NTO-R-0106

NTO TEST REPORT FOR

Duct Coolant System Water Flow Tests. Duct Experimental Plan I & NES Experimental Plans I, II, III and IV.

NERVA TEST OPERATIONS

Jackass Flats, Nevada

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NERVA TEST OPERATIONS Nuclear Rocket Development Station

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NTO-M-15750

March , 1967

Mr. C. M. Rice, Program Manager
Nuclear Rocket Operations
Aerojet-General Corporation
Post Office Box 15847
Sacramento, California 95813

Attention: J. R. DaVolio

Subject: Transmittal of NTO Test Report for Duct Coolant System Water Flow Tests, Duct Experimental Plan I and NES Experimental Plans I, II, III and IV, NTO-R-0106

Dear Mr. Rice:

Attached is the final report for the NES Duct Coolant Water Flow Tests conducted during Duct Experimental Plan I and NES Experimental Plans I, II, III, and IV.

Very truly yours,

N. E. Erickson, Manager
NERVA Test Operations

DHC:NEE:eo

Attachment
Distribution: (See attached list)

MASTER

NTO TEST REPORT

FOR

DUCT COOLANT SYSTEM WATER FLOW TESTS

DUCT EXPERIMENTAL PLAN I AND

NES EXPERIMENTAL PLANS I, II, III & IV

NTO-R-0106

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MARCH 1967

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1.0 INTRODUCTION

The objectives of the NES Duct Coolant System Water Flow Tests was to check out the Duct Coolant System under dynamic flow condition, to determine adjustments needed to achieve the prescribed flow rates in the various flow paths, and to determine its operational characteristics.

Generally, the objectives were met in the first series of the tests conducted, Duct Experimental Plan I, and verified or completed during Phase I of the NES Experimental Plan I through IV. This report covers this test period.

1.1 SPECIFIC TEST OBJECTIVES

1.1.1 To determine the optimum duct fill procedure and determine the water flow required to compensate for the bleed and drain discharge.

1.1.2 To determine the flow rates through the several parallel flow paths within the duct, and to adjust the flow rates if necessary by resizing the appropriate orifices.

1.1.3 To determine the system flow dynamics and characteristics over the range of process water tank level.

1.1.4 To determine whether any instability occurs during flow tests which might cause vibrations detrimental to the duct structure and, if so, collect data on which to base corrective action.

2.0 SUMMARY

The DEP-I Tests showed that the duct will withstand the flow rates required without the occurance of detrimental vibration, and that flow can be controlled by FCV-32. Flow through the three duct sections was adjusted to meet specified requirements with the exception of Section One, which flows approximately 16% in excess of the specified minimum rate.

DEP-I-1, the first orifice sizing test conducted on 16 November 1966, was run at full flow with all three flow control valves 100% open. Flow rates through Sections One and Three were lower than required and the flow rate through Section Two was higher than required. Severe vibrations were visually observed and were attributed to cavitation induced by the reduced back-pressure conditions. Analysis showed that with a backpressure of approximately 60 psi on the duct and with flow control orifices removed from Sections One and Three, the flow rate in each section would be at or near the design requirements. This increase in backpressure would have the additional advantage of suppressing cavitation resulting in a smoother operation.

DEP-I-2, conducted on 7 December 1966, used FCV-32 to establish the required flow of approximately 5576 GPM at FE-56 and FE-57, the flow elements for Section Two. Measured flows in Sections One and Three were approximately 6850 and 7700 GPM, respectively, as compared to the specified 5878 and 7563 GPM minimum.

Observed duct vibration was significantly less than in the previous test. The NES Phase I Tests were conducted during the period of 19 January through 7 February 1967. Prior to initiating these tests, the 4" and 12" duct supply valves, RSV-296 and RSV-297, respectively, which were being repaired during the DEP-I Test Series, were installed and the automatic bleed-in portion of the test program was conducted. It was determined that RSV-296 is sufficient to fill and maintain the NES Duct Coolant System in the full condition.

It was also determined during the Phase I Tests that the flow through the secondary duct exit eight tube cooling system as presently constituted was inadequate with flow rates of approximately 650 GPM being recorded and a minimum of 800 GPM required.

Section One of the NES duct was rebalanced during this phase and the main flow system is now considered in balance.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

As a result of the NES Duct Cooling System evaluation, the following conclusions are made:

3.1.1 The minimum required cooling flow rates can be accommodated by each section (total of three) of the duct at the minimum expected water tank level.

3.1.2 By utilizing the flow control valve (FCV-32) to maintain sufficient backpressure, the cooling flow rates can be attained and duct cavitation suppressed. Some cavitation is still evident at the outlet of FCV-32 as reflected by P-600.

3.1.3 The cooling flow through the secondary duct exit eight tube cooling circuit was inadequate with the flow measured being in the range of 650 GPM while the required minimum flow was 800 GPM.

3.1.4 Initial bleed-in of the duct can be affected by the use of RSV-296, the 4" water supply valve. Completion of the bleed-in (requiring approximately 38 minutes) is constrained by the shield water tank. Initial bleed-in time of the duct can be decreased by increasing the size of the two shield water tank fill orifices, RO-84 and RO-85. However, this will increase the water consumption, since water flows through these orifices continuously. It is not now recommended that this action be initiated.

3.1.5 Control of the drain flow was manually effected through GLV-2469 and GLV-2470. These valves were closed during hold periods to conserve water, but were adequate to permit duct draining when required.

3.1.6 Pressure sensing instrumentation as installed appears to be marginal because of the following:

a. Some transducers operating at above nominal working pressure,

b. Water leakage problems in the connectors,

c. Noisy pressure transducer signals possible caused by vibration transmitted through the transducer mounts,

3.2 RECOMMENDATIONS

Based on the above conclusions, the following recommendations are made:

3.2.1 Cavitation in the FCV-32 discharge line should be suppressed by appropriate orificing.

3.2.2 The secondary duct exit eight tube cooling circuit should be discharged to atmosphere through two RSV's, instead of being returned to the duct discharge circuit. The discharge line size should be increased to reduce the excessive pressure drop. Effect of cavitation should be evaluated in the re-design.

3.2.3 The duct drain valves should be converted to remotely operated valves since access to the area is not always possible. This recommendation is being initiated.

3.2.4 The duct pressure sensing instrumentation should be re-evaluated as follows:

3.2.4.1 Delete extraneous sensors such as the following:

a. Section 3 outlet orifice transducers (total of 2) because of deletion of the balance orifices

b. Duct section inlet pressures (total of 6) because they are duplicated by facility transducers which are accessible after a nuclear engine test

3.2.4.2 Re-size the existing transducers so they do not operate above their normal working pressure range.

3.2.4.3 Design and install vibration attenuation mounts and evaluate means for mechanically or electrically filtering the transducer signal.

3.2.4.4 Evaluate means for waterproofing the transducer connections since access to the duct vault area will be limited after a nuclear rocket test. Investigate the feasibility of modifying the transducer-armoured cable joint to incorporate a water proof connector. This will facilitate the replacement of transducers which is now a very difficult and tedious task.

3.2.4.5 Modify the ETS-1 signal conditioner mode card on the strain gauge channels to be compatible with the grounding circuit to eliminate the large zero offsite present.

3.2.5 The TV camera mounted on the Duct Vault south wall near the forward trunnion provided very good visual information. If heat and radiation are not too extreme, a camera should be placed in that location for engine tests.

4.0 TECHNICAL DISCUSSION

4.1 GENERAL

The Duct Coolant System Water Flow Tests were initiated on 16 November 1966 and completed on 7 February 1967. The tests were conducted in accordance with the following documents:

a. NRO Test Specification No. 101

b. Test Description for Duct Experimental Plan I, NTO-I-0137A (presented as Appendix I)

c. Support Operational Requirements Document for NES Experimental Plans I, II, III, and IV, NTO-I-0157

The Field Action Request (FAR) procedure, established by the NES Project Department to define, specify, detail and approve all work on or affecting the NES Duct System, was initiated. An index of the FAR's received between 25 October 1966 and 7 February 1967 is presented as Appendix II.

Table I, Duct Water Flow Test Summary, presents a brief description of the test planning data and results of the test series. The NES Duct System Test Data Tabulation, which is shown in Table II, presents data from the test runs and as well as calculated fluid flow rates. The symbols used to denote instrumentation parameters are defined in Figure 2.

The Duct Coolant System Water Flow Tests consisted of a leak test, orifice sizing tests, and water flow in support of NES Design Demonstration Tests. The tests were conducted from the ETS-1 Control Room utilizing the control console specifically provided for operation of the NES Duct Water System. The following documents describe the testing procedure:

a. Control Room Operating Procedure for Duct Experimental Plan #1, NTO-I-0147.

b. Control Room Operating Procedure for Duct Experimental Plan I-2, NTO-I-0147, Revision A.

c. Control Room Operating Procedure for NES Experimental Plan I, NTO-I-0166.

d. Control Room Operating Procedure for NES Experimental Plan II, NTO-I-0169.

e. Control Room Operating Procedure for NES Experimental Plans II, IV and V, NTO-I-0170.

f. Control Room Operating Procedure for NEX Experimental Plan IV, NTO-I-0199.

4.1.1 Instrumentation

Problems were encountered throughout the test program with the permanent pressure transducers. The pressure transducers were of such a pressure range that during the duct-filling phase, the transducers were grossly overranged. Failure of low range differential pressure transducers was due to open circuits or short circuits in the transducer electrical bridge circuits. Some of these failures were definitely traced to water leakage at the transducer cable interface. These transducers are constructed such that the cable and transducer are inseparable. Other failures of the differential pressure transducers were due to either high differential pressure transients or severe mechanical vibration.

There was also excessive noise from the low pressure transducers. This was thought to be due to mechanical vibration. However, parallel transducers, with and without shock mounts, installed during the NEP series indicated that the major low frequency (300 to 500 cps) component of the noise is due to flow perturbations.

Problems were also encountered with the strain gauge sensors. Large zero offsets were experienced which was caused by grounding the shields at the transducer creating a ground loop in the ETS-1 Data System.

4.2 DEP-I-1

DEP-I-1, conducted 16 November 1966, consisted of a Leak Test and the first Orifice Sizing Test.

4.2.1 Leak Test

In order to obtain and hold operating pressure for leak checking the instrumentation connections, certain flow passages were blocked.

Because the two small supply valves, RSV-296 and RSV-297, had been removed for repair, the filling operation was not completely remote. RSV-298 was opened approximately 5% as estimated by personnel stationed in the pipe vault, and then BFV-666 was manually opened approximately 5%. A 12-inch flange in the pipe vault began leaking, but the leak was stopped after the flange bolts were tightened. The duct was then filled without incident, with bleeding taking place in the provided locations. Numerous duct leaks were noted, however, all expect one on the elbow secondary water jacket has been found during hydrotest and accepted. Some are built in by the duct design. After all leaks had been noted, the draining of the duct was initiated so that the blocked lines could be opened for the Orifice Sizing Test to follow.

4.2.2 Orifice Sizing Test

At the beginning of the Orifice Sizing Test, the water level in the Process Water Tank, T-3302, was at 42' 10" as observed at the tank level indicator.

4.2.2.1 The duct was refilled, using the same technique as for the earlier leak test; this time however, with all lines open, water flowing from bleeds could be observed and the water shield jacket and water shield tank filled with water. Also, RSV-298 was positioned at 10% instead of 5% to decrease fill time. Water from the eight high point bleeds, directed outward from the water shield tank, could be seen on the television monitor in the Control Room, as could the overflow from the tank. Tank overflow was first observed 45 minutes after filling was started.

4.2.2.2 Flow was initiated through the system with the opening of FCV-30. A visual inspection lasting about 5 minutes revealed no evidence of leakage or abnormal vibration in the pipe or duct vaults. RSV-298 was then opened 100%, followed by the opening of FCV-31. After another visual inspection of pipe and duct vaults, FCV-32 was opened. With the duct then at full flow, a third visual inspection was conducted; this time however, there was significant evidence of cavitation induced vibration. Valve GAV-669 was opened to simulate flow to the Steam Generator System (SGS) and Engine Test Compartment (ETC). This caused no observable change to system behavior, except to drop the supply pressure approximately 3 psig, measured at PT-168 and PT-597.

4.2.2.3 The attempt to get motion pictures of water discharge areas was unsuccessful because of insufficient light.

4.2.2.4 FCV-32 was then closed to the 50% position causing the backpressure measured at PT-596 to increase from approximately 12 psig to approximately 21 psig, but caused no noticeable change in flow.

4.2.2.5 Shutdown was started by closing FCV-31, FCV-30, and RSV-298 in turn when the level in the Process Water Tank, T-3302, reached 13 feet. The system was then drained of residual water below BFV-666. The final level of T-3302 was observed as 12 feet.

4.2.2.6 A chronology of events during DEP-I-1 is presented as Table III.

4.2.3 Data Review

4.2.3.1 Static values were recorded during the leak test to disclose any anomalies in the data acquisition system. The entire system was exposed to the full operating pressure of approximately 250 psig, grossly overranging the 0-100 psig transducers (P-204, P-205, P-209, P-210, P-223, and P-226. These were replaced with temporary 0-300 psig transducers in the interval between DEP-I-1 and DEP-I-2 and are denoted as "-2" in Table II.

4.2.3.2 Differential pressure measurements at duct flow elements showed that flow in Sections 1 and 3 was too low, and Section 2 was excessive. Pressures and flows for the six duct flow elements are tabulated in Table II for full flow conditions.

4.2.3.3 An analysis of pressures and flows revealed that design flow rates could be expected in Sections 1 and 3 if flow control orifices in those sections were removed, and if FCV-32 was used to establish the design flow rate in Section 2, the elbow. A backpressure of approximately 60 psig measured at PT-596 was expected. The major advantage of this concept is that the experienced cavitation induced vibration would be suppressed.

4.2.3.4 Most of the pressure transducer traces, both absolute and differential, were very hashy and sometimes erratic. This is suspected to be caused by vibration transmitted to the instrument through the mounting brackets. As a temporary fix before DEP-I-2, ΔP transducers on the duct were raised off their mounts and cushioned with an open cell foam material commonly used for packing electrical components.

4.2.3.5 Values for three data points are given in Table II. The data points were selected to show values during startup when FCV-32 was 50% open (range time 58543), during full flow when FCV-32 was 100% open (range time 59414, and when backpressure at PT-596 was at 60 psig (range time 61067).

4.2.3.6 Figure 2 shows Process Water Tank level vs time. From this, maximum flow rate is 39,000 GPM. This correlates with a flow of 37,000 GPM measured through the duct plus a calculated flow of 2,200 GPM through GAV-669, for a total flow of 39,200 GPM.

4.3 DEP-I-2

DEP-I-2, the second Orifice Sizing Test, was conducted on 7 December 1966. Flow control orifices had been removed from Sections 1 and 3. It was planned to use flow through FE-56 and FE-57 (flow meters for Section 2) as a basis for control by partially opening FCV-32 to establish the required rate of 5,576 GPM (15.7 psid) at those points.

4.3.1 <u>Test Phase</u>

4.3.1.1 The filling procedure was the same as for the first Orifice Sizing Test because the two small supply valves, RSV-296 and RSV-297, were still out of the system. After RSV-298 was opened to the 10% position, filling started with the opening of BFV-666, and water was reported overflowing the water shield tank 35 minutes later. Automatic vent valves in the pipe vault supply and return lines were observed to be operating properly and bleeding was taking place at the points provided on the duct. Instrument lines were manually bled as were valve actuation systems. The flow control valves were bled by unseating the valves momentarily. An inspection after the system was filled revealed no leaks or abnormalities.

