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TITAN

SLTF

FLIGHT TEST REPORT

MISSILE VS-1 (U)

RETURN OR DESTROY

34002

TECHNICAL OBJECTIVE DOCUMENT

WS — 107A — 2 PROGRAM

FLIGHT TEST WORKING GROUP

VANDENBERG AFB, CALIFORNIA

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FLIGHT TEST REPORT

MISSILE VS-1 (U)

684TC
840FL

TECHNICAL OBJECTIVE DOCUMENT

ISSUE DATE 18 MAY 1961

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TITAN - MISSILE VS-1

FOREWORD

The flight preparation, and test of Missile VS-1 were conducted in accordance with the requirement of the Flight Test Directive for that Missile. This report was prepared by the Test Manager in collaboration with the Test Conductor and the associate contractors' members of the SLTF Flight Test Working Group.

The report is submitted in fulfillment of Section 6, AFBMDR 11-17 and Section 3.10.1 of WDD-M-S-334.

CONCURRENCE

J R Beckett
For C. E. Carnahan
Director
Martin-Vandenberg

John Stanley
for J. C. Vogel, Head, LRP
Field Operations
Aerojet-General Corporation

David C. McDowell
D. C. McDowell
Activation Manager
Ralph M. Parsons Company

C. D. Bivins
for D. C. Roberts
Field Station Manager
AVCO Corporation

for R. B. Kimari
Manager of Engineering
Kellogg Switchboard & Supply Company

APPROVED

E. S. Franklin
E. S. Franklin, Test Manager
Space Technology Laboratories, Inc.
VAFB Field Office

N. B. Robins
N. B. Robins, Lt Col., USAF
Chief, TITAN Division

Joseph J. Cody
Joseph J. Cody, Col., USAF
Commander, 6565th Test Wing

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1.0 PROGRAM

WS 107A-2 (TITAN)

2.0 FACILITY

Silo Launch Test Facility, Vandenberg Air Force Base, California.

3.0 TEST

Flight (In-Silo Launch) Test, TP-53 (Rev. 1) TMC Document M-371-60-44, conducted on 3 May 1961.

4.0 MISSILE

XSM-68, Series 3, VS-1, Air Force Serial Number 6-03636.

5.0 PARTICIPATING CONTRACTORS

SPACE TECHNOLOGY LABORATORIES, INC.- Test Manager and Test Director.

THE MARTIN COMPANY - Airframe, GOE Contractor and Test Conductor.

AEROJET-GENERAL CORPORATION - Engine Contractor.

RALPH M PARSONS COMPANY - Facility Contractor.

KELLOGG SWITCHBOARD AND SUPPLY COMPANY - Communications Contractor.

AVCO CORPORATION - Re-entry Vehicle.

6.0 TEST OBJECTIVES AND RESULTS

The purpose of this test was to demonstrate the silo launch capability of a TITAN missile, and to acquire systems data applicable to TITAN II development.

6.1 PRIMARY OBJECTIVE 1

Record vibration and acceleration levels of selected missile equipment packages and structural elements during launch.

6.1.1 Results

Vibration and acceleration levels were obtained in the guidance compartment of the missile for a 10.3 second period starting at FS-1, and in the Stage I engine compartment for a 5.1 second period after FS-1. The maximum vibration levels observed during these periods were as follows:

Location	Maximum Level	Approximate Time of Occurrence after FS-1
Guidance Bay Ref. Gyro Mounting	2.8 g rms overall	+3.5 seconds
Stage I Engine Compartment Skin (Radial)	40 g rms overall	+5 seconds

Two accelerometers were also installed on the rate-gyro mounting in the interstage compartment, but these provided no usable data.

6.2 PRIMARY OBJECTIVE 2

Record sound pressure levels at selected stations on the missile during launch until engine bells are 100 feet above ground level.

6.2.1 Results

All acoustic data obtained are usable. The following maximum overall sound pressure levels were measured:

Location	Maximum Level	Approximate Time of Occurrance of Maximum after FS-1
Guidance Bay, Exterior	148 db	7.5 seconds
Range Safety Bay, Exterior	151 db	8.5 seconds
Interstage Compartment, Exterior	149 db	8.0 seconds
Stage I Between Tanks, Exterior	154 db	4.0 seconds
Stage I Engine Compartment, Exterior	156 db	5.5 seconds

Furthermore, the constancy of the data as a function of time at each measurement point indicates that the exhaust duct liners performed effectively, for the overall sound pressure levels above ground do not exceed the in-silo overalls by more than 3 db.

6.3 PRIMARY OBJECTIVE 3

Obtain exhaust duct flow parameters to determine launch duct air entrainment throughout the launch event.

6.3.1 Results

Exhaust duct flow parameters were obtained. All data except two pressure differential measurements (SL0044 and SL0045) were obtained. A preliminary estimate of the air entrainment ratio is 3.1 throughout the in-silo portion of the launch event.

6.4 PRIMARY OBJECTIVE 4

Record transient pressure wave data and thermal wave data in the launch duct during engine start.

