NE-014
(02/95)

NUCLEAR ENGINEERING DEPARTMENT

Calculation Cover Sheet
Cook Nuclear Plant

NSP SECTION SHEET 1 OF 17

CALCULATION No. NESP032395JWS

SAFETY RELATED YES X NO ___

SYSTEM CVCS-Boron Make Up

TITLE Bat Pump NPSHR VS Bast Level

RFC/MM/PM/PR/CR/TM No. N/A

FILE LOCATION CVC

INDIANA MICHIGAN POWER COMPANY

UNIT No. 1

CALCULATED BY: Jack T. Creiglow 6/2/95 DATE

VERIFIED BY: ~~JTS~~ atw 6/26/95 DATE

APPROVED BY: [signature] 6/29/95 DATE

CALCULATION DESCRIPTION: Determine the NSPH required, NPSH available and boric acid storage tank level (minimum) in order to supply boric acid solution to the boric acid transfer pumps under a severe accident scenario. (Using Proto-Flo software for calculation)

METHOD OF VERIFICATION: ALTERNATE CALCULATION ✓ DESIGN REVIEW ___

REVISION

NO.	REASON FOR CHANGE	Calculated By	Date	Verified By	Date	Approved By	Date
1	Using Proto-Flo to get a more accurate calculation.	JTC	6/2/95	~~JTS~~	6/26/95	[signature]	6/29/95

NE-015
(02/95)

DONALD C. COOK NUCLEAR PLANT

NESP Section —

DESIGN VERIFICATION CHECKLIST - CALCULATIONS

Calculation Number NESP032395WS Rev. 1

Signature of Verifier 6/26/95 Date

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

Basis: Inputs Include: Protoflo Computer Program; Isometric Dwg's; Pump Curve; Valve Dwg. & Hydraulic Data

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

Basis: Assumptions Listed Are Reasonable For A NPSH / Pressure Drop Calculation

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 Required For This Calculation.

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

Basis: Standard NPSH / Pressure Drop Calculation

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

Basis: Under Conservative Conditions, The Calculation Proved That The Currently Installed Equipment Will Function As Designed.

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

Basis: The Verification Calculation Has Shown That The Results Are Within Reasonable Accuracy of A Hydraulic Analysis.

$NPSH_a = h_a - h_{vpr} + h_{st} - h_{fs}$

h_a = atmospheric pressure

= 33.96 ft H_2O

h_{vpr} = vapor pressure of solution @ 180°F

= (7.511 psi)(2.377 ft/psi)

= 17.85 ft H_2O

h_{st} = static head (From bottom of tank)

= (589.427' − 588.53')

= 0.897 ft H_2O

h_{fs} = Frictional losses

= (4.404') + (3.476') + (3.290')

= 11.17 ft H_2O

$NPSH_a$ = (33.96') − (17.85') + (0.89') − (11.17')

= 5.83 ft H_2O

$NPSH_R - NPSH_a$ = 5.9 ft − 5.83 ft

= 0.07 ft × 12 $\frac{in}{ft}$

= 0.84 in above tank discharge

∴ ProtoFlo calculated the required level in the BAST to be 3.93 in above tank discharge to attain the pump's $NPSH_R$. The manually calculated value of 0.84 in is within reasonable accuracy of hydraulic analysis, thus proving the ProtoFlo calculated value [illegible]

06-02-1995 11:32 PROTOFLO 2.01 by PROTO-POWER CORPORATION Page 1

Utility - D:\PROTOFLO\JIM.PDB - Version

Plant - System

Combined Summary 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

Pipe: 1.00	ID = 2.067	Flow = 75.00		Vel = 7.172		
	Turbulent f = 0.0200		Reynold's Number = 3.2281E+05			
N1: NODE1		** Press= 14.84	Elev= 589.43	Flow= 0.00	Temp= 180.00	
N2: NODE2		Press= 12.98	Elev= 588.53	Flow= 0.00	Temp= 180.00	
		1.86 x 2.377 = 4.42 Ft H_2O				
Pipe: 2.00	ID = 2.067	Flow = 75.00		Vel = 7.172		
	Turbulent f = 0.0200		Reynold's Number = 3.2281E+05			
N1: NODE2		Press= 12.98	Elev= 588.53	Flow= 0.00	Temp= 180.00	
N2: NODE3		Press= 11.52	Elev= 588.53	Flow= 0.00	Temp= 180.00	
		1.46 x 2.377 = 3.47 Ft H_2O				
Pipe: 3.00	ID = 2.067	Flow = 75.00		Vel = 7.172		
	Turbulent f = 0.0200		Reynold's Number = 3.2281E+05			
N1: NODE3		Press= 11.52	Elev= 588.53	Flow= 0.00	Temp= 180.00	
N2: NODE4		Press= 10.14	Elev= 588.53	Flow= 0.00	Temp= 180.00	
		1.38 x 2.377 = 3.28 Ft H_2O				
Pipe: 4.00	ID = 2.067	Flow = 75.00		NPSHA = 5.97	NPSHR = 5.90	
N1: NODE4		Press= 10.14	Elev= 588.53	Flow= 0.00	Temp= 180.00	
N2: NODE5		Press= 110.67	Elev= 588.53	Flow= 0.00	Temp= 180.00	
Pipe: 5.00	ID = 2.067	Flow = 75.00		Vel = 7.172		
	Turbulent f = 0.0200		Reynold's Number = 3.2281E+05			
N1: NODE5		Press= 110.67	Elev= 588.53	Flow= 0.00	Temp= 180.00	
N2: NODE6		Press= 110.28	Elev= 588.53	Flow= 0.00	Temp= 180.00	
Pipe: 10.00	ID = 2.067	Flow = 75.00		Vel = 7.172		
	Turbulent f = 0.0200		Reynold's Number = 3.2281E+05			
N1: NODE6		Press= 110.28	Elev= 588.53	Flow= 0.00	Temp= 180.00	
N2: NODE6.5		** Press= 33.70	Elev= 592.50	Flow= 0.00	Temp= 180.00	

