Maine Yankee

RELIABLE ELECTRICITY FOR MAINE SINCE 1972

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May 30, 1989
MN-89-74 GDW-89-188

Director of Nuclear Reactor Regulation
UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, D. C. 20555

Attention: Mr. Richard H. Wessman, Project Director I-3
Division of Reactor Projects I/II

References: (a) License No. DPR-36 (Docket No. 50-309)
(b) MYAPCo Letter to USNRC dated December 28, 1989 - Proposed Change No. 147
(c) USNRC Letter to MYAPCo dated March 27, 1989
(d) MYAPCo Letter to USNRC dated April 27, 1989

Subject: Component Cooling Heat Balance

Gentlemen:

This letter is to provide additional information regarding Maine Yankee's component cooling water heat balance to support operation at 2700 MWth.

The safety function of the Component Cooling Water systems is to provide an intermediate heat transfer path between safety-related heat loads and the ultimate heat sink (Service Water System) following postulated design basis plant accidents. The design basis for the safety-related heat loads assumes that the maximum CCW inlet temperature to them is 102°F.

A bounding analysis was conducted to confirm the capability of the CCW systems to perform all of its intended design basis safety functions without exceeding a CCW cold side temperature of 102°F. Specific details for this analysis are given in Attachments 1 and 2. The results of this analysis confirm that the new CCW heat exchangers, E-4A and E-5B, are capable of meeting their safety-related functions at 2700 MWth at service water temperatures of up to 75°F. The older CCW heat exchangers are capable of meeting their safety-related functions at 2700 MWth at service water temperatures up to 60°F. In all cases the analysis assumptions were made to maximize the loads on the CCW system heat exchangers and therefore, provide conservative results.

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The results from the bounding analysis are based on the assumption that the CCW heat exchangers would be operating above the minimum performance level stated by the manufacturer. In the case of the new heat exchangers (E-4A and 5B), it was assumed that the heat exchangers would be operating approximately 9% above the manufacturer's specified service capability. This assumption is justified because Maine Yankee normally operates with the new heat exchangers in service and the Amertap heat exchanger tube cleaning system is aligned to each heat exchanger for 24 hours every other day.

Approximately once per month cooling loads are shifted to the older heat exchangers (E-4B and E-5A) in order to conduct mussel control on the new heat exchangers. In the case of the older heat exchangers, it was assumed that the heat exchangers would be operating at or above the manufacturer's specified service capability. To assure that these assumed conditions are met, Maine Yankee will continue to periodically clean these heat exchangers, and further, circumstances permitting, will clean them just prior to putting them in service unless they have already been cleaned within a few days.

A third party independent review of the analysis described in Attachment 1 was performed by Stone and Webster Engineering Corporation (SWEC). The SWEC review consisted of a detailed review of the calculation (not including a number check) and independent verification of the results using the Heat Transfer Research Inc. (HTRI) computer program. SWEC concluded that the approach used in the calculation was logical and appropriate to meet the stated objectives. Although some minor differences were observed, the results from their independent checks correlated well with the Maine Yankee analysis.

Maine Yankee has conducted conservative analyses which justify operation at 2700 MWth. When CCW heat exchangers E-4A and 5B are in service, each CCW system can meet all required safety-related functions as long as the service water temperature is less than 75°F. When heat exchangers E-4B and 5A are in service, each CCW system can meet all required safety-related functions as long as the service water temperature is less than 60°F. Pending completion of more detailed and more realistic analyses, Maine Yankee will impose administrative controls to restrict plant operation as follows:

- With only the two new heat exchangers in service, within one hour operation will be restricted to no more than 2630 MWth if service water inlet temperature exceeds 75°F.

- With only one old heat exchanger in service, for either train, within one hour operation will be restricted to no more than 2630 MWth if service water inlet temperature exceeds 60°F.

When the Stone and Webster analysis is complete, we expect that these limitations can be reduced.

Very truly yours,

MAINE YANKEE

SENichols

for G. D. Whittier, Manager
Nuclear Engineering and Licensing

GDW:BPB

Attachments

c: Mr. William T. Russell
Mr. Patrick M. Sears
Mr. Cornelius F. Holden

ATTACHMENT 1

DETAILS OF CCW HEAT BALANCE CALCULATION

Objective

A simplified flow diagram of the system is shown on Figure 1.

