RTR-2347

FDB 26 B.6.8

April 2, 1986

TO: G. F. MERZ, 703-A

FROM: J. H. HINTON, 707-C

HYDRAULIC TESTS OF EMERGENCY COOLING SYSTEM - L-AREA

INTRODUCTION

The delay in L-Area startup provided an opportunity to obtain valuable data on the Emergency Cooling System (ECS) which will permit reactor operation at the highest safe power level. ECS flow is a major input to the FLOOD code which calculates reactor ECS power limits. The FLOOD code assesses the effectiveness of the ECS cooling capacity by modeling the core and plenum hydraulics under accident conditions. Presently, reactor power is not limited by the ECS cooling capacity (power limit). However, the manual calculations of ECS flows had been recently updated to include piping changes (debris strainer, valve changes, pressure release systems) and update fitting losses. Both updates resulted in reduced calculated ECS flows. Upon completion of the current program to update, validate, and document, reactor power may be limited under certain situations by ECS cooling capacity for some present reactor charge designs.

A series of special hydraulic tests (Reference 1, 3) were conducted in L-Area using all sources of emergency coolant including the ECS pumps (Reference 2). The tests provided empirical hydraulic data on the ECS piping. These data will be used in computer models of the system as well as manual calculations of ECS flows. The improved modeling and accuracy of the flow calculations will permit reactor operation at the highest safe power level with respect to an ECS power limit.

SUMMARY

A series of hydraulic tests were performed in L Area to obtain empirical data on the ECS piping system (Reference 3). The tests included combinations of sources [redacted] Booster Pump and two Emergency Pumps) and combinations of Supplies [redacted]) with flows from 0 to 100 percent. The data obtained is tabulated in the appendices of this report.

The data shows the ECS flow under accident conditions to be up to 20 percent higher than previously calculated. The tests also showed that as high as 30 percent additional ECS flow capacity can be expected

with multiple sources supplying the ECS. In addition, one series of tests provided flow data from [redacted] with combinations of 190 Building cooling water pumps and heat exchangers on line. The tests proved that the tables in DPSOL 105-1219A, Reactor Shutdown Rules and Equipment Checks, which lists combinations of qualified sources are satisfactory.

The tests provide sufficient empirical data to accurately calculate ECS flows for the LKC piping systems. P Area piping is sufficiently different to warrant similar tests once magnetic flow meters are installed in the individual ECS piping systems (Reference 4).

CONCLUSIONS

- The tests provided the data needed to more accurately calculate ECS flows (± 6% compared to ± 17%).
- The ECS flows are as much as 20 percent higher than previously calculated using limited empirical data. Higher ECS flows will permit reactor operation of the higher power levels.
- The empirical data obtained from the tests should be incorporated in an ECS piping model.
- Because of the piping differences, tests should be conducted in P Area after the installation of magnetic flow meters (Reference 5).

DISCUSSION

Extensive tests of the Emergency Cooling System piping were proposed for L Area. L Area was chosen because of the delay in reactor startup and because L Area has the only ECS piping system with in-line magnetic flow meters installed. Tests to obtain empirical data had not been conducted since 1974 (Reference 5). Major piping system changes had been completed since that time (Reference 6). The magnetic flow meters in the ECS supply piping allowed rapid and accurate data collecton. No special test equipment was required. Digital Heise Gages were utilized where accurate pressure data was required.

ECS flow is a major input to the FLOOD code which calculates ECS power limits. The FLOOD code assesses the effectiveness of the ECS cooling capacity by modeling the core and plenum hydraulics under accident conditions. Presently reactor power is not limited by the ECS cooling capacity (power limit). However upon completion of the FLOOD code's update, validation, and documentation, reactor power may be limited under certain situations by ECS cooling capacity for some present reactor charge designs. The manual calculations of ECS flows had been

updated to include piping changes (Reference 6) using theoretical pressure drop data. The accuracy of the calculations were estimated to be ±17% (Reference 7). The hydraulic tests in L Area resulted in empirical corrections which improved the accuracy of the calculations to 3 to 6% (Reference 8). The test procedure and test equipment information is given in Appendices I, II, III, and IV.

The first series of tests determined the effect on system flow when more that one source was supplying the ECS. ECS flows are conservatively calculated using only one source of cooling water. The results of the tests indicate that ECS flow could be as much as 30% higher (Table 1) with multiple supply sources on line (Appendix V).

The second series of tests were to determine the adequacy of combinations of 190 Building cooling water pumps to supply the ECS as outlined in the operating procedure, DPSOL 105-1219A, Reactor Shutdown Rules and Equipment Checks. The tests showed that the combinations as outlined, provided ECS flow equal to or greater than the flow with all heat exchangers online with a full compliment of 190 Building pumps (Appendix VI.) The test also showed that sufficient ECS flow will be supplied even if one 190 Building cooling water pump is lost (Table 2).

The third series of tests provided the empirical data on the hydraulics of the individual supply piping. The test results showed that ECS flows are higher than previously calculated by as much as 20% (Tables 3 and 4 and References 9 and 10). The tests did not allow direct determination of individual component pressure loss coefficients. The tests did provide sufficient data to calculate the piping system loss coefficient with an accuracy of 3 to 6 percent (Reference 8).

The data obtained from the hydraulic tests should be incorporated in the Pipeflow Code (Reference 11). Manual calculations are cumbersome and are subject to human error. Computer calculations can be made in the future using this code.

The data from the three test series is recorded in Appendices V, VI, and VII as raw data. No attempt was made in these appendices to adjust or delete inconsistant data. However, some tests were repeated to confirm data.

Data tabulations are included in the appendices. Empirical piping loss coefficients calculated from the test data are given in Appendix XIII. In addition, Appendices VIII, IX and X contain the performance curve data for the ECS Pumps, the booster pump, and the 190 Building cooling water pumps. Appendix XIV is a tabulation of empirical and theoretical pipe coefficients previously determined.

Appendix XV gives the manual calculation methodology. Appendix XVI is included to record the results of the 1974 ECS tests for historical purpose.

REFERENCES

1. Hinton, J. H., Special Hydraulic Tests of Emergency Cooling System - L-Area, RTM-4676, May 5, 1985.

2. Project S-3148, Restore Pumping System for Emergency Coolant, 105-PLKC, August 17, 1984.

3. RSP-85-001, Emergency Cooling System - Special Hydraulic Tests - L-Area.

4. Project S-3630, Emergency Cooling System Flow Instrumentation, August 28, 1984.

5. Black, J. E., Emergency Cooling System Test Results, Unissued Report (Appendix XVI).

6. Project S-1830, Improved Supply Of Emergency Coolant, December 22, 1977.

7. McAllister, J. E., QA of ECS Flows in RTR-2239, IOM, May 15, 1985.

8. McAllister, J. E., Uncertainty Analysis of Emergency Cooling System, RTR-2341, to be issued.

9. Hinton, J. H., Emergency Cooling System Flows, RTR-2239, Rev. 1, December 3, 1985.

10. Hinton, J. H., Emergency Cooling System Flows, RTR-2239, March 13, 1985.

11. Wood, D. J., Professor in Department of Civil Engineering of University of Kentucky, User's Manual - Computer Analysis of Flow in Pipe Networks Included Extended Period Simulation, October, 1981, update version.

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TABLE 1

SUMMARY
TOTAL FLOW FOR SOURCES AND COMBINATION FLOW THROUGH TEST PIPING THREE ADDITION SYSTEMS

TEST NO.	SOURCE	GPM TOTAL
1	[redacted]	13550
2	[redacted]	14900
3	[redacted]	15800
4	[redacted]	15735
5	[redacted]	15720
6	[redacted]	16345
7	[redacted]	15855
8	[redacted]	15960
9	[redacted]	15920
10	[redacted]	16180
11	[redacted]	16495
12	[redacted]	16490
13	[redacted]	16675
14	[redacted]	16115
15	[redacted]	16105
16	[redacted]	16205
17	[redacted]	15810
18	[redacted]	15365
19	[redacted]	15390
20	[redacted]	15870
21	[redacted]	15725
22	[redacted]	15755
23	[redacted]	15875
24	[redacted]	13879
25	[redacted]	13815
26	[redacted]	15120
27	[redacted]	15090
28	[redacted]	15620
29	[redacted]	12465
30	[redacted]	12370
31	[redacted]	15240

TABLE 2

SUMMARY
DPSOL 105-1219 COMBINATIONS
FLOW THROUGH TEST PIPING
TWO ADDITION SYSTEMS

TEST NO.	SOURCE	NO. 190 PUMPS	NO. 105 HXS	TOTAL FLOW GPM
31	[redacted]	3	2	10551
32a	[redacted]	3	2	10550
33	[redacted]	2	2	7863
33a	[redacted]	2	2	7840
34	[redacted]	4	3	9892
35	[redacted]	3	3	8490
36	[redacted]	5	6	7995
37	[redacted]	4	6	6914
38	[redacted]	3	2	10750
39	[redacted]	2	2	8020
39a	[redacted]	1	2	3891

TABLE 3

CALCULATION ECS FLOWS FOR LOCA

EMERGENCY COOLING SYSTEM ON	WITH LEAK	BOOSTER PUMP FLOW, GPM: THEORECTICAL CALCULATIONS P	THEORECTICAL CALCULATIONS LKC	EMPIRICAL BASED CALCULATION P	EMPIRICAL BASED CALCULATION LKC	EMERGENCY PUMP FLOW, GPM: P 1 Pump	P 2 Pump	LKC 1 Pump	LKC 2
[redacted]	2	4740	4960	5600	5790				
	2	8150	8650	8420	8990				
	2	-	-	5410	5660				
		[redacted] FLOW, GPM							
	2	4390	4420	5070	5410				
	2	-	-	4950	5260				
[redacted]	2	-	-			5210	5950	5395	6200
	2	-	-			7630	8800	7930	9360
	2	-	-			5120	5650	5320	6050

TABLE 4

CALCULATION ECS FLOWS FOR LOPA

EMERGENCY COOLING SYSTEM ON	BOOSTER PUMP FLOW, GPM — THEORETICAL CALCULATIONS P	THEORETICAL CALCULATIONS LKC	EMPIRICAL BASED CALCULATIONS P	EMPIRICAL BASED CALCULATIONS LKC
[redacted]	6620	6730	6630	6850
[redacted]	6660	6790	7120	7250
[redacted]	5690	5750	6950	7080
[redacted]	10280	10720	10300	10770
[redacted]	9920	10360	10470	10980
[redacted]	9750	10170	10310	10780
[redacted]	11830	12600	11750	12460

EMERGENCY COOLING SYSTEM ON	[redacted] FLOW, GPM — THEORETICAL P	THEORETICAL LKC	EMPIRICAL P	EMPIRICAL LKC
[redacted]	4820	5000	5940	6060
	-	-	5760	5980

EMERGENCY COOLING SYSTEM ON	THEORETICAL P	THEORETICAL LKC	EMERGENCY PUMP FLOW, GPM — P 1 Pump	P 2 Pump	LKC 1 Pump	LKC 2 Pum
[redacted]	-	-	7310	7640	7440	7820
	-	-	9850	10930	10160	11440
	-	-	10800	12270	11210	13000
	-	-	7030	7300	7100	7420
	-	-	7180	7520	7300	7680

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2. Project S-3148, Restore Pumping System for Emergency Coolant, 105-PLKC, August 17, 1984.

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10. Hinton, J. H., Emergency Cooling System Flows, RTR-2239, March 13, 1985.

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TABLE 1

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TOTAL FLOW FOR SOURCES AND COMBINATION
FLOW THROUGH TEST PIPING
THREE ADDITION SYSTEMS

TEST NO.	SOURCE	GPM TOTAL
1	[redacted]	13550
2	[redacted]	14900
3	[redacted]	15800
4	[redacted]	15735
5	[redacted]	15720
6	[redacted]	16345
7	[redacted]	15855
8	[redacted]	15960
9	[redacted]	15920
10	[redacted]	16180
11	[redacted]	16495
12	[redacted]	16490
13	[redacted]	16675
14	[redacted]	16115
15	[redacted]	16105
16	[redacted]	16205
17	[redacted]	15810
18	[redacted]	15365
19	[redacted]	15390
20	[redacted]	15870
21	[redacted]	15725
22	[redacted]	15755
23	[redacted]	15875
24	[redacted]	13879
25	[redacted]	13815
26	[redacted]	15120
27	[redacted]	15090
28	[redacted]	15620
29	[redacted]	12465
30	[redacted]	12370
31	[redacted]	15240

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TABLE 2

SUMMARY
DPSOL 105-1219 COMBINATIONS
FLOW THROUGH TEST PIPING
TWO ADDITION SYSTEMS

TEST NO.	SOURCE	NO. 190 PUMPS	NO. 105 HXS	TOTAL FLOW GPM
31	[redacted]	3	2	10551
32a		3	2	10550
33		2	2	7863
33a		2	2	7840
34		4	3	9892
35		3	3	8490
36		5	6	7995
37		4	6	6914
38		3	2	10750
39		2	2	8020
39a		1	2	3891

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TABLE 3

CALCULATION ECS FLOWS FOR LOCA

BOOSTER PUMP FLOW, GPM

EMERGENCY COOLING SYSTEM ON	WITH LEAK	THEORECTICAL CALCULATIONS P	THEORECTICAL CALCULATIONS LKC	EMPIRICAL BASED CALCULATION P	EMPIRICAL BASED CALCULATION LKC
[redacted]	2	4740	4960	5600	5790
	2	8150	8650	8420	8990
	2	-	-	5410	5660
		[redacted] FLOW, GPM			
	2	4390	4420	5070	5410
	2	-	-	4950	5260

EMERGENCY PUMP FLOW, GPM

EMERGENCY COOLING SYSTEM ON	WITH LEAK	THEORECTICAL CALCULATIONS P	THEORECTICAL CALCULATIONS LKC	P 1 Pump	P 2 Pump	LKC 1 Pump	LKC 2
[redacted]	2	-	-	5210	5950	5395	6200
	2	-	-	7630	8800	7930	9360
	2	-	-	5120	5650	5320	6050

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TABLE 4

CALCULATION ECS FLOWS FOR LOPA

EMERGENCY COOLING SYSTEM ON	BOOSTER PUMP FLOW, GPM			
	THEORETICAL CALCULATIONS		EMPIRICAL BASED CALCULATIONS	
	P	LKC	P	LKC
[redacted]	6620	6730	6630	6850
	6660	6790	7120	7250
	5690	5750	6950	7080
	10280	10720	10300	10770
	9920	10360	10470	10980
	9750	10170	10310	10780
	11830	12600	11750	12460
	[redacted] FLOW, GPM			
[redacted]	4820	5000	5940	6060
	-	-	5760	5980

EMERGENCY COOLING SYSTEM ON	THEORETICAL P	THEORETICAL LKC	EMERGENCY PUMP FLOW, GPM			
			P		LKC	
			1 Pump	2 Pump	1 Pump	2 Pum
[redacted]	-	-	7310	7640	7440	7820
	-	-	9850	10930	10160	11440
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	-	-	7030	7300	7100	7420
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SUMMARY

A series of hydraulic tests were performed in L Area to obtain empirical data on the ECS piping system (Reference 3). The tests included combinations of sources [redacted] Booster Pump and two Emergency Pumps) and combinations of Supplies [redacted] with flows from 0 to 100 percent. The data obtained is tabulated in the appendices of this report.

The data shows the ECS flow under accident conditions to be up to 20 percent higher than previously calculated. The tests also showed that as high as 30 percent additional ECS flow capacity can be expected

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with multiple sources supplying the ECS. In addition, one series of tests provided flow data from [redacted] ith combinations of 190 Building cooling water pumps and heat exchangers on line. The tests proved that the tables in DPSOL 105-1219A, Reactor Shutdown Rules and Equipment Checks, which lists combinations of qualified sources are satisfactory.

The tests provide sufficient empirical data to accurately calculate ECS flows for the LKC piping systems. P Area piping is sufficiently different to warrant similar tests once magnetic flow meters are installed in the individual ECS piping systems (Reference 4).

CONCLUSIONS

- The tests provided the data needed to more accurately calculate ECS flows (± 6% compared to ± 17%).
- The ECS flows are as much as 20 percent higher than previously calculated using limited empirical data. Higher ECS flows will permit reactor operation of the higher power levels.
- The empirical data obtained from the tests should be incorporated in an ECS piping model.
- Because of the piping differences, tests should be conducted in P Area after the installation of magnetic flow meters (Reference 5).

DISCUSSION

Extensive tests of the Emergency Cooling System piping were proposed for L Area. L Area was chosen because of the delay in reactor startup and because L Area has the only ECS piping system with in-line magnetic flow meters installed. Tests to obtain empirical data had not been conducted since 1974 (Reference 5). Major piping system changes had been completed since that time (Reference 6). The magnetic flow meters in the ECS supply piping allowed rapid and accurate data collecton. No special test equipment was required. Digital Heise Gages were utilized where accurate pressure data was required.

ECS flow is a major input to the FLOOD code which calculates ECS power limits. The FLOOD code assesses the effectiveness of the ECS cooling capacity by modeling the core and plenum hydraulics under accident conditions. Presently reactor power is not limited by the ECS cooling capacity (power limit). However upon completion of the FLOOD code's update, validation, and documentation, reactor power may be limited under certain situations by ECS cooling capacity for some present reactor charge designs. The manual calculations of ECS flows had been

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updated to include piping changes (Reference 6) using theoretical pressure drop data. The accuracy of the calculations were estimated to be ±17% (Reference 7). The hydraulic tests in L Area resulted in empirical corrections which improved the accuracy of the calculations to 3 to 6% (Reference 8). The test procedure and test equipment information is given in Appendices I, II, III, and IV.

The first series of tests determined the effect on system flow when more that one source was supplying the ECS. ECS flows are conservatively calculated using only one source of cooling water. The results of the tests indicate that ECS flow could be as much as 30% higher (Table 1) with multiple supply sources on line (Appendix V).

The second series of tests were to determine the adequacy of combinations of 190 Building cooling water pumps to supply the ECS as outlined in the operating procedure, DPSOL 105-1219A, Reactor Shutdown Rules and Equipment Checks. The tests showed that the combinations as outlined, provided ECS flow equal to or greater than the flow with all heat exchangers online with a full compliment of 190 Building pumps (Appendix VI.) The test also showed that sufficient ECS flow will be supplied even if one 190 Building cooling water pump is lost (Table 2).

The third series of tests provided the empirical data on the hydraulics of the individual supply piping. The test results showed that ECS flows are higher than previously calculated by as much as 20% (Tables 3 and 4 and References 9 and 10). The tests did not allow direct determination of individual component pressure loss coefficients. The tests did provide sufficient data to calculate the piping system loss coefficient with an accuracy of 3 to 6 percent (Reference 8).

The data obtained from the hydraulic tests should be incorporated in the Pipeflow Code (Reference 11). Manual calculations are cumbersome and are subject to human error. Computer calculations can be made in the future using this code.

The data from the three test series is recorded in Appendices V, VI, and VII as raw data. No attempt was made in these appendices to adjust or delete inconsistant data. However, some tests were repeated to confirm data.

Data tabulations are included in the appendices. Empirical piping loss coefficients calculated from the test data are given in Appendix XIII. In addition, Appendices VIII, IX and X contain the performance curve data for the ECS Pumps, the booster pump, and the 190 Building cooling water pumps. Appendix XIV is a tabulation of empirical and theoretical pipe coefficients previously determined.

Appendix XV gives the manual calculation methodology. Appendix XVI is included to record the results of the 1974 ECS tests for historical purpose.

REFERENCES

1. Hinton, J. H., Special Hydraulic Tests of Emergency Cooling System - L-Area, RTM-4676, May 5, 1985.

2. Project S-3148, Restore Pumping System for Emergency Coolant, 105-PLKC, August 17, 1984.

3. RSP-85-001, Emergency Cooling System - Special Hydraulic Tests - L-Area.

4. Project S-3630, Emergency Cooling System Flow Instrumentation, August 28, 1984.

5. Black, J. E., Emergency Cooling System Test Results, Unissued Report (Appendix XVI).

6. Project S-1830, Improved Supply Of Emergency Coolant, December 22, 1977.

7. McAllister, J. E., QA of ECS Flows in RTR-2239, IOM, May 15, 1985.

8. McAllister, J. E., Uncertainty Analysis of Emergency Cooling System, RTR-2341, to be issued.

9. Hinton, J. H., Emergency Cooling System Flows, RTR-2239, Rev. 1, December 3, 1985.

10. Hinton, J. H., Emergency Cooling System Flows, RTR-2239, March 13, 1985.

11. Wood, D. J., Professor in Department of Civil Engineering of University of Kentucky, User's Manual - Computer Analysis of Flow in Pipe Networks Included Extended Period Simulation, October, 1981, update version.

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TABLE 1

SUMMARY
TOTAL FLOW FOR SOURCES AND COMBINATION
FLOW THROUGH TEST PIPING
THREE ADDITION SYSTEMS

TEST NO.	SOURCE	GPM TOTAL
1	[redacted]	13550
2	[redacted]	14900
3	[redacted]P	15800
4	[redacted]EPA	15735
5	[redacted]EPB	15720
6	[redacted]EPA&B	16345
7	[redacted] BP	15855
8	[redacted] EPA	15960
9	[redacted] EPB	15920
10	[redacted] EPA&B	16180
11	[redacted] BP, EPA	16495
12	[redacted] BP, EPB	16490
13	[redacted] BP, EPA&B	16675
14	[redacted] BP, EPA	16115
15	[redacted] BP, EPB	16105
16	[redacted], BP, EPA&B	16205
17	[redacted] BP	15810
18	[redacted] EPA	15365
19	[redacted] EPB	15390
20	[redacted] EPA&B	15870
21	[redacted] BP, EPA	15725
22	[redacted] BP, EPB	15755
23	[redacted] BP, EPA&B	15875
24	[redacted]	13879
25	BP	13815
26	BP, EPA	15120
27	BP, EPB	15090
28	EP, EPA&B	15620
29	EPA	12465
30	EPB	12370
31	EPA&B	15240

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TABLE 2

SUMMARY
DPSOL 105-1219 COMBINATIONS
FLOW THROUGH TEST PIPING
TWO ADDITION SYSTEMS

TEST NO.	SOURCE	NO. 190 PUMPS	NO. 105 HXS	TOTAL FLOW GPM
31	[redacted]	3	2	10551
32a		3	2	10550
33		2	2	7863
33a		2	2	7840
34		4	3	9892
35		3	3	8490
36		5	6	7995
37		4	6	6914
38		3	2	10750
39		2	2	8020
39a		1	2	3891

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TABLE 3

CALCULATION ECS FLOWS FOR LOCA

EMERGENCY COOLING SYSTEM ON	WITH LEAK	BOOSTER PUMP FLOW, GPM THEORECTICAL CALCULATIONS P	LKC	EMPIRICAL BASED CALCULATION P	LKC
[redacted]	[redacted]	4740	4960	5600	5790
		8150	8650	8420	8990
		-	-	5410	5660
		[redacted] FLOW, GPM			
[redacted]	[redacted]	4390	4420	5070	5410
		-	-	4950	5260

Pump				EMERGENCY PUMP FLOW, GPM P 1 Pump	P 2 Pump	LKC 1 Pump	LKC 2
[redacted]	[redacted]	-	-	5210	5950	5395	6200
		-	-	7630	8800	7930	9360
		-	-	5120	5650	5320	6050

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TABLE 4

CALCULATION ECS FLOWS FOR LOPA

EMERGENCY COOLING SYSTEM ON	BOOSTER PUMP FLOW, GPM			
	THEORETICAL CALCULATIONS		EMPIRICAL BASED CALCULATION[illegible]	
	P	LKC	P	LKC
[redacted]	6620	6730	6630	6850
	6660	6790	7120	7250
	5690	5750	6950	7080
	10280	10720	10300	10770
	9920	10360	10470	10980
	9750	10170	10310	10780
	11830	12600	11750	12460

	[redacted] FLOW, GPM			
[redacted]	4820	5000	5940	6060
	-	-	5760	5980

			EMERGENCY PUMP FLOW, GPM			
			P		LKC	
			1 Pump	2 Pump	1 Pump	2 Pu[illegible]
[redacted]	-	-	7310	7640	7440	782[illegible]
	-	-	9850	10930	10160	1144[illegible]
	-	-	10800	12270	11210	1300[illegible]
	-	-	7030	7300	7100	742[illegible]
	-	-	7180	7520	7300	768[illegible]

APPENDIX I

TEST PROCEDURE

RSP-85-001

RSP-85-001

DISTRIBUTION

H. F. Allen, 707-C
C. E. Ahlfeld, 707-C
R. F. Anderson, 704-L
A. M. Cwalina, 707-C
L. V. DeWitt, 105-L
J. E. Fetterman, 105-L
J. L. Jones, 707-C
L. R. Jones, 703-A/A-237
G. F. Merz, 703-A/A-241
T. M. Monahon, 707-C
J. S. Petersen, 707-C
D. B. Rose, 707-C (2)
M. H. Tennant, 707-C
J. H. Hinton, 707-C
704-L File
706-C File
Central Files, 703-A/A-027
SRL Files, 773-A/A-0261

REACTOR SPECIAL PROCEDURE
RSP-85-001 (RTM-4676)

July 3, 1985

EMERGENCY COOLING SYSTEM - SPECIAL HYDRAULIC TESTS REACTOR SPECIAL PROCEDURE UNDER RTM-4676 L AREA

APPROVAL DATE:: July 3, 1985

FREQUENCY: One Time only.

REFERENCES:

DPSOL 105-1015,	Cooling Water System Startup
105-1201,	Transfer of Sodium Polyborate Solution from ECS to Tank Cars
105-1841,	Switching Disassembly HX Cooling Water Supply
105-1853,	Functional Check of Incident Switch
105-1858A,	Preparing for Test and Returning to Normal - ECS
105-2315,	Booster Pump Operations
QAAR 100-PLKC-11,	Emergency Cooling and Liquid Confinement Protection

GENERAL LIMITATIONS AND CAUTIONS

1. The reactor must be void of heat-generating assemblies.
2. The sodium polyborate solution must be removed from the ECS.
3. DO NOT use handwheels on hydraulically operated valves [redacted] to check valve position or seating.
4. If any valve fails to operate correctly, stop the test immediately and notify supervisor.

INFORMATION:

EQUIPMENT REQUIRED:

1. Eleven (11) 0-100 psig Heise gages calibrated within 30 days of test.
2. One 0-300 inch H_2O ΔP (Barton) gage.

PROCEDURE:

A. PREPARATION

CHECK

1. Verify that there are no heat-generating assemblies in the reactor. ______
2. Verify that the emergency cooling system is ready for testing per Part I of DPSOL 105-1858A. ______
3. Verify that the ECS has been drained, then filled with water per DPSOL 105-1201. ______
4. Verify that sodium polyborate solution has not been charged to ECS. ______
5. Verify that cooling water flow [redacted] is at gravity flow or greater. ______

Completed by ______________________

Date ____________ Time ____________p.m.

CHECK

6.a) Have E&I Mechanic install 0-100 psig Heise gages at the following locations:

At valve 1392 (at valve [redacted] ______
At valve 1395 (at valve [redacted] ______
At valve 1397 (at valve [redacted] ______
At valve 376B ______
At valve Em Pump 1 Discharge ______
At valve Em Pump 2 Discharge ______
At valve 1512 [redacted] ______
At valve 1530 [redacted] ______
At valve 1527 [redacted] ______
At valve 1545 [redacted] ______
At valve Booster Pump Discharge ______

6.b) Have E&I install a 0-300 inch Barton at sodium borate header strainer. ______

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CHECK

7. Have Works Engineering remove the flow orifices in the following lines: [redacted] ______

8. Have Reactor Technology Test Coordinator determine elevation of center line of each gage and record below:

Gage Elevations

Gage No.	Serial No.	Elevation
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

9. Verify that the following valves are positioned as indicated:

[redacted] CLOSED ______
CLOSED ______
CLOSED ______
CLOSED ______
CLOSED ______
CLOSED ______
CLOSED ______
CLOSED ______
CLOSED ______
CLOSED ______
CLOSED ______

10. Verify that all Heise and Barton gage pressure taps are OPEN. ______

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B. TEST OF ECS SOURCES

CHECK

1. Verify that:
   a. Cooling water flow through cooling water headers [redacted] is at gravity flow or less. ___
   b. Cooling water header effluent valves [redacted] are OPEN. ___
   c. Both inlet and outlet CW valves on at least 2 heat exchangers on each cooling water header are OPEN. ___
   d. Valve [redacted] is OPEN. ___
   e. Valve [redacted] is CLOSED. ___
   f. Crosstie header isolation valves are CLOSED.
      [redacted] ___ ___ ___ ___
   g. Bypass line valves around crosstie header isolation valves [redacted] are CLOSED.
      [redacted] ___ ___

2. Station observers as follows:
   - HX bay to observe operation of valves in field and to observe the Heise gages. ___
   - Graphic panel to operate valves, to record flow and to record field data. ___
   - Hydraulic unit to check operation of pump and motor for valves when valves are first opened. ___
   - At ECS storage header strainer to verify that the strainer Bypass relief valves remain closed while valves are open and to record strainer ΔP (pt #9) ___
   - At Booster Pump to record data ___
   - At -20 clean area to record data ___

CHECK

3. If an ECS strainer bypass relief valve starts to open, proceed as follows:

   a. Close valves opened below ____

   b. Request Maintenance Mechanics to check and reset, if necessary, the torque required per DPSOL 105-1268 to open to strainer bypass relief valves. ____

   c. Resume test. ____

   d. If a strainer bypass relief valve again starts to open, stop the test and notify day supervision. ____

4. Establish supply of test water per Table 1

   Test Combinations - Sources

   a. Verify the valve [redacted] is CLOSED ____

   b. Verify that valve [redacted] is OPEN ____

   c. Establish [redacted] supply with 3 small pumps, heat exchangers and valve [redacted] OPEN. ____

   d. Establish [redacted] supply with 3 small pumps, 2 heat exchangers and valve [redacted] OPENS. ____

5. Unlock and energize the following valves in crane maintenance area. Verify that CLOSED indicating lights on the graphic panel are ON. [redacted] ____ ____

6. Request observer in field to OPEN the following valves:

   Block valve, flow test line [redacted] OPEN ____
   OPEN ____
   OPEN ____

7. Set valving to establish test condition per Table 1 Test 1.
   [redacted] Supply - Valve [redacted] open ____

8. Establish contact with all observers in the field. ____

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CHECK

9. Cycle valves [redacted] (close to open; open to closed) ____

10. Press open button for valve [redacted] at graphic panel. ____

    Verify the following:

    a. Green light on graphic panel in ON for valve [redacted] ____

    b. Position indicator on the graphic panel indicates full OPEN for valve [redacted] ____

    c. If valve [redacted] fails to open, stop test immediately. ____

    d. Repeat steps for [redacted] ____

11. Press open button for valve [redacted] at graphic panel. ____

    Verify that valve [redacted] opened as follows:

    a. Green light on graphic panel is ON for valve [redacted] ____

    b. By visually checking at valve. ____

    c. If valve [redacted] fails to open, stop test immediately. ____

    d. Repeat step for [redacted] ____

12. Verify that flow through magnetic flowmeters is indicated on graphic panel.

13. Allow water to flow for fifteen minutes to flush lines. ____

14. Check for leaks. Repair as necessary. ____

15. Complete Data Sheet 1. ____

16. Continue by starting and stopping pumps, opening and closing valves [redacted] until all combinations in Table 1 have been completed. Record data on Data Sheet 1. ____

CHECK

NOTE: The Booster Pump will be started using appropriate steps in DPSOL 105-2315. The cooling water pumps will be started under the direction of Power Department supervision. The emergency pumps will be started from the Graphic Panel.

