Enclosure 1 To NL-12-029

IP-CALC-10-00121 BACKUP SPENT FUEL POOL COOLING SYSTEM (BSFPCS) HEAT REMOVAL CAPABILITY

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286

☐ ANO-1 ☐ ANO-2 ☐ GGNS ☐ IP-2 ☒ IP-3 ☐ PLP
☐ JAF ☐ PNPS ☐ RBS ☐ VY ☐ W3
☐ NP-GGNS-3 ☐ NP-RBS-3

CALCULATION COVER PAGE	**EC # 34105**	**Page 1 of 66**

Design Basis Calc. ☐ YES ☒ NO	☒ CALCULATION ☐ EC Markup
Calculation No: IP-CALC-10-00121	**Revision: 1**
Title: Backup Spent Fuel Pool Cooling System (BSFPCS) Heat Removal Capability	**Editorial** ☐ YES ☒ NO

System(s): BSFPC, SFPC	**Review Org (Department): Design Engineering - Mechanical**	
Safety Class: ☐ **Safety / Quality Related** ☐ **Augmented Quality Program** ☒ **Non-Safety Related**	**Component/Equipment/Structure Type/Number:**	
Document Type: Calculation		
Keywords (Description/Topical Codes): **Backup Spent Fuel Pool Cooling System** **BSFPC**		

REVIEWS

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CALCULATION REFERENCE SHEET	CALCULATION NO: IP-CALC-10-00121 REVISION: 1

I. EC Markups Incorporated (N/A to NP calculations)
1. 34105

II. Relationships:	Sht	Rev	Input Doc	Output Doc	Impact Y/N	Tracking No.
1.			☐	☐		

III. CROSS REFERENCES:

1. APV Plate Heat Exchanger Data Sheet E2449
2. Wang, L., Bengt Sunden, and R.M. Manglik. *Plate Heat Exchangers: Design, Applications, and Performance*.
3. IP3-DBD-308, Attachment A
4. Cengel, Yunus A. *Heat and Mass Transfer: A Practical Approach*. 3rd ed.
5. EVAPCO AT 12-724B Performance Curve

IV. SOFTWARE USED: None

Title: N/A Version/Release:________ Disk/CD No.______

V. DISK/CDS INCLUDED: None

Title: N/A Version/Release________ Disk/CD No.______

VI. OTHER CHANGES:

Revision	Record of Revision
0	Initial issue.
1	Revision 1 of IP-CALC-10-00121 developed additional heat removal curves for the BSFPCS for Spent Fuel Pool Bulk Temperatures of 160 °F, 170 °F, 175 °F, and 180 °F over a wet bulb temperature (WBT) range of 40 °F to 75 °F.

4.0 Table of Contents

5.0 Purpose

In response to SOER 09-01, Recommendation 9, Minimizing potential for boiling on loss of Spent Fuel Pool (SFP) cooling during full core off-load; system capability curves need to be developed to better understand and use the decay heat removal capabilities of the Unit 3 Backup Spent Fuel Pool Cooling System (BSFPCS) as requested in CR-IP2-2009-03464 CA #23. As a result, Revision 0 of this calculation developed two BSFPCS heat removal curves for Spent Fuel Pool Bulk Temperatures of 150 °F and 190 °F over a wet bulb temperature (WBT) range of 40 °F to 75 °F.

It is also desired to determine the heat removal capability of the BSFPCS heat exchanger using a variety of Spent Fuel Pool Bulk temperatures over the same WBT range of 40 °F to 75 °F. To accomplish this, Revision 1 of this calculation developed additional heat removal curves for the BSFPCS for Spent Fuel Pool Bulk Temperatures of 160 °F, 170 °F, 175 °F, and 180 °F over a wet bulb temperature (WBT) range of 40 °F to 75 °F.

6.0 Conclusion

Wet Bulb Temperature [°F]	Secondary Loop Inlet Temperature [°F]	Q_{sfp} [Btu/hr]	SFP Temperature [°F]
40	73.7	27,482,000	150
45	76.1	26,618,000	150
50	78.0	25,933,000	150
55	80.2	25,141,000	150
60	82.2	24,421,000	150
65	84.7	23,520,000	150
70	87.0	22,692,000	150
75	88.8	22,044,000	150
40	73.7	31,048,000	160
45	76.1	30,220,000	160
50	78.0	29,535,000	160
55	80.2	28,743,000	160
60	82.2	28,023,000	160
65	84.7	27,122,000	160
70	87.0	26,294,000	160
75	88.8	25,645,000	160
40	73.7	34,650,000	170
45	76.1	33,821,000	170
50	78.0	33,137,000	170

55	80.2	32,345,000	170
60	82.2	31,624,000	170
65	84.7	30,724,000	170
70	87.0	29,895,000	170
75	88.8	29,247,000	170
40	73.7	36,451,000	175
45	76.1	35,622,000	175
50	78.0	34,938,000	175
55	80.2	34,146,000	175
60	82.2	33,425,000	175
65	84.7	32,525,000	175
70	87.0	31,696,000	175
75	88.8	31,048,000	175
40	73.7	38,252,000	180
45	76.1	37,423,000	180
50	78.0	36,739,000	180
55	80.2	35,946,000	180
60	82.2	35,226,000	180
65	84.7	34,326,000	180
70	87.0	33,497,000	180
75	88.8	32,849,000	180
40	73.7	41,889,000	190
45	76.1	41,025,000	190
50	78.0	40,341,000	190
55	80.2	39,548,000	190
60	82.2	38,828,000	190
65	84.7	37,927,000	190
70	87.0	37,099,000	190
75	88.8	36,451,000	190

See Attachments for Heat Removal Capability Curves

7.0 Input and Design Criteria

7.1 Cooling Tower

- Flow Rate:

  m_s = 1,250,000 lb_m/hr [Reference 11.1]

7.2 Plate Heat Transfer

- Heat Transfer Area:

  A = 686.5 ft^2 [Reference 11.1]

- Specific Heat Capacity:

  c_p = 1.00 Btu/lb-°F [Reference 11.1]

- Flow Rate:
  m_p = 750,000 lb_m/hr [Reference 11.1]
- Heat Transfer Coefficient:
  U = 859.6 Btu/ft^2-h-°F [Reference 11.1]
  Note: The design U value for the plate heat exchanger is assumed constant for this calculation due to the single-phase flow of the System [Reference 11.2].

Note: These inputs were obtained from the technical specification sheet for the plate heat exchanger, the cooling tower performance curve and the design basis document for the Backup Spent Fuel Pool Cooling System (BSFPCS).

