Attachment

W3F1-2012-0004

Calculations ECM95-008 and ECM95-009

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

CALCULATION COVER PAGE	(1) **EC # 2918**	(2) **Page 1 of 55**

(3) Design Basis Calc. ☒ YES ☐ NO	(4) ☒ CALCULATION ☐ EC Markup
(5) **Calculation No: ECM95-008**	(6) **Revision: 3**

(7) **Title: Ultimate Heat Sink Design Basis**

(8) **System(s): ACC, CC**	(9) **Review Org (Department): DE-Mech**

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REVIEWS

(14) Name/Signature/Date Dale Gallodoro see associated EC **Responsible Engineer**	(15) Name/Signature/Date Steven Moynan see associated EC ☒ **Design Verifier** ☐ **Reviewer** ☐ Comments Attached	(16) Name/Signature/Date John Russo see associated EC **Supervisor/Approval** ☐ Comments Attached

CALCULATION REFERENCE SHEET	CALCULATION NO: ECM95-008 REVISION: 3

I. EC Markups Incorporated:

II. Relationships:	Rev	Input Doc	Output Doc	Impact Y/N	Tracking No.
R1. MN(Q)9-52, Ultimate Heat Sink Performance	2	☒	☐		
R2. MN(Q)9-3, Ultimate Heat Sink Study	2	☒	☐		
R3. 9C2-5Y, Chillers Heat Rejections	0	☒	☐		
R4. W3-DBD-4, CCW/ACCW Design Bases Document	3-8	☒	☒	N	
R5. WO-00050576, Per CC/ACC Train A Flow Balance Per PE-04-024	0	☒	☐		
R6. PE-004-024, ACCW & CCW System Flow Balance	2-1	☒	☐		
R7. EC-I91-036, CCWHx Outlet Temperature (DCT Fan Control) Instrument Loop Uncertainty Calculation	1	☒	☐		
R8. EC-S05-013, UHS Containment Heat Loads	0	☒	☐		
R9. W3 Technical Specification 3/4.7.4		☒	☐		
R10. MN(Q)9-65, CCW Temperature Evaluation.	1	☒	☒	N	
R11. ECM03-007, Review of UHS Atmospheric Temperature Design Parameters to Support EPU Implementation	0	☒	☐		
R12. TD-Z010.0025, Zurn Industries Tech. Document	2	☒	☐		
R13. Spec LOU-1564.86 – Dry Cooling Towers	8	☐	☒	N	
R14. Spec LOU-1564.114A – Wet Cooling Towers	10	☐	☒	N	
R15. Spec LOU-1564.75 – CCW Heat Exchanger	9	☐	☒	N	
R20. W3-DBD-13, Containment Spray Design Basis Document	1-12	☐	☒	N	
R21. MN(Q)9-50, ACCW System Resistance	1	☐	☒	N	
R22. ECM95-009, Ultimate Heat Sink Fan Requirements	1	☐	☒	N	
R23. FSAR – Chapter 9	13B	☐	☒	N	

III. CROSS REFERENCES:

C1. Letter ES-LOU-87-77, Dated July 18, 1977, Subject: Design Meteorological Data for the Ultimate Heat Sink, File No. 14Q-B-3A

C2. ASME Section III Code, Subsection NC-3611 & ND-3611, 1971 Edition including Winter 72 Addenda

IV. SOFTWARE USED: STER Version 5.04 by Holtec , W3 Software Manual 460000024 Vol. 1
Microsoft Excel Version 2002 SP3

V. OTHER CHANGES: NONE

Revision	Record of Revision
0	Original Issue
0-1	Determine equivalent meteorological conditions that UHS can reject the design basis heat load.
0-2	CR 97-0777 documented that the containment heat loads for the UHS did not contain certain conservative assumptions. The purpose of this calculation change is to revise the UHS design bases requirements corresponding to maximum containment heat load rate determined by calculation MN(Q)-9-3. This is a complete rewrite; therefore no revision bars are used.
1	Provides justification for use of hot air recirculation values and adds computation of the ACCW System design temperature in response to the recommended dispositions of Design Basis Review Open Items: OI-CCW-296-C and OI-CCW-297-C. Adds Keywords to Section 3. Replaces Reference 3.3 and removes references to the FSAR. Corrects typographical errors. This is a complete rewrite; therefore no revision bars are used.
DRN 03-509	Modified UHS Design Basis as a result of Total Heat Duty input changes at 3716 MW_t. A methodology change was made in section 5.4 to ensure Tech Spec 3/4.7.4 compliance. Calculation and Attachment changes have been made accordingly. Added page 2 of 2 to Attachment 7.3 to include the regression analysis for the DCT. This analysis was referenced in section 6.1.1 of the calculation. Section 6.6.4 was added to address Met tower conditions from Calculation ECM03-007 (Ref. R22). The basis for the heat load from emergency diesel generators and the LPSI/HPSI/CS pumps in circular. Calculation ECM95-008 references calculation MNQ9-3 for this heat load and MNQ9-3 references ECM95-008 for the same heat load. ECM95-008 now references Calculation MNQ9-65 which develops the basis for these heat loads.
DRN 05-766	Added Assumption 4.7 to clarify that containment heat loads were determined assuming 112°F CCW temperature (ECS01-005).
2	This revision incorporated all outstanding changes and DRNs. ECS05-013 was changed to the new input for containment heat loading and all calculations were revised accordingly. CR-WF3-2005-0230 documented that the CCW flows used in the calc did not bound the As-Built flows determined during flow testing. The CCW accident flow has been increased to a bounding 6900 gpm.
3	Corrected transposition errors in paragraphs 5.3 and 5.4, math operator in paragraph 6.3.1, and copy and paste error in Attachment 7.1, identified on CR-WF3-2007-1420. The errors did not affect the results of the calculation. Therefore, this is an administrative change only.

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EFFECTIVE PAGES

Rev. 3 - ALL

1.0 PURPOSE

1.1 The purpose of this calculation is to determine the Ultimate Heat Sink design basis under LOCA conditions using the worst combination meteorological design parameters.

1.2 This calculation also determines the ACCW System design temperature.

2.0 CONCLUSION

2.1 The UHS is capable of dissipating the LOCA heat duty requirements for both worst combination meteorological design parameters, 102°F_{db}/78°F_{wb} and 98°F_{db}/83°F_{wb}. The 102°F_{db}/78°F_{wb} meteorological condition would allow less fouling in the CCW heat exchanger in order to maintain a CCW outlet temperature of 115°F, therefore is chosen as the UHS design point. The design conditions for the UHS are given below.

Dry Bulb Temperature (T_{db})	- 102°F
Wet Bulb Temperature (T_{wb})	- 78°F
DCT CCW Inlet Temperature	- 164.56°F
DCT CCW Outlet/CCWHx Inlet Temp.	- 131.11°F
DCT Heat Duty	- 113.38 x 10^6 BTU/Hr
WCT ACCW Outlet/CCWHx Inlet Temp.	- 89.3°F*
CCWHx CCW Outlet Temperature	- 115.0°F
CCWHx ACCW Outlet Temperature	- 113.77°F*
CCWHx Allowable Fouling Factor	- 0.00159*
CCWHx Heat Duty	- 54.62 x 10^6 BTU/Hr
WCT ACCW Inlet Temperature	- 111.79°F*
WCT Heat Duty	- 59.72 x 10^6 BTU/Hr
WCT Cooling Range	-22.49°F

*As discussed in section 5.4, these values are calculated using an ACCW inlet temperature to the CCWHx of 89.3°F in order to maintain the Tech. Spec. maximum ACCW temperature of 89°F.

As discussed in section 6.6.4, the meteorological condition of 91.3°F_{db}/84.9°F_{wb} from Reference R11 is not more limiting than 102°F_{db}/78°F_{wb} case above.

2.2 Using the limiting historical meteorological parameter, 102°F_{db}/78°F_{wb}, a relationship (See Attachment 7.3) was developed to provide equivalent dry bulb temperature/corresponding wet bulb temperature required to maintain overall UHS design heat duty capacity. The linear relationship demonstrates that for a dry bulb temperature increase/decrease of 1.0°F, the corresponding wet bulb temperature can decrease/increase approximately 1.7°F and maintain the UHS design heat duty capacity. The relationship also demonstrates the UHS can dissipate its design heat load for any dry bulb temperature below 93°F, regardless of wet bulb temperature, since wet bulb temperature can not exceed dry bulb temperature.

2.3 ACCW System design temperature is 125°F.

3.0 INPUT CRITERIA

3.1 Peak UHS Heat Duty Requirements

Containment Heat Duty[1]	=	158×10^6 BTU/hr	(Ref. R8)
Essential Chiller Heat Duty	=	5.1×10^6 BTU/hr	(Ref. R3)
Auxiliary Heat Duty[2]	=	10.0×10^6 BTU/hr	(Ref. R10)
Total Heat Duty	=	173.1×10^6 BTU/hr	
CCWS Heat Duty	=	168.0×10^6 BTU/hr	

Notes: 1. Containment heat duty has been conservatively rounded up from 157.69×10^6 BTU/Hr given in Ref. R8.
2. Includes Diesel Generator and HPSI, LPSI and Containment Spray pumps

3.2 Maximum One Hour Ambient Conditions

Drybulb Temperature

Ref. C1 contains a table which shows the maximum drybulb and concurrent wetbulb for the New Orleans area is 102 and 77°F respectively. One degree is added to the wetbulb temperature for conservatism bringing the maximum 1 hour drybulb/corresponding wetbulb temperatures to 102/78°F.

Wetbulb Temperature

Ref. C1 discusses that 83°F is the maximum wetbulb temperature of record at Moisant Field for the period between 1946 and 1977. The reference discusses that 83°F is an acceptable design value and satisfies the requirements of Reg. Guide 1.27. A table attached to the reference provides maximum wetbulb and corresponding drybulb temperatures however, 83°F is not an entry in the table. An entry is provided for 83°F in the table for maximum drybulb and corresponding wetbulb temperatures. Based on this evaluation, at 83°F wetbulb temperature, the corresponding drybulb temperature is 98°F.

The site Met Tower data was evaluated in calculation Reference R11 over a period from 1997 to 2001. This review indicates that the maximum one hour wetbulb temperature exceeded 83°F at 84.9°F with an associated drybulb temperature of 91.27°F. This calculation will determine if the $84.9°F_{wb}/91.3°F_{db}$ met condition is more limiting for the highest T_{wb} and coincident T_{db} case.

3.3 Maintain a CCW outlet temperature of 115°F to the plant auxiliaries. (Ref. R4)

3.4 Accident Flow Rates

CCW Flow Rate – (Ref. R5)

CFC (1400 gpm ea.) =	2800 gpm
Emergency Diesel Gen. =	950 gpm
Shutdown Cooling Hx. =	3100 gpm
Safeguard Pumps =	50 gpm
Total =	6900 gpm

ACCW Flow Rate – (Ref. R6)

CCWHx =	4500 gpm
Chiller =	850 gpm
Total =	5350 gpm

3.5 Hudson Products DCT Performance Curves - Heat Duty vs. Outlet Temperature as a function of Dry Bulb Temperature. (Ref. R1)

3.6 Zurn Industries WCT Performance Curves - Outlet Temperature vs. Wet Bulb Temperature as a function of Cooling Range. (Ref. R12)

3.7 Hot Air Recirculation Effect

Dry Bulb Temperature - 1.9°F (Ref. 7.4)

Wet Bulb Temperature - 1.0°F (Ref. 7.4)

4.0 ASSUMPTIONS

4.1 100% tube capacity on the DCT.

4.2 95% tube capacity on the CCWHx.

4.3 Linear interpolation between the flow rates of 6500 gpm and 7500 gpm will be used to determine the DCT performance at the accident CCW flow rate of 6900 gpm at 115°F CCW temperature.

4.4 Linear interpolation between the flow rates of 5000 gpm and 5750 gpm will be used to determine the WCT performance at the accident ACCW flow rate of 5350 gpm.

4.5 The uncertainty associated with the CCW temperature control given in Reference R7 does have to be accounted for in this analysis. Valves ACC-127A(B), located downstream of the CCW temperature control valves ACC-126A(B), will be throttled to ensure the design flow to the essential chiller is maintained. Therefore, should ACC-126A(B) respond by increasing ACCW flow through the CCW heat exchanger to maintain CCW temperature at 112.6°F (115°F less 2.4°F maximum uncertainty), CCW temperature will rise to a maximum of 115°F since ACC-127A(B) will prevent ACCW flow from exceeding a value where design flow the essential chiller is not maintained. By design, the UHS will then self-correct and CCW temperature will rise to a maximum of 115°F until ambient conditions become more favorable or when the accident heat load is reduced.

4.6 This analysis assumes the Post Accident Sampling (PAS) system is secured. The impact is negligible since the operation of the PAS system is intermittent, and the PAS system heat load and cooling water flow are negligible. In addition, PAS is required to be placed in service after 3 hours post-accident, after peak accident heat load has occurred. (Ref. R2)

4.7 Containment heat loads were determined assuming a 112°F CCW temperature because this maximizes the heat input into the Ultimate Heat Sink. This calculation will use these maximum heat loads assuming 115°F CCW temperature to determine the heat removal contribution from the Dry Cooling tower, Wet Cooling Tower and the CCW Heat Exchangers. This is acceptable because if CCW temperature were being controlled at 115°F, the heat load into the Ultimate heat Sink would be less. (Ref. R8)

5.0 METHODS OF ANALYSIS

5.1 Linear equations can be derived to describe the DCT and WCT performance since their performance curves assume a linear relationship (y = mx +b). Using the "Regression" Tool in Microsoft Excel, the slope and intercept of the DCT and WCT performance curves are calculated. These results will provide an equation to describe the DCT performance as a function of dry bulb temperature and CCW flow and a WCT performance as a function of cooling range and wet bulb temperature.

5.2 The DCT heat duty and associated CCW outlet temperatures at dry bulb temperatures of 98° and 102°F are calculated using the equations derived from Section 5.1 and the conservation of energy.

5.3 The WCT heat duty at dry bulb temperatures of 98° and 102°F is determined by subtracting the DCT heat duty from the UHS total heat duty. The WCT outlet temperature is calculated using dry bulb/wet bulb temperatures of 102°F/78°F and 98°F/83°F using the equations derived from Section 5.1.

5.4 The CCWHx heat duty is determined by subtracting the Essential Chiller heat duty from the WCT heat duty. With the CCW and ACCW inlet temperatures calculated and requiring a CCW outlet temperature of 115°F, STER Version 5.04 will calculate an allowable CCWHx fouling factor.

The ACCW heat exchanger inlet temperature is set equal to 89.3°F if the calculated WCT outlet temperature in section 6.3 is less than 89.0°F. The Technical Specification maximum WCT basin water temperature is 89.0°F (Tech. Spec. Requirement 3/4.7.4). The WCT performance is dictated by wet bulb temperature conditions as shown in the performance curves and will perform as calculated at the limiting atmospheric conditions. However for the cases in which the WCT can cool the ACCW flow below 89°F, the Tech. Spec. WCT basin temperature limit of 89°F is the more limiting condition impacting the CCW heat exchanger fouling (Section 6.4).

5.5 The design basis of the UHS will be based on the worst combination meteorological design parameter, maximum one hour T_{db}/coincident T_{wb} or maximum one hour T_{wb}/coincident T_{db}, that produces the lowest CCWHx fouling factor.

5.6 Using the most limiting historical meteorological design parameter as the baseline, a heat balance will be performed for various dry bulb temperatures to determine the maximum wet bulb temperature allowed for the UHS to maintain its overall design heat duty capacity.

5.7 Water density is determined using the average respective system temperature i.e. [(CCWmax+CCWmin)/2]. This density is used throughout the calculations such that the conservation of mass is maintained.

6.0 CALCULATION

6.1 Equation Fitting on Performance Curves

6.1.1 Dry Cooling Tower

Two data points, CCW outlet temperature (CCW_{out}) and Heat Duty (Q), for dry bulb temperatures (T_{db}) of 80°F, 90°F and 102°F were obtained from the Hudson DCT performance curves. The slope and intercept of these curves were calculated using Microsoft Excel Linear Regression Analysis. The results are provided below. The printouts are provided in Attachment 7.1.

CCW Flow Rate of 6500 gpm

Temp. Dry Bulb (°F)	Slope (CCW_{out}- °F)	Intercept (BTU x 10^6)	ΔIntercept Ref.- 80°F T_{db} (BTU x 10^6)
80	4.4	-354	N/A
90	4.4	-398	-44
102	4.4	-442	-88

ΔIntercept/°F T_{db} = -4.4 (Worst Case)

From the above table, the linear equation at a CCW flow rate of 6500 gpm that fits the DCT performance as a function of Dry Bulb Temperature is described below:

$$Q_{6500\ gpm} = 4.4CCW_{out} - (354 + 4.4(T_{db} - 80))$$

where:

$Q_{6500\ gpm}$ = DCT Heat Duty Performance (BTU/Hr x 10^6)
CCW_{out} = CCW Outlet Temperature (°F)
T_{db} = Dry Bulb Temperature (°F)

CCW Flow Rate of 7500 gpm

Temp. Dry Bulb (°F)	Slope (CCW_{out}- °F)	Intercept (BTU x 10^6)	ΔIntercept Ref.- 80°F T_{db} (BTU x 10^6)
80	4.0	-320	N/A
90	4.0	-360	-40
102	4.0	-408	-88

ΔIntercept / °F T_{db} = -4.0

From the above table, the linear equation at a CCW flow rate of 7500 gpm that fits the DCT performance as a function of Dry Bulb Temperature is described below:

$Q_{7500\ gpm} = 4.0CCW_{out} - (320 + 4.0(T_{db} - 80))$

where:

$Q_{7500\ gpm}$ = DCT Heat Duty Performance - BTU/Hr x 10^6
CCW_{out} = CCW Outlet Temperature (°F)
T_{db} = Dry Bulb Temperature (°F)

6.1.2 Wet Cooling Tower

Two data points, Wet Bulb Temperature (T_{wb}) and ACCW outlet temperature ($ACCW_{out}$), for cooling ranges of 10.8°F, 21.6°F and 27°F were obtained from the Zurn WCT performance curves. The slope and intercept of these curves were calculated using Microsoft Excel Regression Analysis. The results are provided below. The printouts are provided in Attachment 7.1.

ACCW Flow Rate of 5000 gpm

Cooling Range (°F)	Slope (T_{wb}-°F)	Intercept ($ACCW_{out}$-°F)
10.8	0.725	27.125
21.6	0.675	34.125
27	0.600	41.75

The linear equation for an ACCW flow of 5000 gpm that fits the WCT performance as a function of Cooling Range between 10.8°F and 21.6°F is described below:

ΔSlope / °F Cooling Range = -0.00463
ΔIntercept / °F Cooling Range = 0.648

$$ACCW_{out} = (0.725 - 0.00463(\Delta T - 10.8))T_{wb} + (27.125 + 0.648(\Delta T - 10.8))$$

The linear equation for an ACCW flow of 5000 gpm that fits the WCT performance as a function of Cooling Range between 21.6°F and 27°F is described below:

ΔSlope / °F Cooling Range = -0.0139
ΔIntercept / °F Cooling Range = 1.412

$$ACCW_{out} = (0.675 - 0.0139(\Delta T - 21.6))T_{wb} + (34.125 + 1.412(\Delta T - 21.6))$$

ACCW Flow Rate of 5750 gpm

Cooling Range (°F)	Slope (T_{wb}-°F)	Intercept ($ACCW_{out}$-°F)
10.8	0.775	24.125
21.6	0.600	42.000
27	0.575	45.125

The linear equation for an ACCW flow of 5750 gpm that fits the WCT performance as a function of Cooling Range between 10.8°F and 21.6°F is described below:

ΔSlope / °F Cooling Range = -0.01620
ΔIntercept / °F Cooling Range = 1.655

$$ACCW_{out} = (0.775 - 0.01620(\Delta T - 10.8))T_{wb} + (24.125 + 1.655(\Delta T - 10.8))$$

The linear equation for an ACCW flow of 5750 gpm that fits the WCT performance as a function of Cooling Range between 21.6°F and 27.0°F is described below:

ΔSlope / °F Cooling Range = -0.00463
ΔIntercept / °F Cooling Range = 0.5787

$$ACCW_{out} = (0.6 - 0.00463(\Delta T - 21.6))T_{wb} + (42.00 + 0.5787(\Delta T - 21.6))$$

where:

$ACCW_{out}$ = ACCW Outlet Temperature (°F)
T_{wb} = Wet Bulb Temperature (°F)
ΔT = WCT Cooling Range Required (°F)

6.2 Dry Cooling Tower Performance

6.2.1 DCT Performance at T_{db} = 102°F

Determine DCT inlet temperature

$Q = mc_p(T_{in} - T_{out})$ or $T_{in} = (Q/mc_p) + T_{out}$

where

T_{in} = DCT Inlet Temperature (°F)
Q = 168.0 x 10^6 BTU/Hr (less Chiller Heat Duty) (Input 3.1)
m = 6900 gpm x 60 min/hr / 0.016293 ft^3/lb_m / 7.4805 gal/ft^3
= 3.39678 x 10^6 lb_m/hr
T_{out} = 115°F @ CCW Heat Exchanger
C_p = 0.998 BTU/lbm - °F
T_{in} = (168.0 x 10^6/ (3.39678 x 10^6 * 0.998)) + 115
T_{in} = 164.56°F
T_{avg} = 139.79°F ≈ 140°F

The CCW_{out} temperature at the DCT can be calculated using the conservation of energy where:

$$Q_{DCT} = mc_p(T_{in} - T_{out})$$

This heat balance will be performed to calculate the DCT T_{out} temperature at DCT performance curve inlet CCW flows of 6500 gpm and 7500 gpm and then interpolated at the CCW accident design flow of 6900 gpm.

