SATURN S-IB STAGE

FINAL STATIC TEST REPORT

STAGE S-IB-2

AUGUST 27, 1965

SYSTEMS STATIC TEST BRANCH

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ABSTRACT

This report describes the acceptance test firing of the Saturn flight stage S-IB-2 conducted at the Static Test Tower East, Marshall Space Flight Center (MSFC), Huntsville, Alabama.

FOREWORD

This report, prepared by Chrysler Corporation Space Division, Systems Static Test Branch, presents the results of acceptance test firing of the Saturn flight stage S-IB-2. Acceptance firings of Saturn S-IB stages are performed by Chrysler's Space Division for the National Aeronautics and Space Administration at the George C. Marshall Space Flight Center under Contract NAS 8-4016, Item No. 2, Static Test Operations.

TABLE OF CONTENTS

APPENDIX

TABLE OF CONTENTS (CONTINUED)

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF TABLES (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF GRAPHS

SUMMARY

This report describes the acceptance test firings of the Saturn flight stage S-IB-2 which were conducted at the Static Test Tower East (STTE), Marshall Space Flight Center (MSFC), Huntsville, Alabama, during the period June 19 to August 2, 1965.

Test SA-27 was terminated at time for commit due to the number 2 Thrust OK pressure (TOP) switch on engine 4 not being picked up at this time. An automatic thrust failure cutoff resulted.

The short duration test SA-28 and the long duration acceptance test SA-29 were both successful. These tests were conducted on July 9 and July 20, respectively.

Test duration for test SA-27 was 3.002 seconds from ignition command to inboard engine cutoff. Test duration for test SA-28 was 35.192 seconds from ignition command to inboard engine cutoff with cutoff being initiated by the firing panel operator. Inboard engine cutoff for test SA-29 was given at ignition command plus 143.285 seconds, 0.5 second after the LOX low level sensor in LOX tank 0-2 was uncovered. Outboard engine cutoff was initiated by the switch selector approximately 1 second after inboard engine cutoff.

For tests SA-28 and SA-29, a signal was jumpered to the all-engines-running relay from the launch sequencer which energized this relay at X-1 second regardless of TOP switch conditions. This assured that a trust failure cutoff would not be given until after commit when cutoff would result from two TOP switches dropping out.

Engine operation and performance were satisfactory during tests SA-28 and SA-29, with all engines producing thrust within the specified limits of 200,000 pounds $\pm$ 3 percent. No reorificing was required.

An investigation of the occurrence and cause of ripples found in previous Saturn booster stages was conducted on stage S-IB-2. A total of five permanent ripples, found in fuel tank F-3 following the long duration firing, are attributed to differential thermal stresses caused by exposure to the exhaust plume. Preventative measures will be taken to protect subsequent stages from this thermal environment. Results of this investigation are presented in Section 4 of this report as well as in Section 4 of the "Preliminary Static Test Report, for Test SA-29."

LOX and fuel tanking computers were installed and used for the first time at Static Test. The LOX computer was used to top LOX in the propellant loading tests as well as for tests SA-27, SA-28, and SA-29. The fuel computer was used for monitoring purposes only. The operation of both computers was satisfactory.

During thust chamber jacket flushing operations following test SA-29, a leak was observed at engine 1, tube 285, 3 inches above the return manifold.

The modified gimbal boots which utilized the layer of aluminized fabric bonded to the inner boot were burned severely during static test. These boots are unsatisfactory, and their use should be discontinued.

The performance of all other stage systems was satisfactory.

SECTION 1

INTRODUCTION

The aborted short duration static firing, test SA-27, of stage S-IB-2, was conducted on July 8, 1965. The short duration static firing, test SA-28, was conducted on July 9, and the long duration acceptance firing, test SA-29, was conducted on July 20. These tests are performed by Chrysler Corporation Systems Static Test Branch.

Stage S-IB-2 is the second of the Saturn 200 series booster stages to be manufactured by the Chrysler Corporation Space Division (CCSD). The stage was shipped from the CCSD manufacturing facility at Michoud, Louisiana, on June 12, 1965, and it was installed in the STTE on June 21. The stage was removed from the tower on July 29 and departed the MSFC dock by barge on August 2.

Four major tests were required for checkout and acceptance of stage S-IB-2: the simulated flight test with full flight pressures, the propellant loading test, the short duration confidence firing, and the full duration acceptance firing. All tests were successfully performed.

The primary objective of the static firing tests of the Saturn S-IB stages is to demonstrate the correct functional performance and operation of the airborne systems under simulated launch conditions. The short duration static firing constitutes a confidence test to verify airborne/ground control system compatibility, to check out instrumentation, and to obtain engine thrust level data. The long duration firing constitutes an acceptance test and confirms the correct operation of all airborne systems. The specific test objectives are further outlined as follows:

SHORT DURATION FIRING

1. Performance check of the 200K engines.

2. Performance check of the gimbal system.

3. Performance check of the telemetry system.

4. Determination of LOX boiloff rate and LOX bulk densities.

5. Evaluation of propellant tank pressurization transients with flight ullages.

LONG DURATION FIRING

1. Determine propellant tank draining rates and terminal LOX draining characteristics.

2. Verify engine performance.

3. Verify performance of the gimbal control system.

4. Verify reliability and performance of telemetry system.

5. Obtain LOX boiloff evaluation data and verify bulk LOX density obtained during initial tanking.

6. Obtain fuel tank structural data in an effort to determine the cause of fuel tank ripples.

The static test configuration of stage S-IB-2 is defined by drawing 60C10016. Deletions from the flight configuration include the following: stabilizer fins, outboard engine shrouds, instrumentation canister doors, and LOX replenish valve. Hardware additions include the following: static test holddown brackets, upper stage deluge firex ring, inboard engine turbine exhaust duct extensions, auxiliary LOX dome purge manifold, three fuel fill and drain valves, and three LOX fill and drain valves. Block II-type static test heat shield panels were used in place of the actual flight hardware except for two stainless steel honeycomb heat shield panels which were installed at Fin Line II during test SA-29. Refurbished engine flame curtains were installed at all engine positions during tests SA-27 and SA-28. For test SA-29, a flight-type flame curtain was used at engine 3 because of severe damage sustained during test SA-28. A peripheral tail skirt radiation shield is also included as a part of the static test configuration.

The following sections of this report present the results of the static test firings of stage S-IB-2.

SECTION 2

ENGINE SYSTEMS

Test SA-27 was terminated automatically at time for commit, 3.002 seconds after ignition command because engine 4 Thrust OK pressure (TOP) switch 2 had not picked up. Fuel pump outlet pressure at this time was 965 psig (measurement *PP104-4) as compared to the specified switch actuation pressure of 800 ± 43 psig. The switch picked up 257 milliseconds after cutoff signal was initiated and dropped out 88 milliseconds after it picked up at a fuel pump outlet pressure of 810 psig (see GRAPH 2-1).

After the aborted test, the TOP switches and related electrical circuitry were functionally checked with no anomalies discovered. Since all components were found to operate normally, the malfunction was attributed to a random failure of the switch.

Prior to test SA-28, the TOP switch harness on engine 4 was connected to switches 1 and 3 instead of 1 and 2, as used for test SA-27 to take the suspected switch out of the control circuit. TOP switch 2 was replaced prior to test SA-29 and returned to Rocketdyne for failure analysis. Rocketdyne subsequently reported that the switch met all specifications and that no cause for the malfunction could be found.

Engine operation during tests SA-28 and SA-29 was satisfactory. All engines produced thrust values within the specified limits of 200K ± 3 percent. No reorificing is recommended prior to launch.

Test SA-28 duration was 35.192 seconds from ignition command to inboard engine cutoff signal, with cutoff being initiated, as planned, by the firing panel operator. Outboard engine cutoff signal was given 110 milliseconds later by the switch selector.

Inboard engine cutoff signal for test SA-29 was initiated by the switch selector at 143.285 seconds after ignition command and 0.5 second after the LOX low level sensor in tank O-2 was uncovered. Outboard engine cutoff signal was triggered by the switch selector approximately 1 second after inboard engine cutoff.

H-1 engine schematics can be found in FIGURES 2-1 and 2-2. Engine static test data for tests SA-28 and SA-29 can be found in TABLES 2-1 and 2-2, respectively. The "Confidential Supplement, Stage S-IB-2" contains the combustion chamber pressures, specific impulse and thrust values for these tests. Ignition and cutoff sequence times for tests

SA-27, SA-28, and SA-29 can be found in TABLES 2-3, 2-4, and 2-5, respectively. GRAPHS 2-2 through 2-17 show the oscillograph traces during the ignition and cutoff transitions of each engine during test SA-29. Engine orifice sizes may be found in Item 13, APPENDIX C of this report.

Engine oscillograph data indicated that the conisphere temperature measurements *PT103-1 and *PT103-8 were lost during test SA-28. Measurement *PT103 is the fast-response half of the dual conisphere temperature probe. All conisphere temperature probes were replaced prior to test SA-29. This is standard practice.

An immediate post test inspection following test SA-29 revealed severe metal erosion on the lower edge of the aspirator lip of engines 3 and 4, directly below tube number 110 and the low side thrust chamber drain screw access port. For test SA-29 the cover plate was installed in the thrust chamber drain screw access port of the aspirator. These cover plates were installed on the inboard side of engines 3 and 4 to prevent hot gases from blowing directly on measurements AT119 and AT113 which were mounted adjacent to the access port. Previous Rocketdyne tests have indicated that when the cover plates are installed in the thrust chamber drain screw access ports, the flow of hot gases is diverted and is concentrated on the areas directly below the access ports causing erosion. Material Review Board action is necessary to determine whether repairs are to be made to the aspirators on engines 3 and 4. It is recommended that since erosion of the aspirator lip does not affect engine performance for launch, no repairs be made. It is further recommended that the chamber drain screw access port covers not be installed for flight.

PRETEST SA-27 HARDWARE INSPECTION AND LEAK CHECKS

1. A visual inspection of all engines after installation of the stage in the tower revealed a considerable amount of fuel in the hypergol containers upon removal of the short shipping plugs (P/N RX20670). The hypergol containers were drained, and the fuel igniter system was purged prior to test SA-27.

2. Bellows inspection at engine 2 revealed a dent in the bellows below the heat exchanger turbine exhaust outlet. The dent is located directly below the boss to which flight measurement D17-2 is plumbed. No leakage was noted at this dent during turbine exhaust system leak check.

3. Inspection of engine 4 revealed a burn spot on the exterior of the thrust chamber, located between the second and third band above the aspirator. This burn spot covers thrust chamber tubes 124 through 129. A brazed repair spot on the inside of the thrust chamber at this location has a longitudinal crack between the tubes. No internal or external leakage was noted at this location during liquid leak checks.

4. Inspection of engine 5 revealed a broken tube support bracket and a loose check valve in the thrust chamber fuel injector purge system. Further investigation revealed torque stripe paint on the external seat of the check valve indicating that the valve had not been fully engaged when it was painted with torque stripe. Also the tube support bracket appeared to have been broken during installation at Michoud. A new support bracket was fabricated and installed and the check valve was cleaned and reinstalled.

5. Rocketdyne personnel replaced defective engine harnesses (P/N's 502314 and 502321) at engines 1 and 6 and completed Engineering Change Proposal (ECP) H1-262 on all engines. This ECP included the installation of a third TOP switch and the rework of the customer connect panel for the addition of a TOP switch calibration manifold port.

6. Engine clearance checks, designated on DMN M-10619, were performed on all engines. The outboard engines were gimbaled while clearances were measured, and the following clearances were not within the specified limits.

ENGINE	CLEARANCE	MEASURED VALUE (INCHES)	MIN. ALLOWABLE (INCHES)
1	GOX Line to Gimbal Block	0.06	0.25
2	GOX Line to LOX Wrap-around Line	Touching ⚠	0.09
4	GOX Line to Gimbal Block	0.12	0.25
4	GOX Line to LOX Wrap-around Line	Touching ⚠	0.09
5	Fuel Wraparound Line to Water Quench System	0.89	1.10
6	Fuel Wraparound Line to Water Quench System	0.96	1.10
7	GOX Manifold Assembly to Turnbuckle Assembly	1.22	1.80

⚠ Since contact was made only at maximum gimbal positions, no action was taken prior to tests SA-27 and SA-28.

7. While performing ignition monitor valve leakage and functional checks, leakage was discovered around the control pressure inlet cap screws on the valve on engine 5. The defective valve (S/N 6356996) was replaced with valve S/N 6352408, which checked out satisfactorily.

8. Turbine exhaust system leak checks prior to test SA-27 revealed the following leaks which were corrected as noted:

ENGINE	LOCATION OF LEAKAGE	CORRECTIVE ACTION
2	Measurement Boss (Meas. D37-2)	Replaced Gasket
6	Measurement Boss (Meas. D37-6)	Replaced Gasket
8	Turbine Inlet Flange	Retorqued

9. Following the initial propellant loading test, the screens at the LOX and fuel pump inlets were removed, and no contamination or abnormal conditions existed. One bolt at engine 5 and one bolt at engine 8 galled slightly in the LOX pump inlet flanges during removal. The threaded inserts at these positions were retapped and new bolts installed.

10. While performing the thrust chamber leak check with gas on engine 7 prior to test SA-27, the chamber pressure increased to 18.5 psig, which was the same as LOX tank pressure. The heat exchanger LOX inlet check valve had allowed reverse leakage at low pressure from the LOX tanks to the thrust chamber. The check valve was replaced and the thrust chamber leak check was performed satisfactorily. No leaks were discovered at any engine prior to test SA-27.

11. An igniter fuel system purge and a thrust chamber fuel injector purge were performed on all engines prior to tests SA-27 and SA-28.*

12. A LOX seal swab check and turbopump torque check were performed on all engines prior to tests SA-27 and SA-28. No contamination was noted and the torque results were satisfactory prior to both tests.

POST TEST SA-28 HARDWARE INSPECTION AND LEAK CHECKS

1. Visual inspection of the engines immediately following test SA-28 revealed a fuel leak at engine 6. The B-nut on the TOP switch system manifold, which connects to TOP switch 2 from the

* NOTE: The LOX dome purge was active during these purging operations.

main fuel valve, was found to be loose. Since there are no provisions for safety wiring the B-nuts, it is possible that it vibrated loose during static firing. It is recommended that safety wire provisions be made for future installations (reference UCR 01736).

2. Gas generator and turbine exhaust system leak checks were performed indicating leakages which were corrected as noted:

ENGINE	LOCATION OF LEAKAGE	CORRECTIVE ACTION
2	Turbine Inlet Flange	Retorqued
3	Turbine Inlet Flange	Replaced Gasket
4	Turbine to Turbine Exhaust Duct Flange	Retorqued
4	Instrumentation Boss on Turbine Inlet	Replaced Copper Crush Seal
4	Turbine Inlet Flange	Retorqued
5	Turbine Inlet Flange	Replaced Gasket
6	Turbine Inlet Flange	Replaced Gasket

3. Turbopump preservation was performed at all engines. The turbopumps were torqued prior to preservation with the following results:

ENGINE	INITIAL BREAKAWAY TORQUE (IN.-LB)	RUNNING TORQUE (IN.-LB)
1	80	70
2	80	70
3	95	85
4	90	80
5	70	60
6	70	60
7	70	60
8	90	80

4. The aspirator covers and flame curtains at all outboard engines were inspected for damage. The damage sustained by these items is described in the ENGINE COMPARTMENT ENVIRONMENT section of this report.

5. A visual inspection of the engines after test SA-28 revealed slight leakage from the chamber pressure port CGIC on engine 4. This port provides sensing pressure for measurement *PP108. The copper crush seal was replaced with no leakage noted during leak check.

PRETEST SA-29 HARDWARE INSPECTION AND LEAK CHECKS

Prior to test SA-29, the following pretest leak and hardware checks were performed: turbine exhaust system leak check, thrust chamber fill leak check with trichloroethylene and fuel, thrust chamber gas leak check, fuel lube blowdown, turbopump torque check, and LOX seal contamination check. The results of all leak and hardware checks were satisfactory.

A special leak check was performed on the body of the LOX-to-heat-exchanger check valves and the LOX dome purge check valves. This special leak check was requested as a result of a failure noted on engine H-5027 by Rocketdyne following approximately 42.5 seconds of hot fire service time. The failure was analyzed by Rocketdyne and was attributed to stress-corrosion cracking of the valve body. The valve was subsequently redesigned and the new valve assemblies will be poppet-type check valves welded into a unitized line. Effectivity of the new type valve is scheduled for stage S-IB-3 engines. Chrysler Corporation was requested to visually inspect and leak check, at frequent intervals, the H-1 engine LOX dome and LOX-to-heat-exchanger check valves on stages prior to S-IB-3. The results of the leak check on stage S-IB-2 were satisfactory with no evidence of body cracking.

POST TEST SA-29 HARDWARE INSPECTION AND LEAK CHECKS

1. The turbopumps were torque checked prior to turbopump preservation with the following values recorded:

ENGINE POSITION	BREAKAWAY TORQUE (IN.-LBS)	RUNNING TORQUE (IN.-LBS)
1	90	80
2	90	70
3	80	70
4	80	70
5	65 ⚠	60
6	60	50
7	60 ⚠	50
8	80 ⚠	70

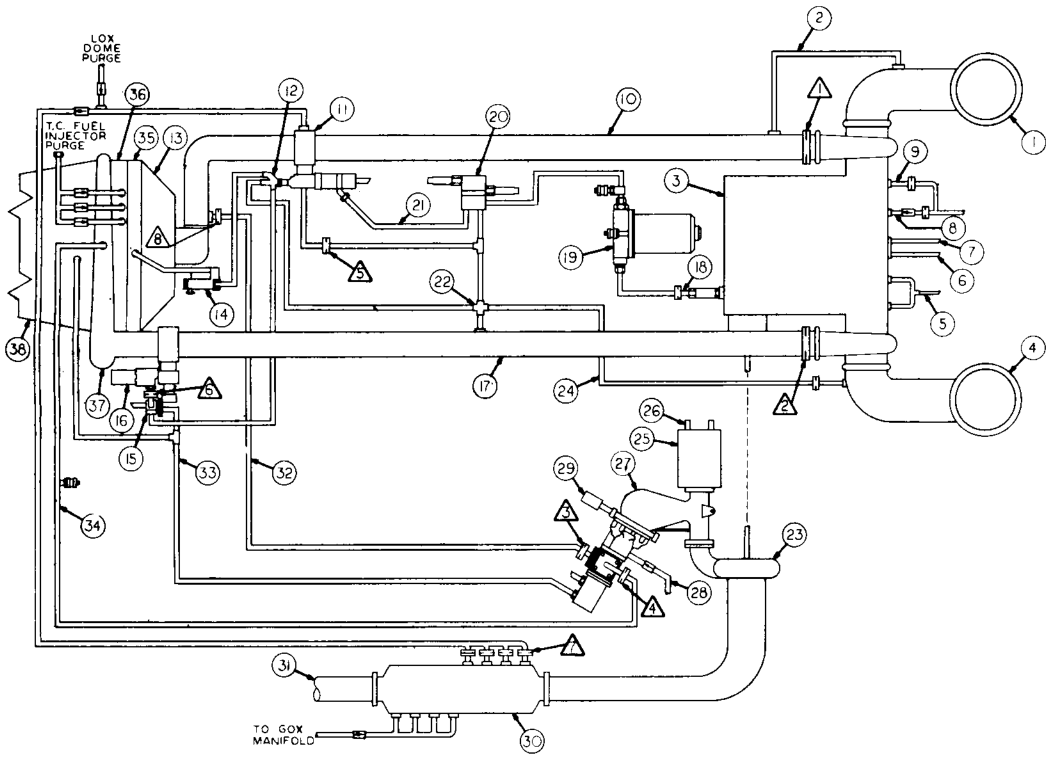
⚠ Initial breakaway torque values for engines 5, 7, and 8, were 100, 160, and 250 in.-lbs, respectively. After turbopump preservation, the turbopumps were again torque checked with satisfactory results.

2. Turbine exhaust system leak checks were performed and the following leakages were corrected:

ENGINE	LOCATION OF LEAKAGE	CORRECTIVE ACTION
2	Turbine - turbine exhaust duct flange	Retorqued
2	Gas Generator - turbine inlet flange	Retorqued
2	Instrumentation Boss on turbine inlet	Replaced Copper Crush Seal
4	Gas Generator - turbine inlet flange	Retorqued
5	Gas Generator - turbine inlet flange	Replaced Gasket
6	Gas Generator - turbine inlet flange	Replaced Gasket
6	Instrumentation Boss on turbine inlet	Replaced Copper Crush Seal
7	Instrumentation Boss on turbine inlet	Replaced Copper Crush Seal
8	Instrumentation Boss on turbine inlet	Replaced Copper Crush Seal

3. The engine thrust chambers were leak checked with trichloroethylene during thrust chamber jacket flushing operations. Engine 1 had a 4 cubic centimeter per minute leak at tube 285, 3 inches above the turnaround manifold. Engine 2 had a slight seep at tubes 291 and 292 at the turnaround manifold. The braze between the thrust chamber tubes and turnaround manifold at engine 6 appeared to be chipped and eroded, but no leakage was noted. It is recommended that the leak location at engine 1 be repaired in order that fuel prefill can be retained during launch countdown at the Cape.

4. The LOX seals were leak checked at all engines. The LOX tanks were pressurized to 30 psig, and a flowmeter was connected to the LOX seal drain line at each engine. No leakage was noted at any engine.

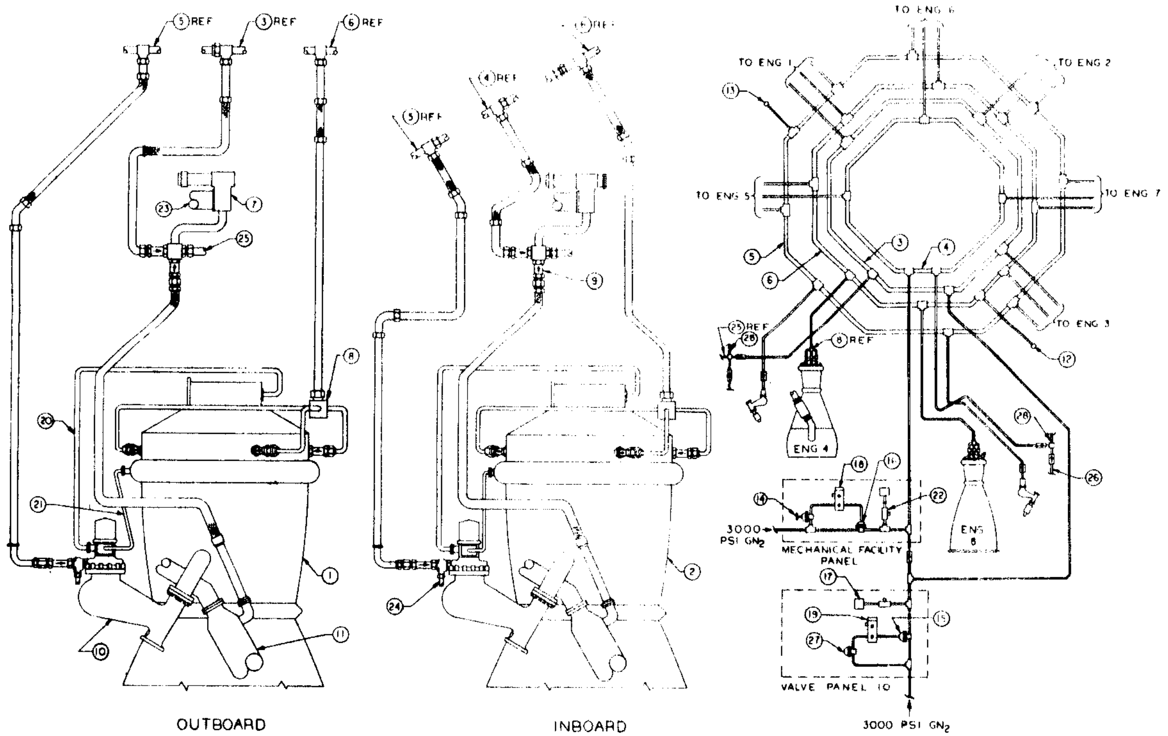


H-1 ENGINE SCHEMATIC-FIGURE 2-1

FIND NO	ITEM
1	LOX SUCTION LINE
2	LOX BLEED LINE
3	TURBO PUMP
4	FUEL SUCTION LINE
5	LUBE DRAIN
6	LUBE SEAL DRAIN
7	LOX SEAL DRAIN
8	GEAR BOX PRESS
9	LOX SEAL PURGE
10	LOX HIGH PRESS DUCT
11	MAIN LOX VALVE
12	IGNITER FUEL VALVE
13	LOX DOME
14	HYPEGOL CONTAINER
15	IGNITION MONITOR VALVE
16	MAIN FUEL VALVE
17	FUEL HIGH PRESS DUCT
18	T/P LUBE LINE
19	FABU
20	CONAX VALVE
21	MAIN LOX VALVE CLOSING CONTROL LINE
22	FUEL CONTROL CROSS
23	2-STAGE TURBINE
24	FUEL BLEED LINE
25	SOLID PROPELLENT GAS GENERATOR
26	SPGG INITIATORS
27	LIQUID PROPELLENT GAS GENERATOR
28	GG LOX INJECTOR PURGE
29	GG AUTO IGNITERS
30	HEAT EXCHANGER
31	TURBINE EXHAUST DUCT
32	LOX BOOTSTRAP LINE
33	CONTROL LINE
34	FUEL BOOTSTRAP LINE
35	LOX INJECTOR
36	FUEL INJECTOR
37	FUEL MANIFOLD
38	COMBUSTION CHAMBER

ORIFICES

1	MAIN LOX
2	MAIN FUEL
3	GG LOX
4	GG FUEL
5	MLV CONTROL
6	MFV CONTROL
7	HEAT EXCHANGER (TYP 3 PLACES)
8	FIXED GG LOX ORIFICE



FIND NO.	ITEM
1	ENGINES 1, 2, 3 & 4
2	ENGINES 5, 6, 7 & 8
3	LOX DOME PURGE MANIFOLD, OUTBOARD ENGINES
4	LOX DOME PURGE MANIFOLD, INBOARD ENGINES
5	GAS GENERATOR LOX INJECTOR PURGE* MANIFOLD (TYPICAL ALL ENGINES)
6	FUEL INJECTOR PURGE (TYPICAL ALL ENGINES)
7	MAIN LOX VALVE (TYPICAL ALL ENGINES)
8	PURGE MANIFOLD (TYPICAL ALL ENGINES)
9	CHECK VALVE (TYPICAL 6 PLACES) (TYPICAL ALL ENGINES)
10	LIQUID PROPELLANT GAS GENERATOR (TYPICAL ALL ENGINES)
11	HEAT EXCHANGER (TYPICAL ALL ENGINES)
12	PURGE SUPPLY, LOWER UMBILICAL, FIN II
13	PURGE SUPPLY, LOWER UMBILICAL, FIN IV
14	HAND OPERATED REGULATOR
15	DOME REGULATOR - 230 PSI
16	DOME REGULATOR - 650 PSI
17	PRESSURE SWITCH (TYPICAL 2 PLACES)
18	AUXILIARY LOX DOME PURGE SOLENOID
19	LOX DOME PURGE SOLENOID
20	LOX BOOTSTRAP LINE (TYPICAL ALL ENGINES)
21	FUEL BOOTSTRAP LINE (TYPICAL ALL ENGINES)
22	CALIBRATION VALVE (TYPICAL 2 PLACES)
23	HIGH PRESSURE LOX DUCT
24	TO MEASUREMENT PP101, PRESSURE GAS GENERATOR LOX INJECTOR MANIFOLD (TYPICAL ALL ENGINES)
25	TO MEASUREMENT D111 (TYPICAL ENGINES 3 & 4)
26	TO HEAT EXCHANGER (TYPICAL ALL ENGINES)
27	FIXED REGULATOR
28	TO MAIN LOX VALVE

H-1 ENGINE PURGE SYSTEM FIGURE 2-2

TABLE 2-1

ENGINE STATIC TEST DATA

Ambient Pressure (psia)	14.37
Ambient Temperature (^{o}F)	87

TEST SA-28

MEAS. NO.	MEASUREMENT DESCRIPTION	ENGINE	VALUES AT	
			IGNITION	X+29-32 SEC.
*PT100	Temperature, Fuel Pump Inlet (^{o}F)	8	69.0	74.5
	Density, Fuel Pump Inlet (lb/ft^3)	8	50.181	50.048
*PP113	Pressure, Fuel Pump Inlet (psig)	1	43.1	27.7
		2	41.2	26.9
		3	42.0	27.6
		4	41.6	27.6
		5	41.7	28.8
		6	41.6	29.0
		7	41.7	29.6
		8	41.1	28.7
*PP104	Pressure, Fuel Pump Outlet (psig)	1		1042.9
		2		969.9
		3		1064.5
		4		966.7
		5		934.9
		6		958.2
		7		946.7
		8		962.5
*PT107	Temperature, LOX Pump Inlet (^{o}F)	1	-278.5	-293.25
		2	-278.9	-293.4
		3	-279.15	-293.55
		4	-278.05	-293.7
		5	-277.6	-293.6
		6	-277.2	-293.6
		7	-278.8	-293.7
		8	-277.65	-293.7
*PP114	Pressure, LOX Pump Inlet (psig)	1	79.4	55.6
		2	81.7	57.6
		3	79.5	56.6
		4	80.0	56.1
		5	79.2	53.6
		6	78.9	54.0
		7	78.0	55.0
		8	79.2	58.3

TABLE 2-1 (CONTINUED)

TEST SA-28

MEAS. NO.	MEASUREMENT DESCRIPTION	ENGINE	VALUES AT	
			IGNITION	X+29-32 SEC.
*PP105	Pressure, LOX Pump Outlet (psig)	1		833.5
		2		842.8
		3		843.6
		4		866.6
		5		824.5
		6		846.4
		7		872.5
		8		832.3
*PT101	Temperature, SPGG Surface (°F)	3	56.3	
		7	56.8	
*PT102	Temperature, Conisphere (°F)	1		1242
		2		1215
		3		1241
		4		1215
		5		1232
		6		1250
		7		1230
		8		1228
*PP100	Pressure, GG Fuel Injector Manifold (psig)	1		675
		2		750
		3		710
		4		725
		5		740
		6		710
		7		675
		8		725
*PP101	Pressure, GG LOX Injector Manifold (psig)	1		765
		2		750
		3		741
		4		742
		5		760
		6		750
		7		739
		8		752
*PP102	Pressure, Turbine Inlet (psig)	1		△1
		2		525
		3		500
		4		500
		5		500
		6		480
		7		500
		8		525

△1 Measurement Lost

TABLE 2-1 (CONTINUED)

TEST SA-28

MEAS. NO.	MEASUREMENT DESCRIPTION	ENGINE	VALUES AT IGNITION	VALUES AT X+29-32 SEC.
	Turbopump Speed (rpm), derived from *PR100, Turbine rpm	1		6886
		2		6803
		3		6805
		4		6730
		5		6745
		6		6821
		7		6734
		8		6771
*PT701	Temperature, Oronite (°F)	1	128.5	
		2	128.5	
		3	133.5	
		4	127.5	
		5	121.9	
		6	124.1	
		7	129.0	
		8	130.0	
*PP112	Pressure, Gearcase (psig)	1		3.8
		2		4.1
		3		3.8
		4		3.6
		5		3.7
		6		4.0
		7		4.5
		8		4.3
*PT700	Temperature, LOX Pump Bearing 1 (°F)	1	88.5	118.0
		2	110.0	125.5
		3	98.0	125.0
		4	91.0	118.0
		5	111.0	128.0
		6	121.0	125.0
		7	113.0	134.2
		8	123.5	137.1
*PT104 △1	Temperature, Turbopump Bearing 2 (°F)	1		
		2		
		3		
		4		
		5		
		6		
		7		
		8		

△1 Measurement *PT104-1/8 Lost

TABLE 2-1 (CONTINUED)

TEST SA-28

MEAS. NO.	MEASUREMENT DESCRIPTION	ENGINE	VALUES AT IGNITION	VALUES AT X+29-32 SEC.
*PT105 ⚠	Temperature, Turbopump Bearing 4 (°F)	1		
		2		
		3		
		4		
		5		
		6		
		7		
		8		
*PT108	Temperature, Turbopump Bearing 8 (°F)	1	68	154.0
		2	70	154.0
		3	71	122.0
		4	62	160.0
		5	70	157.0
		6	74	166.0
		7	73	173.0
		8	76	169.0
*PP115	Pressure, Lube Oil, Bearing 1 (psig)	1		144.0
		2		133.0
		3		129.5
		4		108.1
		5		140.0
		6		130.1
		7		134.1
		8		124.2

⚠ Measurement *PT105-1/8 Lost

TABLE 2-2

ENGINE STATIC TEST DATA

Ambient Pressure (psia)	14.41
Ambient Temperature (^oF)	90

TEST SA-29

MEAS. NO.	MEASUREMENT DESCRIPTION	ENGINE	VALUES AT IGNITION	X+29-32 SEC.	CUTOFF
*PT100	Temperature, Fuel Pump Inlet (^oF)	8	66.5	75.0	76.0
	Density, Fuel Pump Inlet (lb/ft^3)	8	50.242	50.025	49.998
*PP113	Pressure, Fuel Pump Inlet (psig)	1	40.6	27.5	11.2
		2	41.0	29.1	12.7
		3	41.6	28.9	12.5
		4	41.7	29.1	13.2
		5	41.5	29.2	13.5
		6	41.3	28.7	13.2
		7	41.0	28.8	12.6
		8	41.2	28.6	13.0
*PP104	Pressure, Fuel Pump Outlet (psig)	1	44	1079.7	1051.3
		2	38	990.6	966.0
		3	20	1100.0	1050.0
		4	52	991.4	964.2
		5	⚠	⚠	1123.0
		6	45	970.4	942.4
		7	18	966.0	941.0
		8	42	967.9	936.8
*PT107	Temperature, LOX Pump Inlet (^oF)	1	-278.00	-292.30	-291.80
		2	-278.00	-292.00	-291.55
		3	-278.50	-292.50	-291.40
		4	-278.45	-292.50	-291.50
		5	-277.20	-292.45	-291.60
		6	-277.50	-292.80	-292.20
		7	-277.75	-292.25	-292.10
		8	-277.30	-292.75	-291.30
*PP114	Pressure, LOX Pump Inlet (psig)	1	78.2	51.8	28.0
		2	79.2	52.7	30.0
		3	80.0	53.6	30.5
		4	79.5	53.0	29.7
		5	80.2	50.7	27.7
		6	78.7	51.3	28.0
		7	78.5	53.0	29.6
		8	78.9	53.5	31.1

⚠ Measurement Lost

TABLE 2-2 (CONTINUED)

TEST SA-29

MEAS. NO.		ENGINE	VALUES AT		
			IGNITION	X+29-32 SEC.	CUTOFF
*PP105	Pressure, LOX Pump Outlet (psig)	1	77	828.9	806.6
		2	84	837.9	815.6
		3	22	753.0	678.8
		4	88	851.7	825.9
		5	⚠	801.8	780.1
		6	83	846.8	819.4
		7	52	800.0	712.2
		8	75	834.6	803.7
*PT101	Temperature, SPGG Surface (°F)	3	55.3		
		7	57.5		
*PT102	Temperature, Conisphere (°F)	1		1270	1255
		2		1233	1225
		3		1224	1205
		4		1215	1200
		5		1287	1270
		6		1260	1255
		7		1252	1240
		8		1250	1235
*PP100	Pressure, GG Fuel Injector Manifold (psig)	1		710	690
		2		706	691
		3		700	683
		4		727	700
		5		727	759
		6		717	696
		7		708	694
		8		703	697
*PP101	Pressure, GG LOX Injector Manifold (psig)	1		755	
		2		740	
		3		736	
		4		727	
		5		729	
		6		727	
		7		732	
		8		741	
*PP102	Pressure, Turbine Inlet (psig)	1		521	515
		2		508	499
		3		515	508
		4		511	502
		5		498	488
		6		501	491
		7		500	491
		8		505	492

⚠ Measurement Lost

TABLE 2-2 (CONTINUED)

TEST SA-29

MEAS. NO.	MEASUREMENT DESCRIPTION	ENGINE	VALUES AT IGNITION	X+29-32 SEC.	CUTOFF
	Turbopump Speed (rpm), derived from *PR100, Turbine rpm	1		6900	
		2		6813	
		3		6832	
		4		6744	
		5		6765	
		6		6854	
		7		6771	
		8		6781	
*PT701	Temperature, Oronite (°F)	1	128.5		
		2	127.1		
		3	130.0		
		4	126.0		
		5	129.0		
		6	123.5		
		7	127.1		
		8	128.0		
*PP112	Pressure, Gearcase (psig)	1		3.9	
		2		4.0	
		3		4.0	
		4		4.0	
		5		3.8	
		6		3.9	
		7		4.0	
		8		4.2	
*PP700	Temperature, LOX Pump Bearing 1 (°F)	1	102.5	125.5	215.0
		2	86.0	116.5	194.5
		3	92.5	123.5	213.0
		4	91.0	119.0	219.0
		5	99.0	125.0	215.0
		6	125.0	139.0	228.0
		7	116.0	143.0	228.0
		8	99.0	129.0	213.9
*PT104	Temperature, Turbopump Bearing 2 (°F)	1	67.3	120.6	206.9
		2	53.2	128.9	204.3
		3	62.0	114.1	211.9
		4	60.0	114.9	209.1
		5	65.5	108.4	196.1
		6	77.8	121.2	199.3
		7	76.9	125.7	216.0
		8	63.1	122.1	214.6

TABLE 2-2 (CONTINUED)

TEST SA-29

MEAS. NO.	MEASUREMENT DESCRIPTION	ENGINE	VALUES AT IGNITION	X+29-32 SEC	CUTOFF
*PT105	Temperature, Turbopump Bearing 4 (°F)	1	68.7	143.1	218.7
		2	53.0	121.1	195.0
		3	62.3	139.6	215.5
		4	59.6	137.0	215.4
		5	66.4	142.5	207.5
		6	78.1	149.2	216.0
		7	76.5	154.6	230.2
		8	65.7	144.0	214.6
*PT108	Temperature, Turbopump Bearing 8 (°F)	1	66	155	358
		2	61	152	350
		3	63	131	335
		4	63	160	355
		5	64	154	364
		6	73	166	356
		7	73	177	356
		8	65	160	354
*PT115	Pressure, Lube Oil, Bearing 1 (psig)	1		144	144
		2		133	133
		3		128	128
		4		111	109
		5		139	137
		6		138	137
		7		138	137
		8		137	136

TABLE 2-3

IGNITION AND CUTOFF SEQUENCE TIMES FROM OSCILLOGRAPH RECORDS

TEST SA-27

ENGINE POSITION	1	2	3	4	5	6	7	8
IGNITION SIGNAL FROM IGNITION COMMAND (MILLISECONDS)	325	224	326	225	25	124	25	125
	TIMES FROM THE IGNITION SIGNAL OF EACH ENGINE IN MILLISECONDS							
MLV Starts Opening	245	260	210	225	250	225	205	200
MLV Full Open	520	550	520	520	570	535	530	535
MLV Opening Time	275	290	310	295	320	310	325	335
Thrust Chamber Ignition	570	580	550	580	610	595	585	585
Pc Prime	965	885	890	885	955	925	870	905
Pc Reaches 90% △1	1200	1075	1080	1060	1150	1100	1085	1105

△1 Percent of slice time value (X+29 to 32 seconds)

TABLE 2-3 (CONTINUED)

TEST SA-27

ENGINE POSITION	1	2	3	4	5	6	7	8
Turbopump Prime Speed (rpm)	5263	5298	5322	5210	5247	5396	5288	5288
Conax Firing Signal (Seconds From Commit)	.152	.150	.152	.150	.033	.034	.034	.033
TIMES FROM CONAX FIRING SIGNAL OF EACH ENGINE IN MILLISECONDS								
MLV Starts Closing	80	75	75	80	75	80	75	75
MLV Full Closed	320	345	315	315	335	325	310	315
MLV Closing Time	240	270	240	235	260	245	235	240
P_c Leaves Mainstage	95	105	105	105	105	115	100	105
P_c Decays to 90% ⚠	150	155	150	155	160	160	150	155
P_c Decays to 10%	330	365	335	335	345	355	365	330
ENGINE RUN TIME FROM P_c REACHES 90% TO P_c DECAYS TO 90% (SECONDS)								
Engine Run Time (this test)	1.777	2.006	1.896	2.020	2.018	1.970	2.074	1.958
Cumulative Engine Run Time	242.877	243.806	327.796	243.620	495.815	239.770	243.674	352.858

⚠ Percent of slice time value (X+29 to 32 seconds).

