(1/97)

NUCLEAR ENGINEERING DEPARTMENT

Calculation Cover Sheet

Cook Nuclear Plant

CALCULATION No. ENSM970919AF	INDIANA MICHIGAN POWER COMPANY
SAFETY RELATED YES ✓ NO ___	UNIT No. 1 & 2 AF 10/13/97
SYSTEM CCW	CALCULATED BY: ~~A. Felicia 9/19/97~~ Walter E. McCrory DATE 10/10/97
TITLE CCW PP NPSH	VERIFIED BY: ~~J.W. [illegible] 9/25/97~~ WEM 10/10/97 DATE
DCP/RFC/MM/PM/PR/CR/TM No. N/A	APPROVED BY: Paul [illegible] 10/13/97 DATE
FILE LOCATION CCW CALC FILE	

CALCULATION DESCRIPTION: The single train cooldown analysis stipulates a CCW supply temperature of 120°F. The results of the cooldown analysis indicate a CCW Hx inlet temperature in excess of the design conditions. This calculation determines if the NPSH available exceeds the required due to the pump suction temperature resulting from the single train cooldown.

METHOD OF VERIFICATION: ALTERNATE CALCULATION ~~[illegible]~~ 10/10/97 WEM REVIEW W. E. McCrory

REVISION

NO.	REASON FOR CHANGE	Calculated By	Date	Verified By	Date	Approved By	Date

To: Gordon C Allen@NEPP@COOK
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From: Paul G Schoepf@NESM@COOK
Subject: Calc Peer Review
Date: Tuesday, October 14, 1997 23:30:19 EDT
Attach:
Certify: N
Priority: Normal
Defer until:
Expires:
Forwarded by:

Ripak, Proulx and I reviewed calc ENSM970926QSL (CCW pressure gradient following a thermal barrier rupture). A CR will be written on Wednesday, and this will be a restart issue. Most comments were admin, however, there were a few that would impact the calculation result. While we don't expect the end conclusion to change, we felt they were technical enough to warrant making it a restart issue to redo the calc.

Comments:

Cover Page

1. Condition Report reference not indicated on cover sheet.

2. Page number not listed on cover sheet.

Purpose

1. Purpose statement refers to CCW design pressure, however, the calculation never indicated what the design pressure is.

2. Purpose statement should also refer to the CR that caused the calculation to be performed.

Inputs

1. Should state CCW system design pressure and source, so there is a clear objective for the calculation results.

2. Inputs discuss Pressurizer Safety Valve uncertainty of 3% (which is the Unit 1 value, Unit 2 is 1%), however, safety valve accumulation should also be included. Should acknowledge the difference in the uncertainties between the units, and use the more conservative one.

3. Calculation refers to RCP suction temperature of 541.27F and ultimately uses a "conservative" temperature of 547F. There is no basis given for either of these numbers, and why the

Problem:

The Westinghouse cooldown analysis uses a maximum CCW supply temperature of 120°F as an input parameter in the analysis. This parameter is a Westinghouse design basis temperature for all Westinghouse plants (see AEW-640, March 31,1969). Plant operating procedures set an operating limit of <120°F to ensure that the 120°F limit is not exceeded when instrument uncertainty is considered. Westinghouse has indicated that during normal operation the design basis CCW supply temperature is 95°F. As a result of this analysis stipulation it is necessary to evaluate the impact on the CCW pump's NPSH available. The results of this calculation are to be used to assure that the CCW pumps have adequate NPSH under the higher temperature conditions. This calculation will include instrument uncertainty for the surge tank level and CCW pump flow instrumentation. These results could potentially impact plant operating procedures and as such the results will be provided to I&C and the Operations Department for their use and implementation.

The CCW supply temperature originates from the outlet of the CCW heat exchanger. The pump circulates the fluid through the CCW heat exchanger, for cooling, prior to supplying the cooling flow to the equipment cooled by the CCW system. On this basis, the return fluid to the CCW pump suction is at a higher temperature in excess of the 120°F CCW heat exchanger outlet temperature. This calculation will evaluate the impact on the CCW pump's NPSH requirements at the design flow of 8000 gpm, and also at the maximum normal flow of 9000 gpm allowed by the plant operating procedure 1,2 OHP 4021.016.003. Additionally, the NPSH will be determined at a pump runout flow, based on extending the performance curve, of 11,000 gpm Finally, since the maximum flow is a measured parameter, an additional flow margin will be included to address flow instrument uncertainty thereby ensuring that the NPSH available exceeds the NPSH required at the maximum measured flow.

Inputs:

1- Piping configuration from the surge tank feed line connection on the return piping to the pump suction obtained from the following isometric drawings (copy attached):

Unit 1 E CCW Pp 1-CCW-35 Unit 1 W CCW Pp 1-CCW-37 1 of 2, 2 of 2

Unit 2 E CCW Pp 2-CCW-39 Unit 2 W CCW Pp 2-CCW-38 1 of 2, 2 of 2

2- CCW pump design flow of 8000 gpm and NPSH required of 16 ft abs, 9000 gpm (maximum flow) and NPSH required 18.5 ft abs. CCW pump flow is measured by CFI-410,-420. These flow instruments are 0 to 10000 gpm full span and have the

following uncertainty associated with the flow indications were obtained from ECP WSI-15:

100 % Span	+1.93%	-3.76%
80% Span	+ 2.38%	-4.68%

Based on the above a 9000 gpm flow reading will be 90% of span and the uncertainty can be determined by interpolation since at these percentages the readings are on the flat portion of the orifice curve. In this case we are only interested in the + uncertainty since this yields a higher flow requiring a greater NPSH.

Interpolation Results

100 % Span			+1.93%			
90% Span	10	20		x	x - 1.93	.45
80% Span			+ 2.38%			

Instrument uncertainty at 90% span, x = 1.93 + .45(10/20) = 2.16%
This results in a flow increase of 194 gpm (9000 x .0216) for a total flow 9194 gpm.
he NPSH required at this flow is 19.0 ft abs.

The NPSH requirements are all obtained from pump characteristic curve number 48839 (copy attached).

3- Resistance coefficient K for friction losses in pipe fittings obtained from Cameron Hydraulic Data Book pg. 3-111 to 3-117.

4- Pipe velocity and head loss per 100 ft flows through pipes obtained from Cameron Hydraulic Data Book pg. 3-12 to 3-31.

5- Fluid vapor pressure and temperature conversion obtained from Cameron Hydraulic Data Book pg. 4-4 to 4-5.

6- Elevation from surge tank low level alarm 657' - 0"; pump suction 610'- 10" results in a difference of 46.17 ft (H_{st}). Pump suction elevation obtained from isometric drawings 1-CCW-35 and 1-CCW-36. Low level alarm setpoint of 657'-0" (CLA-412,-413) and instrument acceptable calibration range of +/- 1" obtained from calibration procedure 12 IHP6030IMP.066. This results in a low level elevation of 656'-11" when accounting for instrument uncertainty of -1". Therefore, the H_{st} to account for uncertainty is 656'-11" minus 610'- 10" which results in 46.09 ft elevation difference.

Formulas:

All formulas used are obtained from Cameron Hydraulic Data Book page numbers noted by formulas.

$H_k = k (V^2)/2g$ (pg. 3-110)

where, H_k – head loss through valves and fittings, ft
k – resistance coefficient, dimensionless
V– velocity, ft/sec
g- gravitational constant, 32 ft/sec^2

$NPSH_{available} = H_a - H_{vpa} + H_{st} - H_{fs}$ (pg. 1-10)

Where, $NPSH_{available}$ - net positive suction head, ft abs
H_a - atmospheric pressure, 34 ft
H_{vpa} - liquid vapor pressure, ft
H_{st} - static head, ft
H_{fs} - friction losses, ft

$H_{pl} = L_p \times (hl/100)$
Where, H_{pl} - head loss for straight pipe length, ft
L_p - straight pipe length, ft
(hl/100) - head loss ft per 100 ft

Assumptions:

1- Piping from surge tank to return header piping not included as part of this analysis. This piping is not included since the CCW system is a closed loop cooling system. This piping does not provided a flow path but allows for the volume change in the system inventory due to thermal effects.

