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DOUGLAS
MISSILE & SPACE SYSTEMS DIVISION

S-IVB-502 STAGE
FLIGHT TEST PLAN

DOUGLAS REPORT SM-46999
23 OCTOBER 1967

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PREPARED FOR:
NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION
UNDER NASA CONTRACT NAS7-101

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ABSTRACT

This report presents the flight test plan for the Saturn S-IVB-502 stage which is the third stage of the AS-502 space vehicle. S-IVB stage performance and mission objectives are defined and include criteria for their evaluation. Included in this test plan are Douglas Aircraft Company responsibilities and support activities as required under NASA Contract NAS7-101.

DESCRIPTORS

AS-502 Mission

SA-502 Launch Vehicle

S-IVB-502 Stage

Sequence of Events

S-IVB-502 Stage Configuration

S-IVB-502 Stage Predicted Flight Performance

S-IVB-502 Stage Mass Characteristics

J-2 Engine

PREFACE

The purpose of this report is to provide a flight test plan for the Saturn S-IVB-502 stage. In general, it provides information and direction to Douglas personnel at Huntington Beach Missile and Space Systems Division, Florida Test Center, and Marshall Space Flight Center.

Included in this report are detailed descriptions of the following: AS-502 vehicle mission and objectives, S-IVB-502 stage configuration and objectives, redlines and launch mission rules, sequence of events, and mass characteristics. The propulsion system performance predictions presented are in accordance with requirements noted in NASA/MSFC Contract Letter I-V-S-IVB-TD-66-45, dated 7 July 1966.

This report, prepared under National Aeronautics and Space Administration Contract NAS7-101, is issued in accordance with the contractual requirements of NAS7-101 *Contract Data Requirements, Saturn S-IVB Stage and GSE, MSFC-DRL-021,* dated 15 September 1966.

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SECTION 1

INTRODUCTION

1. INTRODUCTION

This document delineates the requirements and responsibilities of the Douglas Aircraft Company in support of the S-IVB-502 stage flight test. The flight test, as defined in this test plan, will be limited to the S-IVB stage contribution toward the accomplishment of the AS-502 flight mission and S-IVB stage performance verification as the third stage of the SA-502 launch vehicle.

1.1 General

This document provides information and direction to Douglas personnel comprising the Saturn S-IVB Test Planning and Evaluation Committees at the Missile and Space Systems Division (MSSD) Huntington Beach, California, Florida Test Center (FTC), and the liaison team at Marshall Space Flight Center, Huntsville, Alabama.

Detailed descriptions of the following are included:

a. Launch vehicle objectives
b. S-IVB stage objectives
c. S-IVB stage configuration
d. S-IVB stage redlines and launch mission rules
e. S-IVB stage flight test management, communication and documentation

1.2 Background

The S-IVB-502 stage was assembled at MSSD where production testing of components and systems was accomplished. The stage was then transported to the Sacramento Test Center (STC), where the acceptance firing was conducted. Preliminary tests consisted of manual and automatic subsystem checkouts, integrated system tests, a simulated acceptance firing, and an automatic propellant loading test. Following these preliminary tests, the stage underwent an automatic acceptance firing which included a first burn, a simulated coast period, and a second burn. Postfiring checkout included manual leak checks, functional tests, and an All Systems Test.

The stage was then shipped to Kennedy Space Center (KSC), installed in the low bay of the Vehicle Assembly Building and subjected to post transportation receiving inspections. After installation of the aft interstage, the stage was transferred to the high bay and mated to the SA-502 launch vehicle. Figure 1-1 presents a checkout and test history of the S-IVB-502 stage.

The cost plus incentive fee (CPIF) technical performance criteria had been included in former releases of flight test plans. With the effectivity of this S-IVB-502 Stage Flight Test Plan, the technical performance criteria will no longer be included but will be released in the Technical Performance Criteria Document.

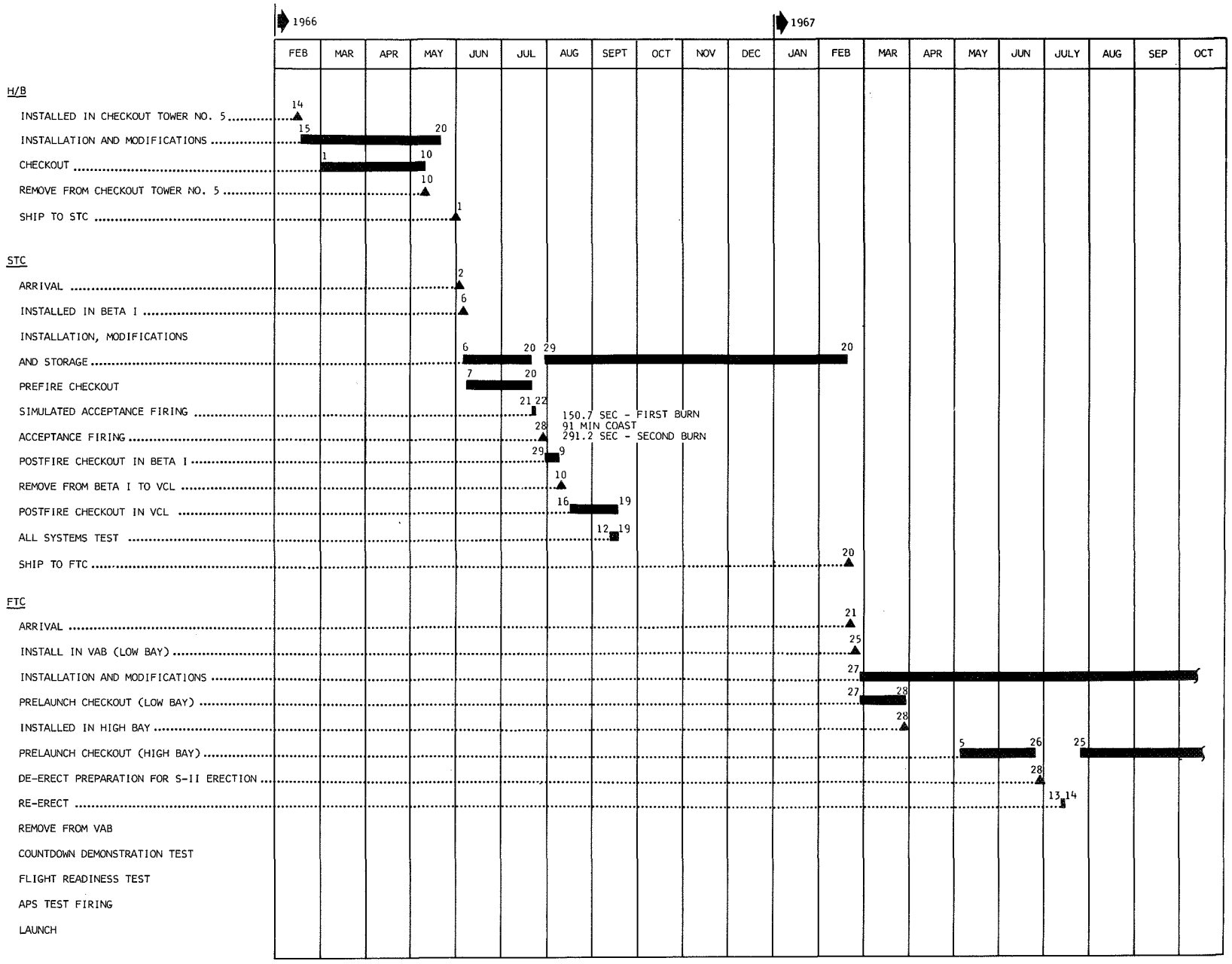


Figure 1-1. S-IVB-502 Stage Checkout and Test History

SECTION 2

MISSION

2. MISSION

The AS-502 is the second Saturn V flight vehicle allocated for launch vehicle and spacecraft development and qualification. This section delineates the objectives of the vehicle as a whole. Section 3 describes the objectives of the S-IVB-502 stage. Figure 2-1 presents the launch configuration of the AS-502 Space Vehicle and Figure 2-2 presents the AS-502 ground trace.

2.1 Mission Objectives

Douglas Aircraft Company (DAC) considers the "*SA-502 Launch Vehicle Mission Directive*" (reference 1) as the official document for providing identification and control of the launch vehicle mission requirements. The "*Apollo Flight Mission Assignments*" document (reference 2) and the "*Program Support Requirements*" document (reference 3) also define mission objectives and can be referred to for supplemental information. The mission directive states that "primary objectives are those which are mandatory and therefore, malfunctions of launch vehicle systems, ground equipment or instrumentation which would result in failure to achieve those objectives will be cause to hold or cancel the mission until the malfunction has been eliminated." According to the mission directive, the primary objectives are:

a. "Demonstrate structural and thermal integrity of launch vehicle throughout powered and coasting flight, and determine inflight structural loads and dynamic characteristics.

b. "Determine inflight launch vehicle internal environment.

c. "Verify prelaunch and launch support equipment compatibility with launch vehicle and spacecraft systems.

d. "Demonstrate the S-IC Stage propulsion system, and determine inflight system performance parameters.

e. "Demonstrate the S-II Stage propulsion system, including programmed mixture ratio shift and the propellant management system and determine inflight performance parameters.

f. "Demonstrate the S-IVB Stage propulsion system including the propellant management systems, and determine inflight system performance parameters.

g. "Demonstrate the launch vehicle guidance and control system during S-IC, S-II, and S-IVB powered flight, achieve guidance cutoff and evaluate system accuracy.

h. "Demonstrate S-IC/S-II dual plane separation.

i. "Demonstrate S-II/S-IVB separation.

j. "Demonstrate launch vehicle sequencing system.

k. "Demonstrate compatibility of the launch vehicle and spacecraft.

l. "Evaluate performance of the emergency detection system (EDS) in a closed-loop configuration.

m. "Demonstrate the capability of the S-IVB auxiliary propulsion system during S-IVB powered flight and orbital coast periods to maintain attitude control and perform required maneuvers.

n. "Demonstrate the adequacy of the S-IVB continuous vent system while in earth orbit.

o. "Demonstrate the S-IVB Stage restart capability.

p. "Demonstrate the mission support capability required for launch and mission operations to high post-injection altitudes."

