PECO ENERGY COMPANY
CALCULATION PM-1010

51 PAGES

THIS PAGE FOLLOWED BY 1 ADDITIONAL PAGE, 1A

Exhibit NE-C-420-1, Rev. 3
Effective Date:

Nuclear Group
Doctype 061

CALCULATION COVER SHEET

1. Calculation No.: PM-1010

2. LGS [ ] PBAPS [X]

3. Unit(s): 2+3

4. Description: RHR PUMP NPSH

5. Last Page No.: 46C

6. Safety Related [X] Non-Safety Related [ ]

7. System/Topic No.: 10

Structure: NA

Component: 2(3)A(B,C,D)P035

Record of Revisions

8. Rev. No.	9. Description of Revision	10. Vendor Calc. Number	10. Vendor Calc. Rev.	11. Assumptions YES	11. Assumptions NO	12. Names (Printed & Signed) - with Dates: Preparer	Reviewer	Approver(s)
5	CALCULATION REVISED TO UPDATE SBO EVENT PER ECR PB 99-02104 REV. 0. AFFECTED PAGES: 3, 1, 6, 43, 43A (new), 46, + 46A	N/A			X	GARY W BECKER (signature) 2/24/00	K.A. Hudson (signature) K.A. Hudson 2/25/00	J.F. O'Rourke (signature) 2/28/00

13. Related Calculation No(s).					
Provides Info. To:					
Receives Info. From:	PM-1013 PM-1004	PM-0760 11187-M-24	ME-0534 ME-0693		
14. Provides Info. To: (SAR/Tech.Spec./etc.)					

15. Manual [X]
Computer [ ]
Computer Program & Version No.:

16. Total Pages: (DS Info. Only) 51

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4	Revision required due to revised COPR input from PM-1013 which resulted in revised NPSH margin for non-purge LOCA, as well as for strainer design basis debris load NPSH margin, added a table of available NPSH margin for Other Events as well as revised COPR for FSSD. No revision bars are included due to the extent of the changes. INCORPS NCR 97-02609, Rev 1				X	[signature] M.W.Idell S&L 2/26/99	[signature] S. Denny 4-5-99	[signature] VINOD K AGGARWAL 5/21/99

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14. Provides Info. To: (UFSAR/Tech.Spec./etc.)					

15. Manual X
    Computer
    Computer Program & Version No.:

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1. PURPOSE / OBJECTIVE

The purpose of this calculation is:

A. to determine the NPSH margin for the RHR pumps and required containment overpressure as a function of time following a DBA LOCA, (recirc. suction line break) assuming one case with the strainer design basis debris loading and one case with the maximum expected post LOCA debris load, maximum torus water level drawdown, maximum high pressure service water temperature and containment sprays activated at time = 600 seconds.

B. Deleted

C. to determine the effect on NPSHA if a LOCA occurs while purging. Some nitrogen and steam will be lost before the purge valves close, which will affect the containment overpressure and therefore NPSH available to the pumps. This is evaluated with the maximum expected post LOCA strainer debris load.

D. to generate curves for various pool levels, pool temperatures and overpressure conditions to determine the limits of these parameters for adequate pump NPSH. Four curves will be generated to demonstrate the temperature impact on allowable pump flow rate for various overpressure conditions for 4 torus water levels: 10.5', 12.3', 14.5' and 20'. All curves assume clean suction strainers.

E. Verify that adequate NPSH exists to support ECCS pump operation during SBO, ATWS, FSSD and IORV events.

NOTE: THIS CALCULATION SUPERCEDES THE NPSH AND SUCTION PIPING PRESSURE DROP CALCULATIONS FOR THE UNITS 2 AND 3 RHR PUMP SUCTIONS FROM THE TORUS IN CALCULATIONS 18247-M-006, 11187-M-060, ME-363, 18247-M-30; AND PARTIALLY SUPERCEDES CALCULATION 11187-M-024 AND 18247-M-001.

Utilization of this calculation by persons without access to the pertinent factors and without proper regard for its purpose could lead to erroneous conclusions. Should it become desirable to use this calculation to support design or station activities other than those explicitly specified in this section, the responsible engineering branch shall be contacted to ensure that the purposes, assumptions, judgements, and limitations are thoroughly understood.

2. SUMMARY OF RESULTS

Part A

The Limiting NPSH margin based on COPL for the DBA LOCA (700 cu. Ft. of NUKON) is 2.02 ft, which occurs at the maximum Torus temperature of 205.7°F and a containment pressure of ~~22.10~~ 21.69 psia. The corresponding margin based on MCPA is 3.10 ft. 4-5-99

Note: At approximately 600 seconds, the assumptions used and the calculation method produces an artificial pressure drop. This is primarily due to the assumption that the containment is instantaneously cooled due to the initiation of containment sprays. This assumption of equilibrium was made because it accurately reflects the behavior of the drywell atmosphere in the long term. However, in the short term, this assumption artificially depresses the containment pressure.

Part B

Long-term NPSH margins were not calculated for the IBA and SBA cases. However, from an inspection of the NPSH margins available in the short-term cases, it can be seen that the IBA and SBA cases are bounded by the DBA LOCA case.

Part C

Should a LOCA occur while the containment is being purged, the NPSH margin, based on MCPA, would be reduced from 3.10 ft. to 1.0 ft., which is still acceptable.

Part D

Curves developed by this calculation for the EPG's (T-102) are included in pages 31 to 42. Inspection of Table D-1 indicates that operation of the RHR pump can be sustained at the rated 10,000 gpm, no containment overpressure and Technical Specification minimum Torus water level up to a torus water temperature of 180.5 °F.

Part E

Adequate NPSH exists to support ECCS pump operation for SBO, ATWS, FSSD and IORV. For the ATWS and the FSSD events, containment overpressure is required.

EVENT	**Margin psig (ft.)**	**Containment Pressure Assumed (Ref. 14) (psig)**
SBO	~~2.37~~ 0.18 ~~(5.6)~~ 0.44	0
ATWS	3.14 (7.4)	4.9
FSSD	2.03 (4.7)	7.5
IORV	0.66 (1.5)	0

3. DESIGN INPUT / CRITERIA

Design Inputs for this calculation are as follows:

1. The torus temperatures and pressures evaluated in Parts A, C and E are taken from Calculation PM-1013 (Ref. 14).
2. Deleted
3. Piping data was derived from Ref. 6-8.
4. Suction strainer data is taken from Ref. 23.
5. RHR pump NPSHR data is taken from Ref. 16 and 17.
6. Torus drawdown is taken from Reference 1.
7. The HPSW system temperature is assumed to be 90°F.
8. HPSW flow to each RHR HX is assumed constant at 4500 gpm.
9. Insulation volumes analyzed are as follows: (Ref. 23, Appendix III)

   Strainer Design Basis: 1026 lbs. / RHR strainer x 3 RHR strainers / 2.4 lbs/ft^3 = 1283 ft^3
   420 lbs. / C.S. strainer x 2 C.S. strainers / 2.4 lbs./ ft^3 = 350 ft^3
   Total = 1633 ft^3

   Post LOCA debris load: 451 lbs. / RHR strainer x 3 strainers / 2.4 lb./ ft^3 = 563 ft^3
   165 lbs. / C.S. strainer x 2 strainers / 2.4 lb./ ft^3 = 137 ft^3
   Total = 700 ft^3

10. Strainer head loss (h) data is as follows: (Ref. 23, Appendix III)

   1633 ft^3 Nukon debris load (strainer design basis)

Temperature (°F)	Pump flow (gpm)	h (ft.)
100	10000	10.28
205.7	10000	7.36
100	11100	11.99
205.7	11100	8.31

   700 ft^3 NUKON debris load (LOCA design basis)

Temperature (°F)	Pump flow (gpm)	h (ft.)
100	10000	4.83
205.7	10000	4.13

   Clean Strainer

Temperature (°F)	Pump Flow (gpm)	h (ft.)
100	11100	2.65

4. Computer Calculations

No computer calculations were used in the development of this calculation. Excel spreadsheets were utilized. However, these spreadsheets were utilized as an automated calculator only.

5. Assumptions

1. For computation of containment overpressure required (COPR), NPSH temperature limits in part D, no NPSH margin is included (i.e. NPSHR = NPSHA).
2. The computation of the torus temperature based on calculated vapor pressure, in part D E, is not completely interpolated in that the pressure conversion factor uses the value of 2.31 rather than a temperature corrected value. The effect on NPSH due to this minor underestimation of temperature is not significant.
3. For part D, vortex limit of 10.5' is used instead of 10.0' (Ref. 24).
4. No debris load for first 10 minutes. 4-5-99

6. References

1. GE letter Report EAS 10-0289 on Suppression Pool Drawdown, May 18,1989, transmitted by G-HE-9-114, dated May 18, 1989, DC# 027673.
2. P&I Diagram M361, Sheet 3, Rev. 59
3. Piping Specification M-300, Rev.14
4. NUREG/CR-2772 - "Hydraulic Performance of Pump Suction Inlets for Emergency Core Cooling Systems in Boiling Water Reactors", June 1982.
5. Peach Bottom UFSAR Fig. 4.8.1, Mode B
6. Bechtel Drawing 6280-M-83, Rev. 17
7. Bechtel Drawing 6280-M-91, Rev. 23
8. Bechtel Drawing 6280-M-103, Rev. 37
9. Crane Technical Paper N. 410 "Flow of Fluids Through Valves, Fittings, and Pipe", 1980 Edition.
10. ASME Steam Tables, 5th Edition
11. Peach Bottom Improved Tech. Spec. 3.6.2.2
12. NE-265 - Specification for ECCS Suction Strainers, Limerick Generating Station, Units 1 and 2 and Peach Bottom Atomic Power Station Units 2 and 3, Rev. A, dated February 11,1997.
13. Calculation PM-1004, Rev 0
14. Calculation PM-1013, Rev. 2
15. Dwg. 6280-M1-U-283-1, RHR Pump Test Data
16. Dwg. 6280-M1-U-284-1, RHR Pump Curve
17. Dwg. 6280-M1-U-296-1, RHR Pump Curve
18. Iso 11187-P-10-1
19. Iso 11187-P-10-2

20. Calculation 11187-M-024, Rev. 4
21. UFSAR Fig. 14.6.10B, Rev.13
22. UFSAR Fig. 14.6.12A, Rev.13
23. SDOC # NE-265-17, Rev.1
24. Calculation ME- 693 Rev. 0 (Unit 3), & ME-0534 Rev. 0 (Unit 2)
25. PM-760, Rev. ~~0~~ 1, "Power Rerate Evaluation - SBO Analysis"
26. NE-163-3 Rev. 0, "Power Rerate Engineering Report"
27. Attachment 1 to PECO NCR 95-05708 "PBAPS Safe S/D Analysis

7. Attachments

Deleted

8. Analysis

A. NPSH MARGINS FOR THE RHR PUMPS UNDER THE WORST EXPECTED ACCIDENT CONDITIONS

The methodology used to perform this calculation was to review the suction piping arrangement for the RHR pumps at Peach Bottom to determine the K value for each suction loop. The bounding K value was then used along with the strainer head losses from Ref. 23 calculate the total head losses through the bounding RHR suction loop for the temperatures given in Ref. 14 and the flows given in Ref. 5. This information was combined with level information from Ref. 5 and containment pressure data from Ref. 14 to calculate NPSHA. This data was compared to the NPSHR for the RHR pumps to determine NPSH margin at various times following a DBA LOCA.

The flow losses are bounding for all RHR pumps and for both Units 2 & 3.

<u>Calculating NPSHA</u>

$NPSHA = Z_{sp}-Z_{pump}+144P_{sp}/\rho - h_f - h_{st} - 144P_{vap}/\rho$

where: Z_{sp} = Elevation of torus water surface (ft.)

Z_{pump} = Elevation of pump suction (ft.)

Note: Center line of the RHR pump suction is at elevation 94'-6", (i.e., equal to the elevation of the bottom of the torus). Thus, $Z_{sp} - Z_p$ is equal to the torus water level.

P_{sp} = Torus pressure (psia)

P_{vap} = vapor pressure at torus water temperature (psia)

h_f = piping friction losses (ft.)

h_{st} = strainer head loss (ft.)

ρ = density of water at torus water temperature (lb/ft^3)

<u>Calculating h_f</u>

The method used to calculate h_f for the various flow rates is as follows:

1) Calculate h_f at some reference flow rate.

2) Calculate h_f at other flows using the following equation:

$h_{f2} = h_{f1} x (Q_2 / Q_1)^2$

where: h_{f1} = reference piping head loss (ft.)

h_{f2} = calculated piping head loss (ft.)

Q_1 = flow rate for reference piping losses (gpm)

Q_2 = flow rate for calculated piping losses (gpm)

Reference piping losses:

From Ref. 9, pg. 3-4 $h_f = 0.00259\ KQ^2/d^4$

For 24" RHR Suction Piping $d = 23.25$ in.

$D = 1.9375$ ft.

From an inspection of Ref. 18 and 19, it was seen that the suction piping arrangement of RHR pumps A and C was identical to the arrangement of pumps B and D. Therefore, piping takeoffs were only performed on the A and C pumps.

Piping Takeoffs:

Pump A Suction Piping:

Piping Segment	Dia. (in.)	Length
1	23.25	18'- 1/4"
2	23.25	16'-11"
3	23.25	3'-3"
4	23.25	3'-0"
5	23.25	4'-0"
Total		45'-2 1/4" or 45.19 ft.

K value for "A" Pump Suction Piping: $K = f_t L/D = 45.19 f_t / 1.9375 = 23.3\ f_t$

Pump C Suction Piping

Piping Segment	Dia (in.)	Length
1	23.25	5' - 4 ¾"
2	23.25	3' - 0"
3	23.25	3' - 0"
4	23.25	18' - 11 ½"
5	23.25	6' - 5 3/8"
6	23.25	4' - 0"
Total		40' - 9 5/8" or 40.8 ft.

K value for "C" Pump Suction Piping: $K = f_t L/D = 40.8 f_t / 1.9375 = 21.1\ f_t$

Pipe Fitting Takeoff (See Ref. 9 pg. A-27 to A-29, for K values)

Pump "A" Suction Piping

Fitting Type	K	No. of Fittings	Total K
90° S.R. Elbow	20 f_t	3	60 f_t
Tee (flow thru run)	20 f_t	1	20 f_t
60° S.R. Elbow	16.4 f_t	1	16.4 f_t
Gate Valve	8 f_t	1	8 f_t
22.5° L.R. Elbow	8 f_t	1	8 f_t
Total			112.4 f_t

Pump "C" Suction Piping

Fitting Type	K	No. of Fittings	Total K
90° S.R. Elbow	20 f_t	2	40 f_t
90° L.R. Elbow	14 f_t	2	28 f_t
Tee (flow thru run)	20 f_t	1	20 f_t
60° S.R. Elbow	16.4 f_t	1	16.4 f_t
67° 30' L.R. Elbow	11.3 f_t	1	11.3 f_t
45° Elbow	10 f_t	1	10 f_t
Gate Valve	8 f_t	1	8 f_t
Total			133.7 f_t

Total Piping Resistance K Value

Pump Suction	Piping K	Fitting K	Total K
A	23.3 f_t	112.4 f_t	135.7 f_t
C	21.1 f_t	133.7 f_t	154.8 f_t

For a reference point. calculate the piping loss for a flow rate of 10000 gpm at a temperature of 205.7°F.

For old RHR pipe assume $\varepsilon/D = 0.00085$ (value for cast iron = 0.00037)

Calculating Reynold's Number $Re = 50.6\ Q\rho / d\mu$ (Ref. 9, pg. 3-2)

$\mu = 0.299$ (Ref. 9, pg. A-2)

$Re = 4.37\ E+06$

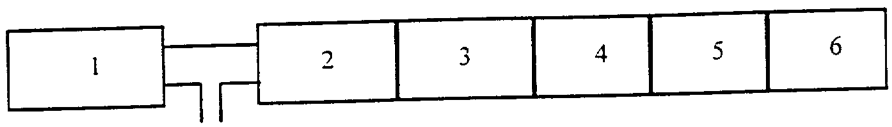
From Ref. 9, pg. A-24 $f_t = 0.0195$

Finally:

Pump	K	hf (ft.)
A	2.65	2.34
C	3.02	2.67

Calculating h_{st}

Given the RHR strainer configuration for Peach Bottom as shown below (Ref. 23), it can be seen that the pressure drop across module 1 must be equal to the pressure drop across modules 2 through 6.



However, to calculate the strainer head loss, the percentage of the total strainer flow that passes through module 1 must be known.

Strainer Design Basis Debris Load (1633 ft^3)

From Ref. 23, Appendix III, page III-3, the percentage of total flow which passes through module 1, the flow rate, temperature and headloss data is given as follows for a debris load of 1633 ft^3 of NUKON.

Total Strainer Flow	Temperature	Module 1, Flow Fraction
11100	205.7	0.2539
11100	100	0.2344
10000	205.7	0.2456
10000	100	0.2251

Choosing 11100 gpm at 205.7°F as the reference value, an equation was developed to calculate the percentage of total flow as a function of flow and temperature.

The function for calculating percentage of total flow is as follows:

$$\%_1 = \%_{ref} \times (Q_1 / Q_{ref})^{0.318} \times (\mu_1 / \mu_{ref})^{-0.0958}$$

Note: The exponents in the above formulas were derived by trial and error

where:

$\%_1$ = Flow fraction at Q_1 and T_1

$\%_{ref}$ = Flow fraction at reference flow rate and temperature

Q_1 = New flow (gpm)

Q_{ref} = Reference flow (gpm)

$\mu_{\varepsilon 1}$= kinematic viscosity at new temperature T_1

μ_{eref} = kinematic viscosity at reference temperature T_{ref}

Calculating Flow percentages for module 1 for the data given in Ref. 23 (Appendix III) yields the following results, which validate the expression used for this correlation:

Flow	Temperature	Ref. 22 Flow Fraction	Calculated Flow Fraction	Percent Difference
11100	205.7	0.2539	0.2539	0
11100	100	0.2344	0.2344	0
10000	205.7	0.2456	0.2456	0
10000	100	0.2251	0.2267	0.7

Maximum Expected Post LOCA Debris Load (700 ft^3)

From Ref. 23, Appendix III, page III-3 the percentage of total flow which passes through module 1, the flow rate, temperature and headloss data is given as follows for a debris load of 700 ft^3 of NUKON.

Total Strainer Flow	Temperature	Module 1, Flow Fraction
10000	205.7	0.3176
10000	100	0.3019

Choosing 10000 gpm at 205.7°F as the reference value, an equation was developed to calculate the percentage of total flow as a function of flow and temperature. Note: This equation assumes that the variation of this percentage of flow as a function of flow is the same as for the strainer design basis debris load case.

The function for calculating fraction of total flow is as follows:

$$\%_1 = \%_{ref} \times (Q_1 / Q_{ref})^{0.318} (\mu_{\varepsilon 1} / \mu_{eref})^{-0.06085}$$

where:

$\%_1$ = Flow fraction at Q_1 and T_1

$\%_{ref}$ = Flow fraction at reference flow rate and temperature

Q_1 = New flow (gpm)

Q_{ref} = Reference flow (gpm)

$\mu_{\varepsilon 1}$ = Kinematic viscosity at new temperature T_1

μ_{eref} = Kinematic viscosity at reference temperature T_{ref}

Calculating Flow fraction for module 1 for the data given in Ref. 23 (Appendix III, page III-7) yields the following results:

Flow	Temperature	Ref. 22 Flow Fraction	Calculated Flow Fraction	Percent Difference
10000	205.7	0.3176	0.3176	0
10000	100	0.3019	0.3019	0

Given the flow percentage, the head loss for the strainer can be extrapolated from some reference value:

Extrapolating Strainer Head Loss:

The head loss across a fouled strainer is equal to the sum of the bed and form losses. The bed losses represent the viscous losses across the debris bed, and the form losses represent the friction losses through the strainer assembly.

Strainer Design Basis Debris Load (1633 ft^3)

Head loss for the replacement strainers is given in Ref. 23 (Appendix III, page III-7) as:

Flow Rate	Temperature	Head Loss (ft.)
11100	205.7	8.31
11100	100	11.99
10000	205.7	7.36
10000	100	10.28

Bed losses:

The bed losses vary as a function of the flow rate and the kinematic viscosity of water at the temperature of the torus water. The bed losses vary as a function of the flow rate and not the flow rate squared because the flow rate across the debris bed is sufficiently low as to be laminar.

The bed losses for the replacement strainers are given in Ref. 23 (App. III, page III-7) as follows:

Flow Rate (gpm)	Temperature (°F)	Bed Loss (ft.)
11100	205.7	7.17
11100	100	10.99
10000	205.7	6.48
10000	100	9.52

Choosing the bed losses at 11100 gpm and 205.7°F as a reference value, the following formula was developed to extrapolate the bed losses to other flows and temperatures:

$$h_1 = h_{ref} x (\%_1 x Q_1 / \%_{ref} x Q_{ref})^{0.727} x (\mu_{e1} / \mu_{eref})^{0.583}$$

where:

h_1 = calculated bed loss (ft.)

h_{ref} = reference bed loss (ft.)

$\%_1$ = calculated flow fraction

$\%_{ref}$ = reference flow fraction

Q_1 = extrapolated total flow (gpm)

Q_{ref} = reference total flow (gpm)

μ_{e1} = kinematic viscosity at extrapolated temperature

μ_{eref} = kinematic viscosity at reference temperature

Calculating the bed losses for the Ref. 23, Appendix III, page III-7, data yields the following results:

Total Flow (gpm)	Temperature (°F)	Bed Loss (Ref.24)	Bed Loss (calculated)	% difference
11100	205.7	7.17	7.17	0
11100	100	10.99	10.99	0
10000	205.7	6.48	6.48	0
10000	100	9.52	9.94	4.4

<u>Form Losses</u>:

The form losses vary as a function of the square of the velocity or flow. The form losses for the replacement strainers are given in Ref. 23, Appendix III. The form losses for the replacement strainers are as follows:

Flow Rate (gpm)	Temperature (°F)	Form Losses (ft.)
11100	205.7	1.14
11100	100	1.00
10000	205.7	0.88
10000	100	0.76

The form losses consist of three components, the drag and turning losses through the strainer mesh, the internal drag losses in strainer module 1 and the drag losses in the common tee discharge.

Choosing the form losses at 11100 gpm and 205.7°F as the reference value, the form losses can be extrapolated to other flow and temperature conditions using the following expression:

$$h_1 = (h_{mesh} + h_{internal}) \times (\%_1 \times Q_1 / \%_{ref} \times Q_{ref})^2 + h_{tee} \times (Q_1 / Q_{ref})^2$$

where:

h_1 = form losses at extrapolated flow and temperature conditions (ft.)

h_{mesh} = reference drag and turning losses for module 1 mesh (ft.)

$h_{internal}$ = reference internal strainer drag losses for module 1 (ft.)

h_{tee} = reference drag losses for common tee (ft.)

$\%_1$ = flow fraction through module 1 at extrapolated flow and temperature conditions

$\%_{ref}$ = flow fraction through module 1 at reference conditions

Q_1 = extrapolated total flow (gpm)

Q_{ref} = reference total flow (gpm)

Values for h_{mesh}, $h_{internal}$ and h_{tee} are found in Ref. 23 Appendix III, page III-10 as follows:

h_{mesh} = 0.553 ft.

$h_{internal}$ = 0.394 ft.

h_{tee} = 0.194 ft.

Calculating the form losses for the Ref. 23, Appendix III data yields the following results:

Flow (gpm)	Temperature (°F)	Form Losses (Ref.24)	Form Losses (Calculated)	% Difference
11100	205.7	1.14	1.14	0
11100	100	1.00	1.00	0
10000	205.7	0.88	0.88	0
10000	100	0.76	0.77	1.0

Finally, the form and bed losses as calculated were summed to provide the total strainer head loss and compared to the Ref. 23, Appendix III values as follows:

Flow (gpm)	Temperature (°F)	Strainer Loss (ft.) (Ref.24)	Strainer Loss (ft.) (Calculated)	% Difference
11100	205.7	8.31	8.31	0.0
11100	100	11.99	11.99	0.0
10000	205.7	7.36	7.36	0.0
10000	100	10.28	10.71	4.2

Maximum Expected Post LOCA Debris Load (700 ft^3)

Head loss for the replacement strainers is given in Ref. 23 (Appendix III, page III-7, Licensing Case) as:

Flow Rate	Temperature	Head Loss (ft.)
10000	205.7	4.13
10000	100	4.833

Bed losses:

The bed losses vary as a function of the flow rate and the kinematic viscosity of water at the temperature of the torus water. The bed losses vary as a function of the flow rate and not the flow rate squared because the flow rate across the debris bed is sufficiently low as to be laminar.

The bed losses for the replacement strainers are given in Ref. 23 (App. III, page III-7, Licensing Case) as follows:

Flow Rate (gpm)	Temperature (°F)	Bed Loss (ft.)
10000	205.7	2.766
10000	100	3.588

Choosing the bed losses at 10000 gpm and 205.7°F as a reference value, the following formula was developed to extrapolate the bed losses to other flows and temperatures:

$$h_1 = h_{ref} \times (\%_1 \times Q_1 / \%_{ref} \times Q_{ref})^{0.713} \times (\mu_{e1} / \mu_{eref})^{0.3558}$$

where:

h_1 = calculated bed loss

h_{ref} = reference bed loss

$\%_1$ = calculated % of total flow

$\%_{ref}$ = reference % of total flow

Q_1 = extrapolated total flow

Q_{ref} = reference total flow

μ_{e1} = kinematic viscosity at extrapolated temperature

μ_{eref} = kinematic viscosity at reference temperature

Calculating the bed losses for the Ref. 23, Appendix III data yields the following results:

Total Flow (gpm)	Temperature (°F)	Bed Loss (Ref.24)	Bed Loss (calculated)	% difference
10000	205.7	2.766	2.77	0
10000	100	3.588	3.59	0

Form Losses:

The form losses vary as a function of the square of the velocity or flow. The form losses for the replacement strainers are given in Ref. 23, Appendix III, Page III-7, Licensing Case. The form losses for the replacement strainers are as follows:

Flow Rate (gpm)	Temperature (°F)	Form Losses (ft.)
10000	205.7	1.361
10000	100	1.245

The form losses consist of three components, the drag and turning losses through the strainer mesh, the internal drag losses in strainer module 1 and the drag losses in the common tee discharge.

Choosing the form losses at 10000 gpm and 205.7°F as the reference value, the form losses can be extrapolated to other flow and temperature conditions using the following expression:

$$h_1 = (h_{mesh} + h_{internal}) \times (\%_1 \times Q_1 / \%_{ref} \times Q_{ref})^2 + h_{tee} \times (Q_1 / Q_{ref})^2$$

where:

h_1 = form losses at extrapolated flow and temperature conditions (ft.)

h_{mesh} = reference drag and turning losses for module 1 mesh (ft.)

$h_{internal}$ = reference internal strainer drag losses for module 1 (ft.)

h_{tee} = reference drag losses for common tee (ft.)

$\%_1$ = % of total flow through module 1 at extrapolated flow and temperature conditions

$\%_{ref}$ = % of total flow through module 1 at reference conditions

Q_1 = extrapolated total flow (gpm)

Q_{ref} = reference total flow (gpm)

Values for h_{mesh}, $h_{internal}$ and h_{tee} are found in Ref. 23 Appendix III, page III-12 as follows:

h_{mesh} = 0.703 ft.

$h_{internal}$ = 0.501 ft.

h_{tee} = 0.157 ft.

Calculating the form losses for the Ref. 23, Appendix III data yields the following results:

Flow (gpm)	Temperature (°F)	Form Losses (Ref.24)	Form Losses (Calculated)	% Difference
10000	205.7	1.361	1.361	0
10000	100	1.245	1.245	0

Finally, the form and bed losses as calculated were compared to the Ref. 23, Appendix III values as follows:

Flow (gpm)	Temperature (°F)	Strainer Loss (ft.) (Ref.24)	Strainer Loss (ft.) (Calculated)	% Difference
10000	205.7	4.127	4.13	0.0
10000	100	4.833	4.83	0.0

NPSH Margin

Combining the piping and strainer losses described above with the pressure and temperature vs. time data from Ref. 14, EXCEL spreadsheets were prepared to calculate the $NPSH_a$ vs. $NPSH_R$, and the required overpressure as a function of time after the accident. The spreadsheets are included on the following sheets. The results of this analysis are shown graphically after the EXCEL spreadsheet for each case. From these graphs, it can be seen that the minimum NPSH margin occurs at the maximum pool temperature. The minimum NPSH margins, based on MCPA (COPL), for the two cases are as follows:

Minimum NPSH Margin (at 205.7°F)

Case	Torus Debris Load (ft^3)	NPSHR (ft.)	NPSHA (ft.)	Margin (ft.)
Strainer Design Basis	1633	26	25.87	-0.13
DBA LOCA Design Basis	700	26	29.10	3.10 (2.02)

* Note: The negative NPSH margin associated with the strainer design basis torus debris load is acceptable based on the following: At approximately 31000 seconds the indicated NPSH margin is slightly negative; this due in part to the very conservative friction factor assigned to the RHR piping. The use of a more representative friction factor, such as that for cast iron, would result in positive NPSH margins.

Table A-1 **Time Dependant NPSH Analysis - DBA LOCA - PBAPS RHR**

1633 ft3 NUKON **Strainer Design Basis Debris Load**

Reference Head loss			Flow (gpm)	Temp. (°F)	Mesh Loss (ft)	Internal Drag Loss (ft)	Common Tee Loss (ft)	Bed Loss (ft)	Flow Fraction
Pipe	2.67	ft	10000	205.7					
Strainer	8.31	ft	11100	205.7	0.553	0.394	0.194	7.165	0.2539

Time (sec)	Pressure (s.p.) (psia)	Temp (S.P.) (°F)	Vap. Press (psia)	Spec. Volume (ft³/lbm)	S.P. Level (ft)	Pump Flow (gpm)	Flow Fraction -	NPSHR (ft)	hf (pipe) (ft)	Form (ft)	hf(strainer) Bed (ft)	Total (ft)
0	14.69	95	0.82	0.01611	12.4	0	0.0000	0	0.00	0.00	0.00	0.00
49	47.50	136	2.60	0.01627	12.4	12000	0.2481	34	3.84	1.28	0.00	1.28
106	46.93	140	2.89	0.01629	12 4	12000	0.2489	34	3.84	1 29	0.00	1.29
600	23.48	148	3.54	0.01633	12.4	12000	0.2505	34	3 84	1.30	0.00	1 30
666	15.73	150.6	3.77	0.01635	13.94	10000	0.2368	26	2.67	0.83	7.88	8.71
805	15.99	154	4.10	0.01636	13.94	10000	0.2374	26	2.67	0.83	7.77	8.60
2074	17.26	168	5.72	0.01644	13.94	10000	0.2398	26	2.67	0.84	7.37	8.21
2622	17.66	172	6.27	0.01646	13.94	10000	0.2405	26	2.67	0.85	7.26	8.11
2995	17.88	174	6.57	0.01647	13.94	10000	0.2408	26	2.67	0.85	7.21	8.06
4290	18.53	180	7.51	0.01651	13.94	10000	0.2418	26	2.67	0.85	7.05	7.91
5571	19.01	184	8.20	0.01653	13.94	10000	0.2424	26	2.67	0.86	6.96	7.82
6475	19.30	186	8.57	0.01655	13.94	10000	0.2427	26	2.67	0.86	6.91	7.77
8592	19.83	190	9.34	0.01657	13.94	10000	0.2433	26	2.67	0.86	6.82	7.68
11143	20.36	194	10.17	0.01660	13.94	10000	0.2439	26	2.67	0.87	6.73	7.60
12505	20.62	196	10.61	0.01661	13.94	10000	0.2442	26	2.67	0.87	6.69	7.55
14383	20.92	198	11.06	0.01662	13.94	10000	0.2445	26	2.67	0.87	6.64	7.51
16448	21.22	200	11.53	0.01664	13.94	10000	0.2448	26	2.67	0.87	6.60	7.47
19302	21.53	202	12.01	0.01665	13.94	10000	0.2451	26	2.67	0.87	6.56	7.43
23787	21.84	204	12.51	0.01666	13.94	10000	0.2454	26	2.67	0.88	6.52	7.39
31667	22.10	205.7	12.95	0.01668	13 94	10000	0.2456	26	2.67	0.88	6.48	7.36
45533	21.84	204.3	12.59	0.01667	13.94	10000	0.2454	26	2.67	0.88	6.51	7.39

Table A-1 Time Dependant NPSH Ana

1633 ft3 NUKON Strainer Design Basis Debr

Reference Head loss

Pipe	2.67	ft
Strainer	8.31	ft

Time (sec)	Pressure (s.p.) (psia)	Temp (S.P.) (°F)	NPSHA based on MCPA (ft)	Psupp req'd (psia)	Req'd Overpressure (psig)	MCPA Margin Avail - Req'd Pressure Margin (psi)	MCPA Margin Avail - Req'd Pressure Margin (ft)	(PM-1013 Data - No Purge) Time (seconds)	(PM-1013 Data - No Purge) MCPA (psig)
0	14.69	95	44.59	-4.53	-19.23	19.22	44.59	**0.00**	***0.0000***
49	47.50	136	112.49	14.01	-0.69	33.49	78.49	**49.26**	***32.8140***
106	46.93	140	110.60	14.28	-0.42	32.65	76.60	**106.89**	***32.2440***
600	23.48	148	54.16	14.91	0.21	8.57	20.16	**594.45**	***8.7940***
666	15.73	150.6	30.71	13.73	-0.97	2.00	4.71	***666.26***	***1.0406***
805	15.99	154	30.69	14.00	-0.70	1.99	4.69	**805.26**	***1.3039***
2074	17.26	168	30.38	15.41	0.71	1.85	4.38	**2,074.89**	***2.5737***
2622	17.66	172	30.16	15.91	1.21	1.75	4.16	**2,622.26**	***2.9705***
2995	17.88	174	30.06	16.17	1.47	1.71	4.06	**2,995.14**	***3.1930***
4290	18.53	180	29.56	17.03	2.33	1.50	3.56	**4,290.89**	***3.8416***
5571	19.01	184	29.18	17.67	2.97	1.34	3.18	**5,571.01**	***4.3191***
6475	19.30	186	29.06	18.01	3.31	1.28	3.06	**6,475.14**	***4.6054***
8592	19.83	190	28.62	18.73	4.03	1.10	2.62	**8,592.64**	***5.1376***
11143	20.36	194	28.03	19.51	4.81	0.85	2.03	**11,142.64**	***5.6710***
12505	20.62	196	27.66	19.92	5.22	0.69	1.66	**12,505.14**	***5.9265***
14383	20.92	198	27.37	20.35	5.65	0.57	1.37	**14,383.64**	***6.2320***
16448	21.22	200	27.02	20.79	6.09	0.43	1.02	**16,447.77**	***6.5305***
19302	21.53	202	26.65	21.25	6.55	0.27	0.65	**19,301.77**	***6.8356***
23787	21.84	204	26.25	21.73	7.03	0.10	0.25	**23,787.39**	***7.1458***
31667	22.10	205.7	25.87	22.15	7.45	-0.05	-0.13	**31,667.02**	***7.4080***
45533	21.84	204.3	26.09	21.81	7.11	0.04	0.09	**45,533.77**	***7.1511***
						-0.05	-0.13		***7.41***

Figure A-1
Minimum Torus Pressure Available vs. Required - Debris Load 1633 ft^3 NUKON
Strainer Design Basis Debris Load

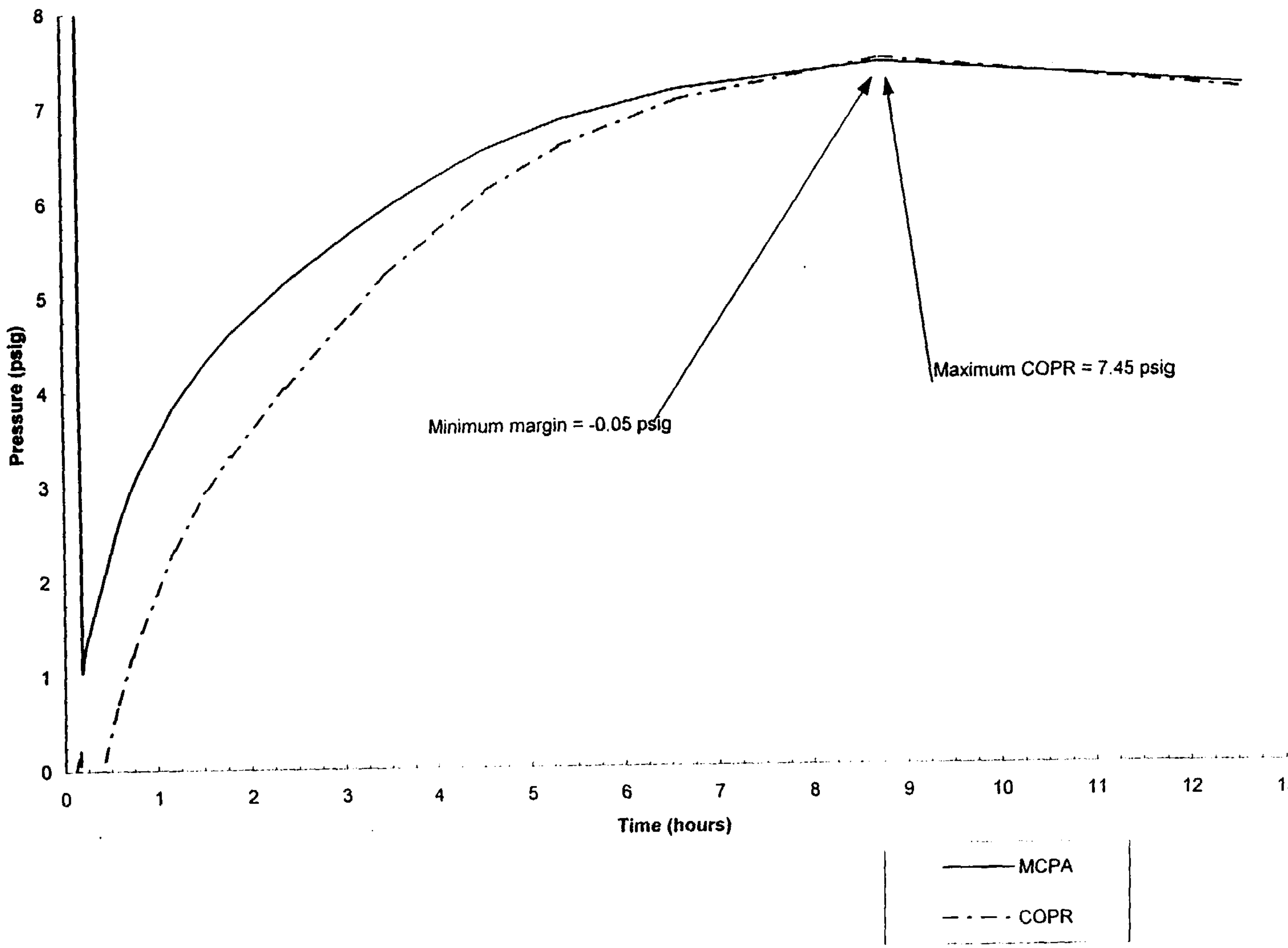


Table A-2 **Time Dependant NPSH Analysis - DBA LOCA - PBAPS RHR**

700 ft3 NUKON LOCA Design Basis Debris Load

Reference Head loss		Flow (gpm)	Temp. (°F)	Mesh Loss ft	Internal Drag Loss ft	Common Tee Loss ft	Bed Loss ft	Flow Fraction
Pipe	2.67 ft	10000	205.7					
Strainer	4.13 ft	10000	205.7	0.702946	0.500949	0.157244	2.766	0.3176

Time (sec)	Pressure (s.p.) (psia)	Temp (S.P.) (°F)	Vap. Press (psia)	Spec. Volume (ft³/lbm)	S.P. Level (ft)	Pump Flow (gpm)	Flow Fraction -	NPSHR (ft)	hf (pipe) (ft)	hf(strainer) Form (ft)	hf(strainer) Bed (ft)	Total hf(strainer) (ft)	NPSHa based on MCPA (ft)	Psupp req'd (psia)
0	14.69	95	0.82	0.01611	12.4	0	0.0000	0	0.00	0.00	0.00	0.00	44.59	-4.53
49	47.50	136	2.60	0.01627	12.4	12000	0.3265	34	3.84	2.06	0.00	2.06	111.72	14.34
106	46.93	140	2.89	0.01629	12 4	12000	0.3271	34	3 84	2 07	0.00	2 07	109.83	14 61
595	23.48	148	3.54	0.01633	12.4	12000	0.3285	34	3.84	2.08	0.00	2.08	53.38	15 24
666	15.73	150.6	3.77	0.01635	13.94	10000	0.3103	26	2.67	1.31	3.11	4.42	34.99	11.91
805	15.99	154	4.10	0.01636	13.94	10000	0.3108	26	2.67	1.31	3.09	4.40	34.89	12.22
2075	17.26	168	5.72	0.01644	13.94	10000	0.3128	26	2.67	1.33	2.99	4.31	34.28	13.77
2622	17.66	172	6.27	0.01646	13.94	10000	0.3134	26	2.67	1.33	2.96	4.29	33.97	14.30
2995	17.88	174	6.57	0.01647	13.94	10000	0.3136	26	2.67	1.33	2.95	4.28	33.84	14.58
4290	18.53	180	7.51	0.01651	13.94	10000	0.3144	26	2.67	1.34	2.91	4.25	33.22	15.49
5571	19.01	184	8.20	0.01653	13.94	10000	0.3150	26	2.67	1.34	2.89	4.23	32.77	16.17
6475	19.30	186	8.57	0.01655	13.94	10000	0.3152	26	2.67	1.34	2.88	4.22	32.61	16.52
8592	19.83	190	9.34	0.01657	13.94	10000	0.3157	26	2.67	1.35	2.85	4.20	32.10	17.27
11143	20.36	194	10.17	0.01660	13.94	10000	0.3162	26	2.67	1.35	2 83	4.18	31.45	18.08
12505	20.62	196	10.61	0.01661	13.94	10000	0.3164	26	2.67	1.35	2.82	4.17	31.05	18 51
14383	20.92	198	11.06	0.01662	13.94	10000	0.3167	26	2.67	1.35	2.81	4.16	30.72	18.95
16448	21.22	200	11.53	0.01664	13.94	10000	0.3169	26	2.67	1.36	2.80	4.15	30.34	19.41
19302	21.53	202	12.01	0.01665	13.94	10000	0.3172	26	2 67	1.36	2.79	4.14	29.94	19.88
23787	21.84	204	12.51	0.01666	13.94	10000	0.3174	26	2.67	1.36	2.77	4.13	29.51	20.37
31667	22.10	205.7	12.95	0.01668	13.94	10000	0.3176	26	2.67	1.36	2.77	4.13	29.10	20.81
45533	21.84	204.3	12.59	0.01667	13.94	10000	0.3174	26	2 67	1.36	2.77	4.13	29.34	20.45

Table A-2 — **Time Dependant NPSH Anal**

700 ft3 NUKON — LOCA Design Basis Debris Lc

Reference Head loss		Flow (gpm)
Pipe	2.67 ft	10000
Strainer	4.13 ft	10000

Time (sec)	Pressure (s.p.) (psia)	Temp (S.P.) (°F)	Req'd Overpressure (psig)	MCPA Press Margin: Avail - Req'd Pressure (psi)	MCPA Press Margin: Avail - Req'd Pressure (ft)	(PM-1013 Data - No Purge) Time (seconds)	(PM-1013 Data - No Purge) MCPA (psig)	(PM-1013 Data - No Purge) COPL (psig)	COPL Press Margin: Avail - Req'd Pressure (psi)	COPL Press Margin: Avail - Req'd Pressure (ft)
0	14.69	95	-19.23	19.22	44.59	0.00	0.0000	2.26	21.47	49.53
49	47.50	136	-0.36	33.16	77.72	49.26	32.8140	2.26	2.60	6.00
106	46.93	140	-0.09	32.32	75.83	106.89	32.2440	2.26	2.33	5.36
595	23.48	148	0.54	8.24	19.38	594.45	8.7940	2.26	1.70	3.92
666	15.73	150.6	-2.79	3.82	8.99	666.26	1.0406	0.62	3.40	7.85
805	15.99	154	-2.48	3.77	8.89	805.26	1.3039	0.89	3.36	7.74
2075	17.26	168	-0.93	3.50	8.28	2,074.89	2.5737	2.16	3.08	7.11
2622	17.66	172	-0.40	3.36	7.97	2,622.26	2.9705	2.66	2.95	6.80
2995	17.88	174	-0.12	3.30	7.84	2,995.14	3.1930	2.78	2.89	6.66
4290	18.53	180	0.79	3.04	7.22	4,290.89	3.8416	3.43	2.62	6.05
5571	19.01	184	1.47	2.84	6.77	5,571.01	4.3191	3.90	2.43	5.60
6475	19.30	186	1.82	2.77	6.61	6,475.14	4.6054	4.19	2.36	5.44
8592	19.83	190	2.57	2.56	6.10	8,592.64	5.1376	4.72	2.14	4.94
11143	20.36	194	3.38	2.28	5.45	11,142.64	5.6710	5.26	1.86	4.30
12505	20.62	196	3.81	2.11	5.05	12,505.14	5.9265	5.61	1.69	3.91
14383	20.92	198	4.25	1.97	4.72	14,383.64	6.2320	5.82	1.56	3.59
16448	21.22	200	4.71	1.81	4.34	16,447.77	6.5305	6.11	1.40	3.22
19302	21.53	202	5.18	1.64	3.94	19,301.77	6.8356	6.42	1.23	2.83
23787	21.84	204	5.67	1.46	3.51	23,787.39	7.1458	6.73	1.05	2.41
31667	22.10	205.7	6.11	1.29	3.10	31,667.02	7.4080	6.99	0.88	2.02
45533	21.84	204.3	5.75	1.39	3.34	45,533.77	7.1511	6.73	0.98	2.25
			6.11	1.29	3.10		7.41	6.99	0.88	2.02

Short-term COPR = +0.54 psig

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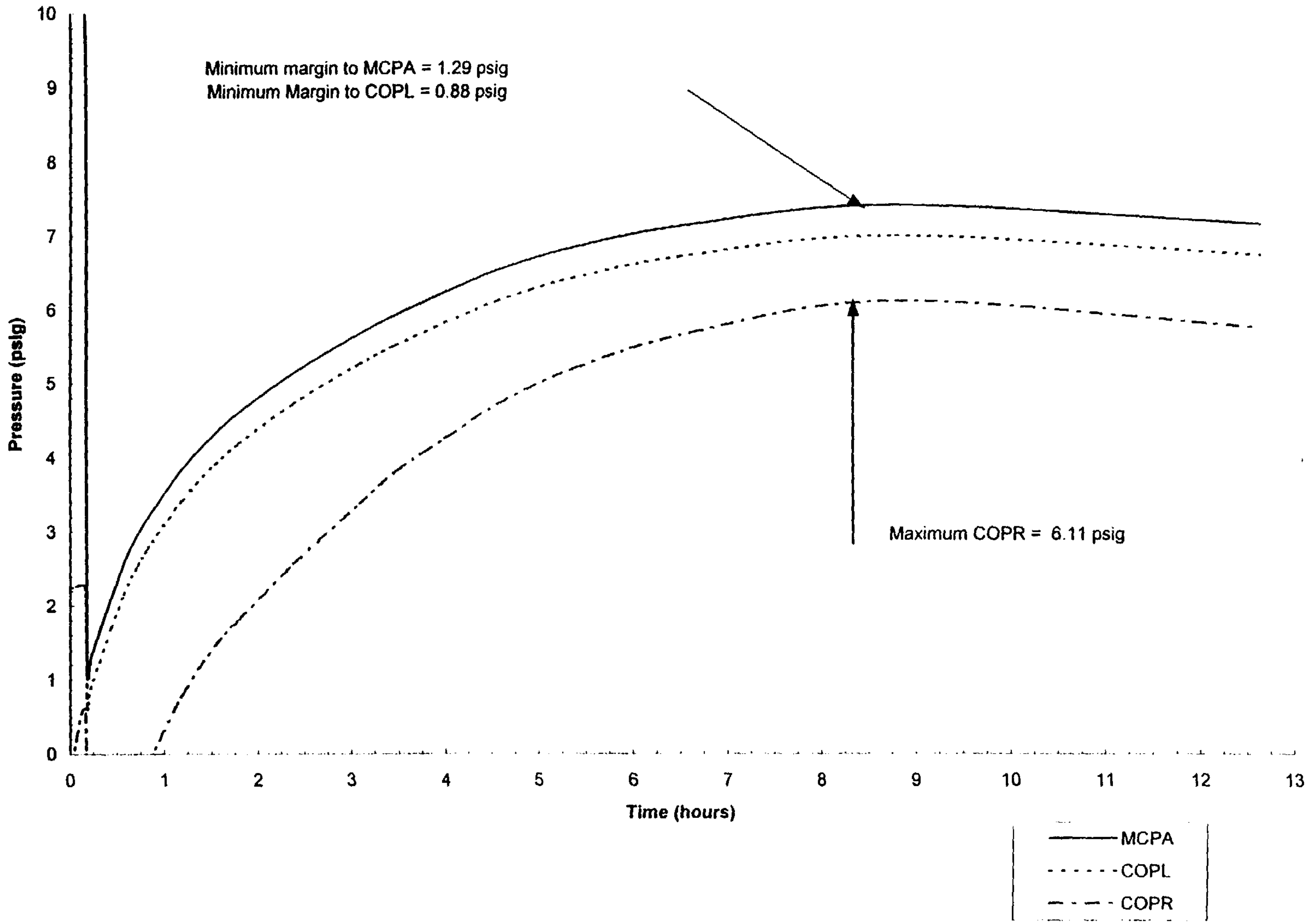
Figure A-2

Minimum Torus Pressure Available vs. Required - Debris Load 700 ft^3 NUKON

LOCA Design Basis Debris Load



B. NPSH MARGIN UNDER IBA AND SBA LOCA CONDITIONS

Upon reviewing the methodology used to perform this DBA LOCA analysis is it can be concluded that the NPSH margin for the DBA LOCA case bounds the SBA and IBA LOCA cases for the following reasons:

1. As a result of a SBA or IBA, the following effects are expected in comparison with the DBA LOCA:
   - Short term sees no pump runnout
   - Pool temperatures are lower. Although this results in lower spray temperatures and therefore lower MCPA, the effect of lower pool temperature on NPSHa and COPR due to drop ~~in MCPA is due to a drop~~ in vapor pressure ~~which~~ is greater than the effect of lower MCPA due to lower spray temperature. This is entirely due to the fact that P_{vap} decreases with decreasing temperature.
   - LB-LOCA already assumes worst-case drawdown.

