9.2 PROPELLANT LOADING AND PRESSURIZATION SYSTEM

9.2.1 General

The flight test of Missile VS-1 was performed on 3 May 1961. Fuel loading was initiated at R-12 hours after successfully completing the PLPS automatic checkout per Procedure 644F-2. Fuel loading was completed without incident with a maximum flow rate of 285 GPM being obtained. Lox loading was initiated at R-115 minutes. Flow rates were approximately 235 GPM from Truck No. 1 (1627), 200 GPM from Truck No. 2 (1035), and 182 GPM from Truck No. 3 (185). The flow rate from Truck No. 4 (182) was not calculated due to insufficient information. Truck Nos. 1 and 2 operated at a nominal pressure of 45 PSIG. Truck Nos. 3 and 4 were equipped with an automatic pressurization system set up for 25 PSIG. Lox loading was complete at R-22 minutes. This was 13 minutes ahead of alloted countdown time. Review of the PLPS film coverage indicates that the 100.5% point sensor was extinguished at 13:08:01 or R-42.7 seconds although it did illuminate several times after the lox tank was pressurized. T-120 seconds occurred at 13:08:43.7 and T-0 seconds at 13:10:43.7. The PLPS systems appeared to function normally throughout the count. No adverse effects were encountered due to loss of umbilical 3B4E and the electrical umbilicals being released by the mechanical lanyard back up. Record of PLPS events are shown in Figure 9-1.

9.2.2 Launch Observations

The launch test of VS-1 missile, SLTF, was performed on 3 May 1961. T-120 seconds was initiated at 1308:43.7, and all events proceeded normally with respect to Propellant Loading and Pressurization System operation with T-0 being reached at 1310:43.7. The missile Propellant and Pressurization System appeared to operate normally from T-120 until missile burnout. From observation of film coverage of the Propellant Loading and Pressurization System pallet during the launch, a loss of Stage I lox tank pressure indication at approximately T+2.3 seconds was detected. Upon further investigation and inspection of the telemetry records, it can be determined that no loss of Stage I lox tank pressure occurred at this time. It can be concluded that the Stage I lox tank pressure indication, which is received through 3B4E electrical umbilical, was lost by the PLPS pallet due to the detachment of the 3B4E electrical umbilical.

CHANNEL	FUNCTION	REAL TIME (ON)	REAL TIME (OFF)	T-TIME ON	T-TIME OFF
4	Press Fuel Tanks	13:08:48.7	13:08:49.7	T-115	T-114
5	Missile Tanks Press	13:09:28.3	----------	T-75.4	------
6	Start Hydraulics	13:08:43.7	13:08:44.7	T-120	T-119
7	Bleed Lox Tank	13:10:08.6	13:10:09.6	T-35.1	T-34.1
8	CK Lox Probe Disc	13:10:42.7	13:10:43.7	T-1	T-0
9	OSBVPV	13:10:08.6	13:10:43.7	T-35.1	T-0
15	Fire Engines	13:10:43.7	13:10:44.7	T-0	T+1
25	Lift Off	13:10:52.7	----------	T+9	-----
27	Shutdown	13:10:51.7	----------	T+8	-----
36	St. I Lox Tk. Press Normal	13:09:26.8	13:10:46.0	T-76.9	T+2.3
37	St. I Fuel Tk. Press Normal	13:08:49.6	13:10:49.1	T-114.1	T+5.4
38	St. I Fuel Tk. Vent Valve(s)	13:08:49.0	13:10:49.1	T-114.7	T+5.4
39	St. I He ACC Press Norm	Prior to T-120	13:10:49.1	Prior to T-120	T+5.4
41	St. I He. Tk. Press Norm	Prior to T-120	13:10:48.5	Prior to T-120	T+4.8

PLPS EVENT RECORD FOR SLTF FLIGHT TEST

VS-1 MISSILE 3 MAY 1961

FIGURE 9-1

9.2.2 (Cont'd)

By observations of film coverage and other inspection means, it was determined that 1B1A air conditioning umbilical was torn free of the missile and launch duct attachment and was ejected upward through the launch duct during the initial pressure pulse at ignition. The remnants of this umbilical was recovered (intact and undamaged with the exception of the loss of the quick disconnect) approximately 100 yards southeast of the silo.

Other kinescope observations disclosed that electrical umbilicals 3B4E, followed 0.4 seconds later by 3B3E, were detached from the missile at approximately T+2.3 seconds. The apparent cause of this detachment was due to the downward plunge of the 2B1A air conditioning umbilical after it was torn free of its attachments due to the downward rush of air pressure existing in the launch duct during engine thrust build-up.

9.2.3 Post Launch Observations

1. Pressurization and Propellants

Damage to the facility Propellant Loading and Pressurization System during the launch of VS-1 missile was contained in the SLTF launch duct and directly associated to the facility umbilicals in the form of heat and blast damage. Evidence of fire and extremely high temperature damage is apparent on all umbilicals brought about by the thrashing action as the umbilicals became subjected to the thrust envelope of the booster engine. Undetermined internal damage may exist in some umbilicals which would permit leakage of associate system fluids. All systems were secured per applicable Procedures 642C-2 and 640F-4 to prevent the possible leakage of system fluids through the damaged umbilicals.

2. Launch Duct

The following information contains a detailed study of the damage incurred by the Propellant Loading and Pressurization System umbilicals:

1E2L (OSBV) Flex hose is stripped of braided wire protective covering from quick disconnect to flange attachment of rigid discharge line. Flex bellows is stretched and burned through at one area. Bellows material is brittle and discolored due to extreme heat.

1E3L (OSBV) Flex hose is stripped of braided wire protective covering from quick disconnect to flange attachment of rigid discharge line. Flex bellows is stretched and has become permanently set due to tempering effect of extreme heating. No burning through of bellows is apparent but bellows is completely discolored and retains none of the original flexibility.

1E1L (Lox Fill Probe) The lox fill probe displays evidence of surface fire which consumed the electrical harness, switches, and terminal connections. The hanger attachment was torn free from the probe allowing the unsupported end to deflect downward from the force of the engine thrust causing bending of the probe and associated plumbing. The protective housing and electrical control junction box were torn free of the probe assembly and destroyed by the blast force and fire.

