Attachment
LIC-92-278R

ATTACHMENT 3

Calculation to Analyze the Test Methodology and Determine
Acceptance Criteria for Flow Testing of Safety Injection Tank Check Valves
(Calculation FC 05428, Revision 1)

CALCULATION COVER SHEET

Calculation Preparation, Review and Approval Form PED-QP-3.1 Form Page No. 1 of 2 Calculation Cover Sheet *SHORT TERM CALC: YES ☐ NO ☒	CALCULATION NUMBER: FC05428 Calc. Page No. 01 of 62 82 *TOTAL PAGES 62 82 QA Category: ☒ CQE ☐ LIMITED CQE ☐ FIRE PROT. ☐ NON CQE *FILE NO. 55879 PED DEPARTMENT Special Services Engr. (353)
CALCULATION TITLE Safety Injection Valves SI-207/SI-208 Full Open Stroke Data Analysis for SP-SI-7 April 1990 Performance	VENDOR CALC.NO. ☐ MR NO. NA ☐ ENGR. ANALYSIS NA ☐ DBD NO. NA ☐ ECN NO. NA ☐ OTHER SP-SI-7 Data Analysis

*APPROVALS - SIGNATURE & DATE

PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)	*REV.NO.	SUPERSEDES *CALC NO.	CONFIRMATION *REQUIRED (✓) YES	NO
Al Newcomer Al Newcomer 4/12/90 AN 4/30/90	Charles N Bloyd Charles N Bloyd 4-13-90 CNB 4-30-90	Jan Uden 5/1/90	0	NA	✓ See ID: Review Sheet	* Jan 5/1/90
REV. 1 Charles N Bloyd 2-12-92	Rev 1 Ron Lippy 2/13/92	Jan Uden 2/14/92	1		** Completed ✓ Ron Lippy 5/29/90	

*EXTERNAL ORGANIZATION DISTRIBUTION

NAME & LOCATION	COPY SENT (✓)	NAME & LOCATION	COPY SENT (✓)

CALCULATION COVER SHEET

Calculation Preparation, Review and Approval Form PED-QP-3.1 Form Page No. 2 of 2 Calculation Cover Sheet	CALCULATION NUMBER: FC 05428 Calc. Page No. 02 of [illegible] FACILITY/SYSTEM: Fort Calhoun Station / S.I. KEYWORD ◦

CALCULATIONS USED AS INPUT IN THE ANALYSIS		EQUIPMENT TAGS		
CALC./REV.NO.	DEPT.NO.◦	SYSTEM	ADDED	DELETED
FC-05280/0 Ref ~~NONE~~ [illegible]/90	353	SI	SI-207	
CE Calc 0-PD-113 (See Ref 11)	Combustion Engineering	R.1 CMB 2-12-92	SI-207	

R.1

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.2 Form Page No. 1 of 1 PRODUCTION ENGINEERING DIVISION CALCULATION REVISION SHEET	CALCULATION NO. FC 05428

REV. NO.	DESCRIPTION /REASON FOR CHANGE
0	ORIGINAL
1	Calculation revised to add reference 11 and use values from Ref 11 to calculate specific acceptance Criteria (Cv) for each SIT.

REV.1

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PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET	FC05428
	Rev. No. Ø

OBJECTIVE

The purpose of this calculation is to determine if the April 2, 1990 performance of Special Procedure SP-SI-7, *Safety Injection Tank SI-6C Dump Test*, successfully accomplished simulated full open stroke in accordance with the Generic Letter 89-04 definition (see page 7) of Safety Injection check valves SI-207 and SI-208.

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METHODS

The data used in this calculation was produced by the April 2, 1990 performance of Special Procedure SP-SI-7, *Safety Injection Tank SI-6C Dump Test.* The data are two strip chart recordings, in voltage cales, of the Safety Injection tank levels and pressures during the test. The level voltages are converted to the form of tank levels in feet and gallons and the pressure voltages as tank pressure in pounds per square inch gage (psig). The main equation this calculation uses is an equation of flow:

$$Q = C\,v \sqrt{\Delta p\,(62.4/\rho)}$$

where Q = flow
Cv = flow coefficient
Δp = change in pressure
ρ = fluid density

This equation can be found in Crane Flow of Fluids, 1985, page 2-10.

This equation will allow us to calculate a C v using the test data. This C v will then be compared to the C v produced from the values used in the LOCA analysis. If the test produced C v is equal to or greater then the LOCA Analysis C v, then valves SI-207 and SI-208 were full open stroked.

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ASSUMPTIONS

The major assumptions of this calculation are the following:

1. The flow coefficient, C v, for the same system boundaries and components is constant under varying operational conditions. (The flow coefficient is a factor of system geometry including diameter, friction factor and equivalent lengths of piping, not operational parameters.)

2. The back pressure induced from the 20 feet of water above the reactor vessel flange is assumed to be a constant because the level change of about 4 inches in the refueling cavity resulting from the S I T dump is negligible.

3. Although the C v values may vary due to changing system configuration (ie. variations of the open / closed position of the motor operated valve HCV-2954) the C v value determined when HCV-2954 is fully open is an acceptable standard because it is representative of the flow configuration during an accident.

4. It is reasonable to expect the flow to increase / decrease in a steady fashion, not as a step function. The selection of data at one second intervals only produces this illusion. Therefore, the optimum *best fit curve* will be one based on interpolated or "rounded" flow values which use actual flows as a basis. Rounded flow values are the approximate average of any given consecutive calculated flows.

5. The density of the SIT water is essentially the same in the test condition as in the accident condition. As such, the density value cancels out.

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PRODUCTION ENGINEERING CALCULATION
SUMMARY SHEET

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INPUTS / REFERENCES

	REF. NO.
• SP-SI-7, *Safety Injection Tank SI-6C Dump Test* of April 2, 1990, for the conversion factors of (3.6 feet in tank / volt) and (531.15 gallons in tank / foot) and data.	1
• Flow of Fluids, Crane, 1985 edition.	2
• Fort Calhoun Station U S A R , section 14.15.	3
• Safety Injection Tank drawing D-7495 for tank dimensions.	4
• RCS elevations vs. LI-106 from page TDB-III-20 of the Technical Data Book for the reactor vessel flange elevation.	5
• Design Basis Document SDBD-SI-LP-133, Rev. 0	6
• FC-05280, Dept 353, *Determination of Safety Injection Tank SI-6C Pressure For Performance of Special Procedure SP-SI-7.*	7
• Generic Letter 89-04, Attachment 1, Item 1, Full Flow Testing of Check Valves for definition of Full Open Stroke: " A check valve's full-stroke to the open position may be verified by passing the maximum required accident condition flow through the valve. This is considered by the staff as an acceptable full-stroke."	8
• *Experimental Methods for Engineers*. J. P. Holman, Fourth Edition, 1984, McGraw-Hill, Inc.	9
• Record of Conversation, dated 27 April 1990, between Bill Weber, OPPD, and Al Newcomer, ABB Impell Corporation. PED-SSE-90-0435 S.	10
• Combustion Engineering Calc. O-PD-113, dated 3-15-74 "LPSI Pump, HPSI Pump, and Safety Injection Tank Data for New ECCS Evaluation Model" (Transmitted by ABB Letter O-MECH-92-015 dated Feb 3, 1992, from F.P. Ferraracco)	11 R.1 CMB 2-12-92

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CONCLUSIONS

This calculation determines if the Safety Injection check valves SI-207 and SI-208 perform their design basis function by full-open stroking under the design basis conditions of a single intact loop 1.0 DECLG break.

Data analysis from SP-SI-7, April 2, 1990, produces a C v value of 1258 ± 3.4% for the period of full open valve position. The comparable Cv produced from values within the LOCA analysis is 1132; a minimum safety margin of 7.4 % (see page 14 for calculation).

Therefore, SI-207 and SI-208 will full-open stroke under design basis accident condition flow. This analysis has also shown that Special Procedure SP-SI-7, *Safety Injection Tank SI-6C Dump Test* is capable of proving the full flow capacity of the Safety Injection tank discharge check valves. Based on the above safety margin, all subsequent Safety Injection tank dump tests should be able to prove tank discharge check valve full flow capacity.

This calculation format may be used for subsequent dumps of the remaining SI tanks; providing test-specific numbers are substituted. Thus allowing for variations in system geometry, starting and ending pressures / levels, recorder settings, etc.

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Symbol Definitions

n :	time @ n seconds
T n+1:	time @ n+1 seconds
L v :	tank level in volts : as recorded
L f :	tank level in feet
L g :	tank level in gallons
Q c :	calculated flow in gpm
Q r :	rounded flow in gpm (for graph smoothing)
P nv :	nitrogen pressure in volts
P np :	nitrogen pressure in psig
P h :	tank variable head pressure
P T :	total tank pressure in psig
P b :	back pressure from 20' water head
C v :	flow coefficient
ρ :	water density = 62.4 lbs/ft^3

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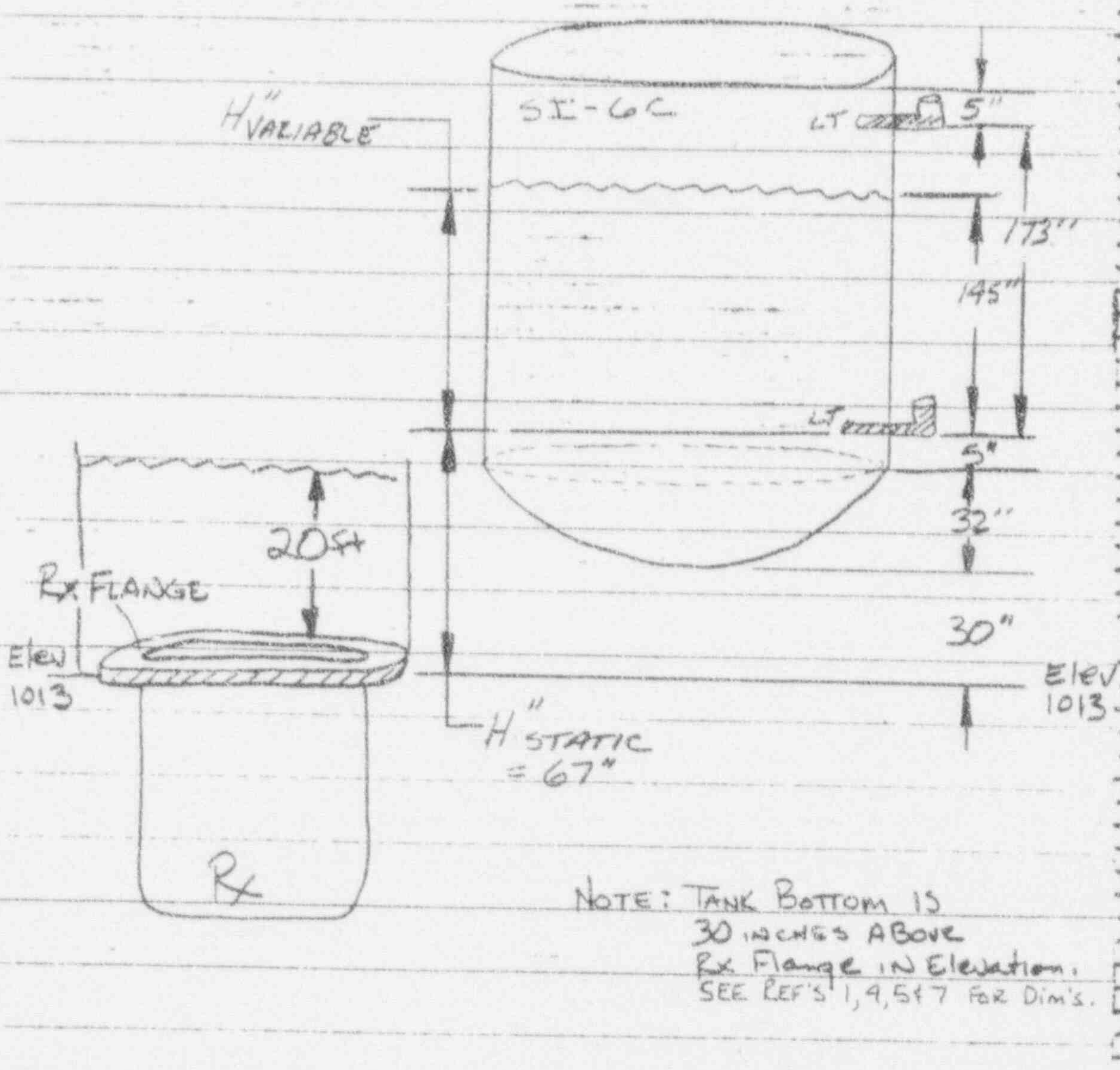
REF. NO.



NOTE: TANK BOTTOM IS 30 INCHES ABOVE Rx Flange IN Elevation.
SEE REF'S 1, 4, 5 & 7 FOR Dim's.

FIG 1

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Level Conversion Factor

The level chart recorder was calibrated to a span of 0 - 173 inches corresponding to a voltage range of 1 - 5 volts. Therefore, the level conversion factor = (173 " - 0 ") / [(5 volts - 1 volt)(12"/ft)]

= 3.60 feet in tank / volt

And, from Reference 1, Gallons in tank = (feet in tank)(531.15 gals/ft)

Pressure Conversion Factor

The pressure chart recorder was calibrated to a span of 0 - 150 psig corresponding to a voltage range of 1 - 3 volts. Therefore, the pressure conversion factor = (150 psig - 0 psig) / (3 volts - 1 volt)

= 75 psig / volt

Sample Calculation

For example purposes, use data when HCV-2954 is fully open at T=52 and 53 seconds.

Lv_{53} = 2.50 volts

Lf_{53} = (2.50 volts- 1 volt) (3.60 ft in tank / volt) = 5.40 feet

Lg_{53} = (5.40 feet) (531.15 gal / ft) = 2868.21 gal

Lv_{52} = 2.54 volts

Lf_{52} = (2.54 volts - 1 volt) (3.60 ft in tank / volt) = 5.54 feet

Lg_{52} = (5.54 feet) (531.15 gal / ft) = 2942.57 gal

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$$Qc = (Lg_{52} - Lg_{53}) / (T_{53} - T_{52})$$

$$= [(2942.57 - 2868.21\ \text{gal}) / (53 - 52\ \text{sec})](60\ \text{sec}/\text{min})$$

$$= 4461.60\ \text{gpm}$$

$$Pnv_{53} = 0.22\ \text{volts}$$

$$Pnp_{53} = (0.22\ \text{volts})(75\ \text{psig}/\text{volt}) = 16.50\ \text{psig}$$

$$Ph_{53} = Lf(.434\ \text{psig}/\text{ft}) = (5.40\ \text{ft})(.434\ \text{psig}/\text{ft}) = 2.34\ \text{psig}$$

$$PT_{53} = Pnp_{53} + Ph_{53} + \underline{(67")(.434\ \text{psig}/\text{ft})/(12\ \text{in}/\text{ft})}$$

Pressure head created by elev diff from tank bott to Rx flange

$$= 16.50\ \text{psig} + 2.34\ \text{psig} + 2.42\ \text{psig}$$

$$= 21.26\ \text{psig}$$

$$Pb = (20\ \text{feet})(.434\ \text{psig}/\text{ft}) = 8.68\ \text{psig}$$

$$\Delta P_{53} = PT_{53} - Pb = 21.26\ \text{psig} - 8.68 = 12.58\ \text{psig}$$

$$Q_{53} = Cv\sqrt{\Delta P(62.4)/\rho} \quad \text{where } \rho = 62.4 \text{ for water}$$

$$\ggg \quad Cv = Q_{53}/\sqrt{\Delta P_{53}} = 4461.6/\sqrt{12.58}$$

$$\boxed{Cv = 1258}$$

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Uncertainty Analysis

Based on the last performed calibration procedure for LT-2944X (12/26/88), the maximum % uncertainty from the level transmitter is:

2.4 % = [(10.00 - 9.76) / 10.00] * 100 where 10.00 is the desired accuracy and 9.76 was the As-Left accuracy.

Based on the last performed calibration procedure for PT-2941 (12/12/88), the maximum % uncertainty from the pressure transmitter is:

0.5 % = [(10.00 - 9.95) / 10.00] * 100 where 10.00 is the desired accuracy and 9.95 was the As-Left accuracy.

The overall uncertainty in Cv is a function of the level and pressure transmitter uncertainty percentages, the recorded values for the times of interest, and the Cv equation's partial derivative coefficients with respect to each of the variables. That is:

$$\%\,\text{UNCERTAINTY} = \left[\left(A\frac{(2.4\%)L_t}{L_t}\right)^2 + \left(B\frac{(2.4\%)(L_{t+1})}{L_{t+1}}\right)^2 + \left(C\frac{(0.5\%)(P_{t+1})}{P_{t+1}}\right)^2\right]^{1/2}$$

where A, B and C are the partial derivative coefficients.

Taking the partial derivatives of our Cv equation,

$$C_v = \frac{(3.6)(531.15)(60)}{T_{t+1} - T_t}(Lv_t - Lv_{t+1})(75 P_{nv_{t+1}} + P_{\underset{HEAD}{static}} + P_h - P_b)^{-1/2}$$

would produce coefficients of 1 or less because we do not have any terms with powers greater than one. So conservatively, we will assume all three coefficients equal to one (1).

