NERVA PROGRAM

MASTER

ETS-1 PROCESS WATER SYSTEM TEST PROGRAM

REPORT NO. NTO-R-0041

14878

TEST SERIES 1-F-3

AUGUST 11, 1965

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NERVA TEST OPERATIONS

NRDS, NEVADA

X-7668

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MASTER

ETS-1
PROCESS WATER SYSTEM
TEST PROGRAM
REPORT

August 11, 1965

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1. INTRODUCTION

During the first series of water flow tests conducted in November 1963 and January 1964 (Test Series 1-F-1) severe vibrations in the process water piping were encountered. The vibrations were suspected to be caused by the impingement of high velocity water discharge from the 20" valve into the 42" drain piping. Figure 1 is an isometric drawing of the system initial configuration. Subsequently, the drain piping was modified and a second series of tests was conducted during the period September - October 1964 (Test Series 1-F-2) to determine the effectiveness of the modification. Vibrations were again noted which were attributed to cavitation in the large flow control valves and inadequate support of the flow control valves.

Figure 2 is an isometric drawing showing initial system modification. Subsequent to the second series of tests, major system modifications were made as follows:

- A. The flow control valves were relocated to a large concrete "block" poured on the pipe chase floor. The concrete block contained a piping "U" bend embedded within it. The 36" return line was re-routed toward the deck level and connected to the inlet of the embedded "U" bend. The 20" angle flow control valve was flanged to the outlet of the "U" bend. The 6" and 1½" flow control valves were tied into the piping near the 20" valve. Photo, Figure 3, shows the flow control valves mounted on top of the concrete block.
- B. The discharge piping from the control valves to the outflow ditch, was constructed of a horizontal run of 24" piping to the open end of the pipe chase and then a vertical run to the level of the outflow ditch. Horizontal and vertical supports for the discharge line were attached to the pipe chase walls. Photo, Figure 4, shows the discharge line and supports.
- C. A 19.4" orifice was installed at the end of the 24" discharge line. Photo 5 shows the orifice installed in position.

- D. The 180° "U" bend and orifice, installed for previous tests to simulate the NES coolant flow were removed and the 36" supply and return lines were extended through the pipe chase wall into the duct vault. The supply and return lines within the duct vault were extended down to the duct vault floor where a new 180° "U" bend and duct simulation orifice was installed. Photo, Figure 6, shows the piping within the duct vault.

- E. New supports were installed on the supply and return lines at the duct vault penetration "window". Photo, Figure 7, shows the lines supported at the wall penetration.

Figure 8 is an isometric drawing showing the process water system modification No. 2.

The objective of the tests performed, and covered by this report, was to demonstrate the effectiveness of these latest modifications.

II. SUMMARY OF TESTS

A. Test Procedure

The process water system flow test program was conducted during the period 22 June 1965 to 24 June 1965. The tests were divided into three phases (A, B, & C) as in the previous test series. The test procedure and general requirements are detailed in the ETS-1 Process Water System Test Program, NERVA Test Operations Operating Instruction NTO-I-0035, dated 14 May 1965, which is included in this report as Appendix "A".

B. Test Observations

Phase "A" of the test program was conducted on 22 June 1965. The purpose of this test was to cycle the flow control and butterfly supply valves at low water flow rates for operational checkout purposes. No system deficiencies were noted during this phase.

The second test (Phase "B") was conducted on 23 June 1965. Approximately 165,000 gallons of water was released at a maximum flow rate of approximately 34,000 GPM. During this test, vibrations were encountered during the operation of the 20" flow control valve, 50 FCV 32, at the 180° "U" bend containing the duct simulation orifice and also at 50 FCV 32. This vibration resulted in the loosening of the anchor bolts securing the "U" bend to the duct vault floor. Before continuing with Phase "C" of the test series, additional bracing was attached to the piping supports at the 180° "U" bend to distribute the load.

Phase "C", simulated system test, was conducted on 24 June 1965. Vibrations were again noted when 50 FCV 32 was operated. Vibrations were the most severe near the duct simulation orifice and 24" drain line. Acceleration loads measured near the duct simulation orifice were approximately 5 g's at 750 cps, with "spikes" to approximately 20 g's and low frequency oscillations of the lines of approximately $\frac{1}{4}$ " at 6 cps were also noted in the same area. Approximately 1,100,000 gallons of water were released at a maximum system flow rate of 33,600 GPM.

