ATTACHMENT 1 TO AEP:NRC:1260G7

COMMITMENT ASSOCIATED WITH RESPONSE TO REQUEST FOR INFORMATION RELATED TO 2.206 PETITION

9808100093

The following is our specific commitment associated with this response to the request for additional information (RAI) regarding the 2.206 petition. No other statements should be considered to be regulatory commitments.

1. Identified UFSAR discrepancies that meet the condition report threshold, including those of the twenty-one systems covered under the restart plan system readiness reviews, will be dispositioned in accordance with the restart plan. These UFSAR discrepancies will be dispositioned by correcting the non-conformance, performing a 10 CFR 50.59 evaluation, performing an operability evaluation in accordance with generic letter 91-18, revision 1, or requesting a license amendment.

ATTACHMENT 2 TO AEP:NRC:1260G7

RESPONSE TO REQUEST FOR INFORMATION
RELATED TO THE 2.206 PETITION
IDENTIFIED ON ENCLOSURE 1 OF THE JUNE 8, 1998, LETTER

BN-014
(1/97)

NUCLEAR ENGINEERING DEPARTMENT

Calculation Cover Sheet

Cook Nuclear Plant

AF 12/11/97

SHEET 1 OF ~~62~~ 66

ENSM

CALCULATION No. ENSM970128AF

SAFETY RELATED YES ✓ NO ___

SYSTEM ECCS

TITLE ECCS Pumps Available NPSH

~~RFC/MM/PM/PR/CR/TM~~ No. NRC IN 96-55

FILE LOCATION ENSM FILES

INDIANA MICHIGAN POWER COMPANY

UNIT No. 1 & 2

CALCULATED BY: Feliciano 6/3/97
DATE

VERIFIED BY: John J Rifak 7/15/97
DATE

APPROVED BY: Paul 7/15/97
DATE

CALCULATION DESCRIPTION: The calculation determines the available NPSH to the ECCS pumps (CTS/RHR/SI&CC) during the recirculation phase. Inadequate NPSH to the ECCS pumps is addressed in NRC Information Notice 96-55.

(This calculation supersedes ENSM 791107AUF-Objective #2) RWH 9/17/97 (CR 97-2223)
(This calculation supersedes NEMP950501JEW-Obj #2) RWH 10/22/97 (CR97-2456)

METHOD OF VERIFICATION: ALTERNATE CALCULATION ________ REVIEW ✓

REVISION

NO.	REASON FOR CHANGE	Calculated By	Date	Verified By	Date	Approved By	Date
1	Calculate recirculation sump screen pressure drop, format to fit table of contents	Felic	12/11/97	J Rifak	12/16/97	Paul	12/20/97
2	Revised to determine sump [illegible] Head loss & Included Rev 1	Felic	1/15/98	J Rifak	1/16/98	Paul	1/13/98

9808100093 980817
PDR ADOCK 05000315
H PDR

EN-015
(1/97)

DONALD C. COOK NUCLEAR PLANT

ENSM Functional Area

VERIFICATION CHECKLIST - CALCULATIONS

Calculation Number ENSM 970128AF Rev. 2

John J. Rifak
Signature of Verifier

1/16/98
Date

1.0 Were the inputs/data sources correctly selected, incorporated and documented into the calculation? Yes ✓ N/A ___

Basis: The Rev 2 inputs sources are documented in the Alden Research Laboratory Report 108-78/M178PF of September 1978 and reference 12 calcs.

2.0 Are assumptions necessary to perform the calculation adequately described and reasonable? Yes ___ N/A ✓

Basis: No assumptions are added by this Revision

3.0 Are the applicable codes, standards and regulatory requirements identified and requirements for design met? Yes ___ N/A ✓

Basis: No codes, standards or regulatory requirements apply to this calculation.

4.0 Was an appropriate design method used? Yes ___ N/A ✓

Basis: This calculation was not based on a design method It calculates hydraulic characteristics based on an emperical study

5.0 Is the output reasonable compared to input? Yes ✓ N/A ___

Basis: The outputs are reasonable compared to inputs from the empirical Lab study

6.0 Are the results numerically correct? Yes ✓ N/A ___

Basis: The arithmetic of the equations used were checked and were duplicated.

Table of Contents

Design Inputs

1 - Required Net Positive Suction Head ($NPSH_R$) for the safety injection, charging, residual heat removal, and containment spray pumps is obtained from the pump curves (Ref 3), attached.

2 - The flow path for this calculation is in accordance with OHP4023.ES-1.3 "Transfer To Cold Leg Recirculation." (Ref 2)

3 - Piping configuration (length, diameter, fittings, elevations, etc.) from the Recirculation sump through the residual heat removal (RHR) pump through the RHR supply to the safety injection and centrifugal charging pumps suction are obtained from the isometric or physical drawings (Ref 4), as shown on attached "Pipe Friction Data Sheets".

4 - RHR heat exchanger pressure drop of 15 psi at 2960 gpm from the heat exchanger's specification data sheet.

5 - Safety Injection pumps flow balanced at 700 gpm per Technical Specification 4.5.2 h. The flow balance is performed to meet flow conditions in accordance with **12 EHP 4030 STP.208SI "U1 and U2 ECCS Flow Balance - Safety Injection System" step 4.11 page 8 of 44.

6 - Centrifugal charging pumps are flow balanced at 550 gpm per Technical Specification 4.5.2 h. The flow balance is performed to meet flow conditions in accordance with **12 EHP 4030 STP.208BI "U1 and U2 EMERGENCY CORE COOLING SYSTEM FLOW BALANCE - BORON INJECTION SYSTEM" step 5.7.20 page 48 of 58.

7 - Containment spray pump flow 3200 gpm (2000 gpm upper and 1200 gpm lower spray flows) per DB-12-CTS, pg. 47 section 4.1.1.1 and pg. 57 section 4.1.7.1.

8 - Fluid vapor pressure of 9.34 psia at 190°f, temperature of recirculation sump fluid during the recirculation phase from UFSAR table 6.1-1 pg. 6.1-12 for U2 which bounds U1 temperature of 160°f.

9 - Recirculation sump level 602'- 10", DB-12-CTS, pg. 34 section 3.9.3.3

10- Recirculation Sump Screen dimensions from calculation ENSM971128TWF (Ref 12) approved 12/8/97 for current configuration. The current configuration is being revamped to conform to the design and installation performed by RFC-2361 in 1979. Calculation ENSM971210TWF (Ref 12) approved 12/11/97 determine a screen open area for the revamped (RFC-2361) installation.

Rev 2

11- 50% design basis blockage based on ALDEN Labs modeling (Ref 13).

References

1- NRC Information Notice 96-55 "Inadequate Net Positive Suction Head of Emergency Core Cooling and Containment Heat Removal Pumps Under Design Basis Accident Conditions"

2- OHP4023.ES-1.3 Transfer to Cold Leg Recirculation

3- Safety Injection (SI) Pump - Pacific Pump curve 39890A
Residual Heat Removal (RHR) Pump - Ingersoll-Rand Pump curve N-315
Centrifugal Charging (CC) Pump - Pacific Pump curve 34617-L
Containment Spray CTS) Pump - Byron-Jackson curve T-32852-7

4-Isometric/Physical Drawings
1-2-5338-7 2-SI-9 Rev 19 2-5415-15 2-SI-7 sh 1 Rev 2, sh 2 Rev 1 2-RH-14 sh 1 Rev 2, sh2 Rev 1 2-RH-18 Rev 13 2-RH-22 Rev 10 2-SI-10 sh 1 Rev 11, Sh 2 Rev 4 2-SI-44 Rev 6 2-CS-79 sh 1 Rev 9, Sh 2 Rev 3 2-RH-23 Rev 12 2-CS-80 Rev 6 2-CS-81 Rev 5

5-Friction Losses in pipe fittings from Cameron Hydraulic Data book 18th Ed pg. 3-111 through 3-117

6-Pipe flow velocity and friction losses from Cameron Hydraulic Data book 18th Ed pg. 3-12 through 3-33

7- Related Calculations:

NESM961021AF approved 12/2/96
HXP840301JN approved 12/14/85

8-U2 FSAR Appendix Q question 212.29-4 amendment 78 10/77 attachment "A" NPSH calculation

9-Flow Diagrams

2-5143-39 2-5142-37 2-5129-34

10-Hydraulic friction loss calculation program revision 5 1988 (HFLC5) will be used to determine the frictional losses through the flow path. HFLC5 is an in-house developed program, which was approved for use on Feb. 28, 1988. This program was validated and approved in accordance with the requirements of GP 2.6 Software Quality Assurance Standard in use in 1988.

11-Crane Technical Paper No. 410, "Flow of Fluids Through Valves, Fittings, And Pipe" 12th printing 1972

12-Calculation ENSM971128TWF titled "Flow Area of recirculation Sump Screen", approved 12/8/97 and ENSM971210TWF approved 12/11/97.

13- ALDEN recirculation sump studies dated 9/78

14- I.E. Idelchik, Handbook Of hydraulic Resistance, 2nd edition 1986

Purpose

NRC Information Notice 96-55 addresses inadequate NPSH of emergency core cooling and containment heat removal pumps under design basis accident conditions. The information notice addresses this condition under the ECCS Recirculation mode of operation.

This calculation will determine the NPSH available to the SI and CC pumps during the ECCS Recirculation mode when one RHR pump is used to supply their flow requirements. This calculation will also check the CTS and RHR pumps NPSH available. These parameters were originally determined in response to U2 FSAR Appendix Q Question 212.29-4. However, currently the RHR system is aligned with the RHR crosstie valves closed due to potential deadheading concerns. This calculation will check the CTS and RHR pumps NPSH available under the flow conditions used to determine the SI and CC pumps NPSH available.

Revision 2 will determine the pressure drop across the recirculation sump screen and if it impacts the RHR pump's available NPSH.

The flow path used in this calculation is shown on figure 1.

Method

In order to obtain the frictional losses, associated with the flow path, the isometric and physical drawings were used to determine the piping configuration. Figure 1 shows the flow path and branching flows to the CTS pump and RHR cold leg injection. The data obtained from the drawings was compiled on the attached pipe friction data sheets . The totals shown on the data sheets are used as input to HFLC5.

HFLC5 calculates the segments frictional losses and is based on the Darcy-Weisbach formula obtained from Cameron page 3-110:

$$H_f = f \frac{L}{D} \frac{v^2}{2g}$$

where:
H_f - frictional loss, ft
f - friction factor, dimensionless
L - pipe length, ft
D - pipe diameter, ft
v - pipe velocity, ft/sec
g - gravitational constant, 32.2 ft/sec^2

SUBJECT Emergency Core Cooling System Pumps NPSH Available

The HFLC5 results are shown on the attached output sheets. This information is then used to determine the operating point of the RHR pump. The operating point occurs at the intersection of the pump performance (head-capacity) curve with the frictional loss (system-head) curve. The resultant flow is then used to determine the flow distribution and resultant pipe friction.

The resultant pipe friction was determined from the following formula obtained from Cameron page 3-110:

$$H_f = K \frac{v^2}{2g}$$

where:
H_f - head loss, ft
K - resistance coefficient
v - velocity, ft/sec
g - gravitational constant - 32.2 ft/sec^2

Based on the preceding the NPSH available to the SI and CC pumps can be determined. The NPSH available is determined from the following formula obtained from Cameron pg. 1-10:

$$NPSH = h_a - h_{vpa} + h_{st} - h_{fs}$$

where:
NPSH - net positive suction head, ft abs
h_a - absolute pressure, ft
h_{vpa} - fluid vapor pressure, ft
h_{st} - static elevation difference, ft
h_{fs} - pipe friction losses, ft

However, before the SI and CC pumps NPSH available can be determined, it is first necessary to determine the RHR pump's suction pressure. The suction pressure can be determined from Bernoulli's equation obtained from Crane Technical paper 410 pg. 1-5.

Bernoulli's equation is written as:

$$Z1 + \frac{144P1}{\rho_1} + \frac{(v1)^2}{2g} = Z2 + \frac{144P2}{\rho_2} + \frac{(v2)^2}{2g} \div h_f$$

where:
Z1, Z2 - elevation, ft
P1, P2 - pressure, psig
v1, v2 - velocity, ft/sec
ρ_1 , ρ_2 - density of fluid, lbs/ft^3
g - gravitational constant - 32.2 ft/sec^2
h_f - head loss, ft

Assumptions

1 - Containment pressure at 14.7 psia. To be conservative this calculation will not include the containment design pressure of 12 psig per FSAR chapter 5 section 5.2.2.2 Design Load Criteria pg. 5.2-16.

2 - Single active failure criteria is failure of one RHR pump. No pump degradation is assumed since bounding highest flow results from this approach.

a) 2 CTS pumps operating, however, only one is supplied from the same source that supplies the operable RHR pump since each CTS pump and RHR trains are supplied individually.

b) 2 CC pumps total flow of 840 gpm or 420 gpm each. This flow condition is obtained from the intersection of the two parallel pump head-capacity curve with the system-head curve at approximately 840 gpm or 1.5 times the 550 gpm flow requirement (see attached curve 34617-L). Note: 1.5 factor is obtained from 840/550.

c) 2 SI pumps total flow of 920 gpm or 460 gpm each. This factor is obtained from the intersection of the two parallel pump head-capacity curve with the system-head curve at approximately 920 gpm or 1.314 times the 700 gpm requirement (see attached curve 39890A). Note: 1.314 factor is obtained from 920/700. For conservatism the 1.5 factor determined for the charging pumps will be used since it yields a higher flow requirement of 1050 gpm (700 x 1.5) or 525 gpm each.

3- Head loss through the Recirculation sump and sump's mesh screen is less than 1 ft as determined in Amendment 78 Appendix Q. For purposes of this calculation the pressure drop will be determined based on the open area and 50% blockage for the maximum potential flow.

The flow for 2b and 2c is based on parallel pump operation. One of the first steps is to draw the system-head curve. The system-head curve consists of the sum of the static head, pipe-friction head, and head losses in valves and fittings. The parallel head-capacity curve is drawn by adding the capacities at the same heads. The head-capacity curves of the single and parallel pumps are plotted on the same drawing and their intersections with the system-head curve represent the operating points.

The system-head curve plotted on the pump performance curves was determined from the known Technical Specification requirements. The system-head curves were developed by multiplying the resistance factor ft/gpm^2 times the square of the flow. Minimum and maximum resistance factors are given in the Technical Specification for the CC pumps

(Design Input 6). The calculation used the minimum factor to obtain the maximum CC pump flow. For the SI pumps, the Technical Specification stipulates a flow requirement (Design Input 5) rather than a resistance factor. The SI resistance factor ft/gpm^2 (1440/700^2) is obtained at the 700 gpm head-capacity point. The resistance factor is comprised of the sum of the static head, pipe-friction head, and head losses in valves and fittings. It is acceptable to use this factor, based on the Technical Specification requirements, since it represents the head-capacity operating point of the pump in the system.

The intersection of the system-head and head-capacity curves provides the total flow delivered to the system. The resultant total flow is generally less than 1.5 times the single pump design flow supplying the same flow path, as stated in assumption 2 above.

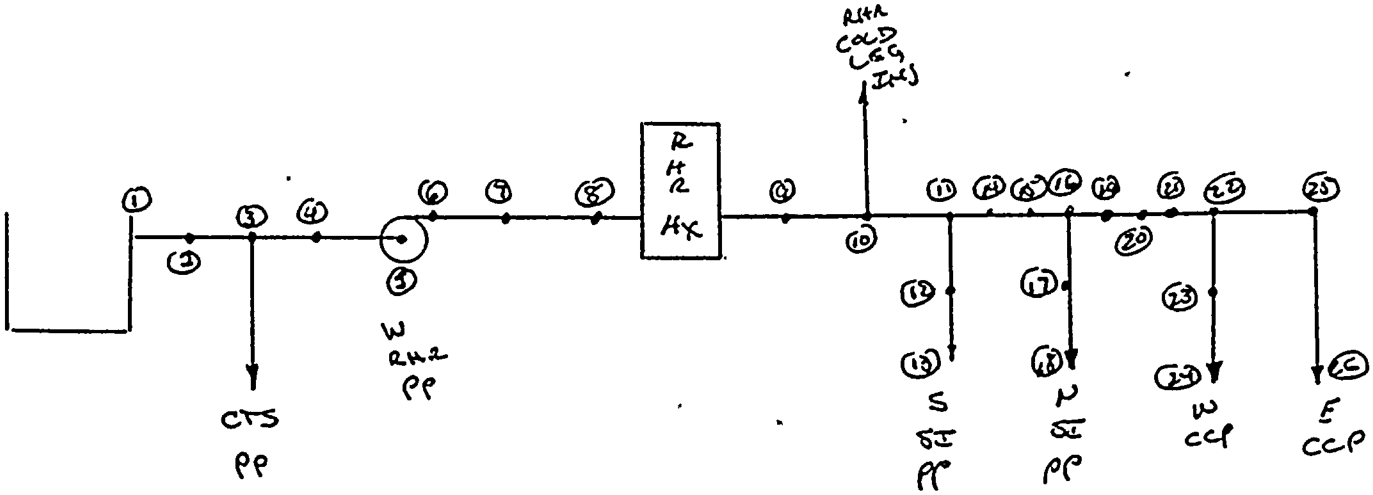


Figure 1
ECCS Recirculation Flow Path
One RHR Pump Out Of Service

Results

The results of this analysis indicate that the SI pump's NPSH available is 132 ft abs for the south pump and 122 ft abs for the north pump at the assumed single pump flow of 525 gpm. The NPSH required at this flow is 13 ft abs. That is, the NPSH available exceeds the NPSH required by 109 to 119 ft abs.

The CC pump's NPSH available is 48 ft abs for the east and 49 ft abs for the west pump at the assumed single pump flow of 420 gpm. The NPSH required at this flow is 17 ft abs. That is, the NPSH available exceeds the NPSH required by 31 to 32 ft abs.

At the RHR pump flow of 4600 gpm, determined from the graphical analysis, the NPSH available was determined to be 29 ft abs. The NPSH required at this flow is 20 ft abs. That is, the NPSH available exceeds the NPSH required by 9 ft abs. A similar check of the CTS pump's NPSH available determined that at 3200 gpm the NPSH available is 31 ft abs. The NPSH required at 3200 gpm is 9 ft abs. That is, the NPSH available exceeds the NPSH required by 22 ft abs.

The determination of the pressure drop across the recirculation sump screens indicates that the assumed revision 0 pressure drop was acceptable. That is, a pressure drop of less than 1 ft was determined and the revision 1 NPSH available results are not impacted by the pressure drop across the screen.

The calculated recirculation sump head loss is based on the empirical results obtained during the ALDEN sump testing. The ALDEN test results obtained a pressure drop of .77 ft for 50% blockage. This compares well with the analytical value of .82 ft determined for 50% blockage. Rev 2

Based on the results of this calculation adequate NPSH is available to assure that the ECCS pumps are capable of performing their safety function under the Recirculation mode of operation.

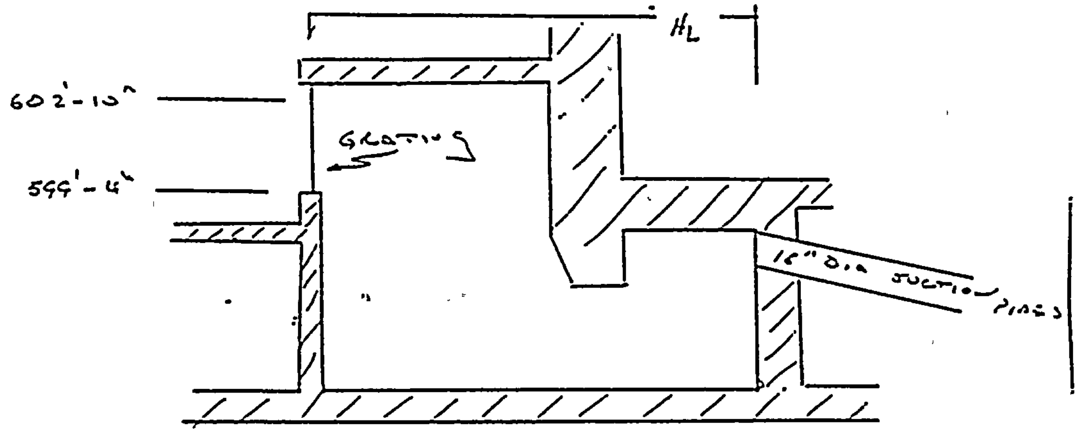
Analysis

Determine the recirculation sump's increased pressure drop due to the addition of a second grating at the maximum expected flow. The maximum expected flow is based on 2 RHR pumps operating at 4600 gpm each and two CTS pumps operating at 3200 gpm each. This results in a total flow of 15,600 gpm through the recirculation sump.

Rev 2

Per the Alden report (Ref 13) the sump test configuration consisted of a single coarse grating and a single fine mesh screen. The existing sump configuration is somewhat different in that a second coarse grating is installed after the fine mesh screen. The Alden report details that the sump head loss (h_L) can be obtained from the loss coefficient C_L.

That is, the Alden report pg 26 section "d" indicates C_L as consisting of the total losses including the screen, grating, and entrance losses at the outlet pipes (see below figure). The report also indicates that the loss of head across the grating and screen was evaluated and found to be about 11.5 times the approach velocity head just upstream of the grating. This information will be used to determine the existing sump's pressure drop.



Rev 2

Recirculation Sump Configuration

The loss coefficients were determined for various tests schemes, and are represented by the equation:

$C_L = h_L / (v^2/2g)$, where

C_L - loss coefficient, dimensions
h_L - sump head loss, ft
v - fluid velocity, ft/sec
g - gravitational constant, 32.2 ft/sec^2

From the report table 10, the highest head loss occurs in test number 3 at a loss coefficient and fluid velocity of .26 and 13.79 ft/sec, respectively. Therefore, h_L is determined as follows:

$C_L = h_L / (v^2/2g)$

$.26 = h_L / (13.79^2/64.4)$ solving for h_L yields .77 ft as the sump's head loss.

The approach velocity is determined using the height of fluid at the

sump entrance elevation of 602 ft 10 in. minus the curb height elevation of 599 ft 4 in. This results in a fluid height of 3.5 ft or 42 in. From reference 12, the grating consists of eight 25.125 in. long sections and one 20 in. long section. The submerged area is determined as follows:

Submerged area, $A_s = (42 \times 25.125 \times 8) + (20 \times 42) = 9282\ in^2$ or $64.46\ ft^2$.

The approach velocity is determined by dividing the flow by the submerged area as represented by

$$velocity = Q/A = \frac{15600gpm}{64.46ft^2} \times \frac{1}{(7.48gal/ft^3 \times 60sec/min)} = .54\ ft/sec$$

REV 2

Therefore, the head across the grating and screen is determined from the Alden relation as follows:

$$h_{gs} = 11.5 \times \text{approach velocity head} = (11.5)\ (.54^2/64.4) = .052\ ft$$

This represents the head loss across the test configuration's grating and screen. Since the existing sump configuration includes a second coarse grating it is conservative to augment the test configuration's head loss of .77 ft by the calculated grating and screen head loss. This results in a sump head loss of .822 ft for the existing configuration.

Based on the above, it will not be necessary to evaluate the impact on the RHR pump's available NPSH since the recirculation sump screen head loss was determined to be less than 1 which is consistent with assumption 3.

Determine RHR pump operating point

In order to determine the RHR pump operating point it is necessary to determine the total system-head. The total system-head is comprised of pipe segments 1-2 through 25-26. The individual segment resistance is obtained from the HFLC5 outputs. It is necessary that flow values not shown on the output be determined.

The flow values can be determine by the following relationship:

$$H_2 = H_1 \frac{(Q2)^2}{(Q1)^2}$$

where:

H_2 - unknown head loss at known flow, ft
H_1 - head loss at known flow, ft
Q2 - known flow at unknown head loss, gpm
Q1 - known flow at known head loss, gpm

For example, segment 1-2 HFLC5 output shows this as 3 ft at 8650 gpm. Using this information a head loss can be determined at another flow, say at 9000 or 7000 gpm.

$$H_{9000} = 3\ \frac{(9000)^2}{(8650)^2} = 3.25\ \text{ft}$$

$$H_{7000} = 3\ \frac{(7000)^2}{(8650)^2} = 1.96\ \text{ft}$$

This method is used to generate the various pipe segment system-head curves shown and labeled as sheet 1 through 3. It should be noted that the addition of these curves is based on the piping arrangement. That is, pipes in parallel are added at the same head values while pipes in series are added at the same flow value. The following describes the process of adding the various segments and obtaining the total system-head curve shown as curve c sheet 3.

The process begins by starting at the east CCP or the last flow distribution point (see fig 1). The summation of the curves starts on sheet 1 and ends on sheet 3.

Sheet 1 Curves

curve 1 - segments 22-25 + 25-26 are added in series
curve 2 - segments 22-23 + 23-24 are added in series
curve 3 - curve 1 + curve 2 in parallel
curve 4 - segments 16-19 + 19-20 + 20-21 + 21-22 in series
curve 5 - curve 3 + 4 in series
curve 6 - segments 16-17 + 17-18 in series
curve 7 - curve 5 + 6 in parallel

Sheet 2

curve 1 - segments 11-14 + 14-15 + 15-16 in series
curve 2 - curve 7 from sheet 1
curve 3 - curve 1 + 2 in series
curve 4 - segments 11-12 + 12-13 in series
curve 5 - curve 3 + 4 in parallel

Sheet 3

curve A - segments 1-2 + 2-3 + 3-4 + 4-5 + 6-7 + 7-8 + 8-9 + 9-10 + 10-11 in series
curve B - curve 5 from sheet 2
curve C - curve A + B in series represents total system-head
curve D - RHR pump performance curve

Note: at the intersection of curves C and D the RHR operating flow of 4600 gpm is obtained. This flow is then used to determine the SI and

charging pumps NPSH available.

