Exelon Generation
4300 Winfield Road
Warrenville, IL 60555

www.exeloncorp.com

Exelon Nuclear

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U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

LaSalle County Station, Units 1 and 2
Facility Operating License Nos. NPF-11 and NPF-18
NRC Docket Nos. 50-373 and 50-374

Subject: Additional Information Supporting Request for Emergency License Amendment to Technical Specification 3.7.3, "Ultimate Heat Sink"

References:

1. Letter from D. M. Benyak (Exelon Generation Company, LLC) to U. S. NRC, "Request for a License Amendment to Technical Specification 3.7.3, 'Ultimate Heat Sink,'" dated June 29, 2007

2. Letter from P. R. Simpson (Exelon Generation Company, LLC) to U. S. NRC, "Additional Information Supporting Request for a License Amendment to Technical Specification 3.7.3, "Ultimate Heat Sink," and Request for Processing on an Emergency Basis," dated August 1, 2007

In Reference 1, as supplemented by Reference 2, Exelon Generation Company, LLC (EGC) requested a change to the Technical Specifications (TS) of Facility Operating License Nos. NPF-11 and NPF-18 for LaSalle County Station (LSCS), Units 1 and 2. The proposed change increased the maximum allowed TS temperature limit, contained in TS Surveillance Requirement 3.7.3.1, of the cooling water supplied to the plant from the Core Standby Cooling System (CSCS) pond (i.e., the Ultimate Heat Sink (UHS)) from 100 °F to 101.25 °F. The proposed change was based on a reduction in instrument uncertainty resulting from the replacement of the originally installed thermocouples with precision resistance temperature devices.

During a conference call with the NRC on August 2, 2007, the NRC requested EGC to submit one of the references listed in Attachment 2 of Reference 2. As requested, the Attachment to this letter contains EC 356645, "Assessment of High Lake Temperature On the Functionality of the Plant (Summer Readiness 2005)," Revision 1.

As discussed in Section 4.2 of Attachment 2 to Reference 2, the results of the evaluation demonstrated an increase in the maximum inlet temperature of cooling water supplied to the plant from the CSCS pond could be justified. However, although margin exists to support increasing the actual inlet temperature, the proposed increase in the allowable indicated temperature is based solely on a reduction of the existing instrument loop uncertainty value. No change in the actual inlet temperature was credited; therefore, there is no change in the containment pressure response, loss-of-coolant accident (LOCA) and non-LOCA analyses, and there is no increase in risk associated with the post-accident heat removal. Thus, the attached evaluation has no impact on the technical justification for the proposed change.

EGC has reviewed the information supporting a finding of no significant hazards consideration that was previously provided to the NRC in Attachment 2 of Reference 2. The information provided in this submittal does not affect the bases for concluding that the proposed license amendment does not involve a significant hazards consideration.

There are no regulatory commitments contained in this letter. Should you have any questions concerning this letter, please contact Ms. Alison Mackellar at (630) 657-2817.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 2nd day of August 2007.

Respectfully,

Darin M Benyak

Darin M. Benyak
Director, Licensing

Attachment:

EC 356645, "Assessment of High Lake Temperature On the Functionality of the Plant (Summer Readiness 2005)," Revision 1

ATTACHMENT

EC 356645, "Assessment of High Lake Temperature On the Functionality of the Plant (Summer Readiness 2005)," Revision 1

Assessment of High Lake Temperature On the Functionality of the Plant (Summer Readiness 2005)

REASON FOR EVALUATION:

This EC revision (Rev. 1) evaluates and documents any changes to EC 354788, a previous evaluation (dated 4/27/05) of plant components for higher inlet cooling water temperatures, and revision 0 of this EC (356645). The EC is prepared to support Summer 2005 Readiness. In the event that the plant's inlet cooling water temperature approaches and is predicted to exceed the Tech Spec SR 3.7.3.1 UHS temperature limit of </= 100 °F, a temporary increase in this limit to 102 °F will likely be requested from the regulator. This increased limit (102 °F) will be the starting temperature for postulated accident analysis involving the UHS and the operating limit for non-safety related equipment.

DESCRIPTION OF CHANGE/SCOPE/APPROACH:

This assessment will address the consequences of an increase in the temperature of cooling water supplied to the plant upon both safety-related and nonsafety related systems. For safety-related systems, the applicable components are part of the CSCS cooling system. These are evaluated for a higher inlet cooling water temperature of 106 °F, versus the current 104 °F (Reference 1). The assessment is based on current (as of the preparation date of this EC) plant equipment condition, e.g. current equipment inspections, monitoring, heat exchanger tube plugging and performance testing information.

The UHS at the time of a postulated LOCA and concurrent cooling lake dike failure will be at a starting temperature of 102 °F. The CSCS piping systems have a design temperature of 200 °F so this temperature increase can be accommodated by the piping systems involved.

The UHS has been previously analyzed utilizing the existing calculation model (Reference 2) to determine the peak inlet cooling water temperature following a LOCA and cooling lake dike failure, based on a starting temperature of 100 °F for small siltation depths. (e.g. up to 6-inches siltation). The most current siltation surveillance indicates the average siltation depth is less than 6 inches and that changes since the previous survey in 2002 have been insignificant (Reference LTS-1000-4, WO 00558360-02 completed 10/15/04, and Ocean Survey drawings 04ES05864.1 and 04ES05864.2).

Worst-case weather data, already contained in the model, was used in the analysis. The UHS analysis effort also included updating the heat input load to include the effects of General Electric SIL 636 (Reference 3). The peak UHS inlet temperatures to the plant for 0" & 6" siltation levels are evaluated as follows:

Siltation Depth	Starting UHS Temperature	Peak UHS Inlet Temperature
0"	100 °F	101.6 °F (Table G.7.2 of Reference 2)
6"	100 °F	101.8 °F (Table G.7.3 of Reference 2)

Allowing the UHS initial temperature to increase 2°F (from 100 °F to 102 °F) would result in a corresponding 2°F increase in the peak temperature during accident conditions. This is reasonable and conservative based on the peak temperatures given above, meaning that during accident conditions the peak temperature of cooling water being supplied to safety-related components could be 104°F.

In this assessment a margin of +2°F is added to this peak UHS temperature. This margin could be used to account for things like lake temperature instrumentation uncertainty. For example, Circulating Water inlet temperature instrumentation, although not safety-related, is used to verify Tech Spec required limits. The CW Inlet temperature uncertainty has been determined in EC 336218 to be as much as ±1.8°F (Reference 4)

In summary, for accidents and transients involving a LOCA and postulated dike break the projected peak post-accident UHS temperature will be assessed as 104 °F + 2 °F for a peak temperature of 106 °F for CSCS system components. Beyond design basis events such as ATWS and SBO are evaluated for a 102 °F + 2 °F (for uncertainty, not post-accident increase) = 104 °F CSCS cooling water temperature.

Non-safety related components are reviewed from an operational standpoint only, because the main concern is with their effect on power operation. They are not credited to mitigate any design basis events. Most components are reliability related and are monitored for parameters such as temperature and pressure. These components can be described as self-limiting, that is, operations personnel will respond to alarms and conditions in accordance with approved plant procedures, including load curtailment per LOA-CW-101/201, as required. These components were evaluated in the Reference 1 Engineering Change (EC) 334017 at 104 °F. For these components the peak cooling water inlet temperature will correspond to the increased UHS temperature limit, i.e. 102 °F.

DETAILED EVALUATION:

Relevant UFSAR Rev. 15 Sections:

The specific UFSAR Sections related to non-safety-related systems are:

9.1.3.2.1.1 "...the Spent Fuel Pool (SFP) cooling system safety design bases are...maintain the SFP water temperature...assumes a Service Water System water temperature of 100 °F ."

9.2.2.2 "Maximum service water supply temperature is 100 °F."

10.4.5.2 "The circulating water system supplies the main condenser with cooling water ranging from 32 °F to 100 °F maximum."

In addition, the UFSAR states the following about the safety-related UHS:

9.2.6.3.2. "The maximum temperature for cooling water supplied to the plant from the UHS during accident conditions is 102 °F."

Fig. 9.2-7 "UHS Lake Temperature Versus Time of Day". This figure indicates that to ensure that the 102 °F limit is not exceeded during accident conditions the UHS temperature must be limited depending upon time of day and depth of siltation.

__**Function Performed by the Equipment :**__

CSCS Equipment Cooling Water System:

The safety function of the core standby cooling system (CSCS) is to circulate lake water from the ultimate heat sink for cooling of the residual heat removal

(RHR) heat exchangers, diesel-generator coolers, CSCS cubicle area cooling coils, RHR pump seal coolers, and low-pressure core spray (LPCS) pump motor cooling coils. This system also provides a source of emergency make up water for fuel pool cooling and also provides containment flooding water for post-accident recovery.

Ultimate Heat Sink (UHS):

The UHS has the following safety functions: to provide sufficient water volume permitting a safe shutdown and cooldown of the station for 30 days with no water makeup – the maximum permissible water temperature supplied to the plant is taken as 102°F (post-accident). It is also designed to provide water for fire protection equipment and to withstand the most severe postulated natural phenomenon such as an earthquake.

Fuel Pool Cooling (FC) System:

The FC System is designed to prevent damage to the fuel elements contained in the fuel pool. Under normal operating conditions, the system is designed to maintain a water level of approximately 22 feet above the top of the spent fuel pool storage racks. The FC System also maintains the fuel pool temperature at or below a limit of 140°F under a maximum normal heat load (during refueling) using service water (cooling water) temperature of 100°F.

Service Water (WS) System:

The service water system removes heat from various equipment in the turbine building, reactor building, auxiliary building, service building, and radwaste facility during normal plant conditions, shutdown, and abnormal plant conditions when offsite power is available. The service water system removes the heat rejected by the reactor building closed cooling water and turbine building closed cooling water systems. It is also designed to supply strained cooling lake water to the radwaste facilities, screen wash, clean gland water, and to serve as a back up to the fire protection system. The service water system provides a reliable source of cooling water for station auxiliaries that are nonessential to the safe shutdown of the station during or following a design-basis LOCA.

Circulating Water (CW) System:

The purpose of the circulating water system is to remove the heat rejected from the main condenser. The circulating water system is designed to convey water between the main condenser and the cooling lake. The circulating water system is not required to effect or support safe shutdown of the reactor or to perform in the operation of reactor safety features.

Evaluation of Safety-Related Equipment:

Safety-related equipment is required to safely shutdown the plant and maintain cooling for 30 days assuming a LOCA and simultaneous dike failure (Reg. Guide 1.27/UFSAR). The LaSalle County Lake serves as the water supply for the service water system and the ultimate heat sink (UHS). The safety-related heat exchangers have been evaluated for a cooling water inlet temperature of 106°F. The existing computer calculation models for most safety-related heat exchangers were utilized for this analysis. Other safety-related heat exchangers, which use the CSCS water, are addressed as well below:

RHR Heat Exchangers (E12-B001A/B)

A review of the RHR Heat Exchangers concludes that they are in good condition. They have no material condition issues that would impair the ability of the components to support a change of the maximum inlet temperature from 104°F to 106°F. (EC 355042, Reference 27)

An assessment of RHR Heat Exchanger performance in the Containment Cooling mode was made with 106°F inlet service water (cooling water) (See Attachment A). The approved heat exchanger computer model (Calc. No. 97-201) was used. The assessment found that with an inlet cooling water temperature of 106°F the heat rejection capacity of the RHR heat exchangers was approximately 172 E06 Btu/hr, which exceeds the required heat rejection rate of 163.1 E06 Btu/hr (Ref. 16). Additionally, several conservatisms were used in the assessment, including (1) the model assumes that 5% of the heat exchanger tubes are plugged. Currently, the maximum number of tubes plugged in any of the RHR heat exchangers are less than this amount (Per Ref. 27, the maximum number of tubes plugged is 29 in the 2A RHR Ht. Ex., this is less than 5% of 1063 total tubes or 53 tubes), and (2) the overall fouling factor used in the assessment is greater than that actually determined from the latest RHR heat exchanger performance testing for the Generic Letter 89-13 Program (NDIT LS-1154 and Calc. L-002571, ECs 340686, 350219). The highest value of fouling based on testing, including uncertainties, is .00105, and a value of .0013 was used in the assessment.

An assessment of RHR Heat Exchanger capability for normal shutdown was also performed for an inlet service water temperature of 106 °F. The design heat rejection capacity for normal shutdown is approximately 42 E06 Btu/hr. The approved heat exchanger computer model referenced above was also used in this assessment. The design case indicates an inlet water temperature for the shutdown cooling flow from the reactor vessel of 120 °F which is based on an inlet service water temperature of 90 °F. For an inlet temperature of 106 °F, the heat rejection capability will be reduced to approximately 22E06 BTU/hr per RHR Hx train. The shutdown temperature can still be obtained; however, the time period required will be longer. An option available to plant operators depending on the plant conditions is to utilize both RHR heat exchanger trains, this will more than accommodate the design normal shutdown heat load. The normal shutdown cooling function is not safety related and the impact of the increased cooling time and its impact on plant availability is not a safety concern (Ref. 35).

These temperatures are well below the containment cooling mode values given previously. Thus the containment cooling mode effect on the heat exchanger is bounding.

Post LOCA Suppression Pool Temperature Analysis:

Since the containment cooling mode heat rejection capability of the RHR Heat Exchanger exceeds the required heat rejection, there will be no impact on the LaSalle suppression pool temperature response following a LOCA. In other words, the post LOCA peak suppression pool temperature (196.1 °F at 102% of uprated reactor thermal power per UFSAR Section 6.2.2.3.5) even with a higher inlet service water temperature of 106°F will still be well below the suppression pool temperature NPSH limit for the ECCS pumps of 212°F.

Due to the expected performance of the RHR heat exchanger, other events that utilize the RHR heat exchangers for cooling would be expected to have the same results, i.e. since the heat removal capacity of the RHR heat exchanger is maintained, an increased (106 °F) CSCS cooling water temperature will not impact suppression pool temperature.

RHR Pump Seal Coolers

The RHR Pump Seal Coolers on both Units 1 and 2 were replaced with new units during L1F35 and L2R07. There is margin between the most current measured cooling water flows (ranging from ~ 11 gpm to 30 gpm per Ref. 33) and the minimum required flow 6.5 gpm (Calculation L-002404). The coolers are flow tested quarterly and cleaned before flows drop below the minimum required. All four coolers have been flow tested satisfactorily since late April 2005 (Ref. 33).

The tube side design inlet water temperature is 360 °F (max.) at a flow of 2 gpm; this flow stream is cooled to 250 °F to cool the pump seals. This operating condition is during normal shutdown conditions only. The Ref. 8 calculation indicates the seal cooler presently is capable of meeting the pump seal limit on exit temperature of 250 °F with the 5 gpm shell side cooling water design flow (equates to the minimum required flow of 6.5 gpm during normal non-accident conditions) at 104 °F with approximately 50% margin in heat removal capability. This indicates an adequate margin currently exists in the coolers to accommodate an increase in inlet service water temperature to 106 °F.

1(2) LPCS Motor Coolers [1(2)E21-C001]

These heat exchangers are a shell and coiled tube type, designed to cool lubricating oil surrounding the three sections of bearing in the LPCS motor. Based on a review of bearing temperature data for the months of June, July and August 2001 the maximum bearing temperatures experienced were at least 27 degrees below the corresponding alarm set points (see Ref. 1, Attachment G). These pumps were operated several different times throughout the summer. These periods of operation were short duration runs, however from a review of the data they were long enough in nature to demonstrate the maximum running bearing temperatures (see Reference 1, Attachment B). The maximum service water temperature experienced during the summer of 2001 was 98.5°F on 7/24/01. Therefore, increasing the service water temperature by 7.5°F (up to 106°F), then correlating a 7.5 degree increase in bearing temperature will not challenge the alarm set points or operability of these components. The service water flow rates have met or exceeded the required flow rates based on current surveillances. They have no material condition issues that would impair the ability of the components to support a change of the maximum inlet temperature from 104 °F to 106 °F. (Based on Ref. 27, this evaluation is still valid).

Diesel Generator Heat Exchangers

The Diesel Generator Heat Exchangers (0, 1A, 1B, 2A, and 2B) have no material condition issues that would impair the ability of the components to support a change of the maximum CSCS inlet temperature from 104°F to 106°F. No tubes are currently plugged on these heat exchangers and their material condition is considered good. (Based on the Ref. 27 EC this assessment of material condition is still valid).

An assessment of the DG Heat Exchangers performance was made with 106°F inlet service water (See Attachments B & C). The approved heat exchanger computer models (Calc. Nos. 97-195 & 97-197) were utilized for this assessment.

The assessment of the Div. 3 HPCS Diesel heat exchanger determined that with an inlet cooling water temperature of 106 °F, the heat rejection capability of the heat exchanger is approximately 8.05 E06 Btu/hr, exceeding the design heat rejection rate of 7.8 E06 Btu/hr.

The assessment of the Div. 1 & 2 EDG heat exchangers determined that with an inlet cooling water temperature of 106 °F, the heat rejection capability of each of these heat exchangers is approximately 9.12 E06 Btu/hr, exceeding the design heat rejection rate of 8.6 E06 Btu/hr.

The fouling factors used in the evaluation were based on current design basis values that are greater than twice those measured in the most recent G.L. 89-13 testing of these heat exchangers. This fouling factor statement is still correct based on as-tested data documented in ECs 352723 and 352877.

ECCS Corner Room Coolers (VY01/2/3/4A)

Assessments were performed on all of the ECCS Corner Room Coolers at a service water inlet temperature of 106 °F (See Attachments D – G of EC 337958) using existing computer models with no tubes plugged (Reference 27). The entering air temperature to the coolers used is the current design basis of 148°F. The assessments demonstrated that at design fouling conditions, the VY01A, 03A & 04A room coolers all had positive margins of at least 8% over the required heat rejection capability. The 1VY04A Cooler was noted, based on Ref. 37, to have a degraded air flow rate approximately 2% below test acceptance criteria. The above stated evaluations and margins are based on including a 10% air flow rate reduction for the VY03A and VY04A coolers. This reduction in air flow bounds the actual measured reduction from a heat rejection capability standpoint.

Additionally, the cooler air flow rates used as input for the computer models were reviewed based on the changes in heat rejection caused by the higher inlet cooling water temperature. Sensitivity computer runs were performed to assess the impact of changes in coil inlet volumetric air flow due to small changes in air density. These effects were found to be negligible, (i.e. less than 1% impact on heat rejection capability).

For the VY02A HPCS Corner Room cooler the current design computer model contained a 5% tube plugging margin. Since no tubes are currently plugged, this cooler was evaluated at its current condition with all tubes in service. The HPCS corner room temperature is predicted to be 150 °F, when the inlet cooling water is at or near its peak of 106 °F (as noted in the section on EQ below this is for a short duration time period). This is the same peak room temperature predicted in the Reference 1 EC. Tthe potential Environmental Qualification (EQ) effects are addressed in the referenced EC and repeated in the section below on EQ. With the above input, the heat removal margin in the 1(2)VY02A coolers is approximately 1.5%. Though not specifically evaluated in this assessment, there is additional margin available in the VY02A coolers. Surveillance data indicates that both units' coolers have airflows approximately 5% higher than the design value. Experience has shown that this would result in approximately 3-4% of additional heat removal margin.

Summary of Specific Inputs used in the Computer Models to Assess Heat Exchanger Performance:

A summary table listing certain inputs and assumptions used in the detailed computer model assessment of the various heat exchangers and coolers discussed above is provided as Attachment M to this EC.

Environmental Qualification of Equipment:

The VY Corner Room cooler for the HPCS room has been analyzed to accommodate the HPCS room heat load. The UHS analysis determined that the peak cooling water inlet temperature occurs during the first 24-hours following the failure of the dike. This cooling water inlet temperature has been increased to 106°F to add margin for analysis purposes. At the 106°F inlet cooling water temperature the room is calculated to increase to 150°F. This room temperature has been evaluated as acceptable to the EQ components in this room under the Reference 1 EC. It should be noted this peak occurs for approximately 6 hours during the first 24 hours (per Reference 2, Figure G.7.1). Although not credited in this assessment, a qualitative review of the EQ data concluded that the equipment in the VY cooler room would likely be acceptable to temperatures of at least 160 °F for the 6 hour period.

Additional CSCS System Issues:

Existing calculations for CSCS System pressure losses and NPSH were based on 100°F (Reference 7). An increase in inlet water temperature from 100°F to 104°F was evaluated in the Reference 1 EC 334017. An additional 2 °F increase to 106 °F will not change the conclusions of that evaluation. The change results in a negligible change in water density and saturation pressure, two key parameters affecting system pressure losses and NPSH. Thus it can be concluded that the temperature increase has negligible impact on these parameters.