17. Repeat tests from Table 1 requested by Reactor Technology. ____

18. Close the following valves:

[redacted] ____ ____ ____ [redacted] ____ ____ ____ ____ [redacted] ____ ____ ____ [redacted] ____ ____ ____

____
____
____

19. Shutdown Emergency Pumps 1 and 2.

1 ____
2 ____

C. COOLING WATER PUMP TEST

1. Verify that:

   a. Cooling water flow through cooling water headers [redacted] is at gravity flow or less. ____

   b. Cooling water header effluent valves [redacted] are open. ____

   c. Both inlet and outlet CW valves on at least 2 heat exchangers on each cooling water header are OPEN. ____

   d. Valve [redacted] is OPEN. ____

   e. Valve [redacted] is CLOSED. ____

   f. Crosstie header isolation valves are CLOSED. [redacted] ____ ____ ____ ____

   g. Bypass line valves around crosstie header isolation valves [redacted] are CLOSED [redacted] ____ ____

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CHECK

2. Station observers as follows:

   - HX bay to observe operation of valves in field and to observe the Heise gages (L Area). _____

   - Graphic panel to operate valves and to record flow and field data. _____

   - Hydraulic unit to check operation of pump and motor for valves [redacted] and [redacted] when valves are first opened. _____

   - At -20 clean area to record data. _____

   - At ECS storage header strainer to verify that the strainer bypass relief valves remain closed while valves are open and to record strainer P (pt #9) _____

3. If an ECS strainer bypass relief valve starts to open, complete the following:

   a. Close valves opened below. _____

   b. Request Maintenance Mechanics to recheck, and reset if necessary, the torque required to open strainer bypass relief valve per DPSOL 105-1268. _____

   c. Resume test. _____

   d. If a strainer bypass relief valve again starts to open, stop the test and notify day supervision. _____

4. Establish a supply of test water per Table II, [redacted] and [redacted] Pump Tests

   a. Verify that valve [redacted] is CLOSED. _____

   b. Verify that valve [redacted] is OPEN. _____

   c. Establish [redacted] supply with 3 small CW pumps and two heat exchangers. _____

CHECK

5. Request observer in field to OPEN the following valves: ____

   Block valve - flow test line [redacted] [redacted] OPEN ____
   OPEN ____

6. Set valving to establish test conditions per Table II, Test 32. [redacted] Supply - [redacted] Open ____

7. Establish contact with all observers in the field ____

8. Press open button for valve [redacted] at graphic panel. Verify the following.

   a. Green light on graphic panel is ON for valve [redacted] ____

   b. Position indicator for valve [redacted] on the graphic panel indicates full OPEN. ____

   c. If valve [redacted] fails to open, stop test imediately.

   d. Repeat step for valve [redacted] ____

9. Press open button for valve [redacted] at graphic panel. Verify that valve [redacted] opened as follows: ____

   a. Green light on graphic panel is ON for valve [redacted] ____

   b. By visually checking at valve. ____

   c. If valve [redacted] fails to open, stop test immediately. ____

   d. Repeat step for valve [redacted] ____

10. Verify that flow through magnetic flow meters for systems [redacted] are indicated on the graphic panel. ____

11. Continue by starting and stopping 190 pumps, opening and closing heat exchanger valves, and opening and closing valves [redacted] until all combinations in Table II have been completed. Record data on Data Sheet 2. ____

NOTE: The cooling water pumps will be started under the direction of Power Department Supervision. Reactor Department will choose the heat xchangers to place on line and open the inlet and outlet valves to each one chosen.

CHECK

12. Repeat tests from Table II requested by Reactor Technology. ____

13. Close the following valves.
[redacted] ____ [redacted] ____ [redacted] ____ [redacted] ____

14. Shutdown 190 pumps on [redacted] ____

D. TEST OF ECS SUPPLIES

1. Verify that:

   a. Cooling water flow through cooling water headers [redacted] is at gravity flow or less. ____

   b. Cooling water header effluent valves [redacted] are open. ____

   c. Both inlet and outlet CW valves on at least 2 heat exchangers on each cooling water header are OPEN. ____

   d. Valve [redacted] is OPEN. ____

   e. Valve [redacted] is CLOSED. ____

   f. Crosstie header isolation valves are CLOSED.
      [redacted] CLOSED ____
      CLOSED ____
      CLOSED ____
      CLOSED ____

   g. Bypass line valves around crosstie header isolation valves [redacted] are CLOSED.
      [redacted] CLOSED ____
      CLOSED ____

2. Station observers as follows:

   o HX bay to observe operation of the valves in the field and to observe Heise gages. ____

   o Graphic panel to operate valves, to record flow, and to record field data. ____

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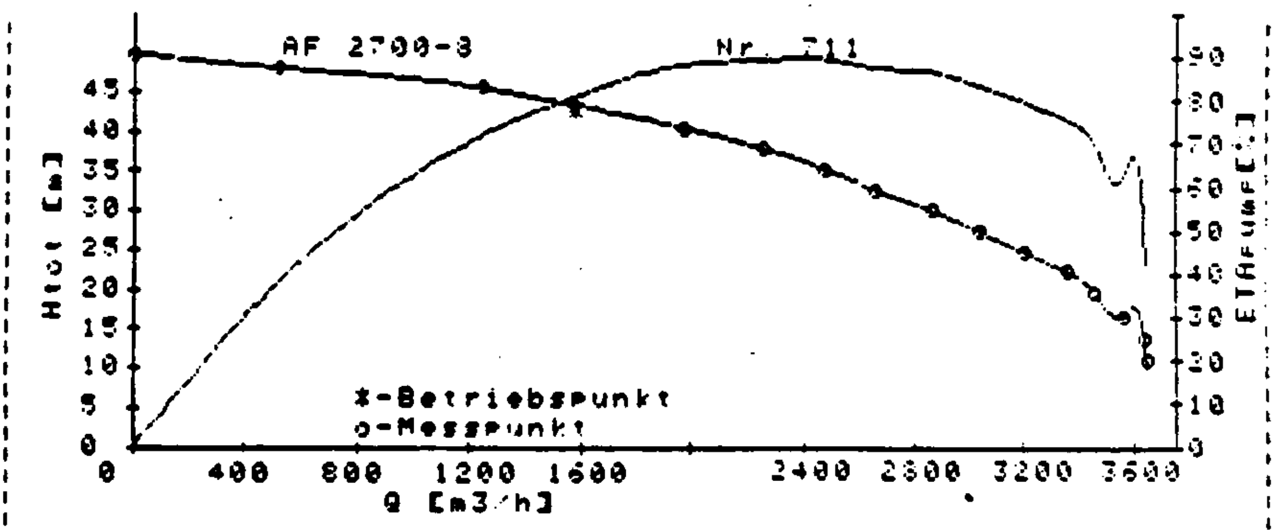
ABS Pumpen AG

Testdepartment

ELECTRICAL & HYDRAULICAL TESTS

663 851	AF 2700 - 8	711	G7/M5	Blönigen	22.05.85	12
Order-No	Type	Serial-No.	OP-No.	Tested by	Date	Page

H [m]	Htot [m]	Q [m3/h]	P1 [kW]	I [A]	cos φ	η ges [%]	η mot [%]	η pump [%]	P2 [kW]
49.8	49.8	0	177	322	0.69	0	92.8	0	164.
47.9	48.0	524	194	338	0.72	35.3	93.0	38.0	180.
44.8	45.5	1244	230	380	0.76	67.1	93.2	71.9	214.
42.3	43.3	1575	247	400	0.78	75.3	93.2	80.8	230.
39.7	40.4	1993	265	423	0.79	82.4	93.2	88.4	246.
35.7	37.8	2257	279	439	0.80	83.4	93.2	89.5	259.
32.6	35.2	2434	285	449	0.80	33.6	93.2	89.9	265.
29.5	32.6	2668	290	452	0.81	81.6	93.2	87.6	270.
26.5	30.0	2863	290	455	0.80	80.8	93.2	86.7	270.
23.4	27.4	3042	292	456	0.80	77.6	93.2	83.3	272.
20.4	24.7	3202	290	456	0.80	74.4	93.2	79.8	270
17.3	22.1	3360	288	451	0.80	70.2	93.2	75.4	268.
14.6	19.6	3453	284	445	0.80	65.1	93.2	69.9	264.
11.2	15.5	3560	273	438	0.80	57.8	93.2	62.1	253.
8.12	13.7	3636	269	426	0.79	50.6	93.1	54.3	250.
5.57	11.2	3645	259	414	0.79	43.0	93.2	46.2	241.



Impeller size: 615 mm

000023

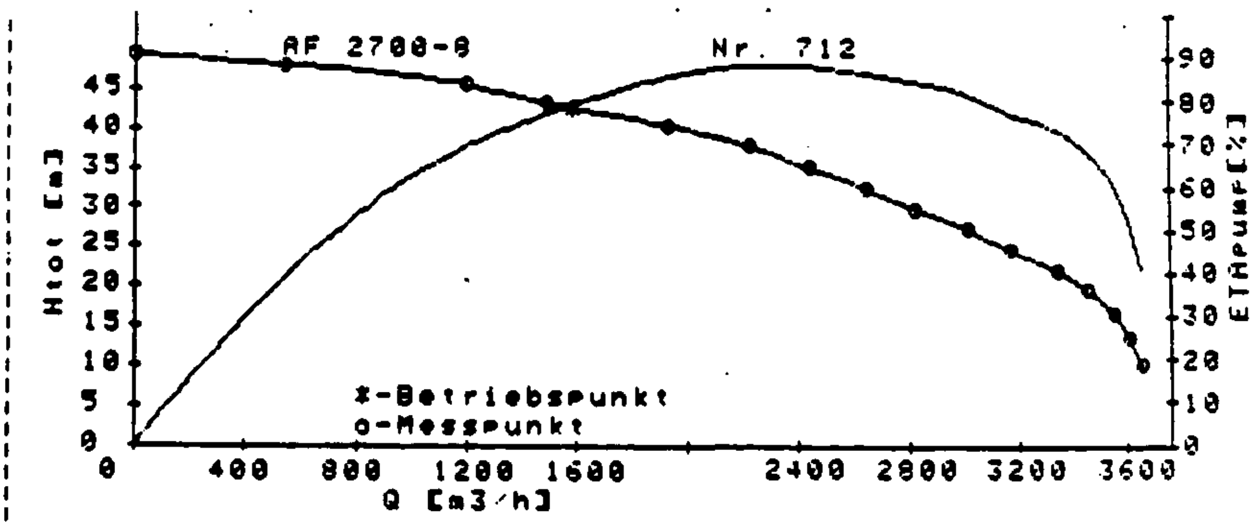
ABS Pumpen AG

Testdepartment

ELECTRICAL & HYDRAULICAL TESTS

663 651	AF 2700 - 8	712	G4/M6	Blönigen	22.05.85	12
Order-No.	Type	Serial-No.	OP-No.	Tested by	Date	Page

H [m]	Htot [m]	Q [m3/h]	P1 [kW]	I [A]	cos φ	η ges [%]	η mot [%]	η pump [%]	P2 [kW]
49.4	49.4	0	180	329	0.69	0	92.9	0	167.
47.9	48.0	542	197	348	0.71	36.0	93.1	38.7	183.
44.9	45.5	1201	230	384	0.75	64.7	93.2	69.4	214.
42.3	43.2	1490	245	400	0.77	71.6	93.2	76.9	228.
38.7	40.3	1939	267	429	0.78	79.8	93.1	85.6	240.
35.7	37.8	2222	278	444	0.79	82.2	93.2	88.3	258.
32.6	35.1	2442	285	451	0.79	82.0	93.2	88.0	265.
29.5	32.5	2645	291	458	0.80	80.5	93.2	86.4	271.
26.5	29.9	2824	292	460	0.80	78.7	93.2	84.4	272.
23.4	27.3	3020	296	463	0.80	75.9	93.2	81.4	275.
20.4	24.6	3168	296	464	0.80	71.8	93.2	77.0	275.
17.3	22.0	3343	294	461	0.80	68.3	93.2	73.3	274.
14.6	19.6	3452	290	457	0.80	63.6	93.2	68.3	270.
11.2	16.5	3549	283	448	0.79	56.5	93.2	60.6	263.
3.12	13.6	3605	276	438	0.79	48.6	93.1	52.1	257.
4.55	10.2	3650	260	420	0.79	39.1	93.2	41.9	242.



Impeller size: 615 mm 000021

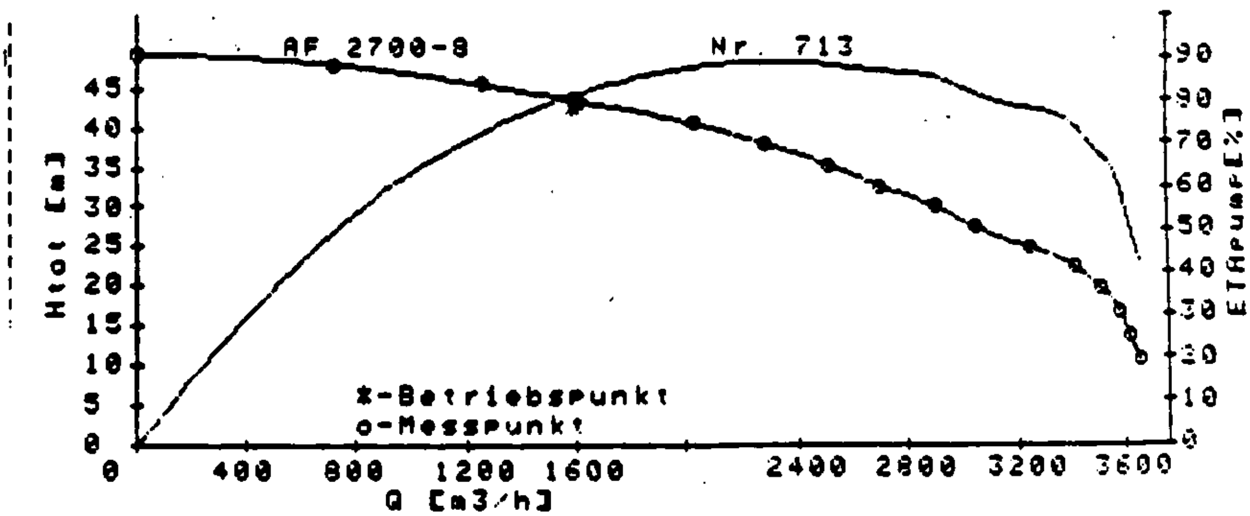
ABS Pumpen AG

Testdepartment

ELECTRICAL & HYDRAULICAL TESTS

683 851	AF 2700 - 8	713	G5/M7	Blönigen	29.05.85	12
Order-No	Type	Serial-No.	OP-No.	Tested by	Date	Page

H [m]	Htot [m]	Q [m3/h]	P1 [kW]	I [A]	cos φ	η ges [%]	η mot [%]	η pump [%]	P2 [kW]
49.4	49.4	0	180	330	0.68	0	92.9	0	167.
47.9	48.1	715	204	354	0.72	46.0	93.1	49.4	189.
44.8	45.5	1256	231	385	0.75	67.4	93.2	72.3	215.
42.3	43.4	1615	251	410	0.77	76.1	93.2	81.6	233.
38.7	40.5	2030	274	434	0.79	81.7	93.1	87.7	255.
35.7	37.9	2290	285	450	0.79	83.0	93.2	89.0	265.
32.6	35.3	2520	294	459	0.81	82.4	93.2	88.4	274.
29.5	32.6	2705	297	465	0.80	81.0	93.2	86.9	276.
26.5	30.1	2900	298	468	0.80	79.7	93.2	85.5	277.
23.4	27.4	3050	299	468	0.80	76.1	93.3	81.6	278.
20.4	24.8	3250	302	471	0.80	72.9	93.3	78.1	281.
17.3	22.3	3420	301	471	0.80	68.9	93.3	73.9	290.
14.6	19.8	3510	300	466	0.81	63.1	93.3	67.6	279.
11.2	16.6	3585	290	455	0.80	56.1	93.2	60.1	270.
8.12	13.7	3620	290	444	0.79	48.2	93.2	51.8	260.
5.06	10.7	3655	266	425	0.79	40.2	93.2	43.2	247.



Impeller size: 615 mm 000025

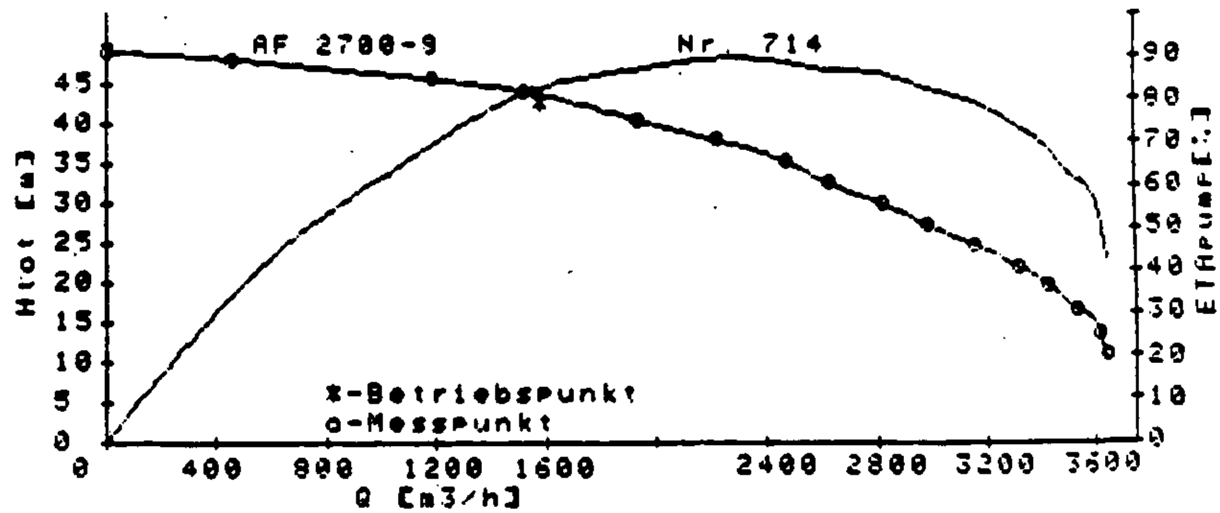
ABS Pumpen AG

Testdepartment

ELECTRICAL & HYDRAULICAL TESTS

Order-No.	Type	Serial-No.	OP-No.	Tested by	Date	Page
663 851	AF 2700 - 8	714	G8/M8	Bonn	29.05.85	12

H [m]	Htot [m]	Q [m3/h]	P1 [kW]	I [A]	cos φ	η ges [%]	η mot [%]	η pump [%]	P2 [kW]
49.0	49.0	0	180	325	0.70	0	92.9	0	167
47.9	48.0	460	190	334	0.71	31.7	93.0	34.0	176
44.8	45.4	1185	228	377	0.76	64.3	93.2	69.0	212.
42.9	43.9	1530	242	398	0.76	75.6	93.2	81.1	225
38.7	40.3	1940	264	420	0.79	80.7	93.2	86.7	245
35.7	37.8	2220	275	437	0.79	83.0	93.1	89.2	256
32.6	35.2	2470	288	447	0.81	82.2	93.2	88.3	268.
29.5	32.5	2625	288	450	0.80	80.6	93.2	86.5	268
26.5	29.9	2820	288	450	0.80	79.7	93.2	85.5	268.
23.4	27.2	2981	288	451	0.80	76.7	93.2	82.3	269.
20.4	24.6	3160	289	452	0.80	73.6	93.2	78.9	268
17.3	22.0	3320	290	452	0.81	68.6	93.2	73.6	270.
14.6	19.6	3432	288	451	0.80	63.5	93.2	68.1	269
11.2	16.5	3540	280	440	0.80	56.9	93.2	61.0	260.
8.12	13.7	3620	273	430	0.80	49.5	93.1	53.1	254.
5.06	10.7	3647	260	415	0.79	40.9	93.2	43.9	242.



Impeller size: 615 mm

000026

APPENDIX IX

BOOSTER PUMP PERFORMANCE DATA

- o Vendor Data
- o Head Curve

100C

FAIRBANKS, MORSE & CO.
POMONA WORKS

PUMP TEST REPORT

P.O. No. ______ Test No. 6739

Test of One Stage 28"XHC Fig.6927 Pump

Tested by A.U. Date 8/2/63 19__

Job Name E.I. DuPont S.O. No. P2F1490

Size Column [redacted] Type Head [redacted] Fab.

Size Discharge Line [redacted] O.D.

Dynam Const. Vertical 3200 Motor 260 H.P.

715 R.P.M. Style ______ Serial ______

Motor Efficiency ______ Meter Const ______

Impeller No. ______ No. Vanes ______ Length ______

D = 21¼" ______ Remarks: ______

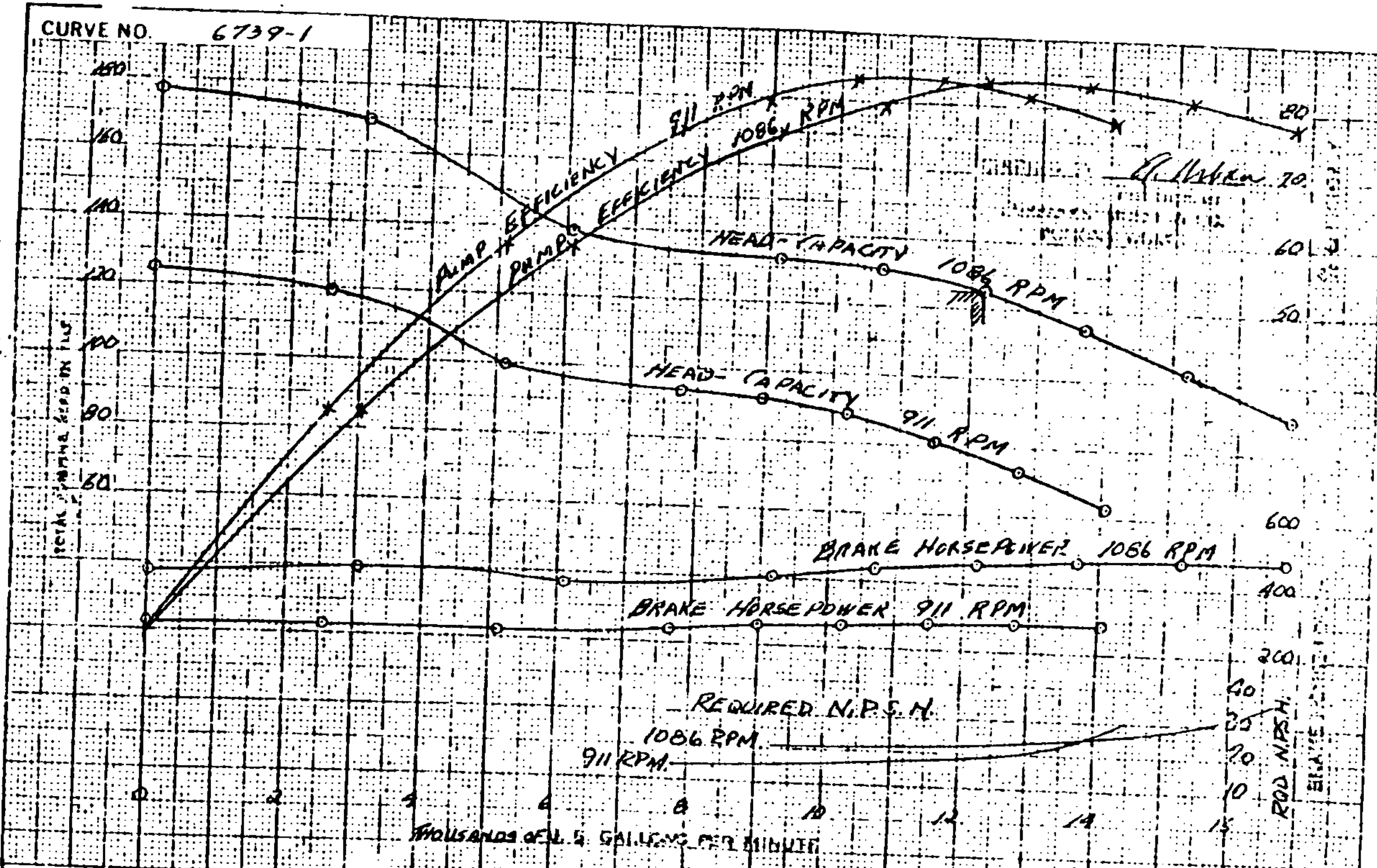
Part Symbols: Impeller T5NA 268F-B1 Disch. Bl. ______

Inter. Bl. ______ Suct. Bl. ______

Computed by ______ Date ______ OK by ______ Date ______

Reading Number		+ Hg. Col. Ft. H_2O	− Hg. Pot Ft. H_2O	+ H_v	H_2O Tank + Lift 2.1	Total Head Feet H	13 x 26 Venturi Meter GPM	Water H.P. WHP	Scale Reading Lbs. S	R.P.M. of Dynam Motor M	Brake H.P. BHP	Pump Efficiency %		F Scale	R
1		79.40	6.9	-	4.0	76.50	0		482.9	713	107.6	-		479.0	486
2		76.20	6.9	-	4.0	73.30	2000		508.3	713	113.2	32.7		504.6	512
3		63.15	6.9	0.13	3.8	60.18	4000		473.7	713	105.5	57.6		470.4	477
4		60.25	7.0	0.30	3.8	57.35	6000		519.3	714	115.7	75.1		516.0	522
5		59.20	7.0	0.41	3.8	56.41	7000		562.1	713	125.2	79.6		559.2	565
6		56.75	7.0	0.54	3.8	54.09	8000		588.5	713	131.1	83.4		585.8	591
7		52.30	7.0	0.68	3.7	49.68	9000		606.5	713	135.2	83.5		603.4	609
8		47.00	7.1	0.84	3.6	44.34	10000		618.9	712	137.7	81.4		616.6	621
9		41.50	7.1	1.00	3.5	38.90	11000		624.4	712	138.8	78.0		621.8	627
10					PREDICTED PERFORMANCE AT 1086 RPM							1900 RPM Diesel			
11						177.5	0			1086	379.8	-			
12						170.0	3044			1086	400.0	32.7			
13						139.7	6030			1086	372.4	57.6			
14						133.0	9140			1086	408.5	75.1			
15						130.8	10670			1086	442.0	79.6			
16						125.5	12180			1086	463.0	83.4			
17						115.2	13700			1086	477.5	83.5			
18						[illegible]3.0	15230			1086	487.0	81.4			
19						90.3	16770			1086	491.0	78.0			
20					PREDICTED PERFORMANCE AT 911 RPM									1600 RPM Diesel	
21						125.0	0			911	224.3	-			
22						119.7	2558			911	236.3	32.7			
23						98.4	5110			911	220.2	57.6			
24						93.[illegible]	7670			911	241.5	75.1			
25						92.2	8960			911	261.6	79.6			
26						88.5	10220			911	273.7	83.4			
27						81.2	11500			911	282.0	83.5			
28						72.6	12790			911	287.8	81.4			
29						63.6	14070			911	290.3	78.0			

CURVE NO. 6739-1



The pump is guaranteed for the set of conditions specified; other points on the curve are approximate. The FIELD PERFORMANCE shown makes allowances for hydraulic and mechanical loss in new column, shaft and discharge elbow or head as specified in the title block. Capacity, head and efficiency guarantees are contingent on the pump being furnished with the specified amount of clear, fresh, non-aerated water at a temperature not to exceed 85 degrees Fahrenheit.

8-6-63

FAIRBANKS, MORSE & CO.

