EN-6??
(8/97)

NUCLEAR ENGINEERING DEPARTMENT

Calculation Cover Sheet
Cook Nuclear Plant

SafetyRelatedMechanicalSystems

CALCULATION NO. ENSM720719FK	INDIANA MICHIGAN POWER COMPANY
	UNIT NO. 1
SAFETY RELATED YES ☒ NO ☐	CALCULATED BY: F. Kuo 7/19/72 DATE
SYSTEM ~~Reactor Letdown and Charging (RL&C)~~	
TITLE ~~Centrifugal Charging Pump (CCP) NPSH~~	VERIFIED BY: DATE
DCP/RFC/MM/PM/PR/CR/TM/NO. N/A	APPROVED BY: DATE
FILE LOCATION ENSM SYSTEM FILES	

CALCULATION DESCRIPTION:
This calculation determines the NPSH to unit 1 east centrifugal charging pump (CCP) from the volume control tank (VCT)

METHOD OF VERIFICATION: ALTERNATE CALCULATION X * SEE NOTE REVIEW ____

REVISION

No.	Reason for Change	Calculated By	Date	Verified By	Date	Approved By	Date
1	Correct NPSH calc using absolute terms instead of gage and update format	J. J. Ripak JJ Ripak	7/1/98 7/1/98	C. VANDERBURGH C Vandenburgh	7/6/98	D. L. Boston	7-6-98

* NOTE: ALTERNATE CALCULATION METHOD USED TO VERIFY REVISION 1.

Table of Contents

Discussion and Purpose

This calculation is being revised to correct the error of using gauge instead of absolute terms when calculating NPSH for the centrifugal charging pump taking suction from the volume control tank (VCT) during normal operation. The format is also updated to current convention and for clarity. Although the original calculation was in error, the error was in the conservative direction wherein the calculated NPSH available (NPSHa) was one atmosphere or 34 ft below the actual value. Therefore the actual margin is 34 ft higher than calculated.

Design Inputs and Data Sources

1. Elevation of VCT outlet pipe flange = 611'-0-1/4" = 611.02', per Drawing 1-5441-12, B/8
2. Elevation of pump centerline = 590'-9" = 590.75', per Drawing 1-5443-23, C/5.
3. Elevation of Pump suction nozzle is 20" above the centerline, per Pacific Pump Drawing FC-45605
   " " " " " = 590'-9" + 20" = 592'-5" = 592.42'
4. Design flow = 150 gpm , per UFSAR Table 9.2-3, however use 204 gpm, per note below
   Note; Max normal operating flow is letdown flow of 120 gpm (max) plus 60 gpm miniflow, all per UFSAR table 9.2-2, plus 24 gpm seal return flow, per assumption 5 below, for a total flow of 204 gpm.
5. Temperature
   Normal suction temperature = 115 ° F, per UFSAR table 9.2-3
   VCT hi temp alarm QTI-451 set at 134 ° F with +/- 3 deg uncertainty, per ECP 1-CG-16B
   Operating procedure limit of 185 ° F, per 01 OHP 4021.003.001, Rev 19
   Use 190 ° F as bounding
6. VCT Pressure = 0 to 60 psig, per UFSAR Table 9.2-3; use 0 psig as a conservatism.
7. NPSH required (NPSHr) at 204 gpm = 12 ft, per representative NPSH curve on Pacific test curve 34617 I.

References

1. Updated Final Safety Analysis (UFSAR)
2. Hydraulic Institute Standards, 12th Edition, 1969
3. Flow of Fluids, Tech Paper No. 410, 14th printing 1974, Crane Co.
4. Procedures 01-OHP 4021.003.001, Rev 19 and 01-OHP 4022.002.001, Rev 8, C. S. 1
5. AEP Drawings 1-5441-12 and 1-5443-23, (Attachment 3, Sheets 1 & 2)
6. Pacific Pump Co Drawing FC-45605 and Test Curve 34617-I, (Attachments 4 & 5)

Method

The NPSHa is defined as the total suction head in feet of liquid absolute, determined at the suction nozzle and referred to datum, less the absolute vapor pressure of the liquid in feet of liquid pumped.

Therefore; (1) NPSHa = Ha - Hvpa + Hs, per Hydraulic Institute Standards page 41

Where

Ha = atmospheric pressure in ft absolute (14.7 psi or 34 ft)

Hvpa = vapor pressure of liquid in ft absolute

Hs = total suction head in ft

(2) $Hs = Z + P/\gamma - Hf$

Where

Z = elevation of liquid in tank above pump suction nozzle in ft

P/γ = tank pressure in psig converted to ft of head by the density factor.

Hf = pipe friction in ft between the tank and the pump suction nozzle.
Note; the pipe friction computed for the original calculation will be used for this revision. The friction value for flows other than the 98 gpm used in the original will be calculated based on the square relationship of flow to friction as shown in the Darcy-Weisbach equation [$Hf = f(L/D)(V^2/2g)$, eq 2-8, pg 2-8 Crane, that is;

(3) $Hf_2 = Hf_1(Q2/Q1)^2$.

ENS/M720719FK Rev 1

Acceptance Criteria

Acceptable operating conditions exist when the NPSHa exceeds the NPSHr.

Assumptions

1. Based on review of the values, the friction value used in the original calc is assumed to be correct.

2. The level in the VCT is conservatively assumed to be below the low level alarm and actually out of the tank.

3. The liquid temperature is conservatively assumed to be 190 ° F, 5 ° F above the highest procedural limit.

4. It is assumed that the values calculated based on the piping configuration of the unit 1 East pump are applicable to all 4 pump installations. This assumption is made since the slight differences in the unit 1 West and both unit 2 pumps are considered insignificant relative to magnitude of the margin of 12 ft.

5. The extremely conservative assumption that the seal leakoff on all 4 RCPs is at the maximum 6 gpm instead of the nominal 3 gpm. Procedure 01-OHP 4022.002.001, Rev 8, C. S. 1, steps 3 & 15 trips the pump and the unit if the flow on any one RCP rapidly increases to 6 gpm (the max reading on the flow instrument). We are assuming the unprecedented condition where the flow on all 4 RCPs reach 6 gpm simultaneously..

Calculation

Calculate the NPSHa at a flow of 204 gpm, at 190 deg F

1. Establish the friction (Hf) at 204 gpm based on the original HFLC2 computer calc at 98 gpm.
   Hf_1 = total friction of the four series segments 1 through 4 from the VCT to the pump at 98 gpm
   = 1.12 + 0.04 + 0.01 + 0.05 = 1.22 ft
   Hf_2 = friction of the segments at 204 gpm
   = $Hf_1(Q2/Q1)^2$ [eq 3] = 1.22ft x.$(204/98)^2$ = 5.29 ft
2. Calculate total suction head
   Hs = Z + P/γ - Hf [eq 2] = (611.02' - 592.42') + 0 - 5.29' = 13.31 ft
3. Calculate NPSHa
   NPSHa = Ha - Hvpa + Hs [eq1]
   vapor pressure of water @ 190 ° F = 9.340 psia per Crane, Pg A-6
   weight density of water @ 190 ° F = 60.343 #/ft^2 per Crane, Pg A-6
   therefore Hvpa = P/γ = 9.340 psia/(60.343 #/ft^2/144in2/ft^2) = 22.29 ft
   NPSHa = 34 - 22.29 + 13.31 = 25.02 ft, use 25 ft
4. Margin of NPSHa over NPSHr = 25 - 12 = 13 ft

Summary of Results and Conclusions

Adequate NPSH exists at the extreme worst case bounding conditions reviewed in this revision since the NPSHa well exceeds the NPSHr with a margin of 13 ft.