2- Piping included is that from the surge tank connection on the return header to the pump suction (see marked isometric drawing).

3- Pump suction temperature of 160°F based on Westinghouse Cooldown analysis (9/15/97 copy pg. 1, 8 through 10 attached) results that indicated maximum CCW temperature of 156.4 °F. At 160°F the vapor pressure and conversion factor are 4.74 psia and 2.361 ft/psi from Cameron pg. 4-4. The vapor pressure in ft is 11.19.

4- Flow through the 14" OD is 5000 gpm based on UFSR table 9.5-2 (copy attached). This pipe represents the return flow from one train of safety pumps and one RHR heat exchanger.

5- Flow through the 18" OD pipe will consists of the total flow returned to the pump of 8000gpm, 9000 gpm , and total flow due to instrument uncertainty.

6- For the runout flow of 11000 gpm it is assumed that both safeguards trains are in service. That is, both trains 14" OD pipe is in service each with a flow of 5000 gpm. The friction loss for this arrangment is the same as the single 14" OD pipe since they are a parallel flow path.

Calculation:

Note: The friction losses required in the NPSH equation will be determined for both units E and W CCW pps. The largest resultant friction loss will be used to bound the individual pumps NPSH available.

Unit 1 ECCW Pp Friction Loss at 8000 gpm

The piping to the suction of the pump consists of a 14" and 18" diameter pipes based on 1-CCW-35 starting from marked point A to B.

For the 14" OD pipe it consists of the following:

tee run, 90° SR elbow, 3.5 ft, 90° LR elbow, tee run, 6.23 ft, 45° elbow, 29.67 ft, t run 45° elbow, 8.34 ft, 90° SR elbow, 2.33 ft, 90° SR elbow, 5.5 ft, 90° LR elbow, 13.5 ft, 90° LR elbow, 16.17 ft, 45° elbow, 6.48 ft, 45° elbow, 58.08 ft, 90° LR elbow, 8.0 ft, 90° LR elbow, 6.91 ft, 2 90° LR elbow, 12.08 ft

Based on the above the totals are determined:

176.79 ft straight pipe length, 6 90° elbows, 3 90° SR elbow, 5 45° elbows, 3 t-run
At 5000 gpm the velocity equals 11.86 ft/sec and the loss is 2.79 ft per 100 ft (pg. 3-26)
90° elbows k = .21 45° elbows k=.21 T-run k = .26 90° SR elbow k = .39
k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 176.79 \times (2.79/100) = 4.93$ ft

$H_{k90°LR} = k\,(V^2)/2g = 6 \times .21 \times (11.86^2/64.4) = 2.75$ ft

$H_{k90°SR} = k\,(V^2)/2g = 3 \times .39 \times (11.86^2/64.4) = 2.56$ ft

$H_{k45°} = k\,(V^2)/2g = 5 \times .21 \times (11.86^2/64.4) = 2.29$ ft

$H_{kT\text{-}run} = k\,(V^2)/2g = 3 \times .26 \times (11.86^2/64.4) = 1.7$ ft

$H_{14"}$ = sum of above = 14.23 ft

For the 18" OD pipe it consists of the following:

tee branch, 14x18 increaser, 3.46 ft, 90° SR elbow, 4.33 ft, tee branch, 2.67 ft, butterfly valve, tee branch

Based on the above the totals are determined:

10.46 ft straight pipe length, 1 90° SR elbow, 1 14/18 increaser, 3 T-branches, 1 butterfly valve

At 8000 gpm the velocity equals 11.5 ft/sec and the loss is 1.94 ft per 100 ft (pg. 3-27) 90° SR elbow k = .36 T-branch k = .72 k for diffuser = $(1-(d1/d2)^2)^2/(d1/d2)^4$ Crane 25th printing 1991 pg A-26 formula 4, butterfly valve k = .3, k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 10.46 \times (1.94/100) = .2$ ft

$H_{k90°SR} = k (V^2)/2g = .36 \times (11.5^2/64.4) = .74$ ft

$H_{kbutterfly} = k (V^2)/2g = .3 \times (11.5^2/64.4) = .62$ ft

$H_{kT\text{-}branch} = k (V^2)/2g = 3 \times .72 \times (11.5^2/64.4) = 4.44$ ft

diffuser = $(1-(d1/d2)^2)^2)/(d1/d2)^4 = (1-(14/18)^2)^2 / (14/18)^4 = .426$

$H_{kdifusser} = k (V^2)/2g = .426 \times (11.5^2/64.4) = .875$ ft

$H_{18"}$ = sum of above = 6.88 ft

$H_{fs} = H_{14"} + H_{18"} = 21.11$ ft

Unit 1 WCCW Pp Friction Loss at 8000 gpm

The piping to the suction of the pump consists of a 14" and 18" diameter pipes based on 1-CCW-37 1 of 2, 2 of 2 starting from marked point A to B.

For the 14" OD pipe it consists of the following:

tee run, 6 ft, 90° LR elbow, 24 ft, 90° LR elbow, tee branch, 7 ft, 90° LR elbow, 9.83 ft, 45° elbow, 3.18 ft, 90° LR elbow, 5.18 ft, 45° elbow, 4 ft, 90° LR elbow, 13 ft, 90° LR elbow, 12.75 ft, 45° elbow, 21.68 ft, 45° elbow, 33.08 ft, 2 90° LR elbow, 27.33 ft,

Based on the above the totals are determined:

167.03 ft straight pipe length, 8 90° elbows, 4 45° elbows, 1 t-run, 1 t branch
At 5000 gpm the velocity equals 11.86 ft/sec and the loss is 2.79 ft per 100 ft (pg. 3-26)
90° LR elbows k = .21 45° elbows k=.21 T-run k = .26 T-branch k = .78
k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 167.03 \times (2.79/100) = 4.66$ ft

$H_{k90°LR} = k (V^2)/2g = 8 \times .21 \times (11.86^2/64.4) = 3.67$ ft

$H_{k45°} = k (V^2)/2g = 4 \times .21 \times (11.86^2/64.4) = 1.83$ ft

$H_{kT\text{-}run} = k (V^2)/2g = .26 \times (11.86^2/64.4) = .57$ ft

$H_{kT\text{-}branch} = k (V^2)/2g = .78 \times (11.86^2/64.4) = 1.7$ ft

$H_{14"}$ = sum of above = 12.43 ft

For the 18" OD pipe it consists of the following:

tee run, 2.67 ft, 3.67 ft, 45° elbow, 4.24 ft, 90° LR elbow, 4.33 ft, t branch, butterfly valve
90° SR elbow, 4.33 ft, tee branch. 2.75 ft, 14x18 increaser

Based on the above the totals are determined:

21.99 ft straight pipe length, 2 90° LR elbow, 1 45° elbow, 1 14/18 increaser,
2 T-branch, 1 T run, 1 butterfly valve

At 8000 gpm the velocity equals 11.5 ft/sec and the loss is 1.94 ft per 100 ft (pg. 3-27)
90° LR elbow k = .19 T-branch k = .72 k for diffuser = $(1-(d1/d2)^2)^2/(d1/d2)^4$ Crane 25th printing 1991 pg A-26 formula 4, butterfly valve k = .3, 45° elbow k = .19
T run k = .24, k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 21.99 \times (1.94/100) = .43$ ft

$H_{k90°LR} = k (V^2)/2g = 2 \times .19 \times (11.5^2/64.4) = .78$ ft

$H_{k45°LR} = k (V^2)/2g = .19 \times (11.5^2/64.4) = .39$ ft

$H_{kbutterfly} = k (V^2)/2g = .3 \times (11.5^2/64.4) = .62$ ft

$H_{kT\text{-}branch} = k (V^2)/2g = 2 \times .72 \times (11.5^2/64.4) = 2.96$ ft

$H_{kT\text{-}run} = k\,(V^2)/2g = .24 \times (11.5^2/64.4) = .49$ ft

diffuser $= (1-(d1/d2)^2)^2)\,/(d1/d2)^4 \;=\; (1-(14/18)^2)^2 / (14/18)^4 = .426$

$H_{kdifusser} = k\,(V^2)/2g = .426 \times (11.5^2/64.4) = .875$ ft

$H_{18"}$ = sum of above = 6.55 ft

$H_{fs} = H_{14"} + H_{18"} = 18.98$ ft

<u>Unit 2 ECCW Pp Friction Loss at 8000 gpm</u>

The piping to the suction of the pump consists of a 14" and 18" diameter pipes based on 2-CCW-39 starting from marked point A to B.