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Uncertainty Analysis (cont)

So, at time = 53 / 52 seconds:

$$\% \text{UNCERTAINTY} = \left[\left(1\frac{(2.4\%)L_{52}}{L_{52}}\right)^2 + \left(1\frac{(2.4\%)(L_{53})}{L_{53}}\right)^2 + \left(1\frac{(\phi.5\% P_{53})}{P_{53}}\right)^2\right]^{1/2}$$

$$= \left[\left(\frac{(.024)(1.54)}{1.54}\right)^2 + \left(\frac{(.024)(1.50)}{1.50}\right)^2 + \left(1\frac{(.005)(.22)}{.22}\right)^2\right]^{1/2}$$

$$= 3.4\%$$

LOCA Analysis Requirement

The effective flow area (A) and representative resistance coefficient (K) in a LOCA condition as used in the accident analysis are 0.5592 sq. ft.and 7.34 respectively (see ref. 10). Equation 2-6, reference 2, gives us:

$$Cv_{LOCA} = 29.9 * d^2/\sqrt{K} = \frac{29.9[(.5592\ ft^2)(144\ in^2/ft^2)(4)/\pi]}{\sqrt{7.34}}$$

$$Cv_{LOCA} = 1131.5$$

Conservatively rounding up,

$$\boxed{Cv_{LOCA} = 1132}$$

Minimum Safety Margin

Minimum Safety Margin = $\{[(Cv_{test}) - 3.4\%(Cv_{test})] / (Cv_{LOCA}\} - 1$

$= \{1258 - .034(1258)\} / (1132)\} - 1$

$= 7.4\%$

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LOCA Analysis Requirements (Cont.)

Revision 0 calculated the acceptance criteria

$$C_v(LOCA) = 1132$$

Reference 11 shows that this Cv Value is specific to SIT SI-6C which was the only tank dumped in 1990. The purpose of Revision 1 to this calculation is to generate similar acceptance values of Cv for the other three (3) SITs. (ie a separate Cv (LOCA) will be calculated for each SIT)

R.1 CMB 2-12-92

From page 14 of 62 of Calculation FC 05428:

$$C_v(LOCA) = \frac{29.9\ d^2}{\sqrt{K}}$$

Rewriting to use A instead of d^2 and since $A = .5592\ ft^2$ for all four (4) SITs.

$$C_v(LOCA) = \frac{29.9\ A\ (144\ in^2/ft^2)\ 4}{\pi\ \sqrt{K}} = \frac{3065.6}{\sqrt{K}}$$

The Table below summarizes the calculation revision results. Reference 11 states the values in Columns B and C. Column D contains the specific acceptance Criteria.

(A) SIT	(B) K	(C) A	(D) Cv(LOCA)
SI-6A	6.65	.5592 ft^2	1189
SI-6B	6.94	.5592 ft^2	1164
SI-6C	7.34	.5592 ft^2	1132
SI-6D	7.00	.5592 ft^2	1159

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* SPREADSHEET PRODUCED BY MICROSOFT EXCEL, VERSION 2.2.

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TABULATED DATA & CALCULATED VALUES

Time (sec)	Level (volts) (recorded)	Level (feet) (calc)	Level (gallons) (calc)	Q (gpm) (calc)	Q (gpm) (rounded)	N2 Press (volts) (recorded)	N2 Press (psig) (calc)	Press Total (psig) (Pgas+Phead)	Δ P (psig) (P ttl-P b)	Cv = Q (calc) / sqrt(Δ P)	Cv = Q (rounded) / sqrt(Δ P)
-3	4.36	12.10	6426.92	0.00	0.00	1.07	80.25	87.92	79.24	0	0
-2	4.36	12.10	6426.92	0.00	0.00	1.07	80.25	87.92	79.24	0	0
-1	4.36	12.10	6426.92	0.00	0.00	1.07	80.25	87.92	79.24	0	0
0	4.36	12.10	6426.92	0.00	0.00	1.07	80.25	87.92	79.24	0	0
1	4.36	12.10	6426.92	0.00	0.00	1.07	80.25	87.92	79.24	0	0
2	4.36	12.10	6426.92	0.00	0.00	1.07	80.25	87.92	79.24	0	0
3	4.36	12.10	6426.92	0.00	0.00	1.07	80.25	87.92	79.24	0	0
4	4.36	12.10	6426.92	0.00	0.00	1.07	80.25	87.92	79.24	0	0
5	4.36	12.10	6426.92	0.00	0.00	1.07	80.25	87.92	79.24	0	0
6	4.36	12.10	6426.92	0.00	0.00	1.07	80.25	87.92	79.24	0	0
7	4.34	12.02	6384.42	2550.00	577.70	1.06	79.50	87.14	78.46	288	65
8	4.34	12.02	6384.42	0.00	577.70	1.05	78.75	86.39	77.71	0	66
9	4.32	11.95	6347.24	2230.80	1115.40	1.04	78.00	85.61	76.93	254	127
10	4.32	11.95	6347.24	0.00	1115.40	1.02	76.50	84.11	75.43	0	128
11	4.30	11.88	6310.06	2230.80	2230.80	1.00	75.00	82.58	73.90	260	260
12	4.28	11.81	6272.88	2230.80	2230.80	0.98	73.50	81.05	72.37	262	262
13	4.26	11.74	6235.7[illegible]	2230.80	2230.80	0.95	71.25	78.77	70.09	266	266
14	4.24	11.66	6193.21	2549.40	2549.40	0.93	69.75	77.23	68.55	308	308
15	4.20	11.52	6118.85	4461.60	2549.40	0.90	67.50	74.92	66.24	548	313
16	4.16	11.38	6044.49	4461.60	2549.40	0.86	64.50	71.86	63.18	561	321
17	4.14	11.30	6002.00	2549.40	3505.80	0.83	62.25	69.57	60.89	327	449
18	4.10	11.16	5927.63	4462.20	3505.80	0.80	60.00	67.26	58.58	583	458
19	4.06	11.02	5853.27	4461.60	3505.80	0.76	57.00	64.20	55.52	599	471
20	4.02	10.87	5773.60	4780.20	4780.20	0.73	54.75	61.89	53.21	655	655
21	3.96	10.66	5662.06	6692.40	4780.20	0.70	52.50	59.55	50.87	938	670
22	3.92	10.51	5582.39	4780.20	4780.20	0.67	50.25	57.23	48.55	686	686
23	3.88	10.37	5508.03	4461.60	4780.20	0.64	48.00	54.92	46.24	656	703
24	3.82	10.15	5391.17	7011.60	5736.60	0.61	45.75	52.58	43.90	1058	866
25	3.78	10.01	5316.81	4461.60	5736.60	0.58	43.50	50.26	41.58	692	890

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TABULATED DATA & CALCULATED VALUES (CONT)

Time (sec)	Level (volts) (recorded)	Level (feet) (calc)	Level (gallons) (calc)	Q (gpm) (calc)	Q (gpm) (rounded)	N2 Press (volts) (recorded)	N2 Press (psig) (calc)	Press Total (psig) (Pgas+Phead)	Δ P (psig) (P ttl-P b)	C v = Q (calc) / sqrt (Δ P)	C v = Q (rounded) / sqrt (Δ P)
26	3.72	9.79	5199.96	7011.00	5736.60	0.56	42.00	48.67	39.99	1109	907
27	3.68	9.65	5125.60	4461.60	5736.60	0.53	39.75	46.36	37.68	727	935
28	3.62	9.43	5008.74	7011.60	5736.60	0.51	38.25	44.76	36.08	1167	955
29	3.58	9.29	4934.38	4461.60	5736.60	0.49	36.75	43.20	34.52	759	976
30	3.52	9.07	4817.53	7011.00	5736.60	0.47	35.25	41.61	32.93	1222	1000
31	3.48	8.93	4743.17	4461.60	5736.60	0.45	33.75	40.05	31.37	797	1024
32	3.42	8.71	4626.32	7011.00	5736.60	0.43	32.25	38.45	29.77	1285	1051
33	3.38	8.57	4551.96	4461.60	5736.60	0.42	31.50	37.64	28.96	829	1066
34	3.32	8.35	4435.10	7011.60	5736.60	0.40	30.00	36.04	27.36	1340	1097
35	3.28	8.21	4360.74	4461.60	5736.60	0.38	28.50	34.48	25.80	878	1129
36	3.22	7.99	4243.89	7011.00	5736.60	0.37	27.75	33.64	24.96	1403	1148
37	3.18	7.85	4169.53	4461.60	5736.60	0.35	26.25	32.08	23.40	922	1186
38	3.14	7.70	4089.86	4780.20	5736.60	0.34	25.50	31.28	22.58	1006	1207
39	3.08	7.49	3978.31	6693.00	5736.60	0.33	24.75	30.42	21.74	1435	1230
40	3.04	7.34	3898.64	4780.20	4780.20	0.32	24.00	29.61	20.93	1045	1045
41	3.00	7.20	3824.28	4461.60	4780.20	0.21	23.25	28.79	20.11	995	1066
42	2.96	7.06	3749.92	4461.60	4780.20	0.30	22.50	27.98	19.30	1016	1088
43	2.90	6.84	3633.07	7011.00	4780.20	0.29	21.75	27.14	18.46	1632	1113
44	2.86	6.70	3558.71	4461.60	4780.20	0.28	21.00	26.33	17.65	1062	1138
45	2.82	6.55	3479.03	4780.80	4780.20	0.27	70.25	25.51	16.83	1165	1165
46	2.78	6.41	3404.67	4461.60	4780.20	0.27	20.25	25.45	16.77	1089	1167
47	2.74	6.26	3325.00	4780.20	4780.20	0.26	19.50	24.64	15.96	1197	1197
48	2.70	6.12	3250.64	4461.60	4780.20	0.25	18.75	23.83	15.15	1146	1228
49	2.66	5.98	3176.28	4461.60	4780.20	0.25	18.75	23.77	15.09	1149	1231
50	2.62	5.83	3096.60	4780.80	4780.20	0.24	18.00	22.95	14.27	1266	1265
51	2.58	5.69	3022.24	4461.60	4780.20	0.23	17.25	22.14	13.46	1216	1303
52	2.54	5.54	2942.57	4780.20	4461.60	0.23	17.25	22.07	13.39	1306	1219
53	2.50	5.40	2868.21	4461.60	4461.60	0.22	16.50	21.28	12.58	1258	1258
54	2.46	5.26	2793.85	4461.60	4461.60	0.22	16.50	21.20	12.52	1261	1261

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PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC05428

Rev. No. Ø

REF. NO.

TABULATED DATA & CALCULATED VALUES (CONT)

Time (sec)	Level (volts) (recorded)	Level (feet) (calc)	Level (gallons) (calc)	Q (gpm) (calc)	Q (gpm) (rounded)	N2 Press (volts) (recorded)	N2 Press (psig) (calc)	Press Total (psig) (Pgas+Phead)	Δ P (psig) (P ttl-P b)	Cv = Q (calc) / sqrt(Δ P)	Cv = Q (rounded) / sqrt(Δ P)
55	2.42	5.11	2714.18	4780.20	4461.60	0.21	15.75	20.39	11.71	1397	1304
56	2.40	5.04	2677.00	223[illegible].80	4461.60	0.21	15.75	20.38	11.68	653	1305
57	2.36	4.90	2602.64	4461.60	4461.60	0.20	15.00	19.55	16.87	1353	1353
58	2.32	4.75	2522.96	4780.80	4063.20	0.20	15.00	19.48	10.[illegible]0	1455	1236
59	2.28	4.61	2448.60	4461.60	4063.20	0.20	15.00	19.42	10.74	1361	1240
60	2.26	4.54	2411.42	2230.80	3505.50	0.19	14.25	18.64	9.96	70[illegible]	1111
61	2.22	4.39	2331.75	4780.20	3505.50	0.19	14.25	18.58	9.90	1519	1114
62	2.20	4.32	2294.57	2230.80	3505.50	0.19	14.25	18.54	9.86	710	1116
63	2.16	4.18	2220.21	4461.60	3505.50	0.18	13.50	17.73	9.05	1483	1165
64	2.12	4.03	2140.53	4780.80	3346.20	0.18	13.50	17.67	8.99	1594	1116
65	2.10	3.[illegible]6	2103.35	2230.80	3346.20	0.18	13.50	17.64	8.96	745	1118
66	2.06	3.82	2028.99	4461.60	3346.20	0.17	12.7[illegible]	16.83	8.15	1563	1172
67	2.04	3.74	1986.50	2549.40	3346.20	0.17	12.75	16.79	8.11	895	1175
68	2.02	3.67	1949.32	2230.86	3080.60	0.17	12.75	16.76	8.08	785	1084
69	1.98	3.53	1874.96	4461.60	3080.60	0.17	12.75	16.7[illegible]	8.02	1575	1088
70	1.96	3.46	1837.78	2230.[illegible]	3080.60	0.17	12.75	[illegible].67	7.99	789	1090
71	1.94	3.38	1795.29	2549.40	3080.60	0.16	12.00	15.89	7.21	949	1147
72	1.90	3.24	1720.93	4461.60	3080.60	0.16	12.00	15.83	7.15	1669	1152
73	1.88	3.17	1683.75	2230.80	3080.60	0.16	12.00	15.80	7.12	836	1155
74	1.86	3.10	1646.57	2230.80	3080.60	0.16	12.00	15.77	7.09	838	1157
75	1.84	3.02	1604.07	2550.00	3080.60	0.16	12.00	15.73	7.05	960	1160
76	1.82	2.95	1566.89	2230.80	3080.60	0.16	12.00	15.70	7.02	842	1163
77	1.78	2.81	1492.53	4461.60	3080.60	0.15	11.25	14.89	6.21	1790	1236
78	1.76	2.74	1455.35	2230.80	2230.80	0.15	11.25	14.86	6.18	897	897
79	1.74	2.66	1412.86	2549.40	2230.80	0.15	11.25	14.82	6.14	1029	900
80	1.72	2.59	1375.68	2[illegible]0.80	2230.80	0.15	11.25	14.79	6.11	902	902
81	1.70	2.52	1338.50	2230.80	2230.80	0.15	11.25	14.76	6.08	905	905
82	1.68	2.45	1301.32	2230.80	2230.80	0.15	11.25	14.73	6.05	907	907
83	1.66	2.38	1264.14	2230.80	2230.80	0.15	11.25	14.70	6.02	909	909

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PRODUCTION ENGINEERING DIVISION
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CALCULATION NO. FC 05428

Rev. No. 0

REF. NO.

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TABULATED DATA & CALCULATED VALUES (CONT)

Time (sec)	Level (volts) (recorded)	Level (feet) (calc)	Level (gallons) (calc)	Q (gpm) (calc)	Q (gpm) (rounded)	N2 Press (volts) (recorded)	N2 Press (psig) (calc)	Press Total (psig) (P_{gas}+Phead)	Δ P (psig) (P ttl-P b)	Cv = Q (calc) / sqrt(Δ P)	Cv = Q (rounded) / sqrt(Δ P)
84	1.64	2.30	1221.65	2549.40	2230.80	0.15	11.25	14.67	5.99	1042	911
85	1.63	2.27	1205.[illegible]	956.40	1673.20	0.15	11.25	14.66	5.96	391	684
86	1.62	2.23	1184.46	1275.00	1673.20	0.15	11.25	14.64	5.96	522	685
87	1.60	2.16	1147.28	2230.80	1673.20	0.15	11.25	14.61	5.93	916	687
88	1.58	2.09	1110.10	2230.80	1673.20	0.15	11.25	14.58	5.90	918	689
89	1.56	2.02	1072.92	2230.80	1673.20	0.15	11.25	14.55	5.87	921	691
90	1.56	2.02	1072.92	0.00	1673.20	0.15	11.25	14.55	5.87	0	691
91	1.54	1.94	1030.43	2549.40	1673.[illegible]	0.14	10.50	13.76	5.08	1131	742
92	1.52	1.87	993.25	2230.80	1673.20	0.14	10.50	13.73	5.05	993	745
93	1.51	1.84	977.32	955.80	1673.20	0.14	10.50	13.72	5.04	426	745
94	1.50	1.80	956.07	1275.00	1115.40	0.14	10.50	13.70	5.02	569	498
95	1.49	1.76	934.82	1275.00	1115.40	0.14	10.50	13.68	5.00	570	499
96	1.48	1.73	918.89	955.80	1115.40	0.14	10.50	13.67	4.99	428	499
97	1.47	1.69	897.64	1275.00	1115.40	0.14	10.50	13.65	4.97	572	500
98	1.46	1.66	881.71	955.80	1115.40	0.14	10.50	13.64	4.96	429	501
99	1.46	1.66	881.71	0.00	637.50	0.14	10.50	13.64	4.96	0	286
100	1.45	1.62	860.46	1275.00	637.50	0.14	10.50	13.62	4.94	574	287
101	1.44	1.58	839.22	1274.40	637.50	0.14	10.50	13.61	4.93	574	287
102	1.44	1.58	839.22	0.00	637.50	0.14	10.50	13.61	4.93	0	287
103	1.43	1.55	823.28	956.40	637.50	0.14	10.50	13.59	4.91	432	288
104	1.42	1.51	802.04	1274.40	637.50	0.14	10.50	13.58	4.90	576	288
105	1.42	1.51	802.04	0.00	0.00	0.14	10.50	13.58	4.90	0	0
106	1.42	1.51	802.04	0.00	0.00	0.15	11.25	14.33	5.65	0	0
107	1.42	1.51	802.04	0.00	0.00	0.15	11.25	14.33	5.65	0	0
108	1.42	1.51	802.04	0.00	0.00	0.15	11.25	14.33	5.65	0	0
109	1.42	1.51	802.04	0.00	0.00	0.15	11.25	14.33	5.65	0	0
110	1.42	1.51	802.04	0.00	0.00	0.15	11.25	14.33	5.65	0	0