Secondary objectives as defined in the mission directive "are those which are desirable but not mandatory. Malfunctions which may result in failure to attain these objectives may be cause to hold or cancel the mission as indicated in the mission rules." The secondary objectives which are listed in the mission directive are as follows:

a. "Determine launch vehicle powered flight external environment.

b. "Determine attenuation effects of exhaust flames on RF radiating and receiving systems during main engine, retro and ullage motor firings."

2.2 Mission Description

2.2.1 Launch Phase

This phase of the launch vehicle trajectory is initiated at guidance reference release, which occurs 16.7 sec prior to first motion. The establishment of liftoff (Time Base one [T_1]) is 0.3 sec after first motion.

The Saturn AS-502 vehicle will be launched from Complex 39, Pad A, of the Kennedy Space Center (KSC) along an azimuth of 90 deg east of north. The vehicle will rise vertically and after clearing the tower at T_1 +10.7 sec will execute a 7 deg pitch and a roll maneuver to the 72 deg flight azimuth. The maximum dynamic pressure will occur 77.3 sec from first motion.

Termination of S-IC Stage powered flight will originate with center engine cutoff (CECO) and start time base two (T_2) at T_1 +143.5 sec. Outboard engine cutoff (OECO) (T_3) will occur 4.8 sec after CECO and will be initiated by either the LOX or the RP-1 depletion sensor actuation.

Between S-IC OECO signal and the S-II engines reaching 90 percent thrust level, S-IC/S-II separation occurs; retrorockets force the S-IC stage away from the flight vehicle, and ullage rockets are fired to settle the S-II stage propellant. The S-II aft interstage is jettisoned at T_3 +30.7 sec, and 5.7 sec later, the launch escape tower (LET) is jettisoned. The iterative guidance mode (IGM) is initiated at T_3 +42 sec and is used continuously to attain the desired earth-parking orbit except during the time of S-II/S-IVB separation. A programmed mixture ratio shift will occur 250 sec after S-II 90 percent thrust level. The S-II engine cutoff commands will occur at T_1 +516 sec and initiate time base four (T_4).

During the period (6.4 sec) from S-II cutoff to the attainment of S-IVB stage 90 percent thrust level, S-II/S-IVB separation occurs, retrorockets force the S-II stage away from the space vehicle, and ullage rockets are fired to settle the S-IVB stage propellant. Between T_4 +0 and S-IVB engine start command (ESC) the guidance computer commands are frozen to minimize the separation transients.

Figures 2-3 through 2-10 present trajectory data pertinent to the S-IVB launch phase. Table 2-1 is a precis of the flight mass summary presented in appendix 2. Tables 2-2 through 2-4 list trajectory conditions at significant launch phase flight times. The IGM for S-IVB is used until approximately 8 sec prior to S-IVB cutoff, at which time the guidance commands are frozen for S-IVB cutoff. The S-IVB engine cutoff command is scheduled to occur at T_1 +645.9 sec and will initiate time base five (T_5).

2.2.2 Circular Earth Parking Orbit Phase

The flight vehicle is inserted into a 100 nmi circular parking orbit at T_5 +10 sec. The vehicle remains in the parking orbit for approximately two revolutions while the vehicle systems are checked. During this time the vehicle longitudinal axis is maintained parallel to the local horizontal by the guidance control system.

2.2.3 Pre-Ignition Sequencing and S-IVB Second Burn Phase

Pre-ignition sequencing for S-IVB second burn starts at initiation of time base six (T_6) which is 327.0 sec before S-IVB second burn ESC. The second burn ignition occurs during the second revolution shortly after the vehicle comes within tracking range of Cape Kennedy. This burn of 320.2 sec will inject the flight vehicle into a conic typical of the translunar conics used for Lunar Landing Missions. The flight vehicle is not targeted to attain terminal conditions, however, the term "translunar" is used to describe the orbit achieved after second burn. Figures 2-11 through 2-16 present predicted trajectory parameters. Tables 2-5 and 2-6 list trajectory conditions at S-IVB second burn ECS and ECC.

2.2.4 Waiting Orbit Phase

Following second S-IVB Stage cutoff the flight vehicle is commanded to the required spacecraft propulsion system (SPS) retroburn inertial attitude. This attitude is maintained until CSM separation, which

occurs at T_7 +181.7 sec. At separation, the lunar module (LM) adapter is deployed, freeing the CSM. The CSM reaction control system (RCS) provides sufficient thrust to separate the CSM from the LV. After CSM separation the LV continues to coast in translunar orbit. The launch vehicle reaches an apogee altitude of approximately 275,648 nmi; the nominal perigee altitude is 359 nmi. First SPS ignition occurs 98.3 sec after CSM separation, and places the CSM on an earth intersecting ellipse so that CM recovery is possible should the SPS fail to reignite. The post first burn trajectory parameters were chosen such that the resulting ground track allows for adequate ground support capability and entry conditions which approximate the structural limits of the command module (CM) thereby providing a high heat rate test on the heat shield should reignition of the SPS fail. First SPS burn also fulfills a requirement to test SPS engine performance during a single burn of at least 320 sec duration. An optimum SPS first burn, targeted to a 10,200 nmi apogee altitude and a -9 deg re-entry elevation flight path angle would require less than 320 sec of burn. Therefore, a yaw maneuver of +39 deg with respect to the inertial velocity vector is performed to yield the desired reentry conditions and a 320 sec SPS burn. After first SPS cutoff the CSM is oriented to the attitude required to cold soak the CM re-entry heat shield under simulated trans-earth conditions. The second SPS burn occurs 5 hr 18 min and 56 sec after CSM separation and lasts 189 sec. This burn accelerates the CSM to approximate lunar return conditions. This will provide a maximum heat load test of the CM. The nominal CM splash will occur near Hawaii at approximately 32 deg north latitude and 151 deg west longitude.

The mission description information presented in this section and appendix 1 are based on NASA trajectory document No. 66-FMP-10, *AS-502/CSM-020 Joint Reference Trajectory*, (Reference 4), and does not reflect changes resulting from incorporation of the propulsion predictions contained in appendix 5. The times indicated in appendix 2 are not compatible with this section for the times in appendix 2 are mean flight times.

TABLE 2-1
PREDICTED S-IVB-502 FLIGHT MASS SUMMARY

ITEM	S-IC LIFTOFF	S-II/ S-IVB SEPARA- RATION	S-IVB FIRST ESC	END FUEL LEAD	90 PERCENT THRUST	S-IVB FIRST ECC	S-IVB FIRST ETD	APS ULLAGE OFF	RESTART PREPA- RATIONS	ESC SECOND BURN	END FUEL LEAD	90 PERCENT THRUST	ECC DEPLETION	ETD DEPLETION	CSM SEPARATION	END TAPE
Frost	300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Launch escape	8,660	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aft frame	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Detonation package	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ullage rocket grain	112	119	112	16	0	0	0	0	0	0	0	0	0	0	0	0
Ullage rocket case	130	130	130	130	130	0	0	0	0	0	0	0	0	0	0	0
Command module	12,200	12,200	12,200	12,200	12,200	12,200	12,200	12,200	12,200	12,200	12,200	12,200	12,200	12,200	0	0
Service module	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	0	0
Service module propellant	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	0	0
SLA ring	90	90	90	90	90	90	90	90	90	90	90	90	90	90	0	0
Lunar module	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Adapter (SLA)	3,810	3,810	3,810	3,810	3,810	3,810	3,810	3,810	3,810	3,810	3,810	3,810	3,810	3,810	3,810	3,810
Vehicle Instrument Unit	4,763	4,763	4,763	4,763	4,763	4,763	4,763	4,763	4,763	4,763	4,763	4,763	4,763	4,763	4,763	4,763
S-IVB-502 dry stage	26,165	26,165	26,165	26,165	26,165	26,165	26,165	26,165	26,165	26,165	26,165	26,165	26,165	26,165	26,165	26,165
LOX ullage gas	40	40	40	42	42	130	131	132	366	376	379	379	493	493	493	493
LOX in tank	192,906	192,906	192,906	192,905	192,886	136,375	136,215	136,212	135,978	135,978	135,978	135,725	167	31	31	31
LOX in ports	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
LOX in lines	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246
LOX in engine	108	108	108	108	138	138	108	108	108	108	108	138	138	108	108	108
LH2 ullage gas	58	58	58	59	60	126	126	137	268	298	304	306	557	557	557	557
LH2 in tank	42,445	42,445	42,445	42,441	42,425	32,102	32,072	32,041	29,377	29,377	29,344	29,235	847	819	819	819
LH2 in lines	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
LH2 in engine	10	10	10	20	20	20	10	10	10	10	18	20	20	10	10	10
Cold helium quad 1	165	165	165	164	164	143	143	143	117	117	116	116	59	59	59	59
Cold helium quad 2	165	165	165	164	164	143	143	143	117	117	116	116	59	59	59	59
APS propellant fin plane I	311	311	311	311	311	310	309	288	225	197	197	197	195	195	192	192
APS propellant fin plane III	311	311	311	311	311	310	309	288	225	197	197	197	195	195	192	192
APS helium	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Helium repressurant	81	81	81	81	81	81	81	81	81	41	41	41	41	41	41	41
GH2 in start tank	5	5	5	5	1	7	7	7	7	7	7	1	7	7	7	7
Service items	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Environmental control fluid	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
Total mass (lbm)	362,169	353,154	353,147	353,059	353,034	286,183	285,954	285,889	283,180	283,125	283,105	282,771	119,077	118,873	57,678	57,678
Time from liftoff (sec)	0.000	522.400	522.600	525.600	526.330	651.350	652.750	739.350	11,072.000	11,399.000	11,407.000	11,409.500	11,767.378	11,768.778	11,948.000	11,749.000