- SFP Bulk Temperatures (Primary Side Inlet):
  $T_{p,in}$ = 150 °F [Reference 11.3]
  190 °F

Additional SFP Bulk to be evaluated are 160 °F, 170 °F, 175 °F, and 180 °F.

8.0 Assumptions

None

9.0 Method of Analysis

9.1 Background

The plate heat exchanger consists of two loops, the Primary (hot) which is cooled by the Secondary (cold). The heat removal capability of the System is the amount of heat that is transferred from the primary loop to the secondary loop of the heat exchanger. The Primary (hot) loop consists of the SFP, two pumps, the plate heat exchanger, and two filters. The Secondary (cold) loop consists of two cooling towers, two pumps and the plate heat exchanger. Both cooling towers are operated simultaneously at 50% flow capacity. This allows for the cooling towers to be analyzed as one unit. Following confirmation from the vendor, the performance curve was generated for a flow rate of 2,500 gpm, which is equivalent to the overall flow rate of the system.

Both loops are in equilibrium. Therefore, an energy balance on both loops is performed to determine the heat removal capability of the plate heat exchanger. The heat transfer rate for a steady-flow system is
$Q = m \times c_p \times \Delta T$ [Reference 11.4]. Since the temperature difference of the loop is unknown, the heat load is also unknown. In order to determine the temperature difference, a heat load is selected. Then, using the selected heat load, an energy balance is performed on both loops and verified using $Q = U \times A \times \Delta T_{LMTD}$. This heat rate equation is used to analyze any type of heat exchanger. The temperature difference between the hot and cold fluids varies along the heat exchanger; therefore it is necessary to use a log

mean temperature difference ΔT_{LMTD}. The log mean temperature difference is defined as:

$$\Delta T_{LMTD} = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)}$$ [Reference 11.4]

In the case of this plate heat exchanger, $\Delta T_1 = T_{p,in} - T_{s,out}$ and $\Delta T_2 = T_{p,out} - T_{s,in}$ [Attachment 1].

Note: The formula above is shown in Section 10.0 with the primary and secondary terms rearranged in the numerator.

9.2 **Methodology**

9.2.1 For a chosen wet bulb temperature, use the cooling tower performance curve [Reference 11.5, Attachment 12.3] to determine the secondary water inlet temperature, $T'_{s,in}$.

9.2.2 Select a SFP heat load ($Q_{sfp,i}$).

9.2.3 Calculate secondary side ΔT_s using $Q_{sfp} = m_s \times c_p \times \Delta T_s$.

9.2.4 Calculate secondary side outlet water temperature ($T_{s,out}$) based on $\Delta T_s = T_{s,out} - T_{s,in}$.

9.2.5 Calculate primary side ΔT_p using $Q_{sfp} = m_p \times c_p \times \Delta T_p$

9.2.6 Calculate primary side outlet water temperature ($T_{p,out}$) based on $\Delta T_p = T_{p,in} - T_{p,out}$ using a $T_{p,in}$ value of 150 °F, 160 °F, 170 °F, 175°F, 180 °F, and 190 °F.

9.2.7 Calculate the LMTD based on the determined temperatures

9.2.8 Compare the value with the LMTD determined from the formula

9.2.8.1 $q = U \times A \times LMTD$.

9.2.9 If the two LMTD values are less than ±1% apart, the selected heat load is acceptable. If not, choose another heat load and perform the above steps until the LMTD values converge.

9.2.10 Repeat steps for other wet bulb temperatures.

9.2.11 Plot the Results.

10.0 Calculations

Design Inputs:

$T_{pin} := 150$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 40$ $T_{sin} := 73.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 27.482 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 21.986$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$T_{sout} := dT_s + T_{sin}$ $T_{sout} = 95.686$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 36.643$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$T_{pout} := T_{pin} - dT_p$ $T_{pout} = 113.357$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 46.602$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 46.571$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.068$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 160$ Area := 686.5 $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 40$ $T_{sin} := 73.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 31.04810^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 24.838$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 98.538$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 41.397$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 118.603$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 52.75$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 52.613$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.259$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 170 \quad Area := 686.5 \quad U := 859.6 \quad c_p := 1 \quad m_p := 750000 \quad m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 40 \quad T_{sin} := 73.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 34.65 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 27.72$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 101.42$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 46.2$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 123.8$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 58.857$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 58.717$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.238$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 175$ Area := 686.5 $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 40$ $T_{sin} := 73.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 36.451 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p}$ $dT_s = 29.161$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$T_{sout} := dT_s + T_{sin}$ $T_{sout} = 102.861$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p}$ $dT_p = 48.601$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$T_{pout} := T_{pin} - dT_p$ $T_{pout} = 126.399$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 61.911$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area}$ $LMTD_2 = 61.769$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.23$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 180$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 40$ $T_{sin} := 73.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 38.252 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 30.602$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 104.302$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 51.003$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 128.997$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 64.965$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 64.821$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.222$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 190$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 40$ $T_{sin} := 73.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 41.889 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$dT_s := \dfrac{Q_{sfp}}{m_s \cdot c_p}$ $dT_s = 33.511$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$T_{sout} := dT_s + T_{sin}$ $T_{sout} = 107.211$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$dT_p := \dfrac{Q_{sfp}}{m_p \cdot c_p}$ $dT_p = 55.852$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) **the outlet temperature can be determined.**