Based on an RHR flow of 4600 gpm the total required flow from the Recirculation sump could be determined. The total flow is comprised of one CTS pump at 3200 gpm + one RHR pump at 4600 gpm or 7800 gpm total. Of the total, 3200 gpm flows to containment spray, 1050 gpm to SI, 840 gpm to CC, and the remainder (2710 gpm) to RHR cold leg injection. The cold leg injection flow is simulated as leaving the system at node 10. The following provides the flow distribution based on the preceding and figure 1:

Segment	Flow
1-2, 2-3	7,800 gpm
3-4 through 9-10	4,600 gpm
10-11	1,890 gpm
11-12, 12-13	525 gpm
11-14 through 15-16	1,365 gpm
16-17, 17-18	525 gpm
16-19 through 21-22	840 gpm
22-23, 23-24	420 gpm
22-25, 25-26	420 gpm

Determine the head loss for each segment:

Determine the head loss per the above listed flows for the respective segments. The head loss for each segment can be determined from the relationship shown below and detailed on page 5:

$$H_f = K \frac{v^2}{2g}$$

Segment 1-2 configuration obtained from pipe friction calculation data sheet

flow 7800 gpm, diameter 18", pipe length 26.66 ft, 1 gate valve, 1 reducer 18x24, 1 entrance
Note: the velocity and head loss/100ft can be obtained from Cameron pg. 3-12 through 3-33 as follows:

flow	velocity	h/100 ft
8000	11.5	1.94
7800	v	h
7000	10.0	1.49

By interpolation the velocity (v) and head loss/100' (h) can be determined as follows:

$$\frac{8000-7800}{8000-7000} = \frac{11.5-v}{11.5-10.0} = \frac{1.94-h}{1.94-1.49}$$

$v = 11.5 - 1.5(200/1000) = 11.2\text{ft/sec}$

$h = 1.94 - .45(200/1000) = 1.85 \text{ ft}/100$

From Cameron pg. 3-111 through 3-118 K values can be obtained for the various fittings as follows:

18″ gate valve $K= .1$, reducer $K = .5(1-\{d1/d2\}^2)$, increaser $K = (1-\{d1/d2\}^2)^2$ pipe entrance $K = 1$

$h_L = L\ (h/100') = 26.66\ (1.85/100) = .49$ ft

$h_{gate} = K\ (v^2)/2g = .1\ (11.2^2)/64.4 = .19$ ft

$h_{pipe\ ent} = 1\ (11.2^2)/64.4 = 1.95$ ft

$K_{red} = .5(1-\{18/24\}^2) = .219$ ft

$h_{red} = .219\ (11.2^2)/64.4 = .43$ ft

Note: Sump exit/pipe entrance losses were already included in sump losses. Including loss here is double counting, but is conservative.

$h_{sump} = 1$ ft (see pg.   )

$h_{1-2} = h_L + h_{gate} + h_{pipe\ ent} + h_{red} + h_{sump} = 4.06$ ft

Segment 2-3 configuration obtained from pipe friction calculation data sheet

flow 7800 gpm, diameter 18″, pipe length 26.15 ft, 2 90° long radius elbows, 1 tee branch

90° LR elbow $K = .19$, tee branch $K = .72$

$h_L = L\ (h/100') = 26.15\ (1.85/100) = .48$ ft

$h_{elbow} = K\ (v^2)/2g = 2(.19)\ (11.2^2)/64.4 = .74$ ft

$h_{branch} = .72\ (11.2^2)/64.4 = 1.4$ ft

$h_{2-3} = h_L + h_{elbow} + h_{branch} = 2.62$ ft

Segment 3-4 configuration obtained from pipe friction calculation data sheet

flow 4,600 gpm, diameter 14″, pipe length 42.93 ft, 6 90° long radius elbows, 1 tee run,
1 reducer 14x18, 1 gate valve

90° LR elbow $K = .21$, tee run $K = .26$, gate valve $K = .1$, reducer $K = .198$

Flow	h/100	v
5000	2.79	11.86
4600	h	v
4500	2.27	10.67

$h/100' = 2.37/100'$ $v = 10.9$ ft/sec

$h_L = L\ (h/100') = 42.93\ (2.37/100) = 1.02$ ft

$h_{elbow} = K\ (v^2)/2g = 6(.21)\ (10.9^2)/64.4 = 2.32$ ft

$h_{run} = .26\ (10.9^2)/64.4 = .48$ ft

$h_{gate} = K\ (v^2)/2g = .1\ (10.9^2)/64.4 = .184$ ft

$h_{3-4} = h_L + h_{elbow} + h_{run} + h_{gate} = 4.0$ ft

Segment 4-5 configuration obtained from pipe friction calculation data sheet

flow 4,600 gpm, diameter 14", pipe length 3.33 ft

$h_{4-5} = L\ (h/100') = 3.33\ (2.37/100) = .079$ ft

Segment 6-7 configuration obtained from pipe friction calculation data sheet

flow 4,600 gpm, diameter 8", pipe length 59.85 ft, 8 90° long radius elbows, 1 gate valve,1 check valve

90° LR elbow K = .22, gate valve K = .11, check valve K = 1.4

Flow	h/100	v
5000	35.6	32.1
4600	h	v
4500	28.9	28.9

$h/100' = 30.24/100'$ $v = 29.54$ ft/sec

$h_L = L\ (h/100') = 59.85\ (30.24/100) = 18.1$ ft

$h_{elbow} = K\ (v^2)/2g = 8(.22)\ (29.54^2)/64.4 = 23.85$ ft

$h_{check} = 1.4\ (29.54^2)/64.4 = 18.97$ ft

$h_{gate} = K\ (v^2)/2g = .11\ (29.54^2)/64.4 = 1.49$ ft

$h_{6-7} = h_L + h_{elbow} + h_{check} + h_{gate} = 62.41$ ft

Segment 7-8 configuration obtained from pipe friction calculation data sheet

flow 4,600 gpm, diameter 8", pipe length 10 ft, 1 90° long radius elbow, 1 gate valve,1 tee branch

90° LR elbow K = .22, gate valve K = .11, tee branch K = .84

$h_L = L\ (h/100') = 10\ (30.24/100) = 3.02$ ft

$h_{elbow} = K\ (v^2)/2g = (.22)\ (29.54^2)/64.4 = 2.98$ ft

$h_{tee} = .84\ (29.54^2)/64.4 = 11.38$ ft

$h_{gate} = K\ (v^2)/2g = .11\ (29.54^2)/64.4 = 1.49$ ft

$h_{7-8} = h_L + h_{elbow} + h_{tee} + h_{gate} = 18.87$ ft

Segment 8-9 configuration obtained from pipe friction calculation data sheet

flow 4,600 gpm, diameter 14", pipe length 0 ft, 1 90° long radius elbow, 1 red 8x14,1 inc. 8x14, hx delta P = 15 psi @ 2960 gpm
15 psi x 2.386 (Cameron pg. 4-4 at 190°f)= 35.79 ft

v = 10.91 ft/sec

90° LR elbow K = .21, red K = .337, inc K = .454

$h_{elbow} = K\ (v^2)/2g = (.21)\ (10.9^2)/64.4 = .39$ ft

$h_{red} = .337\ (10.9^2)/64.4 = .622$ ft

$h_{inc} = K\ (v^2)/2g = .454\ (10.9^2)/64.4 = .838$ ft

$h_{hx} = 35.79\ (4600/2960)^2 = 86.44$ ft

$h_{8-9} = h_{elbow} + h_{red} + h_{inc} + h_{hx} = 88.29$ ft

Segment 9-10 configuration obtained from pipe friction calculation data sheet

flow 4,600 gpm, diameter 8", pipe length 3 ft

$h_{9-10} = L\ (h/100') = 3(30.24/100) = .91$ ft

Segment 10-11 configuration obtained from pipe friction calculation data sheet

flow 1890 gpm, diameter 8", pipe length 68.695 ft, 8 90° long radius elbows, 1 gate valve,4 45° elbows, 1 tee branch

90° LR elbow K = .22, gate valve K = .11, 45° elbow K = .22, tee branch K = .84

Flow	h/100	v
2000	5.91	12.8
1890	h	v
1800	4.81	11.5

h/100' = 5.31/100' v = 12.09 ft/sec

h_L = L (h/100') = 68.695 (5.31/100) = 3.65 ft

h_{90}= K $(v^2)/2g$ = 8(.22) $(12.09^2)/64.4$ = 3.99 ft

h_{45}= .22 $(12.09^2)/64.4$ = .49 ft

h_{gate} = K $(v^2)/2g$ = .11 $(12.09^2)/64.4$ = .25 ft
h_{branch} = K $(v^2)/2g$ = .84 $(12.09^2)/64.4$ = 1.91 ft

h_{10-11} = h_L + h_{90} + h_{45} + h_{gate} + h_{branch} = 10.3 ft

Segment 11-12 configuration obtained from pipe friction calculation data sheet

flow 525 gpm, diameter 6", pipe length 5.156 ft, 1 90° long radius elbow, 1 red 6x8,1 tee branch

90° LR elbow K = .24, red K = .219, tee branch K = .9

Flow	h/100	v
550	1.97	6.11
525	h	v
500	1.64	5.55

h/100' = 1.81/100' v = 5.83 ft/sec

h_L = L (h/100') = 5.156 (1.87/100) = .093 ft

h_{elbow} = K $(v^2)/2g$ = (.24) $(5.83^2)/64.4$ = .13 ft

h_{branch} = K $(v^2)/2g$ = .9 $(5.83^2)/64.4$ = .48 ft

h_{red} = K $(v^2)/2g$ = .219 $(5.83^2)/64.4$ = .116 ft

$h_{11-12} = h_L + h_{elbow} + h_{branch} + h_{red} = .82$ ft

Segment 12-13 configuration obtained from pipe friction calculation data sheet

flow 525 gpm, diameter 4", pipe length 1.167 ft, 1 red 4x6 K = .278

Flow	h/100	v
550	15.8	13.9
525	h	v
500	13.1	12.6

$h/100' = 14.4/100'$ $v = 13.25$ ft/sec

$h_L = L\ (h/100') = 1.167\ (14.45/100) = .169$ ft

$h_{red} = K\ (v^2)/2g = .278\ (13.25^2)/64.4 = .758$ ft

$h_{12-13} = h_L + h_{red} = .93$ ft

Segment 11-14 configuration obtained from pipe friction calculation data sheet

flow 1365 gpm, diameter 6", pipe length 13.885 ft, 1 gate valve, 1 red 6x8, 1 tee branch

gate valve K = .12, red K = .219, tee branch K = .9

Flow	h/100	v
1400	12	15.5
1365	h	v
1300	10.4	13.2

$h/100' = 11.44/100'$ $v = 14.69$ ft/sec

$h_L = L\ (h/100') = 13.885\ (11.44/100) = 1.59$ ft

$h_{gate} = K\ (v^2)/2g = .12\ (14.69^2)/64.4 = .402$ ft

$h_{branch} = K\ (v^2)/2g = .9\ (14.69^2)/64.4 = 3.02$ ft

$h_{red} = K\ (v^2)/2g = .219\ (14.69^2)/64.4 = .73$ ft

$h_{11-14} = h_L + h_{tee} + h_{branch} + h_{red} = 5.74$ ft

Segment 14-15 configuration obtained from pipe friction calculation data sheet

flow 1365 gpm, diameter 8", pipe length 1.86 ft, 1 90° LR Elbow K = .22

Flow	h/100	v
1400	2.96	8.98
1365	h	v
1300	2.56	8.34

$h/100' = 2.82/100'$ $v = 8.76$ ft/sec

$h_L = L\ (h/100') = 1.86\ (2.82/100) = .052$ ft

$h_{elbow} = K\ (v^2)/2g = .22\ (8.76^2)/64.4 = .262$ ft

$h_{14-15} = h_L + h_{elbow} = .314$ ft

Segment 15-16 configuration obtained from pipe friction calculation data sheet

flow 1365 gpm, diameter 6", pipe length 18.313 ft, 1 gate valve, 1 red 6x8,1 tee run, 1 90° LR elbow

gate valve K = .12, red K = .219, tee run K = .3, 90° elbow K = .24

$h/100' = 11.44/100'$ $v = 14.69$ ft/sec

$h_L = L\ (h/100') = 18.313\ (11.44/100) = 2.09$ ft

$h_{gate} = K\ (v^2)/2g = .12\ (14.69^2)/64.4 = .402$ ft

$h_{run} = K\ (v^2)/2g = .3\ (14.69^2)/64.4 = 1$ ft

$h_{red} = K\ (v^2)/2g = .219\ (14.69^2)/64.4 = .73$ ft

$h_{elbow} = K\ (v^2)/2g = .24\ (14.69^2)/64.4 = .8$ ft

$h_{15-16} = h_L + h_{tee} + h_{branch} + h_{red} + h_{elbow} = 5.02$ ft

Segment 16-17 configuration obtained from pipe friction calculation data sheet

flow 525 gpm, diameter 6", pipe length 4.542 ft, 1 tee run K = .3

$h/100' = 1.92/100'$ $v = 5.83$ ft/sec

$h_L = L\ (h/100') = 4.542\ (1.92/100) = .087$ ft

$h_{run} = K\ (v^2)/2g = .3\ (5.83^2)/64.4 = .158$ ft

$h_{16-17} = h_L + h_{run} = .245$ ft

Segment 17-18 configuration obtained from pipe friction calculation data sheet

flow 525 gpm, diameter 4",pipe length 1.167 ft,1 red 4x6 K = .278

$h/100' = 14.4/100'$ $v = 13.25$ ft/sec

$h_L = L\ (h/100') = 1.167\ (14.45/100) = .169$ ft

$h_{red} = K\ (v^2)/2g = .278\ (13.25^2)/64.4 = .758$ ft

$h_{17-18} = h_L + h_{red} = .93$ ft

Segment 16-19 configuration obtained from pipe friction calculation data sheet

flow 840 gpm, diameter 4", pipe length 15.163 ft, 1 red 4x6, 3 90° LR elbows, 1 tee branch

90° elbow K = .27, red K = .278, tee branch K = 1.02

Flow	h/100	v
850	37	21.4
840	h	v
800	32.8	20.2

$h/100' = 36.16/100'$ $v = 21.16$ ft/sec

$h_L = L\ (h/100') = 15.163\ (36.16/100) = 5.48$ ft

$h_{elbow} = K\ (v^2)/2g = .27\ (21.16^2)/64.4 = 1.88$ ft

$h_{branch} = K\ (v^2)/2g = 1.02\ (21.16^2)/64.4 = 7.1$ ft

$h_{red} = K\ (v^2)/2g = .278\ (21.16^2)/64.4 = 1.93$ ft

$h_{16-19} = h_L + h_{elbow} + h_{branch} + h_{red} = 16.39$ ft

Segment 19-20 configuration obtained from pipe friction calculation data sheet

flow 840 gpm, diameter 4", pipe length 5 ft, 1 gate valve, 2 90° LR elbows, 2 tee branch

90° elbow K = .27, gate valve K = .14, tee branch K = 1.02

$h/100' = 36.16/100'$ $v = 21.16$ ft/sec

$h_L = L\ (h/100') = 5\ (36.16/100) = 1.81$ ft

$h_{gate} = K\ (v^2)/2g = .14\ (21.16^2)/64.4 = .97$ ft

$h_{branch} = K\ (v^2)/2g = (2)\ 1.02\ (21.16^2)/64.4 = 14.18$ ft

$h_{elbow} = K\ (v^2)/2g = (2)\ .27\ (21.16^2)/64.4 = 3.75$ ft

$h_{19-20} = h_L + h_{elbow} + h_{branch} + h_{gate} = 20.71$ ft

Segment 20-21 configuration obtained from pipe friction calculation data sheet

flow 840 gpm, diameter 4", pipe length 46.125 ft, 1 gate valve, 8 90° LR elbows

90° elbow K = .27, gate valve K = .14

$h/100' = 36.16/100'$ $v = 21.16$ ft/sec

$h_L = L\ (h/100') = 46.125\ (36.16/100) = 16.68$ ft

$h_{gate} = K\ (v^2)/2g = .14\ (21.16^2)/64.4 = .97$ ft

$h_{elbow} = K\ (v^2)/2g = (8)\ .27\ (21.16^2)/64.4 = 15.02$ ft

$h_{20-21} = h_L + h_{elbow} + h_{gate} = 32.67$ ft

Segment 21-22 configuration obtained from pipe friction calculation data sheet

flow 840 gpm, diameter 8", pipe length 17.167 ft, 1 90° LR elbow 1 tee branch

90° elbow K = .22, tee branch K = .84

Flow	h/100	v
850	1.14	5.45
840	h	v
800	1.01	5.13

$h/100' = 1.11/100'$ $v = 5.39$ ft/sec

$h_L = L\ (h/100') = 17.167\ (1.11/100) = .19$ ft

$h_{elbow} = K\ (v^2)/2g = .22\ (5.39^2)/64.4 = .099$ ft

$h_{branch} = K\ (v^2)/2g = .84\ (5.39^2)/64.4 = .38$ ft

$h_{21-22} = h_L + h_{elbow} + h_{branch} = .67$ ft

Segment 22-23 configuration obtained from pipe friction calculation data sheet

flow 420 gpm, diameter 6", pipe length 10.5 ft, 1 red 6x8, 1 90° LR elbow
1 tee branch, 1 45° elbow

90° elbow K = .24, red K = .219, tee branch K = .9, 45° elbow K = .24

Flow	h/100	v
450	1.34	5
420	h	v
400	1.07	4.44

$h/100' = 1.178/100'$ $v = 4.66$ ft/sec

$h_L = L\ (h/100') = 10.5\ (1.178/100) = .124$ ft

$h_{90} = K\ (v^2)/2g = .24\ (4.66^2)/64.4 = .08$ ft

$h_{branch} = K\ (v^2)/2g = .9\ (4.66^2)/64.4 = .303$ ft

$h_{red} = K\ (v^2)/2g = .219\ (4.66^2)/64.4 = .074$ ft

$h_{45} = K\ (v^2)/2g = .24\ (4.66^2)/64.4 = .081$ ft

$h_{22\text{-}23} = h_L + h_{elbow} + h_{branch} + h_{red} + h_{45} = .66$ ft

Segment 23-24 configuration obtained from pipe friction calculation data sheet

flow 420 gpm, diameter 6", pipe length 8.969 ft, 1 90° LR elbow
1 tee branch, 1 gate valve

90° elbow K = .24, gate valve K = .12, tee branch K = .9,

$h/100' = 1.178/100'$ $v = 4.66$ ft/sec

$h_L = L\ (h/100') = 8.969\ (1.178/100) = .106$ ft

$h_{90} = K\ (v^2)/2g = .24\ (4.66^2)/64.4 = .08$ ft

$h_{branch} = K\ (v^2)/2g = .9\ (4.66^2)/64.4 = .3$ ft

$h_{gate} = K\ (v^2)/2g = .12\ (4.66^2)/64.4 = .04$ ft

$h_{23\text{-}24} = h_L + h_{elbow} + h_{branch} + h_{gate} + = .526$ ft

Segment 22-25 configuration obtained from pipe friction calculation data sheet

flow 420 gpm, diameter 8", pipe length 15.95 ft, 1 tee branch

tee branch K = .84

Flow	h/100	v
450	.341	2.89
420	h	v
400	.284	2.57

h/100' = .31/100'   v = 2.69 ft/sec

h_L = L (h/100') = 15.958 (.31/100) = .05 ft

$h_{branch} = K (v^2)/2g = .84 (2.69^2)/64.4 = .09$ ft
$h_{22-25} = h_L + h_{branch} = .14$ ft

Segment 25-26 configuration obtained from pipe friction calculation data sheet

flow 420 gpm, diameter 6", pipe length 15.73 ft, 1 90° LR elbow
1 tee branch, 1 gate valve

90° elbow K = .24, gate valve K = .12, tee branch K = .9,

h/100' = 1.178/100'   v = 4.66 ft/sec

h_L = L (h/100') = 15.73 (1.178/100) = .185 ft

$h_{90} = K (v^2)/2g = .24 (4.66^2)/64.4 = .08$ ft

$h_{branch} = K (v^2)/2g = .9 (4.66^2)/64.4 = .3$ ft

$h_{gate} = K (v^2)/2g = .12 (4.66^2)/64.4 = .04$ ft

$h_{25-26} = h_L + h_{elbow} + h_{branch} + h_{gate} + = .61$ ft

Determine the RHR pump's suction pressure

The RHR pump's suction pressure is determined by the relationship shown below and detailed on page 5 (Note: All elevations are obtained from Pipe Friction calculation data sheets):

$$Z1 + \frac{144P1}{\rho_1} + \frac{(v1)^2}{2g} = Z2 + \frac{144P2}{\rho_2} + \frac{(v2)^2}{2g} + h_f$$

SUBJECT Emergency Core Cooling System Pumps NPSH Available

solve equation for P2

$$P2 = \frac{\rho_2}{144}\{(Z1-Z2) + \frac{144(P1)}{\rho_1} + \frac{(v1)^2}{2g} - \frac{(v2)^2}{2g} - h_f \}$$

Note: the 1 and 2 shown in the equations represent the first pipe segment's circled nodes 1 to 2 from figure 1. For succeeding pipe segments the node numbers are changed in the equations.
Pressure at P2

$Z1 = 602.83$ ft $Z2 = 589.33$ ft $P1 = 14.7$ psia $v1 = 11.2$ ft/sec
$v2 = 11.2$ ft/sec $h_{1-2} = 4.06$ ft
$\rho_1 = \rho_2 = 60.32$ lbs/ft^3

$$P2 = \frac{60.32}{144}\{(602.83 - 589.33) + \frac{144(14.7)}{60.32} + \frac{(11.2)^2}{64.4} - \frac{11.2)^2}{64.4} - 4.06\}$$

$= 18.65$ psia

Pressure at P3

$Z2 = 589.33$ ft $Z3 = 586.43$ ft $P2 = 18.65$ psia $v2 = 11.2$ ft/sec
$v3 = 10.9$ ft/sec $h_{2-3} = 2.62$ ft
$\rho_2 = \rho_3 = 60.32$ lbs/ft^3

$$P3 = \frac{60.32}{144}\{(589.33 - 586.43) + \frac{144(18.65)}{60.32} + \frac{(11.2)^2}{64.4} - \frac{10.9)^2}{64.4} - 2.62\}$$

$= 18.76$ psia

Pressure at P4

$Z3 = 586.43$ ft $Z4 = 575.17$ ft $P3 = 18.76$ psia $v3 = 10.9$ ft/sec
$v4 = 10.9$ ft/sec $h_{3-4} = 4$ ft
$\rho_3 = \rho_4 = 60.32$ lbs/ft^3

$$P4 = \frac{60.32}{144}\{(586.43 - 575.17) + \frac{144(18.76)}{60.32} + \frac{(10.9)^2}{64.4} - \frac{10.90^2}{64.4} - 4\}$$

$= 21.8$ psia
Pressure at P5 - RHR Suction Pressure

$Z4 = 575.17$ ft $Z5 = 575.08$ ft $P4 = 21.8$ psia $v4 = 10.9$ ft/sec $v5 = 10.9$ ft/sec $h_{4-5} = .079$ ft $\rho_4 = \rho_5 = 60.32$ lbs/ft^3

$$P5 = \frac{60.32}{144}\{(575.17 - 575.08) + \frac{144(21.8)}{60.32} + \frac{(10.9)^2}{64.4} - \frac{10.9)^2}{64.4} - .079\}$$

$= 21.8$ psia

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DATE 12/9/97 BY A. Feliciano CK.
PLANT Cook Nuclear Plant Unit 1&2
System Emergency Core Cooling System

SUBJECT Emergency Core Cooling System Pumps NPSH Available

Determine the ECCS pump's NPSH Available

$$NPSH = h_a - h_{vpa} + h_{st} - h_{fs}$$

where:

NPSH - net positive suction head available, ft abs
h_a - absolute pressure, ft
h_{vpa} - fluid vapor pressure, ft
h_{st} - static elevation difference, ft
h_{fs} - pipe friction losses, ft

NPSH Available South Safety Injection Pump

h_{fs} = the sum of segments $h_{6-7} + h_{7-8} + h_{8-9} + h_{9-10} + h_{10-11} + h_{11-12} + h_{12-13}$

$h_{fs} = 62.41 + 18.87 + 88.29 + .91 + 10.3 + .82 + ..93 = 182.53$ ft

h_a = RHR PP suction pressure + RHR PP TH

= (21.8 * 2.386) + 300 (from pp curve at 4600 gpm)

= 352.01 ft

$h_{vpa} = 9.34 * 2.386 = 22.29$ ft

$h_{st} = 575 - 589.21 = -14.21$ ft

NPSH available = $h_a - h_{vpa} + h_{st} - h_{fs}$

= $352.01 - 22.29 + (-14.21) - 182.53$

= 132.98 ft abs @ 525 gpm

NPSH required is 13 ft abs at 525 gpm from curve 39890A

Available NPSH exceeds required NPSH by 119.98 ft abs

NPSH Available North Safety Injection Pump

h_{fs} = the sum of segments $h_{6-7} + h_{7-8} + h_{8-9} + h_{9-10} + h_{10-11} + h_{11-14} + h_{14-15} + h_{15-16} + h_{16-17} + h_{17-18}$

$h_{fs} = 62.41 + 18.87 + 88.29 + .91 + 10.3 + 5.74 + .31 + 5.02 + .245 + .93 = 193.03$ ft

h_a = RHR PP suction pressure + RHR PP TH

= (21.8 * 2.386) + 300 (from pp curve at 4600 gpm)
= 352.01 ft

h_{vpa} = 9.34 * 2.386 = 22.29 ft

h_{st} = 575 - 589.21 = -14.21 ft

NPSH available = $h_a - h_{vpa} + h_{st} - h_{fs}$

= 352.01 - 22.29 + (-14.21) - 193.03

= 122.48 ft abs @ 525 gpm

NPSH required is 13 ft abs at 525 gpm from curve 39890A
Available NPSH exceeds required NPSH by 109.48 ft abs