$Q_{6500\ gpm} = 4.4{*}T_{out} - (354 + 4.4(T_{db} - 80)) = mc_p(T_{in} - T_{out})$ (Sec. 6.1.1)

where:

Q_{6500} = Heat Transferred @ CCW Flow of 6500 gpm
T_{out} = CCW_{out} temperature
T_{db} = 103.9°F (adding 1.9°F for Recirculation) (Input. 3.2, 3.7)
m = 6500 gpm x 60 min/hr / 0.016293 ft^3/lbm / 7.4805 gal/ft^3
= 3.200 x 10^6 lb_m/hr
c_p = 0.998 BTU/lb_m - °F
T_{in} = 164.56°F

Solving for T_{out} yields

$4.4{*}T_{out} + mc_pT_{out} = (354 + 4.4(T_{db} - 80)) + mc_pT_{in}$
$4.4{*}T_{out} + (3.200)(0.998)T_{out} = 354 + 4.4(103.9-80) +$
$(3.200)(0.998){*}164.56$
T_{out} = 129.67°F

Calculating Heat Transferred:

$Q_{6500} = mc_p(T_{in} - T_{out})$
$Q_{6500} = (3.200)(0.998)(164.56 - 129.67)$
$Q_{6500} = 111.42 \times 10^6$ BTU/Hr

Performing Heat Balance at a CCW Flow Rate of 7500 gpm:

$Q_{7500\ gpm} = 4.0^*T_{out} - (320 + 4.0(T_{db} - 80)) = mc_p(T_{in} - T_{out})$ (Sec. 6.1.1)

where:

Q_{7500}	= Heat Transferred @ CCW Flow of 7500 gpm
T_{out}	= CCW_{out} Temperature
T_{db}	= 103.9°F (adding 1.9°F for Recirculation) (Input 3.2, 3.7)
m	= 7500 gpm x 60 min/hr / 0.016293 ft^3 / lbm / 7.4805 gal/ft^3
	= 3.692×10^6 lb_m/hr
c_p	= 0.998 BTU/lb_m - °F
T_{in}	= 164.56°F

Solving for T_{out} yields:

$4.0^*T_{out} + mc_pT_{out} = (320 + 4.0(T_{db} - 80)) + mc_pT_{in}$
$4.0^*T_{out} + (3.692)(0.998)T_{out} = 320 + 4.0(103.9-80) + (3.692)(0.998)^*164.56$
$T_{out} = 132.99$°F

Calculating Heat Transferred:
$Q_{7500} = mc_p(T_{in} - T_{out})$
$Q_{7500} = (3.692)(0.998)(164.56 - 132.99)$
$Q_{7500} = 116.32 \times 10^6$ BTU/Hr

By linear interpolation, the DCT heat duty @ 6900 gpm is:

$$Q_{6900\ gpm} = Q_{6500\ gpm} + \frac{6900-6500}{7500-6500} * (Q_{7500\ gpm} - Q_{6500\ gpm})$$
$Q_{6900\ gpm} = 111.42\times10^6 + (0.4)(116.32\times10^6 - 111.42\times10^6)$
$Q_{6900\ gpm} = 113.38\times10^6$ BTU/Hr

Calculating CCW_{out} Temperature:

$m = 3.39678 \times 10^6$ lb_m/hr
$c_p = 0.998$ BTU/lb_m - °F
$T_{out} = T_{in} - (Q/mc_p)$
$T_{out} = 164.56 - (113.38/3.39678/0.998)$
$T_{out} = 131.11$°F

6.2.2 DCT Performance at T_{db} = 98°F

The method of analysis for the DCT performance at a dry bulb temperature of 98°F is identical to the analysis given 6.2.1.

$Q_{6500\ gpm} = 4.4*T_{out} - (354 + 4.4(T_{db} - 80)) = mc_p(T_{in} - T_{out})$ (Sec. 6.1.1)

where:

Q_{6500}	= Heat Transferred @ CCW Flow of 6500 gpm	
T_{out}	= CCW_{out} Temperature	
T_{db}	= 99.9°F (adding 1.9°F for Recirculation)	(Input 3.2, 3.7)
m	= 3.200 lb_m/hr (x 10^6) (6500 gpm)	
c_p	= 0.998 BTU/lb_m - °F	
T_{in}	= 164.56°F	

Solving for T_{out} yields

$4.4*T_{out} + mc_pT_{out} = (354 + 4.4(T_{db} - 80)) + mc_pT_{in}$
$4.4*T_{out} + (3.200)(0.998)T_{out} = 354 + 4.4(99.9\text{-}80) + (3.200)(0.998)*164.56$
$T_{out} = 127.36°F$

Calculating Heat Transferred:

$Q_{6500} = mc_p(T_{in} - T_{out})$
$Q_{6500} = (3.200)(0.998)(164.56 – 127.36)$
$Q_{6500} = 118.8 \times 10^6$ BTU/Hr

Performing Heat Balance at a CCW Flow Rate of 7500 gpm:

$Q_{7500\ gpm} = 4.0*T_{out} - (320 + 4.0(T_{db} - 80)) = mc_p(T_{in} - T_{out})$ (Sec. 6.1.1)

where:

Q_{7500}	= Heat Transferred @ CCW Flow of 7500 gpm	
T_{out}	= CCW_{out} Temperature	
T_{db}	= 99.9°F (adding 1.9°F for Recirculation)	(Input 3.2, 3.7)
m	= 3.692 lb_m/hr (x 10^6) (7500 gpm)	
c_p	= 0.998 BTU/lb_m - °F	
T_{in}	= 164.56°F	

Solving for T_{out} yields:

$4.0*T_{out} + mc_pT_{out} = (320 + 4.0(T_{db} - 80)) + mc_pT_{in}$
$4.0*T_{out} + (3.692)(0.998)T_{out} = 320 + 4.0(99.9\text{-}80) +$
$(3.692)(0.998)*164.36$
$T_{out} = 130.90°F$

Calculating Heat Transferred:

$Q_{7500} = mc_p(T_{in} - T_{out})$

$Q_{7500} = (3.692)(0.998)(164.56 – 130.90)$

$Q_{7500} = 124.02 \times 10^6$ BTU/Hr

By linear interpolation, the DCT heat duty @ 6900 gpm is:

$$Q_{6900\ gpm} = Q_{6500\ gpm} + \frac{6900\text{-}6500}{7500\text{-}6500} * (Q_{7500\ gpm} - Q_{6500\ gpm})$$

$Q_{6900\ gpm} = 118.8\text{x}10^6 + (0.4)(124.02\text{x}10^6 - 118.8\text{x}10^6)$

$Q_{6900\ gpm} = 120.89 \times 10^6$ BTU/Hr

Calculating CCW_{out} Temperature:

$m = 3.39678 \times 10^6\ lb_m/hr$

$c_p = 0.998\ BTU/lb_m - °F$

$T_{out} = T_{in} - (Q/mc_p)$

$T_{out} = 164.56 - (120.89/3.39678/0.998)$

$T_{out} = 128.90°F$

6.3 Wet Cooling Tower Performance

6.3.1 <u>WCT Performance at T_{wb} = 78°F and T_{db} = 102°F</u>

Determine WCT Heat Duty

Q_{wct} = Total Heat Duty-DCT Heat Dissipated @ T_{db} of 102°F.

$Q_{wct} = 173.10 \times 10^6 - 113.38 \times 10^6$ (Input 3.1, Sec. 6.2.1)

$Q_{wct} = 59.72 \times 10^6$ BTU/Hr

Determine WCT Cooling Range

$Q_{wct} = mc_p(\Delta T)$ or $\Delta T = Q_{wct}/mc_p$

where

ΔT = Cooling Range (°F)

m = 5350 gpm / 0.01613 ft^3/lb_m / 7.4805 gal/ft^3 x 60 min/hr
=2.660 x $10^6\ lb_m/hr$

c_p = 0.998 BTU/lb_m - °F

$\Delta T = 59.72 \times 10^6 / 2.660 \times 10^6 / 0.998 = 22.49°F$

Using a 22.49°F WCT Cooling range and increasing T_{wb} by 1.0°F to account for recirculation, the ACCW outlet temperature can be calculated. (Input 3.7)

At 5000 gpm

$ACCW_{out}$ = (0.675 - 0.0139(22.49 – 21.6))*79 +(34.125 + 1.412(22.49 – 21.6))
$ACCW_{out}$ = 87.73°F (Sec. 6.1.2)

At 5750 gpm

$ACCW_{out}$ = (0.6 - 0.00463(22.49 – 21.6))*79 + (42.00 + 0.5787(22.49 – 21.6))
$ACCW_{out}$ = 89.59°F (Sec. 6.1.2)

By linear interpolation, the WCT heat duty @ 5350 gpm is:

$$ACCW_{out} = 87.73 + \frac{5350\text{-}5000}{5750\text{-}5000} * (89.59 - 87.73)$$

$ACCW_{out}$ = 88.60°F

$ACCW_{out}$ is less than 89.0°F, therefore:

$ACCW_{out}$ = 89.3°F (for CCWHx analysis) (Sec. 5.4)

WCT inlet Temperature

WCTin = 89.3°F + 22.49°F = 111.79°F

6.3.2 <u>WCT Performance at T_{wb} = 83°F and T_{db} = 98°F</u>

Determine WCT Heat Duty

Q_{wct} = Total Heat Duty-DCT Heat Dissipated @ T_{db} of 98°F.
$Q_{wct} = 173.1 \times 10^6 - 120.89 \times 10^6$ (Input. 3.1, Sec. 6.2.2)
$Q_{wct} = 52.21 \times 10^6$ BTU/Hr

Determine WCT Cooling Range

$Q_{wct} = mc_p(\Delta T)$ or $\Delta T = Q_{wct}/mc_p$

Where:
ΔT = Cooling Range (°F)
m = 5350 gpm / 0.01613 ft^3/lb_m / 7.4805 gal/ft^3 x 60 min/hr
= 2.660×10^6 lb_m/hr
c_p = 0.998 BTU/lb_m - °F

$\Delta T = 52.21 \times 10^6 / 2.660 \times 10^6 / 0.998 = 19.66$°F

Using a 19.66°F WCT Cooling range and increasing T_{wb} by 1.0°F to account for recirculation, the ACCW outlet temperature can be calculated. (Input 3.7)

At 5000 gpm

$ACCW_{out}$ = (0.725 - 0.00463(19.66 – 10.8))*84 + (27.125 + 0.648(19.66 – 10.8)) (Sec. 6.1.2)

ACCWout = 90.32°F

At 5750 gpm

$ACCW_{out}$ = (0.775 - 0.01620(19.66 – 10.8))*84 + (24.125 + 1.655(19.66 – 10.8)) (Sec. 6.1.2)

$ACCW_{out}$ = 91.83°F

By linear interpolation, the WCT heat duty @ 5350 gpm is:

$$ACCW_{out} = 90.32 + \frac{5350-5000}{5750-5000} * (91.83 - 90.32)$$

$ACCW_{out}$ = 91.03°F

6.4 CCW Heat Exchanger Performance

6.4.1 CCWHx Performance at T_{wb} = 78°F and T_{db} = 102°F

Determine CCWHx Heat Duty

Q_{CCWHx} = WCT - Chiller Heat Duty @ T_{db} of 102°F. (Sec. 6.3.1)
$Q_{CCWHx} = 59.72 \times 10^6 - 5.1 \times 10^6$ (Input 3.1)
$Q_{CCWHx} = 54.62 \times 10^6$ BTU/Hr

As determined in Section 6.3.1, the WCT will return the ACCW flow back to the WCT basins at a temperature of 88.60°F in order to meet the Tech. Spec. Maximum WCT Basin Temperature Limit, the maximum allowable CCW heat exchanger fouling will be calculated using and ACCW inlet temperature of 89.3°F. The maximum allowable fouling is determined for an ACCW inlet temperature of 89.3°F, because the maximum allowable fouling is minimized at the higher ACCW inlet temperature.

Determine $ACCW_{out}$ Temperature

$Q_{CCWHx} = mc_p(T_{out} - T_{in})$ or $T_{out} = Q_{CCWHx}/mc_p + T_{in}$

where:

m = 4500 gpm / 7.4805 gal/ft3 / 0.01613 ft3/lbm * 60 min/hr
=2.238×10^6 lb_m/hr @ 89°F

c_p = 0.998 BTU/lb_m - °F

T_{in} = 89.3°F (Sec. 6.3.1)

$T_{out} = 54.62 \times 10^6 / 2.238 \times 10^6 / 0.998 + 89.3$
T_{out} = 113.76°F

Using STER Version 5.04, the following heat exchanger performance is calculated for a CCW_{out} temperature of 115°F. The printouts are provided in Attachment 7.2

CCW_{in}	CCW_{out}	$ACCW_{in}$	$ACCW_{out}$*	Fouling* Factor
131.11	115.0	89.3	113.77	0.00159

* Calculated by STER Version 5.04

Additionally, the ACCWout temperature will be calculated using the actual WCT outlet temperature (i.e. CCW heat exchanger inlet temperature). $ACCW_{in}$ temperature calculated in Section 6.3.1.

T_{in} = 88.60°F (Sec. 6.3.1)
$T_{out} = 54.62 \times 10^6 / 2.238 \times 10^6 / 0.998 + 88.60$
T_{out} = 113.06°F

Using STER Version 5.04, the following heat exchanger performance is calculated for a CCW_{out} temperature of 115°F.

CCW_{in}	CCW_{out}	$ACCW_{in}$	$ACCW_{out}$*	Fouling* Factor
131.11	115.0	88.60	113.07	0.00172

* Calculated by STER Version 5.04

6.4.2 CCWHx Performance at T_{wb} = 83°F and T_{db} = 98°F

Determine CCWHx Heat Duty

Q_{CCWHx} = WCT - Chiller Heat Duty @ T_{db} of 98°F.
$Q_{CCWHx} = 52.21 \times 10^6 - 5.1 \times 10^6$ (Sec. 6.3.2)
$Q_{CCWHx} = 47.11 \times 10^6$ BTU/Hr (Input 3.1)

Determine $ACCW_{out}$ Temperature

$Q_{CCWHx} = mc_p(T_{out} - T_{in})$ or $T_{out} = Q_{CCWHx}/mc_p + T_{in}$

where:

m = 4500 gpm / 7.4805 gal/ft^3 / 0.01613 ft^3/lbm * 60 min/hr
= 2.238×10^6 lb$_m$/hr
c_p = 0.998 BTU/lb$_m$ - °F
T_{in} = 91.03°F (Sec. 6.3.2)

$T_{out} = 47.11 \times 10^6 / 2.238 \times 10^6 / 0.998 + 91.03$
$T_{out} = 112.12°F$

Using STER Version 5.04, the following heat exchanger performance is calculated for a CCW_{out} temperature of 115°F. The printouts are provided in Attachment 7.2

CCW_{in}	CCW_{out}	$ACCW_{in}$	$ACCW_{out}$*	Fouling* Factor
128.90	115.0	91.03	112.14	0.00197

* Calculated by STER Version 5.04

6.5 Ultimate Heat Sink Design Points

The worst case ambient condition for the UHS is a T_{db} of 102°F and a T_{wb} of 78°F. This conclusion is based on the allowable fouling for the CCW heat exchanger to maintain a CCW outlet temperature of 115°F is less under these ambient conditions. The design points for the UHS are given below.

Dry Bulb Temperature (T_{db})	- 102°F	(Input 3.2)
Wet Bulb Temperature (T_{wb})	- 78°F	(Input 3.2)
DCT CCW Inlet Temperature	- 164.56°F	(Sec. 6.2.1)
DCT CCW Outlet/CCWHx Inlet Temperature	- 131.11°F	(Sec. 6.2.1)
DCT Heat Duty	- 113.38x 10^6 BTU/Hr	(Sec. 6.2.1)
WCT ACCW Outlet/CCWHx Inlet Temperature	- 89.3°F *	(Sec. 6.3.1)
CCWHx CCW Outlet Temperature	- 115.0°F	(Input 3.3)
CCWHx ACCW Outlet Temperature	- 113.77°F*	(Sec. 6.4.1)
CCWHx Allowable Fouling Factor	- 0.00159	(Sec. 6.4.1)
CCWHx Heat Duty	- 54.62 x 10^6 BTU/Hr	(Sec. 6.4.1)
WCT ACCW Inlet Temperature	- 111.79°F*	(Sec. 6.3.1)
WCT Heat Duty	- 59.72 x 10^6 BTU/Hr	(Sec. 6.3.1)
WCT Cooling Range	-22.49°F	(Sec. 6.31)

*As discussed in section 5.4, these values are calculated using an ACCW inlet temperature to the CCWHx of 89.3°F in order to maintain the Tech. Spec. maximum ACCW temperature of 89.0°F.

6.6 Maximum T_{wb} at Various T_{db} to Maintain Overall UHS Design Heat Duty Capacity.

The most limiting historical ambient condition for the UHS was determined to be a T_{db} of 102°F and a T_{wb} of 78°F. This analysis will determine equivalent meteorological conditions for the UHS to maintain its overall design heat duty capacity using the limiting fouling factor determined in the previous sections for the CCW heat exchanger.