4.3.1.2 After opening RSV-298 100%, flow was started by fully opening FCV-30. FCV-31 and FCV-32 were opened next. FCV-31 was positioned full open, and FCV-32 was opened until FE-56 and FE-57 indicated 15.7 psid. FCV-31 was then closed, diverting essentially all of the flow through FCV-32 for better control. A differential pressure of 15.7 psid was again established at FE-56 and FE-57, as FCV-32 was opened. GAV-669 was then opened to simulate flow to the SGS and ETC. The effect on duct flow was not discernable on the visual flow meters at the console, and FCV-32 was not readjusted. With the system at full flow, an inspection was made in pipe and duct vaults. No significant leaks were found, and it was reported that duct vibration was considerably less than during DEP-I-1.

4.3.1.3 As the water level at the Process Water Tank reached 13 feet, flow shutdown was initiated. The first step was to reopen FCV-31 so that

FCV-32, the 20" valve, would not be coming closed with only the $1\frac{1}{2}$" valve FCV-30 flowing. FCV-32, FCV-31, RSV-298, and BFV-666 were then closed in that order and the system drained of residual water.

4.3.2 Data Review

4.3.2.1 Differential pressures at the duct flow elements are presented in Table II with the corresponding flows. The flows in Sections 2 and 3 were very near the minimum requirements. Section 1 flow was approximately 17% in excess of the required minimum.

4.3.2.2 Pressure transducer traces were somewhat less hashy than they were during the DEP-I-1 traces. This could be attributed to the temporary shock mounts, however, the entire system was probably vibrating less than during DEP-I-1.

4.3.2.3 Values for two full flow data points are given in Table II. The range times selected were 48230 for full flow without simulated flow to the SGS and ETC and 48503 for full flow with simulated flow to SGS and ETC.

4.3.2.4 Cavitation was evident downstream of FCV-32 and was recorded by P-600 which read negative values during the full flow condition.

4.4 NEP-I

NEP-I was conducted on 19 January 1967, for the purpose of evaluating TEC pulldown with the Steam Generator System operational. DEP-I-3 was conducted within the scope of NEP-I for the purpose of evaluating the automatic bleed-in capability of the water supply system and duct combination. The permanent pressure transducers which are overranged during duct filling (P-204, P-205, P-209, P-210, P-223 and P-226) were re-installed to obtain parallel instrumentation at these points.

4.4.1 Bleed-In Evaluation

The two small supply valves, RSV-296 and RSV-297, were installed prior to this test. Filling of the duct was initiated by opening RSV-296 with the duct drain valves, GLV-2469 and GLV-2470, closed. The three facility line automatic vent valves operated satisfactorily and the last vent valve was finished venting air from the system approximately 25 minutes after bleed-in flow was initiated. Water was observed overflowing the shield water tank approximately 38 minutes after bleed-in flow was initiated. The duct drain valves, GLV-2469 and GLV-2470, were then opened and water continued overflowing from the shield water tank indicating that RSV-296 was of sufficient capacity to maintain the duct full with all bleeds and drains open. This successfully concluded this portion of the test.

4.4.2 Full Flow Test

Prior to initiating this test, a 17.2 inch diameter orifice was installed at the outlet of FCV-32 in an attempt to suppress cavitation through the valve. Full water flow was achieved by opening FCV-32 until F-56 and F-57 indicated 15.7 psid. No improvement in the attempt to suppress cavitation through FCV-32 was evident, for if some improvement did occur through the valve, it was not apparent in the discharge line transducer (P-600). The system should be re-evaluated with view to installing a smaller orifice (< 17.2) downstream in the discharge pipe preferably immediately upstream of its discharge into the 42" drain line. There was no evidence of over heating due to the steam flow and temperature throughout the test.

4.5 NEP-II-1 AND NEP-II-2

These two tests were conducted on 26 January 1967 and, because of the low water tank level, FCV-31 was only partially opened, with FCV-32 closed to obtain a flow rate of about 6000 GPM. This flow rate was more than adequate to prevent Section 3 overheating due to the admission of steam. At the conclusion of NEP-II-2, the water flow rate was momentarily increased to nominal full flow conditions so that the secondary duct exit eight tube cooling circuit could be measured. The flow rate was determined to be 577 GPM as measured by a $2\frac{1}{2}$" rotating vane flow meter (F-87) installed in the 3" discharge line.

4.6 NEP-III

This test was conducted on 2 February 1967. In support of this test, the duct was operated in the nominal full flow condition. Prior to this test, a 6.0" diameter orifice was installed at FT-72 and FT-73 location at the outlet of Section 1 because this section has been flowing approximately 17% higher than its nominal value. The effect of the orifice was to reduce the flow in Section 1 to approximately 7% higher than its nominal value which is considered acceptable. The flow through the secondary duct exit eight tube cooling circuit (F-87) was determined to be 554 GPM.

4.7 NEP-IV

This test was conducted on 7 February 1967. In support of this test, the duct was operated in the nominal full flow condition. Because of the low water level in the Process Water Tank the duct drain valves, GLV-2469 and GLV-2470, were closed throughout the test. There were no anomalies noted during the test.

4.8 NEP TEST DUCT COOLANT WATER FLOW CONTROL

For the NEP tests full duct flow was established by positioning FCV-30 and FCV-31 full open and then opening FCV-32 as required to achieve the specified flow rate. It was found that the flow could be just as easily controlled by this method as it was for the method described in test DEP-I-2 with fewer operational steps being required. Shutdown was accomplished by merely revising the procedure.

TABLE I

DUCT WATER FLOW TEST SUMMARY

				SECTION 1				SECTION 2				SECTION 3						
TEST NUMBER	DATE	DUCT INLET PRESSURE PSIG	DUCT OUTLET PRESSURE PSIG	ACTUAL FLOW GPM	PERCENT TOTAL FLOW	KW	MINIMUM REQUIRED FLOW GPM	ACTUAL FLOW GPM	PERCENT TOTAL FLOW	KW	MINIMUM REQUIRED FLOW GPM	ACTUAL FLOW GPM	PERCENT TOTAL FLOW	KW	MINIMUM REQUIRED FLOW GPM	TOTAL FLOW GPM	DUCT KW	REMARKS
DEP-I-1	11/16/66	207	13	10,600	28.2	766	11,756	13,600	36.2	984	11,152	13,400	35.6	970	15,126	37,600	2720	Original System
DEP-I-2	12/7/66	201	-	13,900	34	-	11,756	11,300	27.5	-	11,152	15,750	38.5	-	15,126	40,950	-	Removed orifices from Sections 1 and 3
NEP-I	1/19/67	197	46	13,880	34	1130	11,756	11,630	28.5	945	11,152	15,300	37.5	1245	15,126	40,820	3320	Installed 17.2" orifice at Outlet of FCV-32
NEP-II-2	1/26/67	198	56	13,310	33.1	1115	11,756	11,290	28.1	945	11,152	15,610	38.8	1310	15,126	40,210	3370	
NEP-III	2/2/67	198	58	12,420	31.4	1050	11,756	11,470	28.9	970	11,152	15,770	39.7	1330	15,126	39,660	3350	Installed 6" orifice in Section 1
NEP-IV	2/7/67	199	61	12,400	31.9	1055	11,756	10,990	28.3	935	11,152	15,490	39.8	1320	15,126	38,880	3310	Drain Valves GLV2469 and GLV-2470 were closed

TABLE II

NES DUCT SYSTEM TEST DATA TABULATION

TEST NUMBER	RANGE TIME	DUCT INLET L15 FEET	P168 PSIG	F31 GPM	F31 GPM	FCV31 %Open	F32 PSID	F32 GPM	FCV32 %Open	P597 PSIG	T47 °R
DEP-I-1	58593	41.5	214			99	2	37100	50	212	531
DEP-I-1	59414	32.5	210			100	2	37100	100	207	525
DEP-I-1	61067	14.5	203			99	2	37100	29	208	526
DEP-I-2	48230	19.5	205			*	3	45400	*	201	532
DEP-I-2	48504	16.5	201			*	2	37100	*	198	529
NEP-I	80715	34.1	202	0.38	1600	97	*		45	197	514
NEP-II-1	78593	14.2	213	4.45	5530	31	*		0	210	527
NEP-II-2	06670	12.5	213	4.52	5590	32	*		0	209	525
NEP-II-2	07195	10.3	201	2.15	3850	34	*		41	198	522
NEP-III	73900	14.7	200			92	2.8	43900	39	198	523
NEP-IV	71430	14.3	200			89	2.8	43900	37	199	525

	SECTION 1																				
	INLET													OUTLET							
TEST NUMBER	T165 °R	P221 PSIG	F54 PSID	F54 GPM	T164 °R	P203 PSIG	F55 PSID	F55 GPM	T90 °R	T89 °R	T88 °R	T87 °R	F60 PSID	T66 °R	P204 PSIG	P204-2 PSIG	F72 PSID	T57 °R	P223 PSIG	P223-2 PSIG	F73 PSID
DEP-I-1		203	26.			187	*						0		16		140	531	31		139
DEP-I-1		198	25			182	*						0		-6		134	527	-16		133
DEP-I-1		205	18			189	*						0		0		107	*	102		104
DEP-I-2		177	43			178	43						0			60				59	
DEP-I-2		175	43			176	43						0			58				57	
NEP-I	520	172	44.7	7080	519	172	41.2	6800	513	513	*	514	*	515	51	50		*	49	46	
NEP-II-1	523	223	0.8	950	522	225	0.9	1000	526	525	525	524	*	523	207	O.R.		*	209	O.R.	
NEP-II-2	521	222	0.8	950	519	224	0.8	950	524	524	524	524	*	522	207	O.R.		*	208	O.R.	
NEP-II-2	521	176	39.6	6660	520	177	39.4	6650	521	521	521	521	*	520	61	60		*	62	58	
NEP-III	526	182	35.1	6270	524	183	33.7	6150	522	523	523	523	.03	523	61	59		*	59	55	
NEP-IV	524	182	34.9	6260	522	183	33.5	6140	525	525	525	525	*	525	64	61		525	63	60	

		SECTION 2														
		INLET														
TEST NUMBER	RANGE TIME	P206 PSIG	F56 PSID	F56 GPM	P224 PSIG	F57 PSID	F57 GPM	T75 °R	T76 °R	T77 °R	T78 °R	T79 °R	T85 °R	T86 °R	T83 °R	T84 °R
DEP-I-1	58543	207	22		201	21										
DEP-I-1	59414	201	23		195	23										
DEP-I-1	61067	210	16		204	16										
DEP-I-2	48230	200	16		194	16										
DEP-I-2	48504	196	16		192	15										
NEP-I	80715	194	16.6	5880	191	16.4	5750	514	514	514	525	514	514	*	514	514
NEP-II-1	78593	229	0.2	635	224	0.3	779	525	525	526	519	525	525	525	525	524
NEP-II-2	06670	228	0.2	635	223	0.3	779	525	524	526	520	527	526	527	528	526
NEP-II-2	07195	199	15.2	5540	193	16.4	5750	521	522	522	515	521	520	522	522	520
NEP-III	73900	198	16.5	5760	194	16.2	5710	523	523	523	518	523	523	523	523	523
NEP-IV	71430	198	*		193	14.9	5490	524	525	525	521	525	525	525	525	525

	SECTION 2 OUTLET															
TEST NUMBER	T67 °R	P205 PSIG	P205-2 PSIG	F74 PSID	T61 °R	P210 PSIG	P210-2 PSIG	F79 PSID	T58 °R	P226 PSIG	P226-2 PSIG	F75 PSID	T60 °R	P209 PSIG	P209-2 PSIG	F78 PSID
DEP-I-1		16		14		57		25	530	49		10		49		10
DEP-I-1		49		19		48		10	525	39		10		39		6
DEP-I-1		97		21		94		22	525	88		10		88		10
DEP-I-2		67		24			51	23	526		79	10			79	10
DEP-I-2		85		22			50	23	523		76	8			76	9
NEP-I	518	78	75	25	516	*	72	23	516	72	*	9	516	*	71	10
NEP-II-1	522	220	O.R.	*	525	*	O.R.	*	525	221	O.R.	.3	525	218	O.R.	.2
NEP-II-2	516	219	O.R.	*	533	*	O.R.	*	537	220	O.R.	.5	537	218	O.R.	.3
NEP-II-2	546	88	90	*	520	*	85	*	522	80	79	9	522	81	80	10
NEP-III	522	88	*	27	524	*	82	21	525	79	78	9	525	80	79	10
NEP-IV	521	90	*	24	527	*	88	22	527	83	81	10	527	83	80	12

TABLE II (Continued)

NES DUCT SYSTEM TEST DATA TABULATION

TEST NUMBER	RANGE TIME	SECTION 3 INLET T167 °R	P207 PSIG	F58 PSID	F58 GPM	T166 °R	P225 PSIG	F59 PSID	F59 GPM	T320 °R	T158 °R	F87 PSID/ CPS	F87 GPM	OUTLET T59 °R	P222 PSIG	F77 PSID	T68 °R	P208 PSIG	F76 PSID	DUCT OUTLET T48 °R	P596 PSIG	P600 PSIA	SG4 Min/ In	SG5 Min/ In	SG6 Min/ In	SG7 Min/ In	SG11 Min/ In	SG12 Min/ In	SG13 Min/ In	SG14 Min/ In	SG15 Min/ In	SG16 Min/ In
DEP-I-1	58543	530	206	27		530	210	28				91/	590	531	219	59		220	99	533	23	*	-30			28		20	49	31	8	40
DEP-I-1	59414	526	199	27		526	203	27				96/	610	526	112	62		108	101	529	13	*	-35			29		25	48	25	7	45
DEP-I-1	61067	526	206	19		526	209	19				67/	510	525	142	46		150	74	528	60	*	-26			28		23	50	29	4	37
DEP-I-2	48230	527	193	38		527	195	37						528	71			72		532	*	*	-143			-17		83	408	60	15	18
DEP-I-2	48504	524	189	37		524	191	36						525	70			67		529	*	*	-137			-19		79	386	53	12	19
NEP-I	80715	513	182	34.9	7600	513	*	35.8	7710	515	514			519	62		519	*		*	46	2	-47	-110	26	8	284	164	235	189	270	185
NEP-II-1	78593	525	225	0.9	1220	525	228	0.8	1150	530	529	/90	132	553	225		551	*		*	209	15	-48	-57	18	-2	66	2	-60	-35	187	95
NEP-II-2	06670	522	222	0.8	1150	523	228	0.9	1220	529	527	/91	133	555	203		554	*		*	208	9	-56	-69	27	11	188	108	41	747	151	83
NEP-II-2	07195	521	187	37.4	7900	521	197	35.8	7710	522	521	/394	577	522	61		522	*		*	56	2	-68	-85	33	8	179	-42	-16	747	12	-44
NEP-III	73900	522	193	37.6	7900	522	192	37.2	7870	524	523	/378	554	528	*		528	78		527	58	4	24	26	1	-1	131	59	33		95	42
NEP-IV	71430	524	186	36.9	7840	524	193	35.2	7650	526	526	/432	632	530	*		530	*		529	61	9	27	37		12	203	123	52		179	87