2. Since an IBA or SBA is not expected to dislodge and transport large amounts of insulation debris to the torus, using the clean strainer headloss data would be appropriate.

Therefore, based on the above, the IBA/SBA is bounded by DBA LOCA.

C. LOCA WHILE PURGING

As previously stated in Part A of this calculation, the available NPSH for the RHR pumps is expressed by the following equation:

$$NPSHA = \frac{144}{\rho} * (P_{cont.} - P_{sat}) + Z - h_f$$

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where P_{cont} = Torus pressure

Z = Static Head (Torus water level)

hf = suction line friction losses (including suction strainer losses)

Psat = vapor pressure of the pumped fluid

From the results in part A, it can be seen that the NPSH margin at the limiting torus temperature and pressure conditions is 3.10 ft based on MCPA and 2.02 ft based on COPL.

From Ref. 14, it can be seen that a LOCA occurring while purging reduces the available containment pressure at the limiting torus temperature to 21.21 psia. From the spreadsheet on the following page, it can be seen that this torus pressure will still provide an NPSH margin of ~~2.76~~ 2.97 ft based on MCPA. Therefore even with maximum expected accident fouling, the Suction strainers can accommodate a DBA LOCA while purging.

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TABLE C-1 **Time Dependant NPSH Analysis - LOCA During Containment Purge**

700 ft3 NUKON LOCA Design Basis Debris Load

Reference Head loss		Flow (gpm)	Temp. (°F)	Mesh Loss ft	Internal Drag Loss ft	Common Tee Loss ft	Bed Loss ft	Flow Fraction
Pipe	2.67 ft	10000	205.7					
Strainer	4.13 ft	10000	205.7	0.70295	0.500949	0.157244	2.766	0.3176

Time (sec)	Pressure (s.p.) (psia)	Temp (S.P.) (°F)	Vap. Press (psia)	Spec. Volume (ft³/lbm)	S.P. Level (ft)	Pump Flow (gpm)	Flow Fraction -	NPSHR (ft)	hf (pipe) (ft)	hf(strainer) Form (ft)	hf(strainer) Bed (ft)
0	14.69	95	0.8153	0.01611	12.4	0	0.00000	0	0.00	0.00	0.00
49	47.50	136	2.6047	0.01627	12.4	12000	0.32648	34	3.84	2.06	0.00
106	46.93	140	2.8892	0.01629	12.4	12000	0.32715	34	3.84	2.07	0.00
595	23.48	148	3.5381	0.01633	12.4	12000	0.32845	34	3.84	2.08	0.00
666	14.90	150.6	3.7740	0.01635	13.94	10000	0.31034	26	2.67	1.31	3.11
805	15.16	154	4.1025	0.01636	13.94	10000	0.31084	26	2.67	1.31	3.09
2075	16.42	168	5.7223	0.01644	13.94	10000	0.31283	26	2.67	1.33	2.99
2622	16.81	172	6.2736	0.01646	13.94	10000	0.31338	26	2.67	1.33	2.96
2995	17.03	174	6.5656	0.01647	13.94	10000	0.31364	26	2.67	1.33	2.95
4290	17.67	180	7.5110	0.01651	13.94	10000	0.31443	26	2.67	1.34	2.91
5571	18.15	184	8.2027	0.01653	13.94	10000	0.31495	26	2.67	1.34	2.89
6475	18.43	186	8.5680	0.01655	13.94	10000	0.31521	26	2.67	1.34	2.88
8592	18.96	190	9.3396	0.01657	13.94	10000	0.31571	26	2.67	1.35	2.85
11143	19.49	194	10.1684	0.01660	13.94	10000	0.31620	26	2.67	1.35	2.83
12505	19.74	196	10.6053	0.01661	13.94	10000	0.31645	26	2.67	1.35	2.82
14383	20.04	198	11.0577	0.01662	13.94	10000	0.31669	26	2.67	1.35	2.81
16448	20.34	200	11.5260	0.01664	13.94	10000	0.31693	26	2.67	1.36	2.80
19302	20.64	202	12.0108	0.01665	13.94	10000	0.31717	26	2.67	1.36	2.79
23787	20.95	204	12.5123	0.01666	13.94	10000	0.31740	26	2.67	1.36	2.77
31667	21.21	205.7	12.9522	0.01668	13.94	10000	0.31760	26	2.67	1.36	2.77
45533	20.95	204.3	12.5891	0.01667	13.94	10000	0.31744	26	2.67	1.36	2.77

TABLE C-1 **Time Depen**

700 ft3 NUKON LOCA Desigr

Reference Head loss

		Flow (gpm)
Pipe	2.67 ft	10000
Strainer	4.13 ft	10000

Time (sec)	Pressure (s.p.) (psia)	Temp (S.P.) (°F)	hf(strainer) (ft)	NPSHa (ft)	Psupp req'd (psia)	Req'd Overpressure (psig)	COP Margin Avail-Req'd Pressure Margin (psi)	Margin (ft)
0	14.69	95	0.00	44.59	-4.53	-19.23	19.22	44.59
49	47.50	136	2.06	111.72	14.34	-0.36	33.16	77.72
106	46.93	140	2.07	109.83	14.61	-0.09	32.32	75.83
595	23.48	148	2.08	53.38	15.24	0.54	8.24	19.38
666	14.90	150.6	4.42	33.05	11.91	-2.79	2.99	7.05
805	15.16	154	4.40	32.94	12.22	-2.48	2.94	6.94
2075	16.42	168	4.31	32.28	13.77	-0.93	2.65	6.28
2622	16.81	172	4.29	31.96	14.30	-0.40	2.51	5.96
2995	17.03	174	4.28	31.82	14.58	-0.12	2.45	5.82
4290	17.67	180	4.25	31.18	15.49	0.79	2.18	5.18
5571	18.15	184	4.23	30.72	16.17	1.47	1.98	4.72
6475	18.43	186	4.22	30.55	16.52	1.82	1.91	4.55
8592	18.96	190	4.20	30.02	17.27	2.57	1.69	4.02
11143	19.49	194	4.18	29.36	18.08	3.38	1.41	3.36
12505	19.74	196	4.17	28.95	18.51	3.81	1.23	2.95
14383	20.04	198	4.16	28.62	18.95	4.25	1.09	2.62
16448	20.34	200	4.15	28.23	19.41	4.71	0.93	2.23
19302	20.64	202	4.14	27.82	19.88	5.18	0.76	1.82
23787	20.95	204	4.13	27.38	20.37	5.67	0.58	1.38
31667	21.21	205.7	4.13	26.97	20.81	6.11	0.40	0.97
45533	20.95	204.3	4.13	27.21	20.45	5.75	0.51	1.21
							0.40	0.97

D. NPSH LIMIT CURVES AND ECCS SUCTION REQUIREMENTS CURVES FOR EPG'S (T-102)

The purpose of this section is to determine:

1) the torus temperature limit at which the NPSH requirements will be satisfied for a variety of flow, torus level and pressure conditions.
2) the torus water level at which the NPSH requirements will be satisfied for a variety of flow, torus temperature and pressure conditions.

These limits are determined by setting NPSHA equal to NPSHR and solving for the required variable. This equation takes the form:

$$NPSHA = NPSHR = 144 * P_a/\rho + h_s - h_f - h_{vap}$$

To solve for torus temperature, the values of NPSHR and h_f, which correspond to various RHR system flows, are input into the equation along with varying torus levels and pressures. The equation is then solved for vapor pressure, which is converted to saturation temperature by reference to the steam tables.

Similarly, when solving for torus level, torus temperature conditions are converted into vapor pressure and combined with the torus pressure and flow dependent variables, and the equation solved directly for static head, which corresponds to torus level, since the RHR pump suction elevation corresponds with torus level zero.

Torus Temperature Limits

The torus temperature limits were calculated for the following conditions:

- RHR system flows of 7500, 9000, 10000, 11000, 11500 and 12000 gpm
- Torus water Levels of 10.5', 12.3', 14.5' and 20'
- Torus overpressures of 0, 3, 6, 10, 20, 30 and 60 psig

A clean suction strainer was assumed in formulating these curves, since these curves will be used to respond to many transients, such as ATWS and Appendix R fires which will not transport insulation debris to the torus.

Suction line friction losses, including strainer losses were calculated using the EXCEL spreadsheet in section A above. These losses were computed as a function of flow. All losses were calculated at 10,000 gpm. These losses were then corrected for other flows by applying the following formula:

$$hf_1 = hf_{ref} (Q_1 / Q_{ref})^2$$

hf_1 = friction losses at new flow

hf_{ref} = friction losses at reference flow (10,000 gpm)

Q_1 = new flow

Q_{ref} = reference flow (10000 gpm)

hf_{ref} = 2.67' (pipe) (page 9)
+2.22' (strnr) (page 4)

NOTE: 2.65' × (10000/11,100)^2 = 2.15'. USE OF 2.22' IS CONSERVATIVE

[initials] 4-4-99

These friction losses are combined in an EXCEL spreadsheet with the flow level and torus pressure conditions given above to calculate the torus temperature limits, using the following equation:

$$h_{vap} = 144\ P_a / \rho + h_s - h_f - NPSHR$$

Once h_{vap} is found, the results are converted into temperature by referring to the ASME Steam Tables (Ref. 10).

The results are shown in the spreadsheet and graphs presented on pages 30 to 34.

Torus Level Limits

The torus levels limits were calculated for the following conditions:

- RHR system flows of 7500, 9000, 10000, 11000, 11500 and 12000 gpm
- Torus water temperatures from 95°F to 300°F
- Torus overpressures of 0, 3, 6, 10, 20, 30 and 60 psig

A clean suction strainer was assumed in formulating these curves, since these curves will be used to respond to many transients, such as ATWS and Appendix R fires which will not transport insulation debris to the torus.

Suction line friction losses, including strainer losses were calculated using the EXCEL spreadsheet in section A above. These losses were computed as a function of flow only. All losses were calculated at 10,000 gpm at 205.7°F. These losses were then corrected for other flows by applying the following formula:

$hf_1 = hf_{ref} (Q_1 / Q_{ref})^2$

hf_1 = friction losses at new flow

hf_{ref} = friction losses at reference flow (10,000 gpm)

Q_1 = new flow

Q_{ref} = reference flow (10000 gpm)

These friction losses are combined in an EXCEL spreadsheet with the flow level and torus pressure conditions given above to calculate the torus temperature limits, using the following equation:

$h_s = NPSHR + hf - 144 (P_a - P_{vap}) / \rho$ g 4-4-99

The results are shown in the spreadsheet and graphs presented on pages 35 to 42.

PM-1010 Rev 4

TABLE D-1 RHR PUMPS CLEAN STRAINERS
Determination of torus temperature vs flow
Conversion of friction loss (Hf) for for new strainers
Clean strainer dP is 2.22 ft@ 10000 gpm and 205.7° F & piping is 2.67 ft @ 10000 gpm and 205.7°F
Using the equation hvap = hst - NPSHR - hf + PA
Friction loss is converted based on the ratio of the flows squared.
Thus the Hf at 10000= 4.89 feet H2O is coverted for various flows

Calculate the Hf at various flows using ratios of flows to 2.0 power

Q (GPM)	Q ratio	Hf new ft.	NPSH R
7500	0.5625	2.75	26
9000	0.81	3.96	26
10000	1	4.89	26
11000	1.21	5.92	28
11500	1.3225	6.47	31
12000	1.44	7.04	34

Torus					Vortex Limit 10.5 Ft Torus Level			Drawdown Level 12.3 Ft Torus Level			Drawdown Level 13.65 Ft Torus Level			Min Tech Spec Level 14.5 Ft Torus Level			20 Ft Torus Level		
Wetwell Pressure PA		FLOW	NPSHR	Fric Loss	Vapor Pressure		TEMP	Vapor Pressure		TEMP	Vapor Pressure		TEMP	Vapor Pressure		TEMP	Vapor Pressure		TEMP
PSIG	FT (ABS)	GPM	FT	FT	FT	PSIA	deg F	FT	PSIA	deg F	FT	PSIA	deg F	FT	PSIA	deg F	FT	PSI	deg F
0	33.95	7500	26	2.75	15.70	6.79	175.50	17.50	7.57	180.36	18.85	8.16	183.74	19.70	8.52	185.76	25.20	10.90	197.33
	33.95	9000	26	3.96	14.49	6.27	171.97	16.29	7.05	177.15	17.64	7.63	180.72	18.49	8.00	182.86	23.99	10.38	194.98
	33.95	10000	26	4.89	13.56	5.87	169.08	15.36	6.65	174.54	16.71	7.23	178.29	17.56	7.60	180.52	23.08	9.98	193.10
	33.95	11000	28	5.92	10.53	4.56	158.34	12.33	5.34	165.00	13.68	5.92	169.47	14.53	6.29	172.10	20.03	8.67	186.53
	33.95	11500	31	6.47	6.98	3.02	141.74	8.78	3.80	150.68	10.13	4.38	156.74	10.98	4.75	160.09	16.48	7.13	177.67
	33.95	12000	34	7.04	3.41	1.47	115.07	5.21	2.25	130.51	6.56	2.84	139.30	7.41	3.21	144.07	12.91	5.59	166.95
3	40.88	7500	26	2.75	22.63	9.79	192.22	24.43	10.57	195.85	25.78	11.16	198.42	26.63	11.52	199.99	32.13	13.90	209.22
	40.88	9000	26	3.96	21.42	9.27	189.65	23.22	10.05	193.44	24.57	10.63	196.12	25.42	11.00	197.75	30.92	13.38	207.31
	40.88	10000	26	4.89	20.49	8.87	187.58	22.29	9.65	191.51	23.64	10.23	194.29	24.49	10.60	195.97	29.99	12.98	205.80
	40.88	11000	28	5.92	17.46	7.56	180.28	19.26	8.34	184.74	20.61	8.92	187.86	21.46	9.29	189.74	26.96	11.67	200.59
	40.88	11500	31	6.47	13.91	6.02	170.21	15.71	6.80	175.55	17.06	7.38	179.23	17.91	7.75	181.43	23.41	10.13	193.83
	40.88	12000	34	7.04	10.34	4.47	157.58	12.14	5.25	164.33	13.49	5.84	168.86	14.34	6.21	171.52	19.84	8.59	186.09
4.856	45.17	7500	26	2.75	26.92	11.65	200.51	28.72	12.43	203.67	30.07	13.01	205.93	30.92	13.38	207.31	36.42	15.76	215.54
	45.17	9000	26	3.96	25.71	11.13	198.29	27.51	11.90	201.56	28.86	12.49	203.90	29.71	12.86	205.33	35.21	15.24	213.82
	45.17	10000	26	4.89	24.78	10.72	196.53	26.58	11.50	199.90	27.93	12.09	202.30	28.78	12.45	203.77	34.28	14.83	212.47
	45.17	11000	28	5.92	21.75	9.41	190.37	23.55	10.19	194.11	24.90	10.78	196.76	25.75	11.14	198.37	31.25	13.52	207.84
	45.17	11500	31	6.47	18.20	7.88	182.15	20.00	8.66	186.47	21.35	9.24	189.50	22.20	9.61	191.33	27.70	11.99	201.91
	45.17	12000	34	7.04	14.63	6.33	172.39	16.43	7.11	177.53	17.78	7.69	181.08	18.63	8.06	183.20	24.13	10.44	195.26
5.734	47.20	7500	26	2.75	28.95	12.53	204.08	30.75	13.31	207.03	32.10	13.89	209.17	32.95	14.26	210.48	38.45	16.64	218.32
	47.20	9000	26	3.96	27.74	12.00	201.97	29.54	12.78	205.05	30.89	13.37	207.26	31.74	13.73	208.61	37.24	16.11	216.68
	47.20	10000	26	4.89	26.81	11.60	200.31	28.61	12.38	203.48	29.96	12.96	205.74	30.81	13.33	207.13	36.31	15.71	215.39
	47.20	11000	28	5.92	23.78	10.29	194.57	25.58	11.07	198.05	26.93	11.65	200.54	27.78	12.02	202.05	33.28	14.40	210.98
	47.20	11500	31	6.47	20.23	8.76	187.00	22.03	9.53	190.96	23.38	10.12	193.76	24.23	10.49	195.46	29.73	12.87	205.37
	47.20	12000	34	7.04	16.66	7.21	178.15	18.46	7.99	182.78	19.81	8.57	186.02	20.66	8.94	187.96	26.16	11.32	199.12
6	47.81	7500	26	2.75	29.56	12.79	205.09	31.36	13.57	208.01	32.71	14.16	210.12	33.56	14.52	211.41	39.06	16.90	219.14
	47.81	9000	26	3.96	28.35	12.27	203.04	30.15	13.05	206.06	31.50	13.63	208.24	32.35	14.00	209.56	37.85	16.38	217.52
	47.81	10000	26	4.89	27.42	11.87	201.41	29.22	12.65	204.52	30.57	13.23	206.75	31.42	13.60	208.11	36.92	15.98	216.25
	47.81	11000	28	5.92	24.40	10.56	195.78	26.20	11.34	199.20	27.55	11.92	201.63	28.40	12.29	203.11	33.90	14.67	211.90
	47.81	11500	31	6.47	20.85	9.02	188.38	22.65	9.80	192.26	24.00	10.38	195.00	24.85	10.75	196.66	30.35	13.13	206.38
	47.81	12000	34	7.04	17.27	7.47	179.78	19.07	8.25	184.28	20.42	8.84	187.43	21.27	9.21	189.32	26.77	11.59	200.25
10	57.06	7500	26	2.75	38.81	16.79	218.80	40.61	17.57	221.15	41.96	18.16	222.86	42.81	18.52	223.91	48.31	20.90	230.32
	57.06	9000	26	3.96	37.60	16.27	217.17	39.40	17.05	219.58	40.75	17.63	221.33	41.60	18.00	222.41	47.10	20.38	228.96
	57.06	10000	26	4.89	36.67	15.87	215.89	38.47	16.65	218.35	39.82	17.23	220.13	40.67	17.60	221.23	46.17	19.98	227.90
	57.06	11000	28	5.92	33.64	14.56	211.52	35.44	15.34	214.16	36.79	15.92	216.06	37.64	16.29	217.23	43.14	18.67	224.32
	57.06	11500	31	6.47	30.09	13.02	205.96	31.89	13.80	208.84	33.24	14.38	210.92	34.09	14.75	212.19	39.59	17.13	219.84
	57.06	12000	34	7.04	26.52	11.47	199.78	28.32	12.25	202.97	29.67	12.84	205.26	30.52	13.21	206.66	36.02	15.59	214.98
20	80.17	7500	26	2.75	61.92	26.79	243.93	63.72	27.57	245.54	65.07	28.16	246.72	65.92	28.52	247.46	71.42	30.90	252.04
	80.17	9000	26	3.96	60.71	26.27	242.83	62.51	27.05	244.46	63.86	27.63	245.66	64.71	28.00	246.41	70.21	30.38	251.06
	80.17	10000	26	4.89	59.78	25.87	241.96	61.58	26.65	243.62	62.93	27.23	244.84	63.78	27.60	245.59	69.28	29.98	250.29
	80.17	11000	28	5.92	56.75	24.56	239.08	58.55	25.34	240.81	59.90	25.92	242.08	60.75	26.29	242.87	66.25	28.67	247.75
	80.17	11500	31	6.47	53.20	23.02	235.54	55.00	23.80	237.36	56.35	24.38	238.69	57.20	24.75	239.52	62.70	27.13	244.64
	80.17	12000	34	7.04	49.63	21.47	231.77	51.43	22.25	233.69	52.78	22.84	235.10	53.63	23.21	235.97	59.13	25.59	241.35
30	103.28	7500	26	2.75	85.03	36.79	262.24	86.83	37.57	263.49	88.18	38.16	264.41	89.03	38.52	264.99	94.53	40.90	268.60
	103.28	9000	26	3.96	83.82	36.27	261.39	85.62	37.05	262.65	86.97	37.63	263.59	87.82	38.00	264.17	93.32	40.38	267.82
	103.28	10000	26	4.89	82.89	35.87	260.73	84.69	36.65	262.00	86.04	37.23	262.94	86.89	37.60	263.53	92.39	39.98	267.22
	103.28	11000	28	5.92	79.86	34.56	258.54	81.66	35.34	259.85	83.01	35.92	260.82	83.86	36.29	261.42	89.36	38.67	265.21
	103.28	11500	31	6.47	76.31	33.02	255.88	78.11	33.80	257.24	79.46	34.38	258.24	80.31	34.75	258.87	85.81	37.13	262.79
	103.28	12000	34	7.04	72.74	31.47	253.09	74.54	32.25	254.51	75.89	32.84	255.55	76.74	33.21	256.20	82.24	35.59	260.26
60	172.61	7500	26	2.75	154.36	66.79	299.79	156.16	67.57	300.56	157.51	68.16	301.14	158.36	68.52	301.50	163.86	70.90	303.80
	172.61	9000	26	3.96	153.15	66.27	299.26	154.95	67.05	300.04	156.30	67.63	300.62	157.15	68.00	300.98	162.65	70.38	303.30
	172.61	10000	26	4.89	152.22	65.87	298.86	154.02	66.65	299.64	155.37	67.23	300.22	156.22	67.60	300.59	161.72	69.98	302.91
	172.61	11000	28	5.92	149.19	64.56	297.53	150.99	65.34	298.32	152.34	65.92	298.91	153.19	66.29	299.28	158.69	68.67	301.64
	172.61	11500	31	6.47	145.64	63.02	295.93	147.44	63.80	296.74	148.79	64.38	297.35	149.64	64.75	297.73	155.14	67.13	300.13
	172.61	12000	34	7.04	142.07	61.47	294.30	143.87	62.25	295.13	145.22	62.84	295.74	146.07	63.21	296.13	151.57	65.59	298.57

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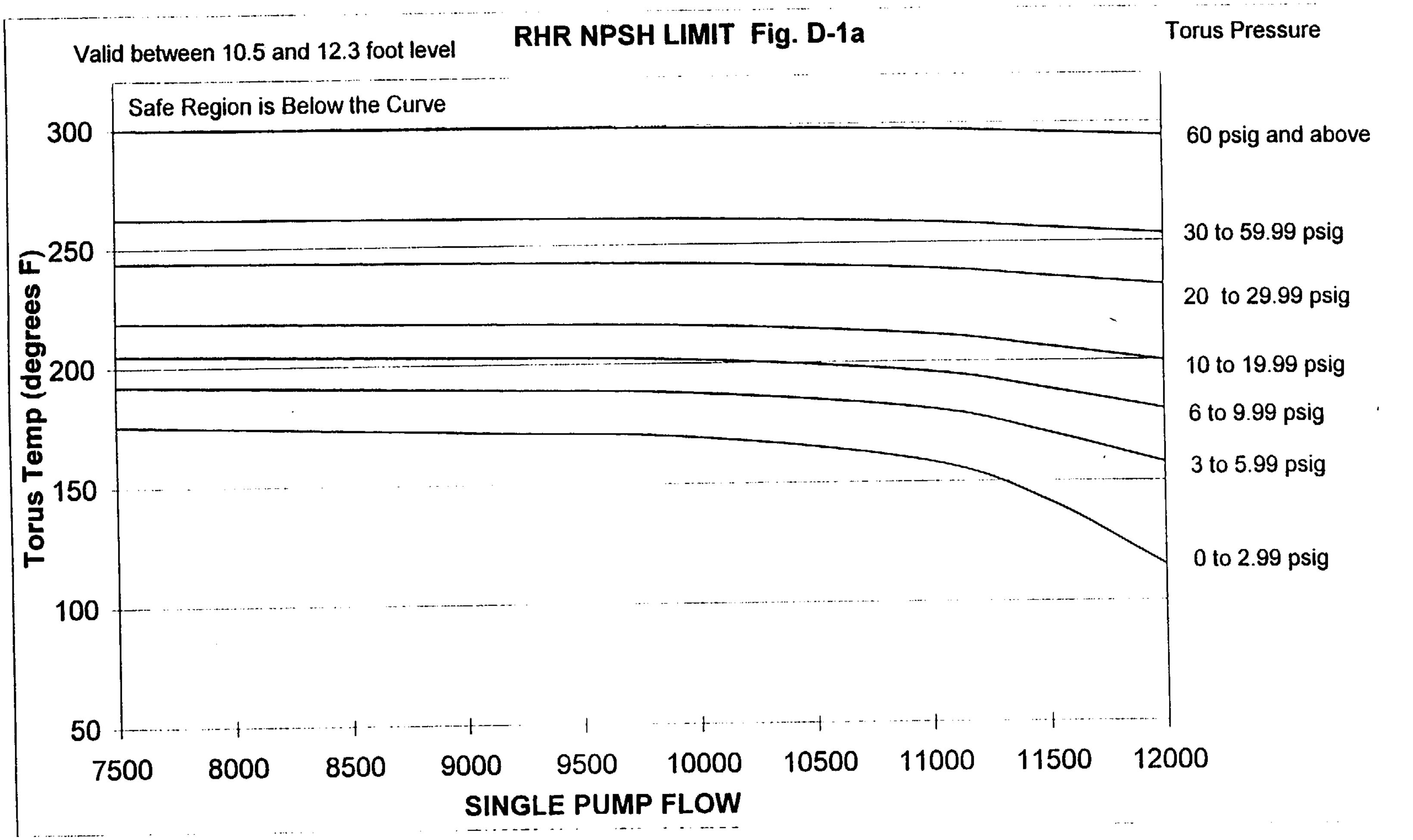
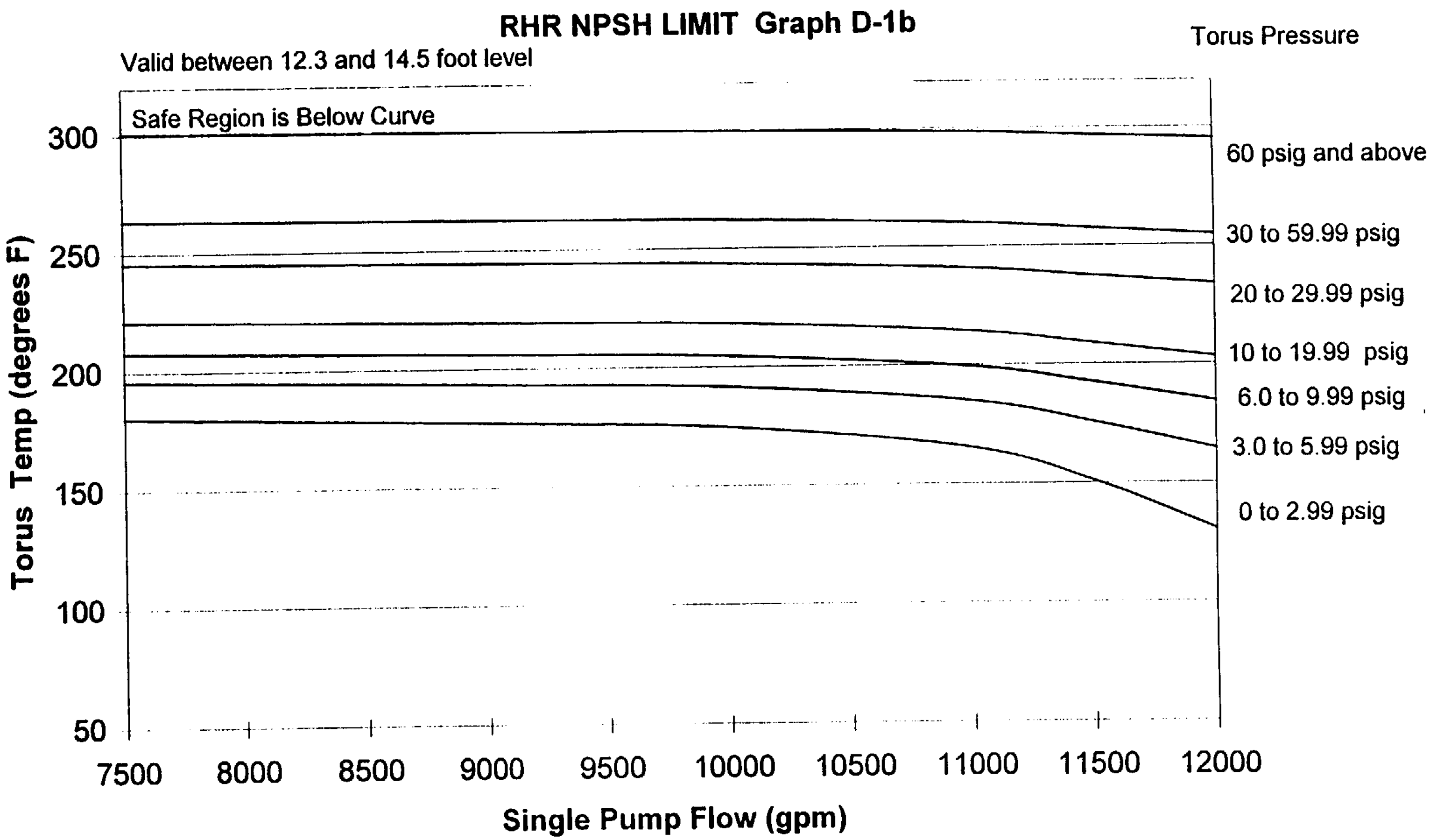
CALCULATION SHEET

CALC. NO.: PM-1010
PAGE: 30
REVISION: 4


RHR NPSH LIMIT Fig. D-1a
Valid between 10.5 and 12.3 foot level
Torus Pressure
Safe Region is Below the Curve
60 psig and above
30 to 59.99 psig
20 to 29.99 psig
10 to 19.99 psig
6 to 9.99 psig
3 to 5.99 psig
0 to 2.99 psig
Torus Temp (degrees F)
300
250
200
150
100
50
7500
8000
8500
9000
9500
10000
10500
11000
11500
12000
SINGLE PUMP FLOW



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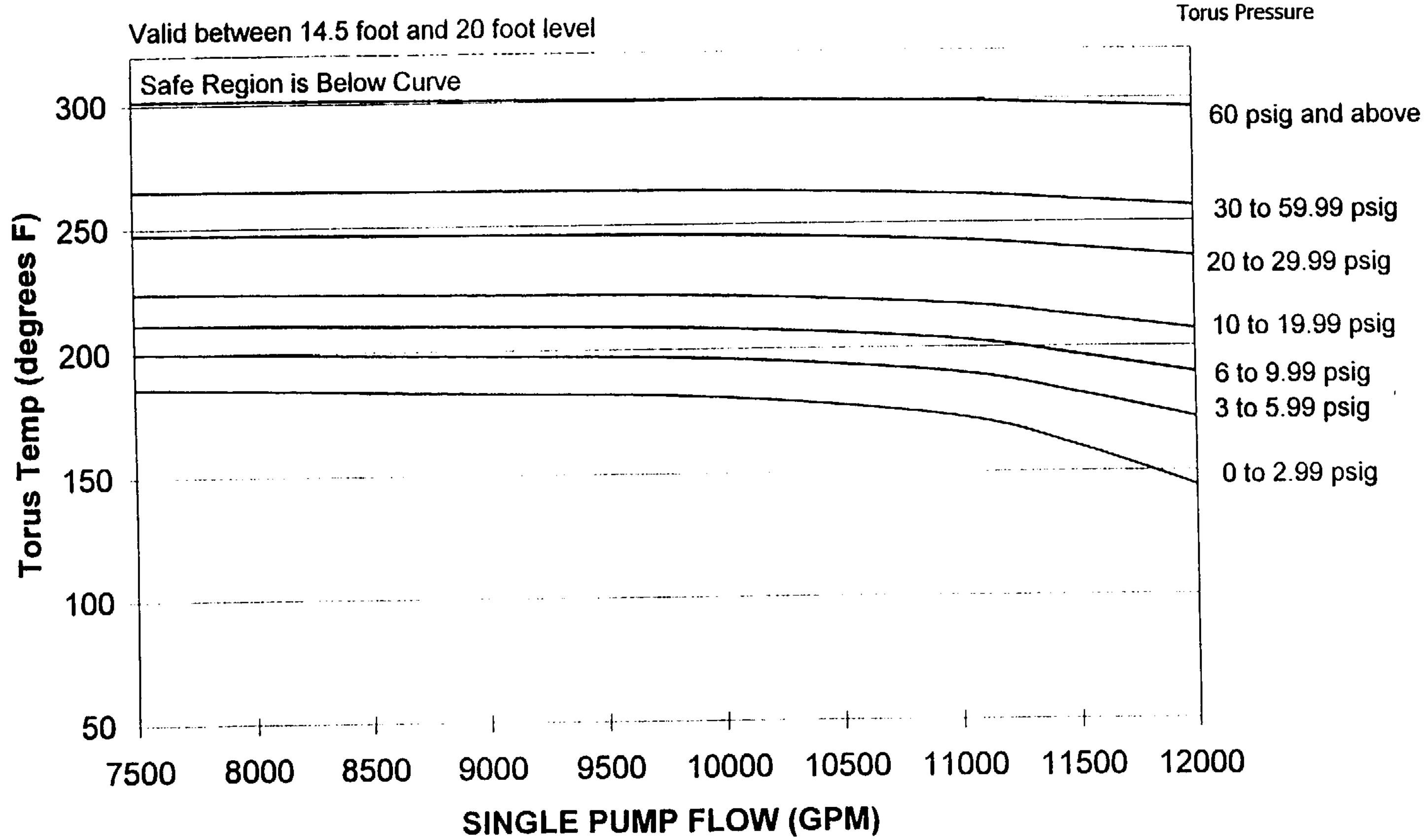
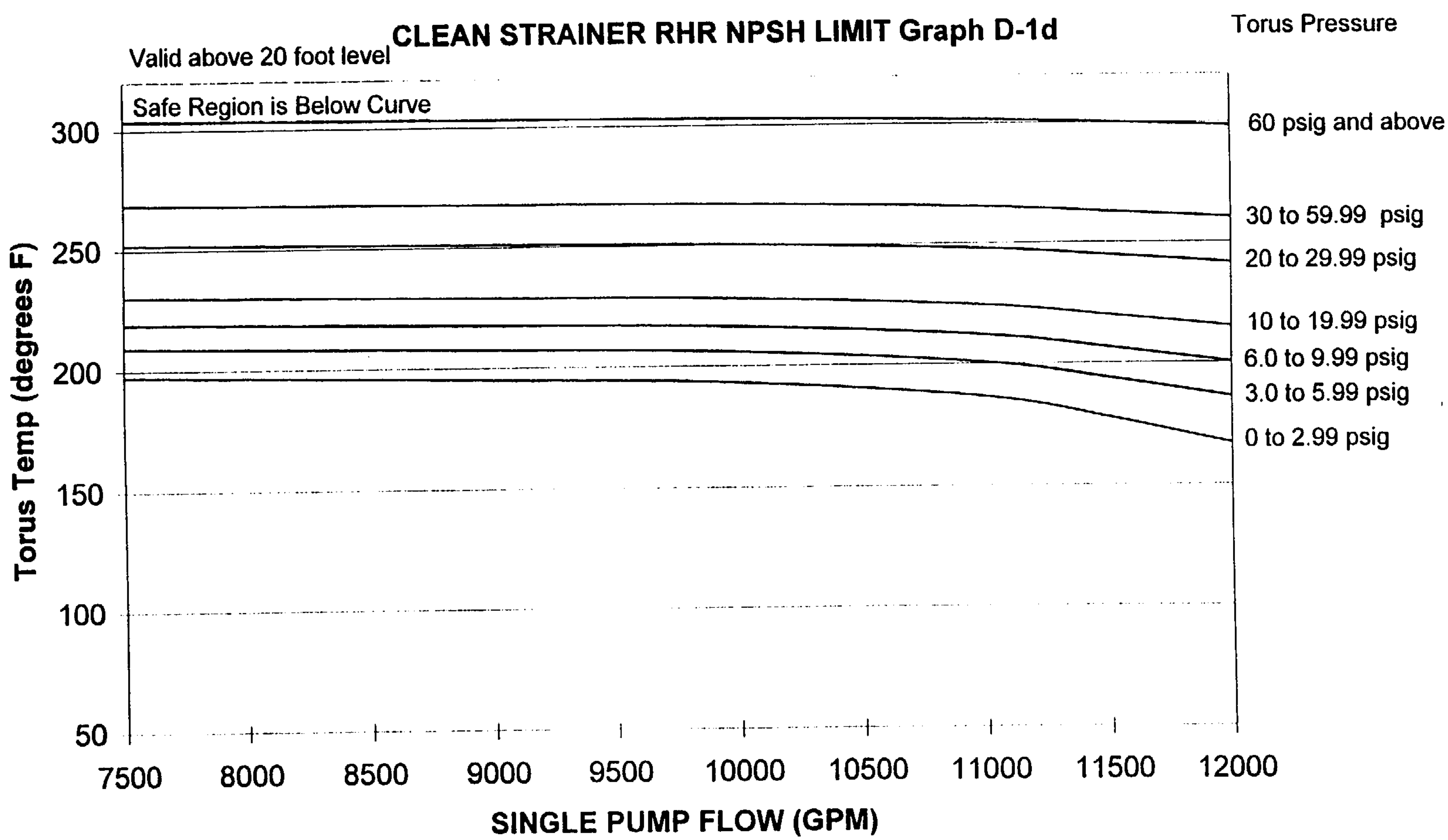
CALCULATION SHEET

CALC. NO.: PM-1010
PAGE: 32
REVISION: 4

RHR NPSH LIMIT Graph D-1c




CLEAN STRAINER RHR NPSH LIMIT Graph D-1d
Valid above 20 foot level
Safe Region is Below Curve
Torus Pressure
60 psig and above
30 to 59.99 psig
20 to 29.99 psig
10 to 19.99 psig
6.0 to 9.99 psig
3.0 to 5.99 psig
0 to 2.99 psig
Torus Temp (degrees F)
300
250
200
150
100
50
7500
8000
8500
9000
9500
10000
10500
11000
11500
12000
SINGLE PUMP FLOW (GPM)

PM-1010 Rev 4

PECO ENERGY
NUCLEAR GROUP

CALCULATION SHEET

CALC. NO.: PM-1010
PAGE: 35
REVISION: 4

Table D-2 RHR Pump Clean Strainer

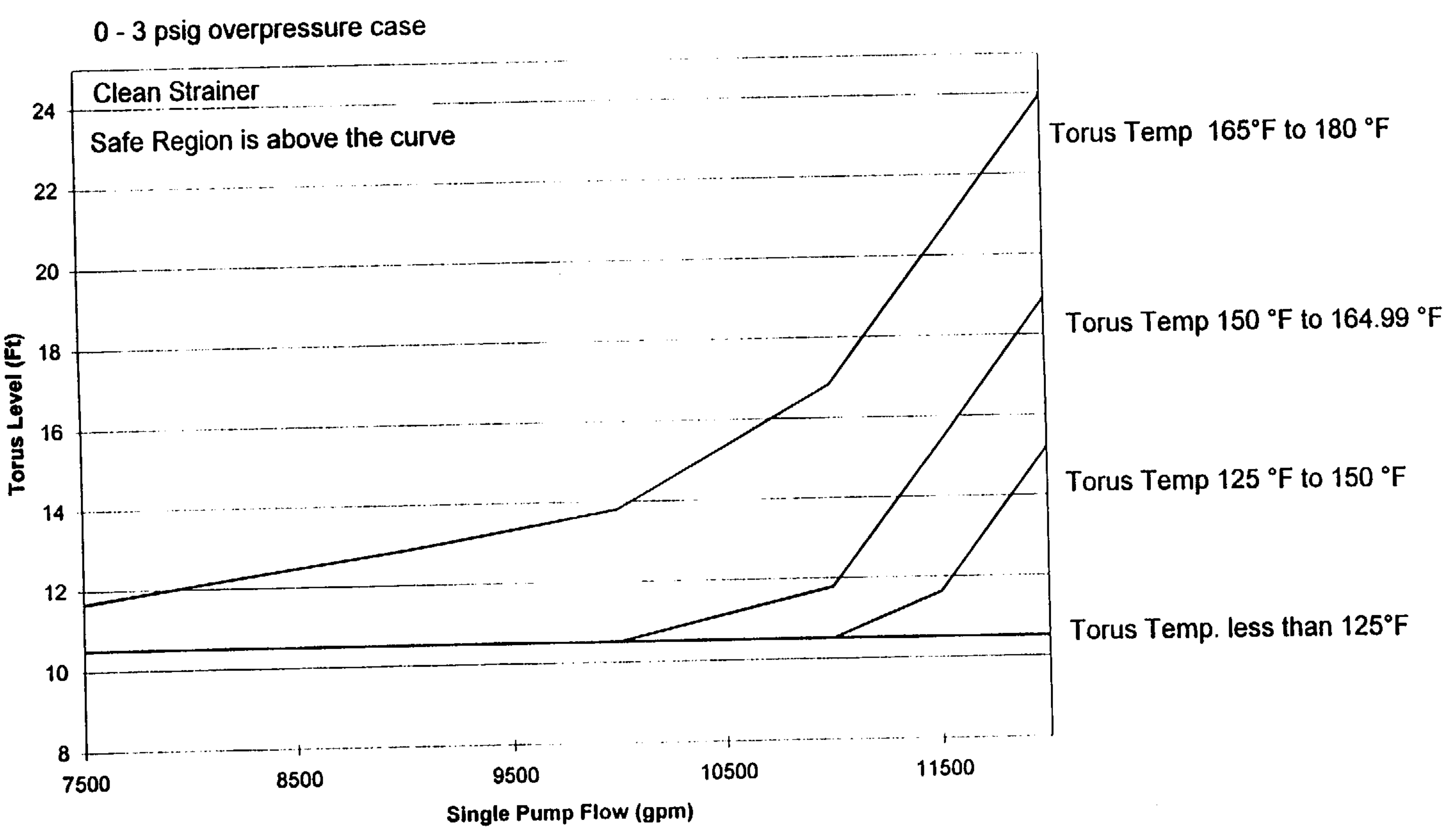
Determine Torus level as a function of flow
using the equation hs = NPSHR + hf - PA + hvap
where hs is static head (which is torus level)
Hf at 10000 gpm & 205.7 4.89 ft H2O

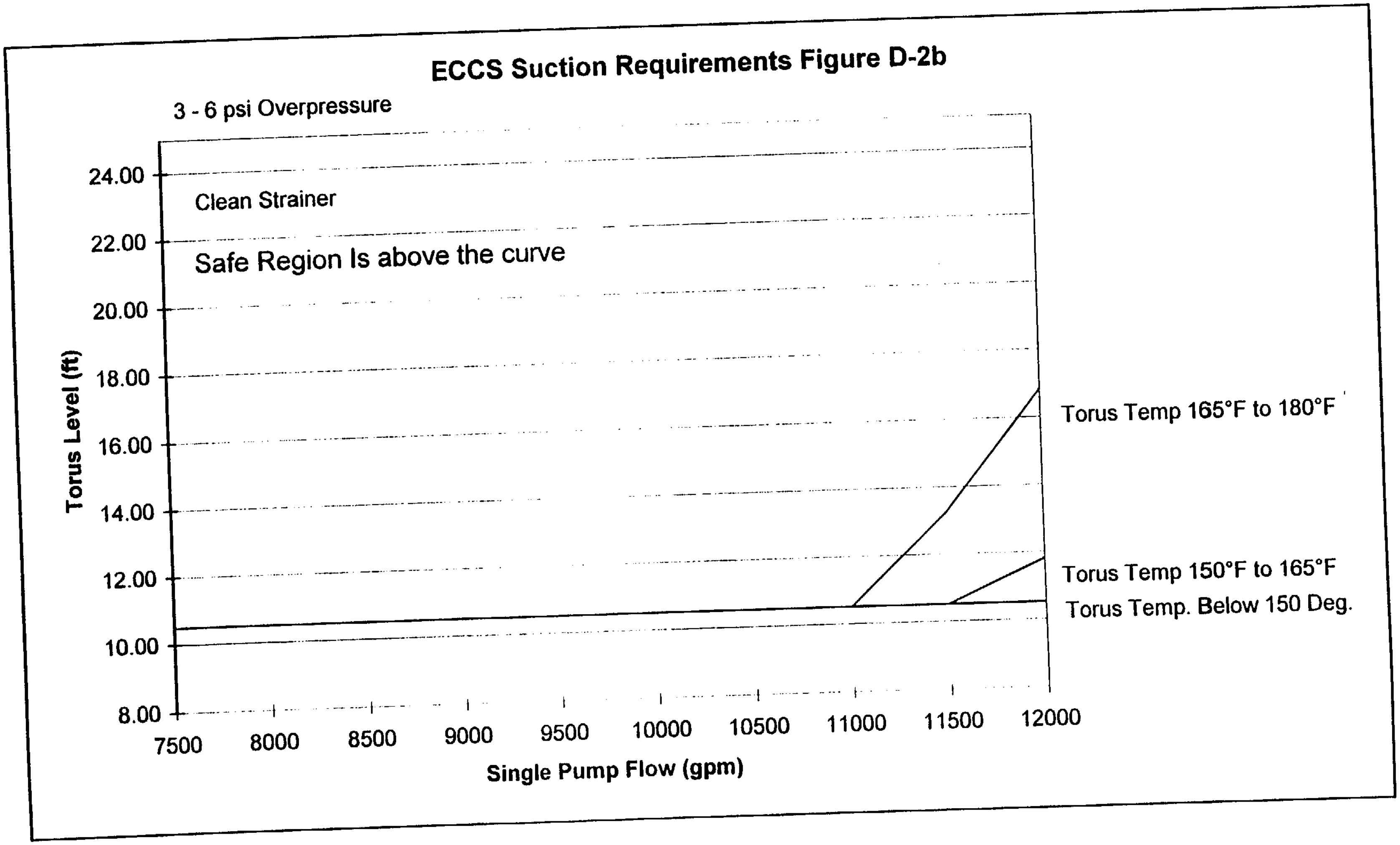
Note: If the calculated required level is less than 10.5 ft (vortex limit), the required Torus level is 10.5 ft.