6.6.1 <u>DCT Performance at T_{db} = 105°F</u>

The CCW_{out} temperature at the DCT can be calculated using the conservation of energy where:

$$Q_{DCT} = mc_p(T_{in} - T_{out})$$

Heat capacity of the DCT at a CCW flow rate of 6500 gpm is calculated using the equation:

$Q_{DCT} = 4.4*T_{out} - (354 + 4.4(T_{db} - 80))$ (Sec. 6.1.1)

Solving the two equations, the heat balance becomes at a CCW flow of 6500 gpm:

$4.4*T_{out}-(354 + 4.4(T_{db} - 80)) = mc_p(T_{in}-T_{out})$

where:

T_{out}	= CCW_{out} temperature	
T_{db}	= 106.9°F (adding 1.9°F for Recirculation)	(Input 3.2, 3.7)
m	= 3.200 lb_m/hr (x 10^6) (6500 gpm)	
c_p	= 0.998 BTU/lb_m - °F	
T_{in}	= 164.56°F	(Sec. 6.2.1)

Solving for T_{out} yields

$4.4*T_{out} + mc_pT_{out} = (354 + 4.4(T_{db} - 80)) + mc_pT_{in}$

$4.4*T_{out} + (3.200)(0.998)T_{out} = 354 + 4.4(106.9-80) + (3.200)(0.998)*164.56$

$T_{out} = 131.41°F$

Calculating Heat Transferred:

$Q_{DCT} = mc_p(T_{in} - T_{out})$

$Q_{DCT} = (3.200)(0.998)(164.56 – 131.41)$

$Q_{DCT} = 105.86 \times 10^6$ BTU/Hr

Heat capacity of the DCT at a CCW flow rate of 7500 gpm is calculated using the equation:

$Q_{DCT} = 4*T_{out} - (320 + 4(T_{db} - 80))$ (Sec. 6.1.1)

Using the Conservation of Energy, the heat balance becomes at a CCW flow of 7500 gpm:

$4*T_{out}-(320 + 4(T_{db} - 80)) = mc_p(T_{in}-T_{out})$

where:

T_{out}	= CCW_{out} temperature	
T_{db}	= 106.9°F (adding 1.9°F for Recirculation)	(Input 3.2, 3.7)
m	= 3.692 lb_m/hr (x 10^6) (7500 gpm)	
c_p	= 0.998 BTU/lb_m - °F	
T_{in}	= 164.56°F	(Sec. 6.2.1)

Solving for T_{out} yields

$4*T_{out} + mc_pT_{out} = (320 + 4(T_{db} - 80)) + mc_pT_{in}$

$4*T_{out} + (3.692)(0.998)T_{out} = 320 + 4(106.9\text{-}80) + (3.692)(0.998)*164.56$

$T_{out} = 134.55°F$

Calculating Heat Transferred:

$Q_{DCT} = mc_p(T_{in} - T_{out})$
$Q_{DCT} = (3.692)(0.998)(164.56 - 134.55)$
$Q_{DCT} = 110.58 \times 10^6$ BTU/Hr

By linear interpolation, the DCT heat duty @ 6900 gpm is:

$$Q_{6900\ gpm} = Q_{6500\ gpm} + \frac{6900\text{-}6500}{7500\text{-}6500} * (Q_{7500\ gpm} - Q_{6500\ gpm})$$
$$Q_{6900\ gpm} = 105.86\text{x}10^6 + (0.4)(110.59\text{x}10^6 - 105.86\text{x}10^6)$$
$$Q_{6900\ gpm} = 107.75\text{x}10^6 \text{ BTU/Hr}$$

Calculating CCW_{out} Temperature:

$m = 3.39678 \times 10^6\ lb_m/hr$
$c_p = 0.998\ BTU/lb_m - °F$
$T_{out} = T_{in} - (Q/mc_p)$
$T_{out} = 164.56 - (107.75/3.39678/0.998)$
$T_{out} = 132.78°F$

6.6.2 Required CCWHx Performance at $T_{db} = 105°F$

Determine CCWHx Heat Duty

Q_{CCWHx} = Total - DCT - Chiller Heat Duty
$Q_{CCWHx} = 173.1 \times 10^6 - 107.75 \times 10^6 - 5.1 \times 10^6$ (Input 3.1, Sec. 6.6.1)
$Q_{CCWHx} = 60.25 \times 10^6$ BTU/Hr

Determine $ACCW_{out}$ Temperature

Using STER Version 5.04, an ACCW inlet temperature of 86.7°F is required to dissipate the above heat load. The printout is provided in Attachment 7.3

6.6.3 Maximum T_{wb} for a T_{db} of 105°F

Determine WCT Heat Duty

Q_{wct} = Total Heat Duty-DCT Heat Dissipated
$Q_{wct} = 173.1 \times 10^6 - 107.75 \times 10^6$ (Input 3.1, Sec. 6.6.2)
$Q_{wct} = 65.35 \times 10^6$ BTU/Hr

Determine WCT Cooling Range

$Q_{wct} = mc_p(\Delta T)$ or $\Delta T = Q_{wct}/mc_p$

where
ΔT = Cooling Range (°F)
m = 2.660×10^6 lb_m/hr (5350 gpm)
c_p = 0.998 BTU/lb_m - °F

$\Delta T = 65.35 \times 10^6 / 2.660 \times 10^6 / 0.998 = 24.61$°F

Using a 24.61°F WCT Cooling range and an ACCW outlet temperature of 86.7°F, the maximum T_{wb} can be calculated.

At 5000 gpm:
86.7°F = (0.675 - 0.0139(24.61 – 21.6))*T_{wb} +
(34.125 + 1.412(24.61 – 21.6)) (Sec. 6.1.2)

Solving for T_{wb} yields:
T_{wb} = 76.32°F

At 5750 gpm:
86.7°F = (0.6 - 0.00463(24.61 – 21.6))*T_{wb} +
(42 + 0.5787(24.61 – 21.6)) (Sec. 6.1.2)

Solving for T_{wb} yields:
T_{wb} = 73.30°F

By linear interpolation and subtracting 1°F to account for recirculation (and @ 5350 gpm) yields: (Input 3.7)

$$T_{wb} = 76.32 + \frac{5350-5000}{5750-5000} * (73.30-76.32) - 1.0$$

T_{wb} = 73.91°F

The methodology given in Section 6.6 was inputted into Microsoft Excel to determine equivalent meteorological conditions to maintain overall UHS design heat duty capacity. The correlation between dry bulb and the corresponding wet bulb is provided in Attachment 7.3.

6.6.4 Equivalent Meteorological conditions

The Equivalent Meteorological Conditions for UHS plot given in Attachment 7.3 *contains the three meteorological condition points:*

1. $102°F_{db}/78°F_{wb}$
2. $98°F_{db}/83°F_{wb}$
3. $91.3°F_{db}/84.9°F_{wb}$

The $91.3°F_{db}/84.9°F_{wb}$ point falls in the acceptable range of the plot and therefore, is bounded by the curve. It is also noted that the $102°F_{db}/78°F_{wb}$ point does not fall on the curve as may be expected. This is due to the methodology discussed in section 5.4. The WCT basin temperature would be maintained cooler than the temperature specified in Technical Specification 3/4.7.4, assuming the design basis meteorological condition of $102°F_{db}/78°F_{wb}$.

6.7 ACCW System Design Temperature

In accordance with ASME Code ND-3611, the piping is designed for the most severe condition of coincident pressure and temperature. The maximum ACCW temperature, which occurs for the meteorological condition of 102°F drybulb and 78°F wetbulb, is 111.79°F. Thus, the design temperature of 125°F as noted in PASSPORT is acceptable for ACCW System piping.

(Ref. C2)

7.0 ATTACHMENT

7.1 Microsoft Excel Regression Analysis (2 pages)

7.2 STER Version 5.04 Printouts (6 pages)

7.3 Equivalent Meteorological Conditions for UHS to Dissipate Design Basis Heat Load (7 pages).

7.4 Recirculation Effect on Dry Cooling Towers (9 Pages)

7.5 Dry Cooling Tower Performance Curves (3 Pages)

Dry Cooling Tower Performance Curves – Regression Analysis
Ref. Hudson Performance Curves

Flow, gpm	6500	
Entering Air Temp., °F	80	
	CCWout °F	Heat Duty x 106 BTU/hr
Point 1	85	20
Point 2	130	218
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	-354	
X Variable 1	4.4	

Flow, gpm	6500	
Entering Air Temp., °F	90	
	CCWout °F	Heat Duty x 106 BTU/hr
Point 1	95	20
Point 2	130	174
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	-398	
X Variable 1	4.4	

Flow, gpm	6500	
Entering Air Temp., °F	102	
	CCWout °F	Heat Duty x 106 BTU/hr
Point 1	105	20
Point 2	130	130
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	-442	
X Variable 1	4.4	

Flow, gpm	7500	
Entering Air Temp., °F	80	
	CCWout °F	Heat Duty x 106 BTU/hr
Point 1	85	20
Point 2	130	200
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	-320	
X Variable 1	4.0	

Flow, gpm	7500	
Entering Air Temp., °F	90	
	CCWout °F	Heat Duty x 106 BTU/hr
Point 1	100	32
Point 2	120	110
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	-360	
X Variable 1	4.0	

Flow, gpm	7500	
Entering Air Temp., °F	102	
	CCWout °F	Heat Duty x 106 BTU/hr
Point 1	105	12
Point 2	130	112
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	-408	
X Variable 1	4.0	

Wet Cooling Tower Performance Curves – Regression Analysis
Ref. Zurn ASME Performance Curves

Flow, gpm	5000	
Range, °F	10.8	
	Twb, °F	ACCWout, °F
Point 1	75	81.5
Point 2	85	88.75
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	27.125	
X Variable 1	0.725	

Flow, gpm	5000	
Range, °F	21.6	
	Twb, °F	ACCWout, °F
Point 1	75	84.75
Point 2	85	91.5
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	34.125	
X Variable 1	40.675	

Flow, gpm	5000	
Range, °F	27	
	Twb, °F	ACCWout, °F
Point 1	75	86.75
Point 2	85	92.75
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	41.75	
X Variable 1	0.6	

Flow, gpm	5750	
Range, °F	10.8	
	Twb, °F	ACCWout, °F
Point 1	75	82.25
Point 2	85	90
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	24.125	
X Variable 1	0.775	

Flow, gpm	5750	
Range, °F	21.6	
	Twb, °F	ACCWout, °F
Point 1	75	87
Point 2	85	93
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	42	
X Variable 1	0.6	

Flow, gpm	5750	
Range, °F	27	
	Twb, °F	ACCWout, °F
Point 1	75	88.25
Point 2	85	94
SUMMARY OUTPUT		
Regression Statistics		
Multiple R	1	
R Square	1	
Adjusted R Square	65535	
Standard Error	0	
Observations	2	
	Coefficients	
Intercept	45.125	
X Variable 1	0.575	

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Monday, November 07, 2005 at 1:03:03 PM

***** EQUIPMENT CONFIGURATION *****

PARAMETER	VALUE	QA REF
Number of Shells in Series/Parallel:	1/ 1	3/3
Shell Type:	TEMA E	1
Bundle Type:	FIXED	1
Shell Inside Diameter [inches]:	45.000	1
Number of Tube Passes:	1	1
Baffle Type:	NTIW	1
Baffle Cut [% of shell ID]:	21.11	5
Central Baffle Spacing [inches]:	92.000	2
Number of Tubes [holes in tubesheet]:	1276	1
Number of Tubes Plugged:	63	
Inlet Baffle Spacing [inches]:	114.000	
Outlet Baffle Spacing [inches]:	114.000	
Number of Pairs of Sealing Strips	0	
Tube Outside Diameter [inches]:	0.7500	1
Tube Wall Thickness [inches]:	0.0280	1
Tube Material:	304 Stainless	1
Thermal Conductivity [Btu/hr/ft/F]:	8.70	*
Tube Layout Angle [degrees]:	30	1
Tube Layout Pitch [inches]:	0.9375	1
Effective Tube Length [feet]:	42.000	2
Flow Orientation:	Counter-Current	
Tube Nozzle Inlet Diameter [inches]:	20.000	1
Tube Nozzle Outlet Diameter [inches]:	20.000	1
Shell Nozzle Inlet Diameter [inches]:	16.000	1
Shell Nozzle Outlet Diameter [inches]:	16.000	1
Integral Low Fin Tubes:	NO	

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Monday, November 07, 2005 at 1:03:03 PM

PARAMETER	VALUE	QA REF
Shell to Bundle Clearance [inches]:	1.0000	4
Shell to Baffle Clearance [inches]:	0.3750	5
Tube to Baffle Clearance [inches]:	0.0156	2
Shell Inlet Annular Distributor:	NO	
Shell Outlet Annular Distributor:	NO	
Number of Baffles per Unit:	4	2
Impingement Plate Dist. [% nozzle dia]:	64.84	2
Omit Tubes at Inlet [% shell dia]:	23.05	
Omit Tubes at Outlet [% shell dia]:	0.00	*

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Monday, November 07, 2005 at 1:03:03 PM

***** QA REFERENCES *****

QA REF	REFERENCE SOURCE DESCRIPTION
1	Struthers Wells Data Sheet Located in 457000087
2	5817-10750 Rev. 0
3	5817-10751 Rev. 0
4	5817-10747 Rev. 0
5	Fax from Merl Rice of Struthers dated 3/2/94

* An Asterisk denotes values determined by the program.

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Monday, November 07, 2005 at 1:03:03 PM

***** PERFORMANCE TEST MODE RESULTS *****

TEST ID: 102/78
DATE: 11-07-05
PROCEDURE: EC-M95-008
CONVERGENCE TOLERANCE: 0.05 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6882.58	4490.71
Inlet Temperature [degrees F]:	131.11	89.30
Outlet Temperature [degrees F]:	115.00	113.77
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	0.00	0.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1302.72	838.20
Pressure Drop [psi]:	3.07	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47325	14021

Total Heat Duty:	54,635,891 Btu/hr
Log Mean Temperature Difference:	21.25 F
Overall Heat Transfer Coefficient:	257.09 Btu/hr/sqft/F
Corrected LMTD:	21.25 F
Effective Surface Area per Shell:	10002.93 sq ft

Reference Temperature [F]:	123.055	101.535
Density [lbm/cu.ft]:	61.666	61.979
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.364
Absolute Viscosity [cP]:	0.539	0.669

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Monday, November 07, 2005 at 1:04:21 PM

***** PERFORMANCE TEST MODE RESULTS *****

TEST ID: 102/78
DATE: 11-07-05
PROCEDURE: EC-M95-008
CONVERGENCE TOLERANCE: 0.05 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6882.58	4490.15
Inlet Temperature [degrees F]:	131.11	88.60
Outlet Temperature [degrees F]:	115.00	113.07
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00172
Operating Pressure [psig]:	0.00	0.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1302.13	836.51
Pressure Drop [psi]:	3.07	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47325	13916

Total Heat Duty:	54,635,441 Btu/hr
Log Mean Temperature Difference:	21.96 F
Overall Heat Transfer Coefficient:	248.79 Btu/hr/sqft/F
Corrected LMTD:	21.96 F
Effective Surface Area per Shell:	10002.93 sq ft

Reference Temperature [F]:	123.055	100.835
Density [lbm/cu.ft]:	61.666	61.988
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.364
Absolute Viscosity [cP]:	0.539	0.674

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Monday, November 07, 2005 at 1:05:17 PM

***** PERFORMANCE TEST MODE RESULTS *****

TEST ID: 98/83
DATE: 11-07-05
PROCEDURE: EC-M95-008
CONVERGENCE TOLERANCE: 0.05 %

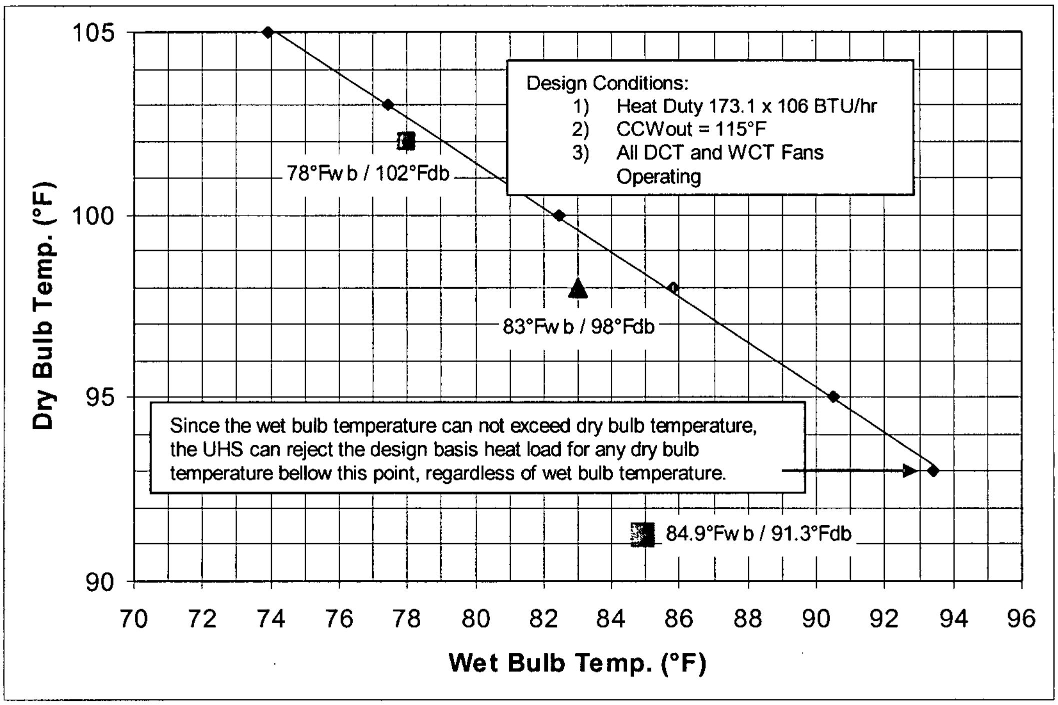
PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6878.42	4492.12
Inlet Temperature [degrees F]:	128.90	91.03
Outlet Temperature [degrees F]:	115.00	112.14
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00197
Operating Pressure [psig]:	0.00	0.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1296.93	837.64
Pressure Drop [psi]:	3.07	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	46834	14029

Total Heat Duty:	47,139,080 Btu/hr
Log Mean Temperature Difference:	20.15 F
Overall Heat Transfer Coefficient:	233.90 Btu/hr/sqft/F
Corrected LMTD:	20.15 F
Effective Surface Area per Shell:	10002.93 sq ft

Reference Temperature [F]:	121.950	101.586
Density [lbm/cu.ft]:	61.684	61.978
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.364
Absolute Viscosity [cP]:	0.544	0.668

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

Equivalent Meteorological Conditions for the Ultimate Heat Sink to Dissipate the Design Basis Heat Load



Note: The 102°F_{db} / 78°F_{wb} point does not fall on the curve as may be expected. This is due to the methodology discussed in section 5.4 and implemented in 6.4.1. The WCT basin temperature would be maintained cooler than the temperature specified in Technical Specification 3/4.7.4, assuming the design basis meteorological condition of 102°F_{db} / 78°F_{wb}.

Dry Bulb Temp. (°F)	DCT Heat Rejected (x 10^6 BTU/Hr)	DCT CCW_{out} (°F)	CCWHx Heat Rejected (x 10^6 BTU/Hr)	CCWH x $ACCW_{in}$ (°F)*	WCT heat Rejected (x 10^6 BTU/Hr)	WCT Range (°F)	Wet Bulb Temp. (°F)
105	107.75	132.78	60.25	86.70	65.35	24.61	73.91
103	111.50	131.67	56.50	88.47	61.60	23.20	77.42
100	117.14	130.01	50.86	91.12	55.96	21.08	82.48
98	120.89	128.90	47.11	92.89	52.21	19.66	85.78
95	126.52	127.24	41.48	95.54	46.58	17.54	90.47
93	130.28	126.13	37.72	97.31	42.82	16.13	93.44

*Calculated using STER Version 5.04. Printouts included in Attachment

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:06:40 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met105
DATE: 11-08-05
PROCEDURE: EC-M95-008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6885.48	4488.56
Inlet Temperature [degrees F]:	132.78	86.70
Outlet Temperature [degrees F]:	115.00	113.71
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1314.88	841.14
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47688	13821

Total Heat Duty: 60,286,041 Btu/hr
Log Mean Temperature Difference: 23.38 F
Overall Heat Transfer Coefficient: 257.77 Btu/hr/sqft/F
Corrected LMTD: 23.38 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	123.888	100.204
Density [lbm/cu.ft]:	61.673	62.007
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.373	0.364
Absolute Viscosity [cP]:	0.535	0.678

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:07:40 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met103
DATE: 11-08-05
PROCEDURE: EC-M95-008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6883.35	4489.94
Inlet Temperature [degrees F]:	131.67	88.47
Outlet Temperature [degrees F]:	115.00	113.79
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1312.22	842.71
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47441	13960

Total Heat Duty:	56,530,060 Btu/hr
Log Mean Temperature Difference:	21.92 F
Overall Heat Transfer Coefficient:	257.81 Btu/hr/sqft/F
Corrected LMTD:	21.92 F
Effective Surface Area per Shell:	10002.93 sq ft

Reference Temperature [F]:	123.333	101.128
Density [lbm/cu.ft]:	61.682	61.995
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.373	0.364
Absolute Viscosity [cP]:	0.537	0.672

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:20:40 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met100
DATE: 11-08-05
PROCEDURE: EC-M95-008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6880.21	4492.08
Inlet Temperature [degrees F]:	130.01	91.12
Outlet Temperature [degrees F]:	115.00	113.92
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1308.25	845.07
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47073	14170

Total Heat Duty: 50,888,081 Btu/hr
Log Mean Temperature Difference: 19.73 F
Overall Heat Transfer Coefficient: 257.87 Btu/hr/sqft/F
Corrected LMTD: 19.73 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	122.505	102.520
Density [lbm/cu.ft]:	61.695	61.977
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.365
Absolute Viscosity [cP]:	0.542	0.662

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:23:27 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met98
DATE: 11-08-05
PROCEDURE: EC-M95-008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6878.13	4493.56
Inlet Temperature [degrees F]:	128.90	92.89
Outlet Temperature [degrees F]:	115.00	114.00
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1305.59	846.62
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	46827	14310

Total Heat Duty:	47,124,352 Btu/hr
Log Mean Temperature Difference:	18.27 F
Overall Heat Transfer Coefficient:	257.90 Btu/hr/sqft/F
Corrected LMTD:	18.27 F
Effective Surface Area per Shell:	10002.93 sq ft

Reference Temperature [F]:	121.949	103.445
Density [lbm/cu.ft]:	61.704	61.965
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.365
Absolute Viscosity [cP]:	0.545	0.655

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:26:44 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met95
DATE: 11-08-05
PROCEDURE: EC-M95-008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6875.05	4495.84
Inlet Temperature [degrees F]:	127.24	95.54
Outlet Temperature [degrees F]:	115.00	114.12
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1301.61	848.94
Pressure Drop [psi]:	3.06	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	46461	14520

Total Heat Duty: 41,493,912 Btu/hr
Log Mean Temperature Difference: 16.08 F
Overall Heat Transfer Coefficient: 257.95 Btu/hr/sqft/F
Corrected LMTD: 16.08 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	121.120	104.830
Density [lbm/cu.ft]:	61.717	61.946
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.365
Absolute Viscosity [cP]:	0.549	0.646

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:28:06 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met93
DATE: 11-08-05
PROCEDURE: EC-M95-008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6873.01	4497.41
Inlet Temperature [degrees F]:	126.13	97.31
Outlet Temperature [degrees F]:	115.00	114.21
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1298.94	850.49
Pressure Drop [psi]:	3.06	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	46216	14662

Total Heat Duty:	37,726,460 Btu/hr
Log Mean Temperature Difference:	14.62 F
Overall Heat Transfer Coefficient:	257.98 Btu/hr/sqft/F
Corrected LMTD:	14.62 F
Effective Surface Area per Shell:	10002.93 sq ft

Reference Temperature [F]:	120.565	105.755
Density [lbm/cu.ft]:	61.726	61.934
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.366
Absolute Viscosity [cP]:	0.552	0.640

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

Recirculation Effect on Dry & wet Cooling Towers

During development of the ultimate heat sink design basis, 1.9°F was added to the drybulb temperature and 1.0°F was added to the wetbulb temperature to account for interaction (recirculation) between the dry cooling tower / wet cooling tower and their surroundings. This attachment serves to show that these values are reasonable and conservative.