TOTAL HEAD LOSS

h_{fs} = 11.17 Ft H_2O

CALCULATION NO. NESP032395MS, REV. 1
VERIFICATION
PAGE 2 OF 2

** Fixed Pressure
%% Pressure Below Vapor Pressure
NPSHA less than NPSHR

!! Reverse Flow Thru Check Valve
++ Section Was Balanced
&& Flow Past End of Pump Curve

CALC. NO. : NESP032395JJS
REV. 1
SHEET: 2 OF 17
DATE: 6/2/95
COMPANY: I&M
PLANT: DCCNP

SUBJECT: BAT PUMP NPSHR vs BAST LEVEL

DESCRIPTION

Model the boric acid tank to the boric acid transfer pump using proto-flo, placing a valve at the end of the model to throttle the pump to 75 GPM. Then changing the atmospheric pressure at the base of the tank until the NSPH available is as close as possible to the NPSH required. This will give the lowest pressure at the base of the tank before the pumps can no longer be supplied with the boric acid solution to maintain 75 GPM out of the transfer pumps. The pressure then can be converted to show the lowest level required to the pumps and have a 75 GPM out put.

PURPOSE

The result of the calculation will be used in the development of NEW Severe Accident Management Guidelines. In the event that an accident progresses to core melt, where emergency operating procedures are no longer valid, these guidelines would be used.

ASSUMPTION & LIMITATIONS

1) BORIC ACID SOLUTION TEMPERATURE = 180°F
2) BORIC ACID SOLUTION HAS SAME VAPOR PRESSURE AS WATER(≈)
3) BORIC ACID SPECIFIC GRAVITY EQUAL TO WATER
4) TANK AT ATMOSPHERIC PRESSURE
5) BORIC ACID TRANSFER PUMP OPERATING AT 75 GPM

RESULTS

1) NSPH required to supply 75 GPM = 5.90 ft.
2) Pressure at the bottom of tank is 14.84 psia, when converted to a tank level it equals .3328' or ≈3 15/16" from the bottom of the tank.

CONCLUSIONS

The minimum BAST tank level that is acceptable to operate the BAT pumps while still having adequate NPSH and supplying 75 GPM is 3 15/16" of boric acid solution form the bottom of the tank.

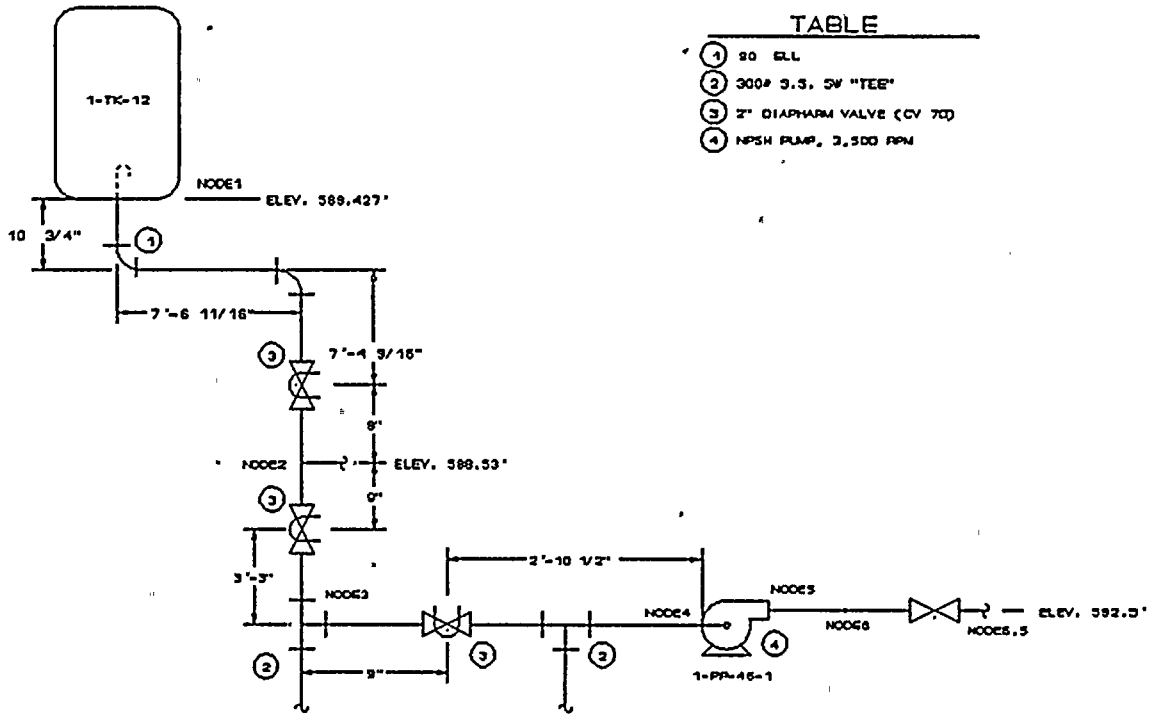
CALC. NO. : NESP032395JJS
REV. 1
SHEET: 3 OF 17
DATE: 6/2/95
COMPANY: I&M
PLANT: DCCNP

SUBJECT: BAT PUMP NPSHR vs BAST LEVEL

REFERENCES

1) CAMERON HYDRAULIC DATA: PROPERTIES OF WATER AT VARIOUS TEMP. (CONVERSION FACTOR FT/LB/IN^2)
2) AEPSC ISOMETRIC DWG. 0-CS-539L1.4
3) AEPSC VALVE DWG W-200D42ZG0 FOR 2" DIAPHRAGM VALVE
4) AEPSC FLOW DIAGRAM ED 12-5131
5) PUMP CURVE FOR PP-46
6) PROTO-FLO SOFTWARE FOR WINDOWS VERSION 2.01 (DATE AND TIME OF RUNS SHOWN ON OUT PUT DATA SHEETS)
7) IBM PERSONAL SYSTEM/2 MODEL 77 486DX2 COMPUTER WITH OS2 SYSTEM (PROTO-FLO OPERATES UNDER OS2 WINDOWS APPLICATION)