AMERICAN ELECTRIC POWER SERVICE CORPORATION

DATE 7-19-72

MEMO TO: Centrifugal Charging Pp.
Suction Piping

Attached calc shows that adequate $NPSH_A$ exists from V.C.T. to CC pump "1-E" (worst case) if latter pump is used for letdown & charging.

$NPSH_R \cong$ (@ 98 gpm) 10 ft

$NPSH_A \cong$ 18 ft (with min el. in V.C.T. of 612'-6" or 1'-6" above discharge nozzle)

$\therefore NPSH_A > NPSH_R$ by ~ 8 ft

FROM F.K.

* Information phoned to Stan Farlow 7-19-72

FORM OM-14
(AD-16)

Attachment 1 sheet 1
ENSM 72 0719FK Rev 1
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CENTRIFUGAL CHARGING PUMP (1-E)

D

FROM V.C.T.

REF. DWGS 1-5441, -5443

ASSUME DESIGN FLOW SAME AS RECIP. PUMP = 98 gpm

V.C.T. PRESS (MIN) 15 PSIG

FLUID TEMP 250°F → 29.83 psia

CC Pp $NPSH_R$ (@ 98 gpm) = 10 FT from characteristic curve

FRICT = 1.22 → 2

$NPSH_A$ = (V.C.T. EL − SUCT. FLG EL) + V.C.T. PRESS − FRICTION − VAP. PRESS

L

SAME WORST CASE

V.C.T. EL = $NPSH_R$ + SUCT. FLG EL + FRICT. + VAP. PRESS − V.C.T PRESS

= 10' + 592'-6" + 2'

V.C.T. EL = 604'-6" minimum el. to satisfy $NPSH_R$

THIS COMPARES WITH V.C.T. EL (FACE OF NOZZLE) 611'-0¼"

TO PRECLUDE VORTEX, V.C.T. MIN EL TO BE 612'-6" → $NPSH_A$ = 18 ft

at 150 gpm · $NPSH_R$ = 11 ft (1½' above impeller)

FRICT ≈ $\left(\frac{150}{98}\right)^2 1.22$ = 2.87 → 3.5 ft

F.C 11-19-72

VCT EL = 11 + 592'-6" + 3.5 = 607' (min)

I

TO PRECLUDE VORTEX, V.C.T. MIN EL 617'-6" (1½ ft above impeller) → $NPSH_A$ = 16'-6"

Attachment 1 sheet 2
ENSM 720719FK Rev 1
Page Grp 1.15

HEAD LOSSES FOR CC PUMP SUCTION PIPING (TO "1-E") FROM V.C.T.

```
U#=TDM47000,AEP000

EEDIVNY1-AEP
ID:ME
SYSTEM- FOR          S
NEW OR OLD--NEW CCPPC

READY
10    250,.00015,4
~~20    57,.81,445~~
20    98,4.026,57,.81,445
30    98,6.065,6,.2,86
40    98,7.981,17,0,60
50    98,6.065,8.5,0,139
SAVE

READY
OLD HFLC2*

READY
RUN


HFLC2*       11:29EDT    07/19/72


PIPE FRICTION CALCULATIONS-COLEBROOK EQUATION
INPUT DATAFILE?CCPPC

WATER TEMP.(F)                = 250.00
DENSITY(LBM/CUFT)             =  58.48
AES.VISCOSITY(LBM/HR/FT)     =0.570931E+00
PIPE ABS.ROUGHNESS(FT)        = 0.150000E-03

NO.   FLOW-GPM   DIA(IN)   VEL(FPS)   RE.NO.        HEAD(FT)   TOT.HD.(FT)

 1        98.0      4.0       2.5      0.30553E+06      1.12        1.12

 2        98.0      6.1       1.1      0.20282E+06      0.04        1.16

 3        98.0      8.0       0.6      0.15413E+06      0.01        1.17

 4        98.0      6.1       1.1      0.20282E+06      0.05        1.22
ARE THERE MORE RUNS IN THIS DATAFILE(YES-NO)?NO
```

Attachment 2 sheet 1
~~ENSM 720719FK R~~
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- 0 0 1 0 0 2 8 0 L 0 -

PIPE FRICTION CALCULATION

PLANT [illegible] BY FK DATE 7-14-79

OBJECT CC Pump Discharge Pipe from V.A.T.

FLUID TEMP. (°F) 95°F PIPE REL. ROUGHNESS .00015 PIPE SEGMENT NUMBER 1

FLUID FLOW (GPM) 65 PIPE DIAMETER (IN) 4" Sch 40

STRAIGHT PIPE LENGHTS			FITTINGS	NUMBER	*K or L/D	ΣK	ΣL/D
[illegible]'			GATE VALVE	1	13		2.6
7.5'			GLOBE VALVE		340		
1'			ANGLE VALVE		145		
2.5'			BUTTERFLY VAL		40		
1'			SWING CHECK		135		135
4.5'			90° STD. ELBOW	1	30		120
3'			90° S.R. ELBOW		50		
1.5'			90° L.R. ELBOW		20		[illegible]
15.5'			90° MITRE ELBOW		57		
[illegible]'			45° STD. ELBOW		16		64
			45° MITRE ELBOW		15		
			45° S.R. ELBOW		26		
			180° CLOSE RETURN		50		
			* LATERAL ∠ OUTLET		1.0		
			* LATERAL ∠ INLET		0.5		
			* STRAIGHT RUN LATERAL		0.15		
			STD. TEE RUN		20		20
			STD. TEE BRANCH		60		60
			* PIPE ENTR PROJ. INWD		0.78		
			* SHARP EDGE	1	0.50	.5	
			* SLIGHT ROUND		0.23		
			* WELL ROUND		0.04		
			* PIPE EXIT SHARP EDGED		1.0		
			* SUDDEN CONTRACTION $d_2/d_1 = .03$		0.42		
			*	0.5	0.33		
			*	0.25	0.17		
			* MISC SUDDEN INCREASE	$\frac{3}{4} = .31$	(1 - .69)	.31	
			* MISC SUDDEN ENLARGE		1		
TALS	57'					.81	445

* ITEMS ARE "K" VALUES ONLY.