TABLE 2-2

PREDICTED CONDITIONS AT MAXIMUM DYNAMIC PRESSURE (AS-502)

PARAMETER		UNITS	NOMINAL VALUE
Time from liftoff	(t)	sec	77.25
Dynamic pressure	(q)	lbf/ft^2	788.00
Altitude	(h)	ft	42,748
Mach number	(m)	--	1.74
Angle of attack	(α)	deg	0.75

TABLE 2-3

PREDICTED CONDITIONS AT S-II/S-IVB STAGE SEPARATION (AS-502)

PARAMETER		UNITS	NOMINAL VALUE
Time from liftoff	(t)	sec	516.92
Earth fixed velocity	(V_E)	ft/sec	21,279.61
Inertial velocity	(V_I)	ft/sec	22,602.00
Inertial flight path elevation angle	(γ_{1_I}')	deg	0.563
Altitude	(h)	nmi	102.4

TABLE 2-4

PREDICTED CONDITIONS, FIRST S-IVB ENGINE CUTOFF COMMAND

PARAMETER		UNITS	NOMINAL VALUE
Time from liftoff	(t)	sec	645.70
Earth fixed velocity	(V_E)	ft/sec	24,237.00
Inertial velocity	(V_I)	ft/sec	25,561.00
Inertial flight path elevation angle	(γ_{1_I}')	deg	-0.0017
Inertial flight path azimuth angle	(γ_{2_I}')	deg	86.73

TABLE 2-5

PREDICTED CONDITIONS, SECOND S-IVB ENGINE START COMMAND

PARAMETER		UNITS	NOMINAL VALUE
Time from liftoff	(t)	sec	11,399.00
Altitude	(h)	nmi	111.20
Earth fixed velocity	(V_E)	ft/sec	24,222.00
Inertial velocity	(V_I)	ft/sec	25,548.00
Inertial flight path elevation angle	(γ_{1_I}')	deg	0.0221
Inertial flight path azimuth angle	(γ_{2_I}')	deg	94.01

TABLE 2-6

PREDICTED CONDITIONS, SECOND S-IVB ENGINE CUTOFF COMMAND

PARAMETER		UNITS	PREDICTED VALUE
Time from second S-IVB Engine Start Command	(t)	sec	318.00
Altitude	(h)	nmi	165.4
Earth fixed velocity	(V_E)	ft/sec	34,265.00
Inertial velocity	(V_I)	ft/sec	35,602.00
Inertial flight path elevation angle	(γ_{1_I}')	deg	6.32
Inertial flight path azimuth angle	(γ_{2_I}')	deg	108.24