For the 14" OD pipe it consists of the following:

tee branch, 3.5 ft, 90° SR elbow, 2.91 ft, 45° elbow, tee run, 8.06 ft, 45° elbow, 20.83 ft, 90° LR elbow, 6.58 ft, 90° LR elbow, 15.25 ft, 90° LR elbow, 4.59 ft, 45° elbow, 78.91 ft, 45° elbow, 3.67 ft, 45° elbow, 14.16 ft, 90° LR elbow, 2.83 ft

Based on the above the totals are determined:

161.25 ft straight pipe length, 4 90° LR elbows, 1 90° SR elbow, 5 45° elbows, 1 t-run, 1 t branch
At 5000 gpm the velocity equals 11.86 ft/sec and the loss is 2.79 ft per 100 ft (pg. 3-26)
90° LR elbows k = .21 45° elbows k=.21 T-run k = .26 90° SR elbow k = .39
T branch k = .78 k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 161.25 \times (2.79/100) = 4.49$ ft

$H_{k90°LR} = k\,(V^2)/2g = 4 \times .21 \times (11.86^2/64.4) = 1.83$ ft

$H_{k90°SR} = k\,(V^2)/2g = .39 \times (11.86^2/64.4) = .85$ ft

$H_{k45°} = k\,(V^2)/2g = 5 \times .21 \times (11.86^2/64.4) = 2.29$ ft

$H_{kT\text{-}run} = k\,(V^2)/2g = .26 \times (11.86^2/64.4) = .57$ ft

$H_{kT\text{-}branch} = k\,(V^2)/2g = .78 \times (11.86^2/64.4) = 1.7$ ft

$H_{14"}$ = sum of above = 11.73 ft

For the 18" OD pipe it consists of the following:

tee branch, 14x18 increaser, 21.5 ft, 90° LR elbow, 9.91 ft, 2.16 ft, tee branch, 2.25 ft, butterfly valve, 90° SR elbow, 4.33 ft, tee branch, 2.66 ft

Based on the above the totals are determined:

42.81 ft straight pipe length, 1 90° SR elbow, 1 90° LR elbow,1 14/18 increaser, 3 T-branches, 1 butterfly valve

At 8000 gpm the velocity equals 11.5 ft/sec and the loss is 1.94 ft per 100 ft (pg. 3-27) 90° SR elbow k = .36 T-branch k = .72 k for diffuser = $(1-(d1/d2)^2)^2/(d1/d2)^4$ Crane 25th printing 1991 pg A-26 formula 4, 90° LR elbow k = .19, butterfly valve k = .3, k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 42.81 \times (1.94/100) = .83$ ft

$H_{k90°SR} = k (V^2)/2g = .36 \times (11.5^2/64.4) = .74$ ft

$H_{k90°LR} = k (V^2)/2g = .19 \times (11.5^2/64.4) = .39$ ft

$H_{kbutterfly} = k (V^2)/2g = .3 \times (11.5^2/64.4) = .62$ ft

$H_{kT\text{-}branch} = k (V^2)/2g = 3 \times .72 \times (11.5^2/64.4) = 4.44$ ft

diffuser = $(1-(d1/d2)^2)^2) /(d1/d2)^4 = (1-(14/18)^2)^2 / (14/18)^4 = .426$

$H_{kdifusser} = k (V^2)/2g = .426 \times (11.5^2/64.4) = .875$ ft

$H_{18"}$ = sum of above = 7.9 ft

$H_{fs} = H_{14"} + H_{18"} = 19.63$ ft

Unit 2 WCCW Pp Friction Loss at 8000 gpm

The piping to the suction of the pump consists of a 14" and 18" diameter pipes based on 2-CCW-38 1 of 2, 2 of 2 starting from marked point A to B.

For the 14" OD pipe it consists of the following:

tee branch, 7.5 ft, tee run, 90° LR elbow, 22.5 ft, 90° LR elbow, 8.5 ft, 90° LR elbow, 36.83 ft, 45° elbow, 2.7 ft, 45° elbow, 12.75 ft

Based on the above the totals are determined:

90.76 ft straight pipe length, 3 90° elbows, 2 45° elbows, 1 t-run, 1 t branch
At 5000 gpm the velocity equals 11.86 ft/sec and the loss is 2.79 ft per 100 ft (pg. 3-26)
90° LR elbows k = .21   45° elbows k=.21   T-run k = .26   T-branch k = .78
k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 90.76 \times (2.79/100) = 2.53$ ft

$H_{k90°LR} = k (V^2)/2g = 3 \times .21 \times (11.86^2/64.4) = 1.38$ ft

$H_{k45°} = k (V^2)/2g = 2 \times .21 \times (11.86^2/64.4) = .92$ ft

$H_{kT\text{-}run} = k (V^2)/2g = .26 \times (11.86^2/64.4) = .56$ ft

$H_{kT\text{-}branch} = k (V^2)/2g = .78 \times (11.86^2/64.4) = 1.7$ ft

$H_{14"}$ = sum of above = 7.09 ft

For the 18" OD pipe it consists of the following:

tee branch,14x18 increaser, 7.83 ft, 90° LR elbow, 42.25 ft, 45° elbow, 3.18 ft, 90° LR elbow, 33.08 ft, 90° LR elbow, 5.66 ft, t branch, 3.33, 90° LR elbow, butterfly valve, 90° LR elbow, 4.33 ft, tee branch. 2.67 ft

Based on the above the totals are determined:

102.33 ft straight pipe length, 5 90° LR elbow, 1 45° elbow, 1 14/18 increaser,
3 T-branch, 1 butterfly valve,

At 8000 gpm the velocity equals 11.5 ft/sec and the loss is 1.94 ft per 100 ft (pg. 3-27)
90° LR elbow k = .19   T-branch k = .72   k for diffuser = $(1-(d1/d2)^2)^2/(d1/d2)^4$ Crane 25th printing 1991 pg A-26 formula 4, butterfly valve k = .3, 45° elbow k = .19
k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 102.33 \times (1.94/100) = 1.99$ ft

$H_{k90°LR} = k (V^2)/2g = 5 \times .19 \times (11.5^2/64.4) = 1.95$ ft

$H_{k45°LR} = k (V^2)/2g = .19 \times (11.5^2/64.4) = .39$ ft

$H_{kbutterfly} = k (V^2)/2g = .3 \times (11.5^2/64.4) = .62$ ft

$H_{kT\text{-}branch} = k (V^2)/2g = 3 \times .72 \times (11.5^2/64.4) = 4.44$ ft

diffuser = $(1-(d1/d2)^2)^2) / (d1/d2)^4$ = $(1-(14/18)^2)^2 / (14/18)^4 = .426$

$H_{kdifusser} = k (V^2)/2g = .426 \times (11.5^2/64.4) = .875$ ft

$H_{18"}$ = sum of above = 10.27 ft

$H_{fs} = H_{14"} + H_{18"} = 17.36$ ft

Determine NPSH available

Based on the preceeding friction loss determinations, the U1 ECCW Pp's suction piping has the highest resistance. The resistance for this piping was detremined as 20.65 ft at 8000 gpm. Therefore, the bounding available NPSH is

$NPSH_{available} = H_a - H_{vpa} + H_{st} - H_{fs}$

$= 34 - 11.19 + 46.09 - 21.11 = 47.79$ ft abs

The available NPSH was determined at a fluid temperature of 160°F.