Determination of hf for flows		
flow	ratio^2	hf
7500	0.5625	2.751
9000	0.81	3.961
10000	1	4.890
11000	1.21	5.917
11500	1.3225	6.467
12000	1.44	7.042

Torus Wetwell Pressure PA					Torus Temperature (deg F)											
					95	110	125	150	165	180	200	220	240	260	280	300
				hvap (ft)	1.892	2.968	4.538	8.751	12.619	17.857	27.613	41.516	60.855	87.178	122.313	168.400
(psig)	(psia)	Flow (gpm)	NPSHR	hf (ft)	hs (ft) (equates to torus level)											
0	14.7	7500	26	2.751	-3.467	-2.500	-1.057	2.907	6.606	11.659	21.147	34.756	53.777	79.755	114.518	160.206
	14.7	9000	26	3.961	-2.257	-1.290	0.154	4.118	7.816	12.870	22.357	35.967	54.987	80.965	115.729	161.416
	14.7	10000	26	4.890	-1.328	-0.361	1.083	5.047	8.746	13.799	23.286	36.896	55.916	81.894	116.658	162.345
	14.7	11000	28	5.917	1.699	2.666	4.110	8.074	11.772	16.826	26.313	39.923	58.943	84.921	119.685	165.372
	14.7	11500	31	6.467	5.249	6.216	7.660	11.624	15.323	20.376	29.863	43.473	62.493	88.471	123.235	168.922
	14.7	12000	34	7.042	8.824	9.791	11.234	15.198	18.897	23.950	33.438	47.047	66.068	92.045	126.809	172.497
3	17.7	7500	26	2.751	-10.428	-9.483	-8.066	-4.153	-0.488	4.527	13.960	27.509	46.465	72.372	107.060	152.666
	17.7	9000	26	3.961	-9.218	-8.273	-6.856	-2.942	0.722	5.737	15.170	28.720	47.675	73.582	108.270	153.876
	17.7	10000	26	4.890	-8.289	-7.344	-5.926	-2.013	1.651	6.666	16.099	29.649	48.604	74.511	109.200	154.805
	17.7	11000	28	5.917	-5.262	-4.317	-2.900	1.014	4.678	9.693	19.126	32.676	51.631	77.538	112.226	157.832
	17.7	11500	31	6.467	-1.712	-0.767	0.651	4.564	8.228	13.243	22.676	36.226	55.181	81.089	115.777	161.382
	17.7	12000	34	7.042	1.863	2.808	4.225	8.138	11.802	16.818	26.251	39.800	58.756	84.663	119.351	164.957
6	20.7	7500	26	2.751	-17.390	-16.467	-15.075	-11.213	-7.583	-2.605	6.773	20.262	39.153	64.990	99.602	145.126
	20.7	9000	26	3.961	-16.179	-15.257	-13.865	-10.002	-6.373	-1.395	7.983	21.473	40.363	66.200	100.812	146.337
	20.7	10000	26	4.890	-15.250	-14.327	-12.936	-9.073	-5.444	-0.466	8.912	22.402	41.292	67.129	101.741	147.266
	20.7	11000	28	5.917	-12.223	-11.301	-9.909	-6.046	-2.417	2.561	11.939	25.429	44.319	70.156	104.768	150.293
	20.7	11500	31	6.467	-8.673	-7.750	-6.359	-2.496	1.133	6.111	15.489	28.979	47.869	73.706	108.318	153.843
	20.7	12000	34	7.042	-5.099	-4.176	-2.784	1.078	4.708	9.686	19.064	32.553	51.444	77.281	111.893	157.417
10	24.7	7500	26	2.751	-26.671	-25.778	-24.421	-20.626	-17.043	-12.115	-2.810	10.600	29.403	55.147	89.658	135.073
	24.7	9000	26	3.961	-25.461	-24.568	-23.211	-19.416	-15.832	-10.905	-1.600	11.810	30.614	56.357	90.868	136.284
	24.7	10000	26	4.890	-24.532	-23.639	-22.281	-18.487	-14.903	-9.976	-0.671	12.739	31.543	57.286	91.797	137.213
	24.7	11000	28	5.917	-21.505	-20.612	-19.255	-15.460	-11.876	-6.949	2.356	15.766	34.570	60.313	94.824	140.240
	24.7	11500	31	6.467	-17.955	-17.062	-15.704	-11.910	-8.326	-3.399	5.906	19.316	38.120	63.863	98.374	143.790
	24.7	12000	34	7.042	-14.380	-13.487	-12.130	-8.335	-4.752	0.176	9.481	22.891	41.694	67.438	101.949	147.364
20	34.7	7500	26	2.751	-49.875	-49.056	-47.785	-44.159	-40.692	-35.890	-26.767	-13.557	5.030	30.539	64.797	109.941
	34.7	9000	26	3.961	-48.665	-47.846	-46.575	-42.949	-39.481	-34.679	-25.557	-12.347	6.240	31.749	66.008	111.151
	34.7	10000	26	4.890	-47.736	-46.916	-45.646	-42.020	-38.552	-33.750	-24.628	-11.418	7.169	32.678	66.937	112.080
	34.7	11000	28	5.917	-44.709	-43.890	-42.619	-38.993	-35.525	-30.723	-21.601	-8.391	10.196	35.705	69.964	115.107
	34.7	11500	31	6.467	-41.159	-40.339	-39.069	-35.443	-31.975	-27.173	-18.051	-4.841	13.746	39.255	73.514	118.657
	34.7	12000	34	7.042	-37.584	-36.765	-35.494	-31.868	-28.401	-23.599	-14.476	-1.266	17.321	42.830	77.088	122.232
30	44.7	7500	26	2.751	-73.079	-72.334	-71.149	-67.693	-64.340	-59.664	-50.724	-37.714	-19.344	5.931	39.937	84.809
	44.7	9000	26	3.961	-71.869	-71.123	-69.939	-66.482	-63.130	-58.454	-49.514	-36.503	-18.133	7.141	41.147	86.019
	44.7	10000	26	4.890	-70.940	-70.194	-69.010	-65.553	-62.201	-57.525	-48.585	-35.574	-17.204	8.070	42.076	86.948
	44.7	11000	28	5.917	-67.913	-67.167	-65.983	-62.526	-59.174	-54.498	-45.558	-32.547	-14.177	11.097	45.103	89.975
	44.7	11500	31	6.467	-64.363	-63.617	-62.433	-58.976	-55.624	-50.948	-42.008	-28.997	-10.627	14.647	48.653	93.525
	44.7	12000	34	7.042	-60.788	-60.043	-58.858	-55.402	-52.049	-47.373	-38.433	-25.423	-7.053	18.222	52.228	97.100
60	74.7	7500	26	2.751	-142.691	-142.167	-141.242	-138.293	-135.287	-130.987	-122.595	-110.184	-92.464	-67.893	-34.645	9.411
	74.7	9000	26	3.961	-141.480	-140.957	-140.032	-137.082	-134.077	-129.777	-121.385	-108.974	-91.254	-66.683	-33.435	10.622
	74.7	10000	26	4.890	-140.551	-140.028	-139.103	-136.153	-133.148	-128.848	-120.456	-108.044	-90.325	-65.754	-32.506	11.551
	74.7	11000	28	5.917	-137.524	-137.001	-136.076	-133.126	-130.121	-125.821	-117.429	-105.018	-87.298	-62.727	-29.479	14.578
	74.7	11500	31	6.467	-133.974	-133.451	-132.526	-129.576	-126.570	-122.271	-113.879	-101.467	-83.748	-59.177	-25.929	18.128
	74.7	12000	34	7.042	-130.4	-129.876	-128.951	-126.002	-122.996	-118.696	-110.304	-97.893	-80.173	-55.602	-22.354	21.702

ECCS Suction Requirements Figure D-2a





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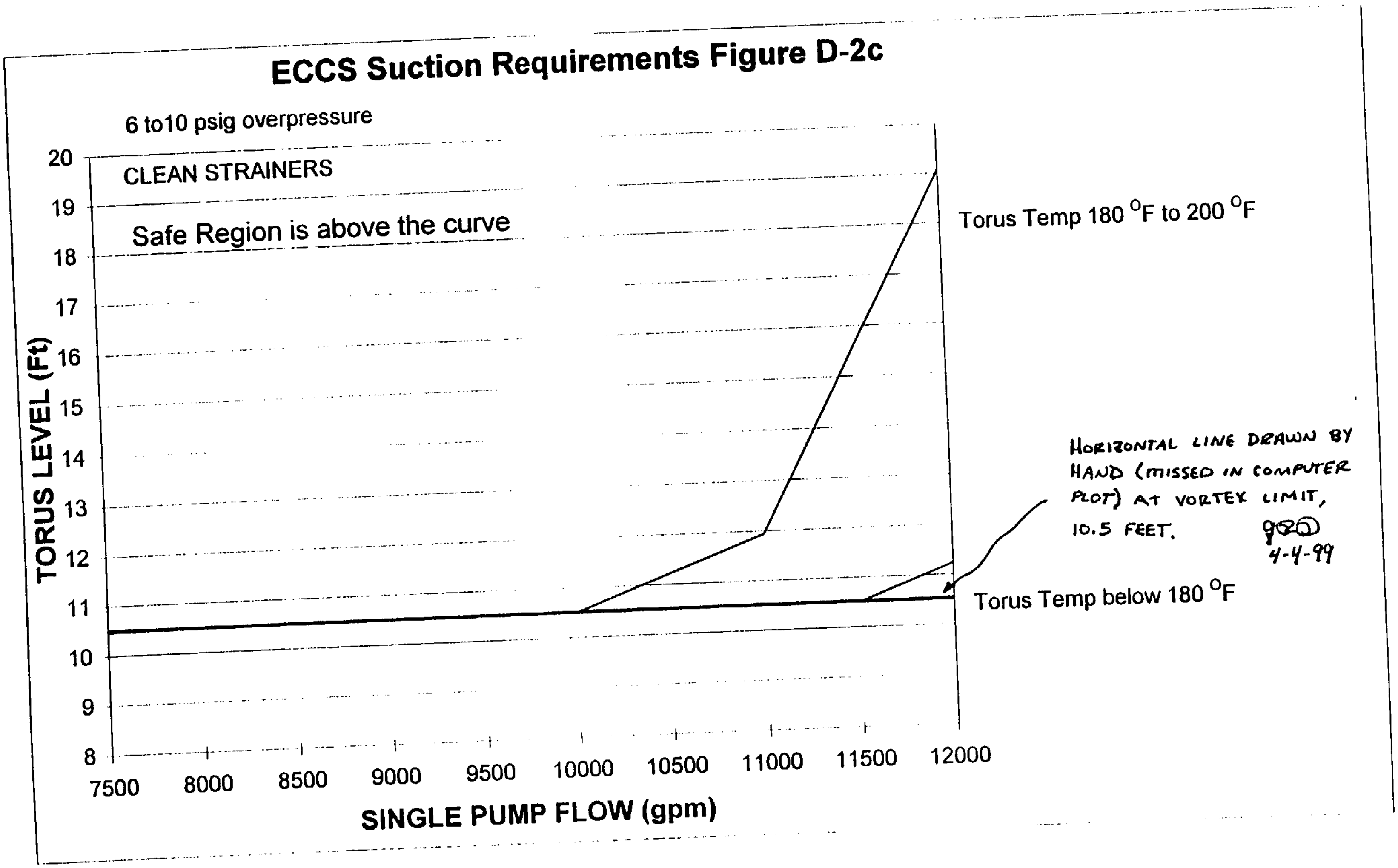
CALC. NO. : PM-1010
PAGE : 37
REVISION : 4

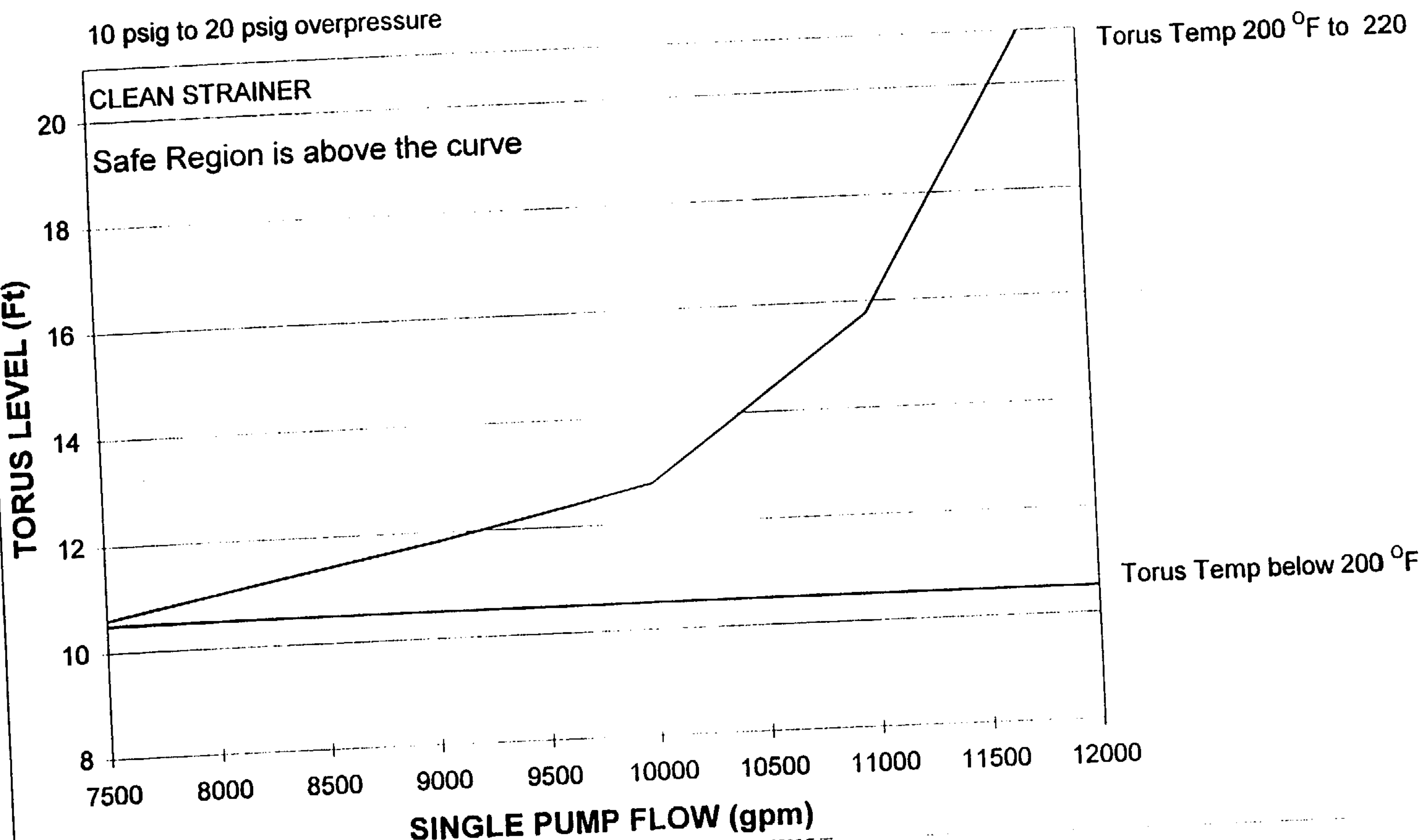

ECCS Suction Requirements Figure D-2c
6 to10 psig overpressure
CLEAN STRAINERS
Safe Region is above the curve
Torus Temp 180 °F to 200 °F
Torus Temp below 180 °F
HORIZONTAL LINE DRAWN BY HAND (MISSED IN COMPUTER PLOT) AT VORTEX LIMIT, 10.5 FEET.
4-4-99
TORUS LEVEL (Ft)
20
19
18
17
16
15
14
13
12
11
10
9
8
SINGLE PUMP FLOW (gpm)
7500
8000
8500
9000
9500
10000
10500
11000
11500
12000

PECO ENERGY
NUCLEAR GROUP

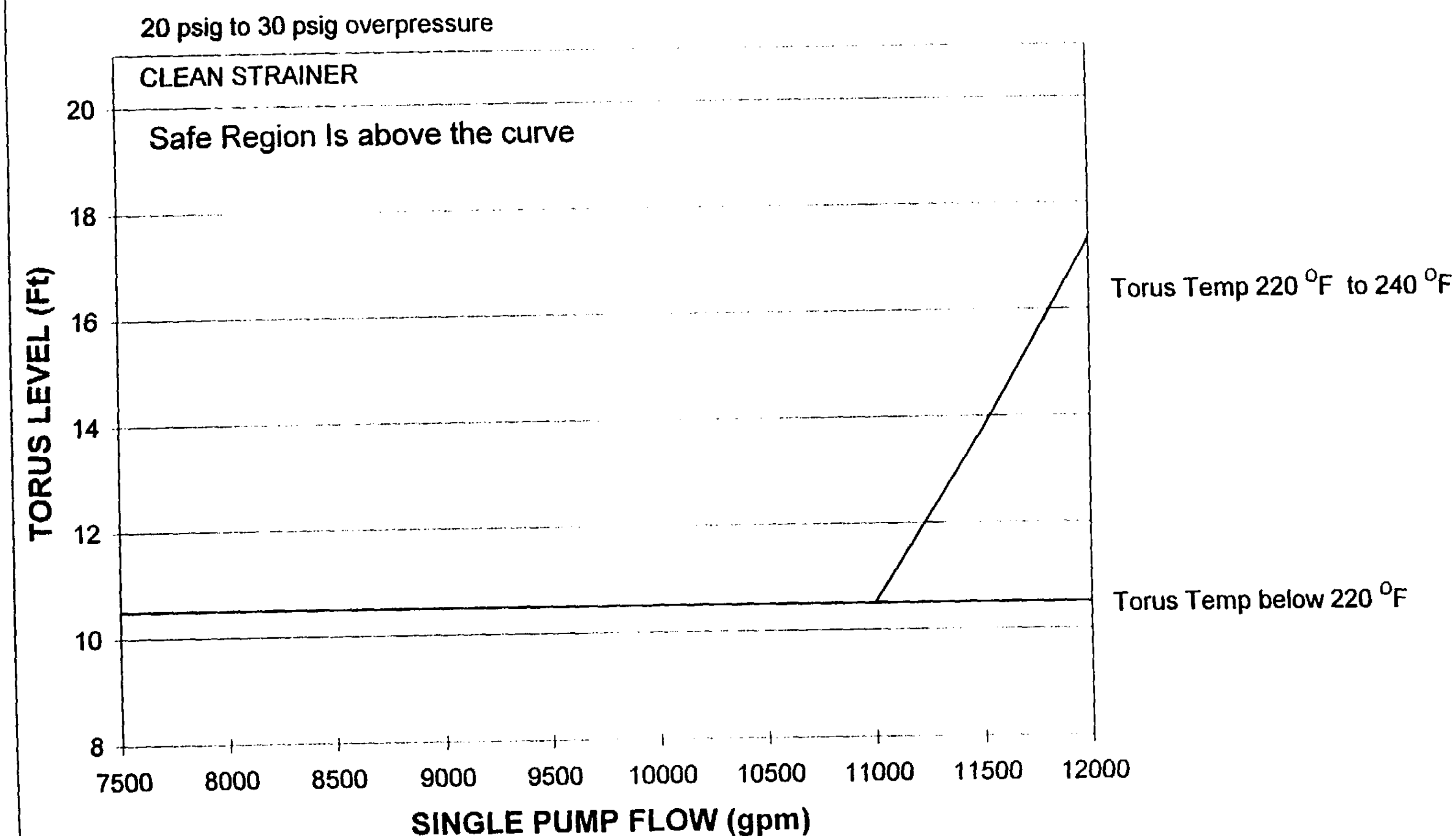
CALCULATION SHEET

CALC. NO.: PM-1010
PAGE: 39
REVISION: 4

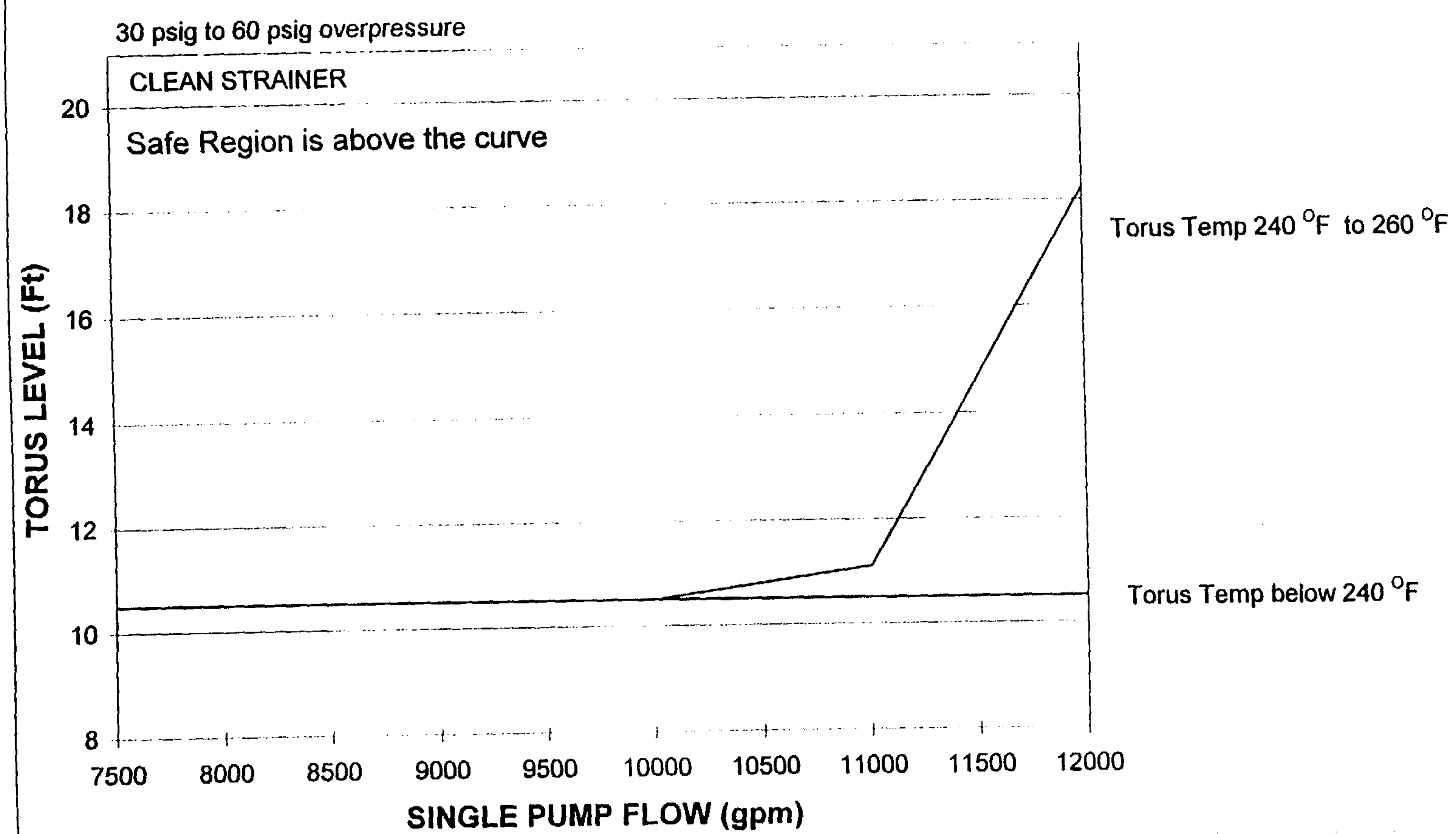
ECCS Suction Requirements Figure D-2d



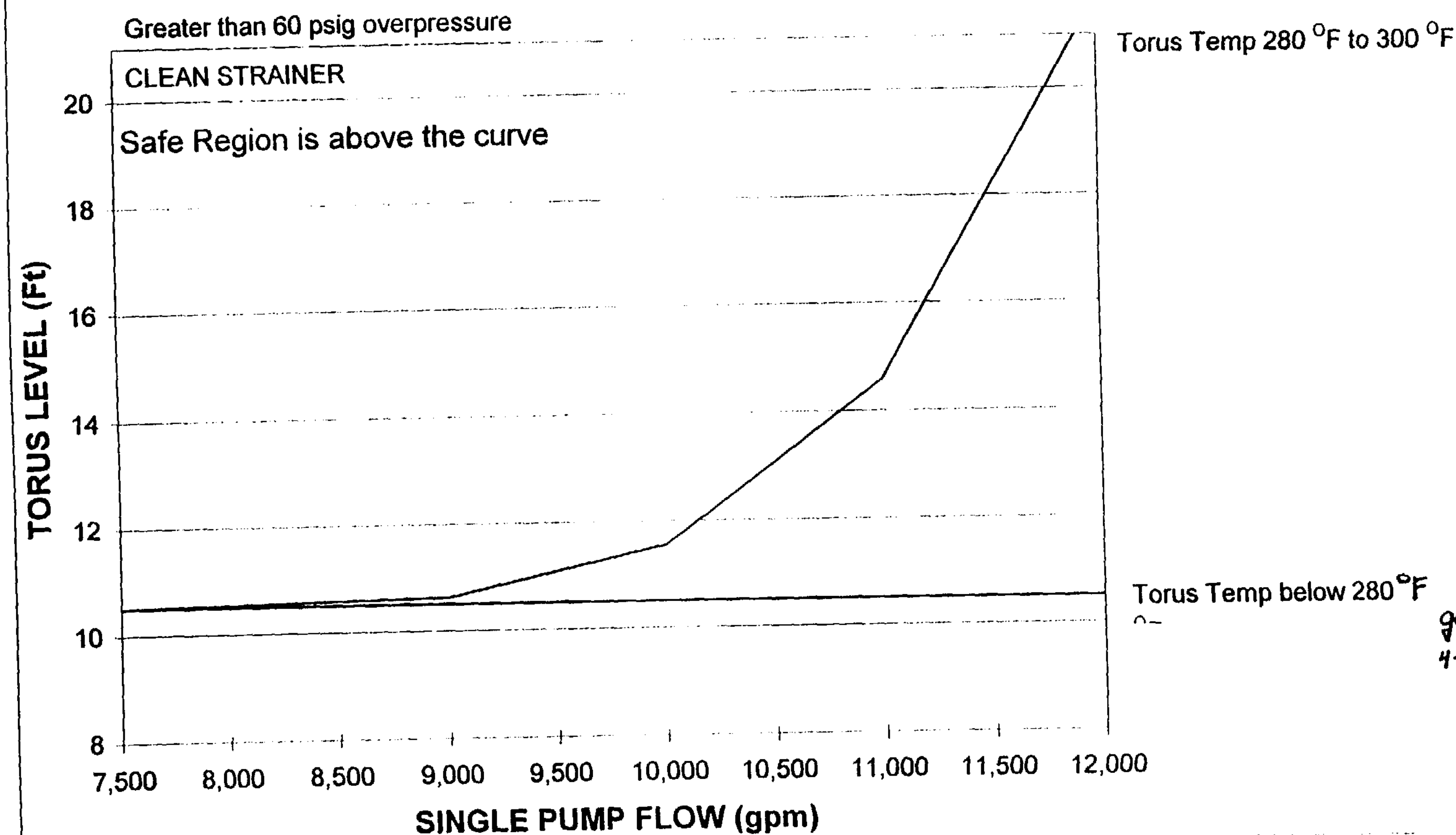
ECCS Suction Requirements Figure D-2e



ECCS Suction Requirements Figure D-2f



ECCS Suction Requirements Figure D-2g



4-4-99

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E. OTHER ANALYZED EVENTS

Design Basis Document P-T-12, Table T2.1-12-1 provides a list of events, which require LPCI containment cooling mode of RHR. These "other analyzed events:": Station Blackout, ATWS, Fire Safe Shutdown (FSSD), and Inadvertent Open Relief Valve (IORV) may require credit for containment overpressure in order to satisfy NPSH requirements. As such, the following analysis was developed using the methodology used in paragraph D. "NPSH LIMIT CURVES AND ECCS SUCTION REQUIREMENTS FOR EPG'S (T-102)" to evaluate the availability of adequate NPSH.

For each of these events, a time-dependent temperature profile for the torus water is not available. Instead, the peak torus water temperature is provided. The analysis provided in paragraph D. "NPSH LIMIT CURVES AND ECCS SUCTION REQUIREMENTS FOR EPG'S (T-102)" provides the limits of maximum allowable suppression pool temperature for various given conditions. The given conditions vary in torus airspace temperature, ECCS pump flow, and suppression pool level.

Table E-2 was developed using the same methodology as used for Table D-1 to evaluate the NPSH margin for the "Other Events". The NPSH margin was evaluated as the difference between calculated containment pressure for the referenced expected containment temperature and the referenced expected containment pressure for the event.

Note: The values for NPSHr used in the Part D are also used herein for conservatism.

STATION BLACKOUT SEE PAGE 43A

Peak torus water temperature for the PBAPS SBO event is calculated in PM-760 "Power Rerate Evaluation - SBO Analysis" (Reference 25) as 161°F at approximately 4.25 hrs. The peak torus water temperature calculated for the SBO event (161°F) is well below temperatures where containment overpressure credit is required; 178°F for 0 psig overpressure, 10,000 gpm ECCS pump flow, and 0.85 ft drawdown (Table ~~E~~ D-1).

From Table E-2, the NPSH margin for the Station Blackout event, not crediting containment overpressure, is 2.37 psig or 5.56 ft.

Therefore, adequate NPSH exists for the SBO event.

ATWS

Peak torus water temperature for the PBAPS ATWS event is calculated in NE-163-3 "Power Rerate Engineering Report" (Reference 26) as 188°F at 3300 seconds. The peak torus water temperature calculated for the ATWS event (188°F) is above temperatures where containment overpressure credit is required; 178°F for 0 psig overpressure, 10,000 gpm ECCS pump flow, and 0.85 ft drawdown (Table E-1). However, crediting the available containment over pressure of 4.856 psig (Reference 14) for this event, the maximum allowable suppression pool temperature is 202°F for 4.856 psig overpressure, 10,000 gpm ECCS pump flow, and 0.85 ft drawdown (Table E-1).

From Table E-2, the NPSH margin for the ATWS event, crediting containment overpressure, is 3.14 psig or 7.37 ft.

Therefore adequate NPSH exists for the postulated ATWS event.

STATION BLACKOUT

The torus water temperature at the end of the 8 hour coping period will remain less than 180 F as determined by Calculation PM-760, "Power Rerate Evaluation - SBO Analysis" (Reference 25). A torus water temperature of 180 F is less than the temperature where containment overpressure credit is required; 180.52 F for 0 psig overpressure, 10,000 gpm ECCS pump flow, and minimum Technical Specification torus water level (Table D-1). A slight reduction in torus water level was calculated in Calculation PM-760 (Reference 25). Utilizing this reduced torus water level, the necessity of containment overpressure is evaluated as follows;

T	=	180 F	(Ref. 25)
P_v	=	7.510 psia	(Ref. 10 sat. press)
ρ	=	60.459 lbm/cuft	(Ref. 10 sat. liquid)
h_{pipe}	=	2.67 feet @ 10,000 gpm	(page 9)
h_{st}	=	2.22 feet @ ~~3,125~~ gpm	(page 28)
h_s	=	14.21 feet	(Ref. 25)
P_a	=	0.00 psig	(Ref. 14)
NPSHR	=	26.0 feet @ 10,000 gpm	(page 17)

10,000 EDITORIAL CORRECTION TO BE MADE IN NEXT REV. (SEE CALC. DB)

$$NPSHA = \frac{144(P_a - P_v + 14.696)}{\rho} + h_s - h_{pipe} - h_{st}$$

$$NPSHA = \frac{144(0.0\,psig - 7.510\,psia + 14.696)}{60.459\,lbm/cuft} + 14.21ft - 2.67ft - 2.22ft = 26.44ft$$

$$\text{Margin} = NPSHA - NPSHR = 26.44ft - 26.0ft = 0.44\,ft\ or\ 0.18\,psig$$

$$COPR = \frac{\rho(NPSHR + h_{pipe} + h_{st} - h_s)}{144} + P_v - P_{atm}$$

$$COPR = \frac{60.459\,lbm/cuft(26.0ft + 2.67ft + 2.22ft - 14.21ft)}{144} + 7.510\,psia - 14.696$$

$COPR\ less\ than\ 0.00\,psig$

Therefore, adequate NPSH exists for the SBO event without containment overpressure.

FSSD

Peak torus water temperature for the PBAPS FSSD event is calculated in Attachment 1 to PECO NCR 95-05708 "PBAPS Safe S/D Analysis" (Reference 27) as 206°F at 28800 seconds. Since the peak torus water temperature for the FSSD event (206°F) is greater than the temperature of 178°F for 0 psig overpressure, 10,000 gpm ECCS pump flow, and 0.85 ft drawdown (Table E-1), overpressure credit is required. Crediting the available containment over pressure of 7.463 psig (Reference 14) for this event, the maximum allowable suppression pool temperature is ~~207~~ 213°F for 7.463 psig overpressure, 10,000 gpm ECCS pump flow, and Minimum Tech Spec Pool level (Table E-1). The use of the minimum Tech Spec pool level is justified in that: if RCIC is available, vessel makeup is provided from the CST, which would increase the suppression pool level, and reactor vessel flooding is not required. In the event that RCIC is not available and RHR is required to provide vessel cooling, and the suppression pool temperature approaches the maximum limit, HPSW is available for increasing the suppression pool level, thereby increasing NPSH.

EDITORIAL MISTAKE TO BE CORRECTED IN NEXT REV.

From Table E-2, the NPSH margin for the FSSD event, crediting containment overpressure, is 2.03 psig or 4.74 ft.

Therefore adequate NPSH exists for the postulated FSSD event.

IORV

Peak torus water temperature for the PBAPS IORV event is calculated in NE-163-3 "Power Rerate Engineering Report" (Reference 26) as 174°F at less than 4000 seconds. The peak torus water temperature calculated for the IORV event (174°F) is well below temperatures where containment overpressure credit is required - 178°F for 0 psig overpressure, 10,000 gpm ECCS pump flow, and 0.85 ft drawdown (Table E-1).

From Table E-2, the NPSH margin for the IORV event, not crediting containment overpressure, is 0.66 psig or 1.54 ft.

Therefore adequate NPSH exists for the IORV event.