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Rev. No. Ø

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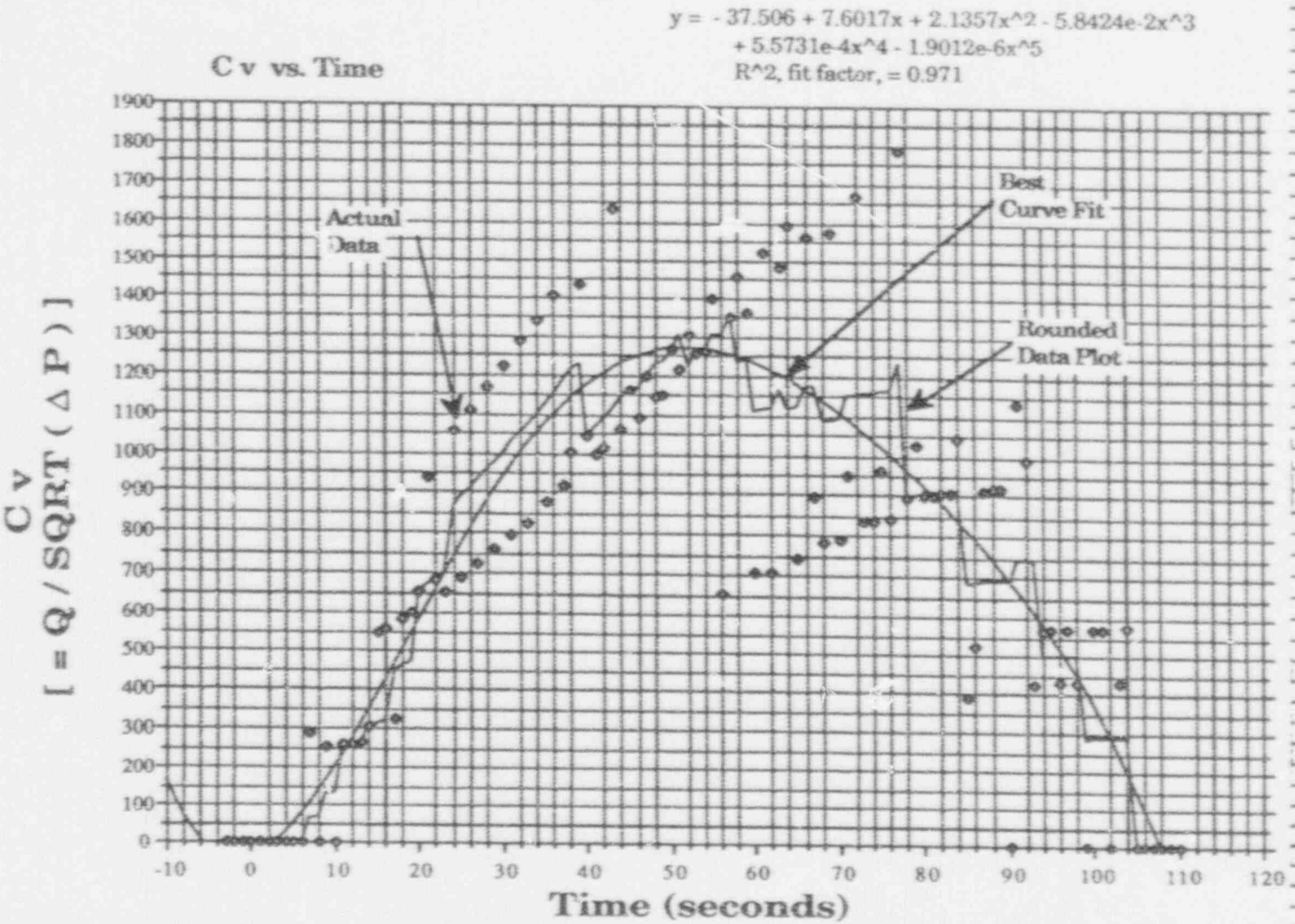
REF. NO.

*GRAPH PRODUCED BY CRICKET GRAPH, CRICKET GRAPH, VERSION 1.3.



PED-QP-3.35

REV.1

4-30-90
CMBloyd

Alternate check Calc.

LOCA Condition

P_1 : 255 psia USAR Table 14.15

P_2 = 70 psia 45 psia (Cont. Press) + 15 psi (Atmos) + 10 psi (ΔP RCS to Cont) (USAR figure 14.15-19)

Q = 14401 GPM (USAR Fig 14.15-18) 2000 lb/Sec

$$Cv = \frac{14401}{\sqrt{(255-70)}} = \frac{14401}{\sqrt{185}} = 1058.78$$

The Cv value from LOCA analysis Requirement of page 14 of FC 05428 is more conservative because it requires a $C_v = 1132$

for example

$$\sqrt{\Delta P} = \frac{Q}{Cv} = \frac{14401}{1132} = 12.72 \Rightarrow \Delta P = 162 \text{ psi}$$

ie if P_1 = 255 psia then P_2 = 93 psia.

or

$$Q = C_v\sqrt{\Delta P} = 1132\sqrt{185 \text{psi}} = 15397 \text{ GPM}$$

Conclusion: The final calculation, April 30, 1990 referencing acceptance criteria in Telecon PED-SSE-90-08355 is more conservative than the April 13, 1990, but 7.4% margin is plausible and workable.

Calc Preparation, Review and Approval PED-QP-3.5 Page 1 of 2 Reviewer's Checklist-Calculations	CALCULATION NUMBER FC 05428

		YES	NO	N/A
1.	Is Calculation Cover Sheet attached and completed, as required, to the calculation?	X		
2.	Is the calculation objective stated? Was this achieved?	X		
3.	Are inputs correctly selected and incorporated into the analysis?	X		
4.	Have inputs and/or assumptions which require confirmation at a later data, been identified on the Calculation Cover Sheet and in the calculation body?			X
5.	Are the applicable codes, standards, regulatory requirements, and other references including issue and addenda identified such that they are traceable to source document?	X		
6.	Was an appropriate calculation method used? Was the basic theory appropriate?	X		
7.	Have assumptions been noted and justified?	X		
8.	Are the calculations free of arithmetic errors?	X		
9.	Is the calculation consistent with the design basis requirements?	X		
10.	Is the conclusion stated?	X		
11.	Is the calculation legible and suitable for microfilming?	X		

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Calc Preparation, Review and Approval PED-QP-3.5 Page 2 of 2 Reviewer's Checklist-Calculations	CALCULATION NUMBER FC05428

		YES	NO	N/A
12.	Are all blocks on the Calculation Cover Sheet addressed correctly?	X		
13.	Have Forms PED-QP-3.2, 3, 4 and 5 been used and correctly completed?	X		
14.	If the calculation has been prepared to supersede another calculation, has all the valid information been transferred in the new calculation?			X

REVIEWER COMMENTS:

Charles M Bloyd 4-13-90
Reviewer Date CMB 4-30-90

Calc Preparation, Review and Approval PED-QP-3.6 Page 1 of 2 Reviewer's Checklist Computer Calculations	CALCULATION NUMBER FC05428

		YES	NO	N/A
1.	Does the computer run have title, date, and page number and alphanumeric program number on every sheet?	X		
2.	Is the listing of computer input provided?	X		
3.	Is the machine generated program name and version on each run or is indicated in the calculation?		X	
4.	Is the computer software validated and verified?		X	
If no:				
4a.	Is the computer code developed for one-time-use on a programmable calculator or micro-computer?	X		
4b.	If yes, has a functional description of the program, identification of the equations, identification of the code (title, revision, manufacturer), identification of the software and brief user's instructions been provided in the calculation?	X		
5.	If the computer software has been loaded on an in-house computer, have the changes made by OPPD been properly reviewed (verified and validated) for their impact on the accuracy of the code and have been found satisfactory, or is the in-house computer software validated?			X
6.	Is the computer program appropriate to do the intended calculation?	X		

Calc Preparation, Review and Approval PED-QP-3.6 Page 2 of 2 Reviewer's Checklist Computer Calculations	CALCULATION NUMBER FC 05428

	YES	NO	N/A
7. Was an alternate calculation or model utilized to verify results? If so, is it attached to this calculation?	X		
8. Is the modeling correct in terms of geometry input and initial conditions?	X		
9. Are the results reasonable when compared to the inputs?	X		

REVIEWER COMMENTS:

Charles M Bloyd
Reviewer

1 4-13-90
Date CMB 4-30-90

Calc Preparation, Review and Approval PED-QP-3.7 Page 1 of 1 Independent Reviewer's Checklist - Calculations	CALCULATION NUMBER FC05428

		YES	NO	N/A
1.	Are the calculation methods accurate and appropriate?	✓		
* 2.	Are input data sufficiently detailed?	✓		
3.	Are the calculation assumptions reasonable?	✓		
4.	Has the basis for engineering judgement been included in the calculation, when used?	✓		
5.	Is the calculation documented sufficiently such that the analysis is understandable to someone competent in the discipline without recourse to the Preparer?	✓		
6.	Have the design interface requirements been satisfied?	✓		
7.	Are the results reasonable and do they resolve the calculation objective?	✓		
8.	If an alternate calculation was used to verify the adequacy of the analysis, is it attached to the calculation?	✓		
9.	If qualification testing was used to verify the adequacy of the analysis, has it been documented using a retrievable source, or attached to the calculation?	✓		
10.	Are calculations involving Technical Specification values and associated margins of safety identified?	✓		

INDEPENDENT REVIEWER COMMENTS:

* 2. Need to confirm accuracy of loop via recalibration of PT-2941 (last cal'd 12/12/88), and LT-2944X (12/26/88) Normal testing practice is to cal. instruments before and after a test. Requires confirmation.

** - SIT Instruments calibration check satisfactory after closeout of test [signature] 5/31/90

[signature] 15/1/90

Independent Reviewer Date

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Calc Preparation, Review and Approval PED-QP-3.5 Page 1 of 2 Reviewer's Checklist-Calculations	CALCULATION NUMBER FC 05428 Rev 1

		YES	NO	N/A
1.	Is Calculation Cover Sheet attached and completed, as required, to the calculation?	X		
2.	Is the calculation objective stated? Was this achieved?	X		
3.	Are inputs correctly selected and incorporated into the analysis?	X		
4.	Have inputs and/or assumptions which require confirmation at a later data, been identified on the Calculation Cover Sheet and in the calculation body?			X
5.	Are the applicable codes, standards, regulatory requirements, and other references including issue and addenda identified such that they are traceable to source document?	X		
6.	Was an appropriate calculation method used? Was the basic theory appropriate?	X		
7.	Have assumptions been noted and justified?	X		
8.	Are the calculations free of arithmetic errors?	X		
9.	Is the calculation consistent with the design basis requirements?	X		
10.	Is the conclusion stated?	X		
11.	Is the calculation legible and suitable for microfilming?	X		

P 25B 0262

Calc Preparation, Review and Approval PED-QP-3.5 Page 2 of 2 Reviewer's Checklist-Calculations	CALCULATION NUMBER FC 05428 Rev 1

		YES	NO	N/A
12.	Are all blocks on the Calculation Cover Sheet addressed correctly?	X		
13.	Have Forms PED-QP-3.2, 3, 4 and 5 been used and correctly completed?	X		
14.	If the calculation has been prepared to supersede another calculation, has all the valid information been transferred in the new calculation?			X

REVIEWER COMMENTS:

NONE

Ron Lippy 12/13/92

Reviewer Date

Calc Preparation, Review and Approval PED-QP-3.7 Page 1 of 1 Independent Reviewer's Checklist - Calculations	CALCULATION NUMBER FC 05428 Rev 1

		YES	NO	N/A
1.	Are the calculation methods accurate and appropriate?	✓		
2.	Are input data sufficiently detailed?	✓		
3.	Are the calculation assumptions reasonable?	✓		
4.	Has the basis for engineering judgement been included in the calculation, when used?			✓
5.	Is the calculation documented sufficiently such that the analysis is understandable to someone competent in the discipline without recourse to the Preparer?	✓		
6.	Have the design interface requirements been satisfied?	✓		
7.	Are the results reasonable and do they resolve the calculation objective?	✓		
8.	If an alternate calculation was used to verify the adequacy of the analysis, is it attached to the calculation?	✓		
9.	If qualification testing was used to verify the adequacy of the analysis, has it been documented using a retrievable source, or attached to the calculation?			✓
10.	Are calculations involving Technical Specification values and associated margins of safety identified?	✓		

INDEPENDENT REVIEWER COMMENTS:

[signature] 12/14/92

Independent Reviewer Date

FC 05428
p. 26 of 62

EXPERIMENTAL METHODS FOR ENGINEERS

Fourth Edition

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McGraw-Hill Book Company

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id variations. I- subsequent sections we shall
g experimental uncertainties in a more precise

3-4 UNCERTAINTY ANALYSIS

A more precise method of estimating uncertainty in experimental results has been presented by Kline and McClintock [1]. The method is based on a careful specification of the uncertainties in the various primary experimental measurements. For example, a certain pressure reading might be expressed as

$$p = 100\ \text{kN/m}^2 \pm 1\ \text{kN/m}^2$$

When the plus or minus notation is used to designate the uncertainty, the person making this designation is stating the degree of accuracy with which he or she *believes* the measurement has been made. We may note that this specification is in itself uncertain because the experimenter is naturally uncertain about the accuracy of these measurements.

If a very careful calibration of an instrument has been performed recently, with standards of very high precision, then the experimentalist will be justified in assigning a much lower uncertainty to measurements than if they were performed with a gage or instrument of unknown calibration history.

To add a further specification of the uncertainty of a particular measurement, Kline and McClintock propose that the experimenter specify certain odds for the uncertainty. The above equation for pressure might thus be written

$$p = 100\ \text{kN/m}^2 \pm 1\ \text{kN/m}^2\ (20 \text{ to } 1)$$

In other words, the experimeter is willing to bet with 20 to 1 odds that the pressure measurement is within $\pm 1\ \text{kN/m}^2$. It is important to note that the specification of such odds can *only* be made by the experimenter based on the total laboratory experience.

Suppose a set of measurements is made and the uncertainty in each measurement may be expressed with the same odds. These measurements are then used to calculate some desired result of the experiments. We wish to estimate the uncertainty in the calculated result on the basis of the uncertainties in the primary measurements. The result R is a given function of the independent variables $x_1, x_2, x_3, \ldots, x_n$. Thus,

$$R = R(x_1, x_2, x_3, \ldots, x_n) \tag{3-1}$$

Let w_R be the uncertainty in the result and $w_1, w_2, \ldots, w_n$ be the uncertainties in the independent variables. If the uncertainties in the independent variables are all given with the same odds, then the uncertainty in the result having these odds is given in Ref. [1] as

$$w_R = \left[\left(\frac{\partial R}{\partial x_1} w_1\right)^2 + \left(\frac{\partial R}{\partial x_2} w_2\right)^2 + \cdots + \left(\frac{\partial R}{\partial x_n} w_n\right)^2\right]^{1/2} \tag{3-2}$$

If this relation is applied to the electric power relation of the previous section, the expected uncertainty is 2.83 percent instead of 4.04 percent.

Example 3-1 The resistance of a certain size of copper wire is given as

$$R = R_0[1 + \alpha(T - 20)]$$

where $R_0 = 6\ \Omega \pm 0.3$ percent is the resistance at 20°C, $\alpha = 0.004\ ^\circ\text{C}^{-1} \pm 1$ percent is the temperature coefficient of resistance, and the temperature of the wire is $T = 30 \pm 1$°C. Calculate the resistance of the wire and its uncertainty.

SOLUTION The nominal resistance is

$$R = (6)[1 + (0.004)(30 - 20)] = 6.24\ \Omega$$

The uncertainty in this value is calculated by applying Eq. (3-2). The various terms are:

$$\frac{\partial R}{\partial R_0} = 1 + \alpha(T - 20) = 1 + (0.004)(30 - 20) = 1.04$$

$$\frac{\partial R}{\partial \alpha} = R_0(T - 20) = (6)(30 - 20) = 60$$

$$\frac{\partial R}{\partial T} = R_0 \alpha = (6)(0.004) = 0.024$$

$$w_{R_0} = (6)(0.003) = 0.018\ \Omega$$

$$w_\alpha = (0.004)(0.01) = 4 \times 10^{-5}\ ^\circ\text{C}^{-1}$$

$$w_T = 1^\circ\text{C}$$

Thus, the uncertainty in the resistance is

$$w_R = [(1.04)^2(0.018)^2 + (60)^2(4 \times 10^{-5})^2 + (0.024)^2(1)^2]^{1/2}$$
$$= 0.0305\ \Omega \text{ or } 0.49\%$$

Particular notice should be given to the fact that the uncertainty propagation in the result w_R predicted by Eq. (3-2) depends on the squares of the uncertainties in the independent variables w_n. This means that if the uncertainty in one variable is significantly larger than the uncertainties in the other variables, say, by a factor of 5 or 10, then it is the largest uncertainty that predominates and the others may probably be neglected.