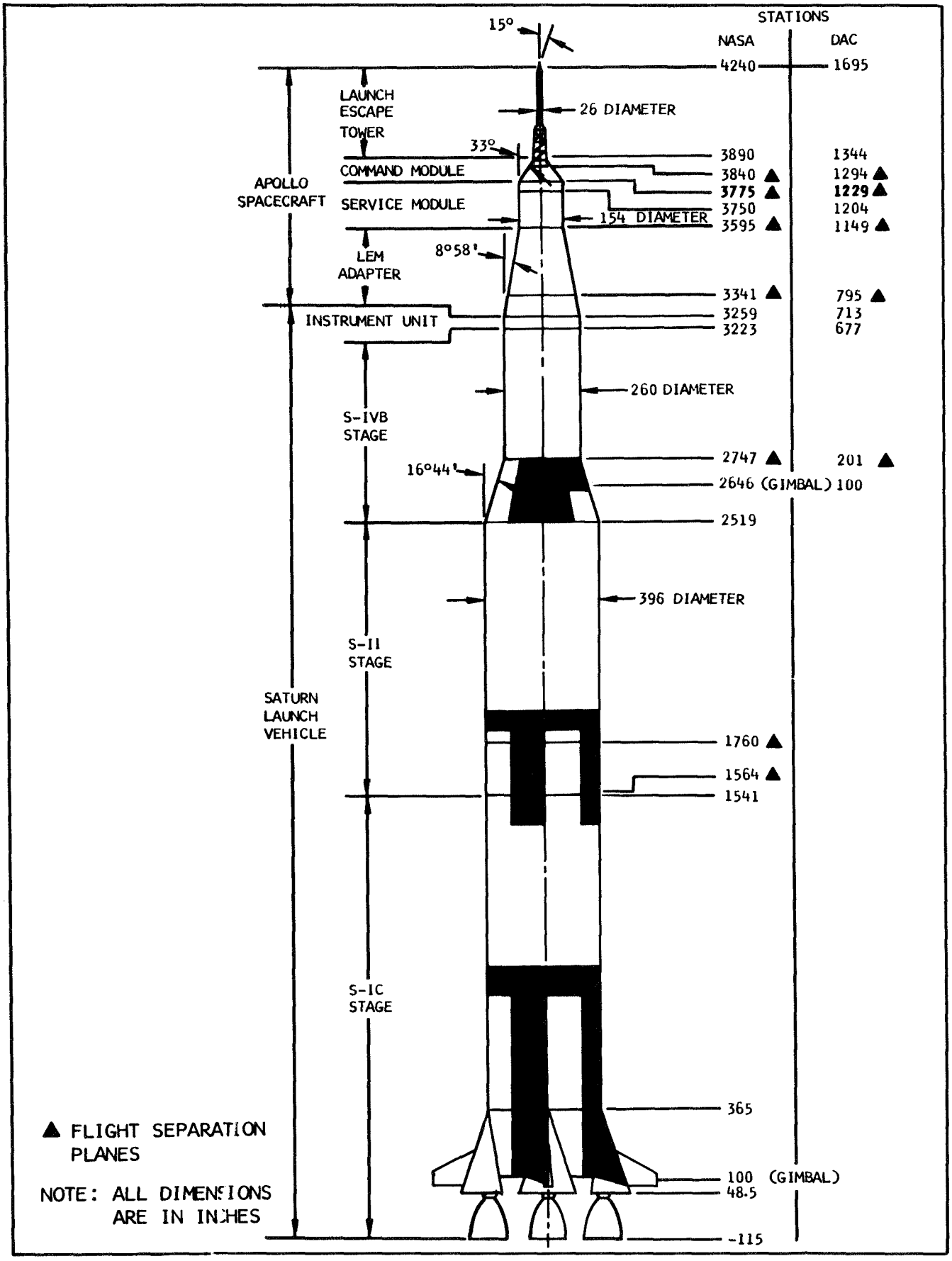


Figure 2-1. AS-502 Space Vehicle

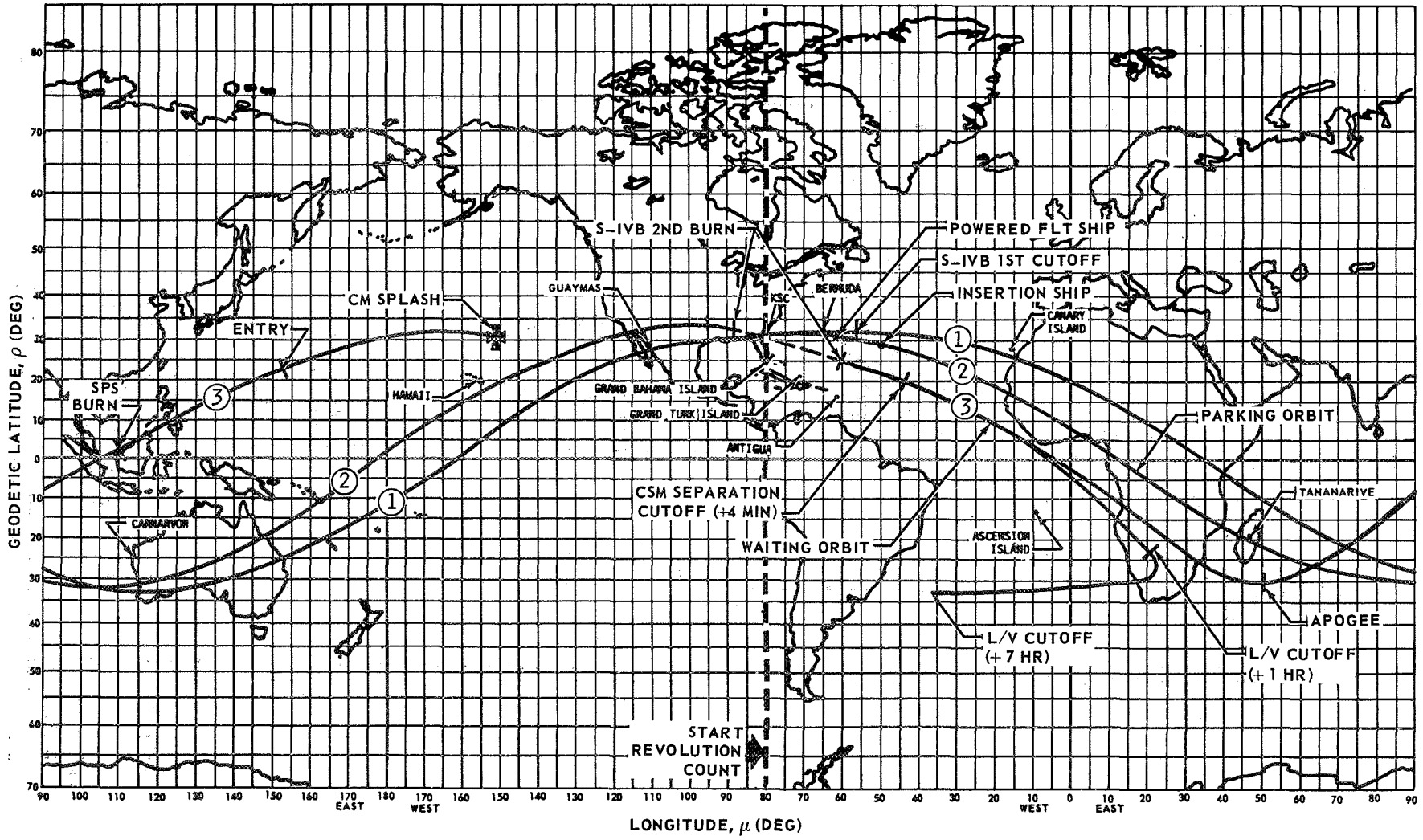


Figure 2-2. AS-502 Ground Trace

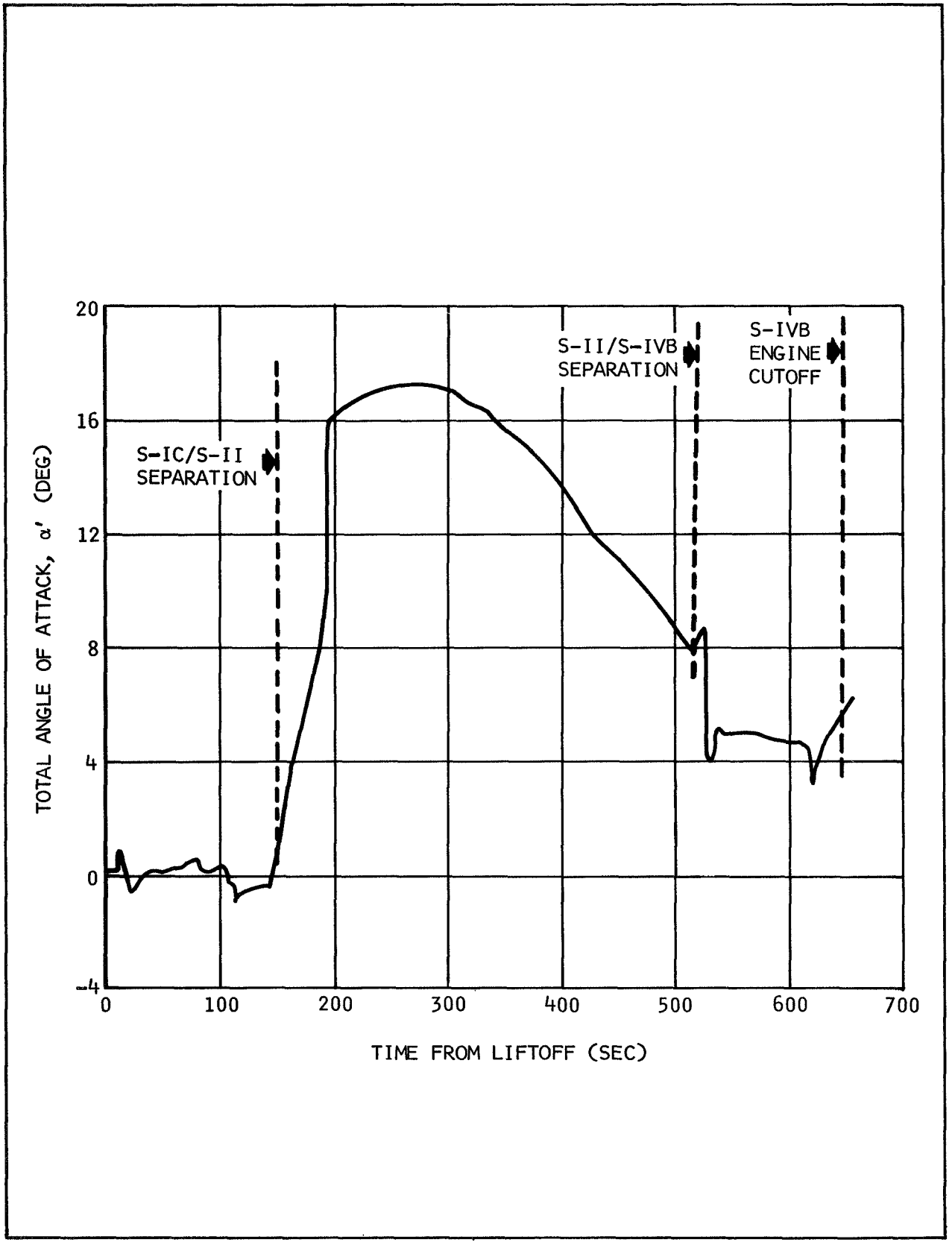


Figure 2-3 Predicted AS-502 Angle of Attack During Boost-to-Parking Orbit

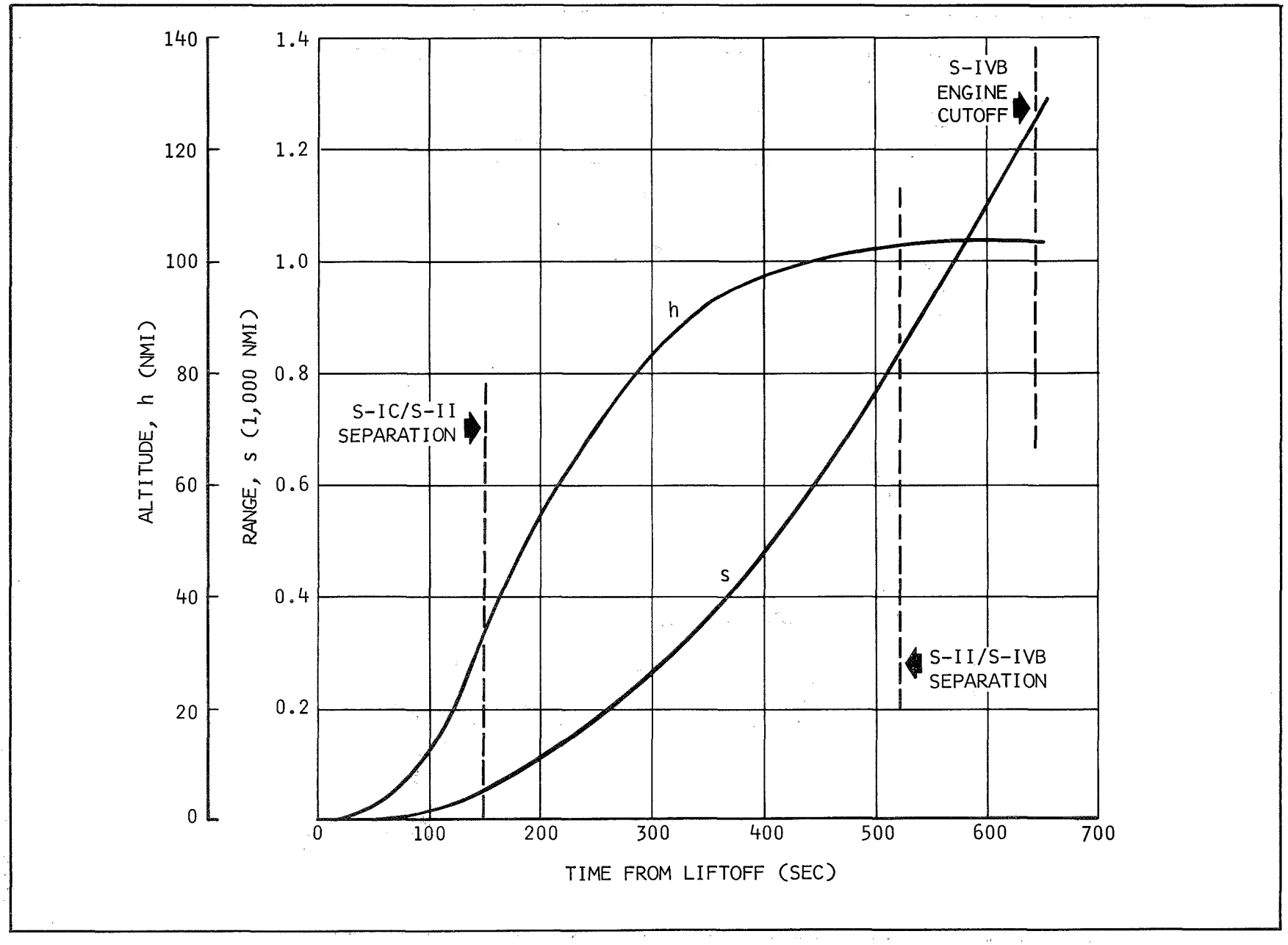