Recirculation Effect on Dry Cooling Tower

PEIR OM-111 (pages 3 through 7 of this attachment) provides drybulb and wetbulb temperatures recorded at the dry and wet cooling towers against the outdoor ambient temperatures recorded at the Met Tower. The PEIR records drybulb and wetbulb temperatures at 6 different locations near the dry and wet cooling towers for 5 consecutive days in June 1996. Readings were taken once per day for various fans operating and not operating. Since this discussion involves recirculation with fans operating, only the data with fans operating is relevant. Thirty drybulb and wetbulb temperatures were recorded.

The drybulb temperature results show that 26 drybulb temperature readings or 86.7% of the total (=26/30x100) were either equal to or less than the temperatures recorded at the Met Tower. Since the temperatures recorded at the dry and wet cooling towers are less than or equal to the ambient temperature, no effects of recirculation (warm air discharging from the cooling towers that makes its way into the suction of the cooling towers) are present. Three readings or 10% of the 30 total readings were 1°F over the temperature recorded at the Met Tower. Note that these are still less than the drybulb temperature value of 1.9°F. The highest reading over the ambient temperature, 2°F, was only recorded once or 3.3% of the 30 total readings. This is within 1/10 of 1°F of the drybulb temperature value. Since this temperature is within 1/10 of 1°F and was only recorded once, the drybulb temperature value of 1.9°F is considered an acceptable value.

Recirculation Effect on Wet Cooling Tower

The wetbulb temperature results show that 22 wetbulb temperature readings or 73.3% (=22/30x100) were either equal to or less than the temperatures recorded at the Met Tower. Thus showing no effects of recirculation. Six readings or 20% were 1°F over the temperature recorded at the Met tower. Since the wetbulb temperature recirculation value is 1°F, 93.3% (=73.3%+20%) of the readings are equal to or less than the wetbulb temperature parameter of 1°F. The highest reading, 2°F over the ambient temperature recorded at the Met Tower, was recorded twice or 6.7% of the total readings. The highest recorded value is within 1°F of the wet bulb value. Since the highest recorded reading is within 1°F of the wetbulb value and was recorded only twice, the wetbulb value of 1.0°F is considered reasonable.

A paper of the Cooling Tower Institute entitled "Recommended Recirculation Allowances" (pages 8 and 9 of this attachment) describes how to determine design wetbulb temperatures. The method is carried out below for the following data from this calculation, EC-M95-008 Rev. 1:

ACCW accident flow rate	5350	gpm
ACCW temperature leaving wet cooling tower	89.3	°F
Design wetbulb temperature	78	°F
Calculated approach temperature (89.3-78)	11.3	°F
Wet cooling tower inlet temperature	111.0 9	°F
Wet cooling tower range	22.49	°F

First, determine the design uncorrected recirculation value using the curve for average maximum recirculation. At 5350 gpm, uncorrected recirculation value is 0.5°F. Second, correct for the actual approach and range. Conservatively take the range to be 30°F and the approach to be 12°F, then the correction factor is 1.49. Third, multiply the uncorrected recirculation value by the correction factor to obtain the actual recirculation value which is 0.75°F (=0.5°F x 1.49). This calculated value is within the wetbulb temperature of 1°F. As a result, the use of the 1°F wetbulb temperature is considered acceptable value.

Conclusion

The present values of 1.9°F for the drybulb temperature and 1.0°F for the wetbulb temperature are reasonable and acceptable.

PAGE 1 of 1 (REQUEST, 4 (RESPONSE

TOTAL NUMBER OF ATTACHMENT 4

PROBLEM EVALUATION / INFORMATION REQUEST

No. OM-111 PRIORITY CODE: T RESPONSE REQUIRED BY: 8/15/96

TO: ~~System Engineering~~ DES. ENG. / BOB THWEATT (GROUP / DEPARTMENT) RB 7/8/96 FROM: Operations (GROUP/DEPARTMENT)

SUPPORT RESPONSE

TO: ______ (GROUP/DEPARTMENT)

FROM: ______ (PRINT NAME) ______ (GROUP/DEPT)

DUE DATE: ______

Rick Williams (ORIGINATOR (PRINT NAME)) 3290 (PHONE)

OPS SYSTEM: ACC

REFERENCES:

PROBLEM/ REQUEST : Operations requests to know if the dry and wet bulb temperatures as read from the met towers is sufficient to use in determining ultimate heat sink fan requirements. If not, where should the temperatures be taken and what type of instrument should be used.

AUTHORIZED BY: Douglas [signature] DATE: 6-13-96

RESPONSE ASSIGNED TO: J.S. REESE DATE: 7-9-96

RESPONSE:

SEE ATTACHMENT

PREPARED BY / DATE: J Reese 8-21-96

REVIEWED BY / DATE : R. B. [signature] 8/22/96 APPROVED BY / DATE: Paul Stark for R.T. THWEATT 8/23/96

RESPONSE ACCEPTABLE: [signature] DATE: 9-23-96

DISTRIBUTION:	REQ.	RESP. X (ORIG)	DISTRIBUTION:	REQ.	RESP.
RECORDS CENTER			TRAINING MANAGER		
DBD PROGRAM MGR. (ALL TECH PEIRS)			NUC. SAFETY & REG. AFFAIRS MANAGER		
NOEC MGR.			NUC. PURCH. & CONTRACTS MANAGER		
NUC. PLANT OPERATIONS MANAGER			MANAGEMENT SYSTEMS MANAGER		
NOSA MGR.			Rick Williams	X	X
NUC. SERVICES MANAGER			Donna Petit	X	X
NUC. QA MANAGER					
CONTROLLER (☐ NOEC. ☒ P. STAFF)	X	X	& PARAGRAPH 5.2.3.1		

PEIR NO.: OM-111 1

PAGE 1 OF 3

PEIR CONTINUATION SHEET

[ ] PROBLEM/REQUEST CONT'D. [X] RESPONSE CONT'D

I. STATEMENT OF PROBLEM/INFORMATION REQUEST

Are dry and wet bulb temperatures as read from the met tower sufficient to use in determining UHS fan requirements? If not, where should the temperatures be taken and what type of instrument should be used?

II. RESULTS AND CONCLUSIONS

Measuring temperatures in the Dry Cooling Tower (DCT) and Wet Cooling Tower (WCT) areas will not provide reliable readings to use for Technical Specification compliance. The Met tower will provide the average temperature of ambient air that would be seen entering the UHS during design accident conditions. Also, temperatures recorded at the Met tower are not affected by the configuration the UHS fans may be operating in during normal operations. Therefore, ambient temperatures recorded at the Met tower should be used for Technical Specification compliance.

III. REFERENCES

CR# 96-0975
Calculation EC-M95-008; Ultimate Heat Sink Design Basis
Calculation EC-M95-009; UHS Fan Requirements Under Various Ambient Conditions
Calculation MN(Q)-9-52; UHS Performance
FSAR Section 9.2.5; Ultimate Heat Sink
FSAR Table 2.3-2(a); UHS Meteorological Design Parameters
Technical Specification 3/4.7.4 Ultimate Heat Sink
W3-DBD-004: Component Cooling Water Auxiliary Component Cooling Water

IV. ASSUMPTIONS

None

PEIR CONTINUATION SHEET

[ ] PROBLEM/REQUEST CONT'D. [X] RESPONSE CONT'D

V. DISCUSSIONS/DETAILS

Background

The design basis of the UHS uses the most limiting coincident ambient conditions of 102 $°F_{db}$ / 78 $°F_{wb}$ and 98 $°F_{db}$ / 83 $°F_{wb}$. These temperatures were obtained from readings taken over a 30 year time period at the New Orleans airport. During development of the UHS design basis, 1.0 °F was added to the wet bulb and 1.9 °F was added to the dry bulb, to account for interaction (recirculation) between the WCT / DCT and their surroundings. These temperatures were used to establish UHS capacity, and are assumed to bound various combinations of ambient conditions that may exist over the plants operational life. Technical Specification table 3.7-3 was developed to maintain the design basis UHS capacity with various combinations of WCT and DCT fans out of service. On June 26, 1996 CR# 96-0975 was written when temperature readings taken in the DCT area indicated 95 °F dry bulb, and temperatures taken in the WCT area indicated 84 °F wet bulb.

Evaluation

The UHS is designed for DBA heat loads, and assumes all fans, required by Technical Specification table 3.7-3 to be operable, are running in fast speed. During normal operations plant heat load is much lower than DBA loads, and the number of UHS fans running depends on current ambient conditions. This can create various configurations of UHS fans actually running. Each one of these configurations alters the environment surrounding the UHS in a different way, and causes local temperature readings to vary depending on the location they are taken and what fans are operating. This effect is illustrated in attachment 1. Temperatures recorded on attachment 1 were taken on five different days, at various locations, and with DCT/WCT fans operating in different configurations.

Measuring temperatures in the DCT and WCT areas will not provide reliable readings to use for Technical Specification compliance. The Met tower will provide the average temperature of ambient air that would be seen entering the UHS during design accident conditions. Also, temperatures recorded at the Met tower are not affected by the configuration the UHS fans may be operating in during normal operations. Any slight variation between temperatures recorded at the Met tower and at the inlet to the UHS, are either captured by the recirculation effect considered in the UHS design basis or within existing UHS margins.

PEIR CONTINUATION SHEET

☐ PROBLEM/REQUEST CONT'D. ☒ RESPONSE CONT'D

VI. FAILURE MODE AND EFFECTS ANALYSIS

Not Required

VII. NUCLEAR SAFETY SIGNIFICANCE

None

VIII. RECOMMENDATIONS/FURTHER ACTIONS

Design Engineering recommends that Operations use the Met tower to record ambient temperatures for Technical Specification Compliance. The Met tower will currently provide a one hour average dry bulb temperature shown on PMC point C48558. By September 30, 1996 the Met tower will be able to provide a 1 hour average wet bulb shown on PMC point C48560.

IX. ATTACHMENTS

1.0 UHS Ambient Temperatures

UHS AMBIENT TEMPERATURES

	Tdb/Twb	Tdb/Twb	Tdb/Twb	Tdb/Twb	Tdb/Twb	Tdb/Twb	Tdb/Twb	
6/26/96	DCT East Up	DCT East Down	DCT West Up	DCT West Down	East WCT	West WCT	Met Tower	Met Data (db)
	Fan motor 7	Fan motor 9	Fan motor 7	Fan motor 9	Outside Door 51	1st Landing off Qdeck		PID C48511
DCT Fans OFF	89/78	N/A	95/79	N/A	88/77	90/78	92/80	90
DCT Fans FAST for 10 mins	88/77	N/A	92/78	N/A	86/76	90/78		
	DCT East Up	DCT East Down	DCT West Up	DCT West Down	East WCT	West WCT		Met Data (db)
6/27/96	Fan motor 7	Fan motor 9	Fan motor 7	Fan motor 9	Outside Door 51	1st Landing off Qdeck	Met Tower	PID C48511
DCT Fans OFF	89/79	89/79	89/79	88/79	86/79	87/78		
DCT Fans FAST for 10 mins	90/78	89/79	87/79	87/79	88/80	86/79	86/79	
	DCT East Up	DCT East Down	DCT West Up	DCT West Down	East WCT	West WCT		Met Data (db)
6/28/96	Fan motor 7	Fan motor 9	Fan motor 7	Fan motor 9	Outside Door 51	1st Landing off Qdeck	Met Tower	PID C48511
DCT Fans OFF	83/75	83/75	84/76	84/76	80/76	83/77	83/75	
DCT Fans FAST for 10 mins	83/75	83/75	84/76	84/76	80/77	83/77		
	DCT East Up	DCT East Down	DCT West Up	DCT West Down	East WCT	West WCT		Met Data (db)
6/28/96	Fan motor 7	Fan motor 9	Fan motor 7	Fan motor 9	Outside Door 51	1st Landing off Qdeck	Met Tower	PID C48511
DCT Fans OFF	89/76	89/76	89/76	89/76	88/74	88/74	89/73	
DCT Fans FAST for 10 mins	89/73	89/73	89/74	89/74	88/74	88/73		
	DCT East Up	DCT East Down	DCT West Up	DCT West Down	East WCT	West WCT		Met Data (db)
6/30/96	Fan motor 7	Fan motor 9	Fan motor 7	Fan motor 9	Outside Door 51	1st Landing off Qdeck	Met Tower	PID C48511
DCT Fans OFF	89/73	89/73	89/73	89/73	85/73	85/73	86/75	
DCT Fans FAST for 10 mins	83/73	83/72	85/72	85/72	84/73	84/73		

COOLING TOWER INSTITUTE

RECOMMENDED RECIRCULATION ALLOWANCES

Supplementing the text of the CTI Technical Sub-Committee #2 report on the study of "Recirculation" (CTI Bulletin PFM-110).

Recirculation in water-cooling towers has been defined as "an adulteration of the atmosphere entering the tower by a portion of the atmosphere leaving the tower." This adulteration by the exhaust air raises the wet bulb temperature of the entering air above that of the ambient air, reducing the tower over-all performance.

In 1958 the Cooling Tower Institute published its Bulletin PFM-110 entitled "Recirculation" which presented the results of a seven year study of the recirculation characteristics of counterflow and crossflow mechanical draft water-cooling towers.

The results of the work indicated that circulation was predominantly a function of tower length. Attempts to include other variables such as frame height, stack height, tower width, exit velocity or inlet velocity did not reveal any trend in influencing the recirculation or improve the correlation. The equation published, in which maximum recirculation is given as a function of tower length only, represents the experimental data adequately for both counterflow and crossflow induced draft towers.*

Maximum recirculation, like maximum wet bulb temperature, occurs only a portion of the time and to design a tower for such maximum conditions is not generally economically justified. Further, proper orientation of the tower with prevailing winds can usually be counted upon to reduce the incidence of maximum recirculation since prevailing winds and high wet bulb temperatures frequently occur simultaneously. A review of the data published indicates the *average* recirculation to be approximately 60 per cent of the *maximum* for the towers included in the study. This allowance is adequate for most operating conditions and is recommended by the Cooling Tower Institute in selecting or designing counterflow or crossflow induced draft cooling towers.

With the publication of reliable recirculation data it is now possible for the purchaser to specify a design inlet wet bulb temperature simply by adding to the appropriate ambient wet bulb temperature the recommended recirculation allowance in degrees F for the specified conditions of performance.

The specification of a design inlet wet bulb temperature corrected for recirculation, in lieu of an ambient wet bulb temperature, provides an adequate recirculation allowance and further makes possible performance testing without shutting down adjacent cooling towers or cells because of their effect on the inlet wet bulb temperature of the tower or cell being tested.

The curves plotted on the reverse of this sheet show wet bulb temperature correction for maximum recirculation and recommended recirculation allowances, based on 60 per cent of maximum, for water flows up to 100,000 gpm. A table of correction factors for various ranges and approaches is also presented.

HOW TO SELECT DESIGN INLET WET BULB TEMPERATURE

The design inlet wet bulb temperature is obtained by adding a recirculation allowance expressed in deg. F, to the ambient wet bulb temperature selected for the area in which the cooling tower will be located.

Example 1. Select a design inlet wet bulb temperature for a tower required to cool 40,000 gpm from 112 F to 82 F when the area ambient wet bulb temperature is 75 F. From the curve, the recommended recirculation allowance at 40,000 gpm is 1.2 F. From the Correction Factor Table, the correction factor for a range of 30 F and an approach of 7 F is 1.25. The recommended recirculation allowance will be 1.2 F × 1.25 = 1.5 F. The design inlet wet bulb temperature is 75 F + 1.5 F = 76.5 F. The tower should be specified and designed to cool 40,000 gpm from 112 F to 82 F at a design inlet wet bulb temperature of 76.5 F.

Example 2. Assume above tower has been installed and a 10,000 gpm extension is desired. The recirculation allowance for the extension should be based on the combined water flow of 50,000 gpm at the specified range and approach. In this case the recirculation allowance will be 1.37 F × 1.25 = 1.7 F. The extension should then be specified and designed to cool 10,000 gpm from 112 F to 82 F at a design inlet wet bulb temperature of 76.7 F.

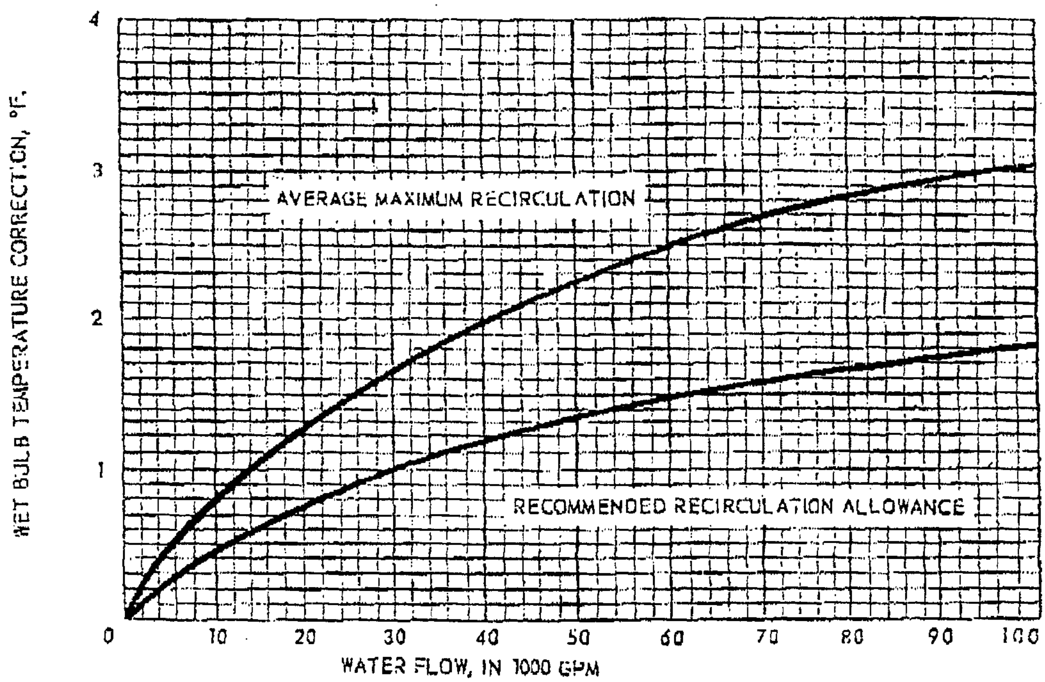
If the design cooling range and approach for the tower extension differ from the original installation, then the cooling range and approach which produce the higher recirculation allowance should be used.