Observation of water dispersal into the desert was made from a helicopter. The channeling and fanning out of the water between the J-12 and Lathrop Wells Road was essentially the same as observed in the previous test series.

C. Instrumentation and Photographic Coverage

1. Instrumentation

Data was obtained by both visual and oscillographic instrumentation. The visual data was recorded by reading bourdon tube pressure gages and indicating lights. The oscillographic data was acquired by means of a 36 channel CEC recorder, Wiancho pressure transducers, Glenite acceleration transducers and associated electronic circuitry.

The pressure transducers were mounted rigidly to the walls of the pipe chase and plumbed with copper tubing to the appropriate piping tap. The accelerometers were bolted to clips welded to the piping. Calibration of the pressure transducers were by the use of a calibrated "Heisse" gage and manometer. The accelerometers were calibrated on a "shaker" to 20 g's at frequencies of 50, 100 and 500 cps. An isometric drawing of process system instrumentation locations is shown in Figure 9.

2. Photographic Coverage

Three 16mm motion picture cameras were used to obtain visual coverage of the flow test. Two were tripod-mounted in the pipe chase and one hand-held for close up views of the piping, valves, etc. Color film at 24 fps were used in all cameras. A documentary film was compiled from film clips of each of the test series (1-F-1, 1-F-2 and 1-F-3). This film, Production No. 330-096, shows a comparison of piping vibrations on each of the test series.

III. TEST RESULTS

A. Phase "A"

Valve timing was satisfactorily obtained and no deficiencies were noted in performance of Phase "A".

B. Phase "B"

No abnormalities were noted during the calibration of the circuit containing 50 RSV 296 and 50 FCV 30 and the circuit containing 50 RSV 297 and 50 FCV 31. High noise level and vibration was evident when 50 RSV 298 and 50 FCV 32 were opened. Inspection of the piping system after the test showed that the bolts which anchor the 36" return line and 36" supply line supports at the pipe chase to duct vault entry had loosened and that the movement of the 180° "U" bend in the duct vault had loosened the deck anchor bolts. The valve position indicators for 50 FCV 30, 31 and 32 failed during the operation of 50 FCV 32, and valve movement data was not obtained during this part of Phase "B".

The following work items, as a result of Phase "B", were performed prior to continuing the testing:

1. Tightened all bolts at the 36" return and supply line supports at the duct vault penetration.
2. Stiffened the 180° "U" bend support with 6" angle anchored to the duct vault floor. Photo, Figure 10, shows the "U" bend with angle bracing installed.
3. Repaired valve movement indicators on 50 FCV 30 and 31. Valve indicator on 50 FCV 32 was not repaired.

C. Phase "C"

After all valves were opened and steady state flow was achieved, a team of observers entered the pipe chase for a close examination of the piping. The following observations were made:

1. Very little vibration was noted in the 36" supply line.
2. High noise level in the pipe chase and duct vault with extreme vibration of the piping at the duct simulation orifice and the 36" return line up to the flow control valves. Low frequency oscillations of the piping of approximately $\frac{1}{4}$ " were noted.
3. The flow control valves, 50 FCV 30 and 31, were vibrating severely.
4. Vibration of the 24" discharge line, downstream of 50 FCV 32 was noted.

The following observations were made after Phase "C" was completed:

1. The anchors on the 180° "U" bend were loosened.
2. The anchor bolts on the 36" supply and return line supports at the duct vault penetration "window" were loosened.
3. The anchor bolts on the vertical and horizontal pipe supports for the 24" discharge line were loosened.

Test data reduced from the oscillograph and strip chart records are presented in the curves of pressure vs time and acceleration vs time for transient conditions of 50 FCV 32. Curves shown in Figures 11, 12 and 13 are for the operating characteristics of the system during 50 FCV 32 opening and curves shown in Figures 14, 15 and 16 show operating characteristics during 50 FCV 32 closing.

Figure 17 shows the system pressure variations after 50 FCV 31 opened. This valve opened in 5.4 seconds and the maximum pressure variation was approximately 100 PSI from peak to dip.