To illustrate, suppose there are three variables with a product of sensitivity and uncertainty $[(\partial R/\partial x)w_x]$ of magnitude 1, and one variable with a magnitude of 5. The uncertainty in the result would be

$$(5^2 + 1^2 + 1^2 + 1^2)^{1/2} = \sqrt{28} = 5.29$$

The importance of this brief remark concerning the relative magnitude of uncertainties is evident when one considers the design of an experiment, procurement

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of instrumentation, etc. Very little is gained by trying to reduce the "small" uncertainties. Because of the square propagation it is the "large" ones that predominate, and any improvement in the overall experimental result must be achieved by improving the instrumentation or experimental technique connected with these relatively large uncertainties. In the examples and problems that follow, both in this chapter and throughout the book, the reader should always note the relative effect of uncertainties in primary measurements on the final result.

In Sec. 2-11 (Table 2-7) the reader was cautioned to examine possible experimental errors *before* the experiment is conducted. Equation (3-2) may be used very effectively for such analysis, as we shall see in the sections and chapters that follow. A further word of caution may be added here. It is equally as unfortunate to overestimate uncertainty as to underestimate it. An underestimate gives false security, while an overestimate may make one discard important results, miss a real effect, or buy much too expensive instruments. The purpose of this chapter is to indicate some of the methods for obtaining reasonable estimates of experimental uncertainty.

In the previous discussion of experimental planning we noted that an uncertainty analysis may aid the investigator in selecting alternative methods to measure a particular experimental variable. It may also indicate how one may improve the overall accuracy of a measurement by attacking certain critical variables in the measurement process. The next three examples illustrate these points.

Example 3-2 A resistor has a nominal stated value of 10 Ω ± 1 percent. A voltage is impressed on the resistor, and the power dissipation is to be calculated in two different ways: (1) from $P = E^2/R$ and (2) from $P = EI$. In (1) only a voltage measurement will be made, while both current and voltage will be measured in (2). Calculate the uncertainty in the power determination in each case when the measured values of E and I are:

$$E = 100 \text{ V} \pm 1\% \qquad \text{(for both cases)}$$

$$I = 10 \text{ A} \pm 1\%$$

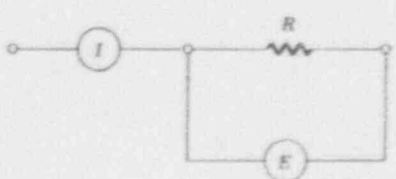

Figure Example 3-2 Power measurement across a resistor.

SOLUTION The schematic is shown in the accompanying figure. For the first case we have

$$\frac{\partial P}{\partial E} = \frac{2E}{R} \qquad \frac{\partial P}{\partial R} = -\frac{E^2}{R^2}$$

and we apply Eq. (3-2) to give

$$w_P = \left[\left(\frac{2E}{R}\right)^2 w_E^2 + \left(-\frac{E^2}{R^2}\right)^2 w_R^2\right]^{1/2} \qquad (a)$$

Dividing by $P = E^2/R$ gives

$$\frac{w_P}{P} = \left[4\left(\frac{w_E}{E}\right)^2 + \left(\frac{w_R}{R}\right)^2\right]^{1/2} \qquad (b)$$

Inserting the numerical values for uncertainty,

$$\frac{w_P}{P} = [4(0.01)^2 + (0.01)^2]^{1/2} = 2.236\%$$

For the second case we have

$$\frac{\partial P}{\partial E} = I \qquad \frac{\partial P}{\partial I} = E$$

and after similar algebraic manipulation, we obtain

$$\frac{w_P}{P} = \left[\left(\frac{w_E}{E}\right)^2 + \left(\frac{w_I}{I}\right)^2\right]^{1/2} \qquad (c)$$

Inserting the numerical values of uncertainty,

$$\frac{w_P}{P} = [(0.01)^2 + (0.01)^2]^{1/2} = 1.414\%$$

Thus, the second method of power determination provides considerably less uncertainty than the first method, even though the primary uncertainties in each quantity are the same. In this example the utility of the uncertainty analysis is that it affords the individual a basis for *selection of a measurement method* to produce a result with less uncertainty.

Example 3-3 The power measurement in Example 3-2 is to be conducted by measuring voltage and current across the resistor with the circuit shown in the accompanying figure. The voltmeter has an internal resistance R_m, and the value of R is known only approximately. Calculate the nominal value of the power dissipated in R and the uncertainty for the following conditions:

$$R = 100\ \Omega \qquad \text{(not known exactly)}$$

$$R_m = 1000\ \Omega \pm 5\%$$

$$I = 5 \text{ A} \pm 1\%$$

$$E = 500 \text{ V} \pm 1\%$$

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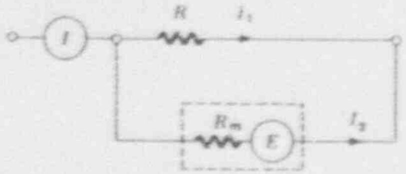

Figure Example 3-3 Effect of meter impedance on measurement.

SOLUTION A current balance on the circuit yields

$$I_1 + I_2 = i$$

$$\frac{E}{R} + \frac{E}{R_m} = 1$$

and

$$I_1 = I - \frac{E}{R_m} \tag{a}$$

The power dissipated in the resistor is

$$P = EI_1 = EI - \frac{E^2}{R_m} \tag{b}$$

The nominal value of the power is thus calculated as

$$P = (500)(5) - \frac{500^2}{1000} = 2250 \text{ W}$$

In terms of known quantities the power has the functional form $P = f(E, I, R_m)$, and so we form the derivatives

$$\frac{\partial P}{\partial E} = I - \frac{2E}{R_m} \qquad \frac{\partial P}{\partial I} = E$$

$$\frac{\partial P}{\partial R_m} = \frac{E^2}{R_m^2}$$

The uncertainty for the power is now written as

$$w_P = \left[\left(I - \frac{2E}{R_m}\right)^2 w_E^2 + E^2 w_I^2 + \left(\frac{E^2}{R_m^2}\right)^2 w_{R_m}^2\right]^{1/2} \tag{c}$$

Inserting the appropriate numerical values gives

$$w_P = \left[\left(5 - \frac{1000}{1000}\right)^2 5^2 + (25 \times 10^4)(25 \times 10^{-4}) + \left(25 \times \frac{10^4}{10^6}\right)^2 (2500)\right]^{1/2}$$

$$= [16 + 25 + 6.25]^{1/2}(5)$$

$$= 34.4 \text{ W}$$

or

$$\frac{w_P}{P} = \frac{34.4}{2250} = 1.53\%$$

In order of influence on the final uncertainty in the power we have

1. Uncertainty of current determination
2. Uncertainty of voltage measurement
3. Uncertainty of knowledge of internal resistance of voltmeter

There are other conclusions we can draw from this example. The relative influence of the experimental quantities on the overall power determination is noted above. But this listing may be a bit misleading in that it implies that the uncertainty of the meter impedance does not have a large effect on the final uncertainty in the power determination. This results from the fact that $R_m \gg R$ ($R_m = 10R$). If the meter impedance were lower, say, 200 Ω, we would find that it was a dominant factor in the overall uncertainty. For a very *high* meter impedance there would be little influence, even with a very inaccurate knowledge of the exact value of R_m. Thus, we are led to the simple conclusion that we need not worry too much about the precise value of the internal impedance of the meter as long as it is very large compared with the resistance we are measuring the voltage across. This fact should influence *instrument selection* for a particular application.

Example 3-4 A certain obstruction-type flowmeter (orifice, venturi, nozzle), shown in the accompanying figure, is used to measure the flow of air at low velocities. The relation describing the flow rate is

$$\dot{m} = CA\left[\frac{2g_c p_1}{RT_1}(p_1 - p_2)\right]^{1/2} \tag{a}$$

where C is an empirical-discharge coefficient, A is the flow area, p_1 and p_2 are the upstream and downstream pressures, T_1 is the upstream temperature, and

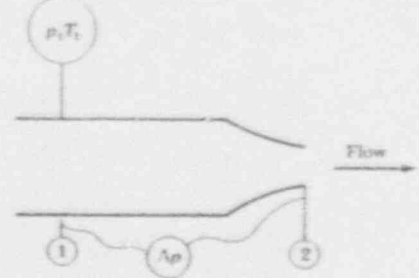

Figure Example 3-4 Uncertainty in a flowmeter.

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R is the gas constant for air. Calculate the percent uncertainty in the mass flow rate for the following conditions:

$C = 0.92 \pm 0.005$ (from calibration data)

$p_1 = 25$ psia ± 0.5 psia

$T_1 = 70°F \pm 2°F \qquad T_1 = 530°R$

$\Delta p = p_1 - p_2 = 1.4$ psia ± 0.005 psia (measured directly)

$A = 1.0\ \text{in}^2 \pm 0.001\ \text{in}^2$

SOLUTION In this example the flow rate is a function of several variables, each subject to an uncertainty.

$$\dot{m} = f(C, A, p_1, \Delta p, T_1) \tag{b}$$

Thus, we form the derivatives:

$$\frac{\partial \dot{m}}{\partial C} = A\left(\frac{2g_c p_1}{RT_1}\Delta p\right)^{1/2}$$

$$\frac{\partial \dot{m}}{\partial A} = C\left(\frac{2g_c p_1}{RT_1}\Delta p\right)^{1/2}$$

$$\frac{\partial \dot{m}}{\partial p_1} = 0.5CA\left(\frac{2g_c}{RT_1}\Delta p\right)^{1/2} p_1^{-1/2} \tag{c}$$

$$\frac{\partial \dot{m}}{\partial \Delta p} = 0.5CA\left(\frac{2g_c p_1}{RT_1}\right)^{1/2} \Delta p^{-1/2}$$

$$\frac{\partial \dot{m}}{\partial T_1} = -0.5CA\left(\frac{2g_c p_1}{R}\Delta p\right)^{1/2} T_1^{-3/2}$$

The uncertainty in the mass flow rate may now be calculated by assembling these derivatives in accordance with Eq. (3-2). Designating this assembly as Eq. (c) and then dividing by Eq. (a) gives

$$\frac{w_{\dot{m}}}{\dot{m}} = \left[\left(\frac{w_C}{C}\right)^2 + \left(\frac{w_A}{A}\right)^2 + \frac{1}{4}\left(\frac{w_{p1}}{p_1}\right)^2 + \frac{1}{4}\left(\frac{w_{\Delta p}}{\Delta p}\right)^2 + \frac{1}{4}\left(\frac{w_{T_1}}{T_1}\right)^2\right]^{1/2} \tag{d}$$

We may now insert the numerical values for the quantities to obtain the percent uncertainty in the mass flow rate.

$$\frac{w_{\dot{m}}}{\dot{m}} = \left[\left(\frac{0.005}{0.92}\right)^2 + \left(\frac{0.001}{1.0}\right)^2 + \frac{1}{4}\left(\frac{0.5}{25}\right)^2 + \frac{1}{4}\left(\frac{0.005}{1.4}\right)^2 + \frac{1}{4}\left(\frac{2}{530}\right)^2\right]^{1/2}$$

$$= [29.5 \times 10^{-6} + 1.0 \times 10^{-6} + 1.0 \times 10^{-4} + 3.19 \times 10^{-6} + 3.57 \times 10^{-6}]^{1/2}$$

$$= [1.373 \times 10^{-4}]^{1/2} = 1.172\% \tag{e}$$

The main contribution to uncertainty is the p_1 measurement with its basic uncertainty of 2 percent. Thus, to improve the overall situation the accuracy of this measurement should be attacked first. In order of influence on the flow-rate uncertainty, we have

1. Uncertainty in p_1 measurement (± 2 percent)
2. Uncertainty in value of C
3. Uncertainty in determination of T_1
4. Uncertainty in determination of Δp
5. Uncertainty in determination of A

By inspecting Eq. (e) we see that the first two items make practically the whole contribution to uncertainty. The value of the uncertainty analysis in this example is that it shows the investigator how to improve the overall measurement accuracy of this technique. First, obtain a more precise measurement of p_1. Then try to obtain a better calibration of the device, i.e., a better value of C. In Chap. 7 we shall see how values of the discharge coefficient C are obtained.

3-5 EVALUATION OF UNCERTAINTIES FOR COMPLICATED DATA REDUCTION

We have seen in the preceding discussion and examples how uncertainty analysis can be a useful tool to examine experimental data. In many cases data reduction is a rather complicated affair and is often performed with a computer routine written specifically for the task. A small adaptation of the routine can provide for direct calculation of uncertainties without resorting to an analytical determination of the partial derivatives in Eq. (3-2). We still assume that this equation applies, although it could involve several computational steps. We also assume that we are able to obtain estimates by some means of the uncertainties in the primary measurements, i.e., w_1, w_2, etc.

Suppose a set of data is collected in the variables $x_1, x_2, \ldots, x_n$ and a result calculated. At the same time one may perturb the variables by Δx_1, Δx_2, and so on, and calculate new results. We would have

$$R(x_1) = R(x_1, x_2, \ldots, x_n)$$
$$R(x_1 + \Delta x_1) = R(x_1 + \Delta x_1, x_2, \ldots, x_n)$$

$$R(x_2) = R(x_1, x_2, \ldots, x_n)$$
$$R(x_2 + \Delta x_2) = R(x_1, x_2 + \Delta x_2, \ldots, x_n)$$

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p 31 of 62

FLOW OF FLUIDS

THROUGH

VALVES, FITTINGS, AND PIPE

By the Engineering Division

CRANE®

CRANE CO.

300 Park Avenue
New York, N.Y. 10022

After May 1, 1985
757 Third Avenue
New York, NY 10017

Technical Paper No. 410 [redacted]

PRINTED IN U. S. A.

(Twenty Second Printing—1985)

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Resistance Coefficient K, Equivalent Length L/D, And Flow Coefficient C_v — continued

The friction factors for clean commercial steel pipe with flow in the zone of complete turbulence (f_T), for nominal sizes from 1/2 to 24-inch are tabulated at the beginning of the "K" Factor Table (page A-26) for convenience in converting the algebraic expressions of f arithmetic quantities.

There are some resistances to flow in piping, such as sudden and gradual contractions and enlargements, and pipe entrances and exits, that have geometric similarity between sizes. The resistance coefficients (K) for these items are therefore independent of size, as indicated by the absence of a friction factor in their values given in the "K" Factor Table.

As previously stated, the resistance coefficient K is always associated with the diameter in which the velocity in the term $v^2/2g$ occurs. The values in the "K" Factor Table are associated with the internal diameter of the following pipe schedule numbers for the various ANSI Classes of valves and fittings.

Class 300 and lower	Schedule 40
Class 400 and 600	Schedule 80
Class 900	Schedule 120
Class 1500	Schedule 160
Class 2500 (sizes ½ to 6")	XXS
Class 2500 (sizes 8" and up)	Schedule 160

When the resistance coefficient K is used in flow equation 2-2, or any of its equivalent forms given in Chapter 3 as Equations 3-14, 3-16, 3-19 and 3-20, the velocity and internal diameter dimensions used in the equation must be based on the dimensions of these schedule numbers regardless of the pipe with which the valve may be installed.

An alternate procedure which yields identical results for Equation 2-2 is to adjust K in proportion to the fourth power of the diameter ratio, and to base values of velocity or diameter on the internal diameter of the connecting pipe.

$$K_a = K_b \left(\frac{d_a}{d_b}\right)^4 \qquad \textit{Equation 2-5}$$

Subscript "a" defines K and d with reference to the internal diameter of the connecting pipe.

Subscript "b" defines K and d with reference to the internal diameter of the pipe for which the values of K were established, as given in the foregoing list of pipe schedule numbers.

When a piping system contains more than one size of pipe, valves, or fittings, Equation 2-5 may be used to express all resistances in terms of one size. For this case, subscript "a" relates to the size with reference to which all resistances are to be expressed, and subscript "b" relates to any other size in the system. For sample problem, see Example 4-14.

It has been found convenient in some branches of the valve industry, particularly in connection with control valves, to express the valve capacity and the valve flow characteristics in terms of the flow coefficient C_v. The C_v coefficient of a valve is defined as the flow of water at 60 F, in gallons per minute, at a pressure drop of one pound per square inch across the valve.

By the substitution of appropriate equivalent units in the Darcy equation, it can be shown that,

$$C_V = \frac{29.9d^2}{\sqrt{K}} \qquad \textit{Equation 2-6}$$

Also, the quantity in gallons per minute of liquids of low viscosity* that will flow through the valve can be determined from:

$$Q = C_V \sqrt{\Delta P \left(\frac{62.4}{\rho}\right)} \qquad \textit{Equation 2-7}$$

$$Q = 7.9\, C_V \sqrt{\frac{\Delta P}{\rho}}$$

and the pressure drop can be computed from the same formula arranged as follows:

$$\Delta P = \frac{\rho}{62.4}\left(\frac{Q}{C_V}\right)^2 \qquad \textit{Equation 2-7}$$

Since Equations 2-2 and 2-7 are simply other forms of the Darcy equation, the limitations regarding their use for compressible flow (explained on page 1-7) apply. Other convenient forms of Equations 2-2 and 2-7 in terms of commonly used units are presented on page 3-4.