TEST NUMBER	RANGE TIME	SG17 Min/ In	SG18 Min/ In	SG19 Min/ In	SG901 Min/ In	SG902 Min/ In	SG903 Min/ In	SG904 Min/ In	SG905 Min/ In	SG907 Min/ In	SG908 Min/ In	SG909 Min/ In	SG910 Min/ In	SG911 Min/ In	SG912 Min/ In	SG913 Min/ In	SG914 Min/ In	SG915 Min/ In	F720 PSID
DEP-I-1	58543	44	18	25	1	67	29	88	54	155	30	134	78	25	20	48	-1	57	0
DEP-I-1	59414	42	21	31	4	70	31	84	57	144	27	132	71	37	18	54	0	55	214
DEP-I-1	61067	54	20	30	-2	64	31	85	61	158	28	133	85	47	29	64	-5	59	214
DEP-I-2	48230	59		47	1		74	91	78		120			107	14	77	13	88	0
DEP-I-2	48504	53		48	10		70	80	73		121			95	10	72	73	84	206
NEP-I	80715	311	146	194															
NEP-II-1	78593	307	114	137															
NEP-II-2	06670	275	109	162															
NEP-II-2	07195	-12	-7	54															
NEP-III	73900	113	50	59															
NEP-IV	71430	198	68	141															

TABLE III

DEP-I-1 CHRONOLOGY

	EVENTS	RANGE TIME (Seconds)
1.	Started to fill the duct	53600
2.	Water overflowing duct water shield tank	56600
3.	Open FCV-30	57621
4.	Open RSV-298	57900
5.	Open FCV-31	58021
6.	Initiate opening of FCV-32	58462
7.	FCV-32 50% open	58543
8.	FCV-32 full open	58655
9.	Open GAV-669	59200
10.	Initiate closure of FCV-32	60272
11.	FCV-32 reached 50% open and held	60344
12.	Re-initiate closure of FCV-32	61042
13.	FCV-32 closed	61113
14.	Initiate closure of FCV-31	61124
15.	FCV-31 closed	61157
16.	FCV-30 closed	61200

TABLE IV

DEP-I-2 CHRONOLOGY

	EVENTS	RANGE TIME (Seconds)
1.	Started to fill the duct	42453
2.	Water overflowing duct water shield tank	44700
3.	Open FCV-30	
4.	Open FCV-31	
5.	Initiate opening of FCV-32 until F-56 and F-57 indicate 15.7 psid	48069
6.	Achieved 15.7 psid on F-56 and F-57	48138
7.	Close FCV-31	
8.	Open GAV-669	48339
9.	Initiate closure of FCV-32	48820
10.	FCV-32 closed	48886
11.	Close FCV-30	

TABLE V

NEP-I CHRONOLOGY

	EVENTS	RANGE TIME (Seconds)
1.	Open FCV-31	80003
2.	Open FCV-32 until F-56 and F-57 indicate 15.7 psid	80025
3.	Achieved 15.7 psid on F-56	80080
4.	Idle steam SG-1	80161
5.	Idle steam SG-2	80170
6.	Idle steam SG-3	80179
7.	Shut off first stage SG-1	80219
8.	Shut off first stage SG-2	80221
9.	Shut off first stage SG-3	80223
10.	Close PCV-447	
11.	Full steam SG-1	80265
12.	Started to adjust FCV-423-1 until F-406-1 indicates 110 psid	80287
13.	Achieved 110 psid on F-406-1	80300
14.	Started to adjust FCV-423-1 until T-534 indicates 1560°F	80355
15.	High temperature shutdown SG-1	80375
16.	Full steam SG-2	80623
17.	Full steam SG-3	80650
18.	Started to adjust FCV-423-2 and -3 until F-406-2 and -3 indicate 110 psid	80680
19.	Achieved 110 psid on F-406-2 and -3	80710
20.	Open PCV-447	

TABLE V (Cont'd)

	EVENTS	RANGE TIME (Seconds)
21.	Initiate ramp up on PCV-446	80774
22.	Initiate ramp down on PCV-446 and PCV-447	80783
23.	PCV-446 and PCV-447 closed	80790
24.	Initiate ramp up on PCV-446	80804
25.	Achieved 30 lb/sec through PCV-446	80812
26.	Shutdown to idle SG-2	80836
27.	Shutdown to idle SG-3	80856
28.	Initiate ramp down on PCV-446	80871
29.	PCV-446 closed	80883
30.	Stop SG-2	80913
31.	Stop SG-3	80915
32.	Initiate closure of FCV-32	80926
33.	FCV-32 closed	80990
34.	FCV-31 closed	81044

TABLE VI

NEP-II-1 CHRONOLOGY

	EVENTS	RANGE TIME (Seconds)
1.	Before the data system was turned on, FCV-30 was open fully and FCV-31 was opened such that F-31 indicated 4.5 psid.	
2.	Idle steam SG-1	78230
3.	Idle steam SG-2	78239
4.	Idle steam SG-3	78246
5.	Increase flow F-427 = 1.5 lb/sec	78287
6.	Full steam SG-3	78315
7.	Full steam SG-2	78337
8.	Start to adjust FCV-423-2 & 3 until F-406-2 & 3 indicate 110 psid	78354
9.	Achieved 110 psid on F-406-2 & 3	78388
10.	Start to adjust steam temperature to 1760°R	78427
11.	Achieved 1760°R steam temperature	78473
12.	Shutdown to idle steam SG-3	78506
13.	Full steam SG-1	78509
14.	Adjust FCV-423-1 & -2 until steam temperature is 1760°R	78525
15.	Initiated ramp up on PCV-449	78573
16.	Achieved 188 psia on P-905	78592
17.	Shutdown to idle steam SG-2	78616
18.	Shutdown to idle steam SG-1	78625
19.	Initiated ramp down on PCV-449	78638
20	PCV-449 closed	78660
21.	Stop SG-1	78701
22.	Stop SG-2	78703
23.	Stop SG-3	78704
24.	Close FCV-31	78753
25.	Close FCV-30	
26.	Close PCV-447	

TABLE VII

NEP-II-2 CHRONOLOGY

	EVENTS	RANGE TIME (Seconds)
1.	Before data system was turned on, purge flow (F-426) was established (0.8 lb/sec)	
2.	Open FCV-31 to 4 psid	06264
3.	Idle steam SG-1	06443
4.	Idle steam SG-2	06452
5.	Idle steam SG-3	06459
6.	Full steam SG-1	06511
7.	Full steam SG-3	06530
8.	Start to adjust FCV-423-1 and -3 until F-406-1 and -3 indicate 110 psid	06551
9.	Achieved 110 psid on F-406-1 and -3	06571
10.	Achieved 1760°R steam temperature	06662
11.	Initiated ramp up on PCV-449	06672
12.	Achieved 180 psia on P-905	06682
13.	Initiated ramp up on PCV-472	06704
14.	Initiated ramp down on PCV-472	06714
15.	PCV-472 closed	06718
16.	Initiated ramp up on PCV-446	06731
17.	Initiated ramp down on PCV-446	06736
18.	PCV-446 closed	06739
19.	Initiated ramp down on PCV-449	06747
20.	PCV-449 closed	06758
21.	Shutdown to idle steam SG-1	06885
22.	Shutdown to idle steam SG-3	06892
23.	Stop SG-1	06913
24.	Stop SG-2	06915
25.	Stop SG-3	06916
26.	Close PCV-447	06954
27.	Started to open FCV-32 to achieve 15.7 psid on F-56 & F-57	07120
28.	Achieved 15.7 psid on F-56	07186
29.	Start to close FCV-32	07206
30.	FCV-32 closed	07265
31.	Close FCV-31	07290

TABLE VIII

NEP-III CHRONOLOGY

	EVENTS	RANGE TIME (Seconds)
1.	Before data system was turned on, purge flow was established at 0.5 lb/sec	
2.	Open FCV-31	73313
3.	Open FCV-32 until F-56 and F-57 indicate 15.7 psid	73344
4.	Achieved 15.7 psid on F-56	73406
5.	Idle steam SG-1	73547
6.	Idle steam SG-2	73556
7.	Idle steam SG-3	73564
8.	Increase TEC purge to 2.0 lb/sec	73604
9.	Full steam SG-1	73634
10.	Full steam SG-2	73655
11.	Started to adjust FCV-423-1 and -2 until F-406-1 and -2 indicate 120 psid	73671
12.	Achieved 120 psid on F-406-1 and -2	73694
13.	Shutdown to idle SG-1	73808
14.	Full steam SG-3	73811
15.	Initiate ramp up on PCV-449	73906
16.	Achieved 512 psia on P-905	73934
17.	Initiate ramp up on PCV-472	73934
18.	Reached 100% open on PCV-449	73941
19.	Initiate ramp down on PCV-472	73942
20.	PCV-472 Closed	73948
21.	Initiate ramp down on PCV-449	73959
22.	PCV-449 Closed	73986
23.	Open FCV-423-2 and -3 to full open	73998
24.	Reduce TEC purge to 1 lb/sec	74003
25.	Initiate closure of FCV-32	74007
26.	FCV-32 closed	74063
27.	Shutdown to idle SG-2	74121
28.	Shutdown to idle SG-3	74129
29.	Stop SG-1	74147
30.	Stop SG-2	74149
31	Stop SG-3	74150
32.	FCV-31 closed	74207
33	TEC purge stopped (PCV-447 closed)	74223

TABLE IX

NEP-IV CHRONOLOGY

	EVENTS	RANGE TIME (Seconds)
1.	Open FCV-31	70922
2.	Open FCV-32 until F-56 and F-57 indicate 15.7 psid	70962
3.	Achieved 15.7 psid on F-57	71021
4.	Idle steam SG-1	71118
5.	Idle steam SG-2	71126
6.	Idle steam SG-3	71134
7.	Open FCV-447 to purge flow rate of 1.5 lb/sec	71182
8.	Full steam SG-2	71213
9.	Full steam SG-3	71238
10.	Started to adjust FCV-423-2 and -3 until F-406-2 and -3 indicate 130 psid	71263
11.	Achieved 130 psid on F-406-2 and -3	71284
12.	Initiate ramp up on PCV-449	71434
13.	Initiate ramp up on PCV-472	71434
14.	P-905 failure	71439
15.	PCV-449 Closed	71439
16.	Achieved 7 lb/sec on P-901	71440
17.	Switch to manual PCV-449	71440
18.	PCV-449 Closed	71450
19.	Started to increase TEC purge flow (F-426)	71451
20.	Initiated ramp down on PCV-472	71456
21.	PCV-472 closed	71459
22.	Achieved 37.6 lb/sec purge flow (F-426) and started to close	71462
23.	Reduced TEC purge flow to 1.5 lb/sec	71463
24.	Open FCV-423-2 and -3 to full open	71490
25.	Initiate closure of FCV-32	71501
26.	FCV-32 Closed	71555
27.	Shutdown to idle SG-2	71612
28.	Shutdown to idle SG-3	71619
29.	STOP SG-1	71643
30.	STOP SG-2	71645
31.	STOP SG-3	71647
32	FCV-31 CLOSED	71710
33.	PCV-447 CLOSED	71741