From the log of process water tank level, a curve of the tank level vs time was made. Calculations from this curve over the period that steady state flow was achieved, show the flow rate to be 33,614 GPM. This flow rate did not correlate with the calculated flows obtained from measurements of 50 FT 32 flow meter. It must be noted that the 20" flow tube, due to its size, was

never calibrated by the manufacturer. Figure 18 shows the curve of tank level vs time. This curve will be used as a basis of calibration of 50 FT 32.

The area at the end of the outflow ditch was eroded to a depth of approximately 4 feet. Figure 19 shows the erosion.

The Pulsation Controls Corporation of Santa Paula, California (PULSCO), a consultant firm was retained to analyze the flow test results and to make corrective recommendations. Mr. J. K. Floyd of PULSCO visited ETS-1 and was given a thorough review of the process water system and the tests conducted to date. The results and recommendations of the PULSCO investigation are published in PULSCO Report R-177, dated 20 July 1965, and entitled "INVESTIGATION OF VIBRATION PROBLEMS IN THE WATER SUPPLY PIPING SYSTEM FOR THE ETS-1 NERVA EXHAUST DUCT". The consultant's analysis also indicated that the severe vibrations and noise encountered were basically caused by cavitation at the duct simulation orifice and 20" flow control valve.

IV. CONCLUSION

The following is concluded after analyzing the results of and observing the Process Water System Test:

- A. Extreme cavitation was encountered immediately downstream of the duct simulation orifice. Acceleration loads measured near this orifice were approximately 5.0 g's at 750 cps with frequent "spikes" to approximately 20 g's. Low frequency oscillations of approximately 6 cps and $\frac{1}{4}$ " amplitude were observed in this area.
- B. A region of marginal flow stability was experienced in the discharge line downstream of the flow control valves. This was evidenced by the pressure fluctuations in the area immediately downstream of the flow control valves and by occasional "cracking" sounds at the 20" flow control valve, 50 FCV 32.
- C. Anchor bolts in general and particularly in the 36" pipe anchoring system in the pass thru to the duct vault were loose. This loosening is concluded to be a result of the aforementioned high frequency accelerations.
- D. Flow control valves 50 FCV 30 and 50 FCV 31, $1\frac{1}{2}$ " and 6" respectively, were vibrating. 50 FCV 31 is located at the end of a 5-foot moment arm and is greatly influenced by the system instability. 50 FCV 30 is connected by piping to 50 FCV 31 and is influenced by that valve and the system instability.
- E. As a result of 50 FCV 31 opening and closing in approximately 5.5 sec, hammer surges were set up in the flow system with a maximum magnitude of 100 PSI.
- F. The flow control valve position measuring system is marginal and was unreliable during the test program due to the severe acceleration loads induced into the system.
- G. Calculations performed subsequent to the test program revealed an insufficient system bleed. This is possibly a contributing factor in the system instability.

- H. Some transducers were not close coupled and errors are possible in the dynamic pressure readings due to resonant characteristics of the instrument lines.
- I. Erosion at the end of the outflow ditch was not so severe as in previous test programs but results were still not satisfactory.

V. RECOMMENDATIONS

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

- A. Replace the duct simulation orifice with a flow restriction tube. The purpose of this change is to simulate the exhaust duct pressure drop at the designed flow condition, without inducing cavitation or producing excessive fluid turbulence.
- B. Replumb a section of the piping downstream of the three flow control valves so that the fluid discharges at a slightly higher elevation than the flow control valves. This modification will eliminate the siphoning condition which now exists. Additionally, a concrete anchor should be provided at the discharge end of the relocated piping and provide provisions for ducting the water to the outflow ditch. Incorporate a pressure tap in 50 FCV 32 to measure the static pressure in the area of maximum velocity.
- C. To minimize the transmission of system disturbances from the pipe vault to the duct vault and vice versa, encase and firmly secure the 36" supply and return lines that pass through the duct vault wall by pouring concrete in the wall penetration window to a point 12" above the supply line.
- D. The flow control valves, 50 FCV 30 and 50 FCV 31, should be restrained from vibrating.
- E. The operating time of 50 FCV 31 should be lengthened from the current 5.5 seconds to approximately 40 seconds to minimize fluid surges.
- F. To eliminate any entrapped air from the system, bleeds should be incorporated at existing high points and dead-ended headers.
- G. Modify the flow control valve position measuring system to obtain more reliable operation.