TABLE 2-4

IGNITION AND CUTOFF SEQUENCE TIMES FROM OSCILLOGRAPH RECORDS

TEST SA-28

ENGINE POSITION	1	2	3	4	5	6	7	8
IGNITION SIGNAL FROM IGNITION COMMAND (MILLISECONDS)	324	224	325	224	24	123	24	123
	TIMES FROM THE IGNITION SIGNAL OF EACH ENGINE IN MILLISECONDS							
MLV Starts Opening	210	215	210	230	195	215	210	210
MLV Full Open	485	545	515	545	530	525	545	550
MLV Opening Time	275	330	305	315	335	310	335	340
Thrust Chamber Ignition	555	580	545	590	570	585	585	595
Pc Prime	910	900	870	900	915	925	895	925
Pc Reaches 90% ⚠1	1085	1085	1030	1075	1130	1135	1145	1215

⚠1 Percent of slice time value (X+29 to 32 seconds)

TABLE 2-4 (CONTINUED)

TEST SA-28

ENGINE POSITION	1	2	3	4	5	6	7	8
Turbopump Prime Speed (rpm)	5419	5195	5396	5210	5050	5374	5196	5280
Conax Firing Signal (Seconds from Commit)	32.344	32.345	32.345	32.344	32.228	32.228	32.228	32.228
TIMES FROM CONAX FIRING SIGNAL OF EACH ENGINE IN MILLISECONDS								
MLV Starts Closing	60	55	60	60	75	75	70	70
MLV Full Closed	285	285	290	290	305	310	295	305
MLV Closed Time	230	240	240	240	240	245	230	240
Pc Leaves Mainstage	75	75	65	70	90	90	90	90
Pc Decays to 90% ⚠	125	120	125	130	145	145	140	145
Pc Decays to 10%	315	330	310	310	320	320	350	315
ENGINE RUN TIME FROM P_c REACHES 90% TO Pc DECAYS TO 90% (SECONDS)								
Engine Run Time (this test)	34.060	34.156	34.115	34.175	34.219	34.115	34.199	34.035
Cumulative Engine Run Time	276.937	277.962	361.911	277.795	530.037	273.885	277.873	386.893

⚠ Percent of slice time value (X+29 to 32 seconds)

TABLE 2-5

IGNITION AND CUTOFF SEQUENCE TIMES FROM OSCILLOGRAPH RECORDS

TEST SA-29

ENGINE POSITION	1	2	3	4	5	6	7	8
IGNITION SIGNAL FROM IGNITION COMMAND (MILLISECONDS)	324	224	324	224	24	125	23	125
	TIMES FROM THE IGNITION SIGNAL OF EACH ENGINE IN MILLISECONDS							
MLV Starts Opening	220	225	210	225	△2	195	220	200
MLV Full Open	505	540	520	525	△2	510	555	535
MLV Opening Time	285	315	310	300	△2	315	335	335
Thrust Chamber Ignition	570	575	540	555	600	565	590	585
Pc Prime	925	885	850	860	944	915	910	915
Pc Reaches 90% △1	1130	1080	1010	1045	1170	1135	1140	1150

△1 Percent of slice time value (X+29 to 32 seconds)

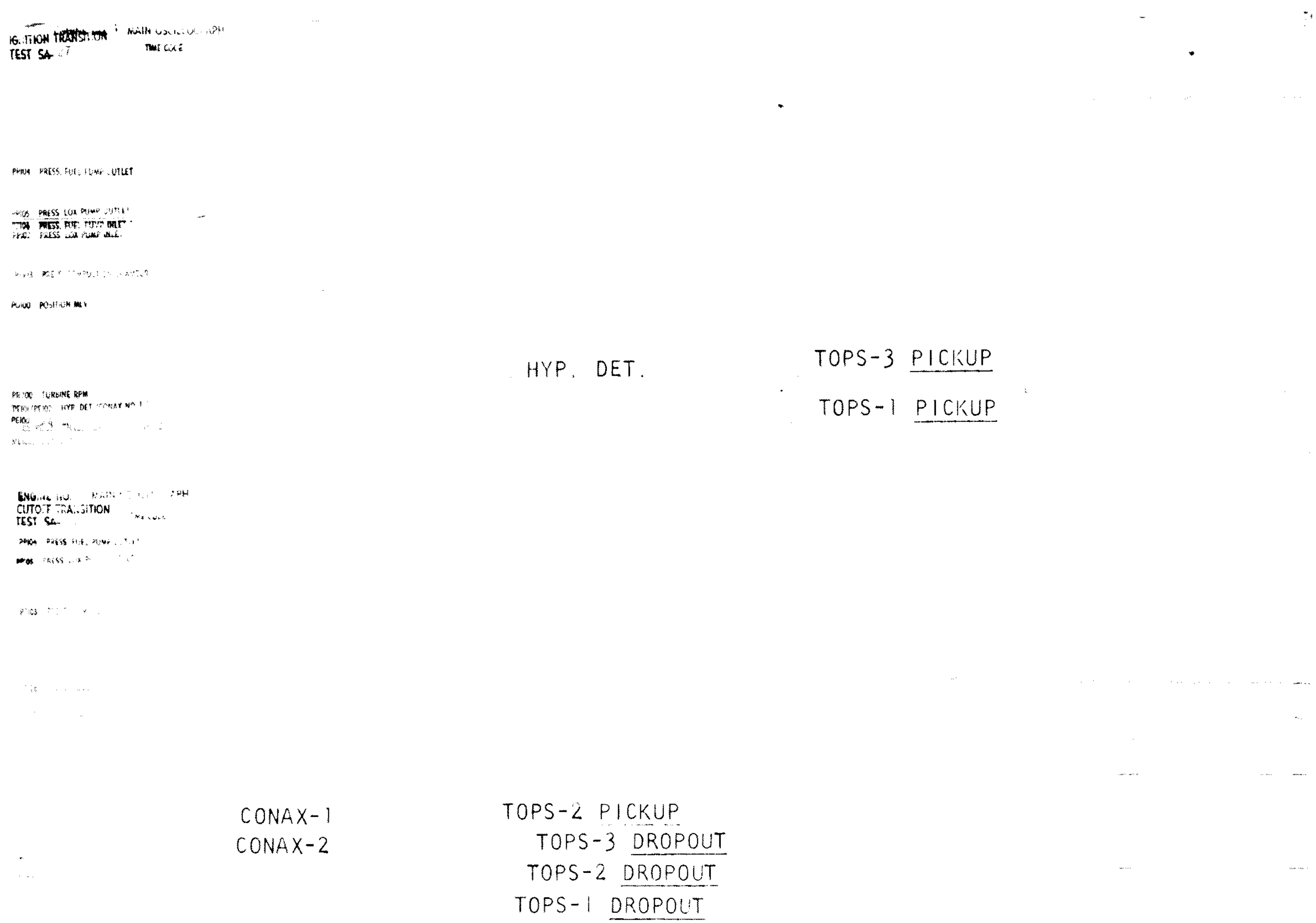
△2 Measurement Lost

TABLE 2-5 (CONTINUED)

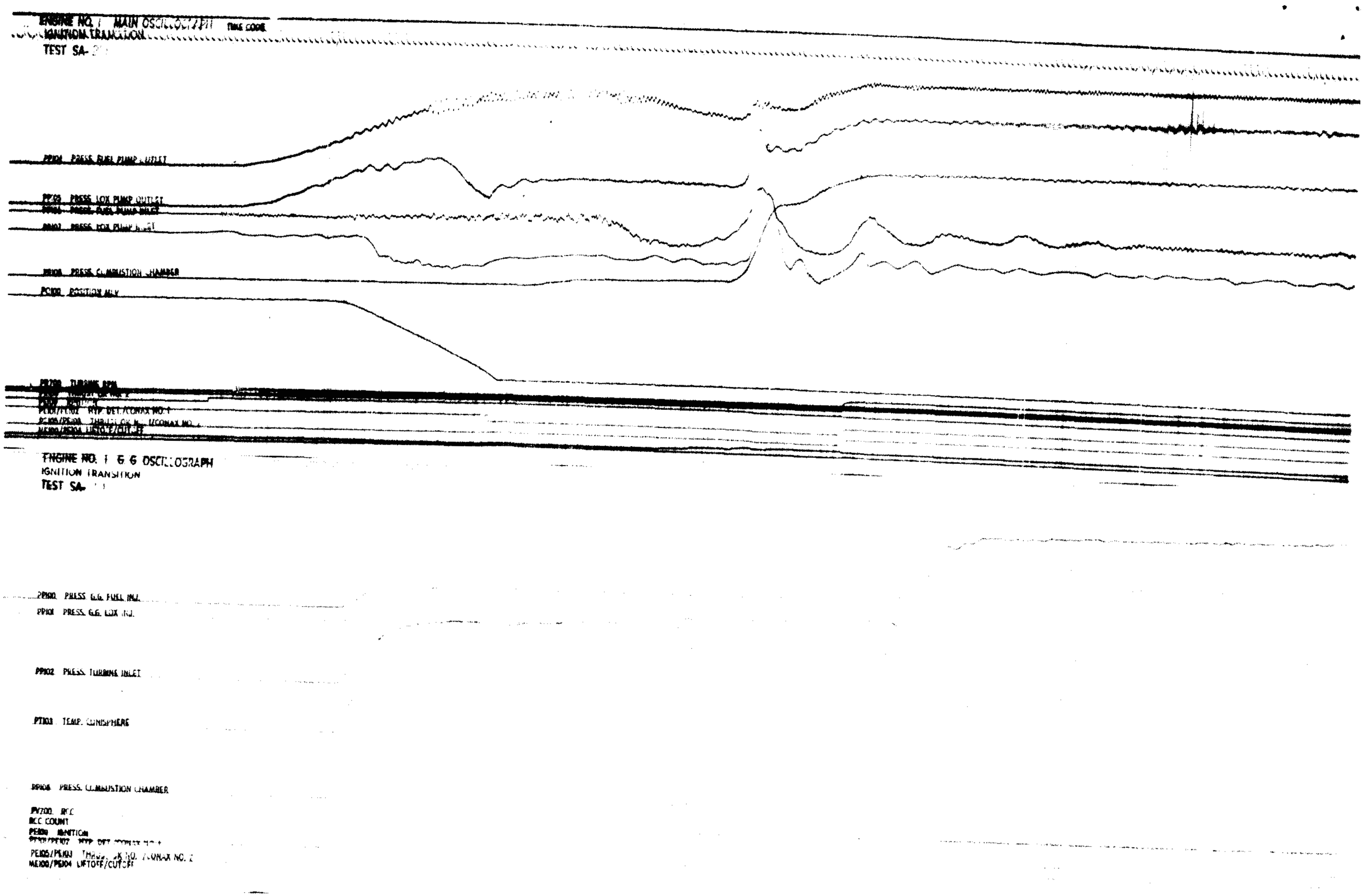
TEST SA-29

ENGINE POSITION	1	2	3	4	5	6	7	8
Turbopump Prime Speed (rpm)	5544	5476	5442	5203	5220	5357	5182	5237
Conax Firing Signal (Seconds from Commit)	141.319	141.318	141.319	141.318	140.317	140.315	140.317	140.315
TIMES FROM CONAX FIRING SIGNAL OF EACH ENGINE IN MILLISECONDS								
MLV Starts Closing	75	75	65	75	75	75	70	70
MLV Full Closed	315	315	310	315	325	320	305	315
MLV Closing Time	240	240	245	240	250	245	235	245
Pc Leaves Mainstage	95	110	85	100	100	100	100	105
Pc Decays to 90% ⚠	145	150	140	150	155	150	145	155
Pc Decays to 10%	335	365	325	335	335	335	360	350
ENGINE RUN TIME FROM P_c REACHES 90% to P_c DECAYS TO 90% (SECONDS)								
Engine Run Time (this test)	143.010	143.168	143.125	143.199	142.278	142.205	142.299	142.195
Cumulative Engine Run Time	419.947	421.126	505.036	420.994	672.315	416.090	420.172	529.088

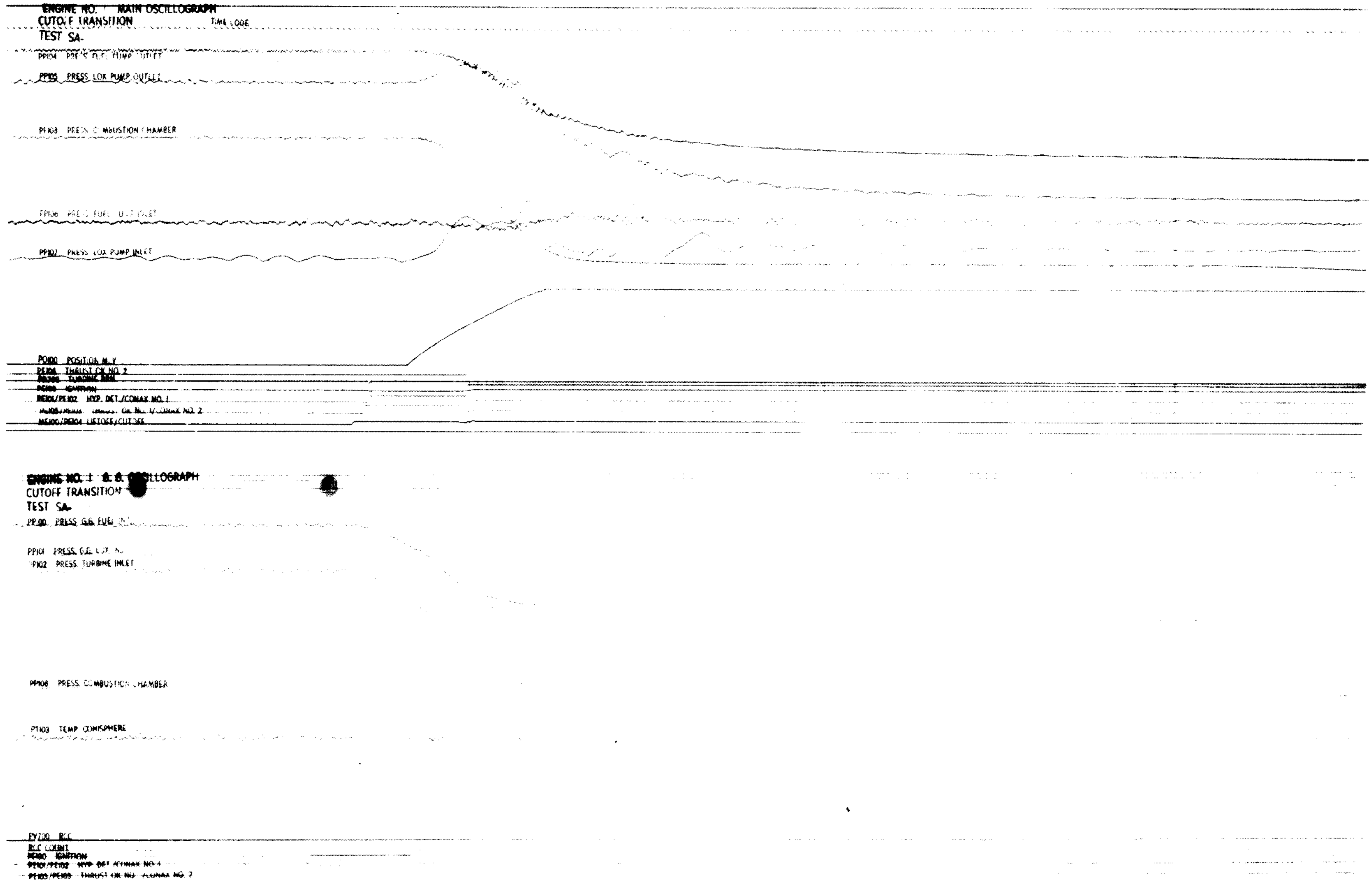
⚠ Percent of slice time value (X+29 to 32 seconds)