The NPSH available for the ECCW Pp will additionally be detremined at 9000 gpm and 9194 gpm.

<u>NPSH Available at 9000 gpm</u>

For the 14" OD pipe it consists of the following:

tee run, 90° SR elbow, 3.5 ft, 90° LR elbow, tee run, 6.23 ft, 45° elbow, 29.67 ft, t run 45° elbow, 8.34 ft, 90° SR elbow, 2.33 ft, 90° SR elbow, 5.5 ft, 90° LR elbow, 13.5 ft, 90° LR elbow, 16.17 ft, 45° elbow, 6.48 ft, 45° elbow, 58.08 ft, 90° LR elbow, 8.0 ft, 90° LR elbow, 6.91 ft, 2 90° LR elbow, 12.08 ft

Based on the above the totals are determined:

176.79 ft straight pipe length, 6 90° elbows, 3 90° SR elbow, 5 45° elbows, 3 t-run
At 5000 gpm the velocity equals 11.86 ft/sec and the loss is 2.79 ft per 100 ft (pg. 3-26)
90° elbows k = .21 45° elbows k=.21 T-run k = .26 90° SR elbow k = .39
k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 176.79 \times (2.79/100) = 4.93$ ft

$H_{k90°LR} = k (V^2)/2g = 6 \times .21 \times (11.86^2/64.4) = 2.75$ ft

$H_{k90°SR} = k (V^2)/2g = 3 \times .39 \times (11.86^2/64.4) = 2.56$ ft

$H_{k45°} = k (V^2)/2g = 5 \times .21 \times (11.86^2/64.4) = 2.29$ ft

$H_{kT\text{-}run} = k (V^2)/2g = 3 \times .26 \times (11.86^2/64.4) = 1.7$ ft

$H_{14"}$ = sum of above = 14.23 ft

For the 18" OD pipe it consists of the following:

tee branch, 14x18 increaser, 3.46 ft, 90° SR elbow, 4.33 ft, tee branch, 2.67 ft, butterfly valve, tee branch

Based on the above the totals are determined:

10.46 ft straight pipe length, 1 90° SR elbow, 1 14/18 increaser, 3 T-branches, 1 butterfly valve

At 9000 gpm the velocity equals 12.9 ft/sec and the loss is 2.43 ft per 100 ft (pg. 3-27) 90° SR elbow k = .36 T-branch k = .72 k for diffuser = $(1-(d1/d2)^2)^2/(d1/d2)^4$ Crane 25th printing 1991 pg A-26 formula 4, butterfly valve k = .3, k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 10.46 \times (2.43/100) = .25$ ft

$H_{k90°SR} = k (V^2)/2g = .36 \times (12.9^2/64.4) = .93$ ft

$H_{kbutterfly} = k (V^2)/2g = .3 \times (12.9^2/64.4) = .78$ ft

$H_{kT\text{-}branch} = k (V^2)/2g = 3 \times .72 \times (12.9^2/64.4) = 5.58$ ft

diffuser = $(1-(d1/d2)^2)^2) /(d1/d2)^4 = (1-(14/18)^2)^2 / (14/18)^4 = .426$

$H_{kdifusser} = k (V^2)/2g = .426 \times (12.9^2/64.4) = 1.1$ ft

$H_{18"}$ = sum of above = 8.64 ft

$H_{fs} = H_{14"} + H_{18"} = 22.87$ ft

$NPSH_{available} = H_a - H_{vpa} + H_{st} - H_{fs}$

$= 34 - 11.19 + 46.09 - 22.87 = 46.03$ ft abs

<u>NPSH Available at 9194 gpm (Flow Instrument Uncertainty)</u>

For the 14" OD pipe it consists of the following:

tee run, 90° SR elbow, 3.5 ft, 90° LR elbow, tee run, 6.23 ft, 45° elbow, 29.67 ft, t run 45° elbow, 8.34 ft, 90° SR elbow, 2.33 ft, 90° SR elbow, 5.5 ft, 90° LR elbow, 13.5 ft, 90° LR elbow, 16.17 ft, 45° elbow, 6.48 ft, 45° elbow, 58.08 ft, 90° LR elbow, 8.0 ft, 90° LR elbow, 6.91 ft, 2 90° LR elbow, 12.08 ft

Based on the above the totals are determined:

176.79 ft straight pipe length, 6 90° elbows, 3 90° SR elbow, 5 45° elbows, 3 t-run
At 5000 gpm the velocity equals 11.86 ft/sec and the loss is 2.79 ft per 100 ft (pg. 3-26)
90° elbows k = .21 45° elbows k=.21 T-run k = .26 90° SR elbow k = .39
k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 176.79 \times (2.79/100) = 4.93$ ft

$H_{k90°LR} = k\,(V^2)/2g = 6 \times .21 \times (11.86^2/64.4) = 2.75$ ft

$H_{k90°SR} = k\,(V^2)/2g = 3 \times .39 \times (11.86^2/64.4) = 2.56$ ft

$H_{k45°} = k\,(V^2)/2g = 5 \times .21 \times (11.86^2/64.4) = 2.29$ ft

$H_{kT\text{-}run} = k\,(V^2)/2g = 3 \times .26 \times (11.86^2/64.4) = 1.7$ ft

$H_{14''}$ = sum of above = 14.23 ft

For the 18" OD pipe it consists of the following:

Interpolation results for velocity and loss, values from Cameron pg 3-26

9000	12.9	2.43
9194	V	L
10000	14.3	2.99

V = 13.17 ft/sec L = 2.54

tee branch, 14x18 increaser, 3.46 ft, 90° SR elbow, 4.33 ft, tee branch, 2.67 ft, butterfly valve, tee branch

Based on the above the totals are determined:

10.46 ft straight pipe length, 1 90° SR elbow, 1 14/18 increaser, 3 T-branches, 1 butterfly valve

At 9194 gpm the velocity equals 13.17 ft/sec and the loss is 2.54 ft per 100 ft (pg. 3-27)
90° SR elbow k = .36 T-branch k = .72 k for diffuser = $(1-(d1/d2)^2)^2/(d1/d2)^4$ Crane 25th printing 1991 pg A-26 formula 4, butterfly valve k = .3, k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 10.46 \times (2.54/100) = .27$ ft

$H_{k90°SR} = k(V^2)/2g = .36 \times (13.17^2/64.4) = .97$ ft

$H_{kbutterfly} = k(V^2)/2g = .3 \times (13.17^2/64.4) = .81$ ft

$H_{kT\text{-}branch} = k(V^2)/2g = 3 \times .72 \times (13.17^2/64.4) = 5.82$ ft

diffuser $= (1-(d1/d2)^2)^2)/(d1/d2)^4 = (1-(14/18)^2)^2/(14/18)^4 = .426$

$H_{kdifusser} = k(V^2)/2g = .426 \times (13.17^2/64.4) = 1.15$ ft

$H_{18"}$ = sum of above = 9.02 ft

$H_{fs} = H_{14"} + H_{18"} = 23.25$ ft

$NPSH_{available} = H_a - H_{vpa} + H_{st} - H_{fs}$

$= 34 - 11.19 + 46.09 - 23.25 = 45.65$ ft abs

NPSH Available at 11000 gpm (Runout Flow)

For the 14" OD pipe it consists of the following:

tee run, 90° SR elbow, 3.5 ft, 90° LR elbow, tee run, 6.23 ft, 45° elbow, 29.67 ft, t run 45° elbow, 8.34 ft, 90° SR elbow, 2.33 ft, 90° SR elbow, 5.5 ft, 90° LR elbow, 13.5 ft, 90° LR elbow, 16.17 ft, 45° elbow, 6.48 ft, 45° elbow, 58.08 ft, 90° LR elbow, 8.0 ft, 90° LR elbow, 6.91 ft, 2 90° LR elbow, 12.08 ft

