NE-014
(D)

NUCLEAR ENGINEERING DEPARTMENT

Calculation Cover Sheet
Cook Nuclear Plant

NEMP SECTION

SHEET 1 OF 7
ATTACHMENTS 2

CALCULATION No. NEMP950501JEW

SAFETY RELATED YES Y NO ___

SYSTEM ~~RHR~~ ENGINEERED SAFEGUARDS

TITLE RHR, SI, CTS - NPSH Available (2)cx

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

FILE LOCATION NEMP CALCS

INDIANA MICHIGAN POWER COMPANY

UNIT No. 12

CALCULATED BY: J. E. Wagner 4/8/96 DATE

VERIFIED BY: John J. Rizzo 4/10/96 DATE

APPROVED BY: D Rizzo 4/11/96 DATE

CALCULATION DESCRIPTION: Request for Severe Accident setpoints (1)cx - RWST water level necessary to supply adequate NPSH for the CTS, SI & RHR Pumps. (Containment Sump water level necessary to provide adequate NPSH for the CTS, RHR PUMPS.)

(**This section of calculation is Superceded by ENSM970128AF RWH 10/22/97 CR97-2455

(1) This calculation Supersedes ENSM791107AOF - Objective #1) RWH 9/17/97 (CR 97-2223)

METHOD OF VERIFICATION: ALTERNATE CALCULATION ___ DESIGN REVIEW AR 4/10/96

REVISION

NO.	REASON FOR CHANGE	Calculated By	Date	Verified By	Date	Approved By	Date
—	Cont. Sump - Superceded (2)	ENSM970128AF		10/22/97		—	
	(ENSM970128AF added CCPs						
	analysis more recent)						

JEW 4/8/96

PURPOSE: CASE 1) Injection Phase
Determine the Refueling Water Storage Tank (RWST) water level necessary to supply adequate NPSH for the (A) Containment spray (CTS) Pumps, (B) Safety Injection (SI) Pumps and (C)Residual Heat Removal(RHR) Pumps. This calculation is being performed in response to R.B.Bennett's memo dated March 6,1995.

CASE 2) Recirculation Phase
Determine the Containment sump water level necessary to supply adequate NPSH for the CTS (A) and RHR (B) Pumps.

RESULTS: CASE 1) Injection Phase

	PUMP NO.	PUMP NAME	FLOW (GPM)	$NPSH_{available}$ (FEET)	$NPSH_{required}$ (FEET)	RWST LEVEL REQUIRED (ELEVATION)
(A)	PP-9	CTS	3200	46.06	9	610.25 $FEET_1$
(B)	PP-26	SI	650	31.75	22	610.25 $FEET_1$
(C)	PP-35	RHR	4500	45.22	19	610.25 $FEET_1$

CASE 2) Recirculation Phase

	PUMP NO.	PUMP NAME	FLOW (GPM)	$NPSH_{available}$ (FEET)	$NPSH_{required}$ (FEET)	CONTAINMENT SUMP LEVEL (ELEVATION)
(A)	PP-9	CTS	3200	23.39	9	595.5 $Feet_1$
(B)	PP-35	RHR	4500	21.89	19	595.5 $FEET_1$

Note:
Although the NPSH determined by the calculation is adequate, the calculation does/did not account for vortexing conditions. Caution should be taken by the operator in severe conditions when the level approaches the general level of the top of the outlet pipe. Under these conditions any unusual fluctuations in pump flow, pressure, vibration, and/or driver power are indication of vortexing. When this occurs the pump flow should be throttled until smooth operation is restored, observing the minimum flow requirements, or operation should be terminated.

ASSUMPTIONS:

1) RWST water level is at minimum elevation (bottom of pipe) 611.25' (24" Suction Pipe Center Line) - 1' (radius of 24" pipe) = 610.25' (See reference 5A).