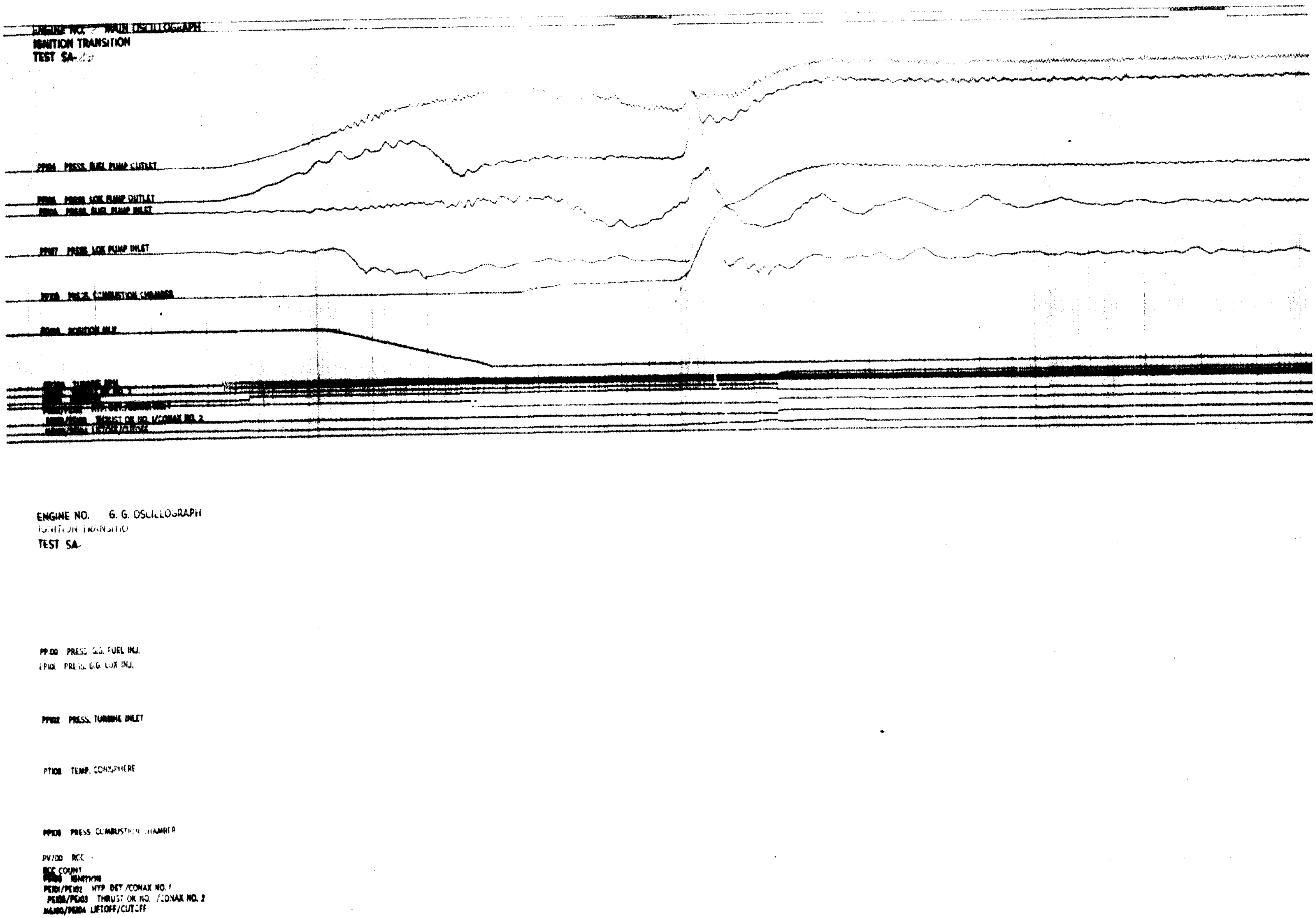
GRAPH 2-1
ENGINE 4, IGNITION AND CUTOFF TRANSITIONS, TEST SA-27



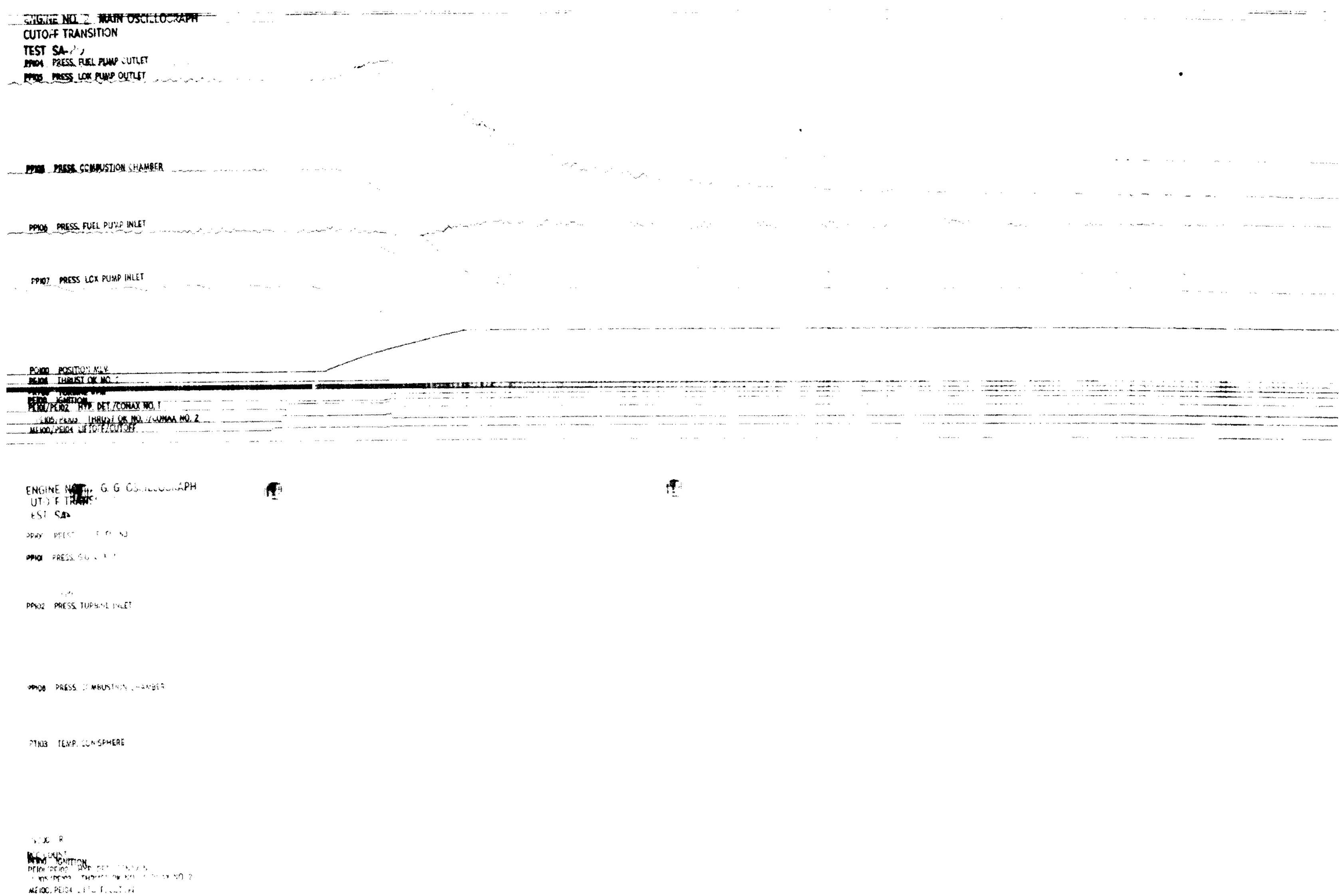
GRAPH 2-2
ENGINE 1, IGNITION TRANSITION, TEST SA-29



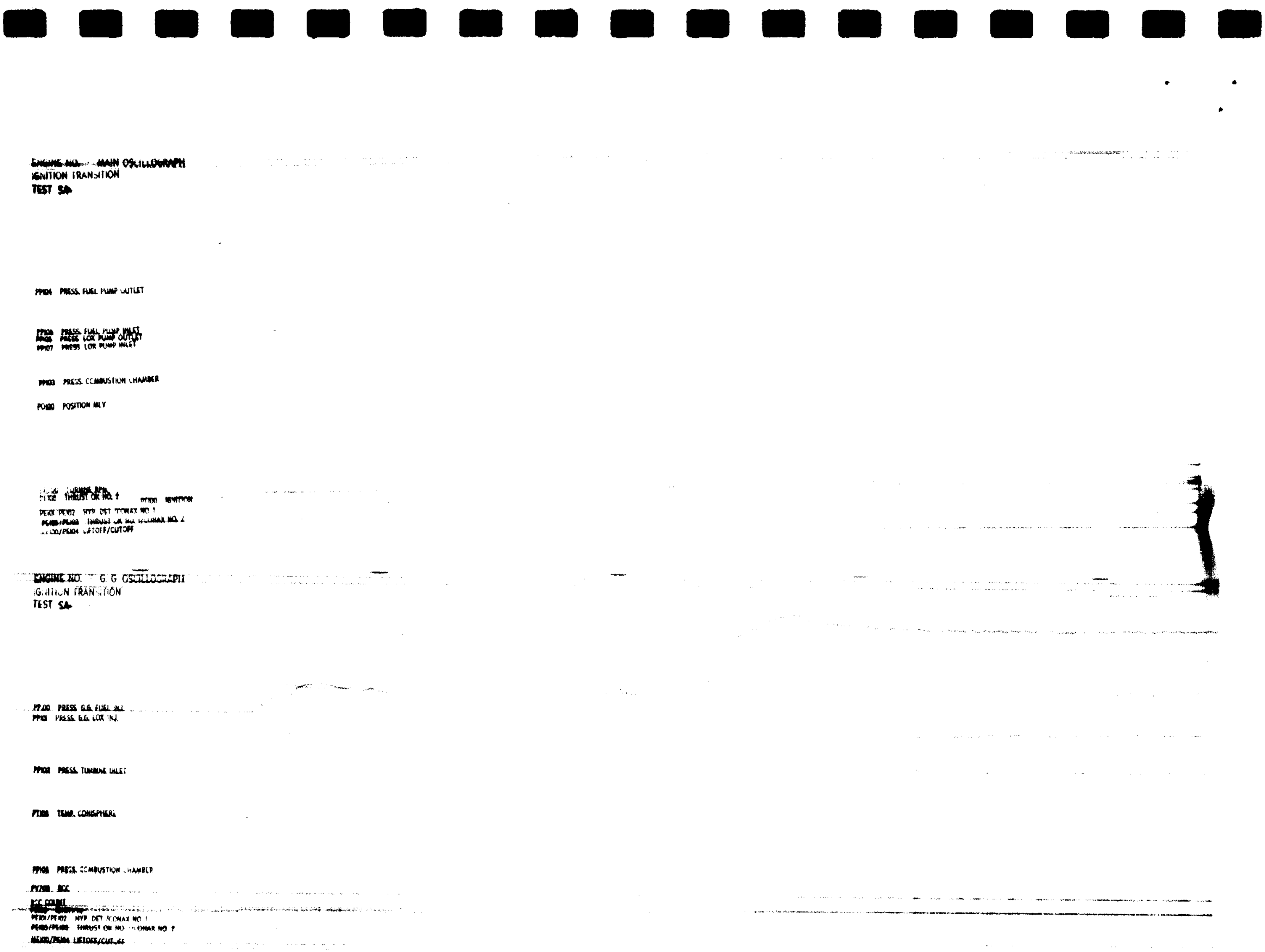
GRAPH 2-3
ENGINE 1, CUTOFF TRANSITION, TEST SA-29



GRAPH 2-4
ENGINE 2, IGNITION TRANSITION, TEST SA-29

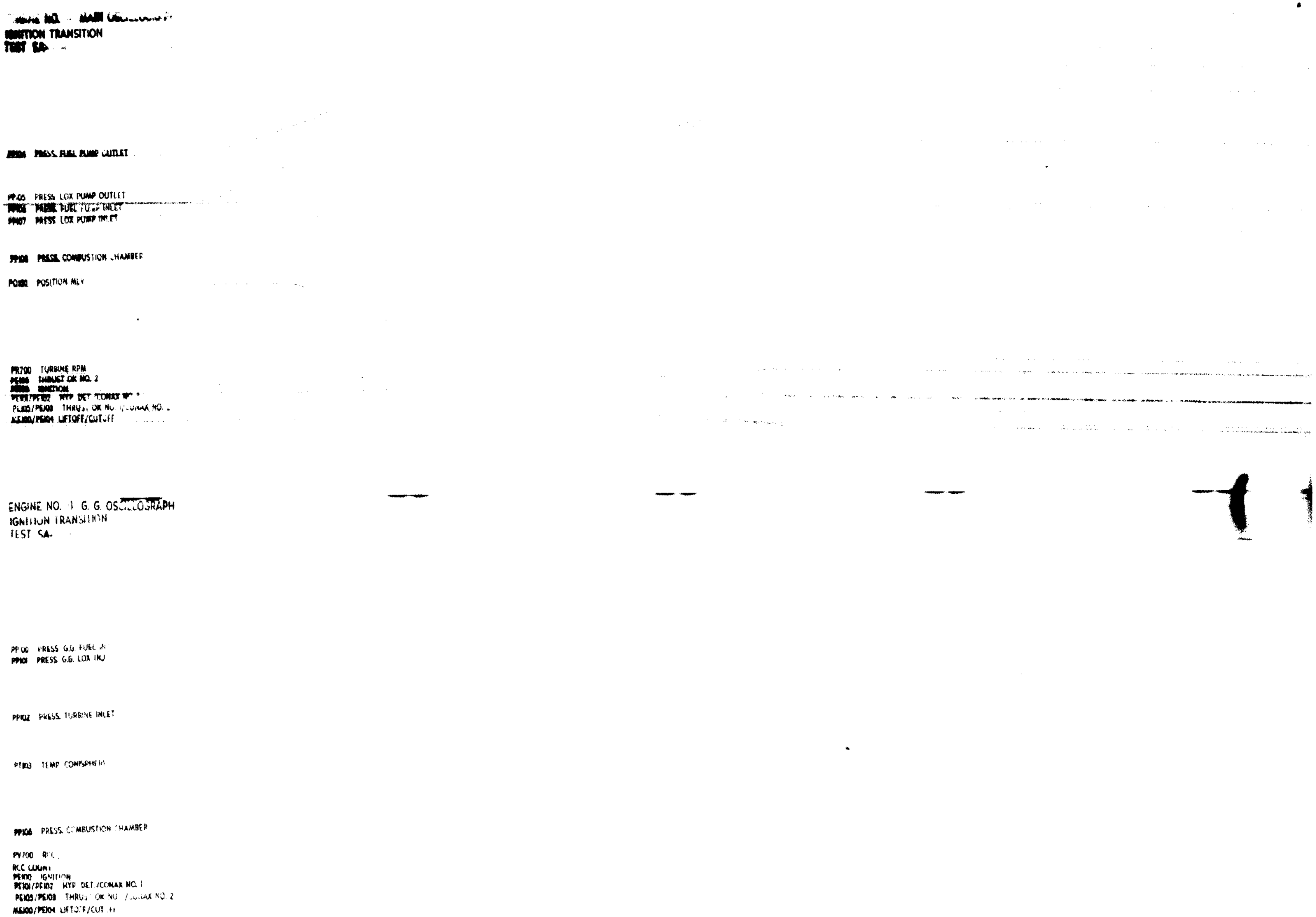


GRAPH 2-5
ENGINE 2 CUTOFF TRANSITION, TEST SA-29

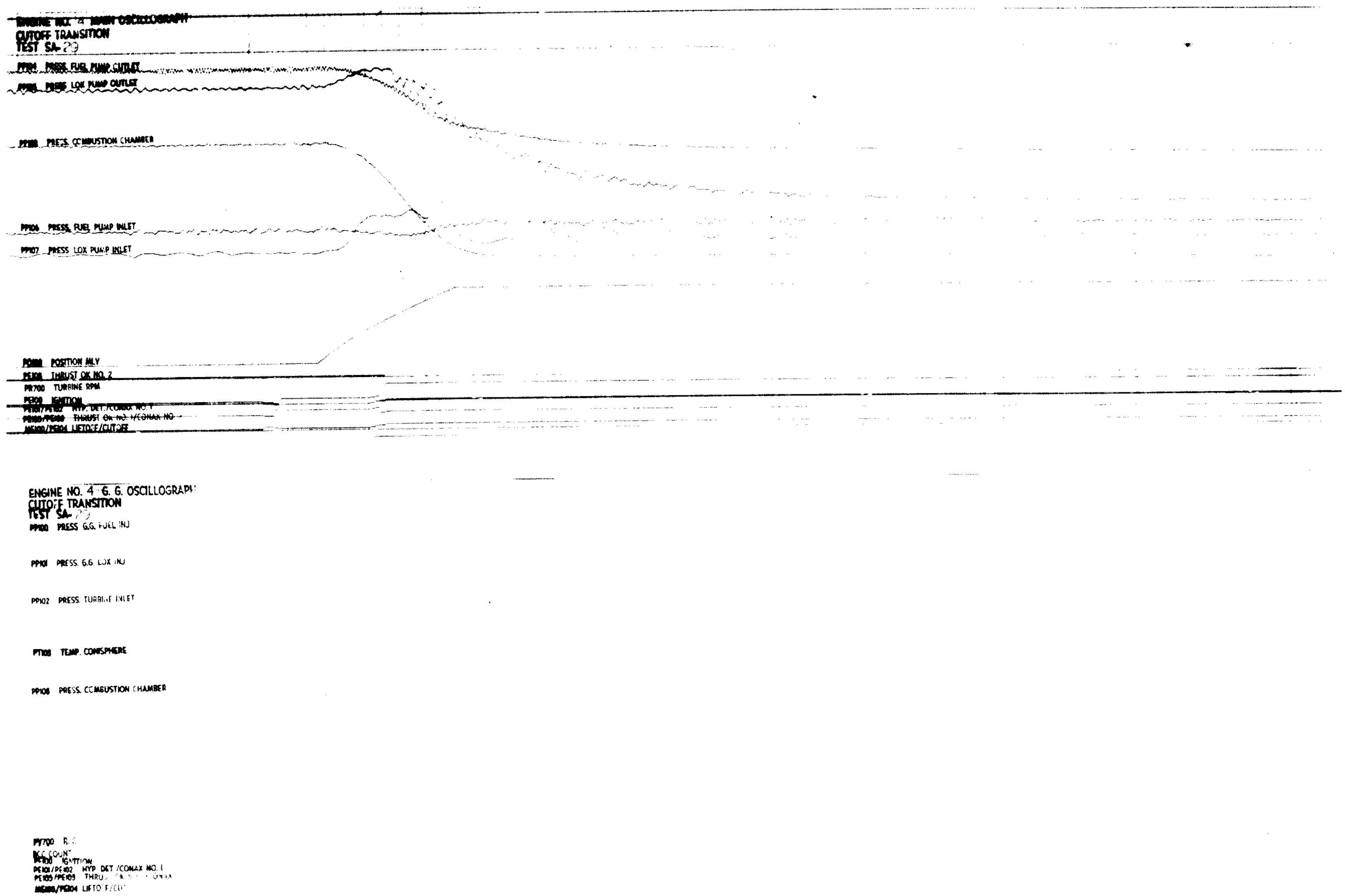


GRAPH 2-6
ENGINE 3, IGNITION TRANSITION, TEST SA-29

GRAPH 2-7
ENGINE 3 CUTOFF TRANSITION, TEST SA-29

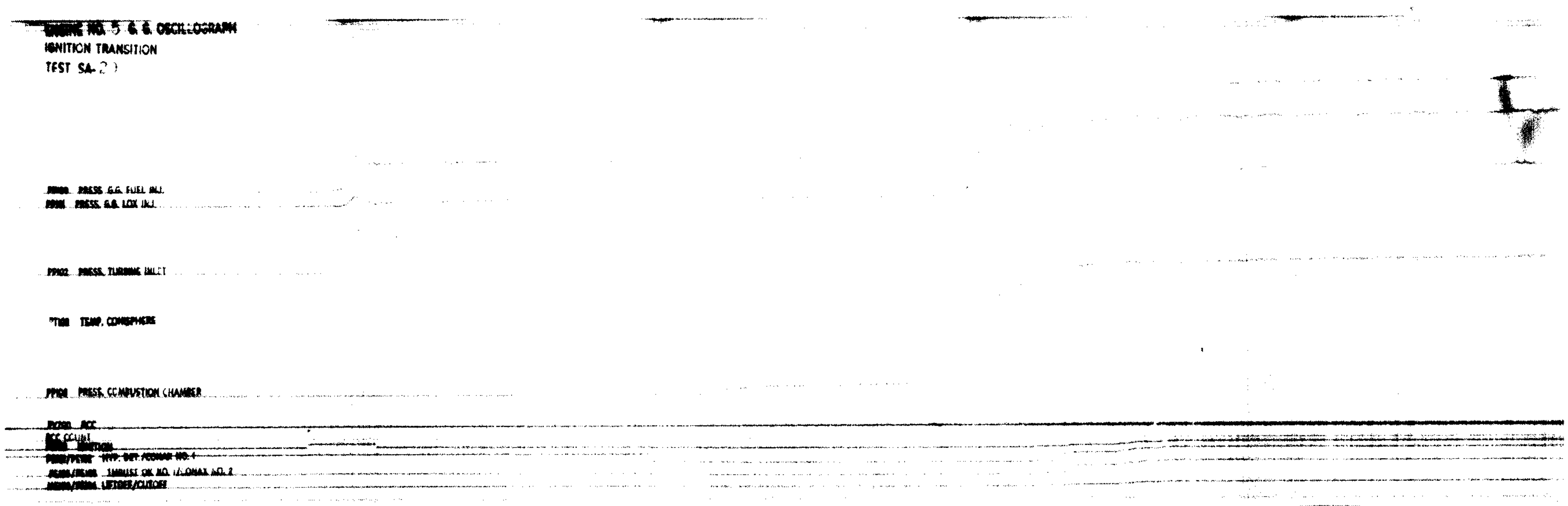


GRAPH 2-8
ENGINE 4, IGNITION TRANSITION, TEST SA-29



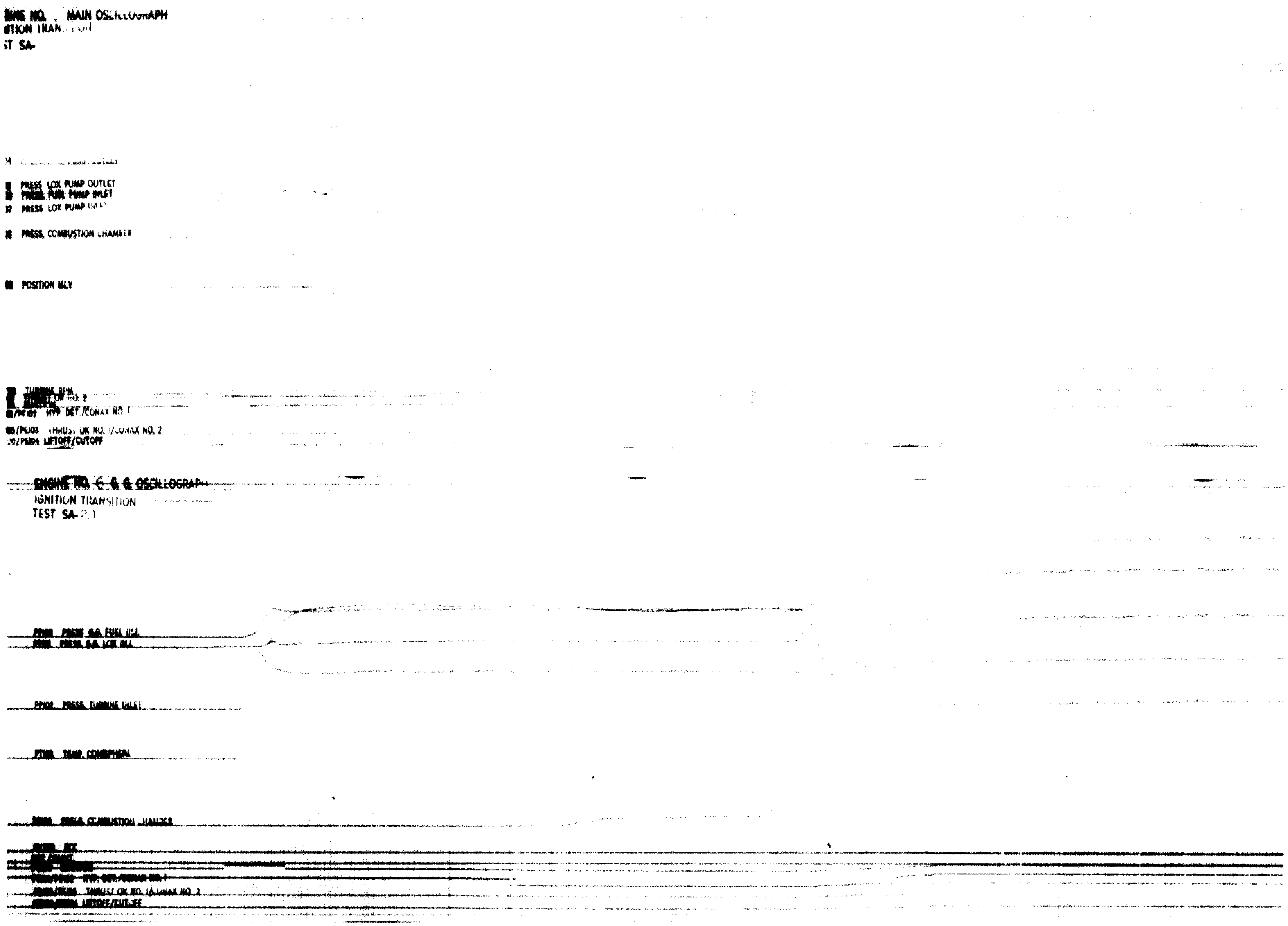
GRAPH 2-9
ENGINE 4, CUTOFF TRANSITION, TEST SA-29

Engine 5 Main Oscillograph did not record until X+109 seconds.

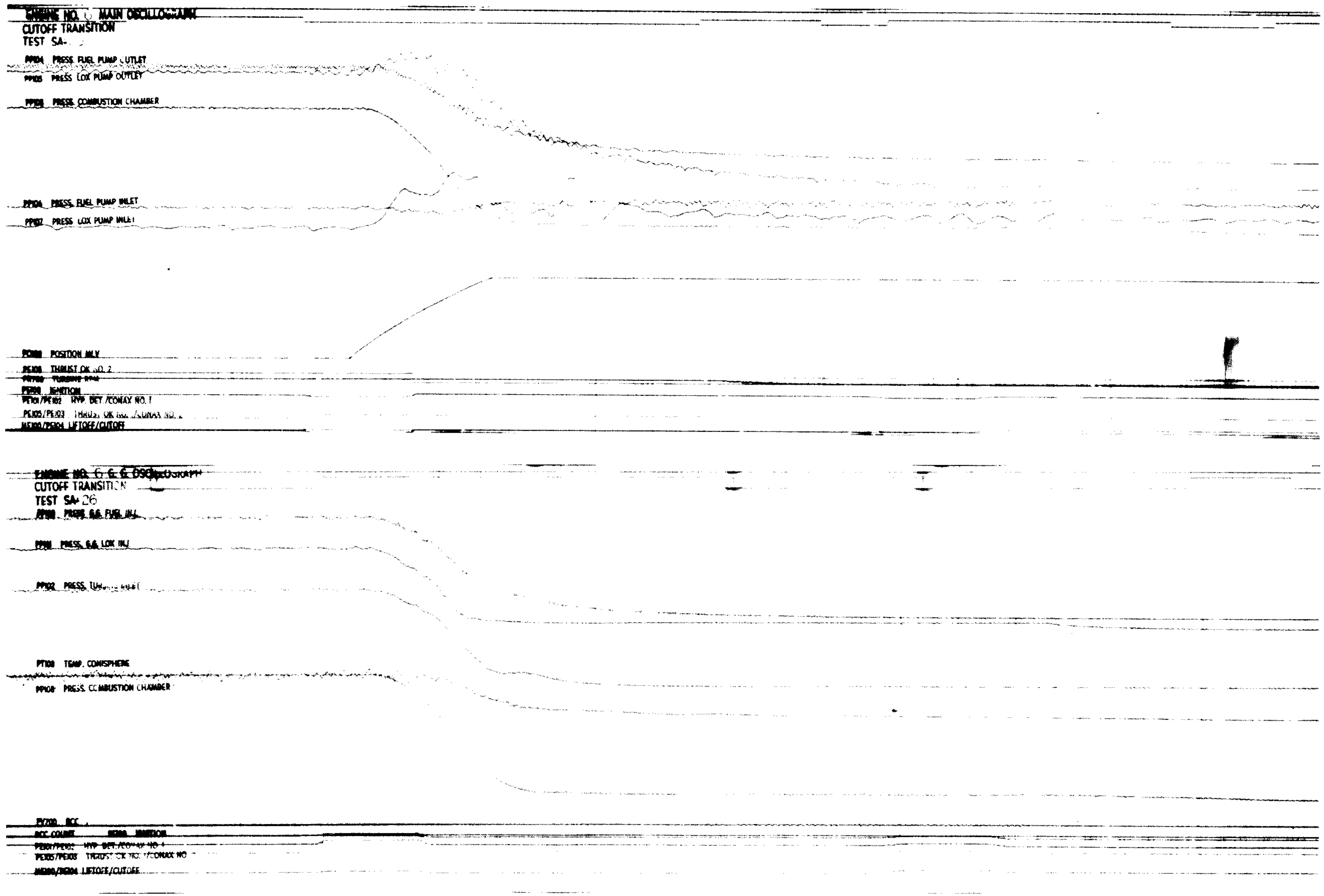


GRAPH 2-10
ENGINE 5, IGNITION TRANSITION, TEST SA-29

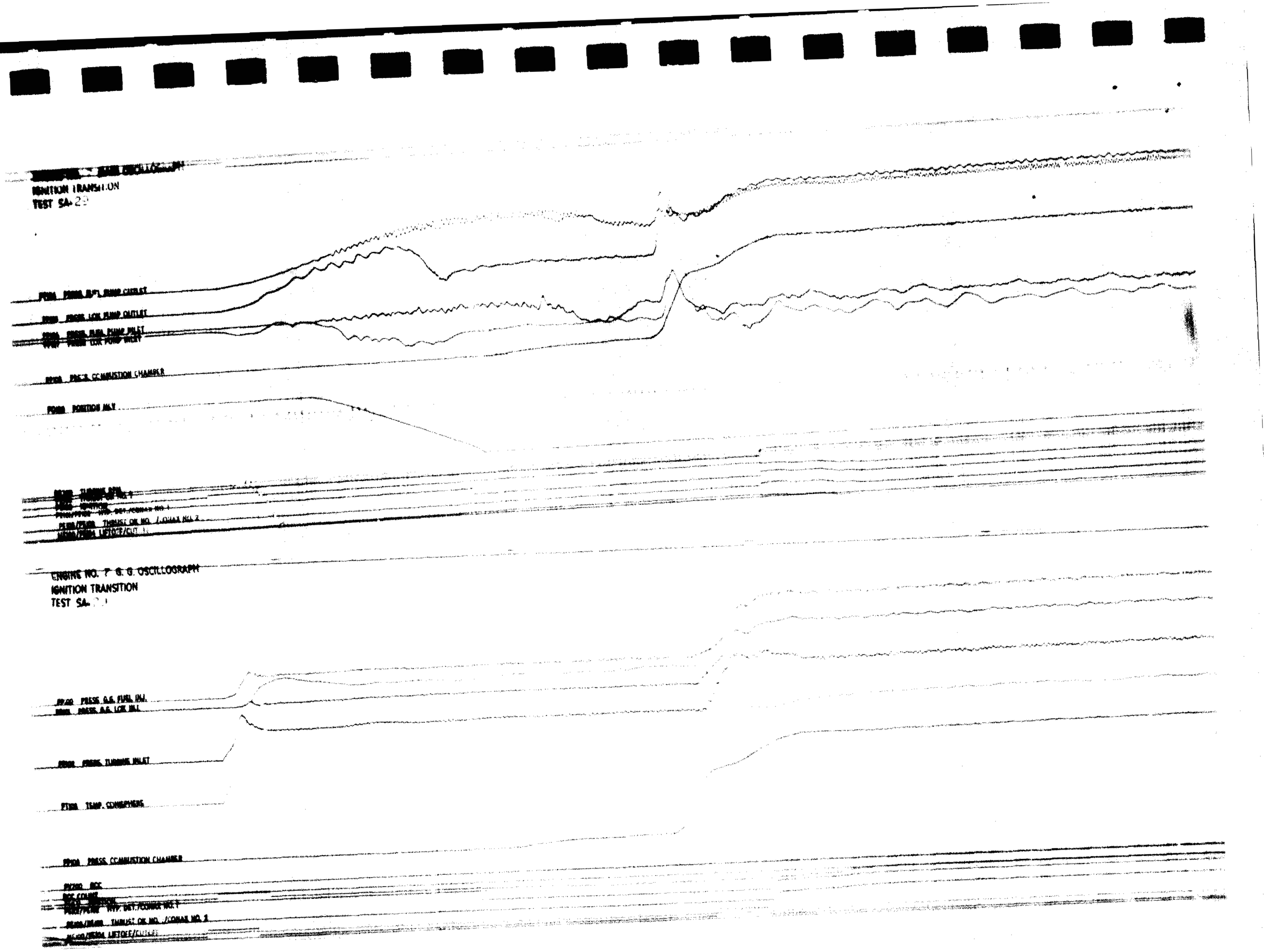
GRAPH 2-11
ENGINE 5, CUTOFF TRANSITION, TEST SA-29



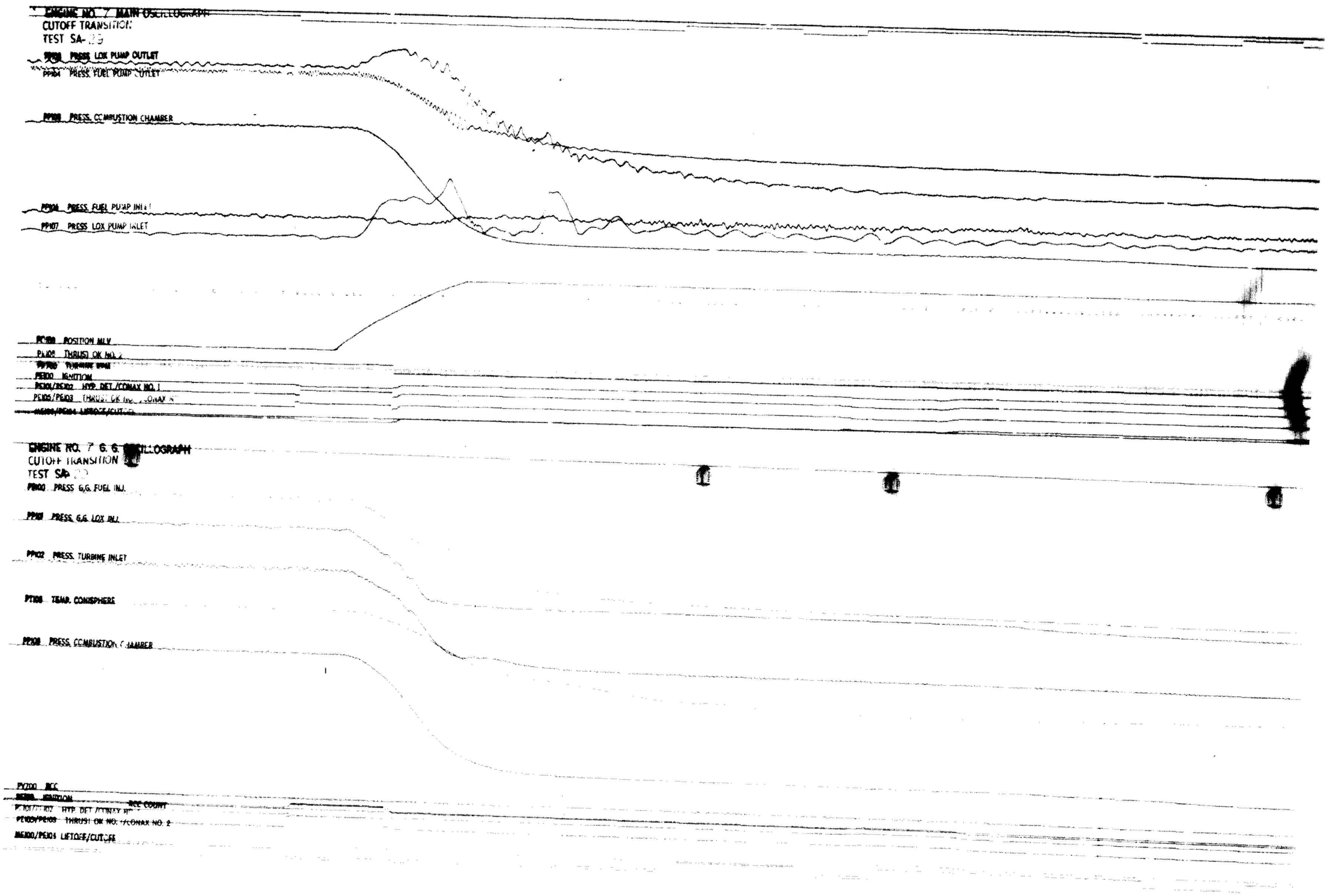
GRAPH 2-12
ENGINE 6, IGNITION TRANSITION, TEST SA-29



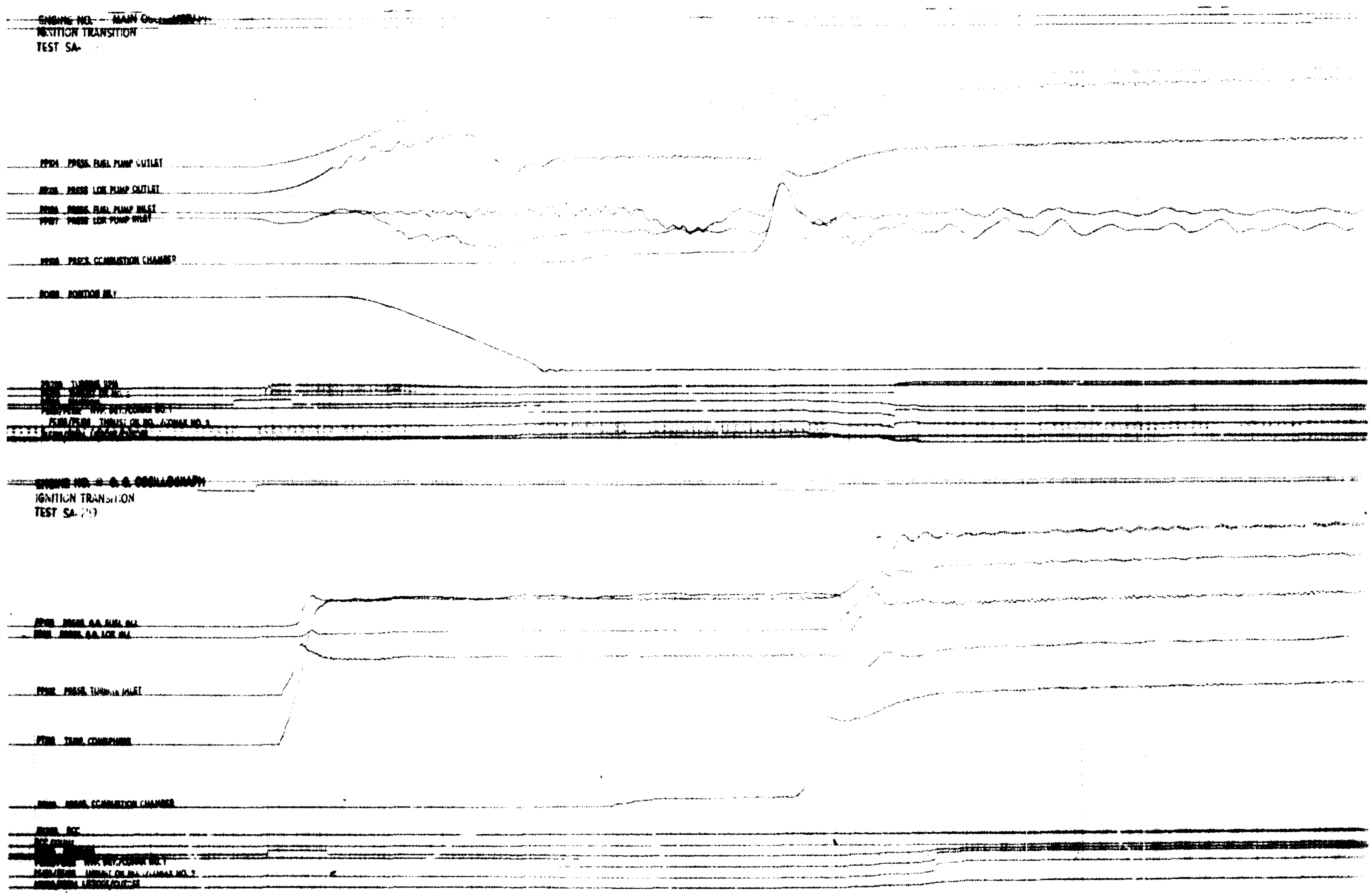
GRAPH 2-13
ENGINE 6, CUTOFF TRANSITION, TEST SA-29



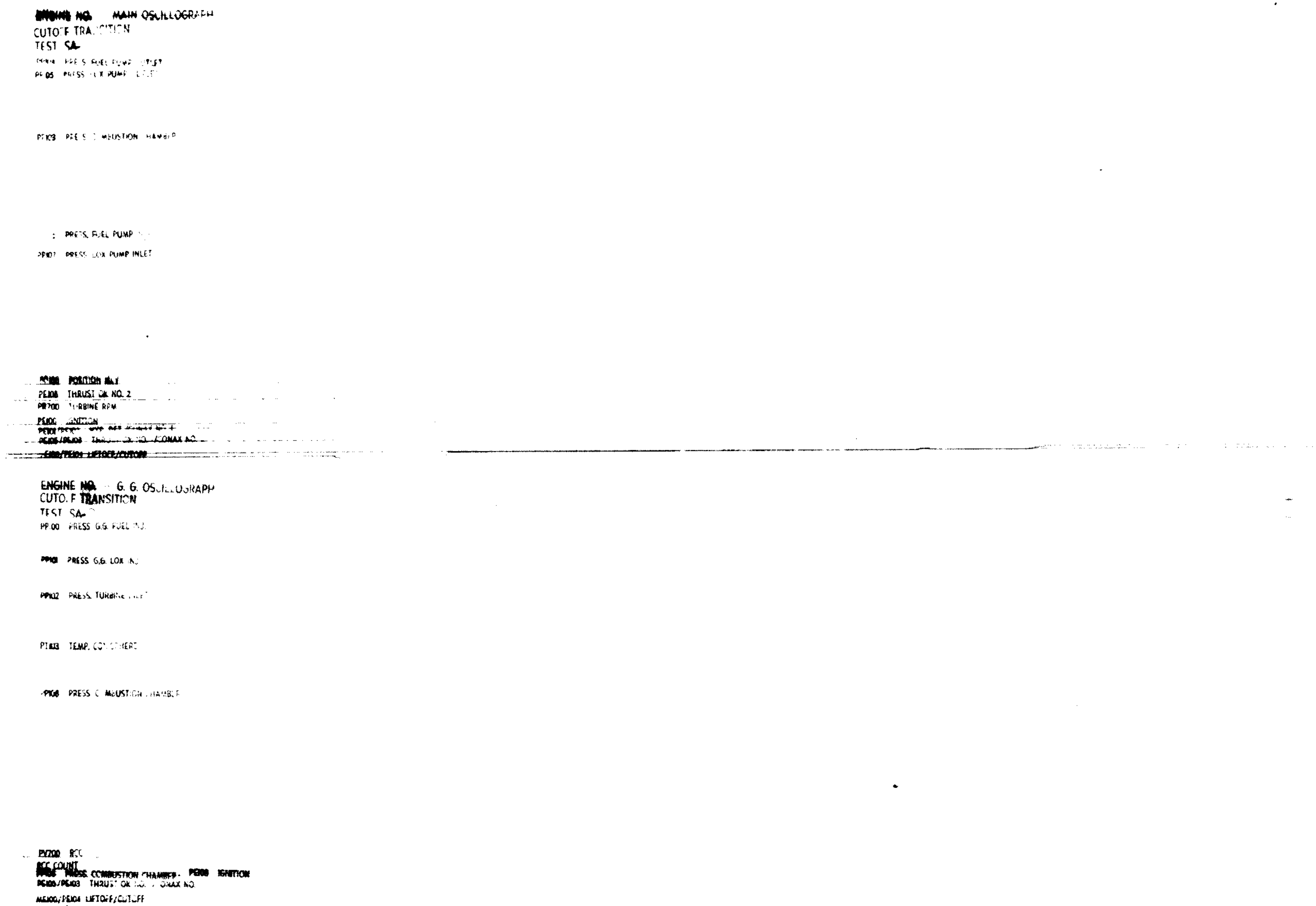
GRAPH 2-14
ENGINE 7, IGNITION TRANSITION, TEST SA-29



GRAPH 2-15
ENGINE 7, CUTOFF TRANSITION, TEST SA-29



GRAPH 2-16
ENGINE 8, IGNITION TRANSITION, TEST SA-29



GRAPH 2-17
ENGINE 8, CUTOFF TRANSITION, TEST SA-29

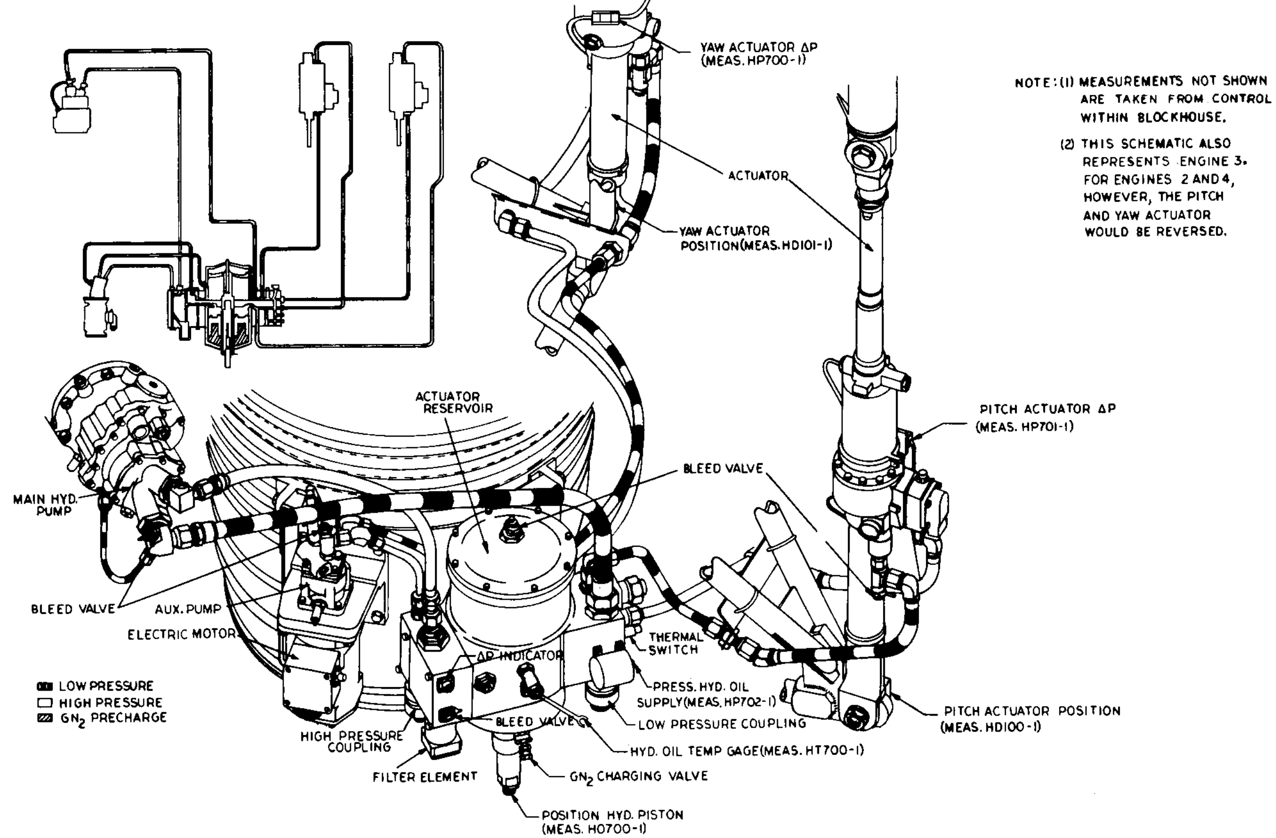
SECTION 3

ENGINE HYDRAULIC SYSTEMS

Because of the premature cutoff of test SA-27, the engines were not gimbaled. No hydraulic systems data were obtained for this test.

The engine hydraulic systems performed satisfactorily during tests SA-28 and SA-29, and all functional requirements were accomplished as outlined by the gimbal programs in TABLES 3-1 and 3-2. Post test inspections were performed and no evidence of hydraulic leakage or damage to system components was observed. A schematic of the engine 1 hydraulic system is shown in FIGURE 3-1.

Test records for test SA-28 revealed that the flight supply pressure traces (measurement *HP702) at engines 2, 3, and 4 were erratic throughout the test. Post test investigations following test SA-28 revealed that the erratic supply pressure traces were due to discrepancies in the measurement circuitry. However, the exact location of these discrepancies could not be found prior to test SA-29. Records for test SA-29 confirmed that these fluctuations are being caused by the blockhouse conditioning equipment and are not a result of fluctuations in the hydraulic pressure system.



HYDRAULIC SYSTEM SCHEMATIC
FIGURE 3-1

TABLE 3-1

GIMBAL PROGRAM

TEST SA-28

ENGINES	TIME ⚠ (SECONDS)	FREQUENCY (CPS)	INPUT (DEGREES)
1, 2, 3, & 4	0 to 3	0	0
1, 2, 3, & 4	3 to 5.5	2	±2 Roll
1, 2, 3, & 4	7 to 12	1	±3 Yaw
1, 2, 3, & 4	14 to 19	1	±3 Pitch
1, 2, 3, & 4	21 to 22	Step	+2 Yaw
1, 2, 3, & 4	23 to 24	Step	-2 Yaw
1, 2, 3, & 4	25 to 26	Step	+2 Pitch
1, 2, 3, & 4	27 to 28	Step	-2 Pitch
1, 2, 3, & 4	28 to Cutoff	0	0

⚠ All times are referenced to simulated liftoff, X+0.25 second.

TABLE 3-2

GIMBAL PROGRAM

TEST SA-29

ENGINES	TIME ⚠ (SECONDS)	FREQUENCY (CPS)	INPUT (DEGREES)
1, 2, 3, & 4	0 to 5	0	0
1, 2, 3, & 4	5 to 35	1 Thru 20	$\pm$0.5 Pitch
1, 2, 3, & 4	35 to 40	0	0
1, 2, 3, & 4	40 to 71	1 Thru 20	$\pm$0.5 Yaw
1, 2, 3, & 4	71 to 76	0	0
1, 2, 3, & 4	76 to 77	Step	+2 Pitch
1, 2, 3, & 4	77 to 81	0	0
1, 2, 3, & 4	81 to 82	Step	-2 Pitch
1, 2, 3, & 4	82 to 86	0	0
1, 2, 3, & 4	86 to 87	Step	+2 Yaw
1, 2, 3, & 4	87 to 91	0	0
1, 2, 3, & 4	91 to 92	Step	-2 Yaw
1, 2, 3, & 4	92 to 100	0	0
1, 2, 3, & 4	100 to 130	0.5	$\pm$2 Roll
1, 2, 3, & 4	130 to Cutoff	0	0

⚠ All times are referenced to simulated liftoff, X+0.24 second.

SECTION 4

PROPELLANT AND PNEUMATIC SYSTEMS

The propellant and pneumatic systems performed satisfactorily during tests SA-28 and SA-29. Insufficient test data were obtained from test SA-27 to perform a system evaluation.

The configuration of the LOX system is shown in FIGURES 4-1 and 4-2. The fuel system configuration is shown in FIGURE 4-3, and the GN_2 control pressure system is shown in FIGURE 4-4. Stage and ground support orifice sizes and pressure switch settings are listed in APPENDIX C of this report. Propellant loading and pressurization data for tests SA-28 and SA-29 are shown in TABLE 4-1.

LOX SYSTEM

The LOX system parameters indicate that the system functioned properly during tests SA-28 and SA-29. The height of LOX on board at firing command of both tests was 655.0 inches in tank O-C, corresponding to the required ullage of 1.7 percent.

Preignition pressurization of the LOX tanks during test SA-28 was accomplished in 65.4 seconds. After the ignition transients, LOX tank pressure increased from 48.5 psia at X+5 seconds to 52.9 psia at cutoff.