POMONA WORKS

POMONA • CALIFORNIA

PHILADELPHIA 915-1AGC25

FIELD PERFORMANCE

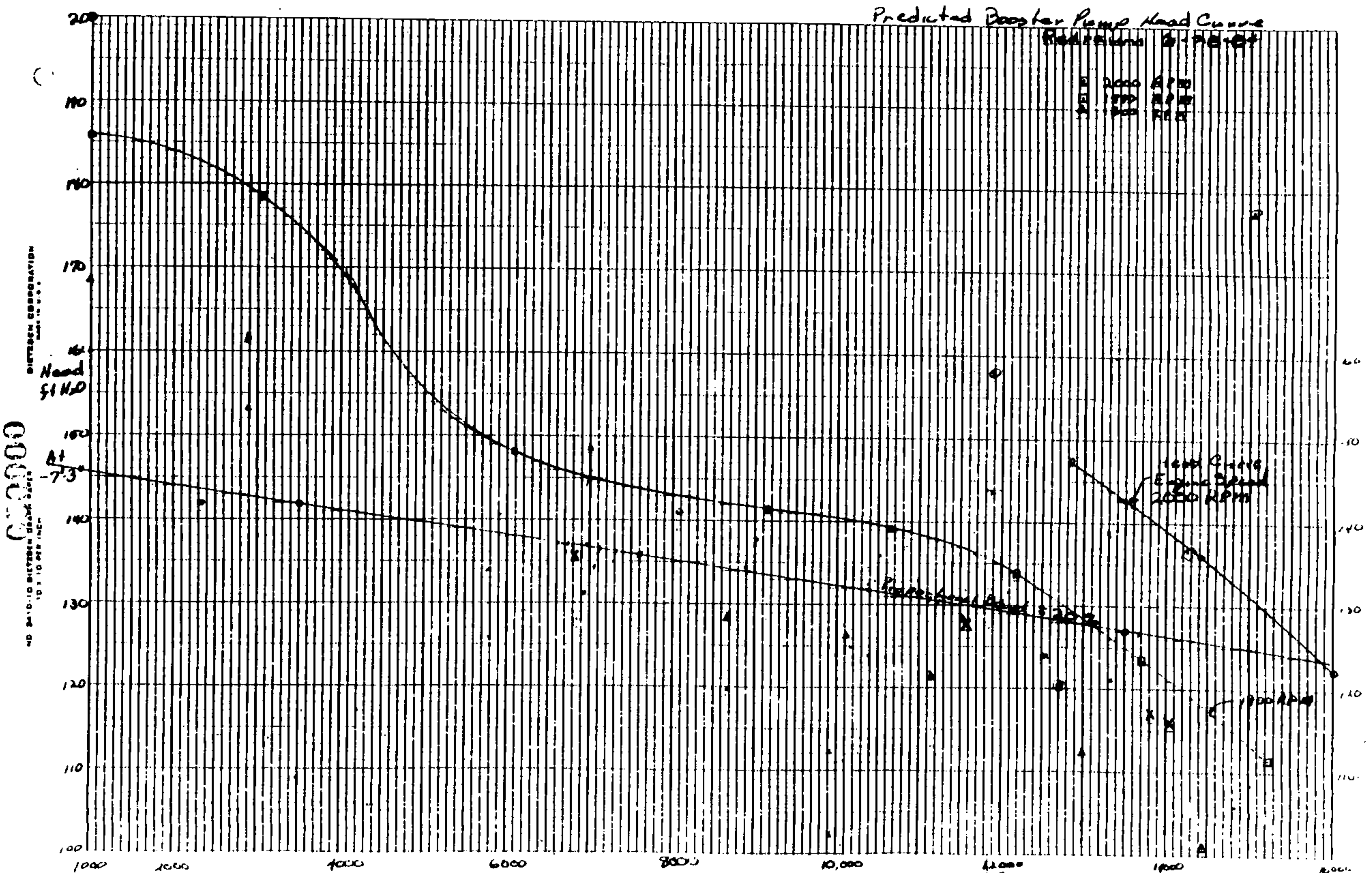
ONE Stage 28" XHC Fig. 6927

Pump operated at 1036 & 911 RPM with

[redacted] Discharge & 5 Ft. of [redacted] Col. & Sh.

E.I. DuPont de Nemours ARF 1430

Appendix IX


Predicted Booster Pump Head Curve
2000 RPM
Head ft H2O
Δt -7.3°
1000
4000
6000
8000
10,000
12,000
14000
16000
1900 RPM
2000 RPM

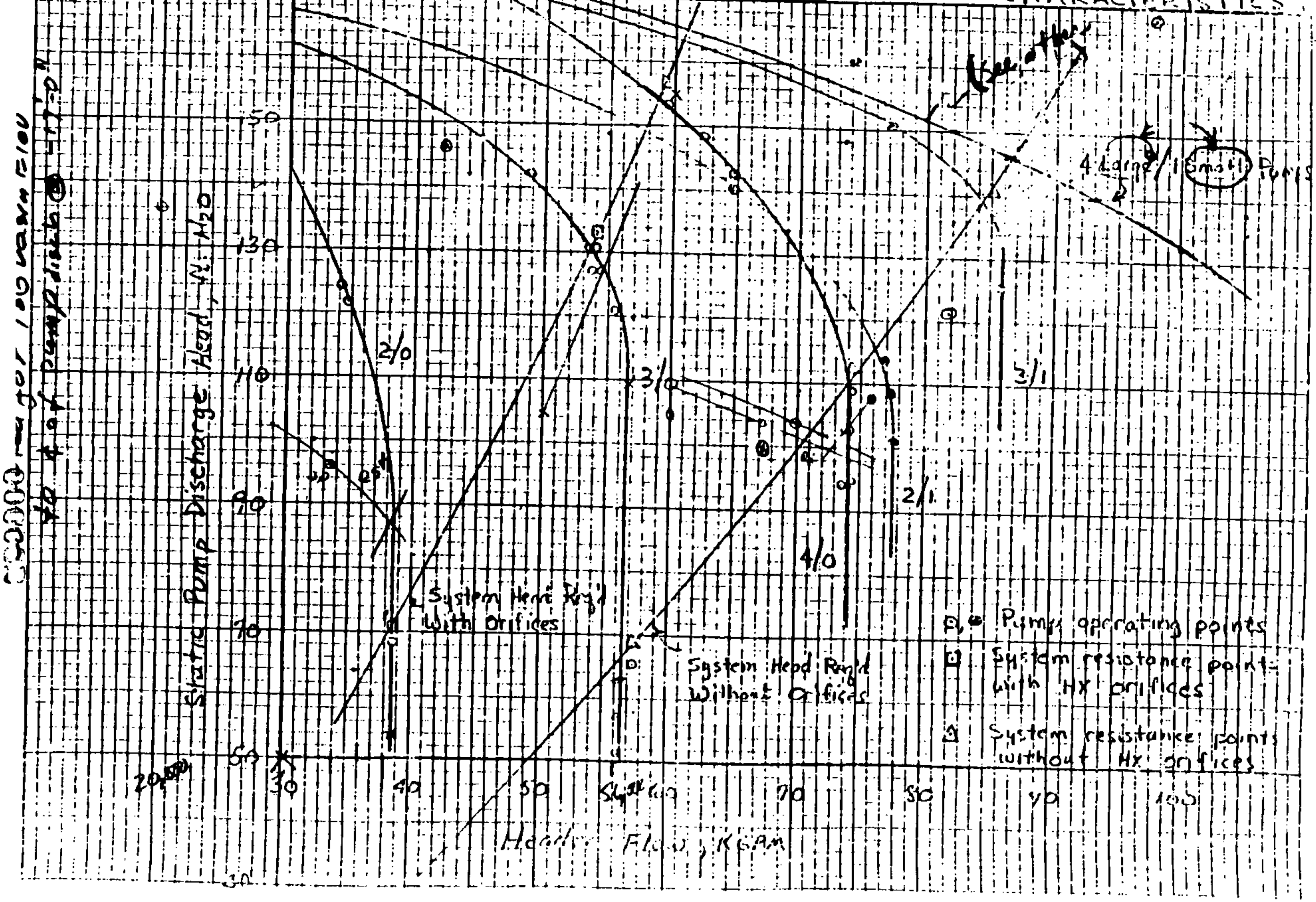
APPENDIX X

190 BUILDING COOLING WATER PUMPS

o Head Curves

Appendix X

FIGURE 2 B HEADER OPERATING CHARACTERISTICS

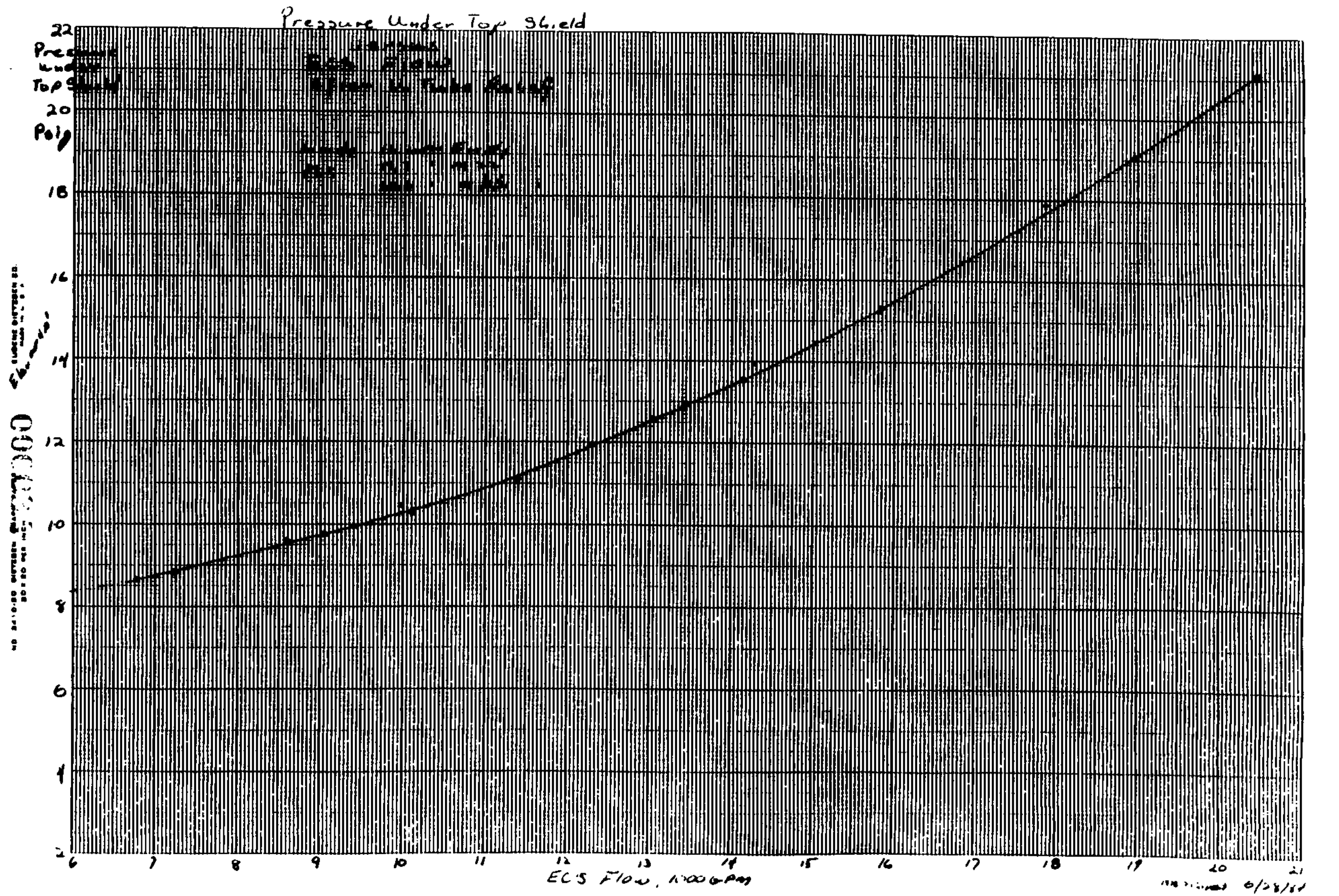


APPENDIX XI

REACTOR PRESSURE RELIEF

- Pressure Under Top Shield Data

A pendix XI



Pressure Under Top Shield
Pressure Under Top Shield Psi
ECS Flow, 1000 GPM
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
2 4 6 8 10 12 14 16 18 20 22

APPENDIX XII

REACTOR AREA ELEVATIONS

ELEVATIONS*

	P	L	K	C
o 186 Basin				
- Wall	323.75	257.75	277.75	293.75
- Weir	322.21	256.21	276.21	292.21
- Nom. Floor	304.50	238.50	258.50	274.50
o PS Well				
- Nom. Floor	304.00	238.0	258.00	274.00
- Bottom	299.00	233.0	253.00	269.00
o 190 Bldg.				
- Floor	303.50	237.50	257.50	273.50
o 105 Bldg.				
- 0' Elev.	316.67	250.67	270.67	286.67
o 107 Bldg.				
- Entr. Pipes	291.00	225.75	245.74	261.75
- Floor	288.00	222.0	242.00	258.00
- Weir 0 gpm	301.00	235.0	255.00	271.00
25kgpm	301.75	235.75	255.75	271.75
100kgpm	303.00	237.0	257.00	273.00

* Elevations above sea level, feet

Xmitter Instruments	P	L	K	C
[redacted]				
X-tie				
[redacted]				
BP				
PS Well Level (Cont. Console)				
Bottom of Top Shield				

(1) W234749
(2) W234684
(3) W138460

APPENDIX XIII

CALCULATION OF "K" COEFFICIENTS FOR EACH PIPING COMPONENT

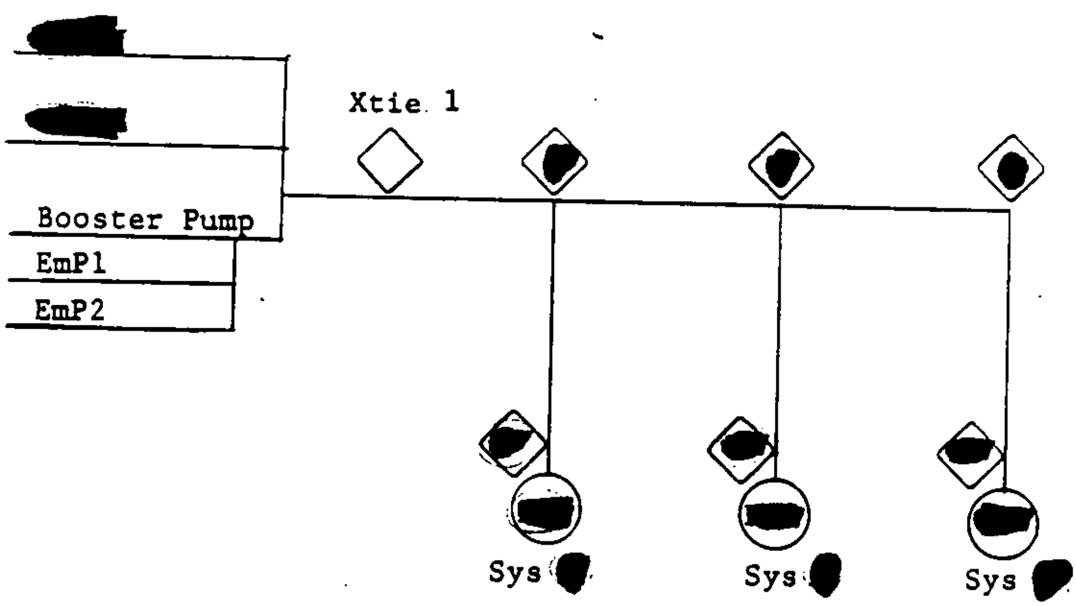
"K" is defined below.

$$H = K\left(\frac{Q}{1000}\right)^2$$

H = piping pressure loss, feet of H_2O
Q = piping flow, gpm

The following "K" coefficients were calculated. Refer to the sketch (Figure 1) to determine piping configuration.

FIGURE 1



DELETED VERSION

[redacted]

[redacted] Press Psig	Xtie[1] Press Psig	Elev[1] Corr ft.	Vel[2] Corr ft.	Flow gpm	K[3]
44.8	28.35	-1.833	3.966	13550	0.2377
52.8	49.4	-1.833	0.808	6155	0.2797
49.0	38.3	-1.833	2.547	10860	0.2458
45.85	28.4	-1.833	4.203	13950	0.2372
				Avg.	0.2501

[redacted]

[redacted] Press Psig	Xtie[1] Press Psig	Elev[1] Corr ft.	Vel[2] Corr ft.	Flow gpm	K[3]
44.67	32.9	-1.833	4.161	13879	0.1716
50.8	48.7	-1.833	0.865	6330	0.1879
47.7	40.6	-1.833	2.623	11020	0.1712
5.3	32.4	-1.833	4.510	14450	0.1725
				Avg.	0.1758

1 Elev Corr [redacted] at 17'-4" Xtie; at -19'2"

2 Vel Corr $H = 0.0216 \left(\frac{Q}{1000}\right)^2$

3 $K = \frac{H}{(Q/1000)^2}$

Booster Pump to [redacted]

BP Press Psig	Xtiel Press Psig	Elev[1] Corr ft.	Vel[2] Corr ft.	Flow gpm	K[3]
55.90	27.6	-0.417	4.122	13815	0.3649
64.0	55.6	-0.417	1.003	6815	0.4466*
60.6	40/8	-0.417	2.899	11585	0.3640
55.4	26.7	-0.417	4.264	14050	0.3581
				Avg	0.3623

1 BP gage elevation at -18'9", Xtie gage at -19'-2"

2 Vel corr $H = 0.0216\ (Q/1000)^2$

3 $K = H/(Q/1000)^2$

186 Basin to Booster Pump

BP Press No Flow Psig	BP Press W/ Flow Psig	Flow GPM	K
10.8	10.0	6815	0.0396
10.8	8.37	11585	0.0416
10.8	7.3	14050	0.0408
10.8	9.9	7035	0.0418
10.8	9.1	10780	0.0336
10.8	8.3	12325	0.0379
		Avg.	0.0392

* Not used in average.

DELETED VERSION

ECS Pump A to [redacted]

Pump A Press Psig	Xtiel Press Psig	Elev[1] Corr ft.	Vel[2] Corr ft.	Flow gpm	K[3]
41.64	22.3	-0.417	9.413	13465	0.3496
69.0	61.4	-0.417	3.088	7140	0.4117
52.0	37.2	-0.417	7.330	11000	0.3454
43.0	22.7	-0.417	9.717	12665	0.3543
				Avg.	0.3653

1 BP gage elevation at -18'9", Xtie gage at -19'-2"

2 Vel corr $H = 0.03898 + 0.0216\ (Q/1000)^2$

3 $K = H/(Q/1000)^2$

186 Basin to ECS Pump A

ECS Pump A No Flow Psig	ECS Pump A W/ Flow Psig	Flow GPM	K
10.76	2.40	12465	0.1238
12.00	11.00	7140	0.0451
12.00	8.5	11000	0.0665
12.00	7.0	7035	0.0790
		Avg.	0.0786

ECS Pump B to [redacted]

Pump B Press Psig	Xtie[1] Press Psig	Elev[1] Corr ft.	Vel[2] Corr ft.	Flow gpm	K[3]
41.99	21.9	-0.417	9.270	12370	0.3653
50.0	35.5	-0.417	7.040	10780	0.3512
40.4	20.4	-0.417	9.202	12325	0.3662
				Avg.	0.3609

1 BP gage elevation at -18'9", Xtie gage at -19'-2"

2 Vel corr $H = 0.03898 + 0.0216\ (Q/1000)^2$

3 $K = H/(Q/1000)^2$

186 Basin to ECS Pump B

ECS Pump B Press No Flow Psig	ECS Pump B Press W/ Flow Psig	Flow GPM	K
11.05	6.35	12370	0.0663
9.8	8.8	7035	0.0465
9.8	6.0	10780	0.0752
9.8	4.3	12325	0.0833
		Avg.	0.0678

DELETED VERSION

[redacted] (100% Flow)

Xtiel Press psig	[redacted] Press psig	[redacted] Corr psig [1]	Elev Corr ft [2]	Vel Corr ft [3]	Flow GPM	K [4]
49.4	27.0	-0.5	4.0	-0.8077	6115	1.2800
48.7	25.0	-0.5	4.0	-0.8655	6330	1.2676
55.6	27.2	-0.5	4.0	-1.0032	6815	1.2740
61.4	31.5	-0.5	4.0	-1.1012	7140	1.2715
58.7	28.5	-0.5	4.0	-1.0690	7035	1.3243
65.0	34.0	-0.5	4.0	-1.1511	7300	1.2197
70.0	51.0	0.5	4.0	-0.6474	5475	1.2644
					Avg.	1.2716

[redacted](100% Flow)

Xtiel Press psig	[redacted] Press psig	[redacted] Corr psig [1]	Elev Corr ft [2]	Vel Corr ft [3]	Flow GPM	K [4]
[illegible].0	37.0	1.6	4.125	-1.2231	7525	0.9779
[illegible].0	56.0	1.6	4.125	-0.6594	5525	0.7775
73.0	65.5	1.6	4.125	-0.2917	3675	0.6777
70.0	56.0	1.6	4.125	-0.4620	4625	1.1188
					Avg.	0.8880

1 Gage zero correction

2 Xtie 1 gage at -19'-2"; [redacted] gage at -15'-2"; [redacted] gage at -15'01/2"

3 $H = -0.0216\ (Q/1000)^2$

4 $K = H/(Q/1000)^2$

DELETED VERSION

[redacted] (100% Flow)

Xtiel Press psig	[redacted] Press psig	[redacted] Corr psig [1]	Elev Corr ft [2]	Vel Corr ft [3]	Flow GPM	K [4]
65.0	31.0	1.1	3.9167	-1.3141	7800	1.1577
70.0	51.0	1.1	3.9167	-0.7141	5750	1.1052
					Avg.	1.1315

[redacted] (50/50 Split)

Xtiel Press psig	[redacted] Press psig	[redacted] Corr psig [1]	Elev Corr ft [2]	Vel Corr ft [3]	Flow GPM	K [4]
38.3	21.5	-0.5	4.0	-2.53	5305	1.1818
40.6	21.0	-0.5	4.0	-2.62	5780	1.1856
40.8	21.0	-0.5	4.0	-2.90	5810	1.1734
37.2	19.0	-0.5	4.0	-2.61	5525	1.1924
35.5	18.3	-0.5	4.0	-2.51	5400	1.1728
[illegible].2	24.3	0.5	4.0	-3.36	6250	1.1894
[illegible].5	18.1	-0.5	4.0	-2.52	5265	1.1670
46.5	23.5	-0.5	4.0	-3.48	6175	1.1610
35.5	17.7	-0.5	4.0	-2.58	5325	1.1712
44.0	22.2	-0.5	4.0	-2.09	5990	1.1956
36.5	20.5	-0.5	4.0	-2.40	5061	1.1420
37.4	20.8	-0.5	4.0	-2.40	5120	1.1684
21.5	11.5	-0.5	4.0	-1.34	3786	1.1518
21.7	11.8	-0.5	4.0	-1.33	3800	1.1281
34.5	21.25	-0.5	4.0	-2.11	4590	1.1019
26.5	16.1	-0.5	4.0	-1.56	3940	1.1086
30.25	23.1	-0.5	4.0	-1.38	3189	0.9750
22.5	16.5	-0.5	4.0	-1.03	2749	1.0083
40.5	21.2	-0.5	4.0	-2.50	5570	1.1842
23.25	11.9	-0.5	4.0	-1.39	4130	1.1470
					Avg.	1.1453

1 Gage zero correction
2 Xtie 1 gage at -19'-2"; [redacted] gage at -15'-3"; [redacted] gage at -15'-2"
3 $H = 0.0216(Q/1000)^2$
4 $K = H(Q/1000)^2$

[redacted] (50/50 Split)

Xtiel Press psig	[redacted] Press psig	Gage Corr psig	Elev Corr ft	Vel Corr ft	Flow GPM	K
46.5	21.9	1.1	3.9167	-3.49	6525	1.0955
47.2	22.2	1.1	3.9167	-3.47	6500	1.1262
35.5	16.9	1.1	3.9167	-2.52	5540	1.1017
35.5	16.5	1.1	3.9167	-2.58	5610	1.1017
					Avg.	1.1063

[redacted] (50/50 Split)

Xtiel Press psig	[redacted] Press psig	[redacted][1] Corr psig	Elev[2] Corr ft	Vel[3] Corr ft	Flow GPM	K[4]
38.3	22.8	1.6	4.125	-2.53	5555	0.8204
40.6	24.8	1.6	4.125	-2.62	5240	0.9438
40.8	21.7	1.6	4.125	-2.90	5775	0.9962
37.2	20.0	1.6	4.125	-2.61	5475	0.9723
35.5	19.0	1.6	4.125	-2.51	5380	0.9548
48.2	25.2	1.6	4.125	-3.36	6220	1.0787
47.2	26.2	1.6	4.125	-3.47	6175	0.9710
36.5	19.6	1.6	4.125	-2.40	5490	0.9511
37.4	19.7	1.6	4.125	-2.40	5430	1.0346
21.5	11.1	1.6	4.125	-1.34	4077	0.9027
21.7	11.2	1.6	4.125	-1.33	4040	0.9199
34.5	18.2	1.6	4.125	-2.11	5302	0.9809
26.5	13.8	1.6	4.125	-1.56	4550	0.9586
30.25	16.0	1.6	4.125	-1.38	4806	1.0213
22.5	11.8	1.6	4.125	-1.03	4165	0.9094
40.5	24.2	1.6	4.125	-2.50	5180	1.0131
23.25	13.5	1.6	4.125	-1.39	3890	0.8743
					Avg.	0.9590

1 Gage zero correction
2 Xtie gage of -19-2"; [redacted] gage at -15'-1/2"
3 H_z -0.0216 $(Q/1000)^2$
4 $K = H/(Q/1000)^2$

DELETED VERSION

DELETED VERSION

[redacted] (33% Split)

Xtiel Press psig	[redacted] Press psig	1 [redacted] Corr psig	2 Elev Corr ft	3 Vel Corr ft	Flow GPM	4 K
21.8	11.6	1.6	4.125	-3.348	4050	0.7503
32.5	17.5	1.6	4.125	-5.0994	5000	0.8639
32.0	17.5	1.6	4.125	-4.9381	4925	0.8496
32.2	17.5	1.6	41.25	-4.9185	4895	0.8800
34.8	10.7	1.6	4.125	-5.2701	5115	0.9156
22.3	12.1	1.6	4.125	-3.3561	4240	0.6841
22.7	12.5	1.6	4.125	-3.4647	4110	0.7217
21.9	12.0	1.6	4.125	-3.3052	4220	0.6547
20.4	11.5	1.6	4.125	-3.2812	4020	0.5807
28.35	15.8	1.6	4.125	-3.0658	4485	0.8499
28.4	15.9	1.6	4.125	-4.2034	4650	0.7743
36.5	23.5	1.6	4.125	-4.7954	4730	0.7732
37.25	21.0	1.6	4.125	-5.3922	5200	0.8941
38.9	19.3	1.6	4.125	-5.3479	5240	1.1628
35.6	19.4	1.6	4.125	-5.3378	5220	0.8850
37.9	20.8	1.6	4.125	-5.7706	5675	0.7997
41.60	26.5	1.6	4.125	-5.4298	5020	0.8530
40.7	26.5	1.6	4.125	-5.5020	5030	0.7649
[illegible].8	21.5	1.6	4.125	-5.4744	5005	1.2419
42.0	27.0	1.6	4.125	-5.6547	5090	0.8121
38.4	21.2	1.6	4.125	-5.8770	5485	0.8602
38.1	21.3	1.6	4.235	-5.8735	5460	0.8373
38.7	21.5	1.6	4.125	-6.0060	5535	0.8405
41.6	27.0	1.6	4.125	-5.6094	5075	0.7830
41.7	27.0	1.6	4.125	-5.6024	5085	0.7890
41.7	27.2	1.6	4.125	-5.6722	5105	0.7625
40.25	25.5	1.6	4.125	-5.3991	4950	0.8457
38.3	24.4	1.6	4.125	-5.0994	4790	0.8310
38.4	24.5	1.6	4.125	-5.1160	4785	0.8320
40.4	25.5	1.6	4.125	-5.4401	4945	0.8598
39.7	25.4	1.6	4.125	-5.3412	4845	0.8411
39.8	25.4	1.6	4.125	-5.3616	4910	0.8277
40.6	25.8	1.6	41.25	-5.4435	4950	0.8485
32.9	21.1	1.6	4.125	-4.1607	4410	0.7802
32.4	21.4	1.6	4.125	-4.5101	4470	0.6499
27.6	15.0	1.6	4.125	-4.1225	4500	0.8421
26.7	14.5	1.6	4.125	-4.2639	4575	0.7640
					Avg.	0.8244

DELETED VERSION

[redacted] (33% Split)

Xtiel Press psig	[redacted] Press psig	1 Gage Corr psig	2 Elev Corr ft	3 Vel Corr ft	Flow GPM	4 K
21.8	11.0	0.5	4.0	-3.348	41.50	0.9489
32.5	16.8	0.5	4.0	-5.0994	5140	0.9788
32.0	17.0	0.5	4.0	-4.9381	5045	0.9591
32.2	16.9	0.5	4.0	-4.9185	5025	0.9949
34.8	18.0	0.5	4.0	-5.2701	5175	1.0537
22.3	11.7	0.5	4.0	-3.3561	4155	0.9195
22.7	12.0	0.5	4.0	-3.4647	4265	0.8793
21.9	11.4	0.5	4.0	-3.3052	4110	0.9291
20.4	11.1	0.5	4.0	-3.2812	4120	0.7634
28.35	16.5	0.5	4.0	-3.9658	4365	0.9520
28.4	16.7	0.5	4.0	-4.2034	4485	0.8728
36.5	21.2	0.5	4.0	-4.7854	5110	0.9668
37.25	21.7	0.5	4.0	-5.3922	5100	0.9697
38.9	20.6	0.5	4.0	-5.3479	5020	1.2536
35.6	20.5	0.5	4.0	-5.3379	5020	0.9620
37.9	22.0	0.5	4.0	-5.7706	5200	0.9486
41.60	23.8	0.5	4.0	-5.4298	5475	1.0128
40.7	23.5	0.5	4.0	-5.5020	5550	0.9385
0.8	23.7	0.5	4.0	-5.4744	5555	0.9302
42.0	24.4	0.5	4.0	-5.6547	5635	0.9346
38.4	22.2	0.5	4.0	-5.8770	5320	0.9269
38.1	22.3	0.5	4.0	-5.8735	5325	0.8928
38.7	22.5	0.5	4.0	-6.0060	5390	0.8985
41.6	24.0	0.5	4.0	-5.6094	5615	0.9427
41.7	24.2	0.5	4.0	-5.6024	5595	0.9423
41.7	24.3	0.5	4.0	-5.6722	5655	0.9130
40.25	21.5	0.5	4.0	-5.3991	5600	1.0388
38.3	20.4	0.5	4.0	-5.0994	5475	1.3476
38.4	20.3	0.5	4.0	-5.1160	5475	1.0463
40.4	21.6	0.5	4.0	-5.4401	5655	1.0210
39.7	22.2	0.5	4.0	-5.3412	5610	0.9456
39.8	21.1	0.5	4.0	-5.3616	5610	1.0326
40.6	21.6	0.5	4.0	-5.4435	2645	1.3511
32.9	19.4	0.5	4.0	-4.1607	4737	0.9688
32.4	17.5	0.5	4.0	-4.5101	5210	0.9066
27.6	14.4	0.5	4.0	-4.1225	4590	1.0009
26.7	14.0	0.5	4.0	-4.2639	4700	0.8962
					Avg.	0.9795