SKETCH



PROTO-FLO 2.01 by PROTO-POWER CORPORATION

Utility - D:\PROTOFLO\JIM.PDB - Version

Plant - System

Hydraulic Resistance 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

Pipe	From Node	To Node	ID (Inches)	Flow (gpm)	DZ (feet)	Velocity (ft/s	Reynolds Number	Pressure Drop (feet)	Pressure Drop (psi)	Hydraulic Resistance (ft/gpm^2)	Hydraulic Resistance (psi/gpm^2)
1.00	NODE1	NODE2	2.067	75.00	1.85	7.172	3.2281E+05	5.314	2.235	9.4470E-04	3.9739E-04
2.00	NODE2	NODE3	2.067	75.00	1.46	7.172	3.2281E+05	3.476	1.462	6.1800E-04	2.5996E-04
3.00	NODE3	NODE4	2.067	75.00	1.38	7.172	3.2281E+05	3.290	1.384	5.8494E-04	2.4606E-04
5.00	NODE5	NODE6	2.067	75.00	0.38	7.172	3.2281E+05	0.926	0.389	1.6470E-04	6.9281E-05
10.00	NODE6	NODE6.5	2.067	75.00	76.58	7.172	3.2281E+05	178.083	74.911	3.1657E-02	1.3317E-02

Calc No: NESP 032395 JJS
Rev. 1
Sheet 4 of 17

Utility - D:\PROTOFLO\JIM.PDB - Version
Plant - System

Pump Status Report

Pump Name:	1-PP-46-1	Manufacturer:		Model:	
	Drawings:				
	Pump Status:	BAST			
	Speed (RPM):	3,500	Flow (gpm): 75.00	Head (ft):	239.00
	Hydraulic Horsepower: 4.40				
	Pump Impeller Elevation (ft):		Inlet Node Elevation (ft): 588.53		
	Pump Suction Temperature (°F) 180.00				
	NPSH Curve:	BAST NPSH			
	NPSH Available: 5.97		NPSH Required: 5.90		

Pump Name:	1-PP-46-2	Manufacturer:		Model:	
	Drawings:				
	Pump Status:	OFF			
	Speed (RPM):	3,500	Flow (gpm):	Head (ft):	
	Hydraulic Horsepower:				
	Pump Impeller Elevation (ft):		Inlet Node Elevation (ft): 588.53		
	Pump Suction Temperature (°F)				
	NPSH Curve:	BAST NPSH			
	NPSH Available:		NPSH Required:		

Utility - D:\PROTOFLO\JIM.PDB - Version
Plant - System

Boundary Condition Report

Node Name	Boundary Type	Boundary Parameters	
NODE1	Pressure Suction	Pressure	14.84 psia
		Elevation	589.43 ft
		Specified Temperature	180.00 °F
NODE10	Pressure Discharge	Pressure	33.70 psia
		Elevation	592.50 ft
		Specified Temperature	180.00 °F
NODE6.5	Pressure Discharge	Pressure	33.70 psia
		Elevation	592.50 ft
		Specified Temperature	180.00 °F

14.84 psia - 14.7 = .14 x 2.377 = .3328' ≈ 3 15/16

Utility - D:\PROTOFLO\JIM.PDB - Version
Plant - System

Combined Summary 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

Pipe: 1.00	ID = 2.067	Flow = 75.00		Vel = 7.172		
	Turbulent f = 0.0200		Reynold's Number = 3.2281E+05			
N1: NODE1		** Press= 14.84	Elev= 589.43	Flow= 0.00	Temp= 180.00	
N2: NODE2		Press= 12.98	Elev= 588.53	Flow= 0.00	Temp= 180.00	
Pipe: 2.00	ID = 2.067	Flow = 75.00		Vel = 7.172		
	Turbulent f = 0.0200		Reynold's Number = 3.2281E+05			
N1: NODE2		Press= 12.98	Elev= 588.53	Flow= 0.00	Temp= 180.00	
N2: NODE3		Press= 11.52	Elev= 588.53	Flow= 0.00	Temp= 180.00	
Pipe: 3.00	ID = 2.067	Flow = 75.00		Vel = 7.172		
	Turbulent f = 0.0200		Reynold's Number = 3.2281E+05			
N1: NODE3		Press= 11.52	Elev= 588.53	Flow= 0.00	Temp= 180.00	
N2: NODE4		Press= 10.14	Elev= 588.53	Flow= 0.00	Temp= 180.00	
Pipe: 4.00	ID = 2.067	Flow = 75.00	NPSHA = 5.97		NPSHR = 5.90	
N1: NODE4		Press= 10.14	Elev= 588.53	Flow= 0.00	Temp= 180.00	
N2: NODE5		Press= 110.67	Elev= 588.53	Flow= 0.00	Temp= 180.00	
Pipe: 5.00	ID = 2.067	Flow = 75.00		Vel = 7.172		
	Turbulent f = 0.0200		Reynold's Number = 3.2281E+05			
N1: NODE5		Press= 110.67	Elev= 588.53	Flow= 0.00	Temp= 180.00	
N2: NODE6		Press= 110.28	Elev= 588.53	Flow= 0.00	Temp= 180.00	
Pipe: 10.00	ID = 2.067	Flow = 75.00		Vel = 7.172		
	Turbulent f = 0.0200		Reynold's Number = 3.2281E+05			
N1: NODE6		Press= 110.28	Elev= 588.53	Flow= 0.00	Temp= 180.00	
N2: NODE6.5		** Press= 33.70	Elev= 592.50	Flow= 0.00	Temp= 180.00	