$T_{pout} := T_{pin} - dT_p$ $T_{pout} = 134.148$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\dfrac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 71.034$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 70.984$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.07$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 150$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 45$ $T_{sin} := 76.1$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 26.618 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p}$ $dT_s = 21.294$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$T_{sout} := dT_s + T_{sin}$ $T_{sout} = 97.394$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p}$ $dT_p = 35.491$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$T_{pout} := T_{pin} - dT_p$ $T_{pout} = 114.509$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 45.136$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area}$ $LMTD_2 = 45.106$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.066$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 160 \quad Area := 686.5 \quad U := 859.6 \quad c_p := 1 \quad m_p := 750000 \quad m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 45 \quad T_{sin} := 76.1$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 30.22010^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 24.176$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$T_{sout} := dT_s + T_{sin} \quad T_{sout} = 100.276$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 40.293$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$T_{pout} := T_{pin} - dT_p \quad T_{pout} = 119.707$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 51.244$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 51.21$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.065$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 170$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 45$ $T_{sin} := 76.1$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 33.821 \cdot 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 27.057$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 103.157$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 45.095$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 124.905$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 57.352$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 57.313$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.069$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 175$ Area := 686.5 $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 45$ $T_{sin} := 76.1$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 35.62210^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 28.498$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 104.598$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 47.496$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 127.504$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 60.406$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 60.364$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.069$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 180$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 45$ $T_{sin} := 76.1$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 37.423 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 29.938$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 106.038$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 49.897$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 130.103$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 63.46$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 63.416$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.069$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 190$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 45$ $T_{sin} := 76.1$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 41.025 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 32.82$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 108.92$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 54.7$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 135.3$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 69.567$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 69.52$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.068$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 150$ Area := 686.5 $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 50$ $T_{sin} := 78$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 25.933\,10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 20.746$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 98.746$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 34.577$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 115.423$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 43.976$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 43.946$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.07$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 160$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 50$ $T_{sin} := 78$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 29.53510^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 23.628$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 101.628$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 39.38$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 120.62$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 50.084$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 50.05$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.069$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 170$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 50$ $T_{sin} := 78$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 33.13710^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 26.51$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 104.51$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 44.183$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 125.817$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 56.191$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 56.153$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.068$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 175$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 50$ $T_{sin} := 78$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 34.93810^{6}$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 27.95$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 105.95$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 46.584$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 128.416$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 59.245$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 59.205$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.067$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 180$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 50$ $T_{sin} := 78$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 36.73910^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 29.391$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 107.391$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 48.985$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 131.015$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 62.299$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 62.257$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.067$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 190$ Area := 686.5 $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 50$ $T_{sin} := 78$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 40.341 \cdot 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 32.273$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 110.273$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 53.788$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 136.212$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 68.407$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 68.361$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.066$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 150 \quad Area := 686.5 \quad U := 859.6 \quad c_p := 1 \quad m_p := 750000 \quad m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 55 \quad T_{sin} := 80.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 25.141 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 20.113$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 100.313$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 33.521$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpout**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 116.479$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 42.632$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 42.604$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.067$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 160$ $\quad Area := 686.5$ $\quad U := 859.6$ $\quad c_p := 1$ $\quad m_p := 750000$ $\quad m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 55 \quad T_{sin} := 80.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 28.74310^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 22.994$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 103.194$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 38.324$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 121.676$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 48.74$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 48.707$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.066$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 170$ Area := 686.5 $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 55$ $T_{sin} := 80.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 32.34510^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 25.876$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 106.076$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 43.127$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 126.873$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 54.847$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 54.811$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.066$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 175$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 55$ $T_{sin} := 80.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 34.14610^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 27.317$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 107.517$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 45.528$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 129.472$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 57.901$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 57.863$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.065$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 180$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 55$ $T_{sin} := 80.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 35.946 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 28.757$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 108.957$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 47.928$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 132.072$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 60.956$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 60.914$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.07$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 190$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 55$ $T_{sin} := 80.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 39.548 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 31.638$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 111.838$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 52.731$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 137.269$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 67.064$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 67.017$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.069$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 150$ Area := 686.5 $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 60$ $T_{sin} := 82.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 24.421 \cdot 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 19.537$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 101.737$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 32.561$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 117.439$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 41.41$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 41.383$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.064$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 160$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 60$ $T_{sin} := 82.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 28.023 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 22.418$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 104.618$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 37.364$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 122.636$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 47.518$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 47.487$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.064$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 170$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 60$ $T_{sin} := 82.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 31.62410^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 25.299$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet *temperature can be determined.*

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 107.499$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 42.165$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 127.835$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 53.626$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 53.59$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.069$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 175$ Area $:= 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 60$ $T_{sin} := 82.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 33.425 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 26.74$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$T_{sout} := dT_s + T_{sin}$ $T_{sout} = 108.94$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 44.567$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$T_{pout} := T_{pin} - dT_p$ $T_{pout} = 130.433$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 56.68$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 56.641$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.068$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 180$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 60$ $T_{sin} := 82.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 35.22610^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 28.181$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 110.381$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 46.968$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 133.032$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 59.734$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 59.693$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.068$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 190$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 60$ $T_{sin} := 82.2$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 38.828 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 31.062$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$T_{sout} := dT_s + T_{sin}$ $T_{sout} = 113.262$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 51.771$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$T_{pout} := T_{pin} - dT_p$ $T_{pout} = 138.229$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 65.842$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 65.797$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.067$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 150$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 65$ $T_{sin} := 84.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 23.52 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 18.816$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 103.516$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 31.36$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 118.64$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 39.884$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 39.857$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.068$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 160$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 65$ $T_{sin} := 84.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 27.12210^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 21.698$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 106.398$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 36.163$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 123.837$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 45.991$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 45.961$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.067$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 170$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 65$ $T_{sin} := 84.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 30.724 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 24.579$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 109.279$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 40.965$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 129.035$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 52.099$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 52.064$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.066$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 175$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 65$ $T_{sin} := 84.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 32.525 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 26.02$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 110.72$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 43.367$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 131.633$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 55.153$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 55.116$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.066$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 180$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 65$ $T_{sin} := 84.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 34.32610^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 27.461$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 112.161$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 45.768$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 134.232$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 58.207$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 58.168$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.066$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 190$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 65$ $T_{sin} := 84.7$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 37.927 \cdot 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 30.342$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 115.042$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 50.569$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 139.431$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 64.315$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 64.27$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.07$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 150$ Area := 686.5 $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 70$ $T_{sin} := 87$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 22.69210^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 18.154$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 105.154$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 30.256$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 119.744$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 38.479$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 38.453$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.065$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 160$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 70$ $T_{sin} := 87$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 26.294 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 21.035$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 108.035$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 35.059$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 124.941$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 44.586$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 44.557$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.064$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 170$ $\quad Area := 686.5$ $\quad U := 859.6$ $\quad c_p := 1$ $\quad m_p := 750000$ $\quad m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 70 \quad T_{sin} := 87$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 29.89510^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 23.916$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 110.916$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 39.86$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 130.14$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 50.695$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 50.66$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.07$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 175$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 70$ $T_{sin} := 87$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 31.69610^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 25.357$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 112.357$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 42.261$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 132.739$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 53.749$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 53.712$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.069$ **Selected Heat Load is Acceptable**

Design inputs:

$T_{pin} := 180$ Area $:= 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 70$ $T_{sin} := 87$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 33.497 \cdot 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 26.798$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 113.798$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 44.663$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpout**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 135.337$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 56.802$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 56.763$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.069$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 190$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 70$ $T_{sin} := 87$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 37.099 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 29.679$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 116.679$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 49.465$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 140.535$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 62.91$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 62.867$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.068$ **Selected Heat Load is Acceptable**

Indian Point Unit 3
Title: Backup Spent Fuel Pool Cooling System (BSFPCS) Heat Removal Capability

Design Inputs:

$T_{pin} := 150$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 75$ $T_{sin} := 88.8$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 22.04410^{6}$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 17.635$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$T_{sout} := dT_s + T_{sin}$ $T_{sout} = 106.435$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 29.392$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$T_{pout} := T_{pin} - dT_p$ $T_{pout} = 120.608$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 37.379$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 37.355$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.062$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 160$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 75$ $T_{sin} := 88.8$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 25.645 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 20.516$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 109.316$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 34.193$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpout) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 125.807$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 43.487$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 43.458$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.069$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 170 \quad Area := 686.5 \quad U := 859.6 \quad c_p := 1 \quad m_p := 750000 \quad m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 75 \quad T_{sin} := 88.8$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 29.24710^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 23.398$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 112.198$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 38.996$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 131.004$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 49.595$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 49.561$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.068$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 175$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 75$ $T_{sin} := 88.8$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 31.048 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 24.838$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 113.638$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 41.397$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 133.603$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 52.649$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 52.613$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.067$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 180$ Area $:= 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 75$ $T_{sin} := 88.8$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 32.849 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 26.279$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin**) the outlet temperature can be determined.**

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 115.079$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 43.799$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpou**) the outlet temperature can be determined.**

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 136.201$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 55.703$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 55.665$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.067$ **Selected Heat Load is Acceptable**

Design Inputs:

$T_{pin} := 190$ $Area := 686.5$ $U := 859.6$ $c_p := 1$ $m_p := 750000$ $m_s := 1250000$

9.2.1 Determination of Secondary Inlet Temperature

$T_{wbt} := 75$ $T_{sin} := 88.8$

9.2.2 Selected SFP Heat Load:

$Q_{sfp} := 36.451 \cdot 10^6$

9.2.3 Using the equation Q = m x cp x dT, the secondary side temperature difference is determined by rearranging the equation.

$$dT_s := \frac{Q_{sfp}}{m_s \cdot c_p} \qquad dT_s = 29.161$$

9.2.4 Using the secondary temperature difference (dTs = Tsout - Tsin) the outlet temperature can be determined.

$$T_{sout} := dT_s + T_{sin} \qquad T_{sout} = 117.961$$

9.2.5 Using the equation Q = m x cp x dT, the primary side temperature difference is determined by rearranging the equation.

$$dT_p := \frac{Q_{sfp}}{m_p \cdot c_p} \qquad dT_p = 48.601$$

9.2.6 Using the primary temperature difference (dTp = Tpin - Tpout) the outlet temperature can be determined.

$$T_{pout} := T_{pin} - dT_p \qquad T_{pout} = 141.399$$

9.2.7 The Log Mean Temperature Difference is calculated:

$$LMTD_1 := \frac{\left[\left(T_{pin} - T_{pout}\right) - \left(T_{sout} - T_{sin}\right)\right]}{\ln\left[\frac{\left(T_{pin} - T_{sout}\right)}{\left(T_{pout} - T_{sin}\right)}\right]} \qquad LMTD_1 = 61.81$$

9.2.8 Rearranging the equation Q = U x A x LMTD, the Log Mean Temperature Difference is calculated:

$$LMTD_2 := \frac{Q_{sfp}}{U \cdot Area} \qquad LMTD_2 = 61.769$$

9.2.9 The values are compared and the percent difference of the two values is determined:

$$PercentDifference := \left[\frac{\left(LMTD_1 - LMTD_2\right)}{LMTD_2}\right] \cdot 100$$

$PercentDifference = 0.066$ **Selected Heat Load is Acceptable**

11.0 References

11.1 APV Plate Heat Exchanger Data Sheet E2449

11.2 Wang, L., Bengt Sunden, and R.M. Manglik. *Plate Heat Exchangers: Design, Applications, and Performance.*

11.3 IP3-DBD-308, Attachment A

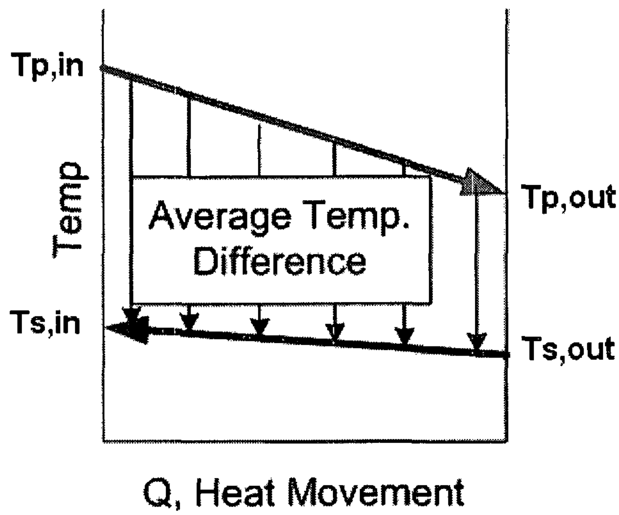
11.4 Cengel, Yunus A. *Heat and Mass Transfer: A Practical Approach.* 3rd ed.

11.5 EVAPCO AT 12-724B Performance Curve

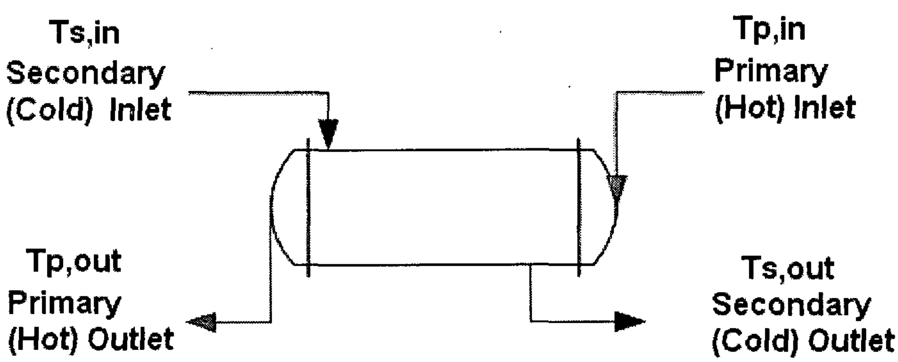
12.0 Attachments

12.1 LMTD Method (1 Page)

The temperature difference between the two streams will vary widely. This is why the log-mean temperature difference is used. Here is how the log-mean temperature difference works:



So, for a heat exchanger as described above, we calculate the LMTD as follows:



$$\Delta T_{LMTD} = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)}$$

Where,

$$\Delta T_1 = T_{p,in} - T_{s,out}$$
$$\Delta T_2 = T_{p,out} - T_{s,in}$$

12.2 APV Plate Heat Exchanger Data Sheet E2449 (1 Page)

APV Plate Heat Exchanger Data Sheet E2449
BURNS & ROE / NY POWER AUTHORITY - INDIAN POINT