Changes in room ambient conditions from piping heat losses due to a 2 °F increase in cooling water temperature are judged to be negligible, given factors such as diurnal reductions in the peak UHS temperature and that most of the CSCS cooling water piping is insulated.

Heat Exchanger Fouling:

The short term operating periods anticipated for the higher cooling water inlet temperatures are not expected to significantly increase fouling in the heat exchangers evaluated. The plant's chemical feed injection system is used during normal plant operation to control lake water chemistry and minimize the potential for scaling of associated heat exchangers. One indicator of fouling resistance is main condenser performance. The condenser is being continuously subjected to heat loading and the higher lake temperatures, whereas most of the safety-related heat exchangers are not. The thermal performance engineer of System Engineering regularly monitors condenser performance. Significant increases in fouling will be detected by trending any changes in condenser performance.

<u>Non Safety Related Equipment:</u>

Fuel Pool Cooling (FC) Heat Exchangers

The station is equipped with two (100% capacity) Fuel Pool Cooling (FC) Heat Exchangers per unit. The original FC heat exchanger heat removal capacity was 14.5 E06 Btu/hr at a service water (cooling water) inlet design temperature of 95 °F and a 120 °F fuel pool temperature. As part of a 5% power uprate, the FC system safety design basis fuel pool temperature was changed to 140 °F at a service water (WS) inlet temperature of 100 °F (as given in the UFSAR Section 9.1.3.2.1.1).

In support of this evaluation, an assessment of FC heat exchanger performance, based on a conservative cooling water inlet temperature of 106 °F, was performed. The heat rejection capacity at a normal operating fuel pool temperature of 140 °F is estimated to be 23.86 E06 Btu/hr with 1% (11) of the tubes plugged (See Attachment I). None of the FC heat exchangers have any tube(s) plugged (Ref. 27). Based on Ref. 27, a bounding estimate for each unit's fuel pool heat load is 6.8 E06 Btu/hr. Thus, it can be concluded that the bulk fuel pool temperature can be maintained at or below 140°F with 106°F inlet service water (cooling water).

An evaluation of the FC system's ability to cope with an emergency full reactor core off-load was also made. The Standard Review Plan Section 9.1.3 "Spent Fuel Cooling and Cleanup System" requires for the case of an (abnormal) emergency full core off-load, the fuel pool shall be maintained less than the boiling point and level maintained. The higher service water temperature will not impact the ability to maintain fuel pool level as this is accomplished with the FC portion of the system. UFSAR Table 9.1-6 indicates a peak temperature for an emergency full core off-load of 155.3 °F. The heat rejection capacity for these "emergency off-load" conditions at a fuel pool temperature of 155.3 °F and a service water inlet temperature of 106 °F is estimated to be 65.5 E06 Btu/hr (See Attachment J using both heat exchangers and pumps).

The maximum heat generation rate for the abnormal (emergency) core off-load case is 59.7 E06 Btu/hr (UFSAR Table 9.1-6). Thus, it can be concluded that the bulk fuel pool temperature can be maintained at or below 155.3 °F with 106 °F inlet service water (cooling water) even under these abnormal conditions. Additionally, the "B" RHR Heat Exchanger and pump is available as a backup to the FC System. The B-RHR heat exchanger heat rejection capacity is much greater since it has over 2.8 times the effective heat transfer area as the FC heat exchanger (Reference the effective areas shown in Attachments A & I).

Other Non Safety Related Components:

Non-safety related components were reviewed from an operational standpoint only, because the main concern is with their effect on power operation. They are not credited to mitigate any design basis events. Most components are reliability related and are monitored for parameters such as temperature and pressure. These components can be described as self-limiting, that is, operations personnel will respond to alarms and conditions in accordance with approved plant procedures, including load curtailment per LOA-CW 101/201, as required. These components could be subjected to the new temporary lake temperature (i.e. 102 °F). These components were evaluated in EC 334017 (Reference 1) for an inlet cooling water temperature of 104 . The main components are listed below and the discussion from the Reference 1 EC is repeated for completeness:

1(2) Main Condenser [1(2)CD01A]

The main condensers use lake water to condense steam returning from the turbine. The consequence of elevated lake temperature above the currently indicated circulating water (CW) system maximum of 100°F occurs in condenser backpressure and condensate temperature. If needed, Operations will execute load curtailment per LOA-CW-101, or -201 to maintain these parameters below their respective limits.

The CW system piping has been reviewed for a temperature of 115 – 120 °F (Reference NDIT LS-1111). This temperature does not impact the CW system piping, supports, or expansion joints. Thus, it is concluded that the condenser can tolerate a maximum lake inlet temperature of 104°F, however unit load curtailment may be necessary due to turbine backpressure limitations.

1(2) RBCCW Heat Exchanger [0(1)(2)WR01A/AA/AB]

The Reactor Building Closed Cooling Water Heat Exchangers remove heat from a closed cooling water loop supplied to heat exchangers within the Reactor Building. An engineering evaluation was previously performed under NDIT# LS-1106, Upgrade 0. This evaluation concluded "an increase of WS inlet temperature to 103°F will not adversely affect the ability of the WR (or RBCCW) system to provide adequate cooling to its associated system loads". A review of this engineering evaluation identified more than enough margin to account for a 1°F increase above what was previously reviewed hence enveloping a WS inlet temperature of 104°F without invalidating the conclusion.

1(2) TBCCW Heat Exchanger [1(2)WT01AA/AB]

The Turbine Building Closed Cooling Water Heat Exchangers remove heat from a closed cooling water loop supplied to heat exchangers within the Turbine Building. An engineering evaluation was previously performed under NDIT# LS-1107, Upgrade 0. This evaluation concluded "an increase of WS inlet temperature to 103°F will not adversely affect the ability of the WT (or TBCCW) system to provide adequate cooling to its associated system loads". A review of this engineering evaluation determined there is more than enough margin to account for a 1°F increase above what was previously reviewed hence enveloping a WS inlet temperature of 104°F without invalidating the conclusion. Per EC 341508, Ref. 9, the only change in tube plugging is with the 2B Heat Exchanger, which has less than 30 tubes plugged per Ref. 27. Based on the total number of tubes being 772, this represents approximately 4% of the tubes being plugged. The evaluation in NDIT LS-1107 listed above concludes the TBCCW outlet temperature from this heat exchanger leads the service water inlet temperature by 2 °F. A 104 °F inlet WS temperature implies that the TBCCW outlet temperature would be projected to be approximately 106 °F. There is still 4 °F margin up to the 110 °F TBCCW maximum supply temperature. The 4% reduction in number of available tubes has not significantly affected TBCCW Heat Exchanger performance, based on Reference 9. Thus, the TBCCW supply temperature design limit of 110 °F (NDIT LS-1107) will not be exceeded with a WS inlet temperature of 104 °F.

Iso-Phase Bus Duct Coolers (cooled by the WT system)

It should be noted that operational experience has shown that the Iso-phase bus duct coolers may experience elevated temperatures above their design maximums under a conservative set of weather and equipment conditions (95°F Air Temp., No Wind, Sunny, 104°F WS inlet, 1124 MW, 1 fan in operation). To mitigate these conditions and avoid exceeding the 167°F maximum design temperature, the Ref. 28 bus duct high temperature alarm response procedure requires the start of supplemental external bus duct cooling per LOP-GA-02 if the duct temperature reaches 167 °F.

1(2) Turbine Oil Coolers [1(2)TO01AA/AB]

The Turbine Oil coolers are designed to maintain turbine lube oil at 110 – 120°F. Under normal operating conditions, one cooler is in service with the other available as additional cooling needs warrant (see Ref. 1, Attachment E, GE Main Oil Coolers). It has been determined that the data used in the Reference 1 EC was taken prior to control system modifications which provided much improved operation of the service water temperature control valve. Based on plant walkdowns by System Engineering on 7/17/02 and 7/22/04, when cooling water inlet temperature was approximately 92 °F, the temperature control valve was approximately 20 - 25% open on both units. Based on this information and the lack of any lube oil high temperature concerns during the high lake temperatures of early August 2005, the turbine lube oil temperature is not expected to be a challenge to operation of the plant up to WS temperatures of 104 °F.

1(2) Primary Containment Drywell Ventilation Chiller 1(2)A/1(2)B/1(2)C [1(2)VP02AA/AB, 1(2)VP16A]

Technical Specification 3.6.1.5 requires the Drywell air temperature to not exceed 135°F. The design WS inlet for each chiller is 100°F. Under normal operation, one of the AA and AB units are in service with the VP16A serving as a backup to provide additional cooling. This additional margin provided by the backup chiller would provide ample cooling to maintain drywell air temperature below 135°F. Therefore, this equipment is expected to accommodate a 104 °F inlet WS temperature and be able to maintain acceptable drywell temperature.

Additional Turbine/Generator Related Components:

The following additional components were evaluated in EC 334017 (Reference 1) and found to be able to accommodate an inlet cooling water temperature of 104 °F:

1(2) Alternator Exciter Cooler [1(2)MP01A]
1(2) Hydrogen Generator Cooler [1(2)TG01AA/AB/AC/AD]
1(2) Stator Coolers [1(2)TG02AA/AB]

Temperature data cited in the Reference 1 EC demonstrates that the Stator Cooler will be close to the inlet high temperature alarm setpoint of 47 °C (116.6 °F). The Ref. 29 alarm response procedure requires that generator load be reduced as necessary to avoid exceeding the maximum limit on stator coolant return temperature.

Miscellaneous Considerations:

Lake make-up and blowdown are negligibly affected by this change. The make-up water is from the Illinois River to the cooling lake and thus is not affected by lake temperature. The blow down system discharges water from the lake, however the discharge is outside the UHS portion of the lake. Blowdown temperatures are addressed in the Summer Readiness Plan by the Chemistry Department (see Ref. 32).

The FP fire water pumps have been evaluated for the inlet temperature of 100°F. The specification for the pumps (J-2570) specified an operating temperature range of 32-100°F. The increase in inlet water temperature from 100 °F to 104°F results in a negligible change in water density and saturation pressure, two key parameters affecting system pressure losses and NPSH. Thus it can be concluded that the temperature increase has negligible impact on fire protection system performance or available NPSH.

To maintain the fire pump diesel engine jacket water temperature within the operating procedure and monthly surveillance normal band of 165 °F to 200 °F, the inlet cooling water pressure can be adjusted in the range from 5 to 55 psig to accommodate an increase in UHS cooling water temperature from 100 °F to 104 °F. If the jacket water temperature and/or cooling water pressure to the engine heat exchanger cannot be maintained in the normal band, procedures require the adjustment of the Engine Cooling Water Supply Regulating Valve or Engine Cooling Water Supply Regulator Bypass Downstream Stop Valve.

Based on information in the Ref. 34 vendor manual, the most temperature limiting components in the fire pump are those of soft materials such as natural rubber and synthetic materials. The general temperature limit provided for bearings of these materials is 125 °F, in excess of the peak UHS water temperature. Gaskets would have similar or higher limits.

EVALUATION OF ACCIDENT ANALYSIS

(Refer to Attachments K & L)

LOCA ANALYSIS

Short Term

The short term LOCA Peak Cladding Temperature (PCT) calculation is independent of Lake Temperature or service water temperature. The ECCS fluid temperature assumed in the analysis is based on a conservative suppression pool temperature. Since the PCT occurs very early in the accident and a conservative ECCS fluid temperature is used, a higher lake or service water temperature will not change the PCT calculation. The calculated results to meet the 10 CFR 50.46 criteria will not change.

Long Term

The post LOCA long term cooling required by 10 CFR 50.46 will also be acceptable with an increase in the lake / service water temperature. The lower 2/3 of the core will remain covered. Also, provided that at least 1 core spray system is available long-term, the upper third of the core will remain wetted by the core spray water, which will prevent further cladding perforation or metal-water reaction. As long as there is water in the suppression pool for core spray and 2/3 height coverage is maintained, higher lake/service water temperature of 106°F will have no significant impact upon LOCA long term cooling.

CONTAINMENT ANALYSIS

The short-term containment response is not affected by lake or service water temperatures. The short-term response is primarily driven by the mass and energy release and containment parameters. These are independent of lake and service water temperature.

An increase in the lake and service water temperature could have an impact on the long term containment response to a LOCA accident. The RHR service water temperature assumed in the suppression pool temperature analyses is 104 °F. The current analysis assumes 104 °F for the duration of the analysis. For the purpose of this evaluation it is postulated that the RHR service water temperature will increase as the ultimate heat sink is increasing to a postulated 106 °F (assumes the unlikely failure of the dike). However, even assuming a 106 °F RHR service water temperature for the duration of the event there will not be a significant impact upon the results. Sensitivity studies, Attachments K & L, were performed with a suppression pool model for the long term heat up analysis with the RHR service water temperature increased from 100 °F to 103 °F. This sensitivity analysis showed that there would be a 2 – 3 °F increase in the peak pool temperature response. The corresponding increase in the peak pool temperature response for an RHR service water temperature of 106°F is a 4 – 6 °F increase. The current post power uprate LaSalle peak suppression pool temperature has been evaluated to be 196.1 °F (Ref. 23 and UFSAR Section 6.2.2.3.5). Since the post-LOCA suppression pool temperature limit is 212 °F, the increase in service water temperature to 106 °F would result in acceptable margins to the limit and the containment/ ECCS equipment will perform the required safety functions. It is expected that in the long term (after the peak suppression pool temperature is mitigated), both RHR heat exchanger trains could be used to keep suppression pool temperature profile within the current analysis results.

Other long-term containment heat up analyses to show compliance to NUREG-0783 (Suppression Pool Temperature Limits for BWR Containment), would result in a similar change as discussed above. These analyses are primarily performed to verify acceptable safety-relief valve quencher performance. Power uprate calculations have been performed for LaSalle and show that the peak suppression pool temperature (bulk) is 190.7 °F for the SRV discharge case (Ref. 23). The acceptance limit for isolation scram containment analyses has been established at 206 °F (Ref. 23). The potential 4 – 6 °F increase due to a higher RHR service water temperature would still provide acceptable margins to the limit and the containment will perform the required safety function. It is expected as in the LOCA assessment above, both RHR heat exchanger trains could be used to keep suppression pool temperature profile within the current analysis results.

TRANSIENT ANALYSIS - UFSAR CHAPTER 5.2 AND 15

UFSAR Section 15.2.9 addresses the Failure of RHR Shutdown Cooling. This event assumes the operation of RHR for suppression pool cooling. The revised power uprate analysis (Ref. 23) assumes 100°F for the duration of the analysis, and an RHR Heat Exchanger heat transfer coefficient K value of 377 Btu/sec-°F. No credit is taken for passive structural heat sinks in the drywell and suppression chamber (airspace and pool) to conservatively maximize the calculated peak suppression pool temperature. The analysis results in a calculated peak suppression pool temperature of 210.4 °F for this event. However, Ref. 24 demonstrates that the current RHR HX K value is at least 416.6 Btu/sec-°F at pool temperatures of 170 °F to 212 °F with an inlet service water temperature of 104 °F. At the 104 °F inlet temperature and the higher K value, the calculated peak suppression pool temperature in Ref. 24 decreased by 5.5 °F from that calculated for the lower K value. Use of the higher current K value in the Ref. 23 would therefore more than offset the increase in peak pool temperature due to the 4 degree increase in the inlet service water temperature to 104°F (102°F + 2 °F margin). Since the suppression pool temperature limit for this event is 212°F, the increase in service water temperature would result in acceptable margins to the limit and the containment and RHR shutdown cooling will perform the required safety functions. It is expected that in the long term (after the peak suppression pool temperature is mitigated), both RHR heat exchanger trains could be used to keep suppression pool temperature profile within the current analysis results.

The balance of the Chapter 15 transient analysis, including Chapter 5.2 ASME vessel overpressurization, are short-term analyses of postulated events to verify core response, to set the fuel thermal limits, and to verify acceptable vessel overpressurization results. Most of these events either result in a scram or result in no significant change in thermal power. Since these events are only analyzed for the short-term response, there is no dependency on the lake temperature or service water temperature for the consequences of these events.

ATWS ANALYSIS - UFSAR SECTION 15.8

The ATWS analysis described in UFSAR Section 15.8 is a beyond design basis event. Analyses have been performed to show that with the installation of the SLCS, ARI and ATWS RPT systems that acceptable ATWS results could be attained. GE performed many of these generic calculations in NEDE-24222. In these calculations, GE stated "Due to the extremely low probability of the occurrence of an ATWS, nominal parameters and initial conditions have been used in the analyses. This is consistent with the NRC staff request." Therefore, it is not required to use a design maximum value for the ATWS analysis. However, it can be explicitly addressed as discussed below.

Power uprate ATWS analysis has been performed for LaSalle. This analysis assumed a service water temperature of 100 °F and a peak suppression pool temperature of 204 °F was calculated (ref. 6). A bounding assessment assumed that the peak suppression pool temperature would increase by the amount of service water temperature increase. Therefore, with a 4 °F increase to the suppression pool temperature (2°F due to the increased service water temperature and 2°F due to uncertainties), the peak temperature is not expected to exceed 212°F, which is the acceptance limit. It is expected that in the long term (after the peak suppression pool temperature is mitigated), both RHR heat exchanger trains could be used to keep suppression pool temperature profile within the current analysis results. Based on the discussion above, the ATWS analysis is acceptable with elevated lake and service water temperatures.

STATION BLACKOUT ANALYSIS - UFSAR SECTION 15.9

The Station Blackout (SBO) analysis discussed in UFSAR Section 15.9 is a beyond design basis event. This event requires the use of the RHR heat exchangers to remove the decay heat from the suppression pool. The Station Blackout event analysis is performed assuming a complete loss of AC for a four hour period. The coping analysis assumes operation of the RCIC and/or the HPCS system, but without crediting the HPCS diesel as an alternate AC source. Postulating a service water temperature of 104 °F (102°F + 2 °F margin) over the entire duration of the event will not significantly affect the peak suppression pool/drywell temperatures predicted in this event since no cooling is available until after AC power is restored. The effect of 104 °F service water temperature was evaluated in the Ref. 1 EC and it was shown that the RHR Heat Exchanger capability is still maintained at a 104 °F inlet cooling water temperature. Consequently, the increased cooling water temperature will have a negligible impact on this, since the cooling effectiveness of the RHR heat exchangers is maintained.

In addition, it should be noted that the SBO analysis was intended to be a best-estimate analysis, based on nominal decay heat values and typical system performance. Therefore it can be argued from a licensing basis that the analysis does not have to bound all postulated ranges of parameters.

10CFR50 APPENDIX R FIRE EVENT

Modeling assumptions for Appendix R analyses are similar to those for SBO. However, since the Appendix R event duration is much shorter than the assumed duration for SBO, the temperature response of the suppression pool is more limiting for the SBO event. (Ref. 36.)

GE SIL 636

General Electric (GE) has issued Services Information Letter (SIL) 636, Rev 1, which identifies that analyses that use decay heat curves from ANSI/ANS-5.1-1979 may be affected by additional actinides and activation products. Individually these actinides and activation products are negligible, but collectively they could have a non-negligible impact. For decay heat calculations that use a 2-sigma uncertainty adder, the effect upon decay heat is offset by the uncertainty up to 10^8 seconds. The specific concern identified in this SIL was evaluated in Operability Evaluation OE01-012 (which has since been closed). The effects of the change on decay heat have been included in the Reference 2 calculation for peak UHS temperature. The RHR Heat Exchanger was evaluated in the Reference 1 EC for these heat loads and was shown to meet or exceed its design basis heat rejection capability. The effects of the change in decay heat on the Fuel Pool Cooling and Cleanup System were addressed in Ref. 26. The effects of these changes in decay heat are negligible.

SUMMARY/CONCLUSION:

Per the above discussion and referenced documents, it has been demonstrated that increasing the maximum allowable temperature of cooling water supplied to the plant from the lake from 100°F to 102°F will have no adverse affect on the safety-related plant heat exchangers or the heat loads they serve. The design requirements of these interfacing components (heat exchangers) have been reviewed and a determination made that thermal margin exists to allow for the increased service water inlet temperature, while maintaining an acceptable heat transfer capability.

Limitations/Risks of Elevated Lake Temperature Operation:

It should be noted that from an operational standpoint the following nonsafety related components have the potential to be limiting during elevated lake water temperatures, i.e. these components may reach alarm setpoints during operation with an inlet service water temperature of >/=100°F (depending on actual condition of the equipment):

- Main Condensers
- Stator Coolers
- Iso-phase Bus Duct Coolers

Load curtailment per LOA-CW 101 or 201 may be required to ensure these components remain below the alarm set points. Refer to the above sections for further detail.