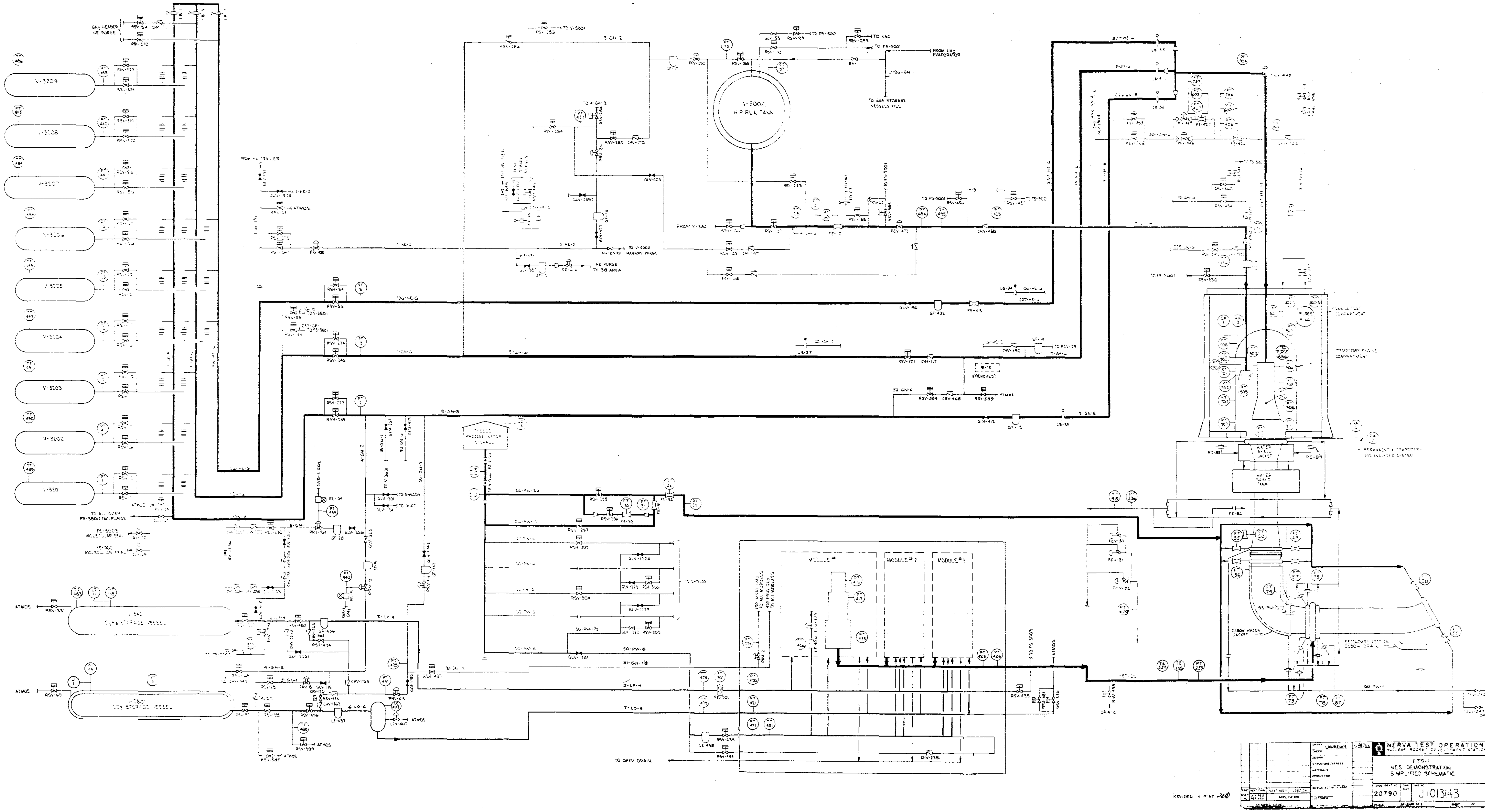


FIGURE 1

NEP SIMPLIFIED SCHEMATIC

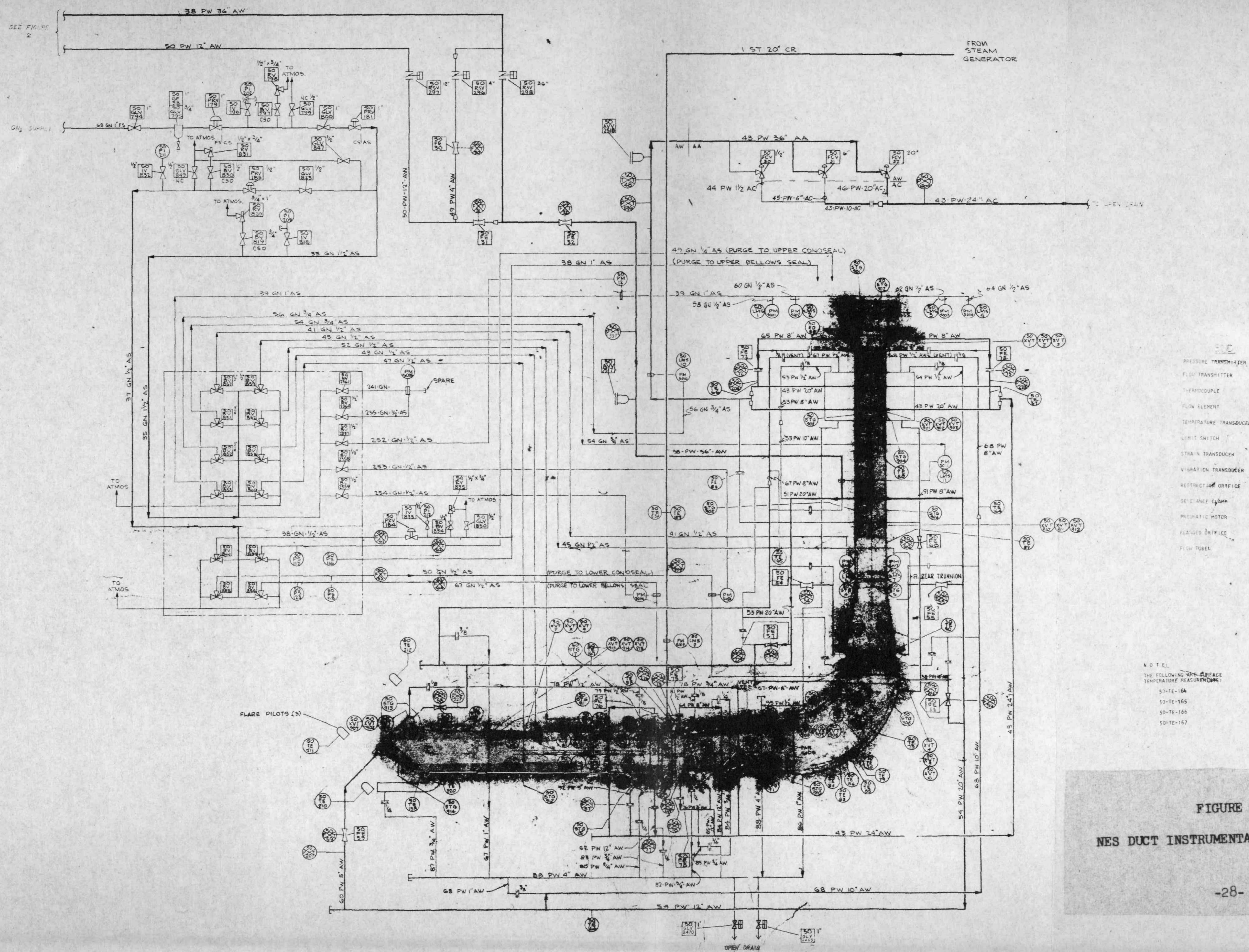


FIGURE 2

NES DUCT INSTRUMENTATION SCHEMATIC

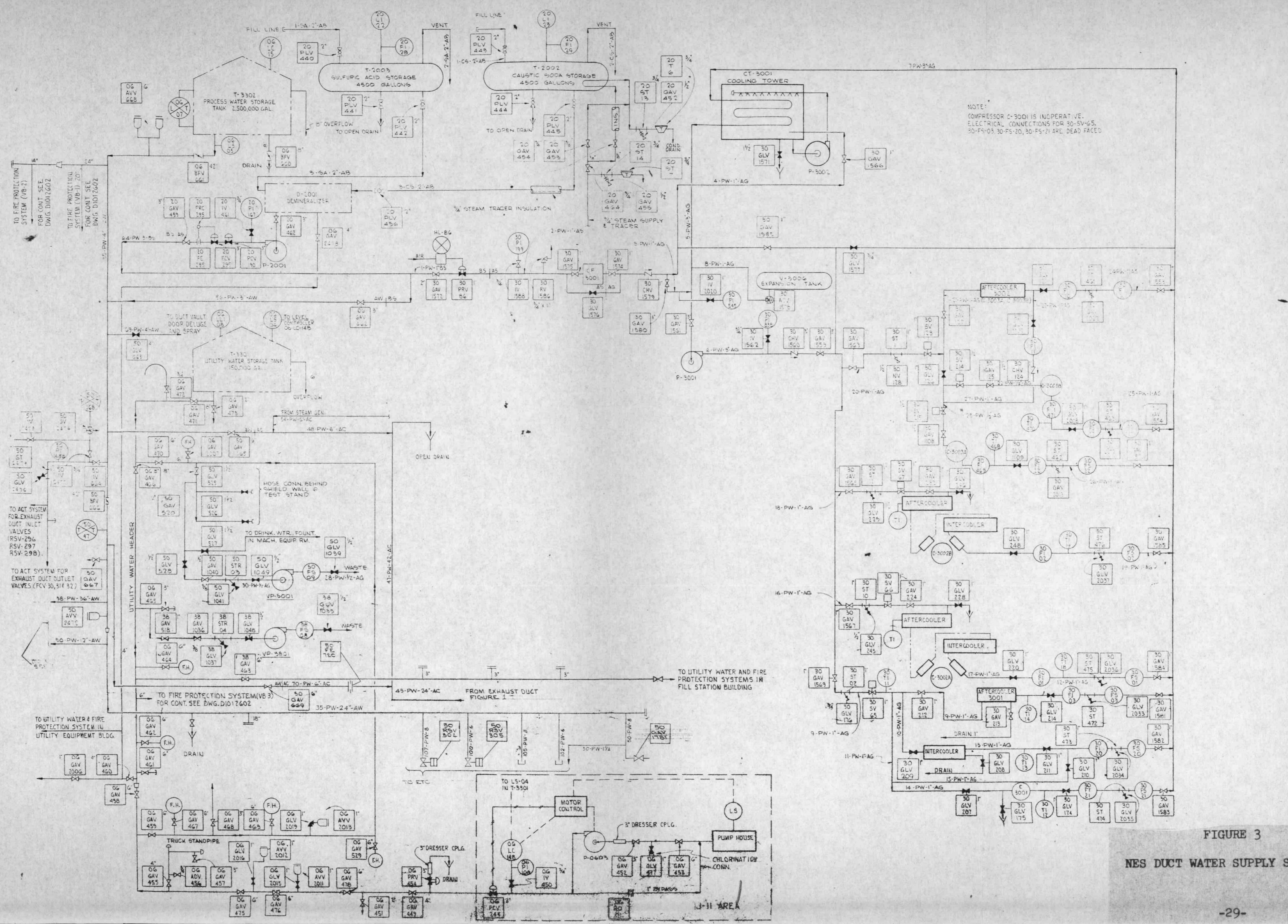
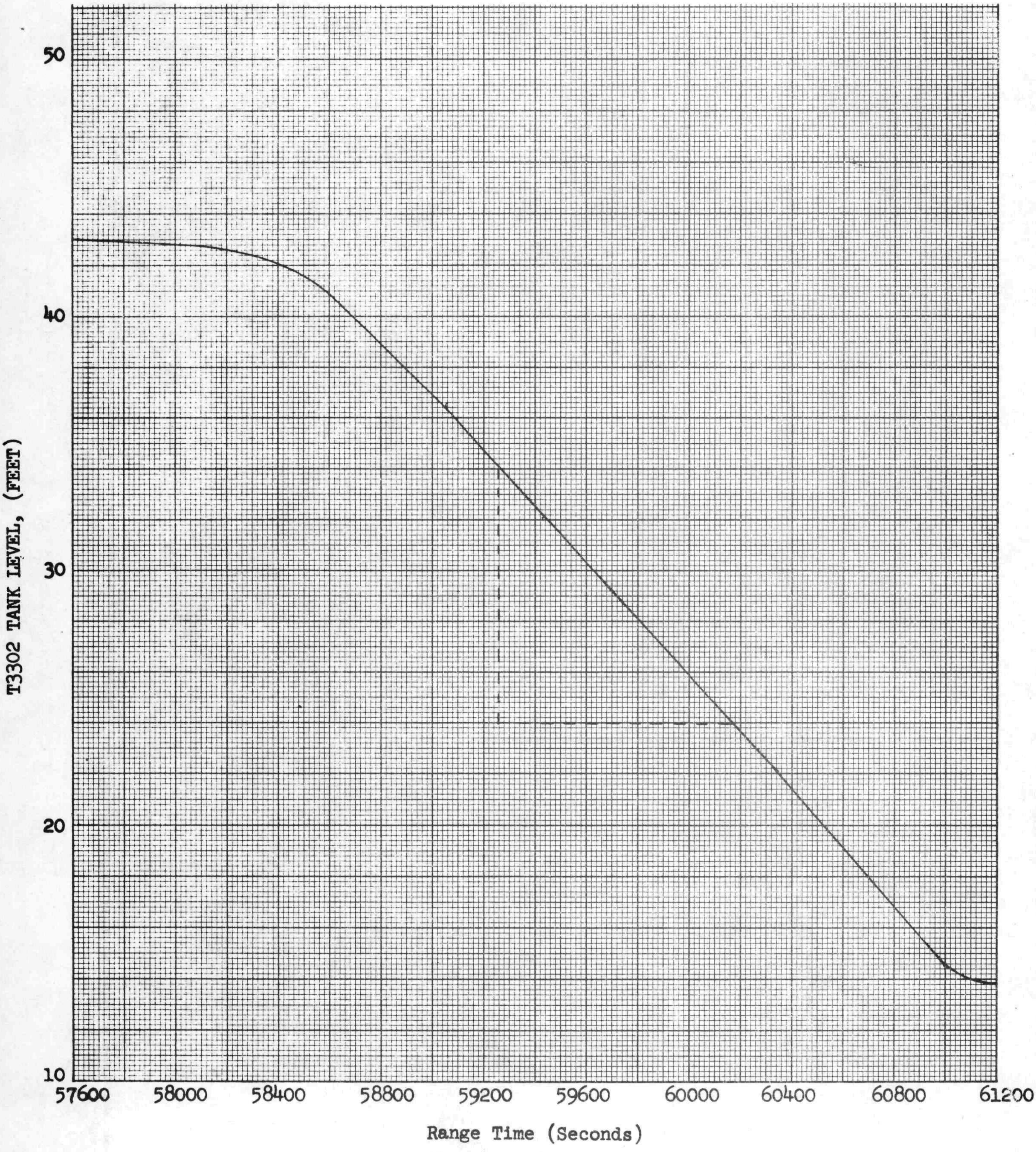


FIGURE 3

NES DUCT WATER SUPPLY SCHEMATIC



$$\text{WATER FLOW RATE} = \frac{(34\ \text{Ft.} - 24\ \text{Ft.})(58500\ \text{Gal/Ft})(60\ \text{sec/min})}{(60170\ \text{sec.} - 59260\ \text{sec.})}$$

$$= 38600\ \text{Gal/Min}$$

FIGURE 4

PROCESS WATER TANK LEVEL (LT015) DURING DEP-I-1

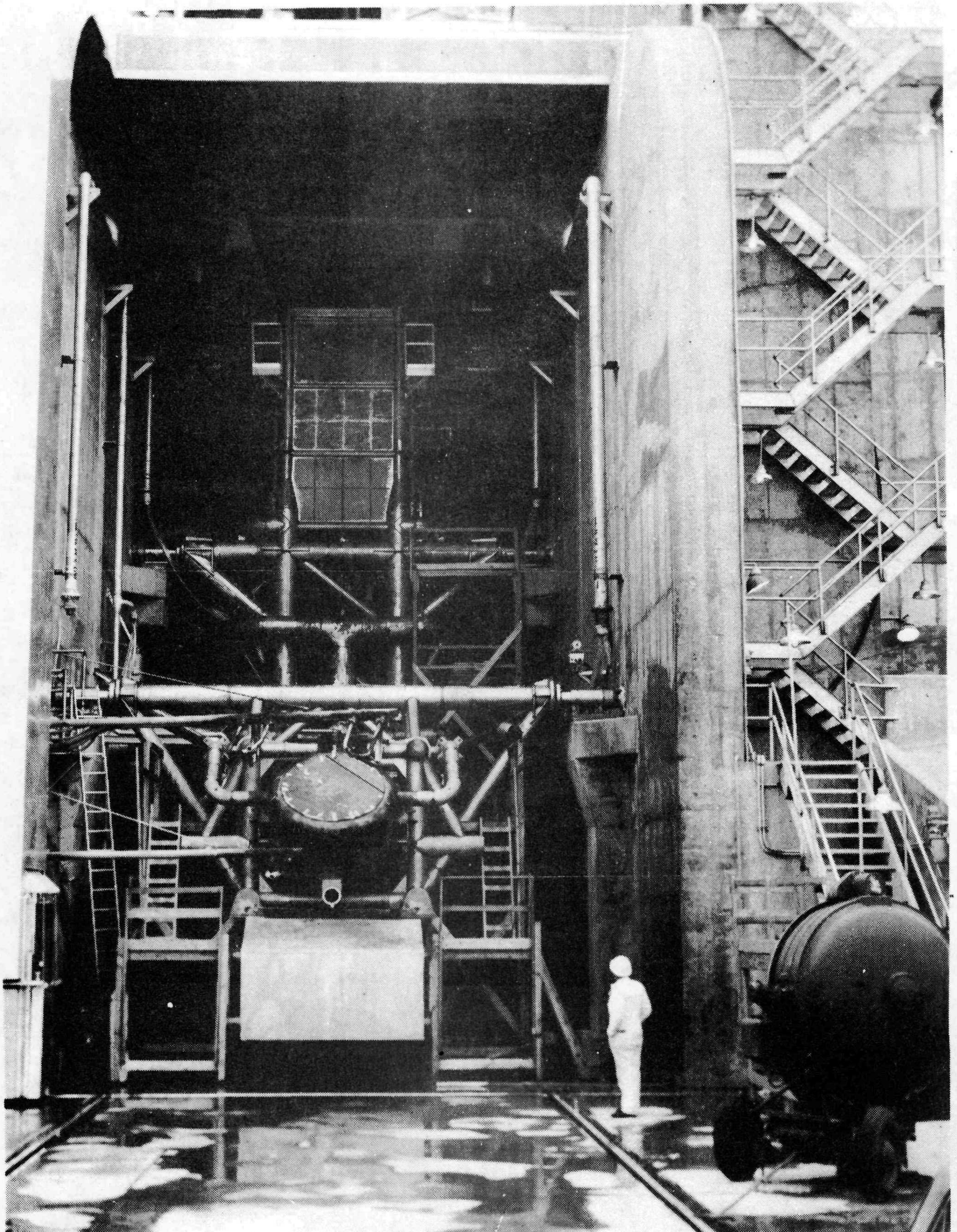
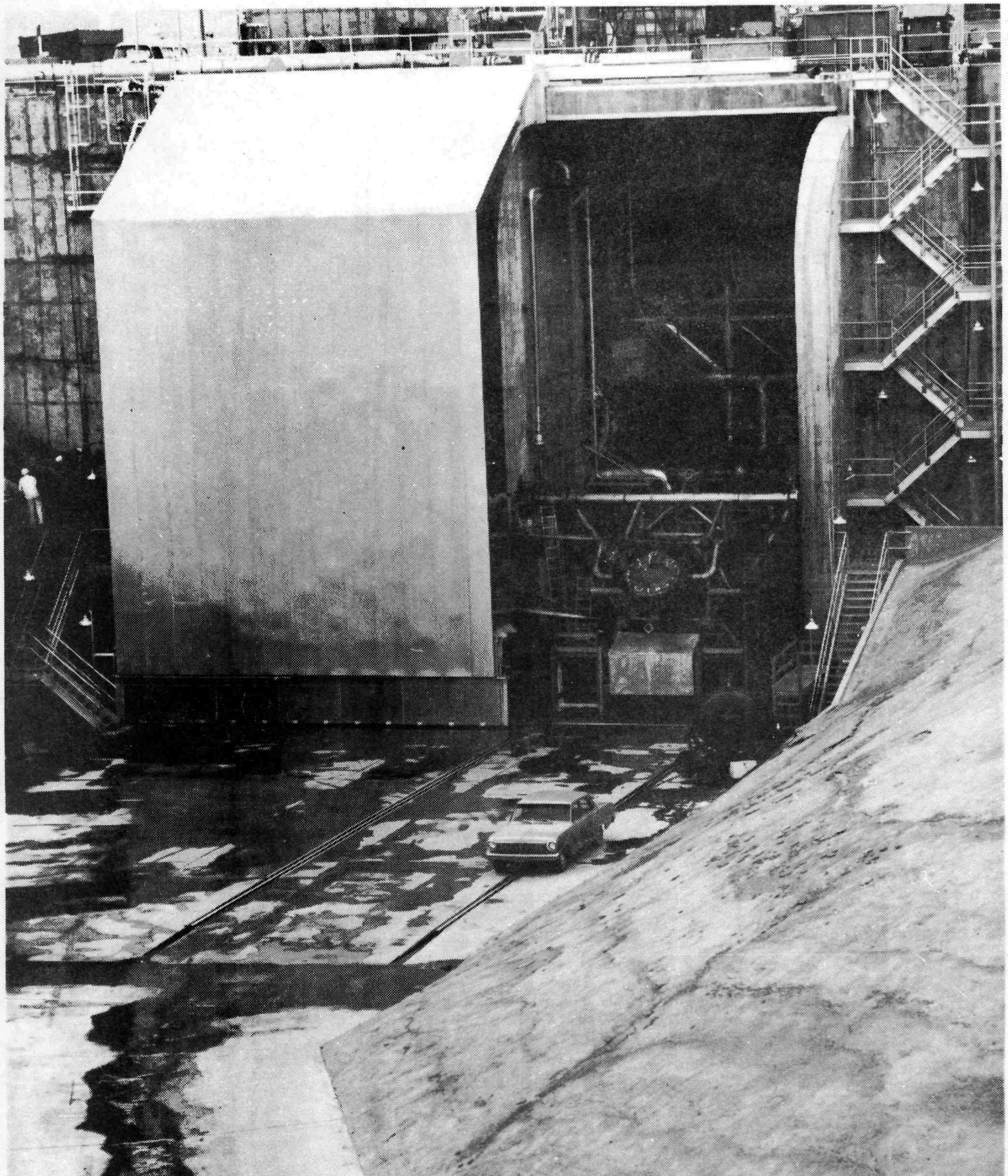