2) Temperature of water in the RWST is 100°F (For injection phase T = 85°F based on RWST temp low alarm (Ref. 7) + 15°F conservatism). Vapor pressure of water at 100 °F is 2.21 ft = .94925 PSI x 2.323 $ft/lb/in^2$ (conversion factor for water at 100 °F)

3) Temperature of water in containment sump is 190°F (for recirculation phase) based on Unit 2 FSAR figure 14.3.4-4 (containment integrity analysis) vapor pressure of water at 190 °F is 22.285 ft = 9.34 PSI x 2.386 ft/lb/in^2 (conversion factor for water at 190 °F). Reference 6.

4) Pressure on RWST is 0 psig (14.7 PSIA 33.96 Feet)

5) For the purpose of this calculation (Severe accident analysis) it is assumed that only one RHR pump is in operation, during the injection phase, and all other safety pumps are running.

6) Pressure in containment is 0 psig (14.7 PSIA 33.96 feet.

INPUTS:

1) CTS Pump Centerline Elevation = 574'-6"(ref 5C)

2) SI Pump Centerline Elevation = 589'-2 1/2"(ref 5D)

3) RHR Pump Centerline Elevation = 575'-0"(ref 5E)

4) Centerline of 24" SI Outlet from RWST = 611'-3" (ref 5A)

5) Containment sump water elevation 595.5' (Centerline of 24" recirc sump suction line) See reference 5B.

6) H_{fs} (Head Loss due to Friction in piping and fittings) for the following cases is taken from reference 4:
   CASE 1A - H_{fs} = 21.44 feet
   CASE 1B - H_{fs} = 21.04 feet
   CASE 2A - H_{fs} = 9.29 feet

7) H_{fs} (Head Loss due to Friction in piping and fittings) for CASE CASE 1C and CASE 2B are as follows:

   CASE 1C - H_{fs} = 21.78 feet (Attachment 1)
   CASE 2B - H_{fs} = 10.29 feet (Attachment 2)

   The H_{fs} for these two cases could not be taken from reference 4 because the assumptions were not the same as for this calculation.

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CALCULATION:

$NPSH = H_a - H_{vpa} + H_{st} - H_{fs}$

where:

H_a = Absolute pressure (in feet of liquid being pumped) on the surface of the liquid supply level.

H_{vpa} = The head in feet corresponding to the vapor pressure of the liquid at the temperature being pumped.

H_{st} = Static head in feet that the liquid supply level is above or below the pump centerline or impeller eye.

H_{fs} = All suction line losses(in feet) including entrance losses and friction losses through pipe, valves and fittings, etc. Friction is determined with both trains of SI, RHR, CC and CTS pumps operating, thus providing worst case (highest) friction values.

CASE 1A
CTS Pump (Suction source RWST)

Given:

H_a = 14.7 PSIA, 33.96 Feet (RWST open to atmosphere)

H_{vpa} = .95 psia, 2.21 Feet (Vapor pressure of water at 100°F from Ref.6 see assumption 2 for basis of 100°F temperature)

H_{st} = 610.25 (assumption 1) - 574.5 (input 1)

= 35.75 Feet

H_{fs} = 21.44 Feet @ 3200 gpm (input 6)

$NPSH_{available}$ = 33.96 - 2.21 + 35.75 - 21.44 Feet

= 46.06 Feet @ 3200 gpm

$NPSH_{REQUIRED}$ = 9 Feet @ 3200 gpm (see reference 1)

JEW 4/5/96

CASE 1B
SI Pump (Suction source RWST)

Given:

H_a = 14.7 PSIA, 33.96 Feet (RWST open to atmosphere)

H_{vpa} = .95 psia, 2.21 Feet (Vapor pressure of water at 100°F from Ref.6 see assumption 2 for basis of 100°F temperature)

H_{st} = 610.25 (assumption 1) - 589.208 (input 2)

= 21.04 Feet

H_{fs} = 21.04 Feet @ 650 gpm (input 6)

$NPSH_{available}$ = 33.96 - 2.21 + 21.04 - 21.04 Feet

= 31.75 Feet @ 650 gpm

$NPSH_{REQUIRED}$ = 22 Feet @ 650 gpm (see reference 3)