DELETED VERSION

DELETED VERSION

[redacted] (33% Split)

Xtiel Press psig	[redacted] Press psig	1 Gage Corr psig	2 Elev Corr ft	3 Vel Corr ft	Flow GPM	4 K
21.8	10.2	1.1	3.9167	-3.348	4250	0.9348
32.5	15.0	1.1	3.9167	-5.0994	5225	0.8408
32.0	15.3	1.1	3.9167	-4.9381	5150	1.0190
32.2	15.1	1.1	3.9167	-4.9185	5170	1.0462
34.8	16.1	1.1	3.9167	-5.2701	5330	1.1015
22.3	10.7	1.1	3.9167	-3.3561	4070	1.0189
22.7	10.7	1.1	3.9167	-3.4647	4290	0.9611
21.9	10.5	1.1	3.9167	-3.3052	4040	1.0090
20.4	9.5	1.1	3.9167	-3.2812	4185	0.8760
28.35	14.1	1.1	3.9167	-3.9658	4700	1.0123
28.4	13.5	1.1	3.9167	-4.2034	4815	1.0188
36.5	21.0	1.1	3.9167	-4.7954	5060	0.9533
37.25	18.2	1.1	3.9167	-5.3922	5500	1.0571
38.9	17.2	1.1	3.9167	-5.3479	5475	1.2715
35.6	16.9	1.1	3.9167	-5.3378	5480	1.0398
37.9	18.0	1.1	3.9167	-5.7706	5470	1.1214
41.60	23.5	1.1	3.9167	-5.4298	5360	1.0356
40.7	22.8	1.1	3.9167	-5.5020	5380	1.0096
0.8	22.6	1.1	3.9167	-5.4744	5360	1.0421
2.0	23.4	1.1	3.9167	-5.6547	5455	1.0310
38.4	18.0	1.1	3.9167	-5.8770	5690	1.0686
38.1	18.0	1.1	3.9167	-5.8735	5705	1.0419
38.7	18.2	1.1	3.9167	-6.0060	5750	1.0661
41.6	23.0	1.1	3.9167	-5.6094	5425	1.0439
41.7	23.1	1.1	3.9167	-5.6024	5425	1.0442
41.7	23.3	1.1	3.9167	-5.6722	5445	1.0187
40.25	22.4	1.1	3.9167	-5.3991	5260	1.0557
38.3	21.5	1.1	3.9167	-5.0994	5100	1.0417
38.4	21.7	1.1	3.9167	-5.1160	5130	1.0202
40.4	22.7	1.1	3.9167	-5.4401	5270	1.0378
39.7	22.4	1.1	3.9167	-5.3412	5270	1.0083
39.8	22.4	1.1	3.9167	-5.3616	5235	1.0294
40.6	22.8	1.1	3.9167	-5.4435	5280	1.0381
32.9	18.6	1.1	3.9167	-4.1607	4732	0.9951
32.4	18.3	1.1	3.9167	-4.5101	4770	0.9438
27.6	13.2	1.1	3.9167	-4.1225	4725	1.0101
26.7	12.1	1.1	3.9167	-4.2639	4775	0.9828
					Avg.	1.0229

ECS Pump Fitting Coefficient (Theoretical)*

Discharge Pipe

Elbow loss (2) 0.64
Velocity at 10,000 gpm 18.15 ft/sec

Suction Pipe

Elbow loss (2) 0.30
Velocity at 10,000 gpm 11.54 ft/sec

$K = H/(Q/1000)^2$

$K = 0.03898$

Engineering Department Design Standards DG5B

APPENDIX XIV

TABULATION OF PREVIOUSLY CALCULATED

COEFFICIENTS FOR PIPING COMPONENTS

Theoretical "K" coefficients for plenum inlet piping*

"K" is defined below:

$K = H/(Q/1000)^2$ where

H = piping pressure loss, ft H_2O

Q Q = piping flow, gpm

	Accident Condition		
		LOCA	
System	LOPA	To Plenum	To Leak
2	0.594	0.775	0.820
4	0.572	0.756	0.801
5	0.576	0.757	0.802

"K" coefficent for reactor plenum and core

"K" = 0.0108

* Engineering Department Design Standards DG5B

Equations for 190 Pump Supply*

Building 190 to Building 105

$$H = 1.572 \times 10^{-8}(Q)^{1.9}$$

Building 105 to Building 107

$$H = 5.468 \times 10^{-8}(Q)^{1.9} \quad (P)$$
$$H = 4.908 \times 10^{-8}(Q)^{1.9} \quad (K)$$
$$H = 4.988 \times 10^{-8}(Q)^{1.9} \quad (C)$$

*Calculations by J. E. Black in 1974

APPENDIX XV

ECS FLOW CALCULATION METHODOLOGY

LOSS OF PUMPING ACCIDENT CALCULATION

Booster Pump Supply

Worst case system [redacted] supply only

		"K" (Appendix XIII & XIV)
a.	186 Basin to Booster pump	0.0392
b.	Booster pump to [redacted]	0.3623
c.	[redacted]	1.2716
d.	[redacted] to reactor plenum	0.576
e.	Fuel	0.0108
f.	Top shield	Appendix XI
g.	Elevation correction[1]	2.19

Total pressure drop from 186 basin through reactor is head required.

$$H_T = H_a + H_b + H_c + H_d + H_e + H_f + H_g$$

here $H = K(Q/1000)^2$

Total pressure drop must equal head available from booster pump (see Appendix IX).

[1] Elevation correction based on elevation used for booster pump head curve (-7'-3") and elevation of bottom of top shield (-5.06')

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Assume flow of 6850 gpm, then

$H_a = 1.84$
$H_b = 17.00$
$H_c = 59.67$
$H_d = 27.03$
$H_e = 0.51$
$H_f = 19.96$
$H_g = 2.19$

$H_T = 128.20$

Head available at 6850 gpm = 137.0 ft H_2O

Flow to reactor with booster pump supply and system [redacted] only is greater than 6850 gpm.

Loss of Coolant Accident Calculation

Booster pump supply

Worst Case

System [redacted] OFF
System [redacted] leak
System [redacted] supply

		"K" (Appendix XIII & XIV)
a.	186 Basin to booster pump	0.0392
b.	Booster pump to [redacted]	0.3623
c.	[redacted] (50%)	1.1063
d.	[redacted] to Reactor Plenum	0.756
e.	[redacted] (50%)	0.9590
f.	[redacted] to leak	0.820
g.	Elevation correction	8.45 [1]

[1] Elevation correction is based on the elevation used for the booster pump head curve (-7'-3") and the reactor plenum (+1.2')

Assume flow of 6850 gpm, then

$H_a = 1.84$
$H_b = 17.00$
$H_c = 59.67$
$H_d = 27.03$
$H_e = 0.51$
$H_f = 19.96$
$H_g = 2.19$

$H_T = 128.20$

Head available at 6850 gpm = 137.0 ft H_2O

Flow to reactor with booster pump supply and system [redacted] only is greater than 6850 gpm.

Loss of Coolant Accident Calculation

Booster pump supply

Worst Case

System [redacted] OFF
System [redacted] leak
System [redacted] supply

		"K" (Appendix XIII & XIV)
a.	186 Basin to booster pump	0.0392
b.	Booster pump to [redacted]	0.3623
c.	[redacted] (50%)	1.1063
d.	[redacted] to Reactor Plenum	0.756
e.	[redacted] (50%)	0.9590
f.	[redacted] to leak	0.820
g.	Elevation correction	8.45 [1]

[1] Elevation correction is based on the elevation used for the booster pump head curve (-7'-3") and the reactor plenum (+1.2')

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Total pressure drop from 186 basin to the reactor plenum is the head required.

$$H_T = H_a + H_b + H_c + H_d + H_g$$

Also

$$H_T = H_a + H_b + H_e + H_f + H_g$$

where $H = K(Q/1000)^2$

Total pressure drop must equal the head available from the Booster pump (see Appendix IX).

Assume Sys [redacted] flow 5800
Sys [redacted] flow 5940

$H_a = 5.40$
$H_b = 49.93$
$H_c = 37.22$
$H_d = 25.50$
$H_g = 8.45$

$H_T = 126.50$

$H_a = 5.40$
$H_b = 49.93$
$H_e = 33.84$
$H_f = 28.93$
$H_g = 8.45$

$H_T = 126.55$

Head available at 11,740 gpm = 129.7 ft. H_2O

Flow to reactor with booster pump supply and system [redacted] is greater than 5800 gpm.

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APPENDIX XVI

J. E. BLACK UNPUBLISHED REPORT

ECS TESTS IN C REACTOR, 1974

EMERGENCY COOLING SYSTEM TESTS
(ROUGH DRAFT)
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INTRODUCTION AND SUMMARY

The Emergency Cooling System (ECS) in C Area was tested in June, 1974 during the C:8.4-9.1 shutdown. These tests were part of an extensive group of tests of the cooling water system made prior to reducing cooling water flow as authorized in TA 1-1925. ESC test objectives were to:

- o define ECS flow resistances for light water addition to the reactor,
- o estimate heat exchanger cooling capacities using ECS sources and/or recirculation,
- o estimate size and potential of any possible problem of pluggage by corrosion scale in the ECS.

This report documents the evaluation of ECS flow resistance of test data given in Reference 1. Flow predictions for light water addition to the reactor core for each reactor area is given in Appendix B for the accidents described in Table B-1. The theoretical model in C Area predicts flows for the loss of circulation accident within +6% of flow predictions based on the theoretical model. A computational hydraulic resistance model for predicting flows in all three areas is given in Appendix B.

Maximum test flow was 6200 gpm, 63% of flow which could be expected for light water addition to the reactor in C Area with two operable top addition systems during a loss of circulation accident [redacted] supply). Prior to testing empirical data defined approximately 14% of the friction loss for the accident described above, currently empirical data defines 70% of the friction loss in C Area.

The most important conclusion from C Area testing is that the theoretical calculational model provides acceptable estimates of ECS flow capability.

DISCUSSION

If a large D_2O leak or loss of D_2O circulation were to occur, emergency coolant could be added to the reactor by one or more of the following light water sources:

- o Building 190 pumps (A and B cooling water headers)
- o River water pump (river water header)
- o Booster pump (186 Building via [redacted]

Water flows from these sources to a common point, the polybor header, before diverging down stream into two top addition systems and a bottom addition system. A schematic of the ECS system for light water addition in C Area is shown in Figure 1. Two top addition systems, numbers [redacted] provide for emergency coolant flow to the plenum by means of plenum inlet nozzles. A bottom addition system provides for emergency coolant flow to the number [redacted] pump suction line.

Top addition valves [redacted] are routinely tested on a biennial basis (Reference 2). Routine test data is used to verify valve nomographs used for emergency coolant flow control during a reactor incident. The bottom addition system is also routinely tested. To permit routine testing, elbows normally connecting the top addition lines to the reactor are diverted to test lines [redacted] and [redacted] (Figure 1). The bottom addition system is connected to test line [redacted] by means of a removable spool piece. Test line flow is routed to effluent headers [redacted] During routine testing, orifices installed between flange taps in test lines [redacted] and [redacted] are used to measure flow.

Calculations showed that test flow could be increased substantially if test line orifice could be removed. To measure flow after orifice removal, pressure loss vs. flow correlations were established for a section of each test line itself, (shown in Figures 2, 3, and 4). :st line sensivity to flow change is approximately six times greater than valve sensitivity. Orifice removal permitted total flows approximately 60% greater than could have been expected with orifices installed. Increased total flow provided better measurements and more closely approximated Reynolds numbers than test flows at reduced rates.

Total test flows were limited by the hydraulic resistance of the test lines; maximum test flows were approximately 6200 gpm.

Definition of friction head loses in the ECS system provided the first check of calculations for light water addition to the reactor. Testing also improved the calculational model for C and K Areas. P Area calculations for light water addition flow are confirmed to the extent C Area theoretical calculations agree closely with data based calculations.

Test data for friction head losses in the C Area ECS are categorized as follows:

o losses from each of the ECS supply source take-off points in the 105 building or the 191 Building in the case of the booster pump to the crosstie header pressure tap,

- losses from the crosstie header tap to the point of branching for top addition system number [redacted]
- losses from the branch of system number [redacted] to the point of branching for bottom addition system number [redacted]
- losses from the branch point of system number [redacted] to downstream side of valve [redacted]
- losses from the branch point of system number [redacted] to the down stream side of valve [redacted]

These losses are shown in Figure A-1.

Piping losses between the downstream side of the [redacted] valve and the plenum is not defined by test data. Losses from the gas space to vacuum breaker overflow are defined in References 3 and 4. Data was analyzed assuming that friction head losses could be represented as follows:

$$h_L = K(L/D)V^{\alpha}/2g$$

$(1.8 < \alpha < 2.0)$. The most extensive data (Figure 5) for ECS source to osstie header friction losses exist for RW-1 as a source. An exponent of $\alpha = 2$ provides good agreement for flows closest to that which could be expected during light water addition. An exponent $\alpha = 2$ also makes extrapolated losses conservative. Since piping area remains fixed, it is possible to write head loss equations in the form $h_L = K q^2$ where q is total flow in gpm between two points of interest. Equations for pressure losses are given in Table A-1.

Data for the bottom addition system have been omitted. The three inch line connecting the bottom addition represents a large hyraulic resistance; furthermore flow through the much less restrictive top addition system test piping enters the same test line as the bottom addition system. The net result if a flow split which results in nearly all of the flow going through the top addition system. Data for the bottom addition system is unreliable and inconsistent because measurable friction pressure drops at reduced flow are comparable to noise in the system. Calculations for flow in the bottom addition system are currently based on published friction factors.

C Area Data Based Head Loss Summary

[redacted] to Crosstie Header Tap

Data for head losses from [redacted] to the crosstie header tap is given in Figure 5. The graph is not approximated by a K $V^2/2g$ relationship

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for small flows. Part of the change at low flow rates can be accounted for by changes in Reynolds number over the flow range; the flow is turbulent but in the transition region for much of the flow range. Data obtained at low flow rates would have given an over conservative estimate of K. For flows approximating the lowest flow rate expected for a loss of circulation accident, the data can be represented by the equation given in Table A-1. The theoretical loss coefficent K is about 75% that actually measured.

Booster Pump to Crosstie Header Tap

The data summary for head losses from the booster pump to the crosstie header tap is given in Table A-1. The factor K given is derived using data from flows in the range that could expected for the lowest flow rate during a loss of circulation accident. Based on theoretical calculations, the estimated loss coefficient is about 78% of that measured.

[redacted] to Crosstie Header Top

Data for the head loss from [redacted] to the crosstie header tap can be represented in the form shown below:

$h_L = [K_o + K_1 B]q^2$ where (1)

K_o = friction factor between [redacted] and the crosstie header tap that is independent of velocity ratio r

K_1 = experimental coefficient to account for the loss due to stream divergence

θ = $1+Kr^2+\cos r$ form of local loss coefficient derived for a divergent stream (Reference 5).

r = V_3/V_1 = ratio of common channel velocity V_3 to velocity V_1 of divergent channel.

ϕ = angle of departure for divergent stream relative to the common channel.

θ account for momentum and velocity changes between the common and divergent channel. With a departure angle of 135°, the data from [redacted] more closely follows the model above than a simpler relationship of the form $hL-kq^2$. Instead of plotting head loss vs flow to assess the validity of the model (since θ changes the value of K), the model is used to predict the measured pressure drop for a given flow. The ratio of model prediction and the observed pressure loss gives a better estimate of the success of the model. Using both Heise gage

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and Barton gage data for flows with orificed and unorificed heat exchangers, the model predicts within ± 10% the observed loss for most of the data points (Figure 6). For the smallest flows which could be expected during a loss of circulation accident with orificed heat exchangers the theoretical model predicts a K about 57% of the measured K.

[redacted] to Crosstie Header Tap

Data for the head loss from [redacted] was analyzed in a manner similar to that for [redacted] Figure 7 represents data assuming a simple $V^2/2g$ relationship. The data is roughly grouped into two bands with approximate valves of $\phi = 30$ and $\phi = 10$. Allowing for momentum and energy changes, and using more exact valves of ϕ the data is represented in Figure 1 by modelΔP ÷ predicted ΔP quotients. Most of the points fall within ± 10%, well within the accuracy of the Heise gage readings.

For the smallest flows which could be expected during a loss of circulation accident with orificed heat exchangers, the theoretical model predicts a K about 60% of the measured K.

Crosstie Header Pressure Tap to Branching Point

The friction losses from the crosstie header tap to the branching point for the first addition system is given in Table A-1. The measured loss, minor though not negligible is represented by a loss coefficient about 9% less than a theoretical estimate of K.

Branch Point of System No. [redacted] to the Downstream Side of [redacted]

Losses from the branch point to the upstream pressure tap for valve [redacted] (References 5 and 6) are given by the equation in Table A-1 for flow ratios $.5 < qb/qr < 1$. Data indicates that the losses are not measurably dependent on the flow split. An estimate of K based on theoretical calculation is about 88% of the measured value (Figure 8).

Test data for the maximum losses measured during testing are represented by the graph in Figure 8. During one series of tests the [redacted] valve only opened to 96%. Subsequently the limit switch was adjusted and the open valve position as indicated on the control panel returned to 100%. However there was a slight increase in valve resistance compared to previously measured values. As shown in Figure 8 the maximum open valve resistance represented by the graph is in good agreement with published loss coefficients for the valve. Valve losses account for approximately 60% of the measured losses between the branch point and the downstream side of the valve.

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Branch Point of System No. [redacted] to the Branch Point of System No. [redacted]

Due to small flows in the bottom addition system and the small resistance of the piping segment, this resistance is not defined by test data. The theoretical resistance is assumed to be an accurate as the theorectical resistance predicted for the number [redacted] system branch point to the downstram side of the valve.

No. [redacted] Branch Point to the Upstream Side of [redacted]

Data-based friction losses from the branch point to the upstream side pressure tap (Reference 7) for the [redacted] valve are graphed in Figure 8 and are given in computational form in Tables A-1 and B-1. No measurable increase in friction losses due to stream divergence at top addition system number [redacted] and the bottom addition system number [redacted] are indicated by the data. An estimate of K based on published friction factors are about 13% less than K based on data (Figure 8).

Test data for the maximum open valve loss coefficient for valve [redacted] are represented by the graph in Figure 8. The loss coefficient is in good agreement with published loss coefficients. The valve resistance during most of the testing was similar to that measured during test line calibration; valve resistance decreased during a later test series. Valve losses account for about 49% of the measured losses for ›tal loss between the number [redacted] system branch point and the downstream side of the valve.

Model Predictions for Pressure Losses Between the Crosstie Header Pressure Tap and the Downstream Side of the [redacted] Valves

As shown in Figure 1, flow from the test lines exits by means of either effluent cooling water header. The relative flow split between addition system changes depending on what the effluent header pressure difference is, for varied flow splits, the measured pressure drop from the crosstie header tap to the downstream side of the [redacted] valve changes with respect to flow through a given addition system. To represent and compare the data as measured with the model based on data, ratios of the model ΔP to the measured ΔP have been plotted for the combined losses measured during flow. Ratios given include the effect of valve resistance change. As shown in Figure 6 (c) and 6 (d) the ratios with few exceptions are within $\pm$ 5%. No observable flow dependence for the model is noted.

ECS Capabilities

ECS flow to the reactor core has been calculated for three cases:

- loss of circulation accident with two operable top addition systems. (This case defines whether operation is within Technical Standards (Reference 8)).

- worst postulated loss of circulation accident.

- worst postulated loss of coolant accident.

Data from C Area testing has been used where applicable; applicability is based on piping similarity. Flows given in Appendix B-4 are based upon the best calculational model available for the Area. K-Area flows include C Area data from the crosstie header tap to the downstream side of the [redacted] valves. Calculations based on C Area data agree within ±6% of flow estimates based on published data for fitting and piping losses. Core melting for flows can be estimated by References 10 and 11

Conclusions

The calculational model for ECS flows to the reactor core is generally confirmed; flows predicted by the model based on published pipe and fittings losses in C Area is with 6% of the flow estimates based on test data. K Area estimates include data for the portion of piping that is most restrictive for flow. P Area estimates are based on iblished loss data and should be within the general accuracy of C Area flows. Because theoretically calculated flows exceed those predicted based on the data in C Area and because theoretically calculated flows are generally less for P Area than other Areas, ECS tests in P Area have been proposed.

The theoretical model is not specifically confirmed; i.e., losses for particular fittings and types of pipe are not supported by data. In particular, losses from the ECS supply source to the crosstie header tap are consistently less than measured. Measurement of these losses in P and K Areas (and C Area when isolation valves are installed in C Area would better define those losses. Source to crosstie header tap loss are approximately an order of magnitude less than losses from the crosstie header tap to the downstream side of the [redacted] valves. For this larger resistance, the theoretical calculations are in good agreement with test data; therefore, overall flow predictions agree well with previously estimated flows.

The losses from the 190 Building to the 105 Building have been measured in C Area. This data was used in estimating losses for K and P Area even though the piping losses and the ECS take-off point is not the same among the Areas. Future tests could eliminate the

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uncertainty. Also suction losses for the booster pump and losses from the river water header to the 105 Building have not been measured but estimated. Tests to define these losses would further reduce uncertainty in estimated ECS flows.

Reference 1 recommends orificing of the ECS system when ball valves replace cameron valves in the ECS addition system. Test data strongly supports this recommendation, particularly when a prototype is tested in a single top addition system. The [redacted] Cameron valve accounts for approximately 49% of the losses between the flow split and the downstream side of the valve; [redacted] Cameron valve accounts for 60% of a comparable loss in the wear side top addition system. Installing the ball valve in a single top addition system without orificing would result in uneven flow distribution between the top addition systems and thus a less even plenum flow distribution. Flow distribution between the top and bottom addition systems for the worst postulated loss of coolant accident would be adversely affected also.

The [redacted] Cameron valve in the bottom addition system is fully ported; the ball valve itself would not change valve resistance.

Information in computational form is given for the ECS piping resistances in Appendix B.

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4. Knoebel, D. H., W. W. F Yau, and D. R. Muhlbaier, Reactor Vent Limitations for ECS Flow, DPST-74-240, February 17, 1974.

5. Ginzburg, I. P., Applied Flued Dynamics, Israel Program For Scientific Translations Ltd., IPST Cat. No. 809, 1963, 258 pp.

6. Engineering Drawing W233951

7. Engineering Drawing W234057

8. Engineering Drawing W233952

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9. "Emergency Cooling Systems", 105 Building Technical Standards, DPST-105-3.02, May 1974.

10. Joseph, J. W., and R. C. Thornberry, Analysis of the Savannah Reactor Emergency Cooling System, DPST-70-463, October 1970.

11. Jones, L. R., Reactor Emergency Cooling System Effectiveness for Current Charges, DPST-74-511, October 23, 1974.

12. Occhipinti, E. S., Emergency Cooling System Improvements, RTR-1378, February 14, 1973.

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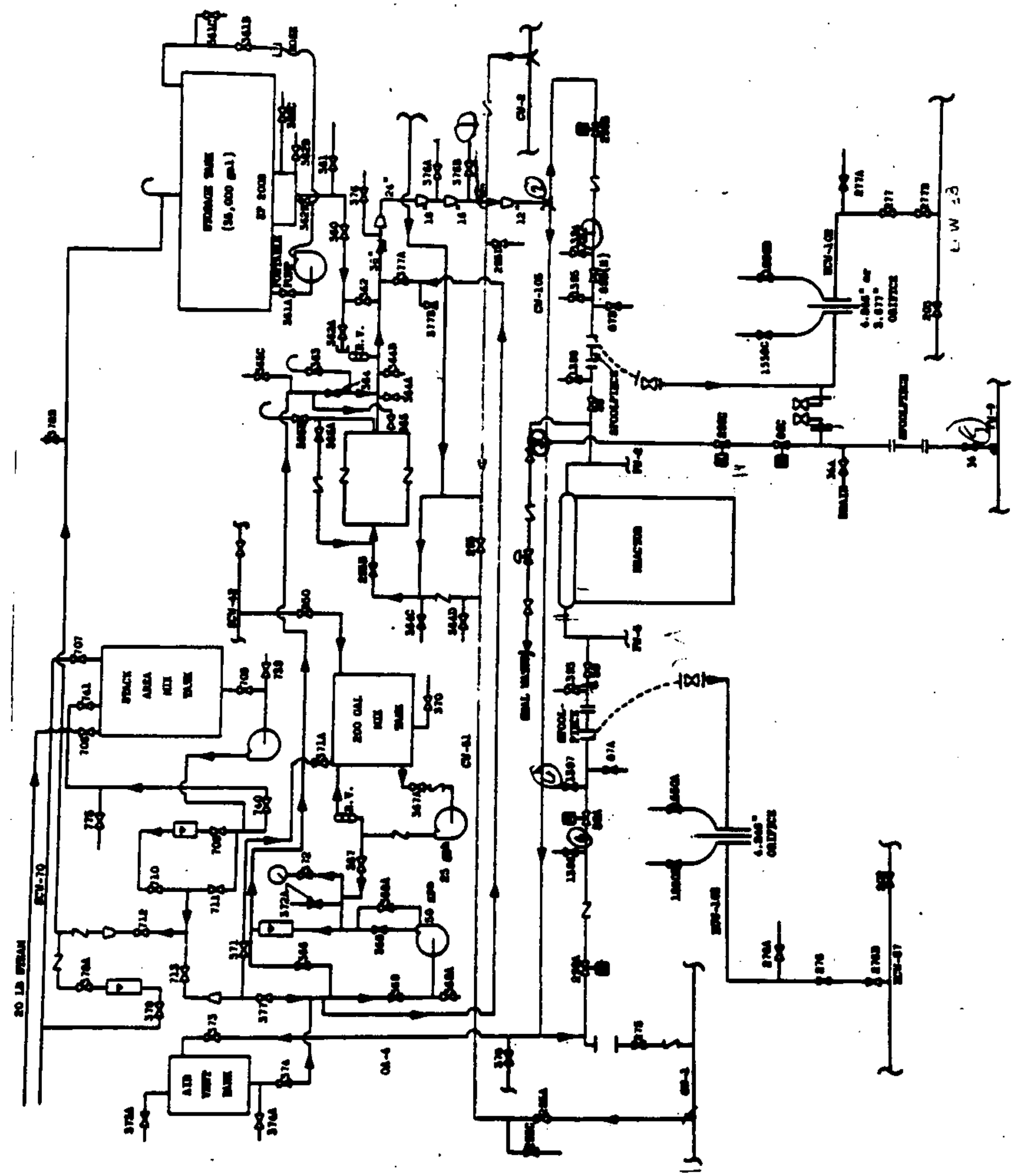
PURSUANT TO SECTION 148, ATOMIC ENERGY ACT OF 1954, AS AMENDED

AND

DEPARTMENT OF ENERGY REGULATION 10 C.F.R. 1017



20 LB STEAM
AIR VENT TANK
200 GAL MIX TANK
STACK AREA MIX TANK
REACTOR

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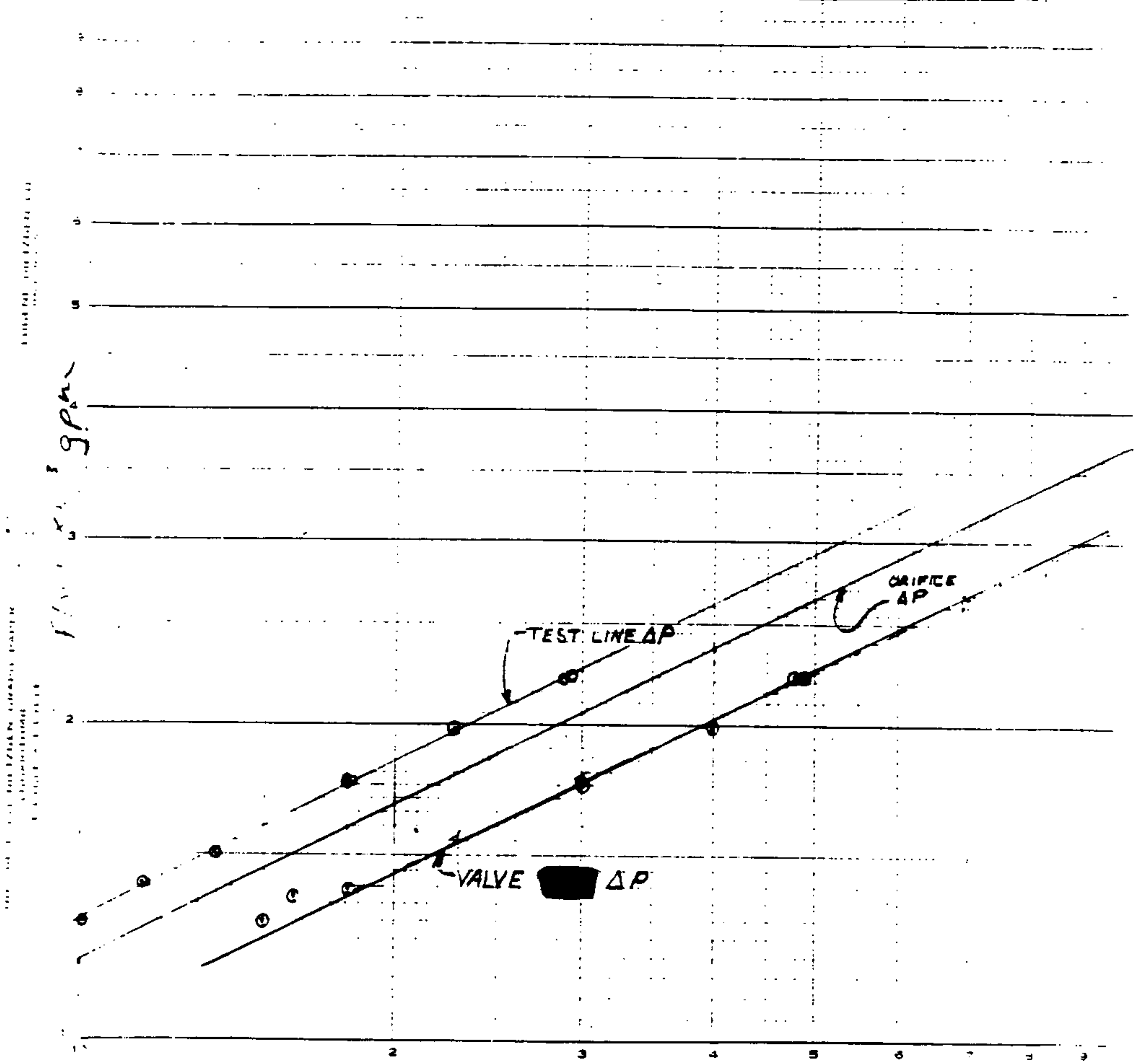
FAR SIDE TOP ADDITION SYSTEM



TEST LINE ΔP (INCHES H_2O X 100)

VALVE [redacted] ΔP (INCHES H_2O X 1..)