NPSH Available West Centrifugal Charging Pump

h_{fs} = the sum of segments $h_{6-7} + h_{7-8} + h_{8-9} + h_{9-10} + h_{10-11} + h_{11-14} + h_{14-15} + h_{15-16} + h_{16-19} + h_{19-20} + h_{20-21} + h_{21-22} + h_{22-23} + h_{23-24}$

h_{fs} = 62.41 + 18.87 + 88.29 + .91 + 10.3 + 5.74 + .31 + 5.02 + 16.39 + 20.71 + 32.67 + .67 + .66 + .526 = 263.48 ft

h_a = RHR PP suction pressure + RHR PP TH

= (21.8 * 2.386) + 300 (from pp curve at 4600 gpm)

= 352.01 ft

h_{vpa} = 9.34 * 2.386 = 22.29 ft

h_{st} = 575 - 592.5 = -17.5 ft

NPSH available = $h_a - h_{vpa} + h_{st} - h_{fs}$

= 352.01 - 22.29 + (-17.5) - 263.48

= 48.74 ft abs @ 420 gpm
NPSH required is 17 ft abs at 420 gpm from curve 34617-L

Available NPSH exceeds required NPSH by 31.74 ft abs

SUBJECT Emergency Core Cooling System Pumps NPSH Available

NPSH Available East Centrifugal Charging Pump

h_{fs} = the sum of segments $h_{6-7} + h_{7-8} + h_{8-9} + h_{9-10} + h_{10-11} + h_{11-14} + h_{14-15} + h_{15-16} + h_{16-19} + h_{19-20} + h_{20-21} + h_{21-22} + h_{22-25} + h_{25-26}$

$h_{fs} = 62.41 + 18.87 + 88.29 + .91 + 10.3 + 5.74 + .31 + 5.02 + 16.39 + 20.71 + 32.67 + .67 + .14 + .61 = 263.04$ ft

h_a = RHR PP suction pressure + RHR PP TH

= (21.8 * 2.386) + 300 (from pp curve at 4600 gpm)

= 352.01 ft

h_{vpa} = 9.34 * 2.386 = 22.29 ft

h_{st} = 575 - 592.5 = -17.5 ft

NPSH available = $h_a - h_{vpa} + h_{st} - h_{fs}$

= 352.01 - 22.29 + (-17.5) - 263.04

= 49.18 ft abs @ 420 gpm

NPSH required is 17 ft abs at 420 gpm from curve 34617-L

Available NPSH exceeds required NPSH by 32.18 ft abs

NPSH Available Residual Heat Removal Pump

h_{fs} = the sum of segments $h_{1-2} + h_{2-3} + h_{3-4} + h_{4-5}$

h_{fs} = 4.06 + 2.62 + 4 + .079 = 10.76 ft

h_a = atmospheric pressure

= 14.7 * 2.386

= 35.075 ft

h_{vpa} = 9.34 * 2.386 = 22.29 ft

h_{st} = 602.83 - 575 = 27.83 ft

NPSH available = $h_a - h_{vpa} + h_{st} - h_{fs}$

= 35.075 - 22.29 + 27.83 - 10.76

= 29.86 ft abs @ 4600 gpm

NPSH required is 20 ft abs at 4600 gpm from curve N-315

Available NPSH exceeds required NPSH by 9.86 ft abs

NPSH Available Containment Spray Pump

h_{fs} = the sum of segments h_{1-2} + h (from app Q , amendment 78)

$h_{fs} = 4.06 + 4.45 = 8.51$ ft

h_a = atmospheric pressure

$= 14.7 * 2.386$

$= 35.075$ ft

$h_{vpa} = 9.34 * 2.386 = 22.29$ ft

$h_{st} = 602.83 - 575.29 = 27.54$ ft

NPSH available $= h_a - h_{vpa} + h_{st} - h_{fs}$

$= 35.075 - 22.29 + 27.54 - 8.51$

= 31.82 ft abs @ 3200 gpm

NPSH required is 9 ft abs at 3200 gpm from curve T-32913-1

Available NPSH exceeds required NPSH by 22.82 ft abs

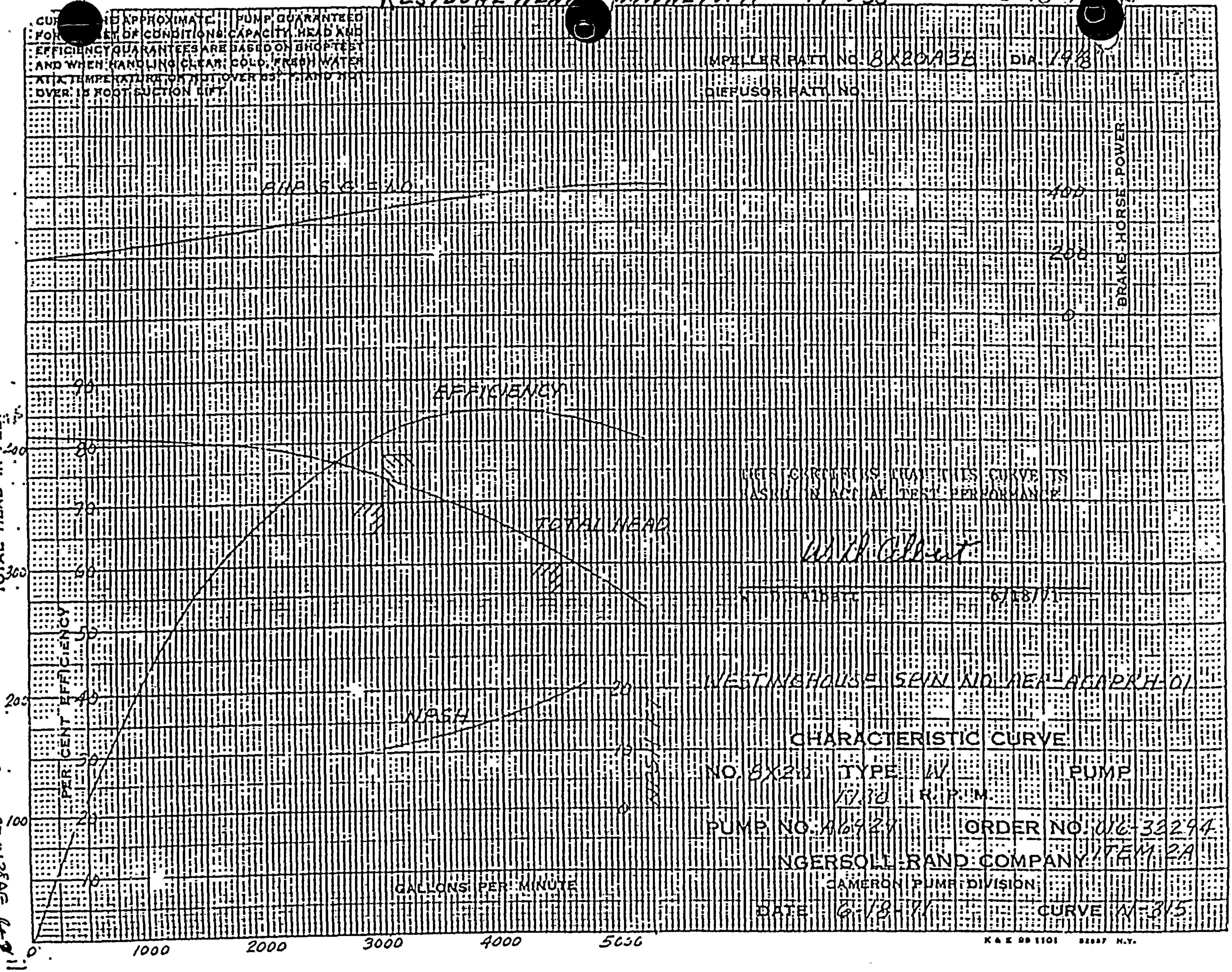
Conclusions

The results of this calculation demonstrate that sufficient NPSH is available to assure that the ECCS pumps perform their safety function when aligned to the Recirculation sump. That is, sufficient NPSH is available with one RHR pump supplying two SI and two CC pumps without taking credit for the containment design pressure.

The attachment to this calculation was performed to evaluate the impact of an RHR pump degraded by 10% from the baseline head-capacity curve. The results detailed in the attachment indicate that an RHR pump degraded by 10% from the baseline head-capacity curve still provides sufficient NPSH in excess of the required NPSH for the SI and CC pumps.

RESIDUAL HEAT [illegible]MOVAL PUMP PP-035

CURVE NO. N-315
DATE 6-18-71



CUR[illegible] APPROXIMATE. PUMP GUARANTEED FOR [illegible] OF CONDITIONS CAPACITY, HEAD AND EFFICIENCY GUARANTEES ARE BASED ON SHOP TEST AND WHEN HANDLING CLEAR, COLD, FRESH WATER AT A TEMPERATURE OF NOT OVER 85° F. AND NOT OVER 15 FOOT SUCTION LIFT.

IMPELLER PATT. NO. 8X20A3E DIA. 19⅛

DIFFUSOR PATT. NO.

THIS CERTIFIES THAT THIS CURVE IS AS [illegible] IN ACTUAL TEST PERFORMANCE

W.H. Albert

W. H. Albert 6/18/71

WESTINGHOUSE SPIN NO. MEA-ACARRH-01

CHARACTERISTIC CURVE

NO. 8X20 TYPE W PUMP

1770 R. P. M.

PUMP NO. A6421 ORDER NO. 016-33294

INGERSOLL-RAND COMPANY ITEM 2A

CAMERON PUMP DIVISION

DATE 6-18-71 CURVE N-315

K & E 99 1101 52807 N.Y.

5770128AF Rev 2

Pg 69 of 69

Ac Effective 1321

$\frac{840}{550} = 1.52$

CONTRACTOR WESTINGHOUSE

CUSTOMER AMP

SFN NO. AMP-2 P.O. 546-CAZ-103311-BN

IMPELLER PATTERN M-7278 M-6534

MAXIMUM DIAMETER $8\frac{1}{4}$ $8\frac{1}{2}$

RATED DIAMETER $8\frac{1}{4}$ $8\frac{1}{2}$ $8\frac{1}{2}$

MINIMUM DIAMETER $7\frac{1}{4}$ $7\frac{1}{4}$

TEST PERFORMANCE CURVE NO. 34617-L

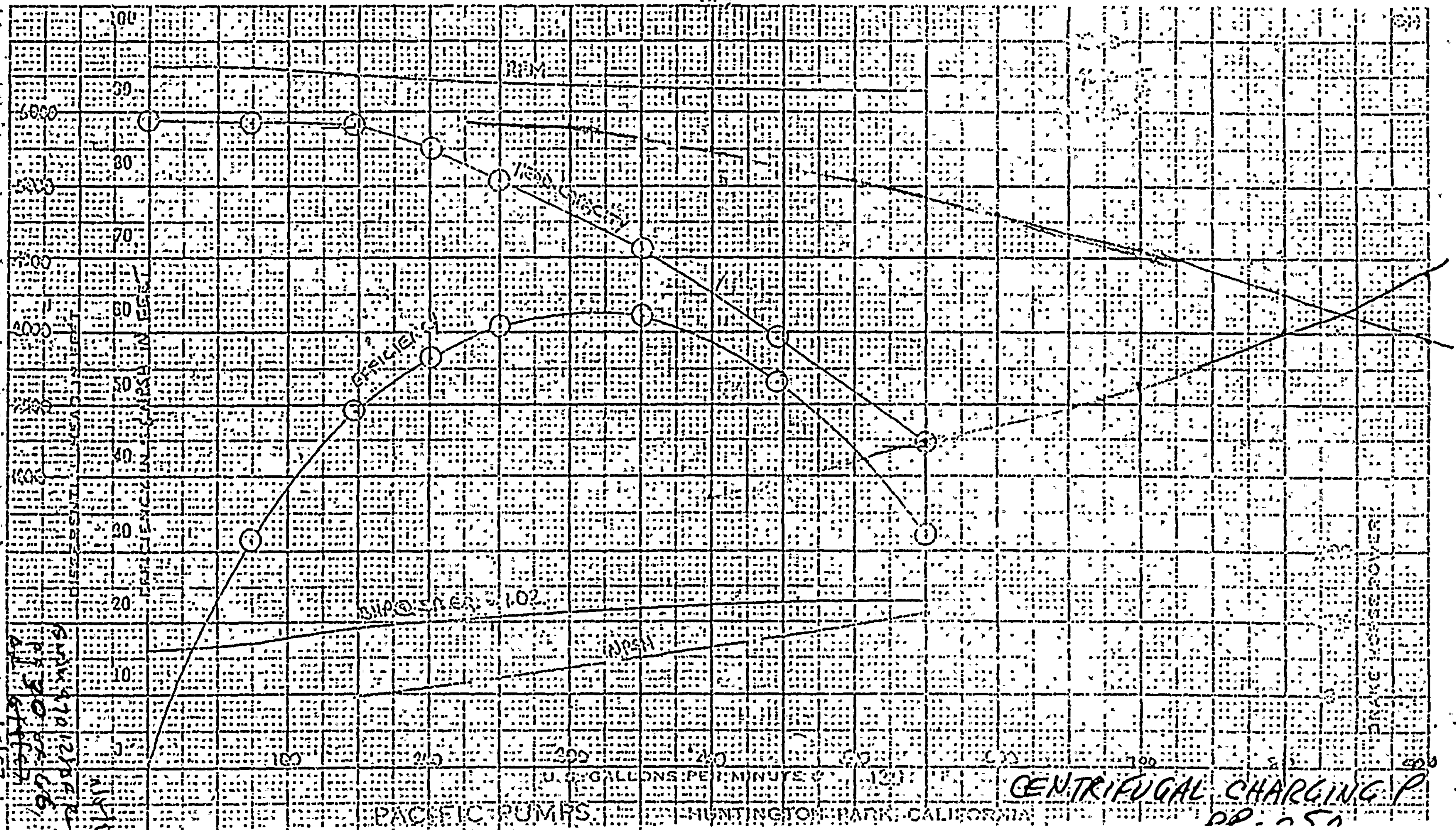
SIZE $2\frac{1}{2}$" RL TYPE IJ STAGES 11

R.P.M. AS SHOWN DATE 17 OCT 1970

PUMP NUMBER 45608

PERFORMANCE ALSO APPLIES TO PUMP

NUMBER CSAPCH.02



CENTRIFUGAL CHARGING P

PACIFIC PUMPS HUNTINGTON PARK, CALIFORNIA

= 1.31

PACIFIC PUMPS DRESSER HUNTINGTON PARK, CALIFORNIA

CONTRACTOR ___

CUSTOMER [illegible]

MARK / ~~ITEM~~ NO. [illegible] P.O. [illegible]

IMPELLER PATTERN M-6146 M-6149/48

MAXIMUM DIAMETER 8 5/8 8 5/8

RATED DIAMETER 8 5/8 [illegible]

MINIMUM DIAMETER 7 5/8 7 5/8

TEST PERFORMANCE CURVE NO. 39890A

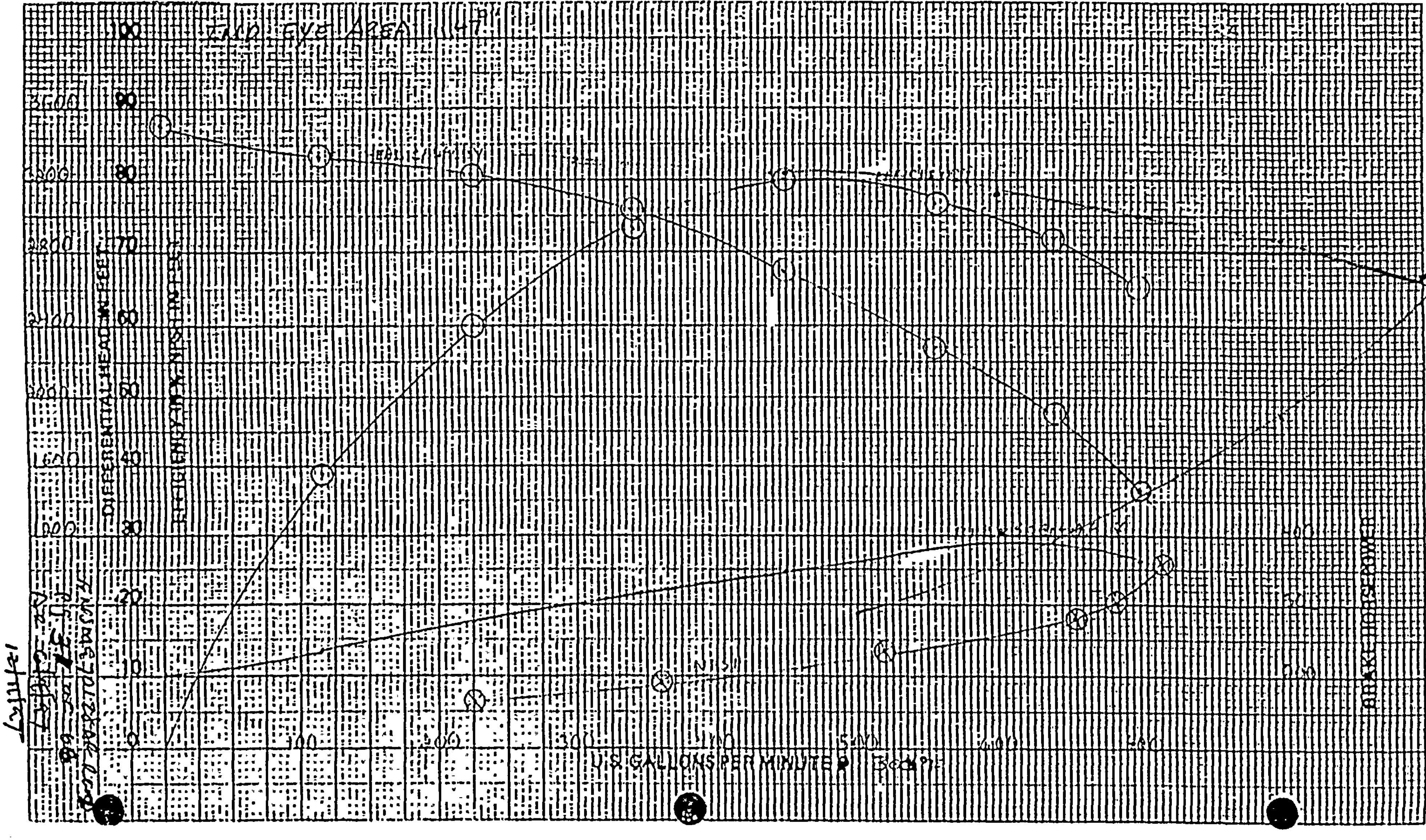
SIZE 2½ TYPE JTCH STAGES 10

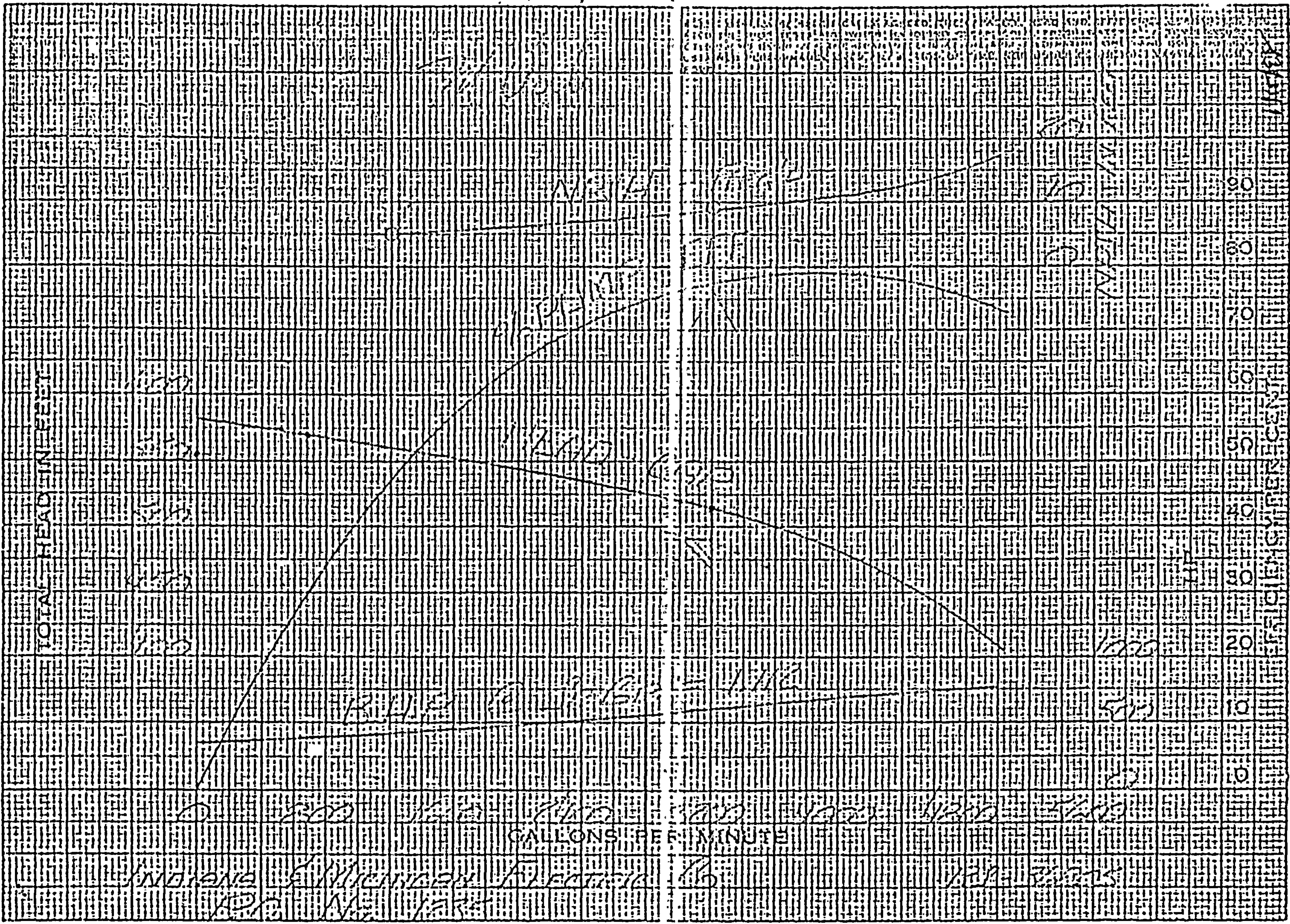
R.P.M. 3570 DATE [illegible]