CASE 1C
RHR Pump (Suction source RWST)

Given:

H_a = 14.7 PSIA, 33.96 Feet (RWST open to atmosphere)

H_{vpa} = .95 psia, 2.21 Feet (Vapor pressure of water at 100°F from Ref.6 see assumption 2 for basis of 100°F temperature)

H_{st} = 610.25 (assumption 1) - 575 (input 3)

= 35.25 Feet

H_{fs} = 21.78 Feet @ 4500 gpm (input 7)

$NPSH_{available}$ = 33.96 - 2.21 + 35.25 - 21.78

= 45.22 Feet @ 4500 gpm

$NPSH_{REQUIRED}$ = 19 Feet @ 4500 gpm (see reference 2)

GL 4/8/96

CASE 2A
CTS (SUCTION SOURCE CONTAINMENT SUMP)

Given:

H_a = 14.7 PSIA, 33.96 Feet (assumption 6)

H_{vpa} = 9.34 psia, 22.285 Feet (assumption 3)

H_{st} = 595.5 Feet (input 5) - 574.5 Feet (Input 1)

= 21 Feet

H_{fs} = 9.29 Feet (input 6)

$NPSH_{available}$ = 33.96 - 22.285 + 21 - 9.29 Feet

= 23.39 ft

$NPSH_{REQUIRED}$ = 9 Feet @ 3200 gpm (see reference 1)

CASE 2B
RHR (SUCTION SOURCE CONTAINMENT SUMP)

Given:

H_a = 14.7 PSIA, 33.96 Feet (assumption 6)

H_{vpa} = 9.34 psia, 22.285 Feet (assumption 4)

H_{st} = 595.5 Feet (assumption 3) - 575 Feet (input 3)

= 20.5 Feet (see assumption 3)

H_{fs} = 10.29 Feet (input 7)

$NPSH_{available}$ = 33.96 - 22.285 + 20.5 - 10.29 Feet

= 21.89 ft

$NPSH_{REQUIRED}$ = 19 Feet @ 4500 gpm (see reference 2)

The CALCULATION DATA SHEETS for the above cases 1C and 2B are included as Attachments 1 and 2) . This data was compiled and entered into an INPUT file for the HFLC5 software. The INPUT data is shown on the above attachments right before the HFLC5 results. The input file includes the following:

Line 1: Fluid Temperature (degrees F), Pipe Roughness (ft), 1st segment, last segment

Subsequent lines in the input provides the following data for each of the segments identified in Line 1.

Design Flow (gpm), Min. Flow, Max. Flow, Flow Increment, Pipe I.D., Pipe Length (ft), Total K Factors, Total L/D Factors

The HFLC5 software calculates the total friction loss in feet of each pipe segment for the range of flows provided. The output of the software program for cases 1C and 2B are shown in Attachment 1 and 2.

REFERENCES:

1) Byron Jackson Pump performance curve T-32913-1

2) Ingersoll-Rand company Pump performance curve No. N-318 (typical for unit 1 and 2) in the Residual Heat Removal Pump (PP-35) instruction manual.

3) Pacific Pump performance curve 34554D (typical for unit 1 and 2) in Safety Injection pump (PP-26) instruction manual.

4) M.J.Treza calculation dated 6/16/72 located in NEMP Nuclear Safeguards calculation file.

5) Drawings:
A) 2-5353-10 24" SI outlet from RWST details.
B) 1-2-5338-7 Containment sump RHR Suction line details.
C) 2-CTS-13 CTS Pump centerline
D) 2-SI-10 (sh. 1 of 2) SI Pump centerline
E) 2-RH-15(sh.1 of 2) RHR Punp centerline

6) Ingersoll-Dresser Pumps Cameron Hydraulic Data ,18th edition.

7) System Description DCC-NEMH104 Rev 7. dated May 14, 1993.