ORIFICE ΔP (PSI X 10)

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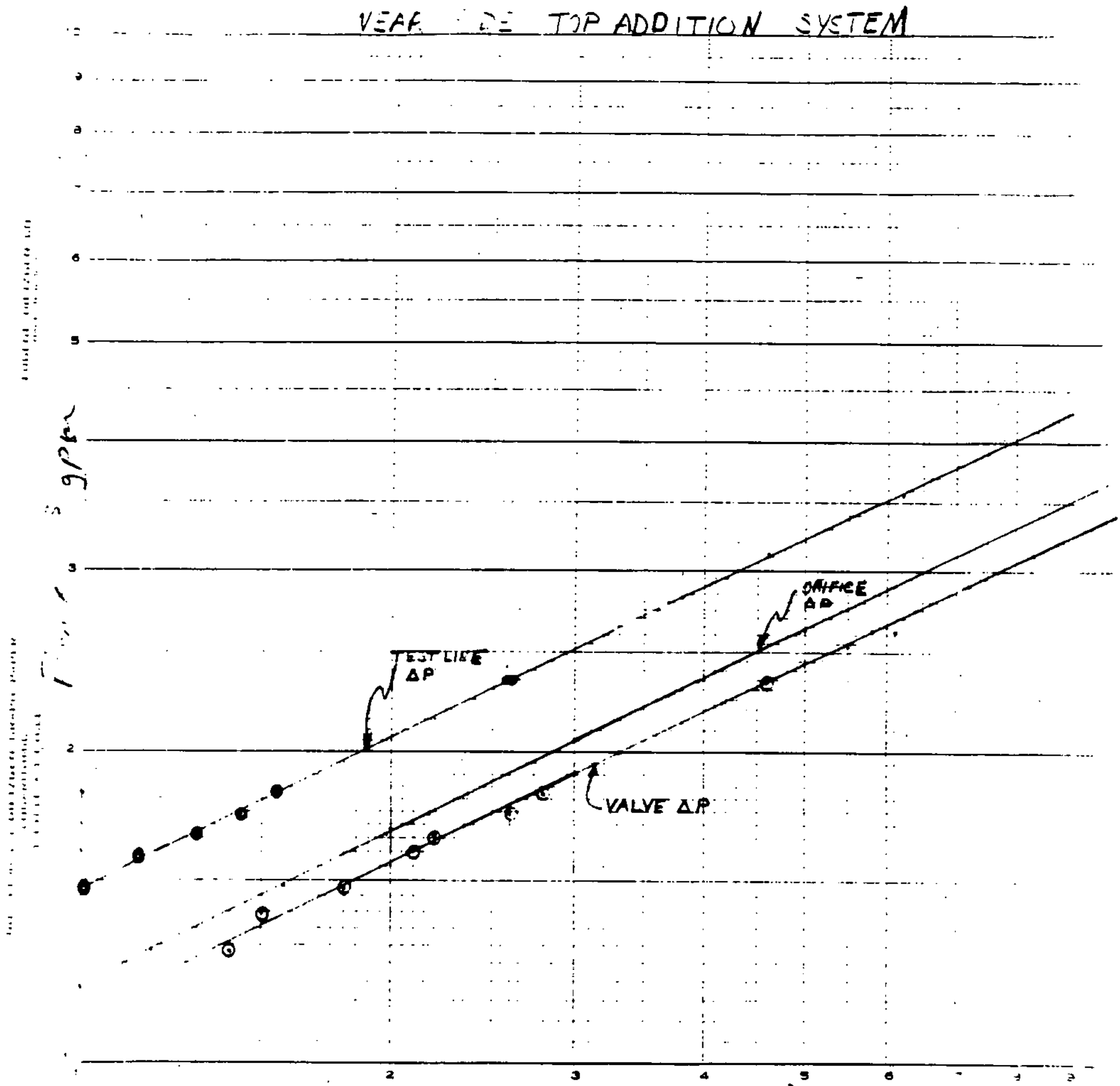
FIGURE 2

000057



TEST LINE ΔP (INCHES H_2O X 100)

VALVE [redacted] ΔP (INCHES H_2O X 10)

ORIFICE ΔP (PSI X10)

FIGURE 3

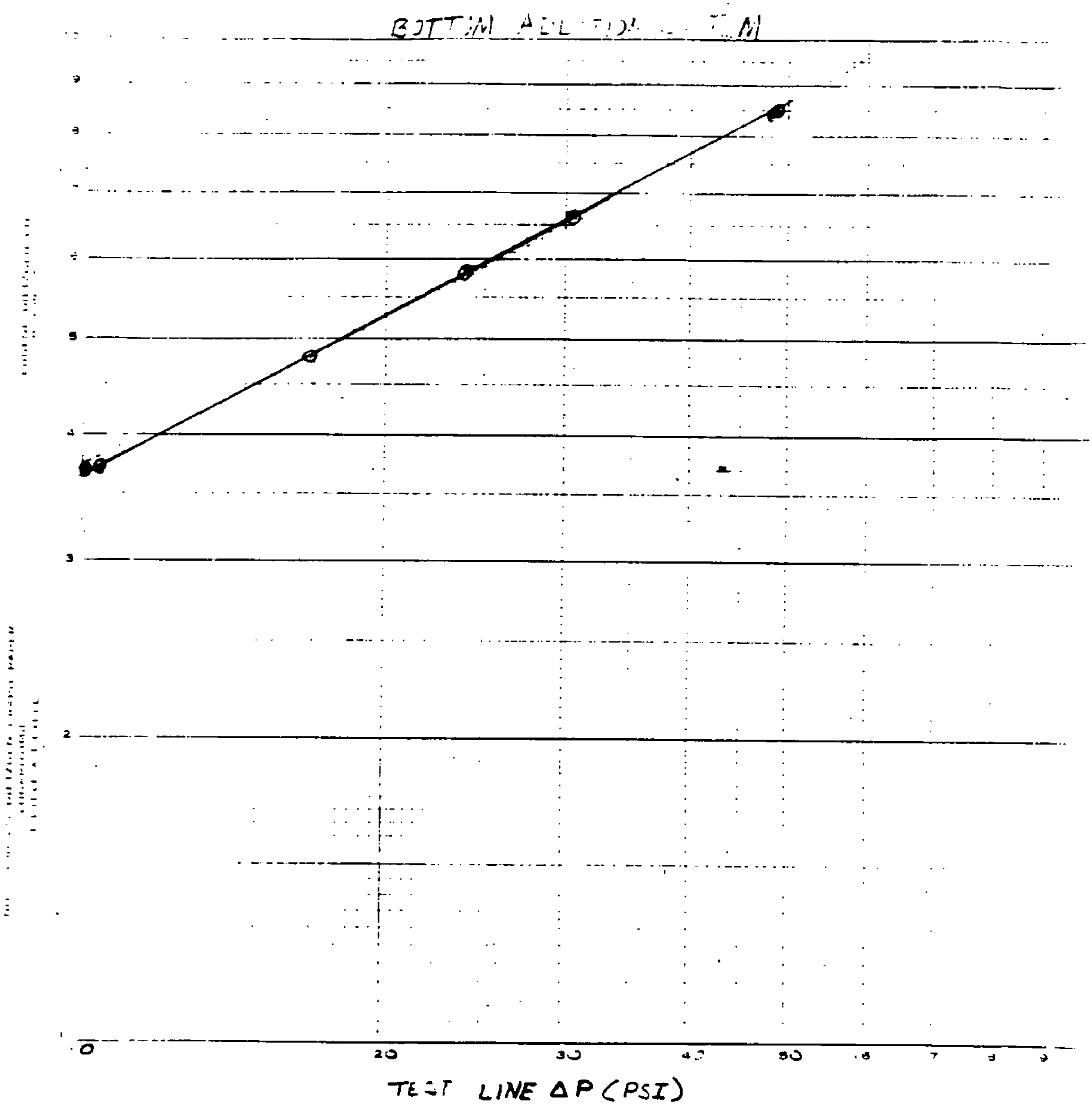


FIGURE 4

000050

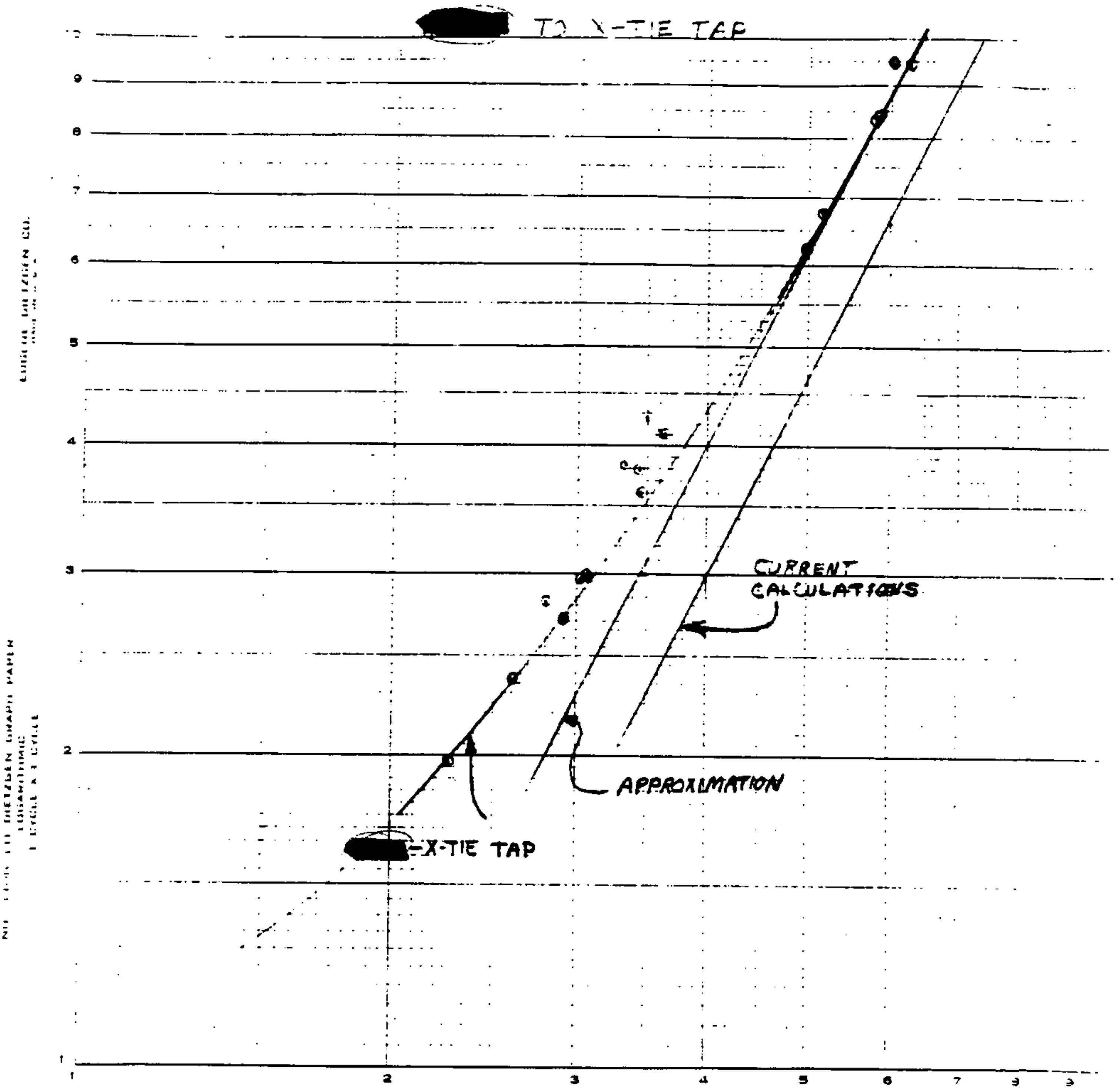

[redacted] TO X-TIE TAP
CURRENT CALCULATIONS
APPROXIMATION
[redacted]-X-TIE TAP
1
2
3
4
5
6
7
8
9

FIGURE 5

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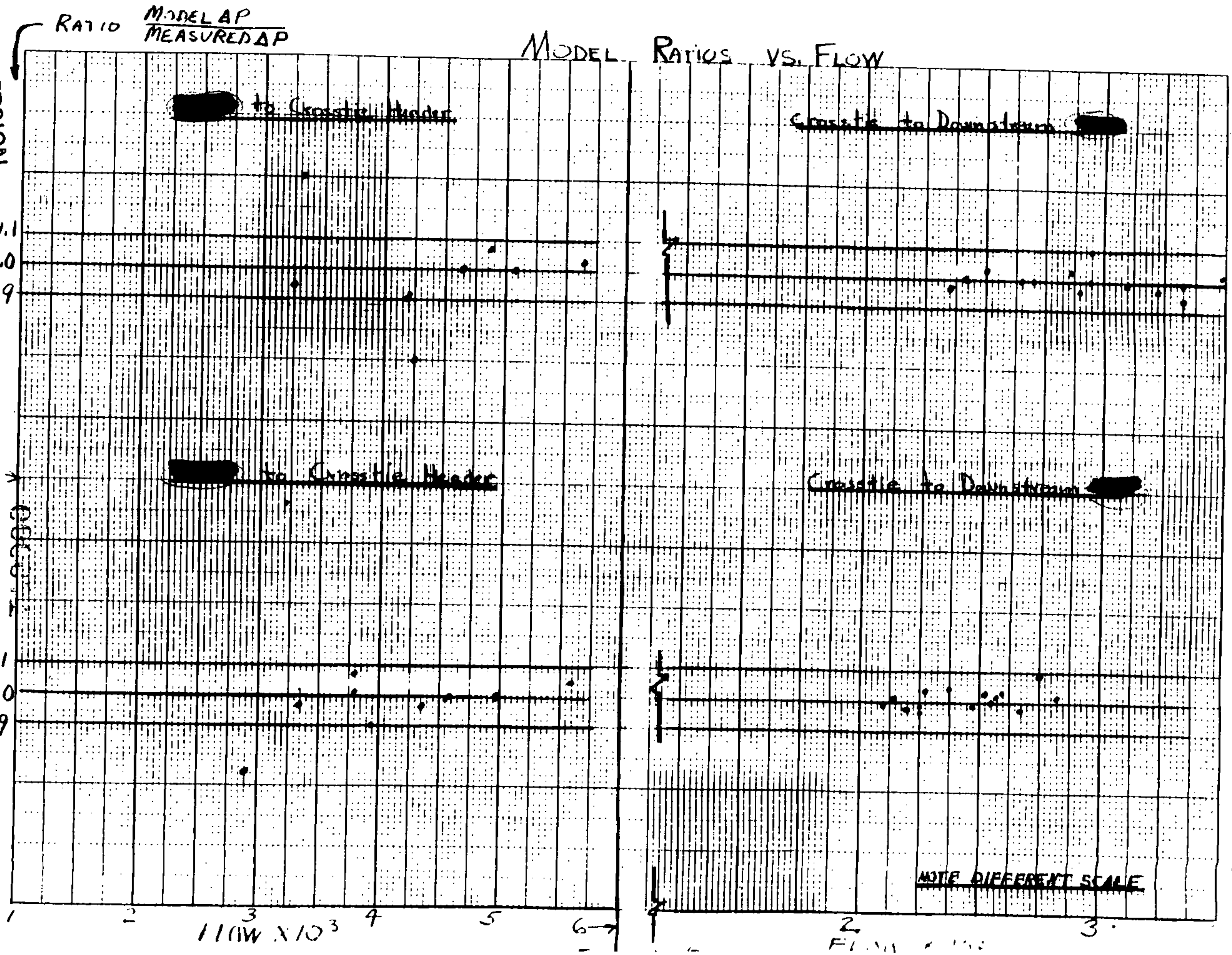

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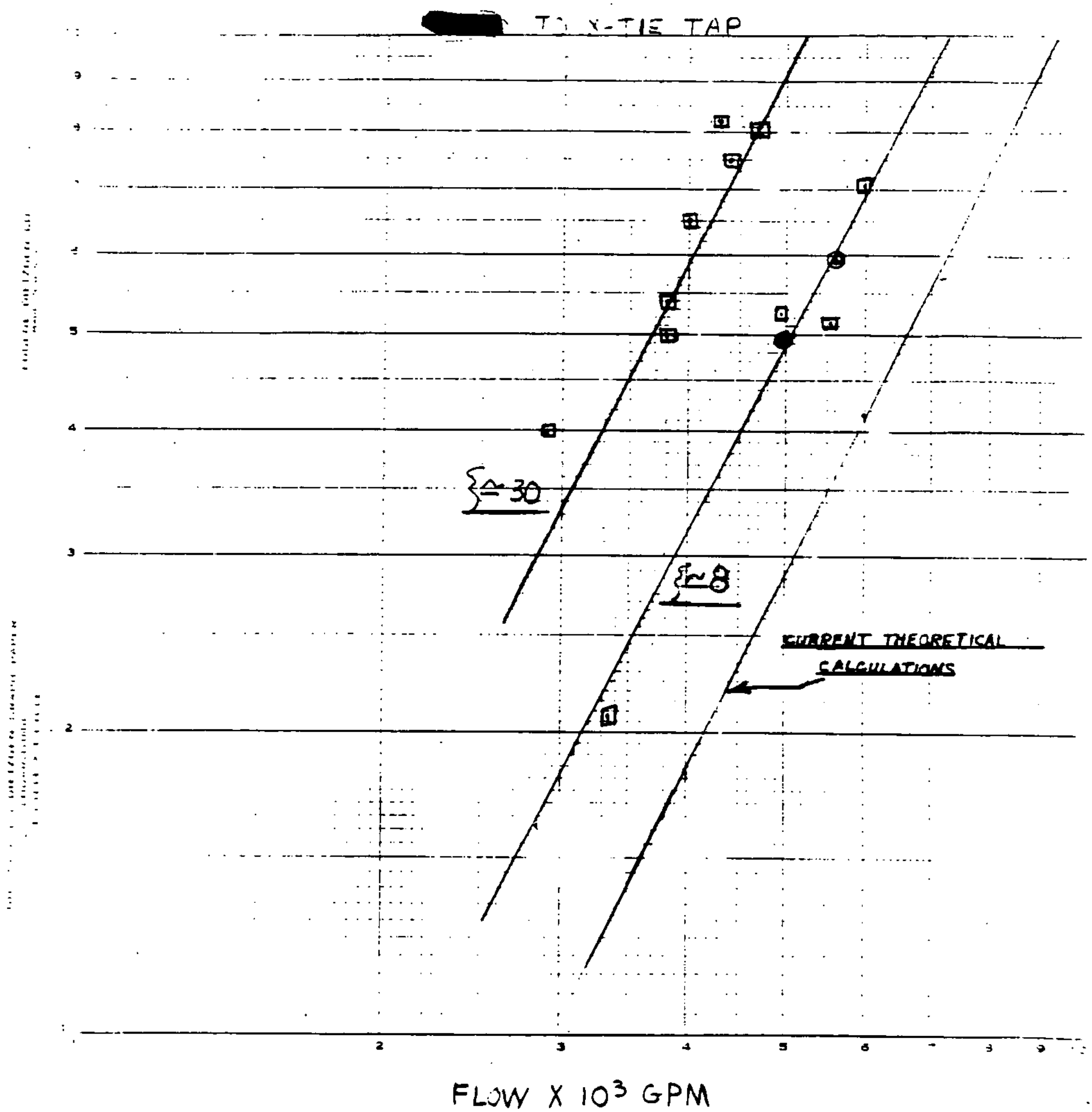

FIGURE 7

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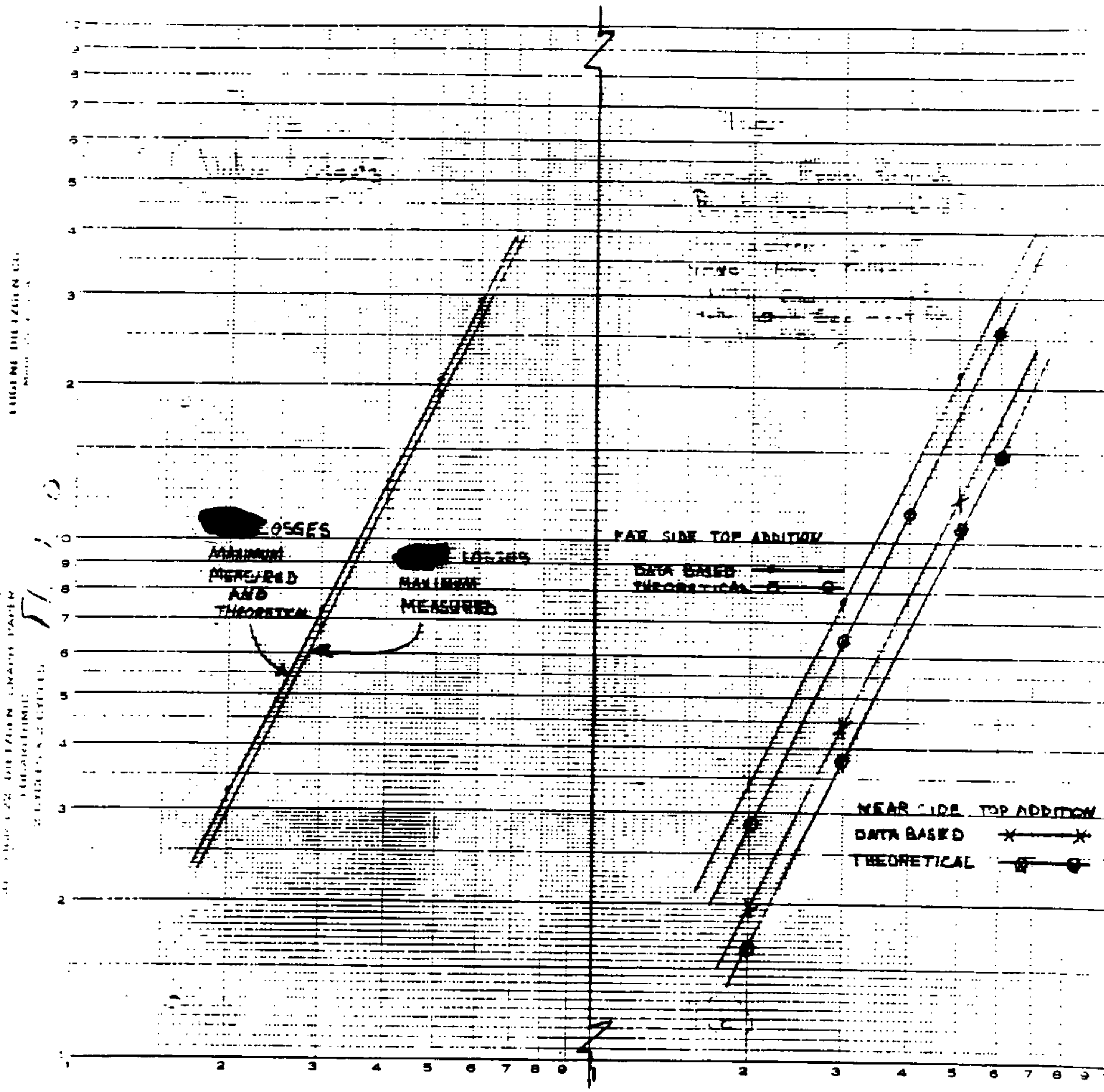

FLOW X 10^3 GPM

FIGURE 8

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APPENDIX A

Table A-1 compares the data based loss coefficient K with the calculated value. Pressure losses are defined by data for the points labeled in Figure A-1. As discussed in the text, the calculated loss coefficient values are generally less than measured value. However, upon summing the loss coefficients for the two most restrictive segments of piping (points (2-4) + (4-4') or points (2-3) + (3-6) + (6-6')) and comparing them with the theoretical values, it is obvious that the theoretical values are quite close to calculated values. Although data-based losses from each source to the crosstie header are greater than calculated using theory, they are small losses from the worst postulated loss of circulation accident (Table B-1). For the worst postulated loss of coolant accident, the flow rates to the bottom addition system is primarily affected by the adverse flow split between the bottom addition system. Although the model for the losses between each cooling water header and the crosstie header tap indicates that the loss is a function of the flow split between the cooling water header and the divergent ECS stream, a conservative value assuming $\alpha \simeq 1.0$ for [redacted] and $\alpha = 8$ for [redacted] was used in making the flow analysis. At large ECS addition flow rates the effect of becomes smaller (according to equation 1 on page 4) and for much smaller ECS flow values the effect of α in the overall ECS resistance is small. For example, assuming one operable top addition system for the loss of circulation accident, the loss from [redacted] to the crosstie header tap represents only about 5% of the total loss in the ECS system.

With these assumptions, flows are calculated for C Area using theoretical and calculated data. As shown in Table A-2 agreement is within ±6%. The theoretical comparison for the worst postulated loss of coolant accident has been omitted since the major losses in the bottom addition system are calculated valves anyhow.

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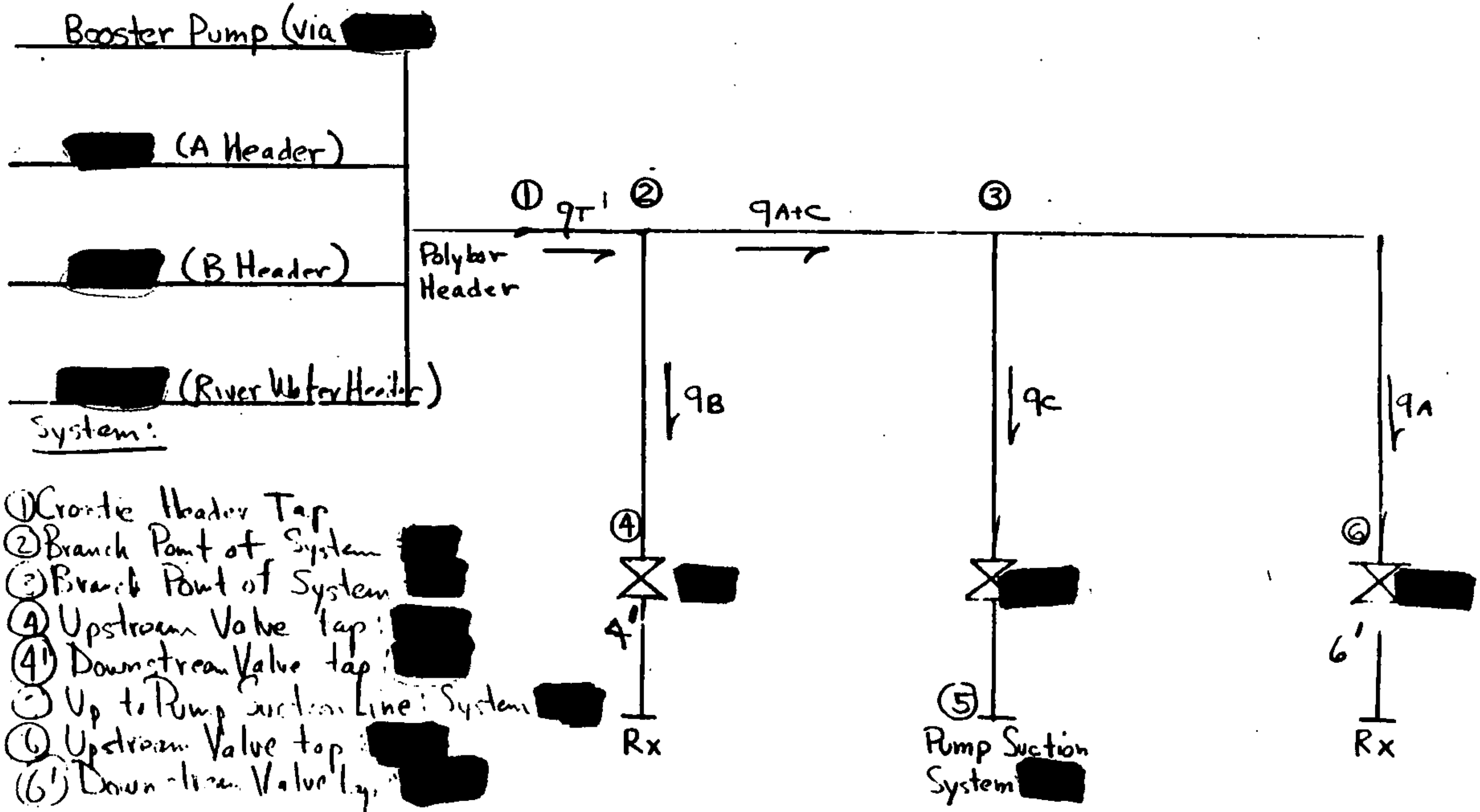
ECS Light Water Addition System



Sources:
Booster pump discharge pressure tap
[redacted] CS takeoff point
River water pressure tap

Fig. A-1

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TABLE A-1

FRICTION LOSSES - C AREA

K(X10^{7})

	Booster Pump to 1	qt [redacted] to 1	[redacted] to 1	[redacted] to 1	1 to 2	qB 2 to 4'	qA 2 to 6'	qB [redacted] Valve	qA [redacted] Valve
Databased	2.669	2.049	2.236 + 0.427 α	.9573 + .0698 α	.5083	12.117	16.659	7.604	8.125
Theoretical	2.083	1.531	1.436	9.439	.5556	12.324	15.710	8.125	8.125

Qr = total flow (gpm)
qB = flow through near top addition system
qA = flow through far top addition system

TABLE A-2

Accident	Booster Pump qDB	Booster Pump qth	[redacted] qDB	[redacted] qth	[redacted] qDB	[redacted] qth	[redacted] qDB	[redacted] qth	[redacted] qDB	[redacted] qth
Loss of circulation 2 operable top addition systems	10300	10600	9100	9400	7550	8000	7800	8100	8400	8750
Loss of circulation 1 operable top addition system	6150	6350	5300	5450	4700	4800	4800	4850	-	-
Loss of coolant	4400		4000		3500		3600		3850	

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APPENDIX B

A calculation model for ECS piping is shown diagrammatically in Figure B-1. All values of K given in Table B-2 for P Area only are theoretically calculated values. KC loss coefficients in column I, II, V and VII are data based. Columns I, II, III, V, and VIII contain loss coefficients through each of the addition systems that are generally applicable for any accident analysis. The loss coefficient in column IV pertains to losses through the bottom addition system including an expansion loss to the pump suction line for system number three. The loss coefficient in column VI applies to the losses from the downstream side of an [redacted] top addiion valve to the bulk moderator in the tank. The loss coefficient assumes D_2O from the downstream side of the [redacted] valve to the reactor tank and is adjusted to give a result in terms of equivalent H_2O loss. Column VI is useful when a loss of circulation accident is postulated. An additional correlation for the equivalent H_2O friction losses from the bulk moderator to vacuum breaker over flow are given in Table B-5. Column XII is useful in evaluating a loss of coolant accident in which the cooling water exit point from the top addition system is assumed to be in the -20 Hx bay at the elevation given in Table B-5.