*When handling highly viscous liquids determine flow rate or required valve C_V as described in the ISA Handbook of Control Valves.

* * * * *

FC 05428
P. 33 of 62

RECORD OF TELEPHONE COMMUNICATION
PED-SSE-90-0435S

DATE: 27 April 1990 TIME: 1430 HRS

PARTY CALLING: Al Newcomer (Name) IMPELL/OPPD Special Services (Company)

PARTY ANSWERING: Bill Weber (Name) OPPD, Supv. of Reactor Perf. Analysis (Company)

SUBJECT: Values of Physical Constants Used in the Ft. Calhoun LOCA Analysis

---

TELECON SUMMARY (Including Decisions and Commitments)

I called Bill Weber to get a flow coefficient (C_v) value as used in the plant LOCA analysis for the safety injection system. Bill informed me that a C_v value would not be possible, but that other parameters might be available. After Bill Called Mr. John Jung, Combustion Engineering, he informed me that the effective flow area and representative resistance coefficient (K) were 0.5592 ft^2 and 7.34 respectively, as used in the C.E. performed LOCA analysis. From these values, he continued, the C_v can be calculated. Bill also added that he would once again contact Mr. Jung for formal documentation of the two constants.

ACTION REQUIRED

Weber contacted Jung for formal documentation of numbers.

DISTRIBUTION: Chuck Bloyd, FCS Special Services
Ron Lippy, FCS Special Services
Bill Weber, OPPD Reactor Perf. Analysis

ABB
ASEA BROWN BOVERI

February 3, 1992

O-MECH-92-015

Mr. C. N. Bloyd
Ft. Calhoun Station
Omaha Public Power District
P. O. Box 399
Ft. Calhoun, NE 68023

Subject: SIT Injection Line Resistance Factor for ECCS Analysis.

Reference: CE Letter: O-PD-113, Omaha and Palisades ECCS Data, dated March 15, 1974. (Enclosed)

Dear Chuck;

This letter transmits an edited copy of the referenced internal letter. It is understood that the information contained in this letter regarding the SIT injection line resistance is needed to support the basis for acceptance criteria in the Ft. Calhoun Station SIT check valve operability test procedure.

The enclosed copy of the letter has been edited since it contained design data on both the Ft. Calhoun Station and the CPCo Palisades Plant. Only that data which relates to the Palisades contract has been edited out. Additionally, in reviewing the OPPD calculation file, we were able to determine that the source of the data for the line resistance values is based upon a calculation which was produce in late 1971 and that Gibbs & Hill line isometric drawings were used to establish the unique values for each of the four lines.

ABB CENS is pleased to provide this information and support to you at this time. Should you have any additional questions, please feel free to contact me at 203-285-3893.

Sincerely,

ABB COMBUSTION ENGINEERING NUCLEAR SERVICES

F. P. Ferraraccio
Supervisor, Plant Engineering Services

R.1
CNB
2-12-92

xc: C. Boughter
G. Anglehart (ABB-CE RSSM)
D. Sentell (ABB-CE)

Rev 1

P 33B of 62

COMBUSTION DIVISION

TO: W. A. Goodwin
F. L. Carpentino
R. D. Haun
V. M. Callaghan
E. M. Smith
G. E. Wuertz
C. Salamon

CC: W. K. Wilhelm w/o attach.
D. F. Streinz w/o attach.
A. O. Schoenbrunn w/o attach.

Omaha and Palisades
ECCS Data

B. M. Pokora
March 15, 1974
O-PD-113

Reference: PD-74-100 dated February 15, 1974

Enclosure: LPSI Pump, HPSI Pump, and Safety Injection Tank Data For New ECCS Evaluation Model

Enclosed are LPSI Pump, HPSI Pump, and Safety Injection Tank data for Omaha and Palisades, as requested from the PCS-Safeguards Systems Group by Safety and Licensing in SA-74-30.

B. M. Pokora

B. M. Pokora

R. 1
CMB
2-12-92

BMP:mjr

I. PALISADES ECCS DATA

This table plus Figures 1 and 2 have been edited from this copy.

II. OMAHA ECCS DATA

4. (a) Number SI Tanks: Four
   (b) SI Tank Temperature: 120°F
   (c) SI Tank Pressures: 255 psia min, 270 psia nom, 284 psia max.
   (d) SI Tank Liquid Volumes: 825 Ft^3 min. 856.9 Ft^3 nom, 895.8 Ft^3 max.
   (e) SI Tank Total Volumes: 1306 Ft^3/Ta
   (f) SI Tank Discharge Line K Factors . area = .5592 Ft^2)
   Tank 6A K=6.65 Tank 6B, K=6.94 k 6C, K=7.34 Tank 6D K=7.0
   (g) SI Tank Minimum Discharge Area = 0. 92 Ft^2
   (h) Elevation of SI Tank Discharge Nozzles above hot leg ℄
   Tank 6A, H=8.1' Tank 6B, H=5' Tank 6C, H=6.63' Tank 6D, H=5'
5. (a) HPSI Pump Liquid Enthalpy: 8.07 to 68.04 btu/lbm
   (b) HPSI Delivery Curves: See Figure 3
   (c) SIAS Setpoints: Pressurizer Pressure ≤ 1600 ± 22 psia
   Containment .ressure ≥ 5 psig
6. (a) LPSI Pump L quid Enthalpy: 8.07 to 68.04 btu/lbm
   (b) LPSI Pump Delivery Curves: See figure 4
   (c) SIAS Setpoints: Pressurizer Pressure ≤ 1600 ± 22 psia
   Containment Pressure ≥ 5 psig

R.1
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2-12-92

[illegible] CURVE Page 33D of 62

(INJECTION MODE-WORST CASE)

Figure 3

R.1
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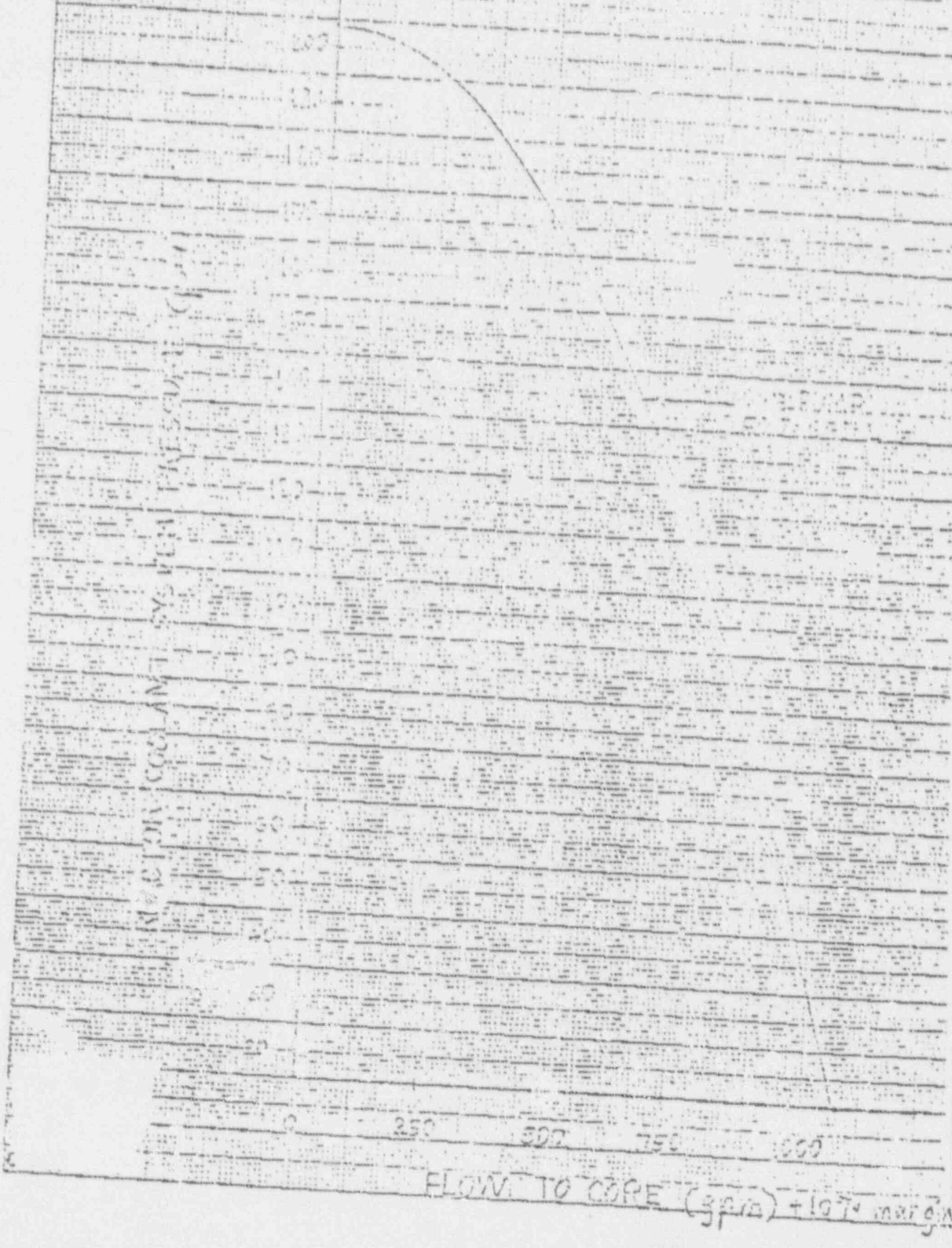
OMAHA LPSI PUMP DELIVERY CURVE P 33E of 62

(INJECTION MODE - WORST CASE) Rev 1

Figure 4



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SAFETY INJECTION TANK SI-6C DUMP TEST

1.0 PURPOSE

1.1 The purpose of this test is to determine if dumping Safety Injection Tank SI-6C to the Reactor Coolant System will result in an adequate method of verifying the operability of Safety Injection Tank discharge check valves SI-207 and SI-208.

1.2 This test will be performed during refueling with the Reactor Head off, the Reactor Core off-loaded, and the Reactor Vessel Refueling Cavity partially filled.

2.0 REFERENCES

2.1 Technical Specifications 2.1.1, 2.3, 2.8 and 3.6.4.b

2.2 ASME Boiler and Pressure Vessel Code, Section XI, 1980 Edition, Winter 1980 Addenda

2.3 USAR Section 6.2

2.4 Piping and Instrumentation Drawings

2.4.1 E-23866-210-130 (sheet 2 of 2) File No. 10480

2.4.2 E-23866-210-110 File No. 10475

2.4.3 11405-M-42 File No. 10450

2.4.4 11405-A-13 File No. 12170

2.5 Instrumentation and Control Interconnection Diagrams

2.5.1 161F561 SHT. 85 File No. 9583

2.5.2 16F561 SHT. 101 File No. 9599

2.6 Instrument Loop Drawings

2.6.1 EM-2941 File No. 20576

2.6.2 EM-2944 File No. 20594

2.7 Mission Valve Manufacturing Drawings

2.7.1 16259 SHT. 1 File No. 16714

2.7.2 16259 SHT. 1A File No. 16716

2.8 Standing Order G-19, "Test Control"

2.9 Standing Order M-28, "Calibration of Test Equipment and Plant Process Instrumentation"

2.10 Calculation FC-05280

2.11 Operating Instructions

2.11.1 OI-SI-1, Safety Injection System-Normal Operation

2.11.2 OI-NG-1, Nitrogen System-Normal Operation

3.0 PREREQUISITES

INITIALS/DATE

NOTE: Prerequisites 3.2 through 3.11 may be accomplished in any order.

3.1 A Test Director (TD) has been designated and a Chronological Test Log (Attachment 1) initiated per Reference 2.8. The Test Log shall be initiated at the first pretest briefing and appended to this test when completed.
OJJ / 3-31-90
SH / 3-31-90
DRR / 3-31-90
TD

3.2 A pretest briefing of all personnel involved in this test has been conducted (briefings may be conducted in segments for ease of accomplishment). If shift turnover occurs during the test, a briefing of the on-coming shift shall be conducted prior to continuing with the test. Attach a list of attendees to the Chronological Test Log.
DRR / 3-31-90
TD

3.3 All temporary or portable test equipment used in the conduct of this test is logged in the appropriate Test Equipment Log per Reference 2.9 and calibration due dates recorded in Attachment 2 of this test.
SH / 3-31-90
TD

3.4 Valve HCV-2954 (SI-6C outlet valve) is closed and is able to be controlled from the Control Room.
JRS / 3-31-90
OPS

3.5 The Reactor Core is off-loaded.
JRS / 3-31-90
OPS

3.6 Makeup water to Safety Injection Tank SI-6C is available.
JRS / 3-31-90
OPS

INITIALS/DATE

3.7 Safety Injection Tank SI-6C level transmitter loop LT-2944X is in service. — JAH / 3/31/90 OPS

3.8 Safety Injection Tank SI-6C pressure transmitter loop PT-2941 is in service. — JAH / 3/31/90 OPS

3.9 A calibrated is available for recording the performance of this test and is loaded with strip chart paper graduated in square centimeters.

Recorder No. ~~19002~~ 19001 Cal Due Date ~~9-22-90~~ 6-21-90 — MC / 3-31-90

3.10 Shutdown cooling is not in service. — JBS / 3-31-90 OPS

3.11 An appropriate Radiation Work Permit has been obtained.

RWP No. 90-196 — PS / 3-31-90 RP

3.12 Notify Quality Control prior to the start of this test. — GF / 3/31/90 QC

3.13 Notify Radiation Protection prior to the start of this test. — PS / 3-31-90 RP

3.14 The Shift Supervisor has reviewed the Technical Specifications regarding the requirements relating to the RCS, ECCS and Refueling Operations (Sections 2.1.1, 2.3 and 2.8) and has granted permission to perform this test. — JBS / 3-31-90 Shift Supv.

4.0 PRECAUTIONS AND LIMITATIONS

4.1 Observe the precautions and limitations specified by the Radiation Work Permit.

4.2 Ensure that no other Engineered Safeguards Tests that could affect or could be affected by this test, are being conducted during the performance of this test.

INITIALS/DATE

4.3 Reactor Vessel Refueling Cavity Level for the performance of this test is between 40% and 50% as indicated by LI-106. This level will provide adequate Radiological Shielding in the event of a crud burst.

5.0 PROCEDURE

NOTE: Steps 5.1 through 5.4 can be performed in any sequence, but prior to continuing with Step 5.5.

5.1 Close or verify closed valves HCV-331, HCV-317 and HCV-318. — JRS / 4-2-90 OPS

5.2 Fill Safety Injection Tank SI-6C to a level as close to 90% as possible. — JRS / 4-2-90 OPS

5.3 Verify or adjust the refueling cavity level to between 40% and 50% as indicated on LI-106. — JRS / 4-2-90 OPS

5.4 Connect the strip chart recorder to the Safety Injection Tank SI-6C instruments such that:

5.4.1 Safety Injection Tank SI-6C level is recorded over a range of 0 to 100% (LT-2944X). — ALC / 3-31-90 I&C

5.4.2 Safety Injection Tank SI-6C pressure is recorded over a range of 0 psig to 150 psig (PT-2941). — ALC / 3-31-90 I&C

5.4.3 Select and record strip chart recorder speed 10mm/sec. — ALC / 3-31-90 I&C

5.5 Record SI-6C Level. 90 % LI-2944X — JRS / 4-2-90 OPS

84 JRS

INITIALS/DATE

CAUTION
Exceeding 65% on LI-106 will cause Reactor Vessel Refueling Cavity overflow.

5.6 Record the current Reactor Vessel Refueling Cavity Level from LI-106:

45

JPS 14-2-90
OPS
JPS

NOTE: The Safety Injection Tank pressure setting to be used in the performance of this test is a function of the current Reactor Vessel Refueling Cavity Level. Typically, the Safety Injection Tank pressure should be set to 120 psig when the Reactor Vessel Refueling Cavity is 50% as indicated by LI-106 with SI-6C 90% full. When the Reactor Vessel Refueling Cavity is less than 50%, then a lower Safety Injection Tank pressure will be used. Also, when the Safety Injection Tank Level is less than 90%, then a lower Safety Injection Tank Pressure will be used. See Calculation FC-05280 for the determination of initial Safety Injection Tank Pressure.