8) HFLC5 Pipe Friction Calculation Software. This software has preprogrammed resistance factors for piping, various fittings, and valves other than diaphragm valves. (Source: HEP&T File 13.22.2.1 for Software QA Information)

NEMP950501JEW
Attachment 1
Page 1 of 10
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NPSHRHR

PIPE FRICTION CALC - INPUT FILE IS-RHRRWST

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
100.00	.00015	1	8

QDES	QMIN	QMAX	QDELT	D	L	K	L/D
13300.00	13300.00	13300.00	.00	23.250	249.83	.50	205.00
12000.00	12000.00	12000.00	.00	23.250	6.00	.00	.00
12000.00	12000.00	12000.00	.00	23.250	16.00	.00	60.00
4500.00	4500.00	4500.00	.00	13.250	2.50	.50	36.00
4500.00	4500.00	4500.00	.00	11.938	.00	.94	71.00
4500.00	4500.00	4500.00	.00	13.124	19.75	.00	140.00
4500.00	4500.00	4500.00	.00	13.124	31.11	.00	70.00
4500.00	4500.00	4500.00	.00	13.124	3.33	.00	20.00

FOLLOWING IS HFLC5 RESULTS

WATER TEMP.(F) = 100.00
DENSITY(LBM/CUFT) = 62.00
ABS VISCOSITY(LBM/SEC/FT) = .460533E-03
PIPE ABS ROUGHNESS(FT) = .150000E-03

PIPE SEG NO 1 PIPE DIA(ID-IN) = 23.250

FLOW-GPM	VEL(FPS)	LHD(FT)	KHD(FT)	LDHD(FT)	TOT HD(FT)
13300.0	10.05	2.48	.78	3.94	7.20

PIPE SEG NO 2 PIPE DIA(ID-IN) = 23.250

FLOW-GPM	VEL(FPS)	LHD(FT)	KHD(FT)	LDHD(FT)	TOT HD(FT)
12000.0	9.07	.05	.00	.00	.05

PIPE SEG NO 3 PIPE DIA(ID-IN) = 23.250

FLOW-GPM	VEL(FPS)	LHD(FT)	KHD(FT)	LDHD(FT)	TOT HD(FT)
12000.0	9.07	.13	.00	.94	1.07

PIPE SEG NO 4 PIPE DIA(ID-IN) = 13.250

FLOW-GPM	VEL(FPS)	LHD(FT)	KHD(FT)	LDHD(FT)	TOT HD(FT)
4500.0	10.47	.05	.85	.84	1.74

PIPE SEG NO 5 PIPE DIA(ID-IN) = 11.938

FLOW-GPM	VEL(FPS)	LHD(FT)	KHD(FT)	LDHD(FT)	TOT HD(FT)

4500.0	12.90	.00	2.43	2.53	4.96

PIPE SEG NO 6 PIPE DIA(ID-IN) = 13.124

FLOW-GPM	VEL(FPS)	LHD(FT)	KHD(FT)	LDHD(FT)	TOT HD(FT)
4500.0	10.67	.44	.00	3.38	3.82

PIPE SEG NO 7 PIPE DIA(ID-IN) = 13.124

FLOW-GPM	VEL(FPS)	LHD(FT)	KHD(FT)	LDHD(FT)	TOT HD(FT)
4500.0	10.67	.69	.00	1.69	2.38

PIPE SEG NO 8 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	.48	.56

REYNOLDS NUMBER FRICTION FACTOR TABLE

PIPE SEG	DES. FLOW	RE.NO.	F-FACTOR	HEAD LOSS
1	13300.0	2621750.0	.0122	7.20
2	12000.0	2365488.0	.0123	.05
3	12000.0	2365488.0	.0123	1.07
4	4500.0	1556536.0	.0136	1.74
5	4500.0	1727601.0	.0138	4.96
6	4500.0	1571480.0	.0136	3.82
7	4500.0	1571480.0	.0136	2.38
8	4500.0	1571480.0	.0136	.56