Attachment 2 - Sheet 2
ENSM 720719 FK Rev 1
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0 0 1 0 0 2 0 0 1 0 6

PIPE P[illegible] ON CALCULATION

PLANT [illegible] BY F.K. DATE [illegible]

SUBJECT [illegible]

FLUID TEMP. (°F) ______ PIPE REL. ROUGHNESS ______ PIPE SEGMENT NUMBER [illegible]

FLUID FLOW (GPM) [illegible] PIPE DIAMETER (IN) [illegible]

STRAIGHT PIPE LENGHTS			FITTINGS	NUMBER	*K or L/D	ΣK	ΣL/D
[illegible]			GATE VALVE		13		
			GLOBE VALVE		340		
			ANGLE VALVE		145		
			BUTTERFLY VAL		40		
			SWING CHECK		135		
			90° STD. ELBOW		30		30
			90° S.R. ELBOW		50		
			90° L.R. ELBOW		20		
			90° MITRE ELBOW		57		
			45° STD. ELBOW		16		
			45° MITRE ELBOW		15		
			45° S.R. ELBOW		26		
			180° CLOSE RETURN		50		
			* LATERAL ∠ OUTLET		1.0		
			* LATERAL ∠ INLET		0.5		
			* STRAIGHT RUN LATERAL		0.15		
			STD. TEE RUN	[illegible]	20		[illegible]
			STD. TEE BRANCH		60		
			* PIPE ENTR. PROJ. INWD		0.78		
			* SHARP EDGE		0.50		
			* SLIGHT ROUND		0.23		
			* WELL ROUND		0.04		
			* PIPE EXIT SHARP EDGED		1.0		
			* SUDDEN CONTRACTION d_2/d_1 = 0.3		0.42		
			* 0.5		0.33		
			* 0.75		0.17		
			* MISC SUDDEN INCREASE	[illegible] .2	[illegible]	.2	
			* MISC SUDDEN ENLARGE		1		
TOTALS 6'						.2	[illegible]

* ITEMS ARE "K" VALUES ONLY.

Attachment 2 Sheet 3
ENSM 720719 FK R[illegible]
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0 0 1 0 0 2 3 0 4 0 7

PIPE FRICTION CALCULATION

PLANT _____ BY _____ DATE _____

SUBJECT _____

FLUID TEMP (°F) _____ PIPE REL. ROUGHNESS _____ PIPE SEGMENT NUMBER 3

FLUID FLOW (GPM) 22 PIPE DIAMETER (IN) _____

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K or ½	ΣK	Σ½
	GATE VALVE		13		
	GLOBE VALVE		340		
	ANGLE VALVE		145		
	BUTTERFLY VAL		40		
	SWING CHECK		135		
	90° STD. ELBOW		30		
	90° S.R. ELBOW		50		
	90° L.R. ELBOW		20		
	90° MITRE ELBOW		57		
	45° STD. ELBOW		16		
	45° MITRE ELBOW		15		
	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
*	LATERAL ∠ OUTLET		1.0		
*	LATERAL ∠ INLET		0.5		
*	STRAIGHT RUN LATERAL		0.15		
	STD. TEE RUN		20		
	STD. TEE BRANCH		60		
*	PIPE ENTR. PROJ. INTO		0.78		
*	SHARP EDGE		0.50		
*	SLIGHT ROUND		0.23		
*	WELL ROUND		0.04		
*	PIPE EXIT SHARP EDGED		1.0		
*	SUDDEN CONTRACTION d_2/d_1 = 0.8		0.42		
*	0.5		0.33		
*	0.25		0.17		
*	MISC SUDDEN INCREASE		(1 v_1^2)		
*	MISC SUDDEN DISCHARGE		1		
TALS	17'			0	0

* ITEMS ARE "K" VALUES ONLY.

Attachment 2 Sheet 4
ENSM 720719 PK Rev1
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0 0 1 0 0 2 6 0 7 0 8

PIPE FRICTION CALCULATION

PLANT D. C. Cook   BY FK   DATE 7-19-72

SUBJECT ____

FLUID TEMP. (°F) ____   PIPE REL. ROUGHNESS ____   PIPE SEGMENT NUMBER [illegible]

FLUID FLOW (GPM) [illegible]   PIPE DIAMETER (IN) [illegible]

STRAIGHT PIPE LENGHTS				FITTINGS	NUMBER	*K or L/D	ΣK	ΣL/D
4.5'				GATE VALVE	1	13		13
1'				GLOBE VALVE		340		
3'				ANGLE VALVE		145		
				BUTTERFLY VAL		40		
				SWING CHECK		135		
				90° STD. ELBOW	III	30		[illegible]
				90° S.R. ELBOW		50		
				90° L.R. ELBOW		20		
				90° MITRE ELBOW		57		
				45° STD. ELBOW	1	16		[illegible]
				45° MITRE ELBOW		15		
				45° S.R. ELBOW		26		
				180° CLOSE RETURN		50		
				* LATERAL ∠ OUTLET		1.0		
				* LATERAL ∠ INLET		0.5		
				* STRAIGHT RUN LATERAL		0.15		
				STD. TEE RUN	1	20		20
				STD. TEE BRANCH		60		
				* PIPE ENTR PROJ. INWD		0.78		
				* SHARP EDGE		0.50		
				* SLIGHT ROUND		0.23		
				* WELL ROUND		0.04		
				* PIPE EXIT SHARP EDGED		1.0		
				* SUDDEN CONTRACTION $d_2/d_1 = 0.3$		0.42		
				* 0.5		0.33		
				* 0.75		0.17		
				* MISC SUDDEN INCREASE		[illegible]		
				* MISC SUDDEN ENLARGE		1		
TOTALS 8.5							0	139

* ITEMS ARE "K" VALUES ONLY

Attachment 2 Sheet 5
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DWG. NO. 1-5441

N

PART. PLAN "A-2"

PART. PLAN @ EL 609'-0"

PLAN ABOVE EL. 618'-0"

PLAN EL. 609'-0"

SECTION "B-9"

SECTION "F-9"

SECTION "J-G"

SECTION "L-7"

DETAIL M-9

GENERAL NOTES

ABBREVIATIONS

REFERENCE DRAWINGS

A E P SERVICE CORP.

MANUFACTURERS DWG'S

WESTINGHOUSE ELEC. CORP.

ATLAS INDUSTRIAL MFG. CO.

REVISIONS

INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN MICHIGAN

AUXILIARY BUILDING VOLUME CONTROL TK & SEAL WTR. HEAT EXCH. PIPING UNIT No. 1

DWG. No. 1-5441-12

AMERICAN ELECTRIC POWER

1 RIVERSIDE PLAZA COLUMBUS, OH 43216

Attachment 3 Sheet 1
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9808100113-01

Attachment 3 Sheet 2
ENVSM 7207 19A Rev 1
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SECTION F-1

SECT "H-1"

SECTION B-2

SECT "A-3"

PLAN "C-3"

SECTION B-5

SECTION B-5 (OPPOSITE HAND)

PLAN E-7 EL 587'-0"

SECTION B-7

SECTION C-7

SECTION B-9

SECTION C-9

DETAIL H-6 (MIN. FLOW ORIFICE)

PLAN H-7

PLAN H-6

SECTION K-

DETAIL J-6

PLAN L-9

MATCH LINE FOR CONT. SEE DWG. 1-5444

GENERAL NOTES

REFERENCE DRAWINGS

MANUFACTURERS DWGS.