Based on the above the totals are determined:

176.79 ft straight pipe length, 6 90° elbows, 3 90° SR elbow, 4 45° elbows, 3 t-run
At 5000 gpm the velocity equals 11.86 ft/sec and the loss is 2.79 ft per 100 ft (pg. 3-26)
90° elbows k = .21   45° elbows k=.21   T-run k = .26   90° SR elbow k = .39
k from pg. 3-112 & 3-113

$H_{pl} = L_p \times (hl/100) = 176.79 \times (2.79/100) = 4.93$ ft

$H_{k90°LR} = k(V^2)/2g = 6 \times .21 \times (11.86^2/64.4) = 2.75$ ft

$H_{k90°SR} = k(V^2)/2g = 3 \times .39 \times (11.86^2/64.4) = 2.56$ ft

$H_{k45°} = k(V^2)/2g = 5 \times .21 \times (11.86^2/64.4) = 2.29$ ft

$H_{kT\text{-}run} = k\,(V^2)/2g = 3 \times .26 \times (11.86^2/64.4) = 1.7$ ft

$H_{14"}$ = sum of above = 14.23 ft

For the 18" OD pipe it consists of the following:

Interpolation results for velocity and loss, values from Cameron pg 3-26

10000	14.3	2.99
11000	V	L
12000	17.2	4.27

V = 15.75 ft/sec   L = 3.63

tee branch, 14x18 increaser, 3.46 ft, 90° SR elbow, 4.33 ft, tee branch, 2.67 ft, butterfly valve, tee branch

Based on the above the totals are determined:

10.46 ft straight pipe length, 1 90° SR elbow, 1 14/18 increaser, 3 T-branches, 1 butterfly valve

At 11000 gpm the velocity equals 15.75 ft/sec and the loss is 3.63 ft per 100 ft (pg. 3-27) 90° SR elbow k = .36 T-branch k = .72 k for diffuser = $(1-(d1/d2)^2)^2/(d1/d2)^4$ Crane 25th printing 1991 pg A-26 formula 4, butterfly valve k = .3, k from pg. 3-112. & 3-113

$H_{pl} = L_p \times (hl/100) = 10.46 \times (3.63/100) = .38$ ft

$H_{k90°SR} = k\,(V^2)/2g = .36 \times (15.75^2/64.4) = 1.39$ft

$H_{kbutterfly} = k\,(V^2)/2g = .3 \times (15.75^2/64.4) = 1.16$ ft

$H_{kT\text{-}branch} = k\,(V^2)/2g = 3 \times .72 \times (15.75^2/64.4) = 8.32$ ft

diffuser = $(1-(d1/d2)^2)^2)\,/(d1/d2)^4 = (1-(14/18)^2)^2 / (14/18)^4 = .426$

$H_{kdifusser} = k\,(V^2)/2g = .426 \times (15.75^2/64.4) = 1.64$ ft

$H_{18"}$ = sum of above = 12.89 ft

$H_{fs} = H_{14"} + H_{18"} = 27.12$ ft

$NPSH_{available} = H_a - H_{vpa} + H_{st} - H_{fs}$

$= 34 - 11.19 + 46.09 - 27.12 = 41.78$ ft abs

Results:

	Design Flow 8000 gpm	Maximum Flow 9000 gpm	Uncertainty 9194 gpm	Runout 11000 gpm
$NPSH_{available}$	47.79 ft abs	46.03 ft abs	45.65 ft abs	41.78 ft abs
$NPSH_{required}$	16 ft abs	18.5 ft abs	19 ft abs	25 ft abs
Margin	31.79 ft abs	27.53 ft abs	26.65 ft abs	16.78 ft abs

Conclusions:

The above tabulation indicates that the available NPSH exceeds the required NPSH under the high temperature CCW conditions. Including the surge tank level and flow instrument uncertainty at the maximum normal procedural CCW flow of 9194 gpm indicates that approximately 26 ft abs of margin exist. However, the maximum flow is not a requirement of the cooldown analysis. The cooldown analysis stipulates a maximum CCW flow of 8000 gpm. Allowing for instrument uncertainty at 8000 gpm of 2.38% results in a flow of 8190 gpm. This is acceptable since the tabulation indicates that margin exist at the higher flows tabulated.

It is noted that the 9000 gpm maximum flow is stated in plant procedure 1,2 OHP 4021.016.003 (normal CCW operation). During normal plant operating conditions the CCW temperature is at the design basis number of 95°F. At this temperature, the CCW fluid temperature supplied to the pump is 114°F from the CCW heat exchanger data sheet. The vapor pressure is determined to be 1.25 psia or 2.91 ft. The NPSH requirements at 114°F and maximum flow of 9194 gpm during normal operation is as follows:

$$NPSH_{available} = H_a - H_{vpa} + H_{st} - H_{fs} = 34 - 2.91 + 46.09 - 23.25 = 53.93 \text{ ft abs}$$

From the above tabulation the NPSH required at 9194 gpm is 19 ft abs which yields a margin of 34.93 ft abs.

Westinghouse Calculation Cover Sheet
Proprietary Class 2C

Title: Cooldown Runs to Support Startup		Page 1 of 15
Project: AEP/AMP	Calculation #: SAE/FSE-C-AEP/AMP-0102	S.O.: ANLP-280
Author/Date: Gary J. Corpora *Gary J. Corpora 9/15/97*		File:

Purpose: Perform single and 2-train cooldown runs with RHRCOOL using parameters agreed upon with AEP.

Results: Both single and 2-train cooldown meet the cooldown times.

Assignment of Verifier: The individual named below is hereby assigned the responsibility of independent reviewer to verify the calculation identified above.

Name: Kenneth N. Garner

Minimum Extent of Verification (identified by responsible Manager):
The minimum extent of verification is identified as follows: (1) Verify calculation to the standards of the Westinghouse ESBU Quality Policy and Procedure Manual, specifically, Procedure WP-4.17.

CC EGJC KNG

Manager's Signature: *R o Mayer* Date: *9/16/97*

Results of Verification (brief statement by verifier):
The following briefly states how this calculation was verified:
methodology, calculation & results were reviewed and found to be acceptable.

Verifier's Signature: *K N Garner* Date: *9/15/97*

Computer Code(s) Used in the Calculation:

Program Name: RHRCOOL	Issue/Rev. No.: 2.0	Computer Used: PC
Release Letter No.: SAE/FSE-M-0202, 8/26/97	Date(s) Used: 8/12,15/97	
Properly Used: (If NO, list restrictions/exclusions and justifications) yes		
Program Name:	Issue/Rev. No.:	Computer Used:
Release Letter No.:	Date(s) Used:	
Properly Used: (If NO, list restrictions/exclusions and justifications)		

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for SM970919AC pg 17 of 26 AC 9/19/97