Total H_{fs} = 21.78 Feet

PIPE FRICTION CALCULATION DATA SHEETS

ATT. 1 SHEET 2 OF 10
PLANT COOK
BY DWC DATE 4/4/96
NEMS960501SEW

SYSTEM: ECCS UNIT: 2

PIPE SEGMENT TO & FROM: From RWST to 8"-SI TAKE-OFF

REF.: 2-SI-53 (sh 1 & 2, 2 of 2), 12-5353, 12-5354, 12-5355, 2-5715,

FLUID TEMP (°F): 85° PIPE ABS. ROUGHNESS (FT): .00015 PIPE SEGMENT NUMBER: 1

① DESIGN FLOW: 13300 ② MINIMUM FLOW: 13300 ③ MAXIMUM FLOW: 13300 ④ FLOW INCREMENT: 0

⑤ PIPE I.D. (IN): 23.25 PIPE EL.: 611'-3" TO EL.: 585'-1 7/8"

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	Σ K	Σ L/D
4'-0"	GATE VALVE		13		
8'-4"	GLOBE VALVE		340		
46'-6"	BUTTERFLY VALVE		40		
2'-6"	SWING CHECK		135		
2'-9"	90° STD. ELBOW		30		
29'-3"	90° S.R. ELBOW	11	50		100
64'-0"	90° L.R. ELBOW	1111	20		80
89'-3"	45° STD. ELBOW	1	16		16
3'-3"	45° S.R. ELBOW		26		
	180° CLOSE RETURN		50		
	STD. TEE RUN		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	.5	
	* " " WELL ROUND		0.04		
	* PIPE EXIT SHARP EDGE		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.				
247'-34"	35° MITRE BEND	1	9		9
TOTALS ⑥ 249.83				⑦ .5	⑧ 205

* ITEMS ARE "K" VALUES ONLY

+ BASED ON SMALLER PIPE DIAMETER

β = d/D RF = RECOVERY FACTOR

PIPE FRICTION CALCULATION
DATA SHEETS

Att. 1 SHEET ___ OF ___
PLANT Cook
BY CWS DATE 4/14/96
UNCMP 9505011 REW

SYSTEM : E C C S. UNIT : 2

PIPE SEGMENT TO & FROM : From 2" SI TAKE-OFF to IRWST RETURN FROM RHR

DWG REF. : 2-SI-6

FLUID TEMP (°F) : 85° PIPE ABS. ROUGHNESS (FT) : .00015 PIPE SEGMENT NUMBER : 5

① DESIGN FLOW : 12.000 ② MINIMUM FLOW : 12.000 ③ MAXIMUM FLOW : 12.000 ④ FLOW INCREMENT: 0

⑤ PIPE I.D. (IN) : 23.25 PIPE EL. : 535'-1" TO EL. : 535'-1"

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	Σ K	Σ L/D
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		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 EDGE		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 ⑥ 6'				⑦ 0,0	⑧ 0,0

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

β = d/D RF = RECOVERY FACTOR

PIPE FRICTION CALCULATION — Att. 1 — SHEET — OF —

DATA SHEETS

PLANT Cook
BY DJS DATE 4/14/94
NEMP 96061SEW

SYSTEM : ECCS UNIT : 2

PIPE SEGMENT TO & FROM : From Top Penetration to the 16" RHR Take-off

D REF. : 2-SI-6

FLUID TEMP (°F) : 85° PIPE ABS. ROUGHNESS (FT) : .00015 PIPE SEGMENT NUMBER : 3

(1) DESIGN FLOW : 12,000 (2) MINIMUM FLOW : 12,000 (3) MAXIMUM FLOW : 12,000 (4) FLOW INCREMENT : 0

(5) PIPE I.D. (IN) : 23.25" PIPE EL. : 5'6-1/2" TO EL. : 5'5-1/2"