The objective of the calculation was to determine the relationship between four parameters associated with the operation of the CCW system following a LOCA. Throughout the calculation, the cold side CCW temperature was assumed to be 102°F. The four parameters are:

- containment sump temperature
- Service Water temperature
- RHR Heat Exchanger heat transfer coefficient, and
- CCW Heat Exchanger heat transfer coefficient.

The results are displayed as a series of graphs (Attachment 2) and apply to both the PCCW and SCCW systems.

Assumptions

Assumptions are made which tend to increase heat transfer from the containment to the CCW system and decrease the heat transfer from the CCW system to the Service Water system.

- RHR Heat Exchanger flow rates are assumed to be their maximum value.

  - CCW = 4700 gpm
  - Containment spray = 3825 gpm

- The Service Water flowrate is assumed to be its minimum value, 10,000 gpm.

- The CCW flowrate through the CCW heat exchanger is assumed to be its nominal value, 6,000 gpm.

- An allowance was made for the possibility of plugging tubes in the CCW heat exchangers. This has the effect of reducing the surface areas available for heat transfer. No plugging was assumed for the RHR Heat Exchangers (maximum heat transferred to CCW). For CCW Heat Exchangers E-4B and 5A, 50 of 1730 tubes were assumed to be plugged. For exchangers E-4A and 5B, 100 of 2200 tubes were assumed to be plugged. The resulting surface areas are:

  - E-4B and 5A = 10,410 ft^2
  - E-4A and 5B = 12,981 ft^2
  - RHR Exchangers = 5,790 ft^2

- The heat load contributed by all sources other than the RHR Heat Exchanger was determined to be less than 10×10^6 BTU/hr. This load was largely due to the emergency diesel generators.