Figure 2-4. Predicted AS-502 Altitude and Range During Boost-to-Parking Orbit

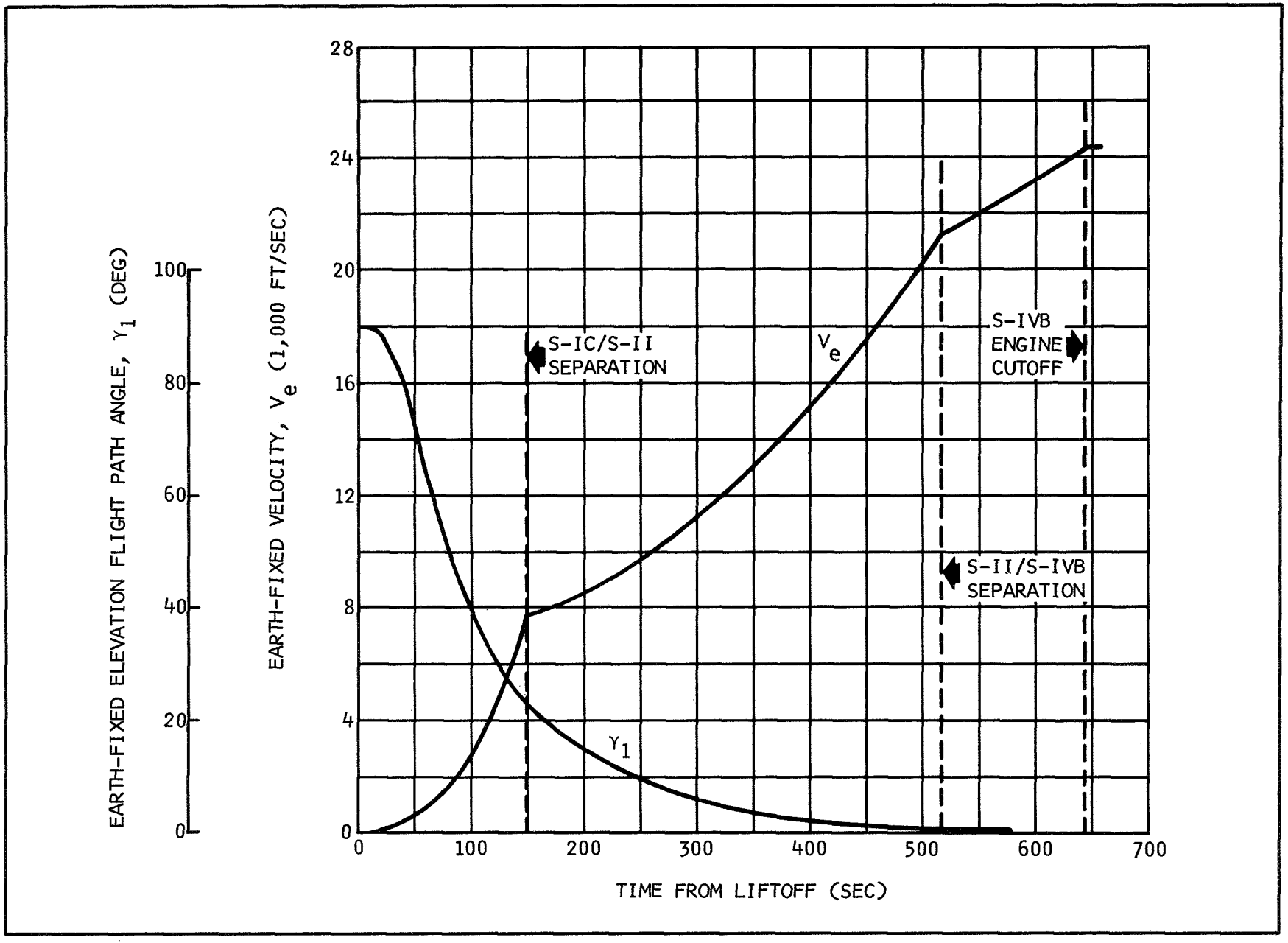


Figure 2-5. Predicted Earth Fixed Velocity and Earth-Fixed Elevation Flight Path Angle During Boost-to-Parking Orbit

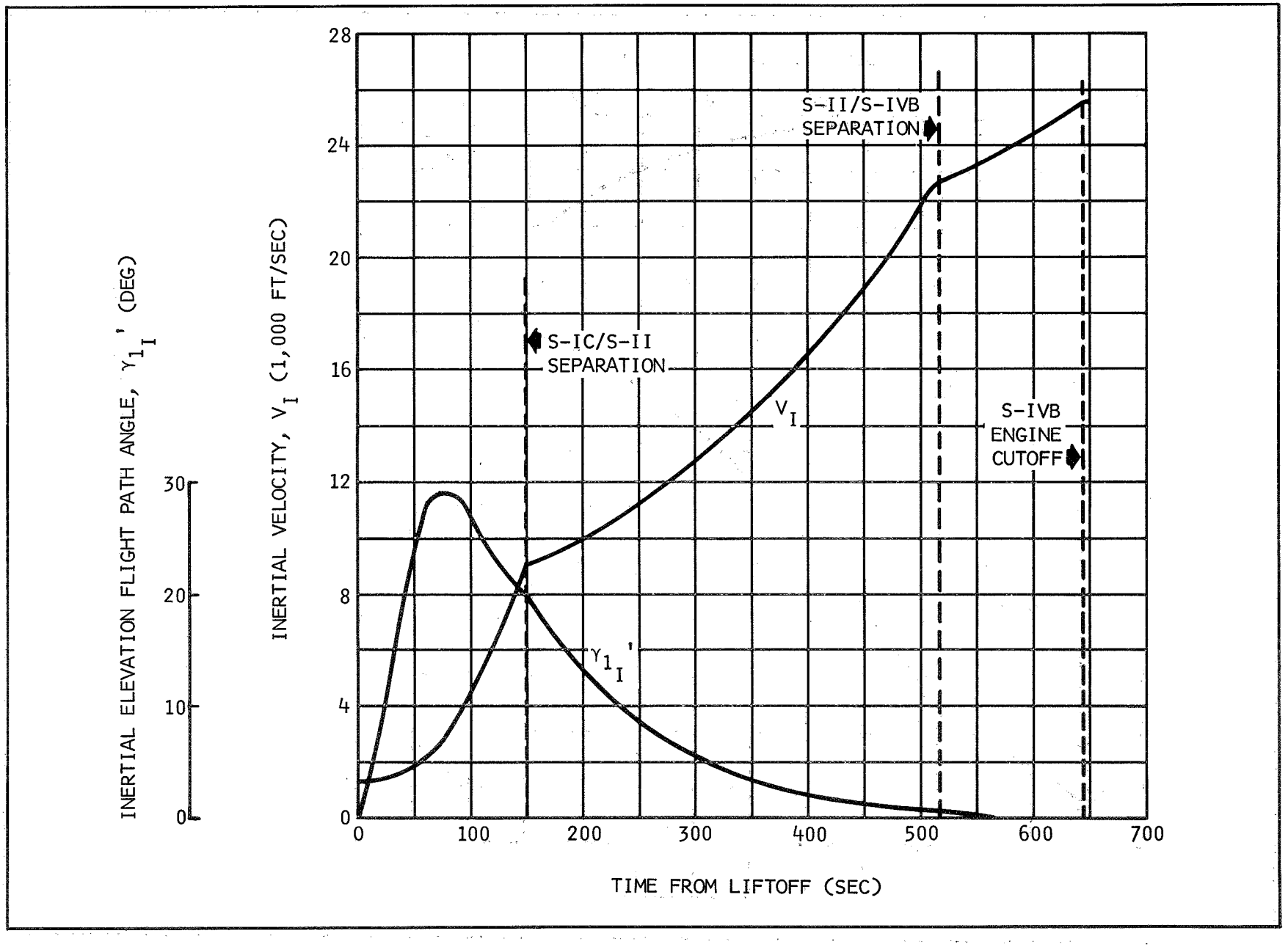


Figure 2-6. Predicted AS-502 Inertial Elevation Angle and Inertial Velocity During Boost-to-Parking Orbit