1E1N (Nitrogen Start) The flex hose is intact and appears to be physically undamaged with the exception of evidence of fire and heat damage. The flex hose is blackened and discolored as a result of fire and heat. It is believed that the damage to this flex hose is superficial. No further investigation has been made to confirm this conclusion.

3D1He (Stage I Pressurization) This umbilical is physically intact and displays signs of fire and heat damage to the braided wire covering. The flex hose and quick disconnect became saturated with hydraulic oil due to the leakage of the hydraulic pressure umbilical after disconnection from the missile. The internal teflon lining of this flex hose has melted and burned during the hydraulic oil fire in the launch duct after launch.

3D1N (Stage I GG Purge) This umbilical remained intact with evidence of fire and heat damage to both the quick disconnect and flex hose. The umbilical became saturated with hydraulic oil which was ignited and burned, resulting in damage to the quick disconnect and seals, flex hose braided wire wrapping and teflon lining.

3D2N (OSBV Actuation) This umbilical remained intact with evidence of fire and heat damage to both the quick disconnect and flex hose. The umbilical became saturated with hydraulic oil which was ignited and burned resulting in damage to the quick disconnect and seals, flex hose braided wire wrapping and internal lining.

3D5N (Stage I Pneumatics) This umbilical remained intact with evidence of fire and heat damage to both the quick disconnect and flex hose. The umbilical became saturated with hydraulic oil which was ignited and burned resulting in damage to the quick disconnect and seals, flex hose braided wire wrapping and internal lining.

3B1He (Stage II Pressurization) This umbilical remained intact with evidence of fire and heat damage to both the quick disconnect and flex hose. The flex hose and quick disconnect are blackened and discolored by the heat of engine exhaust.

3B2N (Stage II Pneumatics) This umbilical remained intact with evidence of fire and heat damage to both the quick disconnect and flex hose. The flex hose and quick disconnect are blackened and discolored by the heat of engine exhaust.

1C1LV (Stage I Lox Vent) The umbilical flex hose and connector are basically undamaged with the exception of blackened and slight discoloration of braided wire protective covering. The electrical actuation harness displays evidence of fire and extreme heat as well as the exterior switches and connections. It is believed that this flex hose and connector can be restored to usable condition, however, no further investigation has been made to confirm this conclusion.

3. Equipment Areas

A complete and detailed inspection of the SLTF equipment areas disclosed no visible damage sustained to the Propellant Loading and Pressurization System, associated equipment and systems. The operating status of each system located on appropriate levels of the silo equipment areas is assumed to be in a completely re-usable condition as indicated by the original emplacement of all operational equipment and the exclusion of any system fluid leakage. All systems were secured per applicable procedures and no further investigation was made to confirm this conclusion. The nitrogen start system still remained pressurized to a value of 2600 PSIG after launch indicating no damage to the Pressurization System and the associate storage vessels and plumbing in the equipment area.

The facility water ballasting system indicates no damage and is considered to be in a completely operational condition. The facility fuel transfer system indicates no damage and is considered to be in a completely operational condition. The Facility Lox Loading System sustained damage only in the vicinity of the launch duct and directly associated to the lox fill probe and OSBV discharge plumbing. All other components of the Lox Loading System indicates no damage and is considered to be in a completely operational condition.

4. Above Ground - Helium System

During the interval of usage of the Facility Helium System for the flight test, the following facts were evidenced:

a. At R-15 and prior to commencing the T-120 count-down, helium storage supply pressure was recorded at 5100 PSIG.

b. At the termination of the T-count and initial inspection of the helium storage supply pressure after launch, a recording of the remaining pressure was made at 2700 PSIG.

c. Helium fill bleed valve (SOV 615) remained in the open position from approximately R-1 hour until the system was secured at which time the valve was de-energized closed due to the loss of PLPS GOE power.

It is quite probable that the excessive loss of helium supply pressure was due to the damage of Stage I pressurization umbilical 3D1He as previously mentioned, which allowed the helium to flow from the storage vessels through the helium fill bleed valve and through the heat and blast damaged umbilical during the period of time the helium fill bleed valve remained open. No further attempt to determine the exact cause of leakage has been made since securing the system. The Helium System is believed to be in a completely re-usable condition with the exception of the Stage I pressurization umbilical.

5. Above Ground - Nitrogen System

During the interval of usage of the Facility Nitrogen System for the flight test, the following facts were evidenced:

a. The 150 PSI Nitrogen System contained a storage supply pressure of 2300 PSIG at the conclusion of the terminal countdown. An inspection of this system after launch verified the supply pressure was still indicating 2300 PSIG.

b. The 1500 PSI Nitrogen System contained a storage supply pressure of 2100 PSIG at the commencing of the terminal countdown. Inspection of this system after launch revealed a loss of nitrogen to a value of 1100 PSIG remaining in the storage supply vessel.

c. Stage I and Stage II pneumatic valves (SOV 544 and SOV 540 respectively) were energized closed at T-5 seconds and remained closed until T+8 seconds at which time the valves were de-energized to open at shutdown signal.

It is believed that the excessive loss of nitrogen of the 1500 PSI system occurred after the Stage I and Stage II pneumatic valves were de-energized and came open at the shutdown signal allowing pneumatic pressure to flow through the damaged pneumatic umbilicals 3B2N and 3D5N. No further effort has been expended to justify the foregoing theory since securing of the Nitrogen System per Procedure 642C-2. It is believed that the Facility Nitrogen System can be completely restored to operational status with the replacement of the damaged nitrogen umbilicals.

6. Above Ground - Propellant Loading Areas

A detailed and thorough inspection of both the fuel and lox ground level loading areas indicate no damage incurred to these systems during the launching exercise. The systems were secured at the completion of propellant loading prior to commencing the terminal countdown for the launch and visually show no effect in the form of damage during the launching. Both the fuel and lox ground level loading areas are considered to be in a completely operational and re-usable condition.