TITLE			PAGE
Cooldown Runs to Support Startup			9 of 15
PROJECT AEP/AMP	AUTHOR G. J. Corpora	CHK'D. BY DATE	VERIFIED BY K. N. Garner DATE
S.O. ANLP-280	CALC NO. SAE/FSE-C-AEP/AMP-0102	FILE NO.	GROUP FSE

```
  117.2   1.81 110.4   .81 106.6 159.6 142.3 112.3 155.7 * 300.0    5.0
  114.4   2.05 104.8 1.27 105.8 157.6 140.7 111.4 159.7 * 250.0    6.0
   91.8   2.13 100.3 1.48 100.0 141.6 128.2 104.6 144.9 * 206.9    7.0
   75.0   2.13  96.6 1.48  95.7 129.7 118.9  99.5 132.4 * 183.0    8.0
   65.7   2.13  93.5 1.48  93.3 123.1 113.7  96.6 125.4 * 169.8    9.0
   60.3   2.13  90.8 1.48  91.9 119.3 110.6  95.0 121.4 * 162.1   10.0
   54.0   2.13  88.5 1.48  90.3 114.8 107.1  93.0 116.7 * 153.2   11.0
   48.9   2.13  86.4 1.48  89.0 111.2 104.2  91.5 112.9 * 146.0   12.0
   45.9   2.13  84.6 1.48  88.2 109.0 102.5  90.5 110.6 * 141.6   13.0
   44.6   2.13  83.6 1.48  87.9 108.1 101.8  90.1 109.7 * 139.8   13.6
 ******************************************************************
 REACTOR COOLED TO  139.82 DEGREES IN  13.6 HOURS.
 RHRHX MAX Q =  120.76 AT   4.0 HRS.
 RCS FLOW W1 THROTTLED TO MEET  50.0 F/HR CRITERION
 STARTED THROTTLING AT    4.0 HRS, AND 350.0 DEGR.
 STOPPED THROTTLING AT    6.2 HRS, AND 240.0 DEGR.
```

```
******************************************************
|        WESTINGHOUSE CONFIGURATION CONTROL           |
|        Westinghouse Proprietary Information         |
|                                                     |
|             Code: RHRCOOL                           |
|          Version: 2.0                               |
|    Configuration: August  1, 1997                   |
|        Execution: September 15, 1997   09:10:18.84  |
|   Control Number: 2991845696673                     |
|                                                     |
|          Program has not yet been verified          |
|                                                     |
|    A record of configured versions exists in the    |
|         Westinghouse Engineering Technology         |
|          Configuration Control Department.          |
******************************************************
```

```
******************RHRCOOL PC REV 2.00*********************************
 SPECIAL COMMENTS  Cook Single Train Cooldown to Support Startup - 31..

 OUTPUT CONTROL, OUTPUT AT N2 HR INTERVALS, N2=1.0
 BOP-FR-8, ENTER 1 ,ANS-5.1-1979, ENTER 2--X1=1.
       Q= REACTOR POWER,  MW= 3411.0
      U1= DESIGN UA CCW HX,  MBTU/HR/F=   4.000
      U2= DESIGN UA RHR HX,  MBTU/HR/F=   2.126
      W1= RCS FLOW THROUGH ONE RHR HX,  MLB/HR=     1.480
      W6= RHR PUMP MINIFLOW, MLB/HR=     .000
      W2= CCW FLOW THROUGH ONE RHR HX,  MLB/HR=     2.480
      W3= SW FLOW THROUGH ONE CCW HX,  MLB/HR=    3.930
      W4= CCW FLOW THROUGH ONE CCW HX,  MLB/HR=     4.000
   A1,A2= AUX HEAT LOAD AT   4.00 HRS AND  20.00 HRS =    5.86    5.86
      C5= RCS HEAT CAPACITY,  MBTU/F=   2.13
       P= RCP POWER,  MBTU/HR=  17.40
   T1,T2= SW TEMP AT   4.00HRS AND  20.00 HRS =  76.00  76.00
```

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

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KC 9/19/97

TITLE Cooldown Runs to Support Startup			PAGE 8 of 15
PROJECT AEP/AMP	AUTHOR G. J. Corpora	CHK'D. BY DATE	VERIFIED BY DATE K. N. Garner
S.O. ANLP-280	CALC NO. SAE/FSE-C-AEP/AMP-0102	FILE NO.	GROUP FSE

```
*******************RHRCOOL PC REV 2.00************************************
   SPECIAL COMMENTS  Cook Normal Cooldown to Support Startup - 3411 MWt

   OUTPUT CONTROL, OUTPUT AT N2 HR INTERVALS, N2=1.0
   BOP-FR-8, ENTER 1 ,ANS-5.1-1979, ENTER 2--X1=1.
        Q= REACTOR POWER,   MW= 3411.0
       U1= DESIGN UA CCW HX,   MBTU/HR/F=   4.000
       U2= DESIGN UA RHR HX,   MBTU/HR/F=   2.126
       W1= RCS FLOW THROUGH ONE RHR HX,  MLB/HR=     1.480
       W6= RHR PUMP MINIFLOW, MLB/HR=      .000
       W2= CCW FLOW THROUGH ONE RHR HX,  MLB/HR=     2.480
       W3= SW FLOW THROUGH ONE CCW HX,  MLB/HR=    3.930
       W4= CCW FLOW THROUGH ONE CCW HX,  MLB/HR=     4.000
    A1,A2= AUX HEAT LOAD AT   4.00 HRS AND  20.00 HRS =   5.86   3.06
       C5= RCS HEAT CAPACITY,  MBTU/F=   2.13
        P= RCP POWER,   MBTU/HR=  17.40
    T1,T2= SW TEMP AT    4.00HRS AND  20.00 HRS =   76.00  76.00
       N3= NUMBER OF CCW HX=   2.
       N4= NUMBER OF RHR HX=   2.
       T7= RCP STOP TEMP,   F=  160.00
       T9= RCS FINAL TEMP,   F=  140.00
       T8= CCW MAX TEMP BEFORE    8.00 HRS,   F=  120.00
      T10= CCW MAX TEMP AFTER    8.00 HRS,   F=  120.00
        X= MAX RCS TEMP GRADIENT,   F/HR=   50.00
       B4= TIME COOLDOWN INITIATED,   HR=   4.0
       B3= RCS START TEMP= 350.0
       L1= CCW HX TYPE, TWO TUBE PASS = 1, COUNTERFLOW = 0 L1=    1
       L2= # RHR HX SHELL PASSES=  1
   ****************************************************************
   *        RHR HX INITIAL UA CORRECTION                          *
   *  RHRHX DESIGN U, BTU/HR/FT**2/F = 350.0                      *
   *  DESIGN UA =    2.126          RCS DESIGN FLOW =     1.480   *
   *                                CCW DESIGN FLOW =     2.480   *
   * CORRECTED UA =    2.126        RCS ACTUAL FLOW =     1.480   *
   *                                CCW ACTUAL FLOW =     2.480   *
   ****************************************************************
   ***********************************************************************
   ****************************************************************
   *        CCW HX INITIAL UA CORRECTION                          *
   *  CCWHX DESIGN U, BTU/HR/FT**2/F = 328.0                      *
   *  DESIGN UA =    4.000          SW DESIGN FLOW =     4.750    *
   *                                CCW DESIGN FLOW =     4.000   *
   * CORRECTED UA =    3.835        SW ACTUAL FLOW =     3.930    *
   *                                CCW ACTUAL FLOW =     4.000   *
   ****************************************************************
   ***********************************************************************
                                    CCW-TEMPERATURES         *
   RHRHX RHRHX DECAY RCS   SWOUT RHRHX CCWHX CCWHX RCOUT * RCS    TIME
   HEAT   UA   HEAT  FLOW  TEMP  TOUT  TIN   TOUT  TEMP  * TEMP
   BT/H BT/H/F BT/H  #/H   DEG F DEG F DEG F DEG F DEG F * DEG F    H
                                                         * 350.0   4.0
```