REFERENCES:

1. EC 334017, Increased Cooling Water Temperature Evaluation to a New Maximum of 104 °F.
2. Calculation L-002457, Rev. 4 – LaSalle County Station Ultimate Heat Sink Analysis
3. Calculation L-002453, Rev. 2, UHS Heat Load
4. EC# 336218, Rev. 0 – Lake Temperature Instrument Accuracy.
5. Procedure LOA-CW-101/201, Rev. 11 – Unit 1 / 2 Circ. Water System Abnormal.
6. GE-NE-A1300384-25-01-R1, LaSalle County Station Power Uprate Project, Task 902: Anticipated Transient Without Scram, June 2000
7. Calculation L-001355, Rev. 4C, LaSalle Station CSCS Hydraulic Model
8. Calculation L-000711, Rev. 4C – Evaluation of RHR Service Water Flow through RHR Pump Seal Coolers.
9. EC 341508, "EVALUATE MATERIAL CONDITION OF HEAT EXCHANGERS TO SUPPORT INCREASED LAKE TEMPERATURE EVALUATION FOR NOED… "
10. Calc. # 97-195, Rev. A00; Diesel Generator Jacket Water Coolers
11. Calc. # 97-196, Rev. A02; Spent Fuel Pool Coolers
12. Calc. # 97-197, Rev. A00; HPCS Diesel Generator Coolers
13. Calc. # 97-198, Rev. A01; LPCS Pump Room Coolers
14. Calc. # 97-199, Rev. B01; B & C RHR Pump Room Coolers
15. Calc. # 97-200, Rev. A01; A RHR Pump Room Coolers
16. Calc. # 97-201, Rev. A01; RHR Heat Exchangers
17. Calc. # L-002404, Rev. 2A, CSCS Cooling Water System "Road Map" Calculation.
18. EC 337958, dated 7-17-02, "ASSESSMENT OF HIGH LAKE TEMPERATURE UPON THE FUNCTIONALITY OF THE PLANT…"
19. EC 340686 Evaluation of Thermal Performance Test Results for the 2A RHR HX
20. EC 352877 Evaluation of Thermal Performance Test Results for the 2A DG HX
21. EC 352723 Evaluation of Thermal Performance Test Results for the 1B HPCS DG HX
22. EC 343719 Evaluate Material Condition of Heat Exchangers to Support Increased Lake Temperature Evaluation for NOED
23. Calc. #L-002874, Rev. 0, LaSalle County Station Power Uprate Project Task 400: Containment System (GE-NE-A1300384-02-01-R3)
24. Calc. L-002857, Rev. 000A, LSCS RHR Heat Exchangers K Factor Sensitivity Study, 1(2)RHR01A & B
25. EC 350219 Evaluation of Unit 1B RHR Heat Exchanger Thermal Performance Test
26. Calc. L-002948, Rev. 1, LaSalle County Station Power Uprate Project Task 603: Project Task Report – Fuel Pool Cooling and Cleanup System (GE-NE-A13-00384-35-02-R2)

27. EC 355042 Evaluate Material Condition of Heat Exchangers to Support Increased Lake Temperature Evaluation for NOED
28. LOR-1(2)PM01J-A315 Rev. 1, Isolated Phase Bus Duct Temp Hi
29. LOR-1(2)PL19JA-1-3 Rev. 0(1), Generator Stator Coolant Inlet Temperature High
30. EC 350308 Assessment of High Lake Temperature On the Functionality of the Plant (Summer Readiness 2004); Input for Contingency NOED T.S. SR 3.7.3.1
31. LOP-GA-02 Rev. 9, Isolation Phase Bus Duct Cooling System Startup and Shutdown
32. EN-LA-402-0005 Rev. 5, Extreme Heat Implementation Plan – LaSalle
33. Work Orders for LTS-200-9 RHR Pump Seal Cooler Flowrate Tests:
    1E12-C002A – WO # 00776656 01 completed 5/4/05,
    1E12-C002B – WO # 00805264 01 completed 7/22/05,
    2E12-C002A – WO # 00793701 04 completed 6/3/05,
    2E12-C002B – WO # 00789817 04 completed 6/27/05.
34. VTIP Binder J-0025, Rev. 006, Tab 001, Doc. No. P115-0043, pg. 28, Peerless Pump – Maintenance Instructions
35. GE-NE-A1300384-12-01, Rev. 0, LaSalle County Station Power Uprate Project, Task 310: Residual Heat Removal System, October 1999
36. Calc. L-002489, Rev. 3A, Suppression Pool Temperature Transient Analysis
37. Work Order # 00594676 completed 4/7/05 for 1VY04A Air Flow Surveillance Test (LTS-200-19); WO # 00583521, 5/24/05 for the 1VY03A; WO # 00581940, 4/14/05 for the 2VY02A; WO # 00678686, 5/19/05 for the 2VY03A.

Attachments (to hardcopy):

A. RHR Heat Exchanger Computer Model Printouts
B. 0, 1A, 2A DG Heat Exchanger Computer Model Printouts
C. 1B, 2B DG (HPCS) Heat Exchanger Computer Model Printouts
D. VY01A Cooler Heat Exchanger Computer Model Printouts
E. VY02A Cooler Heat Exchanger Computer Model Printouts
F. VY03A Cooler Heat Exchanger Computer Model Printouts
G. VY04A Cooler Heat Exchanger Computer Model Printouts
H. VY Cooler Air Flow Trending Data (from System Engr Notebook as of 4-25-03)
I. FC Heat Exchanger Computer Model Printouts
J. FC Heat Exchanger Computer Model Printouts-Emergency Offload Case
K. Letter dated 7-21-01 from K. Ramsden to D. Bost "Assessment of High Lake Temperature Upon the Transient and Accident Analyses"
L. NFM Memo BSA-99-071, R. Tsai to D. Bost dated 7-29-99.
M. Table – Hx Model Results for 106°F Inlet Water Temperatures.

EC 356645

ATTACHMENT A

17:34:17 **PROTO-HX 3.02 by Proto-Power Corporation (SN#663-7371)** 07/12/02

Commonwealth Edison

Calculation Report for E12-B001 - LSCS - RHR Hx.

CCM-5% Plug;CSCS=106 F; 2 X Test FF

REF. CALC. 97-201, REV. A00

Calculation Specifications

Constant Inlet Temperature Method Was Used
Extrapolation Was to User Specified Conditions
Fouling Was Input by User

Test Data		Extrapolation Data	
Data Date		Tube Flow (gpm)	7,348.0
Shell Flow (gpm)		Shell Flow (gpm)	6,905.0
Shell Temp In (°F)		Tube Inlet Temp (°F)	106.0
Shell Temp Out (°F)		Shell Inlet Temp (°F)	212.0
Tube Flow (gpm)			
Tube Temp In (°F)			
Tube Temp Out (°F)		Input Fouling Factor	0.001300

Fouling Calculation Results

Shell Mass Flow (lbm/hr)		U Overall (BTU/hr·ft²·°F)	
Tube Mass Flow (lbm/hr)		Shell-Side ho (BTU/hr·ft²·°F)	
		Tube-Side hi (BTU/hr·ft²·°F)	
Heat Transferred (BTU/hr)		1/Wall Resis (BTU/hr·ft²·°F)	
LMTD		LMTD Correction Factor	
Effective Area (ft²)			
		Overall Fouling (hr·ft²·°F/BTU)	

G.L. 89-13 TESTING
HIGHEST VALUE
ff = 0.00065

Property	Shell-Side	Tube-Side		
Velocity (ft/s)			Shell Temp In (°F)	
Reynold's Number			Shell Temp Out (°F)	
Prandtl Number			Tav Shell (°F)	
Bulk Visc (lbm/ft·hr)			Shell Skin Temp (°F)	
Skin Visc (lbm/ft·hr)			Tube Temp In (°F)	
Density (lbm/ft³)			Tube Temp Out (°F)	
Cp (BTU/lbm·°F)			Tav Tube (°F)	
K (BTU/hr·ft·°F)			Tube Skin Temp (°F)	

Ref. ~~[illegible]~~ CALC. L-002571, R.0
NDIT LS-1154, R.0

Extrapolation Calculation Results

Shell Mass Flow (lbm/hr)	3.454E+6	Overall Fouling (hr·ft²·°F/BTU)	0.001300
Tube Mass Flow (lbm/hr)	3.676E+6	Shell-Side ho (BTU/hr·ft²·°F)	1,126.0
		Tube-Side hi (BTU/hr·ft²·°F)	2,078.4
Heat Transferred (BTU/hr)	1.717E+8	1/Wall Resis (BTU/hr·ft²·°F)	2,148.1
LMTD	57.8	LMTD Correction Factor	0.8714
Effective Area (ft²)	10,926.6		
		U Overall (BTU/hr·ft²·°F)	311.8

Property	Shell-Side	Tube-Side		
Velocity (ft/s)	3.26	7.08	Shell Temp In (°F)	212.0
Reynold's Number	5.566E+04	6.902E+04	Shell Temp Out (°F)	162.4
Prandtl Number	2.06	3.31	Tav Shell (°F)	187.2
Bulk Visc (lbm/ft·hr)	0.80	1.24	Shell Skin Temp (°F)	171.2
Skin Visc (lbm/ft·hr)	0.89	1.13	Tube Temp In (°F)	106.0
Density (lbm/ft³)	60.41	61.56	Tube Temp Out (°F)	152.8
Cp (BTU/lbm·°F)	1.00	1.00	Tav Tube (°F)	129.4
K (BTU/hr·ft·°F)	0.39	0.37	Tube Skin Temp (°F)	139.4

** Reynolds Number Outside Range of Equation Applicability
!! With Minimum Fouling The Test Heat Load Could Not Be Achie

Commonwealth Edison

Calculation Report for E12-B001 - LSCS - RHR Hx.

CCM-5% Plug;CSCS=106 F; 2 X Test FF

Shell and Tube Heat Exchanger Input Parameters

		Shell-Side	Tube-Side
Fluid Quantity, Total	gpm	7,446.28	7,396.31
Inlet Temperature	°F	120.00	90.00
Outlet Temperature	°F	108.80	101.25
Fouling Factor		0.00250	0.00000

Shell Fluid Name	Fresh Water
Tube Fluid Name	Fresh Water
Design Heat Transfer (BTU/hr)	41,600,000
Design Heat Trans Coeff (BTU/hr·ft²·°F)	215.00
Emprical Factor for Outside h	0.563555000
Performance Factor (% Reduction)	0.00
Heat Exchanger Type	TEMA-E
Effective Area (ft^2)	11,500.00
Area Factor	0.996344561
Area Ratio	
Number of Shells per Unit	1
Shell Minimum Area	4.880000000
Shell Velocity (ft/s)	3.400
Tube Pitch (in)	1.0000
Tube Pitch Type	Triangular
Number of Tube Passes	2
U-Tubes	Yes
Total Number of Tubes	1,063
Number of Active Tubes	1,010
Tube Length (ft)	55.30
Tube Inside Diameter (in)	0.652
Tube Outside Diameter (in)	0.750
Tube Wall Conductivity (BTU/hr·ft·°F)	9.40
Ds, Shell Inside Diameter (in)	0.000
Lbc, Central Baffle Spacing (in)	0.000
Lbi, Inlet Baffle Spacing (in)	0.000
Lbo, Outlet Baffle Spacing (in)	0.000
Dotl, Tube circle diameter (in)	0.000
Bh, Baffle cut height (in)	0.000
Lsb, Diametral difference between Baffle and Shell (in)	0.000
Ltb, Diametral difference between Tube and Baffle (in)	0.000
Nss, Number Sealing Strips	0.000

17:41:00 **PROTO-HX 3.02 by Proto-Power Corporation (SN#663-7371)** 07/12/02

Commonwealth Edison

Calculation Report for E12-B001 - LSCS - RHR Hx.

SDC-5% Plug;2 X Test FF;CSCS=106 F

Calculation Specifications

Constant Inlet Temperature Method Was Used
Extrapolation Was to User Specified Conditions
Fouling Was Input by User

Test Data

Data Date	
Shell Flow (gpm)	
Shell Temp In (°F)	
Shell Temp Out (°F)	
Tube Flow (gpm)	
Tube Temp In (°F)	
Tube Temp Out (°F)	

Extrapolation Data

Tube Flow (gpm)	7,348.0
Shell Flow (gpm)	7,124.0
Tube Inlet Temp (°F)	106.0
Shell Inlet Temp (°F)	120.0
Input Fouling Factor	0.001300

Fouling Calculation Results

Shell Mass Flow (lbm/hr)	
Tube Mass Flow (lbm/hr)	
Heat Transferred (BTU/hr)	
LMTD	
Effective Area (ft²)	

Property	Shell-Side	Tube-Side
Velocity (ft/s)		
Reynold's Number		
Prandtl Number		
Bulk Visc (lbm/ft·hr)		
Skin Visc (lbm/ft·hr)		
Density (lbm/ft³)		
Cp (BTU/lbm·°F)		
K (BTU/hr·ft·°F)		

U Overall (BTU/hr·ft²·°F)	
Shell-Side ho (BTU/hr·ft²·°F)	
Tube-Side hi (BTU/hr·ft²·°F)	
1/Wall Resis (BTU/hr·ft²·°F)	
LMTD Correction Factor	
Overall Fouling (hr·ft²·°F/BTU)	
Shell Temp In (°F)	
Shell Temp Out (°F)	
Tav Shell (°F)	
Shell Skin Temp (°F)	
Tube Temp In (°F)	
Tube Temp Out (°F)	
Tav Tube (°F)	
Tube Skin Temp (°F)	

Extrapolation Calculation Results

Shell Mass Flow (lbm/hr)	3.564E+6
Tube Mass Flow (lbm/hr)	3.676E+6
Heat Transferred (BTU/hr)	2.223E+7
LMTD	7.8
Effective Area (ft²)	10,926.6

Property	Shell-Side	Tube-Side
Velocity (ft/s)	3.29	7.05
Reynold's Number	3.291E+04	5.691E+04
Prandtl Number	3.76	4.09
Bulk Visc (lbm/ft·hr)	1.39	1.50
Skin Visc (lbm/ft·hr)	1.42	1.48
Density (lbm/ft³)	61.76	61.87
Cp (BTU/lbm·°F)	1.00	1.00
K (BTU/hr·ft·°F)	0.37	0.37

Overall Fouling (hr·ft²·°F/BTU)	0.001300
Shell-Side ho (BTU/hr·ft²·°F)	962.1
Tube-Side hi (BTU/hr·ft²·°F)	1,857.1
1/Wall Resis (BTU/hr·ft²·°F)	2,148.1
LMTD Correction Factor	0.8878
U Overall (BTU/hr·ft²·°F)	292.0
Shell Temp In (°F)	120.0
Shell Temp Out (°F)	113.8
Tav Shell (°F)	116.9
Shell Skin Temp (°F)	114.5
Tube Temp In (°F)	106.0
Tube Temp Out (°F)	112.1
Tav Tube (°F)	109.0
Tube Skin Temp (°F)	110.4

** Reynolds Number Outside Range of Equation Applicability
!! With Minimum Fouling The Test Heat Load Could Not Be Achie

Shell and Tube Heat Exchanger Input Parameters

		Shell-Side	Tube-Side
Fluid Quantity, Total	gpm	7,446.28	7,396.31
Inlet Temperature	°F	120.00	90.00
Outlet Temperature	°F	108.80	101.25
Fouling Factor		0.00250	0.00000

Shell Fluid Name	Fresh Water
Tube Fluid Name	Fresh Water
Design Heat Transfer (BTU/hr)	41,600,000
Design Heat Trans Coeff (BTU/hr·ft²·°F)	215.00
Emprical Factor for Outside h	0.563555000
Performance Factor (% Reduction)	0.00
Heat Exchanger Type	TEMA-E
Effective Area (ft^2)	11,500.00
Area Factor	0.996344561
Area Ratio	
Number of Shells per Unit	1
Shell Minimum Area	4.880000000
Shell Velocity (ft/s)	3.400
Tube Pitch (in)	1.0000
Tube Pitch Type	Triangular
Number of Tube Passes	2
U-Tubes	Yes
Total Number of Tubes	1,063
Number of Active Tubes	1,010
Tube Length (ft)	55.30
Tube Inside Diameter (in)	0.652
Tube Outside Diameter (in)	0.750
Tube Wall Conductivity (BTU/hr·ft·°F)	9.40
Ds, Shell Inside Diameter (in)	0.000
Lbc, Central Baffle Spacing (in)	0.000
Lbi, Inlet Baffle Spacing (in)	0.000
Lbo, Outlet Baffle Spacing (in)	0.000
Dotl, Tube circle diameter (in)	0.000
Bh, Baffle cut height (in)	0.000
Lsb, Diametral difference between Baffle and Shell (in)	0.000
Ltb, Diametral difference between Tube and Baffle (in)	0.000
Nss, Number Sealing Strips	0.000

15:36:33 **PROTO-HX 3.02 by Proto-Power Corporation (SN#663-7371)** ATTACHMENT B 07/16/02

Commonwealth Edison

Calculation Report for DG01A - DG Jacket Water Cooler

CSCS = 106 F, all tubes

Ref. Calc.# 97-195

Calculation Specifications

Constant Inlet Temperature Method Was Used
Extrapolation Was to User Specified Conditions
Fouling Was Input by User

Test Data		Extrapolation Data	
Data Date		Tube Flow (gpm)	795.3
Shell Flow (gpm)		Shell Flow (gpm)	1,064.5
Shell Temp In (°F)		Tube Inlet Temp (°F)	106.0
Shell Temp Out (°F)		Shell Inlet Temp (°F)	190.0
Tube Flow (gpm)			
Tube Temp In (°F)			
Tube Temp Out (°F)		Input Fouling Factor	0.002200

Fouling Calculation Results

Shell Mass Flow (lbm/hr)		U Overall (BTU/hr·ft²·°F)	
Tube Mass Flow (lbm/hr)		Shell-Side ho (BTU/hr·ft²·°F)	
		Tube-Side hi (BTU/hr·ft²·°F)	
Heat Transferred (BTU/hr)		1/Wall Resis (BTU/hr·ft²·°F)	
LMTD		LMTD Correction Factor	
Effective Area (ft²)			
		Overall Fouling (hr·ft²·°F/BTU)	

F.C. 89-13 TEST ff = 0.000534 (Ref. Calc. 97-195) 7/16/02

Property	Shell-Side	Tube-Side		
Velocity (ft/s)			Shell Temp In (°F)	
Reynold's Number			Shell Temp Out (°F)	
Prandtl Number			Tav Shell (°F)	
Bulk Visc (lbm/ft·hr)			Shell Skin Temp (°F)	
Skin Visc (lbm/ft·hr)			Tube Temp In (°F)	
Density (lbm/ft³)			Tube Temp Out (°F)	
Cp (BTU/lbm·°F)			Tav Tube (°F)	
K (BTU/hr·ft·°F)			Tube Skin Temp (°F)	

Extrapolation Calculation Results

Shell Mass Flow (lbm/hr)	5.325E+5	Overall Fouling (hr·ft²·°F/BTU)	0.002200
Tube Mass Flow (lbm/hr)	3.978E+5	Shell-Side ho (BTU/hr·ft²·°F)	2,029.9
		Tube-Side hi (BTU/hr·ft²·°F)	2,214.9
Heat Transferred (BTU/hr)	9.118E+6	1/Wall Resis (BTU/hr·ft²·°F)	25,594.8
LMTD	63.9	LMTD Correction Factor	0.9839
Effective Area (ft²)	471.2		
		U Overall (BTU/hr·ft²·°F)	307.6

Q = 8.6×10⁶ Btu/hr Design Basis

Property	Shell-Side	Tube-Side		
Velocity (ft/s)	4.99	8.21	Shell Temp In (°F)	190.0
Reynold's Number	8.224E+04	7.191E+04	Shell Temp Out (°F)	172.9
Prandtl Number	2.15	3.73	Tav Shell (°F)	181.5
Bulk Visc (lbm/ft·hr)	0.83	1.38	Shell Skin Temp (°F)	171.8
Skin Visc (lbm/ft·hr)	0.88	1.25	Tube Temp In (°F)	106.0
Density (lbm/ft³)	60.54	61.75	Tube Temp Out (°F)	128.9
Cp (BTU/lbm·°F)	1.00	1.00	Tav Tube (°F)	117.5
K (BTU/hr·ft·°F)	0.39	0.37	Tube Skin Temp (°F)	127.7

** Reynolds Number Outside Range of Equation Applicability
!! With Minimum Fouling The Test Heat Load Could Not Be Achie

Commonwealth Edison

Calculation Report for DG01A - DG Jacket Water Cooler

CSCS = 106 F, all tubes

Shell and Tube Heat Exchanger Input Parameters

		Shell-Side	Tube-Side
Fluid Quantity, Total	gpm	1,099.45	775.61
Inlet Temperature	°F	190.00	100.00
Outlet Temperature	°F	174.40	122.20
Fouling Factor		0.00220	0.00000

Shell Fluid Name	Fresh Water
Tube Fluid Name	Fresh Water
Design Heat Transfer (BTU/hr)	8,600,000
Design Heat Trans Coeff (BTU/hr-ft²-°F)	255.20
Emprical Factor for Outside h	0.780339000
Performance Factor (% Reduction)	0.00
Heat Exchanger Type	TEMA-E
Effective Area (ft^2)	471.23
Area Factor	0.981978184
Area Ratio	
Number of Shells per Unit	1
Shell Minimum Area	0.490000000
Shell Velocity (ft/s)	5.000
Tube Pitch (in)	0.7500
Tube Pitch Type	Triangular
Number of Tube Passes	2
U-Tubes	No
Total Number of Tubes	188 } ALL TUBES
Number of Active Tubes	188 }
Tube Length (ft)	13.00
Tube Inside Diameter (in)	0.652
Tube Outside Diameter (in)	0.750
Tube Wall Conductivity (BTU/hr-ft-°F)	112.00
Ds, Shell Inside Diameter (in)	0.000
Lbc, Central Baffle Spacing (in)	0.000
Lbi, Inlet Baffle Spacing (in)	0.000
Lbo, Outlet Baffle Spacing (in)	0.000
Dotl, Tube circle diameter (in)	0.000
Bh, Baffle cut height (in)	0.000
Lsb, Diametral difference between Baffle and Shell (in)	0.000
Ltb, Diametral difference between Tube and Baffle (in)	0.000
Nss, Number Sealing Strips	0.000

15:20:30 **PROTO-HX 3.02 by Proto-Power Corporation (SN#663-7371)** ATTACHMENT C 07/16/02

Commonwealth Edison

Calculation Report for DG01B - LSCS - HPCS DG Hx.