- H. For future testing the pressure transducers should be installed as close as possible to the pipeline. This should eliminate potential errors in the dynamic pressure readings due to possible resonant conditions of the instrument lines. The possibility of improving the accelerometer measuring system to provide direct indication of amplitude should be investigated.
- I. Repair the end of the outflow ditch to prevent undermining of the concrete apron.
- J. Another test program should be initiated to evaluate the results of the above recommendations.
- K. Additionally, a study should be undertaken to determine the requirement for flow straightening vanes at specific locations in the piping system, such as the inlet and outlet elbows leading to and from the duct.

PROCESS WATER SYSTEM ETS-1
INITIAL INSTALLATION

Figure 1

PROCESS WATER SYSTEM ETS-1
MODIFICATION NO. 1

FOR OFFICIAL USE ONLY - UNCLASSIFIED

6 5 7 3 3 5

FOR OFFICIAL USE ONLY - UNCLASSIFIED

657338

FOR OFFICIAL USE ONLY - UNCLASSIFIED

657334

FOR OFFICIAL USE ONLY - UNCLASSIFIED

FIG. 6

Fig. 7

FOR OFFICIAL USE ONLY - UNCLASSIFIED

6 5 7 3 3 1 2

PROCESS WATER SYSTEM ETS-1
MODIFICATION NO. 2

**PROCESS WATER SYSTEM ETS-1
INSTRUMENTATION**

FOR OFFICIAL USE ONLY - UNCLASSIFIED

657333

ETS-1 PROCESS WATER SYSTEM FLOW TEST

24 June 1965

50 FCV 32 Opening

ETS-1 PROCESS WATER SYSTEM FLOW TEST

24 June 1965
50 FCV 32 Opening

ETS-1 PROCESS WATER SYSTEM FLOW TEST

24 June 1965

50 FCV 32 Closing

ril 7/19/65

ETS1 PROCESS WATER SYSTEM FLOW TEST

24 June 1965

50 FCV 32 Closing

ril 7/19/65

SYSTEM OSCILLATIONS AFTER

50 FCV 31 OPEN

Pressures (PSIG)

50 PT 168	230	-	265	215	240	225
PT 1	225	147	244	190	219	205
PT 2	237	145	237	186	214	197
PT 4	235	145	237	187	214	199

18.5 Sec.

$$\text{ACOUSTICAL VELOCITY} = \frac{6000}{4.625} \times 2 = 2600 \text{ Ft/Sec.}$$

VALVE OPENING TIME = 5.4 Sec.

PRESSURE VARIATION CYCLE

CYCLES.	1st	2nd	3rd	4th	5th
50 PT 168	-	-	50	25	15
PT 1	78	97	46	29	14
PT 2	92	92	51	28	17
PT 4	90	92	50	27	15

fil 7/15/65

FIG. 19

AEROJET-GENERAL CORPORATION
AZUSA, CALIFORNIA

QUADRILLE WORK SHEET

PAGE 2 OF 3 PAGES

DATE _____

SUBJECT _____ BY _____ WORK ORDER _____

① Ref: Action Drug NTS 400; 3350-P9.2 & 3350-P13.2

① Trap Volume:

$$V = hA = 9" \times \frac{\pi}{4} (14")^2$$

$$V = 1390 \text{ m}^3 \text{ or } 0.8 \text{ ft}^3$$

② Ref: Measured

③ Ref: Measured

② Trap Volume:

$$V = 18" \times \frac{\pi}{4} \left(\frac{57}{\pi}\right)^2 = 18" \times \frac{\pi}{4} (18")^2$$

$$V = 4580 \text{ m}^3 \text{ or } 2.65 \text{ ft}^3$$

③ $V = 60 \times \frac{\pi}{4} \left(\frac{14 \frac{3}{4}}{\pi}\right)^2 = 60 \times \frac{\pi}{4} (4")^2$

$$V = 752 \text{ m}^3 \text{ or } 0.48 \text{ ft}^3$$

④ Ref: Measured

⑤ Trap Volume:

$$\frac{1}{2}V = 21 \frac{1}{2} \times \frac{\pi}{4} \left(\frac{24 \frac{1}{2}}{\pi}\right)^2 = 21 \frac{1}{2} \times \frac{\pi}{4} (6")^2$$