IND PNT 2192-92

BURNS AND ROE ENTERPRISES, INC.
DOCUMENT DISPOSITION

PHE Type: SR9 Quotation No: P8004833, R2
Engineer: JJE Date. . . . . : 1999 FEB 11

Process Data

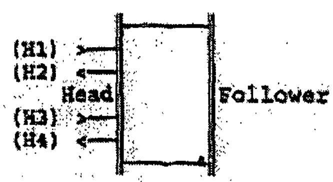
	Hot	Cold
Fluid . . . . :	WATER	WATER
Mass Flow Rate. . . . . lb/h:	750000	1250000
Inlet Temperature. . . . . °F:	190.0	90.0
Outlet Temperature, Duty. . . . °F:	142.0	118.9
Pressure Drop, calculated . . . psi:	3.2	8.4
Specific Gravity (w.r.t. Water) . :	0.975	0.992
Specific Heat Capacity. . BTU/lb °F:	1.001	0.998
Thermal Conductivity. . BTU/h°F ft:	0.384	0.363
Inlet Viscosity . . . . cP:	0.32	0.76
Outlet Viscosity. . . . . cP:	0.46	0.56
Fluid Volume in PHE . . . gal(U.S.):	50	50
Connection Placement, Inlet . . . :	H1	H3
Connection Placement, Outlet. . . :	H4	H2
Heat Exchange Rate, Duty. . . BTU/h:	36030000	
Clean HTC . . . . BTU/h°Fft²:	945.9	
Design (Duty) HTC . . . . BTU/h°Fft²:	859.6	
% Difference in HTC . . . . :	10.0	

Plate Heat Exchanger Specifications

PHE Type. . . . . : SR9
Total Number of Plates. . : 81 Total Active Area: ft²: 686.5
Hot Side Flow Arrangement : 1*40
Cold Side Flow Arrangement: 1*40

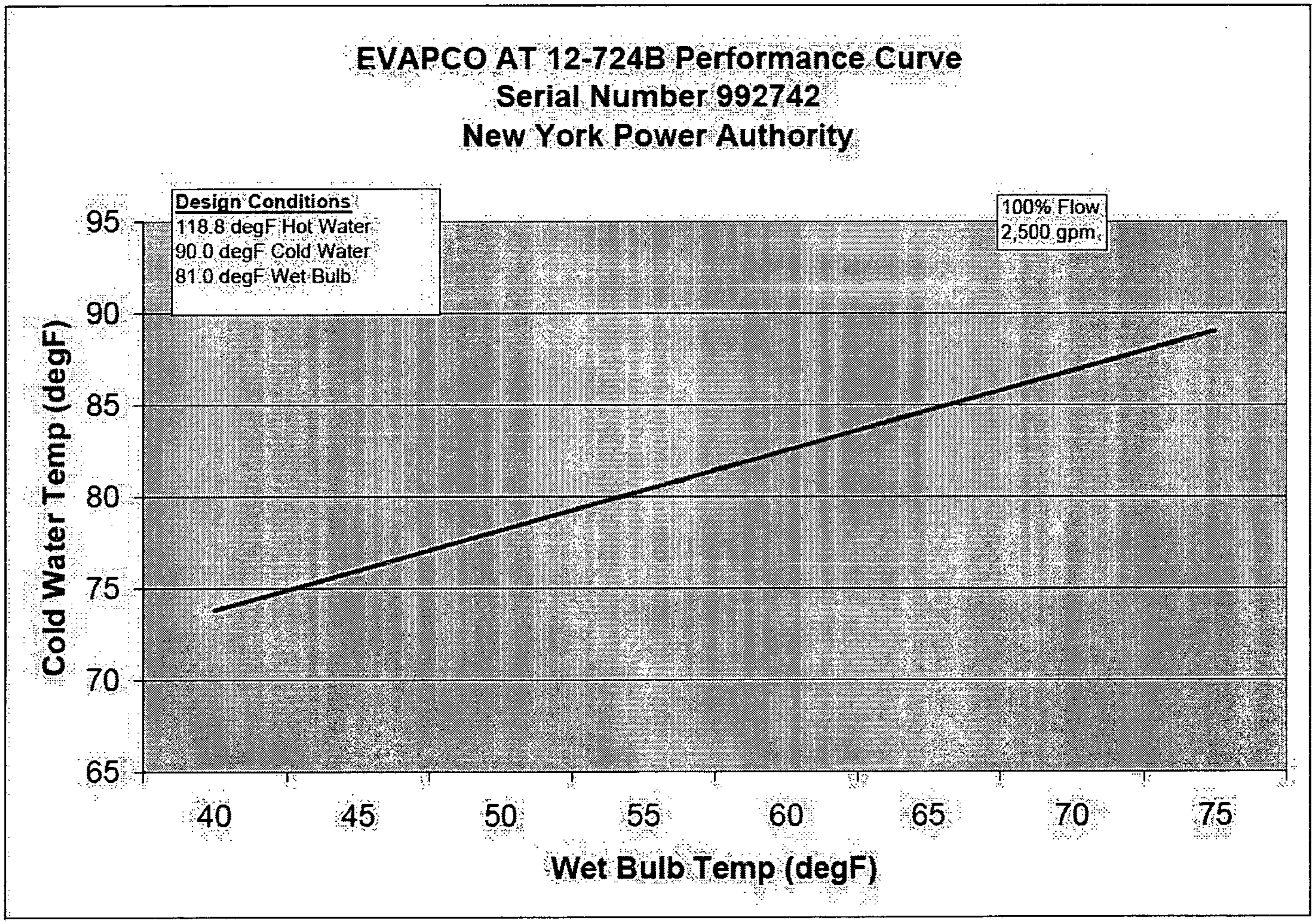
Plate Material. . . . . . . : 0.7 mm Stainles Steel AISI 316

Design Temperature °F: 275 / 5 Mass, Flooded. . .lbm: 6060
Design Pressure. .psi: 150.0 Mass, Empty. . . .lbm: 5220
Test Pressure. . .psi: 225.0
Dimensions (H*W*L) in: 0*0*0