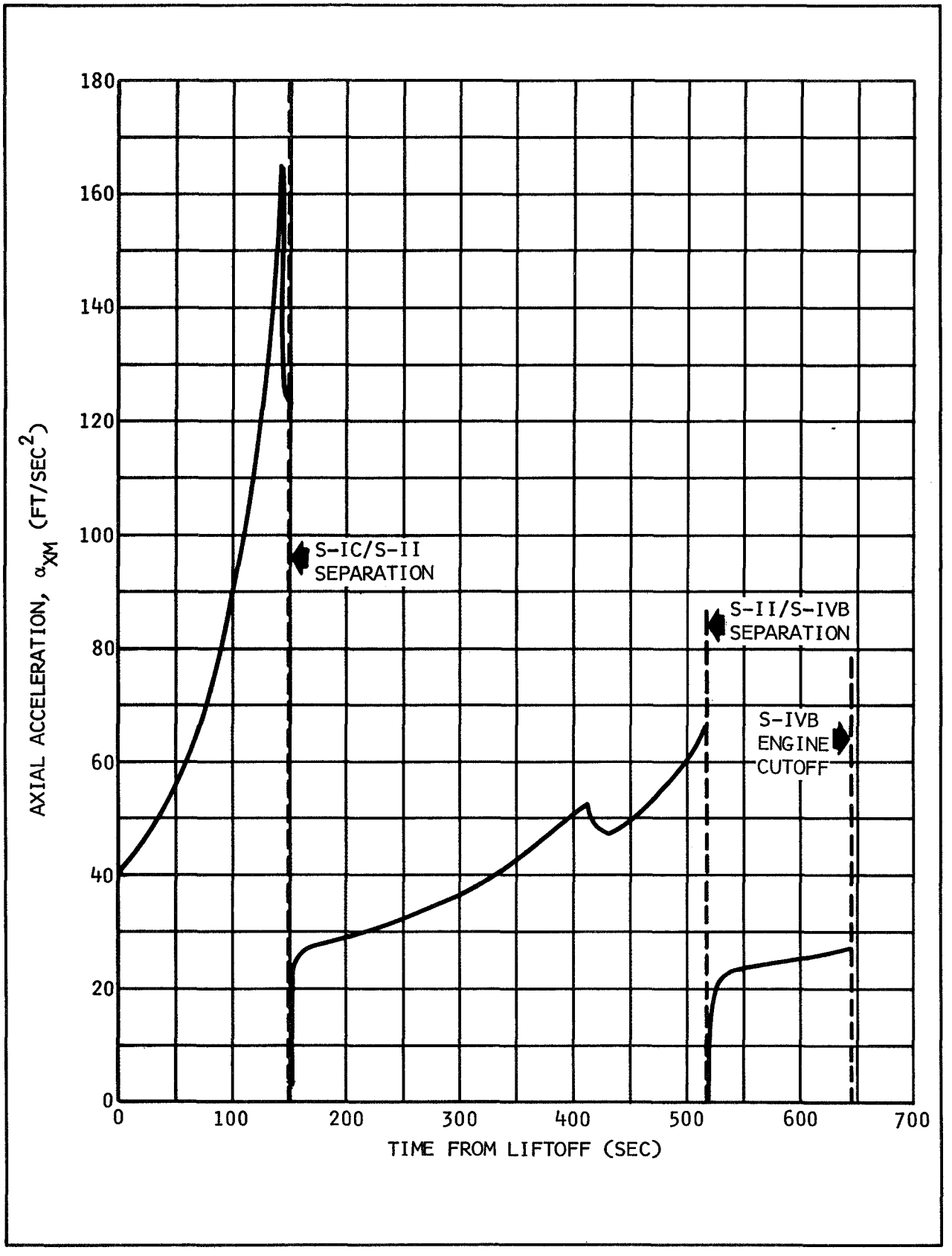


Figure 2-7. Predicted AS-502 Axial Acceleration During Boost-to-Parking Orbit

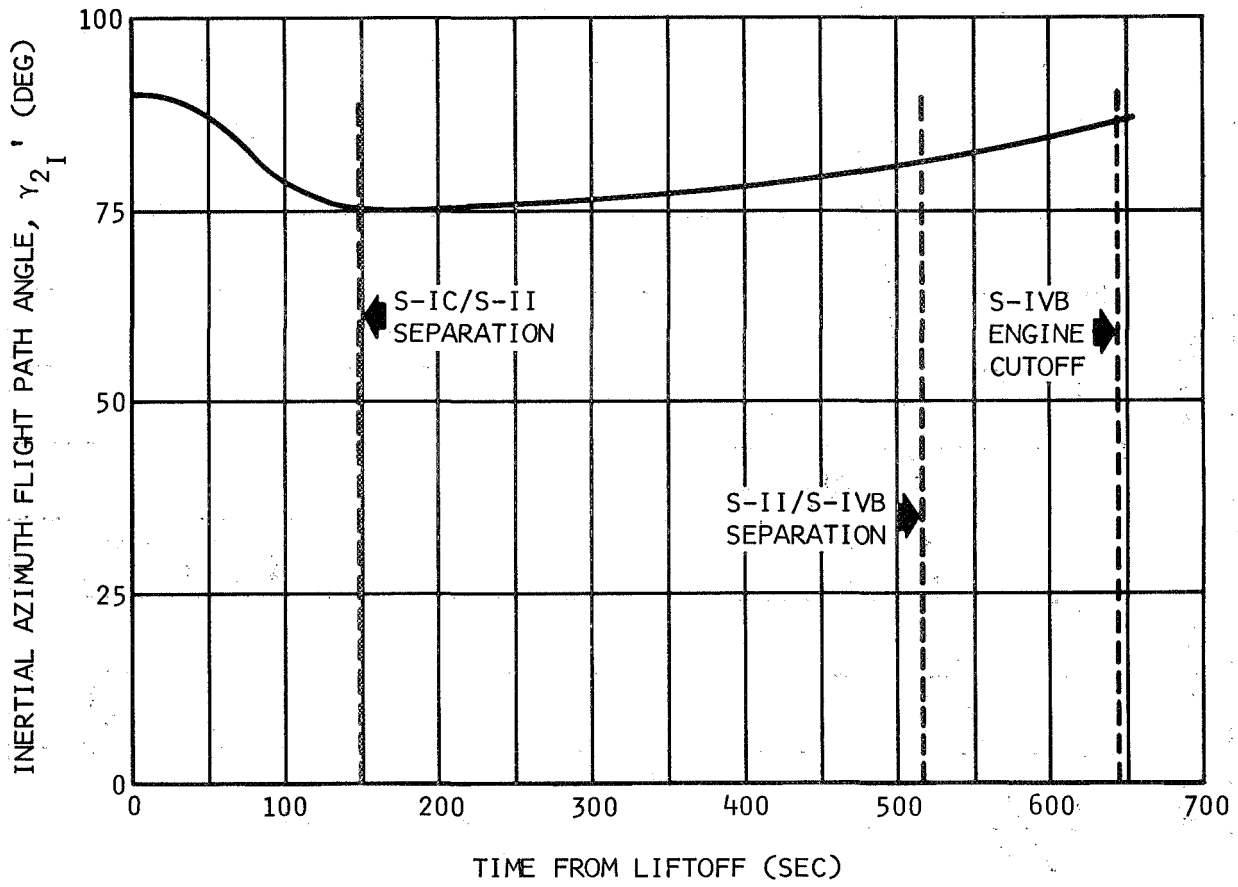


Figure 2-8. Predicted AS-502 Inertial Azimuth Flight Path Angle During Boost-to-Parking Orbit

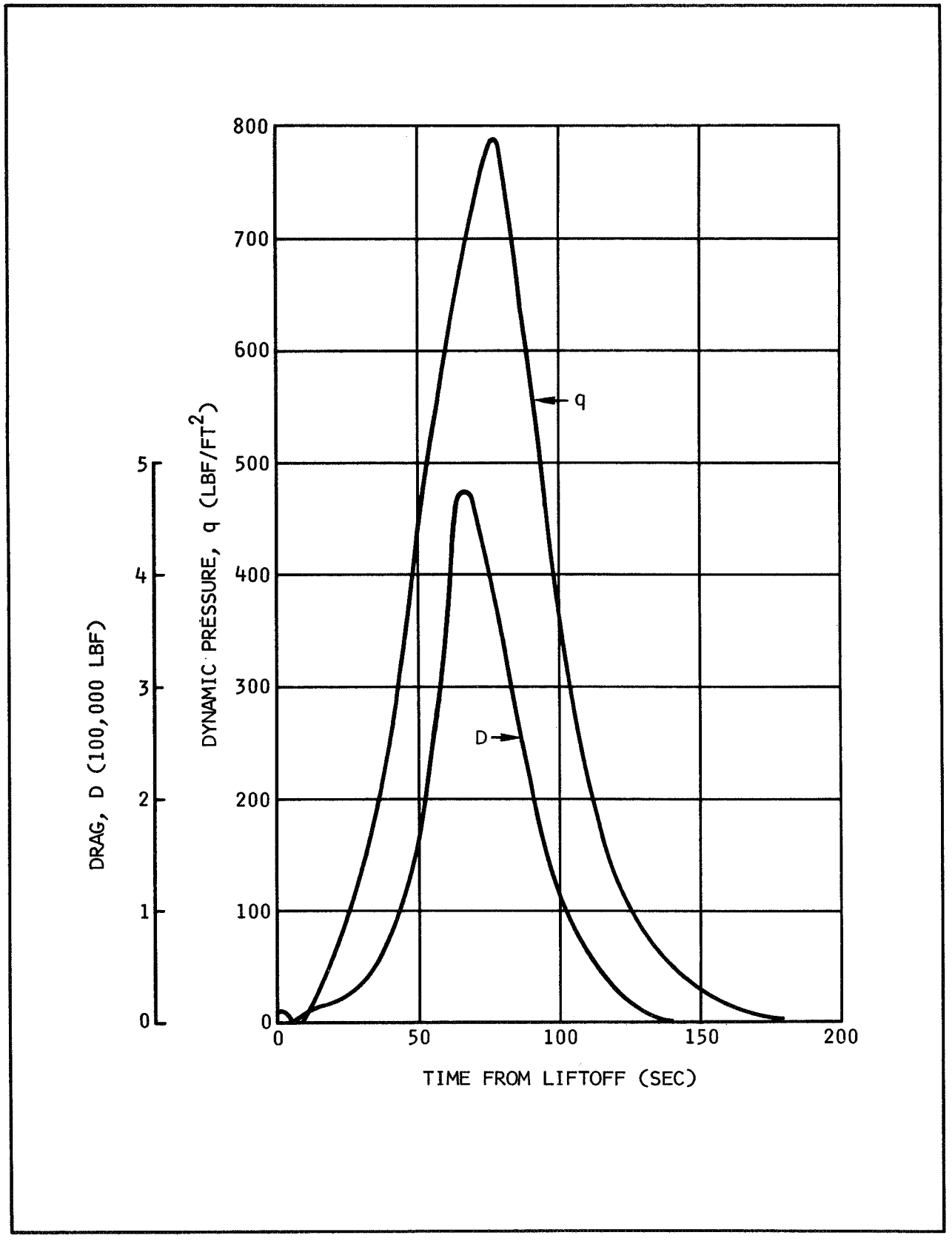


Figure 2-9. Predicted AS-502 Drag and Dynamic Pressure During Boost-to-Parking Orbit