7. 2500 Chassis and Inter-Connecting Wiring

The 2500 chassis performed as designed until T+10.3 seconds at which time an electrical short circuit was experienced in the launch duct causing the loss of all indication except PLPS GO, fuel load, load lox, and fill and drain valve heater. The fill and drain valve heater indication was extinguished approximately 5 seconds later due to a short circuit in the operate bus in the launch duct wiring. The remaining indications are illuminated from busses contained in the chassis.

Inspection of the PLPS wiring in the silo equipment area and launch duct indicate that no damage was sustained to the electrical wiring outside the launch duct.

Restoration of the system to an operational condition would require replacement of all PLPS cables from junction boxes to the end function in the launch duct.

9.2.4 Actual Lift Off Weight

Dry wt. with Mark IV Re-Entry Vehicle	17, 692	lbs.
Stage II LOX 3,020 Gal (water)	25,200	lbs.
Stage II Fuel 2,035 Gal (water)	16,950	lbs.
Stage I Fuel 7,746 Gal	52,250	lbs
Helium	56	
Lubricant	18	
Stage I LOX 117,638 lb. less boiloff	117,595	
Loaded wt. at T-120 sec.	229,761	
Less Start & Ground losses (estimated)	7,812	
Actual lift off wt.	221,949	

9.2.5 Missile Tank Pressurization Data (Reference Figure 9-2)

Stage I LOX Tank (nominal)	37.5	PSIA
Stage I Fuel Tank (nominal)	28.1	PSIA
Stage II LOX Tank (nominal)	34.3	PSIA
Stage II Fuel Tank (nominal)	35.8	PSIA

Stage I LOX Tank pressure appeared stable until approximately T+10 seconds. It then underwent a steady decay to burnout pressure which was 21.4 PSIA. Stage I Fuel Tank pressure started to decay at approximately the same time as LOX tank pressure decay started. The pressure at burnout was 12.7 PSIA. Stage II LOX tank pressure remained stable until burnout at 34.3 PSIA and Stage II Fuel tank pressure was also stable to burnout at 35.8 PSIA. Missile tank pressures, including the decay rate on Stage I LOX and Fuel tanks are normal.

T-Time	Real-Time	Stage I LOX (PSIA)	Stage I Fuel (PSIA)	Stage II LOX (PSIA)	Stage II Fuel (PSIA)
T-120	13:08:43.7	16.75	16.1	15.3	15.3
T-115		16.75	16.1	15.3	15.3
T-110		16.75	29.3	15.9	15.3
T-105		16.75	29.3	21.6	21.6
T-100		16.75	28.1	26.3	26.8
T-95		16.75	28.1	32.95	33.25
T-90		----	----	----	----
T-85		----	----	----	----
T-80		16.75	28.1	34.3	35.8
T-75		36.2	28.1	34.3	35.8
T-70		36.8	28.1	34.3	35.8
T-65		36.2	28.1	34.3	35.8
T-60	13:09:43.7	36.8	28.1	34.3	35.8
T-55		37.5	28.1	34.3	35.8
T-50		----	----	----	----
T-45		37.5	28.1	34.3	36.5
T-40		37.5	28.1	34.3	35.8
T-35		37.5	28.1	34.95	35.8
T-30		37.5	28.1	34.3	35.8
T-25		37.5	28.1	34.3	35.8
T-20		----	----	----	----
T-15		37.5	28.1	34.3	35.8

MISSILE TANK PRESSURE DATA

FIGURE 9-2

T-Time	Real-Time	Stage I LOX (PSIA)	Stage I Fuel (PSIA)	Stage II LOX (PSIA)	Stage II Fuel (PSIA)
T-10		36.2	28.1	34.3	35.8
T-5		36.2	28.1	34.3	35.8
T-0	13:10:43.7	36.2	28.1	34.3	35.8
T+10		36.2	26.8	34.3	35.8
T+50		29.5	20.1	34.3	35.8
T+100		21.4	13.4	34.3	35.8
T+125		21.4	12.7	34.3	35.8
Burnout	13:13:01.5	21.4	12.7	34.3	35.8

FIGURE 9-2 (Continued)

9.2.6 Commodity Data

RP-1 conforming to Specification MIL-R-25576B; liquid oxygen conforming to Specification MIL-P-25508C; helium conforming to Grade A as produced by the Bureau of Mines; nitrogen conforming to Specification MIL-P-27401A, Type I; commercially available water; and hydraulic fluid conforming to Specification MIL-H-6083B were the commodities used. The sample analyses, as applicable, are listed below.

1. RP-1

Quantity: 7,746 Gal

Trailer # 330		Trailer # 331	
Temperature 62°		Temperature 62°	
Purity (NA)		Purity (NA)	
Dissolved H_2O	40 PPM (by wt.)	Dissolved H_2O	63 PPM (by wt.)
Free H_2O	0	Free H_2O	0
Total Solids	0 (Non filt.)	Total Solids	0 (Non filt.)

Particle Count (Microns)

40-150	31	330
150-300	1	8
300-750	0	2
150-1000	0	0
1000+	2 (Fibers)	3 (Fibers)

The RP-1 was processed through an above ground filter/dewatering unit and a 10 micron filter F-107 prior to being introduced into the missile.

2. Liquid Oxygen

Quantity: 117,638 lbs.

Trailer #	1627	1035	185	182
Purity	99.85%	99.83%	99.85%	99.8%
Vol Hyd/Carbons	6.7 PPM	6.7 PPM	7.3 PPM	7.5 PPM
Acetylene	0	0	0	0

9.2.6 (Cont'd)

Total Solids	0.1 Mg/Ltr	0.1 Mg/Ltr	0.1 Mg/Ltr	0.1 Mg/Ltr
Particle Count (Microns)				
40-150	690	860	3060	2200
150-300	5	9	50	6
300-750	3	0	3	2
750-1000	0	0	0	0
1000+	7 (fibers)	4 (fibers)	4 (fibers)	4 (fibers)

The liquid oxygen was processed through two 10 micron filters prior to being introduced into the missile.