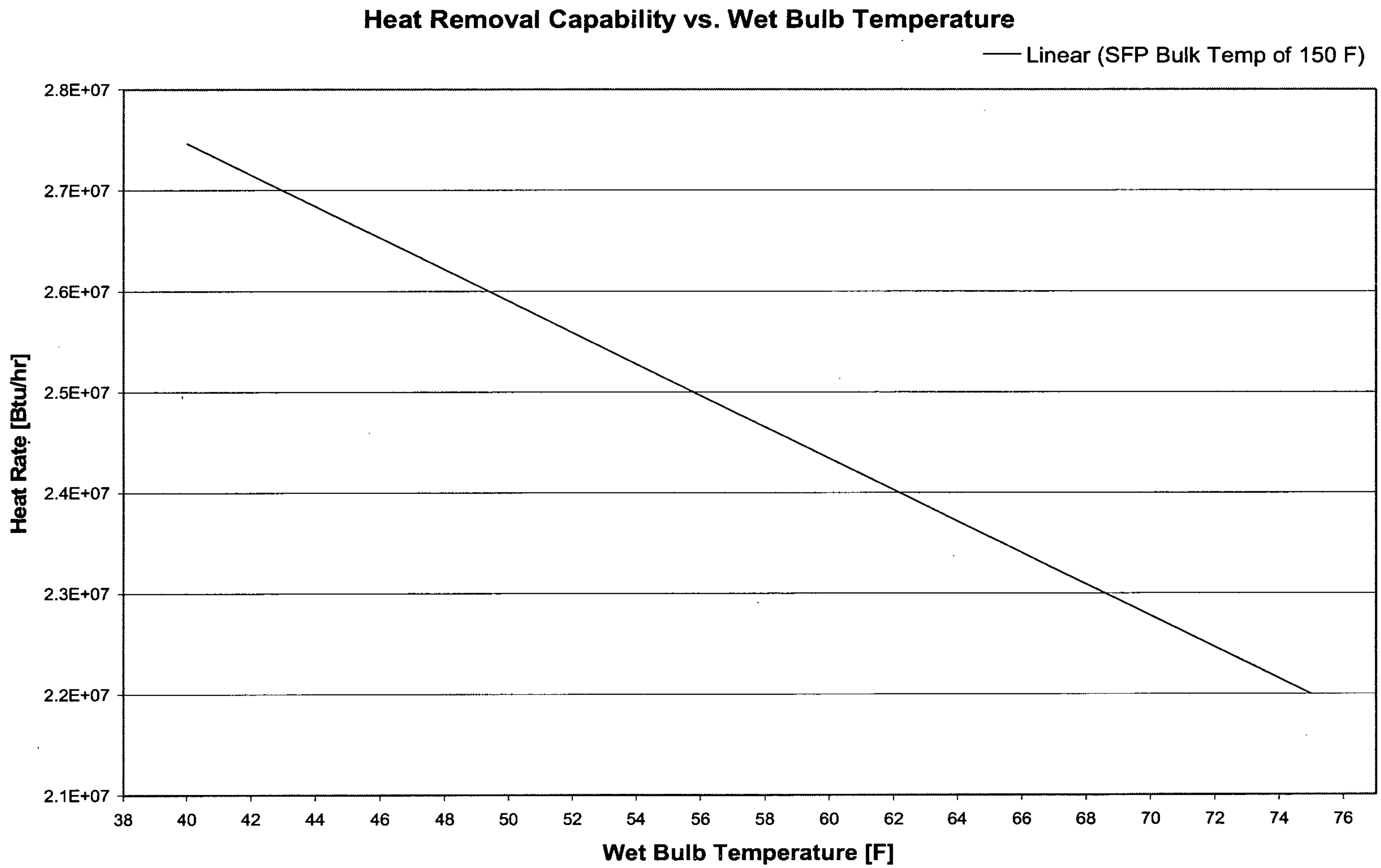


Remarks. . : MODEL: SR9 MGS-12, FRAME SIZE 2
GASKETS: PARACRIL (NITRILE RUBBER) CLIP-IN
CONNECTIONS: 316L SS, 8" 150# ANSI CS LAP-JOINT FLANGED

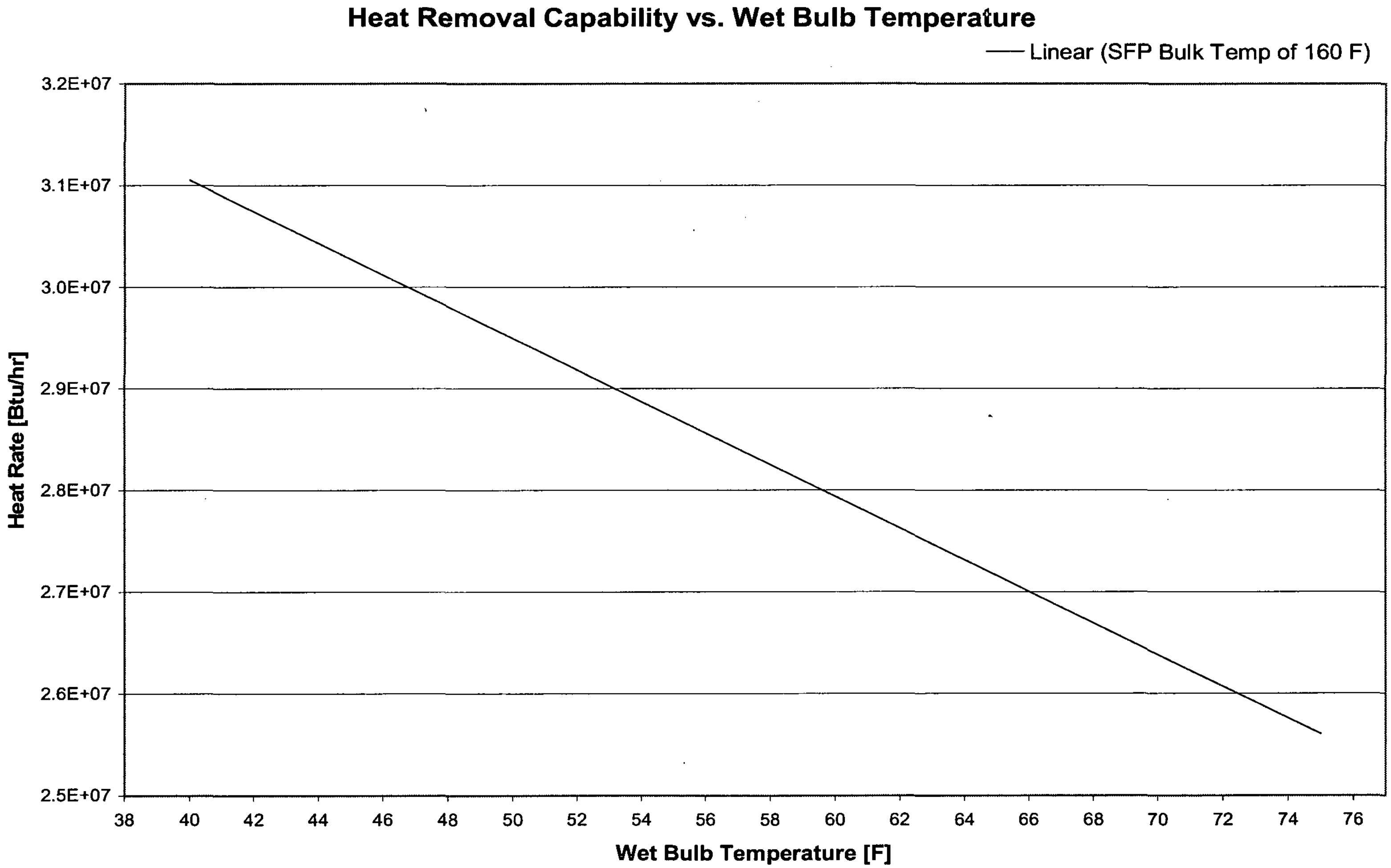
12.3 EVAPCO AT 12-724B Performance Curve (1 Page)