P Area loss coefficients are different from losses for KC Areas due to piping differences among the areas. Loss coefficients for C Area when isolation valves are installed in the light water addition system can adequately be represented by loss coefficients given for K Area.

Friction loss coefficients for piping between each ECS supply source and the crosstie header tap is given in Table B.3.

Analysis of the ECS system is based upon the three accidents described in Table B-1. Flows for K and C Area were calculated using the actual friction loss data from the crosstie header tap to the downstream side of the [redacted] valves. The actual maximum measured valve loss coefficient for the [redacted] valve is slightly less than valve given in Table B-2. This flow difference is slight for the loss of circulation accident with two operable top addition systems only. A lower average loss coefficient for valve [redacted] based on data was used in the analysis of the worst postulated loss of coolant accident in KC Areas. Flows to the reactor core through the bottom addition system given in Table B-3 are thus slightly more conservative than would be calculated by using Table B-2. Maximum core melting estimates for the worst postulated accident were about 3%, approximately that maximum stated in Reference 9. More detailed estimates for other flows can be obtained by using References 10 and 11.

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TABLE B-1

ECS ACCIDENT ANALYSIS

- Loss of Circulation Accident:

  The loss of circulation accident is one in which the Bingham pumps would not circulate water through the reactor core or heat exchangers. It is assumed that the reactor remains full of water, and that light water added exits through the vacuum breakers and forest standpipes. The postulated cause for a loss of circulation accident is flooding of the AC or DC motors caused by a large cooling water leak.

  Technical Standards require that at least two sources be capable of providing at least 8000 gpm flow to the reactor core within 20 seconds after system actuation (Reference 9). Assuming no component failure, the loss of circulation accident with two operable top addition systems would result in the minimum ECS flow to the reactor core.

  Accident analysis is based on a single component failure; namely a single top addition valve for the loss of circulation accident.

- Loss of Coolant Accident

  The loss of coolant accident in one in which a large (75,000 gpm maximum) process water leak due to rupture of a plenum inlet line is assumed. Bingham pumps are assumed operable. The worst postulated accident assumes that the plenum inlet line rupture is in the near top addition system; the singel component failure assumed is the other top addition valve.

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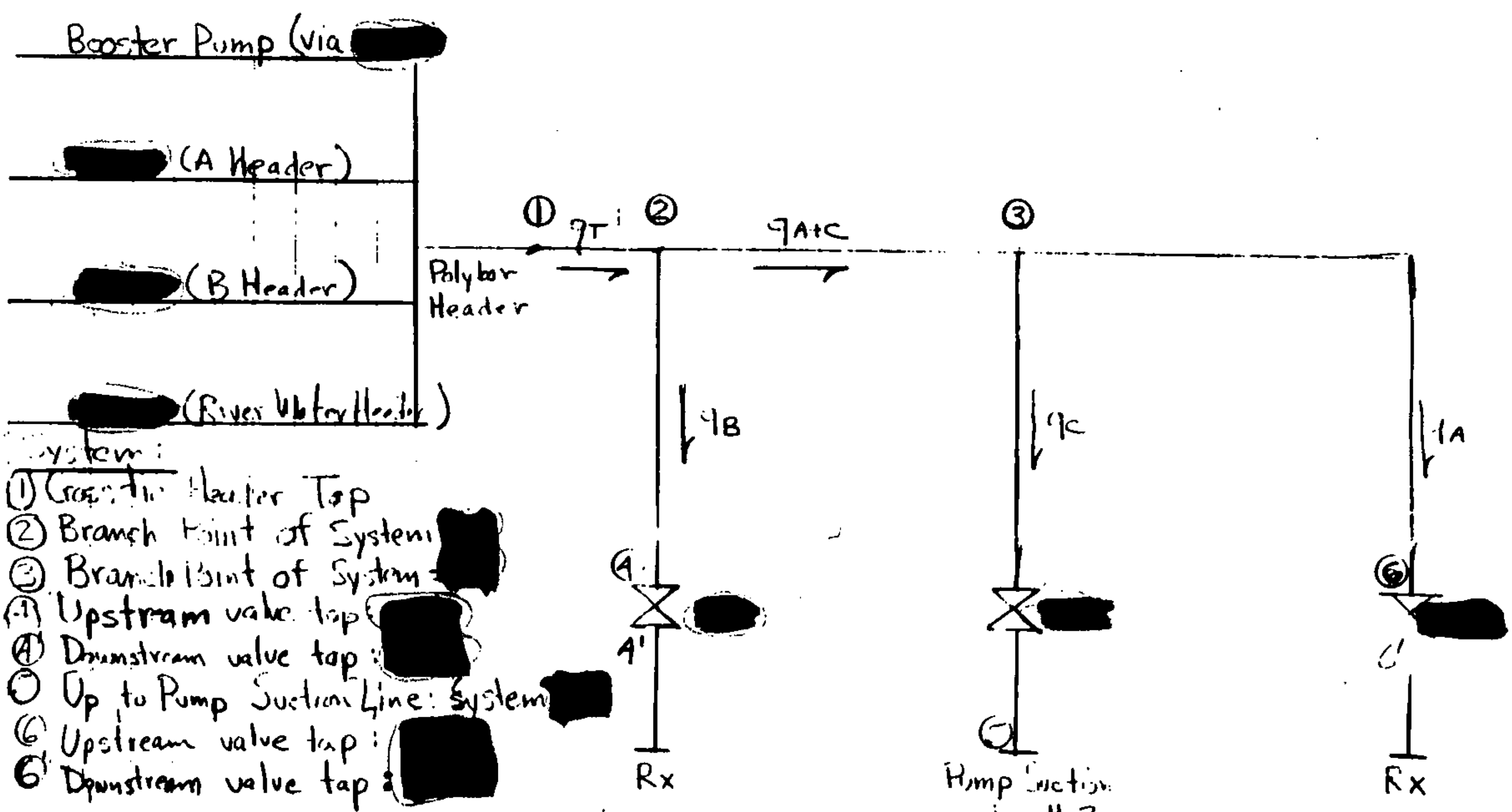
ECS Light Water Addition System



Sources:

Booster pump discharge pressure tap

[redacted] ECS takeoff point

River Water pressure tap

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... B 1

TABLE B-1

ECS ACCIDENT ANALYSIS

- Loss of Circulation Accident:

  The loss of circulation accident is one in which the Bingham pumps would not circulate water through the reactor core or heat exchangers. It is assumed that the reactor remains full of water, and that light water added exits through the vacuum breakers and forest standpipes. The postulated cause for a loss of circulation accident is flooding of the AC or DC motors caused by a large cooling water leak.

  Technical Standards require that at least two sources be capable of providing at least 8000 gpm flow to the reactor core within 20 seconds after system actuation (Reference 9). Assuming no component failure, the loss of circulation accident with two operable top addition systems would result in the minimum ECS flow to the reactor core.

  Accident analysis is based on a single component failure; namely a single top addition valve for the loss of circulation accident.

- Loss of Coolant Accident

  The loss of coolant accident in one in which a large (75,000 gpm maximum) process water leak due to rupture of a plenum inlet line is assumed. Bingham pumps are assumed operable. The worst postulated accident assumes that the plenum inlet line rupture is in the near top addition system; the singel component failure assumed is the other top addition valve.

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TABLE B-2

FRICTION LOSSES DOWNSTREAM OF CROSSTIE HEADER TAP

$K(X10^7)$

Area	I 1 to 2	II 2 to 4'	III 2 to 3	IV 3 to 5 loss of coolant	V 2 to 6'	VI 4 or 6 to Bulk moderator loss of circulation	VII 4 to Exit -20 HX Bay Loss of coolant	VIII Valve [redacted] Valve
	qT	qB	qA and C	qC	qA	qA or qB	qB	qA or qB
P	1.222	12.324	.4226	59.42	15.06	12.12	23.16	8.125
KC	.5083	12.117	.4226	59.43	16.66	12.12	23.16	8.125

Qi = flow through subscripted branch (gpm)
$hL = kqi^2$ ($Ft.H_2O$)

TABLE B-3

FRICTION LOSSES BETWEEN ECS SUPPLY SOURCES AND 1

$K(X10^7)$

Area	Booster Pump	[redacted]	[redacted]	[redacted]
P	2.939	1.602	1.002	2.333
KC	2.3972	1.214	.8178	1.685

qA = flow through far top addition system
qB = flow through near top addition system
qC = flow through bottom addition system
qT = total ECS flow rate

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TABLE B-4

Accident	Booster Pump P	Booster Pump KC	[redacted] P	[redacted] KC	[redacted] P	[redacted] KC	[redacted] P	[redacted] KC	[redacted] P	[redacted] KC
Loss of Circulation 2 operable top addition systems	10000	10400	8800	9150	7700	7850	7750	7950	8300	8600
Loss of circulation 1 operable top addition system	6250	6300	5350	5300	4700	4700	4750	4650	-	-
Loss of coolant (worst postulated)	4300	4450	4000	4100	3450	3600	3600	3600	3900	3900

TABLE B-5

ADDITIONAL INFORMATION

Loss-of Circulation Accident

	Elevations relative to 0
Booster pump discharge	-6.93'
[redacted]	-17.0'
	-17.0'
	-17.0'
Vacuum breaker overflow	12.65
Top of Upper Forest Deck	16.05'

Friction loss - bulk moderator to exit.

$$h_L = 2.1636 \times 10^{-7} (q)^{1.98}$$ (ft. of equivalent H_2O) (References 3 and 4)

Loss of Coolant Accident

	Elevations relative to 0
System [redacted] discharge	-19.25'
System [redacted] discharge	-12.0 '

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CHECK

- o Hydraulic unit to check operation of pump and motor for valves when valves are first opened. _____
- o At Booster Pump or the emergency pumps to record data. _____
- o At -20 clean area to record data. _____
- o At ECS storage header strainer to verify that the strainer bypass relief valves remain closed while valves are open and to record strainer ΔP (pt #9 of Figure 1) _____

3. If an ECS strainer bypass relief valve starts to open complete the following:

   a. Close valves opened below: _____

   b. Request Maintenance Mechanics to recheck, and reset if necessary, the torque required to open the strainer bypass relief valves per DPSOL 105-1268. _____

   c. Resume test. _____

   d. If a strainer bypass relief valve again starts to open, stop the test and notify day supervision. _____

4. Establish a supply of test water as follows:

   a. Verify that valve [redacted] is CLOSED. _____

   b. Verify that valve [redacted] is OPEN. _____

   c. Start booster pump per applicable steps of DPSOL 105-2315. _____

      or

      Start emergency pumps 1 and 2 from the graphic panel.
      No. 1 started _____
      No. 2 started _____

   d. Cycle valve [redacted] to pressurize crosstie header. _____

   e. Verify that crosstie header pressure is at least 65 psig in P Area or 55 psig in L, K and C Areas; if it is not, stop test and check the pump operation. _____

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CHECK

5. Unlock and energize the following valves in crane maintenance area. Verify that CLOSED indicating lights on graphic panel are ON.
[redacted]

6. Request observer in field to OPEN the valves in flow test line [redacted] [redacted] OPEN

7. Open valves [redacted] and [redacted]

8. Establish contact with all observers in the field.

9. Set valving to establish test conditions per Table III.

Test 40a. Valves [redacted] and [redacted] open.
Valves [redacted] open and [redacted] open.
Valves [redacted] open and [redacted] open.
Valve [redacted] open.
Valve [redacted] closed.
Valve [redacted] closed.

Note: Flow change will be accomplished by adjusting one or more of the following valves:

[redacted] in Line ECW [redacted]
[redacted] in Line ECW [redacted]
[redacted] in Line ECW [redacted]

10. Verify that flow through magnetic flow meter [redacted] is indicated on the graphic panel.

11. Check for leaks. Repair as necessary.

12. Continue by opening and closing valves [redacted] and trottling valves [redacted] until all combinations in Table III have been completed. Record data on Data Sheet 3. Repeat tests from Table III requested by Reactor Technology.

13. Stop Booster Pump.

or

Stop Emergency Pump No. 1
Stop Emergency Pump No. 2

CHECK

14. Close the following valves:

[redacted] CLOSED ____
CLOSED ____
CLOSED ____
CLOSED ____
CLOSED ____
CLOSED ____

Crosstie header isolation valves [redacted] CLOSED ____
Block valve in line [redacted] CLOSED ____
" " " " CLOSED ____
CLOSED ____
CLOSED ____

15. Have test equipment installed in Step A6 removed. Save test equipment for Reactor Technology Test Coordinator.

Completed By ______________________

Date ________ Time __________ a.m./p.m.

16. Give all test data to Reactor Technology representative.

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TABLE 1

TEST COMBINATIONS - SOURCES

Test No.	Valve Positions				Cooling Water Supply				
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	Booster Pump	Emergency Pump 1	2
1	OPEN	CLOSED	CLOSED	CLOSED	ON	OFF	OFF	OFF	OFF
2	OPEN	OPEN	CLOSED	CLOSED	ON	ON	OFF	OFF	OFF
3	OPEN	CLOSED	OPEN	OPEN	ON	OFF	ON	OFF	OFF
4	OPEN	CLOSED	OPEN	OPEN	ON	OFF	OFF	ON	OFF
5	OPEN	CLOSED	OPEN	OPEN	ON	OFF	OFF	OFF	ON
6	OPEN	CLOSED	OPEN	OPEN	ON	OFF	OFF	ON	ON
7	OPEN	OPEN	OPEN	OPEN	ON	ON	ON	OFF	OFF
8	OPEN	OPEN	OPEN	OPEN	ON	ON	OFF	ON	OFF
9	OPEN	OPEN	OPEN	OPEN	ON	ON	OFF	OFF	ON
10	OPEN	OPEN	OPEN	OPEN	ON	ON	OFF	ON	ON
11	OPEN	CLOSED	OPEN	OPEN	ON	OFF	ON	ON	OFF
12	OPEN	CLOSED	OPEN	OPEN	ON	OFF	ON	OFF	ON
13	OPEN	CLOSED	OPEN	OPEN	ON	OFF	ON	ON	ON
14	OPEN	OPEN	OPEN	OPEN	ON	ON	ON	ON	OFF
15	OPEN	OPEN	OPEN	OPEN	ON	ON	ON	OFF	ON
16	OPEN	OPEN	OPEN	OPEN	ON	ON	ON	ON	ON
17	CLOSED	OPEN	OPEN	OPEN	OFF	ON	ON	OFF	OFF
18	CLOSED	OPEN	OPEN	OPEN	OFF	ON	OFF	ON	OFF
19	CLOSED	OPEN	OPEN	OPEN	OFF	ON	OFF	OFF	ON
20	CLOSED	OPEN	OPEN	OPEN	OFF	ON	OFF	ON	ON
21	CLOSED	OPEN	OPEN	OPEN	OFF	ON	ON	ON	OFF
[illegible]	CLOSED	OPEN	OPEN	OPEN	OFF	ON	ON	OFF	ON
[illegible]3	CLOSED	OPEN	OPEN	OPEN	OFF	ON	ON	ON	ON
24	CLOSED	OPEN	CLOSED	CLOSED	OFF	ON	OFF	OFF	OFF
25	CLOSED	CLOSED	OPEN	OPEN	OFF	OFF	ON	OFF	OFF
26	CLOSED	CLOSED	OPEN	OPEN	OFF	OFF	ON	ON	OFF
27	CLOSED	CLOSED	OPEN	OPEN	OFF	OFF	ON	OFF	ON
28	CLOSED	CLOSED	OPEN	OPEN	OFF	OFF	ON	ON	ON
29	CLOSED	CLOSED	OPEN	OPEN	OFF	OFF	OFF	ON	OFF
30	CLOSED	CLOSED	OPEN	OPEN	OFF	OFF	OFF	OFF	ON
31	CLOSED	CLOSED	OPEN	OPEN	OFF	OFF	OFF	ON	ON

NOTE: Check off each position as it is verified.

TABLE II

[redacted] PUMP TEST

TEST COMBINATIONS

Test No	Valve Position				Cooling Water Pumps		Heat Exchangers	
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
32	OPEN	CLOSED	CLOSED	CLOSED	3 SMALL	NONE	2	2
33	OPEN	CLOSED	CLOSED	CLOSED	2 SMALL	NONE	2	2
34	OPEN	CLOSED	CLOSED	CLOSED	4 SMALL	NONE	3	2
35	OPEN	CLOSED	CLOSED	CLOSED	3 SMALL	NONE	3	2
36	OPEN	CLOSED	CLOSED	CLOSED	4 SMALL, 1 LARGE	NONE	6	2
37	OPEN	CLOSED	CLOSED	CLOSED	4 SMALL	NONE	6	2
38	CLOSED	OPEN	CLOSED	CLOSED	3 SMALL	3 SMALL	2	2
39	CLOSED	OPEN	CLOSED	CLOSED	2 SMALL	2 SMALL	2	2

NOTE: Check off each position as it is verified.

DELETED VERSION

TABLE III

Test Combinations - Supplies

Test No.	Valve Positions			Percent Flow		
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
40 a	OPEN	CLOSED	CLOSED	100[1]	0	0
b	THROTTLED	CLOSED	CLOSED	75	0	0
c	THROTTLED	CLOSED	CLOSED	50	0	0
d	THROTTLED	CLOSED	CLOSED	25	0	0
41 a	CLOSED	OPEN	CLOSED	0	100	0
b	CLOSED	THROTTLED	CLOSED	0	75	0
c	CLOSED	THROTTLED	CLOSED	0	50	0
d	CLOSED	THROTTLED	CLOSED	0	25	0
42 a	CLOSED	CLOSED	OPEN	0	0	100
b	CLOSED	CLOSED	THROTTLED	0	0	75
c	CLOSED	CLOSED	THROTTLED	0	0	50
d	CLOSED	CLOSED	THROTTLED	0	0	25
43 a	CLOSED	OPEN	OPEN	0	100	100
b	CLOSED	THROTTLED	OPEN	0	75	100
c	CLOSED	THROTTLED	OPEN	0	50	100
d	CLOSED	THROTTLED	OPEN	0	25	100
e	CLOSED	OPEN	THROTTLED	0	100	75
f	CLOSED	OPEN	THROTTLED	0	100	50
g	CLOSED	OPEN	THROTTLED	0	100	25
44 a	OPEN	CLOSED	OPEN	100	0	100
b	THROTTLED	CLOSED	OPEN	75	0	100
c	THROTLLED	CLOSED	OPEN	50	0	100
d	THROTTLED	CLOSED	OPEN	25	0	100
e	OPEN	CLOSED	THROTTLED	100	0	75
f	OPEN	CLOSED	THROTTLED	100	0	50
g	OPEN	CLOSED	THROTTLED	100	0	25
45 a	OPEN	OPEN	CLOSED	100	100	0
b	OPEN	THROTTLED	CLOSED	100	75	0
c	OPEN	THROTTLED	CLOSED	100	50	0
d	OPEN	THROTTLED	CLOSED	100	25	0
e	THROTTLED	OPEN	CLOSED	75	100	0
f	THROTTLED	OPEN	CLOSED	50	100	0
g	THROTTLED	OPEN	CLOSED	25	100	0
46	OPEN	OPEN	OPEN	100	100	100

NOTE: Check off each position as it is verified.

1 Number is percent of total flow

DELETED VERSION

DELETED VERSION

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Page 17
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TEST DATA - DATA SHEET 1

Test No	PRESSURES												FLOW		
	[redacted]			mP1	EmP2	Xtie	[redacted]		P	[redacted]					
	1	2	3	4	5	6	7	8	9	10	11	12			
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															
22															
23															
24															

DELETED VERSION

DELETED VERSION

TEST DATA - DATA SHEET 1 (Cont.)

Test No	PRESSURES												FLOW		
	[redacted]		BP	EmP1	EmP2	Xtie([redacted]			ΔP	[redacted]			[redacted]		
	1	2	3	4	5	6	7	8	9	10	11	12			
25															
26															
27															
28															
29															
30															
31															

TEST DATA - DATA SHEET 2

Test No.	Pressures									Flow	
	[redacted]		Xtle	[redacted]		ΔP	[redacted]			[redacted]	
	1	2	6	7	8	9	10	11	12		
32											
33											
34											
35											
36											
37											
38											
39											

DELETED VERSION

DELETED VERSION

TEST DATA - DATA SHEET 3

Test	PRESSURES							FLOW				
No	BP	EMP1	EMP2	Xtie	[redacted]	[redacted]	ΔP	[redacted]			[redacted]	
	3	4	5	6	7	8	9	10	11	12		
40a												
b												
c												
d												
41a												
b												
c												
d												
42a												
b												
c												
d												
43a												
b												
c												
d												
e												
f												
g												
44a												
b												
c												
d												
e												

DELETED VERSION

TEST DATA - DATA SHEET 3

Test No	PRESSURES							FLOW				
	BP	EMP1	EMP2	Xtie	[redacted]		ΔP	[redacted]				
	3	4	5	6	7	8	9	10	11	12		
f												
g												
45a												
b												
c												
d												
e												
f												
g												
46												

DELETED VERSION

PAGE DELETED 000094

PURSUANT TO SECTION 148, ATOMIC ENERGY ACT OF 1954, AS AMENDED

AND

DEPARTMENT OF ENERGY REGULATION 10 C.F.R. 1017

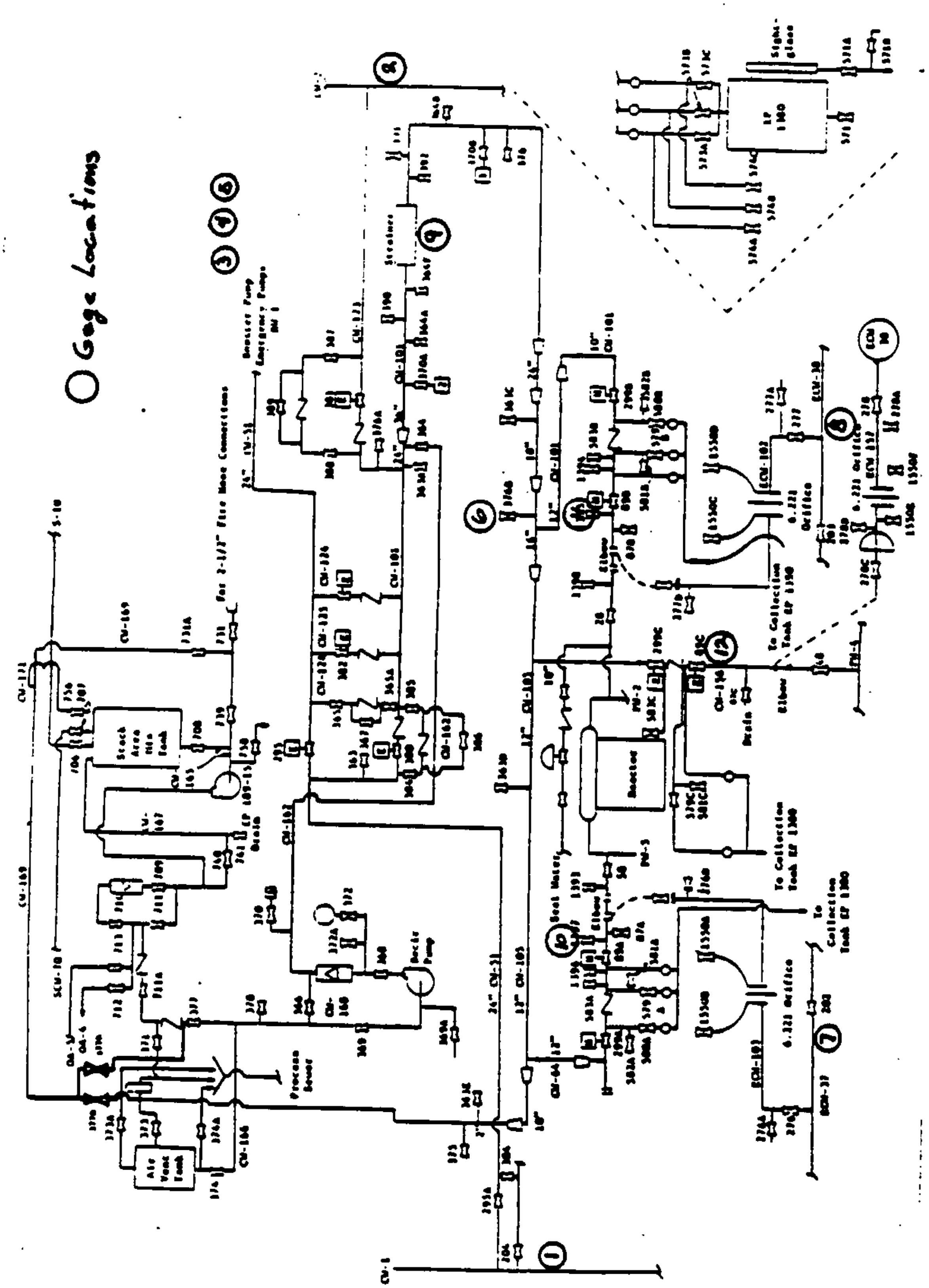


FIGURE 1d. L-AREA EMERGENCY COOLING SYSTEM

DELETED VERSION

APPENDIX II

TEST GAGE SERIAL NUMBERS AND ELEVATIONS

Gage No.*	Serial No.	Elevation	Location
1	S7-18411	-17'-4"	[redacted]
2	S7-18412	-17'-4"	[redacted]
3	S7-18456	-18'-9"	BP
4	S7-18456	-18'-9"	EP1**
5	S7-18456	-18'-9"	EP2***
6	S7-9838	-19'-2"	Xtie1
7	S7-18411	-17'-4"	[redacted]
8	S7-18412	-17'-4"	[redacted]
9	853637	NA	Strainer P
10	CMM88441	-15'-2"	[redacted]
11	CMM88440	-15'-1/2"	[redacted]
12	CMM88439	-15'-3"	[redacted]
14	S7-18412	-17'-4"	Xtie2
15	S7-18456	-18'-9"	[redacted]

* Refer to Figure 1 of Appendix I for gage locations.
** EP1 = ECS Pump "A"
*** EP2 = ECS Pump "B"

000095

DELETED VERSION

APPENDIX III

TEST GAGE CALIBRATION DATA

GAGE ZERO CORRECTION

Serial No.	Location	Zero Corr, psi
CMM88441	[redacted]	-0.5
CMM88440		-1.6
CMM88439		-1.1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure PSI　　Date 8/22/85

Equipment Under Test HEISE GAUGE　　No S/N 57-9838

Standard Used RUSKA DDR 6000　　No. Q 00068

Range 0- 70 PSI　Calibration Expires 8/22/86　By [signature]

Barometric Pressure ______　Humidity ______ % Temperature ______

Equipment From: Foreman SHIRLEY JOHNSON　Bldg. 723　Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	0	0	0	21	63	63.03	.03
2	7	7.0	0	22	56	56.06	.06
3	14	14.0	0	23	49	49.06	.06
4	21	21.0	0	24	42	42.06	.06
5	28	28.0	0	25	35	35.04	.04
6	35	35.01	.01	26	28	28.03	.03
7	42	42.03	.03	27	21	21.03	.03
8	49	49.03	.03	28	14	14.02	.02
9	56	56.03	.03	29	7	7.01	.01
10	63	63.02	.02	30	0	0	0
11	70	69.99	-.01	31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks ______

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure PSI Date 8/22/85

Equipment Under Test HEISE GAUGE No. S/N 57-18456

Standard Used RUSKA DDR-6000 r No. Q00068

Range 0-100 PSI Calibration Expires 8/22/86 By S Parker

Barometric Pressure ______ Humidity ______ % Temperature ______

Equipment From: Foreman SHIRLEY JOHNSON Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	0	0	0	21	90	89.99	-.01
2	10	10.00	0	22	80	80.00	0
3	20	20.00	0	23	70	70.00	0
4	30	29.99	-.01	24	60	60.00	0
5	40	40.00	0	25	50	50.00	0
6	50	50.00	0	26	40	40.01	.01
7	60	60.00	0	27	30	30.00	0
8	70	69.98	-.02	28	20	20.00	0
9	80	80.00	0	29	10	10.00	0
10	90	89.99	-.01	30	0	0	0
11	100	99.99	-.01	31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks ______