Test SA-29 preignition pressurization of the LOX tanks was accomplished in 60.6 seconds. LOX tank pressure at ignition was 59.5 psia, decaying to 49.0 psia at cutoff. The GOX flow control valve started leaving the closed position at X+60 seconds, and maintained LOX tank pressure for the remainder of the test. GRAPH 4-1 shows LOX system pressurization characteristics for test SA-29.

During the propellant loading test conducted on stage S-IB-2, three bubbling tests were performed. These tests are listed as follows:

1. LOX bubbling initiated at X-170 seconds, 10 seconds after vent closure, utilizing a helium flowrate of 45 scfm.

2. LOX bubbling initiated at X-170 seconds, 10 seconds after vent closure, utilizing a helium flowrate of 70 scfm.

3. LOX bubbling initiated at X-153 seconds, 30 seconds prior to vent closure, utilizing a helium flowrate of 45 scfm.

LOX bubbling for test SA-28 was initiated at X-169.5 seconds, 8.9 seconds after vent closure, with a helium flowrate of 45 scfm, increasing LOX tank pressure by 4.5 psi. The maximum LOX pump inlet temperature at ignition was -277.3° F at engine 6.

LOX bubbling for test SA-29 was initiated at X-169.6 seconds, 8.7 seconds after vent closure, utilizing a helium flowrate of 45 scfm. LOX tank pressure increased 5.0 psi during bubbling. The maximum LOX pump inlet temperature at ignition was -277.2° F at engine 5.

The results of these various bubbling tests are presented in TABLE 4-2.

The average boiloff rate during standby prior to test SA-28 was 6.7 pounds per second as calculated from liquid level measurement LP111-0C. Test SA-29 data gave an average boiloff rate of 6.6 pounds per second.

Test SA-29 LOX depletion characteristics using continuous level probe data indicate a variation in levels of 12 to 13 inches between the outer tanks and the center tank. This difference in levels is the result of the 19.00-inch diameter flight orifice in the center LOX tank sump. This orifice was not replaced with a 19.75-inch diameter static test orifice because of the objective of conducting both short and long duration tests with minimum tank ullages.

The LOX discrete probe actuation times for test SA-29 are shown in TABLE 4-3, and the corresponding LOX volumes below the discrete probes are presented in TABLE 4-4.

During the static testing of stage S-IB-2, a shrinkage factor for the LOX tanks was determined. This factor was determined by comparing elevations of the LOX tanks before and after LOX was loaded (see FIGURE 4-5). The result of these comparisons indicate that when LOX is on board, the LOX tanks shrink to 0.9958 of their length at ambient temperature.

FUEL SYSTEM

The fuel system parameters indicated that the system functioned properly during tests SA-28 and SA-29. A fuel level of 634.5 inches at ignition of both tests provided the required 2 percent ullage.

Prior to SA-28, the fuel spheres were pressurized to 3,175 psig from 1,375 psig in 394 seconds. The temperature of the fuel spheres prior to pressurization from 1,375 psig to operating pressure was approximately 102° F. The maximum temperature attained in the spheres was 156° F. The fuel tanks were pre-pressurized to 19.6 psig in 1.4 seconds. At ignition the fuel tank pressure was 18.2 psig, gradually decaying to 11.05 psig at cutoff as the pressure in the fuel spheres decayed to 1,800 psig.

During test SA-29, the fuel spheres were pressurized from 1384 psig to 3233 psig in 399 seconds. Fuel sphere temperature prior to final pressurization was 89°F. The maximum temperature attained in the spheres was 145°F. Lower fuel sphere temperature for test SA-29 is attributed to the fact that pre-pressurization of the spheres to 1500 psig was accomplished earlier in the day, thus allowing the spheres to cool down prior to final pressurization. The fuel tanks were pre-pressurized to 18.5 psig in 1.4 seconds. Fuel tank pressure was maintained by the stage system until X+71.50 seconds, at which time this pressurization program terminated. At X+69.28 seconds, when the fuel tank pressure had decreased to 6.45 psig, the facility pressurizing system was activated by the emergency fuel pressurizing switch. The facility fuel tank pressurizing system locked in at the end of stage pressurizing (X+71.50 seconds) and maintained pressure for the remainder of the test.

The fuel consumption characteristics during test SA-29 show that the level in fuel tank F-3 was approximately 9 inches higher than the level in the other tanks at X+15 seconds. At X+80 seconds, the fuel tank levels had converged, and by cutoff, the level in fuel tank F-2 was highest by approximately 6 inches.

The fuel discrete probe actuation times for test SA-29 are shown in TABLE 4-5, and the corresponding volumes below these probes are shown in TABLE 4-6.

FUEL TANK RIPPLES

During inspection of the booster, following test SA-29, five ripples were observed in fuel tank F-3. Similar ripples had been noted on stages S-I-10 and S-IB-1. The section of the tank in which the ripples are present is painted black and faces the flame deflector. FIGURE 4-6 shows the location of the fuel tank structural measurements and the approximate location of the ripples. The dimensions of the ripples observed after the test are listed below:

STATION	LENGTH (IN.)	WIDTH (IN.)	DEPTH (IN.)
756	12	3	0.100
700	12	2	0.075
698	14	2.5	0.200
640	15	4	0.200
638	13	3	0.250

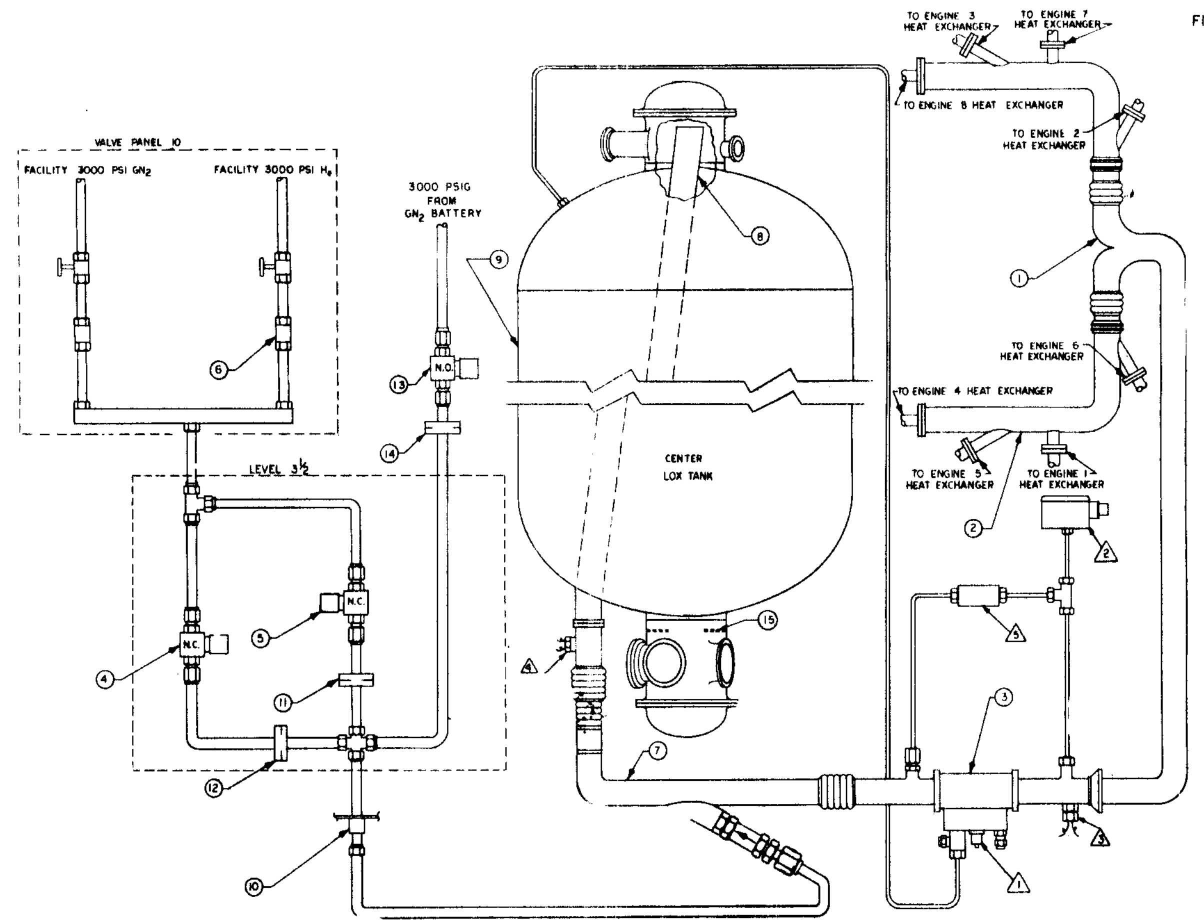
Evaluation of the data gathered during test SA-29 indicates that the ripples were formed as a result of thermal stresses within the tank wall. Radiant energy from the exhaust plume was absorbed more readily by the black painted areas of the tanks. This heat was initially dissipated to the fuel within the tanks, but as the fuel level dropped, a significant difference in temperature was noted between black painted portions of the tank and the white painted areas. Thermal stresses resulting from this temperature differential exceeds the structural limits of the tank in local areas and causes the ripples to occur.

It is recommended that fuel tanks F-3 and F-4 both be painted white for static firings. This action is intended to reduce thermal stress in the tanks and to give a more uniform temperature distribution over the entire surface of the tanks. For additional information, refer to GRAPHS 4-18 through 4-22 of the "Preliminary Static Test Report, for Test SA-29".

GN_2 CONTROL SYSTEM

The GN_2 control system functioned normally during tests SA-28 and SA-29. The operating pressure was maintained with the gearcase and four simulated calorimeter purges on. The calorimeter purge was initiated automatically at power transfer (X-28 seconds). During test SA-28, control sphere pressure decayed from 2,932 psig at ignition to 2,450 psig at cutoff. Test SA-29 pressure at ignition was 2,965 psig, decaying to 1,450 psig at cutoff.

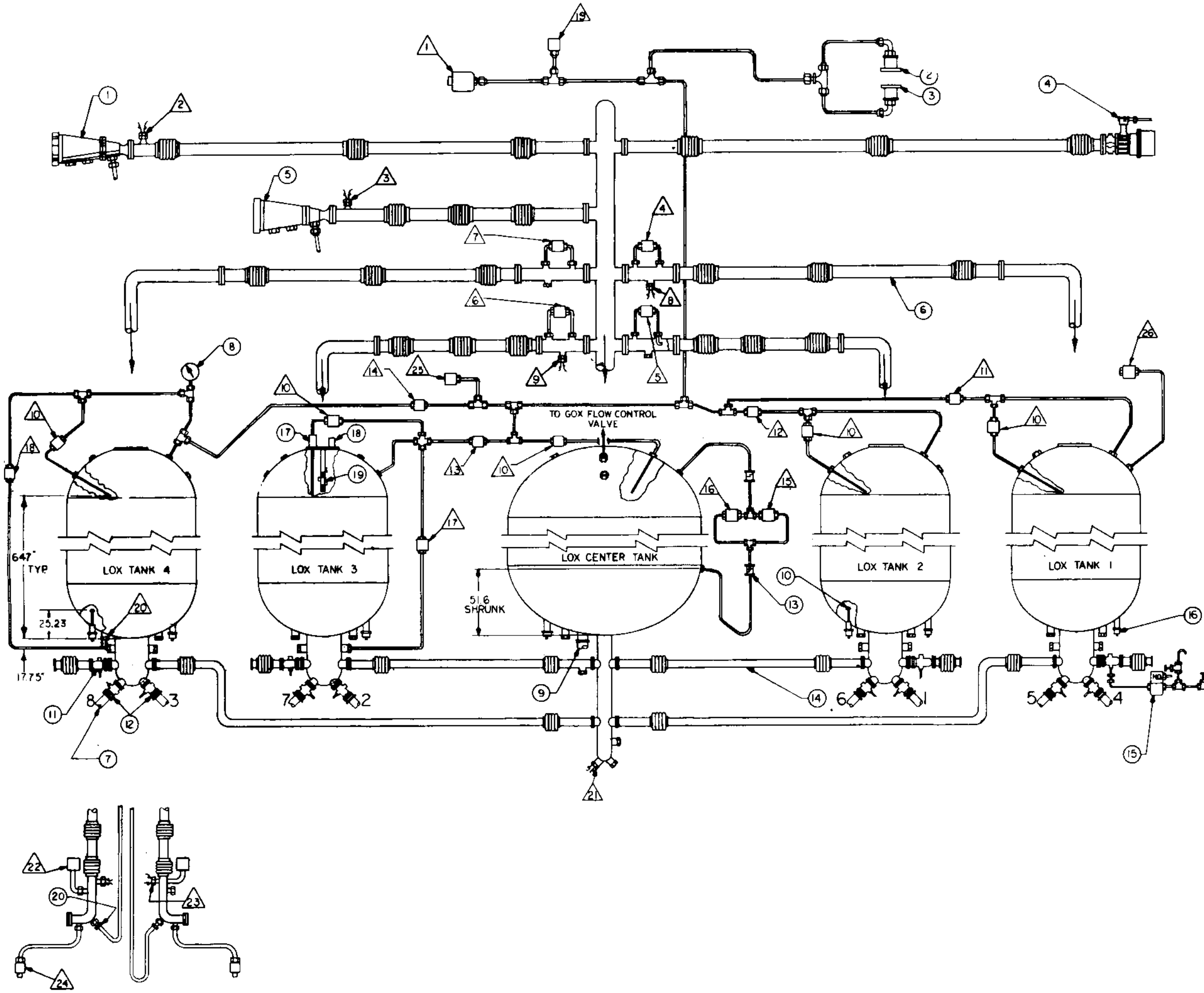
Post test inspection of the control sphere inner liner revealed that bubbles were present in this liner. The number and size of these bubbles had increased when the sphere was inspected after a 12-hour period. These bubbles have been observed on previous stages at Static Test. The control sphere was removed from the stage and sent to Michoud for further analysis.



FIND NO.	ITEM
1	GOX COLLECTOR
2	GOX MANIFOLD
3	GOX FLOW CONTROL VALVE
4	GROUND LOX PRESSURIZING SOLENOID VALVE
5	ORIFICE BYPASS PRESSURIZING SOLENOID VALVE
6	FILTER (TYPICAL 2 PLACES)
7	LOX PRESSURIZATION LINE
8	GOX STANDPIPE
9	CENTER LOX TANK
10	LOWER UMBILICAL FIN 2
11	.31 DIAMETER ORIFICE
12	.100 DIAMETER ORIFICE
13	FACILITY LOX PRESSURIZING SOLENOID.
14	.537 DIAMETER ORIFICE
15	19.00 DIAMETER ORIFICE

- △5 MEASUREMENT D114-9 DIFFERENTIAL PRESSURE ACROSS THE GOX FLOW CONTROL VALVE
- △4 MEASUREMENT ST100-9 TEMPERATURE GOX LINE
- △3 MEASUREMENT 0234-9 TEMPERATURE INLET GOX FLOW CONTROL VALVE.
- △2 MEASUREMENT D119-9 PRESSURE INLET GOX FLOW CONTROL VALVE.
- △1 MEASUREMENT L0700-9 POSITION GOX FLOW CONTROL VALVE.

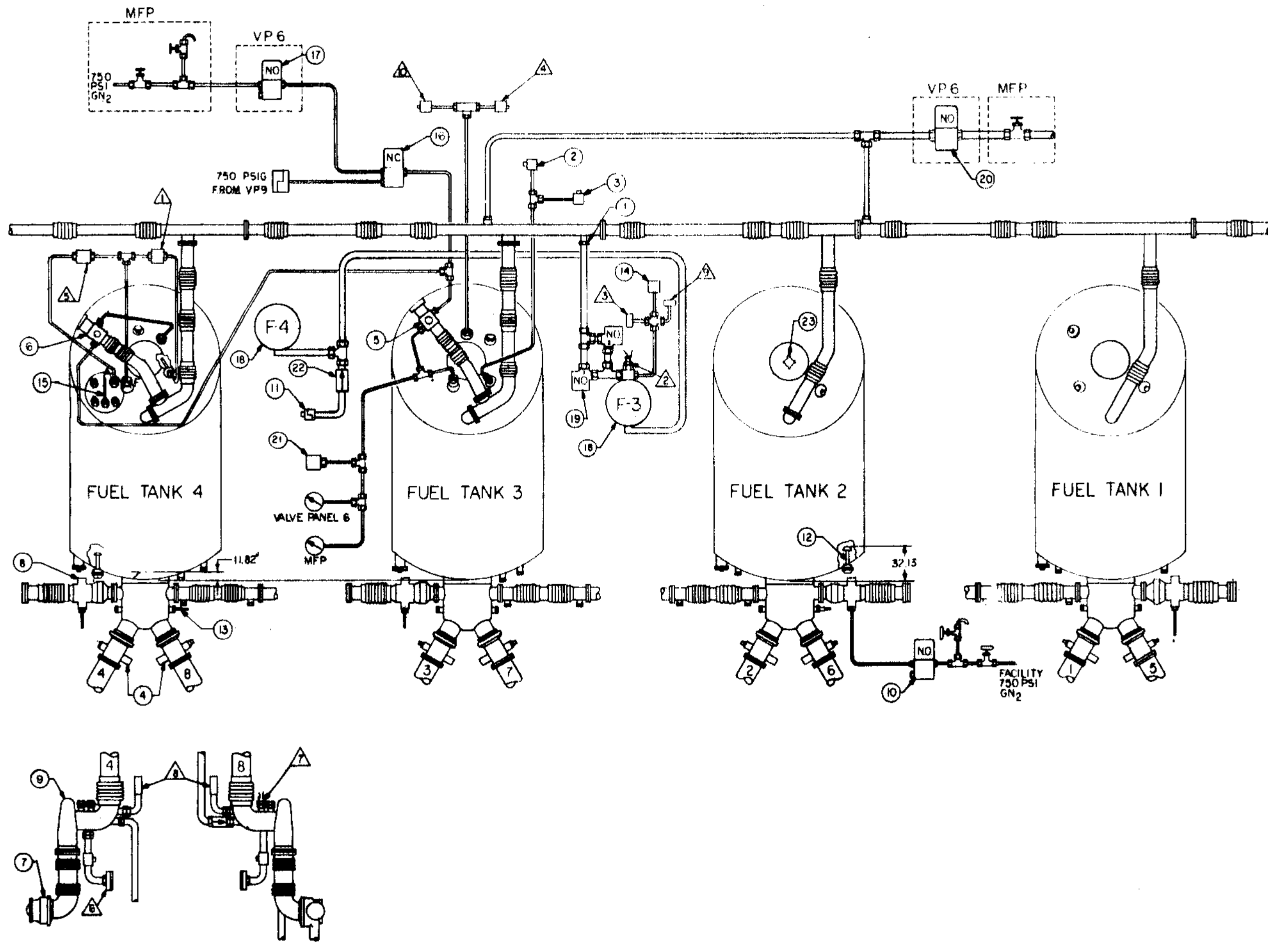
LOX PRESSURIZATION SYSTEM - FIGURE 4-2



FIND NO.	ITEM
1	LOX RELIEF VALVE 2
2	LOX TANK PRESSURIZED & RELIEF PRESSURE SWITCH
3	LOX TANK EMERGENCY VENT PRESSURE SWITCH
4	7 INCH LOX VENT VALVE
5	LOX RELIEF VALVE 1
6	GOX INTERCONNECT (TYPICAL)
7	LOX SUCTION LINE (TYPICAL 8 PLACES)
8	LOX TANK PRESSURE GAGE
9	GOX LINE
10	LOX LOW LEVEL CUTOFF SENSOR (TYPICAL 2 PLACES)
11	LOX FILL & DRAIN VALVE (TYPICAL 4 PLACES)
12	LOX PREVALVE (TYPICAL 8 PLACES)
13	LOX SENSING LOWER (UMBILICAL FIN 4)
14	LOX INTERCONNECT LINE (TYPICAL)
15	LOX FILL AND DRAIN VALVE CONTROL SOLENOID (TYPICAL 4 PLACES)
16	CONTINUOUS LEVEL PROBE TYPICAL 5 PLACES
17	CAMERA
18	LIGHT
19	DISCRETE PROBE RACK
20	LOX BUBBLING ORIFICE (TYP 8 PLACES)

26	MEASUREMENT LP102-01 PRESS. LOX TANK
25	MEASUREMENT LP102-0C PRESS. LOX TANK
24	MEASUREMENT LP114 LOX PUMP INLET PRESSURE TRANSDUCER (TYP 8 PLACES)
23	MEASUREMENT PT107 TEMPERATURE LOX PUMP INLET (TYP 8 PLACES)
22	MEASUREMENT LP107 PRESS LOX PUMP INLET (TYP 8 PLACES)
21	MEASUREMENT LT101-0C TEMP, TANK SUMP
20	MEASUREMENT LT101-04 TEMP, TANK BOTTOM
19	MEASUREMENT SP205-0C PRESS LOX TANK 0 TO 5 PSI
18	MEASUREMENT LP111-04 ΔP FROM SUMP SUPP SCALE
17	MEASUREMENT LP111-03 ΔP FROM SUMP SUPP. SCALE
16	MEASUREMENT LP100-0C DIFF PRESS
15	MEASUREMENT LP111-0C DIFF PRESS SUPRESSED SCALE
14	MEASUREMENT LP110-10 DIFF PRESS 04 TO 0C.
13	MEASUREMENT LP109-10 DIFF PRESS 03 TO 0C.
12	MEASUREMENT LP108-10 DIFF PRESS 02 TO 0C.
11	MEASUREMENT LP107-10 DIFF PRESS 01 TO 0C.
10	MEASUREMENT SP206-0C,01,02,03,04 ΔP
9	MEASUREMENT ST102-11 TEMP GOX INTERCONNECT 03 TO 0C.
8	MEASUREMENT ST101-11 TEMP. GOX INTERCONNECT 01 TO 0C.
7	MEASUREMENT SP204-11 TOTAL PRESS GOX INTERCONNECT 04 TO 0C.
6	MEASUREMENT SP203-11 TOTAL PRESS GOX INTERCONNECT 03 TO 0C.
5	MEASUREMENT SP202-11 TOTAL PRESS GOX INTERCONNECT 02 TO 0C.
4	MEASUREMENT SP201-11 TOTAL PRESS GOX INTERCONNECT 01 TO 0C.
3	MEASUREMENT ST103-11 TEMP LOX RELIEF VALVE #1
2	MEASUREMENT ST104-11 TEMP LOX RELIEF VALVE #2
1	MEASUREMENT D3-0C PRESSURE LOX TANK

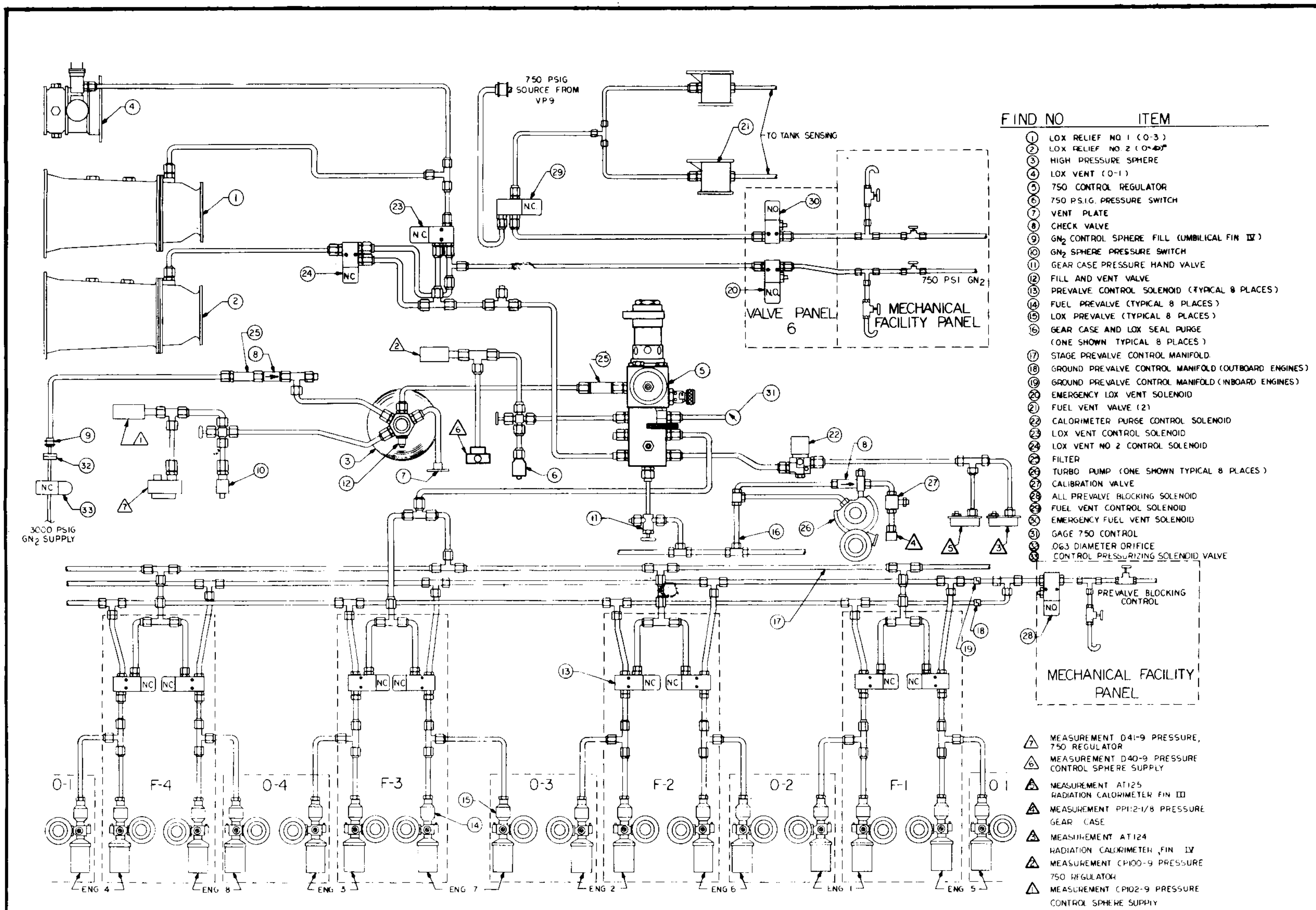
LOX SYSTEM FIGURE 4-1



FIND NO	ITEM
1	NOZZLE 0.210 DIA (SONIC)
2	FUEL TANK EMERGENCY VENT PRESSURE SWITCH
3	FUEL TANK PRESSURIZED PRESSURE SWITCH
4	FUEL PREVALVE (TYP 8 PLACES)
5	FUEL VENT VALVE 1
6	FUEL VENT VALVE 2
7	MAIN FUEL VALVE (TYP 8 PLACES)
8	FUEL FILL & DRAIN VALVE (TYP 4 PLACES)
9	FUEL TURBO PUMP (TYP 8 PLACES)
10	FUEL FILL & DRAIN VALVE CONTROL SOLENOID (TYP TANKS 1,2,3,4)
11	FUEL PRESSURIZING SPHERE FILL UPPER UMBILICAL FIN 2
12	ENGINE CUTOFF SENSOR (TYP 2 PLACES)
13	FUEL DEPLETION SENSOR (TYP 2 PLACES)
14	FUEL SPHERE PRESSURIZE PRESSURE SWITCH
15	FUEL DENSITY (NOT USED ON STATIC TEST)
16	FUEL VENT CONTROL SOLENOID
17	EMERGENCY FUEL VENT CONTROL SOLENOID
18	FUEL PRESSURIZING SPHERE (TYP 2 PLACES)
19	FUEL TANK PRESSURIZING VALVES 1&2
20	FACILITY FUEL TANK PRESSURIZING SOLENOID
21	PRESSURE SWITCH, EMERGENCY FUEL TANK PRESSURIZING
22	CHECK VALVE
23	DISCRETE PROBE RACK

- 10 MEAS D2-F3 PRESS. FUEL TANK NO. 3
- 9 MEAS. D139-11 FUEL SPHERE PRESS.
- 8 MEAS. PP113 FUEL INLET PRESSURE (TYP 8 PLACES)
- 7 MEAS. PT100-8 TEMPERATURE FUEL PUMP INLET
- 6 MEAS. PP106 FUEL INLET PRESS (TYP 8 PLACES)
- 5 MEAS. FP109-F4 FUEL DIFF PRESS
- 4 MEAS. FP101-F3 PRESSURE FUEL TANK 3
- 3 MEAS. FP103-11 FUEL SPHERE PRESSURE
- 2 MEAS. FT700-11 TEMPERATURE FUEL SPHERES
- 1 MEAS. SP200-F4 FUEL DIFF PRESS

FUEL PROPELLANT & PRESSURIZATION SYSTEMS FIGURE 4-3



GN_2 CONTROL PRESSURE SYSTEM FIGURE 4-4

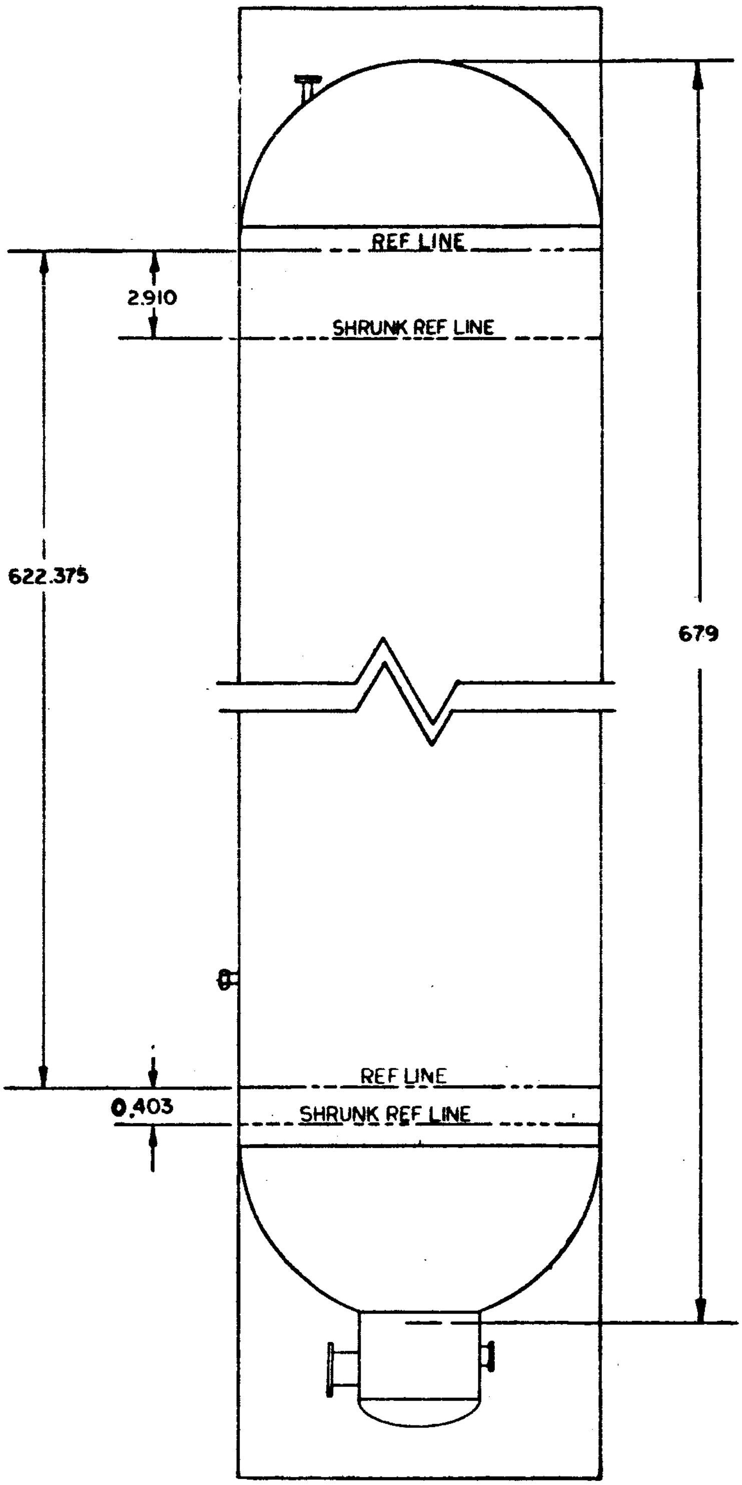


FIGURE 4-5 LOX TANK SHRINKAGE

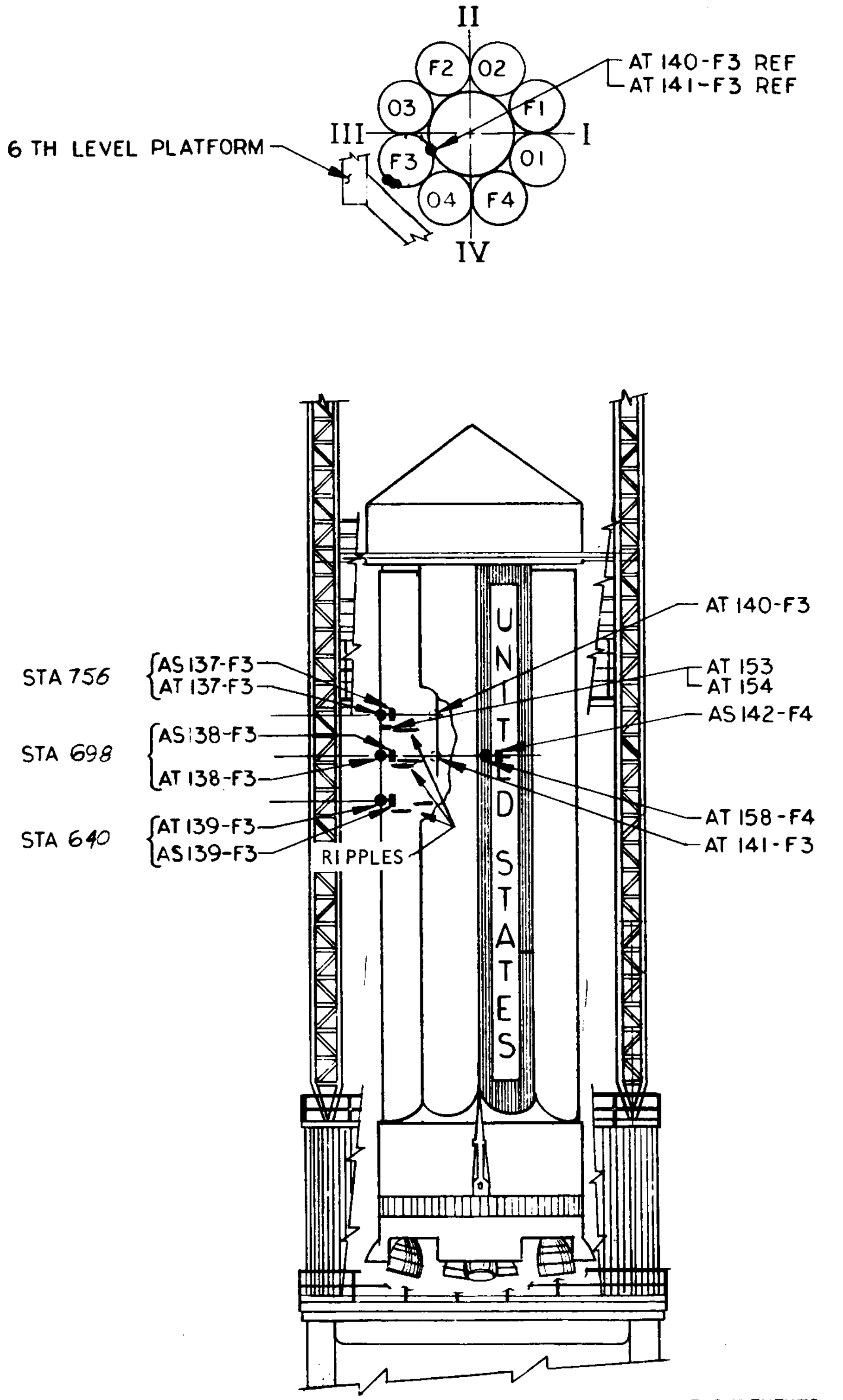


FIGURE 4-6 LOCATION OF FUEL TANK STRUCTURAL MEASUREMENTS AND FUEL TANK RIPPLES

TABLE 4-1

PROPELLANT LOADING AND PRESSURIZATION DATA

LOX

		TEST SA-28	TEST SA-29
1.	Tank pressurant..................................	Helium	Helium
2.	Pressurizing time (seconds)......................	65.4	60.6
3.	Height from tank bottom at ignition command (inches)	655.0	655.0
4.	Ullage volume at ignition (gallons)..............	1036	1036
5.	Ullage volume at ignition (percent)..............	1.7	1.7
6.	Volume at ignition (gallons).....................	66,940	66,940
7.	Volume at outboard cutoff signal.................	–	3,165
8.	Average boiloff rate during standby (pounds/second)	6.7	6.6

FUEL

		TEST SA-28	TEST SA-29
1.	Tank pressurant..................................	Helium	Helium
2.	Pressurizing time (seconds)......................	1.4	1.4
3.	Height from tank bottom at ignition (inches)......	634.5	634.5
4.	Ullage at ignition (gallons).....................	855	855
5.	Ullage at ignition (percent).....................	2.0	2.0
6.	Volume at ignition (gallons).....................	42,100	42,100
7.	Volume at outboard cutoff signal.................	–	2,065

TABLE 4-2

LOX PUMP INLET TEMPERATURES, °F

TEST	ENGINE	START OF BUBBLING	END OF BUBBLING ⚠1	IGNITION COMMAND ⚠2
Propellant Loading Test. Vents closed at X-180. LOX bubbling at X-170 seconds at 45 scfm.	1	-274.1	-280.6	-278.0
	2	-274.3	-281.0	-278.3
	3	-274.4	-281.1	-278.9
	4	-274.3	-281.2	-278.1
	5	-274.3	-280.0	-277.8
	6	-274.0	-279.7	-276.8
	7	-274.1	-280.3	-277.9
	8	-274.3	-279.9	-276.7
Propellant Loading Test. Vents closed at X-180. LOX bubbling at X-170 seconds at 70 scfm.	1	-274.4	-282.1	-279.4
	2	-274.5	-282.1	-279.5
	3	-275.0	-282.2	-280.1
	4	-274.7	-282.4	-279.6
	5	-274.2	-281.7	-279.0
	6	-273.7	-280.8	-277.8
	7	-274.0	-281.2	-279.0
	8	-274.4	-281.4	-278.4
Propellant Loading Test. LOX bubbling at X-153 seconds at 45 scfm. Vents closed at X-123.	1	-274.3	-281.5	-279.2
	2	-274.3	-281.2	-279.5
	3	-274.4	-282.1	-279.8
	4	-274.6	-281.8	-279.4
	5	-274.3	-280.7	-278.3
	6	-273.8	-280.3	-277.6
	7	-274.2	-280.5	-278.4
	8	-274.4	-280.2	-278.1
Test SA-28. Vents closed at X-178.4 LOX bubbling at X-169.5 seconds at 45 scfm.	1	-273.9	-280.2	-278.5
	2	-274.4	-280.5	-278.9
	3	-274.5	-280.4	-279.1
	4	-274.6	-280.6	-278.1
	5	-274.3	-279.9	-277.6
	6	-274.0	-280.1	-277.3
	7	-274.6	280.6	-278.7
	8	274.6	280.2	-277.7
Test SA-29 Vents closed at X-178.3 LOX bubbling at X-169.6 seconds at 45 scfm.	1	-273.7	-279.3	-278.0
	2	-273.8	-279.7	-278.0
	3	-273.9	-279.9	-278.6
	4	-274.1	-279.8	-278.5
	5	-273.7	-279.4	-277.2
	6	-274.6	-280.3	-277.6
	7	-274.1	-279.9	-277.3
	8	-274.1	-274.6	-277.4

⚠1 End of bubbling (X-103 seconds)

⚠2 Ignition command (X-3 seconds)

TABLE 4-3

LOX DISCRETE PROBE ACTUATION TIMES ⚠1

TEST SA-29

PROBE	TANK 0-C	TANK 0-1	TANK 0-2	TANK 0-3	TANK 0-4
P1	14.023	11.286	11.003	11.128	11.004
P2	23.747	20.494	20.068	20.295	20.119
P3	33.271	29.717	29.068	29.467	29.435
P4	42.835	39.075	38.402	38.702	38.712
P5	52.222	48.527	47.743	47.968	48.043
P6	61.616	57.916	57.075	57.367	57.536
P7	70.982	67.374	66.314	66.764	67.133
P8	80.334	76.952	75.781	86.284	76.524
P9	89.648	86.536	85.215	85.814	86.273
P10	98.983	96.006	94.989	95.147	95.523
P11	108.490	105.463	104.338	104.745	105.236
P12	117.945	114.980	113.795	114.286	114.814
P13	126.956	124.577	123.662	123.904	124.062
P14	137.038	134.127	133.286	133.412	133.536
P15	⚠2	144.081	142.654	142.936	143.194

⚠1 Times shown are periods in seconds after ignition command.