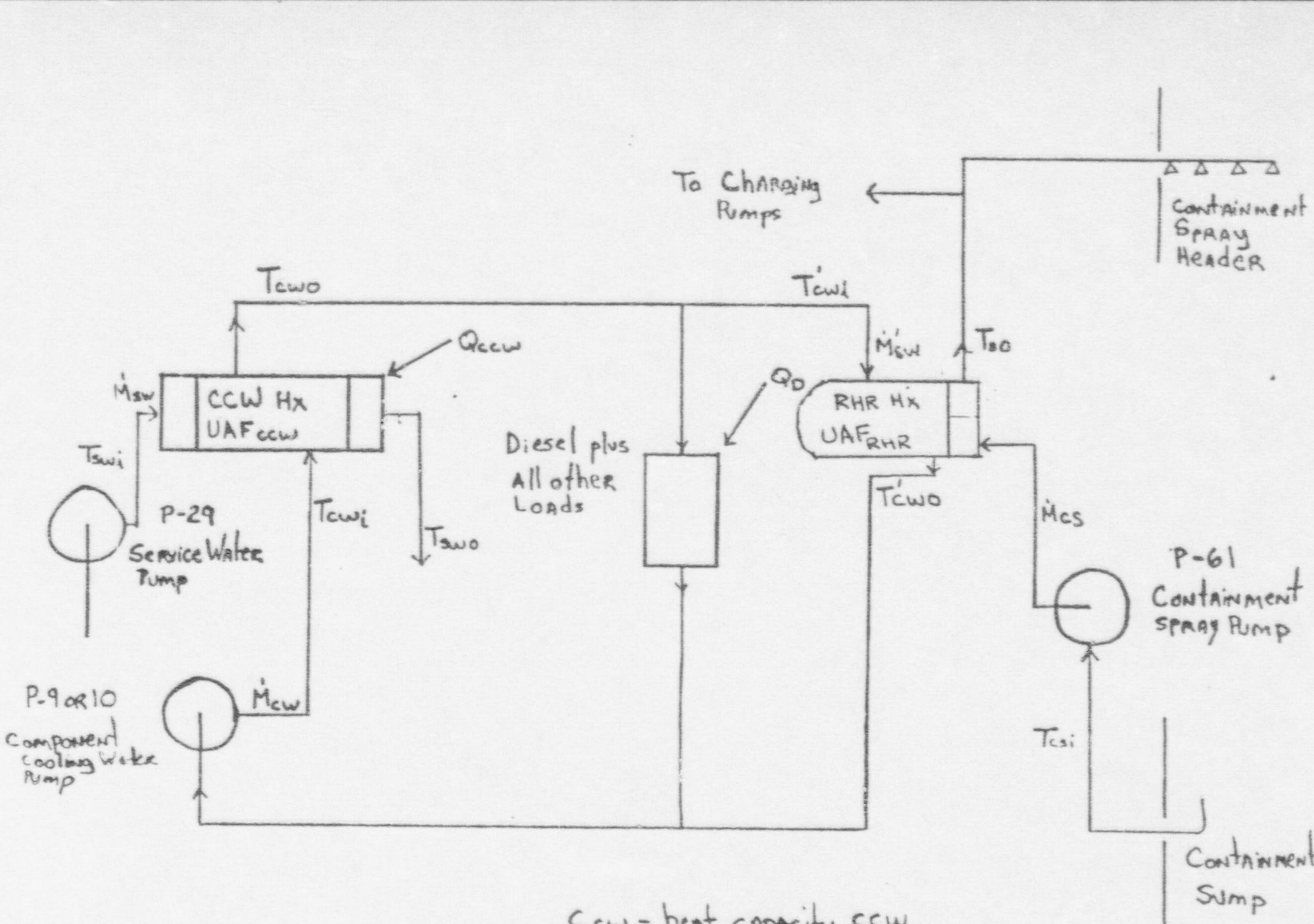
Method

A heat balance was performed across each heat exchanger. For the CCW Heat Exchangers, this resulted in a formula relating the heat transfer coefficient to the Service Water inlet temperature. For the RHR Heat Exchangers, the formula relates the heat transfer coefficient to the containment sump temperature. These relationships are plotted in Attachment 2.

The plots illustrate the operation of the heat exchangers over a range of heat transfer coefficients. On the left hand side of the plot at the position marked "fouled" is the service transfer coefficient for the heat exchangers. The service transfer coefficient includes the Tubular Exchanger Manufacturers Association (TEMA) recommended fouling factors. The clean transfer coefficient is indicated on the right hand side of the plot. Note that because some fouling is always present, the clean transfer coefficient represents an unattainable level of performance.

The heat transfer coefficient increases with both temperature and flowrate. For the CCW Heat Exchangers, the fouled and clean transfer coefficients were taken directly from the manufacturers data sheets. This was possible because the flow and temperature conditions shown on the data sheets were comparable to those following a LOCA. This introduced an additional conservatism for heat exchangers E-4B and 5A.

For the RHR heat exchanger, the flow and temperature conditions shown on the data sheet were much less than those assumed in this problem. To obtain appropriate heat transfer coefficients, a simple model of the heat exchanger was developed and benchmarked against the information on the data sheet. The resulting heat transfer coefficients are shown on Plot 2-1 in Attachment 2.



C_{cw} - heat capacity CCW

C_{cs} - heat capacity containment spray

C_{sw} - heat capacity service water

Simplified SW, CCW, Containment Spray Flow Diagram

Figure 1

ATTACHMENT 2

JUSTIFICATION FOR CCW SYSTEMS CAPABILITIES FOR OPERATION AT 2700 MWth

Plots 2-1, 2-2 and 2-3 can be used to describe the capability of the CCW system following a LOCA.

The plots demonstrate the relationship between four parameters associated with the operation of the CCW system, while holding the cold side CCW temperature at 102°F. These four parameters are: containment sump water temperature, Service Water temperature, RHR heat exchanger heat transfer coefficient and CCW heat exchanger heat transfer coefficient. The plots allow the user to vary each parameter and determine its effect on the overall operation of the CCW system while maintaining the outlet CCW temperature at 102°F.

Plot 2-1 demonstrates the capability of the RHR heat exchanger to remove heat from the containment after a LOCA. Plot 2-2 demonstrates the ability of the new CCW heat exchangers, E-4A and E-5B, to remove heat from the CCW system and maintain the CCW outlet temperature below 102°F. Plot 2-3 represents the old CCW heat exchangers, E-4B and E-5A. The plots are applicable to either the PCCW or SCCW systems. To use the plots, the user would go to plot 2-1 and determine the heat addition to the CCW system from the RHR heat exchanger assuming a specific containment sump water temperature and heat transfer coefficient for the RHR heat exchanger. After a heat load is determined, the user can then go to either plot 2-2 or 2-3, depending on which heat exchanger is assumed in service, to determine the service water temperature and heat transfer coefficient required to maintain a CCW outlet temperature of 102°F.