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	Σ K	Σ L/D
16'-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		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 EDGE		1.0		
	* ORIFICE (C_D = .61)		2.69 RF/β⁴		
	* SUDDEN CONTRACTION +		.5(1-β²)		
	* SUDDEN INCREASE +		(1- β²)²		
	* VALVE, MISCELLANEOUS		891.4 d^4/C_v^2		
	MISC.				
TOTALS (6) 16'-0"				(7) 0.0	(8) 60

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

β = d/D RF = RECOVERY FACTOR

PIPE FRICTION CALCULATION
DATA SHEETS

Att. 1

SHEET ___ OF ___
PLANT: Cook
BY: [illegible] DATE: 4/4/96
NEMP 95050 [illegible]

SYSTEM: ECCS UNIT: 2

PIPE SEGMENT TO & FROM: From [illegible] TEE to (14x12) [illegible]

D[illegible] REF.: 1-5415, 2-5415

FLUID TEMP (°F): 85 PIPE ABS. ROUGHNESS (FT): .00015 PIPE SEGMENT NUMBER: 4

(1) DESIGN FLOW: 4500 (2) MINIMUM FLOW: 4500 (3) MAXIMUM FLOW: 4500 (4) FLOW INCREMENT: 0

(5) PIPE I.D. (IN): 13.25 PIPE EL.: 583'-1 7/16 TO EL.: 591'-0'

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	Σ K	Σ L/D
0'-10''	GATE VALVE		13		
1'-8''	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		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	1	0.50	.5	
	* " " WELL ROUND		0.04		
	* PIPE EXIT SHARP EDGE		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 (6) 2.5'				(7) .5	(8) 36

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

β = d/D RF = RECOVERY FACTOR

PIPE FRICTION CALCULATION

DATA SHEETS

AA 1

PLANT Cook
BY [illegible] DATE 4/4/96
NTEM9606 01 JEW

SYSTEM : ECCS UNIT : 2

PIPE SEGMENT TO & FROM : From (14x12) [illegible] TEE [illegible]

D REF. : 2-SI-9

FLUID TEMP (°F) : 25 PIPE ABS. ROUGHNESS (FT) : .00015 PIPE SEGMENT NUMBER : 5

(1) DESIGN FLOW : 4500 (2) MINIMUM FLOW : 4500 (3) MAXIMUM FLOW : 4500 (4) FLOW INCREMENT: 0

(5) PIPE I.D. (IN) : 11.938 PIPE EL. : 591'-0' TO EL. : 591'-0'

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	Σ K	Σ L/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		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 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 EDGE		1.0		
	* ORIFICE (C_D = .61)		2.59 RF/B^4		
	* SUDDEN CONTRACTION (14X12)	1	.5(1-B^2)	.094	
	* SUDDEN INCREASE +		$(1-B^2)^2$		
	* VALVE, MISCELLANEOUS		891.4 d^4/C_v^2		
	MISC.				
	IMO-390 (L/D=21)	1			21
	SI-148 (30 CE 12 SS) (L/D=50)	1			50
TOTALS (6) 0.0				(7) .094	(8) 71.0

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

B = d/D RF = RECOVERY FACTOR

PIPE FRICTION CALCULATION
DATA SHEETS

Att. 1

SHEET 2 OF 10
PLANT COOK
BY JWW DATE 11/19/96
NEN195061GEW

SYSTEM: ECCS UNIT: 2

PIPE SEGMENT TO & FROM: From TEE (RHR) to TEE RHR Pump

D REF.: 2-SI-9

FLUID TEMP (°F): 85 PIPE ABS. ROUGHNESS (FT): 0.0005 PIPE SEGMENT NUMBER: 6

(1) DESIGN FLOW: 4500 (2) MINIMUM FLOW: 4500 (3) MAXIMUM FLOW: 4500 (4) FLOW INCREMENT: 0

(5) PIPE I.D. (IN): 13.124 PIPE EL.: 591 - TO EL.: 585' 8 5/8"

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	Σ K	Σ L/D
0' - 2"					
3' - 7"	GATE VALVE		13		
14' - 8"	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	11	60		120
	* 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 EDGE		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	(6) 19.75			(7) 0-0	(8) 140