PUMP NUMBER [illegible] JN51890

PERFORMANCE ALSO APPLIES TO ~~PUMP~~

~~NUMBER~~ FINAL MECHANICAL TEST RUN 4/27/83



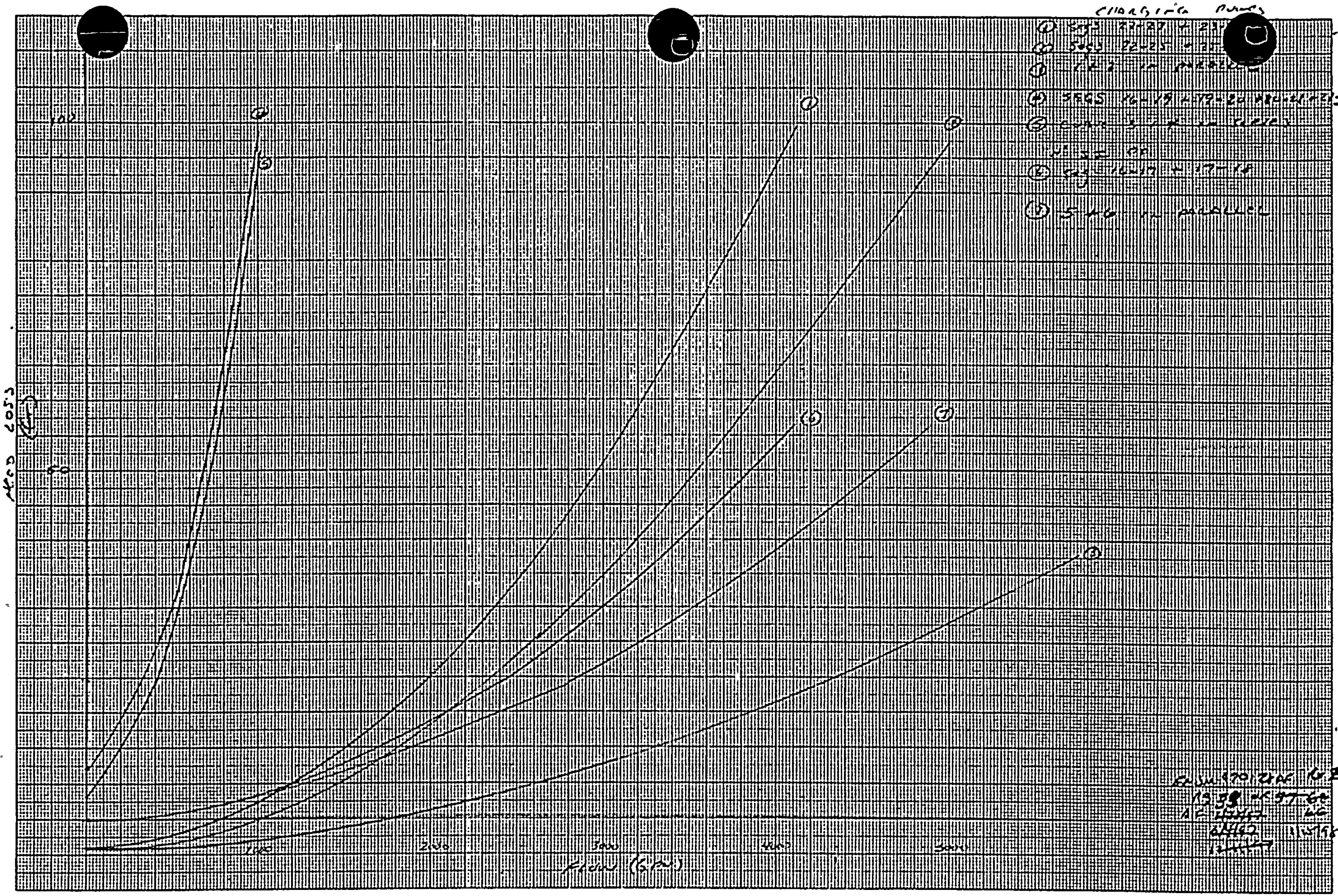


ENSM970128AF Rev. 1
PG 32 of 66
A.C. ~~6/4/97~~ 12/11/97

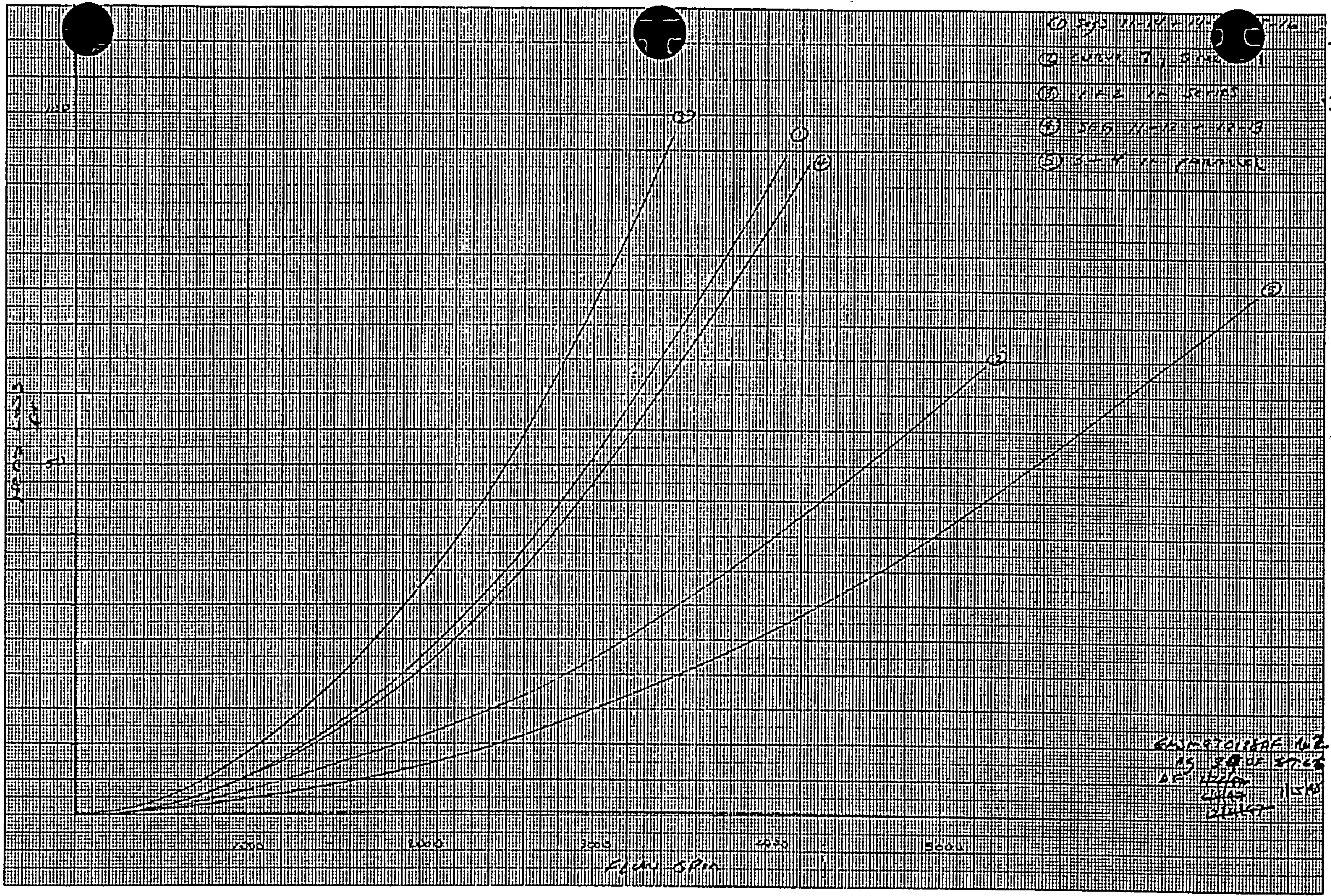
PUMP SIZE AND TYPE 8[illegible]2 × 24 DVDS	RPM 1780	ASSEMBLY NO. IC-77[illegible]	IMPELLER NO. R-3352	DIA 22	UNDER OVER	FILED TO	BYRON JACKSON TEST T-3[illegible]52-1
		FACTORY NO. 191-N-[illegible]	DATE 4-13-72	DATA BY LR		DRAWN BY LR	

SHEET 1

CHARGING PUMPS

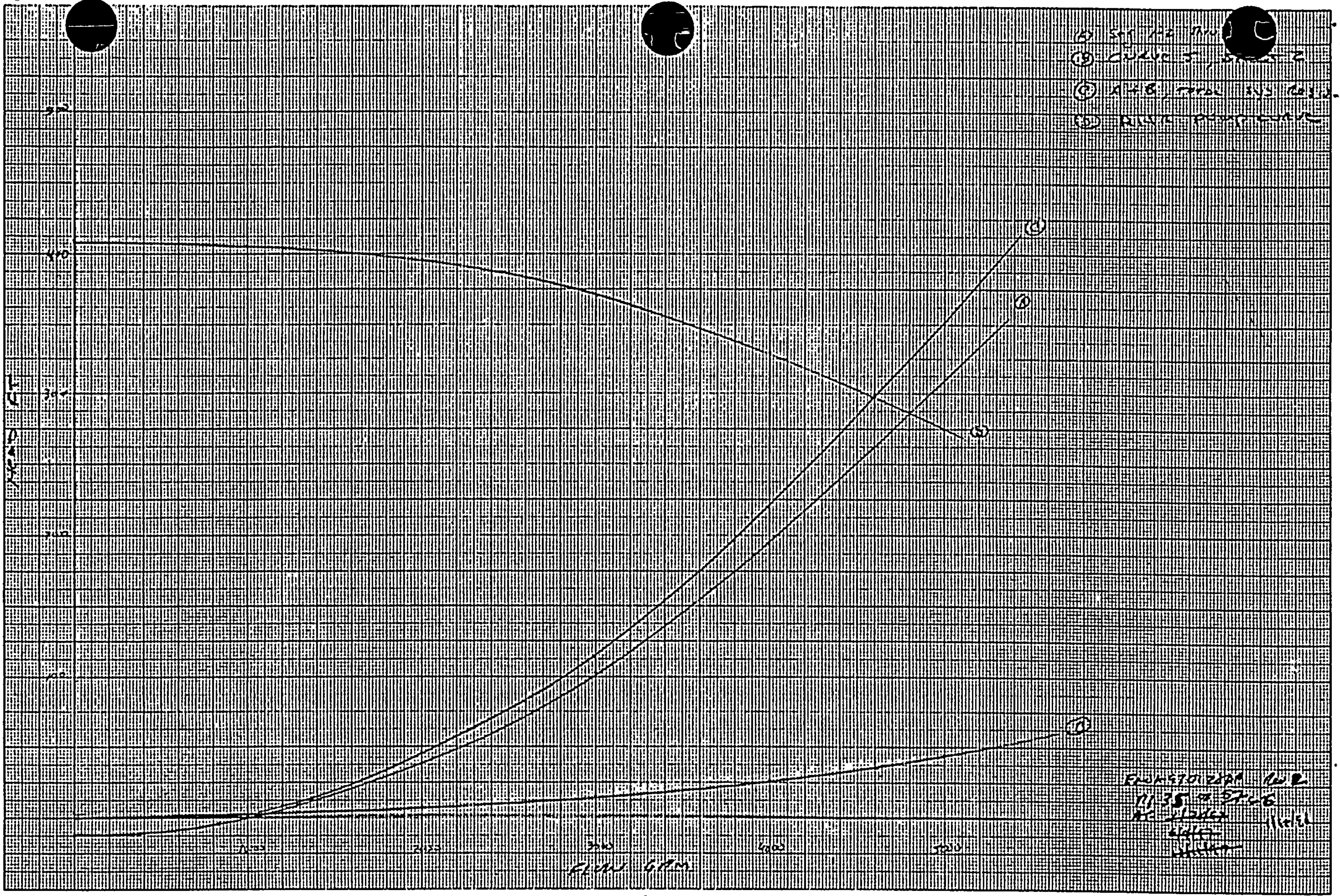


SHEET 2



EWM670128AF No.2
AS 3 OF 87
AC [illegible]
[illegible] 1152
[illegible]

Sheet 3



Ⓐ
Ⓑ CURVE 3, SHEET 2
Ⓒ A+B, TOTAL SYS
Ⓓ
400
300
200
100
1000
2000
3000
4000
5000
FLOW GPM
Ⓐ
Ⓑ
Ⓒ
Ⓓ
REV 2

~~NEMP950501JEW~~
~~Attachment 2~~
~~Page 1 of 6~~
~~jw 4/4/96~~
AC 1/28/97

```
                         rhrout

F  FRICTION CALC - INPUT FILE IS-rhrrecir

THE INPUT DATA FOR THE HFLC5 SYS. RES. CALC.
CONSISTS OF THE FOLLOWING DATA:
T - TEMPERTURE DEG F
E - PIPE ABSOLUTE ROUGHNESS (FT.)
N - FIRST PIPE SEGMENT NUMBER
N1 - LAST PIPE SEGMENT NUMBER
QDES - DESIGN FLOW THRU PIPE SEGMENT (GPM)
QMIN - MINIMUM FLOW THRU PIPE SEGMENT (GPM)
QMAX - MAXIMUM FLOW THRU PIPE SEGMENT (GPM)
QDELT - FLOW INCREMENT THRU PIPE SEGMENT (GPM)
D - PIPE SEGMENT INTERNAL DIA. (IN.)
L - PIPE SEGMENT LENGTH (FT.)
K - PIPE SEGMENT K FACTORS
L/D - PIPE SEGMENT L/D FACTORS

FOLLOWING IS YOUR INPUT DATA
 T        E          N        N1
190.00   .00015      1        4

 QDES      QMIN      QMAX      QDELT    D         L       K      L/D
 7700.00  7700.00   7700.00      .00  17.124    26.66    .97    10.00
 7700.00  7700.00   7700.00      .00  16.876    26.15    .00   100.00
 4500.00  4500.00   4500.00      .00  13.124    42.93    .20   160.00
   0.00   4500.00   4500.00      .00  13.124     3.33    .00      .00

FOLLOWING IS HFLC5 RESULTS

WATER TEMP.(F)                  = 190.00
DENSITY(LBM/CUFT)               =  60.32
ABS VISCOSITY(LBM/SEC/FT)       =  .217609E-03
PIPE ABS ROUGHNESS(FT)          =  .150000E-03


PIPE SEG NO     1      PIPE DIA(ID-IN) =  17.124
 FLOW-GPM    VEL(FPS)   LHD(FT)    KHD(FT)  LDHD(FT)   TOT  HD(FT)
  7700.0      10.73       .42       1.73       .22      2.38           1-2

PIPE SEG NO     2      PIPE DIA(ID-IN) =  16.876
 FLOW-GPM    VEL(FPS)   LHD(FT)    KHD(FT)  LDHD(FT)   TOT  HD(FT)
  7700.0      11.04       .44        .00      2.38      2.83           2-3

PIPE SEG NO     3      PIPE DIA(ID-IN) =  13.124
 FLOW-GPM    VEL(FPS)   LHD(FT)    KHD(FT)  LDHD(FT)   TOT  HD(FT)
  4500.0      10.67       .92        .35      3.74      5.01           3-4

PIPE SEG NO     4      PIPE DIA(ID-IN) =  13.124
 FLOW-GPM    VEL(FPS)   LHD(FT)    KHD(FT)  LDHD(FT)   TOT  HD(FT)
  4500.0      10.67       .07        .00       .00       .07           4-5

  NOLDS NUMBER FRICTION FACTOR TABLE
PIPE SEG      DES. FLOW       RE.NO.      F-FACTOR        HEAD LOSS
    1           7700.0      4243402.0       .0126           2.38
    2           7700.0      4305761.0       .0126           2.83
    3           4500.0      3235750.0       .0132           5.01
```

Post-it™ brand fax transmittal memo 7671 | # of pages ▸

To A. Feliciano
From Ripak
Co.
Co.
Dept. Buchanan
Phone #
Fax # 284-5574
Fax #

Rev 2
ENSM970128DF
pg 36 of ~~57~~ 66
AC ~~1/28/97~~
~~6/18/97~~
12/11/97

~~NEMP9505013EW~~
~~Attachment 2~~
~~Page 2 of 6~~
~~JW 4/4/96~~

4	4500.0	3235750.0	.0132	.07

Total H_{ss} = 10.29 Feet

AF 1/28/97

Rev 2

ENSM970128AF
pg 39 of ~~57~~ 66.
AF ~~1/28/97~~
~~6/4/97~~ 1/15/98
~~12/4/97~~

38 ~~34~~ 5TG6

PIPE FRICTION CALCULATION

DATA SHEET

~~Att. 7~~

SHEET 3 OF 6
PLANT Cook
BY Jot DATE ~~4/4/91~~
~~NEAR 950650 JSW~~
FMSM 970178 AF Rev 2
AF ~~12/2/97~~ 1/15/98
~~6/4/97~~
12/11/97

STEM From Containment Sump to ICM 306

(G. REF. 1-2-5338-17

UID TEMP.(F) 190 PIPE ABS. ROUGHNESS (FT) .00015 PIPE SEGMENT NUMBER 1

UID FLOW (GPM) 7700 ΦPIPE I.D. (IN) (18 OD) 17.124 ID PIPE EL. 593'-6" TO EL. 569'-9"

RAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	ΣK	ΣL/D
0-22 1/8"	GATE VALVE)JOM-306) * L/D=10	1	13		10
20'-1 1/16"	GLOBE VALVE		340		
1'-9 7/16"	BUTTERFLY VALVE		40		
0'-9 9/16"	SWING CHECK		135		
2'-1 3/4"	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW		20		
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH		60		
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.	1	0.78	.78	
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION † 24×18	1	$.5(1-\beta^2)$		
	• SUDDEN INCREASE † (22.876× 17.124)		$(1-\beta^2)^2$	.19	
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_v^2$		
	MISC				
S ① 26.66				⊙ .97	⊙ 10

* ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER
$\beta = d/D$ RF = RECOVERY FACTOR

FK-9-1-72

~~39~~ STG6

PIPE FRICTION CALCULATION

DATA SHEET

~~Att. 2~~

SHEET ~~1~~ OF 6

PLANT Cook

BY [illegible] DATE ~~4/4/86~~

~~NC 9005 0136 W~~

STEM From Iem. 306 to CTS TAKE (18" x 18" x 14" TEE) Rev 2 11/5/

DWG. REF. 2-SI-9, Sh. 1 of 2 rev. 2, 2-5415-15 ~~E~~ ESN 9715 78 AF ~~11/5/~~ AF ~~1/20/1~~ 6/4/97

FLUID TEMP. (F) 190 PIPE ABS. ROUGHNESS (FT) .00015 PIPE SEGMENT NUMBER 2

FLUID FLOW (GPM) 7700 ①PIPE I.D. (IN) (18" OD) 16.876 PIPE EL. 589'-9" TO EL. 586'-5 1/2"

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	ΣK	ΣL/D
2'-2 7/16"	GATE VALVE		13		
21'-4 1/2"	GLOBE VALVE		340		
2'-6 7/8" ✓	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW	11	20		40
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH	1	60		60
	* MITRE BENDS		$1.2(1-\cos\theta)$		
	* LATERAL ◁ OUTLET		1.0		
	* LATERAL ◁ INLET		0.5		
	* STRAIGHT RUN LATERAL		0.15		
	* PIPE ENTR PROJ. INWD.		0.78		
	* " " SHARP EDGE		0.50		
	* " " WELL ROUND		0.04		
	* PIPE EXIT SHARP EDGED		1.0		
	* ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	* SUDDEN CONTRACTION † ~~(16.876 x 13.124)~~		$.5(1-\beta^2)$	~~.198~~	
	* SUDDEN INCREASE †		$(1-\beta^2)^2$		
	* VALVE, MISCELLANEOUS		$891.4\ d^4/C_v^2$		
	MISC				
✓				0.0	
TOTALS ① 26.15				① ~~.198~~	① 100

* ITEMS ARE "K" VALUES ONLY † BASED ON SHALLER PIPE DIAMETER

FK-5-1-72

1/15/84

40 ~~36~~ 5766

PIPE FRICTION CALCULATION

DATA SHEET

new ~~A.H.~~

ENSM970728AF
DC ~~H28H97G1114AT~~
12114197

SHEET ~~5~~ OF ~~6~~
PLANT COOK
BY ~~Joe~~ DATE ~~9/4/96~~
~~DEAPE2508 81J5EW~~

'STEM From TEE (CTS TAKE-OFF) to Tee (Suction of RHR PP 2W-14 LINE From RWST & 3" RHR MINI-FLOW)

YG. REF. 2-SI-7 Sh. 1 of 2 r.2

.UID TEMP. (F) 196° PIPE ABS. ROUGHNESS (FT) .00015 PIPE SEGMENT NUMBER 3

.UID FLOW (GPM) 4500 ①PIPE I.D. (IN) (14" OD) 13.124 ID PIPE EL. 581'-5⅛" TO EL. 575'-2"

RAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	ΣK	ΣL/D
3'-0"	GATE VALVE (2-RH-404W) L/D=10 *	1	~~13~~ 10		10
6'-11⅛"	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
14'-8"	SWING CHECK		135		
6'-4"	90° STD. ELBOW		30		
4'-6"	90° S.R. ELBOW		50		
0-14"	90° L.R. ELBOW	1 ~~||||~~	20		120
	45° STD. ELBOW		16		
1'-2"	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
5'-2"	STD. TEE RUN	1	20		20
	STD. TEE BRANCH		60		
	* MITRE BENDS		1.2(1-COS θ)		
	* LATERAL ◁ OUTLET		1.0		
	* LATERAL ◁ INLET		0.5		
	* STRAIGHT RUN LATERAL		0.15		
	* PIPE ENTR PROJ. INWD.		0.78		
	* " " SHARP EDGE		0.50		
	* " " WELL ROUND		0.04		
	* PIPE EXIT SHARP EDGED		1.0		
	* ORIFICE (C_D = .61)		2.69 RF/β^4		
	* SUDDEN CONTRACTION † (β.37(Xβ.124))		.5(1-β^2)	.198	
	* SUDDEN INCREASE †		(1-β^2)^2		
	* VALVE, MISCELLANEOUS		891.4 d^4/C_v^2		
	MISC				
① 42.93				.198 ② ~~.0.0~~	③ 160

* ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER

$\beta = d/D$ RF – RECOVERY FACTOR

PIPE FRICTION CALCULATION

Att. 2

DATA SHEET

SHEET ~~55~~ 41 OF ~~6~~ ~~56~~ 66
PLANT Cook
BY [illegible] DATE ~~4/4/97~~
~~REA195050~~7JEW 1/15/97
Rev 2
ELJM970178AF
AE ~~AG~~ ~~4/4/97~~
4/4/97
~~10/11/97~~

YSTEM From Tee (From RWST & 3" mini flow) to RHR PUMP 2W
WG. REF. 2-SI-7 sh. 1 of 2 rev. 2
LUID TEMP. (F) 190° PIPE ABS. ROUGHNESS (FT) .00015 PIPE SEGMENT NUMBER 4
LUID FLOW (GPM) 4500 ①PIPE I.D. (IN) (14" D) 13.124 ID PIPE EL. 575'-2" TO EL. 575'-0"

TRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	ΣK	ΣL/D
2'-0"	GATE VALVE		13		
0'-16"	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW		20		
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH		60		
	* MITRE BENDS		$1.2(1-\cos\theta)$		
	* LATERAL ∢ OUTLET		1.0		
	* LATERAL ∢ INLET		0.5		
	* STRAIGHT RUN LATERAL		0.15		
	* PIPE ENTR PROJ. INWD.		0.78		
	* " " SHARP EDGE		0.50		
	* " " WELL ROUND		0.04		
	* PIPE EXIT SHARP EDGED		1.0		
	* ORIFICE (C_D = .61)		$2.59\ RF/\beta^4$		
	* SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	* SUDDEN INCREASE †		$(1-\beta^2)^2$		
	* VALVE, MISCELLANEOUS		$891.4\ d^4/C_v^2$		
	MISC				
LS ① 3.33				① 0.0	① 0.0

* ITEMS ARE "K" VALUES ONLY
$\beta = d/D$
RF = RECOVERY FACTOR
† BASED ON SMALLER PIPE DIAMETER

FK-3-1-72

```
                 c:\calc\npshsr

E FRICTION CALC - INPUT FILE IS-c:\calc\rsnpsh

THE INPUT DATA FOR THE HFLC5 SYS. RES. CALC.
CONSISTS OF THE FOLLOWING DATA:
T - TEMPERTURE DEG F
E - PIPE ABSOLUTE ROUGHNESS (FT.)
N - FIRST PIPE SEGMENT NUMBER
N1 - LAST PIPE SEGMENT NUMBER
QDES - DESIGN FLOW THRU PIPE SEGMENT (GPM)
QMIN - MINIMUM FLOW THRU PIPE SEGMENT (GPM)
QMAX - MAXIMUM FLOW THRU PIPE SEGMENT (GPM)
QDELT - FLOW INCREMENT THRU PIPE SEGMENT (GPM)
D - PIPE SEGMENT INTERNAL DIA. (IN.)
L - PIPE SEGMENT LENGTH (FT.)
K - PIPE SEGMENT K FACTORS
L/D - PIPE SEGMENT L/D FACTORS

FOLLOWING IS YOUR INPUT DATA
 T       E          N       N1
190.00     .00015   1        3

 QDES      QMIN      QMAX     QDELT      D       L        K      L/D
 5050.00  1050.00  5050.00  1000.00  7.981    59.85     .00   308.00
 5050.00  1050.00  5050.00  1000.00  7.981    10.00     .00    93.00
 5050.00  1050.00  5050.00  1000.00 13.124      .00     .79    20.00

 LOWING IS HFLC5 RESULTS

WATER TEMP.(F)                = 190.00
DENSITY(LBM/CUFT)             =  60.32
ABS VISCOSITY(LBM/SEC/FT)     =  .217609E-03
PIPE ABS ROUGHNESS(FT)        =  .150000E-03


PIPE SEG NO     1        PIPE DIA(ID-IN) =    7.981
 FLOW-GPM        VEL(FPS)    LHD(FT)    KHD(FT)   LDHD(FT)   TOT  HD(FT)
  1050.0           6.73        .94        .00       3.23       4.17
  2050.0          13.15       3.52        .00      12.03      15.55
  3050.0          19.56       7.72        .00      26.41      34.13
  4050.0          25.97      13.55        .00      46.37      59.92
  5050.0          32.39      21.01        .00      71.91      92.92
```

6-7

```
PIPE SEG NO     2        PIPE DIA(ID-IN) =    7.981
 FLOW-GPM        VEL(FPS)    LHD(FT)    KHD(FT)   LDHD(FT)   TOT  HD(FT)
  1050.0           6.73        .16        .00        .97       1.13
  2050.0          13.15        .59        .00       3.63       4.22
  3050.0          19.56       1.29        .00       7.98       9.27
  4050.0          25.97       2.26        .00      14.00      16.27
  5050.0          32.39       3.51        .00      21.71      25.22
```

7-8

```
PIPE SEG NO     3        PIPE DIA(ID-IN) =  13.124
  OW-GPM         VEL(FPS)    LHD(FT)    KHD(FT)   LDHD(FT)   TOT  HD(FT)
  1050.0           2.49        .00        .08        .03        .10
  2050.0           4.86        .00        .29        .10        .39
  3050.0           7.23        .00        .64        .22        .86
  4050.0           9.61        .00       1.13        .38       1.51
  5050.0          11.98        .00       1.76        .59       2.35
```

8-9

42 Rev 2
ENSM 970128AF 66
pg ~~78~~ of ~~57~~ ~~67~~
AR ~~4/28/97~~
~~6/4/97~~
~~12/11/97~~
1/15/98

```
R  NOLDS NUMBER FRICTION FACTOR TABLE
     SEG     DES. FLOW        RE.NO.    F-FACTOR         HEAD LOSS
      1       5050.0        5971215.0     .0143        92.92
      2       5050.0        5971215.0     .0143        25.22
      3       5050.0        3631231.0     .0132         2.35


THE INPUT DATA FOR THE HFLC5 SYS. RES. CALC.
CONSISTS OF THE FOLLOWING DATA:
T - TEMPERTURE DEG F
E - PIPE ABSOLUTE ROUGHNESS (FT.)
N - FIRST PIPE SEGMENT NUMBER
N1 - LAST PIPE SEGMENT NUMBER
QDES - DESIGN FLOW THRU PIPE SEGMENT (GPM)
QMIN - MINIMUM FLOW THRU PIPE SEGMENT (GPM)
QMAX - MAXIMUM FLOW THRU PIPE SEGMENT (GPM)
QDELT - FLOW INCREMENT THRU PIPE SEGMENT (GPM)
D - PIPE SEGMENT INTERNAL DIA. (IN.)
L - PIPE SEGMENT LENGTH (FT.)
K - PIPE SEGMENT K FACTORS
L/D - PIPE SEGMENT L/D FACTORS

FOLLOWING IS YOUR INPUT DATA
 T         E          N        N1
130.00    .00015    4       20
   ES       QMIN      QMAX     QDELT      D          L         K       L/D
 5050.00  1050.00  5050.00  1000.00   7.981       3.00       .00       .00
 2500.00  1000.00  2500.00   500.00   7.981      68.69       .00    297.00
  700.00   100.00   800.00   100.00   6.357       5.16       .22     80.00
  700.00   100.00   800.00   100.00   4.260       1.17       .28       .00
 1800.00  1000.00  2600.00   800.00   6.357      13.89       .22     73.00
 1800.00  1000.00  2600.00   800.00   8.329       1.76       .19     20.00
 1800.00  1000.00  2600.00   800.00   6.357      18.31       .22     53.00
  700.00   100.00   800.00   100.00   6.357       4.54       .00     20.00
  700.00   100.00   800.00   100.00   4.260       1.17       .28       .00
 1100.00  1000.00  1200.00   100.00   4.260      15.16       .28    120.00
 1100.00  1000.00  1200.00   100.00   4.260       5.00       .00    193.00
 1100.00  1000.00  1200.00   100.00   4.260      46.13       .00    173.00
 1100.00  1000.00  1200.00   100.00   8.329      17.17       .00     80.00
  550.00   150.00   550.00   100.00   6.357      10.50       .22     96.00
  550.00   150.00   550.00   100.00   6.357       8.97       .00     93.00
  550.00   150.00   550.00   100.00   8.329      15.96       .00     60.00
  550.00   150.00   550.00   100.00   6.357      15.73       .22     93.00

FOLLOWING IS HFLC5 RESULTS

WATER TEMP.(F)                     = 130.00
DENSITY(LBM/CUFT)                  =  61.54
ABS VISCOSITY(LBM/SEC/FT)          =  .342668E-03
   E ABS ROUGHNESS(FT)             =  .150000E-03


PIPE SEG NO     4         PIPE DIA(ID-IN) =    7.981
 FLOW-GPM       VEL(FPS)    LHD(FT)    KHD(FT)   LDHD(FT)   TOT  HD(FT)
  1050.0          6.73        .05        .00        .00        .05
  2050.0         13.15        .18        .00        .00        .18
```