⚠2 Probe 15 in tank 0-C was not uncovered.

TABLE 4-4

PROPELLANT VOLUMES BELOW DISCRETE PROBES

LOX
(UNSHRUNK GALLONS)

TEST SA-29

PROBE	TANK 0-C	TANK 0-1	TANK 0-2	TANK 0-3	TANK 0-4
P1	22187	9965	9971	9967	9969
P2	20632	9277	9263	9278	9280
P3	19079	8584	8587	8584	8586
P4	17523	7893	7894	7894	7895
P5	15968	7202	7205	7204	7204
P6	14412	6512	6513	6511	6512
P7	12855	5820	5822	5823	5821
P8	11302	5127	5131	5130	5129
P9	9746	4439	4438	4438	4438
P10	8189	3743	3745	3745	3745
P11	6639	3053	3053	3055	3054
P12	5084	2363	2365	2364	2364
P13	3530	1671	1671	1671	1671
P14	1980	981	981	981	980
P15	485	301	303	302	302

TABLE 4-5

FUEL DISCRETE PROBE ACTUATION TIMES ⚠1

TEST SA-29

PROBE	TANK F-1	TANK F-2	TANK F-3	TANK F-4
P1	13.994	14.546	16.494	14.819
P2	23.362	23.746	25.936	23.622
P3	32.712	32.979	35.060	32.979
P4	42.294	42.385	44.176	42.426
P5	50.684	51.794	52.959	51.768
P6	60.067	61.234	62.652	61.143
P7	69.540	70.632	71.881	70.614
P8	79.546	80.334	80.233	80.366
P9	89.039	90.000	89.349	89.624
P10	98.488	99.715	98.548	98.915
P11	108.055	109.306	107.898	108.206
P12	117.566	118.862	117.088	117.505
P13	127.112	128.428	126.476	126.914
P14	⚠2	137.928	135.854	136.286

⚠1 Times shown are periods in seconds after ignition command.

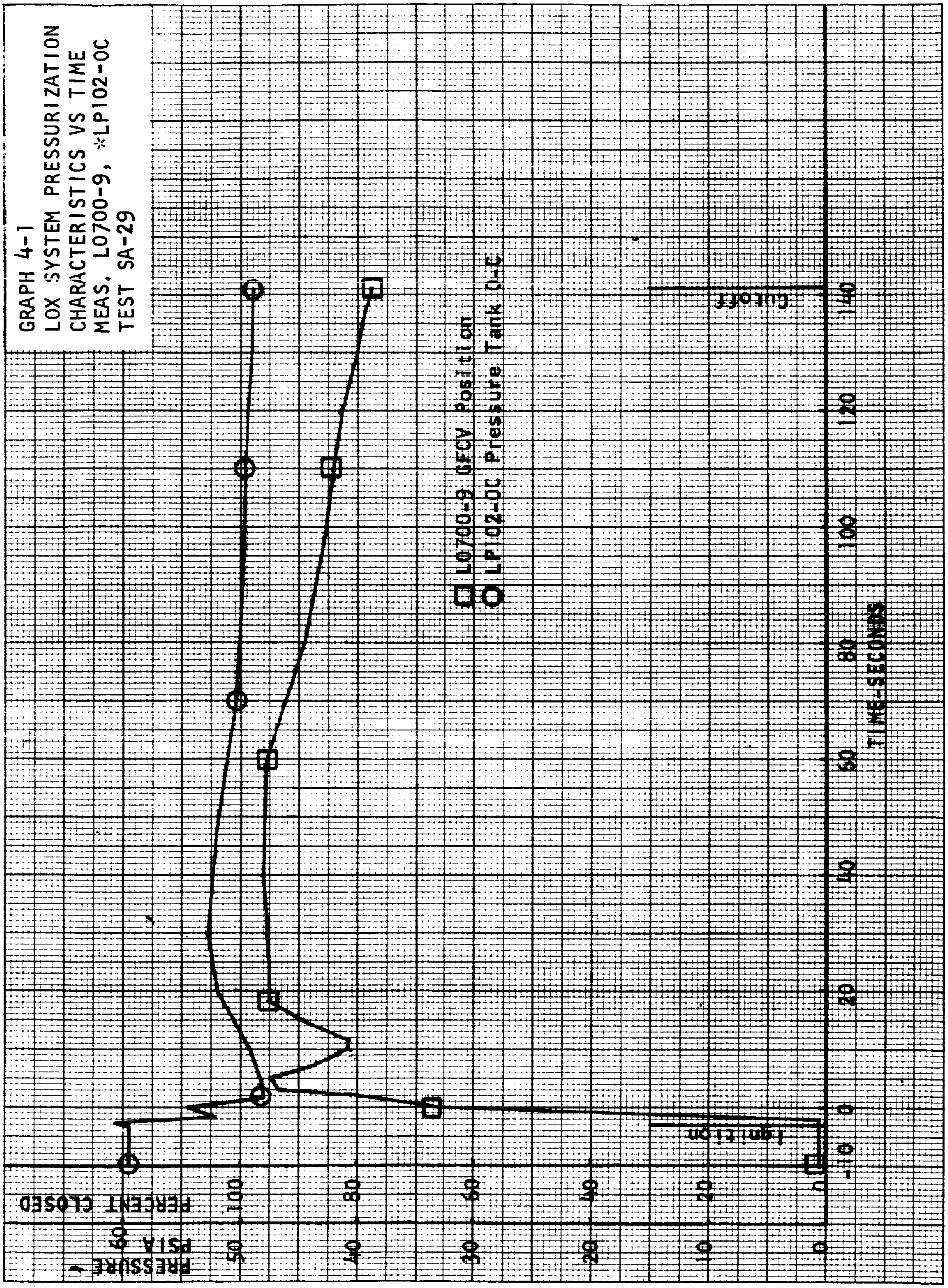
⚠2 Probe 14 actuation time could not be determined due to noise.

TABLE 4-6

PROPELLANT VOLUMES BELOW DISCRETE PROBES
FUEL

TEST SA-29

PROBE	TANK F-1	TANK F-2	TANK F-3	TANK F-4
P1	9473	9468	9471	9483
P2	8814	8807	8810	8822
P3	8156	8149	8153	8165
P4	7498	7492	7495	7506
P5	6841	6836	6841	6848
P6	6182	6176	6178	6190
P7	5524	5520	5520	5529
P8	4867	4861	4863	4872
P9	4208	4202	4203	4211
P10	3554	3545	3545	3553
P11	2896	2890	2888	2896
P12	2239	2231	2232	2237
P13	1576	1572	1573	1577
P14	919	916	920	919
P15	276	270	271	274



GRAPH 4-1
LOX SYSTEM PRESSURIZATION CHARACTERISTICS VS TIME
MEAS. L0700-9, *LP102-0C
TEST SA-29
L0700-9 GFCV Position
LP102-0C Pressure Tank 0-C
Cutoff
Ignition
PRESSURE PSIA
PERCENT CLOSED
TIME-SECONDS

SECTION 5

ENGINE COMPARTMENT ENVIRONMENT

The engine compartment environment of stage S-IB-2 was satisfactory during tests SA-28 and SA-29. Turbine spinner temperatures were maintained within the specified limits of 40°F to 75°F by the boattail conditioning system.

Post test inspection of the heat shield panels revealed that only slight damage was incurred during tests SA-28 and SA-29. No separation of M-31 was noted, and only minor cracking occurred. The two S-IB stainless steel honeycomb heat shield panels which were installed at Fin line II prior to test SA-29 were only slightly damaged. The damage that was observed consisted of numerous cracks. No separation of M-31 insulating material from the stage panels occurred. The panels were discolored, and large amounts of M-31C were burned away. The post test status of the heat shield panels following test SA-29 is shown in FIGURE 5-1 and TABLE 5-1.

The refurbished gimbal boots used on stage S-IB-2 were of a modified type which utilized one layer of aluminized fabric bonded to the inner rubber boot. These gimbal boots were installed for evaluation during static test of this stage. The previous configuration consisted of 30C03566-5 insulation material loosely covered (not bonded) by a curtain of Refrasil insulation material (C100-48) and a layer of reflective tape (Y-9050).

Post test inspection of the outboard engine gimbal boots following test SA-28 revealed that the aluminized fabric on engine 3 was burned completely through, and the flexible gimbal boot was charred. This boot was replaced following test SA-28 with the flight-type boot used on previous stages.

Inspection following test SA-29 revealed that the inboard sides of the flame curtains at engines 1, 2, and 4 were damaged. Two large holes were burned through the reflective material at engine 4, allowing the boot to become severely burned (see FIGURE 5-2). One large hole was burned through the reflective material at engine 2, allowing the boot to become severely burned (see FIGURE 5-3). The reflective material at engine 1 was burned to the extent that it became dry and brittle (see FIGURE 5-4). The flame curtains at engines 2 and 4 were observed to burn for approximately 5 minutes following cutoff. The flame curtain at engine 3 received little or no damage during this test. Normally this curtain receives the most damage.

There has been no evidence of gimbal boot charring on previous short duration firings, nor has such extensive damage been noted during previous long duration firings. It is concluded that the aluminized fabric flame curtains used during static test of S-IB-2 are unsatisfactory. It is recommended that the previously used 10C11462 flame curtains be employed on all future stages.

Post test SA-29 inspection of the center access chute cover revealed only slight damage.

There was no evidence of any fire or hot gas leaks in the engine compartment.

Meteorological data for tests SA-28 and SA-29 are presented in Appendix D.

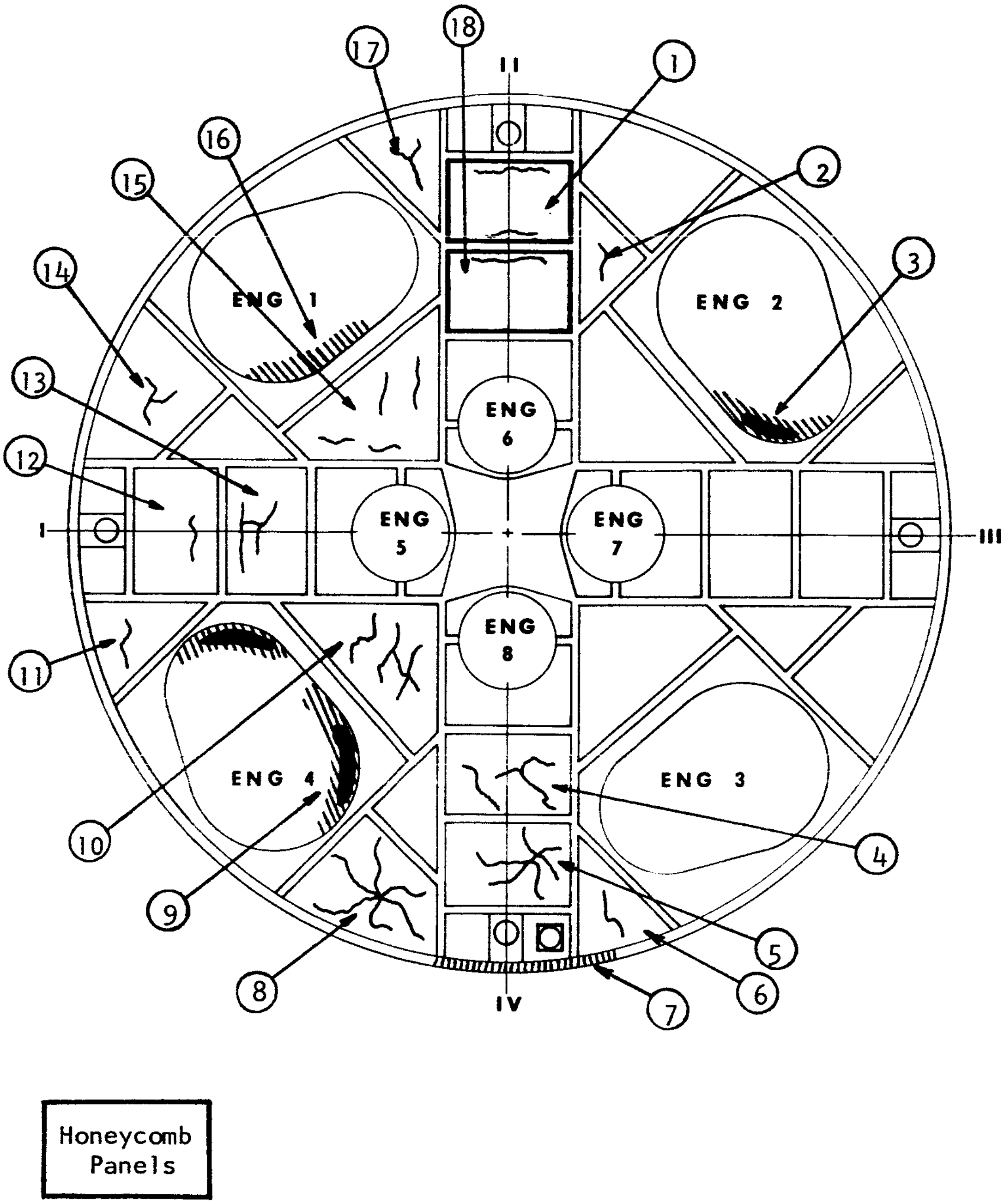


FIGURE 5-1

TEST SA-29
HEAT SHIELD DAMAGE

(AFT LOOKING FORWARD)

FIGURE 5-2
ENGINE 4 FLAME CURTAIN (ENGINE 1 SIDE),
FOLLOWING TEST SA-29

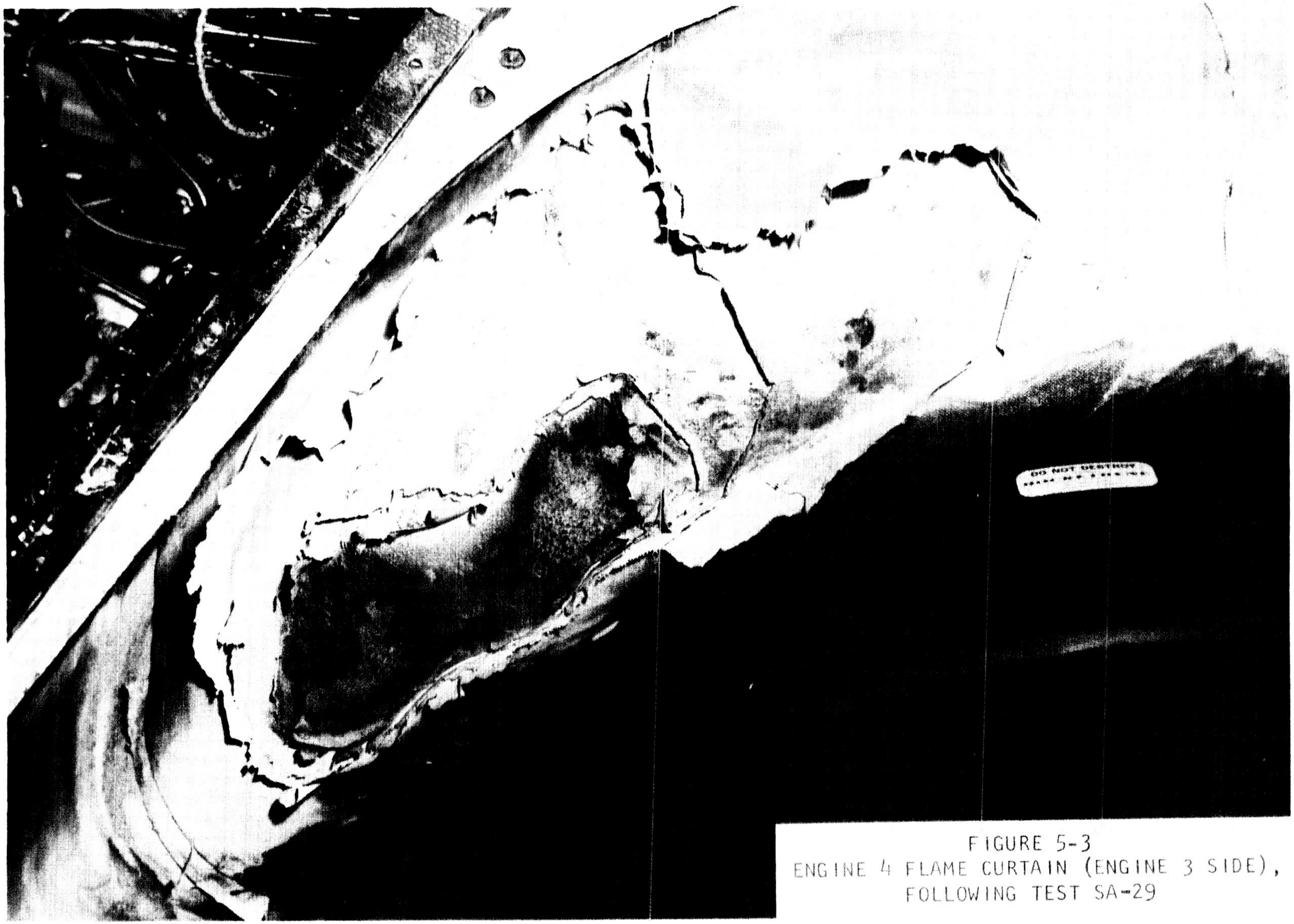


FIGURE 5-3
ENGINE 4 FLAME CURTAIN (ENGINE 3 SIDE),
FOLLOWING TEST SA-29

FIGURE 5-4
ENGINE 2 FLAME CURTAIN
FOLLOWING TEST SA-29

TABLE 5-1

HEAT SHIELD DAMAGE
TEST SA-29

REFERENCE FIG. 5-1	EXTENT OF DAMAGE
1	45 linear inches of cracked M-31.
2	15 linear inches of cracked M-31.
3	Tattered reflective heat shield curtain. Gimbal boot charred. (Approximately 30 square inches.)
4	30 linear inches of cracked M-31.
5	90 linear inches of cracked M-31.
6	20 linear inches of cracked M-31.
7	Tattered radiation shield curtain.
8	110 linear inches of cracked M-31.
9	Tattered reflective heat shield curtain. Gimbal boot charred badly in two places. (Approximately 50 square inches.)
10	100 linear inches of cracked M-31.
11	15 linear inches of cracked M-31.
12	15 linear inches of cracked M-31.
13	35 linear inches of cracked M-31.
14	20 linear inches of cracked M-31.
15	75 linear inches of cracked M-31.
16	Tattered reflective heat shield curtain.
17	25 linear inches of cracked M-31.
18	20 linear inches of cracked M-31.

SECTION 6

VIBRATION AND SPECIAL INSTRUMENTATION

VIBRATION INSTRUMENTATION

A total of 121 vibration measurements were recorded during static test SA-28. Useful information was obtained on 116 of these measurements.

A total of 124 vibration measurements were recorded during static test SA-29. Useful information was obtained on 120 of these measurements. A more detailed discussion of the vibration data will be published in the "Vibration and Acoustic Evaluation Report, Stage S-IB-2", by Systems Static Test Branch.

Root mean square (rms) level readings were taken during a slice time of X+20-25 seconds, for test SA-28 and X+30-35 seconds for test SA-29. These levels were obtained using a 0-5 kilocycle (kc) filter and a true rms voltmeter having a 1-second time constant and a flat frequency response to 3 cycles per second. During static test of stage S-IB-2, 36 measurements were made for investigation of "Pogo" effect (see TABLE 6-1). Note that these values have been revised from those listed in the "Preliminary Static Test Reports" for tests SA-27 and SA-28, and test SA-29. The "Pogo" vibration measurement rms levels were obtained using a 0-100 cps filter. Further analysis of "Pogo" vibration data will be performed by the NASA Propulsion and Vehicle Engineering Laboratory.

The post test gearcase vibration checks conducted on all engines did not indicate any abnormal conditions.

No abnormal LOX dome vibrations were recorded on any engine during either test SA-28 or SA-29. RCC measurements indicated a LOX dome vibration level of 3 ± 1 g rms during ignition transition and 9 ± 2 g rms during mainstage of test SA-28 and 3 ± 1 g rms during ignition transition and 8 ± 1 g rms during mainstage of test SA-29.

FIRE DETECTION SYSTEM

The fire detection system for stage S-IB-2 consisted of 12 Test Laboratory harnesses and 4 flight harnesses. The automatic cutoff fire detection system was set for a rise rate of five chart scales per second (3.0 mv) with a cutoff time delay of 1 second for the Test Laboratory harnesses, and a time delay of one-half second for the flight harnesses.

During test SA-28, measurement *DT702-1 (flight transducer XC116-1) was inactive. The system was erratic during the countdown. Post test checks revealed that this measurement was defective. The 15 active indicators functioned as required, and no abnormal temperatures were detected.

Measurement *DT101-4 was inactive during test SA-29 because four thermocouples of the harness were relocated near engine 4 gimbal boot. The gimbal boot was badly burned during test SA-28, and the thermocouples were relocated to ensure that any fire in this area would be detected. Flight harness *DT703 was inoperative after X+90 seconds because of a loose connector at one of the thermocouples.

HEAT AND FLAME SHIELD INSTRUMENTATION

Test SA-28 data from the heat and flame shield temperature measurements were not obtained due to operational problems encountered in the digital recording system at the blockhouse. Good data were obtained during test SA-29.

One acoustic measurement was recorded on the access chute covers. The sound pressure level at slice time was 177 db during test SA-28 and 173 db during test SA-29.

TABLE 6-1

"POGO" VIBRATIONS ⚠

MEASUREMENT	MEASUREMENT NAME	TEST SA-28 (g rms)	TEST SA-29 (g rms)
AV213-11	Vibration, Station 962, Fin Line 2, Top Spider Beam, Longitudinal	0.27	0.40
AV214-F1	Vibration, Station 350, Skin Fuel Tank F-1, Longitudinal	0.16	0.25
AV214-F2	Vibration, Station 350, Skin Fuel Tank F-2, Longitudinal	0.18	0.24
AV214-F3	Vibration, Station 350, Skin Fuel Tank F-3, Longitudinal	0.18	0.22
AV214-F4	Vibration, Station 350, Skin Fuel Tank F-4, Longitudinal	0.18	0.38
AV215-01	Vibration, Station 210, LOX Tank 0-1 Horizontal Rib, Bottom LOX Tank Skirt, Longitudinal	0.09	0.15
AV215-02	Vibration, Station 210, LOX Tank 0-2 Horizontal Rib, Bottom LOX Tank Skirt, Longitudinal	0.12	0.23
AV215-03	Vibration, Station 210, LOX Tank 0-3 Horizontal Rib, Bottom LOX Tank Skirt, Longitudinal	0.18	0.19
AV215-04	Vibration, Station 210, LOX Tank 0-4 Horizontal Rib, Bottom LOX Tank Skirt, Longitudinal	0.08	0.16
AV216-OC	Vibration, Station 210, Center LOX Tank, Horizontal Rib, Bottom LOX Tank Skirt, Longitudinal	0.04	0.16
AV217-9	Vibration, Lower Thrust Ring, Fin Line 2, Longitudinal	0.12	0.18
AV218-9	Vibration, Outboard Engine Thrust Pad, Engine 2, Longitudinal	0.22	0.30

⚠ NOTE: The values listed in this table have been revised from those listed in the "Preliminary Static Test Reports", for tests SA-28 and SA-29.

TABLE 6-1 (CONTINUED)

MEASUREMENT	MEASUREMENT NAME	TEST SA-28 (g rms)	TEST SA-29 (g rms)
AV219-9	Vibration, Inboard Engine Thrust Pad, Engine 6, Longitudinal	0.95	0.95
AV220-9	Vibration, Near Line Inlets on Sump, LOX Tank O-2, Longitudinal	△1	△2
AV221-9	Vibration, Near Line Inlets on Sump, LOX Tank O-3, Longitudinal	△1	0.10
AV222-9	Vibration, Near Line Inlets on Sump, Fuel Tank F-2, Longitudinal	0.34	△2
AV223-9	Vibration, Near Line Interchange Outlet, Bottom Center LOX Tank, Longitudinal	0.28	0.36
AV224-9	Vibration, Engine 6 Fuel Suction Line, Station 114 Downstream, Longitudinal	0.95	1.30
AV225-9	Vibration, Engine 6 Fuel Suction Line, Station 114 Upstream, Longitudinal	1.45	1.90
AV226-9	Vibration, Engine 6 Fuel Suction Line, Station 145, Longitudinal	△1	0.16
AV227-9	Vibration, Engine 6 Fuel Suction Line, Station 173.7, Longitudinal	0.37	0.90
AV228-9	Vibration, Engine 2 Fuel Suction Line, Station 90, Longitudinal	0.60	0.96
AV229-9	Vibration, Engine 2 Fuel Suction Line, Station 114 Downstream, Longitudinal	1.00	5.00
AV230-9	Vibration, Engine 2 Fuel Suction Line, Station 114 Upstream, Longitudinal	0.63	4.60

△1 Data too low for analysis

△2 No data, system discrepancy at the blockhouse.

TABLE 6-1 (CONTINUED)

MEASUREMENT	MEASUREMENT NAME	TEST SA-28 (g rms)	TEST SA-29 (g rms)
AV231-9	Vibration, Engine 2 Fuel Suction Line, Station 145, Longitudinal	0.76	1.80
AV232-9	Vibration, Engine 2 Fuel Suction Line, Station 173.7, Longitudinal	0.40	1.20
AV233-9	Vibration, Engine 6, LOX Suction Line, Station 90 Downstream, Longitudinal	0.75	4.40
AV234-9	Vibration, Engine 6, LOX Suction Line, Station 90 at Elbow, Longitudinal	0.95	4.60
AV235-9	Vibration, Engine 6, LOX Suction Line, Station 90 Upstream, Longitudinal	0.76	2.32
AV236-9	Vibration, Engine 6, LOX Suction Line, Station 130.1, Longitudinal	0.40	5.00
AV237-9	Vibration, Engine 6, LOX Suction Line, Station 157.2, Longitudinal	0.80	5.40
AV238-9	Vibration, Engine 2, LOX Suction Line, Station 87, Longitudinal	0.80	1.00
AV239-9	Vibration, Engine 2, LOX Suction Line, Station 101 Downstream, Longitudinal	1.25	1.10
AV240-9	Vibration, Engine 2, LOX Suction Line, Station 101 Upstream, Longitudinal	0.70	1.40
AV241-9	Vibration, Engine 2, LOX Suction Line, Station 130.1, Longitudinal	0.42	0.34
AV242-9	Vibration, Engine 2, LOX Suction Line, Station 157.2, Longitudinal	0.60	0.90

SECTION 7

ELECTRICAL CONTROL SYSTEMS

NETWORKS

Ignition command time of day (X-3 seconds) and test durations in seconds, from ignition command to inboard engine cutoff signal (IECOS) and outboard engine cutoff signal (OECOS), for the three static tests of stage S-IB-2, are listed below:

TEST	DATE	IGNITION COMMAND TIME OF DAY	TEST DURATION TO: IECOS	OECOS
SA-27	July 8, 1965	16:41:24.827 CST	3.002	3.123
SA-28	July 9, 1965	16:36:23.820 CST	35.192	35.302
SA-29	July 20, 1965	14:35:59.166 CST	143.285	144.282

Test SA-27 was aborted at time for commit due to Thrust OK pressure (TOP) switch 2 on engine 4 not being picked up. (See SECTION 2, ENGINE SYSTEMS, for further discussion of this deficiency.) All electrical systems functioned properly during this test.

Test SA-28 was terminated as scheduled by the firing panel operator at commit plus 32.192 seconds. Again all electrical systems functioned properly.

Termination of test SA-29 was as planned, with inboard engine cutoff being initiated by the switch selector approximately 0.5 second after closure of the LOX low level sensor in LOX tank 0-2. Outboard engine cutoff was initiated by the switch selector approximately 1 second after inboard engine cutoff.

The LOX and fuel tanking computers were installed and used for the first time at Static Test. The LOX computer was used to top LOX in the propellant loading test as well as tests SA-27, SA-28, and SA-29. The fuel computer was used for monitoring purposes only. Both computers worked satisfactorily.

Vehicle battery simulators were installed on stage S-IB-2 at Static Test. These simulators provide shunts in the vehicle power distribution system for telemetry measurements of the 1D10 and 1D20 bus currents. They also provided mass simulation for vibration measurements of the battery assemblies in instrument compartment 12.

The controls to the engine purge valves were modified requiring the LOX dome purge pressure switch to be picked up before the thrust chamber fuel injector purge solenoid could be opened. This change was made to prevent purged fuel vapors from contaminating the LOX injector prior to ignition. To accomplish this series sequencing in approximately the same total time, the 0.031-inch orifices in the LOX dome and thrust chamber fuel injector purge lines were replaced by 0.063-inch orifices. This assured that the purge pressure switches would be picked up before X-3 seconds (time for ignition command).

Prior to test SA-27, a broken connector was replaced on cable 8W10P3 (engine 8 turbine spinner, squib 2). Cables 1W4 (TOP switch 2 on engine 1) and 6W11 (Conax valve squib 1 on engine 6, and TOP switch 1 on engine 6) were replaced prior to test SA-27 to satisfy Defective Material Notice M07924.

In the simulated flight test prior to test SA-27, cutoff was initiated at time for commit due to a Thrust OK indication not being received from engine 3. This trouble would not repeat during subsequent simulated flight tests and troubleshooting procedures. After extensive checks, it was determined that the normally open contacts of either relay K33-1 or K33-3, or both, had failed to close. The contacts of these relays are in series, making it impossible to determine which relay had malfunctioned. These relays, located in distributor 9A1, were both replaced prior to test SA-27 (reference UCR 01709).

During tests SA-27 and SA-28, only TOP switches 1 and 2 of each engine were in the cutoff circuitry. TOP switch 3 was monitored only. Prior to test SA-28, the circuitry for TOP switches 2 and 3 at engine 4 was switched to remove the malfunctioning TOP switch 2 from the cutoff circuitry. TOP switch 2 at engine 4 was replaced following test SA-28.

To prevent the possibility of a single TOP switch causing the termination of either static test SA-28 or SA-29, a signal was jumpered to the all-engines-running relay from the launch sequencer, such that at X-1 second, the all-engines-running relay would pick up regardless of TOP switch conditions. This ensured that a thrust failure cutoff would not be given until after commit if thrust was low. After commit, cutoff would be given if two TOP switches dropped out.

The jumpered signal at X-1 second was not needed during test SA-28 as an all-engines-running signal was received at X-1.59 seconds as the result of the normal pickup of both TOP switches at all engine positions.

For test SA-29, all three TOP switches were in the cutoff circuitry. Signals from the three TOP switches for each engine were interrupted at the input to the 9A1 distributor and connected to a 14-plug facility patch rack designated the thrust distributor. Signals from the three TOP switches were then voted in the thrust distributor in much the same manner as will be done in the flight configuration of this stage. These signals were then sent to the 9A1 distributor.

Circuitry within the thrust distributor required that all three TOP switches from an individual engine be picked up before a Thrust OK signal for that engine could be generated within the 9A1 distributor. All TOP switches had to remain picked up through commit for the all-engines-running signal to be received at commit. Following commit, control of the Thrust OK cutoff circuitry transferred to stage circuitry where 2 out of 3 TOP switches must drop out before a thrust failure cutoff would be given.

During the ignition sequence for test SA-29, a signal from the engine 1 thrust distributor was not received at the 9A1 distributor. This trouble was later traced to a faulty connection in a facility cable. Although the Thrust OK signal for engine 1 was not received, thrust failure cutoff was not experienced at time for commit due to the modification to the all-engines-running circuit. Following commit, control was transferred to the stage wiring where the faulty facility connection did not affect system performance. With this exception, the three pressure switches for each engine and the associated circuitry functioned properly.

During test SA-29, the fuel tanks were initially pressurized by the stage pressurizing system. Fuel pressurizing valves 1 and 2 were disabled at X+71.50 seconds by the launch sequencer and fuel tank pressure was maintained by the facility fuel tank pressurizing system. This system was energized by X+69.28 seconds when tank pressure dropped below 6.45 psig.