6.4.1 Results

Records of the starting pressure transients within the launch duct were obtained on magnetic tape for three locations and corresponding peak pressures are as follows: (See paragraph 9.7.2 for thermal wave data)

Opposite M. S. 1000	(Data Questionable)
Opposite M. S. 438	3.7 psig
Opposite M. S. 130	2.4 psig

6.5 SECONDARY OBJECTIVE A-1

Record the behavior of the following missile subsystems during launch and subsequent Stage I flight to determine performance.

a) Propulsion

b) Flight Controls

c) Electrical, Instrumentation, and Range Safety

6.5.1 Results

1) (SA-1a) Propulsion

This objective is considered as having been achieved, since the data received indicated that the propulsion system did perform satisfactorily.

2) (SA-1b) Flight Controls

The Flight Controls subsystem performance was satisfactory throughout the flight and 100% usable information was obtained from all but one channel monitoring this subsystem. Measurement 259, Stage II Yaw Rate Gyro output, calibrated correctly but remained at the zero volt level throughout the rest of the run, and therefore no usable data was obtained from this channel. Poor quality T/M information was acquired prior to lift-off, but the data was excellent from lift-off to the end of flight.

3) (SA-1c) Electrical, Instrumentation, and Range Safety

a) The instrumentation data related to electrical performance was acquired and reflected satisfactory operation of the airborne electrical systems throughout flight.

b) Telemetry performance was considered satisfactory, but marginal prior to engine ignition. At R-4 minutes the signal strength at PMR was reported to be between 20 and 30 microvolts. At T+1.9 seconds the signal strength increased to a value between 50 and 100 microvolts. Upon missile emergence this value increased to 1000 microvolts and was steady thereafter.

c) The telemtry coverage of the Range Safety System was satisfactory. Adequate data was obtained on all the assigned channels:

AGC on both command receivers
IRSS battery voltage
APS inverter output voltage
TM reference voltages

6.6 SECONDARY OBJECTIVE A-2

Record the termperature environment and gradients of the missile first stage during flight.

6.6.1 Results

Usable information was obtained from all data associated with this objective.

6.7 SECONDARY OBJECTIVE A-3

Record radiation flux and convection temperatures in the Stage I engine compartment, during launch until the engine bells are 100 feet above ground.

6.7.1 Results

Usable information was obtained from all data associated with this objective.

6.8 SECONDARY OBJECTIVE A-4

Monitor umbilical behavior and missile release during launch.

6.8.1 Results

Records and film data indicate that the electrical umbilicals were not released by their Primary System, which is 1500 psig pneumatic pressure. Umbilical release was accomplished by lanyard pull which is the Back-Up Release System. Two electrical umbilicals (3B4E and 3B3E) were prematurely released when struck by falling sections of Air Conditioning Umbilical 2B1A.

Air Conditioning Umbilical 1B1A was torn free of the missile and launch duct attachment and ejected upward through the launch duct during the initial pressure pulse at ignition. The remnants of this umbilical were recovered (intact and undamaged with the exception of the loss of the Quick Disconnect) approximately 100 yards southeast of the silo. The remaining Air Conditioning Umbilicals were completely destroyed. Therefore, it is not known exactly how they disconnected, due to the lack of any kinescope coverage on these items.

The remaining umbilicals were disconnected by their primary means which is lanyard pull on missile motion. For further information on umbilicals see Electrical, Pressurization, and Propellants, and Facility Subsystems Performance.

Missile release was satisfactorily accomplished.

6.9 SECONDARY OBJECTIVE A-5

Record performance of Ground Operating Equipment during countdown from T-120 seconds to lift-off.

6.9.1 Results

All events measurements related to GOE were acquired. The GOE functioned properly throughout the terminal count.

6.10 SECONDARY OBJECTIVE A-6

Record missile drift from re-entry vehicle emergence until it has reached an elevation of approximately 100 feet above ground surface.

6.10.1 Results

Missile disturbances were indicated by the Stage II Pitch Rate Gyro 1.6 seconds after lift-off (Nose Cone emergence from Silo) and by the Stage I Pitch Rate Gyro 2.4 seconds after lift-off (Stage II Engine Compartment emergence from Silo). These disturbances lasted until $4\frac{1}{2}$ seconds after lift-off (Booster Engine emergence from Silo). These indications consisted of high frequency oscillations with maximum amplitudes of 2.9 deg/seconds p-p and 2.1 deg/seconds on the Stage I and II Rate Gyros respectively. Pitch and Yaw actuator response to this disturbance started 2.6 seconds after lift-off and lasted for 5.1 seconds. The total overall actuator corrections were: 0.7 degrees for an initial missile pitch down and 0.9 degrees for an initial missile yaw right.

6.11 SECONDARY OBJECTIVE B-1

Monitor silo air temperature in the region of the Stage I engine compartment.

6.11.1 Results

Silo air temperature was +57°F at R-3 minutes. (See Airframe Performance for other temperature readings.)