Selection of an inlet wet bulb temperature for a tower or tower extension in the vicinity of other cooling towers should be made in the same manner as given in Examples 1 and 2 above. However, the ambient wet bulb temperature upon which the inlet wet bulb temperature is to be based should be selected to provide for the effect of neighboring cooling towers on the site chosen.

For those interested in the subject, a complete discussion of the data is presented in CTI Bulletin PFM-110. An Appendix containing all summary sheets and pertinent data is also available.

RECOMMENDED RECIRCULATION ALLOWANCES

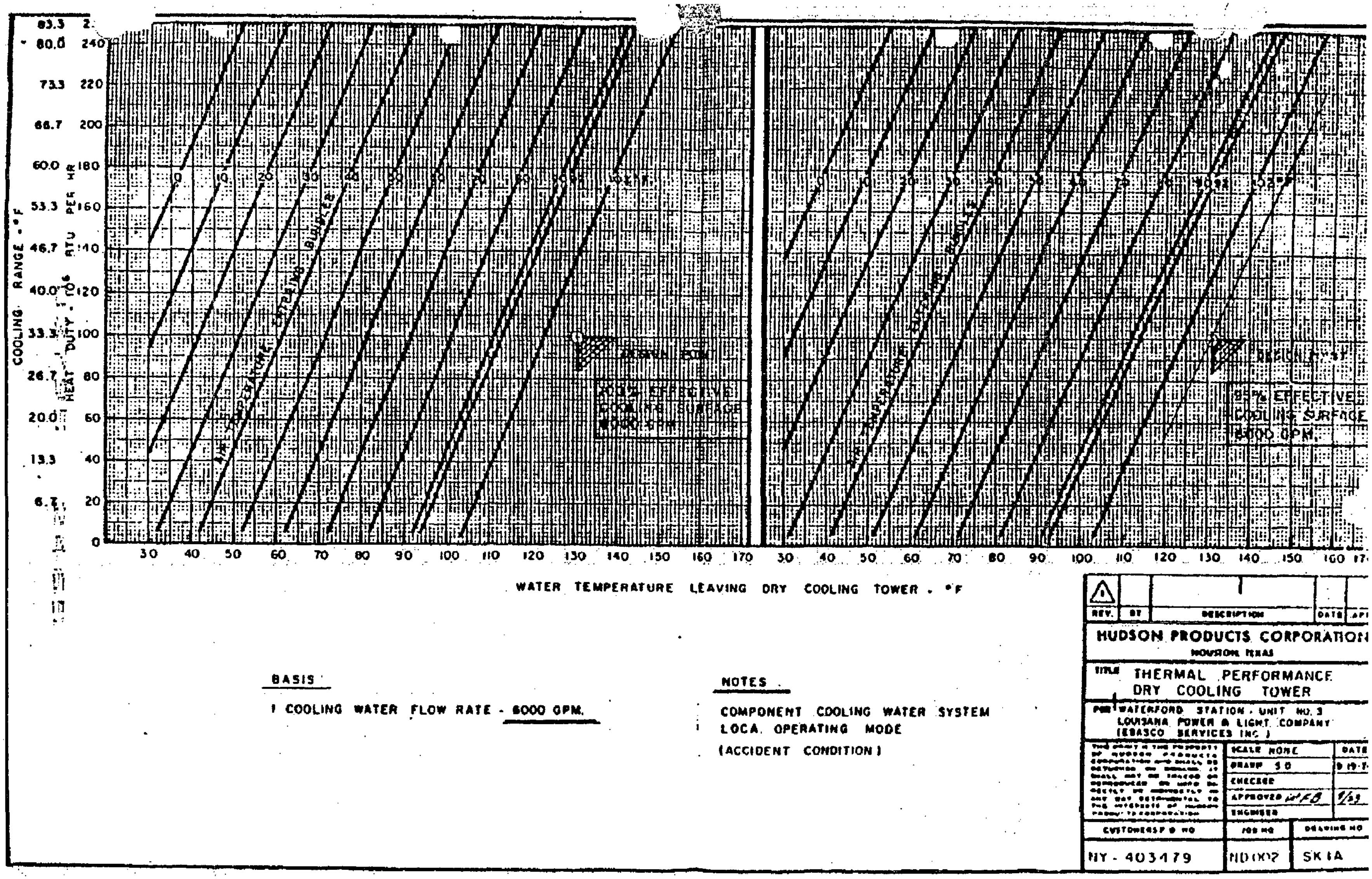
FOR COUNTERFLOW AND CROSSFLOW INDUCED DRAFT COOLING TOWERS



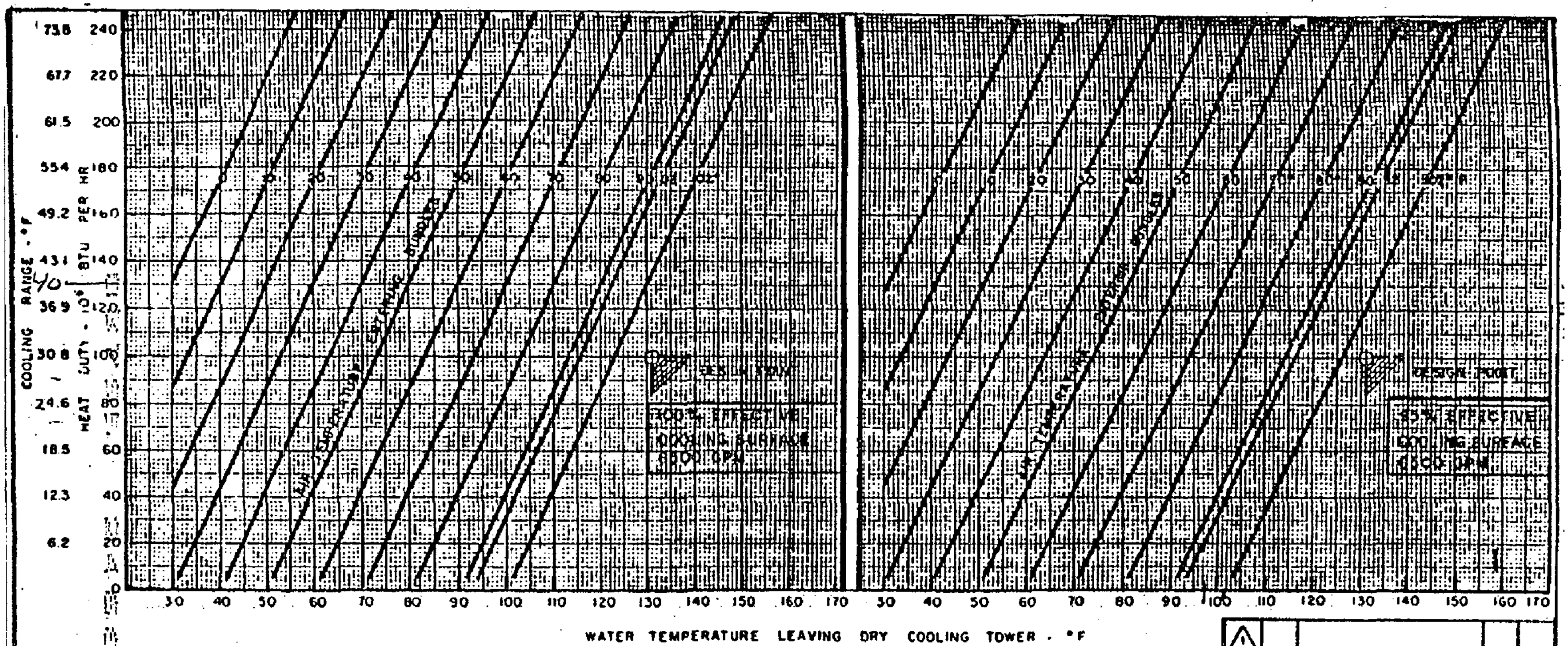
NOTE: Recirculation allowances shown in Curve above are based on a 20 F cooling range and a 10 F approach to any wet bulb temperature. Recirculation allowances for other performance conditions can be obtained by means of the Correction Factors shown at right. For further instructions see reverse of this sheet.

CORRECTION FACTORS

Approach to Ambient WBT, °F	Range, °F									
	5	10	15	20	25	30	35	40	45	50
5	0.29	0.47	0.64	0.80	0.97	1.14	1.30	1.47	1.63	1.80
6	0.31	0.49	0.68	0.85	1.03	1.20	1.37	1.56	1.73	1.91
7	0.33	0.51	0.71	0.89	1.08	1.25	1.44	1.63	1.83	2.01
8	0.35	0.53	0.74	0.93	1.12	1.30	1.50	1.70	1.91	2.10
9	0.37	0.55	0.76	0.97	1.16	1.35	1.56	1.77	1.97	2.18
10	0.39	0.57	0.78	1.00	1.20	1.40	1.62	1.83	2.04	2.25
11	0.41	0.59	0.81	1.04	1.24	1.45	1.66	1.88	2.09	2.31
12	0.43	0.61	0.84	1.07	1.27	1.49	1.70	1.92	2.13	2.36
13	0.45	0.63	0.86	1.10	1.30	1.52	1.74	1.96	2.17	2.40
14	0.46	0.65	0.88	1.13	1.33	1.55	1.77	1.99	2.21	2.44
15	0.47	0.67	0.90	1.15	1.36	1.57	1.80	2.02	2.25	2.47
16	0.49	0.69	0.93	1.18	1.39	1.61	1.83	2.06	2.29	2.52
17	0.51	0.70	0.95	1.20	1.42	1.64	1.86	2.10	2.33	2.57
18	0.52	0.72	0.97	1.22	1.44	1.66	1.89	2.13	2.37	2.61
19	0.53	0.74	0.99	1.24	1.46	1.68	1.92	2.16	2.40	2.64
20	0.54	0.75	1.00	1.26	1.48	1.70	1.95	2.19	2.43	2.67
21	0.55	0.77	1.02	1.28	1.50	1.71	1.98	2.22	2.46	2.70
22	0.56	0.79	1.04	1.30	1.52	1.76	2.00	2.25	2.49	2.73
23	0.57	0.80	1.05	1.31	1.54	1.78	2.02	2.27	2.52	2.76
24	0.58	0.81	1.06	1.32	1.56	1.80	2.04	2.29	2.54	2.79
25	0.58	0.82	1.07	1.33	1.57	1.82	2.06	2.31	2.56	2.81



PERFORMANCE CURVES FOR DRY TOWER



BASIS.

1 COOLING WATER FLOW RATE - 6500 GPM.

NOTES.

COMPONENT COOLING WATER SYSTEM
LOCA OPERATING MODE
(ACCIDENT CONDITION)

REV.	BY	DESCRIPTION	DATE	APP

HUDSON PRODUCTS CORPORATION
HOUSTON, TEXAS

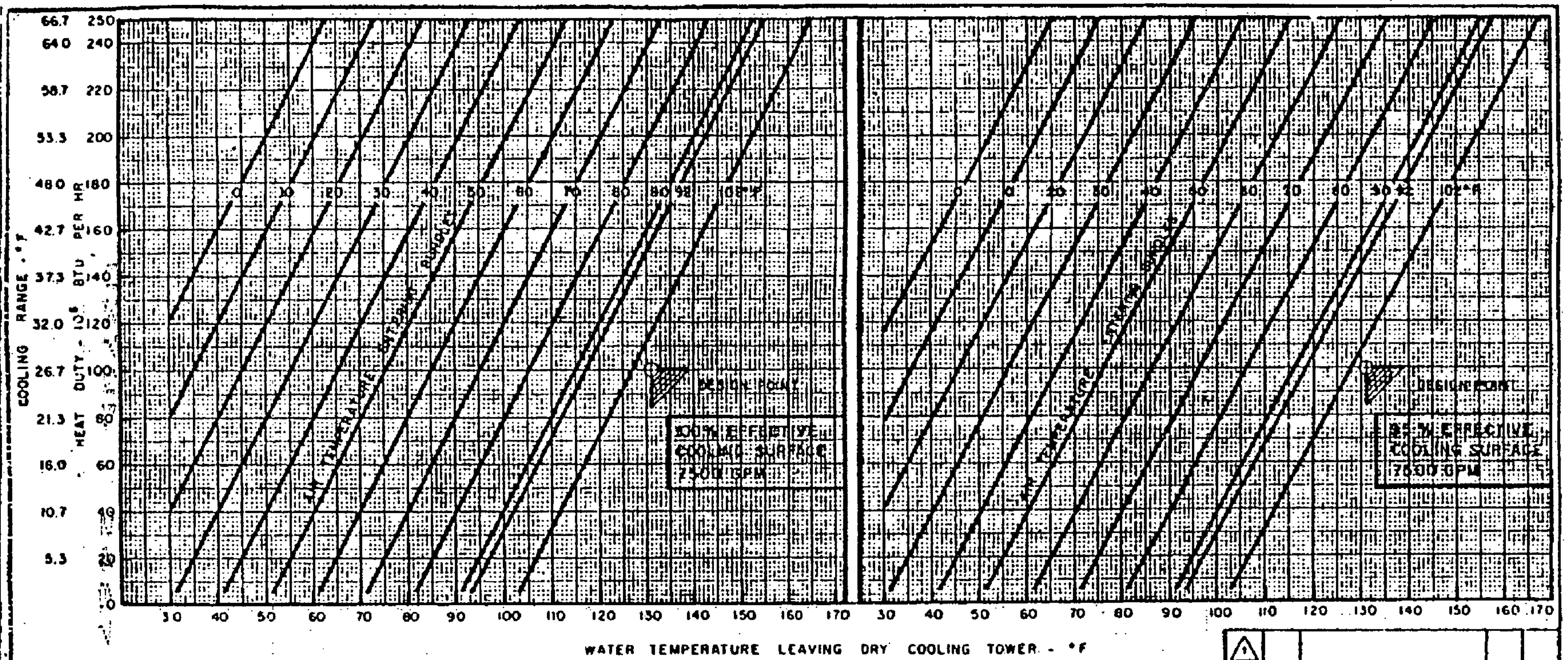
TITLE THERMAL PERFORMANCE
DRY COOLING TOWER

FOR WATERFORD STATION - UNIT NO. 3
LOUISIANA POWER & LIGHT COMPANY
(EBASCO SERVICES INC.)

SCALE NONE		DATE
DRAWN S D		9-19-74
CHECKED		
APPROVED		
ENGINEER		

CUSTOMER'S P.O. NO.	JOB NO.	DRAWING NO.
NY - 403-179	ND 002	SK 1B

PERFORMANCE CURVES FOR DRY TOWER



BASIS

1 COOLING WATER FLOW RATE - 7500 GPM

NOTES

COMPONENT COOLING WATER SYSTEM
LOCA. OPERATING MODE
(ACCIDENT CONDITION)

REV.	BY	DESCRIPTION	DATE	APP.

HUDSON PRODUCTS CORPORATION
HOUSTON, TEXAS

TITLE THERMAL PERFORMANCE DRY COOLING TOWER

FOR WATERFORD STATION - UNIT NO 3
LOUISIANA POWER & LIGHT COMPANY
(EBASCO SERVICES INC.)

SCALE NONE		DATE
DRAWN S D		9 13 74
CHECKED		
APPROVED		
ENGINEER		

CUSTOMER'S P.O. NO.	JOB NO.	DRAWING NO.
NY - 403479	ND 002	SK 1C

PERFORMANCE CURVES FOR DRY TOWER

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

CALCULATION COVER PAGE	(1) **EC # 8465**	(2) **Page 1 of 42**

(3) Design Basis Calc. ☒ YES ☐ NO	(4) ☐ CALCULATION ☒ EC Markup
(5) **Calculation No: ECM95-008**	(6) **Revision: 3**
(7) **Title: Ultimate Heat Sink Design Basis**	(8) **Editorial:** ☐ YES ☒ NO
(9) **System(s): ACC, CC**	(10) **Review Org (Department):**

(11) **Safety Class:** ☒ **Safety / Quality Related** ☐ **Augmented Quality Program** ☐ **Non-Safety Related**	(12) **Component/Equipment/Structure Type/Number:**	
	CC MPMP001-A	**ACCMPMP0001A**
	CC MPMP001-AB	**ACCMPMP0001B**
	CC MPMP001-B	**ACCMTWR0001A**
(13) **Document Type:**	**CC MHX0001A**	**ACCMTWR0001B**
(14) **Keywords (Description/Topical Codes):** **RSG, 3716 MWt, EPU, Ultimate Heat Sink, UHS, ACCW, CCW, WCT, DCT, Cooling Tower**	**CC MHX0001B**	
	CC MTWR0001A	
	CC MTWR0001B	

REVIEWS

(15) Name/Signature/Date	(16) Name/Signature/Date	(17) Name/Signature/Date
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Responsible Engineer	☐ **Design Verifier** ☒ **Reviewer** ☐ Comments Attached	**Supervisor/Approval** ☐ Comments Attached

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

CALCULATION COVER PAGE | (1) EC # 8465 | (2) Page 1 of 41

(3) Design Basis Calc. ☒ YES ☐ NO | (4) ☐ CALCULATION ☒ EC Markup

(5) **Calculation No: ECM95-008** | (6) **Revision: 3**

(7) **Title: Ultimate Heat Sink Design Basis** | (8) **Editorial:** ☐ YES ☒ NO

(9) **System(s): ACC, CC** | (10) **Review Org (Department):**

(11) **Safety Class:**

☒ **Safety / Quality Related**
☐ **Augmented Quality Program**
☐ **Non-Safety Related**

(12) **Component/Equipment/Structure Type/Number:**

CC MPMP0001-A	ACCMPMPOOO1A
CC MPMP0001-AB	ACCMPMPOOO1B
CC MPMP0001-B	ACCMTWROOO1A
CC MHX0001A	ACCMTWROOO1B
CC MHX0001B	
CC MTWR0001A	
CC MTWR0001B	

(13) **Document Type: B13.18**

(14) **Keywords (Description/Topical Codes):**

RSG, 3716 MWt, EPU, Ultimate Heat Sink, UHS, ACCW, CCW, WCT, DCT, Cooling Tower

REVIEWS

(15) Name/Signature/Date	(16) Name/Signature/Date	(17) Name/Signature/Date
Jacob Register 1/19/10 Jacob Register (Westinghouse) **Responsible Engineer**	Carl Patrickson for 1/19/10 Carl Patrickson (Westinghouse) ☒ **Design Verifier** ☐ **Reviewer** ☐ Comments Attached	Ed Brouwer 1/19/10 Ed Brouwer (Westinghouse) **Supervisor/Approval** ☐ Comments Attached

CALCULATION REFERENCE SHEET	CALCULATION NO: ECM95-008 REVISION: 3

I. EC Markups Incorporated (N/A to NP calculations)
1. None
2.

II. Relationships:	Sht	Rev	Input Doc	Output Doc	Impact Y/N	Tracking No.
R1. MN(Q)9-52, Ultimate Heat Sink Performance	1	2	☒	☐	N	
R2. MN(Q)9-3, Ultimate Heat Sink Study	1	4	☒	☐	N	
R3. 9C2-5Y, Chillers Heat Rejections	1	1	☒	☐	N	
R8. ECS-05-013, UHS Containment Heat Loads	1	1	☒	☐	N	
R10. MN(Q)9-65, CCW Temperature Evaluation.	1	2	☒	☒	Y	EC-8465
R22. ECM95-009, Ultimate Heat Sink Fan Requirements	1	2	☐	☒	Y	EC-8465

III. CROSS REFERENCES:
1. None.
2.
3.

IV. SOFTWARE USED:

Title: STER

Version/Release: Version 5.04 by Holtec, W3 Software Manual 460000024 Vol.