The operating times for major functions from firing command to reset for test SA-29 are shown in FIGURES 7-1 through 7-3. Fuel bubbling time was not recorded due to a faulty connection in the recorder distributor.

GIMBAL CONTROLS

Since cutoff occurred prior to lift-off during test SA-27, no gimbal data were received from that test. The gimbal program for test SA-28 is given in TABLE 3-1. Operation of the gimbal control system was normal except for erratic hydraulic pressure traces on engines 2, 3, and 4.

The gimbal program for test SA-29 is presented in TABLE 3-2. During this test, the gimbal system performed normally with two minor exceptions. The yaw input signal trace on engine 3 oscillograph decreased steadily from 0.500 degree at 8 cps to 0.425 degree at 20 cps. This problem was investigated in post test checkout and found to have been caused by a faulty galvanometer. The galvanometer was replaced and the problem did not recur. Engines 2 and 4 also showed erratic supply pressure traces during test SA-29. This problem is discussed in more detail in the HYDRAULIC SYSTEMS section of this report. All other electrical signals appeared satisfactory.

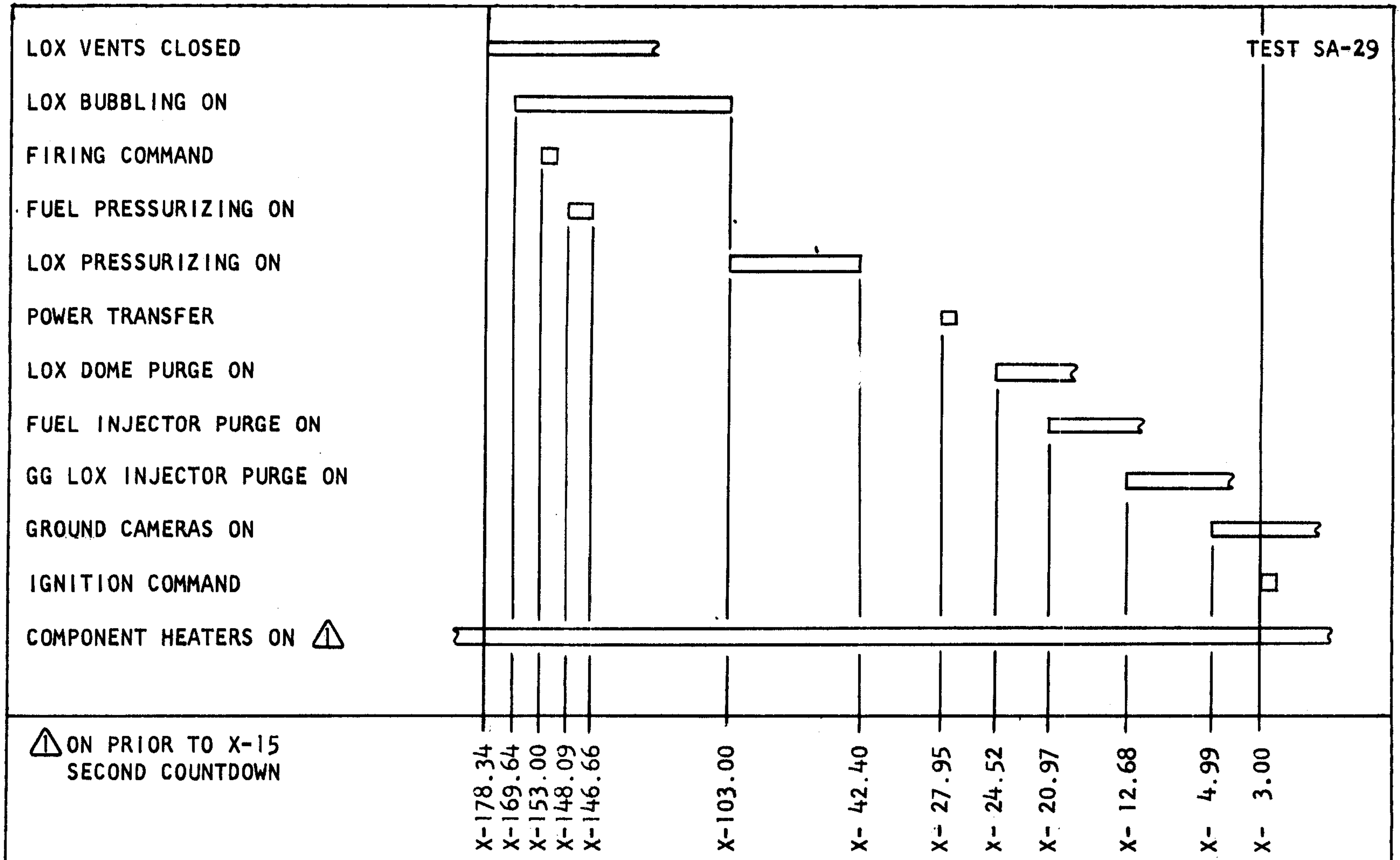


FIGURE 7-1

FIRING COMMAND TO IGNITION COMMAND

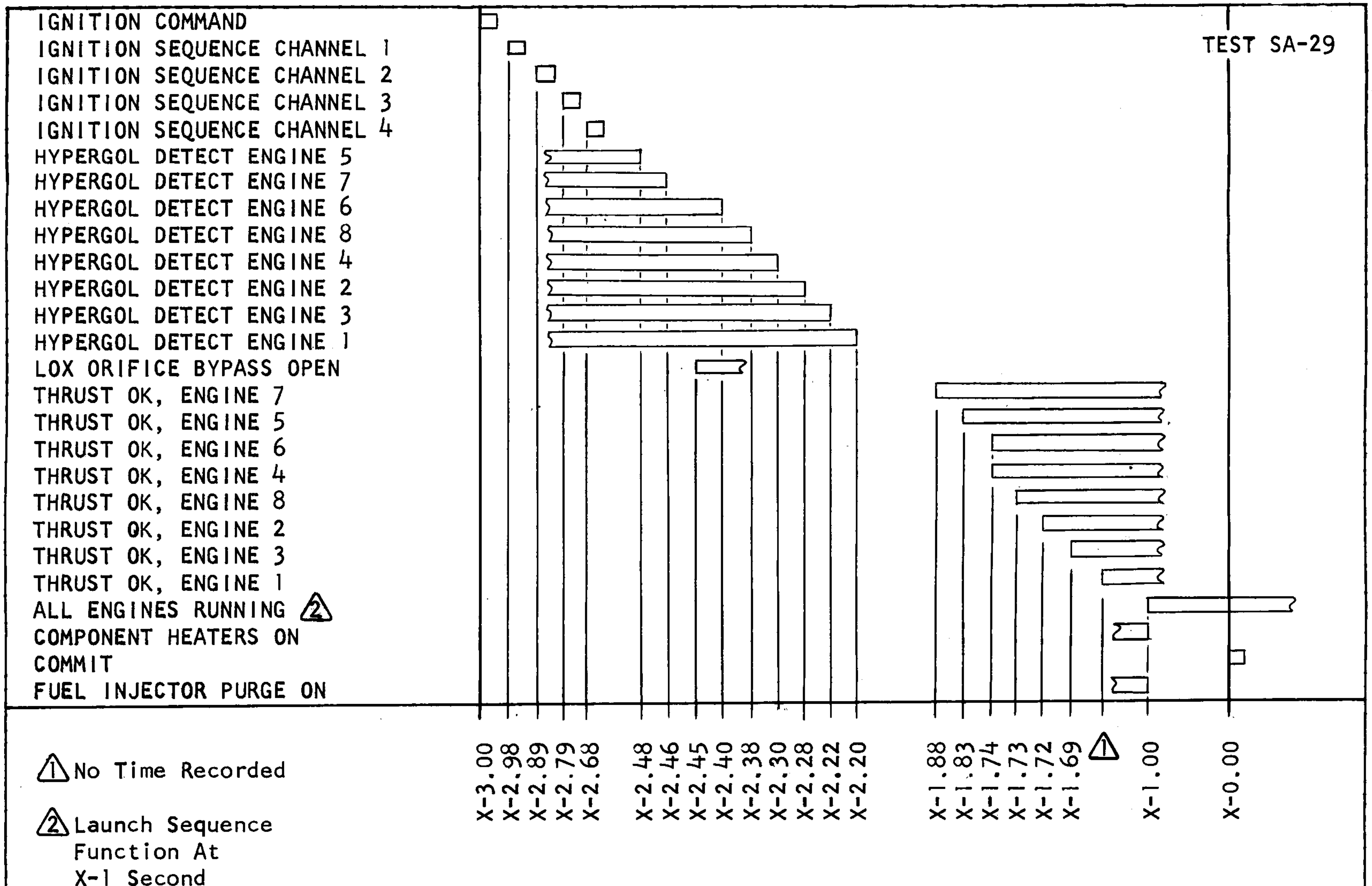


FIGURE 7-2

IGNITION COMMAND TO COMMIT

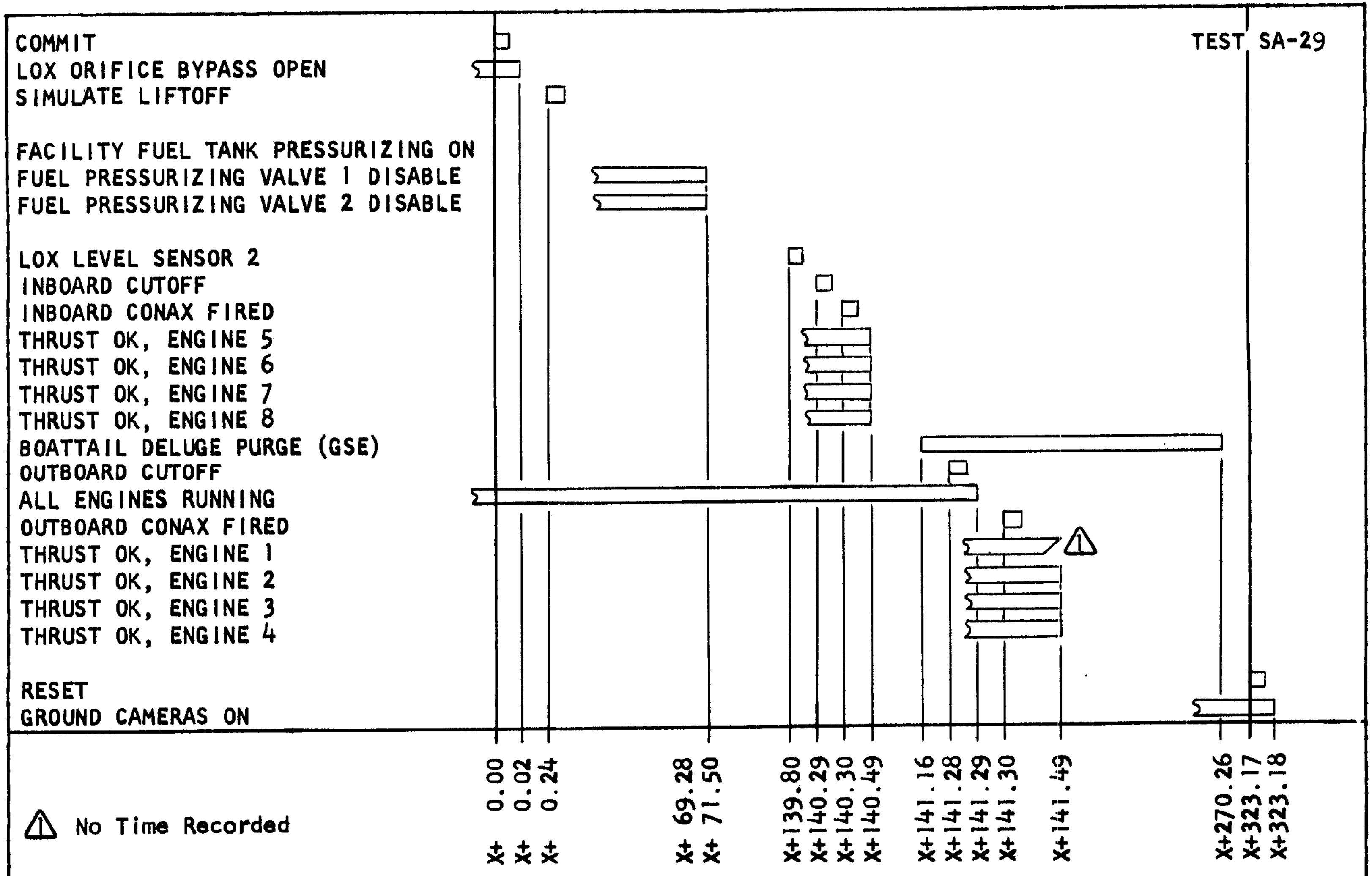


FIGURE 7-3

COMMIT TO RESET

SECTION 8

TELEMETRY SYSTEMS

Flight instrumentation requirements for stage S-IB-2 are specified in drawing 60C50006, Instrumentation Program and Components List. A Measurements Data Flow Chart is shown in FIGURE 8-1. The primary purpose of operating the telemetry (T/M) system during static test is to verify the proper operation of the flight T/M components in a simulated flight environment prior to launch. During the static test, signals from the various flight transducers and simulated signals are transmitted by an RF link from the static test tower antennas to the Chrysler telemeter ground station.

For tests SA-27 and SA-28, 61 flight transducers were disconnected and hardwired to recorders in the blockhouse. These measurements are required for acceptance test data evaluation and redline monitoring. An additional 145 transducers, which were hardwired or not installed, were simulated by utilizing a constant signal for checkout of the telemeter system. The remainder of the stage measurements (323) were in flight condition for tests SA-27 and SA-28.

For test SA-29, 62 flight transducers were disconnected and hardwired to recorders in the blockhouse. These measurements are required for acceptance test data evaluation and redline monitoring. An additional 149 transducers, which were hardwired or not installed, were simulated by utilizing a constant signal for checkout of the telemeter system. The remainder of the stage measurements (318) were in flight condition for test SA-29.

Results from all tests indicate that the overall function of the T/M systems was satisfactory. The percentage of T/M system instrumentation discrepancies is shown in TABLE 8-1. A significant number of parameters were measured independently by T/M and hardwire. Comparisons of T/M and hardwire measurement values at a slice time of X+29 to 32 seconds are shown in TABLES 8-2, 8-3, and 8-4.

PRESTATIC TEST TELEMETRY OPERATIONS

1. Calibration of the Telemetry-Airborne DDAS. The verification of the accuracy of the Telemetry-Airborne DDAS was performed through the use of the RCA 110 computer located in the blockhouse. Satisfactory results were obtained.

2. Initial Status of Measurement. Upon initial application of power to stage S-IB-2 following erection in the Static Test Tower, an automated scan of flight measurements was performed through the DDAS to determine the initial status of flight instrumentation. Since all measurements do not appear on the DDAS link, a measurement scan was also performed on single side band type measurements and the FM/FM type measurements over their broadcast loops. The initial status of the flight instrumentation was compiled and is shown in TABLE 8-5. This table lists all measurements that required some type of work (calibration, troubleshooting, initial installation, etc.) necessary for static firing. It can be seen that about 72 percent of all measurements required work at Static Test. The majority of measurements that were rejected were strain gage measurements that were calibrated when the stage was in the horizontal position. These required recalibration when the stage was erected in STTE.

3. Flight Measurement Status Prior to Test SA-28. All flight measurements were accepted for static firing with the exception of those measurements shown in TABLE 8-6.

4. T/M Packages RF Power Measurements. Prior to test SA-27 and following test SA-29, the following telemetry system parameters were checked:

a. RF Frequency
b. RF Power
c. Subcarrier Oscillator Frequency
d. Subcarrier Oscillator Preemphasis

All values were within tolerance or were adjusted to be within tolerance.

During prestatic tests, the bias of the F2 telemetry package 70 KC subcarrier oscillator was found to be drifting. A replacement for this oscillator was not available prior to test SA-28. Following test SA-29, this oscillator investigation revealed the 5 volts dc telemetry reference voltage for measurement D89 had shifted from 5.00 volts to 4.90 volts. The D89 voltage was adjusted and all SCO's of the telemetry packages were recalibrated.

5. P1 Multiplexer. Four channels, P1B0-07-01, P1B0-06-06, P1B0-08-10, and P1B1-09-10, to the P1 multiplexer had no assigned measurements. These channels are wired to open-circuited terminals in a measurement distributor. A 100K input resistor on the submultiplexer card was removed for each of the four inputs. The open-circuited input to the submultiplexer generates approximately 2 volts of noise.

It is recommended that a 100K resistor be installed in an associated measuring distributor for all vacant channels which have the 100K resistor removed. This will eliminate the open circuit condition and its inherent excessive noise.

6. Outrigger Strain Measurements. Outrigger strains are being measured for the first time on stage S-IB-2. These measurements are currently undergoing redesign. Those measurements that could be properly calibrated at Static Test were calibrated and showed usable data.

7. PCM/RF Assembly. Prior to test SA-25, of stage S-IB-1, two PCM/RF assemblies, P/N 50M12187-1, malfunctioned. One PCM/RF assembly, S/N 002, was found to generate no RF power during initial tests. The second PCM/RF assembly, S/N 001, was found to lose RF modulation after being installed for approximately 1 hour. Prior to test SA-27 on stage S-IB-2, two of these PCM/RF assemblies malfunctioned. Each of these RF assemblies on stage S-IB-2 (serial numbers 002 and 003) failed to modulate the RF signal properly (reference UCR's 01112, 01115, 01703, and 01717 on stages S-IB-1 and S-IB-2). Only two PCM/RF assemblies out of a total of six were reliable at static test. Because of the very short periods of usefulness of these packages, an investigation should be conducted to determine methods of improvement of the reliability of these assemblies.

8. Liquid Level Discrete. While stage S-IB-2 was at the static test facility six liquid level discrete probes became defective. Since there are 135 probes on stage S-IB-2, this represents a failure rate of about 4 percent. The probes are inside the propellant tanks and are highly inaccessible. Because of the large number of probes involved and because of their inaccessibility, 4 percent is considered a high failure rate. It is recommended that an investigation be conducted to find a more rugged type transducer to be installed on all future Chrysler built Saturn S-IB stages.

9. Command Destruct Receivers. During static test SA-29, the command destruct receivers (CDR's) did not respond to interrogation from a transmitter located in the Chrysler Ground Station (on previous stages the transmitter has been located on the roof of building 4708 within a few feet of the transmitting antenna). As a result of the failure of this system, measurements K65-13, K66-13, K63-11, K64-11, VK134-11, and VK135-11 did not operate.

The transmitter is crystal controlled and operates at a frequency of 449.963 mc although the desirable frequency would be that of the command destruct receivers (450.000 mc).

Tests conducted after test SA-29 revealed that both receivers would respond if the deviation was increased from 30 kc to 33.2 kc for receiver 2 (S/N 362), and 50 kc for receiver 1 (S/N 361). Since specifications require that the receivers respond to 50 kc deviation or less, it was decided to remove receiver 1 for bench tests. Bench tests at exactly 450 mc showed that 25 kc deviation would interrogate the receiver. Although this is somewhat less sensitive than previous stage CDR's, it is well within specifications.

It may be concluded that a combination of insufficient signal strength, insufficient deviation, and improper center frequency of the transmitter was responsible for the failure of the CDR to respond during test SA-29.

10. Level Sensors Settings and Indications. During the long duration static firing, test SA-29, the low level cutoff sensors in tanks 0-2, 0-4, F-2, and F-4 operated satisfactorily. The propellant heights as indicated by the continuous level probes, when the low level sensor actuated in each tank are as follows:

Tank	Continuous Level Probe Height
0-2	13.4 inches
0-4	12.7 inches
F-2	21.1 inches
F-4	21.7 inches

The actual location of the LOX level cutoff sensors is 14.06 inches above the zero position of the continuous level probe, and fuel level sensors are 20.96 inches above the zero position in the fuel tanks.

Since the height of the cutoff sensors is nominal, it is concluded that all sensors operated properly.

11. Combustion Chamber Pressure Measurements D1-1 through D1-8. Combustion chamber pressure measurements were calibrated by means of the Digital Data Acquisition System (DDAS). These measurements were also transmitted over a hardwire loop to the blockhouse. A comparison of the T/M and hardwire combustion chamber pressure measurements is shown in TABLE 8-4. Telemetered data from these measurements were satisfactory.

12. Inflight Tape Recorder. The flight tape recorder records information from the F1 and F2 telemeter packages commencing with step 4 of the switch selector (simulated lift-off plus 39.2 seconds) until 26 seconds after the Separation Explosive Bridge Wire (EBW) Command. At that time, a signal from the 26-second timer starts the tape recorder playback function. The tape recorder plays back until step 12 of the switch selector.

During test SA-29, the tape recorder recorded 128.4 seconds of information. The playback function started 26.0 seconds after the Separation EBW Command, which occurred 1.88 seconds after the LOX low level sensor (K15-02) was energized. The inflight tape recorder operated satisfactorily and good data were obtained.

13. Measurements That Exceeded Their Operating Range. TABLE 8-7 shows measurements that exceeded their operating range during static test SA-29. Except for the excessive operating range, the measurements appeared satisfactory and are not considered discrepant. Measurement E33-7 is discussed in Static Test Telemetry Operations, paragraph 2.

STATIC TEST TELEMETRY OPERATIONS

1. Turbine RPM Measurements T12-1 Through T12-8. Upon arrival of stage S-IB-2 at the static test facility, the bias of the frequency dividers for the rpm measurements was found to be improperly adjusted to +2.5 volts and improper operation was noted. The bias was readjusted to 0.5 volts and satisfactory operation was obtained. During the test firing, very good data were received from all frequency dividers. Comparison of T/M and hardwire rpm values is shown in TABLE 8-3.

2. Vibration, Thrust Chamber Dome. On previous Saturn stages, the E33 measurements (thrust chamber dome vibrations) indicated maximum readings (more than 35 g rms) during static firing. Vibration measurements at the same location, which have been hardwired to the blockhouse during previous firing, indicated less severe vibrations.

The transducer used in the normal hardwire measurement at engine 1, PV107-1, is a Cubic transducer, connected to the blockhouse in the normal manner. This transducer indicated a vibration of 10 g rms during the test SA-28. The flight measurement (E33-1) transducer was hardwired to the blockhouse in the same manner as PV107-1. This was a Glennite transducer. The oscillograph test record indicated a vibration of 90 g rms for measurement E33-1. Flight measurement E33-5 transducer and its associated Universal Measuring Amplifier (UMA) was also hardwired to the blockhouse to determine the effect of the UMA on the vibration data. The oscillograph test record of measurement E33-5 indicated a vibration of 35 g rms. The UMA caused some filtering of frequencies above 3 kilocycles (KC), the frequency limit of the single side band telemetry system. Measurement E33-7 was broadcast over the single side band telemetry loop in its normal manner. The oscillograph test record indicated a vibration of 35 g rms. To measure the efficiency of the single side band telemetry system, a 1 KC and a 2 KC signal were fed into two channels. Satisfactory response of the telemetry system to this input was noted. Some noise is seen on the peaks of both of these signals. This may be due to noise on the +28 volt vehicle power. The single side band telemetry is highly sensitive to noise on the +28 volt line (reference, "Preliminary Static Test Report" for test SA-26). This noise was less during test SA-28 than during previous tests. However, the noise that is present is clearly seen on the 1 KC and 2 KC signals.

This investigation was continued for test SA-29. Two Glennite flight transducers (E33-1 and E33-5) and a CEC vibration transducer were connected directly to a portable tape recorder located in the static test tower. A frequency spectrum analysis of the Glennite (E33-1) and CEC transducers was performed. It was noted that both transducers show g forces from 2 to 4 g rms from 500 cps to 6,000 cps. Each of the two show a peak value at about 7,000 cps; however, the Glennite transducer indicates 16 g rms, while the CEC indicates only about 6 g rms. Both transducers indicate a decrease in amplitude above 7,000 cps, with the CEC showing a gradual increase at frequencies above 20,000 cps. A frequency analysis was also performed on a Cubic transducer that was hardwired to the blockhouse. A comparison of the results of the CEC and the Cubic transducers show that similar data up to 10,000 cps are generated in each case. A 10,000 cps filter limits data above 10,000 cps for the Cubic transducer.

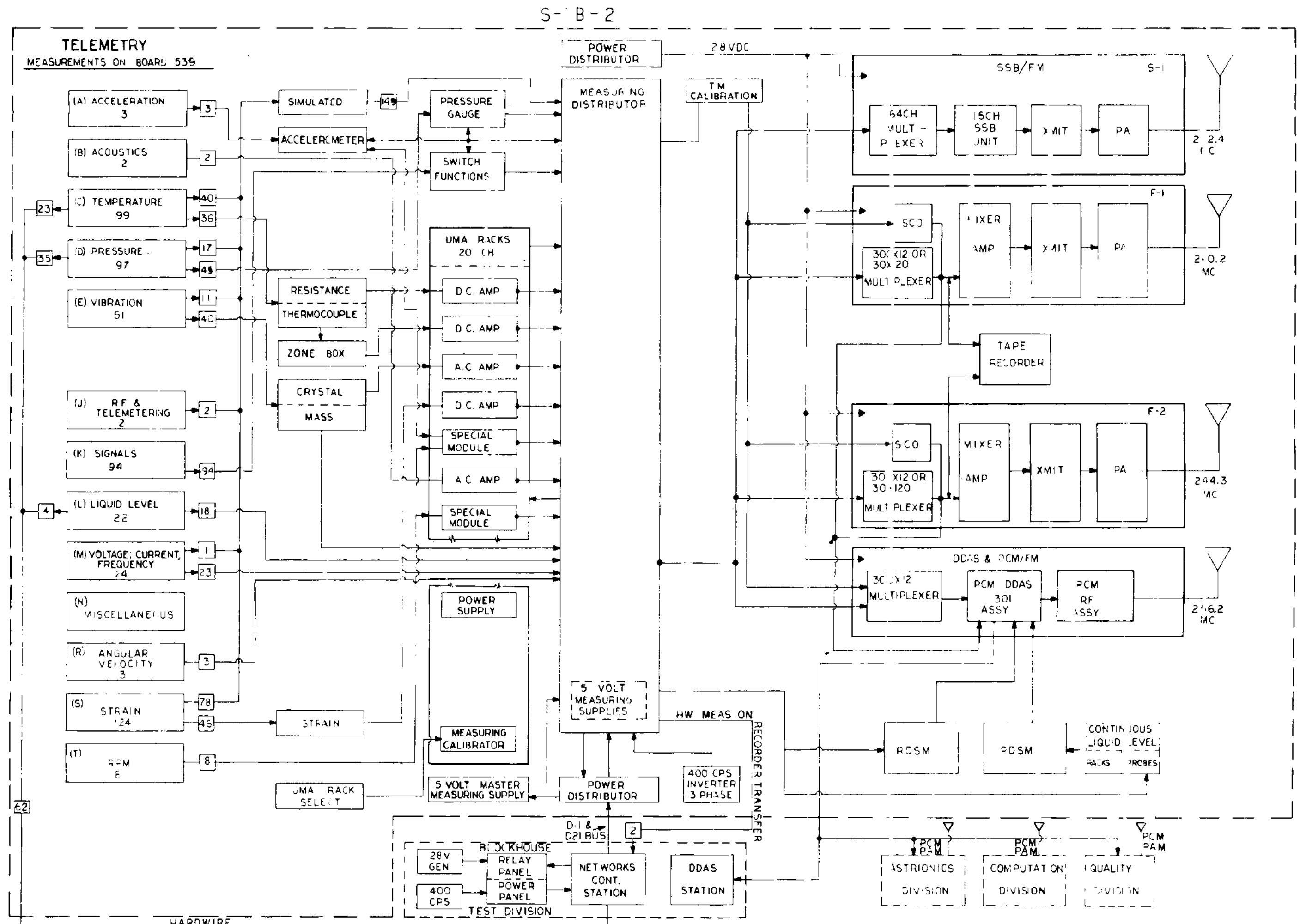
The frequency analyses indicate a possible resonance of the Glennite transducer about 7,000 cps. Therefore, the Glennite and the CEC transducers were vibration tested on a shake table. The CEC transducer responded in a linear fashion from 0 to 10,000 cps. The Glennite transducer output voltage increased in amplitude from 4,000 cps to 7,000 cps, with a resonant peak at approximately 7,000 cps.

High vibration energy is present at about 7,000 cps on the engine chamber domes and the Glennite flight transducer has a natural resonant frequency at about 7,000 cps. These two factors cause the Glennite transducer to indicate a very high amplitude around 7,000 cps. This very high amplitude causes the telemetry system to indicate noise instead of data.

As a part of the thrust chamber dome vibration investigation, four vibration channels (measurements E33-1, E33-3, E33-5, and E33-7) were broadcast over the single side band telemetry loop. The comparison appears to substantiate the findings of the spectrum analyses previously described.

It is recommended that use of the Glennite type transducer be discontinued for thrust chamber dome vibration measurements. A proposed replacement is manufactured by CEC, Part Number 4-280-0105.

Prior to test SA-29, a filter was installed in the +28 volt power to the single side band telemetry package. To test the effect of this filter an oscillator input was connected to two channels (measurements E33-1 and E33-5). The 1 kc and 200 cps signals showed very little of the noise that has been noted on similar oscillograph traces when no filter was installed. This substantiates the fact that the single side band telemetry package is sensitive to noise on the +28 volts supply.



MEASUREMENT DATA FLOW CHART

FIGURE 8-1

TABLE 8-1

TELEMETRY SYSTEM INSTRUMENTATION
DISCREPANCIES

TYPE OF MEASUREMENT	TEST SA-28	TEST SA-29
Active Flight Measurements	323	318
Discrepant Measurements	8	13
Percent Failure	2.5%	4.0%
Simulated Measurements	206	211
Discrepant Measurements	1	4
Percent Failure	0.5%	1.9%
Total Measurements	529	529
Total Discrepant Measurements	9	17
Total Percent Failure	1.7%	3.2%

TABLE 8-2

COMPARISON OF TELEMETERED AND LANDLINED TRANSDUCERS

$$\text{PERCENT DIFFERENCE} = \frac{\text{HW-TM}}{\text{HW}} \times 100$$

TEST SA-29

HARDWIRE NUMBER	MEASURED VALUE	FLIGHT NUMBER	MEASURED VALUE (°F)	PERCENT DIFFERENCE
CP102-9	2479 psia	D40-9	2480 psia	-0.04
CP100-9	767 psia	D41-9	749 psia	+2.35
FP101-F3	26.5 psia	D2-F3	25.7 psia	+3.02
FP103-11	1864 psia	D139-11	1840 psia	+1.29
LP102-0C	52.9 psia	D3-0C	50.9 psia	+3.78
*PP100-1	724 psia	D34-1	740 psia	-2.21
*PP100-2	720 psia	D34-2	732 psia	-1.67
*PP100-3	714 psia	D34-3	728 psia	-1.96
*PP100-4	741 psia	D34-4	735 psia	+0.81
*PP100-5	786 psia	D34-5	730 psia	+7.12
*PP100-6	731 psia	D34-6	728 psia	+0.41
*PP100-7	722 psia	D34-7	716 psia	+0.83
*PP100-8	717 psia	D34-8	730 psia	-1.81
*PP113-1	41.9 psia	D12-1	41.7 psia	+0.48
*PP113-2	43.5 psia	D12-2	43.0 psia	+1.15
*PP113-3	43.3 psia	D12-3	42.4 psia	+2.08
*PP113-4	43.5 psia	D12-4	39.5 psia	+9.20
*PP114-1	66.2 psia	D13-1	66.0 psia	+0.30
*PP114-2	67.1 psia	D13-2	66.5 psia	+0.89
*PP114-3	68.0 psia	D13-3	65.6 psia	+3.53
*PP114-4	67.0 psia	D13-4	65.3 psia	+2.54
*PT102-1	1270°F	C9-1	1344°F	-5.83
*PT102-2	1233°F	C9-2	1323°F	-7.30
*PT102-3	1224°F	C9-3	1253°F	-2.37
*PT102-4	1215°F	C9-4	1234°F	-1.56
*PT102-5	1287°F	C9-5	1250°F	+2.87
*PT102-6	1260°F	C9-6	1255°F	+0.40
*PT102-7	1252°F	C9-7	1269°F	-1.36
*PT102-8	1250°F	C9-8	1264°F	-1.12
*PT107-1	-292.3°F	C54-1	-292.2°F	+0.03
*PT107-2	-292.0°F	C54-2	-292.7°F	-0.21
*PT107-3	-292.5°F	C54-3	-292.6°F	-0.03
*PT107-4	-292.5°F	C54-4	-292.6°F	-0.03
*PT107-5	-292.5°F	C54-5	-292.9°F	-0.14
*PT107-6	-292.8°F	C54-6	-293.0°F	-0.07
*PT107-7	-292.3°F	C54-7	-292.4°F	-0.03
*PT107-8	-293.8°F	C54-8	-292.7°F	+0.03

TABLE 8-3

COMPARISON OF T/M AND HARDWIRE TURBINE RPM VALUES

TEST SA-29

HARDWIRE NUMBER	MEASURED VALUE	FLIGHT NUMBER	MEASURED VALUE	RPM DIFFERENCE
*PR100-1	Data Lost	T12-1	33,709	-
*PR100-2	33,281	T12-2	33,350	69
*PR100-3	33,375	T12-3	33,367	8
*PR100-4	32,944	T12-4	32,944	0
*PR100-5	33,047	T12-5	33,025	22
*PR100-6	33,481	T12-6	33,469	12
*PR100-7	33,074	T12-7	33,054	20
*PR100-8	33,124	T12-8	33,115	9

TABLE 8-4

COMPARISON OF TELEMETERED AND HARDWIRED CHAMBER PRESSURE MEASUREMENTS

TEST SA-29

HARDWIRE NUMBER	MEASURED VALUE ⚠1	FLIGHT NUMBER	MEASURED VALUE ⚠1	PERCENT DIFFERENCE
*PP108-1		D1-1		-0.453
*PP108-2		D1-2		-1.320
*PP108-3		D1-3		-0.537
*PP108-4		D1-4		-0.644
*PP108-5		D1-5		-0.468
*PP108-6		D1-6		-0.401
*PP108-7		D1-7		-0.466
*PP108-8		D1-8		-0.052

⚠1 The Actual Values of Combustion Chamber Pressures Can Be Obtained From The "Confidential Supplement, Stage S-IB-2".

TABLE 8-5

INITIAL S-IB-2 MEASUREMENT STATUS AT STTE

TOTAL NUMBER OF MEASUREMENTS	529
MEASUREMENTS THAT REQUIRED WORK:	
a. Installation of Simulators	211
b. Strain Measurements that Required Calibration	124
c. Active Flight Measurements that Required Calibration	53
TOTAL MEASUREMENTS THAT REQUIRED WORK	388
PERCENTAGE OF MEASUREMENTS THAT REQUIRED WORK	73%

TABLE 8-6

MEASUREMENT STATUS PRIOR TO TEST SA-28

MEASUREMENTS	REMARKS
C546-16	No Simulator Available (OK for Test SA-29)
C548-16	No Simulated Available (OK for Test SA-29)
S556-22	Defective Resistor Inside Dummy Plug (OK for Test SA-29)
S627-9	No Gage
S671-9	Defective Amplifier (OK for Test SA-29)
S613-9	No Gage

MEASUREMENT STATUS PRIOR TO TEST SA-29

MEASUREMENTS	REMARKS
L20-F2	Marginal Output. Will Require Repair During Post Static Operations.

TABLE 8-7

MEASUREMENTS THAT EXCEEDED THEIR RANGE

MEASUREMENT NUMBER AND DESCRIPTION		RANGE	TEST SA-28	TEST SA-29
C555-11	Temperature Manhole Cover Tank O-C	$+45^{\circ}C$ -20	$-80^{\circ}C$	$-80^{\circ}C$
E33-7	Vibration Thrust Chamber Dome, Long.	±50 g	±55 g	±55 g
E226-11	Vibration Upper Structure, Long.	±5 g	±6 g	±6 g
E227-11	Vibration Upper Structure, Pitch	±5 g	±6.5 g	±6 g
E505-11	Vibration Spider Beam, Perpendicular	±10 g	±12 g	±12 g
A54-11	Acceleration, Yaw	±0.5 g	Within Range	-0.7 +0.8 g
C37-0C	Temperature Gas TOP LOX Tank	$+200^{\circ}C$ -150	Within Range	$-164^{\circ}C$
E168-10	Vibration Center Tank Yaw	±0.5 g	Within Range	+0.75 g

SECTION 9

CONCLUSIONS

Based on the analysis of the results of tests SA-27, SA-28, and SA-29 and the post test hardware inspection, the following conclusions are presented.