CSCS = 106 F; all tubes

Ref. Calculation No. 97-197

Calculation Specifications

Constant Inlet Temperature Method Was Used
Extrapolation Was to User Specified Conditions
Fouling Was Input by User

Test Data		Extrapolation Data	
Data Date		Tube Flow (gpm)	646.1
Shell Flow (gpm)		Shell Flow (gpm)	1,064.5
Shell Temp In (°F)		Tube Inlet Temp (°F)	106.0
Shell Temp Out (°F)		Shell Inlet Temp (°F)	190.0
Tube Flow (gpm)			
Tube Temp In (°F)			
Tube Temp Out (°F)		*Input Fouling Factor*	0.002230

Fouling Calculation Results

Shell Mass Flow (lbm/hr)		U Overall (BTU/hr·ft²·°F)	
Tube Mass Flow (lbm/hr)		Shell-Side ho (BTU/hr·ft²·°F)	
		Tube-Side hi (BTU/hr·ft²·°F)	
Heat Transferred (BTU/hr)		1/Wall Resis (BTU/hr·ft²·°F)	
LMTD		LMTD Correction Factor	
Effective Area (ft²)			
		Overall Fouling (hr·ft²·°F/BTU)	

G.L. 89-13 Testing
ff = 0.0011
(Ref. Calc. 97-197)

Property	Shell-Side	Tube-Side		
Velocity (ft/s)			Shell Temp In (°F)	
Reynold's Number			Shell Temp Out (°F)	
Prandtl Number			Tav Shell (°F)	
Bulk Visc (lbm/ft·hr)			Shell Skin Temp (°F)	
Skin Visc (lbm/ft·hr)			Tube Temp In (°F)	
Density (lbm/ft³)			Tube Temp Out (°F)	
Cp (BTU/lbm·°F)			Tav Tube (°F)	
K (BTU/hr·ft·°F)			Tube Skin Temp (°F)	

Extrapolation Calculation Results

Shell Mass Flow (lbm/hr)	5.325E+5	Overall Fouling (hr·ft²·°F/BTU)	0.002230
Tube Mass Flow (lbm/hr)	3.232E+5	Shell-Side ho (BTU/hr·ft²·°F)	1,890.4
		Tube-Side hi (BTU/hr·ft²·°F)	1,394.1
Heat Transferred (BTU/hr)	8.057E+6	1/Wall Resis (BTU/hr·ft²·°F)	15,431.0
LMTD	63.8	LMTD Correction Factor	0.9845
Effective Area (ft²)	468.2		
		U Overall (BTU/hr·ft²·°F)	273.8

$Q_{DESIGN\ REQ'D} = 7.80 \times 10^6$ Btu/hr

Property	Shell-Side	Tube-Side		
Velocity (ft/s)	5.58	4.34	Shell Temp In (°F)	190.0
Reynold's Number	7.718E+04	3.182E+04	Shell Temp Out (°F)	174.9
Prandtl Number	2.13	3.69	Tav Shell (°F)	182.5
Bulk Visc (lbm/ft·hr)	0.82	1.37	Shell Skin Temp (°F)	173.2
Skin Visc (lbm/ft·hr)	0.87	1.20	Tube Temp In (°F)	106.0
Density (lbm/ft³)	60.52	61.74	Tube Temp Out (°F)	131.0
Cp (BTU/lbm·°F)	1.00	1.00	Tav Tube (°F)	118.5
K (BTU/hr·ft·°F)	0.39	0.37	Tube Skin Temp (°F)	133.0

** Reynolds Number Outside Range of Equation Applicability
!! With Minimum Fouling The Test Heat Load Could Not Be Achie

Commonwealth Edison

Calculation Report for DG01B - LSCS - HPCS DG Hx.

CSCS = 106 F; all tubes

Shell and Tube Heat Exchanger Input Parameters

		Shell-Side	Tube-Side
Fluid Quantity, Total	gpm	1,064.46	795.25
Inlet Temperature	°F	190.00	100.00
Outlet Temperature	°F	175.00	121.00
Fouling Factor		0.00050	0.00193

Shell Fluid Name	Fresh Water
Tube Fluid Name	Fresh Water
Design Heat Transfer (BTU/hr)	8,505,000
Design Heat Trans Coeff (BTU/hr·ft²·°F)	241.70
Emprical Factor for Outside h	0.633693000
Performance Factor (% Reduction)	0.00
Heat Exchanger Type	TEMA-E
Effective Area (ft^2)	468.17
Area Factor	0.973212339
Area Ratio	
Number of Shells per Unit	1
Shell Minimum Area	0.438000000
Shell Velocity (ft/s)	5.600
Tube Pitch (in)	0.7500
Tube Pitch Type	Triangular
Number of Tube Passes	2
U-Tubes	No
Total Number of Tubes	420
Number of Active Tubes	420
Tube Length (ft)	7.00
Tube Inside Diameter (in)	0.541
Tube Outside Diameter (in)	0.625
Tube Wall Conductivity (BTU/hr·ft·°F)	58.00
Ds, Shell Inside Diameter (in)	0.000
Lbc, Central Baffle Spacing (in)	0.000
Lbi, Inlet Baffle Spacing (in)	19.688
Lbo, Outlet Baffle Spacing (in)	19.688
Dotl, Tube circle diameter (in)	0.000
Bh, Baffle cut height (in)	0.000
Lsb, Diametral difference between Baffle and Shell (in)	0.000
Ltb, Diametral difference between Tube and Baffle (in)	0.000
Nss, Number Sealing Strips	0.000

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Calculation Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY01A,CSCS=106 F, design FF,all tube

REF. CALC. NO. 97-200, REV. ... 7/17/...

Calculation Specifications

Constant Inlet Temperature Method Was Used
Extrapolation Was to User Specified Conditions
Design Fouling Factors Were Used

Test Data

Data Date	
Air Flow (acfm)	
Air Dry Bulb Temp In (°F)	
Air Dry Bulb Temp Out (°F)	
Relative Humidity In (%)	
Relative Humidity Out (%)	
Wet Bulb Temp In (°F)	
Wet Bulb Temp Out (°F)	
Atmospheric Pressure	
Tube Flow (gpm)	
Tube Temp In (°F)	
Tube Temp Out (°F)	
Condensate Temperature (°F)	

Extrapolation Data

Tube Flow (gpm)	75.00
Air Flow (acfm)	19,120.00
Tube Inlet Temp (°F)	106.00
Air Inlet Temp (°F)	148.0
Inlet Relative Humidity (%)	12.76
Inlet Wet Bulb Temp (°F)	0.00
Atmospheric Pressure	14.315

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Calculation Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY01A,CSCS=106 F, design FF,all tube

Extrapolation Calculation Summary

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	70,654.85	37,246.03	Tube-Side hi (BTU/hr·ft²·°F)	
Inlet Temperature (°F)	148.00	106.00	j Factor	
Outlet Temperature (°F)	114.03	122.16	Air-Side ho (BTU/hr·ft²·°F)	
Inlet Specific Humidity			Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Outlet Specific Humidity			Overall Fouling (hr·ft²·°F/BTU)	0.02882467
Average Temp (°F)				
Skin Temperature (°F)			U Overall (BTU/hr·ft²·°F)	
Velocity ***			Effective Area (ft²)	7,242.65
Reynold's Number			LMTD	
Prandtl Number			Total Heat Transferred (BTU/hr)	600,336
Bulk Visc (lbm/ft·hr)				
Skin Visc (lbm/ft·hr)			Surface Effectiveness (Eta)	
Density (lbm/ft³)			Sensible Heat Transferred (BTU/hr)	600,336
Cp (BTU/lbm·°F)			Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)			Heat to Condensate (BTU/hr)	

$Q_{REQUIRED}$ = 517 239 Btu/hr. ~16% MARGIN

Extrapolation Calculation for Row 1(Dry)

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	70,654.85	37,246.03	Tube-Side hi (BTU/hr·ft²·°F)	973.05
Inlet Temperature (°F)	148.00	118.94	j Factor	0.0082
Outlet Temperature (°F)	141.23	122.16	Air-Side ho (BTU/hr·ft²·°F)	8.24
Inlet Specific Humidity	0.0203		Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Outlet Specific Humidity	0.0203		Overall Fouling (hr·ft²·°F/BTU)	0.02882467
Average Temp (°F)	144.62	120.55		
Skin Temperature (°F)	127.02	123.14	U Overall (BTU/hr·ft²·°F)	5.53
Velocity ***	3,376.53	2.77	Effective Area (ft²)	905.33
Reynold's Number	796**	20,154	LMTD	23.88
Prandtl Number	0.7254	3.6138	Total Heat Transferred (BTU/hr)	119,633
Bulk Visc (lbm/ft·hr)	0.0490	1.3395		
Skin Visc (lbm/ft·hr)		1.3076	Surface Effectiveness (Eta)	0.9186
Density (lbm/ft³)	0.0623	61.7031	Sensible Heat Transferred (BTU/hr)	119,633
Cp (BTU/lbm·°F)	0.2402	0.9988	Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)	0.0162	0.3702	Heat to Condensate (BTU/hr)	

** Reynolds Number Outside Range of Equation Applicability

PAGE D2

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY01A,CSCS=106 F, design FF,all tube

Extrapolation Calculation for Row 2(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,654.85	37,246.03
Inlet Temperature (°F)	141.23	116.18
Outlet Temperature (°F)	135.41	118.94
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	138.32	117.56
Skin Temperature (°F)	123.15	119.82
Velocity ***	3,376.53	2.77
Reynold's Number	802**	19,591
Prandtl Number	0.7260	3.7278
Bulk Visc (lbm/ft·hr)	0.0486	1.3780
Skin Visc (lbm/ft·hr)		1.3488
Density (lbm/ft³)	0.0629	61.7491
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0161	0.3692

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	958.16
j Factor	0.0082
Air-Side ho (BTU/hr·ft²·°F)	8.21
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.51
Effective Area (ft²)	905.33
LMTD	20.60
Total Heat Transferred (BTU/hr)	102,820
Surface Effectiveness (Eta)	0.9189
Sensible Heat Transferred (BTU/hr)	102,820
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 3(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,654.85	37,246.03
Inlet Temperature (°F)	135.41	113.80
Outlet Temperature (°F)	130.41	116.18
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	132.91	114.99
Skin Temperature (°F)	119.83	116.96
Velocity ***	3,376.53	2.76
Reynold's Number	808**	19,111
Prandtl Number	0.7264	3.8306
Bulk Visc (lbm/ft·hr)	0.0483	1.4126
Skin Visc (lbm/ft·hr)		1.3860
Density (lbm/ft³)	0.0634	61.7876
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0160	0.3683

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	945.29
j Factor	0.0082
Air-Side ho (BTU/hr·ft²·°F)	8.19
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.49
Effective Area (ft²)	905.33
LMTD	17.78
Total Heat Transferred (BTU/hr)	88,459
Surface Effectiveness (Eta)	0.9191
Sensible Heat Transferred (BTU/hr)	88,459
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY01A,CSCS=106 F, design FF,all tube

Extrapolation Calculation for Row 4(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,654.85	37,246.03
Inlet Temperature (°F)	130.41	111.76
Outlet Temperature (°F)	126.10	113.80
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	128.25	112.78
Skin Temperature (°F)	116.96	114.49
Velocity ***	3,376.53	2.76
Reynold's Number	813**	18,702
Prandtl Number	0.7268	3.9229
Bulk Visc (lbm/ft·hr)	0.0480	1.4435
Skin Visc (lbm/ft·hr)		1.4195
Density (lbm/ft³)	0.0639	61.8201
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0159	0.3675

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	934.17
j Factor	0.0081
Air-Side ho (BTU/hr·ft²·°F)	8.17
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.48
Effective Area (ft²)	905.33
LMTD	15.36
Total Heat Transferred (BTU/hr)	76,172
Surface Effectiveness (Eta)	0.9192
Sensible Heat Transferred (BTU/hr)	76,172
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 5(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,654.85	37,246.03
Inlet Temperature (°F)	126.10	109.99
Outlet Temperature (°F)	122.39	111.76
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	124.24	110.87
Skin Temperature (°F)	114.49	112.36
Velocity ***	3,376.53	2.76
Reynold's Number	817**	18,351
Prandtl Number	0.7271	4.0053
Bulk Visc (lbm/ft·hr)	0.0478	1.4711
Skin Visc (lbm/ft·hr)		1.4494
Density (lbm/ft³)	0.0643	61.8476
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0158	0.3669

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	924.56
j Factor	0.0081
Air-Side ho (BTU/hr·ft²·°F)	8.15
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.46
Effective Area (ft²)	905.33
LMTD	13.27
Total Heat Transferred (BTU/hr)	65,642
Surface Effectiveness (Eta)	0.9194
Sensible Heat Transferred (BTU/hr)	65,642
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils
VY01A,CSCS=106 F, design FF,all tube

Extrapolation Calculation for Row 6(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,654.85	37,246.03
Inlet Temperature (°F)	122.39	108.47
Outlet Temperature (°F)	119.18	109.99
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	120.78	109.23
Skin Temperature (°F)	112.36	110.53
Velocity ***	3,376.53	2.76
Reynold's Number	821**	18,051
Prandtl Number	0.7274	4.0786
Bulk Visc (lbm/ft·hr)	0.0475	1.4956
Skin Visc (lbm/ft·hr)		1.4762
Density (lbm/ft³)	0.0647	61.8709
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0157	0.3663

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	916.25
j Factor	0.0081
Air-Side ho (BTU/hr·ft²·°F)	8.14
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.45
Effective Area (ft²)	905.33
LMTD	11.47
Total Heat Transferred (BTU/hr)	56,605
Surface Effectiveness (Eta)	0.9195
Sensible Heat Transferred (BTU/hr)	56,605
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 7(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,654.85	37,246.03
Inlet Temperature (°F)	119.18	107.16
Outlet Temperature (°F)	116.42	108.47
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	117.80	107.81
Skin Temperature (°F)	110.53	108.94
Velocity ***	3,376.53	2.76
Reynold's Number	824**	17,793
Prandtl Number	0.7276	4.1436
Bulk Visc (lbm/ft·hr)	0.0473	1.5172
Skin Visc (lbm/ft·hr)		1.4999
Density (lbm/ft³)	0.0650	61.8906
Cp (BTU/lbm·°F)	0.2402	0.9989
K (BTU/hr·ft·°F)	0.0156	0.3657

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	909.07
j Factor	0.0081
Air-Side ho (BTU/hr·ft²·°F)	8.12
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.44
Effective Area (ft²)	905.33
LMTD	9.91
Total Heat Transferred (BTU/hr)	48,842
Surface Effectiveness (Eta)	0.9196
Sensible Heat Transferred (BTU/hr)	48,842
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

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*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY01A,CSCS=106 F, design PF,all tube

Extrapolation Calculation for Row 8(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,654.85	37,246.03
Inlet Temperature (°F)	116.42	106.02
Outlet Temperature (°F)	114.03	107.16
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	115.23	106.59
Skin Temperature (°F)	108.94	107.57
Velocity ***	3,376.53	2.76
Reynold's Number	827**	17,572
Prandtl Number	0.7277	4.2010
Bulk Visc (lbm/ft·hr)	0.0472	1.5363
Skin Visc (lbm/ft·hr)		1.5210
Density (lbm/ft³)	0.0652	61.9075
Cp (BTU/lbm·°F)	0.2402	0.9989
K (BTU/hr·ft·°F)	0.0156	0.3653

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	902.86
j Factor	0.0081
Air-Side ho (BTU/hr·ft²·°F)	8.11
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.43
Effective Area (ft²)	905.33
LMTD	8.57
Total Heat Transferred (BTU/hr)	42,164
Surface Effectiveness (Eta)	0.9197
Sensible Heat Transferred (BTU/hr)	42,164
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

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*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

22:56:50 **PROTO-HX 3.01 by Proto-Power Corporation (SN#663-7371)** 07/16/02

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Data Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY01A,CSCS=106 F, design FF,all tube

Air Coil Heat Exchanger Input Parameters

	Air-Side	Tube-Side
Fluid Quantity, Total	21,179.00 acfm	150.00 gpm
Inlet Dry Bulb Temp	150.00 °F	105.00 °F
Inlet Wet Bulb Temp	92.00 °F	
Inlet Relative Humidity	%	
Outlet Dry Bulb Temperature	109.40 °F	115.30 °F
Outlet Wet Bulb Temp	84.10 °F	
Outlet Relative Humidity	%	

Tube Fluid Name	Fresh Water
Tube Fouling Factor	0.001500
Air-Side Fouling	0.000500 ← HIGHER AIR SIDE FOULING USED
Design Heat Transfer (BTU/hr)	750,000
Atmospheric Pressure	14.315
Sensible Heat Ratio	1.00
Performance Factor (% Reduction)	0.000
Heat Exchanger Type	Counter Flow
Fin Type	Circular Fins
Fin Configuration	LaSalle VY Coolers 01A/02A j = EXP[-2.5088 + -0.3436 * LOG(Re)]
Coil Finned Length (in)	104.250
Fin Pitch (Fins/Inch)	10.000
Fin Conductivity (BTU/hr·ft·°F)	128.000
Fin Tip Thickness (inches)	0.0120
Fin Root Thickness (inches)	0.0120
Circular Fin Height (inches)	1.495
Number of Coils Per Unit	2
Number of Tube Rows	8
Number of Tubes Per Row	20.00 } ALL TUBES IN SERVICE
Active Tubes Per Row	20.00 }
Tube Inside Diameter (in)	0.5270
Tube Outside Diameter (in)	0.6250
Longitudinal Tube Pitch (in)	1.500
Transverse Tube Pitch (in)	1.452
Number of Serpentines	1.000
Tube Wall Conductivity (BTU/hr·ft·°F)	225.00

ATTACHMENT 8

13:48:42 **PROTO-HX 3.01 by Proto-Power Corporation (SN#663-7371)** 07/16/02

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Data Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY02A 106 F; Dsn FF tube; Inc. Air FF

Ref. Calculation No. 97-200, Rev. ... 7/17/02

Air Coil Heat Exchanger Input Parameters

	Air-Side	Tube-Side
Fluid Quantity, Total	21,179.00 acfm	150.00 gpm
Inlet Dry Bulb Temp	150.00 °F	105.00 °F
Inlet Wet Bulb Temp	92.00 °F	
Inlet Relative Humidity	%	
Outlet Dry Bulb Temperature	109.40 °F	115.30 °F
Outlet Wet Bulb Temp	84.10 °F	
Outlet Relative Humidity	%	

Tube Fluid Name	Fresh Water
Tube Fouling Factor	0.001500
Air-Side Fouling	0.000500 ← HIGHER AIR SIDE FOULING
Design Heat Transfer (BTU/hr)	750,000
Atmospheric Pressure	14.315
Sensible Heat Ratio	1.00
Performance Factor (% Reduction)	0.000
Heat Exchanger Type	Counter Flow
Fin Type	Circular Fins
Fin Configuration	LaSalle VY Coolers 01A/02A
	j = EXP[-2.5088 + -0.3436 * LOG(Re)]
Coil Finned Length (in)	104.250
Fin Pitch (Fins/Inch)	10.000
Fin Conductivity (BTU/hr·ft·°F)	128.000
Fin Tip Thickness (inches)	0.0120
Fin Root Thickness (inches)	0.0120
Circular Fin Height (inches)	1.495
Number of Coils Per Unit	2
Number of Tube Rows	8
Number of Tubes Per Row	20.00 } ALL TUBES IN SERVICE
Active Tubes Per Row	20.00
Tube Inside Diameter (in)	0.5270
Tube Outside Diameter (in)	0.6250
Longitudinal Tube Pitch (in)	1.500
Transverse Tube Pitch (in)	1.452
Number of Serpentines	1.000
Tube Wall Conductivity (BTU/hr·ft·°F)	225.00