6.12 SECONDARY OBJECTIVE B-2

Record acoustic levels in silo equipment areas.

6.12.1 Results

The sound pressure levels during launch were measured at four locations within the equipment areas. All data was obtained and preliminary analysis indicates the following peak levels:

Equipment Area Number 1, Level 1	141 db at T+10.5
Equipment Area Number 2, Level 2	140 db at T+9.5
Equipment Area Number 3, Level 5	139 db at T+8.0
Equipment Area Number 4, Level 6	142 db at T+8.0

6.13 SECONDARY OBJECTIVE B-3

Record base pressure in Stage I engine compartment from ignition to lift-off.

6.13.1 Results

Base pressure in Stage I engine compartment was obtained (see Propulsion Performance for details).

6.14 SECONDARY OBJECTIVE B-4

Examine flight control stability in region of T+96 seconds to termination of powered flight, with the absence of a flight control gain change, in order to permit comparison of theoretically predicted stability margins with actual flight performance.

6.14.1 Results

Examination of the recordings from this flight in the region of T+96 seconds to burnout did not reveal the anticipated instability data. The significance of the data obtained must be determined by a more thorough and detailed analysis.

6.15 SECONDARY OBJECTIVE B-5

Determine the extent of heating at selected locations within the exhaust duct acoustic liner during launch.

6.15.1 Results

Probes coated with Templaq paint were inserted into an exhaust duct liner at locations shown in Figure 6-1. The results obtained from these indicators also appear on Figure 6-1.

The satisfactory condition of the top 55 feet of the exhaust duct liners subsequent to the launch does not contradict the 425°F Templaq indications in this area. If the temperature had exceeded 600°F some blackening of the outer surface should have been apparent.

In the lower 35 feet of liner, blast damage to the TWF filler, together with fusion of the TWF and cover plate warpage increased with increasing depth within the silo. It is recommended that further study be made of the condition of the liner in the lower 35 feet of its length in order to ascertain the damage mechanism most appropriate to the results.

It is believed that the upper 66 feet of the exhaust duct liner could be reused with the SLTF propellant combination. Had the TITAN II propellants been used in the launch together with water injection for start-transient attentuation, it is highly probable that over 85 per cent of the exhaust duct liner could be reused without refurbishing.

6.16 SECONDARY OBJECTIVE B-6

Determine the survivability of various types of launch duct acoustic liner modules during the launch.

6.16.1 Results

An examination of the launch duct acoustic liner resulted in the following general conclusions:

1. The regular three foot thick fiberglass modules housed in expanded metal cages sustained severe thermal and pressure damage in increasing amounts from top to bottom in the launch duct. This type of acoustic liner would suffice for "one time only" use unless repair between firings is planned.

2. All of the various sample modules constructed with 3/16 inch perforated facing survived very well indicating that this type of liner should be used in installations where multi firings are anticipated.