TABLE E-1 RHR PUMPS CLEAN STRAINERS - OTHER EVENTS

Determination of torus temperature vs flow
Conversion of friction loss (Hf) for for new strainers
Clean strainer dP is 2.22 ft@ 10000 gpm and 205.7° F & piping is 2.67 ft @ 10000 gpm and 205.7°F
Using the equation hvap = hst - NPSHR - hf + PA
Friction loss is converted based on the ratio of the flows squared
thus the Hf at 10000= 4.89 feet H2O is coverted for various flows

Calculate the Hf at various flows using ratios of flows to 2.0 power

Q (GPM)	Q ratio	Hf new ft.	NPSH R
7500	0.5625	2.75	26
9000	0.81	3.96	26
10000	1	4.89	26
11000	1.21	5.92	28
11500	1.3225	6.47	31
12000	1.44	7.04	34

USE OF 34.5' @ 12,000 gpm IS CONSERVATIVE
[initials] 4-4-99

Torus Wetwell Pressure PA		FLOW	NPSHR	Fric Loss	Vortex Limit 10.5 Ft Torus Level			LOCA Drawdown Level 12.3 Ft Torus Level			Drawdown Level 13.65 Ft Torus Level			Min Tech Spec Level 14.5 Ft Torus Level		
					Vapor Pressure		TEMP	Vapor Pressure		TEMP	Vapor Pressure		TEMP	Vapor Pressure		TEMP
PSIG	FT (ABS)	GPM	FT	FT	FT	PSIA	deg F	FT	PSIA	deg F	FT	PSIA	deg F	FT	PSIA	deg F
0	33.95	7500	26	2.75	15.70	6.79	175.50	17.50	7.57	180.36	18.85	8.16	183.74	19.70	8.52	185.76
	33.95	9000	26	3.96	14.49	6.27	171.97	16.29	7.05	177.15	17.64	7.63	180.72	18.49	8.00	182.86
	33.95	10000	26	4.89	13.56	5.87	169.08	15.36	6.65	174.54	16.71	7.23	178.29	17.56	7.60	180.52
	33.95	11000	28	5.92	10.53	4.56	158.34	12.33	5.34	165.00	13.68	5.92	169.47	14.53	6.29	172.10
	33.95	11500	31	6.47	6.98	3.02	141.74	8.78	3.80	150.88	10.13	4.38	156.74	10.98	4.75	160.09
	33.95	12000	34.5	7.04	2.91	1.26	109.53	4.71	2.04	126.75	6.06	2.62	136.24	6.91	2.99	141.32
3	40.88	7500	26	2.75	22.63	9.79	192.22	24.43	10.57	195.85	25.78	11.16	198.42	26.63	11.52	199.99
	40.88	9000	26	3.96	21.42	9.27	189.65	23.22	10.05	193.44	24.57	10.63	196.12	25.42	11.00	197.75
	40.88	10000	26	4.89	20.49	8.87	187.58	22.29	9.65	191.51	23.64	10.23	194.29	24.49	10.60	195.97
	40.88	11000	28	5.92	17.46	7.56	180.28	19.26	8.34	184.74	20.61	8.92	187.86	21.46	9.29	189.74
	40.88	11500	31	6.47	13.91	6.02	170.21	15.71	6.80	175.55	17.06	7.38	179.23	17.91	7.75	181.43
	40.88	12000	34.5	7.04	9.84	4.26	155.53	11.64	5.04	162.55	12.99	5.62	167.23	13.84	5.99	169.97
4.856	45.17	7500	26	2.75	26.92	11.65	200.51	28.72	12.43	203.67	30.07	13.01	205.93	30.92	13.38	207.31
	45.17	9000	26	3.96	25.71	11.13	198.29	27.51	11.90	201.56	28.86	12.49	203.90	29.71	12.86	205.33
	45.17	10000	26	4.89	24.78	10.72	196.53	26.58	11.50	199.90	27.93	12.09	202.30	28.78	12.45	203.77
	45.17	11000	28	5.92	21.75	9.41	190.37	23.55	10.19	194.11	24.90	10.78	196.76	25.75	11.14	198.37
	45.17	11500	31	6.47	18.20	7.88	182.15	20.00	8.66	186.47	21.35	9.24	189.50	22.20	9.61	191.33
	45.17	12000	34.5	7.04	14.13	6.11	170.87	15.93	6.89	176.15	17.28	7.48	179.79	18.13	7.84	181.97
5.734	47.20	7500	26	2.75	28.95	12.53	204.06	30.75	13.31	207.03	32.10	13.89	209.17	32.95	14.26	210.48
	47.20	9000	26	3.96	27.74	12.00	201.97	29.54	12.78	205.05	30.89	13.37	207.26	31.74	13.73	208.61
	47.20	10000	26	4.89	26.81	11.60	200.31	28.61	12.38	203.48	29.96	12.96	205.74	30.81	13.33	207.13
	47.20	11000	28	5.92	23.78	10.29	194.57	25.58	11.07	198.05	26.93	11.65	200.54	27.78	12.02	202.05
	47.20	11500	31	6.47	20.23	8.76	187.00	22.03	9.53	190.96	23.38	10.12	193.76	24.23	10.49	195.46
	47.20	12000	34.5	7.04	16.16	6.99	176.79	17.96	7.77	181.54	19.31	8.35	184.84	20.16	8.72	186.83
6	47.81	7500	26	2.75	29.56	12.79	205.09	31.36	13.57	208.01	32.71	14.16	210.12	33.56	14.52	211.41
	47.81	9000	26	3.96	28.35	12.27	203.04	30.15	13.05	206.06	31.50	13.63	208.24	32.35	14.00	209.56
	47.81	10000	26	4.89	27.42	11.87	201.41	29.22	12.65	204.52	30.57	13.23	206.75	31.42	13.60	208.11
	47.81	11000	28	5.92	24.40	10.56	195.78	26.20	11.34	199.20	27.55	11.92	201.63	28.40	12.29	203.11
	47.81	11500	31	6.47	20.85	9.02	188.38	22.65	9.80	192.26	24.00	10.38	195.00	24.85	10.75	196.66
	47.81	12000	34.5	7.04	16.77	7.26	178.46	18.57	8.04	183.07	19.92	8.62	186.28	20.77	8.99	188.22
10	57.06	7500	26	2.75	38.81	16.79	218.80	40.61	17.57	221.15	41.96	18.16	222.86	42.81	18.52	223.91
	57.06	9000	26	3.96	37.60	16.27	217.17	39.40	17.05	219.58	40.75	17.63	221.33	41.60	18.00	222.41
	57.06	10000	26	4.89	36.67	15.87	215.89	38.47	16.65	218.35	39.82	17.23	220.13	40.67	17.60	221.23
	57.06	11000	28	5.92	33.64	14.56	211.52	35.44	15.34	214.16	36.79	15.92	216.06	37.64	16.29	217.23
	57.06	11500	31	6.47	30.09	13.02	205.96	31.89	13.80	208.84	33.24	14.38	210.92	34.09	14.75	212.19
	57.06	12000	34.5	7.04	26.02	11.26	198.86	27.82	12.04	202.11	29.17	12.62	204.42	30.02	12.99	205.84
20	80.17	7500	26	2.75	61.92	26.79	243.93	63.72	27.57	245.54	65.07	28.16	246.72	65.92	28.52	247.46
	80.17	9000	26	3.96	60.71	26.27	242.83	62.51	27.05	244.46	63.86	27.63	245.66	64.71	28.00	246.41
	80.17	10000	26	4.89	59.78	25.87	241.96	61.58	26.65	243.62	62.93	27.23	244.84	63.78	27.60	245.59
	80.17	11000	28	5.92	56.75	24.56	239.08	58.55	25.34	240.81	59.90	25.92	242.08	60.75	26.29	242.87
	80.17	11500	31	6.47	53.20	23.02	235.54	55.00	23.80	237.36	56.35	24.38	238.69	57.20	24.75	239.52
	80.17	12000	34.5	7.04	49.13	21.26	231.22	50.93	22.04	233.16	52.28	22.62	234.58	53.13	22.99	235.46
30	103.28	7500	26	2.75	85.03	36.79	262.24	86.83	37.57	263.49	88.18	38.16	264.41	89.03	38.52	264.99
	103.28	9000	26	3.96	83.82	36.27	261.39	85.62	37.05	262.65	86.97	37.63	263.59	87.82	38.00	264.17
	103.28	10000	26	4.89	82.89	35.87	260.73	84.69	36.65	262.00	86.04	37.23	262.94	86.89	37.60	263.53
	103.28	11000	28	5.92	79.86	34.56	258.54	81.66	35.34	259.85	83.01	35.92	260.82	83.86	36.29	261.42
	103.28	11500	31	6.47	76.31	33.02	255.88	78.11	33.80	257.24	79.46	34.38	258.24	80.31	34.75	258.87
	103.28	12000	34.5	7.04	72.24	31.26	252.70	74.04	32.04	254.12	75.39	32.62	255.17	76.24	32.99	255.82

NOTE: THIS SHEET IS A DUPLICATE OF TABLE D-1, EXCEPT 1) NPSHR @ 12,000 gpm IS 34.5' (CONSERVATIVE) AND NO COLUMNS FOR "20 FT TORUS LEVEL"
[initials] 4-4-99

TABLE E-2 RHR PUMPS CLEAN STRAINERS - OTHER EVENTS

Determination of torus temperature vs flow
Conversion of friction loss (Hf) for for new strainers
Clean strainer dP is 2.22 ft@ 10000 gpm and 205.7° F & piping is 2.67 ft @ 10000 gpm and 205.7°F
Using the equation hvap = hst - NPSHR - hf + PA
Friction loss is converted based on the ratio of the flows squared.
thus the Hf at 10000= 4.89 feet H2O is coverted for various flows

Calculate the Hf at various flows using ratios of flows to 2.0 power

Q (GPM)	Q ratio	Hf new ft.	NPSH R
7500	0.5625	2.75	26
9000	0.81	3.96	26
10000	1	4.89	26
11000	1.21	5.92	28
11500	1.3225	6.47	31
12000	1.44	7.04	34

Event	Torus Wetwell Pressure PA		FLOW	NPSHR	Fric Loss	Drawdown Level 13.65 Ft Torus Level			Min Tech Spec Level 14.5 Ft Torus Level		
						Vapor Pressure		TEMP	Vapor Pressure		TEMP
	PSIG	FT (ABS)	GPM	FT	FT	FT	PSIA	deg F	FT	PSIA	deg F
sbo	-2.37442	28.46	10000	26	4.89	~~11.22~~	~~4.86~~	~~161.00~~			
	0	33.95	~~10000~~	~~26~~	4.89	16.71	7.23	178.29			
atws	1.716844	37.92	10000	26	4.89	20.68	8.95	**188.00**			
	4.856	45.17	10000	26	4.89	27.93	12.09	202.30			
fssd	5.433354	46.51	10000	26	4.89				30.12	13.03	**206.00**
	7.463	51.20	10000	26	4.89				34.81	15.06	213.24
iorv	-0.66449	32.41	10000	26	4.89	15.17	6.57	**174.00**			
	0	33.95	10000	26	4.89	16.71	7.23	178.29			

sbo: ~~-2.374419~~ psig or **5.558901** ft

SEE PAGE 43A

atws: **3.139156** psig or **7.372207** ft

fssd: **2.029646** psig or **4.744145** ft

iorv: **0.664492** psig or **1.540009** ft

THIS PAGE FOLLOWED BY ~~TWO~~ THREE PAGES OF REVIEWER'S ALTERNATE COMPUTATION, PAGES 46a & b: c

4-5-99

This page followed by page 46b

E. Other Analyzed Events (cont'd)

SBO SEE PAGE 43A

T	=	**161**	°F	(Ref. 25)
P_v	=	4.855602	psia	(Ref. 10 sat. pressure)
ρ	=	60.972938	lbm/cuft	(Ref. 10 sat. liquid)
h_{pipe}	=	2.67	feet @ 10,000 gpm	(page 9)
h_{st}	=	2.22	feet @ 10,000 gpm	(page 28)
h_s	=	14.5	feet (T.S. min and no drawdown)	(Ref. 11)
P_a	=	**0.0**	psig (no containment overpressure)	(Ref. 14)
NPSHR	=	26	feet @ 10,000 gpm	(page 17)

$$NPSHA = \frac{144(P_a - P_v + 14.696)}{\rho} + h_s - h_{pipe} - h_{st} =$$ **32.85 feet**

$$Margin = NPSHA - NPSHR =$$ **6.85 feet**

$$COPR = \frac{\rho(NPSHR + h_{pipe} + h_{st} - h_s)}{144} + P_v - P_{atm} =$$ **0.00 psig**

ATWS

T	=	**188**	°F	(Ref. 26)
P_v	=	8.946868	psia	(Ref. 10 sat. pressure)
ρ	=	60.389019	lbm/cuft	(Ref. 10 sat. liquid)
h_{pipe}	=	2.67	feet @ 10,000 gpm	(page 9)
h_{st}	=	2.22	feet @ 10,000 gpm	(page 28)
h_s	=	14.5	feet (T.S. min and no drawdown)	(Ref. 11)
P_a	=	**4.856**	psig (containment overpressure)	(Ref. 14)
NPSHR	=	26	feet @ 10,000 gpm	(page 17)

$$NPSHA = \frac{144(P_a - P_v + 14.696)}{\rho} + h_s - h_{pipe} - h_{st} =$$ **34.90 feet**

$$Margin = NPSHA - NPSHR =$$ **8.90 feet**

$$COPR = \frac{\rho(NPSHR + h_{pipe} + h_{st} - h_s)}{144} + P_v - P_{atm} =$$ **1.12 psig**

Rev. 4 Reviewer's Alternate Computation

5

[initials] 4-5-99

This page followed by page 46c

Rev. 4 Reviewer's Alternate Computation

4-5-99

E. Other Analyzed Events (cont'd)

FSSD

T	=	**206**	°F	(Ref. 27)
P_v	=	13.031183	psia	(Ref. 10 sat. pressure)
ρ	=	59.962187	lbm/cuft	(Ref. 10 sat. liquid)
h_{pipe}	=	2.67	feet @ 10,000 gpm	(page 9)
h_{st}	=	2.22	feet @ 10,000 gpm	(page 28)
h_s	=	14.5	feet (T.S. min and no drawdown)	(Ref. 11)
P_a	=	**6.99**	psig (maximum COPL)	(Ref. 14)
NPSHR	=	26	feet @ 10,000 gpm	(page 17)

$$NPSHA = \frac{144(P_a - P_v + 14.696)}{\rho} + h_s - h_{pipe} - h_{st} =$$ **30.39 feet**

$$Margin = NPSHA - NPSHR =$$ **4.39 feet**

$$COPR = \frac{\rho(NPSHR + h_{pipe} + h_{st} - h_s)}{144} + P_v - P_{atm} =$$ **5.16 psig**

IORV

T	=	**174**	°F	(Ref. 26)
P_v	=	6.565627	psia	(Ref. 10 sat. pressure)
ρ	=	60.700586	lbm/cuft	(Ref. 10 sat. liquid)
h_{pipe}	=	2.67	feet @ 10,000 gpm	(page 9)
h_{st}	=	2.22	feet @ 10,000 gpm	(page 28)
h_s	=	14.5	feet (T.S. min and no drawdown)	(Ref. 11)
P_a	=	**0.0**	psig (no containment overpressure)	(Ref. 14)
NPSHR	=	26	feet @ 10,000 gpm	(page 17)

$$NPSHA = \frac{144(P_a - P_v + 14.696)}{\rho} + h_s - h_{pipe} - h_{st} =$$ **28.90 feet**

$$Margin = NPSHA - NPSHR =$$ **2.90 feet**

$$COPR = \frac{\rho(NPSHR + h_{pipe} + h_{st} - h_s)}{144} + P_v - P_{atm} =$$ **0.00 psig**

Rev. 4 Reviewer's Alternate Computation

9/5/99 4-5-99

F. Torus Water Temperature for which Containment Overpressure is not Required (with 700 cuft strainer load)

Calculation PM-1013 extrapolates the torus water temperature profile to determine the time following the design basis LOCA when credit for containment overpressure is no longer required. PM-1013 assumed overpressure is not required for pool temperatures below 170°F. This section of this calculation will confirm that containment overpressure is not required following a design basis LOCA once torus water temperature drops below 170°F

Assumptions

1. RHR pump flow rate is 10,000 gpm maximum
2. Design basis LOCA strainer load of 700 cuft
3. Maximum long term torus water drawdown of 0.60 feet (Reference 1 and bounds all LOCA)
4. No NPSH margin (i.e., NPSHA = NPSHR)

From Table C-1

NPSHR	=	26.00	feet	
h_{pipe}	=	2.67	feet	
$h_{strainer}$	=	4.42	feet	(taken at time = 666 seconds, T_T=150.6°F, which is conservative)
h_s	=	13.94	feet	

$$T_T = T_{sat}\left(P_{atm} - \frac{\rho(T_T)}{144}\left[NPSHR + h_{pipe} + h_{strainer} - h_s\right]\right)_{iterate on T_T} = \quad \mathbf{174.396°F}$$

Thus the assumption made in PM-1013 of no containment pressure required for torus water temperatures below 170°F is confirmed.

PECO ENERGY COMPANY
CALCULATION PM-1013

62 PAGES

THIS PAGE FOLLOWED BY 1 ADDITIONAL PAGE, 1A

Exhibit NE-C-420-1, Rev. 3
Effective Date:

Nuclear Group
Doctype 061

CALCULATION COVER SHEET

1. Calculation No.: PM-1013

2. LGS [ ] PBAPS [X]

3. Unit(s): 2+3

4. Description: MINIMUM CONTAINMENT PRESSURE AVAILABLE

5. Last Page No.: ATTACH 1, PAGE 5

6. Safety Related [X] Non-Safety Related [ ]

7. System/Topic No.: 10, 13, 14, 23, 32, 902, 910, 912

Structure: N/A

Component: 2(3)A(B,C,D)P035, 2(3)0P036, 2(3)A(B,C,D) P037, 2(3)0P033

Record of Revisions

8. Rev. No.	9. Description of Revision	10. Vendor Calc. Number	10. Vendor Calc. Rev.	11. Assumptions YES	11. Assumptions NO	12. Names (Printed & Signed) - with Dates: Preparer	Reviewer	Approver(s)
3	CALCULATION REVISED TO UPDATE SBO EVENT PER ECR PB 99-02104 R.0. IN ADDITION MINOR EDITORIAL CORRECTIONS WERE MADE. ~~AFFECTED PAGES~~ AFFECTED PAGES: 19, 19A (new), +20	N/A			X	GARY W BECKNELL [signature] 2/24/00	K.A. Hudson [signature] 2/25/00	J.F. O'ROURKE [signature] 2/28/00

13. Related Calculation No(s).					
Provides Info. To:	PM-1010	PM-1011			
Receives Info. From:	1187-M-24 R4	PM-0760			
14. Provides Info. To: (UFSAR/Tech.Spec./etc.)	UFSAR SECTION 5.2.4				

15. Manual [X]
Computer [ ]
Computer Program & Version No.:

16. Total Pages: (DS Info. Only)

Exhibit NE-C-420-1, Rev. 3
Effective Date:

Nuclear Group
Doctype 061

CALCULATION COVER SHEET

1. Calculation No.: PM-1013

2. LGS
PBAPS X

3. Unit(s): 2 & 3

4. Description:

Minimum Containment Pressure Available

5. Last Page No.: 58 + 5 pgs attachment

6. Safety Related X
Non-Safety Related

7. System/Topic No.: 10, 13, 14, 23, 32, 902, 910, 912

Structure: NA

Component: 2(3)A(B,C,D)P035, 2(3)0P036, 2(3)A(B,C,D)P037, 2(3)0P033

Record of Revisions

8. Rev. No.	9. Description of Revision	10. Vendor Calc. Number	10. Vendor Calc. Rev.	11. Assumptions YES	11. Assumptions NO	12. Names (Printed & Signed) - with Dates: Preparer	Reviewer	Approver(s)
2	Revised analysis to address short term MCPA, added discussion and presentation of COPL, removed reference to 18247-M-001 in text and replaced with reference to PM-1010 and PM-1011, revised replaced 40°F SW flow with 90°F SW flow for FSSD analysis and updated MCPA results from 5.73 psig to 7.46 psig, added Attachment 8.c to include an evaluation of the two sigma decay heat adder. No revision bars are included due to the extent of the required changes. INCORPS NCR 97-02609, Rev 1				X	[signature] M.W.Idell S&L 2/26/99	[signature] S. Denny 3/8/99 [initials]	[signature] VINOD K. AGGARWAL 9/21/99

13. Related Calculation No(s).					
Provides Info. To:	PM-1010	PM-1011			
Receives Info. From:	11187-M-24, R4				

15. Manual X
Computer
Computer Program & Version No.:

14. Provides Info. To: (UFSAR/Tech.Spec./etc.)	UFSAR Section 5.2.4			

16. Total Pages: (DS Info. Only) 65

1. Purpose / Objective

The purpose of this calculation is to determine the minimum containment pressure available (MCPA) following a design basis large break loss of coolant accident (DBA LG-LOCA). This MCPA will be used by other calculations to demonstrate that there is sufficient ECCS pump net positive suction head (NPSH) margin.

PBAPS Units 2 & 3 are not committed to NRC Safety Guide 1.1, and have always taken credit for containment overpressure. During NRC review and approval of the PBAPS FSAR, the NRC questioned the use of containment overpressure for the DBA LOCA event (Reference Question 6.3 of the PBAPS FSAR). In response to the NRC question, PBAPS provided a curve of the MCPA, which showed a margin between the MCPA and the containment overpressure required for the ECCS pumps to maintain adequate NPSH. Assumptions used in the analysis and described in the text of the question response were chosen to minimize the margin.

This calculation will document the re-analysis of the MCPA expected following a DBA LG-LOCA using the results of the PBAPS Power Rerate containment analysis. In addition, a calculation of the MCPA following a DBA LG-LOCA during containment purge operation is also performed. Associated with the calculation of the MCPA is the establishment of the licensed over pressure credit (COPL) discussed and agreed upon with the USNRC.

Data provided by General Electric for the Post DBA LG-LOCA for the Torus temperature ended at approximately 12 hours following initiation of the event. Temperatures are sufficiently elevated that credit for containment overpressure will be required for some time beyond this interval. This calculation will extrapolate the Torus temperature data provided by General Electric, to assist in determining the point where credit for containment overpressure is no longer required.

At the end of the calculation, an assessment of the MCPA is performed for other events, which require credit for containment overpressure.

ACCEPTANCE CRITERIA

This calculation will determine the MCPA following a DBA LG-LOCA for use in other calculations to determine that adequate NPSH margin exists for the ECCS pumps. As such, there are no specific acceptance criteria for this calculation. The results should be presented in a format, which facilitates the use in other calculations.

IMPACT STATEMENT

This calculation and its results make no impact on the following:

	TRUE	FALSE
Station administrative and implementing procedures, including Surveillance Test procedures	☒	☐
Station operating procedures	☒[1]	☐
Issued Design Basis Documents (DBDs)	☐	☒[2]
Licensing documents (i.e., SAR) **CM-1**	☒	☐
Existing calculations	☐	☒[2]

Explanation of checkmarks is as follows:

[1] This calculation does not depend on any specific operating procedure and supports the use of the plant Transient Response Implementation Program (TRIP) procedures, including use of containment sprays.

2. Changes required to DBDs and existing calculations are addressed in NCR 97-2609, Rev. 1.

2. Summary of Results

The MCPA and COPL available for any ECCS pump NPSH following the DBA LG-LOCA is shown in the following figures. The peak MCPA value of 22.10 psia (7.41 psig) coincides, as expected, with the time of peak Torus temperature of 205.7 °F and peak licensing basis drywell pressure (post blowdown) of 29.60 psia. Similarly, the peak COPL value of 21.69 psia (6.99 psig) coincides, as expected, with the time of peak Torus temperature of 205.7 °F and peak licensing basis drywell pressure (post blowdown) of 29.60 psia.

With the DBA LG-LOCA occurring concurrent with containment purge, sufficient nitrogen is lost from the containment (1091 lbm) to reduce the peak MCPA value to 21.21 psia (6.52 psig) and coincides, as expected, with the time of peak Torus temperature of 205.7 °F and peak licensing basis drywell pressure (post blowdown) of 29.60 psia. This reduction is expected since it lowers the partial pressure contribution of the nitrogen due to the reduced mass, while the partial pressure of the water vapor remains unaffected (a function of containment temperature only). In that the LOCA event concurrent with the purge valves open is not design basis, evaluation and use of COPL to determine the available NPSH is not required. [1]

During the "Other Events", it was determined that Station Blackout and Inadvertent SRV Opening did not require containment overpressure credit. The MCPA during the ATWS event was calculated to be 4.86 psig, and the MCPA during the FSSD event was calculated to be 7.46 psig.

The extrapolation of the Torus temperature shows that the temperature is expected to be below 170°F at approximately 50.4 hours following the beginning of the event.

---

[1] Because plant Technical Specifications do not limit operation of the plant with the purge valves open, the NRC requires that an analysis be performed to demonstrate the plants capability to safely mitigate a Lg-LOCA and shutdown with offsite dose below 10CFR100 limits. Adequate NPSH is one factor of that assessment. However, a Lg-LOCA during purge operation is beyond the design basis of the plant. As such, it is acceptable to merely show margin to the true available pressure (MCPA) rather than the licensed limit of containment pressure credit (COPL).

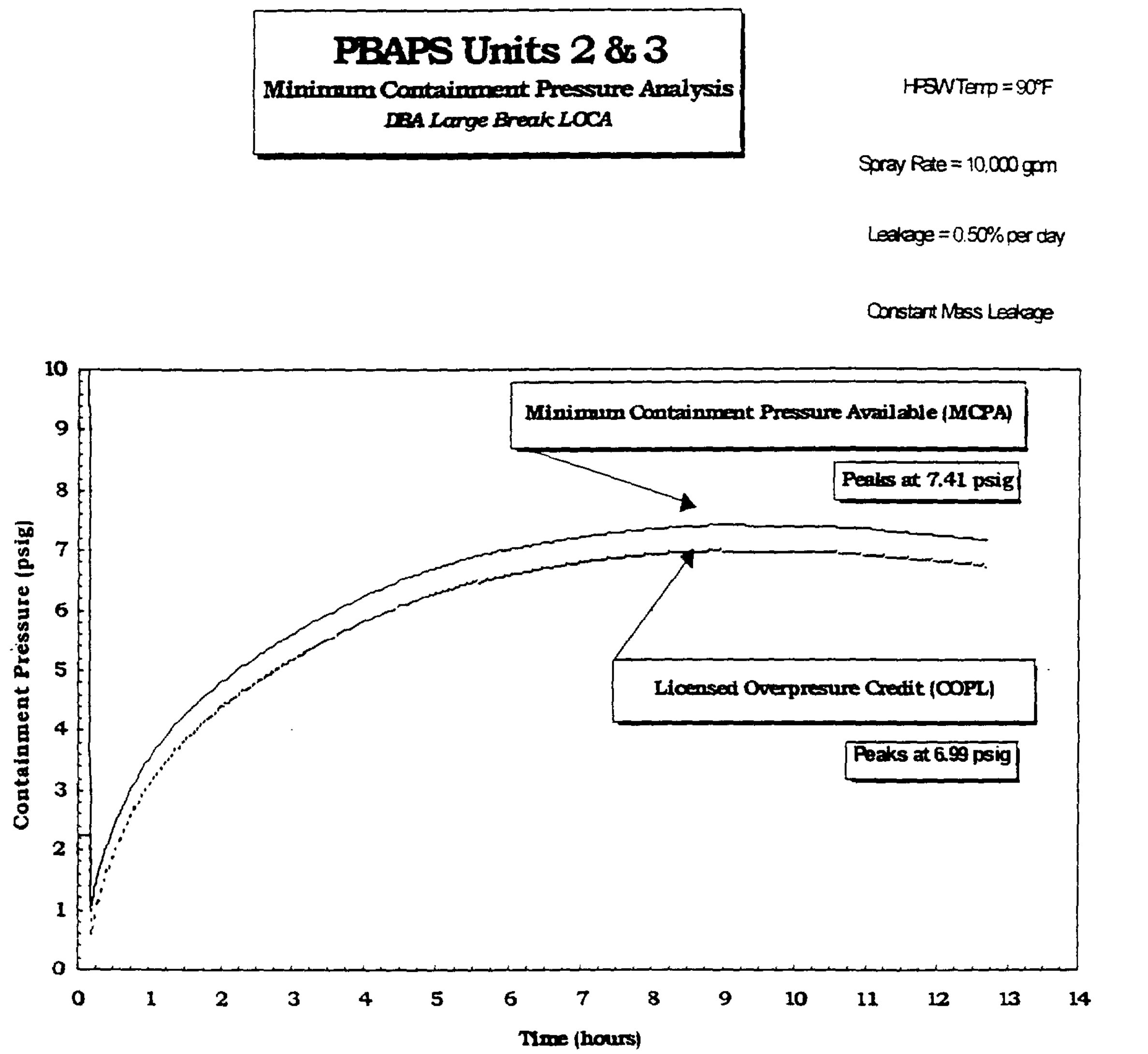


Figure 1 – Minimum Containment Pressure Available Following a DBA LOCA– No Containment Purge

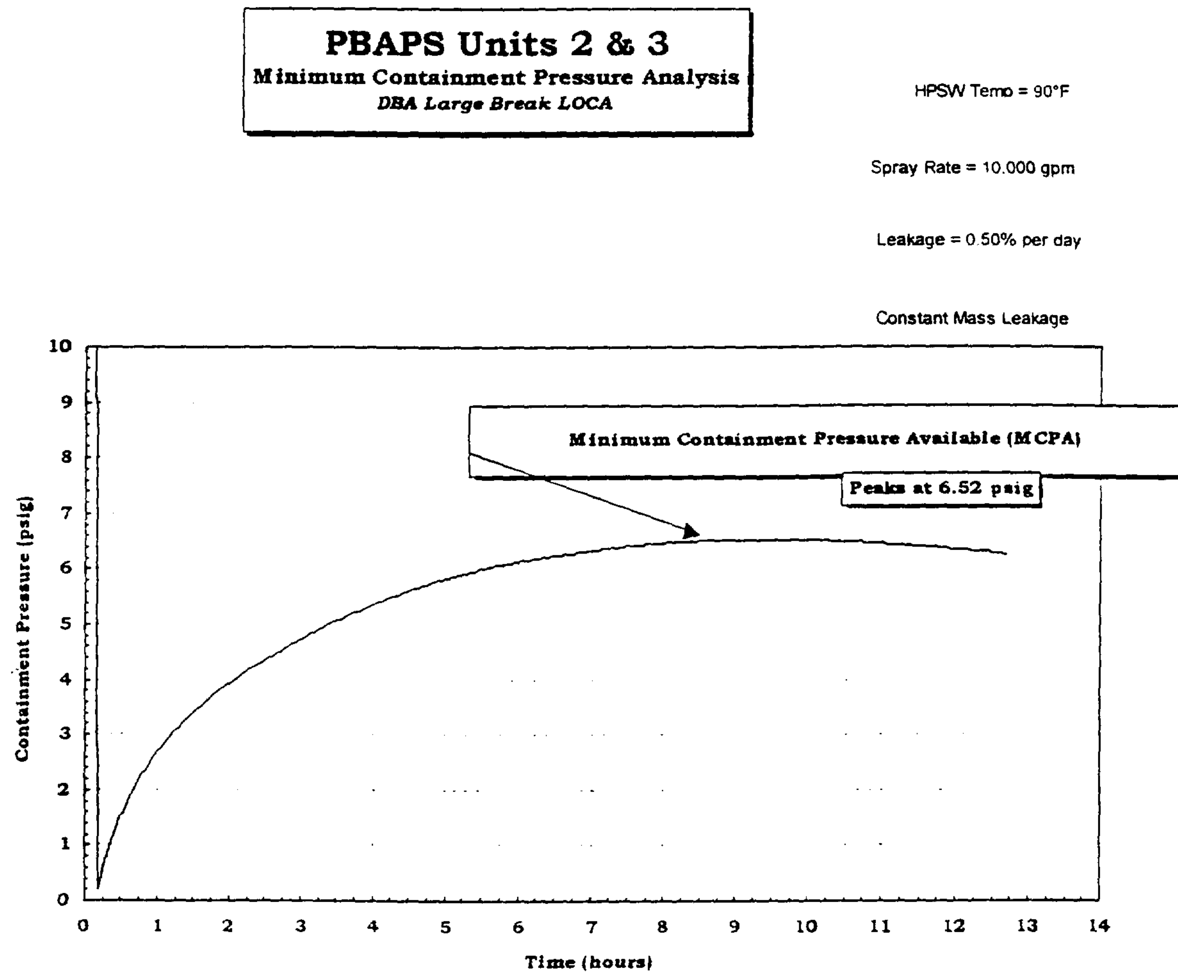


Figure 2 – Minimum Containment Pressure Available Following a DBA LOCA– Containment Purge in Progress [2]

[2] Reference to COPL is not appropriate for this beyond-design–basis event analysis see Footnote 1 on page 3.

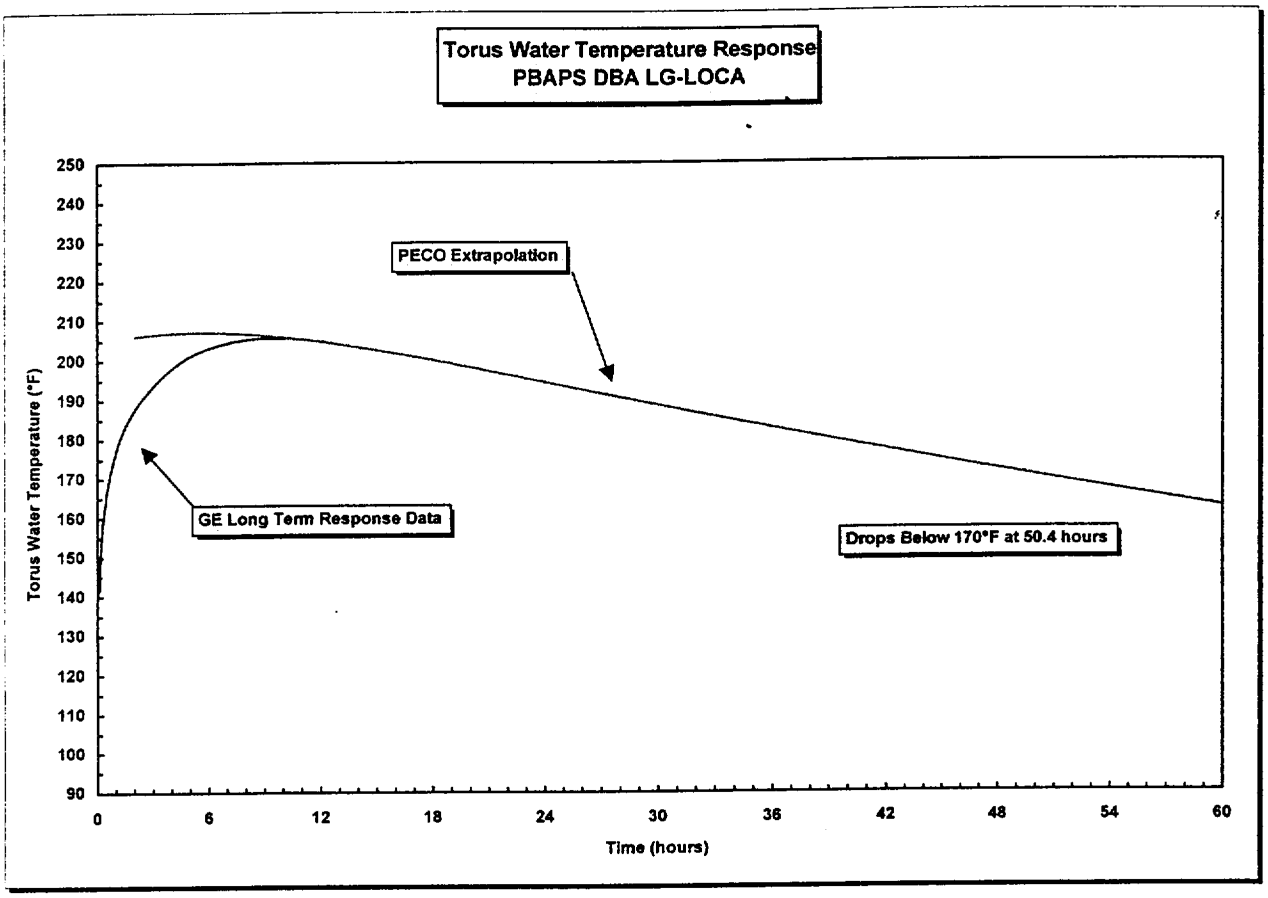


Figure 3 - Torus Temperature Extrapolation

REVIEWER'S COMMENT

FROM OBSERVATION OF ATTACHMENT 8A AND AT TIME = 666 SECONDS, COPL = 0.62 psig AT T_{sp} = 150.6°F. THUS COPL RETURNS TO ZERO WHEN THE TORUS WATER TEMP. DROPS BELOW 150°F. (CONTAINMENT LEAKAGE OF 0.5% PER DAY, WHICH DOES NOT SIGNIFICANTLY IMPACT MCPA, IS COMPENSATED FOR BY THE +0.62 PSIG. THIS IS ENGINEERING JUDGEMENT.) THE PECO EXTRAPOLATION DROPS BELOW 150°F AT 78 HOURS. THUS COPL EXTENDS TO 78 HOURS.

[signature]
3-8-99

3. Design Input / Criteria

Constants			Reference
Patm	14.69598677	psia	6.L
	7.480519481	gal/cuft	6.L
R (Nitrogen)	55.2	ft-lbf/lbm-°R	6.M
To	459.67	°R	6.L

Inputs	Drywell	Wetwell		Reference
RHR SPC/Spray Flowrate		***10,000***	gpm	6.B, 5.J.xiv
RHR Hx Ueff		**216.52**	BTU/hr-sqft-°F	6.B, 5.J.ix
RHR Hx Area		***5851***	sqft	6.B, 5.J.ix
RHR Hx MTD Correction Factor		**0.977**	(unitless)	6.B, 5.J.ix
HPSW Flowrate		**4500**	gpm	6.T
HPSW Temperature		**90**	°F	6.B, 5.J.viii
Airspace Volume	**175,800**	**127,700**	cuft	6.A, 5.J.i
Initial Temperature	**145**	**95**	°F	6.B, 5.J.iii
Initial Pressure	**0.00**	**0.00**	psig	5.J.ii
Initial Relative Humidity	**100%**	**100%**		5.J.iv
Initial Containment Purge		**1091**	lbm N2	6.V
Containment Leakage (v/o)		***0.5%***	per day	5.J.x

In addition, the containment temperature (T_L) and pressure (P_L) used to calculate the constant mass leakage rate is 95°F and 15 psig, respectively.

4. Computer Calculation

NA. Although this calculation uses the results of a GE computer run, and process all input values using a spreadsheet developed by the Originator, this calculation is treated as a manual calculation.

5. Assumptions and Identified Facts

The following assumptions are made in performing this calculation, all of which are conservative and none of which require any verification. In addition, various facts are identified for clarification.

5.A. The event analyzed is the DBA LG-LOCA, which assumes a complete guillotine break of a recirculation pump suction line. The event is modeled because it results in the hottest torus water temperature, compared to an intermediate or small line break.

5.B. Reactor blowdown mass and energy release is not re-evaluated. Instead, the temperature profile of the torus water and drywell pressure is used as the driving force for the evaluation. This is acceptable because the Rerate analysis that generated the profile included various conservative assumptions that tend to predict maximum pool temperatures, which is also conservative in our consideration of ECCS pump NPSH. For the first 10 minutes of the event before the containment sprays are initiated, the torus air space pressure is assumed to be the drywell pressure. This is specifically not conservative but is considered acceptable due to the magnitude of the drywell pressure.

5.C. Pump flow rates during the first 10 minutes of the event are assumed to be at pump runout.

5.D. After the initiation of the event at time = 0, containment spray is assumed to be initiated at 10 minutes (time = 600 seconds). This time delay is considered sufficient account for vessel reflood and to provide time for the operators to align RHR from the LPCI to the containment cooling mode. As such, this evaluation does not consider cooling water flow to the RHR heat exchanger until 10 minutes after initiation of the event.

5.E. At 10 minutes after the initiation of the event, the containment sprays are assumed to be initiated by the operator.

5.F. The "system" is considered quasi-steady state. This is conservative because the time of peak torus water temperature occurs hours after initiation of the event. The dynamics of the blowdown and mass/energy/momentum conservation are of significance only early in the event when things are happening rapidly. At the time of concern (peak pool temperature), things are happening relatively slowly.

5.G. Heat removal from the containment is independent of the point of return of torus cooling water, i.e., whether returned directly to the torus or via containment sprays. This is consistent with statements made in the UFSAR for PBAPS. Thus use of sprays does not alter the torus water temperature profile as developed by GE.

5.H. The time assumed for the initiation of sprays is early in the event such that the containment atmosphere is at the same temperature as the spray water. This also assumes that the sprays are 100% efficient and sufficient for the containment size. This assumption is conservative in that, if undersized or less efficient, the containment atmosphere would be at a higher temperature than the sprays and thus the containment pressure would also be higher.

5.I. As a quasi-steady state system, with the temperature profile already computed using the GE SHEX code, evaluation of containment environment parameters can be performed for any point in time irrespective of any prior (or later) point in time. No differential or integral equations are necessary.

5.J. Values for input parameters are used which will tend to result in hot torus water temperatures and minimum containment pressures, in that order of preference. Following this guidance, the following inputs are used:

5.J.i. The containment air volume, taken from PBAPS UFSAR Table 5.2.1, is assumed at the maximum values. This assumption, although resulting in a greater initial mass of non-condensables (NCs), results in a smaller increase in pressure as a result of increasing containment pressure. This was confirmed by changing the input to the smaller containment values and confirming that the margin increased.

5.J.ii. Initial containment pressure is assumed at 0.0 psig instead of 0.75 used in the maximum containment pressure analyses. This assumption is consistent with the original MCPA analysis and results in less mass of

NCs and thus smaller containment pressures.

5.J.iii. Initial containment temperature is assumed at the Tech. Spec. maximum allowables of 145°F in the drywell and 95°F in the torus. This assumption again results in less mass of NCs. This assumption is consistent with the licensing analyses, which assumed these values because they result in higher peak (short-term) containment temperatures and thus higher peak (short-term) containment pressures.

5.J.iv. Initial containment airspace relative humidity of 100% for both the drywell and the torus. This assumption again results in less mass of NCs. The licensing analyses used a relative humidity in the drywell of 20%, giving more mass of NCs and thus (slightly) higher peak pressures.

5.J.v. Deleted.

5.J.vi. No credit is taken for generation and release of non-condensables from the reactor vessel.

5.J.vii. Deleted.

5.J.viii. Service water temperature is assumed at 90°F, consistent with the current licensing analyses. Although a lower temperature would result in lower containment pressure, it would also yield lower torus water temperatures. The following sensitivity study confirms use of higher service water temperatures is conservative:

The existing analysis uses a service water temperature of 90°F and yielded a maximum pool temperature of 206°F for the 102% of 110% of original power and 10,000 gpm RHR flowrate (non-PERFORM).

GE has provided PECO with a letter stating that a change in service water temperature of 5°F (increase to 95°F) conservatively would increase the peak pool temperature by NO GREATER THAN 5°F. The negative of this is thus also true, that a decrease in service water temperature of 5°F (to 85°F) will drop the peak pool temperature NO GREATER THAN 5°F.

At a hot inlet temperature of 206°F and a service water temperature of 90°F, the hot exit will be NO LESS THAN 183.4°F. With a decrease in service water temperature of 85°F, GE states that the peak pool temperature will be NO LESS THAN 201°F, and the hot exit will be NO LESS THAN 179.7°F. This decrease in spray temperature (and thus containment temperature) from 183.4°0F to 179.7°F results in a decrease in available overpressure from 21.90 psia to 21.19 psia, or 0.71 psi. However, the decrease in peak pool temperature also results in a decrease in required overpressure due to the drop of saturation pressure from 13.03 psia to 11.77 psia, or 1.26 psi. This confirms that hot service water is conservative, with respect for minimum containment pressure analysis, for the DBA LOCA event.

5.J.ix. The RHR heat exchanger effective surface area used in determining the spray temperature is the same as the value used in the GE analysis for pool temperature heatup. This value is conservatively low and assumes 5% tubes plugged. Low values for this parameter result in higher pool temperatures, which is conservative, but also results in higher containment pressures, which is non-conservative. However, for the same change in this parameter, the net impact is that low values of this parameter are conservative for safety system NPSH concerns, and thus conservative for this analysis.

5.J.x. Containment leakage is assumed at the rate of 0.5% per day by volume. Results of the analysis have indicated that this has a minor impact on available overpressure. It is also conservatively assumed that only the nitrogen leaks. Similarly, only nitrogen is assumed to be expelled during the evaluation of MCPA with the purge valves open.

5.J.xi. It is assumed that the drywell and wetwell airspaces are connected by a large opening such that they are one volume. This is conservative since the wetwell pressure cannot become greater than the drywell pressure by any appreciable amount due to the vacuum breakers. This assumption ~~results~~ allows as much return of NCs to the drywell as is required to balance pressures.

5.J.xii. Deleted.

5.J.xiii. Deleted

5.J.xiv. PECO Calculation 11187-M-08 indicates a maximum spray flow rate of 9,350 gpm, instead of the

10.000 assumed in this calculation. The design basis flow required for torus cooling remains 10.000 gpm. Use of 9.350 gpm has little impact on the margin calculated herein (approximately 0.02 psid).

5.J.xv. Deleted

5.K The effort to resolve the issues associated with the NRC Bulletin 97-04. have lead to discussions with the USNRC. These discussions have resulted in the need to establish a Licensing limit to the containment overpressure credited. The Licensed Overpressure Credit (COPL) is established as 2.25 psig for the short term (time from event initiation to approximately 10 minutes) and the MCPA less 0.42 psi for the long term (greater than 600 seconds). At 10 minutes, the operators are assumed to realign the RHR system, initiate the HPSW system, and control system flows. The specific value 0.42 psi (1 ft margin at maximum Torus temperature 205.7°F) was established to provide sufficient operational flexibility yet provide a reasonable licensing limit.

6. References

6.A PBAPS UFSAR Table 5.2.1

6.B NE-163-3 "Peach Bottom Power Rerate Project Engineering Report"

6.C PECO Calculation 18247-M-30 "RHR Pumps NPSH Post LOCA"

6.D PECO Calculation 18247-M-29 "Core Spray [Pump] NPSH Post LOCA"

6.E PECO Calculation 18247-M-31 "HPCI System NPSH Following a LOCA"

6.F PECO Calculation 18247-M-32 "RCIC System NPSH Following a LOCA "

6.G PECO Calculation PM-1010 "RHR Pump NPSH"

6.H PECO Calculation PM-1011 "Core Spray Pump NPSH"

6.I Pump Curves M-1-U-283 through 286, 293 through 296, 419 through 426, 430 through 437, and M-1-JJ-49

6.J Drawing S-51 "Containment Vessels - Requirements"

6.K EAS 10-0289 "Peach Bottom Suppression Pool Drawdown"

6.L ASME Steam Tables (fifth edition)

6.M Crane Technical Paper No. 410 (25th printing)

6.N Hydraulic Institute Standards (13th edition)

6.O Standards of the Tubular Exchanger Manufacturers Association (TEMA) (7th edition)

6.P Attachment 1 to PECO NCR 95-05708 "PBAPS Safe S/D Analysis"

6.Q PECO Calculation 18247-M-001 "Maximum Torus Temp. For The ECCS System."

6.R PECO Calculation PM-760 "Power Rerate Evaluation - SBO Analysis"

6.S NEDC-24380-P "PBAPS 2 & 3 Suppression Pool Temperature Response"

6.T M-1-DD-9 "Process Diagram RHR System"

6.U PECO Calculation 11187-EC-017-0101 "Pressure Drops Core Spray Strainers Across the RHR and "

6.V PECO Calculation 18247-M-24 Rev.4 (Containment Purge N2 loss)

6.W GE-NE-T23-00765-00 Rev. 0, "Peach Bottom Containment Analysis Two Sigma Adder Evaluation", Dated November 1998 (Attached – See Attachment 8.D)

6.X 11187-ME-17, Rev. 9, "Reactor Building Temperature Curves – Post LOCA"

6.Y Mechanical Engineering Reference Manual - Tenth Edition, Michael Lindeburg

6.Z Marks' Standard Handbook for Mechanical Engineers – Eighth Edition, Baumeister Avallone Baumeister

7. Calculation

A simplified model of the PBAPS containment is used. Initial conditions are assumed that tend to decrease the margin between the MCPA and the required OP for the DBA LG-LOCA analysis.

CONVERSION FACTORS AND CONSTANTS USED

P_{atm}	Conversion factor - psig to psia	14.6959
G	Conversion factor - U.S. gallons per cubic foot	1728 / 231
R_a	Ideal gas constant for nitrogen (ft-lbf/lbm-°R)	55.2
T_a	Conversion factor - °F to °R	459.67

INPUT PARAMETERS AND VARIABLES USED

Note: A subscript "i" denotes the initial condition value for the variable.

t	Time from initiation of the event (seconds)	
$T_T(t)$	Torus water temperature at time t (°F)	
V_d	Volume (airspace) of the drywell (cuft)	175,800
V_w	Volume (airspace) of the wetwell (cuft)	127,700
V	Total containment volume (cuft)	
P_d	Atmospheric Pressure in the drywell (psig)	
P_w	Atmospheric Pressure in the wetwell (psig)	
T_d	Atmospheric Temperature in the drywell (°F)	
T_w	Atmospheric Temperature in the wetwell (°F)	
RH_d	Relative Humidity of the drywell atmosphere (%)	
RH_w	Relative Humidity of the wetwell atmosphere (%)	
$P_{sat}(T)$	Saturation pressure of water for a given temperature (psia)	
Pv_d	Partial pressure of water vapor in the drywell airspace (psia)	
Pv_w	Partial pressure of water vapor in the wetwell airspace (psia)	
Pa_d	Partial pressure of nitrogen in the drywell airspace (psia)	
Pa_w	Partial pressure of nitrogen in the drywell airspace (psia)	
Ma_d	Mass of nitrogen in the drywell airspace (lbm)	
Ma_w	Mass of nitrogen in the wetwell airspace (lbm)	
Ma	Total mass of nitrogen in containment (lbm)	
Mp	Total mass of nitrogen purged from containment during blowdown (lbm)	

Lv	Volumetric leakage rate of nitrogen (% per day by volume)	0.5%
Lm	Mass leakage rate of nitrogen (lbm/sec)	
P_l	Conservatively high pressure for computing Lm (psig)	15
T_l	Conservatively low temperature for computing Lm (°F)	95
U	RHR heat exchanger overall coefficient of heat transfer (BTU/hr-sqft-°F)	216.52
A	RHR heat exchanger effective tube surface area (sqft)	5851
LMTD	RHR heat exchanger log-mean temperature difference (°F)	
F	RHR heat exchanger mean temperature difference correction factor (unitless)	0.977
Q_R	RHR containment cooling flow rate through the heat exchanger (gpm)	10,000
Q_S	HPSW flow rate through the RHR heat exchanger (gpm)	4500
T_S	HPSW cooling water temperature (°F)	90
M_S	HPSW mass flow rate through the RHR heat exchanger (lbm/sec)	
$Cp_S(T_S)$	Specific heat at constant pressure for the HPSW (BTU/lbm °F)	
$M_R(T_R)$	RHR mass flow rate through the RHR heat exchanger (lbm/sec)	
$Cp_R(T_R)$	Specific heat at constant pressure for the RHR (BTU/lbm °F)	
P_0	Total containment pressure (psig)	
$v_f(T)$	Specific volume of water at the given temperature (cuft/lbm)	

EQUATIONS USED - MCPA

Constants

$$V = V_d + V_w$$ **Equation 1**

$$Lm = \frac{144 * (P_L + P_{atm}) * Lv * V}{24 * 3600 * R_a * \left(T_L + T_0\right)}$$ **Equation 2**

$$M_S = \frac{Q_S}{60 * G * v_f(T_s)}$$ **Equation 3**

Initial Conditions

$$Ma_{d_i} = \frac{144 * \left(P_{d_i} + P_{atm} - RH_{d_i} * P_{sat}(T_{d_i})\right) * V_d}{R_a * \left(T_{d_i} + T_0\right)}$$ **Equation 4**

$$Ma_w = \frac{144*\left(P_w + P_{atm} - RH_w * P_{sat}(T_w)\right)*V_w}{R_a*\left(T_w + T_0\right)}$$ **Equation 5**

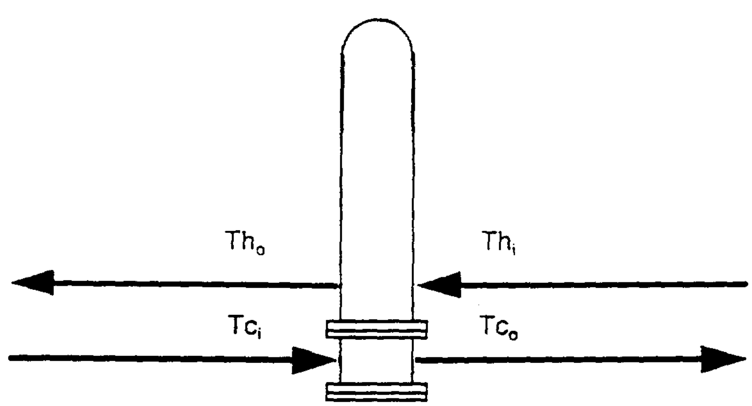
$$Ma_i = Ma_{d_i} + Ma_{w_i}$$ **Equation 6**

Once initial conditions are determined, conditions at any subsequent time can be determined, independent of conditions since the initiation of the event. This is founded in the conservative assumption that the containment sprays are sized such that they can completely control the containment environment and the containment environment will be at the temperature of the sprays.