ABBREVIATIONS

REVISIONS

INDIANA MICHIGAN POWER COMPANY
DONALD C. COOK NUCLEAR PLANT
BRIDGMAN MICHIGAN

AUXILIARY BUILDING
CHARGING PUMPS
SUCTION & DISCHARGE PIPING
UNIT NO. 1

DWG. NO. 1-5443-23

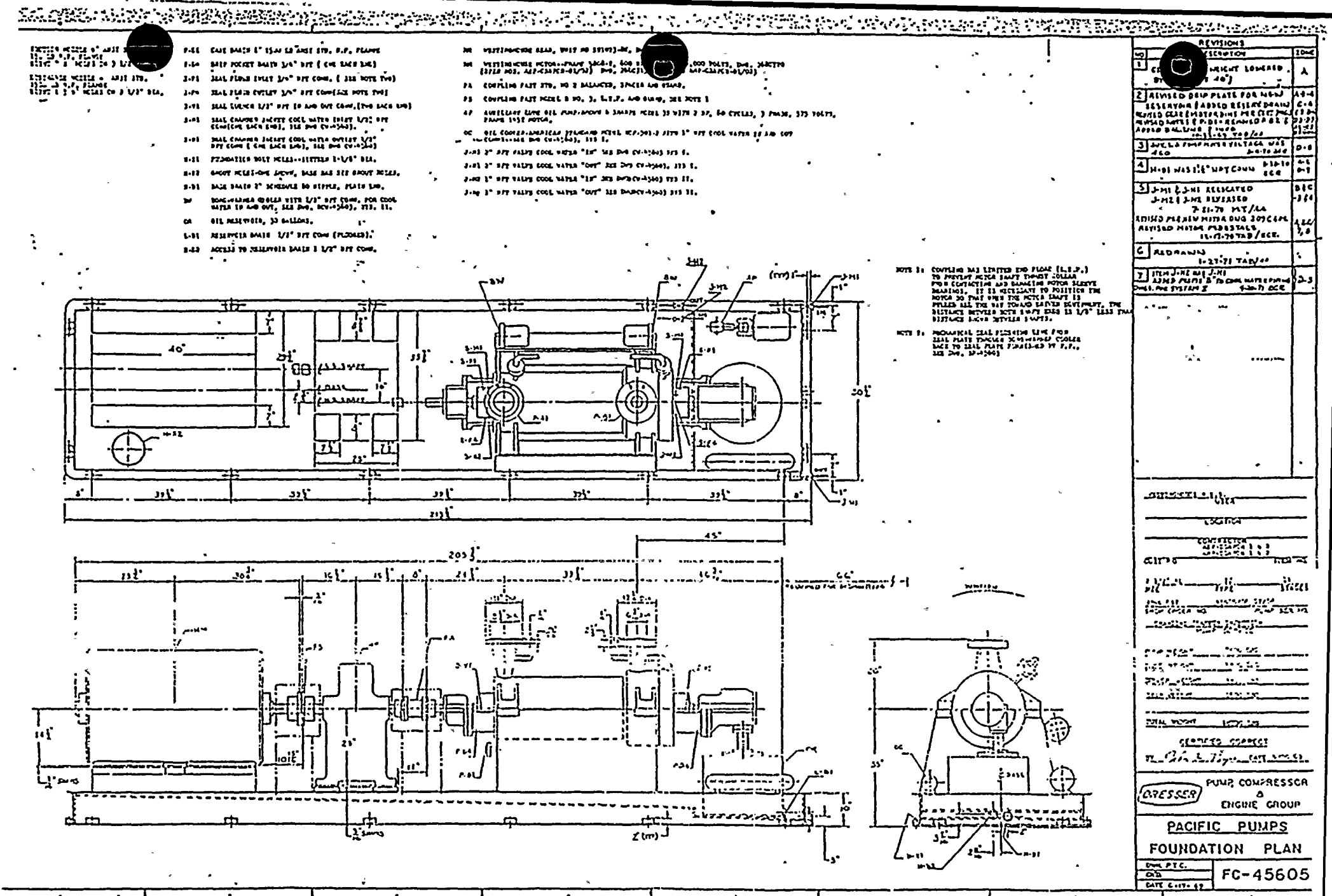
FOR SIGNATURE RECORD OF DWG. 1-5443-23 SEE MICROFILM COPY

AEP AMERICAN ELECTRIC POWER — 1 RIVERSIDE PLAZA, COLUMBUS, OH 43215

ADM

PLANT STATUS

9808100113-02



Attachment 4
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PACIFIC PUMPS | FORESSER | HUNTINGTON PARK, CALIFORNIA

CONTRACTOR Westinghouse

CUSTOMER Indiana & Michigan Electric

ITEM NO. _____ P.O. 118564-6041-3X

IMPELLER PATTERN M-7278 M-6334

MAXIMUM DIAMETER 8¼ 8¼

RATED DIAMETER 8¼ 8¼

MINIMUM DIAMETER 7¼ 7¼

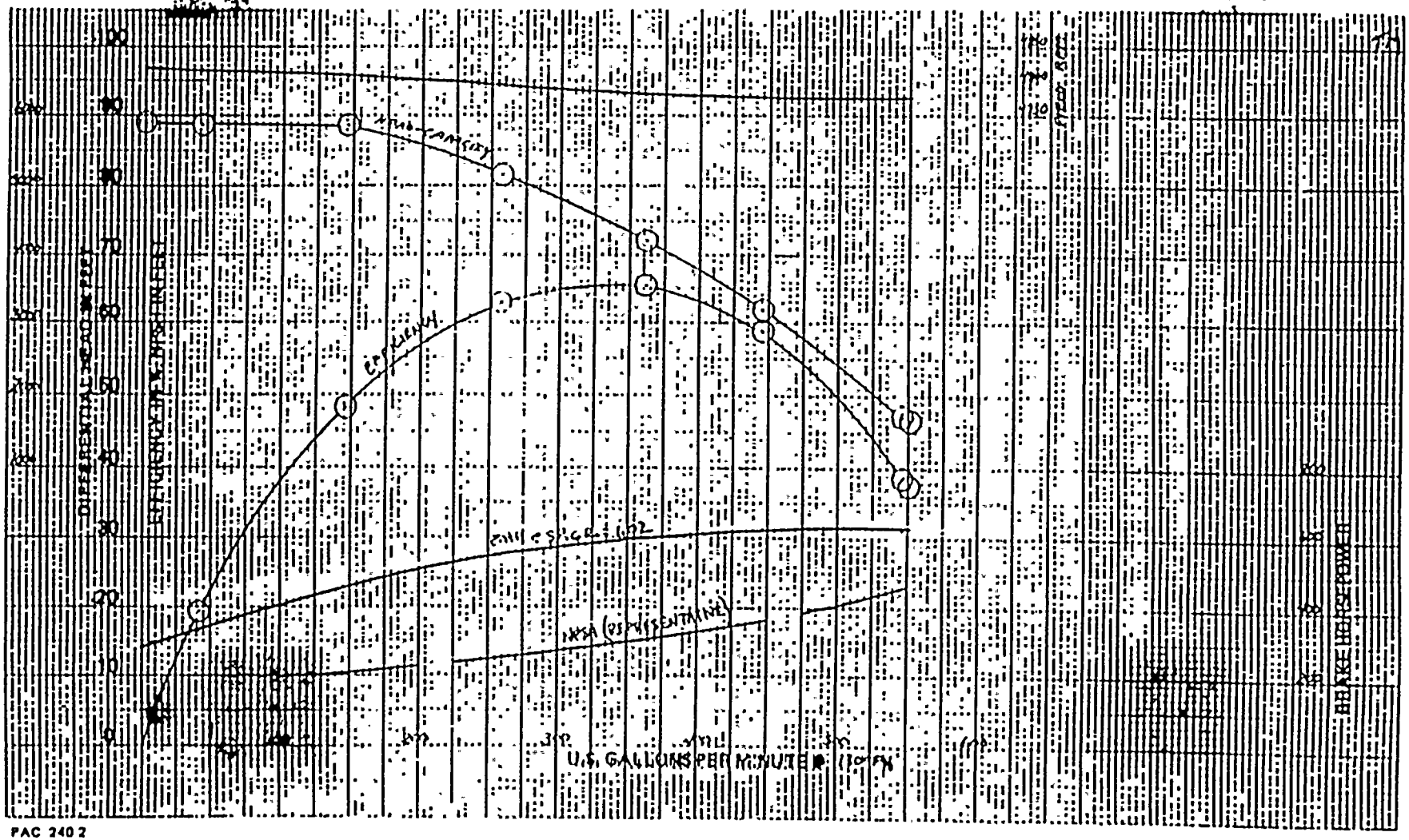
TEST PERFORMANCE CURVE NO. 24617-I-SM

SIZE 2½" CC TYPE 15 STAGES 11

R.P.M. Field DATE 1/26/84

PUMP NUMBER Same Element as 42624-8

PERFORMANCE ALSO APPLIES TO PUMP NUMBER NE 90993



PAC 2402

48

Attachment 5
ENSM 720719 FK Rev 1
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EN-015
(1/97)