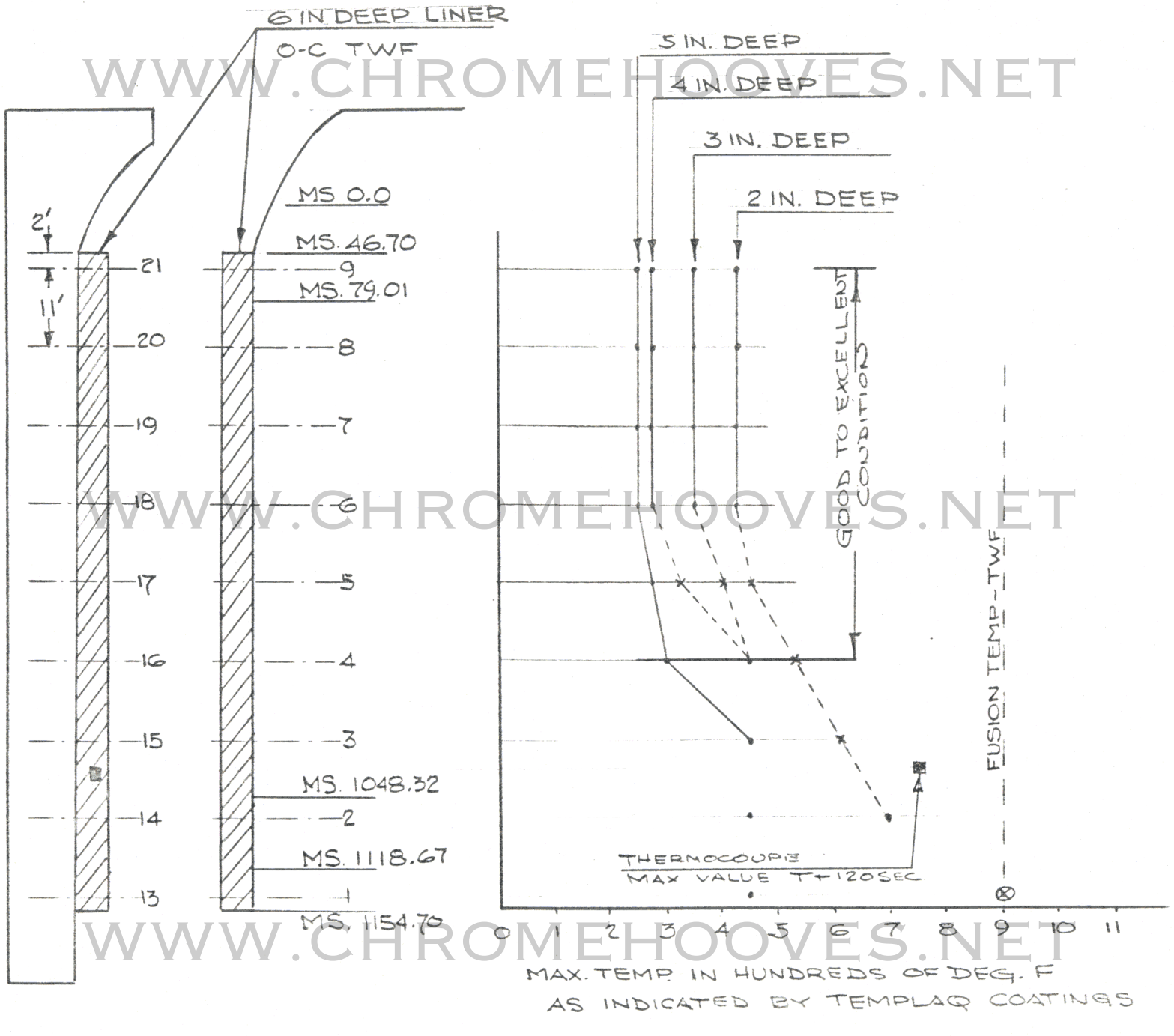

FIG. 6-1 SLTF TEMPERATURE PROBE LOCATIONS FOR EXHAUST DUCT LINER

7.0 COUNTDOWN PROCEDURES, HOLD AND REASONS FOR HOLDS

7.1 PROCEDURES

1. Administrative Procedure 327R9030618J-3, Revision B, dated 18 April 1961, title "Administrative Procedure Integrated Countdown TP-53 Launch (R and T Time)", was the R and T Time countdown procedure employed for this test.

2. Administrative Procedure 327R9030618L-3, PCN-1, dated 18 April 1961, title "Administrative Procedure Post Launch Inspection TP-53 (H Time)", was the H Time countdown procedure employed for this test.

3. Administrative Procedure 327R9030618K-3, PCN-1, dated 18 April 1961, title "Administrative Procedure TP-53 H Time (Launch Abort)", was a standby procedure in case of a launch abort.

7.2 COUNTDOWN

Significant countdown functions versus clocktime together with holds and reasons for holds are listed below.

	Planned		Actual		
Countdown	Date	Time	Date	Time	Remarks
R-48 Hours	5-1-61	0800	5-1-61	0800	Start of Countdown Preps.
R-24 Hours	5-2-61	0400	5-2-61	0400	Start of Formal Count.
R-13:30 Hours	5-2-61	1430	5-2-61	1430	Apply GOE Power.
R-13 Hours	5-2-61	1500	5-2-61	1500	Auto-Checkout PLPS,
R-12 Hours	5-2-61	1600	5-2-61	1600	Start Fuel Loading.
R-11 Hours	5-2-61	1700	5-2-61	1700	Apply Missile Power.
R-10 Hours	5-2-61	1800	5-2-61	1800	Complete Fuel Loading.
R-10 Hours	5-2-61	1800	5-2-61	1800	Install Missile Batteries.
R-10 Hours	5-2-61	1800	5-2-61	1800	Commence Subsystem Checks.

Countdown	Planned Date	Planned Time	Actual Date	Actual Time	Remarks
R-9 Hours	5-2-61	1900	5-2-61	1900	Complete Subsystem Checks.
R-8 Hours (Holding)	5-2-61	2000	5-2-61	2000	Start of Planned Hold.
R-8 Hours (Counting)	5-3-61	0400	5-3-61	0400	End of Planned Hold.
R-6:50 Hours	5-3-61	0510	5-3-61	0513	Commence TM and CD Checks.
R-6:40 Hours (Holding)	5-3-61	0520	5-3-61	0523	Hold to Check TM Signal Strength and Repair Hydraulic QD. (Hold Period 50 Minutes).
R-6:40 Hours (Counting)	5-3-61	0520	5-3-61	0613	TM and CD Checks Completed.
R-6:15 Hours	5-3-61	0545	5-3-61	0630	Start Ordnance Installation.
R-4:45 Hours	5-3-61	0715	5-3-61	0903	Ordnance Installation Completed.
R-4 Hours	5-3-61	0800	5-3-61	0828	Start 4 Hour Clock.
R-2:45 Hours (Holding)	5-3-61	0915	5-3-61	0942	Hold to Complete Platform Retraction.
R-2:45 Hours (Counting)	5-3-61	0915	5-3-61	1010	Count Resumed.
R-2:25 Hours	5-3-61	0935	5-3-61	1030	First Two LOX Trailers Called to the Site.
R-115 Min.	5-3-61	1005	5-3-61	1058	Ready to Load LOX from Trailer 1627.
R-110 Min.	5-3-61	1010	5-3-61	1103	Chill Down Complete. Start Rapid Load.
R-9 Min.	5-3-61	1151	5-3-61	1230	100.5% Light On. LOX Loading Completed.
R-5 Min.	5-3-61	1155	5-3-61	1246	Check TM and CD on Internal Power.

