVIEW	☐ Yes ☒ No

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		

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:

ATTACHMENT A Page A-12

TVAN TVAN CALCULATION COVERSHEET/CCRIS UPDATE

REV 0 EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
R14981118108	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	008	009	Entire calc ☒ Selected pages ☐
NEW	CN	NUC						

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 and/or ISFSI SAR/CoC 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
Fady Galed	1-312-269-6382	MEB	DESIGN REVIEW	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
Fady Galed	8/3/06	Chris Rennels	8/3/06
VERIFIER SIGNATURE	DATE	APPROVAL SIGNATURE	DATE
Chris Rennels	8/3/06		

STATEMENT OF PROBLEM/ABSTRACT

Problem:

The purpose of this calculation is to determine the Net Positive Suction Head (NPSH) available at various points for the Residual Heat Removal (RHR) pump and the Core Spray (CS) pumps.

Abstract:

This revision establishes and evaluates uncontrolled flows for Short-Term LOCA and Appendix R cases. This revision also determines the impact on the water level in the suppression pool due to drywell hold-up volume.

MICROFICHE/EFICHE Yes ☒ No ☐ FICHE NUMBER(S) TVA-F-U001823, TVA-F-U001824, TVA-F-U001825

☐ 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:

Attachment - B-2 Page B-1 005

005 By DJK
CKED. MA

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	4.231	1.382	2.357	-2.62 2.59	-5.73 -5.60	3	1.34 1.32
Long Term LOCA	13,000	8,250	177	7.026	601	152.0	3.963	-3.063	2.355	5.87 5.71	13.08 12.45	0	13.08 12.45
				7.026	4150	175.83	6.837	-0.189	2.374	5.87 5.71	6.32 6.19	0	6.32 6.19
				7.026	4500	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	7000	181.85	7.837	0.811	2.379	5.87	3.94 3.71	1	6.32 6.17
				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	1.02 1.79	2	6.64 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 5.71	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		1.382	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 6.46	0	6.76 6.46
					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
					7000	181.85 End of 1 psi		0.811	2.379	-0.45	-2.38 -2.73	1	0.00 -0.35
					7100	181.9 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 -2.84	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 G of T0400 Report, Reference 2)

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

06/1[illegible]

Attachment 2 B Page B-3
Calcs By DJK
CHKD: MBT

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	155.1	~~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	6.65 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	32	0	Less than 1 psi of overpressure required for long-term for CS pumps

Attachment 2, Page B-3 of 9
EDS By DJK
CMED: N04

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

MD-Q0999-970046

Attachment E
Rev. -009

1

LIMITED WALKDOWN REQUEST AND DATA COLLECTING FORM

Requesting Organization: Sargent & Lundy LLC Date: 07/25/06

Initiating Document: ECCS

Walkdown Location (Unit/Bldg/Elev/Room/Column Lines)
Unit 1 / Reactor Building /Drywell

Scope
Walkdown:

Please identify the elevation of point A see detail D-D on the attached drawing or the vertical distance between Point A and Point C.

Name: Fady S. Galed Signature: [signature] Date: 07/25/06

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)

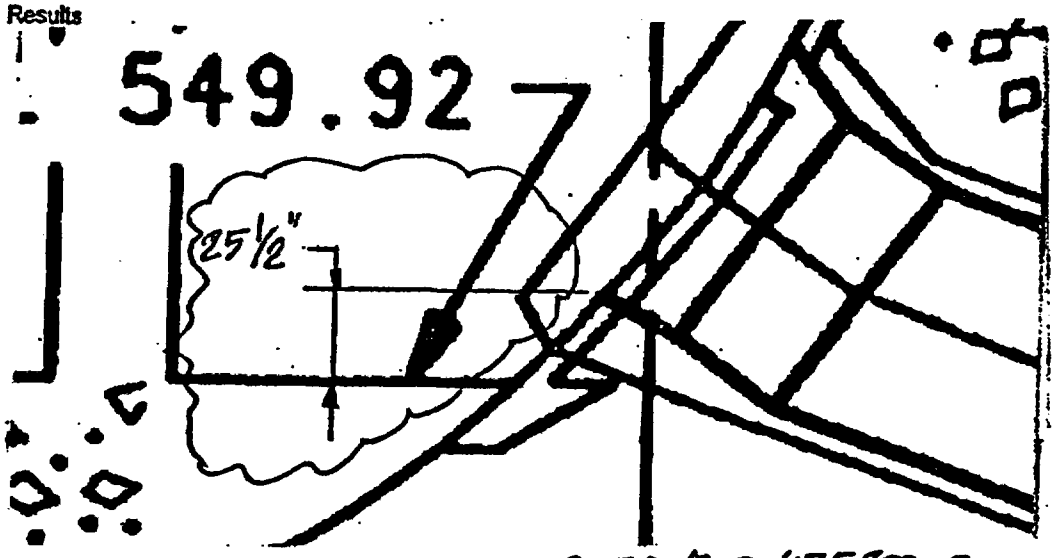
MD-Q 0999-970046

Attachment E 2
Rev.-009

LIMITED WALKDOWN REQUEST AND DATA COLLECTING FORM

Performing Organization Sargent & Lundy LLC Date

Results



DIM. TAKEN @ 42.30°. REF DWG 0-47E200-9

ROMAN KARPINSKI	[signature]	7-25-06
Data Taker Name	Signature	Date
K. G. Gauthaman	[signature]	07.25.06
Data Verifier Name	Signature	Date

MD-Q0999-970046

Attachment F 1
Rev. 009

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

To <donald.l.mcqueen@sargentlundy.com>
cc <FADY.S.GAIED@sargentlundy.com>, "Wolcott, James D" <jdwolcott@tva.gov>
bcc
Subject PUMP/FLOW COMBINATIONS FOR REVISION OF MULTIFLOW NPSH CALCULATION

Don,

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

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

S&L Revised Pump Flow Cases.doc

MUQ0444410040

Attachment F 2
Rev. 009

Pump/Flow Combinations for Revision to NPSH (MultiFlow) Calculation

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

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