DONALD C. COOK NUCLEAR PLANT

ENSM Functional Area

VERIFICATION CHECKLIST - CALCULATIONS

Calculation Number ENSM 920719FK Rev. 1

Signature of Verifier 7/6/98 Date

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

Basis: INPUTS WERE CONSERVATIVE AND BOUNDING CONDITIONS FOR CHARGING PUMP NPSH WHILE OPERATING IN THE CVCS/ NORMAL CHARGING CAPACITY.

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

Basis: ASSUMPTIONS HAVE BEEN IDENTIFIED. AND JUSTIFICATION WAS PROVIDED AS TO WHY EACH ASSUMPTION IS CONSERVATIVE FOR THIS NPSH CALCULATION.

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

Basis: DESIGN REQUIRED NPSH AVAILABLE TO EXCEED THE NPSH REQUIRED, EVEN UNDER WORST CASE ASSUMPTIONS. AS SHOWN BY THIS CALCULATION SYSTEM DESIGN CONTAINS ENOUGH MARGIN TO ENSURE ADEQUATE NPSH

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

Basis: NPSH WAS CALCULATED IN A METHOD CONSISTENT WITH THE METHOD DESCRIBED IN THE HYDRAULIC INSTITUTE STANDARDS 12TH EDITION. THIS METHOD HAS NOT BEEN CHANGED BY SUBSEQUENT EDITIONS.

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

Basis: THE OUTPUT WAS VERIFIED THROUGH AN ALTERNATE CALCULATION, WHICH VERIFIED THE OUTPUT TO BE CORRECT.

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

Basis: AN ALTERNATE CALCULATION HAS BEEN PERFORMED USING A PREVIOUSLY APPROVED PRATO-FIC COMPUTER MODEL. THE MODEL WAS PREVIOUSLY USED IN CALCULATION ~~ENSM 9612~~ ON 7/6/98 ENSM 961213AF REV 1.

RESULTS OF THE ALTERNATE CALCULATION CONFIRMED THE RESULTS OF THIS CALCULATION TO BE CORRECT.

ENSM 720719FK Rev.1 Alternate Calculation Verification

INPUTS

1. Proto-Flo Version 3.04 Model for CVCS Normal charging flow path developed for approved Calculation # ENSM961213AF Rev.1, Approval Date 5/28/97.

2. Model inputs Specific to Charging Pump NPSH Calculation # ENSM 720719FK Rev.1 under worst case normal operating conditions.

   - Suction Temperature 190 ° F
   - VCT Pressure 14.7 psia
   - Seal water injection flow 44 gpm
   - Charging header flow 100 gpm
   - CCP mini–flow in service (model calculated flow at 57.24 gpm vs the 60 gpm assumed by calculation initiator)

Discussion

Charging Pump NPSH calculation was verified using a previously approved Proto-flo model of the CVCS system under calculation ENSM 961213AF Rev. 1. Model inputs were revised slightly to reflect inputs used by calculation ENSM 720719FK Rev. 1. The revised inputs are stated under item #2 of the inputs listed.

The revised Proto-flo model was run 7/6/98 on a Dell computer model # GXMT5133, AEP specific PC # 6738. Results of this alternate calculation along with a CVCS System Nodal Model Drawing have been attached with the Verification Check List. The Proto-flo model automatically calculates NPSHa and compares the value against the NPSHr curve which was input as part of the model design. The verification calculation confirms within one ft the results obtained under ENSM 720719FK Rev.1

I&M - C:\PROTOFLO\CVCS1.PDB -
Cook Plant - ECCS/CCP System

Pump Status Report

Pump Name:	PP50W	Manufacturer:	Model:
	Drawings:		
	Pump Status: OFF		
	Speed (RPM):	Flow (gpm):	Head (ft):
	Hydraulic Horsepower:		
	Pump Impeller Datum (ft)		Inlet Node Elevation (ft): 597.00
	Pump Suction Temperature (°F 190.00		
	NPSH Curve: PP50 NPSH		
	NPSH Available:	NPSH Required:	

Pump Name:	PP50E	Manufacturer:	Model:
	Drawings:		
	Pump Status: PP50		
	Speed (RPM):	Flow (gpm): 201.25	Head (ft): 5.494.61
	Hydraulic Horsepower: 270.37		
	Pump Impeller Datum (ft)		Inlet Node Elevation (ft): 596.33
	Pump Suction Temperature (°F 190.00		
	NPSH Curve: PP50 NPSH		
	NPSH Available: 24.21	NPSH Required: 11.02	

VERIFIES 25 ft OBTAINED BY
TNSM 720719 FK REV. 1

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Cook Plant - ECCS/CCP System

Combined Output Report

Convergence: Pressure=1.0E-5 Sum Q=1.0E-2 Friction=1.0E-6 FCV=1.0E-4 PCV=1.0E-3 Temperature=5.0E-3 - Balancing Parameters Used