13:48:42 **PROTO-HX 3.01 by Proto-Power Corporation (SN#663-7371)** 07/16/2002

ComEd -- LaSalle

Calculation Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY02A 106 F; Dsn FF tube; Inc. Air FF

Calculation Specifications

Constant Inlet Temperature Method Was Used
Extrapolation Was to User Specified Conditions
Design Fouling Factors Were Used

Test Data

Data Date	
Air Flow (acfm)	
Air Dry Bulb Temp In (°F)	
Air Dry Bulb Temp Out (°F)	
Relative Humidity In (%)	
Relative Humidity Out (%)	
Wet Bulb Temp In (°F)	
Wet Bulb Temp Out (°F)	
Atmospheric Pressure	
Tube Flow (gpm)	
Tube Temp In (°F)	
Tube Temp Out (°F)	
Condensate Temperature (°F)	

Extrapolation Data

Tube Flow (gpm)	108.00	
Air Flow (acfm)	19,105.00	← CORRECTED DOWNWARD BASED ON AIR OUTLET TEMP. & DENSITY
Tube Inlet Temp (°F)	106.00	
Air Inlet Temp (°F)	150.0	
Inlet Relative Humidity (%)	12.76	
Inlet Wet Bulb Temp (°F)	0.00	
Atmospheric Pressure	14.315	

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Calculation Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY02A 106 F; Dsn FF tube; Inc. Air FF

Extrapolation Calculation Summary

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	70,250.97	53,634.29	Tube-Side hi (BTU/hr·ft²·°F)	
Inlet Temperature (°F)	150.00	106.00	j Factor	
Outlet Temperature (°F)	112.76	118.20	Air-Side ho (BTU/hr·ft²·°F)	
Inlet Specific Humidity			Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Outlet Specific Humidity			Overall Fouling (hr·ft²·°F/BTU)	0.02882467
Average Temp (°F)				
Skin Temperature (°F)			U Overall (BTU/hr·ft²·°F)	
Velocity ***			Effective Area (ft²)	7,242.65
Reynold's Number			LMTD	
Prandtl Number			Total Heat Transferred (BTU/hr)	655,870
Bulk Visc (lbm/ft·hr)				
Skin Visc (lbm/ft·hr)			Surface Effectiveness (Eta)	
Density (lbm/ft³)			Sensible Heat Transferred (BTU/hr)	655,870
Cp (BTU/lbm·°F)			Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)			Heat to Condensate (BTU/hr)	

$Q_{REQUIRED}$ = 646,235 Btu/hr

Extrapolation Calculation for Row 1(Dry)

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	70,250.97	53,634.29	Tube-Side hi (BTU/hr·ft²·°F)	1,278.20
Inlet Temperature (°F)	150.00	115.45	j Factor	0.0082
Outlet Temperature (°F)	141.62	118.20	Air-Side ho (BTU/hr·ft²·°F)	8.21
Inlet Specific Humidity	0.0213		Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Outlet Specific Humidity	0.0213		Overall Fouling (hr·ft²·°F/BTU)	0.02882467
Average Temp (°F)	145.81	116.83		
Skin Temperature (°F)	124.04	119.25	U Overall (BTU/hr·ft²·°F)	5.67
Velocity ***	3,357.23	3.98	Effective Area (ft²)	905.33
Reynold's Number	790**	28,013	LMTD	28.77
Prandtl Number	0.7253	3.7568	Total Heat Transferred (BTU/hr)	147,605
Bulk Visc (lbm/ft·hr)	0.0491	1.3877		
Skin Visc (lbm/ft·hr)		1.3560	Surface Effectiveness (Eta)	0.9189
Density (lbm/ft³)	0.0621	61.7602	Sensible Heat Transferred (BTU/hr)	147,605
Cp (BTU/lbm·°F)	0.2402	0.9988	Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)	0.0163	0.3689	Heat to Condensate (BTU/hr)	

** Reynolds Number Outside Range of Equation Applicability

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY02A 106 F; Dsn FF tube; Inc. Air FF

Extrapolation Calculation for Row 2(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,250.97	53,634.29
Inlet Temperature (°F)	141.62	113.19
Outlet Temperature (°F)	134.74	115.45
Inlet Specific Humidity	0.0213	
Outlet Specific Humidity	0.0213	
Average Temp (°F)	138.18	114.32
Skin Temperature (°F)	120.26	116.33
Velocity ***	3,357.23	3.98
Reynold's Number	798**	27,340
Prandtl Number	0.7260	3.8584
Bulk Visc (lbm/ft·hr)	0.0486	1.4219
Skin Visc (lbm/ft·hr)		1.3943
Density (lbm/ft³)	0.0629	61.7976
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0161	0.3681

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	1,261.16
j Factor	0.0082
Air-Side ho (BTU/hr·ft²·°F)	8.18
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.65
Effective Area (ft²)	905.33
LMTD	23.69
Total Heat Transferred (BTU/hr)	121,066
Surface Effectiveness (Eta)	0.9191
Sensible Heat Transferred (BTU/hr)	121,066
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 3(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,250.97	53,634.29
Inlet Temperature (°F)	134.74	111.33
Outlet Temperature (°F)	129.10	113.19
Inlet Specific Humidity	0.0213	
Outlet Specific Humidity	0.0213	
Average Temp (°F)	131.92	112.26
Skin Temperature (°F)	117.16	113.93
Velocity ***	3,357.23	3.98
Reynold's Number	804**	26,792
Prandtl Number	0.7265	3.9450
Bulk Visc (lbm/ft·hr)	0.0482	1.4509
Skin Visc (lbm/ft·hr)		1.4272
Density (lbm/ft³)	0.0635	61.8277
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0160	0.3674

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	1,247.13
j Factor	0.0082
Air-Side ho (BTU/hr·ft²·°F)	8.15
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.63
Effective Area (ft²)	905.33
LMTD	19.52
Total Heat Transferred (BTU/hr)	99,432
Surface Effectiveness (Eta)	0.9194
Sensible Heat Transferred (BTU/hr)	99,432
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

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*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY02A 106 F; Dan FF tube; Inc. Air FF

Extrapolation Calculation for Row 4(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,250.97	53,634.29
Inlet Temperature (°F)	129.10	109.81
Outlet Temperature (°F)	124.46	111.33
Inlet Specific Humidity	0.0213	
Outlet Specific Humidity	0.0213	
Average Temp (°F)	126.78	110.57
Skin Temperature (°F)	114.61	111.96
Velocity ***	3,357.23	3.98
Reynold's Number	810**	26,345
Prandtl Number	0.7269	4.0187
Bulk Visc (lbm/ft·hr)	0.0479	1.4756
Skin Visc (lbm/ft·hr)		1.4553
Density (lbm/ft³)	0.0640	61.8519
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0158	0.3667

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	1,235.56
j Factor	0.0081
Air-Side ho (BTU/hr·ft²·°F)	8.13
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.61
Effective Area (ft²)	905.33
LMTD	16.09
Total Heat Transferred (BTU/hr)	81,755
Surface Effectiveness (Eta)	0.9196
Sensible Heat Transferred (BTU/hr)	81,755
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 5(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,250.97	53,634.29
Inlet Temperature (°F)	124.46	108.55
Outlet Temperature (°F)	120.63	109.81
Inlet Specific Humidity	0.0213	
Outlet Specific Humidity	0.0213	
Average Temp (°F)	122.54	109.18
Skin Temperature (°F)	112.51	110.33
Velocity ***	3,357.23	3.97
Reynold's Number	814**	25,979
Prandtl Number	0.7272	4.0810
Bulk Visc (lbm/ft·hr)	0.0476	1.4964
Skin Visc (lbm/ft·hr)		1.4791
Density (lbm/ft³)	0.0644	61.8716
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0157	0.3662

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	1,226.01
j Factor	0.0081
Air-Side ho (BTU/hr·ft²·°F)	8.11
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.60
Effective Area (ft²)	905.33
LMTD	13.27
Total Heat Transferred (BTU/hr)	67,281
Surface Effectiveness (Eta)	0.9197
Sensible Heat Transferred (BTU/hr)	67,281
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

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*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY01A & 02A - CSCS Equipment Area Cooling Coils

VY02A 106 F; Dan FF tube; Inc. Air FF

Extrapolation Calculation for Row 6(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,250.97	53,634.29
Inlet Temperature (°F)	120.63	107.52
Outlet Temperature (°F)	117.49	108.55
Inlet Specific Humidity	0.0213	
Outlet Specific Humidity	0.0213	
Average Temp (°F)	119.06	108.03
Skin Temperature (°F)	110.78	108.99
Velocity ***	3,357.23	3.97
Reynold's Number	818**	25,679
Prandtl Number	0.7275	4.1334
Bulk Visc (lbm/ft·hr)	0.0474	1.5138
Skin Visc (lbm/ft·hr)		1.4992
Density (lbm/ft³)	0.0647	61.8876
Cp (BTU/lbm·°F)	0.2402	0.9989
K (BTU/hr·ft·°F)	0.0157	0.3658

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	1,218.14
j Factor	0.0081
Air-Side ho (BTU/hr·ft²·°F)	8.10
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.59
Effective Area (ft²)	905.33
LMTD	10.95
Total Heat Transferred (BTU/hr)	55,412
Surface Effectiveness (Eta)	0.9199
Sensible Heat Transferred (BTU/hr)	55,412
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 7(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,250.97	53,634.29
Inlet Temperature (°F)	117.49	106.66
Outlet Temperature (°F)	114.89	107.52
Inlet Specific Humidity	0.0213	
Outlet Specific Humidity	0.0213	
Average Temp (°F)	116.19	107.09
Skin Temperature (°F)	109.36	107.88
Velocity ***	3,357.23	3.97
Reynold's Number	821**	25,433
Prandtl Number	0.7277	4.1774
Bulk Visc (lbm/ft·hr)	0.0472	1.5285
Skin Visc (lbm/ft·hr)		1.5162
Density (lbm/ft³)	0.0650	61.9006
Cp (BTU/lbm·°F)	0.2402	0.9989
K (BTU/hr·ft·°F)	0.0156	0.3655

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	1,211.64
j Factor	0.0081
Air-Side ho (BTU/hr·ft²·°F)	8.09
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.58
Effective Area (ft²)	905.33
LMTD	9.04
Total Heat Transferred (BTU/hr)	45,666
Surface Effectiveness (Eta)	0.9200
Sensible Heat Transferred (BTU/hr)	45,666
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

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*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

Extrapolation Calculation for Row 8(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	70,250.97	53,634.29
Inlet Temperature (°F)	114.89	105.96
Outlet Temperature (°F)	112.76	106.66
Inlet Specific Humidity	0.0213	
Outlet Specific Humidity	0.0213	
Average Temp (°F)	113.83	106.31
Skin Temperature (°F)	108.19	106.97
Velocity ***	3,357.23	3.97
Reynold's Number	824**	25,231
Prandtl Number	0.7278	4.2143
Bulk Visc (lbm/ft·hr)	0.0471	1.5407
Skin Visc (lbm/ft·hr)		1.5304
Density (lbm/ft³)	0.0653	61.9113
Cp (BTU/lbm·°F)	0.2402	0.9989
K (BTU/hr·ft·°F)	0.0155	0.3652

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	1,206.27
j Factor	0.0081
Air-Side ho (BTU/hr·ft²·°F)	8.08
Tube Wall Resistance (hr·ft²·°F/BTU	0.00031430
Overall Fouling (hr·ft²·°F/BTU)	0.02882467
U Overall (BTU/hr·ft²·°F)	5.57
Effective Area (ft²)	905.33
LMTD	7.46
Total Heat Transferred (BTU/hr)	37,653
Surface Effectiveness (Eta)	0.9201
Sensible Heat Transferred (BTU/hr)	37,653
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY03A - CSCS Equipment Area Cooling Coils

CSCS=106 F,Dsn tube&inc.airFF;10%

REF. CALC. 97-199, Rev. 3

7/17/02

Calculation Specifications

Constant Inlet Temperature Method Was Used
Extrapolation Was to User Specified Conditions
Design Fouling Factors Were Used

Test Data

Data Date	
Air Flow (acfm)	
Air Dry Bulb Temp In (°F)	
Air Dry Bulb Temp Out (°F)	
Relative Humidity In (%)	
Relative Humidity Out (%)	
Wet Bulb Temp In (°F)	
Wet Bulb Temp Out (°F)	
Atmospheric Pressure	
Tube Flow (gpm)	
Tube Temp In (°F)	
Tube Temp Out (°F)	
Condensate Temperature (°F)	

Extrapolation Data

Tube Flow (gpm)	72.50
Air Flow (acfm)	25,210.00
Tube Inlet Temp (°F)	106.00
Air Inlet Temp (°F)	148.0
Inlet Relative Humidity (%)	12.76
Inlet Wet Bulb Temp (°F)	0.00
Atmospheric Pressure	14.315

10% AIR FLOW REDUCTION

14:55:12 **PROTO-HX 3.01 by Proto-Power Corporation (SN#663-7371)** 07/16/02

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Calculation Report for: 1(2)VY03A - CSCS Equipment Area Cooling Coils

CSCS=106 F,Dsn tube&inc.airFF;10%

10% AIR FLOW REDUCTION

Extrapolation Calculation Summary

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	93,159.45	36,004.50	Tube-Side hi (BTU/hr·ft²·°F)	
Inlet Temperature (°F)	148.00	106.00	j Factor	
Outlet Temperature (°F)	114.45	127.74	Air-Side ho (BTU/hr·ft²·°F)	
Inlet Specific Humidity			Tube Wall Resistance (hr·ft²·°F/BTU	0.00029413
Outlet Specific Humidity			Overall Fouling (hr·ft²·°F/BTU)	0.02700655
Average Temp (°F)				
Skin Temperature (°F)			U Overall (BTU/hr·ft²·°F)	
Velocity ***			Effective Area (ft²)	10,532.34
Reynold's Number			LMTD	
Prandtl Number			Total Heat Transferred (BTU/hr)	781,790
Bulk Visc (lbm/ft·hr)				
Skin Visc (lbm/ft·hr)			Surface Effectiveness (Eta)	
Density (lbm/ft³)			Sensible Heat Transferred (BTU/hr)	781,790
Cp (BTU/lbm·°F)			Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)			Heat to Condensate (BTU/hr)	

8% margin

Q_REQUIRED = 722,217 Btu/hr

Extrapolation Calculation for Row 1(Dry)

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	93,159.45	36,004.50	Tube-Side hi (BTU/hr·ft²·°F)	840.87
Inlet Temperature (°F)	148.00	124.58	j Factor	0.0074
Outlet Temperature (°F)	143.12	127.74	Air-Side ho (BTU/hr·ft²·°F)	8.28
Inlet Specific Humidity	0.0203		Tube Wall Resistance (hr·ft²·°F/BTU	0.00029413
Outlet Specific Humidity	0.0203		Overall Fouling (hr·ft²·°F/BTU)	0.02700655
Average Temp (°F)	145.56	126.16		
Skin Temperature (°F)	131.41	128.44	U Overall (BTU/hr·ft²·°F)	5.60
Velocity ***	3,773.57	2.23	Effective Area (ft²)	1,053.23
Reynold's Number	841**	17,098	LMTD	19.27
Prandtl Number	0.7253	3.4149	Total Heat Transferred (BTU/hr)	113,625
Bulk Visc (lbm/ft·hr)	0.0491	1.2719		
Skin Visc (lbm/ft·hr)		1.2460	Surface Effectiveness (Eta)	0.9267
Density (lbm/ft³)	0.0621	61.6138	Sensible Heat Transferred (BTU/hr)	113,625
Cp (BTU/lbm·°F)	0.2402	0.9989	Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)	0.0163	0.3720	Heat to Condensate (BTU/hr)	

** Reynolds Number Outside Range of Equation Applicability

PAGE F2

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

Extrapolation Calculation for Row 2(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	93,159.45	36,004.50
Inlet Temperature (°F)	143.12	121.70
Outlet Temperature (°F)	138.68	124.58
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	140.90	123.14
Skin Temperature (°F)	127.96	125.25
Velocity ***	3,773.57	2.23
Reynold's Number	846**	16,631
Prandtl Number	0.7258	3.5198
Bulk Visc (lbm/ft·hr)	0.0488	1.3076
Skin Visc (lbm/ft·hr)		1.2825
Density (lbm/ft³)	0.0625	61.6624
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0162	0.3711

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	828.48
j Factor	0.0074
Air-Side ho (BTU/hr·ft²·°F)	8.26
Tube Wall Resistance (hr·ft²·°F/BTU	0.00029413
Overall Fouling (hr·ft²·°F/BTU)	0.02700655
U Overall (BTU/hr·ft²·°F)	5.58
Effective Area (ft²)	1,053.23
LMTD	17.64
Total Heat Transferred (BTU/hr)	103,668
Surface Effectiveness (Eta)	0.9269
Sensible Heat Transferred (BTU/hr)	103,668
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 3(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	93,159.45	36,004.50
Inlet Temperature (°F)	138.68	119.06
Outlet Temperature (°F)	134.62	121.70
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	136.65	120.38
Skin Temperature (°F)	124.81	122.34
Velocity ***	3,773.57	2.23
Reynold's Number	851**	16,209
Prandtl Number	0.7261	3.6202
Bulk Visc (lbm/ft·hr)	0.0485	1.3416
Skin Visc (lbm/ft·hr)		1.3173
Density (lbm/ft³)	0.0630	61.7058
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0161	0.3702

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	817.12
j Factor	0.0073
Air-Side ho (BTU/hr·ft²·°F)	8.25
Tube Wall Resistance (hr·ft²·°F/BTU	0.00029413
Overall Fouling (hr·ft²·°F/BTU)	0.02700655
U Overall (BTU/hr·ft²·°F)	5.56
Effective Area (ft²)	1,053.23
LMTD	16.15
Total Heat Transferred (BTU/hr)	94,635
Surface Effectiveness (Eta)	0.9270
Sensible Heat Transferred (BTU/hr)	94,635
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

PAGE F1

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

Extrapolation Calculation for Row 4(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	93,159.45	36,004.50
Inlet Temperature (°F)	134.62	116.66
Outlet Temperature (°F)	130.91	119.06
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	132.76	117.86
Skin Temperature (°F)	121.93	119.67
Velocity ***	3,773.57	2.23
Reynold's Number	855**	15,827
Prandtl Number	0.7265	3.7161
Bulk Visc (lbm/ft·hr)	0.0483	1.3740
Skin Visc (lbm/ft·hr)		1.3506
Density (lbm/ft³)	0.0634	61.7445
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0160	0.3693

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	806.71
j Factor	0.0073
Air-Side ho (BTU/hr·ft²·°F)	8.23
Tube Wall Resistance (hr·ft²·°F/BTU	0.00029413
Overall Fouling (hr·ft²·°F/BTU)	0.02700655
U Overall (BTU/hr·ft²·°F)	5.55
Effective Area (ft²)	1,053.23
LMTD	14.79
Total Heat Transferred (BTU/hr)	86,431
Surface Effectiveness (Eta)	0.9271
Sensible Heat Transferred (BTU/hr)	86,431
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 5(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	93,159.45	36,004.50
Inlet Temperature (°F)	130.91	114.46
Outlet Temperature (°F)	127.52	116.66
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	129.21	115.56
Skin Temperature (°F)	119.30	117.24
Velocity ***	3,773.57	2.23
Reynold's Number	859**	15,481
Prandtl Number	0.7267	3.8074
Bulk Visc (lbm/ft·hr)	0.0481	1.4048
Skin Visc (lbm/ft·hr)		1.3823
Density (lbm/ft³)	0.0637	61.7792
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0159	0.3685

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	797.16
j Factor	0.0073
Air-Side ho (BTU/hr·ft²·°F)	8.21
Tube Wall Resistance (hr·ft²·°F/BTU	0.00029413
Overall Fouling (hr·ft²·°F/BTU)	0.02700655
U Overall (BTU/hr·ft²·°F)	5.53
Effective Area (ft²)	1,053.23
LMTD	13.55
Total Heat Transferred (BTU/hr)	78,974
Surface Effectiveness (Eta)	0.9273
Sensible Heat Transferred (BTU/hr)	78,974
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY03A - CSCS Equipment Area Cooling Coils