5.6.1 Obtain the Safety Injection Tank pressure to be used to perform this test from the Test Director (Safety Injection Tank pressure will be based on current reactor vessel refueling cavity level see Calculation FC-05280):

~~104~~ psig
80 JPS

OJZ 14/2/90
TD OJZ 4/2/90

5.7 Set Safety Injection Tank SI-6C to the pressure required to perform this test using OI-NG-1.

Efm 14/2/90
OPS Efm 4/2/90

INITIALS/DATE

5.8 WHEN Safety Injection Tank SI-6C pressure has been adjusted to the pressure required to perform this test, THEN:

5.8.1 Monitor Reactor Vessel Refueling Cavity level using LI-106 to prevent exceeding 65% in the Reactor Vessel Refueling Cavity. PQ 14-2-90 OPS PQ 4-2-90

5.8.2 Start the strip chart recorder. PS 14-2-90 I&C PS 4-2-90

5.8.3 Open valve HCV-2954. PQ 14-2-90 OPS PQ 4-2-90

5.8.4 WHEN HC-2954 indicates open, THEN close HCV-2954. PQ 14-2-90 OPS PQ 4-2-90

5.8.5 WHEN HCV-2954 indicates closed, THEN stop the brush recorder. PS 14-2-90 I&C PS 4-2-90

5.9 Perform the calculations as indicated in Attachment 3 using data collected from the strip chart recorder strip chart. DJ 14/2/90 TD

5.10 Ensure that the following information has been written on the brush recorder strip chart and the strip chart has been attached to this procedure. DJ 14/2/90 TD

6.0 SYSTEM RESTORATION

6.1 Disconnect and remove the brush recorder. PS 14-2-90 I&C

Independent Verification DJ 14/2/90

6.2 Restore Safety Injection Tank SI-6C to service as directed by the Shift Supervisor. Sa 14/2/90 OPS

INITIALS/DATE

6.3 Place valves HCV-331, HCV-317 and HCV-318 to positions as directed by the Shift Supervisor.

[signature] / 4/2/90
OPS

7.0 SHIFT SUPERVISOR SIGN OFF

7.1 The Shift Supervisor has been informed that the test is complete.

[signature] 14-2-90
SS

8.0 COMPLETION SIGN-OFF

8.1 Forward completed test to Special Services Engineering for further evaluation.

[signature] / 4/2/90
TD

ATTACHMENT 1
PAGE 1 OF 1

CHRONOLOGICAL TEST LOG

Procedure No. SP-SI-7 /Rev R2

TIME		LOGGED BY
3/31/90 2040	PREREQS. SIGNED OFF	SH
3/31/90 2200	Step 5.4 completed (strip recorder installed)	[initials]
4/2/90 2100	Gave another prejob briefing to operators	[initials]
4/2/90 2105	Signed of steps 5.5 & 5.6	[initials]
4/2/90 2108	Calculated SIT pressure (initial) to be 104 psig with 90%	
	level in SIT 6C, 95% level in cavity (EL. 1033) and atmospheric	
	pressure in containment of 14.5	[initials]
4/2/90 2116	Notified HP that we are ready to dump the SIT	[initials]
4/2/90 2132	Opened HCV-2954, however, valve was reclosed when both	
	red lights came on - but green light weren't off. Reclosed HCV-2954.	[initials]
2135	With HCV-2954 reclosed SIT 6C level dropped to 84% with pressure	
	at 77 psig. Recalculated a new initial pressure of 80 psig.	[initials]
2140	Established 80 psig in SIT 6C and recommenced the test, by resigning steps 5.5 through 5.7	[initials]
2145	Performed step 5.8 and opened HCV-2954 (took ~ 54 secs. to open).	
	SIT 6C ended up with 10% level and 13 psig with HCV-2954 closed.	[initials]
2155	Performed Restoration steps.	[initials]

2200 Test completion acknowledged by Shift Supervisor. [initials]

This Test Log must be maintained with the appropriate test documentation.

Log reviewed and all items are appropriately addressed.

[signature] / 4/2/90

Test Director / Date

ATTACHMENT 2

TEST EQUIPMENT CALIBRATION DATA

EQUIPMENT	OPPD#	CALIBRATION DUE	QC INITIALS/DATE
RECORDER	19001	6-21-90	[illegible] 3-31-90
RECORDER	19002	9-22-90	[illegible] 3-31-90

ATTACHMENT 3

SAFETY INJECTION TANK SI-6C FLOW CALCULATION

1.0 Determine the Safety Injection Tank SI-6C discharge flowrate as follows: INITIALS/DATE

1.1 From the brush recorder strip chart developed during the test, identify the trace used to record change in Safety Injection Tank level. ___ TD 4/2/90

1.2 Determine the segment of the level trace that has the greatest slope over time. ___ TD 4/2/90

1.2.1 Mark the ends of the segment selected: ___ TD 4/2/90

A. Selected segment begins (PT-1):

3.98 Volts

B. Selected segment ends (PT-2):

3.48 Volts

1.2.2 Measure the vertical chart run (D) between the two points: ___ TD 4/2/90

100 mm

1.3 Determine the Safety Injection Tank SI-6C level Rate-of-Change (R) by the following formula: ___ TD 4/2/90

$$(R) = \frac{(PT\ 1\text{-}PT\ 2)\ \text{Volts}}{(D)\text{mm}} \times \frac{3.60\ \text{Ft}}{\text{Volt}} \times \frac{\cancel{100}\ 10\ \text{mm}}{\text{Sec}} = \frac{\text{FT}}{\text{Sec}}$$

4/2/90

$$1.3.1\ (R) = \frac{0.5\ \text{Volts}}{100\ \text{MM}} \times \frac{3.60\ \text{FT}}{\text{Volt}} \times \frac{*\text{mm}}{\text{Sec}} = \frac{0.13\ \text{FT}}{\text{Sec}}$$

___ TD 4/2/90

ATTACHMENT 3

INITIALS/DATE

1.4 Determine the Safety Injection Tank SI-6C discharge Volumetric flowrate (Q) by the following formula:

TD [initials] 1/4/2/90

$$(Q) = \frac{(R)\ FT}{Sec} \times \frac{60\ Sec}{1\ min} \times \frac{531.15\ Gal}{FT} = \underline{\quad}\ GPM$$

1.4.1 $(Q) = \frac{0.18\ FT}{Sec} \times \frac{60\ sec}{1\ min} \times \frac{531.15\ Gal}{FT} =$ 5736 GPM

TD [initials] 1/4/2/90

Attachment 4
Page 1 of 1

DEFICIENCY LOG

Instruction Number N/A

If deficiency affects acceptance criteria, the SS must be notified. The person notifying the SS shall Initial, time, and date in the last column of the log.

Deficiency No.	Paragraph No.	Page No.	Description of Deficiency	Disposition of Deficiency	SS Notified By - - Initial, Time , Date
NONE					

This Deficiency Log must be maintained with the appropriate test package date sheet.

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SP-SI-7

OG 1 of 1
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BRIEFING ATTENDANCE AND SIGNATURE SHEET

Signature	Print	Department	Initials
D L Rollins	D L Rollins	353	[illegible]
J A Spiker	[illegible]	841	[illegible]
J.R. Shuck	[illegible]	841	JRS
Lanny Thornsberry	[illegible]	353	WLT
Philip Ferrone	Philip Ferrone	344	PF
[illegible]	Richard J. Campbell	842	RC
Scott Hofstetter	Scott Hofstetter	353	SH
Frank H. Rivera	FRANK H. RIVERA	Q.C	FHR
Preston Swafford	Preston Swafford	RP	PS
[illegible]	GEORGE CARY	842	[illegible]
John A Drahota	JOHN A DRAHOTA	842	JAD
E.A. Griggs	[illegible]	841	[illegible]
Pat Seabeck	Pat Seabeck	842	PS
P Avery	PHILIP AVERY	841	PA

CALCULATION COVER SHEET

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Calculation Preparation, Review and Approval Form PED-QP-3.1 Form Page No. 1 of 2 Calculation Cover Sheet •SHORT TERM CALC: YES ☒ NO ☐	CALCULATION NUMBER •FC - [illegible] QA Category: ☒ CQE ☐ LIMITED CQE ☐ FIRE PROT. ☐ NON CQE •FILE NO. 55[illegible] PED DEPARTMENT Special Services Eng. ([illegible])	Calc. Page No. [illegible] •TOTAL PAGES 16

CALCULATION TITLE	VENDOR CALC. NO. N/A
Determination of Initial Safety Injection Tank SI-6C Pressure for Performance of Special Procedure SP-SI-7	☐ MR NO. N/A ☐ ENGR. ANALYSIS N/A ☐ DBD NO. N/A ☒ OTHER Misc. Calc. to support Procedure SP-SI-7

•APPROVALS - SIGNATURE & DATE			•REV. NO.	SUPERSEDES •CALC NO.	CONFIRMATION •REQUIRED (√)	
PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)			YES	NO
[signature] 12/4/89	[signature] 12/5/89	[signature] 12/5/89	C	N/A		√

•EXTERNAL ORGANIZATION DISTRIBUTION

NAME & LOCATION	COPY SENT (√)	NAME & LOCATION	COPY SENT (√)

•SEE INSTRUCTIONS ON REVERSE SIDE
•COMPLETED BY DOCUMENT CONTROL

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Calculation Preparation, Review and Approval Form PED-QP-3.1 Form Page No. 2 of 2 Calculation Cover Sheet	CALCULATION NUMBER FC - 05??? | Calc. Page No. ? FACILITY/SYSTEM ??? KEYWORD*

CALCULATIONS USED AS INPUT IN THE ANALYSIS		EQUIPMENT TAGS		
CALC./REV.NO.	DEPT.NO.*	SYSTEM	ADDED	DELETED
N/A		SI	SI-6?	

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.3 FORM Page No. 1 of 5 PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET	CALCULATION NO. FC - [illegible] Rev. No. [illegible]

OBJECTIVE

THE PURPOSE OF THIS CALCULATION IS TO DETERMINE THE REQUIRED INITIAL NITROGEN PRESSURE FOR SAFETY INJECTION TANK SI-6C, WHICH WHEN OUTLET ISOLATION VALVE HCV-2954 IS OPENED, WOULD ALLOW A DECREASE OF LEVEL IN THE TANK FROM 70% TO NO WATER IN THE TANK, AGAINST A BACKPRESSURE OF 20 FT (ELEVATION 1033') OF WATER ABOVE THE REACTOR VESSEL FLANGE IN THE REACTOR REFUELING CAVITY. THIS INITIAL PRESSURE CAN THEN BE USED IN SPECIAL PROCEDURE SP-SI-7.

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED–QP–3.3 FORM Page No. 2 of 5	CALCULATION NO.
PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET	FC – 05428
	Rev. No. 0

METHODS

THERE ARE ONLY TWO FORMULAS USED IN THIS CALCULATION. THE FIRST ONE IS THE EQUATION WHICH EXPRESSES THE PRESSURE/VOLUME RELATIONSHIP OF AN IDEAL GAS DURING AN ISOTHERMAL PROCESS (i.e. $P_1V_1 = P_2V_2$) WHICH CAN BE FOUND IN MARK'S STANDARD HANDBOOK FOR MECHANICAL ENGINEERS, 8TH EDITION, PAGE 4-19. THE SECOND EQUATION IS THE VOLUME OF A CYLINDER (i.e. $V = \pi r^2 h$) WHICH CAN BE FOUND IN NUMEROUS LOCATIONS. THE CALCULATION METHOD IS BASICALLY THESE SIMPLE ALGEBRAIC EQUATIONS WHICH CAN BE SOLVED WITH A SIMPLE FOUR FUNCTION HAND HELD CALCULATOR.

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.3 FORM Page No. 3 of 5

CALCULATION NO.

PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET

FC [illegible]

Rev. No. [illegible]

ASSUMPTIONS

THE MAJOR ASSUMPTION ASSOCIATED WITH THIS CALCULATION IS THAT THE EXPANSION OF THE NITROGEN WHEN VALVE HCV-2954 IS OPENED IS AN ISOTHERMAL PROCESS. THIS IS THE MOST CONSERVATIVE ASSUMPTION WITH REGARD TO STARTING WITH TOO MUCH PRESSURE (WHICH COULD RESULT IN NITROGEN ENTERING THE RCS) BECAUSE THE ISOTHERMAL CASE GIVES A MUCH LOWER INITIAL TANK PRESSURE THAN THE ISENTROPIC CASE. [illegible] IS ALSO PROBABLY THE MOST REALISTIC ASSUMPTION BECAUSE OF THE GREATER AMOUNT OF MASS IN THE TANK COMPARED TO THE MASS OF THE NITROGEN. ANOTHER ASSUMPTION THAT WAS MADE WAS THAT THE VOLUME OF THE SMALL NITROGEN LINES OFF THE TANK IS NEGLIGIBLE COMPARED WITH THE VOLUME OF NITROGEN IN THE TANK (I.E. LESS THAN ~~[illegible]~~ .7 [illegible] 1 FT³ COMPARED TO OVER 200 FT³). THE LAST ASSUMPTION IS THAT THE ENDCAPS (TOP AND BOTTOM) OF THE TANK ARE SYMMETRICAL AND HAVE EQUAL VOLUMES.

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED–QP–3.3 FORM Page No. 4 of 5

PRODUCTION ENGINEERING CALCULATION
SUMMARY SHEET

CALCULATION NO.
FC 05280
Rev. No. 0

INPUTS

- Volume of the Safety Injections Tanks = 1860 FT3 comes from the Safety Injection System Description, Rev. 7, page S.D. I-3-13.
- Safety Injection Tank Drawing D-7435 (File # 89) for tank dimensions.
- Calibration Procedures CP-2944X performed 10/21/77 Roll 0176/Frame 0585 actual level compared to indicated levels. and on 12/15/78 Roll 0176/Frame 0582
- RCS elevations vs. LI-106 from page TDB-III-20 of the Technical Data Book for Reactor Vessel Flange elevation & per cent level on LI-106, for 20 feet of water above the flange.

REFERENCES

1) Safety Injection System Description, Rev 7, page S.D. I-3-13
2) Drawing D-7435 (File # 89)
3) Page TDB-III-20 of the Technical Data Book
4) Marks Standard Handbook for Mechanical Engineers, 8th Edition, Page 4-19
5) Calibration procedures CP-2944X performed on 10/21/77 and 12/15/78 on microfilm roll 0176/Frames 0585 and 0582 respectively.

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.3 FORM Page No. 5 of 5 PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET	CALCULATION NO. FC 05280 Rev. No. 0

CONCLUSIONS

THIS CALCULATION DETERMINES THE INITIAL NITROGEN PRESSURE REQUIRED IN SAFETY INJECTION TANK SI-6C WHICH WOULD ALLOW A DECREASE IN LEVEL IN THE TANK FROM 90% FULL (AS INDICATED ON LI-2944X) TO NO WATER LEFT IN THE TANK, AGAINST A BACKPRESSURE OF 20 FEET OF WATER ABOVE THE REACTOR VESSEL FLANGE IN THE REFUELING CAVITY WHEN TANK OUTLET ISOLATION VALVE HCV-2954 IS OPENED. THIS SAME CALCULATION WOULD APPLY TO ALL 4 SAFETY INJECTION TANKS SINCE ALL TANKS ARE DIMENSIONALLY IDENTICAL. EVEN THOUGH THIS CALCULATION SPECIFICALLY DETERMINES THE INITIAL PRESSURE REQUIRED WITH THE TANK INITIALLY 90% FULL (AS INDICATED ON LI-2944X) AND AGAINST A BACKPRESSURE OF 20 FEET OF WATER ABOVE THE FLANGE IN THE CAVITY, THE SAME FORMULAS/METHODOLOGY OF CALCULATION WOULD BE USED TO DETERMINE THE REQUIRED INITIAL PRESSURE IN THE TANK FOR ANY INITIAL TANK LEVEL AND ANY BACKPRESSURE.

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO.
FC -05280
Rev. No. 0

REF NO.

ASSUMING THAT THE EXPANSION OF THE NITROGEN IN THE SAFETY INJECTION TANK WILL BE AN ISOTHERMAL PROCESS, THE FOLLOWING EQUATION WILL BE USED TO ENSURE THAT THE SAFETY INJECTION TANK LEVEL GOES NO LOWER THAN THE BOTTOM OF THE TANK WITH AN INITIAL LEVEL OF 90% (AS INDICATED ON LI-2944X) AND AN INITIAL REACTOR REFUELING CAVITY LEVEL OF 20 FEET ABOVE THE REACTOR VESSEL FLANGE (45% AS READ ON LI-106): 3)

$$P_1 V_1 = P_2 V_2$$ 4)

$$P_1 = P_2 \left[\frac{V_2}{V_1} \right]$$

WHERE: P_1 = INITIAL TANK PRESSURE
P_2 = FINAL TANK PRESSURE
V_1 = INITIAL VOLUME OF N_2
V_2 = FINAL VOLUME OF N_2

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED—QP—3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO.
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Rev. No. 0

REF. NO.

Determining volume V_2:

From the Safety Injection System Description, the internal volume of the Safety Injection Tanks is 1300 ft³. 1)

From drawing D-7495 (File # 87), the volume of the cylindrical portion of the tank is calculated as follows: 2)

$V = \pi r^2 h$ where $r = 57$ in
$h = 183$ in
$\pi = 3.14$

$V = (3.14)(57\text{ in})^2(183\text{ in})$

$V = 1866940\text{ in}^3 = 1080.4\text{ ft}^3$

According to drawing D-7495, the top and bottom endcaps of the tank appear to be the same size. Therefore the volume in each endcap would be calculated as follows: 2)

$$V_{endcap} = \frac{300\text{ ft}^3 - 1080.4\text{ ft}^3)}{2}$$

$V_{endcap} = 109.8\text{ ft}^3$

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.4 Form Page No. 1 of 1

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Rev. No. 0

REF. NO.

IF THE TANK LEVEL IS TO GO NO LOWER THAN THE BOTTOM OF THE TANK AFTER THE NITROGEN EXPANDS, THE VOLUME OF NITROGEN AFTER EXPANSION (V_2) WOULD BE 1500 FT^3 1)

DETERMINING VOLUME V_1:

NOTE: ALL OF THE NITROGEN PIPING COMING OFF THE SAFETY INJECTION TANK WHICH IS INITIALLY PRESSURIZED TO PRESSURE P_1 ACCOUNTS FOR A TOTAL VOLUME OF LESS 1 FT^3 AND THEREFORE IS CONSIDERED NEGLIGIBLE AND IS DISREGARDED IN THE CALCULATION OF VOLUME V_1.