3. Nitrogen

	Trailer # 056	Trailer # 322
Dew Point	-72°F	-74°F
Vol Hyd/Carbon	0	0
Acetylene	0	0
Particle Count (Micron)		
40-150	24 (Plastic)	18 plastic
150-300	1 (Plastic Fiber)	2 (fibers)
300-750	0	0
750-1000	0	0
1000+	0	0

The nitrogen supply was passed through two 10 micron filters prior to being introduced into the system. All of the GN_2 systems were maintained at a level above the minimum requirement as defined in the BMD specification.

4. Helium

Sample taken down stream of Control Point 1902

Trailer # 59L54

Dew Point -90°F

Vol Hyd/Carbon 0

Acetylene 0

	Particle Count (Microns)
40-150	8 (Plastic fibers)
150-300	0
300-750	0
750-1000	0
1000+	0

The helium supply was passed through two 10 micron filters prior to being introduced into the missile. The Helium System was maintained at a level above the minimum requirements as defined in the BMD specification.

5. Ballast Water

Quantity:	Stg. II	LOX Tank	3020 Gal
	Stg. II	Fuel Tank	2035 Gal

No provisions are provided at the SLTF Site to filter or condition the water used for ballast loading. The water used was obtained from a commercially supplied source.

6. Hydraulic Fluid

Quantity: 30 Gal (Approx.)

Total Solids 0.2 Mg/Ltr

Particle Count (Microns)

0-25	750
25-100	70
100+	5

9.3 INSTRUMENTATION

9.3.1 Condition of Data

The general quality of data obtained in the operation was excellent. Ninety-eight per cent of all scheduled measurements were obtained. All primary objectives and secondary objectives SA-1c, SA-6, and SB-2 were fulfilled.

9.3.2 Landline (Appendix A)

1. CEC

   All CEC's functioned properly. Base timing appeared properly on all records. All measurements were recovered with the exception of SL0044 and SL0045. These two measurements (L4 differential pressures) did not appear on the records at any time. No further discrepancies thus far have been uncovered.

2. Strip Charts

   SL3341, 3342 and 3343 were programmed and operated normally.

3. Events Recorder

   All channels operated normally. Lift-off signal (Channel 25) did not function until T+9. Telemetry data showed this same reading indicating the problem to be in the lift-off circuit and not the events recorder. Kinescope film indicates missile first motion (T+5.4).

4. Magnetic Tape

   All measurements appear to have performed properly except for the following:

   SL0067: Unreasonably high reading, and could not be balanced subsequent to the launch.

   SL3003: Electrical noise (transients) in output. In addition, signal was lost at T+5.1 seconds.

SL3004: No data obtained after T+5.1 seconds.

SL3005: No data obtained after T+5.1 seconds.

SL3006: Center frequency drifted to band-edge immediately after ignition. No data.

SL3008: Electrical transients present in output prior to and during engine firing. Center frequency drifted to 50% of band-edge soon after ignition. No data.

There is presently no positive explanation for the loss of these measurement channels. However, there is no indication that they malfunctioned because of inadequate installation, calibration, or checkout operations. Representative overall sound pressure levels as a function of time after FS-1 are plotted on Figures 9-3, 9-4, and 9-5

9.3.3 Telemetry (Appendix B)

1. Signal Strength

Prior to fire engines, signal strength was below optimum level. Some dropouts occurred prior to T-0. At T-0, signal strength was reading 15 mv; at T+1.9 this level increased to 50/100 mv. At T+8 seconds, the signal strength increased to 2K uv and then settled down to 1K uv at 180.5 seconds (destruct). Signal strength dropped for two seconds at this time and then returned at 20/50 mv until T+416. Investigation of low levels prior to T-0 is continuing and appears to be an antenna problem.

2. Data Taken

All channels appear to have functioned properly with the exception of Thrust Chamber #1. This parameter read 680 PSIA which is 102 psi above expected value. Further investigation indicated a transducer zero level shift during thrust build-up. Measurements 535, 537, 540 and 541 performed properly in the initial phases of flight. Data on these measurements went off scale at the times indicated in Appendix "D".