Title: Microsoft Excel Version/Release: 2002

Disk/CD No. N/A 1

V. DISK/CDS INCLUDED:

Title: N/A Version/Release: ____ Disk/CD No. ____

VI. OTHER CHANGES: None

Revision	Record of Revision
0	Initial issue.
0 - 1	Determine equivalent meteorological conditions that UHS can reject the design basis heat load.
0 -2	CR 970777 documented that the containment heat loads for the UHS did not contain certain conservative assumptions. The purpose of this calculation change is to revise the UHS design bases requirements corresponding to maximum containment heat load rate determined by calculation MN(Q)93. This is a complete rewrite; therefore no revision bars are used.
1	Provides justification for use of hot air recirculation values and adds computation of the ACCW System design temperature in response to the recommended dispositions of Design Basis Review Open Items: OICCW296Cand OICCW297C. Adds Keywords to Section 3. Replaces Reference 3.3 and removes references to the FSAR. Corrects typographical errors. This is a complete rewrite; therefore no revision bars are used.
DRN 03-509	Modified UHS Design Basis as a result of Total Heat Duty input changes at 3716 MW_t. A methodology change was made in section 5.4 to ensure Tech Spec 3/4.7.4 compliance. Calculation and Attachment changes have been made accordingly. Added page 2 of 2 to Attachment 7.3 to include the regression analysis for the DCT. This analysis was referenced in section 6.1.1 of the calculation. Section 6.6.4 was added to address Met tower conditions from Calculation ECM03007 (Ref. R22). The basis for the heat load from emergency diesel generators and the LPSI/HPSI/CS pumps in circular. Calculation ECM95-008 references calculation MNQ9-3 for this heat load and MNQ9-3 references ECM95-008 for the same heat load. ECM95-008 now references Calculation MNQ9-65 which develops the basis for these heat loads.
DRN 05-766	Added Assumption 4.7 to clarify that containment heat loads were determined assuming 112°F CCW temperature (ECS01-005).
2	This revision incorporated all outstanding changes and DRNs. ECS05-013 was changed to the new input for containment heat loading and all calculations were revised accordingly. CR-WF3-2005-0230 documented that the CCW flows used in the calc did not bound the As-Built flows determined during flow testing. The CCW accident flow has been increased to a bounding 6900 gpm.

3	Corrected transposition errors in paragraphs 5.3 and 5.4, math operator in paragraph 6.3.1, and copy and paste error in Attachment 7.1, identified on CR-WF3-2007-1420. The errors did not affect the results of the calculation. Therefore, this is an administrative change only.
EC-8465	This EC Markup addresses the impact of Replacement Steam Generators (RSGs) on this calculation. Changes are incorporated on pages 1 - 3, 11- 22, Attachment 7.2: 4 – 6, Attachment 7.3: 1 – 7, Attachment 7.4: 2.

1.0 PURPOSE

1.1 The purpose of this calculation is to determine the Ultimate Heat Sink design basis under LOCA conditions using the worst combination meteorological design parameters.

1.2 This calculation also determines the ACCW System design temperature.

1.3 This calculation also accounts for the impact of Replacement Steam Generators (RSGs) on the results of this analysis.

EC-8465

2.0 CONCLUSION

2.1 The UHS is capable of dissipating the LOCA heat duty requirements for both worst combination meteorological design parameters, 102°F $_{db}$/78°F $_{wb}$ and 98°F $_{db}$/83°F $_{wb}$. The 102°F $_{db}$/78°F $_{wb}$ meteorological condition would allow less fouling in the CCW heat exchanger in order to maintain a CCW outlet temperature of 115°F, therefore is chosen as the UHS design point. The design conditions for the UHS are given below.

Dry Bulb Temperature (T_{db})	- 102°F
Wet Bulb Temperature (T_{wb})	- 78°F
DCT CCW Inlet Temperature	- ~~164.56°F~~ 166.68°F
DCT CCW Outlet/CCWHx Inlet Temp.	- ~~131.11°F~~ 132.06°F
DCT Heat Duty	- ~~113.38~~ 117.36 x 10^6 BTU/Hr
WCT ACCW Outlet/CCWHx Inlet Temp.	- 89.3°F*
CCWHx CCW Outlet Temperature	- 115.0°F
CCWHx ACCW Outlet Temperature	- ~~113.77°F*~~ 115.21°F
CCWHx Allowable Fouling Factor	- ~~0.00159*~~ 0.00133
CCWHx Heat Duty	- 57.84 ~~64.62~~ x 10^6 BTU/Hr
WCT ACCW Inlet Temperature	- ~~111.79°F*~~ 113.01°F
WCT Heat Duty	- 62.94 ~~59.72~~ x 10^6 BTU/Hr
WCT Cooling Range	- ~~22.49°F~~ 23.71°F

EC-8465

*As discussed in section 5.4, these values are calculated using an ACCW inlet temperature to the CCWHx of 89.3°F in order to maintain the Tech. Spec. maximum ACCW temperature of 89°F.

As discussed in section 6.6.4, the meteorological condition of 91.3°F$_{db}$/84.9°F$_{wb}$ from Reference R11 is not more limiting than 102°F$_{db}$/78°F$_{wb}$ case above.

2.2 Using the limiting historical meteorological parameter, 102°F $_{db}$/78°F $_{wb}$, a relationship (See Attachment 7.3) was developed to provide equivalent dry bulb temperature/corresponding wet bulb temperature required to maintain overall UHS design heat duty capacity. The linear relationship demonstrates that for a dry bulb temperature increase/decrease of 1.0°F, the corresponding wet bulb temperature can decrease/increase approximately 1.7°F and maintain the UHS design heat duty capacity. The relationship also demonstrates the UHS can dissipate its design heat load for any dry bulb temperature below 93°F, regardless of wet bulb temperature, since wet bulb temperature can not exceed dry bulb temperature.

2.3 ACCW System design temperature is 125°F.

3.0 INPUT CRITERIA

3.1 Peak UHS Heat Duty Requirements

165.2

Containment Heat Duty[1]	= ~~158~~ x 10^6 BTU/hr		(Ref. R8)
Essential Chiller Heat Duty	=5.1 x 10^6 BTU/hr		(Ref. R3)
Auxiliary Heat Duty[~~2~~]	= 10.0 x 10^6 BTU/hr		(Ref. R10)
Total Heat Duty	= ~~173.1~~ 180.3 x 10^6 BTU/hr		
CCWS Heat Duty	= ~~168.0~~ 175.2 x 10^6 BTU/hr		

Notes: ~~1. Containment heat duty has been conservatively rounded up from 157.60 x 10^6 BTU/Hr given in Ref. R8.~~

~~2.~~ 1 Includes Diesel Generator and HPSI, LPSI and Containment Spray pumps

EC-8465

3.2 Maximum One Hour Ambient Conditions

<u>Drybulb Temperature</u>

Ref. C1 contains a table which shows the maximum drybulb and concurrent wetbulb for the New Orleans area is 102 and 77°F respectively. One degree is added to the wetbulb temperature for conservatism bringing the maximum 1 hour drybulb/corresponding wetbulb temperatures to 102/78°F.

<u>Wetbulb Temperature</u>

Ref. C1 discusses that 83°F is the maximum wetbulb temperature of record at Moisant Field for the period between 1946 and 1977. The reference discusses that 83°F is an acceptable design value and satisfies the requirements of Reg. Guide 1.27. A table attached to the reference provides maximum wetbulb and corresponding drybulb temperatures however, 83°F is not an entry in the table. An entry is provided for 83°F in the table for maximum drybulb and corresponding wetbulb temperatures. Based on this evaluation, at 83°F wetbulb temperature, the corresponding drybulb temperature is 98°F.

The site Met Tower data was evaluated in calculation Reference R11 over a period from 1997 to 2001. This review indicates that the maximum one hour wetbulb temperature exceeded 83°F at 84.9°F with an associated drybulb temperature of 91.27°F. This calculation will determine if the 84.9°F $_{wb}$/91.3°F $_{db}$ met condition is more limiting for the highest T_{wb} and coincident T_{db} case.

3.3 Maintain a CCW outlet temperature of 115°F to the plant auxiliaries. (Ref. R4)

6.2 Dry Cooling Tower Performance

6.2.1 DCT Performance at T_{db} = 102°F

Determine DCT inlet temperature

$Q = mc_p(T_{in} - T_{out})$ or $T_{in} = (Q/mc_p) + T_{out}$

where

T_{in} = DCT Inlet Temperature (°F)

Q = ~~168.0~~ 175.2 x 10^6 BTU/Hr (less Chiller Heat Duty) (Input 3.1)

m = 6900 gpm x 60 min/hr / 0.016293 ft^3/lb_m / 7.4805 gal/ft^3 = 3.39678 x 10^6 lb_m/hr

T_{out} = 115°F @ CCW Heat Exchanger

C_p = 0.998 BTU/lbm - °F

T_{in} = (~~168.0~~ 175.2 x 10^6/ (3.39678 x 10^6 * 0.998)) + 115

T_{in} = ~~164.56°F~~ 166.68

T_{avg} = ~~139.79°F~~ 140.84 ≈ ~~140°F~~ 141

The CCW_{out} temperature at the DCT can be calculated using the conservation of energy where:

$$Q_{DCT} = mc_p(T_{in} - T_{out})$$

This heat balance will be performed to calculate the DCT T_{out} temperature at DCT performance curve inlet CCW flows of 6500 gpm and 7500 gpm and then interpolated at the CCW accident design flow of 6900 gpm.

$$Q_{6500\,gpm} = 4.4*T_{out} - (354 + 4.4(T_{db} - 80)) = mc_p(T_{in} - T_{out}) \quad \text{(Sec. 6.1.1)}$$

where:

Q_{6500} = Heat Transferred @ CCW Flow of 6500 gpm

T_{out} = CCW_{out} temperature

T_{db} = 103.9°F (adding 1.9°F for Recirculation) (Input. 3.2, 3.7)

m = 6500 gpm x 60 min/hr / 0.016293 ft^3/lbm / 7.4805 gal/ft^3 = 3.200 x 10^6 lb_m/hr

c_p = 0.998 BTU/lb_m - °F

T_{in} = ~~164.56°F~~ 166.68

Solving for T_{out} yields

$4.4*T_{out} + mc_pT_{out} = (354 + 4.4(T_{db} - 80)) + mc_pT_{in}$

$4.4*T_{out} + (3.200)(0.998)T_{out} = 354 + 4.4(103.9 - 80) + (3.200)(0.998)*$ ~~164.56~~ 166.68

T_{out} = ~~129.67°F~~ 130.57

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Calculating Heat Transferred:

$Q_{6500} = mc_p(T_{in} - T_{out})$ 166.68 130.57
$Q_{6500} = (3.200)(0.998)(\cancel{164.56} - \cancel{129.67})$
$Q_{6500} = \cancel{111.42}$ 115.32 $\times 10^6$ BTU/Hr

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Performing Heat Balance at a CCW Flow Rate of 7500 gpm:

$Q_{7500\,gpm} = 4.0^*T_{out} - (320 + 4.0(T_{db} - 80)) = mc_p(T_{in} - T_{out})$ (Sec. 6.1.1)

where:

Q_{7500} = Heat Transferred @ CCW Flow of 7500 gpm
T_{out} = CCW_{out} Temperature
T_{db} = 103.9°F (adding 1.9°F for Recirculation) (Input 3.2, 3.7)
m = 7500 gpm x 60 min/hr / 0.016293 ft^3 / lbm / 7.4805 gal/ft^3
= $3.692 \times 10^6\ lb_m/hr$
c_p = 0.998 BTU/lb_m - °F
T_{in} = $\cancel{164.56}$ 166.68 °F

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Solving for T_{out} yields:

$4.0^*T_{out} + mc_pT_{out} = (320 + 4.0(T_{db} - 80)) + mc_pT_{in}$
$4.0^*T_{out} + (3.692)(0.998)T_{out} = 320 + 4.0(103.9 - 80) +$
$(3.692)(0.998)^*\cancel{164.56}$ 166.68
$T_{out} = \cancel{132.99}$ 134.00 °F

Calculating Heat Transferred:
$Q_{7500} = mc_p(T_{in} - T_{out})$ 166.68 134.00
$Q_{7500} = (3.692)(0.998)(\cancel{164.56} - \cancel{132.99})$
$Q_{7500} = \cancel{116.32}$ 120.41 $\times 10^6$ BTU/Hr

By linear interpolation, the DCT heat duty @ 6900 gpm is:

$Q_{6900\,gpm} = Q_{6500\,gpm} + \frac{6900 - 6500}{7500 - 6500}^* (Q_{7500\,gpm} - Q_{6500\,gpm})$
$Q_{6900\,gpm} = \cancel{111.42}$ 115.32 $\times 10^6 + (0.4)(\cancel{116.32}$ 120.41 $\times 10^6 - \cancel{111.42}$ 115.32 $\times 10^6)$
$Q_{6900\,gpm} = \cancel{113.38}$ 117.36 $\times 10^6$ BTU/Hr

Calculating CCW_{out} Temperature:

$m = 3.39678 \times 10^6\ lb_m/hr$
$c_p = 0.998$ BTU/lb_m - °F
$T_{out} = T_{in} - (Q/mc_p)$
$T_{out} = \cancel{164.56}$ 166.68 $- ((\cancel{113.38/3.39678/0.998})$ (117.36/3.39678/0.998)
$T_{out} = \cancel{131.11}$ 132.06 °F

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6.2.2 DCT Performance at T_{db} = 98°F

The method of analysis for the DCT performance at a dry bulb temperature of 98°F is identical to the analysis given 6.2.1.

$Q_{6500\,gpm} = 4.4{*}T_{out} - (354 + 4.4(T_{db} - 80)) = mc_p(T_{in} - T_{out})$ (Sec. 6.1.1)

where:

Q_{6500} = Heat Transferred @ CCW Flow of 6500 gpm
T_{out} = CCW_{out} Temperature
T_{db} = 99.9°F (adding 1.9°F for Recirculation) (Input 3.2, 3.7)
m = 3.200 lb_m/hr (x 10^6) (6500 gpm)
c_p = 0.998 BTU/lb_m - °F
T_{in} = ~~164.56°F~~ 166.68

Solving for T_{out} yields

$$4.4{*}T_{out} + mc_pT_{out} = (354 + 4.4(T_{db} - 80)) + mc_pT_{in}$$
$$4.4{*}T_{out} + (3.200)(0.998)T_{out} = 354 + 4.4(99.9 - 80) + (3.200)(0.998){*}\cancel{164.56}\ 166.68$$
$$T_{out} = \cancel{127.36°F}\ 128.25$$

Calculating Heat Transferred:

$$Q_{6500} = mc_p(T_{in} - T_{out})$$
$$Q_{6500} = (3.200)(0.998)(\cancel{164.56}\ 166.68 - \cancel{127.36}\ 128.25)$$
$$Q_{6500} = \cancel{118.8}\ 122.73 \times 10^6 \text{ BTU/Hr}$$

Performing Heat Balance at a CCW Flow Rate of 7500 gpm:

$Q_{7500\,gpm} = 4.0{*}T_{out} - (320 + 4.0(T_{db} - 80)) = mc_p(T_{in} - T_{out})$ (Sec. 6.1.1)

where:

Q_{7500} = Heat Transferred @ CCW Flow of 7500 gpm
T_{out} = CCW_{out} Temperature
T_{db} = 99.9°F (adding 1.9°F for Recirculation) (Input 3.2, 3.7)
m = 3.692 lb_m/hr (x 10^6) (7500 gpm)
c_p = 0.998 BTU/lb_m - °F
T_{in} = ~~164.56°F~~ 166.68

Solving for T_{out} yields:

$$4.0{*}T_{out} + mc_pT_{out} = (320 + 4.0(T_{db} - 80)) + mc_pT_{in}$$
$$4.0{*}T_{out} + (3.692)(0.998)T_{out} = 320 + 4.0(99.9 - 80) + (3.692)(0.998){*}\cancel{164.36}\ 166.68$$
$$T_{out} = \cancel{130.90°F}\ 131.92$$

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EC-8465

Calculating Heat Transferred: EC-8465

$Q_{7500} = mc_p(T_{in} - T_{out})$ 166.68 131.92

$Q_{7500} = (3.692)(0.998)(\cancel{164.56} - \cancel{130.90})$

$Q_{7500} = \cancel{124.02} \times 10^6$ BTU/Hr 128.08

By linear interpolation, the DCT heat duty @ 6900 gpm is:

$$Q_{6900\,gpm} = Q_{6500\,gpm} + \frac{6900-6500}{7500-6500} * (Q_{7500\,gpm} - Q_{6500\,gpm})$$

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122.73 128.08

$Q_{6900\,gpm} = \cancel{118.8} \times 10^6 + (0.4)(\cancel{124.02} \times 10^6 - \cancel{118.8} \times 10^6)$ 122.73

$Q_{6900\,gpm} = \cancel{120.89} \times 10^6$ BTU/Hr 124.87

Calculating CCW_{out} Temperature:

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$m = 3.39678 \times 10^6$ lb_m/hr

$c_p = 0.998$ BTU/lb_m - °F

$T_{out} = T_{in} - (Q/mc_p)$

166.68

$T_{out} = \cancel{164.56} - (\cancel{120.89}/3.39678/0.998)$ 124.87

$T_{out} = \cancel{128.90}$°F 129.85

6.3 Wet Cooling Tower Performance

6.3.1 <u>WCT Performance at T_{wb} = 78°F and T_{db} = 102°F</u>

Determine WCT Heat Duty EC-8465

Q_{wct} = Total Heat Duty- DCT Heat Dissipated @ T_{db} of 102°F.

180.3

$Q_{wct} = \cancel{173.10} \times 10^6 - \cancel{113.38} \times 10^6$ (Input 3.1, Sec. 6.2.1)

117.36

$Q_{wct} = \cancel{59.72} \times 10^6$ BTU/Hr 62.94

Determine WCT Cooling Range

$Q_{wct} = mc_p(\Delta T)$ or $\Delta T = Q_{wct}/mc_p$

where

ΔT	= Cooling Range (°F)
m	= 5350 gpm / 0.01613 ft³/lb_m / 7.4805 gal/ft³ x 60 min/hr
	=2.660 x 10^6 lb_m/hr
c_p	= 0.998 BTU/lb_m - °F

EC-8465

62.94

$\Delta T = \cancel{59.72} \times 10^6 / 2.660 \times 10^6 / 0.998 = \cancel{22.49}$°F 23.71

23.71

Using a ~~22.49~~°F WCT Cooling range and increasing T_{wb} by 1.0°F to account for recirculation, the ACCW outlet temperature can be calculated. (Input 3.7)

At 5000 gpm

ACCW$_{out}$ = (0.675 - 0.0139(~~22.49~~ 23.71 - 21.6))*79 +(34.125 + 1.412(~~22.49~~ 23.71 - 21.6))
ACCW$_{out}$ = ~~87.73~~ 88.11°F (Sec. 6.1.2)

At 5750 gpm

ACCW$_{out}$ = (0.6 - 0.00463(~~22.49~~ 23.71 - 21.6))*79 +(42.00 + 0.5787(~~22.49~~ 23.71 - 21.6))
ACCW$_{out}$ = ~~89.59~~ 89.85°F (Sec. 6.1.2)

By linear interpolation, the WCT heat duty @ 5350 gpm is:

$$ACCW_{out} = \cancel{87.73}\ 88.11 + \frac{5350 - 5000}{5750 - 5000} * (\cancel{89.59}\ 89.85 - \cancel{87.73}\ 88.11)$$

ACCW$_{out}$ = ~~88.60~~ 88.92°F

ACCW$_{out}$ is less than 89.0°F, therefore:

ACCW$_{out}$ = 89.3°F (for CCWHx analysis) (Sec. 5.4)

WCT inlet Temperature

WCTin = 89.3°F + ~~22.49~~ 23.71°F = ~~111.79~~ 113.01°F

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6.3.2 <u>WCT Performance at T_{wb} = 83°F and T_{db} = 98°F</u>

Determine WCT Heat Duty

Q_{wct} = Total Heat Duty- DCT Heat Dissipated @ T_{db} of 98°F.
Q_{wct} = ~~173.1~~ 180.3 x 10^6 - ~~120.89~~ 124.87 x 10^6 (Input. 3.1, Sec. 6.2.2)
Q_{wct} = ~~52.21~~ 55.43 x 10^6 BTU/Hr

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Determine WCT Cooling Range

$Q_{wct} = mc_p(\Delta T)$ or $\Delta T = Q_{wct}/mc_p$

Where:

ΔT = Cooling Range (°F)
m = 5350 gpm / 0.01613 ft^3/lb_m / 7.4805 gal/ft^3 x 60 min/hr
= 2.660 x 10^6 lb_m/hr
c_p = 0.998 BTU/lb_m - °F

ΔT = ~~52.21~~ 55.43 x 10^6 / 2.660 x 10^6 / 0.998 = ~~19.66~~ 20.88°F

EC-8465

Using a 19.66°F WCT Cooling range and increasing T_{wb} by 1.0°F to account for recirculation, the ACCW outlet temperature can be calculated. (Input 3.7)

At 5000 gpm

$$ACCW_{out} = (0.725 - 0.00463(\cancel{19.66}\ 20.88 - 10.8))*84 + (27.125 + 0.648(\cancel{19.66}\ 20.88 - 10.8)) \quad \text{(Sec. 6.1.2)}$$

$ACCW_{out}$ = ~~90.32°F~~ 90.64

At 5750 gpm

$$ACCW_{out} = (0.775 - 0.01620(\cancel{19.66}\ 20.88 - 10.8))*84 + (24.125 + 1.655(\cancel{19.66}\ 20.88 - 10.8)) \quad \text{(Sec. 6.1.2)}$$

$ACCW_{out}$ = ~~91.83°F~~ 92.19

By linear interpolation, the WCT heat duty @ 5350 gpm is:

$$ACCW_{out} = \cancel{90.32}\ 90.64 + \frac{5350 - 5000}{5750 - 5000}*(\cancel{91.83}\ 92.19 - \cancel{90.32}\ 90.64)$$

$ACCW_{out}$ = ~~91.03°F~~ 91.36

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6.4 CCW Heat Exchanger Performance

6.4.1 <u>CCWHx Performance at T_{wb} = 78°F and T_{db} = 102°F</u>

Determine CCWHx Heat Duty

Q_{CCWHx} = WCT - Chiller Heat Duty @ T_{db} of 102°F. (Sec. 6.3.1)

Q_{CCWHx} = ~~59.72~~ 62.94 x 10^6 - 5.1 x 10^6 (Input 3.1)

Q_{CCWHx} = ~~54.62~~ 57.84 x 10^6 BTU/Hr

As determined in Section 6.3.1, the WCT will return the ACCW flow back to the WCT basins at a temperature of ~~88.60°F~~ 88.92 in order to meet the Tech. Spec. Maximum WCT Basin Temperature Limit, the maximum allowable CCW heat exchanger fouling will be calculated using and ACCW inlet temperature of 89.3°F. The maximum allowable fouling is determined for an ACCW inlet temperature of 89.3°F, because the maximum allowable fouling is minimized at the higher ACCW inlet temperature.