FIGURE 5
NES DUCT



FOR OFFICIAL USE ONLY - UNCLASSIFIED

FIGURE 6
NES DUCT VAULT

APPENDIX I

TEST DESCRIPTION

FOR

DUCT EXPERIMENTAL PLAN I

DUCT COOLANT SYSTEM WATER FLOW TESTS

NTO-I-0137A

PREPARED BY:

ETS-1 NES Task Group

APPROVED BY: ____________________
C. K. Soppet, Manager
Engine Test Operations

APPROVED BY: ____________________
N. E. Erickson, Manager
NERVA Test Operations

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TABLE OF CONTENTS

I INTRODUCTION

A. General

This ammendment describes certain changes in the manner in which the duct water flow tests will be conducted. The sections of the original Test Description (NTO-I-0137) affected are Section III A on page 4, and Sections III B and III C on page 5. All other sections of NTO-I-0137 remain unchanged.

B. Water Supply System Changes

The two small supply valves, 50 RSV 296 and 50 RSV 297 will not be available for the Leak Test and the Orifice Sizing Test. All water will be supplied through 50 RSV 298. Because meaningfull data could not be obtained from the Fill and Bleed Test and the Final Flow Test without the use of all the valves, these two tests will be deferred until RSV 296 and RSV 297 are installed.

II TEST DESCRIPTION

A. Leak Test

1. The Leak Test will be conducted as described in the basic Test Description except for the filling technique. As presently planned, the Duct will be filled by first opening 50-RSV-298 approximately 5%, then opening 50-BFV-666 approximately 5%.

B. Fill and Bleed Test

1. The Fill and Bleed Test will be deferred until all valves in the supply system are installed. It will be conducted just prior to the Final Flow test, rather than just prior to the Orifice Sizing Test as stated in the original Test Description.

C. Orifice Sizing Test

1. The Orifice Sizing Test will be conducted without 50-RSV-296 and 50-RSV-297 and will be the first test after the Leak Test.

2. The flow through the system will be started by opening the supply and return valves in the following order:

   a. 50-RSV-298: OPEN approximately 5 %.

   b. 50-BFV-666: OPEN approximately 5 %.

   c. 50-BFV-666: FULL OPEN after air has been bled from the system high points, and the water shield tank is full.

   d. 50-FCV-30: FULL OPEN, and hold at least 5 minutes.

   e. 50-RSV-298: FULL OPEN.

   f. 50-FCV-31: FULL OPEN, and hold at least 5 minutes.

   g. 50-FCV-32: FULL OPEN, and hold at least 5 minutes.

   h. 50-GAV-669: FULL OPEN at a pre-determined time.

   After each return valve (FCV) is opened, and if no unsafe conditions are observed, a team of at least two men will enter the duct vault and the pipe vault during the hold periods to check for significant leaks and audible vibration.

3. At the completion of the test, the remote valves will be closed in the reverse order of the start-up. The simulated flow to the Steam Generator System (SGS) and the Engine Test Compartment (ETC) will be shut off last by closing 50-GAV-669, and the system secured by closing 50-BFV-666 and draining all residual water in the pipe and duct vaults systems.

4. Actual observed flow rates will be compared to the required flow rates specified in Table I of the original Test Description, NTO-I-0137. If the requirements have not been met, new orifice sizes will be calculated based upon test data and the flow element calibration curves, Figure 2 (a) through 2 (e) of NTO-I-0137.

5. After new orifices have been fabricated as required and installed, the test will be repeated to verify that the specified flow distribution in the Duct circuits has been obtained.

secondary section elbow drain. Due to this added pressure drop, a small exit manifold inside the main exit manifold receives the flow from these 8 channels. A 3-inch diameter line, with a calibrated orifice installed, runs from the internal manifold to the main 24-inch diameter water return line. Water from the remaining 142 coolant channels flows into the main manifold, then through two 12-inch diameter orificed outlet lines into the main 24-inch diameter water return line.

4. Vent and Drain System

The rear vertical truss members and the main 24-inch diameter water return lines act as the common bleed manifolds for all vent ports on the duct and truss members. The water flows from the rear vertical truss members and from the inlet water lines vent ports into the duct water shield tank. The two horizontal bottom truss members act as the common drain manifold for each section of the duct as well as for the rear vertical truss members and the water shield tank. The vent and drain lines will normally be flowing during an entire test.

II SPECIFIC TEST OBJECTIVES

A. To determine the optimum duct fill procedure and determine the water flow required to compensate for the bleed and drain discharge.

B. To determine the flow rates through the several parallel flow paths within the duct, and to adjust the flow rates if necessary by re-sizing the appropriate orifices.

C. To determine the system flow dynamics and characteristics with and without Steam Generator System (SGS) and Engine Test Compartment flow (ETC) over the range of process water tank level.

D. To determine whether any instability occurs during flow tests which might cause vibrations detrimental to the duct structure and, if so, collect data on which to base corrective action.

E. To provide operator training.

III TEST DESCRIPTION

A. Leak Test

1. The duct will be filled with water through one or more of the water supply valves. The three flow control valves in the water return line will be closed during the filling and leak test as will the supply valves to the SGS and the ETC. Bleeding of entrapped air will be accomplished at the high points in the system and also through the flow control valves. Flow control orifices in the pipes supplying water to the duct water shield jacket will be removed and replaced with blank discs and 93 PW 1/2 AW will be capped for the leak test. This is necessary in order to obtain and hold the water system operating pressure in the duct passages. The duct drain line (88 PW 4" AW) will be capable of being shut off by hand valves to prevent the system from draining during a hold, if required.

2. Instrumentation and piping connections will be checked visually for significant leakage while the system is filling, and corrected, if appropriate, without closing the water supply valves.

3. The system will be brought to maximum system head pressure (operating pressure) and held while the leak check is completed. Where possible, vents will be checked to be sure they are free flowing.

4. At the completion of the leak test, the system will be shut down and drained. The flow control orifices in the Water Shield Jacket supply lines will be re-installed and 93 PW 1/2 AW recoupled in preparation for the Fill and Bleed test to follow.

B. <u>Fill and Bleed Test</u>

1. The system will be filled through one or more of the supply valves, with the flow control valves closed except for bleeding as required, and with no flow to the SGS or the ETC.

2. The time required for the system to fill and bleed will be recorded. After the system has filled, and with the flow control valves in the water return lines closed, the flow required to compensate for the constant bleed flow will be recorded for at least 5 minutes. This measurement will be taken at 50 FE 30 with the Duct drain line (88-PW-4-AW) open, and again with the drain line closed.

3. At the completion of the test, the system will be shut down and drained of excess water, or held for the beginning of the Orifice Sizing test, as determined by the Test Director.

C. <u>Orifice Sizing Test</u>

1. During the orifice sizing tests, flow to the Steam Generator System and Engine Shield System will be simulated and controlled through 50-GAV-669. The duct drain line 88-PW-4"-AW will be open.

2. The system will be started by opening the supply and return valves in the following order:

   a) 50-RSV-296: Full open to "top off" or fill the system, depending upon the status of the system after the preceeding Fill and Bleed test.

b) 50-FCV-30: Full open after the system is filled. Hold at least 5 minutes before opening the next valve.

c) 50-RSV-297: Full open

d) 50-FCV-31: Full open immediately after RSV-297. Hold at least 5 minutes before opening the next valve.

e) 50-RSV-298: Full open

f) 50-FCV-32: Full open immediately after RSV-298. Hold at least 5 minutes to record steady state data.

g) 50-GAV-669: Full open to simulate flow to the SGS and ETC. Hold to record at least 1 minute of steady state data before shut-down.

As each pair of supply and return valves is opened, a flow "plateau" will be reached. If no unsafe conditions are observed at each plateau, a team of at least 2 men will enter the duct vault and the pipe vault during the hold periods to check for significant leaks and audible vibration. The system will be run for at least 5 minutes at each plateau with all parameters recorded.

3. At the completion of the test, the system will be shut down in the reverse order of the start-up, without the 5 minute hold at each plateau, and drained of residual water.

4. Actual observed flow rates will be compared to the required minimum flow rates specified in Table I. If the requirements have not been met, new orifice sizes will be calculated based upon test data and the flow element calibration curves, Figure 2 (a) through 2 (e).

5. After new orifices have been fabricated as required and installed, the test will be repeated to verify that the specified flow distribution in the duct circuits has been obtained.

D. Final Flow Test

1. The process water tank will be filled to a minimum of 40+ ft at the beginning of the test. Flow to the Engine Shield System and the Steam Generator System will be simulated through 50-GAV-669. The drain line, 88-PW-4"AW will be open.

2. The system will be started by opening the supply and return valves in the following order:

   a) 50-RSV-296: Full open for filling the system.

   b) 50-FCV-30: Full open after the system is filled.

   c) 50-GAV-669: Full open to simulate flow to the SGS and ETC.

   d) 50-RSV-297: Open when steady state conditions have been reached.

   e) 50-FCV-31: Full open immediately after RSV-297. Hold 5 minutes before opening the next valve.

   f) 50-RSV-298: Full open.

   g) 50-FCV-32: Full open immediately after RSV-298.

   50-GAV-669 will be closed for 2 minutes then re-opened when the process water storage tank level reaches 35, 30, 25 and 20 ft. All other valves will remain open until the level in the process water tank, T-3302, reaches 13 feet.

3. When the 13 ft. level in the tank is reached, the system will be shut down by closing the valves in the reverse order of that given above in Paragraph 2. The system will be allowed to reach steady state conditions between each valve closing. All residual water will be allowed to drain from the duct.

IV TEST LIMITS

A. Process Water Level (T-3302)

The water level in the tank will not be allowed to drop below 10 feet for Fire Protection System Requirements.

V SAFETY REQUIREMENTS

A. The Area Surveillance System will be used during each test.

B. A Bosun chair will be installed prior to the tests to provide emergency egress from the top of the duct.

C. Area Control will be established for the Duct and Pipe Vaults, the spillway the Reservoir basin, the control room, and the Instrumentation Equipment Rooms (See Figure 3).

VI TEST SCHEDULE

To be supplied later

VII STATUS BOARD

A. A Status Board will be established for this DEP and will assume control of the facility at 1400 hours on R-1 Day. Input to the Status Board must be submitted to ETS-1 Test Planning by R-7 Day.

B. Area control will be established between 10:00 A.M. and 4:00 P.M., depending on the test to be conducted.

VIII PRODUCT ASSURANCE REQUIREMENTS

A. Product Assurance personnel will follow the conduct of this DEP and maintain a discrepancy log of all systems which are exercised during this DEP.

B. Product Assurance will assure that current calibration records exist for all Duct Water Flow Test equipment.

C. All duct bolts, nuts and instrumentation fittings will be checked after the tests for evidence of disturbed torque stripping or disturbed lockwire.

IX DATA REQUIREMENTS

A. Data requirements are listed in Appendix A, NTO ETS-1 Measurements and Control Requirements. See Figure 2 (a) through 2 (e) for Duct Flow Element calibration curves.

B. Data Recording

1. Specific operation of the oscillograph charts and strip recorders will be in accordance with the Data System Operator's checklist. Oscillographs will be run at 10 ips during transient phases, and at 1 ips during steady state phases. Oscillographs may be shut down during steady state operation at the Test Director's discretion.

2. Tape data system operation will be in accordance with the Data System Operator's checklist.

C. Television coverage will be required for test observation and surveillance of the facility and for safety consideration. The following television cameras will be used, although all cameras will be operational and capable of being substituted.

Monitor No.	Camera Position No.	Location	Observation
1	1	North side of duct pit	Duct
2	2	West side of duct pit	Duct
3	3	West side of ditch	Duct exhaust
5	11	Pipe chase interior	Pipe chase
6	10	Equipment chase	Duct vault interior

Kinescope capability will be available during all phases of the test operation.