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TITLE			PAGE
Coo... an Runs to Support Startup			10 of 15
PROJECT: AMP	AUTHOR: G. J. Corpora	CHK'D BY / DATE:	VERIFIED BY / DATE: K. N Garner
S.O.: ANLP-280	CALC NO.: SAE/FSE-C-AEP/AMP-0102	FILE NO.:	GROUP: FSE

```
N3= NUMBER OF CCW HX=  1.
N4= NUMBER OF RHR HX=  1.
T7= RCP STOP TEMP,   F=  160.00
T9= RCS FINAL TEMP,   F=  200.00
T8= CCW MAX TEMP BEFORE    8.00 HRS,   F=  120.00
T10= CCW MAX TEMP AFTER    8.00 HRS,   F=  120.00
 X= MAX RCS TEMP GRADIENT,   F/HR=   50.00
B4= TIME COOLDOWN INITIATED,   HR=   4.0
B3= RCS START TEMP= 350.0
L1= CCW HX TYPE, TWO TUBE PASS = 1, COUNTERFLOW = 0 L1=
L2= # RHR HX SHELL PASSES=  1
*******************************************************
*        RHR HX INITIAL UA CORRECTION                 *
*  RHRHX DESIGN U, BTU/HR/FT**2/F = 350.0             *
*  DESIGN UA =   2.126        RCS DESIGN FLOW =   1.480 *
*                             CCW DESIGN FLOW =   2.480 *
* CORRECTED UA =   2.126      RCS ACTUAL FLOW =   1.480 *
*                             CCW ACTUAL FLOW =   2.480 *
*******************************************************
*******************************************************
*******************************************************
*        CCW HX INITIAL UA CORRECTION                 *
*  CCWHX DESIGN U, BTU/HR/FT**2/F = 328.0             *
*  DESIGN UA =   4.000        SW DESIGN FLOW =   4.7[illegible] *
*                             CCW DESIGN FLOW =   4.000 *
* CORRECTED UA =   3.835      SW ACTUAL FLOW =   3.930 *
*                             CCW ACTUAL FLOW =   4.000 *
*******************************************************
*******************************************************
```

RHRHX HEAT BT/H	RHRHX UA BT/H/F	DECAY HEAT BT/H	RCS FLOW #/H	SWOUT TEMP DEG F	RHRHX TOUT DEG F	CCWHX TIN DEG F	CCWHX TOUT DEG F	RCOUT TEMP DEG F	*	RCS TEMP DEG F	TIME H
						CCW-TEMPERATURES			*		
									*	350.0	4..
139.6	1.80	110.4	.80	113.0	176.3	156.4	120.0	171.5	*	346.2	5.0
139.6	1.83	104.8	.83	113.0	176.3	156.4	120.0	172.2	*	339.4	6.0
139.6	1.86	100.3	.89	113.0	176.3	156.4	120.0	173.2	*	330.3	7.0
139.6	1.91	96.6	.97	113.0	176.3	156.4	120.0	174.6	*	319.2	8.0
139.6	1.96	93.5	1.07	113.0	176.3	156.4	120.0	176.3	*	306.4	9.0
139.7	2.03	90.8	1.23	113.0	176.3	156.4	120.0	178.4	*	292.4	10.0
139.6	2.12	88.5	1.45	113.0	176.3	156.4	120.0	181.0	*	277.1	11.0
130.5	2.13	86.4	1.48	110.7	169.8	151.3	117.2	174.5	*	262.6	12.0
122.6	2.13	84.6	1.48	108.7	164.3	147.0	114.8	168.7	*	251.5	13.0
116.5	2.13	82.9	1.48	107.1	159.9	143.6	113.0	164.1	*	242.8	14.0
111.6	2.13	81.4	1.48	105.9	156.5	140.9	111.5	160.5	*	236.0	15.0
107.8	2.13	80.1	1.48	104.9	153.8	138.8	110.4	157.7	*	230.5	16.0
104.7	2.13	78.8	1.48	104.1	151.6	137.1	109.4	155.4	*	226.1	17.0
102.1	2.13	77.7	1.48	103.5	149.8	135.6	108.6	153.5	*	222.4	18.0
99.9	2.13	76.6	1.48	102.9	148.3	134.4	108.0	151.9	*	219.4	19.0
98.1	2.13	75.5	1.48	102.4	147.0	133.4	107.4	150.5	*	216.6	20.0
96.4	2.13	74.3	1.48	102.0	145.8	132.5	106.9	149.3	*	214.4	21.0
94.9	2.13	73.2	1.48	101.6	144.8	131.7	106.5	148.2	*	212.3	22.0
93.6	2.13	72.2	1.48	101.3	143.8	130.9	106.1	147.2	*	210.4	23.0
92.3	2.13	71.3	1.48	101.0	142.9	130.2	105.7	146.2	*	208.6	24.0

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

ENSW970919NF
07 19 OC 21
AP 9/19/97

Component Cooling Pumps CURVE NO. DATE PP-010

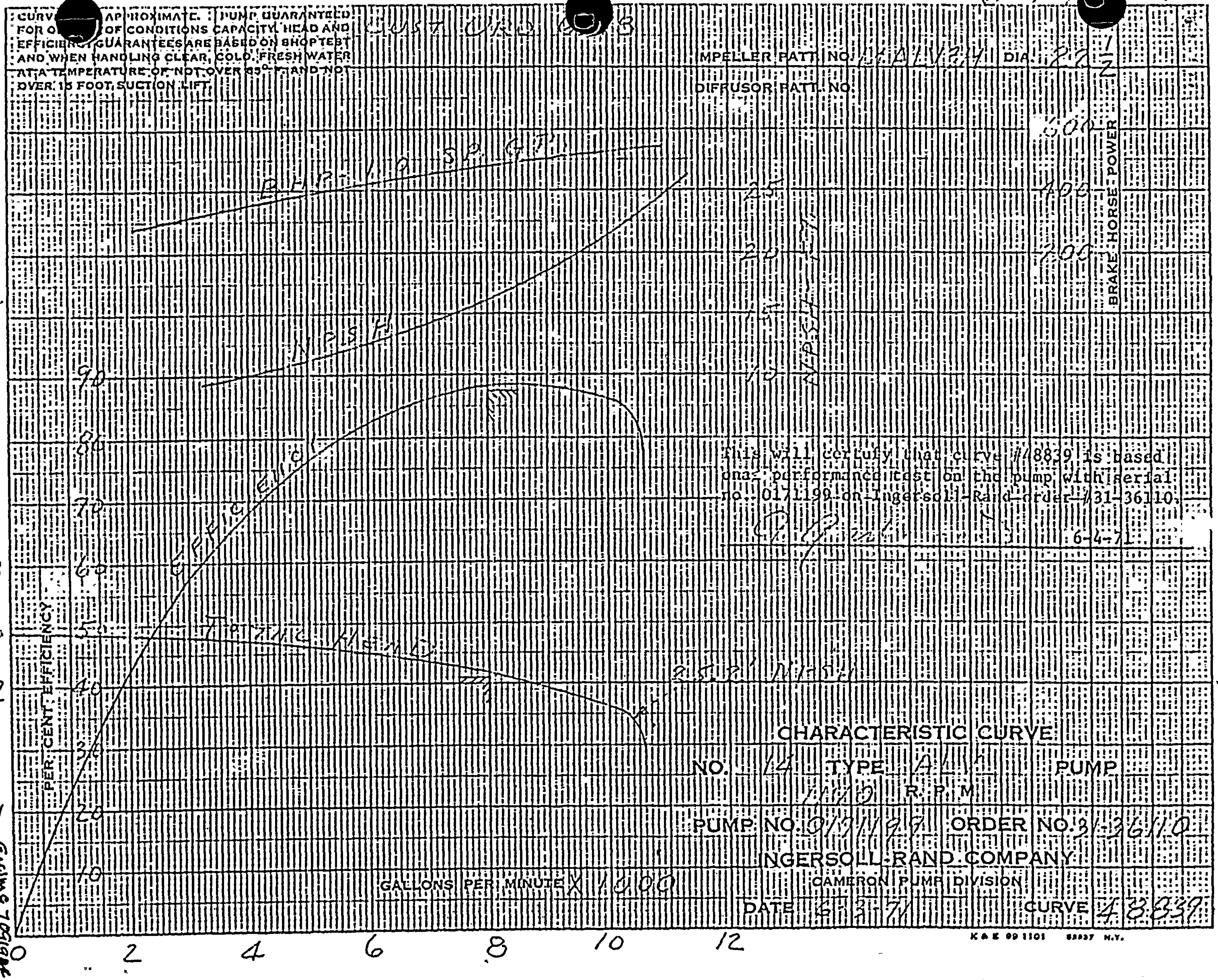

TABLE 9.5-2
COMPONENT COOLING WATER SYSTEM
MINIMUM FLOW REQUIREMENTS PER TRAIN (GPM)