** Fixed Pressure
%% Pressure Below Vapor Pressure
NPSHA less than NPSHR

!! Reverse Flow Thru Check Valve
++ Section Was Balanced
&& Flow Past End of Pump Curve

System Pipe Section Data Sheet

From: NODE1	Elev: 589.43	To: NODE2	Elev: 588.53

Description:
Drawings:

Fluid: Fresh Water

Material Roughness: 0.000150 Carbon Steel

2.000 inch Schedule: STD 40 - Inside Diameter: 2.067

Length: 16.58 Misc L/D: Misc K Fixed:

Valves: 1-CS-437N / /

Pipe Flow Summary Title:

Tees: 1 Run; Branch Only; Branch

Elbows: Welded - , 2 90s, 45s; **Threaded -** 90s, 45s

Bends: with angle = , r/d =
with angle = , r/d =

Entrances: 1 **Abrupt Reductions from d =**
Exits: **Abrupt Expansions to d =**

System Pipe Section Data Sheet

From: NODE2 Elev: 588.53 To: NODE3 Elev: 588.53

Description:
Drawings:

Fluid: Fresh Water

Material Roughness: 0.000150 Carbon Steel

2.000 inch Schedule: STD 40 - Inside Diameter: 2.067

Length: 4.00 Misc L/D: Misc K Fixed:

Valves: 1-CS-410 / /

Pipe Flow Summary Title:

Tees: Run; 1 Branch Only; Branch

Elbows: Welded - 90s, 45s; Threaded - 90s, 45s

Bends: with angle = , r/d =
with angle = , r/d =

Entrances: Abrupt Reductions from d =
Exits: Abrupt Expansions to d =

System Pipe Section Data Sheet

From: NODE3 Elev: 588.53 To: NODE4 Elev: 588.53

Description:
Drawings:

Fluid: Fresh Water

Material Roughness: 0.000150 Carbon Steel

2.000 inch Schedule: STD 40 - Inside Diameter: 2.067

Length: 3.63 Misc L/D: Misc K Fixed:

Valves: 1-CS-412-1 / /

Pipe Flow Summary Title:

Tees: 1 Run; Branch Only; Branch

Elbows: Welded - 90s, 45s; Threaded - 90s, 45s

Bends: with angle = , r/d =
with angle = , r/d =

Entrances: Abrupt Reductions from d =
Exits: Abrupt Expansions to d =

System Pipe Section Data Sheet

From: NODE4	Elev: 588.53	To: NODE5	Elev: 588.53

Description:
Drawings:

Fluid: Fresh Water

Material Roughness: 0.000150 Carbon Steel

2.000 inch Schedule: STD 40 - Inside Diameter: 2.067

Length: 0.00 **Misc L/D:** **Misc K Fixed:**

Pump: 1-PP-46-1

Pipe Flow Summary Title:

Tees: Run; Branch Only; Branch

Elbows: Welded - 90s, 45s; **Threaded -** 90s, 45s

Bends: with angle = , r/d =
with angle = , r/d =

Entrances: Abrupt Reductions from d =
Exits: Abrupt Expansions to d =

System Pipe Section Data Sheet

From: NODE5	Elev: 588.53	To: NODE6	Elev: 588.53

Description:
Drawings:

Fluid: Fresh Water

Material Roughness: 0.000150 Carbon Steel

2.000 inch Schedule: STD 40 - Inside Diameter: 2.067

Length: 10.00 Misc L/D: Misc K Fixed:

Pipe Flow Summary Title:

Tees: Run; Branch Only; Branch

Elbows: Welded - 90s, 45s; **Threaded -** 90s, 45s

Bends: with angle = , r/d =
with angle = , r/d =

Entrances: Abrupt Reductions from d =
Exits: Abrupt Expansions to d =

System Pipe Section Data Sheet

From: NODE2 Elev: 588.53 To: NODE7 Elev: 588.53

Description:
Drawings:

Fluid: Fresh Water

Material Roughness: 0.000150 Carbon Steel

2.000 inch Schedule: STD 40 - Inside Diameter: 2.067

Length: 3.63 Misc L/D: Misc K Fixed:

Valves: 1-CS-412-2 / /

Pipe Flow Summary Title:

Tees: 1 Run; Branch Only; 1 Branch

Elbows: Welded - 90s, 45s; Threaded - 90s, 45s

Bends: with angle = , r/d =
with angle = , r/d =

Entrances: Abrupt Reductions from d =
Exits: Abrupt Expansions to d =

System Pipe Section Data Sheet

From: NODE7 Elev: 588.53 To: NODE8 Elev: 588.53

Description:
Drawings:

Fluid: Fresh Water

Material Roughness: 0.000150 Carbon Steel

2.000 inch Schedule: STD 40 - Inside Diameter: 2.067

Length: 0.00 Misc L/D: Misc K Fixed:

Pump: 1-PP-46-2

Pipe Flow Summary Title:

Tees: Run; Branch Only; Branch

Elbows: Welded - 90s, 45s; Threaded - 90s, 45s

Bends: with angle = , r/d =
with angle = , r/d =

Entrances: Abrupt Reductions from d =
Exits: Abrupt Expansions to d =

System Pipe Section Data Sheet

From: NODE8	Elev: 588.53	To: NODE9	Elev: 588.53

Description:
Drawings:

Fluid: Fresh Water

Material Roughness: 0.000150 Carbon Steel

2.000 inch Schedule: STD 40 - Inside Diameter: 2.067

Length: 20.00 Misc L/D: Misc K Fixed:

Pipe Flow Summary Title:

Tees: Run; Branch Only; Branch

Elbows: Welded - 90s, 45s; Threaded - 90s, 45s

Bends: with angle = , r/d =
with angle = , r/d =

Entrances: Abrupt Reductions from d =
Exits: Abrupt Expansions to d =

System Pipe Section Data Sheet

From: NODE9 Elev: 588.53 To: NODE10 Elev: 592.50

Description:
Drawings:

Fluid: Fresh Water

Material Roughness: 0.000150 Carbon Steel

2.000 inch Schedule: STD 40 - Inside Diameter: 2.067

Length: 10.00 Misc L/D: Misc K Fixed:

Valves: test-1 / /

Pipe Flow Summary Title:

Tees: Run; Branch Only; Branch

Elbows: Welded - 90s, 45s; Threaded - 90s, 45s

Bends: with angle = , r/d =
with angle = , r/d =

Entrances: Abrupt Reductions from d =
Exits: Abrupt Expansions to d =

System Pipe Section Data Sheet

From: NODE6	Elev: 588.53	To: NODE6.5	Elev: 592.50

Description:
Drawings:

Fluid: Fresh Water

Material Roughness: 0.000150 Carbon Steel

2.000 inch Schedule: STD 40 - Inside Diameter: 2.067

Length: 10.00 Misc L/D: Misc K Fixed:

Valves: test-1 / /

Pipe Flow Summary Title:

Tees: Run; Branch Only; Branch

Elbows: Welded - 90s, 45s; Threaded - 90s, 45s

Bends: with angle = , r/d =
with angle = , r/d =

Entrances: **Abrupt Reductions from d =**
Exits: **Abrupt Expansions to d =**

N.E.D. RECORD COVER SHEET

COOK NUCLEAR PLANT
NED RECORD-NED COPY
SECTION NESP
ENGINEER DLBates
DATE 4-11-95
☑ PLANT LIFETIME
DATE TO PLANT N/A
☐ NON PERMANENT
MINIMUM RETENTION ___ YRS.

CALCULATION # NESP032395JJS REV. 0
FILE: .CVC

SUBJECT TO: N.E.P. 6.4 (CALCULATIONS)
N.E.P. 17.0 (RECORD RETENTION)
N.E.P. 17.2 (MICROFILMING)

NE-015
(02/95)

DONALD C. COOK NUCLEAR PLANT

NESP Section

DESIGN VERIFICATION CHECKLIST - CALCULATIONS

Calculation Number NESP0225955JS Rev. 0

Signature of Verifier

3/27/95
Date

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

Basis: THE REQUIREMENTS TO CALCULATE NPSH VS. % level per Severe Accident Analysis Guideline was incorporated

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

Basis: All ASSUMPTIONS were checked AGAINST Technical MANUALS, DRAWINGS, ETC.

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

Basis: No codes reqd.

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

Basis: STANDARD NPSH CALCULATION used.

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

Basis: 3-4' HEAD over A pump AT 75 GPMIS REASONABLE.

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

Basis: All Numbers were verified.

NE-Q14
(02/95)

NUCLEAR ENGINEERING DEPARTMENT

Calculation Cover Sheet
Cook Nuclear Plant

NESP SECTION

CALCULATION No. NESP032395 JJS

SAFETY RELATED YES X NO ___

SYSTEM CVCS - BORON MAKE UP

TITLE BAT PUMP NPSHR VS. BAST LEVEL

RFC/MM/PM/PR/CR/TM No. N/A

FILE LOCATION CVC

INDIANA MICHIGAN POWER COMPANY

UNIT No. 1

CALCULATED BY: [signature] 3/28/95 DATE

VERIFIED BY: Mary C. Bost 3/27/95 DATE

APPROVED BY: [signature] 4/11/95 DATE

CALCULATION DESCRIPTION: DETERMINE TIME NPSH REQUIRED, NPSH AVAILABLE AND BORIC ACID STORAGE TANK LEVEL (MINIMUM) IN ORDER TO SUPPLY BORIC ACID SOLUTION TO THE BORIC ACID TRANSFER PUMPS UNDER A SEVERE ACCIDENT SCENARIO.

METHOD OF VERIFICATION: ALTERNATE CALCULATION ___ DESIGN REVIEW ✓

REVISION

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

CALCULATION NO. NESP032395JS

7223(9-83)
FORM GE-8 (C) ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 2 OF 5
DATE 3/23/95 BY JJSatic CK.
COMPANY I & M G.O.
PLANT DCCNP -

SUBJECT BAT PUMP NPSHR VS. BAST LEVEL

DESCRIPTION

DETERMINE THE NPSH AVAILABLE FOR THE BORIC ACID TRANSFER PUMPS WHEN LINED UP TO THE BORIC ACID STORAGE TANKS. THIS MINIMUM NPSH AVAILABLE SHALL RELATE TO A MINIMUM PERCENT OF TANK LEVEL. ONCE DETERMINED, THIS VALUE SHALL BE COMPARED AGAINST THE NPSH REQUIRED FOR THE BORIC ACID TRANSFER PUMPS.

PURPOSE

THE RESULTS OF THIS CALCULATION WILL BE USED IN THE DEVELOPMENT OF NEW SEVERE ACCIDENT MANAGEMENT GUIDELINES, IN THE EVENT THAT AN ACCIDENT PROGRESSES TO CORE MELT, WHERE EMERGENCY OPERATING PROCEDURES ARE NO LONGER VALID, THESE GUIDELINES WOULD BE USED

ASSUMPTIONS & LIMITATIONS

1) BORIC ACID SOLUTION TEMPERATURE = 180°F
2) BORIC ACID SOLUTION HAS SAME VAPOR PRESSURE AS WATER (≈)
3) ATMOSPHERIC PRESSURE = 33.96 ft H_2O
4) BORIC ACID SPECIFIC GRAVITY EQUAL TO WATER
5) BORIC ACID TRANSFER PUMP OPERATING AT 75 gpm
6) BORIC ACID STORAGE TANK 1-TK-12N AND BORIC ACID TRANSFER PUMP 1-PP-46-11 LINED UP

RESULTS

1) NPSH REQUIRED RANGES FROM 4 ft TO 10 ft
   - DESIGN POINT = 6 ft
2) NPSH AVAILABLE AT 7.9% TANK LEVEL (AS INDICATED ON 1-QLA-410) EQUALS 6.0 ft

CONCLUSIONS

THE MINIMUM BAST LEVEL THAT IS ACCEPTABLE TO OPERATE THE BAT PUMPS WHILE STILL HAVING ADEQUATE NPSH AVAILABLE IS 7.9% BAST LEVEL AS INDICATED BY 1-QLA-410.