D. Communications

1. The ETS-1 communication system will be operational and audio tape recording of selected trunk lines will be required.

2. RF communications will be required.

E. Photography

1. Still photos will be taken after each test of any parts failure or other abnormalities.

2. Motion pictures will be taken of the following water discharge areas during full flow condition. (24 fps color, 16 mm)

   a) The top of the water shield tank (top of the primary section).

   b) The main water discharge line at the entrance to the drainage ditch.

   c) The discharge from the drain line, 88 PW 4" AW.

   d) Others at the discretion of the Forward Area Control.

X OPERATIONAL REQUIREMENTS

A. Control Point

The following consoles and their associated equipment will be operational for the conduct of DEP-I.

Test Director

Deputy Test Director

Lead Facility Engineer

Remote Installation Console

Site Electrical Power Console

Lead Safety Engineer

Lead Instrument Engineer

Digital Data Operator

Remote Recorder Operator

TV Operator

B. Facility and Test Stand

The following systems and their associated equipment will be operational for the conduct of DEP-I.

Process and Utility Water System

Area Surveillance and Warning System

XI REPORT REQUIREMENTS

A. A TWX will be sent to the REON Project Office within 48 hours following a flow test giving steady state values for the following parameters:

FT-54	PT-203
FT-55	PT-204
FT-56	PT-205
FT-57	PT-206
FT-58	PT-207
FT-59	PT-208
FT-60	PT-209
	PT-210
FT-72	
FT-73	PT-221
FT-74	PT-222
FT-75	PT-224
FT-76	PT-225
FT-77	PT-226
FT-78	
FT-87	TE-59
	TE-166

B. One week after the completion of a flow test the following data will be submitted to the REON Project Office:

1. Identified microfilm copies of oscillograph records.

2. Digital data tabulation.

C. Technical memorandum final report will be published approximately four weeks after the last flow test.

FLOW REQUIREMENTS FOR

NES DUCT FLOW BALANCE

Tag No.	Min.** Flow Rate GPM	Min.** Differential Pressure Reading PSID
FT54	5,878	30.6*
FT55	5,878	30.6*
FT56	5,576	15.7*
FT57	5,576	15.7*
FT58	7,563	34.4*
FT59	7,563	34.4*
FT60	10	.025*
FT87	806	114 *

NOTE: Differential Pressure for FE87 is a calculated value.

* See Figure 2 for flow tube calibration data (curve for FT-87 is calculated data)

** Must be obtained with water tank at minimum usable level and with full flow to SGS and ETC.

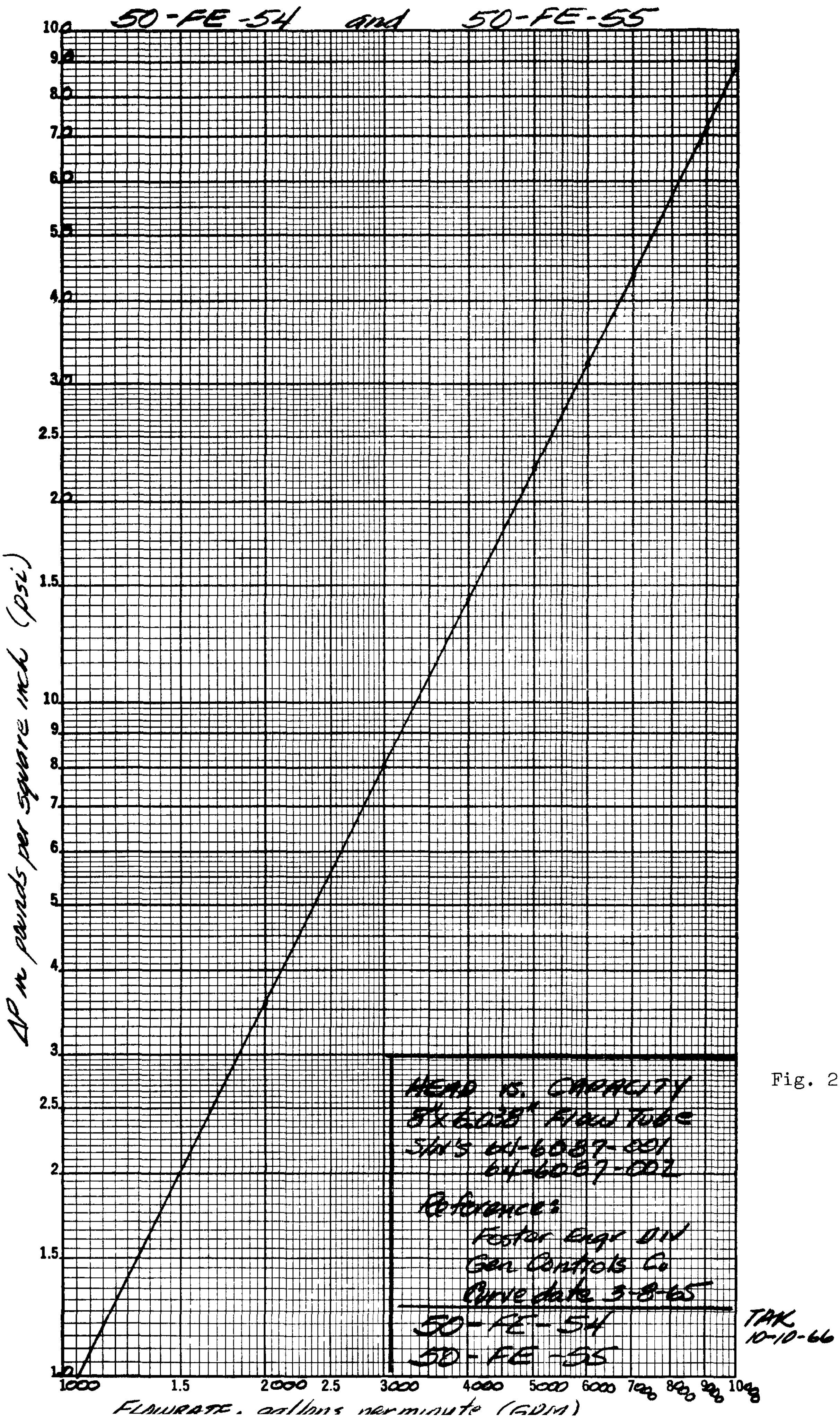

50-FE-54 and 50-FE-55
ΔP in pounds per square inch (psi)
FLOWRATE, gallons per minute (GPM)
HEAD vs. CAPACITY
8" x 6.038" Flow Tube
S/N's 64-6087-001
64-6087-002
Reference:
Foster Engr DIV
Gen Controls Co
Curve date 3-8-65
50-FE-54
50-FE-55
TAK
10-10-66

Fig. 2 (a)

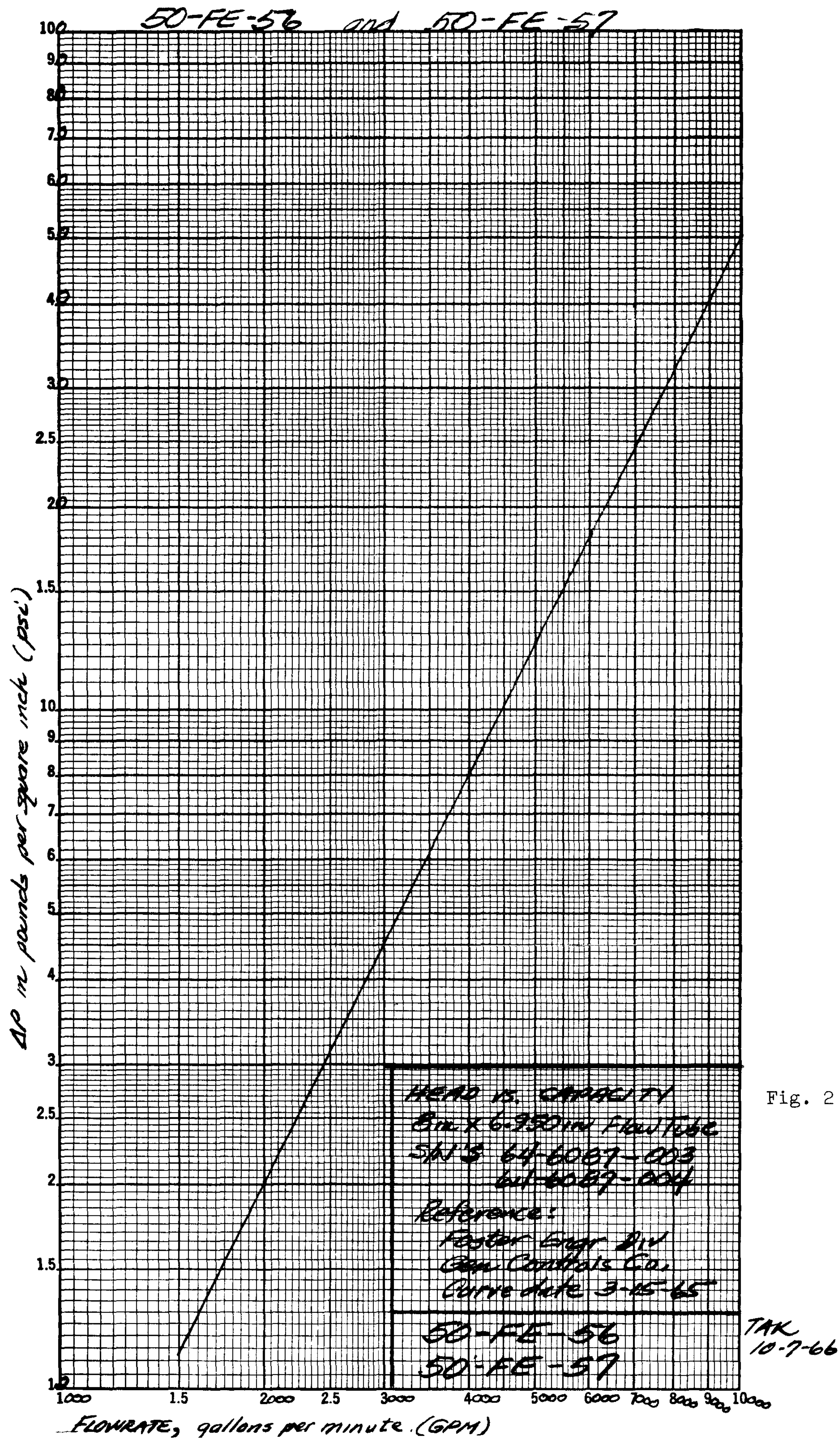
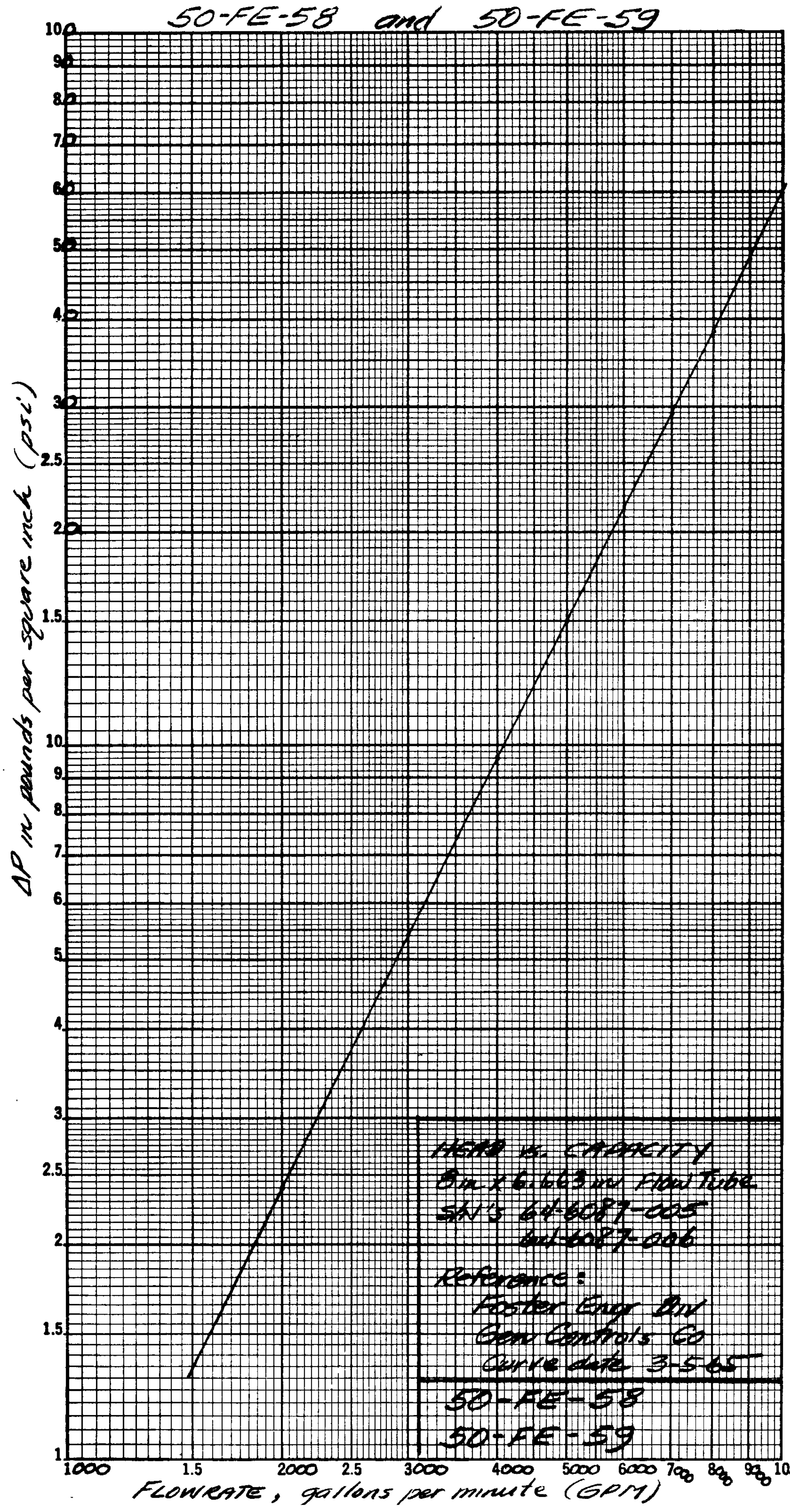

50-FE-56 and 50-FE-57
ΔP in pounds per square inch (psi)
FLOWRATE, gallons per minute (GPM)
HEAD vs. CAPACITY
8 in x 6.950 in FloTube
S/N'S 64-6087-003
64-6087-004
Reference:
Foster Engr Div
Gen Controls Co.
Curve date 3-15-65
50-FE-56
50-FE-57
TAK
10-7-66

Fig. 2 (b)



TAK
10-7-66

Fig. 2 (c)

K+E LOGARITHMIC 46 7083
2 X 1 CYCLES MADE IN U.S.A.
KEUFFEL & ESSER CO.