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EMSM970128AF
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AF ~~4/20/97~~
~~6/4/97~~
~~12/11/97~~
1/15/98

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  3050.0      19.56      .39        .00        .00        .39
  4050.0      25.97      .68        .00        .00        .68
  5050.0      32.39     1.06        .00        .00       1.06

   E SEG NO    5         PIPE DIA(ID-IN) =   7.981
 FLOW-GPM     VEL(FPS)   LHD(FT)   KHD(FT)   LDHD(FT)   TOT  HD(FT)
  1000.0       6.41     1.01        .00       2.89       3.90
  1500.0       9.62     2.22        .00       6.37       8.59
  2000.0      12.83     3.89        .00      11.20      15.09
  2500.0      16.03     6.04        .00      17.37      23.41

PIPE SEG NO    6         PIPE DIA(ID-IN) =   6.357
 FLOW-GPM     VEL(FPS)   LHD(FT)   KHD(FT)   LDHD(FT)   TOT  HD(FT)
   100.0       1.01      .00        .00        .02        .03
   200.0       2.02      .01        .01        .09        .12
   300.0       3.03      .02        .03        .19        .25
   400.0       4.04      .04        .06        .34        .43
   500.0       5.05      .06        .09        .52        .67
   600.0       6.07      .09        .13        .73        .95
   700.0       7.08      .12        .17        .99       1.28
   800.0       8.09      .16        .22       1.28       1.66

PIPE SEG NO    7         PIPE DIA(ID-IN) =   4.260
 FLOW-GPM     VEL(FPS)   LHD(FT)   KHD(FT)   LDHD(FT)   TOT  HD(FT)
   100.0       2.25      .00        .02        .00        .03
   200.0       4.50      .02        .09        .00        .11
   300.0       6.75      .04        .20        .00        .24
   400.0       9.00      .07        .35        .00        .42
   500.0      11.25      .11        .55        .00        .66
   600.0      13.51      .16        .79        .00        .94
   700.0      15.76      .21       1.07        .00       1.29
   800.0      18.01      .28       1.40        .00       1.68

PIPE SEG NO    8         PIPE DIA(ID-IN) =   6.357
 FLOW-GPM     VEL(FPS)   LHD(FT)   KHD(FT)   LDHD(FT)   TOT  HD(FT)
  1000.0      10.11      .65        .35       1.81       2.81
  1800.0      18.20     2.06       1.13       5.74       8.93
  2600.0      26.28     4.26       2.35      11.87      18.48

PIPE SEG NO    9         PIPE DIA(ID-IN) =   8.329
 FLOW-GPM     VEL(FPS)   LHD(FT)   KHD(FT)   LDHD(FT)   TOT  HD(FT)
  1000.0       5.89      .02        .10        .16        .29
  1800.0      10.60      .07        .33        .51        .91
  2600.0      15.31      .13        .70       1.06       1.89

PIPE SEG NO    10        PIPE DIA(ID-IN) =   6.357
 FLOW-GPM     VEL(FPS)   LHD(FT)   KHD(FT)   LDHD(FT)   TOT  HD(FT)
  1000.0      10.11      .86        .35       1.31       2.52
  1800.0      18.20     2.72       1.13       4.17       8.01
  2600.0      26.28     5.62       2.35       8.62      16.59

PIPE SEG NO    11        PIPE DIA(ID-IN) =   6.357
 FLOW-GPM     VEL(FPS)   LHD(FT)   KHD(FT)   LDHD(FT)   TOT  HD(FT)
   100.0       1.01      .00        .00        .00        .00
   200.0       2.02      .00        .00        .02        .03
   300.0       3.03      .02        .00        .05        .07
   400.0       4.04      .04        .00        .08        .12
   500.0       5.05      .06        .00        .13        .18
   600.0       6.07      .08        .00        .18        .26
   700.0       7.08      .11        .00        .25        .35
```

9-10 ✓

10-11 ✓

11-12 ✓

12-13 ✓

11-14 ✓

14-15 ✓

15-16 ✓

16-17 ✓ REV 2

SMSN 970128 AF
44
PS ~~40~~ OX ST 66
AF ~~1/28/97~~
~~6/4/97~~
2/4/97

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   800.0        8.09       .14         .00         .32         .46

PIPE SEG NO     12      PIPE DIA(ID-IN) =    4.260
   W-GPM       VEL(FPS)    LHD(FT)     KHD(FT)    LDHD(FT)    TOT  HD(FT)
  100.0         2.25       .00         .02         .00         .03
   200.0        4.50       .02         .09         .00         .11
   300.0        6.75       .04         .20         .00         .24
   400.0        9.00       .07         .35         .00         .42
   500.0       11.25       .11         .55         .00         .66
   600.0       13.51       .16         .79         .00         .94
   700.0       15.76       .21        1.07         .00        1.29
   800.0       18.01       .28        1.40         .00        1.68
```

17-18

```
PIPE SEG NO    13      PIPE DIA(ID-IN) =    4.260
 FLOW-GPM     VEL(FPS)    LHD(FT)     KHD(FT)    LDHD(FT)    TOT  HD(FT)
  1000.0       22.51      5.56        2.19       15.63       23.39
  1100.0       24.76      6.72        2.65       18.88       28.24
  1200.0       27.01      7.98        3.15       22.42       33.56
```

18-19

```
PIPE SEG NO    14      PIPE DIA(ID-IN) =    4.260
 FLOW-GPM     VEL(FPS)    LHD(FT)     KHD(FT)    LDHD(FT)    TOT  HD(FT)
  1000.0       22.51      1.83         .00       25.14       26.98
  1100.0       24.76      2.22         .00       30.36       32.57
  1200.0       27.01      2.63         .00       36.06       38.70
```

19-20

```
PIPE SEG NO    15      PIPE DIA(ID-IN) =    4.260
 FLOW-GPM     VEL(FPS)    LHD(FT)     KHD(FT)    LDHD(FT)    TOT  HD(FT)
  1000.0       22.51     16.93         .00       22.54       39.46
   100.0       24.76     20.44         .00       27.21       47.65
    00.0       27.01     24.28         .00       32.33       56.61
```

20-21

```
PIPE SEG NO    16      PIPE DIA(ID-IN) =    8.329
 FLOW-GPM     VEL(FPS)    LHD(FT)     KHD(FT)    LDHD(FT)    TOT  HD(FT)
  1000.0        5.89       .20         .00         .66         .86
  1100.0        6.48       .24         .00         .79        1.03
  1200.0        7.07       .29         .00         .93        1.22
```

21-22

```
PIPE SEG NO    17      PIPE DIA(ID-IN) =    6.357
 FLOW-GPM     VEL(FPS)    LHD(FT)     KHD(FT)    LDHD(FT)    TOT  HD(FT)
   150.0        1.52       .01         .00         .06         .08
   250.0        2.53       .03         .02         .16         .22
   350.0        3.54       .06         .04         .31         .42
   450.0        4.55       .10         .07         .51         .68
   550.0        5.56       .15         .11         .74        1.00
```

22-23

```
PIPE SEG NO    18      PIPE DIA(ID-IN) =    6.357
 FLOW-GPM     VEL(FPS)    LHD(FT)     KHD(FT)    LDHD(FT)    TOT  HD(FT)
   150.0        1.52       .01         .00         .06         .07
   250.0        2.53       .03         .00         .16         .19
   350.0        3.54       .06         .00         .30         .36
   450.0        4.55       .09         .00         .49         .58
   550.0        5.56       .13         .00         .72         .85
```

23-24

```
PIPE SEG NO    19      PIPE DIA(ID-IN) =    8.329
   OW-GPM     VEL(FPS)    LHD(FT)     KHD(FT)    LDHD(FT)    TOT  HD(FT)
   150.0         .88       .00         .00         .01         .02
   250.0        1.47       .01         .00         .04         .05
   350.0        2.06       .03         .00         .07         .09
   450.0        2.65       .04         .00         .11         .15
   550.0        3.24       .06         .00         .16         .22
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24-25 1/11/96

45 2002

[illegible]

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AT= ~~[illegible]~~ [illegible]

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PIPE SEG NO    20        PIPE DIA(ID-IN) =    6.357
 FLOW-GPM      VEL(FPS)   LHD(FT)   KHD(FT)   LDHD(FT)   TOT  HD(FT)
   150.0         1.52       .02        .00        .06         .09
   250.0         2.53       .05        .02        .16         .23
   350.0         3.54       .10        .04        .30         .44
   450.0         4.55       .16        .07        .49         .72
   550.0         5.56       .23        .11        .72        1.06


REYNOLDS NUMBER FRICTION FACTOR TABLE
PIPE SEG     DES. FLOW       RE.NO.   F-FACTOR        HEAD LOSS
     4       5050.0      3868241.0       .0144         1.06
     5       2500.0      1914971.0       .0146        23.41
     6        700.0       673170.9       .0159         1.28
     7        700.0      1004542.0       .0168         1.29
     8       1800.0      1731011.0       .0153         8.93
     9       1800.0      1321171.0       .0147          .91
    10       1800.0      1731011.0       .0153         8.01
    11        700.0       673170.9       .0159          .35
    12        700.0      1004542.0       .0168         1.29
    13       1100.0      1578565.0       .0165        28.24
    14       1100.0      1578565.0       .0165        32.57
    15       1100.0      1578565.0       .0165        47.65
    16       1100.0       807382.4       .0151         1.03
    17        550.0       528919.9       .0161         1.00
    18        550.0       528919.9       .0161          .85
    19        550.0       403691.2       .0159          .22
    20        550.0       528919.9       .0161         1.06
```

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AF ~~1/28/97~~
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REV: 4/79

ES-PIPE-1013-QCN Rev 0

PIPE FRICTION CALCULATION

DATA SHEET

SHEET ~~43~~ 47 OF ~~57~~ 66
PLANT COOK
BY DF DATE ~~12/28/67~~
Rev 2 ESNS 670128 DF ~~12/11/67~~ 11/6/67

SYSTEM FROM D-h WATER CT TO TEE SPEC- TO KPER HC/BYPASS

DWG. REF. 2-RH-14 1 OF 2

FLUID TEMP. (F) 190 PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 4A

①FLUID FLOW (GPM) 5050 ①PIPE I.D. (IN) 8"Ø G-14 7.961 PIPE EL. 575 TO EL. 613-0

~~4K~~ 6 ~~5~~ 7

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	ΣK	ΣL/D
13'	GATE VALVE 30 GE 2E-- (RH 113W)		13		13
7'-9"	GLOBE VALVE		340		
5'-5"	BUTTERFLY VALVE		40		
8'-10"	SWING CHECK 30 CE 0255		135		135
22-5"	90° STD. ELBOW		30		
3'-9¼	90° S.R. ELBOW		50		
1'-7"	90° L.R. ELBOW	8	20		160
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH		60		
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	• SUDDEN INCREASE †		$(1-\beta^2)^2$		
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_V{}^2$		
	MISC				
TOTALS ① 59.85				④	⑤ 308

• ITEMS ARE "K" VALUES ONLY
$\beta = d/D$ RF = RECOVERY FACTOR

† BASED ON SMALLER PIPE DIAMETER

FK-9-1-72

REV. 4/73

PIPE FRICTION CALCULATION

DATA SHEET

SHEET ~~44~~ 48 OF ~~57~~ 66
PLANT COOK ~~6/14/97~~
BY AT DATE ~~1/28/97~~
SASMG70128AF
REV 2 ~~11/14/97~~
11/15/98

SYSTEM FLOW TEE (2NR HX(AE)) CONN TO 8X14 INC.

DWG. REF. 2-RH-14 1 OF 2

FLUID TEMP.(F) 190 PIPE ABS. ROUGHNESS(FT) ______ PIPE SEGMENT NUMBER 5

①FLUID FLOW (GPM) 5050 ②PIPE I.D. (IN) 8"Ø S-14 7.981 PIPE EL. 613-0 TO EL. 613-0

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	7 ΣK	8 ΣL/D
10'	GATE VALVE 30GE085 (2NI16W)		13		13
	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		20
	90° L.R. ELBOW	1	20		
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		60
	STD. TEE BRANCH	1	60		
	* MITRE BENDS		$1.2(1-\cos\theta)$		
	* LATERAL ◁ OUTLET		1.0		
	* LATERAL ◁ INLET		0.5		
	* STRAIGHT RUN LATERAL		0.15		
	* PIPE ENTR PROJ. INWD.		0.78		
	* " " SHARP EDGE		0.50		
	* " " WELL ROUND		0.04		
	* PIPE EXIT SHARP EDGED		1.0		
	* ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	* SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	* SUDDEN INCREASE †		$(1-\beta^2)^2$		
	* VALVE, MISCELLANEOUS		$891.4\ d^4/C_v^2$		
	MISC				
TOTALS ③ 10				④	⑤ 93

* ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER

$\beta = d/D$ RF = RECOVERY FACTOR

FK-9-1-77

REV. 4/73K

PIPE FRICTION CALCULATION
DATA SHEET

SHEET ~~49~~ 62 OF 57
PLANT COOF
BY AR DATE ~~1/20/97~~ 6/4/97 ~~10/17/97~~ 11/15/98
ENCSUA970028AF
Rev 2

SYSTEM From 2X14 INC Tee [illegible] to 2X14 DEC

DWG. REF. 2-RH-14 1052 2-RH-18

FLUID TEMP.(F) 190 PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 6

①FLUID FLOW (GPM) 5050 ②PIPE I.D. (IN) ND 5-14 13.124 PIPE EL. 613-0 TO EL. 613-0

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	8 ΣK	9 ΣL/D
	GATE VALVE		13		
	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW	1	20		20
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH		60		
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION † 5X14		$.5(1-\beta^2)$	.337	
	• SUDDEN INCREASE † 5X14		$(1-\beta^2)^2$	.454	
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_V^2$		
	MISC W LHR HX 15 PSI @ 2,960 gpm 2.3 ft.				
TOTALS ①				④ .791	⑤ 20

• ITEMS ARE "K" VALUES ONLY
$\beta = d/D$ RF = RECOVERY FACTOR

† BASED ON SMALLER PIPE DIAMETER

PIPE FRICTION CALCULATION

DATA SHEET

SHEET ~~46~~ 50 OF ~~57~~ 66
PLANT Cook ~~[illegible]~~
BY AF DATE ~~12/01/97~~
ENSMG70128 AF
Rev 2 ~~12/11/97~~
1/15/98

TEM From 14x8 Red to tee

DWG. REF. 2-RH-18

FLUID TEMP.(F) 130 PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 7

①FLUID FLOW (GPM) 5050 ②PIPE I.D. (IN) 8" G-14 7.981 PIPE EL. 613-0 TO EL. 613-0

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	9 ΣK	10 ΣL/D
3'-0'	GATE VALVE		13		
	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW		20		
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH		60		
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	• SUDDEN INCREASE †		$(1-\beta^2)^2$		
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_V^2$		
	MISC				
TOTALS ③ 3				④ 0	⑤ 0

• ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER

$\beta = d/D$ RF = RECOVERY FACTOR

FK-9-1-72

PIPE FRICTION CALCULATION
DATA SHEET

SHEET ~~44~~ 51 OF ~~57~~ 66
PLANT COOK ~~4/97~~
BY AF DATE ~~12/2/97~~
EASM 970128 AF
Rev 2 ~~12/11/97~~
1/15/98

EM FROM TEE TO TEE SPLIT

DWG. REF. 2-RH-18 2-RH-22 2-SI-1020F2

FLUID TEMP. (F) 150 PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 8

①FLUID FLOW (GPM) 2400 ②PIPE I.D. (IN) 8DG-14 7.981 PIPE EL. 613-0 TO EL. 589-2½

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	10 ΣK	11 ΣL/D
3'-9"	GATE VALVE IMO-350		13		13
5'-2"	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
2'-9"	SWING CHECK		135		
9'-6"	90° STD. ELBOW		30		
15'-9"	90° S.R. ELBOW		50		
7'-0"	90° L.R. ELBOW	8	20		160
3'-0"	45° STD. ELBOW	4	16		64
	45° S.R. ELBOW		25		
5'-7"	180° CLOSE RETURN		50		
3.32'	STD. TEE RUN		20		
7'-½"	STD. TEE BRANCH	1	60		60
5'-10"	* MITRE BENDS		1.2(1-COS θ)		
	* LATERAL ◁ OUTLET		1.0		
	* LATERAL ◁ INLET		0.5		
	* STRAIGHT RUN LATERAL		0.15		
	* PIPE ENTR PROJ. INWD.		0.78		
	* " " SHARP EDGE		0.50		
	* " " WELL ROUND		0.04		
	* PIPE EXIT SHARP EDGED		1.0		
	* ORIFICE (C_D = .61)		2.69 RF/β^4		
	* SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	* SUDDEN INCREASE †		$(1-\beta^2)^2$		
	* VALVE, MISCELLANEOUS		891.4 d^4/C_V^2		
✓	MISC				
TOTALS ① 68.695				③	⑤ 297

* ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER
$\beta = d/D$ RF = RECOVERY FACTOR

PIPE FRICTION CALCULATION
DATA SHEET

SHEET ~~48~~ 52 OF ~~57~~ ~~62~~ 66
PLANT Conn ~~6/4/97~~
BY DF DATE ~~4/28/97~~
GHS-970128AF
Rev 2 ~~12/4/97~~ 1/15/98

SYSTEM FROM Tee TO 6X4 Red ("S" SI PP)

DWG. REF. 2-SI-10 2OF2 + Sheet 1 of 2

FLUID TEMP.(F) 130 PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 9

①FLUID FLOW (GPM) 700 ②PIPE I.D. (IN) 6Ø B-14 6.357 PIPE EL. 589-2½ TO EL. 589-2½

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	11 ΣK	ΣL/D 12
2'-7"	GATE VALVE		13		
1'-0"	GLOBE VALVE		340		
18 7/8"	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW	1	20		20
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH	1	60		60
	• MITRE BENDS		1.2(1-COS θ)		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		2.69 RF/β^4		
	• SUDDEN CONTRACTION † 6 x 8		.5(1-β^2)	.219	
	• SUDDEN INCREASE †		(1-β^2)^2		
	• VALVE, MISCELLANEOUS		891.4 d^4/C_V^2		
	MISC				
TOTALS ③ 5.156				④ .219	⑤ 80

• ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER

β = d/D RF = RECOVERY FACTOR

FK-9-1-72

PIPE FRICTION CALCULATION
DATA SHEET

SHEET ~~49~~ 53 OF ~~57~~ ~~62~~ 66
PLANT Cook ~~[illegible]~~
BY AR DATE ~~[illegible]~~
GFSN-470128AR
Rev 2 ~~12/4/97~~ 1/5/98

SYSTEM From 6x4 Red to "S" SI PP Suction

DWG. REF. 2-SI-10 20F2

FLUID TEMP.(F) 130. PIPE ABS. ROUGHNESS(FT) ____ PIPE SEGMENT NUMBER 10

①FLUID FLOW (GPM) 700 ①PIPE I.D. (IN) 40 8-14 4.26 PIPE EL. ~~589~~-2½ TO EL. ~~589~~-2½

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	12 ΣK	13 ΣL/D
1-2	GATE VALVE		13		
	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW		20		
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH		60		
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION † 6×4		$.5(1-\beta^2)$	.278	
	• SUDDEN INCREASE †		$(1-\beta^2)^2$		
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_V^2$		
	MISC				
TOTALS ① 1.167				④ .278	⑤

• ITEMS ARE "K" VALUES ONLY
$\beta = d/D$ RF = RECOVERY FACTOR

† BASED ON SMALLER PIPE DIAMETER

FK-9-1-72

REV. 4/73

PIPE FRICTION CALCULATION

DATA SHEET

SHEET ~~30~~ 54 OF ~~57~~ 66
PLANT COOK ~~6/4/97~~
BY AR DATE ~~11/20/97~~
ENSW470178AF
Rev 2 ~~11/20/97~~ 11/5/98

SYSTEM FROM TEE TO 8X6 INC (to North Pp)

DWG. REF. 2-SI-10 (1 of 2)

FLUID TEMP. (F) 130. PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 11

①FLUID FLOW (GPM) 1700 ①PIPE I.D. (IN) 6P B-14 6.357 PIPE EL. 589-2½ TO EL. 589-2½

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	11 ΣK	ΣL/D 14
12" 1'-10 5/8"	GATE VALVE 156 80 653	1	13		13
	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW		20		
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH	1	60		60
	• MITRE BENDS		1.2(1-COS θ)		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		2.69 RF/β^4		
	• SUDDEN CONTRACTION † 6X8,		$.5(1-\beta^2)$	.219	
	• SUDDEN INCREASE †		$(1-\beta^2)^2$		
	• VALVE, MISCELLANEOUS		891.4 d^4/C_V^2		
	MISC				
TOTALS ① 13.885				④ .219	⑤ 73

• ITEMS ARE "K" VALUES ONLY
$\beta = d/D$ RF = RECOVERY FACTOR

† BASED ON SMALLER PIPE DIAMETER

FK-9-1-72

REV. 4/73

PIPE FRICTION CALCULATION
DATA SHEET

SHEET ~~54~~ 55 OF ~~57~~ ~~62~~ 66
PLANT Cook ~~6/11/97~~
BY AF DATE ~~12/11/97~~
GN SR 970128AF
Rev 2 ~~12/11/97~~ 1/15/98

EM FROM ~~8X6~~ INL TO (8x6) Tee (2-SI-6)

DWG. REF. 2-SI-10 (1 of 2)

FLUID TEMP. (F) 130. PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 11a

①FLUID FLOW (GPM) 1700 ①PIPE I.D. (IN) ~~8Ø~~ ~~8.14~~ 8.329 PIPE EL. 5892½ TO EL. 589-2½
14 15

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	ΣK	ΣL/D
21 1/8"	GATE VALVE		13		
	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW	1	20		20
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH		60		
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	• SUDDEN INCREASE † 8x6		$(1-\beta^2)^2$	.191	
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_V^2$		
	MISC				
TOTALS ① 1.76				① .191	① 20

• ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER
$\beta = d/D$ RF = RECOVERY FACTOR

FK-9-1-72

PIPE FRICTION CALCULATION

DATA SHEET

SHEET ~~58~~ 56 OF 57 68
PLANT Ceos K ~~6/10/97~~
BY AC DATE 1/28/97
ENSM 9701 28PF
Rev 2 ~~12/10/97~~ 1/6/98

EM FROM 8X6 (RWST Supply) TO Tee (CCP XTIE Supply)

DWG. REF. Z-SI-10 (1of2)

FLUID TEMP.(F) 130. PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 12

①FLUID FLOW (GPM) 1700 ①PIPE I.D. (IN) 6Φ B.14 6.357 PIPE EL. 589-2½ 15 TO EL. 589-2½ 16

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	ΣK	ΣL/D
12'-8 7/8"	GATE VALVE 15-G806SJ		13		13
3'-7 3/8"	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
2'-3 1/2"	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		20
	90° L.R. ELBOW	1	20		
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		20
	STD. TEE RUN	1	20		
	STD. TEE BRANCH		60		
	• MITRE BENDS		1.2(1-COSθ)		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		2.69 RF/β^4		
	• SUDDEN CONTRACTION † 8x6		.5(1-β^2)	.219	
	• SUDDEN INCREASE †		(1-β^2)^2		
	• VALVE, MISCELLANEOUS		891.4 d^4/C_V^2		
	MISC				
TOTALS ① 18.313				④ .219	⑤ 53

• ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER
β = d/D RF = RECOVERY FACTOR

FK-9-1-72

PIPE FRICTION CALCULATION

DATA SHEET

SHEET ~~59~~ 57 OF ~~57~~ 66
PLANT Cook ~~6/4/97~~
BY AR DATE ~~12/4/97~~
GLJW4701 2 8AF
Rev I ~~12/4/97~~ 1/15/97

SYSTEM FROM Tee TO 4×6 red to N SI

DWG. REF. 2-SI-10 (1 of 2)

FLUID TEMP.(F) 130 . PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 13

①FLUID FLOW (GPM) 700 ①PIPE I.D. (IN) 6∅ B-14 6.357 PIPE EL. 589-2½ ~~14~~ 16 TO EL. 589-2½ ~~15~~ 17

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	ΣK	ΣL/D
	GATE VALVE		13		
23 5/8"	GLOBE VALVE		340		
12"	BUTTERFLY VALVE		40		
18 7/8"	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW		20		
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN	1	20		20
	STD. TEE BRANCH		60		
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	• SUDDEN INCREASE †		$(1-\beta^2)^2$		
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_V^2$		
	MISC				
TOTALS ① 4.542'				④ .0	⑤ 20