Figure 1 000093

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure PSI　　Date 8/22/85

Equipment Under Test HEISE GAUGE　　No SN 57-18412

Standard Used RUSKA DDR 6000　　No. Q00068

Range 0-150 PSI　　Calibration Expires 8/22/86　　By [signature]

Barometric Pressure ______　　Humidity ______ %　　Temperature ______

Equipment From: Foreman SHIRLEY Johnson　　Bldg. 723　　Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	0	0.00	0.00	21	135	134.97	-.03
2	15	15.00	0.00	22	120	119.96	-.04
3	30	29.98	-.02	23	105	105.00	0.00
4	45	44.95	-.05	24	90	90.00	0.00
5	60	59.96	-.04	25	75	74.99	-.010
6	75	74.96	-.04	26	60	60.00	0.00
7	90	89.96	-.04	27	45	44.98	-.02
8	105	104.96	-.04	28	30	30.01	.01
9	120	119.93	-.07	29	15	15.01	.01
10	135	134.95	-.05	30	0	0.00	0.00
11	150	150.00	0.00	31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks ______

000090

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure PSI Date 8/22/85

Equipment Under Test HEISE GAUGE No. SN 57-18411

Standard Used RUSKA DDR-6000 No. Q00068

Range 0-150 PSI Calibration Expires 8/22/86 By [signature]

Barometric Pressure ______ Humidity ______ % Temperature ______

Equipment From: Foreman SHIRLEY JOHNSON Bldg. 723 Area 4

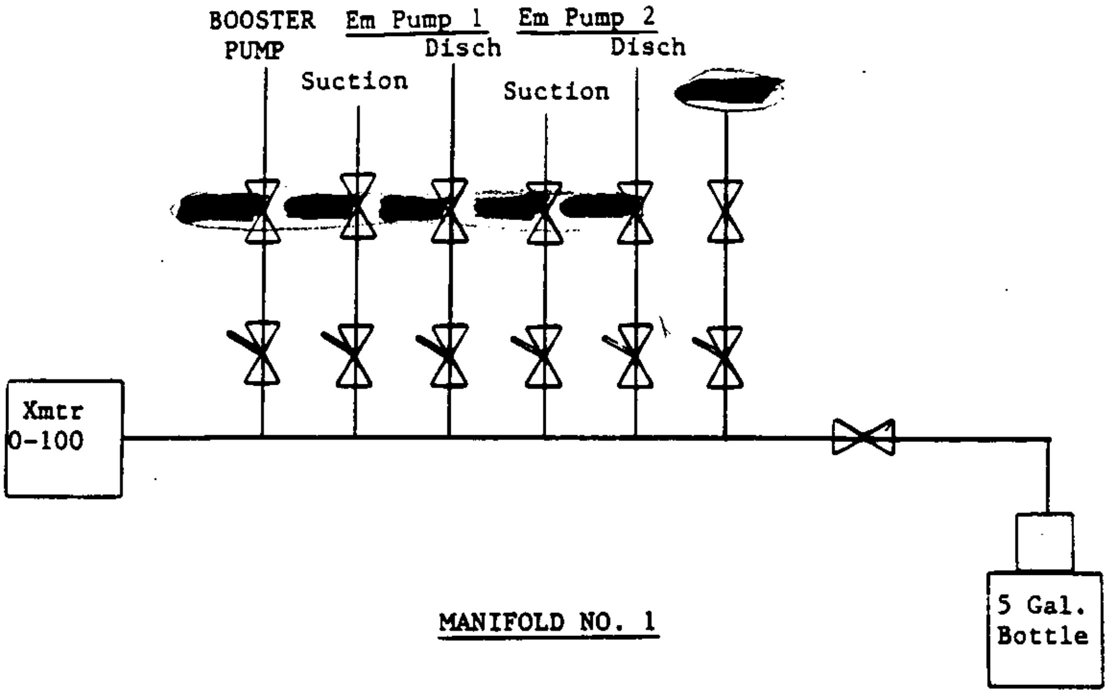
Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	0	0	0	21	135	135.10	.10
2	15	15.09	.09	22	120	120.17	.17
3	30	30.15	.15	23	105	105.20	.20
4	45	45.19	.19	24	90	90.24	.24
5	60	60.20	.20	25	75	75.26	.26
6	75	75.24	.24	26	60	60.23	.23
7	90	90.21	.21	27	45	45.21	.21
8	105	105.17	.17	28	30	30.16	.16
9	120	120.14	.14	29	15	15.10	.10
10	135	135.08	.08	30	0	.01	.01
11	150	150.00	0	31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks ______

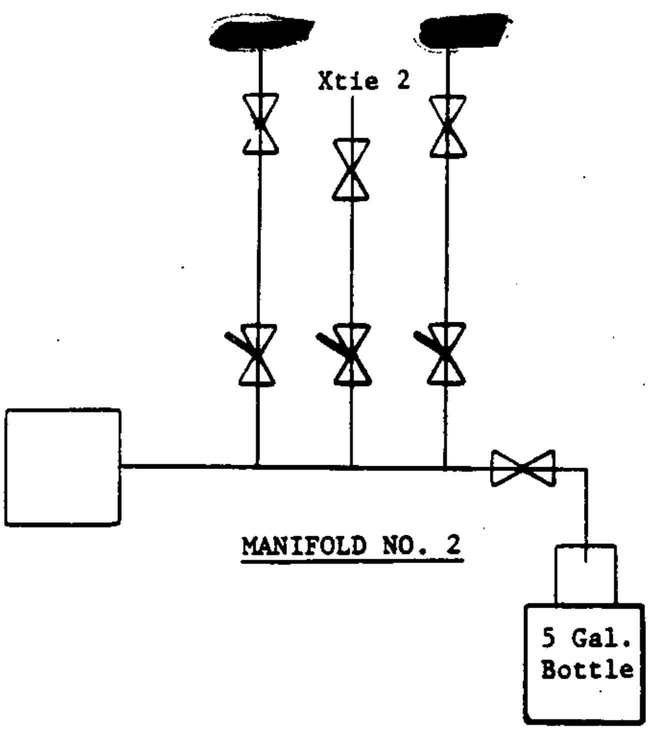
Figure 1

APPENDIX IV

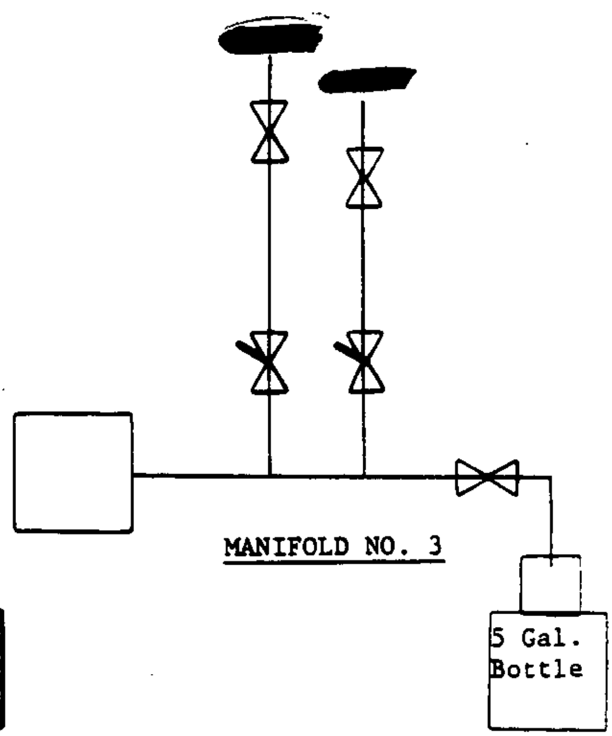
DIGITAL HEISE GAGE MANIFOLD HOOKUP AND PROCEDURE



MANIFOLD NO. 1



MANIFOLD NO. 2



MANIFOLD NO. 3

Toggle Valve Caption 27
Item No. 147200
Bin Loc BB7825C1

DELETED VERSION

GITAL HEISE GAGE MANIFOLD READINGS BEFORE TAKING READINGS*

1. Verify that test conditions have been established.

2. Purge each impulse line by opening the drain valve and then each toggle valve one at the time. Purge long enough to ensure that no air remains in the impulse line. Close the drain valve after all purging is complete.

To Take Readings

1. Open toggle valve for pressure to be read.

2. Crack open the drain valve. Verify that pressure decreases. Close drain valve.

3. Record reading.

4. Continue until all data requested has been recorded.

* It will not be necessary to purge the impulse lines for each test condition unless the sources of water [redacted] Booster Pump, ECS Pump A or ECS Pump B) are changed. Example: Purge if the Booster Pump is shutdown and [redacted] is placed online.

APPENDIX V

DATA SHEET 1 - TEST DATA

COMBINATION OF SOURCES

DELETED VERSION

Test No	Source	PRESSURE, PSIG									
		[redacted]	[redacted]	Booster Pump	ECS Pump A Suction	ECS Pump A Disch	ECS Pump B Suction	ECS Pump B Disch	Xtie 1	[redacted]	[redacted]
1		44.8	6.23	9.79	9.81	9.84	9.82	9.82	28.35	5.7	-1.05
1a		52.8	8.90	12.8	13.3	12.5	12.5	12.5	49.4	8.7	3.44
1b		49.0	8.75	12.7	13.1	12.4	12.4	12.4	38.8	8.25	3.72
1c		45.85	8.72	12.6	13.1	12.3	12.3	12.3	28.4	7.90	4.20
2		50.75	49.06	7.29	7.29	7.29	7.30	7.29	36.50	6.35	8.63
3		52.35	6.47	62.5	7.51	7.50	7.55	7.54	37.25	6.57	-1.02
4		50.95	7.69	6.75	5.50	47.9	6.71	6.92	38.9	6.42	1.96
5		50.82	7.55	7.15	7.27	7.28	5.9	50.5	35.6	6.53	0.26
6		53.10	7.40	6.03	4.93	58.91	4.55	61.56	37.9	6.79	0.92
7		55.77	54.20	63.5	8.9	8.9	9.1	9.0	41.60	7.85	9.70
8		55.39	53.80	10.8	9.0	61.0	9.2	9.3	40.7	8.95	10.9
9		54.95	53.60	10.8	10.3	9.5	8.0	61.4	40.8	9.00	11.25
10		56.5	54.7	9.1	8.5	67.5	7.2	68.4	42.0	9.2	11.3
11		54.37	8.55	65.5	8.9	64.6	8.6	8.8	38.4	8.85	4.25
12		54.20	8.29	65.8	9.2	8.5	7.4	64.5	38.1	8.83	4.50
13		55.0	8.35	68.0	8.1	67.6	7.2	68.0	38.7	8.95	4.45
14		56.1	54.0	66.1	7.7	65.4	7.8	7.8	41.6	7.27	11.60
15		56.0	54.2	66.5	9.7	8.2	7.6	65.5	41.7	8.65	11.48
16		56.3	54.8	67.8	7.8	67.8	6.4	68.5	41.7	7.35	11.70
17		3.27	53.13	63.2	8.8	8.8	8.9	8.8	40.25	7.49	9.35
18		6.86	50.57	8.36	6.30	58.21	7.74	7.75	38.3	2.20	9.53
19		6.71	50.64	8.26	7.99	7.99	6.39	58.69	38.4	0.80	9.47
20		6.58	52.57	7.05	5.35	65.74	4.93	65.82	40.4	2.07	9.68
21		6.23	51.58	64.89	5.27	63.95	6.38	6.39	39.7	2.14	9.65
22		6.01	51.78	64.92	6.31	6.31	5.31	64.3	39.8	2.19	9.50
23		6.40	52.68	67.25	5.07	66.55	4.85	66.89	40.6	2.19	9.70
24		55.47*	44.67	7.29	7.32	7.33	7.30	7.30	32.9	6.72	7.91
24a		6.90	50.8	10.70	11.4	10.6	10.7	10.6	48.7	2.3	8.9
24b		6.93	47.7	10.7	11.5	10.7	10.7	10.7	40.6	2.28	9.74
24c		6.95	45.3	10.7	11.5	10.7	10.7	10.7	32.4	2.30	10.2
25		6.3	5.90	55.90	5.92	5.70	5.65	5.70	27.6	1.8	-1.03
25a		8.26	7.83	64.0	11.0	10.0	10.0	10.0	55.6	1.85	2.68
25b		8.26	7.90	60.6	9.3	8.4	8.3	8.4	40.8	1.80	2.95
25c		8.33	7.92	55.4	8.0	7.3	7.3	7.3	26.7	1.84	3.20

* CW-1 with three 190 pumps and two 105 heat exchangers.

DELETED VERSION

APPENDIX V
Page 2

DELETED VERSION

Test No.	Strainer ΔP**	PRESSURE, PSIG					FLOW, GPM			
		Xtie 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	Total
1	95	-	8.65	16.5	15.8	14.1	4365	4485	4700	13550
1a	-	50.25	-	27.0	-	-	6115	-	-	6115
1b	-	43.00	-	21.5	20.8	-	5305	5555	-	10860
1c	-	37.25	12.3	16.7	15.9	13.5	4485	4650	4815	13950
2	105	-	7.30	21.2	23.5	21.0	5110	4730	5060	14900
3	115	-	7.15	21.7	21.0	18.2	5100	5200	5500	15800
4	-	-	6.6	20.6	19.3	17.2	5020	5240	5475	15735
5	-	46.0	6.95	20.5	19.4	16.9	5020	5220	5480	15720
6	-	49.33	5.98	22.0	20.8	18.0	5200	5675	5470	16345
7	115	-	8.9	23.8	26.5	23.5	5475	5020	5360	15855
8	-	52.40	10.0	23.5	26.5	22.8	5550	5030	5380	15960
9	-	52.00	10.0	23.7	21.5	22.6	5555	5005	5360	15920
10	-	53.6	8.5	24.4	27.0	23.4	5635	5090	5455	16180
11	125	50.30	9.2	22.2	21.3	18.0	5320	5485	5690	16495
12	-	50.50	8.6	22.3	21.3	18.0	5325	5460	5705	16490
13	-	51.78	8.3	22.5	21.5	18.2	5390	5535	5750	16675
14	-	53.3	8.2	24.0	27.0	23.0	5615	5075	5425	16115
15	115	53.2	8.7	24.2	27.0	23.1	5595	5085	5425	16105
16	-	53.7	8.0	24.3	27.2	23.3	5655	5105	5445	16205
17	110	-	8.8	21.5	25.5	22.4	5600	4950	5260	15810
18	-	48.77	8.37	20.4	24.4	21.5	5475	4790	5100	15365
19	-	48.27	8.29	20.3	24.5	21.7	5475	4785	5130	15390
20	-	51.09	7.04	21.6	25.5	22.7	5655	5945	5270	15870
21	-	51.3	6.91	22.2	25.4	22.4	5610	4845	5270	15725
22	-	50.63	6.68	21.1	25.4	22.4	5610	4910	5235	15755
23	-	51.75	6.52	21.6	25.8	22.8	5645	4950	5280	15875
24*	95	-	7.30	19.4	21.1	18.6	4737	4410	4732	13879
24a	-	49.8	10.6	25.0	-	-	6330	-	-	6330
24b	-	45.28	10.6	21.0	24.8	-	5780	5240	-	11020
24c	-	42.2	10.6	17.5	21.4	18.3	5210	4470	4770	14450
25	95	-	4.9	14.4	15.0	13.2	4590	4500	4725	13815
25a	-	57.4	10.0	28.2	-	-	6815	-	-	6815
25b	-	46.5	8.0	21.0	21.7	-	5810	5775	-	11585
25c	-	35.8	7.0	14.0	14.5	12.1	4700	4575	4775	14050

** Δ P for strainer, in. H_2O

DELETED VERSION

C00105

DELETED VERSION

Test No	Source	PRESSURE, PSIG									
		[redacted]	[redacted]	Booster Pump	ECS Pump A Suction	ECS Pump A Disch	ECS Pump B Suction	ECS Pump B Disch	Xtie 1	[redacted]	[redacted]
26	BP, EPA	6.07	5.54	62.38	3.37	60.75	4.61	4.62	32.0	1.97	1.51
27	BP, EPB	5.88	5.40	62.47	4.72	4.72	3.34	60.79	32.2	1.87	2.17
28	BP, EPA&B	6.01	5.47	65.69	3.14	64.77	2.87	65.55	34.8	1.93	2.30
29	EPA	5.56	6.79	6.79	2.40	41.64	5.59	5.59	22.3	1.89	2.09
29a1	FPA	-	-	8.49	5.05	50.98	7.20	7.19	-	-	-
29b1	EPA	-	-	9.49	7.77	66.45	8.65	8.71	-	-	-
29c1	FPA	-	-	10.76	11.76	77.48	10.33	10.46	-	-	-
29a2	EPA	9.65	9.00	12.00	11.00	69.00	11.00	11.0	61.4	3.85	3.68
29b2	EPA	9.62	9.02	11.0	8.5	52.0	9.5	9.5	37.2	3.80	3.95
29c2	EPA	9.58	9.05	10.5	7.0	43.0	8.3	8.3	22.7	3.75	4.03
30	EPB	6.23	5.75	7.19	6.22	6.37	6.35	41.99	21.9	1.93	2.01
30a1	EPB	6.38	6.16	7.98	7.33	7.44	5.02	50.93	35.5	2.02	1.73
30b1	EPB	6.40	6.30	9.11	8.52	8.77	7.66	62.19	57.7	1.68	1.78
30c1	EPB	-	-	11.05	10.61	10.48	11.89	78.01	-	-	-
30a2	EPB	8.09	7.70	9.9	10.0	9.8	8.8	67.0	58.7	0.48	2.56
30b2	EPB	8.16	7.73	9.1	9.8	8.5	6.0	50.0	35.5	2.0	2.8
30c2	EPB	8.17	7.80	8.3	8.0	7.6	4.3	40.4	20.4	1.90	3.00
31	EPA&B	6.22	5.70	5.65	3.25	60.85	2.93	61.56	32.2	1.93	2.23

000195

DELETED VERSION

Test No.	Strainer ΔP	PRESSURE, PSIG					FLOW, GPM			
		Xtie 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	Total
26	-	42.25	5.3	17.0	17.5	15.3	5045	4925	5150	15120
27	-	37.22	5.09	16.9	17.5	15.1	5025	4895	5170	15090
28	-	43.25	4.73	18.0	18.7	16.1	5175	5115	5330	15620
29	-	30.2	6.55	11.7	12.1	10.7	4155	4240	4070	12465
29a1	-	41.0	8.11	-	-	-	5260	-	5580	10840
29b1	-	60.0	9.20	-	-	-	-	-	7330	7330
29c1	-	76.48	10.76	-	-	-	-	-	-	-
29a2	-	63.0	12.0	31.5	-	-	7140	-	-	7140
29b2	-	42.50	10.5	19.0	20.0	-	5525	5475	-	11000
29c2	-	29.75	10.0	12.0	12.5	10.7	4265	4110	4290	12665
30	-	29.8	7.00	11.4	12.0	10.5	4110	4220	4040	12370
30a1	-	37.26	7.99	18.1	1.7	16.9	5265	-	5540	10805
30b1	-	44.30	9.08	0.6	1.8	28.0	-	-	7300	7300
30c1	-	77.10	10.18	-	-	-	-	-	-	-
30a2	-	60.8	9.8	28.5	-	-	7035	-	-	7035
30b2	-	40.5	8.8	18.3	19.0	-	5400	5380	-	10780
30c2	-	28.0	8.0	11.1	11.5	9.5	4120	4020	4185	12325
31	-	35.48	5.56	16.8	17.5	15.2	5050	5190	5000	15240

DELETED VERSION

APPENDIX VI

DATA SHEET 2 - TEST DATA

DPSOL 105-1219 - 190 PUMP COMBINATIONS

APPENDIX VI
Page 1

DELETED VERSION

Test No.	Source	No. 190 Pumps	No. 105 HXS	Pressure, PSIG* [redacted]	[redacted]	Xtie	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	Strainer P*	[redacted]	Flow GPM [redacted]	[redacted]	[redacted]
32	[redacted]	3	2	54.2	5.7	36.50	4.2	1.1	20.5	19.6	0	50	-	5061	5490	0
32a		3	2	47.33	-	37.4	6.3	-	20.8	19.7	4.0	-	10.8	5120	5430	0
32b		3	2	55.40	-	-	5.64	-	-	-	-	-	-	0	0	0
33		2	2	26.8	5.63	21.50	2.05	0.84	11.5	11.1	0	25	-	3786	4077	0
33a		2	2	26.8	-	21.70	-	-	11.8	11.2	2.6	-	8.2	3800	4040	0
33b		2	2	23.85	7.82	15.8	3.52	3.66	-	-	-	-	-	3150	3260	3360
34		4	3	43.6	5.61	34.50	9.55	2.31	21.25	18.2	-	45	-	4590	5302	0
35		3	3	30.27	5.64	26.50	7.13	1.88	16.1	13.8	0	35	-	3940	4550	0
36		5**	6	33.98	5.67	30.25	16.9	1.17	23.1	16.0	-	30	0	3189	4806	0
37		4	6	26.68	5.71	22.50	12.60	1.29	16.5	11.8	-	20	-	2749	4165	0
38		3	2	4.59	47.11	40.50	2.11	7.24	21.2	24.2	7	50	-	5570	5180	0
39		2	2	4.74	26.71	23.25	1.73	4.34	11.9	13.5	4.1	55	-	4130	3890	0
39a		1	2	2.0	-	6.5	-	-	--	--	-	25	-	1857	2034	0

*Strainer P, in H_2O

** Only test in this series using double capacity 190 pump.

DELETED VERSION

APPENDIX VII

DATA SHEET 3 - TEST DATA

SYSTEM PRESSURE DROP DATA

000110

DELETED VERSION

APPENDIX VII
Page 1

Test No.	Booster Pump	[redacted]	ECS Pump A Suction	ECS Pump A Disch	ECS Pump B Suction	ECS Pump B Disch	Xtie	[redacted]	[redacted]	Xtie	[redacted]	[redacted]	[redacted]	Flow, GPM [redacted]	[redacted]	[redacted]
	PRESSURE, PSIG															
40a	9.62	10.26	9.8	74.3	10.1	74.2	65.0	1.9	1.03	67.0	34.0	65.5	64.0	7300	-	-
b	10.5	10.38	11.2	76.0	10.9	76.3	70.0	2.3	1.0	70.5	51.0	69.0	63.5	5475	-	-
c	10.4	10.7	11.5	77.2	11.5	77.7	73.0	3.3	1.01	73.1	62.5	74.0	74.5	3835	-	-
d	11.15	11.04	12.3	77.9	12.1	78.0	76.0	1.5	0.97	74.3	71.0	76.5	77.0	1875	-	-
41a	11.16	11.15	10.6	74.7	10.8	74.9	65.0	-0.55	3.55	67.5	67.0	37.0	64.0	-	7525	-
b	11.45	11.46	12.2	76.7	12.02	76.8	70.0	0.55	2.25	71.5	72.5	56.0	71.5	-	4625	-
c	11.74	11.75	12.8	77.5	12.5	77.7	73.0	-0.39	1.69	73.5	76.0	65.5	75.5	-	3675	-
d	12.0	11.94	13.25	78.0	13.0	78.0	75.0	-0.39	1.54	74.7	77.5	73.0	77.5	-	1900	-
42a	10.8	10.75	10.15	73.5	10.30	73.7	65.0	-0.42	1.45	66.8	65.5	65.0	31.0	-	-	780
b	11.35	11.30	11.7	76.5	11.7	76.4	70.0	-0.42	1.4	70.5	70.0	71.5	51.0	-	-	575
c	11.83	11.8	12.9	77.6	12.6	77.6	71.0	-0.44	1.80	73.5	75.5	75.0	63.0	-	-	395
d	12.14	12.8	13.3	78.5	13.1	78.7	73.0	-0.50	2.3	74.6	77.5	77.5	73.0	-	-	192
43a	9.67	9.50	7.70	67.51	7.82	68.9	47.2	-0.67	2.44	54.08	54.1	26.2	22.2	-	6175	650
b	9.77	9.74	8.53	70.12	8.44	70.28	52.3	-0.60	3.30	58.40	53.1	41.2	25.3	-	4300	700
c	10.53	10.38	9.52	72.43	9.60	73.34	59.8	-0.39	3.40	63.57	52.5	55.5	28.5	-	2100	750
d	10.75	10.64	9.95	73.36	9.82	73.55	61.2	-0.39	3.31	64.57	52.1	57.5	28.3	-	1475	759
e	9.92	9.84	8.79	69.35	8.44	70.78	52.5	-0.39	3.76	58.18	51.1	29.3	38.2	-	6600	485
f	10.36	10.31	9.34	71.50	9.32	72.57	57.9	-0.39	3.87	61.71	50.8	32.5	50.0	-	6950	319
g	10.82	10.76	10.15	73.29	10.05	73.34	61.5	-0.39	3.67	64.67	50.8	34.5	57.5	-	7200	180
44a	9.13	9.03	7.63	67.34	7.43	68.55	46.5	0.74	3.41	53.21	23.5	45.6	21.9	6175	-	652
b	9.43	9.48	8.25	68.52	8.13	69.85	51.3	0.71	3.34	57.67	38.5	58.4	24.5	4675	-	691
c	9.83	9.73	8.66	71.44	8.85	72.31	57.1	0.65	3.36	60.78	49.5	55.5	27.0	3000	-	727
d	10.23	9.38	10.11	72.19	9.19	72.43	60.4	0.51	3.33	63.64	56.0	59.5	28.5	1950	-	747
e	9.68	9.73	8.63	70.45	8.46	71.04	54.0	0.76	3.33	58.87	27.5	53.0	41.5	6625	-	440
f	10.19	10.39	9.34	72.39	9.23	71.84	60.0	0.75	3.22	63.45	30.4	58.5	53.5	6975	-	259
g	10.42	10.35	9.64	73.16	9.59	73.64	61.5	0.73	3.26	64.80	31.5	60.5	57.5	7100	-	186
45a	9.56	9.56	8.25	68.54	7.95	68.02	48.2	0.111	3.45	55.63	24.3	25.2	45.3	6250	6220	-
b	10.06	10.08	9.01	70.67	8.81	71.56	55.2	0.90	3.29	59.87	28.2	43.5	52.0	6700	4100	-
c	10.11	10.29	9.33	71.18	8.24	72.24	58.8	0.65	3.55	65.18	29.8	51.2	56.0	6900	3000	-
d	10.51	10.41	9.86	73.65	9.76	73.30	62.5	0.91	3.24	64.60	31.5	57.5	60.0	7140	1590	-
e	10.12	10.15	8.98	70.05	8.86	72.15	54.4	0.56	3.51	59.71	40.8	28.8	50.5	4525	6640	-
f	10.71	9.82	9.74	72.36	9.69	72.65	60.1	0.69	3.56	63.34	54.5	32.7	56.5	2485	7060	-
g	10.87	10.84	10.12	72.86	10.06	73.29	62.6	0.65	3.55	65.18	58.2	34.0	59.5	1735	7180	-
46	7.77	7.66	5.31	61.55	5.06	62.37	32.5	0.64	0.39	42.87	16.8	17.5	15.0	5140	5000	522

DELETED VERSION

00011[illegible]

APPENDIX VIII

ECS PUMP PERFORMANCE DATA

PROJECT S-3148

- Validation Data
- Head Curve
- Vendor Data

DELETED VERSION

APPENDIX VIII
Page 1

ECS PUMP HEAD CURVE VALIDATION DATA
Reference DPSOL RSP-85-001 (L-Area)

Special* Test No.	Booster Pump	[redacted]	ECS Pump A Suction	ECS Pump A Disch	ECS Pump B Suction	ECS Pump B Disch	Xtie	[redacted]	[redacted]	Xtie	[redacted]	[redacted]	[redacted]	Flow, GPM [redacted]	Flow, GPM [redacted]	Flow, GPM [redacted]
1	9.51	8.99	8.27	8.23	5.31	42.60	21.8	0.51	3.75	28.62	11.0	11.60	10.2	4150	4050	4250
2	9.91	9.29	9.02	8.96	6.83	51.94	35.5	0.17	3.35	38.45	17.7	1.2	16.5	5325	-	5610
3	10.33	9.71	9.46	9.45	7.63	57.11	44.0	0.27	3.37	48.27	22.2	1.0	1.9	5990	-	3850
4	10.12	10.34	10.24	10.20	9.21	65.79	57.0	0.35	3.32	57.90	-	1.0	1.9	3265	-	4470
5	10.04	11.11	11.01	10.98	10.58	72.84	67.0	0.72	3.14	67.45	-	0.7	-	3550	-	1625
6	10.86	11.41	11.44	11.47	11.67	76.63	73.0	0.44	3.19	72.90	-	0.7	-	1170	-	1680
7	10.26	11.36	11.26	11.34	11.18	75.72	71.0	0.69	3.17	70.50	-	0.7	-	1625	-	2240
8	10.72	11.09	11.08	11.11	10.43	71.89	66.0	0.26	3.21	66.79	-	0.7	-	3040	-	2530
9	10.47	10.92	10.66	10.79	9.99	68.62	62.0	0.36	3.22	63.72	-	0.9	-	2960	-	3540
10	10.01	9.98	9.67	9.69	7.86	57.05	44.0	0.51	3.28	49.20	6.1	1.1	7.8	4730	-	5050