Pipe: 1.00	ID = 4.260	Flow = 144.01		Vel = 3.242		
	Turbulent f = 0.0177		Reynold's Number = 3.2017E+05			
N1: CS1		** Press= 14.70	Elev= 611.02	Flow= 0.00		Temp= 190.00
N2: CS2		Press= 14.71	Elev= 610.42	Flow= 0.00		Temp= 190.00
Pipe: 2.00	ID = 4.260	Flow = 201.25		Vel = 4.530		100.00% Vel
	Turbulent f = 0.0173		Reynold's Number = 4.4742E+05			
N1: CS2		Press= 14.71	Elev= 610.42	Flow= 0.00		Temp= 190.00
N2: CS3		Press= 19.39	Elev= 597.00	Flow= 0.00		Temp= 190.00
Pipe: 4.00	ID = 6.357	Flow = 201.25		Vel = 2.034		
	Turbulent f = 0.0169		Reynold's Number = 2.9983E+05			
N1: CS3		Press= 19.39	Elev= 597.00	Flow= 0.00		Temp= 190.00
N2: CS5		Press= 19.61	Elev= 596.33	Flow= 0.00		Temp= 190.00
Pipe: 5.00	ID = 8.329	Flow = 201.25		Vel = 1.185		
	Turbulent f = 0.0169		Reynold's Number = 2.2884E+05			
N1: CS5		Press= 19.61	Elev= 596.33	Flow= 0.00		Temp= 190.00
N2: CS6		Press= 19.60	Elev= 596.33	Flow= 0.00		Temp= 190.00
Pipe: 6.00	ID = 6.357	Flow = 201.25		NPSHA = 24.21	NPSHR = 11.02	
N1: CS6		Press= 19.60	Elev= 596.33	Flow= 0.00		Temp= 190.00
N2: CS7		Press= 2,324.70	Elev= 590.75	Flow= 0.00		Temp= 190.00
Pipe: 8.00	ID = 3.626	Flow = 201.25		Vel = 6.253		
	Turbulent f = 0.0176		Reynold's Number = 5.2565E+05			
N1: CS7		Press= 2,324.70	Elev= 590.75	Flow= 0.00		Temp= 190.00
N2: CS9		Press= 2,323.84	Elev= 592.00	Flow= 0.00		Temp= 190.00
Pipe: 10.00	ID = 1.689	Flow = 57.24		Vel = 8.197		100.00% Vel
	Turbulent f = 0.0208		Reynold's Number = 3.2095E+05			
N1: CS9		Press= 2,323.84	Elev= 592.00	Flow= 0.00		Temp= 190.00
N2: CS10		Press= 24.26	Elev= 592.00	Flow= 0.00		Temp= 190.00
Pipe: 11.00	ID = 2.067	Flow = 57.24		Vel = 5.473		
	Turbulent f = 0.0202		Reynold's Number = 2.6226E+05			
N1: CS10		Press= 24.26	Elev= 592.00	Flow= 0.00		Temp= 190.00
N2: CS11		Press= 17.21	Elev= 605.58	Flow= 0.00		Temp= 190.00
Pipe: 12.00	ID = 4.260	Flow = 57.24		Vel = 1.288		
	Turbulent f = 0.0194		Reynold's Number = 1.2725E+05			
N1: CS11		Press= 17.21	Elev= 605.58	Flow= 0.00		Temp= 190.00
N2: CS12		Press= 16.89	Elev= 606.33	Flow= 0.00		Temp= 190.00

!! Reverse Flow Thru Check Valve
++ Section Was Balanced
** Fixed Pressure
%% Pressure Below Vapor Pressure
?? Temperature Outside Fluid Property Range
NPSHA less than NPSHR
&& Flow Past End of Pump Curve

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Cook Plant - ECCS/CCP System

Combined Output Report

Convergence: Pressure=1.0E-5 Sum Q=1.0E-2 Friction=1.0E-6 FCV=1.0E-4 PCV=1.0E-3 Temperature=5.0E-3 - Balancing Parameters Used

Pipe: 13.00	ID = 4.260	Flow = 57.24		Vel = 1.288		
	Turbulent f = 0.0194		Reynold's Number = 1.2725E+05			
N1: CS12		Press= 16.89	Elev= 606.33	Flow= 0.00	Temp= 190.00	
N2: CS2		Press= 14.71	Elev= 610.42	Flow= 0.00	Temp= 190.00	
Pipe: 17.00	ID = 3.626	Flow = 144.01		Vel = 4.475		100.00% Vel
	Turbulent f = 0.0179		Reynold's Number = 3.7615E+05			
N1: CS9		Press= 2,323.84	Elev= 592.00	Flow= 0.00	Temp= 190.00	
N2: CS16		Press= 2,324.86	Elev= 588.50	Flow= 0.00	Temp= 190.00	
Pipe: 18.00	ID = 3.626	Flow = 144.01		Vel = 4.475		
	Turbulent f = 0.0179		Reynold's Number = 3.7615E+05			
N1: CS16		Press= 2,324.86	Elev= 588.50	Flow= 0.00	Temp= 190.00	
N2: CS15		Press= 2,321.33	Elev= 596.17	Flow= 0.00	Temp= 190.00	
Pipe: 19.00	ID = 2.626	Flow = 144.01		Vel = 8.531		
	Turbulent f = 0.0187		Reynold's Number = 5.1939E+05			
N1: CS15		Press= 2,321.33	Elev= 596.17	Flow= 0.00	Temp= 190.00	
N2: CS17		Press= 2,283.15	Elev= 594.58	Flow= 0.00	Temp= 190.00	
Pipe: 20.00	ID = 2.626	Flow = 144.01		Vel = 8.531		
	Turbulent f = 0.0187		Reynold's Number = 5.1939E+05			
N1: CS17		Press= 2,283.15	Elev= 594.58	Flow= 0.00	Temp= 190.00	
N2: CS18		Press= 2,279.61	Elev= 596.08	Flow= 0.00	Temp= 190.00	
Pipe: 21.00	ID = 2.626	Flow = 100.01		Vel = 5.925		
	Turbulent f = 0.0190		Reynold's Number = 3.6069E+05			
N1: CS18		Press= 2,279.61	Elev= 596.08	Flow= 0.00	Temp= 190.00	
N2: CS19		Press= 2,282.08	Elev= 588.50	Flow= 0.00	Temp= 190.00	
Pipe: 22.00	ID = 2.626	Flow = 100.01		Vel = 5.925		
	Turbulent f = 0.0190		Reynold's Number = 3.6069E+05			
N1: CS19		Press= 2,282.08	Elev= 588.50	Flow= 0.00	Temp= 190.00	
N2: CS19A		Press= 2,281.67	Elev= 588.50	Flow= 0.00	Temp= 190.00	
Pipe: 23.00	ID = 2.626	Flow = 100.01 ++		Vel = 5.925		
	Turbulent f = 0.0190		Reynold's Number = 3.6069E+05			
N1: CS19A		Press= 2,281.67	Elev= 588.50	Flow= 0.00	Temp= 190.00	
N2: CS19B		Press= 2,161.75	Elev= 594.50	Flow= 0.00	Temp= 190.00	
Pipe: 24.00	ID = 2.626	Flow = 100.01		Vel = 5.925		100.00% Vel
	Turbulent f = 0.0190		Reynold's Number = 3.6069E+05			
N1: CS19B		Press= 2,161.75	Elev= 594.50	Flow= 0.00	Temp= 190.00	
N2: CS19C		Press= 2,087.86	Elev= 613.75	Flow= 0.00	Temp= 190.00	

!! Reverse Flow Thru Check Valve
++ Section Was Balanced
** Fixed Pressure
%% Pressure Below Vapor Pressure
?? Temperature Outside Fluid Property Range
NPSHA less than NPSHR
&& Flow Past End of Pump Curve

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Cook Plant - ECCS/CCP System

Combined Output Report

Convergence: Pressure=1.0E-5 Sum Q=1.0E-2 Friction=1.0E-6 FCV=1.0E-4 PCV=1.0E-3 Temperature=5.0E-3 - Balancing Parameters Used