CALCULATION NO. NESP0323955 NS

7223(9-83)
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

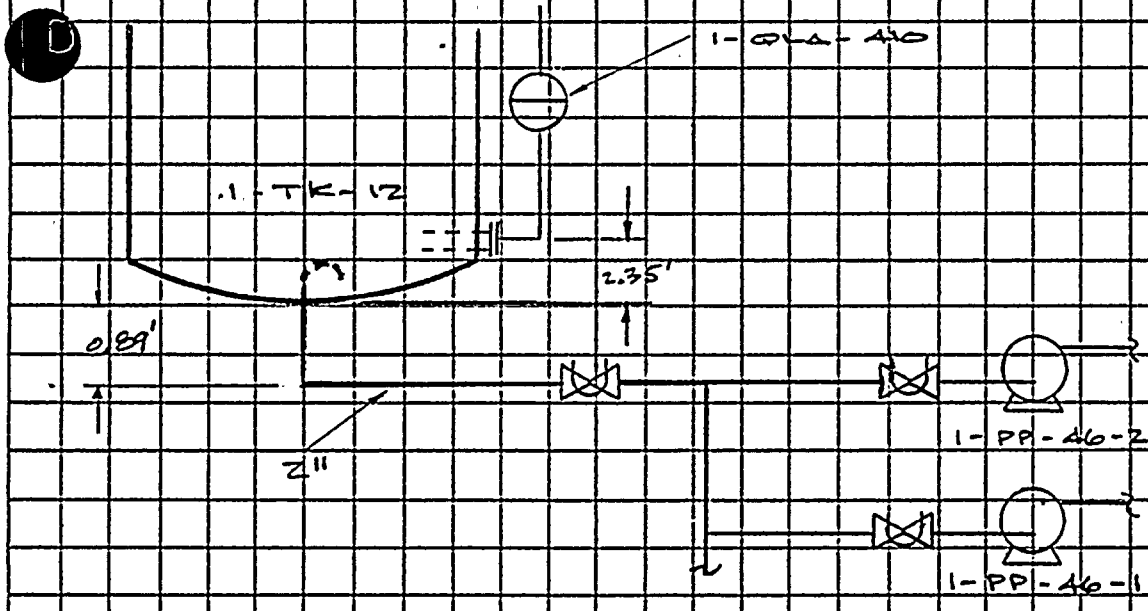
SHEET 3 OF 5
DATE 3/27/95 BY HSW CK.
COMPANY I & M G.O.
PLANT DCCNP

SUBJECT BAT PUMP NPSHR VS. BAST LEVEL

REFERENCES

1) CAMERON HYDRAULIC DATA; INGERSOL - RAND; PP 1-10; 3-16; 3-120
2) CRC HANDBOOK; 66TH ED.; STEAM TABLES; PP E-20
3) CRANE TECHNICAL PAPER 140; 21ST PRINTING, 1982; PP 3-4; EQ. 3-16
4) AEPSC ISOMETRIC DWG. 0-CS-539 U4
5) WESTINGHOUSE DWG. 542F225
6) AEPSC VALVE DWG. M-200D427G0 FOR 21 DIAPHRAGM VALVE
7) AEPSC FLOW DIAGRAM ED 12-5131-34, INCLUDING VALVE LIST
8) PUMP CURVE FOR PP-46; CNP ENGR. BOOK FOR PUMPS
9) ECP NO. 1-2-94-01, Rev. 11 Sheet 3 of 7

SKETCH



CALCULATION NO. NESP032395 MS

7223(9-83)
FORM GE-3 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 4 OF 5
DATE 3/27/95 BY MSutin CK.
COMPANY I & M G.O.
PLANT DCCNP

SUBJECT BAT PUMP NPSHR VS. BAST LEVEL

CALCULATION

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

h_a = absolute pressure
= 33.96 ft

h_{vpa} = vapor pressure @ 180°F (assume H_2O)
= 7.51 psia
= 17.34 ft

h_{-st} = static head
= 2.35 ft From 0% level to discharge
+ 0.89 ft From discharge to pump ℄
= 3.24 ft

h_{fs} = Pipe Suction loss From Tank to pump

=	12' - 2"	12.16
+	7' - 6.75"	7.56
+	0' - 9"	0.75
+	0.89	
+	2' - 10.5"	2.87
+	2(5.17')	10.34 gooseneck + 2 elbows
+	2(5.17')	10.34 elbows
+	2(3.45')	6.9 flow turn T
+	1(10.3')	branch T
=	62.11 ft of pipe	
=	(62.11) x 10.1 ft / 100 ft	
=	6.27 ft	

h_{fs} = 6.27 ft + 3(2.63) + 0.62 ft
h_{fs} = 14.78 ft

DIAPHRAGM VALVES

$\Delta P = \left(\frac{Q}{C_v}\right)^2 \frac{\rho}{62.4}$

$= \left(\frac{75}{70}\right)^2 \frac{62.4}{62.4}$ $C_v = 70$

ΔP = 1.14 psi x 2.31 ft/psi
= 2.63 ft

ENTRANCE LOSSES

$h_f = K \frac{V^2}{2g} = (0.78)\left[\frac{(7.17)^2}{2(32.174)}\right]$

= 0.62 ft

V = velocity
= 7.17 ft/sec

K = 0.78

NPSH = (33.96) + (17.34) + (3.24) - (14.78) = 5.08 ft @ 0% BAST LEVEL

CALCULATION NO. NESP 032395 MS

7223(9-83)
FORM.GE.8(C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 5 OF 5
DATE 3/27/95 BY [illegible] CK.
COMPANY I & M G.O.
PLANT DCCNP