Countdown	Planned Date	Planned Time	Acutal Date	Acutal Time	Remarks
R-4 Min. (Holding)	5-3-61	1156	5-3-61	1248	Hold for Assessment of TM Signal.
R-4 Min. (Counting)	5-3-61	1156	5-3-61	1257	Count Resumed.
R-3 Min. (Holding)	5-3-61	1159	5-3-61	1258	Planned Hold for Evacuation of SLTF Control Center.
R-3 Min. (Counting)	5-3-61	1214	5-3-61	1305	Resume Count from Remote Control Center.
R-0/T-120 Sec.	5-3-61	1217	5-3-61	1308: 43.7	Start Automatic Sequence.
T-0	5-3-61		5-3-61	1310: 43.7	FS-1.

8.0 DESCRIPTION OF TEST

8.1 TEST PREPARATION

Preparation for the flight test from the Silo Launch Test Facility were initiated following the successful captive firing that was conducted on 7 March. Major items of interest in preparations for this flight test are listed below:

1. Post Captive Inspection of missile and silo.
2. Minor repairs to the silo.
3. Installation of the exhaust duct acoustic liner.
4. Removal of the Captive Kit from GOE and missile.
5. Installation of new temperature and pressure sensors in the exhaust ducts.
6. Installation of temperature indicating sticks in the exhaust duct liner.
7. Flush mounting of acoustic transducers (microphones) on the missile skin.
8. GOE and Missile Compatibility tests in the launch mode (Dry Run).
9. Wet Mock firings using LN_2 in lieu of LO_2.

8.2 FLIGHT TEST

The R-48 hour countdown consisting of pre-test functions, was initiated at 0800 hours on 1 May 1961. The formal countdown (R-24 hours) was initiated at 0400 hours on 2 May 1961. Checkout of all subsystems and fuel loading were accomplished as scheduled. The planned hold at R-8 hours occurred as scheduled at 2000 hours on 2 May 1961.

8.2.1 Flight Day Activities

Flight day activities (R-8 hours) were initiated as scheduled, at 0400 hours on 3 May 1961. Minor unscheduled holds were encountered at R-6:15 hours, R-2:45 hours, and R-4 minutes. (See Countdown, Holds and Reasons for holds). LOX loading was completed well within the allotted time of 106 minutes. (LOX loading was accomplished within a 93 minute interval including facility plumbing cool down time.) Initiation of the terminal count (R-0/T-120 seconds) occurred at 1308:43.7 hours PDT (approximately one hour behind schedule). T-0 (FS-1) occurred at 1310:43.7 hours PDT.

8.2.2 Flight Sequence of Events

The following major sequence of events occurred as indicated:

Event	Time from T-0 (FS-1) Expected (Sec.)	Actual (Sec.)
TCPS1	T+1.9 to T+2.4	T+1.95
TCPS2	T+1.9 to T+2.4	T+2.00
Fire Launch Bolts	T+4.8 to T+5.3	T+5.1
Lift-Off/First Motion	T+4.9 to T+5.4	*T+5.4
Umbilical Release	T+4.9 to T+5.4	*T+5.4
Nose of R/V Appears	T+6.63 to T+7.13	T+7.0
Engine Bells Clear Silo	T+9.6 to T+10.1	T+9.84
Flyaway Umbilical Off	T+11.4 to T+11.9	**T+10.3 to T+11.09
Roll Program Start	T+14.0 to T+14.5	T+14.4
Roll Program End	T+23.0 to T+23.5	T+23.4
Pitch Program Start	T+25.0 to T+25.5	T+25.4
Burnout	T+138.4	T+138.8
Destruct	T+150	T+180.5

*Lift-off switch malfunction precluded use of this signal for umbilical release and data analysis. Missile time of first motion and umbilical release was determined from TV Kinescope film and events record.
**Data provided via the Flyaway umbilical ceased at T+10.3 (engine bells 28 feet above ground level) seconds, indicating electrical discontinuity at this time. Motion picture films indicate mechanical disconnect of the flyaway umbilical at T+11.09 (engine bells 100 feet above ground level) seconds.

8.2.3 Flight Particulars

1. The total integrated roll angle as determined from preliminary data was approximately 51 degrees clockwise as viewed from the base of the missile. The specified total roll angle was 50.5 degrees clockwise.

2. The Flight Control System gain change, normally programmed for T+96 seconds, was disabled in order to study stability margins.