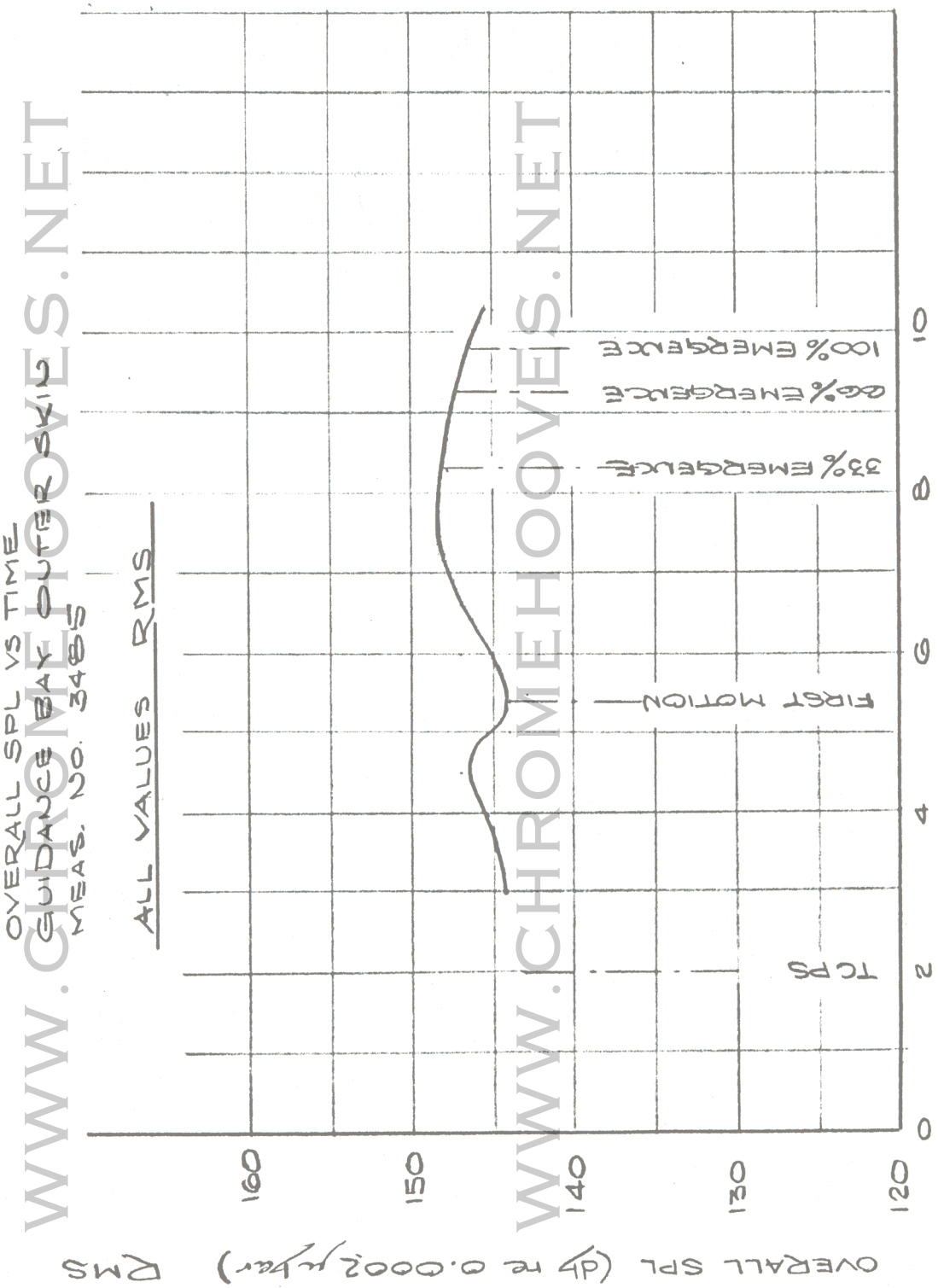

FIG 9-3

OVERALL SPL VS TIME
INTERSTAGE OUTER SKIN
MEAS NO 3486

ALL VALUES RMS

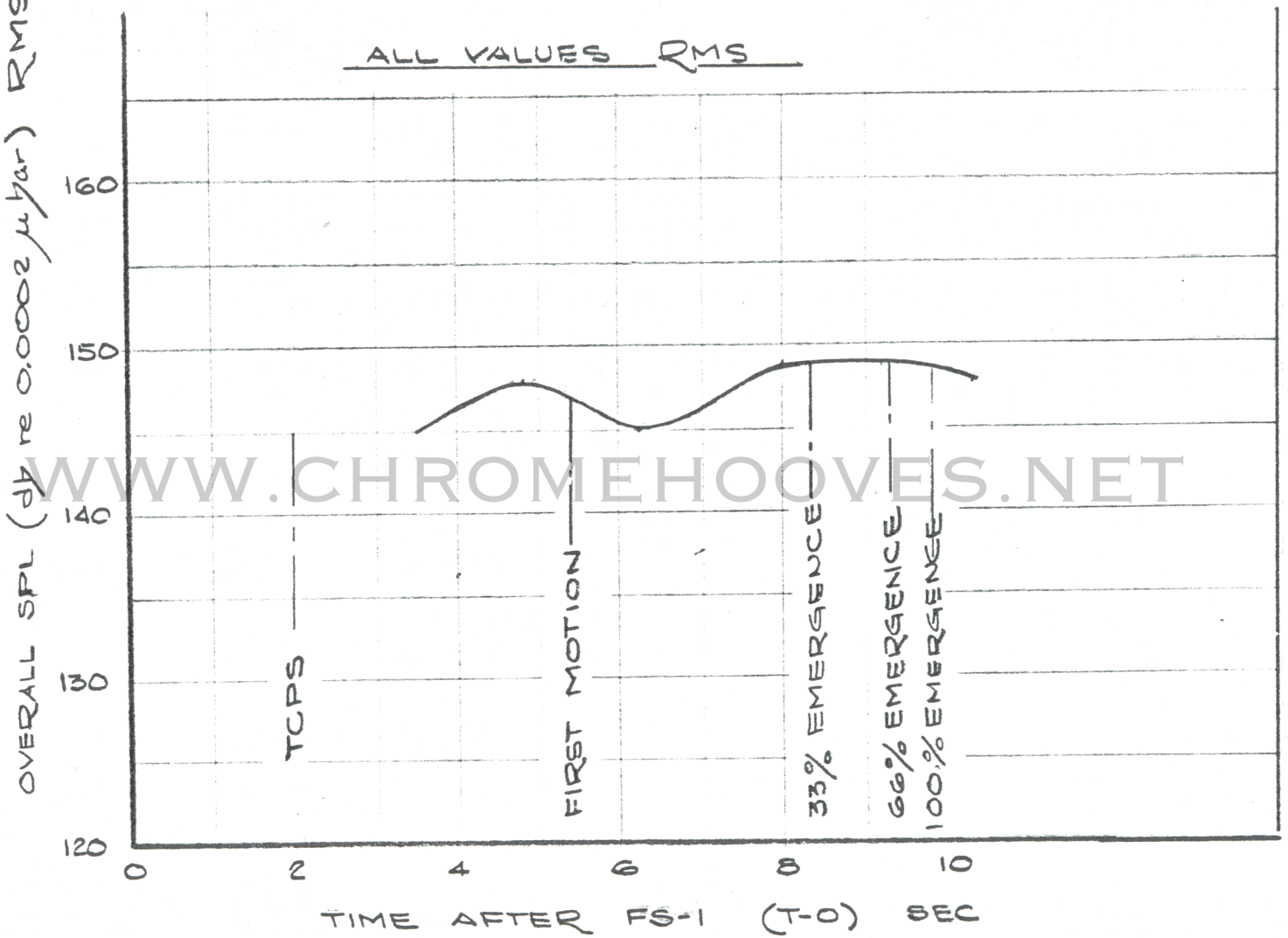

FIG. 9-4

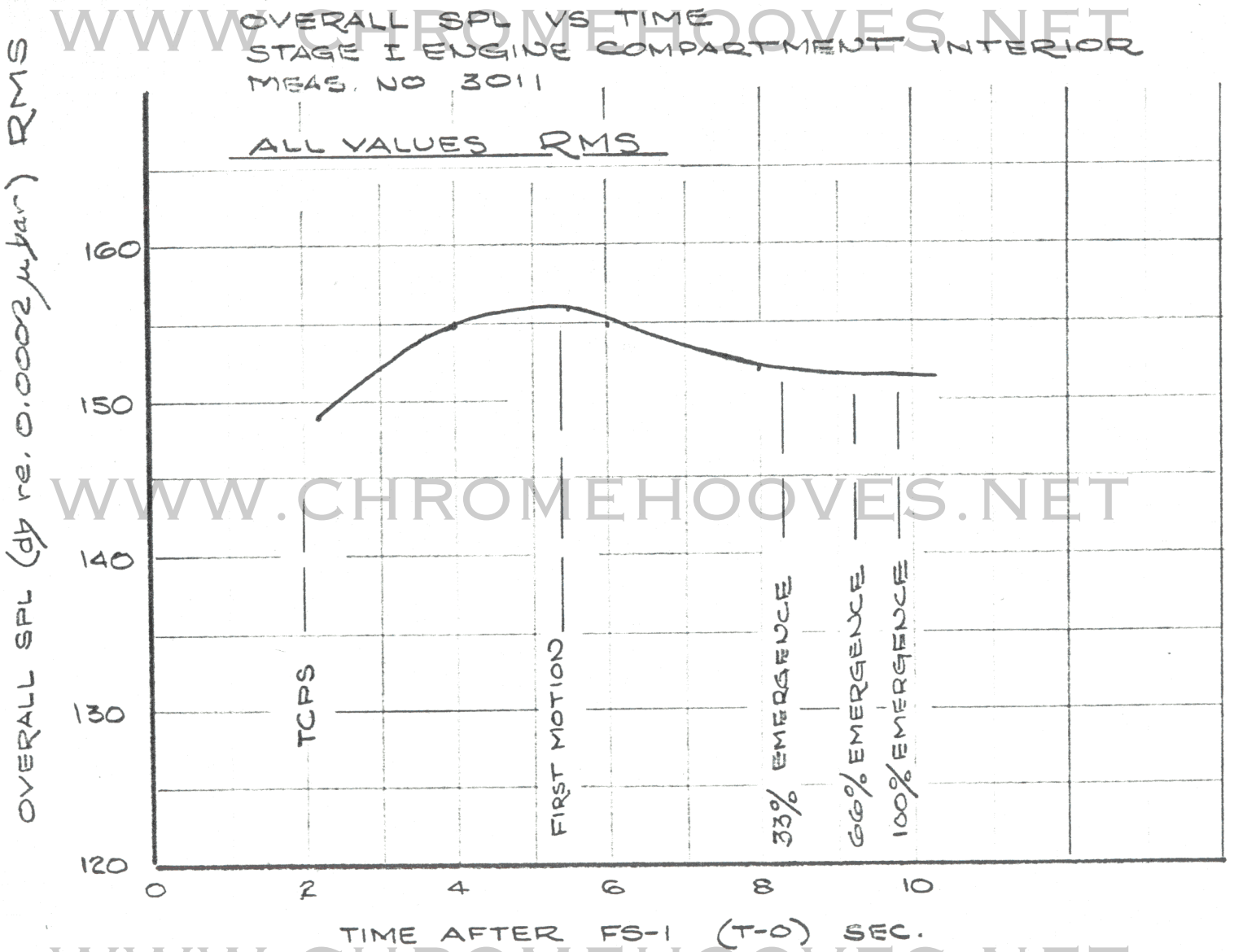

FIG. 9-5

9.4 FLIGHT CONTROLS

9.4.1 General

The Flight Controls Data used in preparing this report was obtained from a play back having an accurate timing reference.

9.4.2 Performance

1. Program

Normal program initiate occurred at lift-off (lanyard pull).

2. Summary

The following table outlines the significant Flight Controls System events occurring during the flight.

Item No.	Event	Time - Seconds after Program Initiate (Lift Off) Actual	Predicted
1	Wind Correction	2.6	N/A
2	Roll Program Start	9.0	9.0
3	Roll Program Stop	18.0	18.0
4	Pitch Program Start	20.0	20.0
5	"Max. Q" Disturbance	41 - 56	Unknown
6	Rigid Body Oscillations	65 - 90	Unknown
7	Rate Gyro Disturbance	106 Burnout	N/A

3. General

Flight Controls subsystem performance was satisfactory and usable information was obtained from all channels monitoring this subsystem except measurement 259, Stage II Yaw Rate Gyro Output. Data indicates that a missile pitch and yaw disturbance started as the nose cone emerged from the silo and continued until the

booster engine had cleared the silo (See Para. 6.10.1 for details). The Stage I and II Pitch Rate Gyros indicated approximately 15 seconds of high frequency oscillation as noted in Para. 9.4.2 (2). The amplitude of these oscillations were 2 deg/second p-p (max.) on the Stage I Pitch Rate Gyro and 1.6 deg/second p-p on Stage II. These oscillations are suspected to be caused by traversing the "Max Q" region, and occur earlier than normal during this flight. Explanation of this phenomenon will require more detailed analysis. The Stage I and II Pitch Rate Gyros and all actuators indicated 1/2 cps rigid body oscillations at an amplitude of 0.4 deg/second p-p. This value appears constant for the 25 second period, as noted in Para. 9.4.2(2), and then decays to steady state. The Stage I Pitch Rate Gyro indicated high frequency oscillations as noted in Para. 9.4.2(2), Item 7. Explanation of this phenomenon will require more detailed analysis. Examination of the recordings from this flight in the region of T+96 seconds to burnout did not reveal the anticipated stability data. The significance of the data obtained must be determined by a more thorough and detailed analysis.

9.5 ELECTRICAL

9.5.1 Airborne Electrical

All elements of the airborne electrical system performed as planned. The instrumentation data related to electrical performance was acquired and reflected satisfactory operation of the airborne system throughout flight. The operation of the APS Inverter was satisfactory throughout the flight as indicated by measurements VS0481 (T/M) and SL 3431 (landline). The output voltage was stable at 117.5 volts for phase A on the T/M measurement. However, the output voltage as measured during sub-system checkout at R-14 hours was 115.5 volts.