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

PIPE FRICTION CALCULATION
DATA SHEETS

Att. 1

PLANT COOK
BY JW DATE 4/4/96
NEW 960401SEW

SYSTEM: FCCS. UNIT:

PIPE SEGMENT TO & FROM: FROM TEE (RH2 EAW SUCT.) TO TEE (LINE FROM RECIRC SUMP)

DWG. REF.: 2-5I-9 , 2-5I-8 , 2-5415

FLUID TEMP (°F): 86 PIPE ABS. ROUGHNESS (FT): .00015 PIPE SEGMENT NUMBER: 7

(1) DESIGN FLOW: 4500 (2) MINIMUM FLOW: 4500 (3) MAXIMUM FLOW: 4500 (4) FLOW INCREMENT: 0

(5) PIPE I.D. (IN): 13.124 PIPE EL.: 565'-5 5/8" TO EL.: 575'-0"

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	Σ K	Σ L/D
10'-9"	GATE VALVE (1N0-310)	1	~~18~~ 10		10
7'-0 3/8"	GLOBE VALVE		340		
	BUTTERFLY VALVE		40		
10'-8"	SWING CHECK		135		
2'-8"	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	1	20		0
	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 EDGE		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.				
					70
TOTALS (6) 31.115'				(7) 0.0	(8) ~~70~~ 50

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

β = d/D RF = RECOVERY FACTOR

DATA SHEETS

HH. 1

PLANT Cook
BY DW DATE 4/4/96
NEMP 9503 01EW

SYSTEM : ECCS UNIT : 2

PIPE SEGMENT TO & FROM : From Tee (Line from Recirc) to 2HR PUMP 2E

DWG. REF. : 2-5I-8

FLUID TEMP (°F) : 85 PIPE ABS. ROUGHNESS (FT) : .00015 PIPE SEGMENT NUMBER : 8

(1) DESIGN FLOW : 4500 (2) MINIMUM FLOW : 4500 (3) MAXIMUM FLOW : 4500 (4) FLOW INCREMENT : 0

(3) PIPE I.D. (IN) : 13.124 PIPE EL. : 575'-0" TO EL. : 575'-0"

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	Σ K	Σ L/D
2'-9"					
-4"	GATE VALVE		13		
-3"	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		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 EDGE		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	(5) 333			(7) 0.8	(8) 20

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

β = d/D RF = RECOVERY FACTOR

NEMP9505010JEW
Attachment 2
Page 1 of 6
jw 4/4/96

rhrout

PIPE FRICTION CALC - INPUT FILE IS-rhrrecir

T 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

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

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

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
4500.00	4500.00	4500.00	.00	13.124	3.33	.00	.00

F 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) = 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

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

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

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

REYNOLDS NUMBER FRICTION FACTOR TABLE

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

4	4500.0	3235750.0	.0132	.07

Total H_{ss} = 10.29 Feet

PIPE FRICTION CALCULATION
DATA SHEET

Att. 2 SHEET 3 OF 6
PLANT Co-K
BY JW DATE 4/4/96
NEMP 95050 JED

YST From Containment Sump to ICM 306

KG. REF. 1-2-5338-7

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

LUID FLOW (GPM) 7700 PIPE I.D. (IN) (18"SD) 17.124 ID PIPE EL. 595'-6" TO EL. 559'-9"

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	ΣK	ΣL/D
0 - 22 1/8"	GATE VALVE (JCM-306) * 4/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-COSθ)		
	* 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/β^4		
	* SUDDEN CONTRACTION † 24x18 (22.876 x 17.124)	1	.5(1-β^2)		
	* SUDDEN INCREASE †		(1-β^2)^2	.19	
	* VALVE, MISCELLANEOUS		891.4 d^4/C_V^2		
	MISC				
ΣLS ⊙ 26.66				⊙ .97	⊙ 10

* 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

Att. 2

SHEET 4 OF 6
PLANT Cook
BY JAL DATE 4/4/96
NEW 9505015EW

YS From Item 306 to CTS TAKE (18"x18"x14" TEE)