Given a time = t, and a torus water temperature for that time of $T_T(t)$ as provided in Reference 6.B:

$$M_R = \frac{Q_R}{60*G*v_f(T_T)}$$ **Equation 7**

We know the temperature of the hot and cold water entering the RHR heat exchanger, Thi, and Tci, respectively. We need to determine the temperature of the hot water exiting the heat exchanger. We can either guess at a LMTD or use the LMTD determined for the previous time step, and use this as an initial value for LMTD, then iterate until exit temperatures and LMTD are consistent.



$$HX = M_R * Cp_R * (Th_i - Th_o)$$
$$= M_S * Cp_S * (Tc_o - Tc_i)$$ **Equation 8**
$$= U * A * LMTD_0 * F$$

Although F is dependent on the results, it does not change significantly and a conservative value can be chosen as a constant. Thus the iteration is simple, guess a value for $LMTD_0$, calculate the heat transferred, HX, then calculate the exit temperature for the hot side, Th_o. A value for the exit temperature of the cold side can also be calculated, but is not important in our analysis.

$$Th_o = Th_i - \frac{U * A * F * LMTD_0}{M_R * Cp_R}$$

Equation 9

$$Tc_o = Tc_i + \frac{U * A * F * LMTD_0}{M_S * CP_S}$$

where,

$$LMTD_0 = \frac{GTD - LTD}{\ln\left(\frac{GTD}{LTD}\right)}$$

Equation 10

$$GTD = Th_o - Tc_i$$

$$LTD = Th_i - Tc_o$$

Assuming the containment spray capacity is oversized for the containment, the containment temperature will be that of the spray water, Th_o. The sprays also ensure the atmosphere in the containment is saturated. Since we know the initial mass of nitrogen and the (constant) mass leakage of nitrogen, we can determine the atmospheric conditions in the containment.

Equation 11

$$Ma = Ma_i - Lm * t - Mp$$

Equation 12

$$Pv = P_{sat}(Th_o)$$

Equation 13

$$Pa = \frac{Ma * R_a * (Th_o + T_0)}{144 * V}$$

Equation 14

$$MCPA = Pv + Pa - P_{atm}$$

The above equations provide us with a conservative profile for the minimum containment pressure available following an evaluated event, such as the DBA LG-LOCA. The "forcing function" for this evaluation is the temperature profile for the torus water. Other events can be evaluated in similar fashion provided a temperature profile for the torus water is available.

Computation of all parameters is simple and straightforward, given input values and using the above equations. A spreadsheet is used for the computations. Inputs to the spreadsheet are provided in Section 3 above. Sample calculations are provided below and confirm the spreadsheet results. Printout from the spreadsheet is provided as Attachment 1.

EQUATIONS USED - TORUS TEMPERATURE EXTRAPOLATION

$$Mc_p\,(dT/dt) = Q_A\,(t) - C(T - 90)$$

where,

C = Heat Removal Rate of RHR Hx (GE Number)

90 = HPSW Temperature

$Q_A(t)$ = Decay Heat + Pump Work

$Q_A(t) = Q_o e^{-\lambda t} + P$

Assume $Q_o e^{-\lambda t} >> P$ for t small

i.e. P is considered negligible

$$Mc_p\,(dT/dt) = Q_o e^{-\lambda t} - C(T - 90)$$

$$(dT/dt) + (C/Mc_p)\,T = (Q_0/Mc_p)e^{-\lambda t} + (90C/Mc_p)$$

$$(dT/dt) + \gamma T = \beta e^{-\lambda t} + 90\gamma$$

where:

$$\gamma = (C/Mc_p)$$

$$\beta = (Q_0/Mc_p)$$

Homogeneous Solution: $T_h = Ae^{-\gamma t}$

Particular Solution: $T_p = Be^{-\lambda t} + D$

Total Solution: $T(t) = Ae^{-\gamma t} + Be^{-\lambda t} + D$

$$(dT/dt) = -\gamma Ae^{-\gamma t} + \lambda Be^{-\lambda t}$$

From this differential equation:

$$(dT/dt) + \gamma T = \beta e^{-\lambda t} + 90\gamma$$

$$(-\gamma Ae^{-\gamma t} - \lambda Be^{-\lambda t}) + \gamma\,(Ae^{-\gamma t} + Be^{-\lambda t} + D) = \beta e^{-\lambda t} + 90\gamma$$

$$-\lambda Be^{-\lambda t} + \gamma Be^{-\lambda t} + \gamma D = \beta e^{-\lambda t} + 90\gamma$$

$e^{-\lambda t}$ terms: $(\gamma - \lambda)B = \beta$ or $B = \beta/(\gamma - \lambda)$

Constants: $\gamma D = 90\gamma$ or $D = 90$

$$T(t) = Ae^{-\gamma t} + [\beta/(\gamma - \lambda)]e^{-\lambda t} + 90$$

Sample Calculations

CONSTANTS

Vd	=			175,800 cuft
Vw	=			127,700 cuft
V	=	175,800 + 127,700	=	303,500.00 cuft
Lv	=			0.5% per day
P_L	=			15 psig
T_L	=			95 °F
Lm	=	$\frac{144*(15+14.69598677)*0.5\%*303,500.00}{24*3600*55.2*(95+459.67)}$	=	0.00245 lbm/sec
Qs	=			4500 gpm
T_s	=			90 °F
v_{fs}	=			0.016098759 cuft/lbm
Ms	=	$\frac{4500}{60*7.480519481*0.016098759}$	=	622.7835 lbm/sec
Cp_s	=			0.9980 BTU/lbm °F

INITIAL CONDITIONS

Pd	=	0.00 psig		
Td	=	145 °F		
RHd	=	100%		
Mad.	=	$\frac{144*(0.00+14.69598677-100\%*Psat(145))*175,800}{55.2*(145+459.67)}$	=	8,657.19 lbm
Pw	=	0.00 psig		
Tw	=	95 °F		
RHw	=	100%		
Maw_i	=	$\frac{144*(0.00+14.69598677-100\%*Psat(95))*127,700}{55.2*(95+459.67)}$	=	8,336.61 lbm
Ma_i	=	8,657.19 + 8,336.61	=	16,993.80 lbm

TIME STEP SAMPLE CALCULATION

t	=	18,045.52	seconds
T_T	=	201.2 °F	
vf(TT)	=	0.016645	cuft/lbm
Cp_s	=	1.00530BTU/lbm °F	
M_R	=	$\frac{10,000}{60*7.480519481*0.016645}$ = 1,338.5	lbm/sec

Thi = 201.20°F
Tci = 90.00 °F

Guess an LMTD.

$LMTD_{guess}$ = 78.77 °F

$$Tho = 201.20 - \frac{216.52 * 5851 * 0.977 * 78.77}{1,338.56 * 1.00530 * 3600} = 180.66\ °F$$

$$Tco = 90.00 + \frac{216.52 * 5851 * 0.977 * 78.77}{622.7835 * 0.9980 * 3600} = 134.46\ °F$$

GTD = 180.66 - 90.00 = 90.74 °F
LTD = 201.20 - 134.74 = 66.74 °F

$$LMTD = \frac{90.74 - 66.74}{\ln(90.74 / 66.74)} = 78.09°F$$

Comparison of LMTD with $LMTD_{guess}$ shows that our original guess was appropriate. Our containment environment temperature is then no less than the spray temperature of 181.07°F.

With the previously calculated nitrogen mass loss due to initial containment purge operations, with the assumed constant nitrogen mass loss due to leakage, we can calculate our nitrogen mass in the containment as.

Mp = 0 lbm (no containment purge)

Ma = 16.993.80 - 0.00245 * 18.045.52 - 0= 16.949.53 lbm

$$Pa = \frac{16,949.53 * 55.2 * (181.07 + 459.67)}{144 * 303,500.00} = 13.7170\ psia$$

$P_{sat}(Temp)$ = 7.6918psia

MCPA = 7.6918 + 13.7170 - 14.69598677 = 6.7128 psig

TORUS TEMPERATURE EXTRAPOLATION

Coefficients for the earlier equations will be determined now.
From GE supplied Torus temperature profile:

t_1 = 39,047.27 seconds T_1 = 205.4°F

t_2 = 43,377.02 seconds T_2 = 204.7°F

t_3 = 45,533.77 seconds T_3 = 204.3°F

Note: These points were chosen arbitrarily, late in the event because that is the timeframe that we are interested in. Since temperature is changing slowly, a wider time span is used to get a little more ΔT and thus increased accuracy.

$$\left.\frac{dT}{dt}\right|_{t_1} = \frac{T_2 - T_1}{t_2 - t_1} = (dT/dt)_1$$

From the differential equation:

$$Mc_p \left.\frac{dT}{dt}\right|_{t_1} = Q_0 e^{-\lambda t1} - c(T_1 - 90)$$

$$\left.\frac{dT}{dt}\right|_{t_2} = \frac{T_3 - T_2}{t_3 - t_2} = (dT/dt)_2$$

$$Mc_p \left.\frac{dT}{dt}\right|_{t_2} = Q_0 e^{-\lambda t2} - c(T_2 - 90)$$

$$Q_0 = [Mc_p(dT/dt)_1 + c(T_1 - 90)]e^{+\lambda t1} = \omega_1 e^{+\lambda t1}$$

$$Q_0 = [Mc_p(dT/dt)_2 + c(T_2 - 90)]e^{+\lambda t2} = \omega_2 e^{+\lambda t2}$$

where:

ω_1 and ω_2 are known from the data points

$1 = (\omega_1 / \omega_2)e^{-\lambda(t2-t1)}$ or $(\omega_1 / \omega_2) = e^{+\lambda(t2-t1)}$

$\lambda(t_2 - t_1) = \ln(\omega_1 / \omega_2)$ or $\lambda = \ln(\omega_1 / \omega_2) / (t_2 - t_1)$

Finally:

$$Q_0 = \omega_1 e^{\lambda t1}$$

and:

$$A = [T_1 - 90 - Be^{-\lambda t1}]e^{-\gamma t1}$$

THIS PAGE FOLLOWED BY 1 ADDITIONAL PAGE, 19A

Other Analyzed Events

Other analyzed events that may require credit for containment overpressure are Station Blackout, ATWS, Fire Safe Shutdown (FSSD), and Inadvertent Open Relief Valve (IORV). Design Basis Document P-T-12, Table T2.1-12-1 provides a list of events, which require containment cooling mode of RHR. The IORV event is chosen to bound all anticipated operational occurrences and abnormal operational transients.

This section will assess the MCPA to ensure that an assessment of margin can be performed within Calculations PM-1010 and PM-1011 (References 6.G and 6.H, respectively). For each of these events, a time-dependent temperature profile for the torus water is not available. Instead, the peak torus water temperature is provided. Comparison of the minimum margin calculated for the DBA LG-LOCA and the margin at the peak torus water temperature indicates that the minimum margin is less than the margin at the peak temperature by less than 1 percent. In other words, it has been observed that the minimum margin between MCPA and the pump required containment overpressure (COPR) for the DBA-LOCA occurs at some small time after the peak torus water temperature, see Attachments 8.A & 8.B. It has been also observed that the "true" minimum margin was less than a margin calculated at the peak pool temperature by no more that 1%.

If the time of the peak pool temperature is unknown (for evaluating total nitrogen leakage), a conservative time of 28800 seconds will be used.

If the events maximum Torus temperature exceeds the point at which NPSH margin requires credit for containment overpressure, an evaluation of MCPA will be performed as required to verify that adequate available containment pressure is available.

STATION BLACKOUT SEE PAGE 19A

Peak torus water temperature for the PBAPS SBO event is calculated in PM-760 (Reference 6.R) as 161°F at 15300 seconds. Calculations PM-1010 and PM-1011 (References 6.G and 6.H, respectively) provide torus water temperatures for each ECCS/RCIC pump above which containment overpressure credit is required. The peak torus water temperature calculated for the SBO event (161°F) is well below temperatures where containment overpressure credit is required.

Therefore, an evaluation of available containment pressure is not required for the SBO event.

ATWS

Peak torus water temperature for the PBAPS ATWS event is calculated in Reference 6.B as 188°F at 3300 seconds. Calculation PM-1010 and PM-1011 (References 6.G and 6.H, respectively) provide torus water temperatures for each ~~ECCS/RCIC~~ RHR and Core Spray pump above which containment overpressure credit is required. Since the peak torus water temperature for the ATWS event (188°F)is greater than the temperatures provided in PM-1010 and PM-1011 (References 6.G and 6.H, respectively), containment overpressure credit is required.

Therefore, an evaluation of available containment pressure is required for the ATWS event.

The analytical method used for the ATWS event analysis is identical to that used for the DBA LG-LOCA analysis, with the exception that time-based pool temperatures are not provided for the ATWS event, only peak pool temperatures. Although using the DBA-LOCA containment temperature profile introduces a small error (≈ 1% see the second paragraph of Other Analyzed Events), there are sufficient conservatism's associated with the calculational methodology and with the input data values to bound this small error. As such, the results are considered acceptable and conservative.

STATION BLACKOUT

Torus water temperature for the PBAPS SBO event is calculated in PM-760 (Reference 6.R) and remains less than 180 °F for the required 8 hour coping period. Calculations PM-1010 and PM-1011 (References 6.G and 6.H. respectively) provide torus water temperatures for the RHR and Core Spray pumps above which containment overpressure credit is required. A torus water temperature of 180 °F is less than the temperature where containment overpressure credit is required.

Therefore, an evaluation of available containment pressure is not required for the SBO event.

The analysis is detailed on the following spreadsheet printout. The MCPA determined was 4.86 psig.

FSSD

Peak torus water temperature for the PBAPS FSSD event is calculated in Reference 6.P as 206°F at 28800 seconds. Calculations PM-1010 and PM-1011 (References 6.G and 6.H, respectively) provide torus water temperatures for each ~~ECCS/RCIC~~ RHR and Core Spray pump above which containment overpressure credit is required. Since the peak torus water temperature for the FSSD event (206°F) is greater than the temperatures of PM-1010 and PM-1011 (References 6.G and 6.H, respectively), containment overpressure credit is required.

Therefore, an evaluation of available containment pressure is required for the FSSD event.

Initial containment parameters are identical to those used in the DBA LG-LOCA analysis. Service water temperature for pool and spray cooling is assumed at 90°F.

The analytical method used for the FSSD event analysis is identical to that used for the DBA LG-LOCA and ATWS analyses, with the exception that time-based pool temperatures are not provided for the FSSD event, only peak pool temperatures. Although using the DBA-LOCA containment temperature profile introduces a small error (≈ 1% see the second paragraph of Other Analyzed Events), there are sufficient conservatism's associated with the calculational methodology and with the input data values to bound this small error. As such, the results are considered acceptable and conservative.

The analysis is detailed on the following spreadsheet printout. The MCPA determined was 7.46 psig.

IORV

Peak torus water temperature for the PBAPS IORV event is calculated in NEDC-24380-P (Reference 6.S) as 172°F at 3790 seconds. Calculations PM-1010 and PM-1011 (References 6.G and 6.H, respectively) provide torus water temperatures for each ~~ECCS/RCIC~~ RHR and Core Spray pump above which containment overpressure credit is required. The peak torus water temperature calculated for the IORV event (172°F) is well below temperatures where containment overpressure credit is required.

Therefore, an evaluation of available containment pressure is not required for the IORV event.

REFERENCE 6.S IS PRE-RERATE. REFERENCE 6.B IS POST-RERATE AND IDENTIFIES A PEAK POOL TEMPERATURE FOR THE IORV (a.k.a. SORV) OF 174°F. THIS IS STILL "WELL BELOW TEMPERATURES WHERE CONTAINMENT OVERPRESSURE CREDIT IS REQUIRED."

[initials]
3-8-99

The results of these evaluations are as follows:

Inputs

Event	Peak Pool Temp. (°F)	Time (seconds)	HPSW Temp. (°F)	RHR Flow (gpm)
SBO	161	15300 -		10,000
ATWS	188	3300	90	10,000
FSSD	206	28800	90	10,000
SORV	172	3790	90	10,000

ATWS

Mao	16,993.80	lbm				TSP	188	°F
dMa/dt	0.002453	lbm/sec				TSW	90	°F
t	3300	secs				LMTDo	69.43963	°F
Ma(t)	16985.701	lbm				Tho	170.3198	°F
						Tco	128.4106	°F
Qr	10,000	gpm	Qs	4,500	gpm	GTD	80.31983	°F
TSP	188	°F	TSW	90	°F	LTD	59.58938	°F
Psat(TSP)	8.9468678	psia	Psat(TSP)	0.698127	psia	LMTD	69.43963	°F
Density	60.389019	lbm/cuft	Density	62.11659	lbm/cuft	T	170.3198	°F
Cpf	1.0036129	BTU/lbm°F	Cpf	0.99802	BTU/lbm°F	Pv	6.036849	psia
Mr	1345.4729	lbm/sec	Ms	622.7835	lbm/sec	Pa	13.51559	psia
						MCPA	**4.856**	**psig**

FSSD

Mao	16,993.80	lbm				TSP	206	°F
dMa/dt	0.002453	lbm/sec				TSW	90	°F
t	28800	secs				LMTDo	82.16234	°F
Ma(t)	16923.149	lbm				Tho	184.9811	°F
						Tco	135.4482	°F
Qr	10,000	gpm	Qs	4,500	gpm	GTD	94.98111	°F
TSP	206	°F	TSW	90	°F	LTD	70.5518	°F
Psat(TSP)	13.031183	psia	Psat(TSP)	0.698127	psia	LMTD	82.16204	°F
Density	59.962187	lbm/cuft	Density	62.11659	lbm/cuft	T	184.9811	°F
Cpf	1.0059786	BTU/lbm°F	Cpf	0.99802	BTU/lbm°F	Pv	8.380231	psia
Mr	1335.9631	lbm/sec	Ms	622.7835	lbm/sec	Pa	13.77919	psia
						MCPA	**7.463**	**psig**

8. Attachments

8.A Spreadsheet Printout for the MCPA following a DBA-LOCA, without containment purge, 14 pages, beginning on the next page.

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
0.00	0.0000	95.0	15.46	0.81534	0.016114	0.00	0.99801	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49.26	0.0137	136.3	47.51	2.62519	0.016276	0.00	0.99933	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70.39	0.0196	139.0	47.48	2.81569	0.016288	0.00	0.99948	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
86.08	0.0239	139.4	47.25	2.84489	0.016290	0.00	0.99950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
106.89	0.0297	139.8	46.94	2.87435	0.016292	0.00	0.99952	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
131.33	0.0365	140.3	46.53	2.91154	0.016295	0.00	0.99955	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
156.20	0.0434	140.8	45.93	2.94914	0.016297	0.00	0.99958	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
181.33	0.0504	141.2	45.19	2.97951	0.016299	0.00	0.99960	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
205.70	0.0571	141.4	44.49	2.99480	0.016300	0.00	0.99961	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
230.20	0.0639	141.5	43.69	3.00246	0.016300	0.00	0.99962	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
255.45	0.0710	141.6	43.01	3.01015	0.016301	0.00	0.99963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
280.70	0.0780	141.6	42.18	3.01015	0.016301	0.00	0.99963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
305.95	0.0850	141.7	41.54	3.01785	0.016301	0.00	0.99963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
331.08	0.0920	141.7	40.77	3.01785	0.016301	0.00	0.99963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
356.58	0.0990	141.7	40.10	3.01785	0.016301	0.00	0.99963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
381.58	0.1060	141.8	39.41	3.02557	0.016302	0.00	0.99964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
406.83	0.1130	141.8	38.71	3.02557	0.016302	0.00	0.99964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
431.83	0.1200	141.8	38.14	3.02557	0.016302	0.00	0.99964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
451.33	0.1254	141.9	32.30	3.03330	0.016302	0.00	0.99964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
472.89	0.1314	142.1	27.42	3.04883	0.016303	0.00	0.99966	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
495.83	0.1377	142.8	25.39	3.10368	0.016307	0.00	0.99970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
520.83	0.1447	143.9	24.43	3.19158	0.016312	0.00	0.99976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
545.08	0.1514	145.2	23.96	3.29818	0.016318	0.00	0.99985	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
569.76	0.1583	146.5	23.67	3.40780	0.016325	0.00	0.99993	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
594.45	0.1651	147.8	23.49	3.52049	0.016331	0.00	1.00001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
666.26	0.1851	150.6	23.41	3.77400	0.016346	1,363.06	1.00020	150.60	90.00	42.97	139.76	113.77	36.83	49.76	42.97
805.26	0.2237	153.9	23.48	4.09250	0.016363	1,361.63	1.00043	153.90	90.00	45.31	142.46	115.06	38.84	52.46	45.31
976.39	0.2712	156.5	23.50	4.35921	0.016376	1,360.49	1.00062	156.50	90.00	47.15	144.59	116.08	40.42	54.59	47.15
1,156.14	0.3209	158.9	23.51	4.61832	0.016389	1,359.43	1.00081	158.90	90.00	48.85	146.56	117.02	41.88	56.56	48.85
1,336.01	0.3711	161.0	23.51	4.85560	0.016401	1,358.48	1.00097	161.00	90.00	50.34	148.27	117.84	43.16	58.27	50.34
1,520.39	0.4223	163.0	23.53	5.09108	0.016412	1,357.57	1.00114	163.00	90.00	51.75	149.91	118.63	44.37	59.91	51.75
1,701.51	0.4726	164.8	23.55	5.31119	0.016422	1,356.75	1.00129	164.80	90.00	53.03	151.38	119.33	45.47	61.38	53.03
1,888.14	0.5245	166.5	23.58	5.52638	0.016431	1,355.96	1.00143	166.50	90.00	54.23	152.77	120.00	46.50	62.77	54.23
2,074.89	0.5764	168.0	23.61	5.72232	0.016440	1,355.26	1.00156	168.00	90.00	55.29	154.00	120.58	47.42	64.00	55.29
2,256.89	0.6269	169.4	23.67	5.91044	0.016448	1,354.60	1.00169	169.40	90.00	56.28	155.14	121.13	48.27	65.14	56.28
2,440.89	0.6780	170.7	23.74	6.08976	0.016455	1,353.99	1.00181	170.70	90.00	57.20	156.20	121.64	49.06	66.20	57.20
2,622.26	0.7284	171.9	23.82	6.25932	0.016462	1,353.42	1.00192	171.90	90.00	58.05	157.18	122.11	49.79	67.18	58.05
2,808.76	0.7802	173.0	23.88	6.41823	0.016468	1,352.89	1.00202	173.00	90.00	58.83	158.08	122.54	50.46	68.08	58.83
2,995.14	0.8320	174.0	23.99	6.56563	0.016474	1,352.41	1.00212	174.00	90.00	59.54	158.90	122.93	51.07	68.90	59.54
3,177.39	0.8826	175.0	24.06	6.71586	0.016480	1,351.93	1.00222	175.00	90.00	60.24	159.71	123.32	51.68	69.71	60.24
3,365.26	0.9348	175.9	24.17	6.85352	0.016485	1,351.50	1.00231	175.90	90.00	60.88	160.45	123.68	52.22	70.45	60.88
3,551.76	0.9866	176.8	24.22	6.99355	0.016491	1,351.06	1.00240	176.80	90.00	61.52	161.18	124.03	52.77	71.18	61.52
3,736.64	1.0380	177.6	24.32	7.12002	0.016496	1,350.67	1.00248	177.60	90.00	62.08	161.84	124.34	53.26	71.84	62.08
3,921.76	1.0894	178.4	24.41	7.24841	0.016500	1,350.28	1.00256	178.40	90.00	62.65	162.49	124.66	53.74	72.49	62.65
4,106.51	1.1407	179.1	24.47	7.36234	0.016505	1,349.93	1.00263	179.10	90.00	63.15	163.06	124.93	54.17	73.06	63.15
4,290.89	1.1919	179.8	24.53	7.47777	0.016509	1,349.59	1.00270	179.80	90.00	63.64	163.63	125.20	54.60	73.63	63.64
4,473.89	1.2427	180.5	24.61	7.59471	0.016513	1,349.24	1.00278	180.50	90.00	64.14	164.20	125.48	55.02	74.20	64.14
4,656.26	1.2934	181.1	24.69	7.69617	0.016517	1,348.95	1.00284	181.10	90.00	64.56	164.69	125.71	55.39	74.69	64.56
4,836.14	1.3434	181.7	24.78	7.79875	0.016520	1,348.65	1.00291	181.70	90.00	64.98	165.18	125.95	55.75	75.18	64.98
5,022.89	1.3952	182.2	24.85	7.88511	0.016523	1,348.40	1.00296	182.20	90.00	65.34	165.59	126.14	56.06	75.59	65.34

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)	COPL (psig)
0.00	0.0000	95.00	2.7906	16,993.80	11.9054	0.0000	0.7540	2.25
49.26	0.0137	136.30	2.6252	16,993.68	12.7917	32.8140	32.8140	2.25
70.39	0.0196	139.00	2.8157	16,993.62	12.8497	32.7840	32.7840	2.25
86.08	0.0239	139.40	2.8449	16,993.58	12.8582	32.5540	32.5540	2.25
106.89	0.0297	139.80	2.8744	16,993.53	12.8668	32.2440	32.2440	2.25
131.33	0.0365	140.30	2.9115	16,993.47	12.8774	31.8340	31.8340	2.25
156.20	0.0434	140.80	2.9491	16,993.41	12.8881	31.2340	31.2340	2.25
181.33	0.0504	141.20	2.9795	16,993.35	12.8967	30.4940	30.4940	2.25
205.70	0.0571	141.40	2.9948	16,993.29	12.9009	29.7940	29.7940	2.25
230.20	0.0639	141.50	3.0025	16,993.23	12.9030	28.9940	28.9940	2.25
255.45	0.0710	141.60	3.0101	16,993.17	12.9051	28.3140	28.3140	2.25
280.70	0.0780	141.60	3.0101	16,993.11	12.9051	27.4840	27.4840	2.25
305.95	0.0850	141.70	3.0179	16,993.05	12.9072	26.8440	26.8440	2.25
331.08	0.0920	141.70	3.0179	16,992.98	12.9071	26.0740	26.0740	2.25
356.58	0.0990	141.70	3.0179	16,992.92	12.9071	25.4040	25.4040	2.25
381.58	0.1060	141.80	3.0256	16,992.86	12.9092	24.7140	24.7140	2.25
406.83	0.1130	141.80	3.0256	16,992.80	12.9091	24.0140	24.0140	2.25
431.83	0.1200	141.80	3.0256	16,992.74	12.9091	23.4440	23.4440	2.25
451.33	0.1254	141.90	3.0333	16,992.69	12.9112	17.6040	17.6040	2.25
472.89	0.1314	142.10	3.0488	16,992.64	12.9154	12.7240	12.7240	2.25
495.83	0.1377	142.80	3.1037	16,992.58	12.9304	10.6940	10.6940	2.25
520.83	0.1447	143.90	3.1916	16,992.52	12.9540	9.7340	9.7340	2.25
545.08	0.1514	145.20	3.2982	16,992.46	12.9818	9.2640	9.2640	2.25
569.76	0.1583	146.50	3.4078	16,992.40	13.0097	8.9740	8.9740	2.25
594.45	0.1651	147.80	3.5205	16,992.34	13.0375	8.7940	8.7940	2.25
666.26	0.1851	139.76	2.8716	16,992.16	12.8649	1.0406	8.7140	0.62
805.26	0.2237	142.46	3.0773	16,991.82	12.9226	1.3039	8.7840	0.89
976.39	0.2712	144.59	3.2480	16,991.40	12.9680	1.5199	8.8040	1.10
1,155.14	0.3209	146.56	3.4125	16,990.96	13.0098	1.7263	8.8140	1.31
1,336.01	0.3711	148.27	3.5623	16,990.52	13.0463	1.9126	8.8140	1.50
1,520.39	0.4223	149.91	3.7100	16,990.07	13.0810	2.0950	8.8340	1.68
1,701.51	0.4726	151.38	3.8473	16,989.62	13.1123	2.2636	8.8540	1.85
1,888.14	0.5245	152.77	3.9809	16,989.16	13.1417	2.4267	8.8840	2.01
2,074.89	0.5764	154.00	4.1020	16,988.71	13.1677	2.5737	8.9140	2.16
2,256.89	0.6269	155.14	4.2178	16,988.26	13.1919	2.7137	8.9740	2.30
2,440.89	0.6780	156.20	4.3278	16,987.81	13.2143	2.8462	9.0440	2.43
2,622.26	0.7284	157.18	4.4315	16,987.36	13.2350	2.9705	9.1240	2.55
2,808.76	0.7802	158.08	4.5283	16,986.91	13.2539	3.0863	9.1840	2.67
2,995.14	0.8320	158.90	4.6179	16,986.45	13.2711	3.1930	9.2940	2.78
3,177.39	0.8826	159.71	4.7090	16,986.00	13.2883	3.3013	9.3640	2.88
3,365.26	0.9348	160.45	4.7922	16,985.54	13.3037	3.3999	9.4740	2.98
3,551.76	0.9866	161.18	4.8767	16,985.08	13.3191	3.4998	9.5240	3.08
3,736.64	1.0380	161.84	4.9528	16,984.63	13.3327	3.5896	9.6240	3.17
3,921.76	1.0894	162.49	5.0300	16,984.18	13.3464	3.6804	9.7140	3.26
4,106.51	1.1407	163.06	5.0983	16,983.72	13.3583	3.7606	9.7740	3.34
4,290.89	1.1919	163.63	5.1674	16,983.27	13.3702	3.8416	9.8340	3.43
4,473.89	1.2427	164.20	5.2372	16,982.82	13.3821	3.9233	9.9140	3.51
4,656.26	1.2934	164.69	5.2978	16,982.37	13.3922	3.9940	9.9940	3.58
4,836.14	1.3434	165.18	5.3589	16,981.93	13.4024	4.0652	10.0840	3.65
5,022.89	1.3952	165.59	5.4102	16,981.47	13.4108	4.1250	10.1540	3.71

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
5,205.89	1.4461	182.8	24.94	7.98980	0.016527	1,348.10	1.00303	182.80	90.00	65.76	166.08	126.38	56.42	76.08	65.76
5,392.51	1.4979	183.3	25.01	8.07793	0.016530	1,347.85	1.00308	183.30	90.00	66.12	166.49	126.57	56.73	76.49	66.12
5,571.01	1.5475	183.8	25.09	8.16687	0.016533	1,347.60	1.00314	183.80	90.00	66.47	166.89	126.77	57.03	76.89	66.47
5,751.64	1.5977	184.3	25.16	8.25663	0.016536	1,347.35	1.00319	184.30	90.00	66.82	167.30	126.96	57.34	77.30	66.82
5,931.76	1.6477	184.8	25.23	8.34722	0.016539	1,347.10	1.00325	184.80	90.00	67.18	167.71	127.16	57.64	77.71	67.18
6,114.76	1.6985	185.2	25.29	8.42028	0.016542	1,346.89	1.00329	185.20	90.00	67.46	168.04	127.32	57.88	78.04	67.46
6,297.76	1.7494	185.6	25.36	8.49388	0.016544	1,346.69	1.00334	185.60	90.00	67.74	168.36	127.47	58.13	78.36	67.74
6,475.14	1.7986	186.1	25.43	8.58663	0.016547	1,346.44	1.00339	186.10	90.00	68.10	168.77	127.67	58.43	78.77	68.10
6,652.14	1.8478	186.5	25.49	8.66145	0.016550	1,346.24	1.00344	186.50	90.00	68.38	169.10	127.82	58.68	79.10	68.38
6,830.89	1.8975	186.8	25.56	8.71791	0.016552	1,346.08	1.00347	186.80	90.00	68.59	169.34	127.94	58.86	79.34	68.59
7,001.51	1.9449	187.2	25.63	8.79368	0.016554	1,345.88	1.00352	187.20	90.00	68.87	169.67	128.10	59.10	79.67	68.87
7,177.89	1.9939	187.6	25.69	8.87000	0.016557	1,345.68	1.00357	187.60	90.00	69.16	169.99	128.25	59.35	79.99	69.16
7,356.76	2.0435	187.9	25.75	8.92760	0.016559	1,345.52	1.00360	187.90	90.00	69.37	170.24	128.37	59.53	80.24	69.37
7,536.76	2.0935	188.3	25.81	9.00489	0.016561	1,345.32	1.00365	188.30	90.00	69.65	170.56	128.53	59.77	80.56	69.65
7,713.51	2.1426	188.6	25.87	9.06322	0.016563	1,345.17	1.00368	188.60	90.00	69.86	170.81	128.65	59.95	80.81	69.86
7,890.51	2.1918	188.9	25.93	9.12186	0.016565	1,345.01	1.00372	188.90	90.00	70.08	171.05	128.76	60.14	81.05	70.08
8,069.14	2.2414	189.3	25.98	9.20055	0.016567	1,344.81	1.00377	189.30	90.00	70.36	171.38	128.92	60.38	81.38	70.36
8,241.14	2.2892	189.6	26.04	9.25994	0.016569	1,344.65	1.00380	189.60	90.00	70.57	171.62	129.04	60.56	81.62	70.57
8,414.39	2.3373	189.9	26.09	9.31985	0.016571	1,344.50	1.00384	189.90	90.00	70.78	171.87	129.15	60.75	81.87	70.78
8,592.64	2.3868	190.2	26.18	9.37968	0.016573	1,344.35	1.00387	190.20	90.00	71.00	172.11	129.27	60.93	82.11	71.00
8,761.76	2.4338	190.4	26.23	9.41988	0.016574	1,344.24	1.00390	190.40	90.00	71.14	172.28	129.35	61.05	82.28	71.14
8,874.26	2.4651	190.6	26.27	9.46022	0.016576	1,344.14	1.00392	190.60	90.00	71.28	172.44	129.43	61.17	82.44	71.28
8,986.76	2.4963	190.8	26.30	9.50071	0.016577	1,344.04	1.00395	190.80	90.00	71.42	172.60	129.51	61.29	82.60	71.42
9,099.26	2.5276	191.0	26.34	9.54134	0.016578	1,343.93	1.00397	191.00	90.00	71.56	172.77	129.58	61.42	82.77	71.56
9,211.76	2.5588	191.2	26.37	9.58211	0.016580	1,343.83	1.00400	191.20	90.00	71.70	172.93	129.66	61.54	82.93	71.70
9,324.26	2.5901	191.3	26.41	9.60258	0.016580	1,343.78	1.00401	191.30	90.00	71.77	173.01	129.70	61.60	83.01	71.77
9,436.76	2.6213	191.5	26.45	9.64355	0.016581	1,343.67	1.00403	191.50	90.00	71.91	173.17	129.78	61.72	83.17	71.91
9,549.26	2.6526	191.7	26.48	9.68469	0.016583	1,343.57	1.00406	191.70	90.00	72.06	173.34	129.86	61.84	83.34	72.06
9,661.76	2.6838	191.9	26.52	9.72598	0.016584	1,343.47	1.00408	191.90	90.00	72.20	173.50	129.94	61.96	83.50	72.20
9,774.26	2.7151	192.0	26.56	9.74667	0.016585	1,343.42	1.00409	192.00	90.00	72.27	173.58	129.97	62.03	83.58	72.27
9,886.76	2.7463	192.2	26.59	9.78818	0.016586	1,343.31	1.00412	192.20	90.00	72.41	173.74	130.05	62.15	83.74	72.41
9,999.26	2.7776	192.4	26.63	9.82984	0.016587	1,343.21	1.00414	192.40	90.00	72.55	173.91	130.13	62.27	83.91	72.55
10,111.77	2.8088	192.6	26.67	9.87164	0.016589	1,343.10	1.00417	192.60	90.00	72.69	174.07	130.21	62.39	84.07	72.69
10,224.27	2.8401	192.7	26.70	9.89260	0.016589	1,343.05	1.00418	192.70	90.00	72.76	174.15	130.25	62.45	84.15	72.76
10,342.89	2.8730	192.9	26.75	9.93462	0.016590	1,342.95	1.00420	192.90	90.00	72.90	174.31	130.33	62.57	84.31	72.90
10,456.39	2.9043	193.1	26.79	9.97679	0.016592	1,342.84	1.00423	193.10	90.00	73.05	174.48	130.41	62.69	84.48	73.05
10,567.89	2.9355	193.2	26.82	9.99794	0.016592	1,342.79	1.00424	193.20	90.00	73.12	174.56	130.44	62.76	84.56	73.12
10,680.39	2.9668	193.4	26.85	10.04033	0.016594	1,342.69	1.00427	193.40	90.00	73.26	174.72	130.52	62.88	84.72	73.26
10,792.89	2.9980	193.6	26.89	10.08288	0.016595	1,342.58	1.00429	193.60	90.00	73.40	174.88	130.60	63.00	84.88	73.40
10,905.39	3.0293	193.7	26.92	10.10421	0.016596	1,342.53	1.00430	193.70	90.00	73.47	174.97	130.64	63.06	84.97	73.47
11,017.89	3.0605	193.9	26.95	10.14699	0.016597	1,342.43	1.00433	193.90	90.00	73.61	175.13	130.72	63.18	85.13	73.61
11,142.64	3.0952	194.1	27.01	10.18991	0.016598	1,342.32	1.00436	194.10	90.00	73.75	175.29	130.80	63.30	85.29	73.75
11,262.39	3.1284	194.2	27.04	10.21143	0.016599	1,342.27	1.00437	194.20	90.00	73.82	175.37	130.84	63.36	85.37	73.82
11,377.77	3.1605	194.4	27.07	10.25458	0.016600	1,342.17	1.00439	194.40	90.00	73.96	175.54	130.91	63.49	85.54	73.96
11,490.14	3.1917	194.5	27.11	10.27621	0.016601	1,342.11	1.00441	194.50	90.00	74.04	175.62	130.95	63.55	85.62	74.04
11,609.77	3.2249	194.7	27.16	10.31959	0.016602	1,342.01	1.00443	194.70	90.00	74.18	175.78	131.03	63.67	85.78	74.18
11,762.77	3.2674	194.9	27.19	10.36312	0.016603	1,341.90	1.00446	194.90	90.00	74.32	175.94	131.11	63.79	85.94	74.32
11,889.14	3.3025	195.1	27.22	10.40681	0.016605	1,341.80	1.00448	195.10	90.00	74.46	176.11	131.19	63.91	86.11	74.46
12,042.02	3.3450	195.3	27.27	10.45065	0.016606	1,341.69	1.00451	195.30	90.00	74.60	176.27	131.27	64.03	86.27	74.60
12,195.52	3.3876	195.5	27.32	10.49464	0.016607	1,341.59	1.00453	195.50	90.00	74.74	176.43	131.34	64.16	86.43	74.74

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)	COPL (psig)
5,206.89	1.4461	166.08	5.4724	16,981.03	13.4209	4.1973	10.2440	3.78
5,392.61	1.4979	166.49	5.5247	16,980.57	13.4293	4.2580	10.3140	3.84
5,571.01	1.5475	166.89	5.5774	16,980.13	13.4377	4.3191	10.3940	3.90
5,751.64	1.5977	167.30	5.6305	16,979.69	13.4461	4.3806	10.4640	3.96
5,931.76	1.6477	167.71	5.6840	16,979.25	13.4545	4.4425	10.5340	4.03
6,114.76	1.6985	168.04	5.7272	16,978.80	13.4611	4.4923	10.5940	4.08
6,297.76	1.7494	168.36	5.7706	16,978.35	13.4678	4.5424	10.6640	4.13
6,475.14	1.7986	168.77	5.8252	16,977.91	13.4762	4.6054	10.7340	4.19
6,652.14	1.8478	169.10	5.8693	16,977.48	13.4828	4.6561	10.7940	4.24
6,830.89	1.8975	169.34	5.9025	16,977.04	13.4877	4.6942	10.8640	4.28
7,001.61	1.9449	169.67	5.9470	16,976.62	13.4944	4.7454	10.9340	4.33
7,177.89	1.9939	169.99	5.9918	16,976.19	13.5010	4.7968	10.9940	4.38
7,356.76	2.0435	170.24	6.0256	16,975.75	13.5059	4.8355	11.0540	4.42
7,536.76	2.0935	170.56	6.0708	16,975.31	13.5126	4.8874	11.1140	4.47
7,713.61	2.1426	170.81	6.1050	16,974.87	13.5175	4.9265	11.1740	4.51
7,890.61	2.1918	171.05	6.1393	16,974.44	13.5224	4.9657	11.2340	4.55
8,069.14	2.2414	171.38	6.1853	16,974.00	13.5290	5.0183	11.2840	4.60
8,241.14	2.2892	171.62	6.2200	16,973.58	13.5339	5.0579	11.3440	4.64
8,414.39	2.3373	171.87	6.2549	16,973.16	13.5388	5.0977	11.3940	4.68
8,592.64	2.3868	172.11	6.2899	16,972.72	13.5437	5.1376	11.4840	4.72
8,761.76	2.4338	172.28	6.3133	16,972.30	13.5469	5.1642	11.5340	4.75
8,874.26	2.4651	172.44	6.3368	16,972.03	13.5501	5.1910	11.5740	4.77
8,986.76	2.4963	172.60	6.3604	16,971.75	13.5534	5.2178	11.6040	4.80
9,099.26	2.5276	172.77	6.3841	16,971.48	13.5567	5.2448	11.6440	4.83
9,211.76	2.5588	172.93	6.4078	16,971.20	13.5600	5.2718	11.6740	4.86
9,324.26	2.5901	173.01	6.4197	16,970.92	13.5615	5.2852	11.7140	4.87
9,436.76	2.6213	173.17	6.4435	16,970.65	13.5648	5.3123	11.7540	4.90
9,549.26	2.6526	173.34	6.4674	16,970.37	13.5680	5.3395	11.7840	4.92
9,661.76	2.6838	173.50	6.4914	16,970.10	13.5713	5.3667	11.8240	4.95
9,774.26	2.7151	173.58	6.5034	16,969.82	13.5728	5.3803	11.8640	4.96
9,886.76	2.7463	173.74	6.5275	16,969.54	13.5761	5.4077	11.8940	4.99
9,999.26	2.7776	173.91	6.5517	16,969.27	13.5794	5.4351	11.9340	5.02
10,111.77	2.8088	174.07	6.5760	16,968.99	13.5827	5.4626	11.9740	5.05
10,224.27	2.8401	174.15	6.5881	16,968.72	13.5842	5.4763	12.0040	5.06
10,342.89	2.8730	174.31	6.6125	16,968.42	13.5874	5.5039	12.0540	5.09
10,455.39	2.9043	174.48	6.6369	16,968.15	13.5907	5.5316	12.0940	5.12
10,567.89	2.9355	174.56	6.6491	16,967.87	13.5922	5.5454	12.1240	5.13
10,680.39	2.9668	174.72	6.6737	16,967.60	13.5955	5.5732	12.1540	5.16
10,792.89	2.9980	174.88	6.6983	16,967.32	13.5988	5.6011	12.1940	5.18
10,905.39	3.0293	174.97	6.7107	16,967.04	13.6003	5.6150	12.2240	5.20
11,017.89	3.0605	175.13	6.7354	16,966.77	13.6036	5.6430	12.2540	5.23
11,142.64	3.0952	175.29	6.7602	16,966.46	13.6068	5.6710	12.3140	5.25
11,262.39	3.1284	175.37	6.7726	16,966.17	13.6083	5.6850	12.3440	5.27
11,377.77	3.1605	175.54	6.7976	16,965.89	13.6116	5.7132	12.3740	5.30
11,490.14	3.1917	175.62	6.8101	16,965.61	13.6131	5.7272	12.4140	5.31
11,609.77	3.2249	175.78	6.8351	16,965.32	13.6164	5.7555	12.4640	5.34
11,762.77	3.2674	175.94	6.8602	16,964.94	13.6196	5.7838	12.4940	5.37
11,889.14	3.3025	176.11	6.8854	16,964.63	13.6228	5.8122	12.5240	5.40
12,042.02	3.3450	176.27	6.9107	16,964.26	13.6260	5.8407	12.5740	5.42
12,195.62	3.3876	176.43	6.9360	16,963.88	13.6292	5.8692	12.6240	5.45