Airojet-General®
CORPORATION

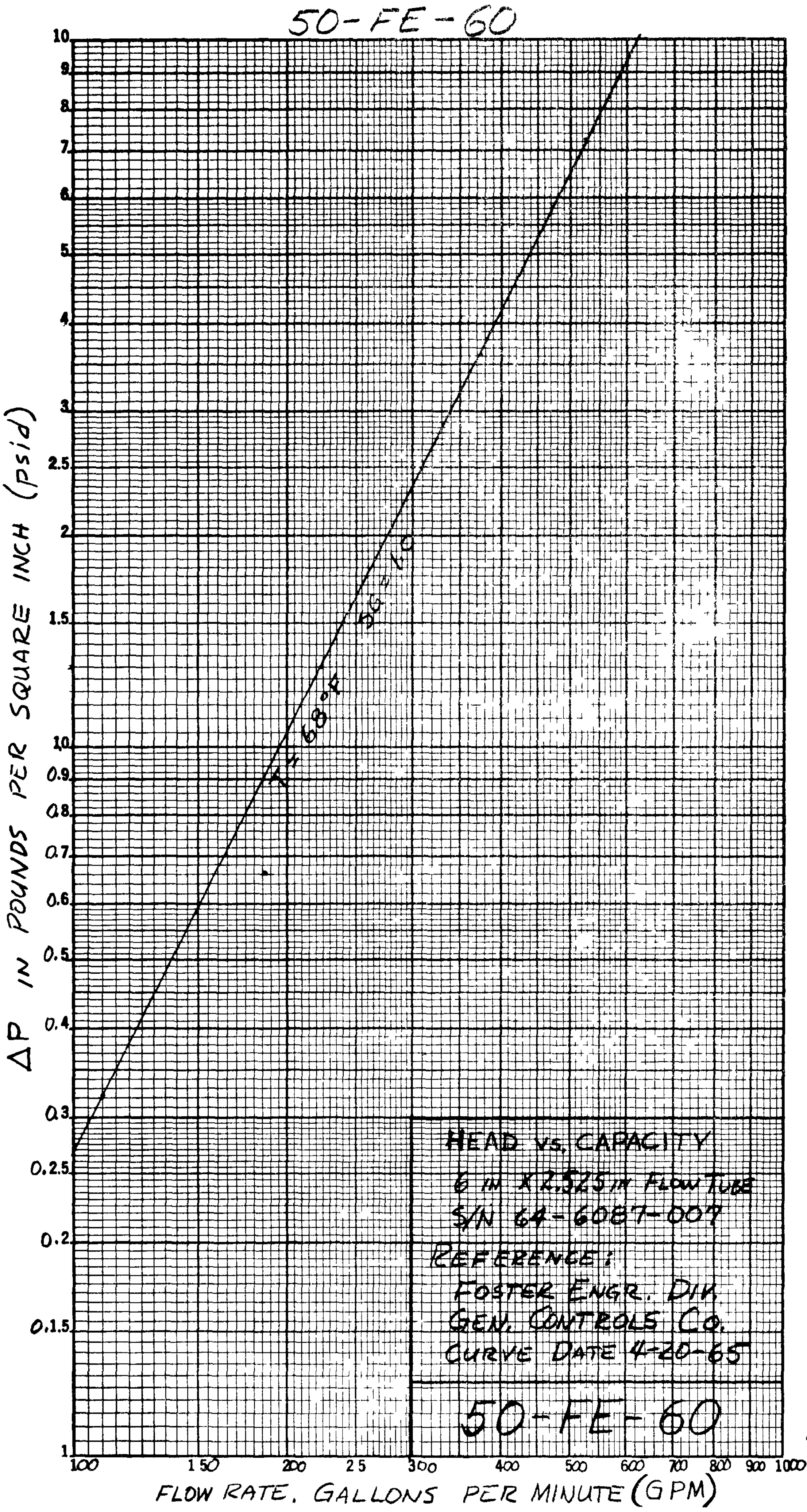


Fig. 2 (d)

OTRM
10-17-66

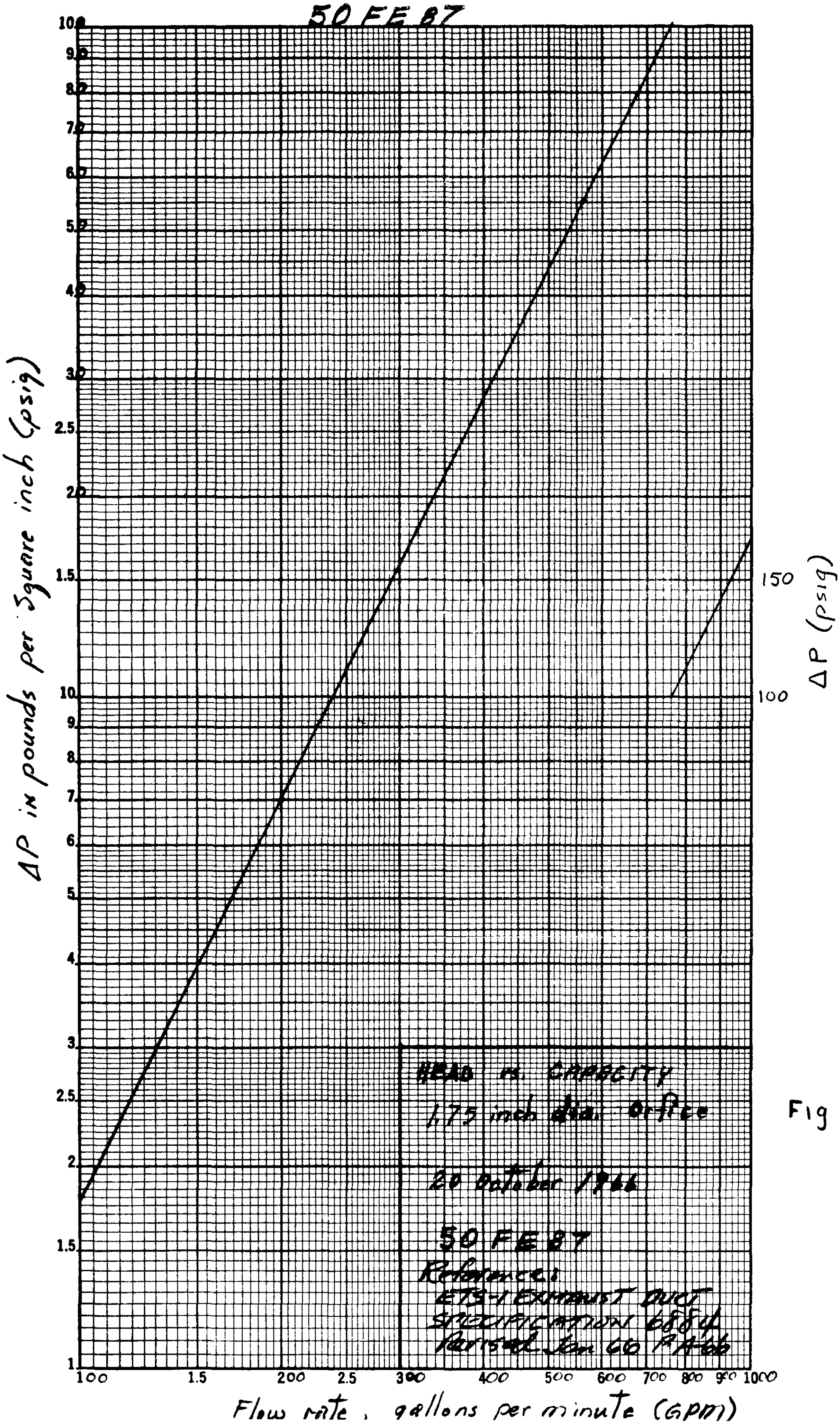

50 FE 87
ΔP in pounds per square inch (psig)
Flow rate, gallons per minute (GPM)
ΔP (psig)
150
100
HEAD vs. CAPACITY
1.75 inch dia. Orifice
20 October 1966
50 FE 87
Reference:
ETS-1 EXHAUST DUCT
SPECIFICATION 6884
Revised Jan 66

Fig 2(e)

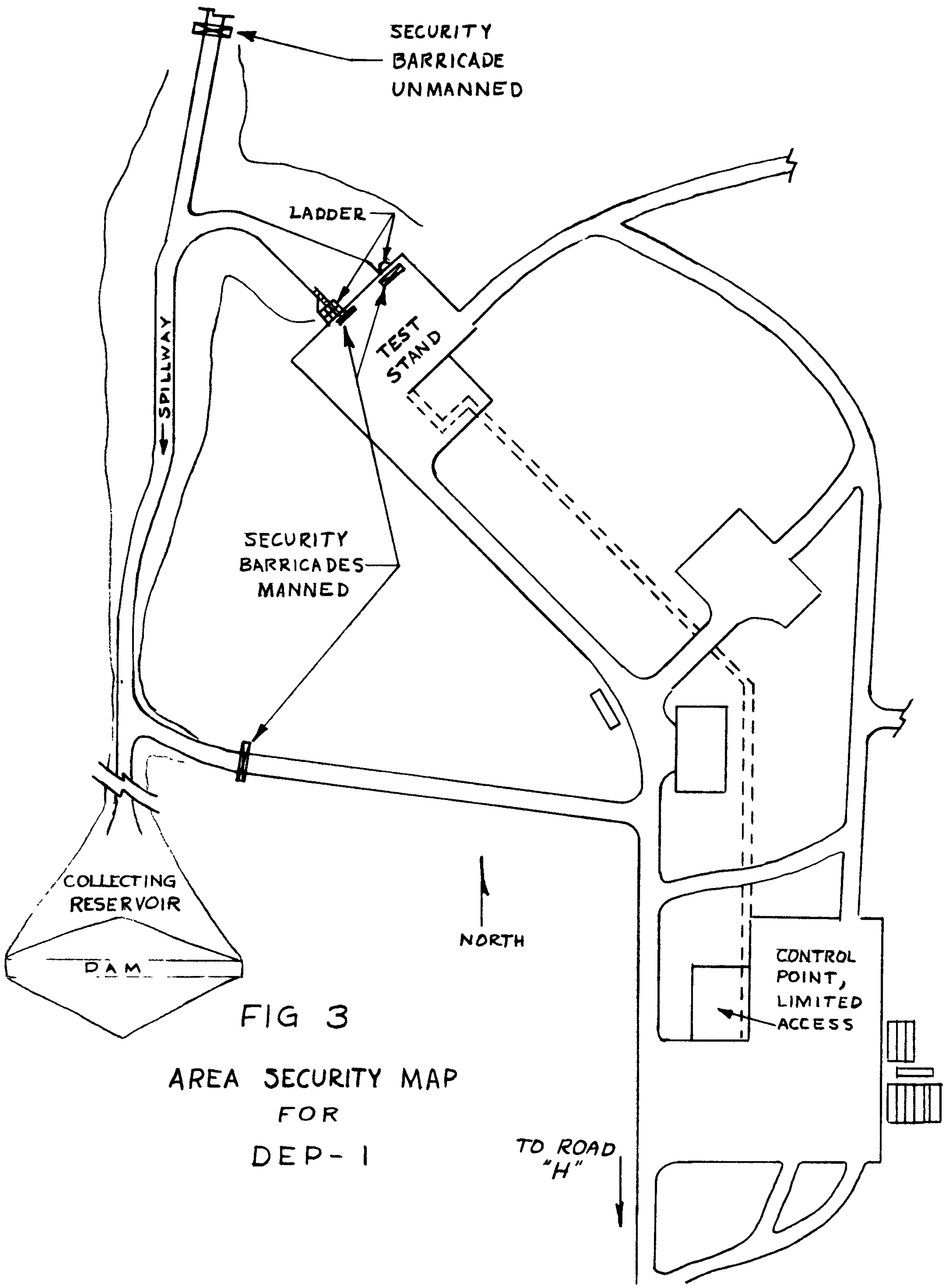


FIG 3

AREA SECURITY MAP
FOR
DEP-1

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INIT.-EP DATA

EP NO. DEP-1 EP TITLE OR DESCRIPTION DUCT COOLANT SYSTEM WATER FLOW TESTS

INITIATOR/TEST ENGR. T. A. KEASLING / O. R. MARTINS NTO ORGANIZATION ETS-1

DATE OF MCR ______ FIRST RUN PLANNED, DATE ______ LAST RUN PLANNED, DATE ______

NUMBER OF RUNS PLANNED ______ COMMENTS/SPEC. INSTR. ______

APPRVL

APPROVAL, TEST PLANNING ______ DATE ______

APPROVAL, I & C DEPT. ______ DATE ______

CE

DATE MCR RCVD, CH ENG. ______ DATE MCR ROUTED WITHIN I & C DEPT. ______

INITIATOR-EP PARAMETERS

TAG NO.	PARAMETER TITLE PERMANENT DUCT INSTRUMENTATION	MEAS RANGE	RECORDING/CONTROL/DISPLAY — ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES.																				
			01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CON-SOLE
50 FT54 *	SECT 1 LEFT CLG H20 IN FT054..FND	0-50 psid										R1		X				X				X	LF
50 FT55 *	SECT 1 RIGHT CLG H20 IN FT055..FND	0-50 psid										R2		X				X				X	LF
50FT56	SECT 2 LEFT TUBES H20 IN FT056..FND	0-25 psid										R3		X				X				X	LF
50FT57	SECT 2 RIGHT TUBES H20 IN FT057..FND	0-25 psid										R4		X				X				X	LF
50FT58 *	SECT 3 LEFT CLG H20 IN FT058..FND	0-50 psid										R5		X				X				X	LF
50FT59 *	SECT 3 RIGHT CLG H20 IN FT059..FND	0-50 psid										R6		X				X				X	LF

* Temporary Transducer

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INITIATOR - EP PARAMETERS

TAG NO.	PARAMETER TITLE PERMANENT DUCT INSTRUMENTATION	MEAS RANGE	01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CONSOLE
50FT60	SECT 2 JACKET H20 IN FT060..FND	± 5 psid				1								X				X				X	LF
50FT72	SECT 1 LEFT CLG H20 OUT FT072..FND	0-200 psid					1							X				X				B 15	RI
50FT73	SECT 1 RIGHT CLG H20 OUT FT073..FND	0-200 psid					2							X				X				B 16	RI
50FT74	SECT 2 UPPER LEFT H20 OUT FT074..FND	0-25 psid					3							X				X				B 17	RI
50FT75	SECT 2 LOWER LEFT CLG H20 OUT FT075..FND	0-10 psid					4							X				X				B 18	RI
50FT76	SECT 3 LEFT CLG H20 OUT FT076..FND	0-150 psid					5							X				X				B 19	RI
50FT77	SECT 3 RIGHT CLG H20 OUT FT077..FND	0-150 psid					6							X				X				B 20	RI
50FT78	SECT 2 LOWER RIGHT CLG H20 OUT FT078..FND	0-10 psid					7							X				X					
50FT79	SECT 2 UPPER RIGHT CLG H20 OUT FT079..FND	0-25 psid					8							X				X					
50FT87*	SECT 3 CLG H20 (3" LINE) FT087..FND	0-200psid										R7		X				X					
50PT203	SECT 1 RIGHT CLG H20 IN PT203..FND	0-250 psig										L1		X				X					

RECORDING/CONTROL/DISPLAY — ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES

* Temporary Transducer

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INITIATOR - EP PARAMETERS

RECORDING/CONTROL/DISPLAY — ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES

TAG NO.	PARAMETER TITLE	MEAS RANGE	01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CON-SOLE
	PERMANENT DUCT INSTRUMENTATION																						
50PT204	SECT 1 LEFT CLG H20 OUT PT204..FND	0-100 psig				2								X				X				B 21	RI
50PT205	SECT 2 LEFT UPPER CLG H20 OUT PT205..FND	0-100 psig				3								X				X				B 23	RI
50PT206	SECT 2 RIGHT CLG H20 IN PT206..FND	0-250 psig				4								X				X					
50PT207	SECT 3 RIGHT CLG H20 IN PT207..FND	0-250 psig				5								X				X					
50PT208	SECT 3 RIGHT CLG H20 OUT PT208..FND	0-250 psig				6								X				X				B 27	RI
50PT209	SECT 2 RIGHT LOWER CLG H20 OUT PT209..FND	0-100 psig				7								X				X				B 26	RI
50PT210	SECT 2 RIGHT UPPER CLG H20 OUT PT210..FND	0-100 psig				8								X				X				B 24	RI
50PT221	SECT 1 LEFT CLG H20 IN PT221..FND	0-250 psig						1						X				X					
50PT222	SECT 3 RIGHT CLG H20 OUT PT222..FND	0-250 psig						2						X				X					
50PT223	SECT 1 RIGHT CLG H20 OUT PT223..FND	0-100 psig						3						X				X				B 22	RI
50PT224	SECT 2 LEFT LOWER H20 IN PT224..FND	0-250 psig						4						X				X					

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INITIATOR - EP PARAMETERS

TAG NO.	PARAMETER TITLE PERMANENT DUCT INSTRUMENTATION	MEAS RANGE	RECORDING/CONTROL/DISPLAY — ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES 01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CON-SOLE
50PT225	SECT 3 LEFT CLG H20 IN PT225..FND	0-250 psig						5						X				X					
50PT226	SECT 2 LEFT LOWER H20 OUT PT226..FND	0-100 psig						6						X				X				B 25	RI
50STG4	REAR LEFT TRUNNION GG004..FND	0-1500*	X											X								B 29	RI
50STG5	REAR RIGHT TRUNNION GG005..FND	0-1500*	X											X								B 30	RI
50STG6	FRONT LEFT TRUNNION GG006..FND	0-1500*	X											X								B 31	RI
50STG7	FRONT RIGHT TRUNNION GG007..FND	0-1500*	X											X								B 32	RI
50STG11	SECT 2 CONE BOTTOM GG011..FND	0-1500*	X											X								B 35	RI
50STG12	SECT 2 CONE RIGHT SIDE GG012..FND	0-1500*	X											X									
50STG13	SECT 2 CONE TOP GG013..FND	0-1500*	X											X								B 36	RI
50STG14	SECT 2 CONE LEFT SIDE GG014..FND	0-1500*	X											X								B 37	RI
50STG15	SECT 3 BOTTOM GG015..FND	0-1500*	X											X								B 38	RI

* μ in/in

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INITIATOR - EP PARAMETERS

TAG NO.	PARAMETER TITLE PERMANENT DUCT INSTRUMENTATION	MEAS RANGE	RECORDING/CONTROL/DISPLAY												ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES							
			01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CONSOLE
50STG16	SECT 3 RIGHT SIDE GG016..FND	0-1500*	X											X									
50STG17	SECT 3 TOP GG017..FND	0-1500*	X											X								B 39	RI
50STG18	SECT 3 LEFT SIDE GG018..FND	0-1500*	X											X									
50STG19	SECT 3 FWD HORIZ. TRUSS GG019..FND	0-1500*	X											X									
50TE57	SECT 1 RIGHT CLG H20 OUT TE057..FND	32-250°F							1					X								X	LF
50TE58	SECT 2 LEFT LOWER CLG H20 OUT TE058..FND	32-250°F							2					X								X	LF
50TE59	SECT 3 RIGHT CLG H20 OUT TE059..FND	32-250°F							3					X								X	LF
50TE166	SECT 3 UPPER TRUSS STA 823 TE166..FND	32-250°F							4					X									
50TE167	SECT 3 LOWER TRUSS STA 823 TE167..FND	32-250°F							5					X									
50XVT-1	SECT 1 SEAL TABLE - IX HT001..FND	0-15 g																X					

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INITIATOR - EP PARAMETERS

RECORDING/CONTROL/DISPLAY — ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES

TAG NO.	PARAMETER TITLE PERMANENT DUCT INSTRUMENTATION	MEAS RANGE	01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CON-SOLE
50XVT-2	SECT 1 SEAL TABLE - 2Y HT002..FND	0-15 g																X					
50XVT-3	SECT 1 SEAL TABLE - 3Z HT003..FND	0-15 g																X					
50XVT-4	SECT 2 ELBOW TABLE - 1X HT004..FND	0-15 g																X					
50XVT-5	SECT 2 ELBOW TABLE - 2Y HT005..FND	0-15 g																X					
50XVT-6	SECT 2 ELBOW TABLE - 3Z HT006..FND	0-15 g																X					
50XVT-7	SECT 3 MID SPAN - 1X HT007..FND	0-15 g																X					
50XVT-8	SECT 3 MID SPAN - 2Y HT008..FND	0-15 g																X					
50XVT-9	SECT 3 MID SPAN - 3Z HT009..FND	0-15 g																X					

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INITIATOR - EP PARAMETERS

TAG NO.	PARAMETER TITLE	MEAS RANGE	RECORDING/CONTROL/DISPLAY — ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES																					
	TEMPORARY DUCT INSTRUMENTATION		01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CON-SOLE
50STG901	SECT 1 FRONT - TOP GG901..FND	0-1500*	X											X									
50STG902	SECT 1 REAR - TOP GG902..FND	0-1500*	X											X									
50STG903	SECT 1 FRONT - MIDSPAN GG903..FND	0-1500*	X											X									
50STG904	SECT 1 REAR - MIDSPAN GG904..FND	0-1500*	X											X									
50STG905	SECT 1 FRONT - BOTTOM GG905..FND	0-1500*	X											X									
50STG906	SECT 1 REAR - BOTTOM GG906..FND	0-1500*	X											X									
50STG907	ELBOW WATER JACKET FRONT - TOP GG907..FND	0-1500*	X											X									
50STG908	ELBOW WATER JACKET REAR - TOP GG908..FND	0-1500*	X											X									
50STG909	ELBOW WATER JACKET FRONT - BOTTOM GG909..FND	0-1500*	X											X									
50STG910	ELBOW WATER JACKET REAR - BOTTOM GG910..FND	0-1500*	X											X									

* μ in/in

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INITIATOR - EP PARAMETERS

TAG NO.	PARAMETER TITLE TEMPORARY DUCT INSTRUMENTATION	MEAS RANGE	RECORDING/CONTROL/DISPLAY — ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES: 01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CONSOLE
50STG911	SECT 3 MIDSPAN - TOP GG911..FND	0-1500*	X											X									
50STG912	SECT 3 MIDSPAN - BOTTOM GG912..FND	0-1500*	X											X									
50STG913	SECT 3 - 45°ELBOW - TOP GG913..FND	0-1500*	X											X									
50STG914	SECT 3 - 45°ELBOW - BOTTOM GG914..FND	0-1500*	X											X									
50XVT901	SECT 1 MIDSPAN SUPPORT RING HT901..FND	0 - 15 g																X					
50XVT902	SECT 1 MIDSPAN SUPPORT RING HT902..FND	0-15 g																X					
50XVT903	SECT 1 MIDSPAN SUPPORT RING HT903..FND	0-15 g																X					
50XVT904	ELBOW H20 JACKET - FRONT HT904..FND	0-15 g																X					
50XVT905	ELBOW H20 JACKET - FRONT HT905..FND	0-15 g																X					
50XVT906	ELBOW H20 JACKET - FRONT HT906..FND	0-15 g																X					
50XVT907	SECT 3 H20 INLET MANIFOLD HT907..FND	0-15 g																X					

* μ in/in

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INITIATOR - EP PARAMETERS

ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES

TAG NO.	PARAMETER TITLE TEMPORARY DUCT INSTRUMENTATION	MEAS RANGE	01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CONSOLE
50XVT908	SECT 3 H20 INLET MANIFOLD HT908..FND	0-15 g																X					
50XVT909	SECT 3 H20 INLET MANIFOLD HT909..FND	0-15 g																X					
50XVT910	REAR TRUNNION MIDSPAN HT910..FND	0-15 g																X					
50XVT911	REAR TRUNNION MIDSPAN HT911..FND	0-15 g																X					
50XVT912	REAR TRUNNION MIDSPAN HT912..FND	0-15 g																X					
50XVT913	FRONT TRUNNION MIDSPAN HT913..FND	0-15 g																X					
50XVT914	FRONT TRUNNION MIDSPAN HT914..FND	0-15 g																X					
50XVT915	FRONT TRUNNION MIDSPAN HT915..FND	0-15 g																X					

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INITIATOR - EP PARAMETERS

TAG NO.	PARAMETER TITLE DUCT WATER SUPPLY	MEAS RANGE	01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CONSOLE
50FE30	FLOW - PARTIAL THRU DUCT 4" LINE FT 030..FWS	0-5 psid										L2						X					
50FE31	FLOW - PARTIAL THRU DUCT 12" LINE FT031..FWS	0-5 psid										L3		X				X				X	LF
50FE32	FLOW - TOTAL THRU DUCT FT032..FWS	0-5 psid										L4		X				X				X	LF
06-LI-15	LIQUID LEVEL-PROCESS WATER SUPPLY TANK LT015..FWS	0-50 FT						7						X					1			X	LF
50PT168	PROCESS H20 HYD PRESS PT168..FWS	0-300 PSIG						8						X								X	LF
50TT047	DUCT COOLANT INLET TEMP TT047..FWS	32-100°F							6					X								X	LF
50TT048	DUCT COOLANT OUTLET TEMP TT048..FWS	32-250 °F							7					X								X	LF
50PT597	DUCT COOLANT INLET PRESS PT597..FWS	0-300 PSIG										L5		X				X				X	LF
50PT596	DUCT COOLANT OUTLET PRESS PT596..FWS	0-300 PSIG										L6		X				X				X	LF
50PT600	DUCT COOLANT FCV OUTLET PRESS PT600..FWS	0-30 PSIA										L7		X				X					

ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INITIATOR - EP PARAMETERS

TAG NO.	PARAMETER TITLE DUCT WATER SUPPLY	MEAS RANGE	RECORDING/CONTROL/DISPLAY 01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CONSOLE
50FT720	SIMULATED SGS & SHIELD FLOW	0-250																					
	FT720..FWS	PSID										L8		X									
50FCV030	DUCT H20 FLOW CONTROL - 1-1/2"																						
	SF030.OFND																			X			
	SF030.CFND																			X			
	BF030.OFND																				X		
	BF030.CFND																				X		LF
50FCV031	DUCTHH20 FLOW CONTROL - 6"																						
	CF031.OFND	0-100 PC																		X			
	CF031.OFND																			X			
	DF031..FND		X											X								X	LF
	BF031.OFND																				X		
	BF031.CFND																				X		
50FCV032	DUCT H20 FLOW CONTROL - 20"																						
	CF032.OFND																			X			
	CF032.CFND																			X			
	DF032..FND	0-100 PC	X											X								X	LF
	BF032.OFND																				X		
	BF032.CFND																				X		
50RSV296	DCT H20 SPLY LO FLOW SOV																						
	SR296.OFND																X			X			
	SR296.CFND																X			X			LF
	BR296.OFND																X				X		
	BR296.CFND																X				X		

ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES

NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

INITIATOR - EP PARAMETERS

TAG NO.	PARAMETER TITLE	MEAS RANGE	RECORDING/CONTROL/DISPLAY — ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES																				
	DUCT WATER SUPPLY		01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CON-SOLE
50RSV297	DCT H2O SPLY MED FLOW SOV																						
	SR297.OFND																X			X			
	SR297.CFND																X			X			LF
	BR297.OFND																X				X		
	BR297.CFND																X				X		
50RSV298	DCT H2O SPLY HI FLO SOV																						
	SR298.OFND																X			X			
	SR298.CFND																X			X			LF
	BR298.OFND																X				X		
	BR298.CNND																X				X		

APPENDIX II

APPENDIX II

NES DUCT SYSTEM

FIELD ACTION REQUESTS INDEX

(FAR's received 25 October 1966 thru 7 February 1967)

FAR NO.	TITLE	DATE RECEIVED	DATE COMPLETED
1001	HIGH POINT VENT MODIFICATION	10-25-66	11-15-66
1002	NES DUCT REPAIR PROGRAM	10-6-66	11-15-66
1003	BLEED LINES FOR EXPANSION JOINTS	10-27-66	11-15-66
1004 (Rev. A)	UPPER (87") MARMON CLAMP MOTORS - REPLACEMENT OF AIR SUPPLY LINES	1-9-67	1-11-67
1005	DUCT DRAIN SHUTOFF VALVES	10-27-66	11-15-66
1006 (Rev. A)	NES DUCT INSTRUMENTATION CABLE CLAMP INSTALLATION (WELDON)	11-10-66	11-15-66
1007	HIGH POINT VENT MODIFICATION	11-7-66	11-16-66
1008	DRAIN SCREENS AT THE BOTTOM OF RADIATION SHIELD WATER TANK	11-7-66	Not completed
1009	SUPPORT BRACKETS FOR DUCT LINES WHERE REQUIRED	11-7-66	12-1-66
1010	INSPECTION AND IDENTIFICATION OF VENT AND DRAIN ORIFICES	11-9-66	11-15-66
1011	NES DUCT FLOW ELEMENT IDENTIFICATION	11-9-66	12-14-66
1012	NES DUCT ORIFICES REMOVAL AND ΔP SENSORS MOUNTING	12-2-66	12-6-66
1013	TUBING DISCONNECT-ELBOW JACKET AND INLET WATER MANIFOLD LEAKAGE VENT	11-16-66	11-18-66
1014	INSTALLATION OF VENT FITTINGS-UPPER BALANCE BELLOWS	11-16-66	11-16-66
1015	NES DUCT FLOW ELEMENT DIFF. PRESSURE TRANSDUCER SHOCKMOUNTS (FT-56 & FT-59)	12-6-66	12-10-66
1016	TURBINE EXHAUST NOZZLES-TEMPORARY ENGINE COMPARTMENT	12-7-66	12-22-66

FAR NO.	TITLE	DATE RECEIVED	DATE COMPLETED
1017	DYE PENETRANT INSPECTION PRIMARY SECTION END CAP	12-7-66	Continuing
1018	NES DUCT FLOW ELEMENT DIFF. PRESS. TRANSDUCER SHOCKMOUNT (50-FT-59)	12-13-66	1-17-67
1019	REPLACEMENT OF TRANSDUCERS 50-PT-204, 50-PT-223	12-16-66	1-17-67
1020	NES DUCT INSTRUMENTATION CHANNELS	12-21-66	1-17-67
1021	NES DUCT STRAIN GAGE INSTRUMENTATION	12-21-66	1-17-67
1022	NES DUCT PRESSURE CHANNELS FOR INTEGRATED NES TESTING	12-21-66	1-17-67
1023	NES DUCT INSTRUMENTATION REPLACEMENT	12-19-66	1-17-67
1024	NES DUCT INSTRUMENTATION TRANSDUCER INSTALLATION	1-5-67	1-18-67
1025	DESIGN DEMONSTRATION TEST PROGRAM TEC SIMULATED TURBINE EXHAUST NOZZLES	1-11-67	1-16-67
1026	RESIZING AND INSTALLATION OF FLOW CONTROL ORIFICES 50-FT-72 AND 50-FT-73	1-23-67	2-1-67
1028	TEMPORARY REPLACEMENT OF DAMAGED TRANSDUCERS	1-31-67	2-1-67
1029	DUCT INSTRUMENTATION MOUNTING HARDWARE MODIFICATION	1-17-67	1-17-67