ING. REF. 2-SI-9; Sh. 1 of 2 rev: 2 2-5415-15

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

LUID FLOW (GPM) 7700 ⊙PIPE I.D. (IN) (15.09) 16.876 PIPE EL. 589'-5" TO EL. 586'-5½"

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	ΣK	ΣL/D
2'-2 7/16"	GATE VALVE		13		
21'-4½"	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-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 † (16.876 x 15.09)		.5(1-β^2)	.198	
	* SUDDEN INCREASE †		$(1-\beta^2)^2$		
	* VALVE, MISCELLANEOUS		891.4 d^4/C_v^2		
	MISC				
				0.005	
ALS ⊙ 26.15				⊙ .198	⊙ 100

* 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

PLANT COOK
BY JW DATE 4/4/96
NEMP 950601JEW

SYST From TEE (CTS TAKE-OFF) to. Tee (suction of RHR PP 2W-14" Line From RWST & 3" RHR MINI-FLOW)

DWG. REF. 2-SI-M. Sh. 1 of 2 r. 2

FLUID TEMP. (F) 190° PIPE ABS. ROUGHNESS (FT) .00015 PIPE SEGMENT NUMBER 3

FLUID FLOW (GPM) 4500 ① PIPE I.D. (IN) (14" OD) 13.124 ID PIPE EL. 581'-5 1/8" TO EL. 575'-2"

STRAIGHT PIPE LENGTHS	FITTINGS	NUMBER	*K OR L/D	ΣK	ΣL/D
3'-0"	GATE VALVE (2-RH-104W) L/D = 10 *	1	~~13~~ 10		10
6'-11 3/8"	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 ~~IIII~~	20		120
1'-2"	45° STD. ELBOW		16		
5'-2"	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 †	11.376"/13.124"	$.5(1-\beta^2)$	.124	
	* SUDDEN INCREASE †		$(1-\beta^2)^2$		
	* VALVE, MISCELLANEOUS		$891.4\ d^4/C_V^2$		
	MISC				
TOTALS ① 42.93				② ~~0.0~~ .124 JW	③ 160

* 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

Att. 2

SHEET 6 OF 6
PLANT Cook
BY JW DATE 4/4/91
PEN 9505 01 JEW

SYS U2 From Tee (from RHR & 3" MINIFLOW) to RHR PUMP 2W

ISOG. REF. 2-SI-7 sh 1052 rev. 2

FLUID TEMP. (F) 190° PIPE ABS. ROUGHNESS (FT) .00015 PIPE SEGMENT NUMBER 4

FLUID FLOW (GPM) 4500 @ PIPE I.D. (IN) (14" OD) (13.124 ID) PIPE EL. 575'-2" TO EL. 575'-0"

STRAIGHT 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)		$2.69\ RF/\beta^4$		
	* SUDDEN CONTRACTION †		$.5(1-\beta^2)$		
	* SUDDEN INCREASE †		$(1-\beta^2)^2$		
	* VALVE, MISCELLANEOUS		$891.4\ d^4/C_v^2$		
	MISC				
ALS ① 3.33				② 0.0	③ 6.0

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

FK-3-1-72

NE-015
(02/95)

DONALD C. COOK NUCLEAR PLANT

_____ Section

DESIGN VERIFICATION CHECKLIST - CALCULATIONS

Calculation Number NEMP 950501NEW Rev. 0

John J. Rudd 4/10/96

Signature of Verifier Date

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

Basis: The inputs are consistent with the hydraulic analysis used for this calculation

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

Basis: The assumptions are appropriate and reasonable. Their basis is well defined when necessary.

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

Basis: There are no codes, standards or regulatory requirements applicable to this calculation

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

Basis: This is not a design process.

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

Basis: The outputs are consistent with the inputs.

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

Basis: check of calculation arithmetic when appropriate. Outputs of the previously verified computer program HFLC5 are assumed to be correct