$$\frac{1}{2}V = 608 \text{ m}^3 \text{ or } 0.35 \text{ ft}^3$$

$$V = 1216 \text{ m}^3 \text{ or } 0.7 \text{ ft}^3$$

⑥

$$\frac{1}{2}V = 22 \frac{1}{2} \times \frac{\pi}{4} \left(\frac{28}{\pi}\right)^2$$

$$\frac{1}{2}V = 1130 \text{ m}^3 \text{ or } 0.65 \text{ ft}^3$$

$$V = 2260 \text{ m}^3 \text{ or } 1.3 \text{ ft}^3$$

④ Trap Volume:

$$V = l \times A = l \times \left[\frac{\pi r^2 \theta}{360} - \frac{r^2 \sin \theta}{2} \right]$$

$$V = 138 \times \left[\frac{\pi (12)^2 130.8}{360} - \frac{(12)^2 0.757}{2} \right] = 138 [109.7]$$

$$V = 15120 \text{ m}^3 = 8.75 \text{ ft}^3$$

QUADRILLE WORK SHEET

AEROJET-GENERAL CORPORATION
AZUSA, CALIFORNIA

PAGE 3 OF 3 PAGES

DATE _____

SUBJECT _____ BY _____ WORK ORDER _____

* Scaled form
Drag

① Trap Volume:

$$V = \frac{1}{2} (L \times A) = \frac{1}{2} (38' \times \frac{\pi}{4} (3')^2)$$

$$V = \frac{1}{2} (269) = 132 \text{ ft}^3$$

② Ref: Verbal from
Calco.

② Trap Volume:

$$V_b = L \times A = 4' \times \frac{\pi}{4} (3')^2$$

$$V_b = 28.3 \text{ ft}^3$$

$$V_b = \frac{1}{2} \times \frac{\pi}{4} (20')^2$$

$$V_b = 3.3 \text{ ft}^3$$

$$V_{\text{Total}} = 28.3 + 3.3 = 31.6 \text{ ft}^3$$

Total Estimated Air Trapped Volume

Location	ft ³
①	0.8
②	2.65
③	0.43
④	8.75
⑤	0.7
⑥	1.3
⑦	132.0
⑧	31.6
Total	178.2

NERVA TEST OPERATIONS
OPERATING INSTRUCTION
NTO - I - 0035

ETS-1
PROCESS WATER
SYSTEM
TEST PROGRAM

Written by:

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Approved by:

B. A. Bernstein, Manager
ETS-1 Facility Operations

Date: 14 May 1963

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1.0 TEST OBJECTIVE

1.1 During previous water flow tests conducted in September and October 1964, severe vibrations were noted in the process water piping. These vibrations were suspected to be caused by cavitation in the Flow Control Valves due to lack of sufficient back pressure and, also, to natural frequency vibration of the piping system due to insufficient support. The Flow Control Valves have been relocated and the piping has been more adequately supported.

1.2 The primary test objective of the present series is to determine the validity of the water system modifications in cavitation and vibration suppression.

1.3 A secondary objective is to determine system flow characteristics at the prototype NES duct cooling flow rate with the process water tank level at both maximum and minimum values.

1.4 As a result of scheduled construction activities at ETS-1, these tests are scheduled for the period 14 June through 1 July 1965.

2.0 TEST PROCEDURE

2.1 GENERAL

The flow tests are subdivided into the following phases:

- A. System Preparation
- B. Preliminary Flow Checks
- C. Flow Tests

The duct flow rate will be 34,000 gpm. The duct impedance simulation will be obtained by inserting an 11-inch orifice in the 24-inch crossover between the 36-inch inlet and outlet lines. Cavitation suppression will be achieved by installing a 17.6-inch orifice at the outlet of the 24-inch Water Disposal Line.

Data points will be obtained from both visual gauges and oscillographic recorded means whenever the operating conditions are changed. Figure 1 is a flow schematic which depicts the location of all pressure taps for transducers and visual gauges. Figure 2 lists the instrumentation requirements and defines which points are visually displayed and/or recorded. The instrumentation and electrical control schematics are shown in Figures 3 and 4. The test data sheet is shown as Figure 5, and will be used to document the progress of the test.

After completion of the testing activity and evaluation of the data, a report will be written.