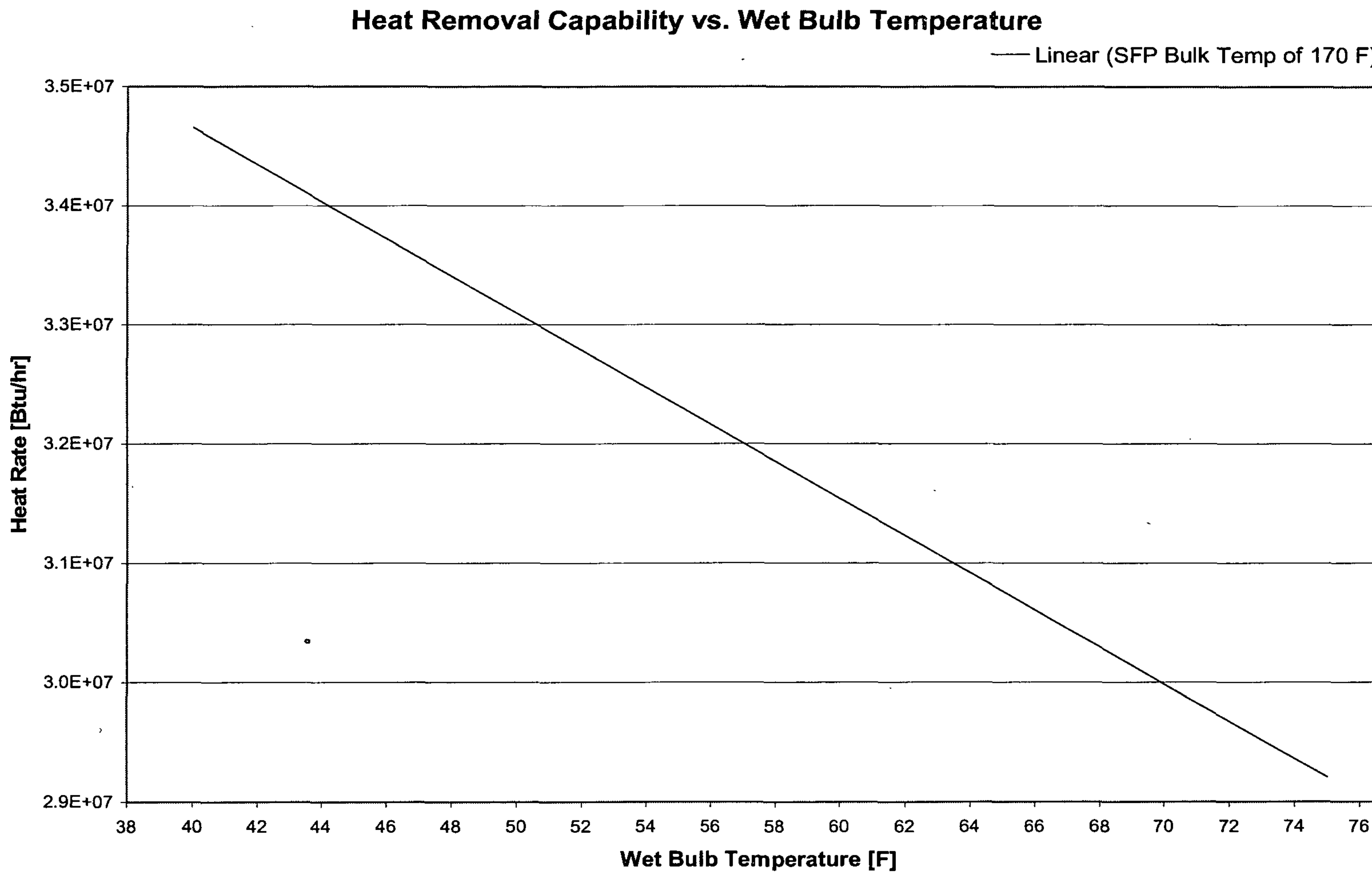
12.4 Heat Removal Capability vs. Wet Bulb Temperature for SFP Bulk Temperature of 150 °F (1 Page)