Hugh Zeiger
Don Bressler
Flatter

3. Engine shutdown relay K-681-2 was disconnected to allow a LOX depletion "shutdown" of Stage I powered flight. Burnout occurred at T+138.8 seconds when the missile was located 223,235 feet down range at an altitude of 198,675 feet above the launch tangent plane. (See Appendix D for trajectory details)

4. Stage II contained an inoperative engine and water ballast in the propellant tanks. Solid staging bolts were used in lieu of explosive bolts to preclude separation of stages.

5. Re-entry Vehicle Mark IV, Mod 6B, Serial No. 001 was employed for this test. This vehicle simulated a War Ready, Mark IV, re-entry vehicle in size, weight, center of gravity and moment of inertia. Fiberglass was utilized in place of ablative material and steel and magnesium for backup structures. It did not contain an arming and fusing package, instrumentation, Sofar Bomb, radioactive materials, gas generating squibs or any other explosive or toxic materials. Separation of the re-entry vehicle was not planned. Structural performance of the re-entry vehicle was satisfactory throughout the test.

6. At T+145 seconds, after all test objectives were achieved, permission was given to the PMR Missile Flight Safety Officer to terminate the flight with a demonstration of the adequacy of the TITAN PMR Destruct System. The destruct system performed as expected and destroyed the missile on command at T+180.5 seconds. At the time of destruct the missile was located 445,715 feet down range at an altitude of 380,152 feet above launch tangent plane.

8.3 SIGNIFICANT "FIRST OF A KIND" ACCOMPLISHMENTS

1. First TITAN launch from Vandenberg Air Force Base.
2. First in-silo launch of an ICBM liquid propellant missile.
3. First flight of TITAN VS [illegible] missile.
4. First complete in-flight demonstration of TITAN destruct system for PMR.
5. First full scale test of exhaust duct liner (Complete certification of exhaust duct liner design based upon extrapolated data from the 1/6 scale model tests; scaled data from the 1/6 scale model tests verified in Captive Test)

6. First TITAN launch with terminal count conducted from a remote control center.
7. First TITAN missile with a roll program as large as 50.5°.
8. First TITAN flight without flight control gain change during Stage I powered flight.
9. First TITAN flight with planned termination of Stage I powered flight by LOX depletion.
10. First TITAN flight with fly-away landline disconnect when missile engine bells are 100 feet above ground level (approximately 215 feet from in-silo lift-off)
11. First "in-silo" degreasing of Stage I engine and performance of major modifications to Stage I engine in silo.
12. First TITAN flight with motor driven switches.
13. First flight of TITAN using operational type ground operating equipment.
14. First entry into TITAN Stage I LOX tank in silo without separating stages or invalidating LOX tank cleanliness.
15. First TITAN flight without LOX topping.
16. First TITAN flight without radiation shield in Stage I engine compartment.
17. First TITAN launch with dry flame deflector.
18. First TITAN launch with surface wind velocity as great as 24 knots.

9.0 SUBSYSTEM PERFORMANCE

9.1 PROPULSION SYSTEM

Data obtained during the test indicate that the Propulsion System performance was satisfactory. There were no indications of malfunctions in the Propulsion System.

9.1.1 History

The Propulsion System of Missile VS-1 is an XLR 87-AJ-3 Rocket Engine Assembly. The engine history and past performance data relative to this engine is presented in Appendix "E".

1. Density Compensator Valve Settings

The following is sequential data concerning setting of the Fuel Density Compensator Valve (DCV) on Engine S/N 1045 on Missile VS-1 at VAFB.

a. Prior to Captive Firing

On 20 January 1961, ECP 630 was initiated which called for inspection of DCV's on Engine 1045 due to calibration error of vernier index scale. The inspection indicated DCV on S/A 1 (S/N 1099) did not meet required tolerances and a table of correction factors was released by AGC Engineering for setting this DCV. To maintain the 2.28 mixture ratio a PCN was issued against TMC Propulsion Procedure 645K-2 to incorporate this data.

S/A 2 DCV (S/N 1098) was inspected and found to be within tolerance.

NOTE: THE DCV IS FULL OPEN AT 0° SETTING (I.E.) THE LARGER DEGREE SETTING OF DCV THE LESS FLOW THROUGH THE FUEL DISCHARGE LINE.

The DCV's on Engine 1045 were set to this procedure on 6 March 1961, following fuel loading of Missile in preparation for TP-52, Run 3, Captive Firing.

FUEL TEMP.	SP. GRAV.	STANDARD AGC DCV SETTING REQ'D	RESET PER ECP 630	M/R
S/A 1 70°F	.8109	67.4°	70.4	2.28
S/A 2 70°F	.8109	67.4°	N/A	2.28

The Captive Firing was conducted on 7 March 1961, with satisfactory 8 second engine firing time. Post fire check of engine showed no change in DCV settings.

b. Prior to Flight Test

Per detailed test plan, Flight Test TP-53, the ETO VS-SLTF-3K, 24 March 1961, covered modified DCV settings to maintain a 2.316 M.R. which would result in a Lox Exhaustion Stage I, engine shutdown.