Pipe: 25.00	ID = 2.626	Flow = 54.02		Vel = 3.200			100.00% Vel
	Turbulent f = 0.0198		Reynold's Number = 1.9484E+05				
N1: CS19C		Press= 2,087.86	Elev= 613.75	Flow= 0.00		Temp= 190.00	
N2: CS20		** Press= 2,085.00	Elev= 615.75	Flow= 0.00		Temp= 190.00	
Pipe: 26.00	ID = 2.626	Flow = 45.99		Vel = 2.724			100.00% Vel
	Turbulent f = 0.0200		Reynold's Number = 1.6585E+05				
N1: CS19C		Press= 2,087.86	Elev= 613.75	Flow= 0.00		Temp= 190.00	
N2: CS21		** Press= 2,085.00	Elev= 615.75	Flow= 0.00		Temp= 190.00	
Pipe: 35.00	ID = 2.626	Flow = 44.00		Vel = 2.607			
	Turbulent f = 0.0201		Reynold's Number = 1.5870E+05				
N1: CS18		Press= 2,279.61	Elev= 596.08	Flow= 0.00		Temp= 190.00	
N2: CS30		Press= 2,277.04	Elev= 601.81	Flow= 0.00		Temp= 190.00	
Pipe: 36.00	ID = 2.626	Flow = 44.00		Vel = 2.607			
	Turbulent f = 0.0201		Reynold's Number = 1.5870E+05				
N1: CS30		Press= 2,277.04	Elev= 601.81	Flow= 0.00		Temp= 190.00	
N2: CS31		Press= 2,280.91	Elev= 591.75	Flow= 0.00		Temp= 190.00	
Pipe: 37.00	ID = 2.626	Flow = 44.00		Vel = 2.607			
	Turbulent f = 0.0201		Reynold's Number = 1.5870E+05				
N1: CS31		Press= 2,280.91	Elev= 591.75	Flow= 0.00		Temp= 190.00	
N2: CS32		Press= 2,280.86	Elev= 591.75	Flow= 0.00		Temp= 190.00	
Pipe: 38.00	ID = 1.689	Flow = 44.00		Vel = 6.301			
	Turbulent f = 0.0211		Reynold's Number = 2.4674E+05				
N1: CS32		Press= 2,280.86	Elev= 591.75	Flow= 0.00		Temp= 190.00	
N2: CS33		Press= 2,279.64	Elev= 587.84	Flow= 0.00		Temp= 190.00	
Pipe: 43.00	ID = 2.626	Flow = 44.00		Vel = 2.607			
	Turbulent f = 0.0201		Reynold's Number = 1.5870E+05				
N1: CS33		Press= 2,279.64	Elev= 587.84	Flow= 0.00		Temp= 190.00	
N2: CS37		Press= 2,279.55	Elev= 587.84	Flow= 0.00		Temp= 190.00	
Pipe: 44.00	ID = 2.626	Flow = 44.00		Vel = 2.607			
	Turbulent f = 0.0201		Reynold's Number = 1.5870E+05				
N1: CS37		Press= 2,279.55	Elev= 587.84	Flow= 0.00		Temp= 190.00	
N2: CS38		Press= 2,279.49	Elev= 587.84	Flow= 0.00		Temp= 190.00	
Pipe: 45.00	ID = 2.626	Flow = 44.00		Vel = 2.607			
	Turbulent f = 0.0201		Reynold's Number = 1.5870E+05				
N1: CS38		Press= 2,279.49	Elev= 587.84	Flow= 0.00		Temp= 190.00	
N2: CS39		Press= 2,276.66	Elev= 594.00	Flow= 0.00		Temp= 190.00	

!! Reverse Flow Thru Check Valve
++ Section Was Balanced
** Fixed Pressure
%% Pressure Below Vapor Pressure
?? Temperature Outside Fluid Property Range
NPSHA less than NPSHR
&& Flow Past End of Pump Curve

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Cook Plant - ECCS/CCP System

Combined Output Report

Convergence: Pressure=1.0E-5 Sum Q=1.0E-2 Friction=1.0E-6 FCV=1.0E-4 PCV=1.0E-3 Temperature=5.0E-3 - Balancing Parameters Used

Pipe: 46.00	ID = 1.689	Flow = 11.00	++	Vel = 1.575				100.00% Vel
	Turbulent f = 0.0236		Reynold's Number = 6.1685E+04					
N1: CS39		Press= 2,276.66	Elev= 594.00	Flow= 0.00		Temp= 190.00		
N2: CS40		Press= 2,085.38	Elev= 616.50	Flow= 0.00		Temp= 190.00		
Pipe: 47.00	ID = 1.689	Flow = 11.00		Vel = 1.575				100.00% Vel
	Turbulent f = 0.0236		Reynold's Number = 6.1685E+04					
N1: CS40		Press= 2,085.38	Elev= 616.50	Flow= 0.00		Temp= 190.00		
N2: CS41		Press= 2,085.30	Elev= 616.50	Flow= 0.00		Temp= 190.00		
Pipe: 48.00	ID = 1.338	Flow = 11.00		Vel = 2.510				
	Turbulent f = 0.0238		Reynold's Number = 7.7867E+04					
N1: CS41		Press= 2,085.30	Elev= 616.50	Flow= 0.00		Temp= 190.00		
N2: CS42		** Press= 2,085.00	Elev= 616.94	Flow= 0.00		Temp= 190.00		
Pipe: 49.00	ID = 2.626	Flow = 33.00		Vel = 1.955				
	Turbulent f = 0.0207		Reynold's Number = 1.1902E+05					
N1: CS39		Press= 2,276.66	Elev= 594.00	Flow= 0.00		Temp= 190.00		
N2: CS43		Press= 2,276.32	Elev= 594.75	Flow= 0.00		Temp= 190.00		
Pipe: 50.00	ID = 1.689	Flow = 11.00	++	Vel = 1.575				100.00% Vel
	Turbulent f = 0.0236		Reynold's Number = 6.1685E+04					
N1: CS43		Press= 2,276.32	Elev= 594.75	Flow= 0.00		Temp= 190.00		
N2: CS44		Press= 2,085.13	Elev= 616.94	Flow= 0.00		Temp= 190.00		
Pipe: 51.00	ID = 1.689	Flow = 11.00		Vel = 1.575				100.00% Vel
	Turbulent f = 0.0236		Reynold's Number = 6.1685E+04					
N1: CS44		Press= 2,085.13	Elev= 616.94	Flow= 0.00		Temp= 190.00		
N2: CS45		Press= 2,085.09	Elev= 616.94	Flow= 0.00		Temp= 190.00		
Pipe: 52.00	ID = 1.338	Flow = 11.00		Vel = 2.510				
	Turbulent f = 0.0238		Reynold's Number = 7.7867E+04					
N1: CS45		Press= 2,085.09	Elev= 616.94	Flow= 0.00		Temp= 190.00		
N2: CS46		** Press= 2,085.00	Elev= 616.94	Flow= 0.00		Temp= 190.00		
Pipe: 53.00	ID = 2.626	Flow = 22.00		Vel = 1.303				
	Turbulent f = 0.0217		Reynold's Number = 7.9350E+04					
N1: CS43		Press= 2,276.32	Elev= 594.75	Flow= 0.00		Temp= 190.00		
N2: CS47		Press= 2,276.00	Elev= 595.50	Flow= 0.00		Temp= 190.00		
Pipe: 54.00	ID = 2.626	Flow = 11.00	++	Vel = 0.652				100.00% Vel
	Turbulent f = 0.0240		Reynold's Number = 3.9675E+04					
N1: CS47		Press= 2,276.00	Elev= 595.50	Flow= 0.00		Temp= 190.00		
N2: CS48		Press= 2,084.23	Elev= 619.00	Flow= 0.00		Temp= 190.00		

Reverse Flow Thru Check Valve
++ Section Was Balanced
** Fixed Pressure
%% Pressure Below Vapor Pressure
?? Temperature Outside Fluid Property Range
NPSHA less than NPSHR
&& Flow Past End of Pump Curve