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
12,350.89	3.4308	195.7	27.35	10.53878	0.016609	1,341.48	1.00456	195.70	90.00	74.88	176.60	131.42	64.28	86.60	74.88
12,505.14	3.4737	195.9	27.40	10.58308	0.016610	1,341.38	1.00459	195.90	90.00	75.02	176.76	131.50	64.40	86.76	75.02
12,660.39	3.5168	196.1	27.44	10.62754	0.016611	1,341.27	1.00461	196.10	90.00	75.17	176.92	131.58	64.52	86.92	75.17
12,813.39	3.5593	196.2	27.49	10.64983	0.016612	1,341.22	1.00462	196.20	90.00	75.24	177.00	131.62	64.58	87.00	75.24
12,970.77	3.6030	196.4	27.53	10.69452	0.016613	1,341.11	1.00465	196.40	90.00	75.38	177.17	131.70	64.70	87.17	75.38
13,117.27	3.6437	196.6	27.56	10.73936	0.016614	1,341.01	1.00468	196.60	90.00	75.52	177.33	131.77	64.83	87.33	75.52
13,275.39	3.6876	196.8	27.61	10.78436	0.016616	1,340.90	1.00470	196.80	90.00	75.66	177.49	131.85	64.95	87.49	75.66
13,438.02	3.7328	197.0	27.65	10.82952	0.016617	1,340.80	1.00473	197.00	90.00	75.80	177.65	131.93	65.07	87.65	75.80
13,593.52	3.7760	197.2	27.69	10.87484	0.016618	1,340.69	1.00476	197.20	90.00	75.94	177.82	132.01	65.19	87.82	75.94
13,748.14	3.8189	197.3	27.72	10.89756	0.016619	1,340.64	1.00477	197.30	90.00	76.01	177.90	132.05	65.25	87.90	76.01
13,907.64	3.8632	197.5	27.77	10.94311	0.016620	1,340.53	1.00479	197.50	90.00	76.16	178.06	132.13	65.37	88.06	76.16
14,071.14	3.9087	197.7	27.80	10.98882	0.016622	1,340.43	1.00482	197.70	90.00	76.30	178.22	132.20	65.50	88.22	76.30
14,222.27	3.9506	197.9	27.84	11.03469	0.016623	1,340.32	1.00485	197.90	90.00	76.44	178.39	132.28	65.62	88.39	76.44
14,383.64	3.9955	198.0	27.90	11.05769	0.016624	1,340.27	1.00486	198.00	90.00	76.51	178.47	132.32	65.68	88.47	76.51
14,549.89	4.0416	198.2	27.93	11.10380	0.016625	1,340.16	1.00489	198.20	90.00	76.65	178.63	132.40	65.80	88.63	76.65
14,706.39	4.0851	198.4	27.96	11.15007	0.016626	1,340.06	1.00491	198.40	90.00	76.79	178.79	132.48	65.92	88.79	76.79
14,866.02	4.1294	198.5	27.99	11.17326	0.016627	1,340.00	1.00493	198.50	90.00	76.86	178.88	132.52	65.98	88.88	76.86
15,027.77	4.1744	198.7	28.05	11.21977	0.016628	1,339.90	1.00495	198.70	90.00	77.00	179.04	132.59	66.11	89.04	77.00
15,188.14	4.2189	198.8	28.08	11.24309	0.016629	1,339.84	1.00497	198.80	90.00	77.07	179.12	132.63	66.17	89.12	77.07
15,343.02	4.2619	199.0	28.11	11.28984	0.016630	1,339.74	1.00499	199.00	90.00	77.22	179.28	132.71	66.29	89.28	77.22
15,495.27	4.3042	199.1	28.14	11.31328	0.016631	1,339.68	1.00501	199.10	90.00	77.29	179.36	132.75	66.35	89.36	77.29
15,660.27	4.3501	199.3	28.17	11.36027	0.016632	1,339.58	1.00504	199.30	90.00	77.43	179.53	132.83	66.47	89.53	77.43
15,819.64	4.3943	199.4	28.20	11.38383	0.016633	1,339.52	1.00505	199.40	90.00	77.50	179.61	132.87	66.53	89.61	77.50
15,979.02	4.4386	199.6	28.23	11.43107	0.016634	1,339.42	1.00508	199.60	90.00	77.64	179.77	132.95	66.65	89.77	77.64
16,132.39	4.4812	199.7	28.27	11.45475	0.016635	1,339.36	1.00509	199.70	90.00	77.71	179.85	132.99	66.71	89.85	77.71
16,296.27	4.5267	199.9	28.30	11.50223	0.016636	1,339.26	1.00512	199.90	90.00	77.85	180.02	133.06	66.84	90.02	77.85
16,447.77	4.5688	200.0	28.32	11.52604	0.016637	1,339.20	1.00513	200.00	90.00	77.92	180.10	133.10	66.90	90.10	77.92
16,604.02	4.6122	200.1	28.35	11.54988	0.016637	1,339.15	1.00514	200.10	90.00	77.99	180.18	133.14	66.96	90.18	77.99
16,766.14	4.6573	200.2	28.38	11.57376	0.016638	1,339.10	1.00516	200.20	90.00	78.06	180.26	133.18	67.02	90.26	78.06
16,922.27	4.7006	200.4	28.41	11.62166	0.016639	1,338.99	1.00518	200.40	90.00	78.21	180.42	133.26	67.14	90.42	78.21
17,086.02	4.7461	200.5	28.43	11.64567	0.016640	1,338.94	1.00520	200.50	90.00	78.28	180.50	133.30	67.20	90.50	78.28
17,248.02	4.7911	200.6	28.49	11.66972	0.016641	1,338.88	1.00521	200.60	90.00	78.35	180.59	133.34	67.26	90.59	78.35
17,414.02	4.8372	200.8	28.52	11.71794	0.016642	1,338.78	1.00524	200.80	90.00	78.49	180.75	133.42	67.38	90.75	78.49
17,568.27	4.8801	200.9	28.53	11.74211	0.016643	1,338.72	1.00525	200.90	90.00	78.56	180.83	133.45	67.45	90.83	78.56
17,730.02	4.9250	201.0	28.56	11.76633	0.016643	1,338.67	1.00527	201.00	90.00	78.63	180.91	133.49	67.51	90.91	78.63
17,890.02	4.9694	201.1	28.57	11.79058	0.016644	1,338.62	1.00528	201.10	90.00	78.70	180.99	133.53	67.57	90.99	78.70
18,045.52	5.0126	201.2	28.59	11.81488	0.016645	1,338.56	1.00530	201.20	90.00	78.77	181.07	133.57	67.63	91.07	78.77
18,204.14	5.0567	201.3	28.62	11.83922	0.016645	1,338.51	1.00531	201.30	90.00	78.84	181.16	133.61	67.69	91.16	78.84
18,363.52	5.1010	201.4	28.65	11.86360	0.016646	1,338.45	1.00532	201.40	90.00	78.91	181.24	133.65	67.75	91.24	78.91
18,512.02	5.1422	201.5	28.67	11.88803	0.016647	1,338.40	1.00534	201.50	90.00	78.98	181.32	133.69	67.81	91.32	78.98
18,671.64	5.1866	201.6	28.68	11.91249	0.016647	1,338.35	1.00535	201.60	90.00	79.05	181.40	133.73	67.87	91.40	79.05
18,825.02	5.2292	201.7	28.70	11.93700	0.016648	1,338.29	1.00536	201.70	90.00	79.12	181.48	133.77	67.93	91.48	79.12
18,984.27	5.2734	201.8	28.72	11.96155	0.016649	1,338.24	1.00538	201.80	90.00	79.19	181.56	133.81	67.99	91.56	79.19
19,141.39	5.3171	201.9	28.75	11.98614	0.016649	1,338.19	1.00539	201.90	90.00	79.27	181.64	133.85	68.05	91.64	79.27
19,301.77	5.3616	202.0	28.77	12.01077	0.016650	1,338.13	1.00541	202.00	90.00	79.34	181.73	133.88	68.12	91.73	79.34
19,458.77	5.4052	202.1	28.78	12.03545	0.016651	1,338.08	1.00542	202.10	90.00	79.41	181.81	133.92	68.18	91.81	79.41
19,613.89	5.4483	202.2	28.80	12.06016	0.016651	1,338.02	1.00543	202.20	90.00	79.48	181.89	133.96	68.24	91.89	79.48
19,766.14	5.4906	202.3	28.82	12.08492	0.016652	1,337.97	1.00545	202.30	90.00	79.55	181.97	134.00	68.30	91.97	79.55
19,920.39	5.5334	202.4	28.84	12.10973	0.016653	1,337.92	1.00546	202.40	90.00	79.62	182.05	134.04	68.36	92.05	79.62
20,079.27	5.5776	202.4	28.86	12.10973	0.016653	1,337.92	1.00546	202.40	90.00	79.62	182.05	134.04	68.36	92.05	79.62

PECO ENERGY
NUCLEAR GROUP

CALCULATION SHEET

CALC. NO. : PM-1013
PAGE : 28
REVISION : 2

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)	COPL (psig)
12,350.89	3.4308	176.60	6.9615	16,963.50	13.6324	5.8978	12.6540	5.48
12,505.14	3.4737	176.76	6.9870	16,963.12	13.6356	5.9265	12.7040	5.51
12,660.39	3.5168	176.92	7.0126	16,962.74	13.6387	5.9553	12.7440	5.54
12,813.39	3.5593	177.00	7.0254	16,962.36	13.6402	5.9696	12.7940	5.55
12,970.77	3.6030	177.17	7.0511	16,961.98	13.6434	5.9985	12.8340	5.58
13,117.27	3.6437	177.33	7.0768	16,961.62	13.6466	6.0274	12.8640	5.61
13,275.39	3.6876	177.49	7.1027	16,961.23	13.6497	6.0565	12.9140	5.64
13,438.02	3.7328	177.65	7.1288	16,960.83	13.6529	6.0856	12.9540	5.67
13,593.52	3.7760	177.82	7.1547	16,960.45	13.6561	6.1148	12.9940	5.70
13,748.14	3.8189	177.90	7.1677	16,960.07	13.6575	6.1292	13.0240	5.71
13,907.64	3.8632	178.06	7.1938	16,959.68	13.6607	6.1585	13.0740	5.74
14,071.14	3.9087	178.22	7.2200	16,959.28	13.6639	6.1879	13.1040	5.77
14,222.27	3.9506	178.39	7.2463	16,958.91	13.6671	6.2174	13.1440	5.80
14,383.64	3.9955	178.47	7.2595	16,958.51	13.6685	6.2320	13.2040	5.82
14,549.89	4.0416	178.63	7.2859	16,958.10	13.6717	6.2616	13.2340	5.85
14,706.39	4.0851	178.79	7.3124	16,957.72	13.6748	6.2913	13.2640	5.87
14,866.02	4.1294	178.88	7.3257	16,957.33	13.6763	6.3060	13.2940	5.89
15,027.77	4.1744	179.04	7.3523	16,956.93	13.6794	6.3357	13.3540	5.92
15,188.14	4.2189	179.12	7.3656	16,956.54	13.6809	6.3505	13.3840	5.93
15,343.02	4.2619	179.28	7.3924	16,956.16	13.6840	6.3804	13.4140	5.96
15,495.27	4.3042	179.36	7.4058	16,955.79	13.6855	6.3953	13.4440	5.98
15,660.27	4.3501	179.53	7.4326	16,955.38	13.6886	6.4253	13.4740	6.01
15,819.64	4.3943	179.61	7.4461	16,954.99	13.6901	6.4402	13.5040	6.02
15,979.02	4.4386	179.77	7.4730	16,954.60	13.6932	6.4703	13.5340	6.05
16,132.39	4.4812	179.85	7.4866	16,954.22	13.6947	6.4853	13.5740	6.07
16,296.27	4.5267	180.02	7.5137	16,953.82	13.6978	6.5155	13.6040	6.10
16,447.77	4.5688	180.10	7.5272	16,953.45	13.6993	6.5305	13.6240	6.11
16,604.02	4.6122	180.18	7.5408	16,953.07	13.7007	6.5456	13.6540	6.13
16,766.14	4.6573	180.26	7.5545	16,952.67	13.7021	6.5606	13.6840	6.14
16,922.27	4.7006	180.42	7.5818	16,952.29	13.7053	6.5911	13.7140	6.17
17,086.02	4.7461	180.50	7.5954	16,951.88	13.7067	6.6062	13.7340	6.19
17,248.02	4.7911	180.59	7.6091	16,951.49	13.7082	6.6213	13.7940	6.20
17,414.02	4.8372	180.75	7.6366	16,951.08	13.7113	6.6519	13.8240	6.24
17,568.27	4.8801	180.83	7.6504	16,950.70	13.7128	6.6671	13.8340	6.25
17,730.02	4.9250	180.91	7.6642	16,950.30	13.7142	6.6824	13.8640	6.27
17,890.02	4.9694	180.99	7.6780	16,949.91	13.7156	6.6976	13.8740	6.28
18,045.52	5.0126	181.07	7.6918	16,949.53	13.7170	6.7128	13.8940	6.30
18,204.14	5.0567	181.16	7.7056	16,949.14	13.7185	6.7281	13.9240	6.31
18,363.52	5.1010	181.24	7.7195	16,948.75	13.7199	6.7434	13.9540	6.33
18,512.02	5.1422	181.32	7.7334	16,948.39	13.7213	6.7587	13.9740	6.34
18,671.64	5.1866	181.40	7.7473	16,947.99	13.7228	6.7741	13.9840	6.36
18,825.02	5.2292	181.48	7.7612	16,947.62	13.7242	6.7894	14.0040	6.37
18,984.27	5.2734	181.56	7.7752	16,947.23	13.7256	6.8048	14.0240	6.39
19,141.39	5.3171	181.64	7.7892	16,946.84	13.7271	6.8202	14.0540	6.40
19,301.77	5.3616	181.73	7.8031	16,946.45	13.7285	6.8356	14.0740	6.42
19,458.77	5.4052	181.81	7.8172	16,946.06	13.7299	6.8511	14.0840	6.43
19,613.89	5.4483	181.89	7.8312	16,945.68	13.7313	6.8666	14.1040	6.45
19,766.14	5.4906	181.97	7.8452	16,945.31	13.7328	6.8820	14.1240	6.47
19,920.39	5.5334	182.05	7.8593	16,944.93	13.7342	6.8976	14.1440	6.48
20,079.27	5.5776	182.05	7.8593	16,944.54	13.7339	6.8972	14.1640	6.48

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	RHR Heat Exchanger Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
20,233.77	5.6205	202.5	28.87	12.13457	0.016654	1,337.86	1.00548	202.50	90.00	79.69	182.13	134.08	68.42	92.13	79.69
20,386.27	5.6629	202.6	28.90	12.15946	0.016654	1,337.81	1.00549	202.60	90.00	79.76	182.21	134.12	68.48	92.21	79.76
20,537.39	5.7048	202.7	28.92	12.18438	0.016655	1,337.75	1.00550	202.70	90.00	79.83	182.30	134.16	68.54	92.30	79.83
20,690.39	5.7473	202.7	28.93	12.18438	0.016655	1,337.75	1.00550	202.70	90.00	79.83	182.30	134.16	68.54	92.30	79.83
20,845.64	5.7905	202.8	28.94	12.20935	0.016656	1,337.70	1.00552	202.80	90.00	79.90	182.38	134.20	68.60	92.38	79.90
20,998.39	5.8329	202.9	28.96	12.23437	0.016656	1,337.65	1.00553	202.90	90.00	79.97	182.46	134.24	68.66	92.46	79.97
21,152.64	5.8757	203.0	28.98	12.25942	0.016657	1,337.59	1.00555	203.00	90.00	80.04	182.54	134.28	68.72	92.54	80.04
21,304.14	5.9178	203.0	28.99	12.25942	0.016657	1,337.59	1.00555	203.00	90.00	80.04	182.54	134.28	68.72	92.54	80.04
21,461.52	5.9615	203.1	29.02	12.28452	0.016658	1,337.54	1.00556	203.10	90.00	80.11	182.62	134.31	68.79	92.62	80.11
21,618.14	6.0050	203.2	29.04	12.30966	0.016658	1,337.48	1.00558	203.20	90.00	80.18	182.70	134.35	68.85	92.70	80.18
21,780.64	6.0502	203.3	29.05	12.33485	0.016659	1,337.43	1.00559	203.30	90.00	80.25	182.78	134.39	68.91	92.78	80.25
21,934.89	6.0930	203.3	29.07	12.33485	0.016659	1,337.43	1.00559	203.30	90.00	80.25	182.78	134.39	68.91	92.78	80.25
22,090.52	6.1363	203.4	29.08	12.36008	0.016660	1,337.38	1.00560	203.40	90.00	80.33	182.87	134.43	68.97	92.87	80.33
22,239.89	6.1777	203.4	29.09	12.36008	0.016660	1,337.38	1.00560	203.40	90.00	80.33	182.87	134.43	68.97	92.87	80.33
22,391.27	6.2198	203.5	29.10	12.38535	0.016660	1,337.32	1.00562	203.50	90.00	80.40	182.95	134.47	69.03	92.95	80.40
22,546.14	6.2628	203.6	29.13	12.41066	0.016661	1,337.27	1.00563	203.60	90.00	80.47	183.03	134.51	69.09	93.03	80.47
22,700.14	6.3056	203.6	29.15	12.41066	0.016661	1,337.27	1.00563	203.60	90.00	80.47	183.03	134.51	69.09	93.03	80.47
22,856.64	6.3491	203.7	29.16	12.43601	0.016662	1,337.21	1.00565	203.70	90.00	80.54	183.11	134.55	69.15	93.11	80.54
23,015.77	6.3933	203.8	29.16	12.46141	0.016662	1,337.16	1.00566	203.80	90.00	80.61	183.19	134.59	69.21	93.19	80.61
23,168.39	6.4357	203.8	29.18	12.46141	0.016662	1,337.16	1.00566	203.80	90.00	80.61	183.19	134.59	69.21	93.19	80.61
23,322.64	6.4785	203.9	29.19	12.48685	0.016663	1,337.11	1.00567	203.90	90.00	80.68	183.27	134.63	69.27	93.27	80.68
23,476.52	6.5213	203.9	29.21	12.48685	0.016663	1,337.11	1.00567	203.90	90.00	80.68	183.27	134.63	69.27	93.27	80.68
23,631.77	6.5644	204.0	29.23	12.51234	0.016664	1,337.05	1.00569	204.00	90.00	80.75	183.35	134.67	69.33	93.35	80.75
23,787.39	6.6076	204.0	29.25	12.51234	0.016664	1,337.05	1.00569	204.00	90.00	80.75	183.35	134.67	69.33	93.35	80.75
23,938.89	6.6497	204.1	29.25	12.53787	0.016664	1,337.00	1.00570	204.10	90.00	80.82	183.43	134.71	69.39	93.43	80.82
24,094.14	6.6928	204.1	29.26	12.53787	0.016664	1,337.00	1.00570	204.10	90.00	80.82	183.43	134.71	69.39	93.43	80.82
24,246.89	6.7352	204.2	29.27	12.56344	0.016665	1,336.94	1.00572	204.20	90.00	80.89	183.52	134.74	69.46	93.52	80.89
24,400.27	6.7779	204.2	29.29	12.56344	0.016665	1,336.94	1.00572	204.20	90.00	80.89	183.52	134.74	69.46	93.52	80.89
24,552.52	6.8201	204.3	29.29	12.58905	0.016666	1,336.89	1.00573	204.30	90.00	80.96	183.60	134.78	69.52	93.60	80.96
24,710.27	6.8640	204.3	29.30	12.58905	0.016666	1,336.89	1.00573	204.30	90.00	80.96	183.60	134.78	69.52	93.60	80.96
24,864.39	6.9068	204.4	29.33	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
25,014.64	6.9485	204.4	29.33	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
25,166.64	6.9905	204.5	29.35	12.64041	0.016667	1,336.78	1.00576	204.50	90.00	81.10	183.76	134.86	69.64	93.76	81.10
25,321.39	7.0337	204.5	29.35	12.64041	0.016667	1,336.78	1.00576	204.50	90.00	81.10	183.76	134.86	69.64	93.76	81.10
25,474.14	7.0762	204.6	29.36	12.66616	0.016668	1,336.73	1.00578	204.60	90.00	81.17	183.84	134.90	69.70	93.84	81.17
25,631.52	7.1199	204.6	29.36	12.66616	0.016668	1,336.73	1.00578	204.60	90.00	81.17	183.84	134.90	69.70	93.84	81.17
25,785.39	7.1626	204.7	29.37	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
25,941.39	7.2059	204.7	29.39	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
26,094.89	7.2486	204.7	29.41	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
26,248.64	7.2913	204.8	29.42	12.71778	0.016669	1,336.62	1.00580	204.80	90.00	81.31	184.00	134.98	69.82	94.00	81.31
26,405.77	7.3349	204.8	29.42	12.71778	0.016669	1,336.62	1.00580	204.80	90.00	81.31	184.00	134.98	69.82	94.00	81.31
26,562.89	7.3786	204.9	29.43	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
26,715.77	7.4210	204.9	29.43	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
26,867.39	7.4632	204.9	29.44	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
27,027.02	7.5075	205.0	29.45	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
27,183.14	7.5509	205.0	29.45	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
27,339.52	7.5943	205.0	29.47	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
27,495.77	7.6377	205.1	29.48	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
27,651.27	7.6809	205.1	29.48	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
27,804.27	7.7234	205.1	29.49	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)	COPL (psig)
20,233.77	5.6205	182.13	7.8734	16,944.16	13.7353	6.9128	14.1740	6.50
20,386.27	5.6629	182.21	7.8875	16,943.79	13.7368	6.9283	14.2040	6.51
20,537.39	5.7048	182.30	7.9017	16,943.42	13.7382	6.9439	14.2240	6.53
20,690.39	5.7473	182.30	7.9017	16,943.04	13.7379	6.9436	14.2340	6.53
20,845.64	5.7905	182.38	7.9158	16,942.66	13.7394	6.9592	14.2440	6.54
20,998.39	5.8329	182.46	7.9300	16,942.29	13.7408	6.9748	14.2640	6.56
21,152.64	5.8757	182.54	7.9442	16,941.91	13.7422	6.9905	14.2840	6.57
21,304.14	5.9178	182.54	7.9442	16,941.54	13.7419	6.9902	14.2940	6.57
21,461.52	5.9615	182.62	7.9584	16,941.15	13.7434	7.0058	14.3240	6.59
21,618.14	6.0050	182.70	7.9727	16,940.77	13.7448	7.0215	14.3440	6.61
21,780.64	6.0502	182.78	7.9870	16,940.37	13.7462	7.0372	14.3540	6.62
21,934.89	6.0930	182.78	7.9870	16,939.99	13.7459	7.0369	14.3740	6.62
22,090.52	6.1363	182.87	8.0012	16,939.61	13.7473	7.0526	14.3840	6.64
22,239.89	6.1777	182.87	8.0012	16,939.24	13.7470	7.0523	14.3940	6.64
22,391.27	6.2198	182.95	8.0156	16,938.87	13.7485	7.0680	14.4040	6.65
22,546.14	6.2628	183.03	8.0299	16,938.49	13.7499	7.0838	14.4340	6.67
22,700.14	6.3056	183.03	8.0299	16,938.11	13.7496	7.0835	14.4540	6.67
22,856.64	6.3491	183.11	8.0442	16,937.73	13.7510	7.0993	14.4640	6.68
23,015.77	6.3933	183.19	8.0586	16,937.34	13.7524	7.1151	14.4640	6.70
23,168.39	6.4357	183.19	8.0586	16,936.96	13.7521	7.1148	14.4840	6.70
23,322.64	6.4785	183.27	8.0730	16,936.59	13.7536	7.1306	14.4940	6.71
23,476.52	6.5213	183.27	8.0730	16,936.21	13.7533	7.1303	14.5140	6.71
23,631.77	6.5644	183.35	8.0874	16,935.83	13.7547	7.1461	14.5340	6.73
23,787.39	6.6076	183.35	8.0874	16,935.45	13.7544	7.1458	14.5540	6.73
23,938.89	6.6497	183.43	8.1019	16,935.07	13.7558	7.1617	14.5540	6.75
24,094.14	6.6928	183.43	8.1019	16,934.69	13.7555	7.1614	14.5640	6.74
24,246.89	6.7352	183.52	8.1163	16,934.32	13.7570	7.1773	14.5740	6.76
24,400.27	6.7779	183.52	8.1163	16,933.94	13.7567	7.1770	14.5940	6.76
24,552.52	6.8201	183.60	8.1308	16,933.57	13.7581	7.1929	14.5940	6.78
24,710.27	6.8640	183.60	8.1308	16,933.18	13.7578	7.1926	14.6040	6.78
24,864.39	6.9068	183.68	8.1453	16,932.80	13.7592	7.2085	14.6340	6.79
25,014.64	6.9485	183.68	8.1453	16,932.43	13.7589	7.2082	14.6340	6.79
25,165.64	6.9905	183.76	8.1598	16,932.06	13.7603	7.2242	14.6540	6.81
25,321.39	7.0337	183.76	8.1598	16,931.68	13.7600	7.2239	14.6540	6.81
25,474.14	7.0762	183.84	8.1744	16,931.31	13.7615	7.2398	14.6640	6.82
25,631.52	7.1199	183.84	8.1744	16,930.92	13.7612	7.2395	14.6640	6.82
25,786.39	7.1626	183.92	8.1889	16,930.54	13.7626	7.2555	14.6740	6.84
25,941.39	7.2059	183.92	8.1889	16,930.16	13.7623	7.2552	14.6940	6.84
26,094.89	7.2486	183.92	8.1889	16,929.78	13.7620	7.2549	14.7140	6.84
26,248.64	7.2913	184.00	8.2035	16,929.41	13.7634	7.2709	14.7240	6.85
26,405.77	7.3349	184.00	8.2035	16,929.02	13.7631	7.2706	14.7240	6.85
26,562.89	7.3786	184.09	8.2181	16,928.64	13.7645	7.2867	14.7340	6.87
26,715.77	7.4210	184.09	8.2181	16,928.26	13.7642	7.2863	14.7340	6.87
26,867.39	7.4632	184.09	8.2181	16,927.89	13.7639	7.2860	14.7440	6.87
27,027.02	7.5075	184.17	8.2327	16,927.50	13.7653	7.3021	14.7540	6.89
27,183.14	7.5509	184.17	8.2327	16,927.12	13.7650	7.3018	14.7540	6.89
27,339.52	7.5943	184.17	8.2327	16,926.73	13.7647	7.3015	14.7740	6.89
27,495.77	7.6377	184.25	8.2474	16,926.35	13.7661	7.3176	14.7840	6.90
27,651.27	7.6809	184.25	8.2474	16,925.97	13.7658	7.3172	14.7840	6.90
27,804.27	7.7234	184.25	8.2474	16,925.59	13.7655	7.3169	14.7940	6.90

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
27,959.02	7.7664	205.2	29.49	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
28,112.14	7.8089	205.2	29.50	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
28,272.64	7.8535	205.2	29.50	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
28,415.27	7.8931	205.3	29.51	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
28,567.52	7.9354	205.3	29.51	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
28,717.64	7.9771	205.3	29.53	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
28,875.39	8.0209	205.3	29.53	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
29,028.27	8.0634	205.4	29.54	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
29,186.64	8.1071	205.4	29.54	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
29,344.64	8.1513	205.4	29.54	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
29,497.89	8.1939	205.4	29.54	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
29,656.39	8.2379	205.5	29.54	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
29,802.52	8.2785	205.5	29.54	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
29,953.77	8.3205	205.5	29.54	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
30,106.39	8.3629	205.5	29.56	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
30,268.77	8.4080	205.5	29.56	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
30,420.39	8.4501	205.5	29.57	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
30,578.27	8.4940	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
30,733.14	8.5370	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
30,893.64	8.5816	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
31,047.77	8.6244	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
31,203.39	8.6676	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
31,358.89	8.7108	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
31,512.64	8.7535	205.6	29.60	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
31,667.02	8.7964	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
31,818.89	8.8386	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
31,966.52	8.8796	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,113.52	8.9204	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,267.14	8.9631	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,421.39	9.0059	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,573.14	9.0481	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,721.77	9.0894	205.7	29.59	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,872.52	9.1313	205.7	29.59	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,024.02	9.1733	205.7	29.59	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,171.27	9.2142	205.7	29.59	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,326.39	9.2573	205.7	29.59	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,481.02	9.3003	205.7	29.58	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,632.52	9.3424	205.7	29.58	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,777.39	9.3826	205.7	29.57	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,931.52	9.4254	205.7	29.57	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,086.02	9.4681	205.7	29.58	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,235.14	9.5098	205.7	29.57	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,390.02	9.5528	205.7	29.57	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,548.64	9.5968	205.7	29.56	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,706.64	9.6407	205.7	29.56	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,860.89	9.6836	205.7	29.58	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,018.89	9.7275	205.7	29.58	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,176.89	9.7714	205.7	29.56	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,332.89	9.8147	205.7	29.56	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,487.64	9.8577	205.7	29.56	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)	COPL (psig)
27,959.02	7.7664	184.33	8.2621	16,925.21	13.7670	7.3330	14.7940	6.92
28,112.14	7.8089	184.33	8.2621	16,924.84	13.7667	7.3327	14.8040	6.92
28,272.64	7.8535	184.33	8.2621	16,924.44	13.7663	7.3324	14.8040	6.92
28,416.27	7.8931	184.41	8.2768	16,924.09	13.7678	7.3486	14.8140	6.93
28,567.52	7.9354	184.41	8.2768	16,923.72	13.7675	7.3483	14.8140	6.93
28,717.64	7.9771	184.41	8.2768	16,923.35	13.7672	7.3480	14.8340	6.93
28,875.39	8.0209	184.41	8.2768	16,922.98	13.7669	7.3476	14.8340	6.93
29,028.27	8.0634	184.49	8.2915	16,922.59	13.7683	7.3638	14.8440	6.95
29,185.64	8.1071	184.49	8.2915	16,922.20	13.7680	7.3635	14.8440	6.95
29,344.64	8.1513	184.49	8.2915	16,921.81	13.7677	7.3632	14.8440	6.95
29,497.89	8.1939	184.49	8.2915	16,921.44	13.7674	7.3629	14.8440	6.95
29,666.39	8.2379	184.57	8.3062	16,921.05	13.7688	7.3790	14.8440	6.96
29,802.52	8.2785	184.57	8.3062	16,920.69	13.7685	7.3787	14.8440	6.96
29,953.77	8.3205	184.57	8.3062	16,920.32	13.7682	7.3784	14.8440	6.96
30,106.39	8.3629	184.57	8.3062	16,919.94	13.7679	7.3781	14.8640	6.96
30,268.77	8.4080	184.57	8.3062	16,919.55	13.7676	7.3778	14.8640	6.96
30,420.39	8.4501	184.57	8.3062	16,919.17	13.7673	7.3775	14.8740	6.96
30,578.27	8.4940	184.66	8.3210	16,918.79	13.7687	7.3937	14.8740	6.98
30,733.14	8.5370	184.66	8.3210	16,918.41	13.7684	7.3934	14.8740	6.98
30,893.64	8.5816	184.66	8.3210	16,918.01	13.7681	7.3931	14.8740	6.98
31,047.77	8.6244	184.66	8.3210	16,917.64	13.7678	7.3927	14.8740	6.98
31,203.39	8.6676	184.66	8.3210	16,917.25	13.7674	7.3924	14.8740	6.98
31,358.89	8.7108	184.66	8.3210	16,916.87	13.7671	7.3921	14.8740	6.98
31,512.64	8.7535	184.66	8.3210	16,916.49	13.7668	7.3918	14.9040	6.98
31,667.02	8.7964	184.74	8.3358	16,916.12	13.7683	7.4080	14.9040	6.99
31,818.89	8.8386	184.74	8.3358	16,915.74	13.7679	7.4077	14.9040	6.99
31,966.52	8.8796	184.74	8.3358	16,915.38	13.7677	7.4074	14.9040	6.99
32,113.52	8.9204	184.74	8.3358	16,915.02	13.7674	7.4071	14.9040	6.99
32,267.14	8.9631	184.74	8.3358	16,914.64	13.7671	7.4068	14.9040	6.99
32,421.39	9.0059	184.74	8.3358	16,914.27	13.7667	7.4065	14.9040	6.99
32,573.14	9.0481	184.74	8.3358	16,913.89	13.7664	7.4062	14.9040	6.99
32,721.77	9.0894	184.74	8.3358	16,913.53	13.7661	7.4059	14.8940	6.99
32,872.52	9.1313	184.74	8.3358	16,913.16	13.7658	7.4056	14.8940	6.99
33,024.02	9.1733	184.74	8.3358	16,912.79	13.7655	7.4053	14.8940	6.99
33,171.27	9.2142	184.74	8.3358	16,912.43	13.7652	7.4050	14.8940	6.99
33,326.39	9.2573	184.74	8.3358	16,912.05	13.7649	7.4047	14.8940	6.99
33,481.02	9.3003	184.74	8.3358	16,911.67	13.7646	7.4044	14.8840	6.99
33,632.52	9.3424	184.74	8.3358	16,911.29	13.7643	7.4041	14.8840	6.99
33,777.39	9.3826	184.74	8.3358	16,910.94	13.7640	7.4038	14.8740	6.99
33,931.52	9.4254	184.74	8.3358	16,910.56	13.7637	7.4035	14.8740	6.99
34,085.02	9.4681	184.74	8.3358	16,910.18	13.7634	7.4032	14.8840	6.99
34,235.14	9.5098	184.74	8.3358	16,909.82	13.7631	7.4029	14.8740	6.99
34,390.02	9.5528	184.74	8.3358	16,909.44	13.7628	7.4026	14.8740	6.99
34,548.64	9.5968	184.74	8.3358	16,909.05	13.7625	7.4023	14.8640	6.99
34,706.64	9.6407	184.74	8.3358	16,908.66	13.7622	7.4020	14.8640	6.99
34,860.89	9.6836	184.74	8.3358	16,908.28	13.7619	7.4017	14.8840	6.99
35,018.89	9.7275	184.74	8.3358	16,907.89	13.7616	7.4013	14.8840	6.98
35,176.89	9.7714	184.74	8.3358	16,907.51	13.7612	7.4010	14.8640	6.98
35,332.89	9.8147	184.74	8.3358	16,907.12	13.7609	7.4007	14.8640	6.98
35,487.64	9.8577	184.74	8.3358	16,906.74	13.7606	7.4004	14.8640	6.98

PECO ENERGY
NUCLEAR GROUP

CALCULATION SHEET

CALC. NO.: PM-1013
PAGE: 32
REVISION: 2

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
35,646.64	9.9018	205.7	29.56	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,798.64	9.9435	205.7	29.54	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,952.52	9.9868	205.7	29.54	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,102.14	10.0284	205.7	29.53	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,255.39	10.0709	205.7	29.53	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,408.39	10.1134	205.7	29.53	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,560.39	10.1557	205.7	29.52	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,712.52	10.1979	205.7	29.53	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,867.02	10.2408	205.7	29.52	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
37,027.52	10.2854	205.6	29.51	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,177.27	10.3270	205.6	29.51	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,331.39	10.3698	205.6	29.50	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,488.89	10.4136	205.6	29.49	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,643.39	10.4565	205.6	29.49	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,798.14	10.4995	205.6	29.48	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,956.52	10.5435	205.6	29.47	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
38,108.89	10.5858	205.5	29.47	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
38,271.52	10.6310	205.5	29.45	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
38,421.14	10.6725	205.5	29.45	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
38,577.64	10.7160	205.5	29.44	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
38,732.14	10.7589	205.5	29.45	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
38,888.64	10.8024	205.5	29.44	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
39,047.27	10.8465	205.4	29.43	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
39,204.14	10.8900	205.4	29.42	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
39,363.89	10.9344	205.4	29.42	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
39,520.77	10.9780	205.4	29.40	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
39,677.02	11.0214	205.4	29.40	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
39,837.39	11.0659	205.3	29.38	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
39,989.64	11.1082	205.3	29.37	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
40,152.52	11.1535	205.3	29.37	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
40,299.02	11.1942	205.3	29.36	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
40,450.27	11.2362	205.2	29.35	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
40,607.64	11.2799	205.2	29.35	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
40,763.14	11.3231	205.2	29.34	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
40,915.52	11.3654	205.2	29.33	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
41,076.14	11.4100	205.1	29.32	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
41,232.14	11.4534	205.1	29.31	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
41,381.27	11.4948	205.1	29.31	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
41,534.64	11.5374	205.1	29.33	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
41,688.02	11.5800	205.0	29.32	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
41,838.14	11.6217	205.0	29.30	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
41,992.14	11.6645	205.0	29.30	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
42,153.02	11.7092	205.0	29.29	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
42,307.52	11.7521	204.9	29.29	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
42,458.64	11.7941	204.9	29.27	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
42,612.52	11.8368	204.9	29.26	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
42,761.02	11.8781	204.9	29.25	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
42,916.89	11.9214	204.8	29.25	12.71778	0.016669	1,336.62	1.00580	204.80	90.00	81.31	184.00	134.98	69.82	94.00	81.31
43,067.89	11.9633	204.8	29.24	12.71778	0.016669	1,336.62	1.00580	204.80	90.00	81.31	184.00	134.98	69.82	94.00	81.31
43,221.64	12.0060	204.8	29.23	12.71778	0.016669	1,336.62	1.00580	204.80	90.00	81.31	184.00	134.98	69.82	94.00	81.31

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)	COPL (psig)
35,646.64	9.9018	184.74	8.3358	16,906.35	13.7603	7.4001	14.8540	6.98
35,796.64	9.9435	184.74	8.3358	16,905.99	13.7600	7.3998	14.8440	6.98
35,952.52	9.9868	184.74	8.3358	16,905.60	13.7597	7.3995	14.8440	6.98
36,102.14	10.0284	184.74	8.3358	16,905.24	13.7594	7.3992	14.8340	6.98
36,255.39	10.0709	184.74	8.3358	16,904.86	13.7591	7.3989	14.8340	6.98
36,408.39	10.1134	184.74	8.3358	16,904.49	13.7588	7.3986	14.8340	6.98
36,560.39	10.1557	184.74	8.3358	16,904.11	13.7585	7.3983	14.8240	6.98
36,712.52	10.1979	184.74	8.3358	16,903.74	13.7582	7.3980	14.8340	6.98
36,867.02	10.2408	184.74	8.3358	16,903.36	13.7579	7.3976	14.8240	6.98
37,027.52	10.2854	184.66	8.3210	16,902.97	13.7558	7.3808	14.8140	6.96
37,177.27	10.3270	184.66	8.3210	16,902.60	13.7555	7.3805	14.8140	6.96
37,331.39	10.3698	184.66	8.3210	16,902.22	13.7552	7.3802	14.8040	6.96
37,488.89	10.4136	184.66	8.3210	16,901.84	13.7549	7.3799	14.7940	6.96
37,643.39	10.4565	184.66	8.3210	16,901.46	13.7546	7.3796	14.7940	6.96
37,798.14	10.4995	184.66	8.3210	16,901.08	13.7543	7.3793	14.7840	6.96
37,956.52	10.5435	184.66	8.3210	16,900.69	13.7540	7.3790	14.7740	6.96
38,108.89	10.5858	184.57	8.3062	16,900.31	13.7519	7.3622	14.7740	6.95
38,271.52	10.6310	184.57	8.3062	16,899.92	13.7516	7.3618	14.7540	6.95
38,421.14	10.6725	184.57	8.3062	16,899.55	13.7513	7.3615	14.7540	6.95
38,577.64	10.7160	184.57	8.3062	16,899.16	13.7510	7.3612	14.7440	6.94
38,732.14	10.7589	184.57	8.3062	16,898.79	13.7507	7.3609	14.7540	6.94
38,888.64	10.8024	184.57	8.3062	16,898.40	13.7504	7.3606	14.7440	6.94
39,047.27	10.8465	184.49	8.2915	16,898.01	13.7483	7.3438	14.7340	6.93
39,204.14	10.8900	184.49	8.2915	16,897.63	13.7480	7.3435	14.7240	6.93
39,363.89	10.9344	184.49	8.2915	16,897.24	13.7477	7.3432	14.7240	6.93
39,520.77	10.9780	184.49	8.2915	16,896.85	13.7474	7.3429	14.7040	6.93
39,677.02	11.0214	184.49	8.2915	16,896.47	13.7471	7.3425	14.7040	6.93
39,837.39	11.0659	184.41	8.2768	16,896.07	13.7450	7.3258	14.6840	6.91
39,989.64	11.1082	184.41	8.2768	16,895.70	13.7447	7.3255	14.6740	6.91
40,152.52	11.1535	184.41	8.2768	16,895.30	13.7444	7.3251	14.6740	6.91
40,299.02	11.1942	184.41	8.2768	16,894.94	13.7441	7.3249	14.6640	6.91
40,450.27	11.2362	184.33	8.2621	16,894.57	13.7420	7.3081	14.6540	6.89
40,607.64	11.2799	184.33	8.2621	16,894.18	13.7417	7.3078	14.6540	6.89
40,763.14	11.3231	184.33	8.2621	16,893.80	13.7414	7.3075	14.6440	6.89
40,915.52	11.3654	184.33	8.2621	16,893.43	13.7411	7.3072	14.6340	6.89
41,076.14	11.4100	184.25	8.2474	16,893.04	13.7390	7.2905	14.6240	6.87
41,232.14	11.4534	184.25	8.2474	16,892.65	13.7387	7.2901	14.6140	6.87
41,381.27	11.4948	184.25	8.2474	16,892.29	13.7384	7.2899	14.6140	6.87
41,534.64	11.5374	184.25	8.2474	16,891.91	13.7381	7.2895	14.6340	6.87
41,688.02	11.5800	184.17	8.2327	16,891.53	13.7361	7.2729	14.6240	6.86
41,838.14	11.6217	184.17	8.2327	16,891.17	13.7358	7.2726	14.6040	6.86
41,992.14	11.6645	184.17	8.2327	16,890.79	13.7355	7.2722	14.6040	6.86
42,153.02	11.7092	184.17	8.2327	16,890.39	13.7352	7.2719	14.5940	6.86
42,307.52	11.7521	184.09	8.2181	16,890.01	13.7331	7.2552	14.5940	6.84
42,458.64	11.7941	184.09	8.2181	16,889.64	13.7328	7.2549	14.5740	6.84
42,612.52	11.8368	184.09	8.2181	16,889.27	13.7325	7.2546	14.5640	6.84
42,761.02	11.8781	184.09	8.2181	16,888.90	13.7322	7.2543	14.5540	6.84
42,916.89	11.9214	184.00	8.2035	16,888.52	13.7302	7.2377	14.5540	6.82
43,067.89	11.9633	184.00	8.2035	16,888.15	13.7299	7.2374	14.5440	6.82
43,221.64	12.0060	184.00	8.2035	16,887.77	13.7296	7.2371	14.5340	6.82

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
43,377.02	12.0492	204.7	29.22	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
43,521.52	12.0893	204.7	29.21	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
43,672.39	12.1312	204.7	29.21	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
43,827.77	12.1744	204.7	29.19	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
43,984.02	12.2178	204.6	29.19	12.66616	0.016668	1,336.73	1.00578	204.60	90.00	81.17	183.84	134.90	69.70	93.84	81.17
44,139.39	12.2609	204.6	29.17	12.66616	0.016668	1,336.73	1.00578	204.60	90.00	81.17	183.84	134.90	69.70	93.84	81.17
44,300.39	12.3057	204.6	29.17	12.66616	0.016668	1,336.73	1.00578	204.60	90.00	81.17	183.84	134.90	69.70	93.84	81.17
44,453.02	12.3481	204.5	29.15	12.64041	0.016667	1,336.78	1.00576	204.50	90.00	81.10	183.76	134.86	69.64	93.76	81.10
44,607.89	12.3911	204.5	29.15	12.64041	0.016667	1,336.78	1.00576	204.50	90.00	81.10	183.76	134.86	69.64	93.76	81.10
44,765.64	12.4349	204.5	29.13	12.64041	0.016667	1,336.78	1.00576	204.50	90.00	81.10	183.76	134.86	69.64	93.76	81.10
44,921.27	12.4781	204.4	29.13	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
45,072.64	12.5202	204.4	29.12	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
45,229.89	12.5639	204.4	29.11	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
45,381.77	12.6060	204.4	29.10	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
45,533.77	12.6483	204.3	29.09	12.58905	0.016666	1,336.89	1.00573	204.30	90.00	80.96	183.60	134.78	69.52	93.60	80.96
45,684.02	12.6900	204.3	29.08	12.58905	0.016666	1,336.89	1.00573	204.30	90.00	80.96	183.60	134.78	69.52	93.60	80.96
Maxima		205.7	47.51												

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)	COPL (psig)
43,377.02	12.0492	183.92	8.1889	16,887.39	13.7275	7.2204	14.5240	6.80
43,521.52	12.0893	183.92	8.1889	16,887.04	13.7272	7.2202	14.5140	6.80
43,672.39	12.1312	183.92	8.1889	16,886.67	13.7269	7.2199	14.5140	6.80
43,827.77	12.1744	183.92	8.1889	16,886.29	13.7266	7.2196	14.4940	6.80
43,984.02	12.2178	183.84	8.1744	16,885.90	13.7246	7.2029	14.4940	6.79
44,139.39	12.2609	183.84	8.1744	16,885.52	13.7243	7.2026	14.4740	6.79
44,300.39	12.3057	183.84	8.1744	16,885.13	13.7239	7.2023	14.4740	6.79
44,453.02	12.3481	183.76	8.1598	16,884.75	13.7219	7.1857	14.4540	6.77
44,607.89	12.3911	183.76	8.1598	16,884.37	13.7216	7.1854	14.4540	6.77
44,765.64	12.4349	183.76	8.1598	16,883.99	13.7213	7.1851	14.4340	6.77
44,921.27	12.4781	183.68	8.1453	16,883.60	13.7192	7.1685	14.4340	6.75
45,072.64	12.5202	183.68	8.1453	16,883.23	13.7189	7.1682	14.4240	6.75
45,229.89	12.5639	183.68	8.1453	16,882.85	13.7186	7.1679	14.4140	6.75
45,381.77	12.6060	183.68	8.1453	16,882.47	13.7183	7.1676	14.4040	6.75
45,533.77	12.6483	183.60	8.1308	16,882.10	13.7163	7.1511	14.3940	6.73
45,684.02	12.6900	183.60	8.1308	16,881.73	13.7160	7.1508	14.3840	6.73
Maxima		184.74				7.41		6.99

8.B Spreadsheet Printout for the MCPA following a DBA-LOCA, with containment purge, 14 pages, beginning on the next page.