This setting was obtained using Fig. 1, ETO-VS-SLTF-3K which utilizes the fuel temperature at time of loading and a constant lox density of 70.9 LB/FT^3.

Prior to fuel loading on board the missile, the fuel temperature was 62°F. From this temperature, 7746 gallons was determined to be the required fuel load for flight and the DCV's were set to the following:

FUEL TEMP	SPECIFIC GRAVITY	STANDARD DCV SETTING	DCV SETTING PER ETO FOR FLIGHT	M/R
S/A 1 62°	.810	70.9° (ECP 630)	71.1°	2.316
S/A 2 62°	.810	66.9°	69.1°	2.316

9.1.2 Ground Support and Ground Operating Equipment

The Engine Control System, Supplementary Group "B" (Engine Hold Fire System) and the Nitrogen Start System did perform satisfactorily throughout the entire countdown and launch operation. The new type heaters on the engine TPA's oxidizer pump bearings indicated satisfactory operation as read on the Hold Fire Rack 2070. The bearing temperature dropped

from ambient at the start of Lox loading to a -62°F on TOB 1, and to a -55°F on TOB 2, and held steady to the end of Lox loading. A review of the camera film which covered the Hold Fire Rack 2070 indicates satisfactory operation prior to T-0. An investigation of performance of the 2070 rack subsequent to T-0 to identify possibile anomalies is in Appendix F.

A portable temperature measurement device located in the equipment area on Level 6, indicated a stable temperature during the lox loading operation. As a result it is assumed that the N_2 Start Bottle Pressure held steady at 3090 psig which it was prior to lox loading.

The Ground Support Equipment used to service this engine was of the operational configuration with the exception of the degreaser. All GSE was periodically calibrated and performed satisfactorily during all engine pre-fire checks and unscheduled maintainence.

9.1.3 Propulsion System Performance

Propulsion System performance was determined to be satisfactory based on a comparison of this data to previous run data available on this engine.

1. Events Recorder Times

Events recorded times of Engine components and Ground Operating Equipment are considered to be normal during this test as compared to average Stage I engine operations.

EVENTS RECORDERS MEASUREMENTS

Measure No.	Channel No.	Description	Actual Time On	Actual Time Off	Normal Time On	Normal Time Off
SL0099	7	Bleed Lox Tank	T-35.1	T-34.1	T-35	T-34
SL0108	9	OSBVPV	T-35.1	T-0	T-35	T-0
SL0106	11	GGOPV	T-35.1	T+1.8	T-35	GGVS
SL0103	13	ECS "GO"	Cont.	T+5.4	Cont.	Lift-off

Measure No.	Channel No.	Description	Actual Time On	Actual Time Off	Normal Time On	Normal Time Off
S10102	14	ECS "NO-GO"	T+5.4		NO-GO	Reset
SL0101	15	Fire Engines	T-0	T+1.0	T-0	T+1.0
SL0097	16	TCIGN (1)	T-0	T+1.8	T-0	GGVS
SL0091	17	TCVS $_{3}$-1	T+1.6	T+5.4	T+1.4 to T+2.0	Lift-off
SL0090	18	TCVS $_{3}$-2	T+1.6	T+5.4	T+1.4 to T+2.0	Lift-off
SL0096	19	GGVPV (0)	R-3 min	T-35.1	R-3 min	T-35
			T+1.6	T+1.8	TCVS$_3$	GGVS
			T+5.4	T+5.6		
SL0095	20	GGIGN (1)	T+1.6	T+1.8	TCVS$_3$	GGVS
SL0087	21	GGVS (1)	T+1.8	Cont.	T+1.6 to T+2.2	Cont.
SL0089	23	TCPS (1)	T+1.95	T+5.4	T+1.8 to T+2.4	Lift-off
SL0092	24	TCPS (2)	T+2.06	T+5.4	T+1.8 to T+2.4	Lift-off
SL0104	25	Lift-off	T+9	Cont.	Lift-off	Cont.
SL0110	26	GGVPV (C)	T+35.1	T+1.6	T-35	TCVS
SL0086	29	Launch Bolt Fire Signal	T+5.1	T+8	TCPS+2.9	T+8
SL0113	34	TCIGN (2)	T-0	T+1.8	T-0	GGVS
SL0112	35	GGIGN (2)	T+1.6	T+1.8	TCVS$_3$	GGVS
SLVF20	43	GGXNV	T-0	T+1	T-0	T+1

2. Telemetry Data

Review of the telemetry data indicated normal start transient on PC1, PC2, Pcgg1 and Pcgg2. The following data was taken from the TM records.

	T + 3 sec.	T + 5 sec.	T + 137 sec.
Pcgg1	450	445	490
Pcgg2	490	480	500
* Pc_1	680	680	680
Pc_2	570	570	570

NOTE: All pressures are in Psia.