DRAWING D-7495 SHOWS THE TAPS FOR THE LEVEL TRANSMITTER BEING 173 INCHES APART. THE LEVEL TRANSMITTER (LT-2944X) WAS ORIGINALLY CALIBRATED TO INDICATE 0% AT 0 INCHES (WHICH CORRESPONDED TO THE LOWER TAP) AND 100% AT 173 INCHES (WHICH CORRESPONDED TO THE UPPER TAP). A PROCEDURE CHANGE (PC#4190) WAS WRITTEN IN DECEMBER 1978, TO REVISE CALIBRATION PROCEDURE CP-2944X TO CHANGE THE INPUTS TO THE TRANSMITTER DURING THE CALIBRATION IN ORDER TO COMPENSATE FOR THE NITROGEN OVERPRESSURE. 2) 5)

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
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REF. NO.

HOWEVER, 0% AND 100% INDICATION STILL CORRESPONDS TO THE UPPER AND LOWER TAPS. AS SHOWN ON DRAWING D-7495, THESE TAPS ARE 5 INCHES ABOVE AND BELOW WHERE THE TANK WALL GOES FROM VERTICAL TO ELLIPTICAL. 2)

WITH AN INITIAL SAFETY INJECTION TANK LEVEL OF 90% AS INDICATED ON LI-2944X, THE VOLUME OF WATER WOULD BE CALCULATED AS FOLLOWS:

$V_t = 1300 \text{ FT}^3 - V_W$ WHERE V_W = VOLUME OF WATER

$V_W = V_{ENDCAP} + \pi r^2 h$ WHERE $V_{ENDCAP} = 109.8 \text{ FT}^3$

$r = 57 \text{ IN}$

$h = 5_{IN} + \overset{0.84}{\cancel{0.9}}(173_{IN}) = \overset{150.3}{\cancel{160.7}}_{IN}$

$\pi = 3.14$

$V_W = 109.8 \text{ FT}^3 + (3.14)(57_{IN})^2(\overset{150.3}{\cancel{160.7}}\text{ IN})$

$V_W = 109.8 \text{ FT}^3 + \overset{1533339.5}{\cancel{1639438.9}} \text{ IN}^3$

$V_W = 109.8 \text{ FT}^3 + \overset{887.3}{\cancel{948.7}} \text{ FT}^3$

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO.
FC - 05280
Rev. No. 0

REF NO

V_w = ~~1058.5~~ 997.1 FT^3

THEREFORE, V_1 = 1300 FT^3 - ~~1058.5~~ 997.1 FT^3

V_1 = ~~241.5~~ 302.9 FT^3

DETERMINING P_2:

P_2 IS THE FINAL PRESSURE IN THE SAFETY INJECTION TANK AFTER EXPANSION OF THE NITROGEN. THIS PRESSURE NEEDS TO BE LESS THAN OR EQUAL TO THE 20 FOOT HEAD OF WATER IN THE REACTOR REFUELING CAVITY MINUS THE ELEVATION DIFFERENCE (IN HEAD) BETWEEN THE BOTTOM OF THE TANK AND THE REACTOR VESSEL FLANGE.

PER DRAWING D-3495, THE BOTTOM OF THE SAFETY INJECTION TANK IS APPROXIMATELY 3.5 FEET ABOVE THE FLOOR. SINCE THE FLOOR ELEVATION 1013 FT IS EVEN WITH THE REACTOR VESSEL FLANGE, THE PRESSURE P_2 IS CALCULATED AS FOLLOWS: 2)

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED–QP–3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION CALCULATION SHEET

CALCULATION NO. FC 05280

Rev. No. 0

REF. NO.

P_2 = 20 FT − 2.5 FT = 17.5 FT

$P_2 = \frac{17.5 \text{ FT}}{2.31 \text{ FT/PSIG}} = 7.6 \text{ PSIG} + \overset{14.5}{\cancel{14.7}} = \overset{22.1}{\cancel{22.3}} \text{ PSIA}$

DETERMINING P_1:

KNOWING $P_2 = \overset{22.1}{\cancel{22.3}}$ PSIA ; $V_1 = \overset{302.9}{\cancel{241.5}}$ FT^3 ; V_2 = 1300 FT^3 ; AND K = 1.4 , P_1 CAN BE CALCULATED AS FOLLOWS:

$$P_1 = P_2 \left[\frac{V_2}{V_1} \right]$$

$$P_1 = (\overset{22.1}{\cancel{22.3}} \text{ PSIA}) \left[\frac{1300 \text{ FT}^3}{\overset{302.9}{\cancel{241.5}} \text{ FT}^3} \right]$$

$$P_1 = \overset{94.8}{\cancel{120.0}} \text{ PSIA} - \overset{14.5}{\cancel{14.7}}$$

$$P_1 = \overset{80.3}{\cancel{105.3}} \text{ PSIG}$$

Calc Preparation, Review and Approval
PED-QP-3.5 Page 1
Reviewer's Checklist-Calculations

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CALCULATION NUMBER
F[illegible] Rev. 0

		YES	NO	N/A
1.	Is Calculation Cover Sheet attached and completed, as required, to the calculation?	✓		
2.	Is the calculation objective stated? Was this achieved?	✓		
3.	Are inputs correctly selected and incorporated into the analysis?	✓		
4.	Have inputs and/or assumptions which require confirmation at a later data, been identified on the Calculation Cover Sheet and in the calculation body?			✓
5.	Are the applicable codes, standards, regulatory requirements, and other references including issue and addenda identified such that they are traceable to source document?	✓		
6.	Was an appropriate calculation method used? Was the basic theory appropriate?	✓		
7.	Have assumptions been noted and justified?	✓		
8.	Are the calculations free of arithmetic errors?	✓		
9.	Is the calculation consistent with the design basis requirements?	✓		
10.	Is the conclusion stated?	✓		
11.	Is the calculation legible and suitable for microfilming?	✓		
12.	Are all blocks on the Calculation Cover Sheet addressed correctly?	✓		
13.	Have Forms PED-QP-3.2, 3, 4 and 5 been used and correctly completed?	✓		
14.	If the calculation has been prepared to supersede another calculation, has all the valid information been transferred in the new calculation?			✓

REVIEWER COMMENTS:
NONE

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CALCULATION NUMBER
FC-05290 Rev. 0

	YES	NO	N/A
1. Does the computer run have title, date, and page number and alphanumeric program number on every sheet?			✓
2. Is the listing of computer input provided?			✓
3. Is the machine generated program name and version on each run or is indicated in the calculation?			✓
4. Is the computer software validated and verified?			✓
If no:			
4a. Is the computer code developed for one-time-use on a programmable calculator or microcomputer?			✓
4b. If yes, has a functional description of the program, identification of the equations, identification of the code (title, revision, manufacturer), identification of the software and brief user's instructions been provided in the calculation?			✓
5. If the computer software has been loaded on an in-house computer, have the changes made by OPPD been properly reviewed (verified and validated) for their impact on the accuracy of the code and have been found satisfactory, or is the in-house computer software validated?			✓
6. Is the computer program appropriate to do the intended calculation?			✓
7. Was an alternate calculation or model utilized to verify results? If so, is it attached to this calculation?			✓
8. Is the modeling correct in terms of geometry input and initial conditions?			✓
9. Are the results reasonable when compared to the inputs?			✓

REVIEWER COMMENTS:
NONE

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CALCULATION NUMBER

FC-05280 Rev. 0

	YES	NO	N/A
1. Are the calculation methods accurate? page number and alphanumeric program number on every sheet?	✓		
2. Are input data sufficiently detailed?	✓		
3. Are the calculation assumptions reasonable?	✓		
4. Has the basis for engineering judgement been included in the calculation, when used?	✓		
5. Is the calculation documented sufficiently such that the analysis is understandable to someone competent in the discipline without recourse to the Preparer?	✓		
6. Have the design interface requirements been satisfied?			✓
7. Are the results reasonable and do they resolve the calculation objective?	✓		
8. Was the design review method used to verify the calculation?	✓		
9. If an alternate calculation was used to verify the adequacy of the analysis, is it attached to the calculation?			✓
10. If qualification testing was used to verify the adequacy of the analysis, has it been documented using a retrievable source, or attached to the calculation?			✓
11. Are calculations involving Technical Specification values and associated margins of safety identified?			✓

REVIEWER COMMENTS: none

JK

S.I. TANK SI-6C LEVEL

1.0 INITIAL CONDITIONS

INITIALS/DATE

1.1 Standing Order M-26 has been reviewed and all conditions set down by this order have been completed. ___ 15.11.90

1.2 Shift Supervisor Equipment Release. CM 15/11/90
Shift Supv

1.3 Calibration Type

1.3.1 Annual Calibration ______

1.3.2 Maintenance Work Order ______

1.3.3 Refueling 9005597

1.3.4 Other (DCR, MR, Etc.) ______

1.4 Procedure Verification:

* *
PROCEDURE
REVISION VERIFICATION

Master Revision No. R8
Signature ______
Date 5.11.90
* *

NOTE: This instrument loop is used in conjunction with the surveillance test(s) listed below. If the "As Found" data for this CP is found out of tolerance, insure that an Incident Report is initiated.

ST-CV-1
ST-CV-2
ST-ESF-8

2.0 REFERENCES

2.1 161F561, Interconnection Diagram

2.2 EM-2944, Block Diagram

3.0. DEVICES TO BE CHECKED

LT-2944X Foxboro 823DP
LIA-2944X Simpson 3623XA
LQ-2944X

4.0 TEST EQUIPMENT REQUIRED/USED

EQUIPMENT	OPPD No./ CALIBRATION DUE DATE
Pressure Source 200" WC	Q2001 / 5-17-90
Variable Resistor	N/A /
(DMM) Digital Multi-Meter	14018 / 9-1-90
(VOM) Voltohm Meter	N/A /

5.0 CALIBRATION PROCEDURE

INITIALS/DATE

5.1 Calibration of LQ-2944X

5.1.1 Using DMM, measure the output DC voltage of LQ-2944X. Record reading in the "As Found" column on Data Sheet 1. N/A / [illegible] 5-14-90

5.1.2 Using DMM, measure the AC ripple voltage of LQ-2944X. Record reading in the "As Found" column on Data Sheet 1. N/A [illegible] 5-14-90

5.1.3 If "As Found" value for LQ-2944X DC output voltage is out-of-tolerance shown on Data Sheet 1 or an improvement in accuracy is warranted, N/A Steps 5.1.4.A and 5.1.4.B then go to Step 5.1.5. N/A [illegible] 5-14-90

5.1.4 If "As Found" value for LQ-2944X DC output voltage is within required tolerance shown on Data Sheet 1, proceed as follows.

A. Record "As Found" value as "As Left" value for LQ-2944X DC output voltage on Data Sheet 1. N/A / [illegible] 5-14-90

B. Enter N/A for Step 5.1.5 and go to Step 5.1.6. N/A [illegible] 5-14-90

INITIALS/DATE

NOTE: If within tolerance cannot be obtained during calibration, notify immediate supervisor.

5.1.5 Adjust LQ-2944X as required to obtain DC output voltage within the required tolerance shown on Data Sheet 1. Record final reading in the "As Left" column. N/A 10/15/90

5.1.6 If "As Found" value for LQ-2944X AC ripple voltage is out-of-tolerance shown on Data Sheet 1, notify immediate supervisor, otherwise go to Step 5.1.7. N/A 10/15/90

5.1.7 Record "As Found" value as "As Left" value for LQ-2944X AC Ripple voltage on Data Sheet 1. N/A 10/15/90

5.2 Calibration of LIA-2944X

5.2.1 Connect variable resistor and DMM to simulate input values shown on Data Sheet 2 for and L-2944X. Identify any lifted leads as required.

Wire # N/A TB# N/A Terminal # N/A

Wire # N/A TB# N/A Terminal # N/A N/A 10/15/90

5.2.2 Simulate input values as shown on Data Sheet 2 for LIA-2944X. Record readings in the "As Found" column on Data Sheet 2. N/A 10/15/90

A. If an improvement in accuracy is required and adjustment is to be made, N/A Step 5.2.3 and go to Step 5.2.4, otherwise N/A this step and go to Step 5.2.3. N/A 10/15/90

INITIALS/DATE

5.2.3 If "As Found" value is within tolerance as shown on Data Sheet 2 for LIA-2944X record "As Found" values as "As Left" values in Data Sheet 2, N/A Step 5.2.4 and go to Step 5.3. DH / 5/11/90

NOTE: If within tolerance cannot be obtained during calibration, notify immediate supervisor.

5.2.4 If "As Found" values are out-of-tolerance as shown on Data Sheet 2 for LIA-2944X or an improvement in accuracy is required then adjust LIA-2944X to within tolerance, and record final readings in "As Left" column of Data Sheet 2. N/A / DH 5/11/90

5.3 Calibration of Computer Point L-2944X

5.3.1 Apply input values as shown for L-2944X on Data Sheet 2. Record computer display values for each input in the "As Found" column. N/A / DH 5/11/90

A. If an improvement in accuracy is required, N/A Step 5.3.2 and go to Step 5.3.3, otherwise this step is N/A. N/A / DH 5/11/90

5.3.2 If "As Found" value is within tolerance record "As Found" value as "As Left" value on Data Sheet 2 for L-2944X and N/A Steps 5.3.3 thru 5.3.7 and go to 5.3.8. N/A / DH 5/11/90

5.3.3 If "As Found" values is for out-of-tolerance or an improvement in accuracy is required adjust variable resistor for input equal to 3 volts for L-2944X. N/A / DH 5/11/90

INITIALS/DATE

5.3.4 With DMM measure voltage across dropping resistor for L-2944X and record reading.

L-2944X ______ N/A ______ VDC (.583 to .616 VDC) — N/A 1 5-11-90

5.3.5 If reading in Step 5.3.4 is out-of-tolerance notify immediate supervisor of results for computer point L-2944X. — N/A 1 5-11-90

5.3.6 If rework of L-2944X cannot be performed in an expeditious manner N/A Step 5.3.7 and go to Step 5.3.8. — N/A 5-11-90

5.3.7 When rework is completed apply input values as shown for L-2944X on Data Sheet 2. Record computer display values for each input in the "As Left" column. — N/A 1 5-11-90

5.3.8 Disconnect variable resistor and DMM, verify leads disconnected during the performance of this procedure as identified in Step 5.2.1 ar re-connected. — N/A 1 5-11-90

5.4 Calibration of LT-2944X

5.4.1 Isolate LT-2944X. — 1 5-11-90

5.4.2 Connect pressure source to simulate input values as shown on Data Sheet 2 for LT-2944X. — 1 5-11-90

5.4.3 Connect DMM to monitor output values as shown on Data Sheet 3 for LT-2944X. Identify any lifted leads as required.

Wire # LT-2944 ✓ TB # N/A Terminal # 1

Wire # N/A TB # N/A Terminal # N/A — 1 5-11-90

INITIALS/DATE

5.4.4 Simulate input values to LT-2944X as shown on Data Sheet 3. Record DMM readings in "As Found" column of Data Sheet 3. — DY 15.11.90

A. If an improvement in accuracy is required and adjustment is to be made, N/A Step 5.4.5 and go to Step 5.4.6, otherwise N/A this step and go to Step 5.4.5. — N/A DY 15.11.90

5.4.5 If "As Found" values are within tolerance as shown on Data Sheet 3 for LT-2944X record "As Found" values "As Left" values in Data Sheet 3, N/A Step 5.4.6 and go to 5.4.7. — DY 15.11.90

5.4.6 If "As Found" value is out-of-tolerance as shown on Data Sheet 3 for LT-2944X or an improvement in accuracy is required, adjust LT-2944X to within tolerance and record final readings in "As Left" column of Data Sheet 3 for LT-2944X. — N/A DY 15.11.90

NOTE: If within tolerances cannot be obtained during calibration, notify immediate supervisor.

5.4.7 Disconnect DMM from LT-2944X and verify leads disconnected during the performance of this procedures as identified in Step 5.4.3. — DY 15.11.90 verifiec
JW 15.11.90

INITIALS/DATE

5.5 Loop Check

5.5.1 Simulate an input value of 43.25"H_2O to LT-2944X and verify that LIA-2944X and L-2944X reads within tolerance as shown below. Record reading. ___ OH 15:##90 ___

LI-2944X 73.5 % 75%(75% to 77%) ___ OH 15:##90 ___

L-2944X 74.87 % 75%(73% to 77%) ___ OH 15:##90 ___

5.5.2 Disconnect pressure source from LT-2944X, re-install testing fitting plugs or instrument tubing as required, fill and vent transmitter, ensure equalizer valve is closed and isolation valve is open. ___ OH 15:##90 ___

5.5.3 If S.I. Tank 6C is in service verify that LI-2944X and L-2944X read within ±2% of each other. If S.I. Tank 6C is not in service, N/A this step. Record readings.