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger: Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
0.00	0.0000	95.0	15.45	0.81534	0.016114	0.00	0.99801	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49.26	0.0137	136.3	47.51	2.62519	0.016276	0.00	0.99933	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70.39	0.0196	139.0	47.48	2.81569	0.016288	0.00	0.99948	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
86.08	0.0239	139.4	47.25	2.84489	0.016290	0.00	0.99950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
106.89	0.0297	139.8	46.94	2.87435	0.016292	0.00	0.99952	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
131.33	0.0365	140.3	46.53	2.91154	0.016295	0.00	0.99955	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
156.20	0.0434	140.8	45.93	2.94914	0.016297	0.00	0.99958	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
181.33	0.0504	141.2	45.19	2.97951	0.016299	0.00	0.99960	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
205.70	0.0571	141.4	44.49	2.99480	0.016300	0.00	0.99961	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
230.20	0.0639	141.5	43.69	3.00246	0.016300	0.00	0.99962	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
255.46	0.0710	141.6	43.01	3.01015	0.016301	0.00	0.99963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
280.70	0.0780	141.6	42.18	3.01015	0.016301	0.00	0.99963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
305.95	0.0850	141.7	41.54	3.01785	0.016301	0.00	0.99963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
331.08	0.0920	141.7	40.77	3.01785	0.016301	0.00	0.99963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
356.58	0.0990	141.7	40.10	3.01785	0.016301	0.00	0.99963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
381.58	0.1060	141.8	39.41	3.02557	0.016302	0.00	0.99964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
406.83	0.1130	141.8	38.71	3.02557	0.016302	0.00	0.99964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
431.83	0.1200	141.8	38.14	3.02557	0.016302	0.00	0.99964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
451.33	0.1254	141.9	32.30	3.03330	0.016302	0.00	0.99964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
472.89	0.1314	142.1	27.42	3.04883	0.016303	0.00	0.99966	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
495.83	0.1377	142.8	25.39	3.10368	0.016307	0.00	0.99970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
520.83	0.1447	143.9	24.43	3.19158	0.016312	0.00	0.99976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
545.08	0.1514	145.2	23.96	3.29818	0.016318	0.00	0.99985	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
569.76	0.1583	146.5	23.67	3.40780	0.016325	0.00	0.99993	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
594.45	0.1651	147.8	23.49	3.52049	0.016331	0.00	1.00001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
666.26	0.1851	150.6	23.41	3.77400	0.016346	1,363.06	1.00020	150.60	90.00	42.97	139.76	113.77	36.83	49.76	42.97
805.26	0.2237	153.9	23.48	4.09250	0.016363	1,361.63	1.00043	153.90	90.00	45.31	142.46	115.06	38.84	52.46	45.31
976.39	0.2712	156.5	23.50	4.35921	0.016376	1,360.49	1.00062	156.50	90.00	47.15	144.59	116.08	40.42	54.59	47.15
1,155.14	0.3209	158.9	23.51	4.61832	0.016389	1,359.43	1.00081	158.90	90.00	48.85	146.56	117.02	41.88	56.56	48.85
1,336.01	0.3711	161.0	23.51	4.85560	0.016401	1,358.48	1.00097	161.00	90.00	50.34	148.27	117.84	43.16	58.27	50.34
1,520.39	0.4223	163.0	23.53	5.09108	0.016412	1,357.57	1.00114	163.00	90.00	51.75	149.91	118.63	44.37	59.91	51.75
1,701.51	0.4726	164.8	23.55	5.31119	0.016422	1,356.75	1.00129	164.80	90.00	53.03	151.38	119.33	45.47	61.38	53.03
1,888.14	0.5245	166.5	23.58	5.52638	0.016431	1,355.96	1.00143	166.50	90.00	54.23	152.77	120.00	46.50	62.77	54.23
2,074.89	0.5764	168.0	23.61	5.72232	0.016440	1,355.26	1.00156	168.00	90.00	55.29	154.00	120.58	47.42	64.00	55.29
2,256.89	0.6269	169.4	23.67	5.91044	0.016448	1,354.60	1.00169	169.40	90.00	56.28	155.14	121.13	48.27	65.14	56.28
2,440.89	0.6780	170.7	23.74	6.08976	0.016455	1,353.99	1.00181	170.70	90.00	57.20	156.20	121.64	49.06	66.20	57.20
2,622.26	0.7284	171.9	23.82	6.25932	0.016462	1,353.42	1.00192	171.90	90.00	58.05	157.18	122.11	49.79	67.18	58.05
2,808.76	0.7802	173.0	23.88	6.41823	0.016468	1,352.89	1.00202	173.00	90.00	58.83	158.08	122.54	50.46	68.08	58.83
2,995.14	0.8320	174.0	23.99	6.56563	0.016474	1,352.41	1.00212	174.00	90.00	59.54	158.90	122.93	51.07	68.90	59.54
3,177.39	0.8826	175.0	24.06	6.71586	0.016480	1,351.93	1.00222	175.00	90.00	60.24	159.71	123.32	51.68	69.71	60.24
3,365.26	0.9348	175.9	24.17	6.85352	0.016485	1,351.50	1.00231	175.90	90.00	60.88	160.45	123.68	52.22	70.45	60.88
3,551.76	0.9866	176.8	24.22	6.99355	0.016491	1,351.06	1.00240	176.80	90.00	61.52	161.18	124.03	52.77	71.18	61.52
3,736.64	1.0380	177.6	24.32	7.12002	0.016496	1,350.67	1.00248	177.60	90.00	62.08	161.84	124.34	53.26	71.84	62.08
3,921.76	1.0894	178.4	24.41	7.24841	0.016500	1,350.28	1.00256	178.40	90.00	62.65	162.49	124.66	53.74	72.49	62.65
4,106.51	1.1407	179.1	24.47	7.36234	0.016505	1,349.93	1.00263	179.10	90.00	63.15	163.06	124.93	54.17	73.06	63.15
4,290.89	1.1919	179.8	24.53	7.47777	0.016509	1,349.59	1.00270	179.80	90.00	63.64	163.63	125.20	54.60	73.63	63.64
4,473.89	1.2427	180.5	24.61	7.59471	0.016513	1,349.24	1.00278	180.50	90.00	64.14	164.20	125.48	55.02	74.20	64.14
4,656.26	1.2934	181.1	24.69	7.69617	0.016517	1,348.95	1.00284	181.10	90.00	64.56	164.69	125.71	55.39	74.69	64.56
4,836.14	1.3434	181.7	24.78	7.79875	0.016520	1,348.65	1.00291	181.70	90.00	64.98	165.18	125.95	55.76	75.18	64.98
5,022.89	1.3952	182.2	24.85	7.88511	0.016523	1,348.40	1.00296	182.20	90.00	65.34	165.59	126.14	56.06	75.59	65.34

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)
0.00	0.0000	95.00	3.5549	15,902.80	11.1410	0.0000	0.7540
49.26	0.0137	136.30	2.6252	15,902.68	11.9705	32.8140	32.8140
70.39	0.0196	139.00	2.8157	15,902.62	12.0247	32.7840	32.7840
86.08	0.0239	139.40	2.8449	15,902.58	12.0327	32.5540	32.5540
106.89	0.0297	139.80	2.8744	15,902.53	12.0407	32.2440	32.2440
131.33	0.0365	140.30	2.9115	15,902.47	12.0507	31.8340	31.8340
156.20	0.0434	140.80	2.9491	15,902.41	12.0607	31.2340	31.2340
181.33	0.0504	141.20	2.9795	15,902.35	12.0687	30.4940	30.4940
205.70	0.0571	141.40	2.9948	15,902.29	12.0727	29.7940	29.7940
230.20	0.0639	141.50	3.0025	15,902.23	12.0746	28.9940	28.9940
255.45	0.0710	141.60	3.0101	15,902.17	12.0766	28.3140	28.3140
280.70	0.0780	141.60	3.0101	15,902.11	12.0765	27.4840	27.4840
305.95	0.0850	141.70	3.0179	15,902.05	12.0785	26.8440	26.8440
331.08	0.0920	141.70	3.0179	15,901.98	12.0784	26.0740	26.0740
356.58	0.0990	141.70	3.0179	15,901.92	12.0784	25.4040	25.4040
381.58	0.1060	141.80	3.0256	15,901.86	12.0804	24.7140	24.7140
406.83	0.1130	141.80	3.0256	15,901.80	12.0803	24.0140	24.0140
431.83	0.1200	141.80	3.0256	15,901.74	12.0803	23.4440	23.4440
451.33	0.1254	141.90	3.0333	15,901.69	12.0822	17.6040	17.6040
472.89	0.1314	142.10	3.0488	15,901.64	12.0862	12.7240	12.7240
495.83	0.1377	142.80	3.1037	15,901.58	12.1002	10.6940	10.6940
520.83	0.1447	143.90	3.1918	15,901.52	12.1223	9.7340	9.7340
545.08	0.1514	145.20	3.2982	15,901.46	12.1483	9.2640	9.2640
569.76	0.1583	146.50	3.4078	15,901.40	12.1744	8.9740	8.9740
594.45	0.1651	147.80	3.5205	15,901.34	12.2005	8.7940	8.7940
666.26	0.1851	139.76	2.8716	15,901.16	12.0389	0.2145	8.7140
805.26	0.2237	142.46	3.0773	15,900.82	12.0929	0.4742	8.7840
976.39	0.2712	144.59	3.2480	15,900.40	12.1353	0.6873	8.8040
1,155.14	0.3209	146.56	3.4125	15,899.96	12.1744	0.8910	8.8140
1,336.01	0.3711	148.27	3.5623	15,899.52	12.2086	1.0748	8.8140
1,520.39	0.4223	149.91	3.7100	15,899.07	12.2411	1.2550	8.8340
1,701.51	0.4726	151.38	3.8473	15,898.62	12.2703	1.4216	8.8540
1,888.14	0.5245	152.77	3.9809	15,898.16	12.2978	1.5827	8.8840
2,074.89	0.5764	154.00	4.1020	15,897.71	12.3221	1.7281	8.9140
2,256.89	0.6269	155.14	4.2178	15,897.26	12.3447	1.8665	8.9740
2,440.89	0.6780	156.20	4.3278	15,896.81	12.3657	1.9975	9.0440
2,622.26	0.7284	157.18	4.4315	15,896.36	12.3850	2.1205	9.1240
2,808.76	0.7802	158.08	4.5283	15,895.91	12.4027	2.2350	9.1840
2,995.14	0.8320	158.90	4.6179	15,895.45	12.4187	2.3407	9.2940
3,177.39	0.8826	159.71	4.7090	15,895.00	12.4348	2.4478	9.3640
3,365.26	0.9348	160.45	4.7922	15,894.54	12.4492	2.5454	9.4740
3,551.76	0.9866	161.18	4.8767	15,894.08	12.4636	2.6443	9.5240
3,736.64	1.0380	161.84	4.9528	15,893.63	12.4763	2.7332	9.6240
3,921.76	1.0894	162.49	5.0300	15,893.18	12.4891	2.8230	9.7140
4,106.51	1.1407	163.06	5.0983	15,892.72	12.5002	2.9025	9.7740
4,290.89	1.1919	163.63	5.1674	15,892.27	12.5113	2.9827	9.8340
4,473.89	1.2427	164.20	5.2372	15,891.82	12.5224	3.0636	9.9140
4,656.26	1.2934	164.69	5.2978	15,891.37	12.5319	3.1336	9.9940
4,836.14	1.3434	165.18	5.3589	15,890.93	12.5413	3.2042	10.0840
5,022.89	1.3952	165.59	5.4102	15,890.47	12.5492	3.2634	10.1540

PECO ENERGY
NUCLEAR GROUP

CALCULATION SHEET

CALC. NO.: PM-1013
PAGE: 39
REVISION: 2

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
5,205.89	1.4461	182.8	24.94	7.98980	0.016527	1,348.10	1.00303	182.80	90.00	65.76	166.08	126.38	56.42	76.08	65.76
5,392.51	1.4979	183.3	25.01	8.07793	0.016530	1,347.85	1.00308	183.30	90.00	66.12	166.49	126.57	56.73	76.49	66.12
5,571.01	1.5475	183.8	25.09	8.16687	0.016533	1,347.60	1.00314	183.80	90.00	66.47	166.89	126.77	57.03	76.89	66.47
5,751.64	1.5977	184.3	25.16	8.25663	0.016536	1,347.35	1.00319	184.30	90.00	66.82	167.30	126.96	57.34	77.30	66.82
5,931.76	1.6477	184.8	25.23	8.34722	0.016539	1,347.10	1.00325	184.80	90.00	67.18	167.71	127.16	57.64	77.71	67.18
6,114.76	1.6985	185.2	25.29	8.42028	0.016542	1,346.89	1.00329	185.20	90.00	67.46	168.04	127.32	57.88	78.04	67.46
6,297.76	1.7494	185.6	25.36	8.49388	0.016544	1,346.69	1.00334	185.60	90.00	67.74	168.36	127.47	58.13	78.36	67.74
6,475.14	1.7986	186.1	25.43	8.58663	0.016547	1,346.44	1.00339	186.10	90.00	68.10	168.77	127.67	58.43	78.77	68.10
6,652.14	1.8478	186.5	25.49	8.66145	0.016550	1,346.24	1.00344	186.50	90.00	68.38	169.10	127.82	58.68	79.10	68.38
6,830.89	1.8975	186.8	25.56	8.71791	0.016552	1,346.08	1.00347	186.80	90.00	68.59	169.34	127.94	58.86	79.34	68.59
7,001.61	1.9449	187.2	25.63	8.79368	0.016554	1,345.88	1.00352	187.20	90.00	68.87	169.67	128.10	59.10	79.67	68.87
7,177.89	1.9939	187.6	25.69	8.87000	0.016557	1,345.68	1.00357	187.60	90.00	69.16	169.99	128.25	59.35	79.99	69.16
7,356.76	2.0435	187.9	25.75	8.92760	0.016559	1,345.52	1.00360	187.90	90.00	69.37	170.24	128.37	59.53	80.24	69.37
7,536.76	2.0935	188.3	25.81	9.00489	0.016561	1,345.32	1.00365	188.30	90.00	69.65	170.56	128.53	59.77	80.56	69.65
7,713.51	2.1426	188.6	25.87	9.06322	0.016563	1,345.17	1.00368	188.60	90.00	69.86	170.81	128.65	59.95	80.81	69.86
7,890.51	2.1918	188.9	25.93	9.12186	0.016565	1,345.01	1.00372	188.90	90.00	70.08	171.05	128.76	60.14	81.05	70.08
8,069.14	2.2414	189.3	25.98	9.20055	0.016567	1,344.81	1.00377	189.30	90.00	70.36	171.38	128.92	60.38	81.38	70.36
8,241.14	2.2892	189.6	26.04	9.25994	0.016569	1,344.65	1.00380	189.60	90.00	70.57	171.62	129.04	60.56	81.62	70.57
8,414.39	2.3373	189.9	26.09	9.31965	0.016571	1,344.50	1.00384	189.90	90.00	70.78	171.87	129.15	60.75	81.87	70.78
8,592.64	2.3868	190.2	26.18	9.37968	0.016573	1,344.35	1.00387	190.20	90.00	71.00	172.11	129.27	60.93	82.11	71.00
8,761.76	2.4338	190.4	26.23	9.41988	0.016574	1,344.24	1.00390	190.40	90.00	71.14	172.28	129.35	61.05	82.28	71.14
8,874.26	2.4651	190.6	26.27	9.46022	0.016576	1,344.14	1.00392	190.60	90.00	71.28	172.44	129.43	61.17	82.44	71.28
8,986.76	2.4963	190.8	26.30	9.50071	0.016577	1,344.04	1.00395	190.80	90.00	71.42	172.60	129.51	61.29	82.60	71.42
9,099.26	2.5276	191.0	26.34	9.54134	0.016578	1,343.93	1.00397	191.00	90.00	71.56	172.77	129.58	61.42	82.77	71.56
9,211.76	2.5588	191.2	26.37	9.58211	0.016580	1,343.83	1.00400	191.20	90.00	71.70	172.93	129.66	61.54	82.93	71.70
9,324.26	2.5901	191.3	26.41	9.60256	0.016580	1,343.78	1.00401	191.30	90.00	71.77	173.01	129.70	61.60	83.01	71.77
9,436.76	2.6213	191.5	26.45	9.64355	0.016581	1,343.67	1.00403	191.50	90.00	71.91	173.17	129.78	61.72	83.17	71.91
9,549.26	2.6526	191.7	26.48	9.68469	0.016583	1,343.57	1.00406	191.70	90.00	72.06	173.34	129.86	61.84	83.34	72.06
9,661.76	2.6838	191.9	26.52	9.72598	0.016584	1,343.47	1.00408	191.90	90.00	72.20	173.50	129.94	61.96	83.50	72.20
9,774.26	2.7151	192.0	26.56	9.74667	0.016585	1,343.42	1.00409	192.00	90.00	72.27	173.58	129.97	62.03	83.58	72.27
9,886.76	2.7463	192.2	26.59	9.78818	0.016586	1,343.31	1.00412	192.20	90.00	72.41	173.74	130.05	62.15	83.74	72.41
9,999.26	2.7776	192.4	26.63	9.82984	0.016587	1,343.21	1.00414	192.40	90.00	72.55	173.91	130.13	62.27	83.91	72.55
10,111.77	2.8088	192.6	26.67	9.87164	0.016589	1,343.10	1.00417	192.60	90.00	72.69	174.07	130.21	62.39	84.07	72.69
10,224.27	2.8401	192.7	26.70	9.89260	0.016589	1,343.05	1.00418	192.70	90.00	72.76	174.15	130.25	62.45	84.15	72.76
10,342.89	2.8730	192.9	26.75	9.93462	0.016590	1,342.95	1.00420	192.90	90.00	72.90	174.31	130.33	62.57	84.31	72.90
10,455.39	2.9043	193.1	26.79	9.97679	0.016592	1,342.84	1.00423	193.10	90.00	73.05	174.48	130.41	62.69	84.48	73.05
10,567.89	2.9355	193.2	26.82	9.99794	0.016592	1,342.79	1.00424	193.20	90.00	73.12	174.56	130.44	62.76	84.56	73.12
10,680.39	2.9668	193.4	26.85	10.04033	0.016594	1,342.69	1.00427	193.40	90.00	73.26	174.72	130.52	62.88	84.72	73.26
10,792.89	2.9980	193.6	26.89	10.08288	0.016595	1,342.58	1.00429	193.60	90.00	73.40	174.88	130.60	63.00	84.88	73.40
10,905.39	3.0293	193.7	26.92	10.10421	0.016596	1,342.53	1.00430	193.70	90.00	73.47	174.97	130.64	63.06	84.97	73.47
11,017.89	3.0605	193.9	26.95	10.14699	0.016597	1,342.43	1.00433	193.90	90.00	73.61	175.13	130.72	63.18	85.13	73.61
11,142.64	3.0952	194.1	27.01	10.18991	0.016598	1,342.32	1.00436	194.10	90.00	73.75	175.29	130.80	63.30	85.29	73.75
11,262.39	3.1284	194.2	27.04	10.21143	0.016599	1,342.27	1.00437	194.20	90.00	73.82	175.37	130.84	63.36	85.37	73.82
11,377.77	3.1605	194.4	27.07	10.25458	0.016600	1,342.17	1.00439	194.40	90.00	73.96	175.54	130.91	63.49	85.54	73.96
11,490.14	3.1917	194.5	27.11	10.27621	0.016601	1,342.11	1.00441	194.50	90.00	74.04	175.62	130.95	63.55	85.62	74.04
11,609.77	3.2249	194.7	27.16	10.31959	0.016602	1,342.01	1.00443	194.70	90.00	74.18	175.78	131.03	63.67	85.78	74.18
11,762.77	3.2674	194.9	27.19	10.36312	0.016603	1,341.90	1.00446	194.90	90.00	74.32	175.94	131.11	63.79	85.94	74.32
11,889.14	3.3025	195.1	27.22	10.40681	0.016605	1,341.80	1.00448	195.10	90.00	74.46	176.11	131.19	63.91	86.11	74.46
12,042.02	3.3450	195.3	27.27	10.45065	0.016606	1,341.69	1.00451	195.30	90.00	74.60	176.27	131.27	64.03	86.27	74.60
12,195.52	3.3876	195.5	27.32	10.49464	0.016607	1,341.59	1.00453	195.50	90.00	74.74	176.43	131.34	64.16	86.43	74.74

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)
5,205.89	1.4461	166.08	5.4724	15,890.03	12.5586	3.3351	10.2440
5,392.51	1.4979	166.49	5.5247	15,889.57	12.5665	3.3952	10.3140
5,571.01	1.5475	166.89	5.5774	15,889.13	12.5743	3.4557	10.3940
5,751.64	1.5977	167.30	5.6305	15,888.69	12.5821	3.5166	10.4640
5,931.76	1.6477	167.71	5.6840	15,888.25	12.5900	3.5780	10.5340
6,114.76	1.6985	168.04	5.7272	15,887.80	12.5962	3.6273	10.5940
6,297.76	1.7494	168.36	5.7706	15,887.35	12.6024	3.6769	10.6640
6,475.14	1.7986	168.77	5.8252	15,886.91	12.6102	3.7394	10.7340
6,652.14	1.8478	169.10	5.8693	15,886.48	12.6164	3.7897	10.7940
6,830.89	1.8975	169.34	5.9025	15,886.04	12.6209	3.8274	10.8640
7,001.51	1.9449	169.67	5.9470	15,885.62	12.6272	3.8781	10.9340
7,177.89	1.9939	169.99	5.9918	15,885.19	12.6334	3.9291	10.9940
7,356.76	2.0435	170.24	6.0256	15,884.75	12.6379	3.9675	11.0540
7,536.76	2.0935	170.56	6.0708	15,884.31	12.6441	4.0190	11.1140
7,713.51	2.1426	170.81	6.1050	15,883.87	12.6487	4.0577	11.1740
7,890.51	2.1918	171.05	6.1393	15,883.44	12.6532	4.0966	11.2340
8,069.14	2.2414	171.38	6.1853	15,883.00	12.6594	4.1488	11.2840
8,241.14	2.2892	171.62	6.2200	15,882.58	12.6640	4.1880	11.3440
8,414.39	2.3373	171.87	6.2549	15,882.16	12.6686	4.2274	11.3940
8,592.64	2.3868	172.11	6.2899	15,881.72	12.6731	4.2670	11.4840
8,761.76	2.4338	172.28	6.3133	15,881.30	12.6761	4.2934	11.5340
8,874.26	2.4651	172.44	6.3368	15,881.03	12.6791	4.3199	11.5740
8,986.76	2.4963	172.60	6.3604	15,880.75	12.6822	4.3466	11.6040
9,099.26	2.5276	172.77	6.3841	15,880.48	12.6852	4.3733	11.6440
9,211.76	2.5588	172.93	6.4078	15,880.20	12.6883	4.4001	11.6740
9,324.26	2.5901	173.01	6.4197	15,879.92	12.6897	4.4134	11.7140
9,436.76	2.6213	173.17	6.4435	15,879.65	12.6927	4.4403	11.7540
9,549.26	2.6526	173.34	6.4674	15,879.37	12.6958	4.4672	11.7840
9,661.76	2.6838	173.50	6.4914	15,879.10	12.6988	4.4942	11.8240
9,774.26	2.7151	173.58	6.5034	15,878.82	12.7002	4.5077	11.8640
9,886.76	2.7463	173.74	6.5275	15,878.54	12.7033	4.5348	11.8940
9,999.26	2.7776	173.91	6.5517	15,878.27	12.7063	4.5620	11.9340
10,111.77	2.8088	174.07	6.5760	15,877.99	12.7094	4.5893	11.9740
10,224.27	2.8401	174.15	6.5881	15,877.72	12.7108	4.6029	12.0040
10,342.89	2.8730	174.31	6.6125	15,877.42	12.7138	4.6303	12.0540
10,455.39	2.9043	174.48	6.6369	15,877.15	12.7169	4.6578	12.0940
10,567.89	2.9355	174.56	6.6491	15,876.87	12.7183	4.6714	12.1240
10,680.39	2.9668	174.72	6.6737	15,876.60	12.7213	4.6990	12.1540
10,792.89	2.9980	174.88	6.6983	15,876.32	12.7244	4.7267	12.1940
10,905.39	3.0293	174.97	6.7107	15,876.04	12.7258	4.7405	12.2240
11,017.89	3.0605	175.13	6.7354	15,875.77	12.7288	4.7682	12.2540
11,142.64	3.0952	175.29	6.7602	15,875.46	12.7319	4.7961	12.3140
11,262.39	3.1284	175.37	6.7726	15,875.17	12.7333	4.8099	12.3440
11,377.77	3.1605	175.54	6.7976	15,874.89	12.7363	4.8379	12.3740
11,490.14	3.1917	175.62	6.8101	15,874.61	12.7377	4.8518	12.4140
11,609.77	3.2249	175.78	6.8351	15,874.32	12.7407	4.8799	12.4640
11,762.77	3.2674	175.94	6.8602	15,873.94	12.7437	4.9079	12.4940
11,889.14	3.3025	176.11	6.8854	15,873.63	12.7467	4.9361	12.5240
12,042.02	3.3450	176.27	6.9107	15,873.28	12.7497	4.9644	12.5740
12,195.52	3.3876	176.43	6.9360	15,872.88	12.7527	4.9927	12.6240

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
12,350.89	3.4308	195.7	27.35	10.53878	0.016609	1,341.48	1.00456	195.70	90.00	74.88	176.60	131.42	64.28	86.60	74.88
12,505.14	3.4737	195.9	27.40	10.58308	0.016610	1,341.38	1.00459	195.90	90.00	75.02	176.76	131.50	64.40	86.76	75.02
12,660.39	3.5168	196.1	27.44	10.62754	0.016611	1,341.27	1.00461	196.10	90.00	75.17	176.92	131.58	64.52	86.92	75.17
12,813.39	3.5593	196.2	27.49	10.64983	0.016612	1,341.22	1.00462	196.20	90.00	75.24	177.00	131.62	64.58	87.00	75.24
12,970.77	3.6030	196.4	27.53	10.69452	0.016613	1,341.11	1.00465	196.40	90.00	75.38	177.17	131.70	64.70	87.17	75.38
13,117.27	3.6437	196.6	27.56	10.73938	0.016614	1,341.01	1.00468	196.60	90.00	75.52	177.33	131.77	64.83	87.33	75.52
13,275.39	3.6876	196.8	27.61	10.78436	0.016616	1,340.90	1.00470	196.80	90.00	75.66	177.49	131.85	64.95	87.49	75.66
13,438.02	3.7328	197.0	27.65	10.82952	0.016617	1,340.80	1.00473	197.00	90.00	75.80	177.65	131.93	65.07	87.65	75.80
13,593.52	3.7760	197.2	27.69	10.87484	0.016618	1,340.69	1.00476	197.20	90.00	75.94	177.82	132.01	65.19	87.82	75.94
13,748.14	3.8189	197.3	27.72	10.89758	0.016619	1,340.64	1.00477	197.30	90.00	76.01	177.90	132.05	65.25	87.90	76.01
13,907.64	3.8632	197.5	27.77	10.94311	0.016620	1,340.53	1.00479	197.50	90.00	76.16	178.06	132.13	65.37	88.06	76.16
14,071.14	3.9087	197.7	27.80	10.98882	0.016622	1,340.43	1.00482	197.70	90.00	76.30	178.22	132.20	65.50	88.22	76.30
14,222.27	3.9506	197.9	27.84	11.03469	0.016623	1,340.32	1.00485	197.90	90.00	76.44	178.39	132.28	65.62	88.39	76.44
14,383.64	3.9955	198.0	27.90	11.05769	0.016624	1,340.27	1.00486	198.00	90.00	76.51	178.47	132.32	65.68	88.47	76.51
14,549.89	4.0416	198.2	27.93	11.10380	0.016625	1,340.16	1.00489	198.20	90.00	76.65	178.63	132.40	65.80	88.63	76.65
14,706.39	4.0851	198.4	27.96	11.15007	0.016626	1,340.06	1.00491	198.40	90.00	76.79	178.79	132.48	65.92	88.79	76.79
14,866.02	4.1294	198.5	27.99	11.17326	0.016627	1,340.00	1.00493	198.50	90.00	76.86	178.88	132.52	65.98	88.88	76.86
15,027.77	4.1744	198.7	28.05	11.21977	0.016628	1,339.90	1.00495	198.70	90.00	77.00	179.04	132.59	66.11	89.04	77.00
15,188.14	4.2189	198.8	28.08	11.24309	0.016629	1,339.84	1.00497	198.80	90.00	77.07	179.12	132.63	66.17	89.12	77.07
15,343.02	4.2619	199.0	28.11	11.28984	0.016630	1,339.74	1.00499	199.00	90.00	77.22	179.28	132.71	66.29	89.28	77.22
15,495.27	4.3042	199.1	28.14	11.31328	0.016631	1,339.68	1.00501	199.10	90.00	77.29	179.36	132.75	66.35	89.36	77.29
15,660.27	4.3501	199.3	28.17	11.36027	0.016632	1,339.58	1.00504	199.30	90.00	77.43	179.53	132.83	66.47	89.53	77.43
15,819.64	4.3943	199.4	28.20	11.38383	0.016633	1,339.52	1.00505	199.40	90.00	77.50	179.61	132.87	66.53	89.61	77.50
15,979.02	4.4386	199.6	28.23	11.43107	0.016634	1,339.42	1.00508	199.60	90.00	77.64	179.77	132.95	66.65	89.77	77.64
16,132.39	4.4812	199.7	28.27	11.45475	0.016635	1,339.36	1.00509	199.70	90.00	77.71	179.85	132.99	66.71	89.85	77.71
16,296.27	4.5267	199.9	28.30	11.50223	0.016636	1,339.26	1.00512	199.90	90.00	77.85	180.02	133.06	66.84	90.02	77.85
16,447.77	4.5688	200.0	28.32	11.52604	0.016637	1,339.20	1.00513	200.00	90.00	77.92	180.10	133.10	66.90	90.10	77.92
16,604.02	4.6122	200.1	28.35	11.54988	0.016637	1,339.15	1.00514	200.10	90.00	77.99	180.18	133.14	66.96	90.18	77.99
16,766.14	4.6573	200.2	28.38	11.57376	0.016638	1,339.10	1.00516	200.20	90.00	78.06	180.26	133.18	67.02	90.26	78.06
16,922.27	4.7006	200.4	28.41	11.62166	0.016639	1,338.99	1.00518	200.40	90.00	78.21	180.42	133.26	67.14	90.42	78.21
17,086.02	4.7461	200.5	28.43	11.64567	0.016640	1,338.94	1.00520	200.50	90.00	78.28	180.50	133.30	67.20	90.50	78.28
17,248.02	4.7911	200.6	28.49	11.66972	0.016641	1,338.88	1.00521	200.60	90.00	78.35	180.59	133.34	67.26	90.59	78.35
17,414.02	4.8372	200.8	28.52	11.71794	0.016642	1,338.78	1.00524	200.80	90.00	78.49	180.75	133.42	67.38	90.75	78.49
17,568.27	4.8801	200.9	28.53	11.74211	0.016643	1,338.72	1.00525	200.90	90.00	78.56	180.83	133.45	67.45	90.83	78.56
17,730.02	4.9250	201.0	28.56	11.76633	0.016643	1,338.67	1.00527	201.00	90.00	78.63	180.91	133.49	67.51	90.91	78.63
17,890.02	4.9694	201.1	28.57	11.79058	0.016644	1,338.62	1.00528	201.10	90.00	78.70	180.99	133.53	67.57	90.99	78.70
18,045.52	5.0126	201.2	28.59	11.81488	0.016645	1,338.56	1.00530	201.20	90.00	78.77	181.07	133.57	67.63	91.07	78.77
18,204.14	5.0567	201.3	28.62	11.83922	0.016645	1,338.51	1.00531	201.30	90.00	78.84	181.16	133.61	67.69	91.16	78.84
18,363.52	5.1010	201.4	28.65	11.86360	0.016646	1,338.45	1.00532	201.40	90.00	78.91	181.24	133.65	67.75	91.24	78.91
18,512.02	5.1422	201.5	28.67	11.88803	0.016647	1,338.40	1.00534	201.50	90.00	78.98	181.32	133.69	67.81	91.32	78.98
18,671.64	5.1866	201.6	28.68	11.91249	0.016647	1,338.35	1.00535	201.60	90.00	79.05	181.40	133.73	67.87	91.40	79.05
18,825.02	5.2292	201.7	28.70	11.93700	0.016648	1,338.29	1.00536	201.70	90.00	79.12	181.48	133.77	67.93	91.48	79.12
18,984.27	5.2734	201.8	28.72	11.96155	0.016649	1,338.24	1.00538	201.80	90.00	79.19	181.56	133.81	67.99	91.56	79.19
19,141.39	5.3171	201.9	28.75	11.98614	0.016649	1,338.19	1.00539	201.90	90.00	79.27	181.64	133.85	68.05	91.64	79.27
19,301.77	5.3616	202.0	28.77	12.01077	0.016650	1,338.13	1.00541	202.00	90.00	79.34	181.73	133.88	68.12	91.73	79.34
19,458.77	5.4052	202.1	28.78	12.03545	0.016651	1,338.08	1.00542	202.10	90.00	79.41	181.81	133.92	68.18	91.81	79.41
19,613.89	5.4483	202.2	28.80	12.06016	0.016651	1,338.02	1.00543	202.20	90.00	79.48	181.89	133.96	68.24	91.89	79.48
19,766.14	5.4906	202.3	28.82	12.08492	0.016652	1,337.97	1.00545	202.30	90.00	79.55	181.97	134.00	68.30	91.97	79.55
19,920.39	5.5334	202.4	28.84	12.10973	0.016653	1,337.92	1.00546	202.40	90.00	79.62	182.05	134.04	68.36	92.05	79.62
20,079.27	5.5776	202.4	28.86	12.10973	0.016653	1,337.92	1.00546	202.40	90.00	79.62	182.05	134.04	68.36	92.05	79.62

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)
12,360.89	3.4308	176.60	6.9615	15,872.50	12.7556	5.0211	12.6540
12,505.14	3.4737	176.76	6.9870	15,872.12	12.7586	5.0496	12.7040
12,660.39	3.5168	176.92	7.0126	15,871.74	12.7615	5.0781	12.7440
12,813.39	3.5593	177.00	7.0254	15,871.36	12.7629	5.0923	12.7940
12,970.77	3.6030	177.17	7.0511	15,870.98	12.7658	5.1209	12.8340
13,117.27	3.6437	177.33	7.0768	15,870.62	12.7688	5.1497	12.8640
13,275.39	3.6876	177.49	7.1027	15,870.23	12.7718	5.1785	12.9140
13,438.02	3.7328	177.65	7.1286	15,869.83	12.7747	5.2074	12.9540
13,593.52	3.7760	177.82	7.1547	15,869.45	12.7777	5.2363	12.9940
13,748.14	3.8189	177.90	7.1677	15,869.07	12.7790	5.2507	13.0240
13,907.64	3.8632	178.06	7.1938	15,868.68	12.7819	5.2798	13.0740
14,071.14	3.9087	178.22	7.2200	15,868.28	12.7849	5.3089	13.1040
14,222.27	3.9506	178.39	7.2463	15,867.91	12.7878	5.3382	13.1440
14,383.64	3.9955	178.47	7.2595	15,867.51	12.7892	5.3527	13.2040
14,549.89	4.0416	178.63	7.2859	15,867.10	12.7921	5.3820	13.2340
14,706.39	4.0851	178.79	7.3124	15,866.72	12.7950	5.4115	13.2640
14,866.02	4.1294	178.88	7.3257	15,866.33	12.7964	5.4261	13.2940
15,027.77	4.1744	179.04	7.3523	15,865.93	12.7993	5.4556	13.3540
15,188.14	4.2189	179.12	7.3656	15,865.54	12.8006	5.4703	13.3840
15,343.02	4.2619	179.28	7.3924	15,865.16	12.8036	5.5000	13.4140
15,495.27	4.3042	179.36	7.4058	15,864.79	12.8049	5.5147	13.4440
15,660.27	4.3501	179.53	7.4326	15,864.38	12.8078	5.5445	13.4740
15,819.64	4.3943	179.61	7.4461	15,863.99	12.8092	5.5592	13.5040
15,979.02	4.4386	179.77	7.4730	15,863.60	12.8121	5.5892	13.5340
16,132.39	4.4812	179.85	7.4866	15,863.22	12.8134	5.6040	13.5740
16,296.27	4.5267	180.02	7.5137	15,862.82	12.8164	5.6340	13.6040
16,447.77	4.5688	180.10	7.5272	15,862.45	12.8177	5.6490	13.6240
16,604.02	4.6122	180.18	7.5408	15,862.07	12.8190	5.6639	13.6540
16,766.14	4.6573	180.26	7.5545	15,861.67	12.8203	5.6788	13.6840
16,922.27	4.7006	180.42	7.5818	15,861.29	12.8233	5.7091	13.7140
17,086.02	4.7461	180.50	7.5954	15,860.88	12.8246	5.7240	13.7340
17,248.02	4.7911	180.59	7.6091	15,860.49	12.8259	5.7391	13.7940
17,414.02	4.8372	180.75	7.6366	15,860.08	12.8288	5.7695	13.8240
17,568.27	4.8801	180.83	7.6504	15,859.70	12.8302	5.7845	13.8340
17,730.02	4.9250	180.91	7.6642	15,859.30	12.8315	5.7996	13.8640
17,890.02	4.9694	180.99	7.6780	15,858.91	12.8328	5.8148	13.8740
18,045.52	5.0126	181.07	7.6918	15,858.53	12.8341	5.8299	13.8940
18,204.14	5.0567	181.16	7.7056	15,858.14	12.8354	5.8451	13.9240
18,363.52	5.1010	181.24	7.7195	15,857.75	12.8367	5.8603	13.9540
18,512.02	5.1422	181.32	7.7334	15,857.39	12.8381	5.8755	13.9740
18,671.64	5.1866	181.40	7.7473	15,856.99	12.8394	5.8907	13.9840
18,826.02	5.2292	181.48	7.7612	15,856.62	12.8407	5.9060	14.0040
18,984.27	5.2734	181.56	7.7752	15,856.23	12.8420	5.9212	14.0240
19,141.39	5.3171	181.64	7.7892	15,855.84	12.8433	5.9365	14.0540
19,301.77	5.3616	181.73	7.8031	15,855.45	12.8447	5.9518	14.0740
19,458.77	5.4052	181.81	7.8172	15,855.06	12.8460	5.9671	14.0840
19,613.89	5.4483	181.89	7.8312	15,854.68	12.8473	5.9825	14.1040
19,766.14	5.4906	181.97	7.8452	15,854.31	12.8486	5.9979	14.1240
19,920.39	5.5334	182.05	7.8593	15,853.93	12.8499	6.0133	14.1440
20,079.27	5.5776	182.05	7.8593	15,853.54	12.8496	6.0130	14.1640

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
20,233.77	5.6206	202.5	28.87	12.13457	0.016654	1,337.86	1.00548	202.50	90.00	79.69	182.13	134.08	68.42	92.13	79.69
20,386.27	5.6629	202.6	28.90	12.15946	0.016654	1,337.81	1.00549	202.60	90.00	79.76	182.21	134.12	68.48	92.21	79.76
20,537.39	5.7048	202.7	28.92	12.18438	0.016655	1,337.75	1.00550	202.70	90.00	79.83	182.30	134.16	68.54	92.30	79.83
20,690.39	5.7473	202.7	28.93	12.18438	0.016655	1,337.75	1.00550	202.70	90.00	79.83	182.30	134.16	68.54	92.30	79.83
20,846.64	5.7905	202.8	28.94	12.20935	0.016656	1,337.70	1.00552	202.80	90.00	79.90	182.38	134.20	68.60	92.38	79.90
20,998.39	5.8329	202.9	28.96	12.23437	0.016656	1,337.65	1.00553	202.90	90.00	79.97	182.46	134.24	68.66	92.46	79.97
21,152.64	5.8757	203.0	28.98	12.25942	0.016657	1,337.59	1.00555	203.00	90.00	80.04	182.54	134.28	68.72	92.54	80.04
21,304.14	5.9178	203.0	28.99	12.25942	0.016657	1,337.59	1.00555	203.00	90.00	80.04	182.54	134.28	68.72	92.54	80.04
21,461.62	5.9615	203.1	29.02	12.28452	0.016658	1,337.54	1.00556	203.10	90.00	80.11	182.62	134.31	68.79	92.62	80.11
21,618.14	6.0050	203.2	29.04	12.30966	0.016658	1,337.48	1.00558	203.20	90.00	80.18	182.70	134.35	68.85	92.70	80.18
21,780.64	6.0502	203.3	29.05	12.33485	0.016659	1,337.43	1.00559	203.30	90.00	80.25	182.78	134.39	68.91	92.78	80.25
21,934.89	6.0930	203.3	29.07	12.33485	0.016659	1,337.43	1.00559	203.30	90.00	80.25	182.78	134.39	68.91	92.78	80.25
22,090.52	6.1363	203.4	29.08	12.36008	0.016660	1,337.38	1.00560	203.40	90.00	80.33	182.87	134.43	68.97	92.87	80.33
22,239.89	6.1777	203.4	29.09	12.36008	0.016660	1,337.38	1.00560	203.40	90.00	80.33	182.87	134.43	68.97	92.87	80.33
22,391.27	6.2198	203.5	29.10	12.38535	0.016660	1,337.32	1.00562	203.50	90.00	80.40	182.95	134.47	69.03	92.95	80.40
22,546.14	6.2628	203.6	29.13	12.41066	0.016661	1,337.27	1.00563	203.60	90.00	80.47	183.03	134.51	69.09	93.03	80.47
22,700.14	6.3056	203.6	29.15	12.41066	0.016661	1,337.27	1.00563	203.60	90.00	80.47	183.03	134.51	69.09	93.03	80.47
22,856.64	6.3491	203.7	29.16	12.43601	0.016662	1,337.21	1.00565	203.70	90.00	80.54	183.11	134.55	69.15	93.11	80.54
23,015.77	6.3933	203.8	29.16	12.46141	0.016662	1,337.16	1.00566	203.80	90.00	80.61	183.19	134.59	69.21	93.19	80.61
23,168.39	6.4357	203.8	29.18	12.46141	0.016662	1,337.16	1.00566	203.80	90.00	80.61	183.19	134.59	69.21	93.19	80.61
23,322.64	6.4785	203.9	29.19	12.48685	0.016663	1,337.11	1.00567	203.90	90.00	80.68	183.27	134.63	69.27	93.27	80.68
23,476.52	6.5213	203.9	29.21	12.48685	0.016663	1,337.11	1.00567	203.90	90.00	80.68	183.27	134.63	69.27	93.27	80.68
23,631.77	6.5644	204.0	29.23	12.51234	0.016664	1,337.05	1.00569	204.00	90.00	80.75	183.35	134.67	69.33	93.35	80.75
23,787.39	6.6076	204.0	29.25	12.51234	0.016664	1,337.05	1.00569	204.00	90.00	80.75	183.35	134.67	69.33	93.35	80.75
23,938.89	6.6497	204.1	29.25	12.53787	0.016664	1,337.00	1.00570	204.10	90.00	80.82	183.43	134.71	69.39	93.43	80.82
24,094.14	6.6928	204.1	29.26	12.53787	0.016664	1,337.00	1.00570	204.10	90.00	80.82	183.43	134.71	69.39	93.43	80.82
24,246.89	6.7352	204.2	29.27	12.56344	0.016665	1,336.94	1.00572	204.20	90.00	80.89	183.52	134.74	69.46	93.52	80.89
24,400.27	6.7779	204.2	29.29	12.56344	0.016665	1,336.94	1.00572	204.20	90.00	80.89	183.52	134.74	69.46	93.52	80.89
24,552.52	6.8201	204.3	29.29	12.58905	0.016666	1,336.89	1.00573	204.30	90.00	80.96	183.60	134.78	69.52	93.60	80.96
24,710.27	6.8640	204.3	29.30	12.58905	0.016666	1,336.89	1.00573	204.30	90.00	80.96	183.60	134.78	69.52	93.60	80.96
24,864.39	6.9068	204.4	29.33	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
25,014.64	6.9485	204.4	29.33	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
25,165.64	6.9905	204.5	29.35	12.64041	0.016667	1,336.78	1.00576	204.50	90.00	81.10	183.76	134.86	69.64	93.76	81.10
25,321.39	7.0337	204.5	29.35	12.64041	0.016667	1,336.78	1.00576	204.50	90.00	81.10	183.76	134.86	69.64	93.76	81.10
25,474.14	7.0762	204.6	29.36	12.66616	0.016668	1,336.73	1.00578	204.60	90.00	81.17	183.84	134.90	69.70	93.84	81.17
25,631.52	7.1199	204.6	29.36	12.66616	0.016668	1,336.73	1.00578	204.60	90.00	81.17	183.84	134.90	69.70	93.84	81.17
25,786.39	7.1626	204.7	29.37	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
25,941.39	7.2059	204.7	29.39	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
26,094.89	7.2486	204.7	29.41	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
26,248.64	7.2913	204.8	29.42	12.71778	0.016669	1,336.62	1.00580	204.80	90.00	81.31	184.00	134.98	69.82	94.00	81.31
26,405.77	7.3349	204.8	29.42	12.71778	0.016669	1,336.62	1.00580	204.80	90.00	81.31	184.00	134.98	69.82	94.00	81.31
26,562.89	7.3786	204.9	29.43	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
26,715.77	7.4210	204.9	29.43	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
26,867.39	7.4632	204.9	29.44	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
27,027.02	7.5075	205.0	29.45	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
27,183.14	7.5509	205.0	29.45	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
27,339.62	7.5943	205.0	29.47	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
27,495.77	7.6377	205.1	29.48	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
27,651.27	7.6809	205.1	29.48	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
27,804.27	7.7234	205.1	29.49	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)
20,233.77	5.6205	182.13	7.8734	15,853.16	12.8510	6.0284	14.1740
20,386.27	5.6629	182.21	7.8875	15,852.79	12.8523	6.0438	14.2040
20,537.39	5.7048	182.30	7.9017	15,852.42	12.8536	6.0593	14.2240
20,690.39	5.7473	182.30	7.9017	15,852.04	12.8533	6.0590	14.2340
20,845.64	5.7905	182.38	7.9158	15,851.66	12.8546	6.0745	14.2440
20,998.39	5.8329	182.46	7.9300	15,851.29	12.8559	6.0900	14.2640
21,152.64	5.8757	182.54	7.9442	15,850.91	12.8573	6.1055	14.2840
21,304.14	5.9178	182.54	7.9442	15,850.54	12.8570	6.1052	14.2940
21,461.52	5.9615	182.62	7.9584	15,850.15	12.8583	6.1207	14.3240
21,618.14	6.0050	182.70	7.9727	15,849.77	12.8596	6.1363	14.3440
21,780.64	6.0502	182.78	7.9870	15,849.37	12.8609	6.1519	14.3540
21,934.89	6.0930	182.78	7.9870	15,848.99	12.8606	6.1516	14.3740
22,090.52	6.1363	182.87	8.0012	15,848.61	12.8619	6.1672	14.3840
22,239.89	6.1777	182.87	8.0012	15,848.24	12.8616	6.1669	14.3940
22,391.27	6.2198	182.95	8.0156	15,847.87	12.8630	6.1825	14.4040
22,546.14	6.2628	183.03	8.0299	15,847.49	12.8643	6.1982	14.4340
22,700.14	6.3056	183.03	8.0299	15,847.11	12.8640	6.1979	14.4540
22,856.64	6.3491	183.11	8.0442	15,846.73	12.8653	6.2135	14.4640
23,015.77	6.3933	183.19	8.0586	15,846.34	12.8666	6.2292	14.4640
23,168.39	6.4357	183.19	8.0586	15,845.96	12.8663	6.2289	14.4840
23,322.64	6.4785	183.27	8.0730	15,845.59	12.8676	6.2446	14.4940
23,476.52	6.5213	183.27	8.0730	15,845.21	12.8673	6.2443	14.5140
23,631.77	6.5644	183.35	8.0874	15,844.83	12.8686	6.2601	14.5340
23,787.39	6.6076	183.35	8.0874	15,844.45	12.8683	6.2597	14.5540
23,938.89	6.6497	183.43	8.1019	15,844.07	12.8696	6.2755	14.5540
24,094.14	6.6928	183.43	8.1019	15,843.69	12.8693	6.2752	14.5640
24,246.89	6.7352	183.52	8.1163	15,843.32	12.8707	6.2910	14.5740
24,400.27	6.7779	183.52	8.1163	15,842.94	12.8704	6.2907	14.5940
24,552.52	6.8201	183.60	8.1308	15,842.57	12.8717	6.3065	14.5940
24,710.27	6.8640	183.60	8.1308	15,842.18	12.8714	6.3062	14.6040
24,864.39	6.9068	183.68	8.1453	15,841.80	12.8727	6.3220	14.6340
25,014.64	6.9485	183.68	8.1453	15,841.43	12.8724	6.3217	14.6340
25,165.64	6.9905	183.76	8.1598	15,841.06	12.8737	6.3375	14.6540
25,321.39	7.0337	183.76	8.1598	15,840.68	12.8734	6.3372	14.6540
25,474.14	7.0762	183.84	8.1744	15,840.31	12.8747	6.3531	14.6640
25,631.52	7.1199	183.84	8.1744	15,839.92	12.8744	6.3528	14.6640
25,785.39	7.1626	183.92	8.1889	15,839.54	12.8757	6.3687	14.6740
25,941.39	7.2059	183.92	8.1889	15,839.16	12.8754	6.3684	14.6940
26,094.89	7.2486	183.92	8.1889	15,838.78	12.8751	6.3681	14.7140
26,248.64	7.2913	184.00	8.2035	15,838.41	12.8764	6.3840	14.7240
26,405.77	7.3349	184.00	8.2035	15,838.02	12.8761	6.3836	14.7240
26,562.89	7.3786	184.09	8.2181	15,837.64	12.8774	6.3996	14.7340
26,715.77	7.4210	184.09	8.2181	15,837.26	12.8771	6.3993	14.7340
26,867.39	7.4632	184.09	8.2181	15,836.89	12.8768	6.3990	14.7440
27,027.02	7.5075	184.17	8.2327	15,836.50	12.8781	6.4149	14.7540
27,183.14	7.5509	184.17	8.2327	15,836.12	12.8778	6.4146	14.7540
27,339.52	7.5943	184.17	8.2327	15,835.73	12.8775	6.4143	14.7740
27,495.77	7.6377	184.25	8.2474	15,835.35	12.8788	6.4302	14.7840
27,651.27	7.6809	184.25	8.2474	15,834.97	12.8785	6.4299	14.7840
27,804.27	7.7234	184.25	8.2474	15,834.59	12.8782	6.4296	14.7940