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Determine $ACCW_{out}$ Temperature

$$Q_{CCWHx} = mc_p(T_{out} - T_{in}) \text{ or } T_{out} = Q_{CCWHx}/mc_p + T_{in}$$

where:

m = 4500 gpm / 7.4805 gal/ft3 / 0.01613 ft3/lbm * 60 min/hr
=2.238×10^6 lb_m/hr @ 89°F

c_p = 0.998 BTU/lb_m - °F

T_{in} = 89.3°F (Sec. 6.3.1)

$T_{out} = \cancel{54.62}\ 57.84 \times 10^6 / 2.238 \times 10^6 / 0.998 + 89.3$

$T_{out} = \cancel{113.76}\ 115.2$°F

Using STER Version 5.04, the following heat exchanger performance is calculated for a CCW_{out} temperature of 115°F. The printouts are provided in Attachment 7.2

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CCW_{in}	CCW_{out}	$ACCW_{in}$	$ACCW_{out}$*	Fouling Factor*
~~131.11~~ 132.06	115.0	89.3	~~113.77~~ 115.21	~~0.00159~~ 0.00133

* Calculated by STER Version 5.04

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Additionally, the ACCWout temperature will be calculated using the actual WCT outlet temperature (i.e. CCW heat exchanger inlet temperature). $ACCW_{in}$ temperature calculated in Section 6.3.1.

$T_{in} = \cancel{88.60}\ 88.92$°F (Sec. 6.3.1)

$T_{out} = \cancel{54.62}\ 57.84 \times 10^6 / 2.238 \times 10^6 / 0.998 + \cancel{88.60}\ 88.92$

$T_{out} = \cancel{113.06}\ 114.82$°F

Using STER Version 5.04, the following heat exchanger performance is calculated for a CCW_{out} temperature of 115°F.

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CCW_{in}	CCW_{out}	$ACCW_{in}$	$ACCW_{out}$*	Fouling Factor*
~~131.11~~ 132.06	115.0	~~88.60~~ 88.92	~~113.07~~ 114.83	~~0.00172~~ 0.00139

* Calculated by STER Version 5.04

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6.4.2 <u>CCWHx Performance at T_{wb} = 83°F and T_{db} = 98°F</u>

Determine CCWHx Heat Duty

Q_{CCWHx} = WCT - Chiller Heat Duty @ T_{db} of 98°F.

$Q_{CCWHx} = \cancel{52.21}\ 55.43 \times 10^6 - 5.1 \times 10^6$ (Sec. 6.3.2)

$Q_{CCWHx} = \cancel{47.11}\ 50.33 \times 10^6$ BTU/Hr (Input 3.1)

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Determine $ACCW_{out}$ Temperature

$Q_{CCWHx} = mc_p(T_{out} - T_{in})$ or $T_{out} = Q_{CCWHx}/mc_p + T_{in}$

where:

m = 4500 gpm / 7.4805 gal/ft^3 / 0.01613 ft^3/lbm * 60 min/hr
= 2.238 x 10^6 lb$_m$/hr

c_p = 0.998 BTU/lb$_m$ - °F

T_{in} = ~~91.03°F~~ 91.36 (Sec. 6.3.2)

T_{out} = ~~47.11~~ 50.33 x 10^6 / 2.238 x 10^6 / 0.998 + ~~91.03~~ 91.36

T_{out} = ~~112.12°F~~ 113.89

Using STER Version 5.04, the following heat exchanger performance is calculated for a CCW_{out} temperature of 115°F. The printouts are provided in Attachment 7.2

CCW_{in}	CCW_{out}	$ACCW_{in}$	$ACCW_{out}$*	Fouling Factor*
~~128.90~~ 129.85	115.0	~~91.03~~ 91.36	~~112.14~~ 113.92	~~0.00197~~ 0.00158

* Calculated by STER Version 5.04

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6.5 Ultimate Heat Sink Design Points

The worst case ambient condition for the UHS is a T_{db} of 102°F and a T_{wb} of 78°F. This conclusion is based on the allowable fouling for the CCW heat exchanger to maintain a CCW outlet temperature of 115°F is less under these ambient conditions. The design points for the UHS are given below.

Dry Bulb Temperature (T_{db})	- 102°F	(Input 3.2)
Wet Bulb Temperature (T_{wb})	- 78°F	(Input 3.2)
DCT CCW Inlet Temperature	- ~~164.56°F~~ 166.68°F	(Sec. 6.2.1)
DCT CCW Outlet/CCWHx Inlet Temperature	- ~~131.11°F~~ 132.06°F	(Sec. 6.2.1)
DCT Heat Duty	117.36 - ~~113.38~~x 10 BTU/Hr	(Sec. 6.2.1)
WCT ACCW Outlet/CCWHx Inlet Temperature	- 89.3°F *	(Sec. 6.3.1)
CCWHx CCW Outlet Temperature	- 115.0°F	(Input 3.3)
CCWHx ACCW Outlet Temperature	- ~~113.77°F*~~ 115.21°F	(Sec. 6.4.1)
CCWHx Allowable Fouling Factor	- ~~0.00159~~ 0.00133	(Sec. 6.4.1)
CCWHx Heat Duty	57.84 - ~~54.62~~ x 10 BTU/Hr	(Sec. 6.4.1)
WCT ACCW Inlet Temperature	- ~~111.70°F~~* 113.01°F	(Sec. 6.3.1)
WCT Heat Duty	62.94 - ~~59.72~~ x 10 BTU/Hr	(Sec. 6.3.1)
WCT Cooling Range	- ~~22.49°F~~ 23.71°F	(Sec. 6.31)

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*As discussed in section 5.4, these values are calculated using an ACCW inlet temperature to the CCWHx of 89.3°F in order to maintain the Tech. Spec. maximum ACCW temperature of 89.0°F.

6.6 Maximum T_{wb} at Various T_{db} to Maintain Overall UHS Design Heat Duty Capacity.

The most limiting historical ambient condition for the UHS was determined to be a T_{db} of 102°F and a T_{wb} of 78°F. This analysis will determine equivalent meteorological conditions for the UHS to maintain its overall design heat duty capacity using the limiting fouling factor determined in the previous sections for the CCW heat exchanger.

6.6.1 DCT Performance at T_{db} = 105°F

The CCW_{out} temperature at the DCT can be calculated using the conservation of energy where:

$$Q_{DCT} = mc_p(T_{in} - T_{out})$$

Heat capacity of the DCT at a CCW flow rate of 6500 gpm is calculated using the equation:

$Q_{DCT} = 4.4*T_{out} - (354 + 4.4(T_{db} - 80))$ (Sec. 6.1.1)

Solving the two equations, the heat balance becomes at a CCW flow of 6500 gpm:

$4.4*T_{out} - (354 + 4.4(T_{db} - 80)) = mc_p(T_{in} - T_{out})$

where:

T_{out} = CCW_{out} temperature
T_{db} = 106.9°F (adding 1.9°F for Recirculation) (Input 3.2, 3.7)
m = 3.200 lb_m/hr (x 10^6) (6500 gpm)
c_p = 0.998 BTU/lb_m - °F
T_{in} = $\cancel{164.56}$°F 166.68 (Sec. 6.2.1) EC-8465

Solving for T_{out} yields

$4.4*T_{out} + mc_pT_{out} = (354 + 4.4(T_{db} - 80)) + mc_pT_{in}$
$4.4*T_{out} + (3.200)(0.998)T_{out} = 354 + 4.4(106.9 - 80) + (3.200)(0.998)*\cancel{164.56}$ 166.68
$T_{out} = \cancel{131.41}$°F 132.30

Calculating Heat Transferred:

$Q_{DCT} = mc_p(T_{in} - T_{out})$
$Q_{DCT} = (3.200)(0.998)(\cancel{164.56} - \cancel{131.41})$ 166.68 132.30
$Q_{DCT} = \cancel{105.86}$ x 10^6 BTU/Hr 109.80 EC-8465

Heat capacity of the DCT at a CCW flow rate of 7500 gpm is calculated using the equation:

$Q_{DCT} = 4*T_{out} - (320 + 4(T_{db} - 80))$ (Sec. 6.1.1)

Using the Conservation of Energy, the heat balance becomes at a CCW flow of 7500 gpm:

$4*T_{out} - (320 + 4(T_{db} - 80)) = mc_p(T_{in} - T_{out})$

where:

T_{out} = CCW_{out} temperature
T_{db} = 106.9°F (adding 1.9°F for Recirculation) (Input 3.2, 3.7)
m = 3.692 lb_m/hr (x 10^6) (7500 gpm)
c_p = 0.998 BTU/lb_m - °F
T_{in} = $\cancel{164.56}$°F 166.68 (Sec. 6.2.1) EC-8465

Solving for T_{out} yields

$4*T_{out} + mc_pT_{out} = (320 + 4(T_{db} - 80)) + mc_pT_{in}$

$4*T_{out} + (3.692)(0.998)T_{out} = 320 + 4(106.9- 80) + (3.692)(0.998)*\cancel{164.56}$ 166.68

$T_{out} = \cancel{134.55°F}$ 135.56

Calculating Heat Transferred:

$Q_{DCT} = mc_p(T_{in} - T_{out})$

$Q_{DCT} = (3.692)(0.998)(\cancel{164.56} - \cancel{134.55})$ 166.68 135.56

$Q_{DCT} = \cancel{110.58} \times 10^6$ BTU/Hr 114.67 EC-8465

By linear interpolation, the DCT heat duty @ 6900 gpm is:

$$Q_{6900\,gpm} = Q_{6500\,gpm} + \frac{6900-6500}{7500-6500} * (Q_{7500\,gpm} - Q_{6500\,gpm})$$

$Q_{6900\,gpm} = \cancel{105.86} \times 10^6 + (0.4)(\cancel{110.59} \times 10^6 - \cancel{105.86} \times 10^6)$ 109.80 114.67 109.80

$Q_{6900\,gpm} = \cancel{107.75} \times 10^6$ BTU/Hr 111.75 EC-8465

Calculating CCW_{out} Temperature:

$m = 3.39678 \times 10^6\ lb_m/hr$

$c_p = 0.998\ BTU/lb_m - °F$

$T_{out} = T_{in} - (Q/mc_p)$

$T_{out} = \cancel{164.56} - (\cancel{107.75}/3.39678/0.998)$ 166.68 111.75

$T_{out} = \cancel{132.78°F}$ 133.72 EC-8465

6.6.2 <u>Required CCWHx Performance at T_{db} = 105°F</u>

Determine CCWHx Heat Duty

Q_{CCWHx} = Total - DCT - Chiller Heat Duty

$Q_{CCWHx} = \cancel{173.1} \times 10^6 - \cancel{107.75} \times 10^6 - 5.1 \times 10^6$ 180.3 111.75 (Input 3.1, Sec. 6.6.1)

$Q_{CCWHx} = \cancel{60.25} \times 10^6$ BTU/Hr 63.45

Determine $ACCW_{out}$ Temperature

Using STER Version 5.04, an ACCW inlet temperature of ~~86.7°F~~ 86.82 is required to dissipate the above heat load. The printout is provided in Attachment 7.3 EC-8465

6.6.3 <u>Maximum T_{wb} for a T_{db} of 105°F</u>

Determine ~~WCT Heat~~ Duty

Q_{wct} = Total Heat Duty- DCT Heat Dissipated

Q_{wct} = ~~173.1~~ 180.3 x 10^6 - ~~107.75~~ 111.75 x 10^6 (Input 3.1, Sec. 6.6.2) EC-8465

Q_{wct} = ~~65.35~~ 68.55 x 10^6 BTU/Hr

Determine WCT Cooling Range

$Q_{wct} = mc_p(\Delta T)$ or $\Delta T = Q_{wct}/mc_p$

where

ΔT	= Cooling Range (°F)
m	= 2.660 x 10^6 lb_m/hr (5350 gpm)
c_p	= 0.998 BTU/lb_m - °F

ΔT = ~~65.35~~ 68.55 x 10^6 / 2.660 x 10^6 / 0.998 = ~~24.61~~ 25.82 °F

25.82

Using a ~~24.61~~ °F WCT Cooling range and an ACCW outlet temperature of ~~86.7°F~~ 86.82 the maximum T_{wb} can be calculated.

At 5000 gpm:

~~86.7°F~~ 86.82 = (0.675 - 0.0139(~~24.61~~ 25.82 - 21.6))*T_{wb} +
(34.125 + 1.412(~~24.61~~ 25.82 - 21.6)) (Sec. 6.1.2)

Solving for T_{wb} yields:

T_{wb} = ~~76.32°F~~ 75.83

At 5750 gpm:

~~86.7°F~~ 86.82 = (0.6 - 0.00463(~~24.61~~ 25.82 - 21.6))*T_{wb} +
(42 + 0.5787(~~24.61~~ 25.82 - 21.6)) (Sec. 6.1.2) EC-8465

Solving for T_{wb} yields:

T_{wb} = ~~73.30°F~~ 73.01

By linear interpolation and subtracting 1°F to account for recirculation (and @ 5350 gpm) yields: (Input 3.7)

$$T_{wb} = \cancel{76.32}\ 75.83 + \frac{5350-5000}{5750-5000} * (\cancel{73.30-76.32}\ (73.01-75.83)) - 1.0$$

T_{wb} = ~~73.91°F~~ 73.51

~~********** STER - 5.04 **********~~

~~Shell and Tube Heat Exchanger Rating Program~~

~~This computer code is validated under Holtec International's QA program.~~

~~File Name: WTFRDCCW.EQP~~
~~Unit Name: CCMHX0001A&B~~
~~Unit Description: CCW Heat Exchangers~~

~~This report was created Monday, November 07, 2005 at 1:03:03 PM~~

~~***** PERFORMANCE TEST MODE RESULTS *****~~

~~TEST ID: 102/78~~
~~DATE: 11- 07- 05~~
~~PROCEDURE: EC- M95- 008~~
~~CONVERGENCE TOLERANCE: 0.05 %~~

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6882.58	4490.71
Inlet Temperature [degrees F]:	131.11	89.30
Outlet Temperature [degrees F]:	115.00	113.77
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	0.00	0.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1302.72	838.20
Pressure Drop [psi]:	3.07	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47325	14021

~~Total Heat Duty: 54,635,891 Btu/hr~~
~~Log Mean Temperature Difference: 21.25 F~~
~~Overall Heat Transfer Coefficient: 257.09 Btu/hr/sqft/F~~
~~Corrected LMTD: 21.25 F~~
~~Effective Surface Area per Shell: 10002.93 sq ft~~

Reference Temperature [F]:	123.055	101.535
Density [lbm/cu.ft]:	61.666	61.979
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.364
Absolute Viscosity [cP]:	0.539	0.669

~~WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.~~

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

Attachment 7.2
Page 4 of 6

File Name: WTFRDCCW.EQP

Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Friday, October 23, 2009 at 12:28:43 PM

***** PERFORMANCE TEST MODE RESULTS *****

TEST ID: 102/78
DATE: 06-29-09

PROCEDURE: ECM95-008

CONVERGENCE TOLERANCE: 0.05 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6884.39	4490.71
Inlet Temperature [degrees F]:	132.06	89.30
Outlet Temperature [degrees F]:	115.00	115.21
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00133
Operating Pressure [psig]:	0.00	0.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1305.85	840.24
Pressure Drop [psi]:	3.06	3.24
Velocity [ft/sec]:	4.81	
Reynolds Number:	47536	14130

Total Heat Duty: 57,859,131 Btu/hr
Log Mean Temperature Difference: 20.96 F
Overall Heat Transfer Coefficient: 275.95 Btu/hr/sqft/F
Corrected LMTD: 20.96 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	123.530	102.257
Density [lbm/cu.ft]:	61.658	61.969
Specific Heat Capacity [Btu/lbm F]:	0.999	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.364
Absolute Viscosity [cP]:	0.536	0.664

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Monday, November 07, 2005 at 1:04:21 PM

***** PERFORMANCE TEST MODE RESULTS *****

TEST ID: 102/78
DATE: 11- 07- 05
PROCEDURE: EC- M95- 008
CONVERGENCE TOLERANCE: 0.05 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6882.58	4490.15
Inlet Temperature [degrees F]:	131.11	88.60
Outlet Temperature [degrees F]:	115.00	113.07
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00172
Operating Pressure [psig]:	0.00	0.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1302.13	836.51
Pressure Drop [psi]:	3.07	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47325	13916

Total Heat Duty: 54,635,441 Btu/hr
Log Mean Temperature Difference: 21.96 F
Overall Heat Transfer Coefficient: 248.79 Btu/hr/sqft/F
Corrected LMTD: 21.96 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	123.055	100.835
Density [lbm/cu.ft]:	61.666	61.988
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.364
Absolute Viscosity [cP]:	0.539	0.674

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP

Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Friday, October 23, 2009 at 12:30:06 PM

***** PERFORMANCE TEST MODE RESULTS *****

TEST ID: 102/78
DATE: 06-29-09

PROCEDURE: ECM95-008

CONVERGENCE TOLERANCE: 0.05 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6884.39	4490.41
Inlet Temperature [degrees F]:	132.06	88.92
Outlet Temperature [degrees F]:	115.00	114.83
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00139
Operating Pressure [psig]:	0.00	0.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1305.52	839.32
Pressure Drop [psi]:	3.07	3.24
Velocity [ft/sec]:	4.81	
Reynolds Number:	47536	14073

Total Heat Duty: 57,858,860 Btu/hr
Log Mean Temperature Difference: 21.35 F
Overall Heat Transfer Coefficient: 270.96 Btu/hr/sqft/F
Corrected LMTD: 21.35 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	123.530	101.877
Density [lbm/cu.ft]:	61.658	61.974
Specific Heat Capacity [Btu/lbm F]:	0.999	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.364
Absolute Viscosity [cP]:	0.536	0.666

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Monday, November 07, 2005 at 1:05:17 PM

***** PERFORMANCE TEST MODE RESULTS *****

TEST ID: 98/83
DATE: 11- 07- 05
PROCEDURE: EC- M95- 008
CONVERGENCE TOLERANCE: 0.05 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6878.42	4492.12
Inlet Temperature [degrees F]:	128.90	91.03
Outlet Temperature [degrees F]:	115.00	112.14
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00197
Operating Pressure [psig]:	0.00	0.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1296.93	837.64
Pressure Drop [psi]:	3.07	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	46834	14029