2.2 SYSTEM PREPARATION

2.2.1 Ensure that 06-BFV-561 is OPEN and all other valves in system are CLOSED.

2.2.2 Flush through 36-inch and 42-inch water lines by OPENING 50-FCV-30, 50-FCV-31, 50-RSV-296 and 50-RSV-297 completely, and 50-FCV-32 and 50-RSV-298 to approximately 5% lift; then OPEN 50-BFV-666 to approximately 5% lift.

2.2.3 Operate the following valves and ascertain that timing is approximately as follows:

<u>VALVE</u>	<u>ACTUATION SWITCH TO "OPEN" MICRO-LIGHT</u>	<u>ACTUATION SWITCH TO "CLOSE" MICRO-LIGHT</u>
50-RSV-296	9 Seconds	9 Seconds
50-RSV-297	70 Seconds	60 Seconds
50-RSV-298	130 Seconds	130 Seconds

2.2.4 CLOSE 50-RSV-296, 50-RSV-297, and 50-RSV-298; then time 50-FCV-30, 50-FCV-31, and 50-FCV-32, as follows:

<u>VALVE</u>	<u>ACTUATION SWITCH TO "OPEN" MICRO-LIGHT</u>	<u>ACTUATION SWITCH TO "CLOSE" MICRO-LIGHT</u>
50-FCV-30	8 Seconds	2 Seconds
50-FCV-31	24 Seconds	10 Seconds
50-FCV-32	240 Seconds	120 Seconds

CLOSE 50-FCV-30, 50-FCV-31, and 50-FCV-32.

2.2.5 Drain line downstream of 50-RSV-296, 50-RSV-297 and 50-RSV-298 by OPENING 50-FCV-30, 50-FCV-31 and 50-FCV-32, then CLOSE 50-FCV-30, 50-FCV-31 and 50-FCV-32 after line has drained.

2.2.6 CLOSE 50-BFV-666.

2.2.7 Inspect system for leaks and other abnormalities, note and correct any deficiencies.

2.2.8 Evaluate results prior to initiating Section 2.3.

2.3 PRELIMINARY FLOW CHECKS

2.3.1 OPEN valve 50-BFV-666 approximately 5%.

2.3.2 Slowly OPEN 50-RSV-296 and 50-FCV-30 and wait until water flows out of drain pipe; observe for unusual noise and vibration.

2.3.3 Bleed air from system at the following locations:

2.3.3.1 Upstream of each Bailey Shield Valve at end of 24" line.

- 2.3.3.2 36" Supply and Return lines in Pipe Vault before entrance to Dust Vault.
- 2.3.3.3 42" high point.
- 2.3.3.4 When bled, CLOSE bleed valves.
- 2.3.4 CLOSE 50-FCV-30. hold pressure for 5 minutes, inspect for leakage or other abnormalities; then OPEN valve 50-BFV-666 and CLOSE 50-RSV-296.
- 2.3.5 Obtain response times of the following valves:
 - 50-RSV-296
 - 50-RSV-297
 - 50-RSV-298
- 2.3.6 OPEN 50-RSV-296 and 50-FCV-30 and record operation of the 50-FE-30, then CLOSE 50-FCV-30, then 50-RDV-296.
- 2.3.7 OPEN 50-RSV-297 and 50-FCV-31 and record operation of 50-FE-31, then CLOSE 50-FCV-31, then 50-RSV-297.
- 2.3.8 Remove All Personnel From Pipe Chase Vault.
- 2.3.9 OPEN 50-RSV-298 and 50-FCV-32 and record operation of 50-FE-32, then CLOSE 50-FCV-32, then 50-RSV-298.
- 2.3.10 CLOSE 50-BFV-666.
- 2.3.11 OPEN 50-RSV-296 and 50-FCV-30 to bleed pressure from system. CLOSE 50-FCV-30 and 50-RSV-296 when bleed is complete.
- 2.3.12 Inspect system for leakage and other abnormalities and note and correct all deficiencies.
- 2.3.13 Evaluate results prior to initiating Section 2.4.

2.4 FLOW TESTS

This test shall be run from the maximum tank level obtainable to the minimum tank level of 13.5 feet above the tank bottom, which will be the normal limits during actual testing operations.

2.4.1 OPEN 50-BFV-666.

2.4.2 OPEN 50-RSV-296 and 50-FCV-30 and wait until water flows out of drain pipe; observe for unusual noise and vibration, then CLOSE 50-FCV-30.