PECO ENERGY
NUCLEAR GROUP

CALCULATION SHEET

CALC. NO.: PM-1013
PAGE: 45
REVISION: 2

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
27,959.02	7.7664	205.2	29.49	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
28,112.14	7.8089	205.2	29.50	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
28,272.64	7.8535	205.2	29.50	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
28,415.27	7.8931	205.3	29.51	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
28,567.52	7.9354	205.3	29.51	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
28,717.64	7.9771	205.3	29.53	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
28,875.39	8.0209	205.3	29.53	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
29,028.27	8.0634	205.4	29.54	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
29,185.64	8.1071	205.4	29.54	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
29,344.64	8.1513	205.4	29.54	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
29,497.89	8.1939	205.4	29.54	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
29,656.39	8.2379	205.5	29.54	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
29,802.52	8.2785	205.5	29.54	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
29,953.77	8.3205	205.5	29.54	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
30,106.39	8.3629	205.5	29.56	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
30,268.77	8.4080	205.5	29.56	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
30,420.39	8.4501	205.5	29.57	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
30,578.27	8.4940	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
30,733.14	8.5370	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
30,893.64	8.5816	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
31,047.77	8.6244	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
31,203.39	8.6676	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
31,358.89	8.7108	205.6	29.57	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
31,512.64	8.7535	205.6	29.60	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
31,667.02	8.7964	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
31,818.89	8.8386	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
31,966.52	8.8796	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,113.52	8.9204	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,267.14	8.9631	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,421.39	9.0059	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,573.14	9.0481	205.7	29.60	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,721.77	9.0894	205.7	29.59	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
32,872.52	9.1313	205.7	29.59	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,024.02	9.1733	205.7	29.59	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,171.27	9.2142	205.7	29.59	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,326.39	9.2573	205.7	29.59	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,481.02	9.3003	205.7	29.58	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,632.52	9.3424	205.7	29.58	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,777.39	9.3826	205.7	29.57	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
33,931.52	9.4254	205.7	29.57	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,085.02	9.4681	205.7	29.58	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,235.14	9.5098	205.7	29.57	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,390.02	9.5528	205.7	29.57	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,548.64	9.5968	205.7	29.56	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,706.64	9.6407	205.7	29.56	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
34,860.89	9.6836	205.7	29.58	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,018.89	9.7275	205.7	29.58	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,176.89	9.7714	205.7	29.56	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,332.89	9.8147	205.7	29.56	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,487.64	9.8577	205.7	29.56	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)
27,969.02	7.7664	184.33	8.2621	15,834.21	12.8795	6.4456	14.7940
28,112.14	7.8089	184.33	8.2621	15,833.84	12.8792	6.4453	14.8040
28,272.64	7.8535	184.33	8.2621	15,833.44	12.8789	6.4450	14.8040
28,415.27	7.8931	184.41	8.2768	15,833.09	12.8803	6.4610	14.8140
28,567.62	7.9354	184.41	8.2768	15,832.72	12.8800	6.4607	14.8140
28,717.64	7.9771	184.41	8.2768	15,832.35	12.8797	6.4604	14.8340
28,875.39	8.0209	184.41	8.2768	15,831.96	12.8793	6.4601	14.8340
29,028.27	8.0634	184.49	8.2915	15,831.59	12.8807	6.4762	14.8440
29,185.64	8.1071	184.49	8.2915	15,831.20	12.8803	6.4758	14.8440
29,344.64	8.1513	184.49	8.2915	15,830.81	12.8800	6.4755	14.8440
29,497.89	8.1939	184.49	8.2915	15,830.44	12.8797	6.4752	14.8440
29,666.39	8.2379	184.57	8.3062	15,830.05	12.8810	6.4913	14.8440
29,802.52	8.2785	184.57	8.3062	15,829.69	12.8807	6.4910	14.8440
29,953.77	8.3205	184.57	8.3062	15,829.32	12.8804	6.4907	14.8440
30,106.39	8.3629	184.57	8.3062	15,828.94	12.8801	6.4904	14.8640
30,268.77	8.4080	184.57	8.3062	15,828.55	12.8798	6.4900	14.8640
30,420.39	8.4501	184.57	8.3062	15,828.17	12.8795	6.4897	14.8740
30,578.27	8.4940	184.66	8.3210	15,827.79	12.8808	6.5058	14.8740
30,733.14	8.5370	184.66	8.3210	15,827.41	12.8805	6.5055	14.8740
30,893.64	8.5816	184.66	8.3210	15,827.01	12.8802	6.5052	14.8740
31,047.77	8.6244	184.66	8.3210	15,826.64	12.8799	6.5049	14.8740
31,203.39	8.6676	184.66	8.3210	15,826.25	12.8796	6.5046	14.8740
31,358.89	8.7108	184.66	8.3210	15,825.87	12.8793	6.5043	14.8740
31,512.64	8.7535	184.66	8.3210	15,825.49	12.8790	6.5039	14.9040
31,667.02	8.7964	184.74	8.3358	15,825.12	12.8803	6.5201	14.9040
31,818.89	8.8386	184.74	8.3358	15,824.74	12.8800	6.5197	14.9040
31,966.52	8.8796	184.74	8.3358	15,824.38	12.8797	6.5195	14.9040
32,113.52	8.9204	184.74	8.3358	15,824.02	12.8794	6.5192	14.9040
32,267.14	8.9631	184.74	8.3358	15,823.64	12.8791	6.5189	14.9040
32,421.39	9.0059	184.74	8.3358	15,823.27	12.8788	6.5185	14.9040
32,573.14	9.0481	184.74	8.3358	15,822.89	12.8785	6.5182	14.9040
32,721.77	9.0894	184.74	8.3358	15,822.53	12.8782	6.5179	14.8940
32,872.52	9.1313	184.74	8.3358	15,822.16	12.8779	6.5176	14.8940
33,024.02	9.1733	184.74	8.3358	15,821.79	12.8776	6.5173	14.8940
33,171.27	9.2142	184.74	8.3358	15,821.43	12.8773	6.5170	14.8940
33,328.39	9.2573	184.74	8.3358	15,821.05	12.8770	6.5167	14.8940
33,481.02	9.3003	184.74	8.3358	15,820.67	12.8767	6.5164	14.8840
33,632.52	9.3424	184.74	8.3358	15,820.29	12.8763	6.5161	14.8840
33,777.39	9.3826	184.74	8.3358	15,819.94	12.8761	6.5158	14.8740
33,931.52	9.4254	184.74	8.3358	15,819.56	12.8758	6.5155	14.8740
34,085.02	9.4681	184.74	8.3358	15,819.18	12.8754	6.5152	14.8840
34,235.14	9.5098	184.74	8.3358	15,818.82	12.8751	6.5149	14.8740
34,390.02	9.5528	184.74	8.3358	15,818.44	12.8748	6.5146	14.8740
34,548.64	9.5968	184.74	8.3358	15,818.05	12.8745	6.5143	14.8640
34,706.64	9.6407	184.74	8.3358	15,817.66	12.8742	6.5140	14.8640
34,860.89	9.6836	184.74	8.3358	15,817.28	12.8739	6.5137	14.8840
35,018.89	9.7275	184.74	8.3358	15,816.89	12.8736	6.5134	14.8840
35,176.89	9.7714	184.74	8.3358	15,816.51	12.8733	6.5130	14.8640
35,332.89	9.8147	184.74	8.3358	15,816.12	12.8730	6.5127	14.8640
35,487.64	9.8577	184.74	8.3358	15,815.74	12.8726	6.5124	14.8640

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
35,646.64	9.9018	205.7	29.55	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,796.64	9.9435	205.7	29.54	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
35,952.52	9.9868	205.7	29.54	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,102.14	10.0284	205.7	29.53	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,255.39	10.0709	205.7	29.53	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,408.39	10.1134	205.7	29.53	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,560.39	10.1557	205.7	29.52	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,712.52	10.1979	205.7	29.53	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
36,867.02	10.2408	205.7	29.52	12.95224	0.016675	1,336.13	1.00593	205.70	90.00	81.95	184.74	135.33	70.37	94.74	81.95
37,027.52	10.2854	205.6	29.51	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,177.27	10.3270	205.6	29.51	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,331.39	10.3698	205.6	29.50	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,488.89	10.4136	205.6	29.49	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,643.39	10.4565	205.6	29.49	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,798.14	10.4995	205.6	29.48	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
37,956.52	10.5435	205.6	29.47	12.92601	0.016674	1,336.18	1.00592	205.60	90.00	81.88	184.66	135.29	70.31	94.66	81.88
38,108.89	10.5858	205.5	29.47	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
38,271.52	10.6310	205.5	29.45	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
38,421.14	10.6725	205.5	29.45	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
38,577.64	10.7160	205.5	29.44	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
38,732.14	10.7589	205.5	29.45	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
38,888.64	10.8024	205.5	29.44	12.89983	0.016674	1,336.24	1.00591	205.50	90.00	81.81	184.57	135.25	70.25	94.57	81.81
39,047.27	10.8465	205.4	29.43	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
39,204.14	10.8900	205.4	29.42	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
39,363.89	10.9344	205.4	29.42	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
39,520.77	10.9780	205.4	29.40	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
39,677.02	11.0214	205.4	29.40	12.87369	0.016673	1,336.29	1.00589	205.40	90.00	81.74	184.49	135.21	70.19	94.49	81.74
39,837.39	11.0659	205.3	29.38	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
39,989.64	11.1082	205.3	29.37	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
40,152.52	11.1535	205.3	29.37	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
40,299.02	11.1942	205.3	29.36	12.84759	0.016672	1,336.34	1.00588	205.30	90.00	81.67	184.41	135.17	70.13	94.41	81.67
40,450.27	11.2362	205.2	29.35	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
40,607.64	11.2799	205.2	29.35	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
40,763.14	11.3231	205.2	29.34	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
40,916.52	11.3654	205.2	29.33	12.82154	0.016672	1,336.40	1.00586	205.20	90.00	81.60	184.33	135.14	70.06	94.33	81.60
41,076.14	11.4100	205.1	29.32	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
41,232.14	11.4534	205.1	29.31	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
41,381.27	11.4948	205.1	29.31	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
41,534.64	11.5374	205.1	29.33	12.79554	0.016671	1,336.45	1.00585	205.10	90.00	81.53	184.25	135.10	70.00	94.25	81.53
41,688.02	11.5800	205.0	29.32	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
41,838.14	11.6217	205.0	29.30	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
41,992.14	11.6645	205.0	29.30	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
42,153.02	11.7092	205.0	29.29	12.76957	0.016670	1,336.51	1.00583	205.00	90.00	81.46	184.17	135.06	69.94	94.17	81.46
42,307.52	11.7521	204.9	29.29	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
42,458.64	11.7941	204.9	29.27	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
42,612.52	11.8368	204.9	29.26	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
42,761.02	11.8781	204.9	29.25	12.74365	0.016670	1,336.56	1.00582	204.90	90.00	81.38	184.09	135.02	69.88	94.09	81.38
42,916.89	11.9214	204.8	29.25	12.71778	0.016669	1,336.62	1.00580	204.80	90.00	81.31	184.00	134.98	69.82	94.00	81.31
43,067.89	11.9633	204.8	29.24	12.71778	0.016669	1,336.62	1.00580	204.80	90.00	81.31	184.00	134.98	69.82	94.00	81.31
43,221.64	12.0060	204.8	29.23	12.71778	0.016669	1,336.62	1.00580	204.80	90.00	81.31	184.00	134.98	69.82	94.00	81.31

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)
35,646.64	9.9018	184.74	8.3358	15,815.35	12.8723	6.5121	14.8540
35,796.64	9.9435	184.74	8.3358	15,814.99	12.8720	6.5118	14.8440
35,952.52	9.9868	184.74	8.3358	15,814.60	12.8717	6.5115	14.8440
36,102.14	10.0284	184.74	8.3358	15,814.24	12.8714	6.5112	14.8340
36,255.39	10.0709	184.74	8.3358	15,813.86	12.8711	6.5109	14.8340
36,408.39	10.1134	184.74	8.3358	15,813.49	12.8708	6.5106	14.8340
36,560.39	10.1557	184.74	8.3358	15,813.11	12.8705	6.5103	14.8240
36,712.52	10.1979	184.74	8.3358	15,812.74	12.8702	6.5100	14.8340
36,867.02	10.2408	184.74	8.3358	15,812.36	12.8699	6.5097	14.8240
37,027.52	10.2854	184.66	8.3210	15,811.97	12.8679	6.4929	14.8140
37,177.27	10.3270	184.66	8.3210	15,811.60	12.8676	6.4926	14.8140
37,331.39	10.3698	184.66	8.3210	15,811.22	12.8673	6.4923	14.8040
37,488.89	10.4136	184.66	8.3210	15,810.84	12.8670	6.4920	14.7940
37,643.39	10.4565	184.66	8.3210	15,810.46	12.8667	6.4917	14.7940
37,798.14	10.4995	184.66	8.3210	15,810.08	12.8664	6.4914	14.7840
37,956.52	10.5435	184.66	8.3210	15,809.69	12.8661	6.4911	14.7740
38,108.89	10.5858	184.57	8.3062	15,809.31	12.8642	6.4744	14.7740
38,271.52	10.6310	184.57	8.3062	15,808.92	12.8638	6.4741	14.7540
38,421.14	10.6725	184.57	8.3062	15,808.55	12.8635	6.4738	14.7540
38,577.64	10.7160	184.57	8.3062	15,808.16	12.8632	6.4735	14.7440
38,732.14	10.7589	184.57	8.3062	15,807.79	12.8629	6.4732	14.7540
38,888.64	10.8024	184.57	8.3062	15,807.40	12.8626	6.4728	14.7440
39,047.27	10.8465	184.49	8.2915	15,807.01	12.8607	6.4562	14.7340
39,204.14	10.8900	184.49	8.2915	15,806.63	12.8604	6.4558	14.7240
39,363.89	10.9344	184.49	8.2915	15,806.24	12.8600	6.4555	14.7240
39,520.77	10.9780	184.49	8.2915	15,805.85	12.8597	6.4552	14.7040
39,677.02	11.0214	184.49	8.2915	15,805.47	12.8594	6.4549	14.7040
39,837.39	11.0659	184.41	8.2768	15,805.07	12.8575	6.4382	14.6840
39,989.64	11.1082	184.41	8.2768	15,804.70	12.8572	6.4379	14.6740
40,152.52	11.1535	184.41	8.2768	15,804.30	12.8568	6.4376	14.6740
40,299.02	11.1942	184.41	8.2768	15,803.94	12.8565	6.4373	14.6640
40,450.27	11.2362	184.33	8.2621	15,803.57	12.8546	6.4207	14.6540
40,607.64	11.2799	184.33	8.2621	15,803.18	12.8543	6.4204	14.6540
40,763.14	11.3231	184.33	8.2621	15,802.80	12.8540	6.4201	14.6440
40,915.52	11.3654	184.33	8.2621	15,802.43	12.8537	6.4198	14.6340
41,076.14	11.4100	184.25	8.2474	15,802.04	12.8517	6.4032	14.6240
41,232.14	11.4534	184.25	8.2474	15,801.65	12.8514	6.4028	14.6140
41,381.27	11.4948	184.25	8.2474	15,801.29	12.8511	6.4025	14.6140
41,534.64	11.5374	184.25	8.2474	15,800.91	12.8508	6.4022	14.6340
41,688.02	11.5800	184.17	8.2327	15,800.53	12.8489	6.3857	14.6240
41,838.14	11.6217	184.17	8.2327	15,800.17	12.8486	6.3854	14.6040
41,992.14	11.6645	184.17	8.2327	15,799.79	12.8483	6.3850	14.6040
42,153.02	11.7092	184.17	8.2327	15,799.39	12.8480	6.3847	14.5940
42,307.52	11.7521	184.09	8.2181	15,799.01	12.8460	6.3682	14.5940
42,458.64	11.7941	184.09	8.2181	15,798.64	12.8457	6.3679	14.5740
42,612.52	11.8368	184.09	8.2181	15,798.27	12.8454	6.3676	14.5640
42,761.02	11.8781	184.09	8.2181	15,797.90	12.8451	6.3673	14.5540
42,916.89	11.9214	184.00	8.2035	15,797.52	12.8432	6.3507	14.5540
43,067.89	11.9633	184.00	8.2035	15,797.15	12.8429	6.3504	14.5440
43,221.64	12.0060	184.00	8.2035	15,796.77	12.8426	6.3501	14.5340

PECO ENERGY
NUCLEAR GROUP

CALCULATION SHEET

CALC. NO.: PM-1013
PAGE: 49
REVISION: 2

Time (seconds)	Time (hours)	SP Temp (°F)	Original DW Pressure (psia)	Psat (psia)	Vf (cuft/lbm)	RHR Heat Exchanger Mass Flow (lbm/sec)	Cp (BTU/lbm °F)	Thi (°F)	Tci (°F)	LMTD (°F)	Tho (°F)	Tco (°F)	LTD (°F)	GTD (°F)	LMTD (°F)
43,377.02	12.0492	204.7	29.22	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
43,521.62	12.0893	204.7	29.21	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
43,672.39	12.1312	204.7	29.21	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
43,827.77	12.1744	204.7	29.19	12.69195	0.016668	1,336.67	1.00579	204.70	90.00	81.24	183.92	134.94	69.76	93.92	81.24
43,984.02	12.2178	204.6	29.19	12.66616	0.016668	1,336.73	1.00578	204.60	90.00	81.17	183.84	134.90	69.70	93.84	81.17
44,139.39	12.2609	204.6	29.17	12.66616	0.016668	1,336.73	1.00578	204.60	90.00	81.17	183.84	134.90	69.70	93.84	81.17
44,300.39	12.3057	204.6	29.17	12.66616	0.016668	1,336.73	1.00578	204.60	90.00	81.17	183.84	134.90	69.70	93.84	81.17
44,453.02	12.3481	204.5	29.15	12.64041	0.016667	1,336.78	1.00576	204.50	90.00	81.10	183.76	134.86	69.64	93.76	81.10
44,607.89	12.3911	204.5	29.15	12.64041	0.016667	1,336.78	1.00576	204.50	90.00	81.10	183.76	134.86	69.64	93.76	81.10
44,765.64	12.4349	204.5	29.13	12.64041	0.016667	1,336.78	1.00576	204.50	90.00	81.10	183.76	134.86	69.64	93.76	81.10
44,921.27	12.4781	204.4	29.13	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
45,072.64	12.5202	204.4	29.12	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
45,229.89	12.5639	204.4	29.11	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
45,381.77	12.6060	204.4	29.10	12.61471	0.016666	1,336.83	1.00575	204.40	90.00	81.03	183.68	134.82	69.58	93.68	81.03
45,533.77	12.6483	204.3	29.09	12.58905	0.016666	1,336.89	1.00573	204.30	90.00	80.96	183.60	134.78	69.52	93.60	80.96
45,684.02	12.6900	204.3	29.08	12.58905	0.016666	1,336.89	1.00573	204.30	90.00	80.96	183.60	134.78	69.52	93.60	80.96
Maxima		205.7	47.51												

Time (seconds)	Time (hours)	Temp (°F)	Pv (psia)	Ma (lbm)	Pa (psia)	MCPA (psig)	Original DW Pressure (psig)	
43,377.02	12.0492	183.92	8.1889	15,796.39	12.8407	6.3336	14.5240	
43,521.52	12.0893	183.92	8.1889	15,796.04	12.8404	6.3333	14.5140	
43,672.39	12.1312	183.92	8.1889	15,795.67	12.8401	6.3330	14.5140	
43,827.77	12.1744	183.92	8.1889	15,795.29	12.8398	6.3327	14.4940	
43,984.02	12.2178	183.84	8.1744	15,794.90	12.8378	6.3162	14.4940	
44,139.39	12.2609	183.84	8.1744	15,794.52	12.8375	6.3159	14.4740	
44,300.39	12.3057	183.84	8.1744	15,794.13	12.8372	6.3156	14.4740	
44,453.02	12.3481	183.76	8.1598	15,793.75	12.8353	6.2991	14.4540	
44,607.89	12.3911	183.76	8.1598	15,793.37	12.8350	6.2988	14.4540	
44,765.64	12.4349	183.76	8.1598	15,792.99	12.8346	6.2985	14.4340	
44,921.27	12.4781	183.68	8.1453	15,792.60	12.8327	6.2820	14.4340	
45,072.64	12.5202	183.68	8.1453	15,792.23	12.8324	6.2817	14.4240	
45,229.89	12.5639	183.68	8.1453	15,791.85	12.8321	6.2814	14.4140	
45,381.77	12.6060	183.68	8.1453	15,791.47	12.8318	6.2811	14.4040	
45,533.77	12.6483	183.60	8.1308	15,791.10	12.8299	6.2647	14.3940	
45,684.02	12.6900	183.60	8.1308	15,790.73	12.8296	6.2644	14.3840	
Maxima		184.74				6.52		0.00

PECO ENERGY
NUCLEAR GROUP

CALCULATION SHEET

CALC. NO.: PM-1013
PAGE: 51
REVISION: 2

8.C Peach Bottom Containment Analysis Two Sigma Adder Evaluation, 6 pages, beginning on the next page.

PURPOSE:

This evaluation is documented to address that the use of the 110% Power Uprate Torus water temperature profile is conservative, with regard to Torus temperature, in comparison with the use of the 105% Power Uprate profile used in conjunction with a 2 sigma adder to the decay heat model.

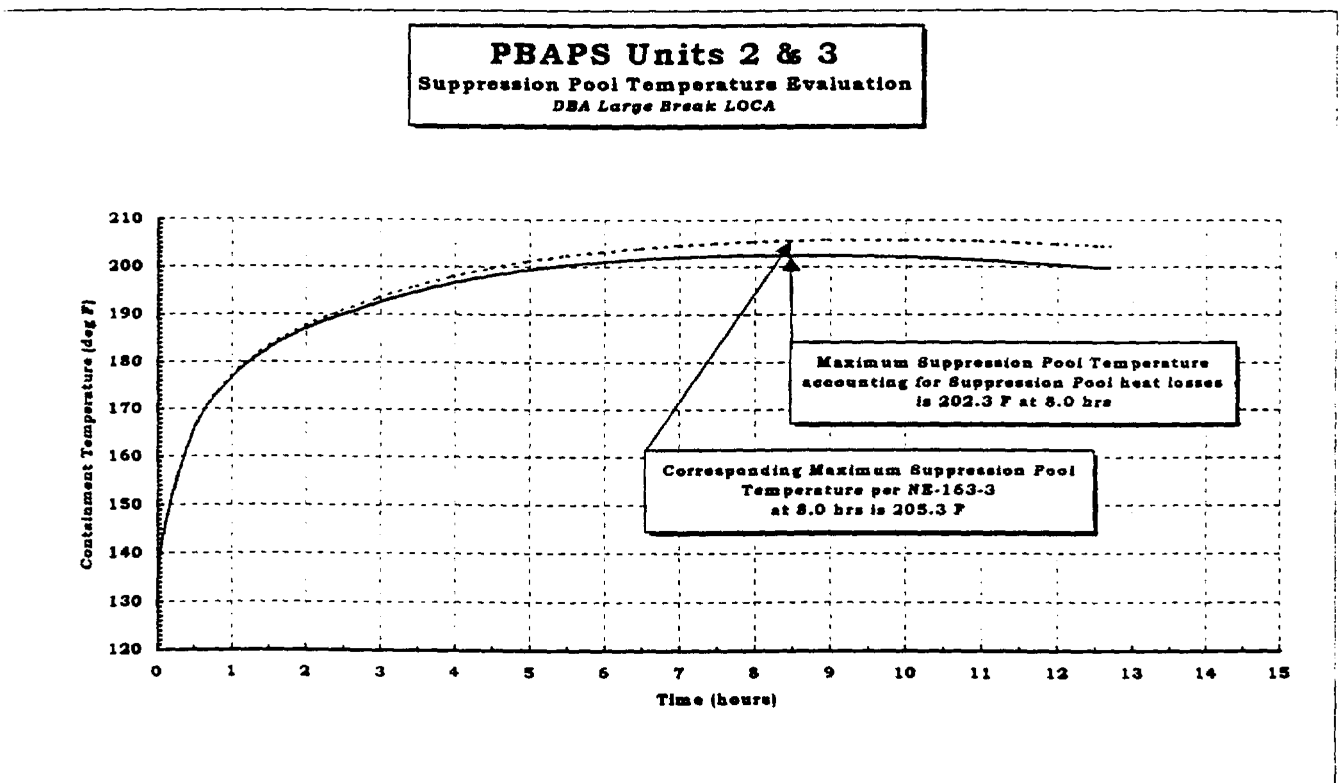
GE, via Reference 6.W, evaluated that impact on the Torus temperature due to:
1) addition of 2 sigma adder to the ANS 5.1-1979 standard decay heat and,
2) reduction of rerate power from 110% to 105% rated.

The addition of the 2 sigma resulted in:
1) an 11°F increase in Torus temperature at 110% rated power and,
2) a 3°F increase in Torus temperature at 105% rated power.

SUMMARY OF RESULTS:

The use of the of the 110% Power Uprate Torus water temperature profile is conservative, with regard to Torus temperature, in comparison with the use of the 105% Power Uprate profile used in conjunction with a 2 sigma adder to the decay heat model, as evidenced by the evaluation herein.

As can be seen in the following curve, accounting for the crediting of suppression chamber heat losses to ambient (Torus Room) results in a 3°F peak pool temperature reduction, and shifts the temperature peak time from approximately 8.8 hours to 8.0 hours.



DESIGN INPUT / CRITERIA:

Inputs	Value	Units	Ref.
Assumed moisture 0% (wc)	0	lbm/lbm	Assumption
Patm (Pa)	**14.69598677**	psia	Standard
Temperature conversion factor (To)	**459.67**	F to K	Standard
Initial pool temp. (Ti)	**95**	F	Technical Specification 3.6.2.1
Initial pool volume (V)	**127,300**	cuft	Technical Specification Basis 3.6.2.2
Minor radius inside (Rminor)	**15.50**	feet	Dwg. S-51 Rev. 11
Major radius (Rmajor)	**55.75**	feet	Dwg. S-51 Rev. 11
Maximum torus temp (Tt)	**205.7**	F	NE-163-3
Initial torus room temp (Tr1)	**115**	F	F
Torus room temp max. (Tr)	**183**	F	Calc. 11187-M-17 Assumes T 24 hrs = 183 F
Torus room wall temp. (Tw)	**100**	F	Assumption
Time at maximum Temp. (tpeak)	**8.80**	hrs	NE-163-3
emissivity torus (et)	**0.61**	-	Marks Handbook Eighth Edition, Baumemeister
emissivity concrete (ec)	**0.90**	-	Marks Handbook Eighth Edition, Baumemeister
Cp for air (cpair)	**0.241**	Btu/lb-deg F	Mechanical Engineering Reference Manual Tenth Edition, M.R.Lindeburg , Appendix A-35.C
Torus shell ave. thickness (th)	**0.640**	in	Dwg.6280-C2-114-10
Cp steel (cpsteel)	**0.113**	Btu/lb F	Mechanical Engineering Reference Manual Tenth Edition, M.R.Lindeburg , Appendix A-24.Y
Density of steel (ds)	**485**	lb/cu ft	Mechanical Engineering Reference Manual Tenth Edition, M.R.Lindeburg , Appendix A-24.Y
Calculations			
Effective Radiant area (era)	1.00	%	
Torus shell mass (Ms)	0.88	Mlbm	=2*PI()^2*Rmajor*((Rminor+th/12)^2-Rminor^2)*ds
Combined emissivity (e)	0.57	-	=1/(1/et+1/ec-1)
Torus water mass (Mo)	7.90	Mlbm	=V/Get_V(Pa,Ti)/1000000
Torus surface area (A)	34,231.58	sqft	=4*PI()^2*(Rminor+th/12)*Rmajor
Torus room air mass	428.18	lbm	=14.7*Vr/53.3/(459.67+120)
Torus room volume (Vr)	899952.33	cuft	=2*(78^2-38^2)*PI()*40-2*PI()^2*Rmajor*(Rminor+th/12)^

COMPUTER CALCULATION:

NA. Although this calculation uses the results of a GE computer run, and process all input values using a spreadsheet developed by the Originator, this calculation is treated as a manual calculation.

ASSUMPTIONS:

1. Moisture content in the Torus room atmosphere is conservatively assumed to be 0%. Increasing the atmospheric moisture content will tend to increase the heat removal rate.
2. The torus room average wall temperature is assumed to be 100°F. Cooler walls are non-conservative in that more radiative heat will be extracted from the torus. However it is conservative to assume that there is no convective heat transfer from the cooler torus room walls to the hotter room air.
3. The torus is assumed to be in thermal equilibrium throughout the event, i.e., the wetwell air space is at the same temperature as the water in the bottom half of the torus.

4. The emissivity factor is evaluated based on a completely enclosed large body (Ref. 6.Y).

CALCULATION:

An iterative calculation using EXCEL was performed to determine the expected heat losses from the torus to the torus room following a DBA LOCA. The following are the equations used in the analysis:

Conversion Factors and Constants

See design Input.

Input Parameters and Variables

See Design Input.

X_n	Variable per time step
X_{n-1}	Variable at the previous time step
t_n	time (hrs)
Tsp_n	Torus Temp (°F)
P_n	Torus Pressure (psia)
Tc_n	Cumulative Temperature Correction (°F)
$Tspc_n$	Corrected Torus Temperature (°F)
Trm_n	Torus Room Temperature (°F)
h_n	Convective Heat Transfer Coefficient (Btu/hr-sq ft-°F)
Q_n	Convective Heat loss (Btu)
E_n	Radiative Heat loss (Btu)
$dTsp_n$	Temperature increase in the Torus (°F)
$Mair_n$	Mass of the Torus Room air (lbm)
$dTair_n$	Increase in Torus Room air Temperature (°F)

Variable	Formula	Reference
t_n	$= \text{Input}$	PM-1013
Tsp_n	$= \text{Input}$	PM-1013
p_n	$= \text{Input}$	PM-1013
Tc_n	$= Tc_{n-1} + dTsp_n$	
$Tspc_n$	$= Tspc_{n-1} + Tsp_n - Tsp_{n-1} - dTsp_n$	
Trm_n	$= IF(Tr_{n-1} + dTair_n > Tr, Tr, Tr_{n-1} + dTair_n)$	
h_n	$= 0.27 * (ABS(Tsp_n - Trm_n) / 2 / (Rminor + th / 12))\text{^}0.25$	MERM, pg 35-5, Table 35-3
Q_n	$= h_n * A * (Tspc_n - Trm_n) * (t_n - t_{n-1})$	MERM, pg 35-2, eq 35-1
E_n	$= 0.0000000001713 * e * A * ((Tspc_n + 459.67)\text{^}4 - (Tw + 459.67)\text{^}4) * (t_n - t_{n-1})$	MERM, pg 37-4, eq 37-15
$dTsp_n$	$= (Q_n + E_n) / (Mb * 1000000 * Cp(p_n, Tspc_n) + Ms * cpsteel * 1000000)$	MERM, pg 34-5, eq 34-15
$Mair_n$	$= 14.7 * Vr / 53.35 / (Trm_n + 459.67) * 144$	MERM, pg 24-13, eq 24.45
$dTair_n$	$= Q_n / (0.24 + wc * Cp(14.7, Trm_n)) / Mair_n$	MERM, pg 38-3, eq 38-19

General Approach

In that the analysis uses an iterative solution the following provides the general logistical solution approach. The Torus temperature is evaluated by first calculating the convective and radiative heat loss from the torus shell using the expected resulting torus temperature for that time step (equations 1, 2 & 3). The Torus temperature differential is then calculated using the total suppression chamber mass (water and torus shell) and the total heat removed (equation 4). The corrected Torus temperature is then calculated by subtracting the Torus temperature differential from the sum of the previous time steps Torus temperature and the difference of the Ref. 6.B (NE-163-3) Torus temperatures for the current and the previous time step (equation 5). In the process of evaluating the heat losses, the torus room temperature is evaluated and limited in temperature to that identified within Ref. 6.X (11187-ME-17) (equation 6 & 7). In that the air temperature is expected to increase the mass of the air is accordingly decreased to maintain a constant air pressure. (equation 8).

RRG 3-8-99 | This page followed by Two pages [illegible] reviewer's alt. check, pages 57a & 57b

Time (seconds)	Time t (hours)	SP Temp Tsp (°F)	Original DW Pressure p (psia)	Cumulative Temp Corr Tc (°F)	Corr Sp Temp Tspc (°F)	Room Temp Trm (°F)	h h (BTU/hr sqft F)	Convective $Q_{convect}$ Q (Btu)	Radiative E_{rad} E (Btu)	dT_{sp} dTsp (°F)	M_{air} Mair (lbm)	w/wc dT_{air} dTair (°F)
0.00	0.00	95.0	15.5	0.0	95.0	115.0	0.2418	0.00E+00	0.00E+00	0.0000	62136.4	0.0000
49.26	0.0137	136.3	47.5	0.0	136.3	115.2	0.2451	2.43E+03	1.29E+04	0.0019	62118.8	0.1628
1,701.51	0.47	164.8	23.6	0.1	164.7	126.7	0.2837	1.69E+05	8.28E+05	0.1244	60893.0	11.5724
3,551.76	0.99	176.8	24.2	0.3	176.5	139.6	0.2819	1.83E+05	1.13E+06	0.1639	59590.6	12.8162
5,392.51	1.50	183.3	25.0	0.5	182.8	150.5	0.2726	1.54E+05	1.24E+06	0.1736	58518.7	10.9755
7,177.89	1.99	187.6	25.7	0.6	187.0	159.4	0.2620	1.23E+05	1.27E+06	0.1741	57681.2	8.8696
8,874.26	2.47	190.6	26.3	0.8	189.8	166.3	0.2516	9.52E+04	1.26E+06	0.1687	57040.6	6.9530
10,680.39	2.97	193.4	26.9	1.0	192.4	172.4	0.2417	8.28E+04	1.39E+06	0.1833	55489.2	6.1102
12,505.14	3.47	195.9	27.4	1.2	194.7	177.6	0.2326	6.91E+04	1.45E+06	0.1888	56033.5	5.1409
14,222.27	3.95	197.9	27.8	1.4	196.5	181.7	0.2245	5.45E+04	1.40E+06	0.1804	55677.1	4.0795
16,132.39	4.48	199.7	28.3	1.6	198.1	183.0	0.2255	6.20E+04	1.58E+06	0.2048	55561.9	4.6491
17,890.02	4.97	201.1	28.6	1.8	199.3	183.0	0.2299	6.28E+04	1.48E+06	0.1919	55561.9	4.7089
19,766.14	5.49	202.3	28.8	2.0	200.3	183.0	0.2333	7.21E+04	1.60E+06	0.2079	55561.9	5.4106
21,461.52	5.96	203.1	29.0	2.2	200.9	183.0	0.2363	6.81E+04	1.46E+06	0.1896	55561.9	5.1054
23,322.64	6.48	203.9	29.2	2.4	201.5	183.0	0.2372	7.78E+04	1.61E+06	0.2100	55561.9	5.8368
25,165.64	6.99	204.5	29.4	2.6	201.9	183.0	0.2385	7.91E+04	1.60E+06	0.2092	55561.9	5.9317
26,867.39	7.46	204.9	29.4	2.8	202.1	183.0	0.2391	7.40E+04	1.48E+06	0.1937	55561.9	5.5518
28,717.64	7.98	205.3	29.5	3.0	202.3	183.0	0.2397	8.15E+04	1.62E+06	0.2112	55561.9	6.1108
30,420.39	8.45	205.5	29.6	3.2	202.3	183.0	0.2397	7.50E+04	1.49E+06	0.1944	55561.9	5.6257
32,267.14	8.96	205.7	29.6	3.4	202.3	183.0	0.2397	8.13E+04	1.61E+06	0.2108	55561.9	6.0971
34,085.02	9.47	205.7	29.6	3.6	202.1	183.0	0.2390	7.90E+04	1.58E+06	0.2069	55561.9	5.9216
35,952.52	9.99	205.7	29.5	3.8	201.9	183.0	0.2384	8.00E+04	1.62E+06	0.2119	55561.9	5.9990
37,643.39	10.46	205.6	29.5	4.0	201.6	183.0	0.2375	7.10E+04	1.46E+06	0.1910	55561.9	5.3273
39,520.77	10.98	205.4	29.4	4.2	201.2	183.0	0.2361	7.67E+04	1.62E+06	0.2108	55561.9	5.7521
41,232.14	11.45	205.1	29.3	4.4	200.7	183.0	0.2345	6.76E+04	1.47E+06	0.1907	55561.9	5.0674
43,067.89	11.96	204.8	29.2	4.6	200.2	183.0	0.2328	6.99E+04	1.56E+06	0.2031	55561.9	5.2433
44,921.27	12.48	204.4	29.1	4.8	199.6	183.0	0.2308	6.75E+04	1.57E+06	0.2032	55561.9	5.0626
45,684.02	12.69	204.3	29.1	4.9	199.4	183.0	0.2301	2.74E+04	6.43E+05	0.0834	55561.9	2.0548
Maxima		205.7	47.5		202.3							

This page followed by page 57b

Reviewer's Alternate Check - 2σ Adder

The NRC has questioned the lack of application of a 2-sigma confidence margin to the decay heat model used in calculation of the torus water temperature following a design basis LOCA. PBAPS maintains that, although an addition of the 2-sigma would add to the confidence of pump capability during a LOCA, adequate confidence is assured by use of conservative assumptions used in the torus water heatup calculation.

The PBAPS design basis LOCA analysis assumed an initial reactor power level of about 5% higher than 10CFR50 Appendix K requirements (110% rerate assumed, while only 105% rerate was implemented). GE has performed an analysis that indicates that including the 2-sigma but reducing the assumed power to the new rated power (including Appendix K adder of 2% power) increases torus water temperature above the current by only 3°F.

The PBAPS design basis LOCA analysis also took no credit for heat loss from the containment walls. PECO believes that crediting heat loss from the torus walls alone can compensate for the 3°F, as shown in the following rough analysis.

Inputs are taken from the PBAPS UFSAR with the following exceptions

T_{torus}	=	**198**	°F	The time-averaged torus water temperature, is an integration of the torus water temperature to the peak, then divided by the time to the peak. (195.6°F)
T_{room}	=	**175**	°F	An estimate of the torus room ambient temperature during the LOCA, including loss of HVAC. Initial temperature is 110°F for. Calculated by integration of the torus room temperature profile to nine (9) hours and dividing by nine (9) hours. Temperature profile is taken from calculation 11187-M-17, Rev. 9, and linearly interpolated at nine (9) hours. (169.0°F)
T_{walls}	=	**95**	°F	An estimate of the torus room wall temperature. From calculation 11187-M-17, Rev. 9, the outside ground temperature is assumed at 55°F. This value for estimated wall temperature is an engineering judgement for the average vertical wall, floor, and ceiling contact temperature.
Emissivity	=	**0.57**		Conservative estimate based on values from the Mechanical Engineering Review Manual, Seventh Edition by Michael R. Lindeburg, P.E., for painted steel.
Time of peak	=	**8.80**	hrs	From PBAPS UFSAR for design basis LOCA containment analysis.

Equations

Natural Convection:

$$Q_{nc} = hA(T_{torus} - T_{room}) * t_{peak}, \qquad where \qquad h = 0.27\left[(T_{torus} - T_{room})/L\right]^{0.25}$$

(where L is the characteristic length, i.e., the minor diameter of the torus) and

Radiative:

$$E = \sigma \varepsilon A\left[(T_{torus} + 460)^4 - (T_{walls} + 460)^4\right] * t_{peak}$$

Using these expressions for heat transfer (taken from the Mechanical Engineering Review Manual, Seventh Edition by Michael R. Lindeburg, P.E., since the temperatures used are time-averaged and can be considered constant, the total heat transferred due to natural convection and radiation can be calculated as **1.73** and **27.30** MBTUs, respectively. Dividing the total heat transfer by the mass of the torus water (**7.90** Mlbm) results in an expected temperature "savings" for the torus water of about **3.67**°F.

This evaluation indicates a conservative estimate for heat loss from the torus compensates for the concurrent addition of the 2-sigma decay heat adder and decrease in assumed reactor power to that required by 10CFR50 Appendix K (102% rated).

PECO ENERGY NUCLEAR GROUP	CALCULATION SHEET	CALC. NO. : PM-1013 PAGE : 58 REVISION : 2

8.D - Reference 6.W