• ITEMS ARE "K" VALUES ONLY
$\beta = d/D$ RF = RECOVERY FACTOR

† BASED ON SMALLER PIPE DIAMETER

FK-9-1-72

PIPE FRICTION CALCULATION
DATA SHEET

SHEET ~~48~~ 58 OF ~~57~~ 68
PLANT Cook ~~6/4/97~~
BY AF DATE ~~7/28/97~~
EHSWG970178AF
Rev 2 ~~12/4/97~~ 1/15/98

SYSTEM FROM 4X6 Red TO "N" SI PP SUCTION

DWG. REF. 2-SI-10

FLUID TEMP.(F) 130. PIPE ABS. ROUGHNESS (FT) ____ PIPE SEGMENT NUMBER 14

①FLUID FLOW (GPM) 700 ①PIPE I.D. (IN) 4Φ B-14 4.26 PIPE EL. 589-2½ ~~15~~ 17 TO EL. 589-2½ ~~15~~ 18

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	ΣK	ΣL/D
1'-2"	GATE VALVE		13		
	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW		20		
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH		60		
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION †	6x4	$.5(1-\beta^2)$	.274	
	• SUDDEN INCREASE †		$(1-\beta^2)^2$		
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_V^2$		
	MISC				
TOTALS ① 1.167				④ .278	⑤

• ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER
$\beta = d/D$ RF = RECOVERY FACTOR

FK-9-1-72

PIPE FRICTION CALCULATION
DATA SHEET

SHEET ~~49~~ 58 OF ~~59~~ 66
PLANT COOK ~~6/4/97~~
BY AE DATE ~~1/28/97~~
Rev." EHJ-970128PF ~~12/4/97~~ 1/11/98

SYSTEM FROM Tee thro CCP xtie Sply TO Tee (IMO-361,-362)

DWG. REF. 2-SI-10, 2-SI-44

FLUID TEMP. (F) 130. PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 15

①FLUID FLOW (GPM) 1000 ①PIPE I.D. (IN) 4Φ B-14 4.26 PIPE EL. 589-2½ ~~14~~ 16 TO EL. 589-1½ ~~17~~ 19

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	ΣK	ΣL/D
1'-0"	GATE VALVE		13		
6'-11¾"	GLOBE VALVE		340		
6.6'	BUTTERFLY VALVE		40		
7"	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW	III	20		60
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH	I	60		60
	• MITRE BENDS		1.2(1-COS θ)		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		2.69 RF/β^4		
	• SUDDEN CONTRACTION † 6x4		.5(1-β^2)	.278	
	• SUDDEN INCREASE †		(1-β^2)^2		
	• VALVE, MISCELLANEOUS		891.4 d^4/C_V^2		
	MISC				
TOTALS ① 15.163'				④ .278	⑤ 120

• ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER
β = d/D RF = RECOVERY FACTOR

FK-9-1-72

REV. 4/73

PIPE FRICTION CALCULATION
DATA SHEET

SHEET ~~56~~ 60 OF ~~57~~ 66
PLANT Cook ~~4/4/97~~
BY AF DATE 1/23/01
GrJM 970128AF
Rev 2 ~~12-4-98~~ 1/10/98

S[illegible]M FROM FCC TO FCC THRU IMO-362

DWG. REF. 2-SI-44

FLUID TEMP.(F) 130. PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 16

①FLUID FLOW (GPM) 1000 ②PIPE I.D. (IN) 40 B-14 4.26 PIPE EL. 589-1½ ~~17~~ 19 TO EL. 589-1½ ~~17~~ 20

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	ΣK	ΣL/D
1'-6"	GATE VALVE IMO-362		13		13
	GLOBE VALVE		340		
6"	BUTTERFLY VALVE		40		
12"	SWING CHECK		135		
6"	90° STD. ELBOW		30		
1'-6"	90° S.R. ELBOW		50		
	90° L.R. ELBOW	11	20		60
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH	11	60		120
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	• SUDDEN INCREASE †		$(1-\beta^2)^2$		
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_V^2$		
	MISC				
TOTALS ① 5				③	⑤ 193

• ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER
$\beta = d/D$ RF = RECOVERY FACTOR

FK-9-1-72

REV. 4/73

PIPE FRICTION CALCULATION
DATA SHEET

SHEET ~~57~~ 61 OF ~~57~~ 66
PLANT Cook ~~6/4/87~~
BY AF DATE ~~4/27/87~~
ENS MG 70178AF
rev 2 ~~12/11/87~~ 1/4/88

M FROM IMO-361,-362 TO 8th TOC

DWG. REF. 2-SI-44, 2-RH-23

FLUID TEMP.(F) 130. PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 17

①FLUID FLOW (GPM) 1000 ②PIPE I.D. (IN) 4@ B-14 4.26 PIPE EL. 589-1½ ~~18~~ 20 TO EL. 600-0 ~~19~~ 21

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	ΣK	ΣL/D
11"	GATE VALVE IMO 360		13		13
3'-6"	GLOBE VALVE		340		
4-2½	BUTTERFLY VALVE		40		
5'-3"	SWING CHECK		135		
5'-0"	90° STD. ELBOW		30		
7'-10"	90° S.R. ELBOW		50		
5'-8"	90° L.R. ELBOW	8	20		160
2'-3"	45° STD. ELBOW		16		
3'-0"	45° S.R. ELBOW		26		
8'-6"	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH		60		
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	• SUDDEN INCREASE †		$(1-\beta^2)^2$		
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_V^2$		
	MISC				
TOTALS ① 46.125				④	⑤ 173

• ITEMS ARE "K" VALUES ONLY
$\beta = d/D$ RF = RECOVERY FACTOR

† BASED ON SMALLER PIPE DIAMETER

FK-9-1-72

PIPE FRICTION CALCULATION
DATA SHEET

SHEET ~~58~~ 62 OF ~~57~~ 66
PLANT Cook ~~[illegible]~~
BY AF DATE ~~[illegible]~~
GTSMA7 01 28DF
Rev 2 ~~12/1/87~~ 1/15/88

SYSTEM FROM Tee TO Tee (to Chg Pps)

DWG. REF: Z-RH-23, Z-CS-79

FLUID TEMP. (F) 130 PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 18

① FLUID FLOW (GPM) 1000 ② PIPE I.D. (IN) 6Φ B-14 S.329 PIPE EL. 600-6 ~~19~~ 21 TO EL. 596-4 5/16 ~~20~~ 22

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	ΣK	ΣL/D
3'-2"	GATE VALVE		13		
13'-6"	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW	1	20		20
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH	1	60 ✓		60
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	• SUDDEN INCREASE †		$(1-\beta^2)^2$		
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_V^2$		
	MISC				
TOTALS ③ 17.167				④	⑤ 80

• ITEMS ARE "K" VALUES ONLY
$\beta = d/D$ RF = RECOVERY FACTOR

† BASED ON SMALLER PIPE DIAMETER

FK-9-1-72

PIPE FRICTION CALCULATION

DATA SHEET

SHEET ~~59~~ 63 OF ~~57~~ 66
PLANT Coux 6/4/57
BY AC DATE 1/20/57
EN MG7012 8AP
Rev 2 1/15/57

SYSTEM FROM TEE TO TEE (SUPPLY TO "W" CEP)

DWG. REF. 2-RH-23, 2-ES-79 1 of 2

FLUID TEMP. (F) 130 PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 17

①FLUID FLOW (GPM) 500 ②PIPE I.D. (IN) 6ϕ 3-14 6.357 PIPE EL. ~~596-4 5/16~~ ~~20~~ 22 TO EL. 597-5/16 ~~21~~ 23

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	ΣK	ΣL/D
10'-6"	GATE VALVE		13		
	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW	1	20		20
	45° STD. ELBOW	1	16		16
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH	1	60		60
	• MITRE BENDS		$1.2(1-\cos\theta)$		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	• SUDDEN CONTRACTION † 6×8		$.5(1-\beta^2)$	.219	
	• SUDDEN INCREASE †		$(1-\beta^2)^2$		
	• VALVE, MISCELLANEOUS		$891.4\ d^4/C_v^2$		
	MISC				
TOTALS ① 10.5				④ .219	⑤ 96

• ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER
$\beta = d/D$ RF = RECOVERY FACTOR

FK-9-1-72

PIPE FRICTION CALCULATION

DATA SHEET

SHEET ~~54~~ 64 OF ~~57~~ 66
PLANT COOK [illegible]
BY DC DATE ~~[illegible]~~
GTSW-G701 28DR
Rev 2 #2 ~~12/11/69~~ 1/13/84

EM FROM TEE TO SUCTION 'W' CCP

DWG. REF. 2 CS-79.1 #2 +2CS-81

FLUID TEMP.(F) 130. PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 20

①FLUID FLOW (GPM) 500 ①PIPE I.D. (IN) 6Ø B-14 6.357 PIPE EL. 597-9/16 TO EL. 592-6

~~21~~ 23 ~~22~~ 24

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	•K OR L/D	ΣK	ΣL/D
3'-5"	GATE VALVE 1569B06SS		13		13
4.5'	GLOBE VALVE		340		
1'-5/8"	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW	1	20		20
	45° STD. ELBOW		16		
	45° S.R. ELBOW		25		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH	1	60		60
	• MITRE BENDS		1.2(1-COSθ)		
	• LATERAL ◁ OUTLET		1.0		
	• LATERAL ◁ INLET		0.5		
	• STRAIGHT RUN LATERAL		0.15		
	• PIPE ENTR PROJ. INWD.		0.78		
	• " " SHARP EDGE		0.50		
	• " " WELL ROUND		0.04		
	• PIPE EXIT SHARP EDGED		1.0		
	• ORIFICE (C_D = .61)		2.69 RF/β^4		
	• SUDDEN CONTRACTION †		.5(1-β^2)		
	• SUDDEN INCREASE †		(1-β^2)^2		
	• VALVE, MISCELLANEOUS		891.4 d^4/C_V^2		
	MISC				
TOTALS ① 8.969 ✓				④	⑤ 93

* ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER

$\beta = d/D$ RF = RECOVERY FACTOR

FK-9-1-72

PIPE FRICTION CALCULATION

DATA SHEET

SHEET ~~58~~ 65 OF ~~57~~ 66
PLANT Cook ~~[illegible]~~
BY AF DATE ~~[illegible]~~
GNSW-87012BDC

SYSTEM From tee to tee (Supply to ECCP) Rev 2 ~~12/1/87~~ 1/15/88

DWG. REF. 2-CS-79 1 OF 2

FLUID TEMP. (F) 130 PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 21

①FLUID FLOW (GPM) 500 ②PIPE I.D. (IN) 6Φ B-14 8.329 PIPE EL. ~~20~~ 22 596-45/16 TO EL. ~~22~~ 23 596-45/16

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	ΣK	ΣL/D
15'-11½"	GATE VALVE		13		
	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW		20		
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH	1	60		60
	* MITRE BENDS		$1.2(1-\cos\theta)$		
	* LATERAL ◁ OUTLET		1.0		
	* LATERAL ◁ INLET		0.5		
	* STRAIGHT RUN LATERAL		0.15		
	* PIPE ENTR PROJ. INWD.		0.78		
	* " " SHARP EDGE		0.50		
	* " " WELL ROUND		0.04		
	* PIPE EXIT SHARP EDGED		1.0		
	* ORIFICE (C_D = .61)		$2.69\ RF/\beta^4$		
	* SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	* SUDDEN INCREASE †		$(1-\beta^2)^2$		
	* VALVE, MISCELLANEOUS		$891.4\ d^4/C_V^2$		
	MISC				
TOTALS ① 15.958				④	⑤ 60

* ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER

$\beta = d/D$ RF = RECOVERY FACTOR

FK-9-1-72

REV. 4/73

PIPE FRICTION CALCULATION
DATA SHEET

SHEET ~~56~~ 62 OF ~~57~~ 62
PLANT CCNX ~~6/4/87~~
BY AR DATE ~~1/20/97~~
EMSNG9701 28 AF
Rev 2 ~~12/11/97~~
1/15/98

ITEM FROM TEE TO 'E' CCP SUCTION

DWG. REF. 2-CS-79, 2-CS-80

FLUID TEMP.(F) 130 PIPE ABS. ROUGHNESS (FT) ______ PIPE SEGMENT NUMBER 22

①FLUID FLOW (GPM) 500 ①PIPE I.D. (IN) 6Φ B-14 6.357 PIPE EL. ~~596-4 5/16~~ TO EL. 592-6

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	~~23~~ 25 ΣK	~~24~~ 26 ΣL/D
.66'	GATE VALVE 1568		13		13
5'-10 13/16"	GLOBE VALVE		340		
3'-5"	BUTTERFLY VALVE		40		
4.5'	SWING CHECK		135		
1'-5/8"	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW	1	20		20
	45° STD. ELBOW		16		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		20		
	STD. TEE BRANCH	1	60		60
	* MITRE BENDS		1.2(1-COSθ)		
	* LATERAL ◁ OUTLET		1.0		
	* LATERAL ◁ INLET		0.5		
	* STRAIGHT RUN LATERAL		0.15		
	* PIPE ENTR PROJ. INWD.		0.78		
	* " " SHARP EDGE		0.50		
	* " " WELL ROUND		0.04		
	* PIPE EXIT SHARP EDGED		1.0		
	* ORIFICE (C_D = .61)		2.69 RF/β^4		
	* SUDDEN CONTRACTION † 6×8		.5(1-β^2)	.219	
	* SUDDEN INCREASE †		(1-β^2)^2		
	* VALVE, MISCELLANEOUS		891.4 d^4/C_V^2		
	MISC				
TOTALS ① 15.73				④ .219	⑤ 93

* ITEMS ARE "K" VALUES ONLY † BASED ON SMALLER PIPE DIAMETER
β = d/D RF = RECOVERY FACTOR

FK-9-1-72

Attachment to Calculation ENSM971028AF

Purpose: Calculation ENSM970128AF determined the available ECCS pumps NPSH. This attachment will review the impact of an RHR pump degraded by 10% from the baseline head-capacity curve. This attachment is performed under the same basis/assumptions that the calculation is performed.

Conclusion: An RHR pump degraded by 10% from the baseline head-capacity curve will still assure adequate NPSH is available to the SI and CC pumps. The NPSH is tabulated as follows:

Pump	Flow (gpm)	$NPSH_A$ (ft abs.)	$NPSH_R$ (ft abs.)
"S" SI	500	124	12
"N" SI	500	114	12
"W" CC	400	47	11
"E" CC	400	48	11
RHR	4400	30	18
CTS	3200	32	9

Method: Plotted on the attached RHR head-capacity curve (N-315) is the system-head curve for the calculation. The intersection is the operating point for the conditions stipulated (4600 gpm) in the calculation. A head-capacity curve for an RHR pump degraded by 10% from the baseline is determined by taking 10% of the head value (370 ft) at 3000 gpm (design flow). This value is then subtracted from each of the head values at each of the flow points to generate the degraded head-capacity curve.

The intersection of the degraded head-capacity curve with the system-head curve represents the new operating point for the RHR pump. The head and flow is 275 ft 4400 gpm. A percent flow reduction can be obtained as follows:

$$\% \text{ Flow}_{\text{Reduction}} = [(4600-4400)/4600] * 100 = 4.35\%$$

This % flow reduction will be applied to the SI and CC pump flows assumed in the calculation. .

AF 6/4/97

Sheet 1 of 9

Attachment to Calculation ENSM971028AF

Calculation: CC pump flow based on % reduction

420 gpm - 420* .0435 = 401.73 gpm use 400 gpm

SI pump flow based on % reduction

525 gpm - 525*.0435 = 502.16 gpm use 500 gpm

Based on these flows the corresponding pipe segment flows are indicated below:

Segment	Flow
1-2,2-3	7,600
3-4 through 9-10	4,400
10-11	1,800
11-12,12-13	500
11-14 through 15-16	1,300
16-17,17-18	500
16-19 through 21-22	800
22-23,23-24	400
22-25,25-26	400

Determine the RHR pump's suction pressure:

Pressure at P2

$$\frac{8000-7600}{8000-7000} = \frac{11.5-v}{11.5-10.0}$$

$$v2 = 11.5 - 1.5(400/1000) = 10.9 \text{ ft/sec}$$

$$h_{1-2} = 4.06(7600/7800)^2 = 3.85 \text{ ft}$$

$$P2 = \frac{60.32}{144}\{(602.83 - 589.33) + \frac{144(14.7)}{60.32} + \frac{(10.9)^2}{64.4} - \frac{10.9)^2}{64.4} - 3.85\}$$

$$= 18.74 \text{ psia}$$

Pressure at P3

$$\frac{4500-4400}{4500-4000} = \frac{10.67-v}{10.67-9.49}$$

$$v3 = 10.67 - 1.18(100/500) = 10.43 \text{ ft/sec}$$

AE 6/4/97

Sheet 2 of 9

Attachment to Calculation ENSM971028AF

$h_{2\text{-}3} = 2.62(7600/7800)^2 = 2.49$ ft

$$P3 = \frac{60.32}{144}\{(589.33 - 586.43) + \frac{144(18.74)}{60.32} + \frac{(10.9)^2}{64.4} - \frac{10.43)^2}{64.4} - 2.49\}$$

$= 18.91$ psia

Pressure at P4

$h_{3\text{-}4} = 4\ (4400/4600)^2 = 3.66$ ft

$$P4 = \frac{60.32}{144}\{(586.43 - 575.17) + \frac{144(18.91)}{60.32} + \frac{(10.43^2}{64.4} - \frac{10.43^2}{64.4}) - 3.66\}$$

$= 22.09$ psia

Pressure at P5 - RHR Suction Pressure

$h_{4\text{-}5} = .079(4400/4600)^2 = .072$ ft

$$P5 = \frac{60.32}{144}\{(575.17 - 575.08) + \frac{144(22.09)}{60.32} + \frac{(10.43)^2}{64.4} - \frac{10.43)^2}{64.4} - .072\}$$

$= 22.1$ psia

<u>NPSH Available South Safety Injection Pump</u>

h_{fs} = the sum of segments $h_{6\text{-}7} + h_{7\text{-}8} + h_{8\text{-}9} + h_{9\text{-}10} + h_{10\text{-}11} + h_{11\text{-}12} + h_{12\text{-}13}$

$h_{6\text{-}7} = 62.41(4400/4600)^2 = 57.1$ ft

$h_{7\text{-}8} = 18.87(4400/4600)^2 = 17.26$ ft

$h_{8\text{-}9} = 88.29(4400/4600)^2 = 80.78$ ft

$h_{9\text{-}10} = .91(4400/4600)^2 = .83$ ft

$h_{10\text{-}11} = 10.3(1800/1890)^2 = 9.34$ ft

$h_{11\text{-}12} = .82(500/525)^2 = .74$ ft

$h_{12\text{-}13} = .93(500/525)^2 = .84$ ft

$h_{fs} = 166.89$ ft

Sheet 3 of 9

AC
6/4/97

Attachment to Calculation ENSM971028AF

h_a = RHR PP suction pressure + RHR PP TH

= (22.1 * 2.386) + 275 (from degraded pp curve at 4400 gpm)

= 327.73 ft

$h_{vpa} = 9.34 * 2.386 = 22.29$ ft

$h_{st} = 575 - 589.21 = -14.21$ ft

NPSH available = $h_a - h_{vpa} + h_{st} - h_{fs}$

$= 327.73 - 22.29 + (-14.21) - 166.89$

= 124.34 ft abs @ 500 gpm

NPSH required is 12 ft abs at 500 gpm from curve 39890A

Available NPSH exceeds required NPSH by 112.34 ft abs

<u>NPSH Available North Safety Injection Pump</u>

h_{fs} = the sum of segments $h_{6\text{-}7} + h_{7\text{-}8} \div h_{8\text{-}9} + h_{9\text{-}10} + h_{10\text{-}11} + h_{11\text{-}14} \div h_{14\text{-}15} + h_{15\text{-}16} + h_{16\text{-}17} + h_{17\text{-}18}$

$h_{6\text{-}7} = 62.41(4400/4600)^2 = 57.1$ ft

$h_{7\text{-}8} = 18.87(4400/4600)^2 = 17.26$ ft

$h_{8\text{-}9} = 88.29(4400/4600)^2 = 80.78$ ft

$h_{9\text{-}10} = .91(4400/4600)^2 = .83$ ft

$h_{10\text{-}11} = 10.3(1800/1890)^2 = 9.34$ ft

$h_{11\text{-}14} = 5.74(1300/1365)^2 = 5.21$ ft

$h_{14\text{-}15} = .314(1300/1365)^2 = .28$ ft

$h_{15\text{-}16} = 5.02(1300/1365)^2 = 4.55$ ft

$h_{16\text{-}17} = .245(500/525)^2 = .22$ ft

$h_{17\text{-}18} = .93(500/525)^2 = .84$ ft

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AF
6/4/97

Attachment to Calculation ENSM971028AF

$h_{fs} = 176.41$ ft

h_a = RHR PP suction pressure + RHR PP TH

= $(22.1 * 2.386) + 275$ (from degraded pp curve at 4400 gpm)

= 327.73 ft

$h_{vpa} = 9.34 * 2.386 = 22.29$ ft

$h_{st} = 575 - 589.21 = -14.21$ ft

NPSH available = $h_a - h_{vpa} + h_{st} - h_{fs}$

$= 327.73 - 22.29 + (-14.21) - 176.41$

= 114.82 ft abs @ 500 gpm

NPSH required is 12 ft abs at 500 gpm from curve 39890A

Available NPSH exceeds required NPSH by 102.82 ft abs

<u>NPSH Available West Centrifugal Charging Pump</u>

h_{fs} = the sum of segments $h_{6\text{-}7} + h_{7\text{-}8} + h_{8\text{-}9} + h_{9\text{-}10} + h_{10\text{-}11} + h_{11\text{-}14} + h_{14\text{-}15} + h_{15\text{-}16} + h_{16\text{-}19} + h_{19\text{-}20} + h_{20\text{-}21} + h_{21\text{-}22} + h_{22\text{-}23} + h_{23\text{-}24}$

$h_{6\text{-}7} = 62.41(4400/4600)^2 = 57.1$ ft

$h_{7\text{-}8} = 18.87(4400/4600)^2 = 17.26$ ft

$h_{8\text{-}9} = 88.29(4400/4600)^2 = 80.78$ ft

$h_{9\text{-}10} = .91(4400/4600)^2 = .83$ ft

$h_{10\text{-}11} = 10.3(1800/1890)^2 = 9.34$ ft

$h_{11\text{-}14} = 5.74(1300/1365)^2 = 5.21$ ft

$h_{14\text{-}15} = .314(1300/1365)^2 = .28$ ft

$h_{15\text{-}16} = 5.02(1300/1365)^2 = 4.55$ ft

$h_{16\text{-}19} = 16.39(800/840)^2 = 14.87$ ft

$h_{19\text{-}20} = 20.71(800/840)^2 = 18.78$ ft

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of 9

AF
6/4/97

Attachment to Calculation ENSM971028AF

$h_{20\text{-}21} = 32.67(800/840)^2 = 29.63$ ft

$h_{21\text{-}22} = .67(800/840)^2 = .61$ ft

$h_{22\text{-}23} = .66(400/420)^2 = .59$ ft

$h_{23\text{-}24} = .526(400/420)^2 = .48$ ft

$h_{fs} = 240.31$ ft

h_a = RHR PP suction pressure + RHR PP TH

= (22.1 * 2.386) + 275 (from degraded pp curve at 4400 gpm)

= 327.73 ft

$h_{vpa} = 9.34 * 2.386 = 22.29$ ft

$h_{st} = 575 - 592.5 = -17.5$ ft

NPSH available = $h_a - h_{vpa} + h_{st} - h_{fs}$

= 327.73 - 22.29 + (-17.5) - 240.31

= 47.63 ft abs @ 400 gpm

NPSH required is 11 ft abs at 400 gpm from curve 34617-L

Available NPSH exceeds required NPSH by 36.63 ft abs

<u>NPSH Available East Centrifugal Charging Pump</u>

h_{fs} = the sum of segments $h_{6\text{-}7} + h_{7\text{-}8} + h_{8\text{-}9} + h_{9\text{-}10} + h_{10\text{-}11} + h_{11\text{-}14} + h_{14\text{-}15} + h_{15\text{-}16} + h_{16\text{-}19} + h_{19\text{-}20} + h_{20\text{-}21} + h_{21\text{-}22} + h_{22\text{-}25} + h_{25\text{-}26}$

$h_{6\text{-}7} = 62.41(4400/4600)^2 = 57.1$ ft

$h_{7\text{-}8} = 18.87(4400/4600)^2 = 17.26$ ft

$h_{8\text{-}9} = 88.29(4400/4600)^2 = 80.78$ ft

$h_{9\text{-}10} = .91(4400/4600)^2 = .83$ ft

$h_{10\text{-}11} = 10.3(1800/1890)^2 = 9.34$ ft

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of 9

AK
6/9/97

$h_{11\text{-}14} = 5.74(1300/1365)^2 = 5.21$ ft

$h_{14\text{-}15} = .314(1300/1365)^2 = .28$ ft

$h_{15\text{-}16} = 5.02(1300/1365)^2 = 4.55$ ft

$h_{16\text{-}19} = 16.39(800/840)^2 = 14.87$ ft

$h_{19\text{-}20} = 20.71(800/840)^2 = 18.78$ ft

$h_{20\text{-}21} = 32.67(800/840)^2 = 29.63$ ft

$h'_{21\text{-}22} = .67(800/840)^2 = .61$ ft

$h_{22\text{-}25} = .14(400/420)^2 = .13$ ft

$h_{25\text{-}26} = .61(400/420)^2 = .55$ ft

$h_{fs} = 239.92$ ft

h_a = RHR PP suction pressure + RHR PP TH

= (22.1 * 2.386) + 275 (from degraded pp curve at 4400 gpm)

= 327.73 ft

$h_{vpa} = 9.34 * 2.386 = 22.29$ ft

$h_{st} = 575 - 592.5 = -17.5$ ft

NPSH available = $h_a - h_{vpa} + h_{st} - h_{fs}$

= 327.73 - 22.29 + (-17.5) - 239.92

= 48.02 ft abs @ 400 gpm

NPSH required is 11 ft abs at 400 gpm from curve 34617-L

Available NPSH exceeds required NPSH by 37.02 ft abs

<u>NPSH Available Residual Heat Removal Pump</u>

h_{fs} = the sum of segments $h_{1\text{-}2} + h_{2\text{-}3} + h_{3\text{-}4} + h_{4\text{-}5}$

AF 6/4/97

Attachment to Calculation ENSM971028AF

$h_{1\text{-}2} = 4.06(7600/7800)^2 = 3.85$ ft

$h_{2\text{-}3} = 2.62(7600/7800)^2 = 2.49$ ft

$h_{3\text{-}4} = 4(4400/4600)^2 = 3.66$ ft

$h_{4\text{-}5} = .079(4400/4600)^2 = .072$ ft

$h_{fs} = 10.07$ ft

h_a = atmospheric pressure

= 14.7 * 2.386

= 35.075 ft

$h_{vpa} = 9.34 * 2.386 = 22.29$ ft

$h_{st} = 602.83 - 575 = 27.83$ ft

NPSH available = $h_a - h_{vpa} + h_{st} - h_{fs}$

= 35.075 - 22.29 + 27.83 - 10.07

= 30.55 ft abs @ 4400 gpm

NPSH required is 18 ft abs at 4400 gpm from curve N-315

Available NPSH exceeds required NPSH by 12.55 ft abs

<u>NPSH Available Containment Spray Pump</u>

h_{fs} = the sum of segments $h_{1\text{-}2}$ + h (from app Q , amendment 78)

$h_{fs} = 4.06(7600/7800)^2 + 4.45 = 8.3$ ft

h_a = atmospheric pressure

= 14.7 * 2.386

= 35.075 ft

$h_{vpa} = 9.34 * 2.386 = 22.29$ ft

$h_{st} = 602.83 - 575.29 = 27.54$ ft

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of 9

6/4/[illegible]

Attachment to Calculation ENSM971028AF

NPSH available = $h_a - h_{vpa} + h_{st} - h_{fs}$

= 35.075 - 22.29 + 27.54 - 8.3

= 32.03 ft abs @ 3200 gpm

NPSH required is 9 ft abs at 3200 gpm from curve T-32913-1

Available NPSH exceeds required NPSH by 23.03 ft abs

Sheet 9 of 9 AF 6/4/97

Indiana Michigan
Power Company
500 Circle Drive
Buchanan, MI 49107 1395

AEP
INDIANA
MICHIGAN
POWER

ENCLOSURE TO AEP:NRC:1260G7

The following presents the questions contained in your June 8, 1998, request for additional information (RAI), with our response following.