* Pc_1 value is not entirely valid as it is indicating 102 PSIA as the ambient pressure after completion of shutdown.

Pc_1 was at 77% thrust level at T+1.90 seconds and Pc_2 was at 77% thrust at T+1.94 seconds. This relates very closely to events recordings of TCPS 1 and 2.

$Pcgg_1$, and $Pcgg_2$, started to rise at T+0.2 seconds. At T+2.3 seconds $Pcgg_1$ and $Pcgg_2$, were 450 psia and 490 psia respectively. Pc overshoot was determined to be approximately 5.5% on Sub-Assembly 1, and 8% on Sub-Assembly 2.

After engine exhaustion Pc_2 read zero psia, but Pc_1 read approximately 100 psia indicating a substantial error in Pc_1 data. During powered flight, Pc_2, read a constant 570 psia. Pc_1, read an apparent 100 psia higher than Pc_2, which would indicate that the Pc_1 data is not valid. This was further substantiated by comparison with Pcgg data, flight controls programming data, and landline engine performance data.

A review of camera film covering flame pattern during powered flight indicated that the thrust chamber exhaust pattern on S/A 2 was longer than on S/A 1. While correlation of data between the patterns may be possible it is felt that further analysis of this occurrence is not necessary at this time since there is no indication that this pattern had any adverse effect during the flight.

3. Landline Data

The landline Propulsion System data is listed below. This data was available until T+5.1 seconds.

MEAS. NO.	DESCRIPTION	TIME T + 3 sec.	T + 5 sec.
SL3076	PFD 1	840	840
SL3078	PFD 2	800	800
SL3077	POD 1	800	800
SL3079	POD 2	810	800
SL3104	TTi_1	1450°F	1450°F
SL3105	TTi_2	1380°F	1380°F
SL3095	Pos_1	47	47
SL3096	Pos_2	39.8	44

NOTE: All pressures are in PSIA. A review of the above parameters indicated that the start transient was normal as compared to the start transient during the Captive Test.

9.1.4 Propulsion System Environment

1. Base Pressures Engine Compartment, Stage I

MEAS. NO.	AXIS	INSTR. LOCATION	DURING START TRANSIENT HIGH	LOW	T+3 SEC	T+5 SEC
3143	YAW	YAW AXIS STATION E-0	17.9 PSIA	12.4 PSIA	14.8 PSIA	14.8 PSIA
3144	PITCH	PITCH AXIS STATION E-0	19.1 PSIA	13.6 PSIA	14.0 PSIA	14.0 PSIA

The variances in Base Pressures during start transient would indicate that a large volume of hot gas would move upward between missile skin and launch duct walls during the engine firing. Photographs of the missile at T+20 shows **frost still intact on exterior skin indicating** that the lox tanks were not subjected to a heat change that could cause excess goxing action.

2. Temperatures at Engine Compartment, Stage II

MEAS. NO.	DESCRIPTION	REMARKS	
3341	Lube Oil Cooler Engine S/A 1	Spiked to full scale 700°F at T+1.8, Decreasing to 180°F.	290°F at T+3 176°F at T+5
3342	Lube Oil Cooler Engine S/A 2	64° at T-0 283° at T+1.8	181°F at T+3 181°F at T+5
3343	Area of Fifth Point Thrust Mount Attachment	52°F at T-0 253°F at 2.5	253°F at T+3 178°F at T+5
3012	Radiation Calimeter Engine Compartment Sta. 1041, WL60 BL57L		200°F at T-0 275°F at T+10.3

MEAS. NO.	DESCRIPTION	REMARKS
3013	Radiation Calimeter Sta. 1041 WL3 BL0 Engine Compartment	62° at T-0 210° at T+10.3
3014	Convection Probe Sta. 1041 WL3 BL0 Engine Compartment	50° prior to T-0. Peaked above 500°F at T+2.5. Dropped to 300°F at T+7 and remained between 300° and 350° to T+10.3.
3015	Convection Probe Sta. 1041 WL60 BL57L Engine Compartment	50° prior to T-0. Peaked above 500°F at T+2.1. Dropped to 300°F at T+6 and remained between 300° and 350° to T+10.3
540	Skin Temp. - Engine Comp. Sta. 1017 WL60 BL60L	See Figure 8, Appendix D
541	Skin Temp. - Engine Comp. Sta. 1018 WL0 BL0	See Figure 8, Appendix D

3. Vibrations - Stage I Engine Compartment

MEAS. NO.	PICK UP AND LOCATION	AXIS	REMARKS
3003	Vibration Pickup Booster Engine Comp. Between umbilicals 3D1E and 3D2E	Longitudinal	Data Questionable

MEAS. NO.	PICK UP AND LOCATION	AXIS	REMARKS
3004	Vibration Pickup Booster Engine Comp. Between umbilicals 3D1E and 3D2E	Lateral	40g RMS overall maximum at T+5 sec.
3005	Vibration Pickup Booster Engine Comp. Between umbilicals 3D1E and 3D2E	Vertical	25g RMS overall maximum at T+5 sec