The APS D.C. voltage was satisfactory throughout the flight. Measurement VS 0507 indicated the voltage to be 27.0 volts at T-0 and at the end of data with maximum excursion of 1.0 volts throughout the flight.

The output voltage of the transformer rectifier was satisfactory at 25.0 volts throughout the flight (VS 0114).

The indications of staging sequence time operations were similar to previous tests with no apparent change due to the flight environment. The RATO signal occurred at T+139.8 seconds and sustainer engine start at T+141.3 seconds.

9.5.2 Umbilical Behavior

Data acquired via kinescope and event records indicate that the electrical umbilicals (excepting 3B3E and 3B4E) were disconnected by missile motion at T+5.4 seconds. Operation of the back-up lanyard disconnect was satisfactory.

Umbilical 3B4E was disconnected at T+2.3 seconds by a falling object. Umbilical 3B3E was disconnected at T+2.6 seconds when a falling air conditioning umbilical struck the lanyard cable on this umbilical. Loss of data from the instrumentation fly-away umbilical occurred at T+10.3 seconds. (Although this would indicate disconnect of 3B1T at this time, the film camera data shows disconnect at about 11.1 seconds).

9.5.3 Missile Release

The missile was released at T+5.1 seconds when the explosive bolts were detonated.

The lift-off switches did not function and as a consequence the disconnect signal for the electrical umbilicals was not generated. The shutdown circuits were re-enabled at T+8 seconds and the Ground Operating Equipment received the shutdown signal at this time. The shutdown was a result of NO/GO signals which had been displayed by the Engine Control and Flight Controls Systems at umbilical disconnect. The lift-off relay in the Accessory System was de-energized at T+9 seconds generating the lift-off signal. The appearance of the signal at this time is attributed to flame damage to cabling within the launch duct.

The malfunction of the lift-off switches was apparently due to shock from explosive bolt detonation. Mechanical damage prevented one of the switches from opening when the missile lifted off. The switches and wiring were subsequently destroyed by the engine blast.

9.5.4 Ground Operating Equipment

The Ground Operating Equipment functioned properly throughout the terminal countdown. The subsystems "NO-GO's" displayed by the ECS and FCS at T+5.4 seconds are normal system reaction to umbilical disconnect. Operation of lift-off switch circuit is covered under objective SA-4. All events measurements related to GOE were acquired.

The fire damage to cabling in the launch duct after lift-off caused short circuits in the lift-off switch wiring and umbilical circuits, tripping circuit breakers on the Accessory Supply power distribution system. The loss of these 28 volt supply voltages to the Accessory Supply and Propellant Loading Systems caused loss of panel indications. The "NO/GO" status of the Flight Controls system at umbilical disconnect was due to the disconnection of umbilical 3D2E through which the system was monitoring the Stage I engine actuator null position.

The open umbilical appeared to the system as an actuator off null position.

The Engine Control System displayed a "NO/GO" on the LCCC at T+5.4 seconds because the lift-off signal did not precede umbilical disconnect. The lift-off signal, normally generated prior to umbilical release, is supplied to the Engine Control System to disable the monitor of engine functions. Therefore, absence of the lift-off signal at umbilical release resulted in the open umbilical appearing to the system as an engine malfunction.

9.5.5 Electrical Damage

Damage to GOE wiring and hydraulic lines in the launch duct was in general no more than anticipated and consisted of the following:

1. Electrical Umbilicals

All electrical umbilicals were damaged to the extent that replacement would be required for further use of the facility. Damage consists of insulation breakdown due to heat, melting of potting and rubber jacket and charring of umbilical connector face-plate by the engine blast. Damage to umbilicals was confined to the launch duct. All umbilicals had been wrapped with asbestos and aluminum tape with 50% overlap in wrapping. Wrapping was from the umbilical connector to the fire-wall conduit. On Levels 3 and 5, all of the aluminum tape and about 20% of the asbestos was destroyed by engine blast. As would be expected, damage to the umbilicals was most extensive where wrapping had been destroyed. Umbilical cables on Level 1 were the least damaged with approximately 90% of aluminum and 15% of the asbestos wrapping destroyed by engine blast.

2. Lift-Off Switches

Lift-off switches, the mounting hardware and wiring, were destroyed during the launch. The two lift-off switches were mounted on the thrust ring near explosive bolts and a two wire cable, wrapped with reflective tape was routed through the launch duct wall to each switch. These cables were routed under the ring to provide maximum protection from the engine blast.

3. Holddown Bolt Cabling

The explosive bolt cables were burned beyond repair during the launch. These four cables were wrapped for heat protection and had satisfactorily performed their function.

4. Hydraulic Umbilicals

Umbilical 3D1H and 3D2H (hydraulic pressure and return umbilicals) were charred with evidence of hydraulic oil on 3D2H. Umbilical 3D1H was ruptured at the junction of the connector and the umbilical (cause unknown). The oil level in the C216 (hydraulic unit) was approximately 75% empty, indicating the loss of about 20 gallons through the break in 3D1H.

9.6 ORDNANCE

All ordnance items performed satisfactorily as evidence by engine operation and command destruct operation. The re-entry vehicle for VS-1 did not contain ordnance items.

9.7 AIRFRAME

9.7.1 Analysis of Flyaway Landline Data (CEC Recorder)

1. Radiation flux and convection temperatures in the Stage I engine compartment were as follows:

   a. Measurement number 3012, radiation calorimeter station E-45.6 (Station 1041.296), WL60, BL57L, Range 0-500°F. At the moment the engines were fired the temperature was approximately 200°F. The maximum temperature of 275°F occurred at the moment the landline disconnected.

   b. Measurement number 3013, radiation calorimeter station E-45.6 (Station 1041.296), WL3, BL0, Range 0-500°F. At engine start the temperature was 62°F. The maximum temperature was 210°F at the time of landline disconnection.

   c. Measurement number 3014, convection probe station E-45.6 (Station 1041.296) WL3, BL0, Range 0-500°F. Prior to engine start the temperature was 50°F. At T+2.1 it peaked above calibrated range. At T+6 it dropped back to 300°F and remained essentially constant to T+10.3.

   d. Measurement number 3015, convection probe station E-45.6, WL60.6, BL57L, Range 0-500°F. Prior to engine start the temperature was 50 F. At T+2.5 it peaked above calibrated range. At T+7 it dropped back to 300°F and remained essentially constant to T+10.3.