1. Maximum containment Sump Temperature

   The containment sump temperature is normally determined as part of the containment response analysis. To date, these analyses have only been performed for minimum heat transfer from the containment. This maximizes the long term containment temperature and pressure. The results of these analyses indicate that the containment sump temperature rises slowly after the Containment Spray system transfer to recirculation cooling. A second peak containment temperature is reached several hours after the transfer. The temperature rises because the active and passive heat transfer mechanisms are unable to remove the entire decay heat for several hours after the accident. Analyses performed at 2630 MWt, with minimum heat transfer, indicate that the peak containment sump temperature is less than 225°F. (Note that the sump temperature is less than the containment temperature.) These analyses were performed with low flowrates through the RHR heat exchanger and a heat transfer coefficient of 227 BTU/hr-ft^{2}-°F.

Stone and Webster is developing calculations which will result in a lower peak sump temperature associated with the higher heat transfer coefficients at 2700 MWt, however, it is conservative to assume that the peak sump temperature at 2700 MWt associated with a high heat transfer coefficient is less than 225°F.

2. Maximum RHR Heat Exchanger Heat Transfer Coefficient

   The RHR Heat Exchanger is used each outage for decay heat removal. During power operation the heat exchanger is aligned to the Containment Spray system and is maintained wet. Thus, it is reasonable to assume that some minimum fouling exists at all times and that the maximum heat transfer coefficient is always less than 430 BTU/hr-ft^{2}-°F.

3. Maximum Heat Transfer Requirement

   Based on (1) and (2) above and Plot 2-1, the maximum RHR heat exchanger heat load is about 125 x 10^6 BTU/hr is contributed by all the other heat loads, so the maximum heat transfer requirement for the CCW Heat Exchanger is about 135 x 10^6 BTU/hr.

4. Minimum CCW Heat Exchanger Heat Transfer Coefficient - E-4A and 5B

   The service water side of CCW Heat Exchangers E-4A and 5B is routinely cleaned with an Amertap tube cleaning system. This system should keep the heat transfer coefficient greater than the vendor provided service transfer coefficient of 275.5 BTU/hr-ft^{2}-°F. Thus, it is reasonable to assume that the minimum CCW Heat Exchanger coefficient for these heat exchangers is at least 300 BTU/hr-ft^{2}-°F.