LI-2944X — N/A — %
L-2944X — N/A — % ___ N/A 10H ___

INITIALS/DATE

6.0 PROCEDURE COMPLETION

6.1 Notify Shift Supervisor Loop returned to normal. — ERE 15/11/90
Shift Supv

6.2 Lead Craftsman assure that all witness blanks are initialed or N/A and dated. — 15-11-90

Anthony Gruss / G Williamson — 5-11-90
Completed by I & C Tech (Signature) — Date

05/14/90
Reviewed by Supervisor I & C/
System Engineer/Coordinator (Signature) — Date

REMARKS: LANNY THORNSBURY, SYSTEM ENGINEER DIRECTED TO ONLY DO CALIBRATION OF TRANSMITTER AFTER WORK ON SI-6C COMPLETED

DATA SHEET 1

CP-2944X

Step 5.1.1, 5.1.4.A, 5.1.5

N/A OY 5.11.90

	LQ-2944X	
AS FOUND (VDC)	TOLERANCE (VDC)	AS LEFT (VDC)
	52.5 (50.0 to 55.0)	

N/A OY 5.11.90

~~Step 5.1.2, 5.1.7~~

	LQ-2944X	
AS FOUND (mVAC)	TOLERANCE (mVAC)	AS LEFT (mVAC)
	Less than 38 mVAC	

DATA SHEET 2

CP-2944X

Step 5.2.2, 5.2.3, 5.2.4

N/A [illegible] 5/1/90

	LI-2944X		
INPUT (mA)	AS FOUND (%)	TOLERANCE (%)	AS LEFT(%)
10		0 (-2 to +2)	
20		25 (23 to 27)	
30		50 (48 to 52)	
40		75 (73 to 77)	
50		100 (98 to 102)	
40		75 (73 to 77)	
30		50 (48 to 52)	
20		25 (23 to 27)	
10		0 (-2 to +2)	

Step 5.3.1, 5.3.2, 5.3.7

N/A [illegible] 5/1/90

	L-2944X		
INPUT (mA)	AS FOUND (%)	TOLERANCE (%)	AS LEFT(%)
10		0 (-2 to +2)	
20		25 (23 to 27)	
30		50 (48 to 52)	
40		75 (73 to 77)	
50		100 (98 to 102)	
40		75 (73 to 77)	
30		50 (48 to 52)	
20		25 (23 to 27)	
10		0 (-2 to +2)	

DATA SHEET 3

CP-2944X

Step 5.4.4, 5.4.5, 5.4.6

	LT-2924X		
INPUT ("H20)	AS FOUND (mA)	TOLERANCE (mA)	AS LEFT (mA)
168.4	9.98	10 (9.2 to 10.8)	9.98
126.3	19.96	20 (19.2 to 20.8)	19.96
84.2	29.95	30 (29.2 to 30.8)	29.95 ~~29.26~~ [illegible]
42.1	40.00	40 (39.2 to 40.8)	40.00
0.0	50.04	50 (49.2 to 50.8)	50.04
42.1	39.96	40 (39.2 to 40.8)	39.96
84.2	29.92	30 (29.2 to 30.8)	29.92
126.3	19.94	20 (19.2 to 20.8)	19.94
168.4	9.96	10 (9.2 to 10.8)	9.96

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ATTACHMENT 4

Fort Calhoun Station Inservice Testing Philosophy

ATTACHMENT 4

FORT CALHOUN STATION
INSERVICE TESTING (IST) PHILOSOPHY

This document describes the philosophy Fort Calhoun Station used to develop and implement the IST Program. This is a guideline used by OPPD in determining components to be tested, tests to be performed, test frequencies, acceptance criteria, etc., pertaining to Fort Calhoun Station's IST Program. The Fort Calhoun Station ISI Program Plan does in some cases deviate from this philosophy. In general, this philosophy is adhered to whenever practical.

1.0 **REFERENCES**

A. ASME Boiler and Pressure Vessel Code Section XI 1980 Edition, Subsections IWA, IWV and IWP, Winter 1980 Addenda

B. ASME Boiler and Pressure Vessel Code Section XI 1989 Edition

C. NRC Generic Letter (GL) 89-04, dated April 3, 1989

D. ASME Operation and Maintenance of Nuclear Power Plants Manual 1987 Edition, 1988 Addenda

E. Fort Calhoun Station ISI Program Plan

F. Fort Calhoun Station ISI Basis Documents

G. Station Engineering Instructions: SEI-11, SEI-13

H. Quality Procedure: QP-33

I. Fort Calhoun Station Standing Orders

1. G-21 Modification Control

   ISI Coordinator reviews all modification packages prior to final acceptance, for compliance with the ISI Program Plan.

2. G-23 Surveillance Test Program

   ISI Coordinator reviews all ISI related surveillance tests for compliance with the ISI Program Plan.

3. G-30 Setpoint/Procedure Changes and Generation

   ISI Coordinator reviews all ISI related surveillance test procedure changes for compliance with the ISI Program Plan.

I. Various meetings/correspondence with NRC

J. Various industry/NRC meetings/symposiums

K. Previous inspections/experience

2.0 DEFINITIONS

A. Active Valves

Valves which are required to change obturator position to accomplish a specific function.

B. Passive Valves

Valves which maintain obturator position and are **not** required to change obturator position to accomplish a specific function.

C. Valve Categories

Category A	-	Valves for which seat leakage is limited to a specific maximum amount in the closed position for fulfillment of their required function.
Category B	-	Valves for which seat leakage in the closed position is inconsequential for fulfillment of their required function.
Category C	-	Valves which are self-actuating in response to some system characteristics, such as pressure (relief valves) or flow direction (check valves) for fulfillment of the required function(s).
Category D	-	Valves which are actuated by an energy source capable of only one operation, such as rupture disks or explosive-actuated valves.

D. Exercising

The demonstration based on direct or indirect visual or other positive indication that the moving parts of a valve function satisfactorily.

E. Operational Readiness

The capability of a valve to fulfill its function.

F. Pressure Isolation Valves (PIVs)

1. Two normally closed valves in series that isolate the RCS from an attached low pressure system. PIVs are within the Reactor Coolant Pressure Boundary (RCPB).

2. Event V PIVs - Two check valves in series at a low pressure/RCS interface whose failure may result in a LOCA that bypasses containment.

G. Check Valve Full-Stroke

A check valve's full-stroke to open position is verified by passing the maximum required accident condition flow through the valve. This is the maximum flow rate for which credit is taken for this component in a safety analyses in any flow condition. The safety analyses are those contained in the plant's Final Safety Analysis Report (FSAR), or equivalent, but are not limited to the accident and transient analyses.

H. Check Valve Partial-Stroke

Any flow rate less than "full-stroke" is a partial stroke.

I. Cold Shutdown Justification

When it is not practical to perform a test at the Code required frequency of quarterly, acceptable technical justification shall be given in the ISI Program Plan and the test will then be performed at a frequency of Cold Shutdown in accordance with the requirements of the ASME Section XI/O&M Codes.

J. Refueling Outage Justification

When it is not practical to perform a test at the Code required frequency of quarterly, acceptable technical justification shall be given in the ISI Program Plan and the test will then be performed at a frequency of refueling outage in accordance with the requirements of the ASME Section XI/O&M Manual.

K. Relief Request

When a Code requirement cannot be met or a deviation from the criteria of the Code is necessary, a Relief Request shall be submitted to the NRC prior to implementation of the deviation.

L. IST Program

1. Interval - Fort Calhoun Station ISI Program Plan complies with the requirements of Inspection Program B as defined in IWA-2420 of Section XI. The ISI Program Plan is divided into four intervals consisting of ten years each. Prior to the beginning of each interval, a revised ISI Program Plan shall be submitted to the NRC for review and approval. The requirements of the latest approved Section XI Code that is accepted by the NRC within 12 months of the beginning of the upcoming interval shall be incorporated into the ISI Program Plan.

2. Period - Each interval consists of three periods of 40 months each.

M. Rapid Acting Valve

Power operated valves with normal stroke times open or closed, of two seconds or less.

N. Normal Plant Operation

The conditions of startup, operation at power, hot standby, and reactor cooldown, as defined by the plant technical specifications.

O. Reference Values/Baseline Data

One or more values of test parameters measured or determined when the equipment is known to be operating acceptably.

P. Instrument Accuracy

The allowable inaccuracy of an instrument loop based on the square root of the sum of the squares of the inaccuracies of each instrument or component in the loop.

Q. Instrument Loop

Two or more instruments or components working together to provide a single output (e.g., a vibration probe and its associated signal conditioning and readout devices).

R. Routine Servicing/Maintenance

The performance of planned, preventive maintenance (e.g., replacing or adjusting valves, adjusting packing, adding packing rings, flushing the cooling system or mechanical seal maintenance or replacement, etc.) which does not require disassembly of the pump or valve or replacement of parts.

S. Valve Position Indication (VPI) Verification

Valves with remote position indicators shall be observed locally in order to verify that the valve operation is accurately indicated. Where practical, the local observations should be supplemented by other indications, such as use of flowmeter or other suitable instrumentation to verify obturator position. These observations need not be concurrent. Where local observation is not possible, other indication shall be used for verification of valve position/operation (e.g., for solenoid valves, use voltage/contact measurements). At Fort Calhoun Station the VPI verification is performed independent of the valve stroke time measurement and has a "once every two years" performance frequency.

3.0 SELECTION CRITERIA FOR COMPONENTS TO BE TESTED

A. Valves (including actuating and position indicating systems)

Selected active or passive Class 1, 2 or 3 valves are ones which are required to perform a specific function in:

a. Shutting down reactor to the Cold Shutdown condition.

b. Maintaining reactor in a Cold Shutdown condition.

c. Mitigating the consequences of an accident.

B. Safety/Pressure Relief Devices (as defined by Article 2000 ASME Section III Subarticles NB, NC and ND)

1. Relief valves are tested in accordance with ANSI/ASME PTC 25.3-1976 Setpoint Test portion only.

2. Safety or relief valves that are selected for testing under ASME XI are ones which protect systems or portions of systems which perform a required function in:

   a. Shutting down reactor to the Cold Shutdown condition.

   b. Maintaining reactor in a Cold Shutdown condition.

   c. Mitigating the consequences of an accident.

3. Do not test relief valves that protect a safety related component or safety related system when not required to operate during an accident condition.

4. Do not test valves that provide a thermal relief function.

C. Pumps (Positive Displacement and Centrifugal)

Selected centrifugal and positive displacement pumps are ones provided with an emergency power source, which are required in:

a. Shutting down reactor to the Cold Shutdown condition.

b. Maintaining reactor in a Cold Shutdown condition.

c. Mitigating the consequences of an accident.

4.0 **EXCLUSIONS (COMPONENT NOT REQUIRING TESTING UNDER ASME XI)**

A. Excluded Valves are:

Valves that do not provide or are not required to perform a specific safety function as described in 3.A.1 and 3.B.2 above, and

1. Are used only for operating convenience such as vent, drain, instrument root and test valves; or,

2. Are used only for systems control, such as pressure regulating valves; or,

3. Are used only for system or component maintenance; or,

4. Are for external control and protection systems responsible for sensing plant conditions and providing signals for valve operation.

B. Excluded Pumps/Drivers are:

1. Drivers, except where the pump and driver form an integral unit and the pump bearings are in the driver.

2. Class 1, 2 and 3 pumps that are supplied with emergency power solely for operating convenience.

5.0 **GENERAL TEST PHILOSOPHY - VALVES**

A. Manual Valves

1. Do not stroke test.

2. Do not verify position indication.

3. May perform Appendix J testing, if applicable.

4. Do not exercise.

B. Dampers

1. Do not stroke test.

2. Do not verify position indication.

3. May perform Appendix J testing, if applicable.

4. Do not exercise.

C. Power Operated Valves

1. Test in direction that valve goes as a result of a safety signal if different than normal position.

2. Test in "fail" position if different than normal position or safety signal (tested by switch from Control Room).

3. Leak test valves if:

   a. Category A; or,

   b. Appendix J; or,

   b. Pressure Isolation Valve (PIV).

4. Stroke test valves closed, open or both as applicable:

   a. Time valve stroke from device (actuation to end of valve travel as indicated by lights).

   b. Only stroke/time valves from Control Room.

   c. Reference value (last three performances averaged) for most valves - established in 1990.

D. Check Valves

1. Test valve in direction the valve is required to travel in order to perform its safety function.

2. Full-stroke exercise valve in either the open, close or both directions as applicable quarterly. If not practical to perform full stroke of the valve quarterly, as required, perform a partial stroke quarterly, and full stroke the valve at the first Cold Shutdown or Refueling Outage as able. If not able to perform either a partial or full stroke of the valve, perform a sample disassembly and inspection of the valve in accordance with GL 89-04.

3. Exercise valve to close position and verify closed by:

   a. ΔP.

   b. Leakage.

4. Perform leak test if required.

E. Safety and Relief Valves

1. Test relief valves that are protecting systems or portions of systems which perform a required function in:

   a. Shutting down reactor to the Cold Shutdown condition.

   b. Maintaining reactor in a Cold Shutdown condition.

   c. Mitigating the consequences of an accident.

2. Perform setpoint pressure or "pop" tests in accordance with ASME PTC 25.3 (setpoint test only) and OM-1.

3. Perform reseat and seat leakage test per ASME OM-1.

4. Class 1 relief valves shall be tested once every five years:

   a. 33% of relief valves tested every refueling outage.

   b. A minimum of 20% tested every 24 months until 100% of the relief valves have been tested.

5. Class 2 and 3 shall be tested once every ten years after the initial test:

   a. 17% of relief valves tested every refueling outage.

   b. A minimum of 20% tested every 48 months until 100% of the relief valves have been tested.

6.0 GENERAL TEST PHILOSOPHY - PUMPS

A. Centrifugal

1. Perform operational test (ΔP vs flow):

   a. Fix flow, ΔP or speed (if required), measure ΔP or flow whichever is not set, typically Fort Calhoun Station sets flow and measures ΔP.

   b. Evaluate, compare with reference value or reference curve for degradation.

B. Positive Displacement

1. Perform operational test (discharge pressure vs flow).

2. Measure flow and discharge pressure and compare to reference values for degradation.

3. Measure vibration per Section XI/O&M Part 6.

7.0 **ACCEPTANCE CRITERIA/CORRECTIVE ACTION**

A. Valves

1. Power Operated

a. Alert Range:

(1) ±25% of reference value if reference value ≥10 seconds.

(2) ±50% of reference value if reference value ≤10 seconds.

(3) No alert range for rapid acting valves.

(4) Alert range may be Engineering judgement if safety analysis value is less than calculated required action range.

(5) Action taken is

(a) Recalibrate instruments and retest valve, or,

(b) Repair or replace valve or,

(c) Engineering analysis to prove acceptability or,

(d) Augment frequency of test.

b. Required Action Range:

(1) 2.5 times reference value or conservative to safety analysis.

(2) Action taken is

(a) Valve is immediately declared inoperable, and

(b) Repair or replace, or,

(c) Recalibrate and retest, or,

(d) Engineering analysis to prove operability.

2. Check Valves

a. Maximum required accident flow for "open".

b. Minimum ΔP for "close".

c. Visual inspection.

d. Leakage criteria, if required.

e. Sample disassembly:

(1) If one valve fails sample disassembly, all other valves in group require sample disassembly.

(2) Typically, one valve every other refueling outage (e.g., all valves in class are disassembled in six-year cycle).

(3) Partial stroke/leak test upon reassembly if practical.

3. Relief/Safety Valves

a. Class 1

(1) If valve measured relief pressure exceeds >103% of stamped set pressure criteria, additional valves of same type and manufacture shall be set pressure tested on the basis of two additional valves for each valve failed up to the total number of valves of the same type and manufacture in the system of concern. If any of the additional valves tested exceed the stamped set pressure criteria by >3%, then all valves of the same type and manufacture shall be tested.

B. Pumps

1. Centrifugal

a. Alert range:

Table IWP-3100-2 of ASME Section XI.

Table 3A and 3B of O&M-6.

b. Required action range:

Table IWP-3100-2 of ASME Section XI.

Table 3A and 3B of O&M-6.

2. Positive Displacement (Reciprocating)

a. Alert range:

Table IWP-3100-2 of ASME Section XI.

Table 3A and 3B of O&M-6.

b. Required action range:

Table IWP-3100-2 of ASME Section XI.

Table 3A and 3B of O&M-6.

NOTES:

1. Data is evaluated within 96 hours of the completion of the test.

2. Class 1, Class 2, ten-year hydros are not performed (reference ASME Code Case N-498).

3. The Fort Calhoun Station design basis definition of a safe shutdown condition is "Hot Shutdown".

4. The Fort Calhoun Station only uses the "setpoint testing" section of Code for relief valve testing criteria and does not commit to the requirements for supervising relief valve testing as stated in PTC 25.3 Code.

5. Components added to the ISI Program Plan as a result of plant/system modifications, engineering changes or re-evaluation of component eligibility requirements are considered operable based on interim acceptance criteria (established by construction, preservice, post maintenance, or preoperational tests), until a trend can be established.

6. Corrective actions as defined in the ISI Program Plan can be one or more of the following:

   a. Check calibration and/or recalibrate instrument, then perform retest of component.

   b. Repair or replace component, then perform acceptable retest.

   c. Engineering analysis to prove that component is capable of performing its design function.

7. In determining selection of components to be include in the ISI Program, Fort Calhoun Station does not consider passive failures of piping seismically qualified per the USAR and not included specifically in the safety analyses contained in the USAR.