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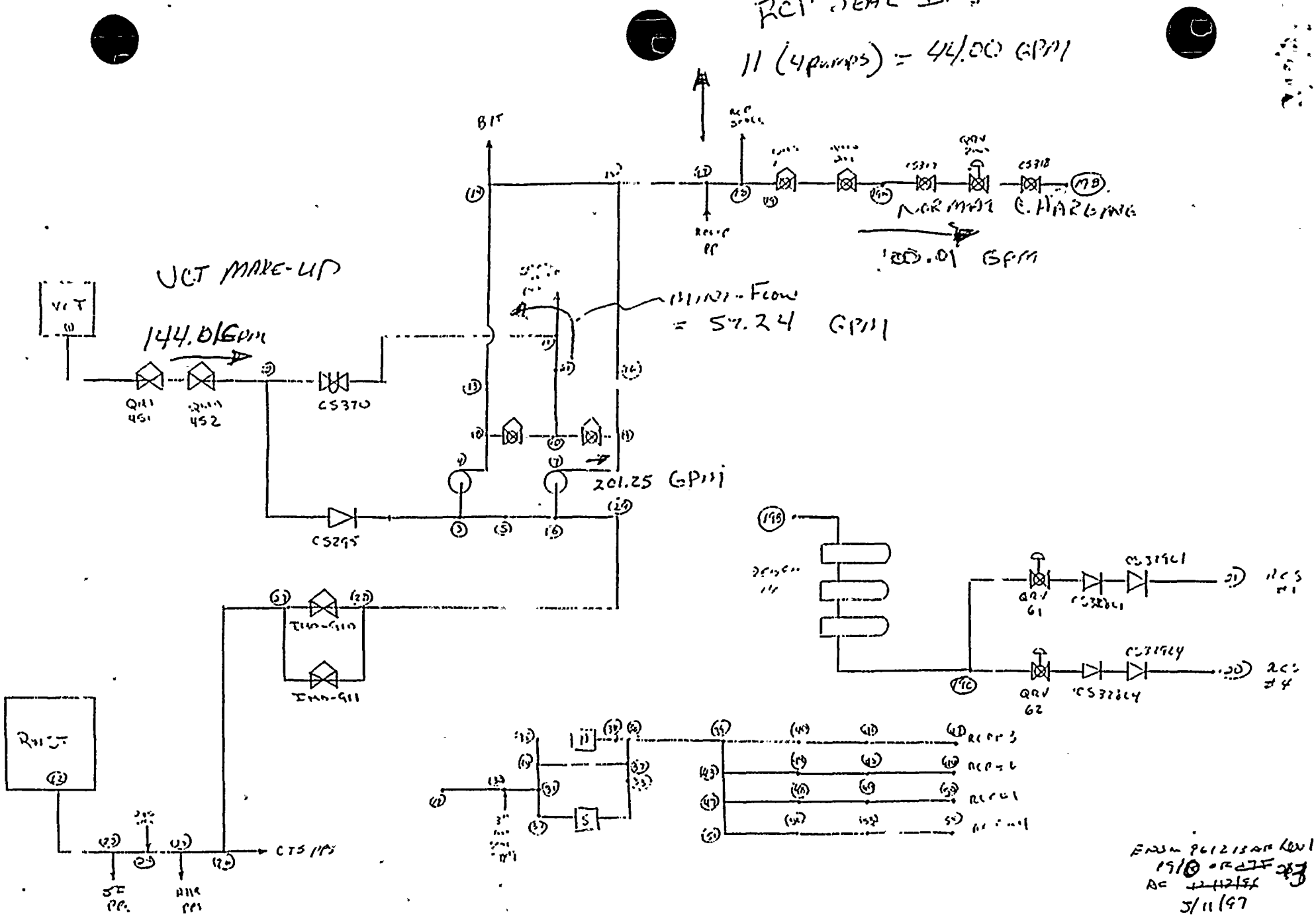
Cook Plant - ECCS/CCP System

Combined Output Report

Convergence: Pressure=1.0E-5 Sum Q=1.0E-2 Friction=1.0E-6 FCV=1.0E-4 PCV=1.0E-3 Temperature=5.0E-3 - Balancing Parameters Used

Pipe: 55.00	ID = 2.626	Flow = 11.00		Vel = 0.652				100.00% Vel
	Turbulent f = 0.0240		Reynold's Number = 3.9675E+04					
N1: CS48		Press= 2,084.23		Elev= 619.00		Flow= 0.00		Temp= 190.00
N2: CS49		Press= 2,085.63		Elev= 615.58		Flow= 0.00		Temp= 190.00
Pipe: 56.00	ID = 1.338	Flow = 11.00		Vel = 2.510				
	Turbulent f = 0.0238		Reynold's Number = 7.7867E+04					
N1: CS49		Press= 2,085.63		Elev= 615.58		Flow= 0.00		Temp= 190.00
N2: CS50		** Press= 2,085.00		Elev= 616.94		Flow= 0.00		Temp= 190.00
Pipe: 57.00	ID = 2.626	Flow = 11.00		Vel = 0.652				
	Turbulent f = 0.0240		Reynold's Number = 3.9675E+04					
N1: CS47		Press= 2,276.00		Elev= 595.50		Flow= 0.00		Temp= 190.00
N2: CS51		Press= 2,275.68		Elev= 596.25		Flow= 0.00		Temp= 190.00
Pipe: 58.00	ID = 2.626	Flow = 11.00	++	Vel = 0.652				100.00% Vel
	Turbulent f = 0.0240		Reynold's Number = 3.9675E+04					
N1: CS51		Press= 2,275.68		Elev= 596.25		Flow= 0.00		Temp= 190.00
N2: CS52		Press= 2,085.33		Elev= 616.50		Flow= 0.00		Temp= 190.00
Pipe: 59.00	ID = 2.626	Flow = 11.00		Vel = 0.652				100.00% Vel
	Turbulent f = 0.0240		Reynold's Number = 3.9675E+04					
N1: CS52		Press= 2,085.33		Elev= 616.50		Flow= 0.00		Temp= 190.00
N2: CS53		Press= 2,085.30		Elev= 616.50		Flow= 0.00		Temp= 190.00
Pipe: 60.00	ID = 1.338	Flow = 11.00		Vel = 2.510				
	Turbulent f = 0.0238		Reynold's Number = 7.7867E+04					
N1: CS53		Press= 2,085.30		Elev= 616.50		Flow= 0.00		Temp= 190.00
N2: CS54		** Press= 2,085.00		Elev= 616.94		Flow= 0.00		Temp= 190.00

: Reverse Flow Thru Check Valve
++ Section Was Balanced
** Fixed Pressure
%% Pressure Below Vapor Pressure
?? Temperature Outside Fluid Property Range .
NPSHA less than NPSHR
&& Flow Past End of Pump Curve


RCP SEAL INJ.
11 (4 pumps) = 44.00 GPM
BIT
NORMAL CHARGING
100.01 GPM
VCT MAKE-UP
144.01 GPM
MINI-FLOW
= 57.24 GPM
201.25 GPM
VCT
QRV 451
QRV 452
CS370
CS295
QRV 61
QRV 62
RCP 3
RCP 2
RCP 1
RCP 4
RWST
CTS
SI PP.
RHR PP.
ECCS #1
ECCS #4