CSCS=106 F,Dsn tube&inc.airFF;10%

Extrapolation Calculation for Row 6(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	93,159.45	36,004.50
Inlet Temperature (°F)	127.52	112.46
Outlet Temperature (°F)	124.42	114.46
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	125.97	113.46
Skin Temperature (°F)	116.89	115.01
Velocity ***	3,773.57	2.23
Reynold's Number	862**	15,167
Prandtl Number	0.7270	3.8941
Bulk Visc (lbm/ft·hr)	0.0479	1.4339
Skin Visc (lbm/ft·hr)		1.4123
Density (lbm/ft³)	0.0641	61.8102
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0158	0.3678

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	788.41
j Factor	0.0073
Air-Side ho (BTU/hr·ft²·°F)	8.20
Tube Wall Resistance (hr·ft²·°F/BTU	0.00029413
Overall Fouling (hr·ft²·°F/BTU)	0.02700655
U Overall (BTU/hr·ft²·°F)	5.52
Effective Area (ft²)	1,053.23
LMTD	12.42
Total Heat Transferred (BTU/hr)	72,192
Surface Effectiveness (Eta)	0.9274
Sensible Heat Transferred (BTU/hr)	72,192
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 7(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	93,159.45	36,004.50
Inlet Temperature (°F)	124.42	110.62
Outlet Temperature (°F)	121.59	112.46
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	123.00	111.54
Skin Temperature (°F)	114.69	112.97
Velocity ***	3,773.57	2.22
Reynold's Number	866**	14,881
Prandtl Number	0.7272	3.9761
Bulk Visc (lbm/ft·hr)	0.0477	1.4614
Skin Visc (lbm/ft·hr)		1.4408
Density (lbm/ft³)	0.0644	61.8381
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0158	0.3671

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	780.38
j Factor	0.0073
Air-Side ho (BTU/hr·ft²·°F)	8.19
Tube Wall Resistance (hr·ft²·°F/BTU	0.00029413
Overall Fouling (hr·ft²·°F/BTU)	0.02700655
U Overall (BTU/hr·ft²·°F)	5.51
Effective Area (ft²)	1,053.23
LMTD	11.39
Total Heat Transferred (BTU/hr)	66,017
Surface Effectiveness (Eta)	0.9275
Sensible Heat Transferred (BTU/hr)	66,017
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

Extrapolation Calculation for Row 8(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	93,159.45	36,004.50
Inlet Temperature (°F)	121.59	108.94
Outlet Temperature (°F)	119.00	110.62
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	120.29	109.78
Skin Temperature (°F)	112.68	111.10
Velocity ***	3,773.57	2.22
Reynold's Number	869**	14,622
Prandtl Number	0.7274	4.0537
Bulk Visc (lbm/ft·hr)	0.0475	1.4873
Skin Visc (lbm/ft·hr)		1.4677
Density (lbm/ft³)	0.0647	61.8631
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0157	0.3665

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	773.01
j Factor	0.0073
Air-Side ho (BTU/hr·ft²·°F)	8.18
Tube Wall Resistance (hr·ft²·°F/BTU	0.00029413
Overall Fouling (hr·ft²·°F/BTU)	0.02700655
U Overall (BTU/hr·ft²·°F)	5.49
Effective Area (ft²)	1,053.23
LMTD	10.44
Total Heat Transferred (BTU/hr)	60,393
Surface Effectiveness (Eta)	0.9276
Sensible Heat Transferred (BTU/hr)	60,393
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 9(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	93,159.45	36,004.50
Inlet Temperature (°F)	119.00	107.41
Outlet Temperature (°F)	116.62	108.94
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	117.81	108.17
Skin Temperature (°F)	110.83	109.39
Velocity ***	3,773.57	2.22
Reynold's Number	872**	14,386
Prandtl Number	0.7276	4.1269
Bulk Visc (lbm/ft·hr)	0.0473	1.5117
Skin Visc (lbm/ft·hr)		1.4931
Density (lbm/ft³)	0.0649	61.8856
Cp (BTU/lbm·°F)	0.2402	0.9989
K (BTU/hr·ft·°F)	0.0156	0.3659

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	766.26
j Factor	0.0073
Air-Side ho (BTU/hr·ft²·°F)	8.17
Tube Wall Resistance (hr·ft²·°F/BTU	0.00029413
Overall Fouling (hr·ft²·°F/BTU)	0.02700655
U Overall (BTU/hr·ft²·°F)	5.48
Effective Area (ft²)	1,053.23
LMTD	9.57
Total Heat Transferred (BTU/hr)	55,266
Surface Effectiveness (Eta)	0.9277
Sensible Heat Transferred (BTU/hr)	55,266
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

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*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

Extrapolation Calculation for Row 10(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	93,159.45	36,004.50
Inlet Temperature (°F)	116.62	106.00
Outlet Temperature (°F)	114.45	107.41
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	115.54	106.70
Skin Temperature (°F)	109.15	107.83
Velocity ***	3,773.57	2.22
Reynold's Number	875**	14,171
Prandtl Number	0.7277	4.1957
Bulk Visc (lbm/ft·hr)	0.0472	1.5346
Skin Visc (lbm/ft·hr)		1.5170
Density (lbm/ft³)	0.0652	61.9059
Cp (BTU/lbm·°F)	0.2402	0.9989
K (BTU/hr·ft·°F)	0.0156	0.3653

** Reynolds Number Outside Range of Equation Applicability

Tube-Side hi (BTU/hr·ft²·°F)	760.06
j Factor	0.0073
Air-Side ho (BTU/hr·ft²·°F)	8.16
Tube Wall Resistance (hr·ft²·°F/BTU	0.00029413
Overall Fouling (hr·ft²·°F/BTU)	0.02700655
U Overall (BTU/hr·ft²·°F)	5.47
Effective Area (ft²)	1,053.23
LMTD	8.78
Total Heat Transferred (BTU/hr)	50,590
Surface Effectiveness (Eta)	0.9277
Sensible Heat Transferred (BTU/hr)	50,590
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

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*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Data Report for: 1(2)VY03A - CSCS Equipment Area Cooling Coils

CSCS=106 F,Dsn tube&inc.airFF;10%

Air Coil Heat Exchanger Input Parameters

	Air-Side	Tube-Side
Fluid Quantity, Total	31,066.00 acfm	180.00 gpm
Inlet Dry Bulb Temp	150.00 °F	105.00 °F
Inlet Wet Bulb Temp	92.00 °F	
Inlet Relative Humidity	%	
Outlet Dry Bulb Temperature	108.80 °F	117.70 °F
Outlet Wet Bulb Temp	84.00 °F	
Outlet Relative Humidity	%	

Tube Fluid Name	Fresh Water
Tube Fouling Factor	0.001500
Air-Side Fouling	0.000500
Design Heat Transfer (BTU/hr)	1,108,000
Atmospheric Pressure	14.315
Sensible Heat Ratio	1.00
Performance Factor (% Reduction)	0.000
Heat Exchanger Type	Counter Flow
Fin Type	Circular Fins
Fin Configuration	LaSalle Cooler 1(2)VY03A
	j = EXP[-2.5939 + -0.3438 * LOG(Re)]
Coil Finned Length (in)	108.000
Fin Pitch (Fins/Inch)	10.000
Fin Conductivity (BTU/hr·ft·°F)	128.000
Fin Tip Thickness (inches)	0.0120
Fin Root Thickness (inches)	0.0120
Circular Fin Height (inches)	1.452
Number of Coils Per Unit	2
Number of Tube Rows	10
Number of Tubes Per Row	24.00
Active Tubes Per Row	24.00
Tube Inside Diameter (in)	0.5270
Tube Outside Diameter (in)	0.6250
Longitudinal Tube Pitch (in)	1.400
Transverse Tube Pitch (in)	1.410
Number of Serpentines	1.000
Tube Wall Conductivity (BTU/hr·ft·°F)	225.00

ALL TUBES IN SERVICE

ATTACHMENT 6

17:45:47 PROTO-HX 3.01 by Proto-Power Corporation (SN#663-7371) 07/16/2002

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Calculation Report for: 1(2)VY04A-Front - CSCS Equipment Area Cooling Coils

CSCS =106 F; 10% less air flow

REF. CALC. 97-198, REV. [illegible]
[illegible]
7/18/02

Calculation Specifications

Constant Inlet Temperature Method Was Used
Extrapolation Was to User Specified Conditions
Design Fouling Factors Were Used

Test Data

Data Date	
Air Flow (acfm)	
Air Dry Bulb Temp In (°F)	
Air Dry Bulb Temp Out (°F)	
Relative Humidity In (%)	
Relative Humidity Out (%)	
Wet Bulb Temp In (°F)	
Wet Bulb Temp Out (°F)	
Atmospheric Pressure	
Tube Flow (gpm)	
Tube Temp In (°F)	
Tube Temp Out (°F)	
Condensate Temperature (°F)	

Extrapolation Data

Tube Flow (gpm)	39.20
Air Flow (acfm)	26,384.00 ← 10% LESS AIR FLOW
Tube Inlet Temp (°F)	106.00
Air Inlet Temp (°F)	148.0
Inlet Relative Humidity (%)	12.76
Inlet Wet Bulb Temp (°F)	0.00
Atmospheric Pressure	14.315

FRONT COIL — 424,918 Btu/hr
BACK COIL — 266,535

TOTAL — 691,453 Btu/hr

$Q_{REQR.}$ > 633,288 Btu/hr

~9% MARGIN

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Calculation Report for: 1(2)VY04A-Front - CSCS Equipment Area Cooling Coils

CSCS =106 F; 10% less air flow

Extrapolation Calculation Summary

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	97,497.78	19,467.26	Tube-Side hi (BTU/hr·ft²·°F)	
Inlet Temperature (°F)	148.00	106.00	j Factor	
Outlet Temperature (°F)	130.58	127.86	Air-Side ho (BTU/hr·ft²·°F)	
Inlet Specific Humidity			Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Outlet Specific Humidity			Overall Fouling (hr·ft²·°F/BTU)	0.02278812
Average Temp (°F)				
Skin Temperature (°F)			U Overall (BTU/hr·ft²·°F)	
Velocity ***			Effective Area (ft²)	2,870.05
Reynold's Number			LMTD	
Prandtl Number			Total Heat Transferred (BTU/hr)	424,898
Bulk Visc (lbm/ft·hr)				
Skin Visc (lbm/ft·hr)			Surface Effectiveness (Eta)	
Density (lbm/ft³)			Sensible Heat Transferred (BTU/hr)	424,898
Cp (BTU/lbm·°F)			Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)			Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 1(Dry)

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	97,497.78	19,467.26	Tube-Side hi (BTU/hr·ft²·°F)	282.62
Inlet Temperature (°F)	148.00	118.16	j Factor	0.0110
Outlet Temperature (°F)	143.56	129.30	Air-Side ho (BTU/hr·ft²·°F)	16.65
Inlet Specific Humidity	0.0203		Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Outlet Specific Humidity	0.0203		Overall Fouling (hr·ft²·°F/BTU)	0.02278812
Average Temp (°F)	145.78	123.73		
Skin Temperature (°F)	135.43	131.86	U Overall (BTU/hr·ft²·°F)	7.02
Velocity ***	5,077.44	0.72	Effective Area (ft²)	717.51
Reynold's Number	1,845	5,425	LMTD	21.51
Prandtl Number	0.7253	3.4990	Total Heat Transferred (BTU/hr)	108,323
Bulk Visc (lbm/ft·hr)	0.0491	1.3005		
Skin Visc (lbm/ft·hr)		1.2088	Surface Effectiveness (Eta)	0.8980
Density (lbm/ft³)	0.0620	61.6530	Sensible Heat Transferred (BTU/hr)	108,323
Cp (BTU/lbm·°F)	0.2402	0.9990	Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)	0.0163	0.3713	Heat to Condensate (BTU/hr)	

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY04A-Front - CSCS Equipment Area Cooling Coils

CSCS =106 F; 10% less air flow

Extrapolation Calculation for Row 2(Dry)

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	97,497.78	19,467.26	Tube-Side hi (BTU/hr·ft²·°F)	276.19
Inlet Temperature (°F)	143.56	116.31	j Factor	0.0110
Outlet Temperature (°F)	139.53	126.42	Air-Side ho (BTU/hr·ft²·°F)	16.61
Inlet Specific Humidity	0.0203		Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Outlet Specific Humidity	0.0203		Overall Fouling (hr·ft²·°F/BTU)	0.02278812
Average Temp (°F)	141.54	121.36		
Skin Temperature (°F)	132.14	128.91	U Overall (BTU/hr·ft²·°F)	6.95
Velocity ***	5,077.44	0.72	Effective Area (ft²)	717.51
Reynold's Number	1,855	5,307	LMTD	19.70
Prandtl Number	0.7257	3.5839	Total Heat Transferred (BTU/hr)	98,236
Bulk Visc (lbm/ft·hr)	0.0488	1.3293		
Skin Visc (lbm/ft·hr)		1.2408	Surface Effectiveness (Eta)	0.8982
Density (lbm/ft³)	0.0625	61.6904	Sensible Heat Transferred (BTU/hr)	98,236
Cp (BTU/lbm·°F)	0.2402	0.9988	Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)	0.0162	0.3705	Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 3(Dry)

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	97,497.78	19,467.26	Tube-Side hi (BTU/hr·ft²·°F)	252.37
Inlet Temperature (°F)	139.53	106.05	j Factor	0.0110
Outlet Temperature (°F)	134.71	118.16	Air-Side ho (BTU/hr·ft²·°F)	16.57
Inlet Specific Humidity	0.0203		Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Outlet Specific Humidity	0.0203		Overall Fouling (hr·ft²·°F/BTU)	0.02278812
Average Temp (°F)	137.12	112.10		
Skin Temperature (°F)	125.85	121.98	U Overall (BTU/hr·ft²·°F)	6.71
Velocity ***	5,077.44	0.72	Effective Area (ft²)	717.51
Reynold's Number	1,865	4,855	LMTD	24.46
Prandtl Number	0.7261	3.9519	Total Heat Transferred (BTU/hr)	117,703
Bulk Visc (lbm/ft·hr)	0.0486	1.4532		
Skin Visc (lbm/ft·hr)		1.3217	Surface Effectiveness (Eta)	0.8984
Density (lbm/ft³)	0.0630	61.8300	Sensible Heat Transferred (BTU/hr)	117,703
Cp (BTU/lbm·°F)	0.2402	0.9988	Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)	0.0161	0.3673	Heat to Condensate (BTU/hr)	

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

Calculation Report for: 1(2)VY04A-Front - CSCS Equipment Area Cooling Coils
CSCS =106 F; 10% less air flow

Extrapolation Calculation for Row 4(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	97,497.78	19,467.26
Inlet Temperature (°F)	134.71	105.96
Outlet Temperature (°F)	130.58	116.31
Inlet Specific Humidity	0.0203	
Outlet Specific Humidity	0.0203	
Average Temp (°F)	132.64	111.14
Skin Temperature (°F)	122.99	119.68
Velocity ***	5,077.44	0.72
Reynold's Number	1,876	4,808
Prandtl Number	0.7265	3.9938
Bulk Visc (lbm/ft·hr)	0.0483	1.4672
Skin Visc (lbm/ft·hr)		1.3505
Density (lbm/ft³)	0.0634	61.8439
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0160	0.3669

Tube-Side hi (BTU/hr·ft²·°F)	249.35
j Factor	0.0110
Air-Side ho (BTU/hr·ft²·°F)	16.53
Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Overall Fouling (hr·ft²·°F/BTU)	0.02278812
U Overall (BTU/hr·ft²·°F)	6.67
Effective Area (ft²)	717.51
LMTD	21.03
Total Heat Transferred (BTU/hr)	100,636
Surface Effectiveness (Eta)	0.8986
Sensible Heat Transferred (BTU/hr)	100,636
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Data Report for: 1(2)VY04A-Front - CSCS Equipment Area Cooling Coils

CSCS =106 F; 10% less air flow

Air Coil Heat Exchanger Input Parameters

	Air-Side	Tube-Side
Fluid Quantity, Total	33,546.00 acfm	118.00 gpm
Inlet Dry Bulb Temp	150.00 °F	105.00 °F
Inlet Wet Bulb Temp	92.00 °F	
Inlet Relative Humidity	%	
Outlet Dry Bulb Temperature	°F	°F
Outlet Wet Bulb Temp	°F	
Outlet Relative Humidity	%	

Tube Fluid Name	Fresh Water
Tube Fouling Factor	0.001500
Air-Side Fouling	0.000500 ← 2 HIGHER AIR SIDE FOULING
Design Heat Transfer (BTU/hr)	
Atmospheric Pressure	14.315
Sensible Heat Ratio	1.00
Performance Factor (% Reduction)	0.000
Heat Exchanger Type	Counter Flow
Fin Type	Circular Fins
Fin Configuration	LaSalle VY Cooler 04A
	j = EXP[-1.9210 + -0.3441 * LOG(Re)]
Coil Finned Length (in)	105.000
Fin Pitch (Fins/Inch)	10.000
Fin Conductivity (BTU/hr·ft·°F)	128.000
Fin Tip Thickness (inches)	0.0120
Fin Root Thickness (inches)	0.0120
Circular Fin Height (inches)	1.347
Number of Coils Per Unit	2
Number of Tube Rows	4
Number of Tubes Per Row	20.00
Active Tubes Per Row	20.00
Tube Inside Diameter (in)	0.5270
Tube Outside Diameter (in)	0.6250
Longitudinal Tube Pitch (in)	2.000
Transverse Tube Pitch (in)	1.370
Number of Serpentines	2.000
Tube Wall Conductivity (BTU/hr·ft·°F)	225.00

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Calculation Report for: 1(2)VY04A-Back - CSCS Equipment Area Cooling Coils

CSCS = 106 F, 10% less air

Calculation Specifications

Constant Inlet Temperature Method Was Used
Extrapolation Was to User Specified Conditions
Design Fouling Factors Were Used

Test Data

Data Date	
Air Flow (acfm)	
Air Dry Bulb Temp In (°F)	
Air Dry Bulb Temp Out (°F)	
Relative Humidity In (%)	
Relative Humidity Out (%)	
Wet Bulb Temp In (°F)	
Wet Bulb Temp Out (°F)	
Atmospheric Pressure	
Tube Flow (gpm)	
Tube Temp In (°F)	
Tube Temp Out (°F)	
Condensate Temperature (°F)	

Extrapolation Data

Tube Flow (gpm)	27.30
Air Flow (acfm)	25,650.00 ← 10% lower air flow
Tube Inlet Temp (°F)	106.00
Air Inlet Temp (°F)	130.6
Inlet Relative Humidity (%)	19.73
Inlet Wet Bulb Temp (°F)	0.00
Atmospheric Pressure	14.315

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Calculation Report for: 1(2)VY04A-Back - CSCS Equipment Area Cooling Coils

CSCS = 106 F, 10% less air

Extrapolation Calculation Summary

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	97,624.99	13,557.56	Tube-Side hi (BTU/hr·ft²·°F)	
Inlet Temperature (°F)	130.58	106.00	j Factor	
Outlet Temperature (°F)	119.66	125.67	Air-Side ho (BTU/hr·ft²·°F)	
Inlet Specific Humidity			Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Outlet Specific Humidity			Overall Fouling (hr·ft²·°F/BTU)	0.02278812
Average Temp (°F)				
Skin Temperature (°F)			U Overall (BTU/hr·ft²·°F)	
Velocity ***			Effective Area (ft²)	5,740.10
Reynold's Number			LMTD	
Prandtl Number			Total Heat Transferred (BTU/hr)	266,555
Bulk Visc (lbm/ft·hr)				
Skin Visc (lbm/ft·hr)			Surface Effectiveness (Eta)	
Density (lbm/ft³)			Sensible Heat Transferred (BTU/hr)	266,555
Cp (BTU/lbm·°F)			Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)			Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 1(Dry)

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	97,624.99	13,557.56	Tube-Side hi (BTU/hr·ft²·°F)	171.18
Inlet Temperature (°F)	130.58	122.88	j Factor	0.0121
Outlet Temperature (°F)	129.66	126.21	Air-Side ho (BTU/hr·ft²·°F)	18.24
Inlet Specific Humidity	0.0200		Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Outlet Specific Humidity	0.0200		Overall Fouling (hr·ft²·°F/BTU)	0.02278812
Average Temp (°F)	130.12	124.55		
Skin Temperature (°F)	128.12	127.37	U Overall (BTU/hr·ft²·°F)	5.83
Velocity ***	5,084.06	0.50	Effective Area (ft²)	717.51
Reynold's Number	1,414	3,807	LMTD	5.39
Prandtl Number	0.7267	3.4702	Total Heat Transferred (BTU/hr)	22,558
Bulk Visc (lbm/ft·hr)	0.0481	1.2907		
Skin Visc (lbm/ft·hr)		1.2581	Surface Effectiveness (Eta)	0.8896
Density (lbm/ft³)	0.0635	61.6399	Sensible Heat Transferred (BTU/hr)	22,558
Cp (BTU/lbm·°F)	0.2402	0.9989	Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)	0.0159	0.3715	Heat to Condensate (BTU/hr)	