SUBJECT: BAT PUMP $NPSH_R$ VS. BAST LEVEL

$NPSH_R$ = 5.03 FT at 0% BAST LEVEL

THE $NPSH_R$ FOR THE BAT PUMP IS 6 FT @ 75 gpm
THEREFORE AN ADDITIONAL 0.92 FT OF BAST LEVEL
ABOVE 0% IS REQUIRED

FROM ECP No. 1-2-Q4-01 100% BAST LEVEL
EQUALS 139.31" AS INDICATED BY 1-QLA-440

$$0.92' \times \frac{12"}{ft} = 11.04"$$

$$\frac{11.04"}{139.31"} = 0.079 = 7.9\% \text{ BAST LEVEL}$$

VERIFIER'S COPY DC BOSTON

NE-014
(02/95)

NUCLEAR ENGINEERING DEPARTMENT

Calculation Cover Sheet
Cook Nuclear Plant

NESS SECTION

SHEET 1 OF 5

CALCULATION No. NESS-0323-915 JJS

SAFETY RELATED YES X NO ___

SYSTEM CVCS - BORON MAKE UP

TITLE BAT PUMP NPSHR VS. BAST LEVEL

RFC/MM/PM/PR/CR/TM No. N/A

FILE LOCATION CVC

INDIANA MICHIGAN POWER COMPANY

UNIT No. 1

CALCULATED BY: JJSantin DATE

VERIFIED BY: ___ DATE

APPROVED BY: ___ DATE

CALCULATION DESCRIPTION: DETERMINE THE NPSH REQUIRED, NPSH AVAILABLE AND BORIC ACID STORAGE TANK LEVEL (MINIMUM) IN ORDER TO SUPPLY BORIC ACID SOLUTION TO THE BORIC ACID TRANSFER PUMPS UNDER A SEVERE ACCIDENT SCENARIO.

METHOD OF VERIFICATION: ALTERNATE CALCULATION ___ DESIGN REVIEW ___

REVISION

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

CALCULATION NO. NESP052395JS

7223(9-83)
FORM GE-8(C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 2 OF 5
DATE 3/23/95 BY [redacted] CK.
COMPANY I & M G.O.
PLANT DCCNP

SUBJECT BAT PUMP NPSHR VS. BAST LEVEL

DESCRIPTION

DETERMINE THE NPSH AVAILABLE FOR THE BORIC ACID TRANSFER PUMPS WHEN LINED UP TO THE BORIC ACID STORAGE TANKS. THIS MINIMUM NPSH AVAILABLE SHALL RELATE TO A MINIMUM PERCENT OF TANK LEVEL. ONCE DETERMINED, THIS VALUE SHALL BE COMPARED AGAINST THE NPSH REQUIRED FOR THE BORIC ACID TRANSFER PUMPS.

PURPOSE

THE RESULTS OF THIS CALCULATION WILL BE USED IN THE DEVELOPMENT OF NEW SEVERE ACCIDENT MANAGEMENT GUIDELINES. IN THE EVENT THAT AN ACCIDENT PROGRESSES TO CORE MELT, WHERE EMERGENCY OPERATING PROCEDURES ARE NO LONGER VALID, THESE GUIDELINES WOULD BE USED

ASSUMPTIONS & LIMITATIONS

1) BORIC ACID SOLUTION TEMPERATURE = 180°F (Heat Trace Req't)
2) BORIC ACID SOLUTION HAS SAME VAPOR PRESSURE AS WATER (NUS Boric Acid Book)
3) ATMOSPHERIC PRESSURE = 33.96 FT H_2O ✓
4) BORIC ACID SPECIFIC GRAVITY EQUAL TO WATER (NUS Boric Acid Book)
5) BORIC ACID TRANSFER PUMP OPERATING AT 75 gpm - 12-5131-33
6) BORIC ACID STORAGE TANK 1-TK-12N AND BORIC ACID TRANSFER PUMP 1-PP-46-1 LINED UP ✓ - MOST CONSERVATIVE LINEUP

RESULTS

1) NPSH REQUIRED RANGES FROM 4 FT TO 10 FT - DESIGN POINT = 6 FT
2) NPSH AVAILABLE AT ~~7.9~~ 2.30% TANK LEVEL (AS INDICATED ON 1-QLA-410) EQUALS 6.0 FT

CONCLUSIONS

THE MINIMUM BAST LEVEL THAT IS ACCEPTABLE TO OPERATE THE BAT PUMPS WHILE STILL HAVING ADEQUATE NPSH AVAILABLE IS 2.30% BAST LEVEL AS INDICATED BY 1-QLA-410.