Service	NORMAL OPERATION	LOCA INJECTION	LOCA RECIRCULATION	COOLDOWN
Safeguards Train[1]				
RHR Heat Exchanger	-	-	4950	4950
CCP PP Hx	31	31	31	31
SI PP Hx	-	20	20	20
RHR PP Hx	-	5	5	5
CTS PP Hx	-	3	3	3
Subtotal	31	59	5009	5009
Miscellaneous Train				
BA Evaporator	1442[5]		-	-
SPF Hx[4]	2980	-	-	-
Waste Gas Compressors	42.5	-	-	42.5
Sample Coolers (U1/U2)	139/169[5]	-	-	139/169[5]
Post Accident Sampling System[3]	-	-	44	-
Letdown Hx[6]	984[5]	-	-	984[5]
Seal Water Heat Exchanger	199	-	-	199
Ctmt. Pen. Cooling	300	-	-	300
CEQ Fan Mtrs[2]	-	-	15	-
RCP Motors	404	-	-	404
RCP Thermal Barrier Hxs	140	-	-	140
Reactor Support Clrs	40	-	-	40
Subtotal (U1/U2)	6670.5/6700.5	59/59	59/59	2248.5/2278.5
Totals (U1/U2)	6701.5/6731.5	59/59	5068/5068	7257.5/7287.5

Notes:
1. The flows shown reflect the use of one safeguard's train. The second safeguard train may be placed in service provided the necessary equipment is operable. Single train operation results in minimum safeguard's requirements and a minimum cooldown.
2. For LOCA Recirculation only one CEQ fan is required. An analysis was performed which determined acceptable performance at a reduced flow of 15 gpm.
3. The 44 gpm flow is based on the use of 3 model QC-563 (10 gpm ea.) and 1 model QC-501 (14 gpm) sample coolers.
4. SPF Hx is assumed to be on the non-accident unit.
5. These flows represent the maximum flows; they may be significantly reduced as necessary to control process temperatures.
6. The Letdown Hx is assumed to be inservice. The excess letdown Hx is placed inservice if the letdown Hx is unavailable. The excess letdown Hx's design flow rate is 230 gpm.

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EN-015 (1/97)

DONALD C. COOK NUCLEAR PLANT

PLE / ENSM Functional Area

VERIFICATION CHECKLIST - CALCULATIONS

Calculation Number ENSM 970919AF Rev. 0

Walter E. McCrory 10/10/97
Signature of Verifier Date

1.0 Were the inputs/data sources correctly selected, incorporated and documented into the calculation? Yes ✓ N/A ___
Basis: Inputs were verified & ISO's rechecked for appropriate inputs.

2.0 Are assumptions necessary to perform the calculation adequately described and reasonable? Yes ✓ N/A ___
Basis: assumptions used were adequately described. The cow temperature of 160°F and the Flow of 5000 GPM in the 14" line

3.0 Are the applicable codes, standards and regulatory requirements identified and requirements for design met? Yes ✓ N/A ___
Basis: calc. was to determine if adequate NPSH was available at a higher temperature as defined by Westinghouse cooldown analysis.

4.0 Was an appropriate design method used? Yes ✓ N/A ___
Basis: Commonly used Engineering method as defined by Cameron Hydraulic Data Book.

5.0 Is the output reasonable compared to input? Yes ✓ N/A ___
Basis: output provided is reasonable relative to Flow balance test Data (U1R97)

6.0 Are the results numerically correct? Yes ✓ N/A ___
Basis: Verified Fittings and length of pipe used in calc. also checked math.

[illegible]

Pipe Length and fitting 41 ECCW Print 1-CCW-35

14"

TEE RUN (START) 12.03 ft
90° SR EL
3.5 ft
90° LR EL
TEE RUN (FROM CCP)
6.23 ft
45° EL
TEE RUN
29.67 ft
45° EL
8.13 ft
90° SREL
2.33 ft
90° SREL
5.5 ft
90° EL
13.5 ft
90° EL
16.17 ft
45° EL
6.48 ft
45° EL
58.08 ft
90° EL
8.0 ft
90° EL
6.92 ft
90° EL
90° EL

TOTAL LENGTH = 176.59 ft

7 90° LR EL
3 90° SR EL
4 45° EL
3 TEE RUN

18"

TEE BRANCH
14 x 18 INCREASER
3.46 ft
TEE BRANCH
BUTTER FLY VALVE
90° SR EL
4.40 ft
TEE BRANCH
2.70 ft

TOTAL = 10.56 ft

1 90° SR EL
3 TEE BRANCH
1 BUTTER FLY VALVE
1 14 x 18 INCREASER

Walter E McCrory
10/10/97

[illegible]

Pipe Length and fittings U1 WCCW Print 1-CCW-37 Sheet 1 and 2

14" PIPE

TEE RUN

6 ft

90° EL

24 ft

90° EL
TEE BRANCH

11 ft

90° EL

7 ft

45° EL

3.97 ft

45° EL
90° EL
90° EL

4.01 ft

90°

13 ft

45°

21.73 ft

45°

33.08 ft

90°

90°

27.67 ft

TOTAL = 151.46

8 90° EL

4 45° EL

1 TEE RUN

1 TEE BRANCH

18" PIPE

14"x18" DIFFUSER
TEE RUN

2.67 ft

3.67 ft

45°

4.24 ft

90°

4.38 ft

TEE BRANCH

BUTTERFLY VALVE

90°

4.41 ft

TEE BRANCH

2.67 ft

TOTAL = 22.04

2 90° EL

1 45° EL

1 14x18" DIFFUSER

2 TEE BRANCH

1 TEE RUN

1 BUTTERFLY VALVE

Walter Cardary
10/10/97

Pipe Length and Fittings — CI 2WCCW Print Z-CCW38 Sheet 1 and 2

14" PIPE

TEE BRANCH

7.5 ft

TEE RUN
90°

22.5 ft

90°

8.5 ft

90°

36.83 ft

45°

2.62 ft

45°

12.75 ft

TOTAL = 90.7 ft

2 45°

3 90° LR

1 TEE RUN

1 TEE BRANCH

18" PIPE 14"x18" DIFFUSER

TEE BRANCH

7.83 ft

90°

40.5 ft

45°

3.18 ft

90°

33.08 ft

90°

6.13 ft

TEE BRANCH

3.37 ft

90°

BUTTERFLY VALVE

90°

6.0 ft

TEE BRANCH

2.70 ft

TOTAL = 162.79

5 90° LR

1 45°

1 BUTTERFLY VALVE

3 TEE BRANCH

1 14X18 DIFFUSER

Walter E. [illegible]
[illegible]

[illegible]

Pipe Length and Fittings

14" PIPE

TEE BRANCH

3.5 ft

90° SR

2.97 ft

45°
TEE RUN

9.35 ft

45°

20.89 ft

90°

6.58 ft

90°

15.25 ft

90°

4.60 ft

45°

68.5 ft

45°

3.29 ft

45°

14.16 ft

90°

2.83 ft.

TOTAL > 152.32
1 90° EL SR
4 90° EL LR
5 45° EL
1 TEERUN
1 TEE BRANCH

42 ECCW Print 2-CCW-39

18" PIPE
TEE BRANCH
14"X18" DIFFUSER

21.5 ft

90°

9.91 ft

2.16 ft

TEE BRANCH

2.25 ft

BUTTER FLY VALVE

90° EL SR

4.33 ft
2.66 ft
TEE BRANCH

TOTAL = 42.81 ft
1 90° EL SR
1 90° EL LR
3 TEE BRANCH
1 BUTTERFLY VALVE
1 14X18 DIFFUSER

Walter E. McElroy
10/10/97

7.