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY04A-Back - CSCS Equipment Area Cooling Coils

CSCS = 106 F, 10% less air

Extrapolation Calculation for Row 2(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	97,624.99	13,557.56
Inlet Temperature (°F)	129.66	121.69
Outlet Temperature (°F)	128.70	125.12
Inlet Specific Humidity	0.0200	
Outlet Specific Humidity	0.0200	
Average Temp (°F)	129.18	123.40
Skin Temperature (°F)	127.12	126.35
Velocity ***	5,084.06	0.50
Reynold's Number	1,415	3,767
Prandtl Number	0.7267	3.5104
Bulk Visc (lbm/ft·hr)	0.0481	1.3044
Skin Visc (lbm/ft·hr)		1.2698
Density (lbm/ft³)	0.0636	61.6582
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0159	0.3712

Tube-Side hi (BTU/hr·ft²·°F)	168.98
j Factor	0.0121
Air-Side ho (BTU/hr·ft²·°F)	18.24
Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Overall Fouling (hr·ft²·°F/BTU)	0.02278812
U Overall (BTU/hr·ft²·°F)	5.79
Effective Area (ft²)	717.51
LMTD	5.59
Total Heat Transferred (BTU/hr)	23,241
Surface Effectiveness (Eta)	0.8896
Sensible Heat Transferred (BTU/hr)	23,241
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 3(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	97,624.99	13,557.56
Inlet Temperature (°F)	128.70	118.56
Outlet Temperature (°F)	127.50	122.88
Inlet Specific Humidity	0.0200	
Outlet Specific Humidity	0.0200	
Average Temp (°F)	128.10	120.72
Skin Temperature (°F)	125.51	124.54
Velocity ***	5,084.06	0.50
Reynold's Number	1,417	3,674
Prandtl Number	0.7268	3.6077
Bulk Visc (lbm/ft·hr)	0.0480	1.3374
Skin Visc (lbm/ft·hr)		1.2909
Density (lbm/ft³)	0.0638	61.7005
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0159	0.3703

Tube-Side hi (BTU/hr·ft²·°F)	163.90
j Factor	0.0121
Air-Side ho (BTU/hr·ft²·°F)	18.22
Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Overall Fouling (hr·ft²·°F/BTU)	0.02278812
U Overall (BTU/hr·ft²·°F)	5.70
Effective Area (ft²)	717.51
LMTD	7.16
Total Heat Transferred (BTU/hr)	29,278
Surface Effectiveness (Eta)	0.8897
Sensible Heat Transferred (BTU/hr)	29,278
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY04A-Back - CSCS Equipment Area Cooling Coils

CSCS = 106 F, 10% less air

Extrapolation Calculation for Row 4(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	97,624.99	13,557.56
Inlet Temperature (°F)	127.50	117.41
Outlet Temperature (°F)	126.32	121.69
Inlet Specific Humidity	0.0200	
Outlet Specific Humidity	0.0200	
Average Temp (°F)	126.91	119.55
Skin Temperature (°F)	124.34	123.38
Velocity ***	5,084.06	0.50
Reynold's Number	1,420	3,633
Prandtl Number	0.7269	3.6515
Bulk Visc (lbm/ft·hr)	0.0479	1.3522
Skin Visc (lbm/ft·hr)		1.3047
Density (lbm/ft³)	0.0639	61.7187
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0158	0.3699

Tube-Side hi (BTU/hr·ft²·°F)	161.60
j Factor	0.0121
Air-Side ho (BTU/hr·ft²·°F)	18.21
Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Overall Fouling (hr·ft²·°F/BTU)	0.02278812
U Overall (BTU/hr·ft²·°F)	5.66
Effective Area (ft²)	717.51
LMTD	7.14
Total Heat Transferred (BTU/hr)	28,989
Surface Effectiveness (Eta)	0.8898
Sensible Heat Transferred (BTU/hr)	28,989
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 5(Dry)

	Air-Side	Tube-Side
Mass Flow (lbm/hr)	97,624.99	13,557.56
Inlet Temperature (°F)	126.32	113.01
Outlet Temperature (°F)	124.78	118.56
Inlet Specific Humidity	0.0200	
Outlet Specific Humidity	0.0200	
Average Temp (°F)	125.55	115.78
Skin Temperature (°F)	122.21	120.97
Velocity ***	5,084.06	0.50
Reynold's Number	1,422	3,505
Prandtl Number	0.7270	3.7986
Bulk Visc (lbm/ft·hr)	0.0478	1.4018
Skin Visc (lbm/ft·hr)		1.3342
Density (lbm/ft³)	0.0641	61.7759
Cp (BTU/lbm·°F)	0.2402	0.9988
K (BTU/hr·ft·°F)	0.0158	0.3686

Tube-Side hi (BTU/hr·ft²·°F)	154.45
j Factor	0.0120
Air-Side ho (BTU/hr·ft²·°F)	18.20
Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Overall Fouling (hr·ft²·°F/BTU)	0.02278812
U Overall (BTU/hr·ft²·°F)	5.53
Effective Area (ft²)	717.51
LMTD	9.48
Total Heat Transferred (BTU/hr)	37,586
Surface Effectiveness (Eta)	0.8898
Sensible Heat Transferred (BTU/hr)	37,586
Latent Heat Transferred (BTU/hr)	
Heat to Condensate (BTU/hr)	

*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY04A-Back - CSCS Equipment Area Cooling Coils

CSCS = 106 F, 10% less air

Extrapolation Calculation for Row 6(Dry)

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	97,624.99	13,557.56	Tube-Side hi (BTU/hr·ft²·°F)	152.45
Inlet Temperature (°F)	124.78	112.18	j Factor	0.0120
Outlet Temperature (°F)	123.33	117.41	Air-Side ho (BTU/hr·ft²·°F)	18.19
Inlet Specific Humidity	0.0200		Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Outlet Specific Humidity	0.0200		Overall Fouling (hr·ft²·°F/BTU)	0.02278812
Average Temp (°F)	124.05	114.79		
Skin Temperature (°F)	120.91	119.74	U Overall (BTU/hr·ft²·°F)	5.49
Velocity ***	5,084.06	0.50	Effective Area (ft²)	717.51
Reynold's Number	1,425	3,471	LMTD	8.99
Prandtl Number	0.7271	3.8388	Total Heat Transferred (BTU/hr)	35,399
Bulk Visc (lbm/ft·hr)	0.0477	1.4153		
Skin Visc (lbm/ft·hr)		1.3497	Surface Effectiveness (Eta)	0.8899
Density (lbm/ft³)	0.0642	61.7906	Sensible Heat Transferred (BTU/hr)	35,399
Cp (BTU/lbm·°F)	0.2402	0.9988	Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)	0.0158	0.3682	Heat to Condensate (BTU/hr)	

Extrapolation Calculation for Row 7(Dry)

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	97,624.99	13,557.56	Tube-Side hi (BTU/hr·ft²·°F)	142.35
Inlet Temperature (°F)	123.33	106.00	j Factor	0.0120
Outlet Temperature (°F)	121.38	113.01	Air-Side ho (BTU/hr·ft²·°F)	18.17
Inlet Specific Humidity	0.0200		Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Outlet Specific Humidity	0.0200		Overall Fouling (hr·ft²·°F/BTU)	0.02278812
Average Temp (°F)	122.36	109.50		
Skin Temperature (°F)	118.16	116.59	U Overall (BTU/hr·ft²·°F)	5.28
Velocity ***	5,084.06	0.50	Effective Area (ft²)	717.51
Reynold's Number	1,428	3,294	LMTD	12.51
Prandtl Number	0.7272	4.0662	Total Heat Transferred (BTU/hr)	47,418
Bulk Visc (lbm/ft·hr)	0.0476	1.4915		
Skin Visc (lbm/ft·hr)		1.3909	Surface Effectiveness (Eta)	0.8900
Density (lbm/ft³)	0.0644	61.8670	Sensible Heat Transferred (BTU/hr)	47,418
Cp (BTU/lbm·°F)	0.2402	0.9988	Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)	0.0157	0.3664	Heat to Condensate (BTU/hr)	

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*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Calculation Report for: 1(2)VY04A-Back - CSCS Equipment Area Cooling Coils

CSCS = 106 F, 10% less air

Extrapolation Calculation for Row 8(Dry)

	Air-Side	Tube-Side		
Mass Flow (lbm/hr)	97,624.99	13,557.56	Tube-Side hi (BTU/hr·ft²·°F)	141.33
Inlet Temperature (°F)	121.38	105.96	j Factor	0.0120
Outlet Temperature (°F)	119.66	112.18	Air-Side ho (BTU/hr·ft²·°F)	18.15
Inlet Specific Humidity	0.0200		Tube Wall Resistance (hr·ft²·°F/BTU	0.00024732
Outlet Specific Humidity	0.0200		Overall Fouling (hr·ft²·°F/BTU)	0.02278812
Average Temp (°F)	120.52	109.07		
Skin Temperature (°F)	116.79	115.40	U Overall (BTU/hr·ft²·°F)	5.26
Velocity ***	5,084.06	0.50	Effective Area (ft²)	717.51
Reynold's Number	1,432	3,280	LMTD	11.15
Prandtl Number	0.7274	4.0859	Total Heat Transferred (BTU/hr)	42,087
Bulk Visc (lbm/ft·hr)	0.0475	1.4980		
Skin Visc (lbm/ft·hr)		1.4069	Surface Effectiveness (Eta)	0.8901
Density (lbm/ft³)	0.0646	61.8731	Sensible Heat Transferred (BTU/hr)	42,087
Cp (BTU/lbm·°F)	0.2402	0.9988	Latent Heat Transferred (BTU/hr)	
K (BTU/hr·ft·°F)	0.0157	0.3662	Heat to Condensate (BTU/hr)	

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*** Air Mass Velocity (Lbm/hr·ft²), Tube Fluid Velocity (ft/sec); Air Density at Inlet T, Other Properties at Average T

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Data Report for: 1(2)VY04A-Back - CSCS Equipment Area Cooling Coils

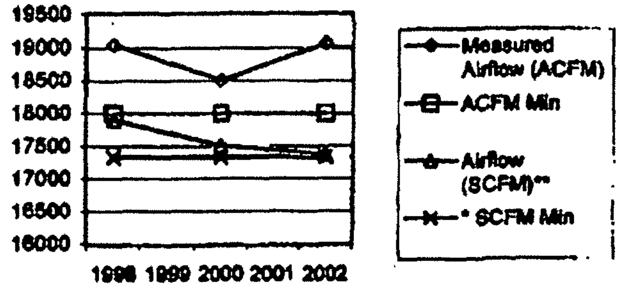
CSCS = 106 F, 10% less air

Air Coil Heat Exchanger Input Parameters

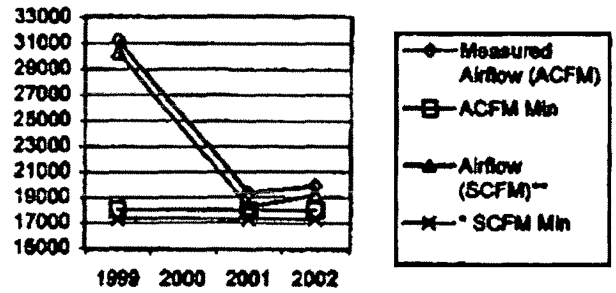
	Air-Side	Tube-Side
Fluid Quantity, Total	32,483.00 acfm	82.00 gpm
Inlet Dry Bulb Temp	°F	105.00 °F
Inlet Wet Bulb Temp	°F	
Inlet Relative Humidity	%	
Outlet Dry Bulb Temperature	°F	°F
Outlet Wet Bulb Temp	°F	
Outlet Relative Humidity	%	

Tube Fluid Name	Fresh Water
Tube Fouling Factor	0.001500
Air-Side Fouling	0.000500 ← HIGHER AIR SIDE FOULING
Design Heat Transfer (BTU/hr)	
Atmospheric Pressure	14.315
Sensible Heat Ratio	1.00
Performance Factor (% Reduction)	0.000
Heat Exchanger Type	Counter Flow
Fin Type	Circular Fins
Fin Configuration	LaSalle Cooler 1(2)VY04A
	j = EXP[-1.9210 + -0.3441 * LOG(Re)]
Coil Finned Length (in)	105.000
Fin Pitch (Fins/Inch)	10.000
Fin Conductivity (BTU/hr·ft·°F)	128.000
Fin Tip Thickness (inches)	0.0120
Fin Root Thickness (inches)	0.0120
Circular Fin Height (inches)	1.347
Number of Coils Per Unit	2
Number of Tube Rows	8
Number of Tubes Per Row	20.00
Active Tubes Per Row	20.00
Tube Inside Diameter (in)	0.5270
Tube Outside Diameter (in)	0.6250
Longitudinal Tube Pitch (in)	1.500
Transverse Tube Pitch (in)	1.370
Number of Serpentines	2.000
Tube Wall Conductivity (BTU/hr·ft·°F)	225.00

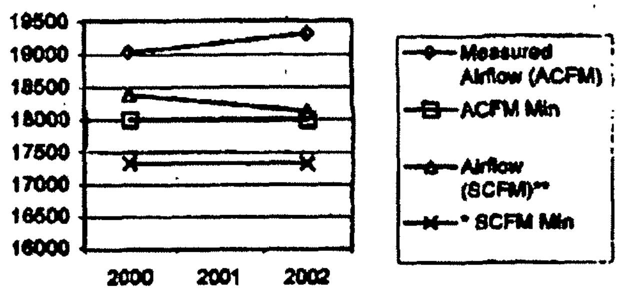
1VY01A



2VY01A



1VY02A



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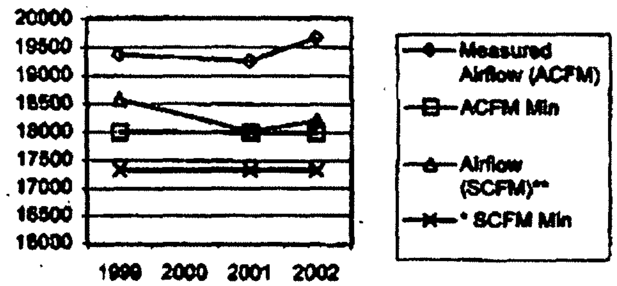

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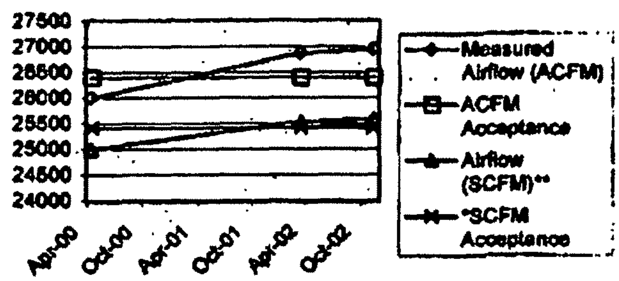

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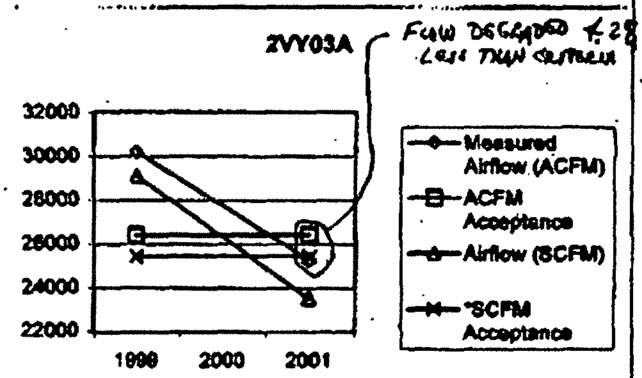
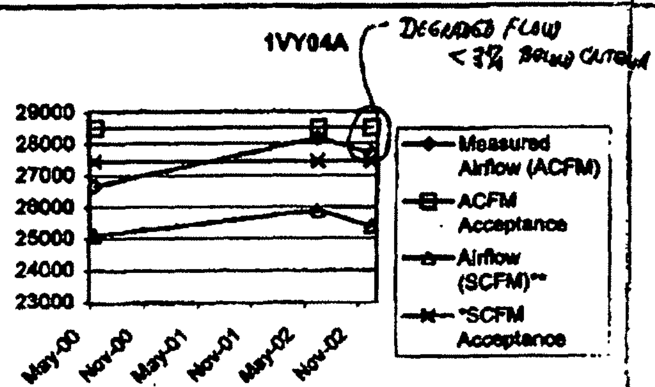
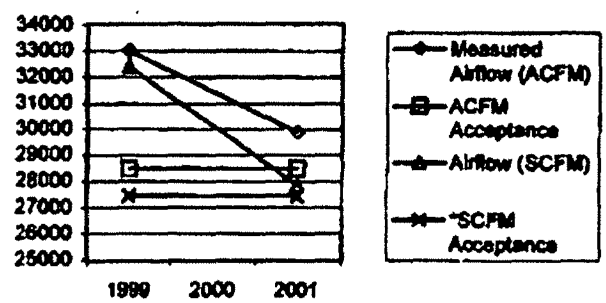


1VY04A



2VY04A



EC 350308 R.0
Attach. I

Commonwealth Edison

Calculation Report for FC01 - LSCS - Spent Fuel Pool Cooling Hx.

NOED EC MNHL, 106F, Max ff, 1% plug

Calculation Specifications

Constant Inlet Temperature Method Was Used
Extrapolation Was to User Specified Conditions
Fouling Was Input by User

Test Data

Data Date	
Shell Flow (gpm)	
Shell Temp In (°F)	
Shell Temp Out (°F)	
Tube Flow (gpm)	
Tube Temp In (°F)	
Tube Temp Out (°F)	

Extrapolation Data

Tube Flow (gpm)	3,972.00
Shell Flow (gpm)	2,952.00
Tube Inlet Temp (°F)	106.00
Shell Inlet Temp (°F)	140.00
Input Fouling Factor	0.001580

Fouling Calculation Results

Shell Mass Flow (lbm/hr)	
Tube Mass Flow (lbm/hr)	
Heat Transferred (BTU/hr)	
LMTD	
Effective Area (ft²)	

Property	Shell-Side	Tube-Side
Velocity (ft/s)		
Reynold's Number		
Prandtl Number		
Bulk Visc (lbm/ft·hr)		
Skin Visc (lbm/ft·hr)		
Density (lbm/ft³)		
Cp (BTU/lbm·°F)		
K (BTU/hr·ft·°F)		

U Overall (BTU/hr·ft²·°F)	
Shell-Side ho (BTU/hr·ft²·°F)	
Tube-Side hi (BTU/hr·ft²·°F)	
1/Wall Resis (BTU/hr·ft²·°F)	
LMTD Correction Factor	
Overall Fouling (hr·ft²·°F/BTU)	
Shell Temp In (°F)	
Shell Temp Out (°F)	
Tav Shell (°F)	
Shell Skin Temp (°F)	
Tube Temp In (°F)	
Tube Temp Out (°F)	
Tav Tube (°F)	
Tube Skin Temp (°F)	

Extrapolation Calculation Results

Shell Mass Flow (lbm/hr)	1,476,736.63
Tube Mass Flow (lbm/hr)	1,986,991.15
Heat Transferred (BTU/hr)	23,860,895.41
LMTD	19.8
Effective Area (ft²)	3,804.0

Property	Shell-Side	Tube-Side
Velocity (ft/s)	4.99	4.35
Reynold's Number	47,646	31,541
Prandtl Number	3.2289	3.9557
Bulk Visc (lbm/ft·hr)	1.2083	1.4545
Skin Visc (lbm/ft·hr)	1.2418	1.3823
Density (lbm/ft³)	61.5180	61.8313
Cp (BTU/lbm·°F)	0.9990	0.9988
K (BTU/hr·ft·°F)	0.3738	0.3673

Overall Fouling (hr·ft²·°F/BTU)	0.001580
Shell-Side ho (BTU/hr·ft²·°F)	2,035.7
Tube-Side hi (BTU/hr·ft²·°F)	1,323.4
1/Wall Resis (BTU/hr·ft²·°F)	3,845.3
LMTD Correction Factor	1.0000
U Overall (BTU/hr·ft²·°F)	316.3
Shell Temp In (°F)	140.0
Shell Temp Out (°F)	123.8
Tav Shell (°F)	131.9
Shell Skin Temp (°F)	128.8
Tube Temp In (°F)	106.0
Tube Temp Out (°F)	118.0
Tav Tube (°F)	112.0
Tube Skin Temp (°F)	117.2

** Reynolds Number Outside Range of Equation Applicability

!! With Zero Fouling The Test Heat Load Could Not Be Achieved

EC 350308 R
Attach. I
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Shell and Tube Heat Exchanger Input Parameters

		Shell-Side	Tube-Side
Fluid Quantity, Total	gpm	2,998.50	3,998.00
Mass Fluid Quantity, Total	lbm/hr	0.00	0.00
Inlet Temperature	°F	120.00	95.00
Outlet Temperature	°F	110.30	102.30
Fouling Factor	hr·ft²·°F/BTU	0.00050	0.00200

Shell Fluid Name	Fresh Water
Tube Fluid Name	Fresh Water
Design Q (BTU/hr)	14,500,000
Design U (BTU/hr·ft²·°F)	229.00
Outside h Factor (Hoff)	0.821991000
Fixed U (BTU/hr·ft²·°F)	0
Fixed Area (ft²)	0.00
Performance Factor (% Reduction)	0.00
Heat Exchanger Type	Counter Flow
Total Effective Area per Unit (ft²)	3,840.00
Area Factor	0.983279772
Area Ratio	0.00000
Number of Shells Per Unit	1
Shell Minimum Area	1.336000000
Shell Velocity (ft/s)	5.000
Tube Pitch (in)	0.8125
Tube Pitch Type	Triangular
Number of Tube Passes	1
U-Tubes	No
Total Number of Tubes	1,174
Number of Active Tubes	1,163
Tube Length (ft)	20.33
Tube Inside Diameter (in)	0.569
Tube Outside Diameter (in)	0.625
Tube Wall K (BTU/hr·ft·°F)	9.40
Lbc, Central Baffle Spacing (in)	0.000
Lbi, Inlet Baffle Spacing (in)	0.000
Lbo, Outlet Baffle Spacing (in)	0.000
Dotl, Tube Circle Diameter	0.000
Bh, Baffle Cut Height (in)	0.000
Ds, Shell Inside Diamter (in)	0.000
Lsb, Diametral difference between Baffle and Shell (in)	0.000
Ltb, Diametral difference between Tube and Baffle (in)	0.000
Nss, Number Sealing Strips	0.000

Commonwealth Edison

Calculation Report for FC01 - LSCS - Spent Fuel Pool Cooling Hx.