9.7.2 Analysis of Telemetry Data

Temperature environment and gradients of the missile first stage during flight are shown in Appendix D.

9.8 RANGE SAFETY

1. AGC on both channels was noisy during the in-silo period, but levels moved up to saturation as the missile left the silo. Levels remained reasonably steady at saturation until destruct was commanded after first stage burnout.

2. IRSS battery voltage remained between the levels of 26.5 and 27.0 volts.

3. APS inverter level remained reasonably steady at 117.5 volts.

4. Reference voltages were:

   0V level was zero through flight.

   5V level was approximately 4.95V for the flight.

   Over-all operation of the Range Safety System was satisfactory. No pre-launch or remote operation problems were reported from the O & C Console operators. Stage I battery level as monitored on the console settled down to 28 to 29 volts shortly after activation.

5. Proper operation of the Range Safety System is evidenced by commanded destruct at T+180.5 seconds. No event recorders were available to correlate initiation of destruct by PMR/MFSO with actual destruct from TLM records.

6. PMR plots have been reviewed and appear to be satisfactory with but one exception. Board I was using data from Radar #2 and at approximately 50 seconds the track became erratic. All other tracks appeared normal so data from Radar #3 was used to the end of this chart. First PMR estimates of the trouble on this one set of data was in their transmission system. On the main IIP charts, which used data from COTAR from 15 seconds to approximately 55 seconds and then Radar #2 to the end of the track, the track was south of the theoretical plot. From this same chart the predicted impact point was approximately 34.8°N and 127.8°W. No plotted data is available from the present position charts beyond the time of 120 seconds to assist in studies of the anticipated instability problem.

9.9 FACILITY

9.9.1 General

In general, damage to the facility could be considered to be very light, with the exception of the launch duct and exhaust duct areas. Only damaged items are enumerated and described herein; those items not mentioned remain essentially in prefiring condition.

Immediately after the launch, the TV monitors at the OSTF Control Center were used to scan the inside of the SLTF Control Center. The silo TV monitors, the facility alarm panel, the GOX sensor indicator, the launch console and the temperature indicator were thus examined.

Apparently due to the loss of silo lighting, no pictures were observed on the silo TV monitors other than the existence of a small fire near the bottom of the silo in Quadrant II of the launch duct. (See also Para. 9.9.4.3 (3i)).

The facility alarm panel, having been disabled, showed no indications of any kind, and the remote temperature monitor was pegged at the lower end of the scale.

These items all seemed to point to a loss of electrical power; this supposition was borne out by actual examination of the site by the safety team, which found power "off" in the silo except for emergency lighting.

It was later established during the "Flash Report" inspection that the main breaker for distribution panel DP-1 in the unit sub-station located in the equipment building had been tripped. Because the total connected load was not heavy, it is most likely that either mechanical shock (or vibration) or planned actuation of the shunt trip switch controlling the circuit breaker feeding panel DP-1 caused the breaker to open. No electrical malfunction has been found (indicating improbability of an electrical overload being responsible) and the breaker did not trip out when re-set at launch plus approximately one hour.

The facility status and alarm panel was totally disabled shortly after lift-off occurred.

Progressive indications appearing on the face of the alarm panel, as recorded on the 16mm film, occurred in the sequence and at the approximate times tabulated herein:

1. Platform Levels #5 amd #6 — T+3.1 sec.
   (Both "hazard" and "clear" lights flickered on and off intermittently to T+10.8 then "hazard" solid to T+53.4)

2. East Work Level Doors — T+3.1
   ("Hazard" light on solid)

3. Platforms, Level #2 — T+3.1
   (Both "hazard" and "clear" lights flickered on and off to T+10.6, then both on solid)

4. Silo Cover — T+3.2
   ("Hazard" light on and off intermittently to T+11.5, then on solid)

5. Fire Detector — T+8.9
   ("Hazard" light on solid to T+64.5)

6. Explosion Detector — T+8.9
   ("Hazard" light on solid to T+64.5)

7. Platforms, Level #3 — T+10.9
   ("Hazard" and "clear" lights off and on in various combinations and in rapid succession until T+12.3, then "clear" to T+35.0, then "hazard" to T+53.4)

8. Platforms, Level #4 — T+45.1
   ("Hazard" light on and off intermittently to T+53.4)

9. All platform, door and cover indications dead. T+53.4

10. All hazard and alarm lights dead T+64.5

The rapid blinking of lights controlled by limit switches indicated making-and-breaking of alarm circuits was occuring due to minor movements of doors, platforms, etc., caused by vibration and/or pressure pulsations or thermal changes. Post-launch inspection showed all platforms and doors to be securely latched.

It has now been determined that electrical wiring in the alarm circuits located in the launch duct and below Platform Level #2 suffered insulation damage due to high temperatures, thereby grounding the circuits. In turn, this caused tripping of circuit breaker Nos. 25, 28, and 30 in lighting panel B-4, which is located in the equipment building. Circuit faults also led to damage to ten (10) of the 115 VAC selective relays in the alarm panel.

The damaged circuits have now been disconnected from the panel in order that undamaged fire and explosion circuits may continue in ready status.

On the day following the launch, the cascade vanes were removed from the north exhaust duct and an inspection of the liner and the flame deflector area was made. This is described in Paragraph 9.9.4.4 of this report.

9.9.2 Spray Ring Water and Engine Compartment - CO_2 System

A detailed investigation has been made of the operational sequences involved in the post-launch attempted use of the spray ring water and engine compartment carbon dioxide systems.

The signal to start the pump and open the supply valve to the spray ring header was initiated at the remote launch console by the Test Conductor when observation of the silo TV monitors indicated the presence of a fire in Quadrant II. This occurred approximately three (3) minutes after lift-off, and the switch remained in the "on" position for approximately twelve (12) minutes. During this period, the system, if operating, should have delivered roughly 8500 gallons of water to the nozzles, thence by gravity to the sump room.