5. Maximum Service Water Temperature for Operation with CCW Heat Exchangers E-4A and 5B

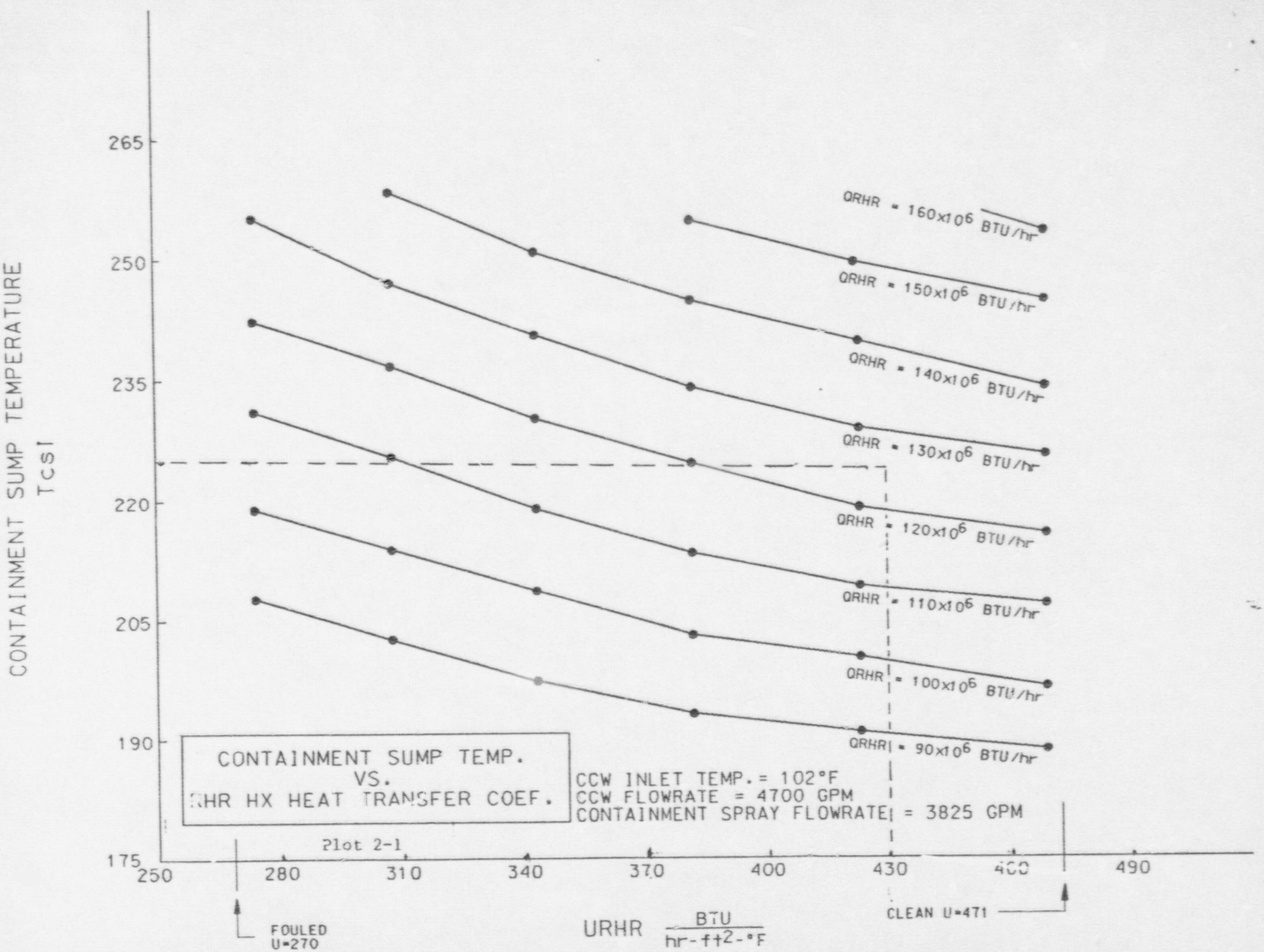
   Based on (3) and (4) above, and Plot 2-2, the maximum Service Water temperature allowable for operation with E-4A and 5B is about 75°F.