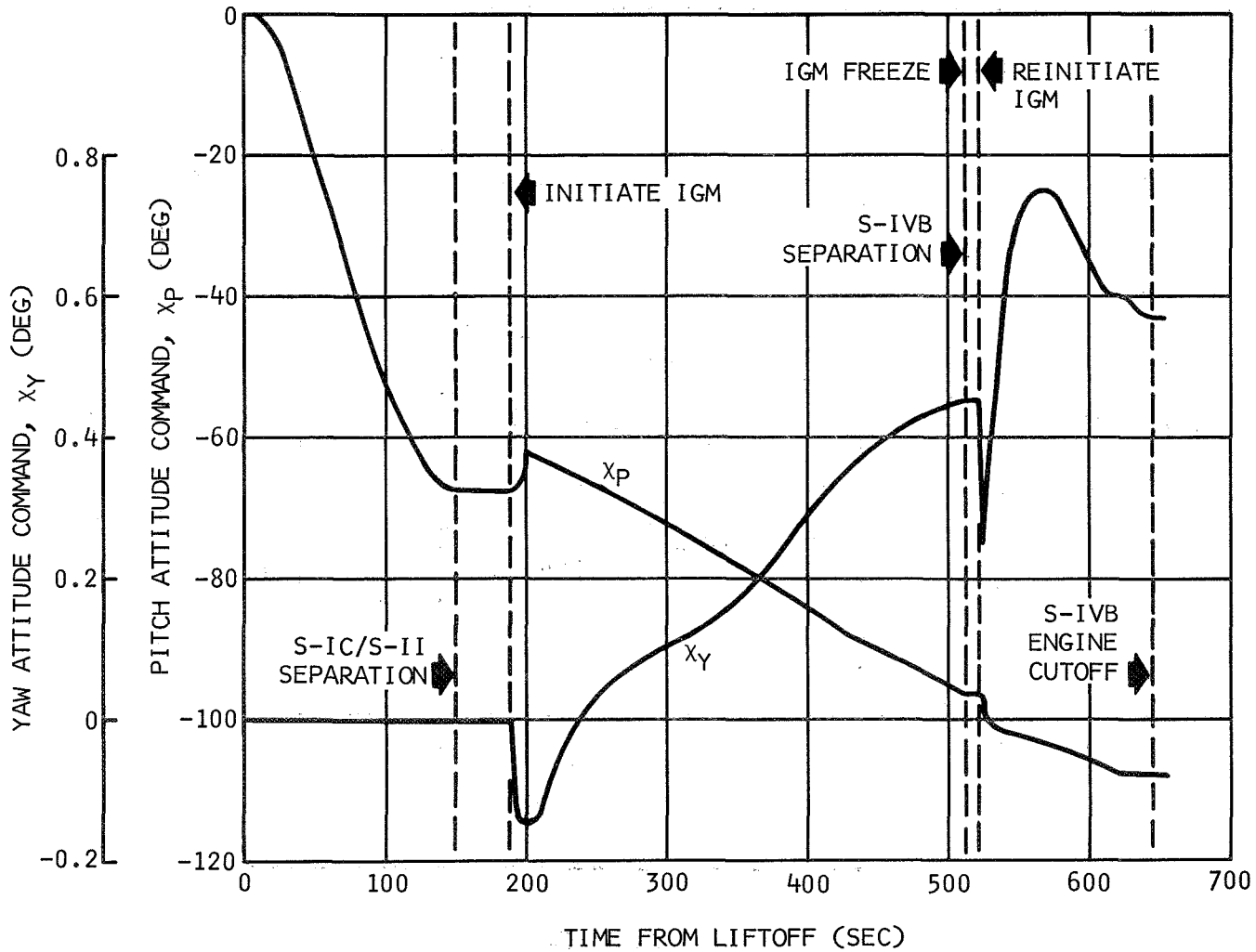


Figure 2-10. Predicted AS-502 Pitch and Yaw Attitude Commands During Boost-to-Parking Orbit