The abortion of test SA-27 at time for commit was a result of delayed pickup of Thrust OK pressure (TOP) switch 2 of engine 4. Test records indicated engine performance was satisfactory.

All stage systems performed satisfactorily during test SA-28 and SA-29.

Special leak checks performed on the LOX dome purge check valves showed no evidence of leakage or body cracking.

The hydraulic oil supply pressure fluctuations noted on oscillograph test records on this stage and previous stages are not a result of fluctuations in the hydraulic oil pressure but are attributed to signal conditioning in the Blockhouse.

The ripples that were observed in the skin of fuel tank F-3 on stage S-IB-2 and previous stages appear to be formed by localized thermal stresses in the tanks during static firings.

The modified gimbal boots utilizing the aluminized fabric bonded to the boots are unsatisfactory for use at Static Test.

The high g-levels noted by the thrust chamber dome vibration measurements E33 are attributed to resonance within the Glennite transducers and not to high vibration levels.

SECTION 10

RECOMMENDATIONS

Based on the analysis of stage S-IB-2 test data and post test hardware inspections, the following recommendations are presented:

ENGINE SYSTEMS

No engine reorificing is required.

The erosion of the aspirator lips on engines 3 and 4, caused by hot gases which were diverted by the thrust chamber drain screw access port covers, requires Material Review Board action to determine whether repairs are required. However, it is recommended that no repairs be made since erosion of the aspirator lip does not effect engine performance for launch. It is further recommended that the drain screw access port covers be deleted for launch.

It is recommended that the leak at engine 1 thrust chamber jacket be repaired at Michoud so that the fuel prefill can be retained during launch countdown.

It is recommended that Rocketdyne provide lockwire holes in the B-nuts on the Thrust OK pressure switch supply manifold connections. (One of the B-nuts loosened during static firing and caused a minor fuel leak.)

The gimbal boots which utilize the aluminized fabric bonded to the boot are unsatisfactory for static test. It is recommended that the 10C11462 flight type boots be installed on future stages.

FUEL CONTAINERS

It is recommended that fuel tanks F-3 and F-4 both be painted white for static firings to reduce localized thermal stresses in these tanks during exposure to exhaust plume radiation.

CONTROL PRESSURE SYSTEM

Post test inspection of the control sphere inner liner revealed that bubbles were present in the liner. Further analysis of the sphere should be conducted at Michoud.

TELEMETRY SYSTEM

Fuel level discrete probe 1, measurement L20-F2, is considered to have marginal output and should be repaired upon receipt of the stage at Michoud.

A 100K input resistor on the submultiplexer card, P/N M2807A, was removed for vacant channels. It is recommended that a 100K resistor be installed in an associated measuring distributor to eliminate the open circuit condition and its inherent excessive noise.

It is recommended that the Glennite flight transducers be discontinued for use on thrust chamber dome vibration measurements. These transducers have a natural resonant frequency at about the same frequency as the predominant chamber dome vibration energy. The resulting high vibration amplitudes cause the telemetry system to indicate noise instead of data. A proposed replacement for the Glennite transducer is Consolidated Electrodynamics Corporation transducer, part number 4-280-0105.

It is recommended that an investigation be conducted to find a more rugged type transducer for liquid level discrete probe measurements. Six of these transducers were defective at Static Test.

An investigation should be conducted to determine methods of improvement of the quality of the PCM/RF assemblies, P/N 50M12187-1, because of the short periods of usefulness of these packages.

APPENDIX A

REFERENCES

REFERENCES

Preliminary Static Test Report, Stage S-IB-1, Test SA-26, May 4, 1965.

Preliminary Static Test Report, Stage S-IB-2, Tests SA-27 and SA-28, July 29, 1965.

Preliminary Static Test Report, Stage S-IB-2, Test SA-29, August 9, 1965.

Vibration and Acoustic Evaluation Report, Stage S-IB-2.

Confidential Supplement, Tests SA-28 and SA-29, Stage S-IB-2, July 30, 1965

APPENDIX B

REDLINE AND BLUELINE VALUES FOR STAGE S-IB-2

APPENDIX B

REDLINE AND BLUELINE VALUES FOR STAGE S-IB-2

Values for parameters which were monitored to assure vehicle safety are outlined below. Prerun checks were made to verify satisfactory engine compartment conditions prior to clearing the stand. Parameters monitored after the start of the automatic countdown as well as mainstage values are listed.

REDLINE LIMITS

The following measurements will be monitored to assure vehicle safety during static test operations. If any redline tolerance is exceeded, cutoff will be initiated by the panel observer. The person initiating cutoff shall then inform the Test Conductor of the reason for initiating cutoff.

1. Prerun Verifications (Redline). The following measurements will be monitored from LOX loading to ignition to ensure that a satisfactory engine compartment environment is maintained through ignition:

Measurement Number	Description	Maximum	Minimum
*PT700	Temperature, Turbopump Bearing No. 1		0° F
*PT701	Temperature, Oronite	156° F	105° F
*PT101	Temperature, Turbine Spinner Surface	75° F	40° F
*PP101	Pressure, GG LOX Injector Manifold	185 psig	165 psig

2. Preignition Verifications (Redline).

Measurement Number	Description	Maximum	Minimum
*PT107	Temperature LOX Pump Inlet (Immediately Prior to Ignition)	-275° F	-300° F
*PP114	Pressure, LOX Pump Inlet		65 psig
*LP102-OC	Pressure, LOX Tank Ullage	50 psig	36 psig
*PT100-8	Temperature, Fuel Pump Inlet	110° F	0° F
*PP113	Pressure, Fuel Pump Inlet		25 psig
*FP101-F3	Pressure, Fuel Tank Ullage	20 psig	14 psig
*PP103	Pressure, Combustion Chamber	720 psig	
	After mainstage equilibrium has been established, any change in either P_c or GG Conisphere Temperature must be accompanied by a similar change in the other parameter before cutoff is to be initiated.		
*PT102	Temperature, GG Conisphere	1,400° F	
	After mainstage equilibrium has been established, any change in either P_c or GG Conisphere Temperature must be accompanied by a similar change in the other parameter before cutoff is to be initiated.		
*PP112	Pressure, Gearcase	10 psig	
	Cutoff is to be initiated only if the corresponding pressure switch indication is obtained.		

Measurement Number	Description	Maximum	Minimum
*LP102-0C	Pressure, LOX Tank Ullage	56 psig	5 psig
*FP101-F3	Pressure, Fuel Tank Ullage	25 psig	2 psig
*PP115	Pressure, Turbopump Bearing No. 1 Lube Jet (within 10 seconds after Ignition Command)		75 psig
*CP102-9	Pressure, Control Sphere		1,000 psig
*PP114	Pressure, LOX Pump Inlet If the recorder pegs down-scale at maximum rate, cutoff shall not be initiated unless the corresponding prevalve closed indication is obtained. If the pressure decays gradually below the redline value, cutoff shall be initiated without regard to the prevalve position indicator.		20 psig
*PP113	Pressure, Fuel Pump Inlet If the recorder pegs down-scale at maximum rate, cutoff shall not be initiated unless the corresponding prevalve closed indication is obtained. If the pressure decays gradually below the redline value, cutoff shall be initiated without regard to the pre-valve position indicator.		5 psig
RP200 RP201	Pressure, Deflector Water Cutoff shall be initiated only if the corresponding pressure switch indication is obtained.		65 psig

Measurement Number	Description	Maximum	Minimum
*PV700	Rough Combustion Cutoff The RCC device will initiate cutoff after 100 milliseconds of vibration level greater than 100 g rms in the frequency range of 960 to 6,000 cps.		
*DT100 *DT101 *DT700 *DT701 *DT702 *DT703	Fire Detection Systen The fire detection system for stage S-IB-2 will consist of 12 Static Test harnesses and 4 flight harnesses. Each rise rate indicator will be set at 5 chart scales per second (3.0 mv) with a time delay of one-half second for the flight harnesses. All 16 rise rate indicators will be active in the cutoff circuitry. For observer monitoring, the redline value is an increase of five major chart divisions per second.		

General instructions for fire detection chart watchers are as follows:

1. If any one fire detection harness pegs upscale - no action.

2. If two or more fire detection harnesses peg upscale - initiate cutoff.

3. If static test LOX or flight harness pegs downscale - no action.

4. If static test fuel harness pegs downscale - initiate cutoff if recorder does not return within 5 seconds.

BLUELINE LIMITS

The following measurements will be monitored to assure vehicle safety during static test operations. If any blueline tolerance is exceeded the Test Conductor shall be notified:

1. Preignition Verifications (Blueline)

Measurement Number	Description	Maximum	Minimum
*HT700	Temperature, Hydraulic Oil	210° F	40° F
*H0700	Position, Hydraulic Reservoir Piston	68 percent	18 percent
*PP112	Pressure, Gearcase	7 psig	2 psig
*PT700	Temperature, Turbopump Bearing No. 1		0° F
*FP103-11	Pressure, High Pressure Spheres	3,200 psig	2,800 psig
*CP102-9	Pressure, Control Spheres	3,200 psig	2,800 psig
ST100-9	Temperature, GOX Line		-65° F

2. Mainstage Verification (Blueline).

Measurement Number	Description	Maximum	Minimum
*HT700	Temperature, Hydraulic Oil	275° F	
*H0700	Position, Hydraulic Reservoir Piston		10 percent
*PT700	Temperature, Turbopump Bearing No. 1		0° F
*PT108	Temperature, Turbopump Bearing No. 8	600° F	

APPENDIX C

STAGE AND GROUND SUPPORT TEST DATA SHEETS STAGE S-IB-2

APPENDIX C

STAGE AND GROUND SUPPORT
TEST DATA SHEET
STAGE S-IB-2

1. TEST NUMBERS:

Attempted Short Duration Test SA-27
Successful Short Duration Test SA-28
Successful Long Duration Test SA-29

2. IGNITION COMMAND TIME AND DATE:

Test SA-27	16:41:24,827 CST	July 8, 1965
Test SA-28	16:36:23.820 CST	July 9, 1965
Test SA-29	14:35:59.166 CST	July 20, 1965

3. TEST DURATION FROM IGNITION COMMAND (Seconds):

	INBOARD ENGINE CUTOFF	OUTBOARD ENGINE CUTOFF
Test SA-27	3.002	3.123
Test SA-28	35.192	35.302
Test SA-29	143.285	144.282

4. ENGINE NUMBERS:

Position 1 H-7051	Position 2 H-7052	Position 3 H-7050	Position 4 H-7054
Position 5 H-4048	Position 6 H-4049	Position 7 H-4050	Position 8 H-4051

5. TEST OBJECTIVES:

Short Duration Tests SA-27 and SA-28.

a. Verification of airborne/ground control systems compatibility.
b. Determine propellant tank draining rates.
c. Check performance of gimbal control system.
d. Verify reliability and performance of telemetry equipment.
e. Verification of engine performance.
f. LOX boiloff rate analysis.
g. Determination of bulk LOX density.
h. Evaluation of LOX topping system.
i. Investigation of fuel tank ripples.

5. TEST OBJECTIVES (Continued):

Long Duration Test SA-29

a. Verification of engine performance.
b. Check performance of gimbal control system.
c. Verify reliability and performance of telemetry equipment.
d. LOX boiloff rate analysis.
e. Determination of bulk LOX density center LOX tank.
f. Investigation of fuel tank ripples.

6. TEST CONDITIONS:

a. Short duration test cutoff will be initiated by the Firing Panel Operator.

b. Long duration tests cutoff will be initiated by uncovering of the first propellant low level sensor and will be controlled by the Switch Selector in the following sequence at cutoff:

0 Sec. - Level sensor actuation
+0.5 Sec. - Inboard engine cutoff
+1.0 Sec. - Arm fuel depletion probes and thrust O.K. pressure switches.
+1.5 Sec. - Outboard engine cutoff. A manual backup cutoff will be initiated at 141 sec. after commit.

c. Center LOX tank orifice diameter - 19.00 inches.
d. Propellants (at X-180 Seconds)

LOX	655 inches (LOX Tank O-C)	1.7% ullage
Fuel	634.5 inches	2.0% ullage

e. Engines to be gimbaled as outlined in the gimbal program. Short duration test, see TABLE 3-1. Long duration test, see TABLE 3-2.
f. Fuel emergency pressurizing armed at power transfer and disarmed at cutoff.
g. The LOX vents will be closed 10 seconds prior to initiation of LOX bubbling.

7. COMMENTS:

a. Fleming initiators will be used for this test.
b. The ground LOX pressurizing orifice diameter is 0.099 inches.
c. LOX bubbling rate will be 45 scfm.
d. At X+70 the stage fuel pressurization will be terminated and facility fuel pressurization initiated (test SA-29 only).

7. COMMENTS (Continued):

e. The all-engines-running signal will be simulated at X-1 seconds to assure that thrust commit will be reached at X=0 seconds. Thereafter, the normal TOP switch requirements will govern cutoff (tests SA-28 and SA-29).

f. The function of the engine controls have been modified through use of ground equipment to simulate the flight system as intended for future S-IB stages. This will require all three TOP switches to actuate to achieve "commit" and drop out of two switches thereafter to provide "cutoff" (test SA-29 only).

8. STAGE PRESSURE SWITCHES:

Description	Actuation	Deactuation
a. LOX Tank Pressurized	60.0 ± 1.5 psia	55.5 psia min
b. LOX Tank Emergency Vent	67.5 ± 1.5 psia	63.0 psia min
c. Fuel Tank Pressurized	32.4 psia max	29.6 psia min
d. Fuel Tank Emergency Vent	38.4 psia max	35.6 psia min
e. Fuel Spheres Pressurized	2965 ± 30 psia	2835 psia min
f. Control Sphere Pressurized	2965 ± 30 psia	2835 psia min
g. Control 750 OK	625 ± 25 psig	550 psig min
h. Thrust OK	800 ± 43 psia	690 psia min

9. STAGE RELIEF VALVES:

Description	Cracking	Reseat
a. Fuel Vent Valves No. 1&2	21.0 ± 0.5 psig	19.0 psig min
b. LOX Relief Valves No. 1&2	60.0 ± 5 psig	53.0 psig min

10. STAGE ORIFICES:

Description	Number	Diameter (Inches)
a. Fuel Tank Pressurizing	1	0.210 (sonic)
b. Fuel Bubbling	8	0.018
c. LOX Bubbling	8	0.102
d. 105-inch LOX Tank Sump	1	19.00

11. GSE PRESSURE SETTING:

Description	Setting (psig)
a. Fuel Bubbling (GN_2) Pressure Switch	110 ± 15
b. Fuel Bubbling Regulator Output	140
c. LOX Bubbling (Helium) Pressure Switch	315 ± 15

11. GSE PRESSURE SETTING (Continued):

	Description	Setting (psig)
d.	LOX Bubbling Regulator Output	394
e.	LOX Dome Purge Pressure Switch	195 $\pm$ 15
f.	LOX Dome Purge Regulator Output	250
g.	GG LOX Injector Purge Pressure Switch	270 $\pm$ 15
h.	GG LOX Purge Regulator Output	300
i.	Fuel Injector Purge Pressure Switch	375 $\pm$ 15
j.	Fuel Injector Purge Regulator Output	490
k.	Turbine Spinner Pressure Switch	40 $\pm$ 10
l.	Gearcase Pressure Switch	12
m.	Facility Helium Pressure Switch	3000 $\pm$ 50
n.	Facility GN_2 Pressure Switch	3000 $\pm$ 50
o.	LOX Dome Purge Bypass Regulator Output	250
p.	Auxiliary LOX Dome Purge Regulator Output	650
q.	Emergency Fuel Pressurizing Switch	5

12. GSE ORIFICES:

	Description	Number	Diameter (inches)
a.	Ground LOX Pressurizing (Helium)	1	0.099
b.	Fuel Sphere Supply (Helium)	1	0.100
c.	Control Spheres Supply	1	0.063
d.	Fuel Jacket Fill Line	1	0.189
e.	Ground LOX Orifice Bypass	1	0.370
f.	Facility LOX Pressurizing (GN_2)	1	0.537

13. PROPELLANT LOW LEVEL SENSORS:

	Description	LOX	Fuel
a.	Height Above Probe Flange	23.23 in.	26.63 in.
b.	Height Above Theoretical Tank Bottom	25.23 in.	32.13 in.

14. ENGINE DATA:

ENGINE POSITION	ENGINE SERIAL NUMBER	ENGINE ORIFICES (INCHES DIAMETER)							
		[1] GG LOX	GG FUEL	TURBINE SPINNER	MLV CONTROL	MLV CONTROL	MAIN LOX	MAIN FUEL	LOX TO H. E. [2]
1	H-7051	0.377	0.700	0.875	0.116	0.073	None	2.575	0.101
2	H-7052	0.373	0.700	0.875	0.116	0.073	None	2.690	0.101
3	H-7050	0.365	0.700	0.875	0.116	0.073	None	2.655	0.101
4	H-7054	0.371	0.700	0.875	0.116	0.073	None	2.950	0.101
5	H-4048	0.391	0.700	0.875	0.116	0.073	None	2.785	0.101
6	H-4049	0.373	0.700	0.875	0.116	0.073	None	2.645	0.101
7	H-4050	0.371	0.700	0.875	0.116	0.073	None	2.785	0.101
8	H-4051	0.373	0.700	0.875	0.116	0.073	None	2.768	0.101

[1] All 200K engines are equipped with dual orifices in the GG LOX bootstrap line. A fixed orifice of 0.400 inch is plumbed in series with the variable orifice listed above.

[2] Three orifices per engine.

APPENDIX D

METEOROLOGICAL DATA

TESTS SA-28 AND SA-29

METEOROLOGICAL DATA
TEST SA-28

LOCATION	BLOCKHOUSE			TOP STATIC TEST TOWER	
TIME OF DAY	TEMP. (°F)	BAROM. PRESS. (IN. HG.)	REL. HUMIDITY (PERCENT)	WIND VEL. (MPH)	WIND DIR. (DEGREES) ⚠
10:00 a.m.	84	29.33	71	6	280
10:30 a.m.	85	29.34	70	9	280
11:00 a.m.	86	29.35	68	8	305
11:30 a.m.	87	29.34	65	5	270
12:00 noon	88	29.33	64	9	300
12:30 p.m.	88	29.31	63	9	250
1:00 p.m.	89	29.29	62	8	290
1:30 p.m.	89	29.28	63	4	240
2:00 p.m.	90	29.27	62	10	255
2:30 p.m.	90	29.27	63	6	255
3:00 p.m.	90	29.27	64	5	280
3:30 p.m.	89	29.27	66	4	255
4:00 p.m.	88	29.27	70	3	265
4:30 p.m.	87	29.26	76	2	240
5:00 p.m.	86	29.26	84	5	230

⚠ Wind is from the direction given in degrees starting north going clockwise.

METEOROLOGICAL DATA
TEST SA-29

LOCATION	BLOCKHOUSE			TOP STATIC TEST TOWER	
TIME OF DAY	TEMP. (°F)	BAROM. PRESS. (IN. HG.)	REL. HUMIDITY (PERCENT)	WIND VEL. (MPH)	WIND DIR. (DEGREES) ⚠1
8:00 a.m.	81	29.340	66	2	150
8:30 a.m.	82	29.345	66	3	170
9:00 a.m.	84	29.380	64	3	140
9:30 a.m.	84	29.380	62	2	170
10:00 a.m.	85	29.380	61	5	160
10:30 a.m.	86	29.380	59	4	165
11:00 a.m.	87	29.380	56	4	150
11:30 a.m.	88	29.380	56	3	195
12:00 noon	88	29.380	56	2	190
12:30 p.m.	89	29.380	53	3	140
1:00 p.m.	90	29.370	51	5	160
1:30 p.m.	90	29.355	52	5	100
2:00 p.m.	90	29.350	53	4	110
2:30 p.m.	90	29.340	46	6	110
3:00 p.m.	90	29.340	45	5	100

⚠1 Wind is from the direction given in degrees starting north going clockwise.

APPENDIX E

OPERATING TIME/CYCLE HISTORY
OF STAGE S-IB-2 COMPONENTS
WHILE AT STATIC TEST

APPENDIX E

OPERATING TIME/CYCLE HISTORY
OF STAGE S-IB-2 COMPONENTS AT STATIC TEST

COMPONENT	OPERATION	
	CYCLES	MINUTES
Auxiliary Hydraulic Pump 1	37	84.3
Auxiliary Hydraulic Pump 2	27	75.1
Auxiliary Hydraulic Pump 3	45	75.6
Auxiliary Hydraulic Pump 4	30	65.8
Fuel Prevalve, Engine 1	159	-
Fuel Prevalve, Engine 2	157	-
Fuel Prevalve, Engine 3	158	-
Fuel Prevalve, Engine 4	158	-
Fuel Prevalve, Engine 5	154	-
Fuel Prevalve, Engine 6	154	-
Fuel Prevalve, Engine 7	156	-
Fuel Prevalve, Engine 8	135	-
LOX Prevalve, Engine 1	161	-
LOX Prevalve, Engine 2	158	-
LOX Prevalve, Engine 3	159	-
LOX Prevalve, Engine 4	159	-
LOX Prevalve, Engine 5	155	-
LOX Prevalve, Engine 6	155	-
LOX Prevalve, Engine 7	162	-
LOX Prevalve, Engine 8	156	-

COMPONENT	OPERATION	
	CYCLES	MINUTES
Fuel Pressurizing Valve 1	285	-
Fuel Pressurizing Valve 2	244	-
Fuel Vent Valve 1	215	-
Fuel Vent Valve 2	220	-
Fuel Fill and Drain Valve 1	89	-
Fuel Overfill Sensor	23	-
LOX Relief 1 and 7-Inch Vent	248	-
LOX Relief 2	252	-
LOX Emergency Pressurizing Switch	9	-
LOX Fill and Drain Valve 3	56	-
LOX Overfill Sensor	13	-
Control Sphere Vent Valve	17	-
Switch Selector	278	-
RF Assembly F1	133	3,285.1
RF Assembly F2	170	1,880.8
RF Assembly S1	114	2,497.8
RF Assembly P1	174	2,370.2
Vibration Multiplexer S1	114	-
TM Multiplexer P1	51	3,527.2
PCM/DDAS Assembly P1	51	3,527.2
Master Measuring Power Supply	40	3,652.8
Measuring Selector Power	51	3,518.6

APPENDIX E (CONTINUED)

COMPONENT	OPERATION	
	CYCLES	MINUTES
22.5-Volt Measuring Power Supply	47	4,496.0
Tape Recorder On (Manual)	26	123.8
Command Destruct Receiver 1	-	2,500.7
Command Destruct Receiver 2	-	2,500.7

APPENDIX F

UNSATISFACTORY CONDITION REPORTS

UCR NUMBER	PART NAME / PART NUMBER / SERIAL NUMBER	DESCRIPTION	REMARKS
01700	Bolt M551096-65 N/A	During the build up of S-IB-2 gauge assemblies (P/N 60C20759-1) it was discovered that the specified bolts, P/N M551096-65, were not satisfactory for the build up and installation of these assemblies. The bolts are used for clamping transducers to mounting blocks, and clamping the mounting blocks to the actuator mounts of the engines. The bolts "bottom out" against each other inside the mounting blocks before the transducers are tightened to the mounting blocks, or the mounting blocks are tightened to the actuator mounts. The same situation exists for gauge mount assemblies, P/N 60C20761-1 and 60C20762-1.	The bolts specified, P/N M551096-65, are too long to be used satisfactorily. A shorter bolt, P/N M551096-64, will be used per procedure, Drawing No. 60C06028. It is recommended that the affected drawings be revised, and that greater care be taken in the design and modification of these assemblies.
01701	Sub Multiplexer Assembly 50M12088-5 002	During initial test prior to test SA-27, it was observed at a DDAS ground station that bits 5, 7, and 9 on frames 3 and 7 in the output of the remote digital submultiplexer (P/N 50M12088-5, S/N 002) was very erratic. During troubleshooting tests it was found that, when "ABC and D sync" common from the PCM/DDAS assembly to the RDSM was grounded to missile skin, the unit operated in a satisfactory manner.	The cause is not known since the internal circuits of the RDSM was not tested. It is believed that an electrical ground is faulty inside the unit. It is recommended that an investigation be conducted to determine the cause of the malfunction, and the results be compiled into a historical record of this type malfunction.
01702	RF Assembly F2 50C12196-9 003	Prior to test SA-27, frequency tests were performed on all major telemetry packages. At this time it was found that F2 RF telemetry package was generating 244.348 mc. The frequency should have been 244.3 mc $\pm$ .01%. The maximum allowable frequency is 244.3 + .024 = 244.324 mc. Therefore, the frequency generated is about 24 kc higher than allowable specifications. The package appeared to operate in a satisfactory manner, except for its high frequency. Total run time at STTE is 1141.5 min.	It is recommended that the F2 RF assembly be subjected to a bench test where its frequency can be adjusted to the correct value and then returned to logistic spares.
01703	PCM/RF Assembly P1 50C12187-1 003	During initial checkout of telemetry systems on S-IB-2 at STTE, it was found that after 5 or 10 minutes warm up time, the PCM/RF P1 unit would not modulate its input wavetrain properly. There was erratic modulation of the input bits of information. The total run time on this package at static test is 236.0 minutes.	Two packages of this type were found to be faulty during static test operations on S-IB-1. The third package operated in a satisfactory manner (see UCR numbers 01112 and 01115 of S-IB-1). Because of the extremely high failure rate of these packages, it is recommended that immediate investigation and re-design be started and the necessary modifications be installed on all Chrysler built Saturn IB vehicle.
01704	Measuring Rack Assembly 50C01184-A SA-0294	Prior to test SA-27, it was discovered by Michoud checkout personnel that wiring inside this Measuring Rack was faulty. (Reference is made to DMN M07999A - Michoud). Even though its operation was normal, it was considered unreliable for static firing by Michoud personnel. The faulty rack S/N SA0294 was replaced by rack S/N C0030. All modules were removed from the faulty rack and installed in the new rack.	The cause was due to faulty workmanship during manufacture. The faulty wiring should be drawn to the attention of manufacturing and quality manufacturing personnel.
01705	DC Amplifier 50C1038815 0263	While measurement D1-6, pressure, combustion chamber, was being calibrated during pre-static checkout of S-IB-2 at STTE; it was found that the associated DC amplifier S/N 0263 experienced a drift in its output voltage. The Hi-Cal value should be 4.382 volts. When the amplifier was set to this value, it was observed to drift away from this setting. The run value also drifted when the Hi-Cal value drifted.	The faulty amplifier S/N 0263 was replaced by amplifier S/N 0153 in a replacement kit. Included in the replacement kit (60C00192 S/N LS0219) was pressure gage, 50C12012, old S/N 30707 with replacement S/N 30702. It is recommended that the cause of the malfunction be investigated and the results compiled into a historical record of this type component.

<table>
<tr><th>UCR NUMBER</th><th>PART NAME
PART NUMBER
SERIAL NUMBER</th><th>DESCRIPTION</th><th>REMARKS</th></tr>
<tr><td>01706</td><td>Radiation Shield Installation
10C11441-1
N/A</td><td>Difficulty was encountered during installation of the radiation shield per drawing 10C11441-1. Two bolts could not be installed between fin positions II and III because the holes in the radiation shield, P/N 30C03934-1, would not align properly with the holes in the stage skin, P/N 30C03810. A bolt could not be installed at fin position IV because the hole drilled through panel assembly, P/N 30C03860, was too close to tail unit member, P/N 30C03802 to get a nut on the bolt.</td><td>Radiation shield installation, drawing No. 10C11441-1, was not adhered to when these holes were drilled at Michoud. Due to similar problems encountered during radiation shield installation on previous stages, it is recommended that the radiation shield, P/N 30C03934-1, be installed at Michoud and left installed when shipped to Static Test.</td></tr>
<tr><td>01707</td><td>Flame Curtain Outboard Engine
10C11462
N/A</td><td>When performing engine hydraulic system clearance and functional checks, damage was incurred by each outboard engine flame curtain. The extent of this damage is as follows:
A. Damage to Snap Fasteners (Reference drawing 30C03566, Sheet 5).
<table><tr><th>Eng.</th><th>No. Fast. Bkn.</th><th>No. Fast. Came Loose</th><th>No. Fast. OK</th></tr><tr><td>1</td><td>9</td><td>10</td><td>5</td></tr><tr><td>2</td><td>0</td><td>7</td><td>17</td></tr><tr><td>3</td><td>2</td><td>17</td><td>5</td></tr><tr><td>4</td><td>0</td><td>14</td><td>10</td></tr></table>B. The bonding between the 30C03566-5 insulation (Red Boot) and the 92-S Aluminized fabric came loose in several places on each outboard engine flame curtain.</td><td>The present flame curtains consist of 30C03566-5 insulation material having one layer of 92-S alumized fabric bonded to it. Previous flame curtains consisted of 30C03566-5 insulation material loosely covered (No bonding) by a layer of refrasil material and a layer of reflective tape. The bonding on the present flame curtain increases the rigidity of the curtain, thus resulting in a greater strain being exerted on the snap fasteners during gimbaling. Since positive type hinge fasteners are located on the inside of the connection where snap fasteners are employed, no danger of the connection separating during a firing exists. Therefore, the snap fasteners will be fastened where possible and the connections covered with reflective tape prior to static firing. It is requested that the refurbished type flame curtains be redesigned and tested while gimbaling prior to installing them on another stage for static firing.</td></tr>
<tr><td>01708</td><td>LOX Prevalve
60C20339
107</td><td>The LOX prevalve on engine 7 failed to give a closed indication when it was cycled at cryogenic temperatures. The closed indication was received approximately 85 seconds after actuation.</td><td>Probable cause is either that the actuator piston froze or the switches failed to actuate at cryogenic temperatures. Reference UCR number 01116 and 01122. It is recommended that a failure analysis be conducted on the prevalve.</td></tr>
<tr><td>01709</td><td>Relay
S2GH6-31
N/A</td><td>During performance of procedure 6-CH SIB-610A (Simulated Flight Test), the simulated engine operation was terminated by the ESE at X-0 ("Time for Commit"). The operation was terminated due to the failure of the ESE to receive a signal from the stage indicating that engine 3 had reached a proper operating thrust level.</td><td>The operation of relays K33-1, K33-2, K33-3 were checked using the EDS Thrust Monitor Panel and thru performance of a Sequence Test. A second attempt at the simulated flight test was completed successfully. Since we were unable to repeat the malfunction and the relays are critical to a successful static firing or launch the relays 9A1K33-1 and 9A1K33-3 will be replaced prior to short duration static firing.</td></tr>
</table>

UNSATISFACTORY CONDITION REPORT (CONTINUED)

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01710	Gauge Mount Assembly 60C20765-1 N/A	During the installation of engine static test instrumentation on S-IB-2, difficulty was encountered in installing gauge mount assembly, P/N 60C20765-1, associated with measurement *PP102 Small clearances between the fuel drain manifold P/N 555238 and associated drain lines and the turnbuckle assembly, P/N 205930, makes it extremely difficult to install the gauge mount assembly. It is also difficult to maintain adequate clearance between the solenoid valve of this measurement and the heat exchanger LOX supply line.	The location of measurement *PP102 did not change when the engines were uprated to 200K. The fuel drain manifold and associated plumbing on the 200K engine is slightly different from the 188K engine configuration, and sufficient clearance does not exist for mounting the measurement in this location using gauge mount assembly, P/N 60C20765-1, on the 200K engine. Since the effective drawings show this measurement in the same location on subsequent stages, it is recommended that the gauge mount assembly be relocated to the top turbopump support bracket for ease of installation. (P/N 402522)
01711	RF Assembly SI 50C12196-5 003	Upon arrival of S-IB-2 at the STTE at MSFC it was found that the single side band RF assembly was not pressurized as it should have been. The unit was given a bench test, checked for leaks, and pressurized. The unit appeared satisfactory and was reinstalled aboard S-IB-2.	It is recommended that this package be rechecked for pressure during post static test operations. If the package is found to again have lost pressure, the package should be removed, and the leak repaired.
01712	Low Liquid Level Probe 20C30429-1 N/A	During LOX transfer (Procedure 6-CH SIB-235) a leak check was performed with 200 inches of LOX in the tanks and with the tanks pressurized to 20 psig. This leak check revealed a leak between the LOX Low Level cutoff sensor and the bottom of the LOX tank 0-4.	This leak was apparently due to the torque values on the fasteners being below the specified value of 55 $\pm$ 10 in-lbs. After LOX was detanked the torque settings were found to be below 35 in-lb. The torque on the LOX low level cutoff sensor bolts under LOX tank 0-2 was also found to be below 35 in-Lb. Reference squawk V00208-29.
01713	Tube Assembly 10M11361-1 N/A	During the control system leak check Procedure 6-CH SIB-205 a leak was detected from a B-nut on the tube assembly 10M11361-1. The system was vented and B-nut torqued. Pressure was reapplied and the B-nut still leaked. An aluminum crush washer was added and B-nut retorqued. Pressure was again applied and no leak was detected.	A bad flare on the tube assembly was the probable cause. It is recommended that the tube assembly be replaced at Post Static Checkout in Michoud.
01714	Sliding Pins 30M00427 N/A	Post propellant loading test inspection revealed that five fuel tank sliding pins had galled and scratched surfaces. The discrepant pins, their locations, and the damage incurred by each is given as: 1. Fuel Tank #1 Toward Tank 0-2 2 Scratches 2. Fuel Tank #2 Toward Tank 0-2 1 Scratch 3. Fuel Tank #3 Toward Tank 0-3 1 Scratch 4. Fuel Tank #3 Toward Tank 0-4 2 Scratches 5. Fuel Tank #4 Toward Tank 0-1 Nick and 2 Polished Areas 6. Fuel Tank #4 Toward Tank 0-4 3 Scratches Upon receipt of the stage it was noted that several of the sliding pins had the grease on them displaced between 1/16 inch and 1/4 inch and that the grease was contaminated. The pins were cleaned and regreased prior to LOX loading.	The cause of this condition was contamination in the grease on the sliding pins. The galling was believed to have started during stage transportation and continued damaging the pins during the propellant loading test. LOX tanks contract approximately 2.3 inches during LOX loading. The pins will be cleaned, inspected, and regreased prior to each LOX loading. The attached photographs show that the grease on several of the sliding pins moved approximately 1/16 to 1/4 of an inch during stage transportation. The grease on the sliding pins on fuel tank 2 was displaced an unequal amount relative to each other. This represents a greater amount of movement on one side of the tank. Ripples were noted on fuel tank 2 prior to erection of the stage. The unequal expansion of the tank on the sliding pins is a probable cause for these ripples.

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01715	Valve Assembly 554838 6356996	During the IMV leak check portion of procedure 6-CH SIB-312, with 725 psig applied to the inlet and control ports of the ignition monitor valve assembly, leakage was noted around the attaching screws for the diaphragm assembly. No leakage is allowed.	1. Foreign matter between the diaphragm and the body assembly. 2. Over pressure on the inlet port causing stretching of the diaphragm. Either of these could cause indentations in the O-ring, allowing control pressure to leak by the O-ring and past the attaching screw threads. It is recommended that a failure analysis be performed by the vendor, to determine the exact cause for the leakage.
01716	DC Amplifier 50C10382-2 C222	Prior to test SA-27, the vibration thrust chamber dome (E33) measurements were calibrated. At this time it was found that the amplifier of E33-3 would not generate a Hi Cal voltage. When placed in the Hi Cal mode, 0.700 volt , RMS, should have been produced; instead, approximately zero volts was noted.	It is recommended that an investigation be undertaken to determine the cause of the malfunction. This malfunction should be compiled into a historical record of this type malfunction. The amplifier S/N C222 was replaced by spare amplifier C152. Also installed as part of the replacement kit (P/N 60C00252, S/N LS0333) was accelerometer P/N 50C10105, S/N 253, Reference Designator 3A453.
01717	PCM/RF Assembly 50M12187-1 002	During initial tests at STTE on S-IB-2, it was found that PI RF Assembly S/N 003 failed to modulate the RF signal properly (reference UCR 01703). Spare PI RF Assembly S/N 002 was installed to replace the faulty RF assembly. Initial operating tests revealed that this package also failed to modulate the RF signal properly. Subsequent tests revealed that the package operates properly when first energized; but after about 5 to 10 minutes warm up time, the package begins to malfunction, and does not modulate its RF signal properly. Run time accumulated at STTE is 139.8 minutes. Because no spare RF assembly is presently available, the faulty PI RF Assembly was not replaced.	Two faulty PI RF Assemblies were found on S-IB-1 (UCR Nos. 01112 and 01115), and the third replacement package was good. Also two faulty PI RF assemblies were found on S-IB-2 (UCR No. 01703 and this UCR). In other words, of five different packages, four were found to malfunction; therefore, the PI RF assembly is considered to be a major telemetry problem. It is recommended that an investigation be conducted to determine the area of marginal design of these packages, and it is recommended that immediate design be inaugurated to correct this major telemetry problem.
01718	Relay S2GH-6-31 N/A	See UCR 01709 for description of condition. The relay is in the same circuit as the one covered in UCR 01709 and was changed at the same time because it was not possible to distinguish which one, or whether both, malfunctioned.	See UCR 01709 for checks made and action taken.
01719	DC Amplifier 50C10388-59 0344	Prior to test SA-27, all flight (active and simulated) measurements were calibrated. At this time it was found that the output of measurement S554-22, strain, fin 7, skin, produced a continuous negative output in both the Hi and Run modes. The readings should have been 4.66 volts in Hi and 2.75 volts in the Run mode. This is a simulated flight measurement.	It is recommended that an investigation be conducted to determine the cause of the malfunction and that the results be compiled into a historical record of this type malfunction.
01720	DC Amplifier 50C10394-41 1601	During initial checkout while performing procedure 3-CH SIB-502, measurement C183-11 would not maintain the same value from one measurement scan to the next. It was noted that the High Cal value would drift as much as 400 mv in 5 or 10 minutes. Replacement of subject amplifier corrected this discrepancy.	It is recommended that an investigation be conducted to determine the cause of the drift in values.