Total Heat Duty: 47,139,080 Btu/hr
Log Mean Temperature Difference: 20.15 F
Overall Heat Transfer Coefficient: 233.90 Btu/hr/sqft/F
Corrected LMTD: 20.15 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	121.950	101.586
Density [lbm/cu.ft]:	61.684	61.978
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.364
Absolute Viscosity [cP]:	0.544	0.668

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

Attachment 7.2
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File Name: WTFRDCCW.EQP

Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Friday, October 23, 2009 at 12:31:20 PM

***** PERFORMANCE TEST MODE RESULTS *****

TEST ID: 98/83
DATE: 06-29-09

PROCEDURE: ECM95-008

CONVERGENCE TOLERANCE: 0.05 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6880.20	4492.39
Inlet Temperature [degrees F]:	129.85	91.36
Outlet Temperature [degrees F]:	115.00	113.92
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00158
Operating Pressure [psig]:	0.00	0.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1300.34	840.47
Pressure Drop [psi]:	3.07	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47045	14188

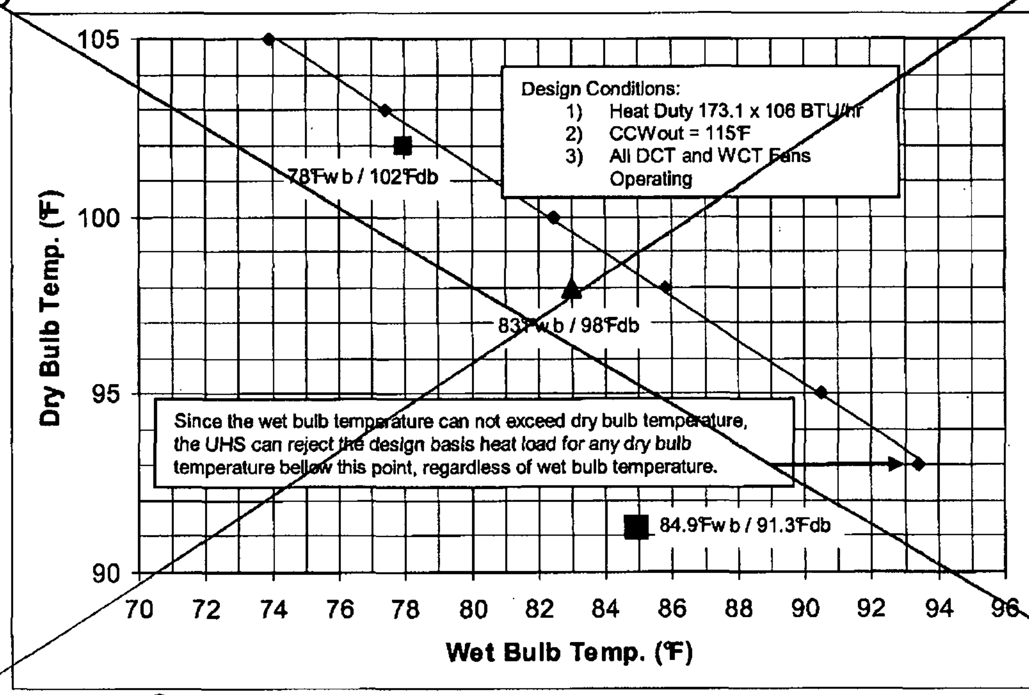
Total Heat Duty: 50,362,221 Btu/hr
Log Mean Temperature Difference: 19.53 F
Overall Heat Transfer Coefficient: 257.75 Btu/hr/sqft/F
Corrected LMTD: 19.53 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	122.425	102.638
Density [lbm/cu.ft]:	61.676	61.964
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.364
Absolute Viscosity [cP]:	0.542	0.661

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

Equivalent Meteorological Conditions for the Ultimate Heat Sink to Dissipate the Design Basis Heat Load



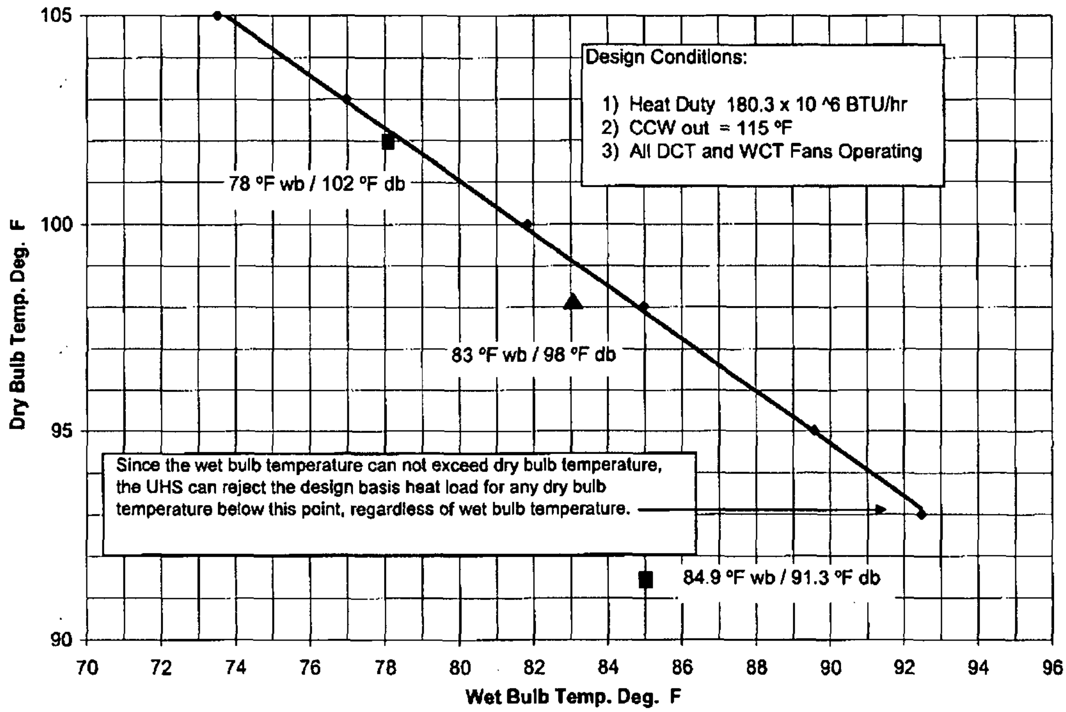
EC-8465

Note: The 102°F $_{db}$ / 78°F $_{wb}$ point does not fall on the curve as may be expected. This is due to the methodology discussed in section 5.4 and implemented in 6.4.1. The WCT basin temperature would be maintained cooler than the temperature specified in Technical Specification 3/4.7.4, assuming the design basis meteorological condition of 102°F $_{db}$ / 78°F $_{wb}$.

Dry Bulb Temp. (°F)	DCT Heat Rejected (x 10^6 BTU/Hr)	DCT CCW_{out} (°F)	CCWHx Heat Rejected (x 10^6 BTU/Hr)	CCWH x $ACCW_{in}$ (°F)*	WCT heat Rejected (x 10^6 BTU/Hr)	WCT Range (°F)	Wet Bulb Temp. (°F)
105	107.75	132.78	60.25	86.70	65.35	24.61	73.91
103	111.50	131.67	56.50	88.47	61.60	23.20	77.42
100	117.14	130.01	50.86	91.12	55.96	21.08	82.48
98	120.89	128.90	47.11	92.89	52.21	19.66	85.78
95	126.52	127.24	41.48	95.54	46.58	17.54	90.47
93	130.28	126.13	37.72	97.31	42.82	16.13	93.44

EC-8465

*Calculated using STER Version 5.04. Printouts included in Attachment


Design Conditions:
1) Heat Duty 180.3 x 10 ^6 BTU/hr
2) CCW out = 115 °F
3) All DCT and WCT Fans Operating
78 °F wb / 102 °F db
83 °F wb / 98 °F db
Since the wet bulb temperature can not exceed dry bulb temperature, the UHS can reject the design basis heat load for any dry bulb temperature below this point, regardless of wet bulb temperature.
84.9 °F wb / 91.3 °F db
Dry Bulb Temp. Deg. F
Wet Bulb Temp. Deg. F
105
100
95
90
70
72
74
76
78
80
82
84
86
88
90
92
94
96

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Dry Bulb Temp. (°F)	DCT Heat Rejected (x10^6 BTU/hr)	DCT CCWout (°F)	CCWHx Heat Rejected (x10^6 BTU/hr)	CCWHx ACCWin (°F)*	WCT Heat Rejected (x10^6 BTU/hr)	WCT Range (°F)	Wet Bulb Temp. (°F)
105	111.75	133.72	63.45	86.82	68.55	25.82	73.51
103	115.48	132.62	59.72	88.52	64.82	24.42	76.98
100	121.12	130.95	54.08	91.01	59.18	22.29	81.82
98	124.85	129.85	50.35	92.68	55.45	20.89	84.98
95	130.49	128.18	44.71	95.18	49.81	18.76	89.56
93	134.22	127.08	40.98	96.86	46.08	17.36	92.46

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:06:40 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met105
DATE: 11- 08- 05
PROCEDURE: EC- M95- 008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6885.48	4488.56
Inlet Temperature [degrees F]:	132.78	86.70
Outlet Temperature [degrees F]:	115.00	113.71
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1314.88	841.14
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47688	13821

Total Heat Duty: 60,286,041 Btu/hr
Log Mean Temperature Difference: 23.38 F
Overall Heat Transfer Coefficient: 257.77 Btu/hr/sqft/F
Corrected LMTD: 23.38 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	123.888	100.204
Density [lbm/cu.ft]:	61.673	62.007
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.373	0.364
Absolute Viscosity [cP]:	0.535	0.678

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP

Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, October 27, 2009 at 10:13:41 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met105
DATE: 06-29-09

PROCEDURE: ECM95-008

CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6887.29	4488.65
Inlet Temperature [degrees F]:	133.72	86.82
Outlet Temperature [degrees F]:	114.98	115.28
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00133
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1317.06	842.84
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47895	13948

Total Heat Duty: 63,522,381 Btu/hr
Log Mean Temperature Difference: 22.96 F
Overall Heat Transfer Coefficient: 276.58 Btu/hr/sqft/F
Corrected LMTD: 22.96 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	124.352	101.048
Density [lbm/cu.ft]:	61.666	61.996
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.373	0.364
Absolute Viscosity [cP]:	0.532	0.672

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:07:40 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met103
DATE: 11- 08- 05
PROCEDURE: EC- M95- 008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6883.35	4489.94
Inlet Temperature [degrees F]:	131.67	88.47
Outlet Temperature [degrees F]:	115.00	113.79
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1312.22	842.71
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47441	13960

Total Heat Duty: 56,530,060 Btu/hr
Log Mean Temperature Difference: 21.92 F
Overall Heat Transfer Coefficient: 257.81 Btu/hr/sqft/F
Corrected LMTD: 21.92 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	123.333	101.128
Density [lbm/cu.ft]:	61.682	61.995
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.373	0.364
Absolute Viscosity [cP]:	0.537	0.672

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

Attachment 7.3
Page 3 of 7

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP

Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, October 27, 2009 at 10:10:01 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met105
DATE: 06-29-09

PROCEDURE: ECM95-008

CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6885.17	4489.98
Inlet Temperature [degrees F]:	132.62	88.52
Outlet Temperature [degrees F]:	115.00	115.28
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00133
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1314.49	844.29
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47653	14076

Total Heat Duty: 59,730,240 Btu/hr
Log Mean Temperature Difference: 21.59 F
Overall Heat Transfer Coefficient: 276.61 Btu/hr/sqft/F
Corrected LMTD: 21.59 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	123.810	101.900
Density [lbm/cu.ft]:	61.674	61.985
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.373	0.364
Absolute Viscosity [cP]:	0.535	0.666

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:20:40 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met100
DATE: 11- 08- 05
PROCEDURE: EC- M95- 008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6880.21	4492.08
Inlet Temperature [degrees F]:	130.01	91.12
Outlet Temperature [degrees F]:	115.00	113.92
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1308.25	845.07
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47073	14170

Total Heat Duty: 50,888,081 Btu/hr
Log Mean Temperature Difference: 19.73 F
Overall Heat Transfer Coefficient: 257.87 Btu/hr/sqft/F
Corrected LMTD: 19.73 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	122.505	102.520
Density [lbm/cu.ft]:	61.695	61.977
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.365
Absolute Viscosity [cP]:	0.542	0.662

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

Attachment 7.3
Page 4 of 7

File Name: WTFRDCCW.EQP

Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, October 27, 2009 at 10:26:18 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met105
DATE: 06-29-09

PROCEDURE: ECM95-008

CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6881.98	4491.99
Inlet Temperature [degrees F]:	130.95	91.01
Outlet Temperature [degrees F]:	114.99	115.25
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00133
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1310.46	846.32
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47280	14262

Total Heat Duty:	54,099,751 Btu/hr
Log Mean Temperature Difference:	19.55 F
Overall Heat Transfer Coefficient:	276.64 Btu/hr/sqft/F
Corrected LMTD:	19.55 F
Effective Surface Area per Shell:	10002.93 sq ft

Reference Temperature [F]:	122.970	103.128
Density [lbm/cu.ft]:	61.688	61.969
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.365
Absolute Viscosity [cP]:	0.539	0.658

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:23:27 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met98
DATE: 11- 08- 05
PROCEDURE: EC- M95- 008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6878.13	4493.56
Inlet Temperature [degrees F]:	128.90	92.89
Outlet Temperature [degrees F]:	115.00	114.00
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1305.59	846.62
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	46827	14310

Total Heat Duty: 47,124,352 Btu/hr
Log Mean Temperature Difference: 18.27 F
Overall Heat Transfer Coefficient: 257.90 Btu/hr/sqft/F
Corrected LMTD: 18.27 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	121.949	103.445
Density [lbm/cu.ft]:	61.704	61.965
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.365
Absolute Viscosity [cP]:	0.545	0.655

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

Attachment 7.3
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File Name: WTFRDCCW.EQP

Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, October 27, 2009 at 10:35:48 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met105
DATE: 06-29-09

PROCEDURE: ECM95-008

CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6879.91	4493.38
Inlet Temperature [degrees F]:	129.85	92.68
Outlet Temperature [degrees F]:	115.00	115.24
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00133
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1307.84	847.70
Pressure Drop [psi]:	3.05	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	47038	14388

Total Heat Duty: 50,351,139 Btu/hr
Log Mean Temperature Difference: 18.19 F
Overall Heat Transfer Coefficient: 276.66 Btu/hr/sqft/F
Corrected LMTD: 18.19 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	122.423	103.958
Density [lbm/cu.ft]:	61.697	61.958
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.365
Absolute Viscosity [cP]:	0.542	0.652

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:26:44 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met95
DATE: 11- 08- 05
PROCEDURE: EC- M95- 008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6875.05	4495.84
Inlet Temperature [degrees F]:	127.24	95.54
Outlet Temperature [degrees F]:	115.00	114.12
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1301.61	848.94
Pressure Drop [psi]:	3.06	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	46461	14520

Total Heat Duty: 41,493,912 Btu/hr
Log Mean Temperature Difference: 16.08 F
Overall Heat Transfer Coefficient: 257.95 Btu/hr/sqft/F
Corrected LMTD: 16.08 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	121.120	104.830
Density [lbm/cu.ft]:	61.717	61.946
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.365
Absolute Viscosity [cP]:	0.549	0.646

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

Attachment 7.3
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File Name: WTFRDCCW.EQP

Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, October 27, 2009 at 10:38:37 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met105
DATE: 06-29-09

PROCEDURE: ECM95-008

CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6876.79	4495.53
Inlet Temperature [degrees F]:	128.18	95.18
Outlet Temperature [degrees F]:	114.99	115.20
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00133
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1303.82	849.73
Pressure Drop [psi]:	3.06	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	46667	14576

Total Heat Duty: 44,705,029 Btu/hr
Log Mean Temperature Difference: 16.15 F
Overall Heat Transfer Coefficient: 276.68 Btu/hr/sqft/F
Corrected LMTD: 16.15 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	121.586	105.192
Density [lbm/cu.ft]:	61.710	61.941
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.366
Absolute Viscosity [cP]:	0.546	0.643

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP
Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, November 08, 2005 at 7:28:06 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met93
DATE: 11- 08- 05
PROCEDURE: EC- M95- 008
CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6873.01	4497.41
Inlet Temperature [degrees F]:	126.13	97.31
Outlet Temperature [degrees F]:	115.00	114.21
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00159
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1298.94	850.49
Pressure Drop [psi]:	3.06	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	46216	14662

Total Heat Duty: 37,726,460 Btu/hr
Log Mean Temperature Difference: 14.62 F
Overall Heat Transfer Coefficient: 257.98 Btu/hr/sqft/F
Corrected LMTD: 14.62 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	120.565	105.755
Density [lbm/cu.ft]:	61.726	61.934
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.366
Absolute Viscosity [cP]:	0.552	0.640

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

EC-8465

********** STER - 5.04 **********

Shell and Tube Heat Exchanger Rating Program

This computer code is validated under Holtec International's QA program.

File Name: WTFRDCCW.EQP

Unit Name: CCMHX0001A&B
Unit Description: CCW Heat Exchangers

This report was created Tuesday, October 27, 2009 at 10:44:31 AM

***** PERFORMANCE PREDICTION MODE RESULTS *****

CASE ID: Met105
DATE: 06-29-09

PROCEDURE: ECM95-008

CONVERGENCE TOLERANCE: 0.01 %

PARAMETER	TUBE SIDE	SHELL SIDE
Mass Flow Rate [1000 lbm/hr]:	3396.78	2237.68
Volume Flow Rate [gpm]:	6874.75	4497.01
Inlet Temperature [degrees F]:	127.08	96.86
Outlet Temperature [degrees F]:	115.00	115.20
Fouling Factor [1/Btu/hr/sqft/F]:	0.00000	0.00133
Operating Pressure [psig]:	110.00	60.00
Heat Transfer Coeff [Btu/hr/sqft/F]:	1301.22	851.12
Pressure Drop [psi]:	3.06	3.24
Velocity [ft/sec]:	4.80	
Reynolds Number:	46426	14704

Total Heat Duty: 40,941,521 Btu/hr
Log Mean Temperature Difference: 14.79 F
Overall Heat Transfer Coefficient: 276.71 Btu/hr/sqft/F
Corrected LMTD: 14.79 F
Effective Surface Area per Shell: 10002.93 sq ft

Reference Temperature [F]:	121.041	106.029
Density [lbm/cu.ft]:	61.718	61.930
Specific Heat Capacity [Btu/lbm F]:	0.998	0.998
Thermal Conductivity [Btu/hr ft F]:	0.372	0.366
Absolute Viscosity [cP]:	0.549	0.638

WARNING 1: Central Baffle Spacing May Exceed TEMA Maximum.

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recorded twice or 6.7% of the total readings. The highest recorded value is within 1°F of the wet bulb value. Since the highest recorded reading is within 1°F of the wetbulb value and was recorded only twice, the wetbulb value of 1.0°F is considered reasonable.

A paper of the Cooling Tower Institute entitled "Recommended Recirculation Allowances" (pages 8 and 9 of this attachment) describes how to determine design wetbulb temperatures. The method is carried out below for the following data from this calculation, EC- M95- 008 Rev. ~~1~~ 3.

ACCW accident flow rate	5350	gpm
ACCW temperature leaving wet cooling tower	89.3	°F
Design wetbulb temperature	78	°F
Calculated approach temperature (89.3- 78)	11.3	°F
Wet cooling tower inlet temperature	~~111.0 °F~~ 113.01°F	
Wet cooling tower range	~~22.49~~ 23.71	°F

First, determine the design uncorrected recirculation value using the curve for average maximum recirculation. At 5350 gpm, uncorrected recirculation value is 0.5°F. Second, correct for the actual approach and range. Conservatively take the range to be 30°F and the approach to be 12°F, then the correction factor is 1.49. Third, multiply the uncorrected recirculation value by the correction factor to obtain the actual recirculation value which is 0.75°F (=0.5°F x 1.49). This calculated value is within the wetbulb temperature of 1°F. As a result, the use of the 1°F wetbulb temperature is considered acceptable value.

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Conclusion

The present values of 1.9°F for the drybulb temperature and 1.0°F for the wetbulb temperature are reasonable and acceptable.