CALCULATION NO. NES-P032395 NS

7223(9-83)
FORM GE-6(C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

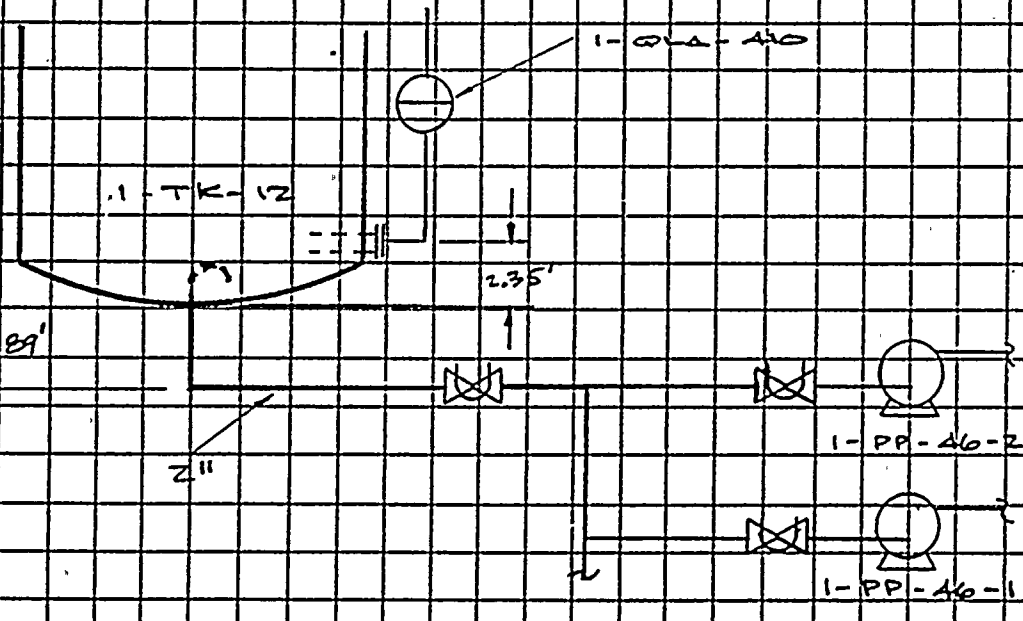
SHEET 3 OF 5
DATE 3/22/95 BY [illegible] CK.
COMPANY I & M G.O.
PLANT DCCNP

SUBJECT BAT PUMP NPSHR VS. BAST LEVEL

REFERENCES

1) CAMERON HYDRAULIC DATA; INGERSOL - RAND; PP 1-10; 3-16; 3-120
2) CRC HANDBOOK; 66TH ED.; STEAM TABLES; PP E-20
3) CRANE TECHNICAL PAPER 140; 21ST PRINTING, 1982; PP. 3-4; EQ. 3-16
4) AEPSC ISOMETRIC DWG. 0-CS-539 W4
5) WESTINGHOUSE DWG. 542F225
6) AEPSC VALVE DWG. W-200D42ZGO FOR 2" DIAPHRAGM VALVE
7) AEPSC FLOW DIAGRAM ED 12-5131-34, INCLUDING VALVE LIST
8) PUMP CURVE FOR PP-46; CNP ENGR. BOOK FOR PUMPS
9) ECP NO. 1-2-94-01, Rev. 11 Sheet 3 of 7

SKETCH



CALCULATION NO. NESP032395 M5

7223(9-83)
FORM GE-8(C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 4 OF 5
DATE 3/27/95 BY JJS CK.
COMPANY I & M G.O.
PLANT DCCNP

SUBJECT BAT PUMP NPSHa VS. BAST LEVEL

CALCULATION

$NPSH_a = h_a - h_{vpa} + h_{st} - h_{fs}$ ✓

h_a = absolute pressure
= 33.96 ft ✓

h_{vpa} = vapor pressure @ 180°F (assume H_2O)
= 7.51 psia (Cameron)
= 17.34 ft ✓

h_{st} = static head
= 2.35 ft. From 0% level to discharge ✓
+ 0.89 ft From discharge to pump ℄ ✓
= 3.24 ft ✓

h_{fs} = Pipe friction loss From Tank to pump

=	12' - 2"	12.16	✓
+	7' - 6.75"	7.56	✓
+	0' - 9"	0.75	✓
+	0.89		✓
+	2' - 10.5"	2.875	✓
+	2(5.17')	10.34 gooseneck	× 2 elbows ✓
+	2(5.17')	10.34 elbows	✓
+	2(3.45')	6.9 Flow thru T	✓
+	1(10.3')	branch T	✓
=	55.715 ft of pipe		
=	(55.71) × 10.1 ft / 100 ft	(Cameron) 98% flow	
=	5.62 ft + 3(2.63) + 0.62 ft		
h_{fs} =	14.13 ft		

DIAPHRAGM VALVES

$\Delta P = \left(\frac{Q}{C_v}\right)^2 \frac{sg}{62.4}$

$= \left(\frac{75}{70}\right)^2 \frac{62.4}{62.4}$ $C_v = 70$

ΔP = 1.14 psi × 2.3 ft/psi
= 2.63 ft ✓

ENTRANCE LOSSES

$h_f = k\frac{V^2}{2g} = (0.78)\left[\frac{(7.17)^2}{2(32.174)}\right]$

= 0.62 ft ✓ V = velocity
= 7.17 ft/sec ✓

K = 0.78

$NPSH_a = (33.96) - (17.34) + (3.24) - (14.13) =$ 5.73 ft @ 0% BAST LEVEL

CALCULATION NO. NESP 032395.11S

7223(9-83)
FORM GE-8(C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 5 OF 5
DATE 3/27/95 BY [illegible] CK.
COMPANY I & M G.O.
PLANT DCCNP

SUBJECT BAT PUMP NPSH$_R$ VS. BAST LEVEL

NPSH$_a$ = ~~5.73~~ 5.09 FT at 0% BAST LEVEL

THE NPSH$_R$ FOR THE BAT PUMP IS 6 FT @ 75 gpm
THEREFORE AN ADDITIONAL ~~0.27~~ 0.92 FT OF BAST LEVEL
ABOVE 0% IS REQUIRED

FROM ECP No. 1-2-94-01 100% BAST LEVEL
EQUALS 139.31" AS INDICATED BY 1-OLA-440

$\frac{0.92'}{.92} \times \frac{12''}{Ft} = \frac{11.04''}{1.04}$

$\frac{11.04''}{35.24''} = 0.313$ ~~7.9%~~

$\frac{35.24''}{139.31''} = 0.253 = 25.3\%$ BAST LEVEL

Corrected values now replaced on revised calculation