Special test completed with DPSOL RSP-85-001

000113

DELETED VERSION

ECS PUMP HEAD CURVE VALIDATION CALCULATIONS
Reference DPSOL RSP-85-001

ECS Pump	Test No.	Pressure, PSIG Suction	Pressure, PSIG Disch	Flow GPM	Vel* Corr	Elev Corr	Head Ft H_2O
A	29	2.40	41.64	12465	6.1	2.25	98.6
A	29a1	5.05	50.98	10840	4.6	2.25	112.5
A	29b1	7.77	66.45	7330	2.1	2.25	139.3
A	29c1	11.96	77.48	0	0	2.25	152.9
A	40a	9.8	74.3	3650	0.68	2.25	151.3
A	40b	11.2	76.0	2737	0.29	2.25	151.6
A	40c	11.5	77.2	1917	0.14	2.25	153.5
A	40d	12.3	77.9	937	0.03	2.25	153.2
B	30	6.35	41.99	12370	6.0	2.25	90.2
B	30a1	5.02	50.93	10805	4.6	2.25	112.4
B	30b1	7.66	62.19	7300	2.1	2.25	129.8
B	30c1	11.89	78.01	0	0	2.25	154.3
B	S	9.45	64.0	8325	2.7	2.25	130.4
B	S	5.31	42.6	12450	6.0	2.25	94.0
B	S	6.83	51.94	10935	4.7	2.25	110.7
B	S	7.63	57.11	9840	3.8	2.25	119.8
B	S	9.21	65.79	7735	2.3	2.25	134.7
B	S	10.58	72.84	5175	1.0	2.25	146.5
B	S	11.67	76.63	2850	0.3	2.25	152.0
B	S	11.18	75.7	3865	0.6	2.25	151.3
B	S	10.43	71.89	5570	1.2	2.25	144.8
B	S	9.09	68.62	6500	1.6	2.25	138.7
B	S	7.86	57.05	9780	3.7	2.25	119.1

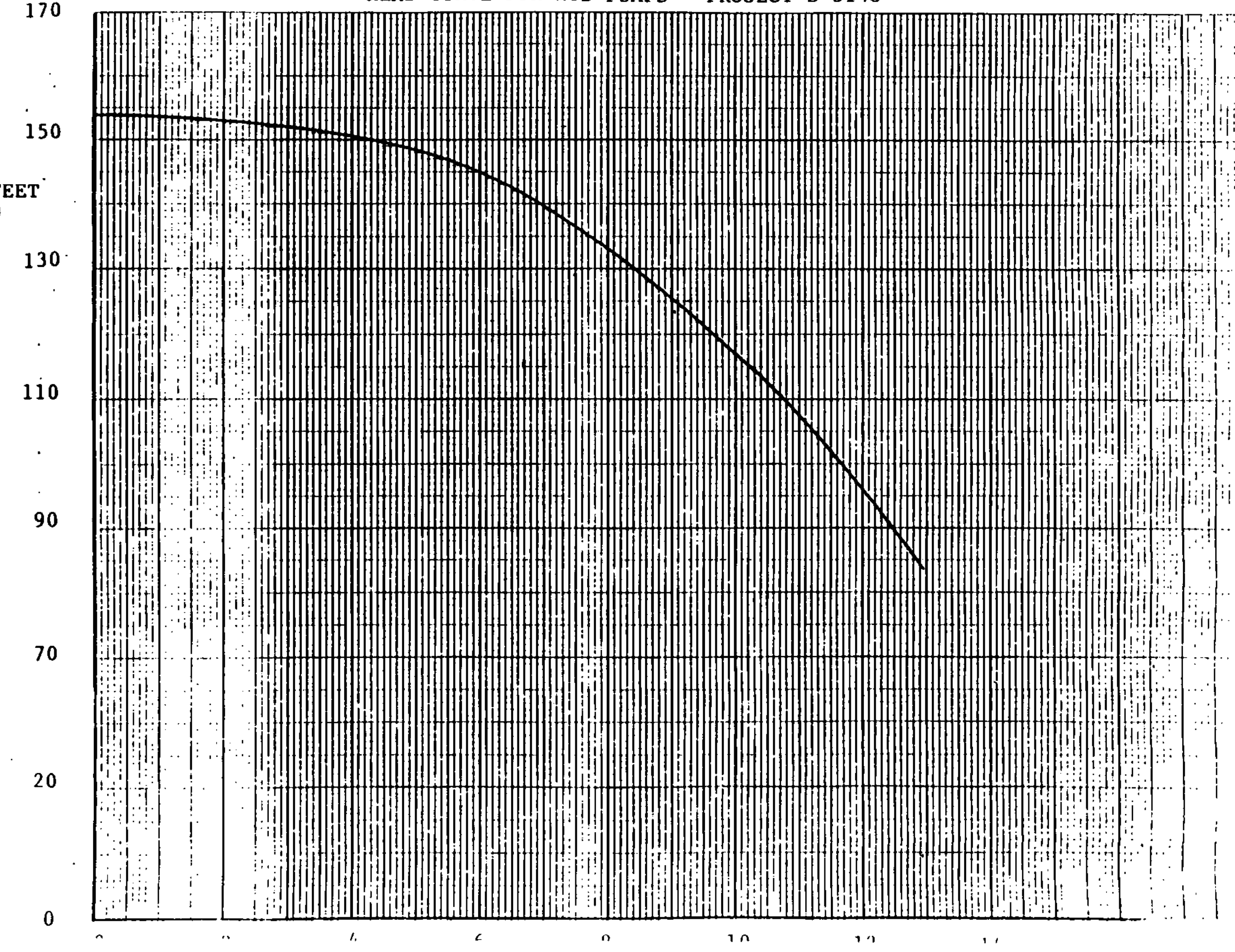
* Head = $0.03898\ (Q/1000)^2$

S = Special test completed with DPSOL RSP-85-001. See page 1 Appendix VIII.

NO. 340R-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.

HEAD CURVE FOR ECS PUMPS - PROJECT S-3148



0001160

CC: C. G. Mullins-AED-707C-SRP
T. A. Mc Cormick-AED-WCCIII
G. C. Cambre-PED-L3306
A. E. Santella-A/S-Louviers
IC 33 (2)

September 25, 1985

I. B. NEW, JR.
ATOMIC ENERGY DIVISION
PETROCHEMICALS DEPARTMENT
MONTCHANIN BUILDING 6600

ATTENTION: D. G. OWEN

PROJECT S-3148 - SAVANNAH RIVER PLANT
RESTORE PUMP SYSTEM FOR EMERGENCY COOLANT - 105 P, K, L, AND C
ABS PUMP PERFORMANCE

Attached are vendor's certified performance curves for each pump. Also attached is Quality Assurance Report No. 7 dated May 8, 1985, which documents the verification of pump cutoff head for Pump L340-181-1 (ABS Serial No. 707).

R. C. Steelman-AES, J. H. Hinton-AED-SRP, and B. Rummel (Du Pont's inspector) witnessed the pump test establishing pump cutoff head at the vendor's manufacturing facility in Germany.

PROJECT ENGINEERING DIVISION
Atomic Engineering Section

T. S. Mc Elrath
Project Engineer

TSM:jsm
TSM:1.13

Atchs

DU PONT DE NEMOURS INTERNATIONAL S.A.
50-52, ROUTE DES ACACIAS
CH-1211 GENEVA 24, SWITZERLAND

DUPONT

QUALITY ASSURANCE ENGINEERING
EUROPE

☒INSPECTION ☐EXPEDITING

REPORT No. 7

C.C. ~~P. C. Fahey~~
R.C. STEELMAN - L3334
J.F. ABELS - L11W15
IC-QAMUE-ORIGINAL

TO : J.I. Slee

DATE: May 8,85

FROM : B. Rummel

PROJECT : 95 3148

PLANT: Savannah River

P.O. NO. : AXC 9201-W

EQ. PC. NO.: L 340-181-1/2

EQUIPMENT: 2 pcs Submersible pumps

VENDOR : ABS Pumps

ADDRESS : 5204 Lohmar

CONTACT : Mr. Sauer, Mr. Flucher
Mr. Bonn

PHONE: 02246

VDR'S REF. : 663851

☐COMPLETE ☒NOT COMPLETE

CURRENT PROMISE: 2 pumps week
Remaining end May 85

JRS
DAO
EWW
RLJ

Visit to ABS May 3,4 and 6,85

1. Material
Two submersible pumps type AF 2700-8/GS III, 16"/20" - 150 FF, 460 Volts, 3 phases, 60 cyc. including double mechanical seal. Serial Nos. 707 and 708. Tag L 340-181-1/2

2. Inspection and testing made in presence of Mr. R.T. Steelman and J.H.Winto on 5/3 and 4.
Pump with Motor No. 707 was kept running at a discharge rate of 1200 gpm (271 m^3/h) till 5/3,85 a.m. On 2/5 the cooling pump was switched off from 15 hrs till 19 hrs to see the temp. rise.
During the last phase of the test, pump was run at a flow as low as 135 m^3/hr and kept running till May 4,85 at 6 a.m.
Pump motor 708 was installed with 620 mm dia impeller to check if its characteristic was similar to the 1st 620 mm dia impeller.
Meanwhile the 1st impeller was machined to 617 mm and trimmed to get closer to the max. head specified for shut off and the operation flow of 7000 gpm.
The performance was now acceptable, however it was proposed by Mr. Winto to leave this impeller dia. and to machine the 2nd down to 615 mm, trying to get even closer.
Following tests were made:

2.1. Completion of endurance test
2.2. Performance test on the 2nd impeller to determine the final diameter
2.3. Oil sample drawn from the oil chamber of pump to test for water contamination.
2.4. Opening of pump top covers opened to check for water penetration.
2.5. Megger test for winding condition after the test.
2.6. Check for flange dimensions on the two spiral casings to be shipped.
2.7. Surface finish of shaft in seal area and of flange faces.
2.8. Nameplate details, painting and preparation for shipping.

3. Results

3.1. Pump 707 passed the endurance test with satisfactory results. Winding and bearing temp. remained stabile during the test. During the 4 hrs. when the cooling circulation pump had been switched off, winding temp rose 37,2 deg. C.(See also enclosed charts)

FAX QAE SERIAL NO 286

DU-PONT DE NEMOURS INTERNATIONAL S.A.
50-82, ROUTE DES ACACIAS
CH-1211 GENEVA 24, SWITZERLAND

QUALITY ASSURANCE ENGINEERING
EUROPE

3. . The performance of pump with the reduced impeller dia. and trimmed blades was acceptable, with the head at shut off 49,6 m (162,7 ft) and about 1 ft lower head at at duty point of 1589 m^3/h (7000 gpm).

3.3. After evacuation of the oil sample in vacuum, no water formation could be observed.

3.4. After opening, motor heads were found free from water. Covers were closed again and chamber leak tested at an air pressure of 1 bar, dipping the pump into water.

3.5. Flange dimensions were found correct to ANSI 20 and 16" FF.

3.6. Surface finish in the area of mechanical seal on shaft No. 4 found 32 AA (16 AA specified for lipprings and journals)
Roughness of flange face specified 126 AA. As this looked too rough, fabrication drwg. was checked, where stock finish was specified. Acc. to Mr. Hinton this is far to rough, and Production manager Mr. Fischer was advised. On monday 3/6, both discharge and suction faces were smoothed until the specified finish was reached.

3.7. Pumps are provided with two nameplates indicating all pump data. Motor ser. No. 663851/00707 equipped with impeller diam. 617 mm, tag No. L 340 - 181 - 1
Each impeller is also die stamped with the diameter.

After supporting the power cables to obtain the appropriate radius, pump was covered with a shrink foil for protection, and the case completed.
Both pumps shipped same day.

. Further schedule:

Next two pumps are scheduled for testing not before May 10,83
Exact time will be obtained by phone from ABS.

Encl. Endurance test sheets
computer print outs for the 3 impeller diameters

000113

ABS Pumpen AG

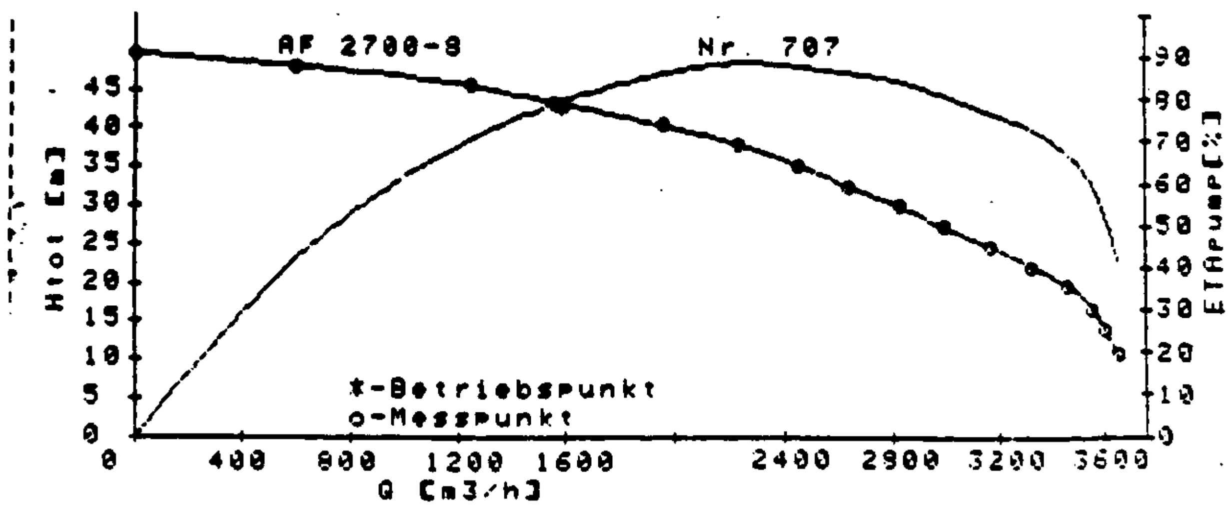
Testdepartment

ELECTRICAL & HYDRAULICAL TESTS

653 851	AF 2700 - 8	707	1	Blön/Grau	04.05.85	12
Order-No.	Type	Serial-No.	OP-No.	Tested by	Date	Page

Item No.	Tests	estimated resp. calculated	Units	Test resp. Value

H [m]	Htot [m]	Q [m3/h]	P1 [kW]	I [A]	cos φ	η ges [%]	η mot [%]	η pump [%]	P2 [kW]
49.7	49.7	0	182	329	0.69	0	92.9	0	169.
47.9	48.1	603	201	349	0.72	39.3	93.1	42.2	187.
44.8	45.5	1244	236	389	0.76	65.3	93.2	70.1	220.
42.3	43.3	1562	251	408	0.77	73.5	93.2	78.8	233.
38.7	40.4	1962	269	428	0.79	80.2	93.1	86.1	250.
35.7	37.8	2230	279	444	0.79	82.6	93.2	88.7	259.
32.6	35.2	2450	280	450	0.80	81.9	93.2	87.8	268.
29.5	32.5	2642	291	456	0.80	80.4	93.2	86.3	271.
26.5	29.9	2835	294	460	0.80	78.6	93.2	84.3	274.
23.4	27.2	2998	295	461	0.80	75.4	93.2	80.9	275.
20.4	24.6	3169	297	465	0.80	71.6	93.2	76.8	276.
17.3	22.0	3330	294	461	0.80	67.9	93.2	72.9	274.
14.6	19.6	3460	295	460	0.80	62.8	93.2	67.3	275.
11.2	16.6	3561	289	452	0.80	55.6	93.2	59.7	269.
9.12	13.7	3610	278	441	0.79	48.3	93.2	51.9	259.
5.06	10.7	3651	269	426	0.79	39.7	93.1	42.6	250.



Impeller size: 617 mm

ABS Pumpen AG

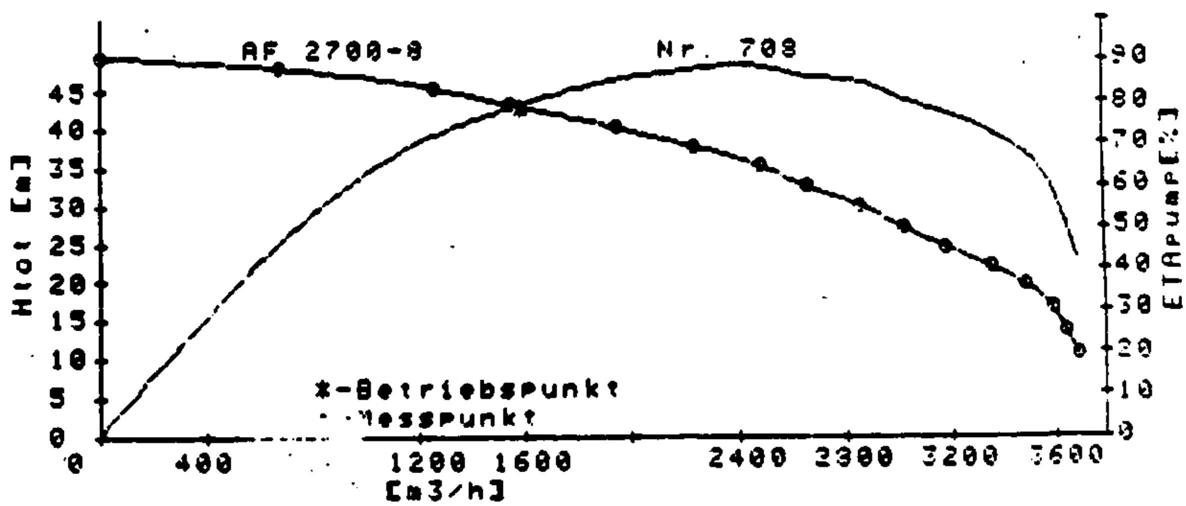
Testdepartment

ELECTRICAL & HYDRAULICAL TESTS

663 851	AF 2700 - 8	708	2	Grau	04.05.85	12
Order-No.	Type	Serial-No.	OP-No.	Tested by	Date	Page

H [m]	Htot [m]	Q [m3/h]	P1 [kW]	I [A]	cos φ	η_{ges} [%]	η_{mot} [%]	η_{pump} [%]	P2 [kW]
49.6	49.6	0	187	334	0.70	0	92.9	0	173
47.9	48.1	679	206	355	0.73	43.2	93.1	46.4	191
44.8	45.5	1260	233	385	0.76	67.1	93.2	[illegible]	217
42.3	43.3	1550	250	404	0.78	73.2	93.2	[illegible]	233
38.7	40.3	1940	269	428	0.79	79.6	93.1	[illegible]	250
35.7	37.8	2233	281	443	0.80	81.8	93.2	87.8	261
32.6	35.2	2484	289	453	0.80	82.5	93.2	88.5	269
29.5	32.5	2658	294	458	0.81	80.2	93.2	86.0	274
26.5	30.0	2861	296	461	0.81	78.9	93.2	[illegible]	275
23.4	27.3	3017	298	465	0.80	75.3	93.2	80.7	277
20.4	24.7	3179	296	464	0.80	72.2	93.2	77.4	275
17.3	22.1	3350	296	462	0.80	68.1	93.2	73.0	275
14.6	19.7	3479	295	462	0.80	63.3	93.2	67.9	275
11.2	16.6	3584	290	453	0.80	56.0	93.2	60.1	270
8.12	13.7	3635	281	443	0.80	48.4	93.2	[illegible]	261
5.06	10.8	3660	271	429	0.79	40.0	93.1	43.0	252

615 mm



Impeller size: 615 mm

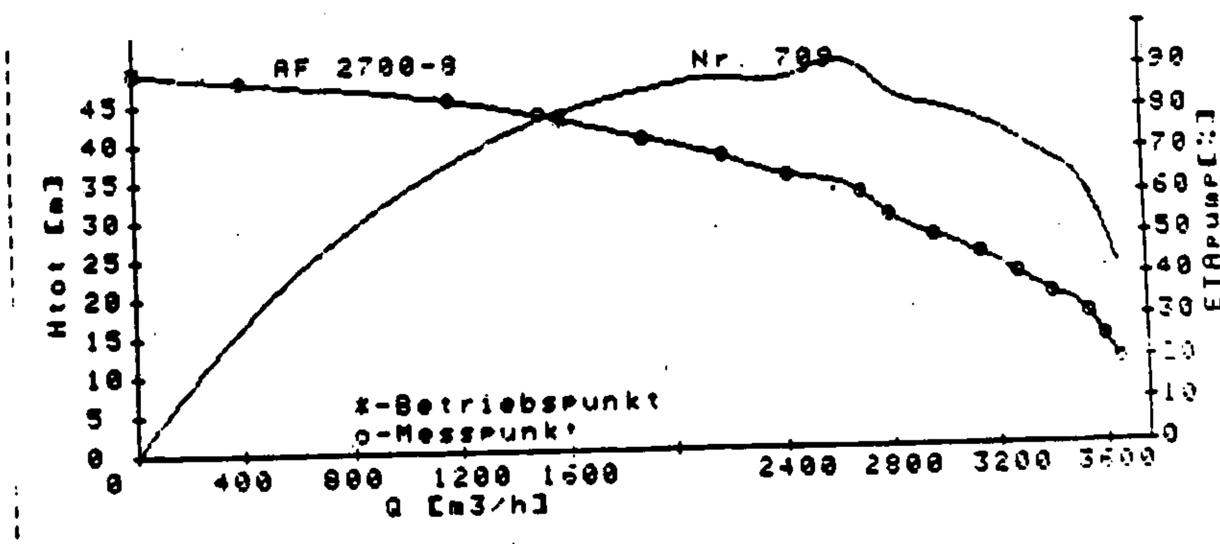
ABS Pumpen AG

Testdepartment

ELECTRICAL & HYDRAULICAL TESTS

Order-No.	Type	Serial-No.	OP-No.	Tested by	Date	Page
663 851	AF 2700 - 8	709	G6/M4	Grau/Blönig	08.05.85	12

H [m]	Htot [m]	Q [m3/h]	P1 [kW]	I [A]	cos φ	η ges [%]	η mot [%]	η pump [%]	P2 [kW]
49.2	49.2	0	178	320	0.70	0	92.8	0	165.
47.9	48.0	394	184	329	0.70	28.0	92.9	30.1	170.
44.8	45.4	1166	226	374	0.76	63.8	93.2	68.5	210.
42.3	43.3	1510	242	392	0.77	73.5	93.2	78.9	225.
38.7	40.2	1891	260	413	0.79	79.7	93.2	85.6	242.
35.7	37.7	2180	272	428	0.80	82.3	93.1	88.3	253.
32.6	35.1	2424	282	441	0.80	82.2	93.2	88.2	262.
29.5	32.6	2698	285	444	0.81	84.2	93.2	90.3	265.
26.5	29.8	2880	288	451	0.80	79.0	93.2	84.7	268.
23.4	27.1	2961	290	451	0.81	75.5	93.2	[illegible]	270.
20.4	24.6	3142	291	452	0.81	72.2	93.2	[illegible]	271.
17.3	21.9	3275	286	449	0.80	68.2	93.2	73.2	266.
14.6	19.5	3401	284	444	0.80	63.5	93.2	68.2	264
11.2	16.5	3535	291	440	0.80	56.5	93.2	60.7	261.
9.12	[illegible]3.6	3[illegible]1	271	430	0.79	49.1	93.1	52.7	252
5.06	[illegible]0.7	3645	264	418	0.79	40.3	93.2	43.2	245.



Impeller size: 615 mm

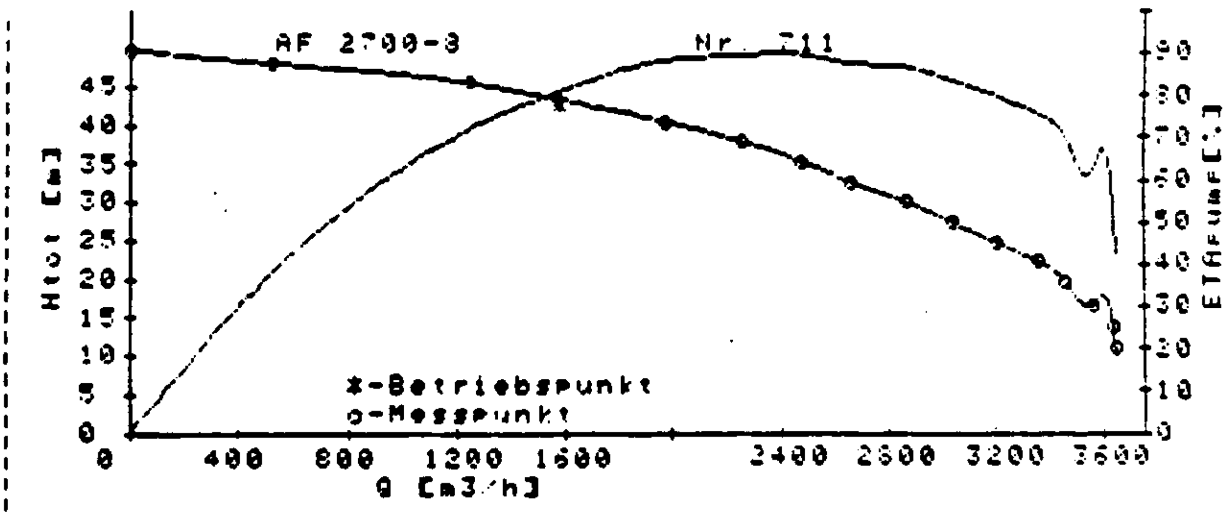
ABS Pumpen AG

Testdepartment

ELECTRICAL & HYDRAULICAL TESTS

Order-No	Type	Serial-No.	OP-No.	Tested by	Date	Page
663 851	AF 2700 - 8	711	G7/M5	Blönigen	22.05.85	12

H [m]	Htot [m]	Q [m3/h]	P1 [kW]	I [A]	cos φ	η ges [%]	η mot [%]	η pump [%]	P2 [kW]
49.8	49.8	0	177	322	0.69	0	92.9	0	164.
47.9	48.0	524	194	339	0.72	35.3	93.0	38.0	180.
44.8	45.5	1244	230	380	0.76	67.1	93.2	71.9	214.
42.3	43.3	1575	247	400	0.78	75.3	93.2	80.8	230.
39.7	40.4	1983	265	423	0.79	82.4	93.2	88.4	246.
35.7	37.8	2257	279	439	0.80	83.4	93.2	89.5	259.
32.6	35.2	2494	285	449	0.80	33.6	93.2	89.9	265
29.5	32.6	2668	290	452	0.81	81.6	93.2	87.6	270.
26.5	30.0	2963	290	455	0.80	80.8	93.2	86.7	270.
23.4	27.4	3042	292	456	0.80	77.6	93.2	83.3	272.
20.4	24.7	3202	290	456	0.80	74.4	93.2	79.8	270
17.3	22.1	3360	288	451	0.80	70.2	93.2	75.4	268.
14.6	19.6	3453	284	445	0.80	65.1	93.2	69.9	264.
11.2	15.5	3560	273	438	0.80	57.3	93.2	62.1	253
8.12	13.7	3636	269	425	0.79	50.5	93.1	54.3	250.
5.57	11.2	3645	259	414	0.79	43.0	93.2	46.2	241.



Impeller size: 615 mm

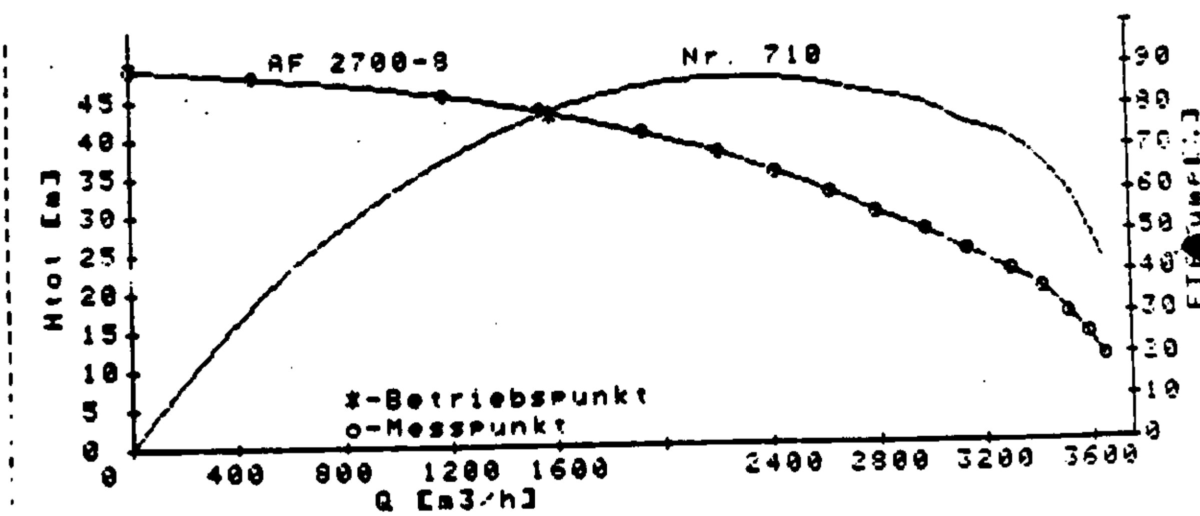
ABS Pumpen AG

Testdepartment

ELECTRICAL & HYDRAULICAL TESTS

Order-No.	Type	Serial-No.	OP-No.	Tested by	Date	Page
863 851	AF 2700 - 8	710	G3/M3	Grau/Blönig	10.05.85	12

H [m]	Htot [m]	Q [m3/h]	P1 [kW]	I [A].	cos φ	η ges [%]	η mot [%]	η pump [%]	P2 [kW]
49.2	49.2	0	181	330	0.69	0	92.9	0	168.
47.9	48.0	465	191	343	0.70	31.8	93.0	34.2	177.
44.8	45.4	1183	230	385	0.75	63.7	93.2	68.3	214.
42.3	43.3	1546	240	407	0.76	73.6	93.2	78.9	231.
38.7	40.3	1929	265	427	0.78	79.9	93.2	85.8	246.
35.7	37.7	2210	278	444	0.79	81.7	93.2	87.7	258.
32.6	35.1	[illegible]	285	451	0.79	81.6	93.2	87.5	265.
29.5	32.5	[illegible]	291	458	0.80	79.9	93.2	85.7	271.
26.5	29.8	2806	293	461	0.80	77.8	93.2	83.5	273.
23.4	27.2	2988	294	462	0.80	75.4	93.2	80.9	274.
20.4	24.6	3142	296	464	0.80	71.0	93.2	76.2	275.
17.3	21.9	3305	292	460	0.80	67.7	93.2	72.6	272.
14.6	19.5	3425	292	459	0.80	62.4	93.2	67.0	272.
11.2	16.4	3520	284	449	0.79	55.5	93.2	59.6	264.
8.12	13.6	3590	276	441	0.79	48.2	93.1	51.7	257.
5.06	10.7	3648	265	426	0.78	40.2	93.2	43.1	246.



10.5.85 G.

Impeller size: 615 mm