2.4.3 Bleed air from system at the following locations:

2.4.3.1 Upstream of each Bailey Shield Valve at end of 24" line.

2.4.3.2 36" Supply and Return lines in Pipe Vault before entrance to Duct Vault.

2.4.3.3 42" High Point

2.4.3.4 When bled, CLOSE Bleed Valve.

2.4.4 CLOSE 50-RSV-296.

2.4.5 OPEN Duct System valves as follows:

2.4.5.1 50-RSV-296

2.4.5.2 50-FCV-30

2.4.5.3 50-RSV-297

2.4.5.4 50-FCV-31

2.4.5.5 50-RSV-298

2.4.5.6 50-FCV-32

2.4.6 Total system operation is now simulated; observe operation for any unusual noise or vibration. If vibration is not excessive, a two-man team will enter chase for visual observation.

2.4.7 Initiate shutdown when the process water tank level reads 17.8 feet above the tank bottom.

2.4.8 CLOSE Duct System Valves as follows:

2.4.8.1 50-FCV-32

2.4.8.2 50-RSV-298

2.4.8.3 50-FCV-31

2.4.8.4 50-RSV-297

2.4.8.5 50-FCV-30

2.4.8.6 50-RSV-296

2.4.9 Inspect system for leakage and other abnormalities.

2.4.10 CLOSE 50-BFV-666, RE-OPEN 50-RSV-296 and 50-FCV-30 until pressure is reduced to Zero.

2.4.11 Position the following valves so that they are approximately 5% OPEN:

2.4.11.1 50-FCV-30

2.4.11.2 50-FCV-31

2.4.11.3 50-FCV-32

3.0 SUPPORT REQUIREMENTS

3.1 GENERAL

All contractor activities will be coordinated so that the flow tests, which will be conducted during the Day Shift, will not interfere with their operations.

3.2 PERSONNEL ASSIGNMENTS

The following operators will be utilized as required for each flow test:

	<u>No. Required</u>	<u>Organization</u>
Test Conductor	1	NTO
Alternate Test Conductor	1	NTO
Control Panel Operator	1	NTO
Visual Data Recorder	1	NTO
Oscillographic Data Operator	2	PAA
Process Water Tank Crew	2	PAA
Test Stand Pipe Chase Crew	2	PAA
Helicopter Crew	2	USAF
Helicopter Observer	1	NTO
Helicopter Photographer	1	PAA
Motion Picture Coverage	2	PAA

The conduct of the test will be directed by the Test Conductor. All the commands for action will emanate from him and will be transmitted via radio communication.

3.3 INSTRUMENTATION AND CONTROLS

Data will be obtained by both visual and oscillographic instrumentation. The visual data will be recorded by reading bourdon-type pressure gauges, and indicating lights. The oscillographic data will be acquired by means of a 36-channel CEC Recorder, Wiancko Pressure and Glenite Acceleration transducers and their associated circuitry.

Figure 1 is the flow system schematic and defines the instrumentation points. Figure 2 is a list of both oscillographic and visual instrumentation.

3.3.1 Visual Instrumentation

The visual gauges will be panel-mounted and located on the railing at the 3810-foot level overlooking the out-flow ditch. Copper tubing having a 1/4-inch O.D. will connect the gauges to the instrumentation tap. Small hand valves will be installed at the gauges to permit water filling of these lines.

3.3.2 Oscillograph Instrumentation

Figure 3 is a schematic of the Wiancko-type instrumentation system. The equipment will be comprised of the following:

3.3.2.1	Oscillator Power Supply	Type 2-105-AMA
3.3.2.2	Oscillator Carrier	Type 1-1019
3.3.2.3	Demodulator Unit	Type 2-1031
3.3.2.4	28 VDC Power Supply	
3.3.2.5	Recording Oscillograph	Type 5-119
3.3.2.6	Wiancko Transducers	
3.3.2.7	Glenite Accelerometers/Gulton Amplifiers	

This equipment will be housed in a weather-proof enclosure and located at the 3810-foot elevation near the railing overlooking the outflow ditch.

The transducers will be close-coupled to the instrumentation taps and will be "in system" calibrated. Calibration of the pressure transducers will be by "Heisse" gauges and the accelerometers by the "turn over 2g" method.