Request 1

"The October 9, 1997 petition from the Union of Concerned Scientists (UCS) raised concerns that the Nuclear Regulatory Commission (NRC) design inspection in August and September of 1997 identified significant operability issues in systems that have recently been evaluated and approved by the D.C. Cook design basis documentation reconstitution program. Following the inspection, the NRC issued a Confirmatory Action Letter (CAL) on September 19, 1997. The CAL references letters that you have docketed and that describe the long- and short-term action plans to be used at D.C. Cook to find and correct engineering problems in other safety-related systems. Please provide specific details of the programs that will be used to identify significant deficiencies in safety-related systems before restart of either D.C. Cook Unit 1 or Unit 2. Your response should include the following details:

a. systems to be reviewed and the logic for selection of the systems,
b. review methodology, including milestones,
c. system deficiencies,
d. corrective actions, and
e. whether each system is in full conformance with the licensing and design basis as described in the Updated Final Safety Analysis Report (UFSAR)."

Response 1

The AEP Nuclear Generation Group (AEPNG) has expanded the scope of our actions to identify and correct discrepancies in safety-related systems that were identified through the Nuclear Regulatory Commission (NRC) Architect Engineer (A/E) inspection and other internal inspections beyond that described in previous submittals. This expanded response is embodied in the Cook Nuclear Plant Restart Plan, which was formally initiated on March 7, 1998. The plan was discussed with NRC personnel at the SALP board meeting on April 3, 1998, and again at the pre-decisional enforcement conference on May 20, 1998, and was docketed under AEP:NRC:1303. The restart plan is similar to those recently used at several other plants.

The specific details of the programs that will be used to identify discrepancies in safety-related systems before restart of either Cook Nuclear Plant Unit 1 or Unit 2 are defined below in our combined response to requests 1.a and 1.b.

a. Systems to be reviewed and the logic for selection of the systems
b. Review methodology, including milestones

The Cook Nuclear Plant Restart Plan and other ongoing efforts are currently underway to provide reasonable assurance that significant discrepancies in the systems evaluated have been identified and are properly dispositioned prior to restart. These actions include:

- Restart plan system readiness reviews
- Review of non-risk significant maintenance rule systems
- Review of non-maintenance rule systems
- Containment spray safety system functional inspection (SSFI)
- Vertical slice inspections of containment and containment systems
- Additional SSFI-type inspection
- UFSAR revalidation project

These actions are discussed below in more detail.

Restart Plan System Readiness Reviews

- The maintenance rule, which provided a pre-existing classification for systems into risk significant categories, was used as the basis for selecting systems for these comprehensive reviews. Various probabilistic risk assessment results (e.g., core damage frequency, risk reduction worth, risk achievement worth, and Fussel-Vessely values) were re-examined to provide additional assurance that the maintenance rule system classification did not exclude important systems. The selected systems encompass risk significant maintenance rule systems at Cook Nuclear Plant, as well as systems classified as important non-risk significant standby maintenance rule systems, as follows:
    - 120 volt AC/CRID Inverters
    - Air Recirculation/Hydrogen Skimmer
    - Auxiliary Feedwater
    - 250 volt DC Station Batteries
    - Component Cooling Water
    - Containment
    - Containment Spray
    - Control Air
    - ECCS Accumulators
    - ECCS Charging/CVCS High Head Injection
    - ECCS Residual Heat Removal
    - ECCS Safety Injection
    - Electrical Safety Busses (4000 volt/600 volt)
    - Emergency Diesel Generators
    - Essential Service Water
    - Ice Condenser
    - Main Steam
    - Non-essential Service Water
    - Plant Air Compressors
    - Reactor Coolant System/RCS Pressure Relief
    - Reactor Protection System/Solid-state Protection/ESFAS

- These reviews are led by system engineers, with input from operations and maintenance personnel.

- Materiel condition and design basis conformance are reviewed to determine whether there exists reasonable assurance that the systems, following resolution of discrepancies identified during the reviews, will be capable of start-up and operation within their design bases.

- The materiel condition reviews include:

  1. system walkdowns by an interdisciplinary team;
  2. review of outstanding condition reports;
  3. review of corrective and preventive maintenance backlog for the affected system;
  4. review of maintenance rule system performance; and
  5. review of operability determinations in effect.

- The design basis conformance reviews include:

  1. review of UFSAR and technical specification design requirements;
  2. review of surveillance tests for the affected system;
  3. review of pre-operational testing;
  4. evaluation of design modifications approved, but not implemented;
  5. review of design modifications in service;
  6. review of temporary modifications currently in service; and
  7. review of industry operating experience.

- Composite results of the system readiness reviews will be examined to determine if horizontal expansion into programmatic areas is warranted.

- Qualifications of system engineers performing the system reviews were specifically evaluated by oral examination before a panel of industry and Cook Nuclear Plant engineering peers and managers.

- Initial review of all twenty-one systems is complete. Final presentations of system readiness to the system engineering review board (SERB) are in progress. Presentations to the restart oversight committee (ROC) are in progress.

Review of Non-Risk Significant Maintenance Rule systems

- The remaining non-risk significant maintenance rule systems will be reviewed under the plant engineering functional area review.

- The reviews of non-risk significant maintenance rule systems by system engineers will include:

  1. review of outstanding condition reports;

2. review of corrective and preventive maintenance backlog for the affected system;
3. review of maintenance rule system performance;
4. review of operability determinations currently in effect;
5. overview of design changes in service; and
6. review of temporary modifications in service.

- Identified discrepancies that meet the restart criteria will be addressed in accordance with the Cook Nuclear Plant restart plan.

- Additionally, non-risk significant maintenance rule systems that are reviewed will be evaluated to determine whether significant materiel condition problems or significant design basis non-conformances exist to warrant additional reviews.

- The reviews of non-risk significant maintenance rule systems will be initiated during July 1998 and will be completed prior to restart.

Review of Non-Maintenance Rule Systems

- Condition reports and maintenance backlogs for plant systems not covered under the maintenance rule will be used as indicators to determine if further functional reviews of individual systems are warranted. Generally, these systems are required for plant operation and are monitored in service.

Containment Spray Safety System Functional Inspection (SSFI)

- Based on issues identified during the A/E inspection, we determined that containment spray will be evaluated in more detail prior to restart.

- An independent contractor was used to conduct an SSFI-type inspection of containment spray. Issues identified during the inspection are currently being addressed.

Vertical Slice Inspection of Containment and Containment Systems

- Based on lessons learned during and following the A/E inspection, it was determined that the containment and accident response systems that it houses will be evaluated in more detail prior to restart.

- An independent contractor was used to conduct a vertical slice inspection of the containment and the containment systems. Issues identified during these inspections are currently being addressed.

Additional SSFI-Type Inspection

- A performance plan for an SSFI of one additional risk-significant system is currently under development and is scheduled to begin in August 1998.

UFSAR Revalidation Project

- This ongoing project involves a line-by-line review and revalidation of design bases as described in the UFSAR. Identified UFSAR discrepancies that meet the condition report threshold, including those of the twenty-one systems covered under the restart plan system readiness reviews, will be dispositioned in accordance with the restart plan. These UFSAR discrepancies will be dispositioned by correcting the non-conformance, performing a 10 CFR 50.59 evaluation, performing an operability evaluation in accordance with generic letter 91-18, revision 1, or requesting a license amendment.

- The UFSAR reviews are performed by an independent team of consultants under the direction of AEPNG.

- UFSAR reviews for twenty-one systems covered by the restart plan system readiness reviews will be completed prior to restart.

c. System deficiencies

As of July 27, 1998, approximately 3366 discrepancies have been identified in the system readiness reviews and vertical slice inspections. Of this number, approximately 69% are materiel condition issues and 15% are design basis issues. About 494 of these have been classified as restart items.

Open items generated during the system readiness reviews are classified according to System Engineer Review Board (SERB) criteria. The SERB criteria contains twenty-five categories related to materiel condition and design basis. The SERB criteria uses attachment C of the restart plan to establish the threshold for restart items. Each open item is categorized to the SERB criteria and is cross-referenced to the restart plan screening criteria. The application of the SERB criteria provides a systematic, uniform method to classify items identified during the system readiness reviews.

d. Corrective actions

Corrective actions will be taken prior to restart for items meeting the restart criteria. Other discrepancies will be addressed through normal corrective action and work control systems.

e. Whether each system is in full conformance with the licensing and design basis as described in the Updated Final Safety Analysis Report (UFSAR).

As described above, the various system review efforts are intended to identify discrepancies in safety-related systems, including non-conformances with the design basis as described in the UFSAR. As discussed above, identified UFSAR discrepancies that meet the condition report threshold, including those of the twenty-one systems covered under the restart plan system readiness reviews, will be dispositioned in accordance with the restart plan. These UFSAR discrepancies will be dispositioned by correcting the non-conformance, performing a 10 CFR 50.59 evaluation, performing an operability evaluation in accordance with generic letter 91-18, revision 1, or requesting a license amendment.

Request 2

"If a system will not be in conformance with its licensing and design bases, please provide the details of the deficiency, and a justification for the system's operability."

Response 2

The system review efforts currently underway are intended to identify discrepancies in safety-related systems, including non-conformances with the design basis as described in the UFSAR. Identified UFSAR discrepancies that meet the condition report threshold, including those of the twenty-one systems covered under the restart plan system readiness reviews, will be dispositioned in accordance with the restart plan. These UFSAR discrepancies will be dispositioned by correcting the non-conformance, performing a 10 CFR 50.59 evaluation, performing an operability evaluation in accordance with generic letter 91-18, revision 1, or requesting a license amendment.

Request 3

Describe the programmatic changes that will be implemented at D. C. Cook before restart and that in the long term will provide reasonable assurance that safety-related systems as described in the UFSAR will perform their intended safety function.

Response 3

Background

The December 2, 1997, response to the NRC Confirmatory Action Letter transmitted, as attachment 4, our short-term assessment program results. This assessment was performed to determine the extent of the previously identified CAL issues. Subsequent to this submittal, the NRC requested additional information on the programmatic implications of the issues raised in the A/E inspection.

In response to this request and to support resolution of issues associated with the CAL, AEPNG initiated a comprehensive assessment of the A/E inspection findings and their potential broader implications, and consolidated this information from a programmatic perspective. An integrated multi-discipline team, the A/E Inspection Programmatic Issues Team (AEPIT), reporting to senior management, was formed in January 1998 to carry out this comprehensive assessment. This assessment examined the program areas of design control, 10 CFR 50.59, corrective action, and relevant parts of other programs related to design control (developing and maintaining procedures, generic NRC operating experience (OE) information review, and quality assurance related

to A/E inspection issues). Nine programs were evaluated by the AEPIT to evaluate the nature and extent of programmatic issues affecting design and configuration control. Separate from the AEPIT initiative, an additional evaluation was performed on the surveillance program. The AEPIT recommendations, including those for the surveillance program, are being dispositioned in accordance with the Cook Nuclear Plant restart plan.

Programmatic Changes

The programmatic changes developed from the A/E Inspection findings and our subsequent evaluations are summarized below as complete, restart or post restart actions. Completed actions are listed to reflect the extent of changes made to date.

Design control is the process used by AEPNG to engineer and document changes to design basis information or physical features of plant structures, systems, and components. The design control process is intended to ensure that regulatory requirements are met and good engineering practices are followed when changing technical, quality, or functional requirements, or performance characteristics of the plant.

Design Change

This program encompasses the processes and procedures used by AEPNG to engineer and document changes to the design of the plant. The scope of this program includes engineering, design, installation, and testing of design changes. Based on the results of the assessment, AEPNG has taken or will take the following steps to address specific A/E inspection issues and areas requiring program improvements.

Completed actions:

- Selected system descriptions, design standards, and design guidelines were revised to incorporate design changes or corrective actions related to A/E inspection issues.
- Completed selected design changes to address A/E inspection issues such as the modification of the control air system.
- Developed a new procedure to enhance program controls for installation of insulation inside containment.
- Developed a new procedure to improve the design change determination process to provide added assurance that the design change process will not be bypassed.
- Revised procedures to establish design review teams for design changes, clarified the use of technical direction, and addressed the practices for abandoned plant equipment.

Restart Actions:

- Complete specific design changes in accordance with the restart plan such as upgrading ice condenser door shock absorbers.
- Revise design change procedure to strengthen ties to the design basis and licensing basis update processes.
- Conduct familiarization training on the use of specific design standards, procedures governing abandoned equipment, and the revised design change procedures.

Post Restart Actions:

- Complete implementation of the Engineering Improvement Program (EIP).
- Conduct self-assessments to monitor the effectiveness of procedural and process enhancements for design changes.

Preservation of the Design and Licensing Bases

Various processes are utilized to document and evaluate the plant design and licensing bases at Cook Nuclear Plant. AEPNG has initiated the following actions to address specific A/E inspection issues and areas requiring program improvements.

Completed Actions:

- Procedures and familiarization training have been implemented to clarify the definitions of 'change,' 'licensing basis,' and 'design basis'
- Established a design basis reconstitution project to integrate and improve the effectiveness of the UFSAR revalidation project, the design basis document reconstitution project, and the normal operating procedure upgrade project.

Restart Actions:

- Revise procedures to improve work processes for maintaining design and licensing basis documents.
- Complete UFSAR revalidation activities for the twenty-one systems covered by the restart plan.

Post Restart Actions:

- Complete the design basis reconstitution project.
- Change the calculation index database to improve access and retrievability of design basis information.

Calculations

See response to request 4c for a detailed discussion of our ongoing plan to address issues associated with the accuracy and quality of engineering calculations at Cook Nuclear Plant.

Instrument Uncertainty

This program captures the process used to provide assurance that instrument uncertainty is appropriately addressed in our calculations and to account for instrument uncertainties in our procedures. AEPNG is taking several steps to address and resolve instrument uncertainty issues, as described below:

Completed Actions:

- Additional guidance has been developed and incorporated in the plant-specific methodology manual.
- Level instruments similar to the refueling water storage tank (RWST) level instruments were reviewed to determine whether problems similar to those encountered with the RWST level instruments exist elsewhere in the plant.
- Procedural improvements to control the use of uncertainties in procedures, analyses, and tests.
- Actions have been taken to modify the design of the RWST level instrumentation to address the flow induced error effects identified in the A/E inspection.
- Operator procedures, used shiftly and daily to verify technical specification compliance, were revised to address instrument uncertainties.
- Engineering standards associated with the design of level measurement systems have been revised.

Restart Actions:

- Enhanced training for affected personnel and interfacing departments. This training will focus on critical parameters, process measurement uncertainties, and instrument uncertainty calculations.
- Required changes resulting from the programmatic review of calculations will be incorporated into the instrument and control (I&C) information system procedures, in accordance with the restart plan.

Post Restart Actions:

- New calculations are being generated to address instrument uncertainties that were not referenced in existing calculations.

- Conduct an assessment of the instrument uncertainty program effectiveness.
- Inputs for instrument uncertainties will be incorporated into the normal operating procedures upgrade program.
- Emergency operating procedures will be reviewed to identify and validate footnote values.

10 CFR 50.59 Implementation

The 10 CFR 50.59 program defines the process by which proposed changes to the plant or procedures, as described in the UFSAR, are reviewed to determine if they can be implemented without prior NRC approval. The process used to perform 10 CFR 50.59 screening and 10 CFR 50.59 evaluations was evaluated. A detailed discussion of the old 10 CFR 50.59 process is provided in our response to request 4b. Additionally, a review was performed to evaluate the controls used to provide assurance that the screening and evaluation processes are not bypassed. The following steps have been or will be taken to address specific A/E inspection issues and areas requiring program improvements.

Completed Actions:

- Procedures and familiarization training have been implemented to clarify the definitions of 'change,' 'licensing basis,' and 'design basis'.
- An industry expert was retained to review the program and procedures, recommend appropriate improvements, and provide training on the new 10 CFR 50.59 procedures.
- Training was conducted, by an industry expert, on new 10 CFR 50.59 procedures.
- Process implemented to communicate management expectations regarding change via the 10 CFR 50.59 process to appropriate personnel.

Restart Actions:

- Revise procedures to address potential 10 CFR 50.59 bypass mechanisms identified by our internal assessment.

Corrective Action Program

This program encompasses the process used to identify and address conditions adverse to quality. The review of this program focused on our capability to take timely corrective and preventive action when non-conformances are identified and to determine whether the program supports maintaining the plant design bases and licensing bases. The following actions have been or will be taken to resolve corrective action program issues:

Completed Actions:

- Established dedicated corrective action group to own the corrective action process, and monitor, motivate, and mentor line management implementation of the corrective action program.
- Ownership of the program has been defined and communicated within the organization.
- Enhanced procedural guidance to establish daily review of condition reports through a management review board to improve classification of observed conditions.
- Reduced the number of significance levels for condition reports to optimize root cause analysis efforts.
- Procedures revised to improve effectiveness, timeliness, and to clarify when 10 CFR 50.59 screenings are required.
- Effectiveness measures have been developed to monitor program performance.

Restart Actions:

- Reduce and maintain the backlog of overdue corrective action items within established standards.
- Clarify line management responsibility and accountability in the implementation of the corrective action program.
- Change the process to align the level of root cause analysis and corrective and preventive actions to be commensurate with event or condition significance.

Post Restart Actions:

- Implement improved condition reporting software to enhance condition trending and event analysis.
- Update corrective action procedures to address process and enhance reporting capability for tracking and trending.
- Conduct additional training on root cause analysis, apparent cause analysis, and error reduction technology.
- Participate in an industry project sponsored by the Electric Power Research Institute (EPRI) plant support engineering subcommittee to develop guidance to optimize engineering activities in support of corrective action programs.
- Conduct assessments of program effectiveness.

Other Related Program Areas

Developing and Maintaining Procedures

This program includes the processes utilized to incorporate design bases and licensing bases information into procedures, and to maintain the procedures current. The following actions have been or will be taken to resolve procedure-related issues.

Restart Actions:

- Update specific AEPNG corporate directive describing the current organization.
- Conduct additional self assessments to evaluate consistency of AEPNG procedural controls.
- Complete A/E inspection condition report actions identified as restart items related to updating specific operating procedures.
- The senior management review team determined that a complete document control and records management functional area assessment will be performed before restart.

Post Restart Actions:

- Complete normal operations procedure upgrade project, which was instituted in October 1997, to address quality and human performance related aspects of the procedures.
- AEPNG corporate and plant procedure processes will be integrated.

Generic NRC Operating Experience (OE) Information Review Program

This program is the process used by AEPNG to review generic NRC correspondence related to industry OE to identify potential impacts on the design and operation of Cook Nuclear Plant. The following actions have been or will be taken to address generic NRC OE related process issues:

Restart Actions:

- Procedure revisions to consolidate the review process for NRC and OE information.
- Evaluate the need for further sampling of past NRC communications for appropriate disposition.
- Conduct familiarization training on procedure revisions that consolidate the review process.

Quality Assurance (QA) Related to A/E Inspection Issues

A review was also conducted of various aspects of the QA program. AEPNG has initiated the following actions to address identified quality assurance issues:

Completed Actions:

- A self assessment, joint utility management audit (JUMA), and root cause analysis were completed to identify issues related to the planning and implementation of QA oversight initiatives.
- Performance assurance has prioritized significant programmatic issues associated with the QA program and escalated them to senior management for action and accountability (this is a continuing process).
- Senior line management has assigned ownership for resolution of these identified programmatic issues.

Restart Actions:

- Audit plans are being revised to specifically require performance assurance to challenge design inputs, such as assumptions, when calculations are assessed.
- The method for directing performance assurance resources is being changed to enhance the oversight of the design and condition of systems.
- Revise performance assurance system surveillance instructions to include passive components.
- Conduct training on the changes to audit plans and surveillance instructions.

Post Restart Actions:

- Develop additional procedural guidance to provide direction for follow-up on previously identified adverse conditions.
- Follow up assessments will be conducted to determine whether restart actions have effectively addressed identified QA issues.

Surveillance Program

The surveillance program was added to the list of programs to be evaluated as part of the restart plan. The following actions have been or will be taken to address surveillance program issues, such as those identified with the ice condensers.

Completed Actions:

- A team was formed to perform a root cause analysis of issues related to the surveillance program.

- Operations department superintendent was designated as the owner of the surveillance program.

Restart Actions:

- A group will be formed, responsible for managing, developing, scheduling, and tracking the completion of surveillances for the plant.
- Training and qualification of personnel performing surveillance testing activities is being evaluated to determine the extent of additional training required.
- Procedures are being revised to enhance consistency between the different work groups.
- Assessments are ongoing to evaluate conformance with regulatory requirements and surveillance program acceptance criteria.

Post Restart Actions:

- New scheduling tools are being evaluated to improve the efficiency of the surveillance scheduling process.

Programmatic Issues Summary

Utilizing a multi-disciplined approach, a comprehensive evaluation of programs, procedures, condition reports, and related processes was completed. As a result of these evaluations, corrective actions have been identified related to programmatic issues and will be addressed in accordance with the Cook Nuclear Plant restart plan. Further, provisions for measuring and monitoring future programmatic effectiveness, as described in the preceding sections, have been or will be developed.

Request 4

By letter dated January 12, 1998, the UCS submitted an addendum to the original 2.206 petition. The January 12, 1998 letter raised six new concerns. Please respond in full to the following five concerns from the January 12, 1998, letter:

a. Concern 1 as it pertains to D. C. Cook Plant. Also, include the detailed action plan for the ice melt, ice condenser inspection, and repair plan.

Response to 4a

The first concern pertained to the Cook Nuclear Plant ice condenser containment and stated,

"The NRC Inspector General's office was informed last summer about alleged problems in the configuration and testing of the ice condenser at Watts Bar. Problems with the bay doors and components of the ice baskets were specifically identified. The allegations also suggested that many of the problems were generic and therefore affected the other ice condenser plants, including D. C. Cook. Finally, it was alleged that the problems were known, but not properly reported by the D.C. Cook licensee, the McGuire licensee, and even Westinghouse:"

The problems discussed regarding the lower inlet doors involved uplift of the ice condenser floor slab at Sequoyah and McGuire nuclear plants due to water intrusion and subsequent freezing, which resulted in binding of the ice condenser lower inlet doors. The problems with the ice basket coupling screws involved the discovery of coupling screw heads and complete screws in the bottom of the Watts Bar ice condenser following thaw of the ice condenser in 1995. The damaged and intact screws at Watts Bar were attributed to improper torquing during initial installation, and possibly due to thermal cycling.

Cook Nuclear Plant personnel had been made aware of the problems with floor heaving and lower inlet door binding through the sharing of ice condenser operating experience among ice condenser plants. When this operating experience became available, Cook Nuclear Plant personnel made tours of each ice condenser at the first opportunity and no evidence of floor uplift was identified. Since that time, Cook Nuclear Plant has not experienced any uplift of the ice condenser floor slab and has not experienced binding of lower inlet doors due to floor uplift. The performance at Cook Nuclear Plant is attributed to an operating practice to perform aggressive floor defrosts to ensure thorough drying of the floor following evolutions where water may have come in contact with the floor.