NOED EC EHL, 106F, Max ff, 1% plug

Calculation Specifications

Constant Inlet Temperature Method Was Used
Extrapolation Was to User Specified Conditions
Fouling Was Input by User

Test Data

Data Date	
Shell Flow (gpm)	
Shell Temp In (°F)	
Shell Temp Out (°F)	
Tube Flow (gpm)	
Tube Temp In (°F)	
Tube Temp Out (°F)	

Extrapolation Data

Tube Flow (gpm)	3,972.00
Shell Flow (gpm)	2,476.00
Tube Inlet Temp (°F)	106.00
Shell Inlet Temp (°F)	155.30
Input Fouling Factor	0.001580

Fouling Calculation Results

Shell Mass Flow (lbm/hr)	
Tube Mass Flow (lbm/hr)	
Heat Transferred (BTU/hr)	
LMTD	
Effective Area (ft²)	

Property	Shell-Side	Tube-Side
Velocity (ft/s)		
Reynold's Number		
Prandtl Number		
Bulk Visc (lbm/ft·hr)		
Skin Visc (lbm/ft·hr)		
Density (lbm/ft³)		
Cp (BTU/lbm·°F)		
K (BTU/hr·ft·°F)		

U Overall (BTU/hr·ft²·°F)	
Shell-Side ho (BTU/hr·ft²·°F)	
Tube-Side hi (BTU/hr·ft²·°F)	
1/Wall Resis (BTU/hr·ft²·°F)	
LMTD Correction Factor	
Overall Fouling (hr·ft²·°F/BTU)	
Shell Temp In (°F)	
Shell Temp Out (°F)	
Tav Shell (°F)	
Shell Skin Temp (°F)	
Tube Temp In (°F)	
Tube Temp Out (°F)	
Tav Tube (°F)	
Tube Skin Temp (°F)	

Extrapolation Calculation Results

Shell Mass Flow (lbm/hr)	1,238,617.85
Tube Mass Flow (lbm/hr)	1,986,991.15
Heat Transferred (BTU/hr)	32,785,610.04
LMTD	27.5
Effective Area (ft²)	3,804.0

Property	Shell-Side	Tube-Side
Velocity (ft/s)	4.20	4.35
Reynold's Number	43,569	32,247
Prandtl Number	2.9394	3.8607
Bulk Visc (lbm/ft·hr)	1.1083	1.4227
Skin Visc (lbm/ft·hr)	1.1522	1.3290
Density (lbm/ft³)	61.3397	61.7985
Cp (BTU/lbm·°F)	0.9994	0.9988
K (BTU/hr·ft·°F)	0.3768	0.3681

Overall Fouling (hr·ft²·°F/BTU)	0.001580
Shell-Side ho (BTU/hr·ft²·°F)	1,879.7
Tube-Side hi (BTU/hr·ft²·°F)	1,342.3
1/Wall Resis (BTU/hr·ft²·°F)	3,845.3
LMTD Correction Factor	1.0000
U Overall (BTU/hr·ft²·°F)	313.4
Shell Temp In (°F)	155.3
Shell Temp Out (°F)	128.8
Tav Shell (°F)	142.1
Shell Skin Temp (°F)	137.4
Tube Temp In (°F)	106.0
Tube Temp Out (°F)	122.5
Tav Tube (°F)	114.3
Tube Skin Temp (°F)	121.4

** Reynolds Number Outside Range of Equation Applicability

!! With Zero Fouling The Test Heat Load Could Not Be Achieved

07-20-2004 08:59:52

PROTO-HX 4.00 by Proto-Power Corporation (SN#PHX-0000)
Commonwealth Edison
Data Report for FC01 - LSCS - Spent Fuel Pool Cooling Hx.
NOED EC EHL, 106F, Max ff, 1% plug

EC 350308 R.C
Attach. J
Pg. 2/2

Shell and Tube Heat Exchanger Input Parameters

		Shell-Side	Tube-Side
Fluid Quantity, Total	gpm	2,998.50	3,998.00
Mass Fluid Quantity, Total	lbm/hr	0.00	0.00
Inlet Temperature	°F	120.00	95.00
Outlet Temperature	°F	110.30	102.30
Fouling Factor	hr·ft²·°F/BTU	0.00050	0.00200

Shell Fluid Name	Fresh Water
Tube Fluid Name	Fresh Water
Design Q (BTU/hr)	14,500,000
Design U (BTU/hr·ft²·°F)	229.00
Outside h Factor (Hoff)	0.821991000
Fixed U (BTU/hr·ft²·°F)	0
Fixed Area (ft²)	0.00
Performance Factor (% Reduction)	0.00
Heat Exchanger Type	Counter Flow
Total Effective Area per Unit (ft²)	3,840.00
Area Factor	0.983279772
Area Ratio	0.00000
Number of Shells Per Unit	1
Shell Minimum Area	1.336000000
Shell Velocity (ft/s)	5.000
Tube Pitch (in)	0.8125
Tube Pitch Type	Triangular
Number of Tube Passes	1
U-Tubes	No
Total Number of Tubes	1,174
Number of Active Tubes	1,163
Tube Length (ft)	20.33
Tube Inside Diameter (in)	0.569
Tube Outside Diameter (in)	0.625
Tube Wall K (BTU/hr·ft·°F)	9.40
Lbc, Central Baffle Spacing (in)	0.000
Lbi, Inlet Baffle Spacing (in)	0.000
Lbo, Outlet Baffle Spacing (in)	0.000
Dotl, Tube Circle Diameter	0.000
Bh, Baffle Cut Height (in)	0.000
Ds, Shell Inside Diamter (in)	0.000
Lsb, Diametral difference between Baffle and Shell (in)	0.000
Ltb, Diametral difference between Tube and Baffle (in)	0.000
Nss, Number Sealing Strips	0.000

Attachment IK

Exelon Nuclear

Memorandum

Date: July 21, 2001

To: D. Bost

From: K. Ramsden 7/21/01

Subject: Assessment of High Lake Temperature Upon the Transient and Accident Analyses

Reference: NFM Memo BSA-99-071, R. W. Tsai to D. Bost, dated July 29, 1999.

As requested by LaSalle Engineering, a review of the Referenced memo has been performed, with respect to the current up-rated plant configuration. The reference memo provided a detailed discussion of the impacts of high lake temperatures on the transient and accident analyses, concluding that 103°F lake temperatures would be acceptable. The purpose of this memo is to address the effects of power uprate on the evaluation of high lake temperatures.

The reference evaluation concluded that the elevated lake temperature would manifest itself in suppression pool temperatures for post-LOCA and the Alternate Shutdown Cooling Event. It also concluded that the ATWS and Station Blackout events would be impacted, but to a limited extent. The remainder of the transient analyses are not dependent on, or affected by lake temperature assumptions.

The Safety Evaluation Report issued for the power uprate amendments lists the following maximum suppression pool temperatures for the events of concern here:

Event	Maximum Suppression Pool Temperature °F
Post-LOCA Heatup	193
Alternate Shutdown Cooling	207
ATWS	204

These temperatures are in relation to the maximum allowable temperature limit of 212°F.

The Station Blackout event is not directly affected by the lake temperature, but the SER does note that constraints in the EOPs regarding vessel depressurization rates are utilized to ensure that subcooling margins of 20°F are met, preventing the potential for steam ingestion by the RCIC strainer. The procedural controls limit the suppression pool maximum temperature to 196°F, and would be expected to continue to do so independent of lake temperature assumptions.

KI-1

BLN 9/17/02

Exelon.
Nuclear

Memorandum

The effect of raising the lake temperature on any of these analyses can be readily determined by evaluating the energy equation for the suppression pool :

$$mc_p \frac{dT}{dt} = Q(t) - Khx(T(t) - Tsw)$$

Where
m= the mass of suppression pool fluid
cp= heat capacity of water
T(t)= time dependent suppression pool temperature °F
Q(t)=heat input to the suppression pool, primarily decay heat and vessel sensible heat
Khx=RHR heat exchanger heat removal rate, in Btu/sec-°F
Tsw=heat sink temperature (lake temperature) °F

At the time of maximum pool temperature, the derivative is zero, and it can be readily seen that increasing the heat sink temperature will result in a comparable increase in the suppression pool maximum temperature, essentially conserving the delta T needed to balance the heat gain and heat removal. Therefore, postulating a 3 degree increase in the lake temperature above the 100°F used in the design analyses will result in no more than a 3°F increase in the peak pool temperatures for the different events analyzed.

Based on the maximum values presented in the table above, it can be concluded that an increase in the lake temperature of three degrees, to 103°F, will not result in any of the events exceeding 212°F. Therefore there is no impact on plant safety for operation at lake temperatures up to 103°F.

RB 7/17/02   RB 7/17/02

Memorandum

Attachment JL

ComEd

Date: July 29, 1999
NFM:BSA:99-071

To: Mr. D. Bost

Subject: Assessment of High Lake Temperature Upon the Transient and Accident Analyses

As requested by LaSalle engineering, NFM has completed an assessment of increased lake water temperature on the relevant UFSAR Chapter 5.2, 6 and 15 safety analyses. LaSalle should assess the other UFSAR and licensing requirements. This assessment assumed a 103°F RHR service water temperature. This assessment is included as Attachment 1.

NFM has concluded that even with the increase in RHR service water, the peak temperature would be within containment acceptance limits. For the long term, after the peak suppression pool temperature excursion is mitigated, it is expected that an additional RHR heat exchanger train could be used to maintain suppression pool temperatures at or below the current calculated values. This will ensure equipment qualification temperatures are met.

If you have any questions on this matter please contact Randy Jacobs at D.G. ext: 3051.

Robert W. Tsai

Robert W. Tsai
BWR Safety Analysis Supervisor
Nuclear Fuel Management

RHJ/RWT

Enclosure

cc: BSA-CF
NFS-CF
Document ID:
R. H. Jacobs
K. P. Donovan
K. B. Ramsden
E. A. McVey (LaSalle)
T. J. Rausch

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J-1

Attachment 1

Accident Analysis Evaluation

1) **LOCA Analysis UFSAR Sections 15.6 and 6.3.3**

Short Term
The short term LOCA Peak Cladding Temperature (PCT) calculation is independent of lake temperature or service water temperature. The ECCS fluid temperature assumed in the analysis is based on a conservative suppression pool temperature for PCT evaluations. Since the PCT occurs very early in the accident and a conservative ECCS fluid temperature is used, a higher lake or service water temperature will not change the PCT calculation. The calculated results to meet the 50.46 criteria will not change.

Long Term
The post LOCA long term cooling required by 10 CFR 50.46 will also be acceptable with an increase in the lake / service water temperature. The lower 2/3 of the core will remain covered. Also, provided that at least 1 core spray system is available long-term, the upper third of the core will remain wetted by the core spray water, which will prevent further cladding perforation or metal-water reaction. As long as there is water in the suppression pool for core spray and 2/3 core height covery is maintained, higher lake / service water temperature of 103°F will have no significant impact on LOCA long term cooling.

2) **Containment Analysis UFSAR Section 6.2**

The short-term containment response is not affected by lake or service water temperature. The short-term response is primarily driven by the mass and energy release from a bounding short term LOCA analysis and containment parameters. These are independent of lake and service water temperature.

An increase in the lake and service water temperature could have an impact on the long term containment response to a LOCA accident. The RHR service water temperature assumed in the suppression pool temperature analyses is 100°F. The current analysis assumes 100°F service water temperature for the duration of the analysis. For the purpose of this evaluation it is postulated that the RHR service water temperature will increase from 100°F as the ultimate heat sink is increasing to a postulated 103°F (assumes the unlikely failure of the dike). However, even assuming a 103°F RHR service water temperature for the duration of the event, there will not be a significant impact on the results. A sensitivity study was performed with a suppression pool model for the long term heat up analysis with the RHR service water at 103°F. This

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sensitivity study showed that there would be about a 2 - 3°F increase in the peak suppression pool response. The current LaSalle peak suppression pool temperature has been evaluated to 200°F. Since the post-LOCA suppression pool temperature limit is 212°F, the increase in service water temperature to 103°F would result in acceptable margins to the limit and the containment / ECCS equipment will perform the required safety functions. It is expected that in the long term (after the peak suppression pool temperature is mitigated), both RHR heat exchanger trains could be used to keep suppression pool temperature profile within the current analysis results (see compensatory action below).

Other long term containment heat up analyses to show compliance to NUREG-0783 (Suppression Pool Temperature Limits for BWR Containments), would result in a similar change as discussed above. These analyses are primarily performed to verify acceptable safety relief valve quencher performance. Draft power uprate calculations have been performed for LaSalle and show that peak suppression pool temperature (bulk) is 188°F for this event. The acceptance limit for isolation scram containment analyses has been established at 208°F to maintain acceptable local pool temperatures and subcooling and to assure operability of ECCS systems. The potential 2 –3 °F increase due to a higher RHR service water temperature would result in acceptable margins to the limit and the containment will perform the required safety function. It is expected that as in the LOCA assessment above, both RHR heat exchanger trains could be used to keep suppression pool temperature profile within the current analysis results (see compensatory action below).

3) UFSAR Chapter 5.2 and 15 Transient Analyses

One event in section 15.2.9 is the Failure of RHR shutdown cooling. This event assumes the operation of RHR. However, as shown in UFSAR Table 15.2-4, the service water temperature assumption is 100°F. The current analysis and the recent power uprate analysis assume 100°F for the duration of the analysis. For the purpose of this evaluation it is postulated that the RHR service water temperature will increase as the ultimate heat sink is increasing to a postulated 103°F. The service water temperature is assumed to be 103°F for the duration of the analysis. The recent draft power uprate analysis resulted in a peak suppression pool temperature of 207°F for this event. Assuming a bounding 3°F increase to the peak suppression pool temperature (based on the sensitivity study performed for the post LOCA containment analysis above), the peak temperature is not expected to exceed 210°F. Since the suppression pool temperature limit for this event is 212°F, the increase in service water temperature to 103°F would result in acceptable

3-3
RD 7/17/02

margins to the limit and the containment and RHR shutdown cooling will perform the required safety functions. It is expected that in the long term (after the peak suppression pool temperature is mitigated), both RHR heat exchanger trains could be used to keep suppression pool temperature profile within the current analysis results (see compensatory action below).

The balance of the Chapter 15 transient analyses, including Chapter 5.2 ASME vessel overpressurization, are short term analyses of postulated events to verify core response, to set the fuel thermal limits and to verify acceptable vessel overpressure results. Most of these events either result in a scram or result in no significant change in thermal power. Since these events are only analyzed for the short-term response, there is no dependency on the lake temperature or service water temperature for the consequences of these events.

4) ATWS Analysis UFSAR Section 15.8

The ATWS analysis described in UFSAR Section 15.8 is a beyond design basis event. Analyses have been performed to show that with the installation of the SLCS, ARI and ATWS RPT systems that acceptable ATWS results could be obtained. GE performed many of these generic calculations in NEDE-24222. In these calculations, GE stated "Due to the extremely low probability of the occurrence of an ATWS, nominal parameters and initial conditions have been used in the analyses. This is consistent with the NRC staff request." Therefore, it is not required to use a design maximum value for the ATWS analysis. However, it can be explicitly addressed as discussed below.

Draft power uprate ATWS analysis has been performed for LaSalle. This analysis assumed a service water temperature of 100°F and a peak suppression pool temperature of 205°F was calculated. A bounding assessment would be to assume that the peak suppression pool temperature would increase by the amount of service water temperature increase. Therefore, with a 3°F increase to the suppression pool temperature, the peak temperature is not expected to exceed 208°F, which is the acceptance limit for analyses using the SRVs to remove the decay heat from the vessel. It is expected that in the long term (after the peak suppression pool temperature is mitigated), both RHR heat exchanger trains could be used to keep suppression pool temperature profile within the current analysis results (see compensatory action below). Based on the discussion above, the ATWS analysis is acceptable with elevated lake and service water temperatures.

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5) **Station Blackout Analysis UFSAR Section 15.9**

The station blackout analysis described in UFSAR Section 15.9 is a beyond design basis event. This event requires the use of the RHR heat exchangers to remove the decay heat from the suppression pool. The Station Blackout event analysis is performed assuming a complete loss of AC for a four hour period. The coping analysis assumes operation of the RCIC and/or the HPCS system, but without crediting the HPCS diesel as an alternate AC source. Postulating a service water temperature of 103°F over the entire duration of the event will not significantly affect the peak suppression pool/drywell temperatures predicted in this event since no cooling is available until after AC power is restored. The effect of 103°F service water temperature for the entire duration would be to change the rate at which the temperature decreases, slightly increasing the time to cool down the suppression pool, drywell and HVAC loads, since the cooling effectiveness of the RHR heat exchangers is reduced slightly.

In addition, it should be noted that the SBO analysis was intended to be a best-estimate analysis, based on nominal decay heat values and typical system performance. Therefore it can be concluded from the licensing basis intent that the analysis does not have to bound all postulated ranges of parameters.

Compensatory Action Required

As discussed above, it is expected that in the long term post accident, both RHR heat exchanger trains could be used to keep suppression pool temperature profile within the current analysis results. LaSalle should consider this a compensatory action should the lake temperature rise above 97°F.

BZB 7/26/00 BH 7/26/00

Hx Model Results for 106F Inlet Water Temperatues

HX	Tube Flow	Other Side Flow	Fouling	Plugged Tubes	Qrequired	Q removed	Margin (%)	Comments
RHR Containment Cooling Mode	Design	Design	70% of design	5%	1.63E+08	1.72E+08	5.5	Reduced fouling of 0.0013 based on GL89-13 testing of RHR HXs. Highest fouling seen was 0.00105, including uncertainties
RHR Shutdown Cooling	Design	Design	70% of design	5%	4.16E+07	4.45E+07	7.0	Reduced fouling of 0.0013 based on GL89-13 testing of RHR HXs. Highest fouling seen was 0.00105, including uncertainties. Q removed assumes 2 RHR trains
VY01A	Design	Design	102% of design	0	5.17E+05	6.00E+05	16.1	no tubes plugged based on plant conditions, increased air side fouling
VY02A	Design	Design	102% of design	0	6.46E+05	6.56E+05	1.5	no tubes plugged based on plant conditions, increased air side fouling
VY03A	Design	90% of design	102% of design	0	7.22E+05	7.82E+05	8.3	no tubes plugged based on plant conditions, increased air side fouling
VY04A	Design	90% of design	102% of design	0	6.33E+05	6.91E+05	9.2	no tubes plugged based on plant conditions, increased air side fouling
DG01A	Design	Design	Design	0	8.60E+06	9.12E+06	6.0	no tubes plugged based on plant conditions
DG01B	Design	Design	Design	0	7.80E+06	8.05E+06	3.2	no tubes plugged based on plant conditions