UNSATISFACTORY CONDITION REPORT (CONTINUED)

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01721	DC Amplifier 50C10394-29 1659	During prefiring checkout while performing procedure 3-CH SIB-502, measurement C1-7 indicated 2.0 volts after Hi-Cal and Run values were properly adjusted. (There is no adjustment other than Hi and Run for Lo-Cal). The Lo-Cal value was observed to drift as low as 0.723 volt ; however, the associated curve specifies 0.570 volt for Lo-Cal. Replacement of the amplifier corrected the problem.	It is recommended that an investigation be conducted to determine the cause of the malfunction, and that a historical record be kept of this type malfunction.
01722	DC Amplifier Assembly 50C10388-57 0418	Prior to test SA-27, all flight instrumentation was calibrated. At this time it was noted that the output of measurement S671-9, strain engine outrigger, was very erratic in both the Hi and Run modes of operation. The readings should have been steady and 4.53 volts in Hi-Cal and 2.48 volts in Run mode.	The cause is unknown. A loose connection inside the amplifier is the suspected cause. It is recommended that the cause of the malfunction be investigated, and that the results be compiled into a historical record of this type malfunction.
01723	DC Amplifier 50C10388-47 0180	Prior to test SA-27, all flight (active and simulated) measurements were calibrated. At this time it was noted that measurement S615-8 would not respond when the Hi or Run adjustments were made.	It is recommended that the amplifier S/N 0180 be subjected to a bench test to determine the cause of the malfunction.
01724	DC Amplifier Assembly 50C10388-25 13420	Prior to test SA-27, all flight (active and simulated) measurements were calibrated. At this time it was noted that measurement S571-22 would not respond when the Hi or Run adjustments were made.	It is recommended that the amplifier S/N 13420 be subjected to a bench test to determine the cause of the malfunction.
01725	DC Amplifier Assembly 50M10382-3 C217	Prior to test SA-27, flight measurements were calibrated. At this time the AC Amplifier S/N C217 was placed in Hi-Cal mode. The amplifier correctly produced 0.701 volts RMS in Hi-Cal, but it could not be taken out of Hi-Cal mode.	It is recommended that an investigation be conducted to determine the cause of the malfunction. It is believed that additional design may be necessary to improve reliability of the Hi, Lo and Run select modes of all flight measurements. It is recommended that a historical study be made of past UCR's of this type malfunction.
01726	Valve Assembly-7-Inch 20M00873 0005	The LOX tanks were pressurized to 20 psig per procedure 6-CH SIB-260 for leak check. It was found during this investigation that the 7-inch LOX vent valve (S/N 0005) was leaking past the lip seal. (Reference UCR's 01145, 234, 231, and 73.)	The vent valve assembly (S/N 0005) was replaced by a similar item (S/N 0006) and it is recommended that a failure analysis be conducted to determine the cause of leakage.
01727	Liquid Level Adapter 50C10699 48	During a fuel tanking test prior to test SA-27, the output of each continuous level liquid measurement was observed at a DDAS ground station. When fuel had covered the probe in fuel tank F-4 the measurement indicated 41.5 inches of fuel. It should have indicated 40.5 inches.	The improper reading is suspected of being caused by one of two factors: 1. A misadjustment of ratio capacitors inside the liquid level adapter. 2. The liquid level probes being out of tolerance. Except for the improper reading, the measurement appeared to operate normally. It is recommended that the measurement be recalibrated during post static test operations at Michoud. The adapter was not removed from S-IB-2 at STTE.

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01728	Liquid Level Adapter 50C10699 47	During a fuel tanking test prior to test SA-27, the output of each continuous level liquid measurement was observed at a DDAS ground station. When fuel had covered the probe in fuel tank F-2 the measurement indicated 40.9 inches of fuel. It should have indicated 40.5 inches.	The improper reading is suspected of being caused by one of two factors: 1. A misadjustment of ratio capacitors inside the liquid level adapter. 2. The liquid level probes being out of tolerance. Except for the improper reading, the measurement appeared to operate normally. It is recommended that the measurement be recalibrated during post static test operations at Michoud. The adapter was not removed from S-IB-2 at STTE.
01729	Liquid Level Adapter 50C10699 45	During a fuel tanking test prior to test SA-27, the output of each continuous liquid level measurement was observed at a DDAS ground station. When fuel had covered the probe in fuel tank F-3 the measurement indicated 41.1 inches of fuel. It should have indicated 40.5 inches.	The improper reading is suspected of being caused by one of two factors: 1. A misadjustment of ratio capacitors inside the liquid level adapter. 2. The liquid level probes being out of tolerance. Except for the improper reading, the measurement appeared to operate normally. It is recommended that the measurement be recalibrated during post static test operations at Michoud. The adapter was not removed from S-IB-2 at STTE.
01730	Liquid Level Adapter 50C10699 22	During a fuel tanking test prior to test SA-27, the output of each continuous level liquid measurement was observed at a DDAS ground station. When fuel had covered the probe in fuel tank F-1 the measurement indicated 40.9 inches of fuel. It should have indicated 40.5 inches.	The improper reading is suspected of being caused by one of two factors: 1. A misadjustment of ratio capacitors inside the liquid level adapter. 2. The liquid level probes being out of tolerance. Except for the improper reading, the measurement appeared to operate normally. It is recommended that the measurement be recalibrated during post static test operations at Michoud. The associated adapter was not removed from S-IB-2 at STTE.
01731	Subcarrier Oscillator 50C60037-3 57	The 70KC ± 30% subcarrier oscillator frequency on F-2 Telemetry was approximately 4KC too high at both low and high band edges when received at Static Test. The oscillator was adjusted properly three times prior to SA-27 and each time it drifted back to the high frequency condition. The high and low band edges should have been 49KC ± 210 cps and 91KC ± 210 cps.	The cause of the drift is unknown. The SCO will be replaced when a spare becomes available. It is recommended that the cause of the drift be investigated.

UNSATISFACTORY CONDITION REPORT (CONTINUED)

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01732	Module 2 Assembly - Calibration 50M12011-3 12	While evaluating Telemetry data after SA-28; it was discovered that the zero to five volts stairstep inflight calibration length was approximately 800 milliseconds for F-1 FM/FM channels. The zero level calibration length was 200 milliseconds, but it should be 140 ± 10 ms totaling 700 ± 50 milliseconds.	Since only F-1 telemetry zero level calibration has excessive length, it is believed that the problem may be in the inflight calibration command circuitry inside the TM calibrator. The calibrator operates satisfactorily except for the above discrepancy and is not being replaced by Static Test. It is recommended consideration be given for widening the specification to cover above functions.
01733	Multiplexer Assembly 50M12192-3 002	While evaluating data from S-1 Telemetry prior to SA-27, it was discovered that the sampling duration of the vibration multiplexer for a complete cycle was 9.6 seconds. The sampling time should have been a minimum of approximately 12 seconds. This malfunction was noticed approximately 25 minutes after the vibration multiplexer was turned on.	The vibration multiplexer operates satisfactorily except for the above discrepancy and will not be replaced by Static Test. It is recommended that the sampling duration be adjusted during post static test operations at Michoud.
01734	Multiplexer Assembly 60C50081-7 002	While evaluating PCM telemetry data records during SA-27 prefiring checkout it was observed that the following unused channels in the P-1 270 channel multiplexer indicated approximately 2 volts output and was extremely erratic. Channel 7, frames 1 and 6 Channel 8, frame 10 Channel 9, frame 10	Channels 7, 8, and 9 on all frames have the 100K ohm input resistors removed and the unused channels are receiving crosstalk from other channels. It is recommended that the unused channels in the P-1 270 channel multiplexer, which have had the 100K ohm resistors removed, be terminated with either 100K ohm resistors or grounded in a measuring distributor.
01735	DC Amplifier 50C10394-27 1665	While performing procedure 3-CH SIB-502 during prefiring (SA-27) checkout, measurement C59-4 indicated a proper output in the Hi-Cal mode but read a low value in the Low-Cal. Investigation of the malfunction revealed a faulty DC amplifier.	It is recommended that the DC Amplifier be returned to CCSD-Michoud. An investigation should be conducted to determine the cause of the malfunction.
01736	B-Nut 4BTX-SS N/A	Visual inspection of engine 6 (S/N 4049), immediately following static test SA-28, revealed a fuel leak at the B-nut (P/N 4BTX-SS) on the system port of the inboard number 2 Thrust OK pressure switch.	It is recommended that the B-nuts on all future Thrust OK pressure switch system manifolds (P/N 308867) be of the type drilled for safety wire.
01737	Inner Connector Line-Fuel 20C00009 N/A	During fuel transfer, leakage was discovered at the flange between the fuel inner connector line and the fuel transfer line from fuel tank F-1. Upon disassembly of this flange joint it was discovered that the O-ring was severely damaged. The O-ring was cut approximately 1/2 through the cross-section diameter.	Probable cause was the improper assembly of the joint. Replaced the O-ring and reinstalled the assembly.
01738	Thermocouple 50C10417 0093	During the monitoring period prior to test SA-27 the output of the fire detect system for measurement DT702 (XC 116-1) was erratic on the strip chart recorder. One of the eight series-wired thermocouples was intermittently opening the circuit.	The thermocouple was opening between pins A and B possibly due to a bad connection at one of these pins. The defective thermocouple was replaced.

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01739	Valve Assembly Fuel Container Vent 20M30000 12	Fuel was loaded to 634.5 inches for test SA-27 per procedure 6-CH SIB-230A and the fuel vents were closed for leak check. Fuel Valve Assembly (S/N 12) failed to give the closed indication. The Valve Assembly was cycled and the closed indication was never attained. To verify that the vent was closed the fuel tanks were pressurized, and during the pressurization the valve assembly gave the closed indication.	The switch mechanism for the fuel vent valve assembly apparently failed during operation. The fuel vent valve assembly (S/N 12) was replaced by a similar item (S/N 23). It is recommended that failure analysis be performed on the Valve Assembly. Reference UCR 00190 and 00189.
01740	LOX Prevalve 60C20339 106	The LOX Prevalve on engine 8 failed to give an open indication at cryogenic temperatures following tests SA-27 and SA-28 when the valve was opened at reset. However, the open indication was received after the valve had achieved ambient conditions.	Probable cause is either that the actuator piston froze or the position switches failed to actuate at cryogenic temperatures. The LOX prevalve (S/N 106) was replaced by a similar item (S/N 114). This is a reoccuring problem on many LOX prevalves. It is recommended that failure analysis be performed on the LOX Prevalve. Reference UCR 01708, 01155, and 1116.
01741	Flame Curtain Outboard Engine Static Test 10C11462 N/A	The inboard side of the flame curtains at engines 3 and 4 were damaged during test SA-28 hot firing. At engine 3, two large holes were burned through the reflective material, thus damaging the boot. At engine 4, the reflective material was burned to the extent that it became dry and brittle. NOTE: This is the first time that a hole has been burned in the reflective material of a flame curtain during a short duration firing.	The 92-s aluminized fabric used on these flame curtains does not appear to reflect heat as well as the reflective tape and refrasil material used on the flame curtains of previous stages. Also, the reflective material on these flame curtains was bonded to the boot rather than hung loosely about the boot as on previous stages. It appears as if the boot is better protected from heat by a loose covering than it is by a bonded one. The damaged flame curtain at engine 3 was removed and returned to Michoud. A new flame curtain (type used on previous stages) was installed at engine 3. The flame curtain at engine 4 was repaired by bonding 92-s aluminized fabric to the damaged area with Dow Corning Q-20103-2 sealant. It is requested that the original type 10C11462 flame curtains (type used on previous stages) be employed on all future stages.
01742	High Pressure Sphere 60C21099-1 N/A	Post test inspection of the GN_2 control sphere revealed the presence of several bubbles in the inner liner of the sphere. Another inspection approximately 12 hours after the discovery of the bubbles revealed that there was a greater number of bubbles and that the bubbles were of greater size. The sphere was reassembled and pressurized. Examination of the sphere's surface with leak check solution revealed the presence of escaping gas.	The control sphere was removed and shipped to Michoud for further investigation.

UNSATISFACTORY CONDITION REPORT (CONTINUED)

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01743	Valve Assembly (7-Inch) 20M00873 0006	During the test of the airborne components after test SA-28 the 7-inch LOX vent valve failed to give a closed indication when the valve was in the closed position. However, the valve was visually checked and found to be in the closed position.	The probable cause of the position indication failure is a malfunction of the position indicator switch. This is a reoccuring problem which has appeared on most previous 7-inch LOX vent valves. It is recommended that the valve be changed during post static checkout at Michoud, and failure analysis be conducted on it. Reference UCR's 01145, 234, 231, and 73.
01744	LOX Prevalve 60C20339 102	The LOX prevalve on engine 4 failed to give a closed indication at cryogenic temperatures when it was closed immediately following test SA-27. The closed indication was received after the valve had achieved ambient condition.	The probable cause is either that the actuator froze or the position switches failed to actuate at cryogenic temperatures. The LOX prevalve operated properly after test SA-28. This is a reoccuring problem on many LOX prevalves. Reference UCR's 01708, 01155, and 01116.
01745	LOX Prevalve 60C20339 105	The LOX prevalve on engine 7 failed to give a closed indication at cryogenic temperatures when it was closed immediately following test SA-27. The closed indication was received after the valve had achieved ambient conditions.	The probable cause is either that the actuator piston froze or the position switches failed to actuate at cryogenic temperatures. The LOX prevalve operated properly after test SA-28. This is a reoccuring problem on many LOX prevalves. Reference UCR's 01155 and 01116.
01746	Valve Assembly Fuel Container Vent	While in the process of installing a new fuel vent valve assembly (S/N 23), it was noted that four studs on the valve assembly did not line up with their respective holes in the fuel container wall. To install the valve assembly, it was necessary to alter the holes in the container wall so that they would fit the stud alignments of the valve assembly. The holes that were altered are numbers 2, 3, 4, and 5, starting at 12 o'clock and going clockwise. The studs were either improperly installed or were damaged during shipment or storage.	It is recommended that a failure analysis be conducted to determined the cause of the misaligned studs.
01747	Accelerometer 50C10406 434	Prior to test SA-29, an effort was made to adjust measurement E500-4, Vibration, engine thrust beam longitudinal. It was found that in the Hi-Cal mode, the output could not be adjusted higher than 0.100 volt RMS. The correct value should have been 0.704 volt RMS.	Investigation revealed that a faulty accelerometer was the cause of the malfunction. The faulty accelerometer was replaced as part of replacement kit. Other parts of the kit, P/N 60C00224-LS-0087, are as follows: PART / OLD S/N / NEW S/N Emitter Follower / 0017 / RA0361 AC Amplifier / C206 / C138

UNSATISFACTORY CONDITION REPORT (CONTINUED)

UCR NUMBER	PART NAME / PART NUMBER / SERIAL NUMBER	DESCRIPTION	REMARKS
01748	Emitter Follower 50C10401-1 027	Prior to test SA-29, an effort was made to adjust measurement E503-9 vibration, engine thrust beam perpendicular. It was found that, the output could not be adjusted higher than 0.300 volt RMS. The correct value should have been 0.702 volt RMS.	Investigation revealed that a faulty Emitter Follower was the cause of the malfunction. The faulty Emitter Follower was replaced as part of a replacement kit. Other parts of the kit, part number 60C00243-LS-0086, are as follows: PART — OLD S/N — NEW S/N Accelerometer — 404 — 462 AC Amplifier — C211 — C197
01749	Accelerometer 50C10105 253	Evaluation of records of test SA-28 revealed that measurement E33-3, Vibration, Thrust Chamber Dome, Longitudinal, did not produce an output during the firing. Investigation revealed that pins A and D of the accelerometer indicated 2 ohms. A +22.5 volts and its ground power source is normally applied between these two pins.	A shorted electronics component in the emitter follower of the accelerometer is the suspected cause of the short circuit. It is recommended that an investigation be conducted to determine the cause of the short circuit. New replacement kit, S/N 60C00252-LS-0364 amplifier, P/N 50C10382-3, S/N C148.
01750	DC Amplifier 50C10394-29 1644	Prior to test SA-29, measurement C1-1, temperature, LOX pump bearing 1, was indicating an incorrect value in the Hi-cal mode. The amplifier was adjusted to the correct value of 4.15 volts in Hi-cal. It was noted that the amplifier drifted out of tolerance within three (3) minutes.	The cause of the drift of the amplifier is not known. A faulty electronic component inside the amplifier is the suspected cause. The cause of the malfunction should be investigated. Drifting amplifiers is a common malfunction, and comparison of the cause of each faulty amplifier should be performed to determine weaknesses in design.
01751	DC Amplifier 50C10394-31 1679	Prior to test SA-29, measurement C533-2, temperature, skin Fin 5, indicated approximately 0.100 volt when placed in the Hi-Cal mode. The value should have been 4.09 volts.	A faulty electronic component inside the faulty amplifier is the suspected cause of the malfunction. It is recommended that the cause of the faulty amplifier be investigated. The results of this investigation should be compiled into a historical record of this type malfunction.
01752	Relief Valve 20C30137A CH-013	After removal of the 750 regulator for shipment to the Cape it was noted that the adjustment screw was corroded (rust) and the screw driver slot was broken on the pressure relief hand valve.	The probable cause of this condition was defective material. Before using this regulator it is recommended that the adjustment screw be changed.
01753	SSB Multiplexer Assembly 50C12089-3 002	During initial checkout of the liquid level system through PCM Telemetry, it was found that output bit 29 (MSD) of the RDSM, intermittently indicated an output in the run condition and when being transferred from Run to Cal condition. It was discovered that large spikes appear at the RDSM 29 bit input.	The large transient spikes appearing at the RDSM input are being transmitted as a digital "one". Source of these spikes is unknown. It is recommended that the PC card containing the 29 bit circuitry for all words be removed from the RDSM since it is not used in this system. Except for the above discrepancy the RDSM functions properly and will not be replaced by Static Test.

UNSATISFACTORY CONDITION REPORT (CONTINUED)

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01754	Tube Assembly 60C10468-1 N/A	Evaluation of records of test SA-28 revealed that measurement D2-F3, Pressure, Gas in fuel tank, did not respond to changes in pressure in the fuel tank. Investigation revealed that a sense line tubing, P/N 60C10468-1, between the transducer and the fuel tank was missing. This tubing was obtained from Manufacturing, Michoud, and installed prior to test SA-29. No malfunction was noted on D2-F3 during SA-28.	The tubing not installed during manufacture, was installed at STTE, Huntsville.
01755	Microphone Cable Assembly 50C10399 2289	Prior to test SA-27, measurement B501-4, acoustic, engine shroud area, failed to indicate an output. Investigation revealed that the cable assembly connected to the microphone was broken.	It is believed that the cable had been stepped on as it is located in an area of foot traffic. It is recommended that a protective cover be designed and installed during manufacturing at Michoud on subsequent vehicles.
01756	Accelerometer 50C10105 249, 230, 250, 231	Evaluation of records of each Chrysler built vehicle, S-I-8, S-I-10, and S-IB-1, revealed that measurements E33-1, E33-3, E33-5, and E33-7, Vibration, Thrust Chamber, Dome, indicated excessive amounts of vibration during each static firing. This indicated vibration was greater than the response limits of the associated telemetry channel. Prior to test SA-27, arrangements were made to compare results from a transducer (manufactured by CUBIC) as measured over landline facilities with a flight transducer (E33-1, manufactured by Glennite) as measured over the same path. The CUBIC transducer indicated approximately 20 to 28 g peak to peak, while the flight transducer (Glennite) indicated approximately 100 g peak to peak. The flight transducers were further investigated during test SA-29. Two transducers, CEC, PN 4-280-0105, were also tested during this test. One of these was connected to the Single Side Band Telemetry System while the second was connected to the landline system. Realistic data were obtained from the CEC transducers while excessive vibration was indicated from the Glennite flight transducers. A Glennite flight transducer and the CEC transducer were each subjected to a shake table test following SA-29. Figure 1 indicates the response of each of the transducers. It can be seen that the CEC transducer responds in an approximate linear fashion to 10 KC, but the Glennite transducer has a resonant point at about 7 KC. Figure 2 indicates a frequency analysis of the Vibration, Thrust Chamber Dome Measurements as recorded by a Glennite and the CEC transducer during the test SA-29. An analysis was also performed on the vibration recorded by a landline CUBIC transducer. The CUBIC and the CEC indicated very similar results. It can be seen in Figure 2 that a high energy level (as recorded by the CEC) of vibration exists at about 8 KC, which corresponds to the resonant point in the Glennite transducer. These two phenomena combine to cause the Glennite transducer to indicate an extremely high peak (approximately 16 g) at about 8 KC as indicated in the figure.	It is recommended that the existing Glennite transducers be removed from Chrysler built Saturn vehicles and be replaced with one that produces realistic data. A proposed replacement is CEC PN 4-280-0105. It is further recommended that additional experiments be conducted to determine effects of signals greater than 3 KC on frequencies less than 3 KC to determine reliability of single side band telemetry channels. In addition to replacement of the Glennite transducers, increase in the efficiency of the 3 KC low pass filters in the associated UMA amplifiers may also be necessary to obtain reliability of the Vibration Thrust Chamber Dome Measurements.

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01756 (Continued)		The single side band telemetry channels are limited to 3 KC; however, experiments reveal that changing frequencies above 3 KC (for example, 7 KC) has a pronounced effect on data in the 3 KC band spectrum. Therefore, 3 KC data is unreliable when high signals above 3 KC (for example, 7 KC) is present.	
01757	Container Unit Assembly Fuel Tank F-3 60C10011-1 N/A	Post test inspection of the stage immediately after test SA-29 revealed the presence of 5 ripples in the black surface of fuel tank F-3. The position and relative size of these ripples is presented by the following list. STATION / LENGTH / DEPTH 756 / 12 in. / 0.100 in. 700 / 12 in. / 0.075 in. 698 / 14 in. / 0.200 in. 640 / 15 in. / 0.200 in. 638 / 13 in. / 0.250 in.	Temperature measurements installed on the black surfaces on fuel tank F-3 revealed that as the fuel level passed these instrumented surfaces there was a significant increase in temperature change. The temperature measurements installed on white surfaces had no increase in temperature change. It therefore appears that thermal stress causes the formation of these ripples. It is recommended that fuel tanks F-3 and F-4 be painted white on future stages for Static Test. This action should reduce thermal stress in these tanks and cause a more uniform temperature distribution over the surface of these tanks.
01758	Tube Assembly 60C10567-1 N/A	During the process of repairing a leak in the control system at LOX prevalve 5, a bad flare was noted on tube assembly 60C10567-1.	The tube assembly had been over torqued. It is recommended that the tube assembly be replaced at post static checkout in Michoud.
01759	Tube Assembly 60C10565-1 N/A	During the process of repairing a leak in the control system at fuel prevalve 3, a bad flare was noted on tube assembly 60C10565-1.	The tube assembly had been over torqued. It is recommended that the tube assembly be replaced at post static checkout in Michoud.
01760	Valve Assembly Fuel Container Assembly 60C20358 23	Fuel was loaded to 634.5 inches for test SA-29 per procedure 6-CH SIB-230A and the fuel vents were closed for leak check. Fuel valve assembly (S/N 23) failed to give the closed indication. To verify that the vent was closed, the fuel tanks were pressurized and during the pressurization the valve assembly gave the closed indication. The same condition occurred before SA-27. Reference UCR 01739.	The fuel vent valve assembly (S/N 23) was replaced by a similar item (S/N 22). It is recommended that a failure analysis be performed on the Valve Assembly.
01761	Flame Curtain Outboard Engine Static Test 10C11462 N/A	The inboard side of the flame curtains at engines 1, 2, and 4 were damaged during test SA-29 hot firing. Two large holes were burned through the reflective material at engine 4 allowing the boot to become severely burned; one large hole was burned through the reflective material at engine 2 allowing the boot to become severely burned; and the reflective material at engine 1 was burned to the extent that it became dry and brittle. Also, the flame curtains at engines 2 and 4 were observed to burn for approximately 5 minutes following cutoff. NOTE: An old type 10C11462 flame curtain, with the reflective material fitting loosely over the boot, was installed at engine 3 prior to test SA-29. This flame curtain received little or no damage during test SA-29. Normally, engine 3 flame curtain receives the most damage during hot firings at static test.	The 92-S aluminized fabric used on the flame curtains at engines 1, 2, and 4 does not appear to reflect heat as well as the reflective tape and refrasil material used on the flame curtain at engine 3. Also, the 92-S aluminized fabric is bonded to the boots of engines 1, 2, and 4; while the reflective tape and refrasil material hangs loosely about the boot on the old type flame curtain at engine 3. It appears as if the boots are better protected from heat by loose coverings than they are by bonded coverings. It is requested that the old type 10C11462 flame curtains (type used on engine 3 during test SA-29 and on previous stages) be employed on all future stages.

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01762	Recorder Assembly Tape Airborne 50C10338 1028	The amplitude of the tape speed compensation signal for Telemeter F-2 was deviating the RF transmitter approximately 13 KC rather than 20 ± 5 KC during reverse playback of the flight tape recorder.	The F-2 transmitter deviation of the tape speed signal was checked prior to SA-27 and found to be 15 KC. It is believed that the deviation sensitivity of the current F-2 RF assembly is less than the F-2 RF assembly that was onboard prior to SA-27 (original RF assembly was replaced due to the frequency drift). Except for the above discrepancy the unit performed satisfactorily. It was removed from the vehicle, adjusted properly at MSFC Quality Control Laboratory and reinstalled on the vehicle.
01763	Thrust OK Pressure Switch (Inboard) NA5-27446 25387	Test SA-27, which was conducted on July 8, 1965, was automatically terminated 3.002 seconds after ignition command due to Thrust OK pressure (TOP) switch 2 (inboard) S/N 25387 on engine 4 (S/N H-7054) not being picked up prior to commit. The oscillograph data indicated that fuel pump outlet pressure, measurement PP104-4, was 965 psig just prior to commit and that the switch did actuate 257 milliseconds after the cutoff signal was initiated. This TOP switch deactuated 88 milliseconds after actuation at a fuel pump outlet pressure of approximately 810 psig.	Following test SA-27 pressure was applied to the TOP switch (S/N 25387 through the calibration port and through the system port). Actuation and deactuation of the switch was within specification. Therefore, it appears that excessive response time of the TOP switch was responsible for the abort of SA-27. The faulty TOP switch (S/N 25387) was replaced by a new switch (S/N 25426). TOP switch (S/N 25387) was sent to Rocketdyne for a complete failure analysis.
01764	Liquid Level Adapter 50C10699 27	During a LOX tanking test prior to SA-29, the output of each liquid level measurement was observed at a DDAS Ground Station. When LOX covered the probe on LOX tank 0-1 the measurement indicated 40.7 inches of LOX. It should have indicated 40.3 inches.	The improper reading is suspected of being caused by one of two factors: 1. A misadjustment of ratio capacitors inside the liquid level adapter. 2. The liquid level probes being out of tolerance. Except for the improper reading, the measurement appeared to operate normally. It is recommended that the measurement be recalibrated during post static operations at Michoud. The adapter was not removed from S-IB-2 at STTE.
01765	Liquid Level Adapter 50C10699 32	During a LOX tanking test prior to SA-29, the output of each liquid level measurement was observed at a DDAS Ground Station. When LOX had covered the probe in LOX tank 0-2, the measurement indicated 40.8 inches of LOX. It should have indicated 40.3 inches.	The improper reading is suspected of being caused by one of two factors: 1. A misadjustment of ratio capacitors inside the liquid level adapter. 2. The liquid level probe being out of tolerance. Except for the improper reading, the measurement appeared to operate normally. It is recommended that the measurement be recalibrated during post static operations at Michoud. The adapter was not removed from S-IB-2 at STTE.

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01766	Liquid Level Adapter 50C10699 31	During a LOX tanking test prior to SA-29, the output of each liquid level measurement was observed at a DDAS Ground Station. When LOX covered the probe in the center LOX tank, the measurement indicated 41.7 inches of LOX. It should have indicated 40.3 inches.	The improper reading is suspected of being caused by one of two factors: 1. A misadjustment of ratio capacitors inside the liquid level adapter. 2. The liquid level probes being out of tolerance. Except for the improper reading, the measurement appeared to operate normally. It is recommended that the measurement be recalibrated during post static operations at Michoud. The adapter was not removed from S-IB-2 at STTE.
01767	Liquid Level Probe 50C10205 2127	Following test SA-29 the condition of the discrete liquid level probes was investigated. At this time probe 4 of L19-01 produced 33 millivolts across a 500 ohm load at 28 volts applied to the lamps. The minimum output should have been 40 millivolts.	The suspected cause of the low output is that one of its two lamps is burned out. Except for its low output the probe operated normally during test SA-29. It is recommended that the faulty probe be replaced during post static operations at Michoud. Of a total of 135 probes on S-IB-2, six probes became faulty during Static Test Operations. Because of the inaccessibility of these probes (they cannot be replaced at Static Test), and because of the large total number (135 probes), this 4% failure rate is considered high. It is therefore recommended that a search be conducted to find a more ruggedized discrete liquid level probe.
01768	Liquid Level Probe 50C10205 2149	Following test SA-29 the condition of the discrete liquid level probes was investigated. At this time probe 11 of L19-02 produced 10 millivolts across a 500 ohm load at +28 volts applied to the lamps. The minimum output should have been 40 millivolts.	The suspected cause of the low output is that one of its two lamps is burned out or that its prism is out of the probe. Except for its low output the probe operated normally during test SA-29. It is recommended that the faulty probe be replaced during post static operations at Michoud. Of a total of 135 probes on S-IB-2, six probes became faulty during static test operations. Because of the inaccessibility of these probes (they cannot be replaced at Static Test), and because of the large total number (135); this 4% failure rate is considered high. It is therefore recommended that a search be conducted to find a more ruggedized discrete liquid level probe.

UCR NUMBER	PART NAME PART NUMBER SERIAL NUMBER	DESCRIPTION	REMARKS
01769	Liquid Level Probe 50C10205 2119	Evaluation of records of test SA-29 revealed that probe 11 of L20-F1 produced an erratic output. Tests revealed that the output of the probe generated a varying voltage from 50-80 millivolts. This changing voltage causes an apparent intermittent operation of its associated amplifier.	The suspected cause of the intermittent operation is a malfunction of the solar cell. It is recommended that the faulty probe be replaced during post static test operations at Michoud. Of a total of 135 probes on S-IB-2, six probes became faulty during static test operations. Because of the inaccessibility of these probes (they cannot be replaced at Static Test), and because of the large total number (135); this 4% failure rate is considered high. It is therefore recommended that a search be conducted to find a more ruggedized discrete liquid level probe.
01770	Liquid Level Probe 50C10205 2122	The resistance readings of the solar cell is extremely low (15K ohms) compared to the other solar cells (50K to 200K ohms), resulting in a low voltage output and a possibility of the probe not operating during flight. This is probe 14 of L20-F1.	The cause may be attributed to one of two factors: 1. Solar cell plates opening up. 2. Breakdown of solar cell resistance. The probes operated at correct time during static firing; however, No. 14 was inhibited by the noise caused by No. 11. Of the total of 135 probes on S-IB-2, six probes became faulty during Static Test Operations. Because of the inaccessibility of these probes (they cannot be replaced at Static Test), and because of the large total number (135 probes), this 4% failure rate is considered high. It is therefore recommended that a search be conducted to find a more ruggedized discrete liquid level probe.
01771	Liquid Level Probe 50C10205 2094	Evaluation of records of test SA-29 revealed that probe 1 of L20-F2 produced an erratic output. Tests revealed that the output of the probe generated a varying voltage from 43-53 millivolts (approximately). This changing voltage causes an apparent intermittent operation of its associated amplifier.	The suspected cause of the intermittent operation is a malfunction of the solar cell and/or failure of 1 light in the probe. It is recommended that the faulty probe be replaced during post static test operations at Michoud. Of a total of 135 probes on S-IB-2 six probes became faulty during static test operations. Because of the inaccessibility of these probes (they cannot be replaced at Static Test), and because of the large total number (135), this 4% failure rate is considered high. It is therefore recommended that a search be conducted to find a more ruggedized discrete liquid level probe.

UCR NUMBER	PART NAME / PART NUMBER / SERIAL NUMBER	DESCRIPTION	REMARKS
01772	Harness, Liquid Level 50C10208 --	The resistance readings of the solar cell common lead (pin 20) to vehicle ground on the discrete liquid level harness assembly is extremely low compared to the harness in the other systems. The plus resistance to vehicle ground, using a Triplett 630 ohmeter, reads from 25 X 100K to 75 X 100K ohms as the solar cells charge. In reverse polarity it reads 12 X 100K to 200 X 100K ohms as the cells charge up. Normal readings are 1000 X 100K ohms in both directions.	The probable cause is that the harness may have a nick or cut along its length permitting voltage leakage to vehicle skin. It was also noted that the current driving this system is approximately 200 milliamps higher than comparable tanks. The system operated normally during drain and showed a double pulse during static firing. Of a total of 135 probes on S-IB-2, six probes became faulty during static test operations. Because of the inaccessibility of these probes (they cannot be replaced at Static Test), and because of the large total number (135 probes), this 4% failure rate is considered high. It is therefore recommended that a search be conducted to find a more ruggedized discrete liquid level probe.
01773	Receptacle 10C20548 --	Following test SA-29, arrangements were made to perform a DDAS (calibration test Procedure 3-CH SIB-518). For this test, flight measurements are removed from the input of the telemetry-DDAS system by disconnecting flight cables at the top of instrumentation compartment 13. A precision input voltage is applied when a ground cable is connected at this point. During the process of connecting the cable the insert around pins KK, LL, and PP was slightly damaged. (Reference UCR 01774)	The insert was damaged because of slight misalignment of the connector during mating. Personnel have been instructed to use great care when mating all connectors.
01774	Wiring List 60C40322 --	Following test SA-29, arrangements were made to perform a DDAS calibration test (procedure 3-CH SIB-518). For this test, flight measurements are removed from the input of the telemetry-DDAS system by disconnecting flight cables at the top of instrumentation compartment 13. A precision input voltage is applied when a ground cable is connected at this point. During the process of connecting these cables, pins KK, LL, and PP were slightly bent (approximately 5 degrees off vertical). Reference is made to UCR 01773.	The pins were bent because of slight misalignment of the connector during connection. The pins were carefully straightened and the connectors were properly mated. Personnel have been instructed to use great care when mating all connectors.
01775	LOX Prevalve 60C20339 114	The LOX prevalve on engine 8 failed to give a closed indication at cryogenic temperatures when it was closed immediately following test SA-29. The closed indication was received after the valve had achieved ambient condition.	The probable cause is either that the actuator piston froze or the position switches failed to actuate at cryogenic temperature. This is a reoccurring problem on many LOX prevalves and it is recommended that failure analysis be performed on the prevalve.
01776	LOX Prevalve 60C20339 105	The LOX prevalve on engine 7 failed to give a closed indication at cryogenic temperature when it was closed immediately following test SA-29. The closed indication was received after the valve had achieved ambient condition.	The probable cause is either that the actuator piston froze or the position switches failed to actuate at cryogenic temperatures. It is recommended that a failure analysis be performed on the prevalve.