Awareness of the experience at other plants has resulted in a heightened sensitivity to the potential to damage the floor due to water intrusion and re-freezing. For example, following the recent thaw of the unit 1 ice condenser, where water clearly came in contact with the floor, extensive measures are being taken that are intended to ensure the floor is sufficiently dry before the ice condenser is cooled below freezing temperatures.

Review of the ice basket coupling screw issue at Watts Bar indicated that the root cause was attributed to screws being over-torqued during initial installation, and also possibly due to thermal cycling of the screws. It was the recollection of Cook Nuclear Plant personnel that ice basket coupling screws or screw heads had been found in the ice condenser or ice melt system in past years, though not in the same numbers as Watts Bar. These screws were attributed to known damage to ice basket top rims, and known separated ice baskets.

Ice basket top rim damage and separated ice basket segments have occurred in the past during ice basket weighing surveillances. Ice baskets are weighed by lifting the basket from the top rim. If an ice basket is frozen in place and a high degree of lifting force is applied, it is possible to distort the top rim of the ice basket, or to separate two adjacent ice basket segments. If the distortion or separation is significant, sheet metal screws, which attach the top rim to the ice basket cylinder, or which attach adjacent ice basket segments, can be sheared. This condition was known to exist on a number of baskets in both units at Cook Nuclear Plant, and remedial actions were taken, such as replacing fasteners, and restraining ice baskets having separated segments to prevent basket ejection. The screws and screw heads observed in the bottom of the ice condenser and in the ice melt system vacuum filter were attributed to these types of basket damage. Subsequently, during early 1998, ice basket inspections were conducted on both units to further investigate the ice basket coupling screw issue. A number of missing screws were identified, and documented under LER 315/98-005. Inspection and repair of ice baskets is ongoing, along with metallurgical analysis of failed and intact screws.

In March of 1998 a decision was made to completely thaw both units' ice condensers to allow a thorough inspection and comprehensive repair and restoration activities. In parallel with inspection and repair activities, a review of the ice condenser surveillance and maintenance programs, procedures and practices is being undertaken.

This review is intended to ensure that these activities are adequate to provide reasonable assurance of ice condenser operability. Upon completion of inspection and repair activities, the ice condenser will be reloaded with ice, and ice condenser surveillances will be performed prior to plant startup. Unit 1 has been selected as the lead unit for ice condenser refurbishment activities and will have first priority for resources. Activity on unit 2 will proceed following unit 1 and will be worked as resources permit. Ice condenser refurbishment activities will be completed prior to entry into mode 4 (hot shutdown), when the ice condenser is required to be operable. The following paragraphs summarize the key facets of the ice condenser refurbishment project.

ICE CONDENSER THAW

Containment Preparations

Prior to beginning the thaw of each ice condenser, each unit's containment will be prepared to handle the water from the ice thaw, which is estimated to be approximately 350,000 gallons per unit. Containment preparations include primarily: removing the lower inlet door shock absorbers; inspecting and sealing the ice condenser floor slab; installing a temporary ice melt water collection and transfer system; and protecting lower inlet doors from melt-water.

Prior to the initiation of the ice condenser thaw, a floor defrost will be initiated to remove ice from and to dry the floor. The floor will then be inspected to ensure floor seals, which prevent water from entering the ice condenser floor slab, are in good condition. Floor seals will be repaired as necessary prior to the ice condenser thaw. Actions are being taken to ensure sufficient drying of the floor of the ice condenser prior to again cooling the ice condenser below freezing.

The normal ice condenser drains consist of a series of twenty-one, twelve inch drains spaced around the ice condenser floor. These drains lead to flapper valves that drain to the lower containment. To facilitate collection of melt water, each ice condenser drain will be fitted with a screen to collect any debris and an inflatable seal plug to prevent drainage of ice melt water to the lower containment. A series of temporary sump pumps and piping will be installed on several of the seal plugs to transfer melted ice from the ice condenser, through a containment penetration, to temporary storage tanks in the plant yard. Melt water will then be pumped, using a second set of temporary pumps and piping, from the temporary storage tanks to the chemical and volume control system (CVCS) monitor tanks for eventual discharge, via the circulating water system in accordance with applicable permits. The total melt-water removed from ice condenser will be measured, by monitoring tank level changes, to provide feedback on the quantity of ice in the ice condenser in the as-found condition. The ice melt-water collection and transfer system will be installed via temporary modifications. In order to expedite the melt process, a heat addition system was designed and installed.

INSPECTIONS, REPAIRS AND REFURBISHMENTS

Ice Baskets

Each ice condenser contains 1944, forty-eight feet tall, ice baskets that are approximately one foot in diameter and contain borated ice. During pre-melt ice basket inspections, several conditions were identified including damaged baskets, missing or damaged ice basket coupling screws and undocumented ice basket hardware configurations. These conditions were documented in LERs 315/98-008 and 315/98-032. Following melt-out of the ice bed, a combination of internal and external video inspections and visual inspections, including some basket removal, will be performed on the ice baskets to identify damage and to determine whether the configuration of the basket and associated hardware is in accordance with design. Bottom rims of ice baskets will be removed to facilitate inspection and repair of ice basket hold down bar welds. A definition of detrimental ice basket damage is being developed. The threshold of detrimental damage will be accepted via the design change process. Damaged ice baskets outside the definition of "detrimental damage", will be repaired or replaced. Any identified missing or damaged coupling screws will be replaced. The hardware configuration of each basket will be documented, and the configuration will be restored to an approved design configuration. Ice baskets will meet applicable foreign material exclusion requirements prior to refill.

Lower Inlet Doors

Each ice condenser is divided into twenty-four bays, each of which contain two lower inlet doors. The lower inlet doors separate the ice condenser from the lower containment and are designed to open under differential pressure, which would be experienced during a postulated accident, to admit blowdown into the ice condenser. The lower inlet doors will be protected from water during the melt-out process and then inspected in place. Hardware such as door skins, hinges and seals will be examined for signs of distress and addressed as required. Any repairs that involve restoring the doors to other than the currently approved design configuration will be authorized via a design change.

Lower Inlet Door Shock Absorbers

The ice condenser lower inlet doors have companion shock absorbers, each of which currently consists of a foam wedge enclosed in a fiberglass reinforced polyethylene bag and steel mesh. The shock absorber is designed to absorb the kinetic energy associated with opening of the lower inlet door during a postulated accident, through crushing of the foam. During ice condenser inspections, the shock absorbers were observed to be deteriorated, as evidenced by worn areas and tears in the bags and tears in the mesh. This condition is being documented via LER 315/98-035. With the exception of the entrance, end wall shock absorbers, the shock absorbers will be removed from the containment to a lay down area, for further disassembly and inspection. The shock absorber components (bags, foam, mesh) will be replaced with a later generation design "air box", which is designed to absorb the kinetic energy of an opening lower inlet door by collapse of the air box. The new design is considered to be significantly more durable than the original shock absorber design. This improvement is being effected via a design change. The end wall shock absorbers will be replaced with new materials of the current design.

Intermediate Deck Doors

Each of the twenty-four ice condenser bays contains eight intermediate deck doors that rest on a steel frame just above the ice baskets. The intermediate deck doors are designed to open due to differential pressure during a postulated accident. The intermediate deck doors consist of insulating foam within a steel box. The intermediate deck doors have experienced wear, including dents and punctures, during surveillance and maintenance activities. The intermediate deck doors will be removed from the ice condenser for repair and refurbishment. In general, the doors will either be replaced, restored to original design specifications, or repaired to an alternate design by design change. Protective covers are being fabricated for these doors, to prevent deterioration during future outages.

Top Deck Doors

Each ice condenser bay has a top deck door that rests on a structure approximately twelve feet above the intermediate deck doors. The top deck doors consist of a framed layer of insulation. These doors also open following a postulated accident to provide a path between the ice condenser and the upper containment. The top deck doors will be inspected in place and hardware such as door fabric and insulation, hinges and seals will be examined for signs of distress and addressed as required. Any repairs that involve restoring the doors to other than the currently approved design will be authorized via a design change.

Air Handlers

Sixty air handlers, located in the plenum between the intermediate deck and upper deck doors, circulate cool air in the ice condenser. Outstanding corrective maintenance on air handlers will be reviewed to ensure the air handlers can support the melt-out process as well as future operation. Following the ice condenser thaw, walkdowns will be performed of the air handlers to ensure hardware is in place and functioning, in accordance with design.

Ice Condenser Structure and Miscellaneous Components

The ice condenser system, structures, and components will be inspected by a multi-disciplined team for integrity and materiel condition. Discrepant conditions will be documented and dispositioned in accordance with the Cook Nuclear Plant restart plan.

ICE CONDENSER RELOAD

Prior to and following the thaw of the ice condensers, debris was identified in ice baskets and adjacent flow passages. These conditions were documented in LER 315/98-017. Therefore, following inspections, repairs and refurbishment, each ice condenser will be thoroughly inspected to provide assurance that it is free of foreign material prior to reload with fresh ice. Controls will be implemented to provide assurance that the ice condenser is, and remains, free of foreign material during and following the ice condenser reload.

ICE CONDENSER SURVEILLANCE PROGRAM

The NRC inspection of the Cook Nuclear Plant ice condenser in early 1998 revealed a number of issues related to ice condenser surveillance testing. Other examples of discrepancies were documented in LERs 315/98-005,-007,-015,-025, and -026. As a result, the basis for ice condenser surveillances will be reviewed and a surveillance basis document will be developed for each ice condenser surveillance required by the technical specifications. The surveillance basis document will serve as a repository for information pertaining to the surveillances, such as basis information, detailed methodology, and assumptions, margins, limitations and quality techniques. Based on the surveillance basis documents, surveillance procedures will be rewritten for the as-left surveillances prior to declaring the ice condenser operable.

b. **Concern 2 as it pertains to the review and assessment of safety evaluations performed under your old 50.59 process. Provide the details of the review and corrective actions.**

Response to 4b

The 10 CFR 50.59 program defines the process by which proposed changes to the plant or procedures, as described in the UFSAR, are reviewed to determine if they can be implemented without prior NRC approval. This evaluation requires an understanding of the potential impact of a change on the design and licensing basis of the facility as described in the UFSAR to determine if an unreviewed safety question (USQ) exists.

During the A/E inspection, concerns were raised relative to the adequacy of our 10 CFR 50.59 program and the potential for inadvertently bypassing this program when making changes to plant systems, structures, components, or procedures. The A/E inspection specifically identified instances where 10 CFR 50.59 reviews were required but not performed, and at least one instance where a USQ determination was required, but not performed. An underlying cause of these discrepancies, as noted by the NRC, was our understanding of what constitutes the plant's design basis, the role of the UFSAR, and how these are affected by 10 CFR 50.59.

Subsequent to the A/E inspection three (3) self-assessments and one independent contractor audit of our 10 CFR 50.59 program were conducted. These assessments identified areas requiring improvement, including programmatic improvements.

The first self-assessment was conducted in December 1997, and reviewed seventy-one 10 CFR 50.59 screenings and USQ determinations performed between January 1996 and September 1997. Several issues were identified that were administrative or procedural in nature. Though discrepancies were identified, these issues were determined to have no impact on the technical conclusions of the evaluations.

The second self-assessment examined 10 CFR 50.59 program effectiveness and was performed in January 1998. The purpose was to determine if the 10 CFR 50.59 program was adequate to support plant restart. Two statistically significant samples of 10 CFR 50.59 evaluations performed between 1980 and 1995 were examined. A key element of this assessment was to examine the rigor and accuracy of the 10 CFR 50.59 evaluations and to characterize the acceptability of a particular evaluation's justification or basis in light of lessons learned regarding the design bases and current regulatory guidance. This self-assessment concluded that administrative issues associated with program documentation needed improvement, but no programmatic weaknesses existed that would prevent plant restart.

The third self-assessment was conducted in January-February 1998 to evaluate the potential for other programs or processes to inadvertently bypass the 10 CFR 50.59 program when implementing changes to the plant or procedures (e.g., failure to recognize change). This review of a statistically significant sample concluded that previous controls had allowed potential changes to be implemented without the benefit of a 10 CFR 50.59 screening. However, in no case were 10 CFR 50.59 reviews found to result in any operability or USQ issues. These potential bypass mechanisms were considered to be administrative/procedural in nature and the assessment concluded that there were no broader safety implications.

As a result of these self assessments a number of programmatic changes have been or will be implemented, including:

Completed Actions:

- Procedures and familiarization training have been implemented to clarify the definitions of 'change,' 'licensing basis,' and 'design basis'.
- An industry expert was retained to review the program and procedures, recommend appropriate improvements, and provide training on new 10 CFR 50.59 procedures.
- Process implemented to communicate management expectations regarding change via the 10 CFR 50.59 process to appropriate personnel.

Restart Actions:

- Revise procedures to address potential 10 CFR 50.59 bypass mechanisms identified by our internal assessment.

In addition to the three self-assessments, an audit was performed by an independent contractor. The audit involved an examination of the licensee's self-assessments performed in 1997 and 1998 and a critical review of the quality of past 10 CFR 50.59 screenings and evaluations. The quality was based on the application of current standards for acceptability in performance of the 10 CFR 50.59 products. Consistent with the licensee's conclusions, the contractor determined that none of the sampled screenings and evaluations identified unreviewed safety questions (USQ), improper screening conclusions, or issues involving equipment inoperability. Discrepancies in some aspects of 10 CFR 50.59 documentation were noted and enhancements to the 10 CFR 50.59 program were recommended. The recommendations to elevate the program standards for future 10 CFR 50.59 screenings and evaluations have been implemented.

In summary, multiple examinations have been conducted since the end of the A/E inspection to evaluate the effectiveness of the 10 CFR 50.59 program at Cook Nuclear Plant. In each of the four examinations, it was concluded that there was a high probability/confidence level that the nature of identified discrepancies has not resulted in unreviewed safety questions or inoperability of equipment. Notwithstanding, programmatic enhancements have been made to elevate our standards and improve communication of the increased expectations to personnel performing future 10 CFR 50.59 screens and evaluations.

c. **Concern 3 pertains to engineering calculations. Please provide the details of the review and assessment performed to date of engineering calculations. The response should include the population and type of calculations reviewed, justification for the population selected, findings, corrective actions, and long-term plan to assure accuracy and quality of engineering calculations at D. C. Cook.**

Response to 4c

Background

The December 2, 1997, letter to the NRC (AEP:NRC:1260G3) described our short-term assessment performed in response to the CAL. Calculations were identified as a contributor to the issues that arose during the A/E inspection. As a short-term action, peer group reviews were established to analyze and review calculations for issues similar to those identified in the A/E inspection and to determine if they lead to equipment or systems being inoperable. The issues included questions regarding assumptions, calculation errors, and process measurement effects on instrument calculations. While AEPNG's review revealed both technical and administrative discrepancies, none were identified that resulted in equipment or systems being inoperable.

The short-term assessment included a review of twenty system functional calculations from a population of 139 calculations. These calculations were listed in the design basis documents for seven risk significant systems (risk significant as identified in our independent plant examination). Later it was decided to expand the review to the risk significant systems identified in our maintenance rule program and to have the review conducted by an independent consultant.

The primary objective of the expanded review was to conduct a systematic and procedurally controlled review to document overall quality, level of detail, completeness, conformance to current nuclear industry calculation preparation standards and technical accuracy of the reviewed calculations. In addition, the review evaluated whether any inoperable conditions resulted. The calculation review process also included overview and acceptance by a technical overview committee (TOC) consisting of senior engineering personnel from both the consultant and AEPNG.

The expanded program reviewed a total of eighty-one system functional calculations, including seventeen of the twenty system functional calculations originally reviewed by the AEPNG peer group (three had been superceded), and sixty-four calculations that were randomly selected from AEPNG design basis documents (DBDs) to provide a representative sample of the total population of AEPNG authored system functional calculations.

The sixty-four calculations sampled were selected using a methodology intended to provide an acceptable level of confidence and reliability that the population did not contain a discrepancy resulting in inoperable equipment or systems. A sample size of sixty-four calculations out of the total population of 239 system functional calculations selected was utilized to establish the confidence and reliability level.

The plant systems in the sample population were: auxiliary feedwater, component cooling water, chemical and volume control system, containment spray, essential service water, residual heat removal, 4kV electrical, safety injection, accumulators, reactor protection system, ESFAS, emergency diesel generator systems, control air, plant air, offsite power, 120 VAC, 250 VDC, 600 VAC, non-essential service water, RCS pressure relief, and main steam.

The review team consisted of twenty-four engineering personnel from an independent consultant with experience in the mechanical, electrical, instrument and controls and civil/structural disciplines.

As a final step, calculation reviews were overviewed by the TOC. The purpose of the TOC was to provide oversight of the review process, ensure consistency and to provide input on issues raised.

Calculation Review Results

The calculation discrepancies identified in the seventeen calculations reviewed by both the AEPNG peer groups and consultant were similar. However, because the scope and level of documentation for the two reviews were different, the review observations were not identical. The AEPNG reviews were primarily focused on identifying technical issues that had the potential to affect equipment or system operability rather than discrepancies affecting the administrative quality of calculations. Also, minor technical discrepancies were not always documented because these type discrepancies were often resolved immediately during the peer group reviews. The consultant's reviewers documented the results of their reviews using detailed checklists while the AEPNG peer group reviewers typically summarized their observations in a brief e-mail format.

The results and conclusion from the sixty-four calculations reviewed in detail by the consultant were similar to those identified above.

The initial review of eighty-one calculations selected for review in the sample is complete. Sixty-nine calculations have been through the entire review and comment resolution process including TOC overview and acceptance. No discrepancies have been identified which resulted in equipment or system inoperability. Only one calculation was identified as having discrepancies that could have a significant impact on results of the calculation. However, in this case, it was determined that the calculation discrepancies would not have affected the operation of the system.

Twelve calculations are in various stages between the comment resolution process and TOC acceptance. Although nine of these calculations have been conservatively designated as having the potential for significantly impacting calculation results, none are expected to result in design basis limits being exceeded or system or component inoperability. The corrective action program is tracking completion of the review process for these twelve calculations in accordance with the restart plan.

Results of Review

AEPNG system functional calculations included a large number of calculations spanning the nearly 30 year history of the plant, and included calculations prepared by several engineering disciplines. As expected, the reviews identified discrepancies that were diverse. However, there were several types of discrepancies that were common, as follows:

Unclear or undocumented calculation purpose or objective at times resulted in confusion as to the intent and use of the information developed in the calculation.

- Some calculations were not well organized or did not contain sufficient detail for the calculation to be easily understood. In these cases, the calculation steps could be difficult to follow.

- Use of undocumented, not referenced, or out of date design input made some of the calculations difficult to review. For example, parameters were used in some of the calculations without providing a basis for their validity. Generally, further investigation or evaluation confirmed that the correct parameters had been used, although in some instances it required significant levels of effort to establish this fact.

- Assumptions were used in some calculations without a clear statement of why the assumption was acceptable, or conservative.

- Referenced calculations, drawings and other documents in some instances did not include an indication of their revision or date, or that the calculation may have been superseded.

- Unclear statements of acceptance criteria for the calculation did not clearly demonstrate that the calculated results met the acceptance criteria.

- It was not always clear how or where the results of the calculation were to be used.

- The calculation process was decentralized and fragmented.

Most administrative discrepancies were related to the level of detail or clarity in the calculations and appeared to be related to the lack of prescriptive direction in AEPNG calculation procedures. Many of the calculation reviews required a significant amount of time and effort on the part of the reviewers and AEPNG personnel to identify and locate the information required to review the calculation and fully understand its purpose, design inputs and results. These types of discrepancies are correctable through the use of detailed calculation preparation standards and procedures combined with an increased focus, by the calculation preparers and verifiers, on the requirements for comprehensive documentation of calculations.

The technical discrepancies identified in the calculation reviews tended to be specific to the individual calculation. Most technical discrepancies, however, were of low significance levels and were resolved during the review by additional research, applying reasonable engineering judgement or by performing simple manual calculations to confirm the assumptions or results. However, several calculations required additional levels of effort, up to and including recalculation, to resolve apparent technical discrepancies.

Programmatic Changes

We are currently implementing programmatic changes to address the calculation issues identified in these reviews. The following actions have been or will be performed to address programmatic issues associated with the calculations:

Completed Actions:

- Communicated management's commitment to improving the quality of the AEPNG calculations.
- A practice has been established to subject new or revised calculations to a peer or consultant review pending implementation of program enhancements.

Restart Actions:

- Calculation procedure is being revised to address identified process discrepancies.
- Calculation preparers, verifiers, and approvers are being given formal training in the required elements of an acceptable AEPNG calculation. This training emphasizes the necessary calculation characteristics, using specific examples.
- Enhancing the calculation control and indexing process to provide specific information on calculation status and location.
- Establish a program to monitor the effectiveness of calculation process improvements.
- Resolve remaining calculation issues identified as restart items relating to the independent review.

Post Restart Actions:

- Upgrade the calculation index to provide more detailed information on the interrelationship of calculations to other plant documents.
- Benchmark external design organizations for calculation development practices and quality improvement.

Calculation Conclusions

The independent reviews performed on a representative sample covering risk significant systems (i.e., identified in our maintenance rule) are intended to provide reasonable assurance that the calculations performed in the past by AEP will not lead to inoperable conditions. As noted previously, calculational activities are on-going. Issues identified as a result of these activities will be dispositioned in accordance with the Cook Nuclear Plan restart plan.

Concern 4. Please include the NPSH calculations for all safety-related pumps. Describe the calculational technique and all assumptions used in the calculations.

Response to 4d

We have reviewed our calculation files to provide assurance that we have acceptable calculations documenting adequate NPSH for the safety-related pumps. In accordance with your request, we have provided NPSH calculations (listed in Table 1) for the safety-related pumps where such calculations are applicable. Included in the calculations are the techniques and assumptions used in their performance. Certain safety-related pumps do not utilize NPSH calculations and are therefore not included in this submittal. These include:

- Essential service water (ESW) pumps that are wet pit design that is subject to submergence considerations rather than NPSHA.

- The reactor coolant system (RCS) pumps do not have an NPSH calculation since their safety function is pressure boundary only.

- None of the pumps associated with the operation of the emergency diesel generators have NPSH calculations as they are typically flooded suction, positive displacement or have only a pressure boundary function.

- The post accident containment hydrogen monitoring system (PACHMS) pump is a vacuum pump for pulling containment air into the hydrogen analyzer. No NPSH calculation is required for the vacuum pump.

Table 1
List of NPSH Calculations
Attached to this Letter Submitted as Proprietary Information

Component	System	Functional Name	Calculation #
PP-10	CCW	Component Cooling Water Pump	ENSM970919AF
PP-26	SI	Safety Injection Pump	ECCS Recirculation Phase ENSM970128AF, Rev. 2 ECCS Injection Phase NEMP950501JEW, Rev. 0
PP-3	AFW	Motor Driven Auxiliary Feedwater Pump	HXP791121AF, Rev. 1
PP-35	RHR	Residual Heat Removal Pump	ECCS Recirculation Phase ENSM970128AF, Rev. 2 ECCS Injection Phase NEMP950501JEW, Rev. 0 RCS HXP900904JEW, Rev. 0
PP-4	AFW	Turbine Driven Auxiliary Feedwater Pump	HXP791121AF, Rev. 1
PP-46	Boric Acid	Boric Acid Storage Tank Transfer Pumps	NESP032395JJS, Rev. 1
PP-50	CVCS	Centrifugal Charging Pump	ECCS Recirculation Phase ENSM970128AF, Rev. 2 ECCS Injection Phase NEMP950501JEW, Rev. 0 VCT NESM961021AF, Rev. 0 CCP ENSM720719FK, Rev. 1
PP-9	CTS	Containment Spray Pump	ECCS Recirculation Phase ENSM970128AF, Rev. 2 ECCS Injection Phase NEMP950501JEW, Rev. 0

e. **Concern 5. Please provide the actions taken to assure the accuracy of the February 6, 1997, response to the NRC request for information pursuant to 10CFR 50.54(f) in light of the inspection findings from the design inspection in September, 1997 and the follow-up design inspection in April 1998**

Response to 4e

The lessons learned from the AE inspection and subsequent inspections have enhanced our understanding of the design and licensing bases and the processes used to maintain them, as originally described in our February 6, 1997, response. Following the A/E inspection and subsequent shutdown of both units in September of 1997, the NRC issued a confirmatory action letter (CAL) that led us to evaluate the applicability of the results and discrepancies identified during the inspection to other systems and components throughout the plant. In addition to the issues identified in the CAL, several new issues arose concerning our containment systems.

In response to these issues, we are performing a comprehensive assessment to provide reasonable assurance of plant system readiness, programmatic readiness, functional area readiness, and containment readiness. The primary mechanism implementing this assessment is the Cook Nuclear Plant restart plan (previously submitted in AEP:NRC:1303). The restart plan describes the activities and controls that are intended to ensure the plant is ready for safe start up and power operation.

The details of these readiness reviews have been discussed in detail in previous sections of this letter (attachment 2), in response to the specific concerns raised in the 2.206 petition. Additionally, as we progress toward restart, many of these issues will be discussed further with the NRC during our ongoing 0350 meetings.

In addition to the readiness assessments and supporting activities described in our restart plan, we have also initiated a revised design basis reconstitution program. The purpose of this program is to provide assurance that:

- there is an adequate understanding of, and control over, the plant's design and licensing basis requirements; and
- requirements are being effectively implemented both in plant design and in the procedures that govern plant operation and maintenance.

The design basis reconstitution program is an ongoing effort that will continue after startup of the units.

In summary, our actions to date, as described in the preceding sections of attachment 2, have served to enhance our understanding of our licensing and design bases as discussed in our February 6, 1997, response. In addition, AEPNG is performing a comprehensive assessment of system, functional area, and programmatic readiness reviews. Issues identified will be dispositioned in accordance with the Cook Nuclear Plant restart

plan. NRC permission for restart will not be requested until the restart plan is complete and reasonable assurance of restart readiness is achieved.