The oscillograph will be operated at the direction of the Test Conductor at a paper speed of 6 inches/sec. This will ensure that all pertinent test conditions will be recorded.

3.3.3 Electrical Control

Figure 4 is an electrical control schematic showing the circuits that will be utilized during the program. The control console utilized during the previous program will be available for this Program.

3.4 PHOTOGRAPHIC COVERAGE

For determination of water flow characteristics on the desert floor, still pictures will be taken from a helicopter. This data will be used to evaluate flooding and the extent of surface water distribution. This will only be required during Phase C testing. The helicopter shall confine its operation West of Road H and shall record the time of water crest at Road H, the road to the J-13 Well, and any other roads which may become inundated, and the final dispersal in the "fan" of Forty Mile Canyon. The expected time from initiation of Phase C are as follows:

Road "H"	30 Minutes
J-13 Road	2 Hours
Fan of Forty Mile Canyon	4 Hours

Motion pictures will be obtained to evaluate the piping stability and obtain visual confirmation of any malfunctions.

FIG. 1

SCHEMATIC OF ETS-1 PROCESS WATER SYSTEM

Water Flow Test
Instrumentation Requirements

Fig. 2

Galvo. No.	Parameter Tag No.	Transducer Range	Visual Display	Function
1	50 PT 168	0-350 PSIG	0-600 PSIG	Supply pressure to system
2	PT 1	0-350 PSIG	0-600 PSIG	Duct inlet pressure
3	PT 2	0-300 PSIG	0-600 PSIG	Duct outlet pressure
4	PT 4	0-300 PSIG		Inlet pressure to FCV's
5	PT 5	0-50 PSIG	0-60 PSIG	FCV 31 discharge pressure
6	PT 6	0-50 PSIG	0-60 PSIG	FCV 32 discharge pressure
7	50 FT 32	0-5 PSID	0-200" H ₂ O	36000 GPM venturi delta P
8	50 FT 31	0-5 PSID		4000 GPM venturi delta P
9	50 FT 30	0-5 PSID		400 GPM venturi delta P
10	LFCV 32			FCV 32 valve position
11	LFCV 31			FCV 31 valve position
12	LFCV 30			FCV 30 valve position
13	ACC 1	20 g.		Piping stability
14	ACC 2	20 g.		Piping stability
15	ACC 3	20 g.		Piping stability
16	ACC 4	20 g.		Piping stability
17	ACC 5	20 g.		Piping stability
18	ACC 6	20 g.		Piping stability
19	Event	Syn. galvo.		Events
	06 LI 07		0-50' H ₂ O	Process water tank level
	50 RSV 296		Lights	Open-closed indication
	50 RSV 297		Lights	Open-closed indication
	50 RSV 298		Lights	Open-closed indication
	50 FCV 30		Lights	Open-closed indication
	50 FCV 31		Lights	Open-closed indication
	50 FCV 32		Lights	Open-closed indication
	PT 3		0-60 PSIG	Pressure at end of 24" discharge line
	PT 7	200 PSID	0-600 PSID	Duct simulation orifice delta P

INSTRUMENTATION
BLOCK DIAGRAM

Fig 4

ETS-1 WATER FLOW Test ELECTRICAL CONTROL SCHEMATIC

WATER CALIBRATION TEST DATA SHEET

Fig 5

Purpose Of Test _____

Run No. _____

Date _____

Time Of Day: _____

REMOTE OPERATED VALVES	VALVE TIMING (Minutes - Seconds)							
	STATIC				DYNAMIC			
	Sw To F.O.	Valve Stroke	Sw To F.C.	Valve Stroke	Sw To F.O.	Valve Stroke	Sw To F.C.	Valve Stroke
50 RSV 296								
50 RSV 297								
50 RSV 298								
50 FCV 30								
50 FCV 31								
50 FCV 32								

FUNCTION	UNITS	RUN DATA POINTS							
TANK LEVEL	FEET								
50-PT-168	PSIG								
50-FT-32	In H ₂ O								
P1 DUCT IN	PSIG								
P2 DUCT OUT	PSIG								
P3 DISCH.	PSIG								
P5 FCV-31 OUT	PSIG								
P6 FCV-32 OUT	PSIG								
P7 DUCT ΔP	PSID								

Test Remarks _____

Test Conductor