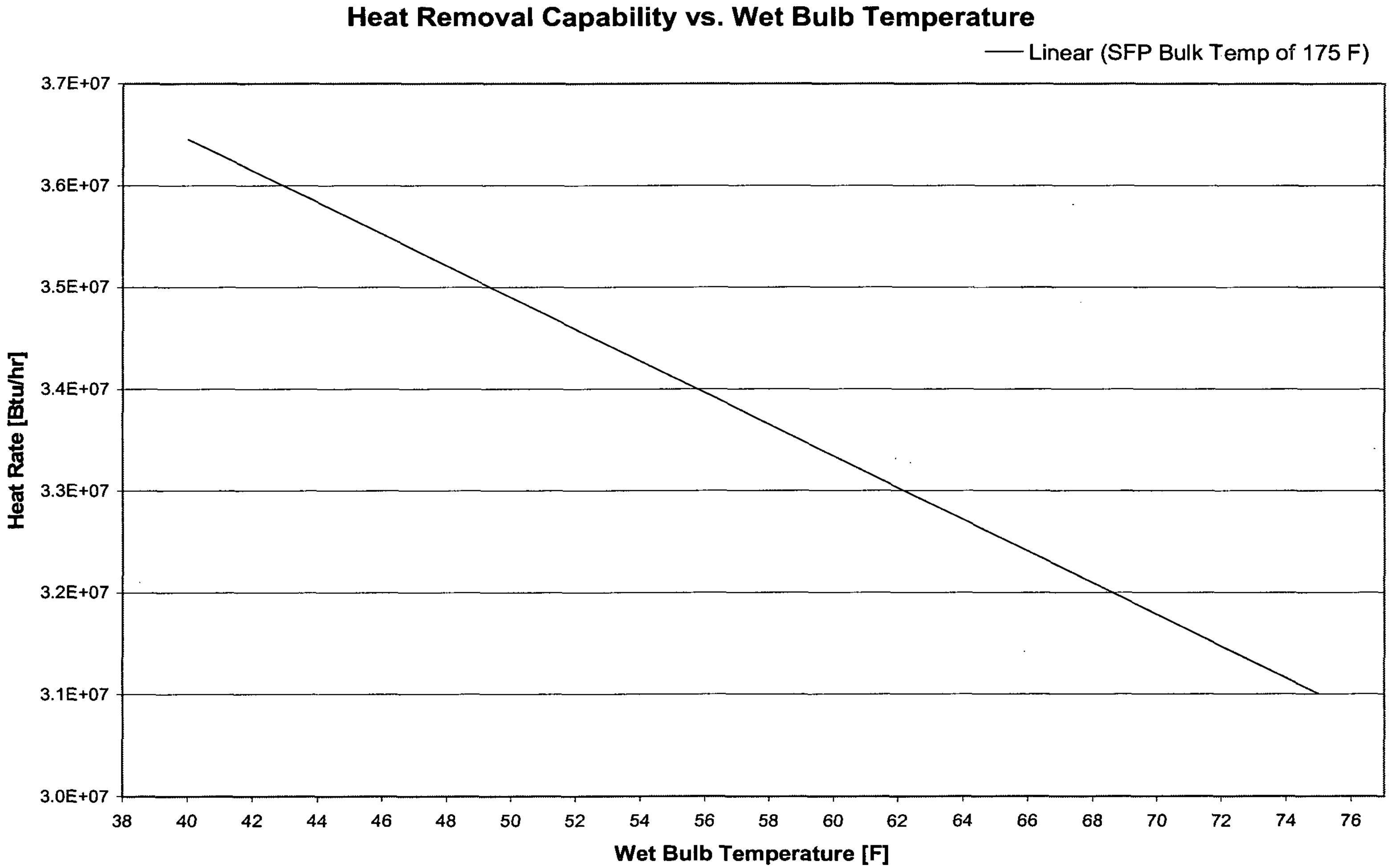
12.5 Heat Removal Capability vs. Wet Bulb Temperature for SFP Bulk Temperature of 160 °F (1 Page)



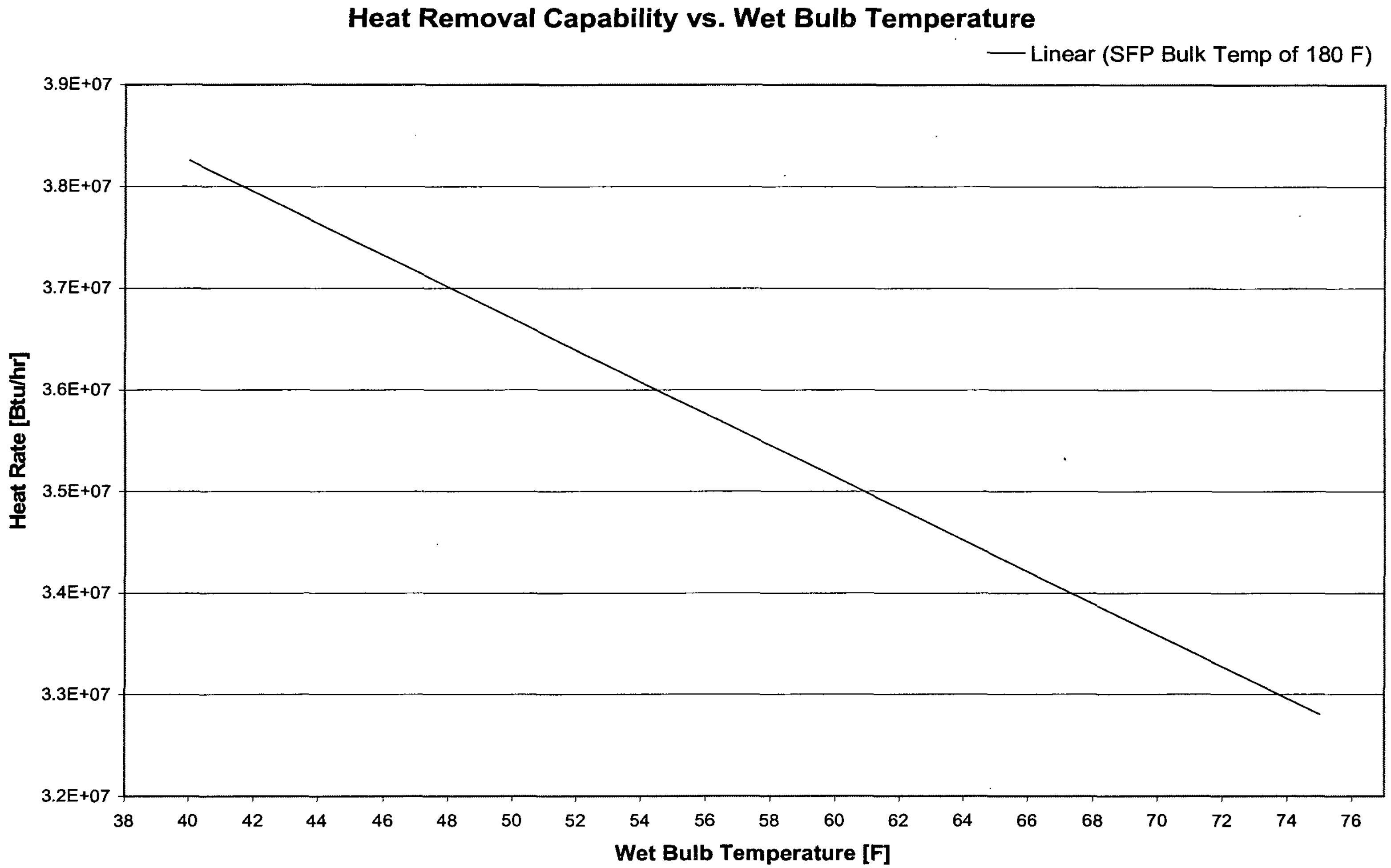
12.6 Heat Removal Capability vs. Wet Bulb Temperature for SFP Bulk Temperature of 170 °F (1 Page)



12.7 Heat Removal Capability vs. Wet Bulb Temperature for SFP Bulk Temperature of 175 °F (1 Page)



12.8 Heat Removal Capability vs. Wet Bulb Temperature for SFP Bulk Temperature of 180 °F (1 Page)



12.9 Heat Removal Capability vs. Wet Bulb Temperature for SFP Bulk Temperature of 190 °F (1 Page)