6. Operating Conditions for CCW Heat Exchangers E-4B and 5A

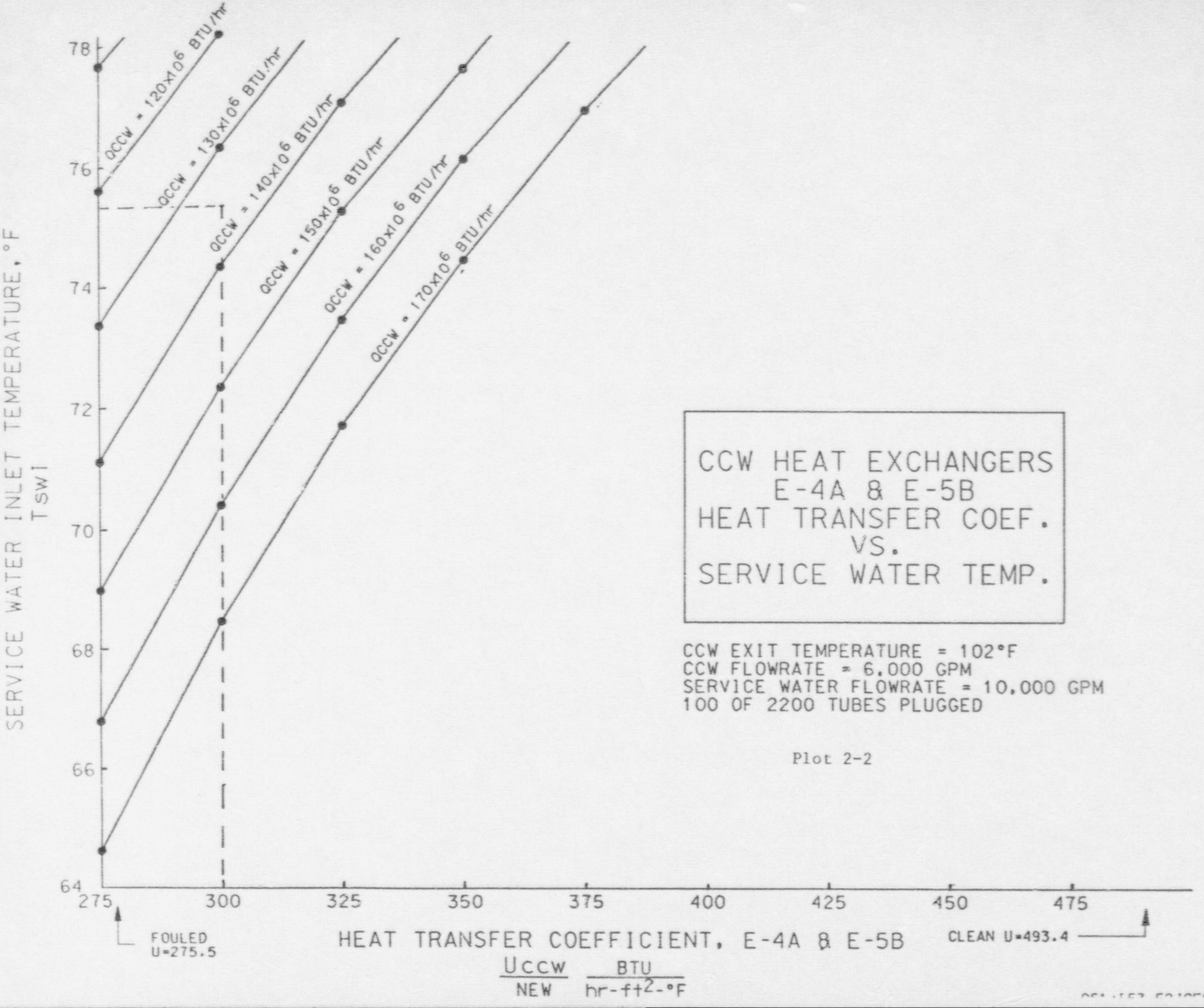
   CCW Heat Exchangers E-4B and 5A are normally out of service in a wet condition. Assuming that the heat exchangers are fouled to the manufacturers stated service transfer coefficient of 257 BTU/hr-ft^{2}-°F, the maximum Service Water temperature allowable for continuous operation with E-4B and 5A is about 60°F. Should it be necessary to operate with E-4B or 5A when the Service Water temperature is greater than 60°F, Maine Yankee will impose administrative controls to operate at 2630 MWth.

Conservatisms

In all cases, the analysis assumptions have been made to maximize the CCW temperature. Work now being performed by Stone and Webster is expected to identify areas where the conservatisms could reasonably be reduced. This effort is expected to be complete by the end of July.

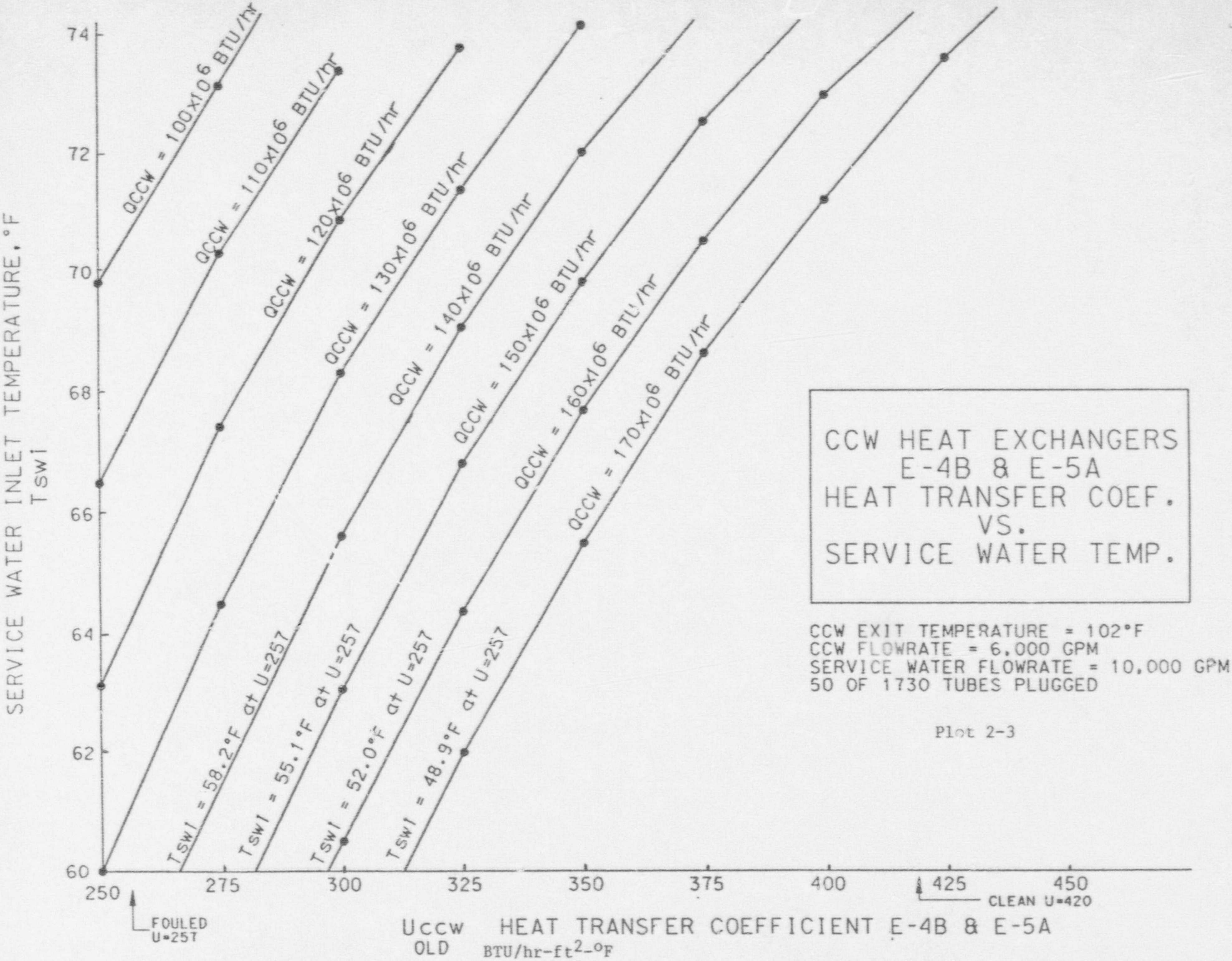

CONTAINMENT SUMP TEMPERATURE
TcsI
265
250
235
220
205
190
175
250
280
310
340
370
400
430
460
490
QRHR = 160x10^6 BTU/hr
QRHR = 150x10^6 BTU/hr
QRHR = 140x10^6 BTU/hr
QRHR = 130x10^6 BTU/hr
QRHR = 120x10^6 BTU/hr
QRHR = 110x10^6 BTU/hr
QRHR = 100x10^6 BTU/hr
QRHR = 90x10^6 BTU/hr
CONTAINMENT SUMP TEMP.
VS.
RHR HX HEAT TRANSFER COEF.
CCW INLET TEMP. = 102°F
CCW FLOWRATE = 4700 GPM
CONTAINMENT SPRAY FLOWRATE = 3825 GPM
FOULED
U=270
CLEAN U=471
URHR BTU/hr-ft2-°F

Plot 2-1



CCW HEAT EXCHANGERS
E-4A & E-5B
HEAT TRANSFER COEF.
VS.
SERVICE WATER TEMP.
CCW EXIT TEMPERATURE = 102°F
CCW FLOWRATE = 6,000 GPM
SERVICE WATER FLOWRATE = 10,000 GPM
100 OF 2200 TUBES PLUGGED
SERVICE WATER INLET TEMPERATURE, °F
Tswi
HEAT TRANSFER COEFFICIENT, E-4A & E-5B
Uccw NEW BTU / hr-ft2-°F
QCCW = 120x10^6 BTU/hr
QCCW = 130x10^6 BTU/hr
QCCW = 140x10^6 BTU/hr
QCCW = 150x10^6 BTU/hr
QCCW = 160x10^6 BTU/hr
QCCW = 170x10^6 BTU/hr
FOULED U=275.5
CLEAN U=493.4
64
66
68
70
72
74
76
78
275
300
325
350
375
400
425
450
475

Plot 2-2



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