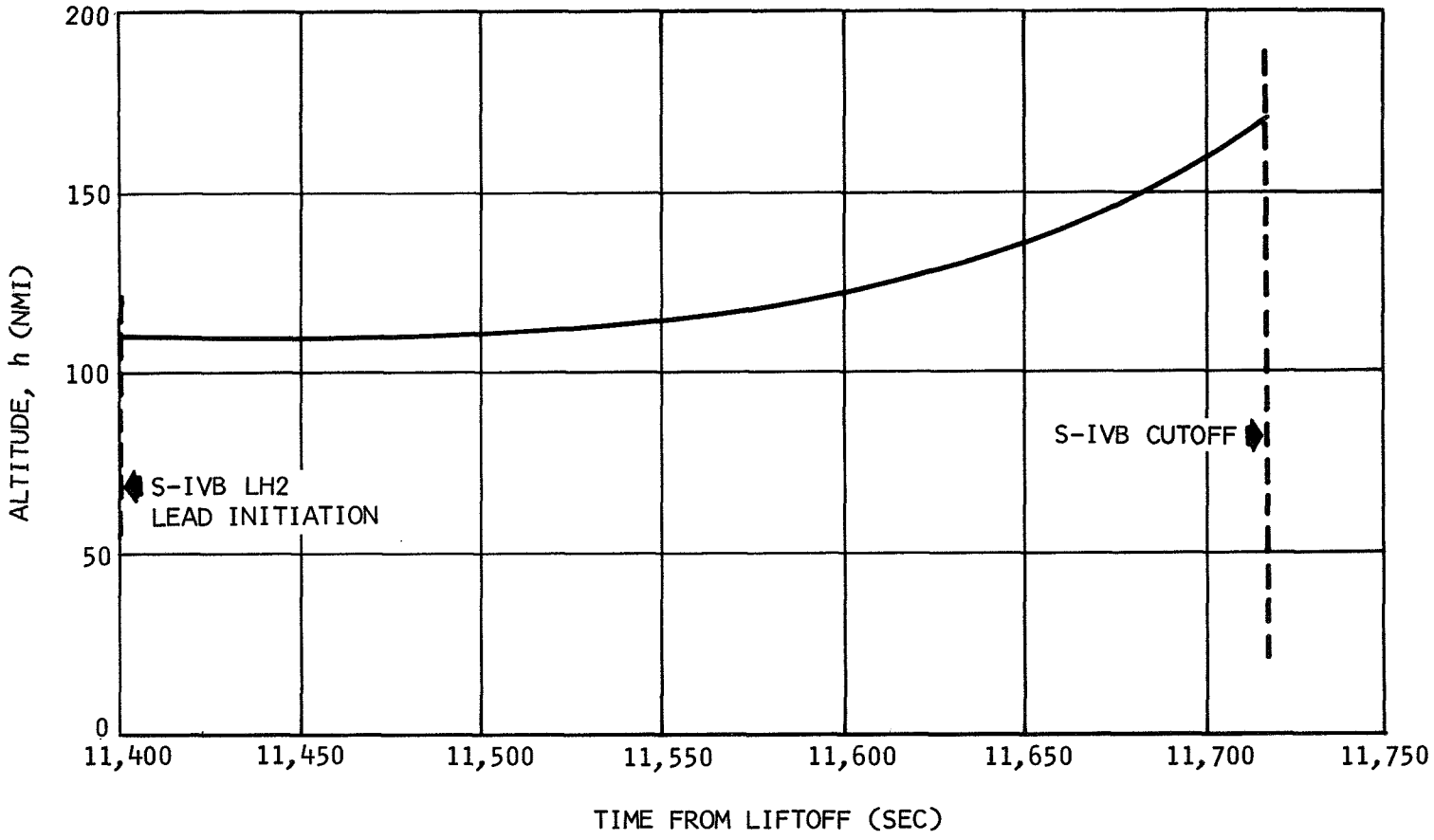


Figure 2-11. Predicted AS-502 Altitude During S-IVB Second Burn

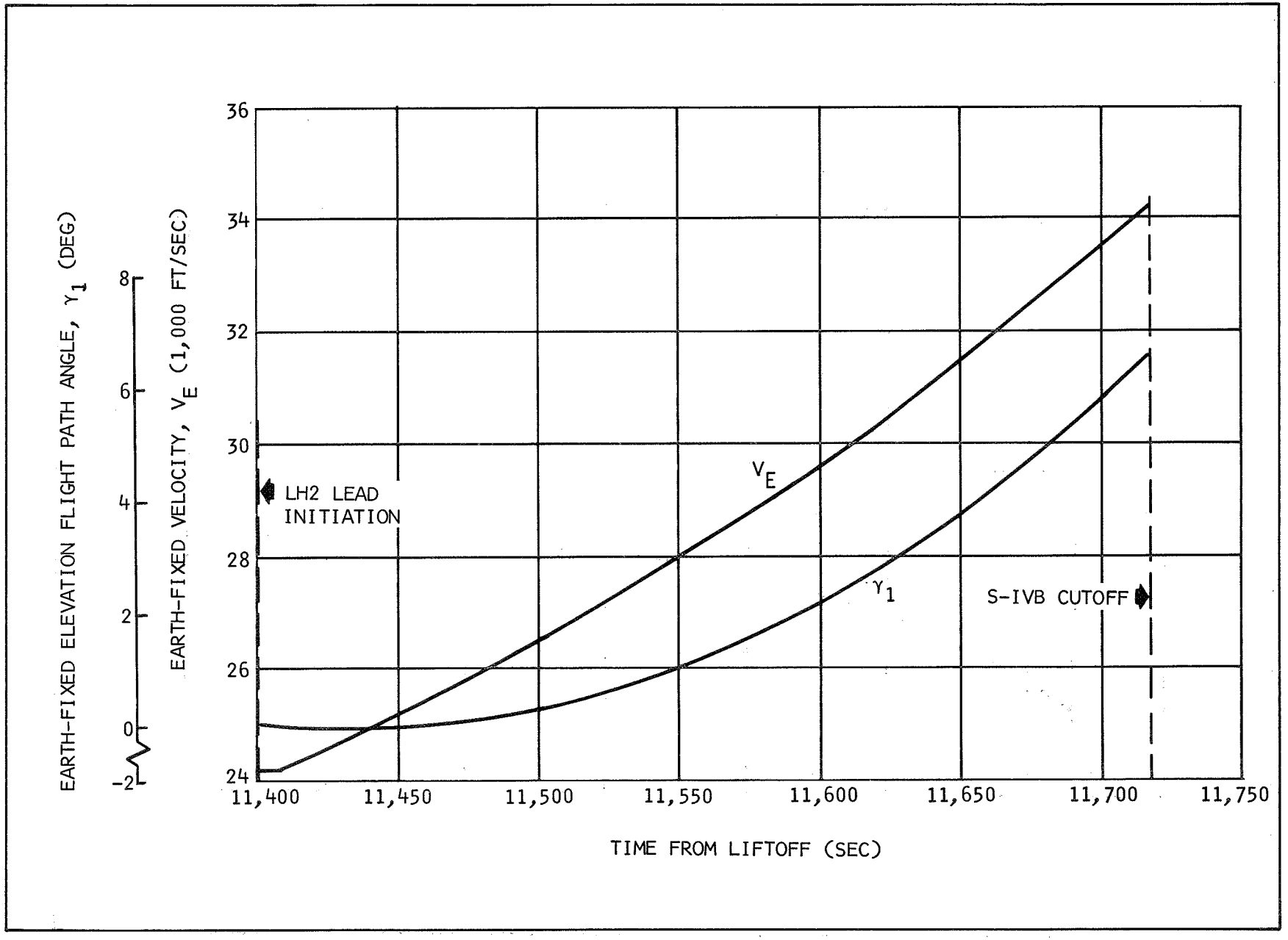


Figure 2-12. Predicted AS-502 Earth-Fixed Elevation Flight Path Angle and Velocity During S-IVB Second Burn

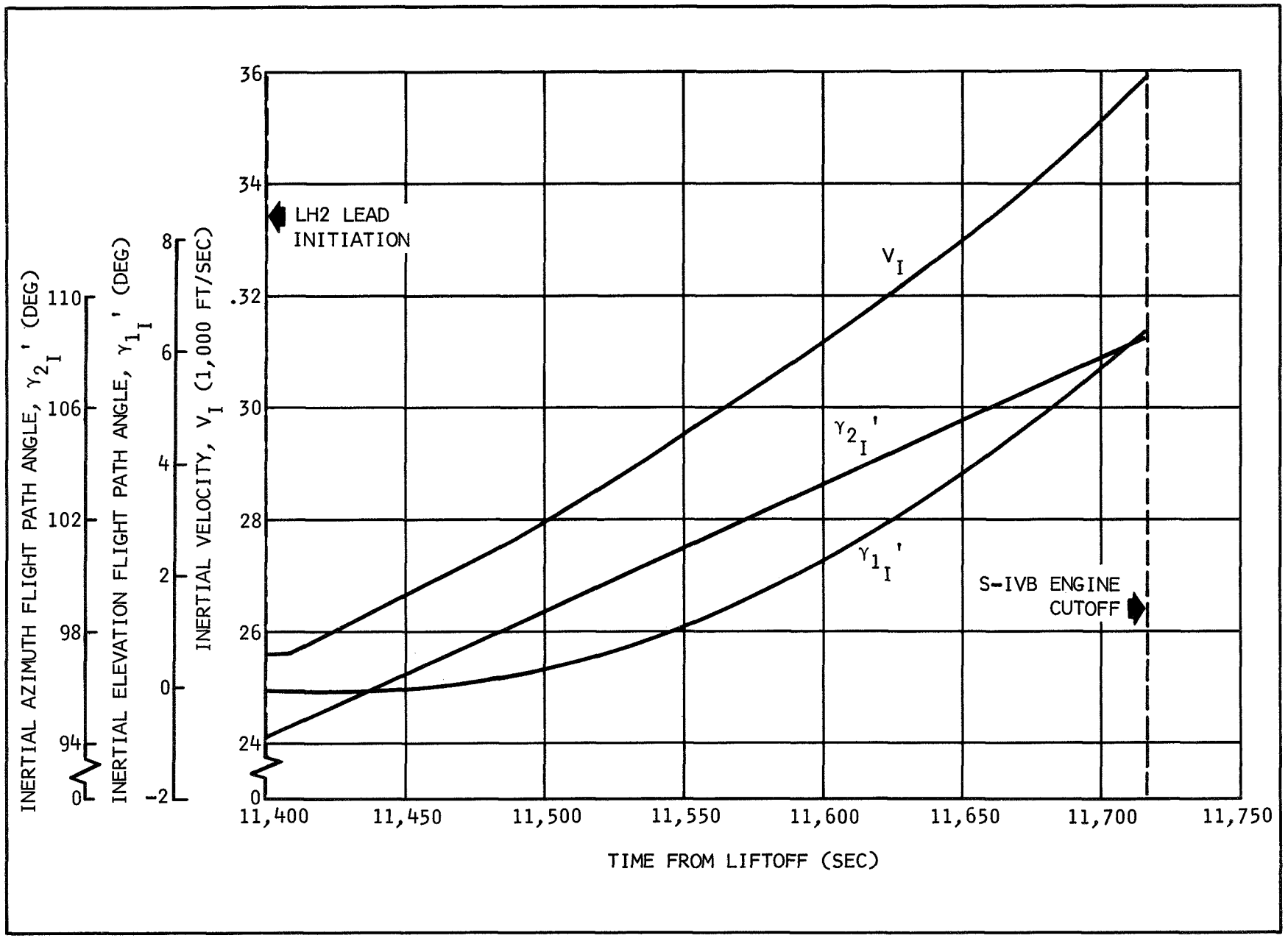


Figure 2-13. Predicted AS-502 Inertial Azimuth Flight Path Angle, Elevation Flight Path Angle, Inertial Velocity During S-IVB Second Burn

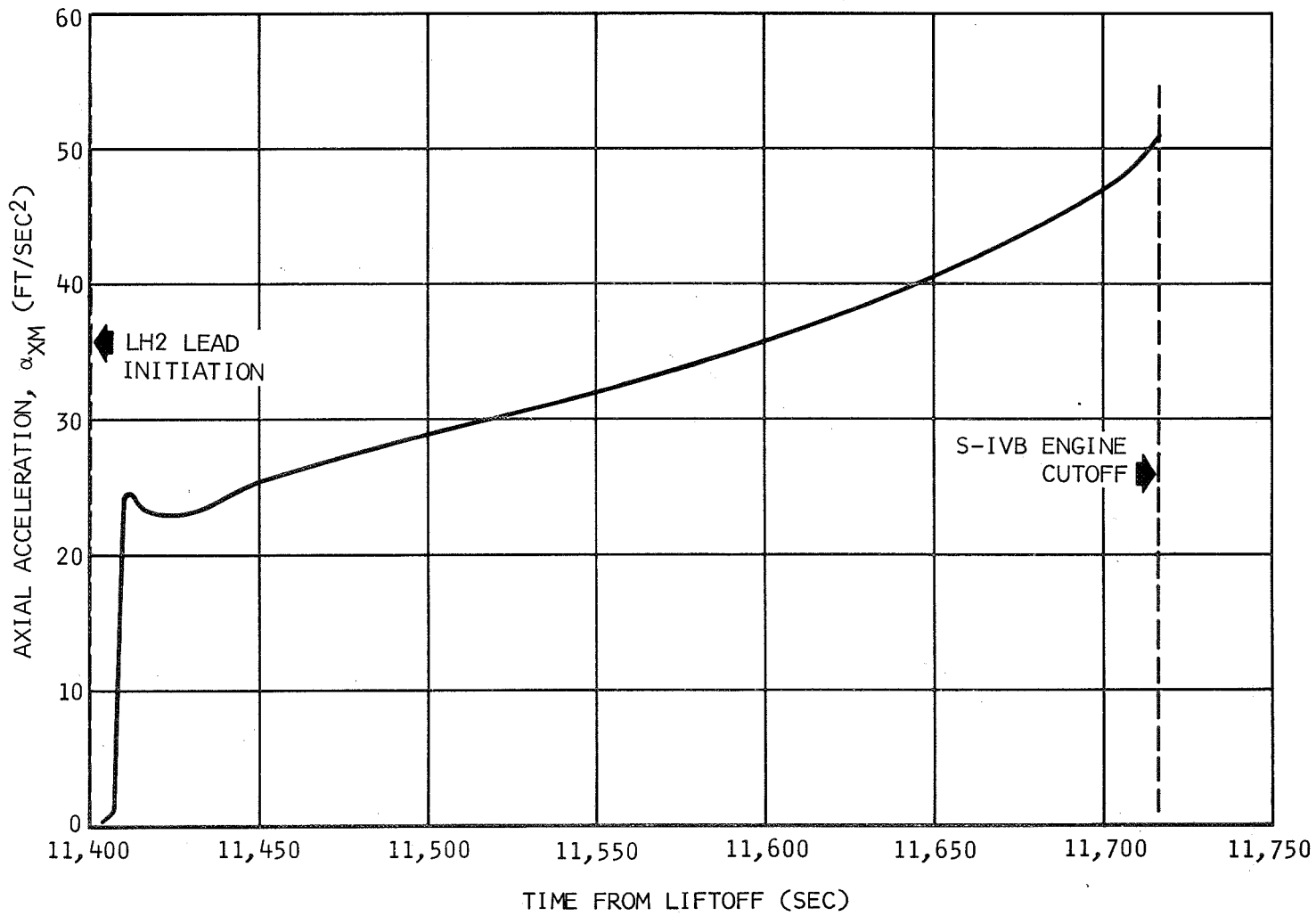


Figure 2-14. Predicted AS-502 Axial Acceleration During S-IVB Second Burn

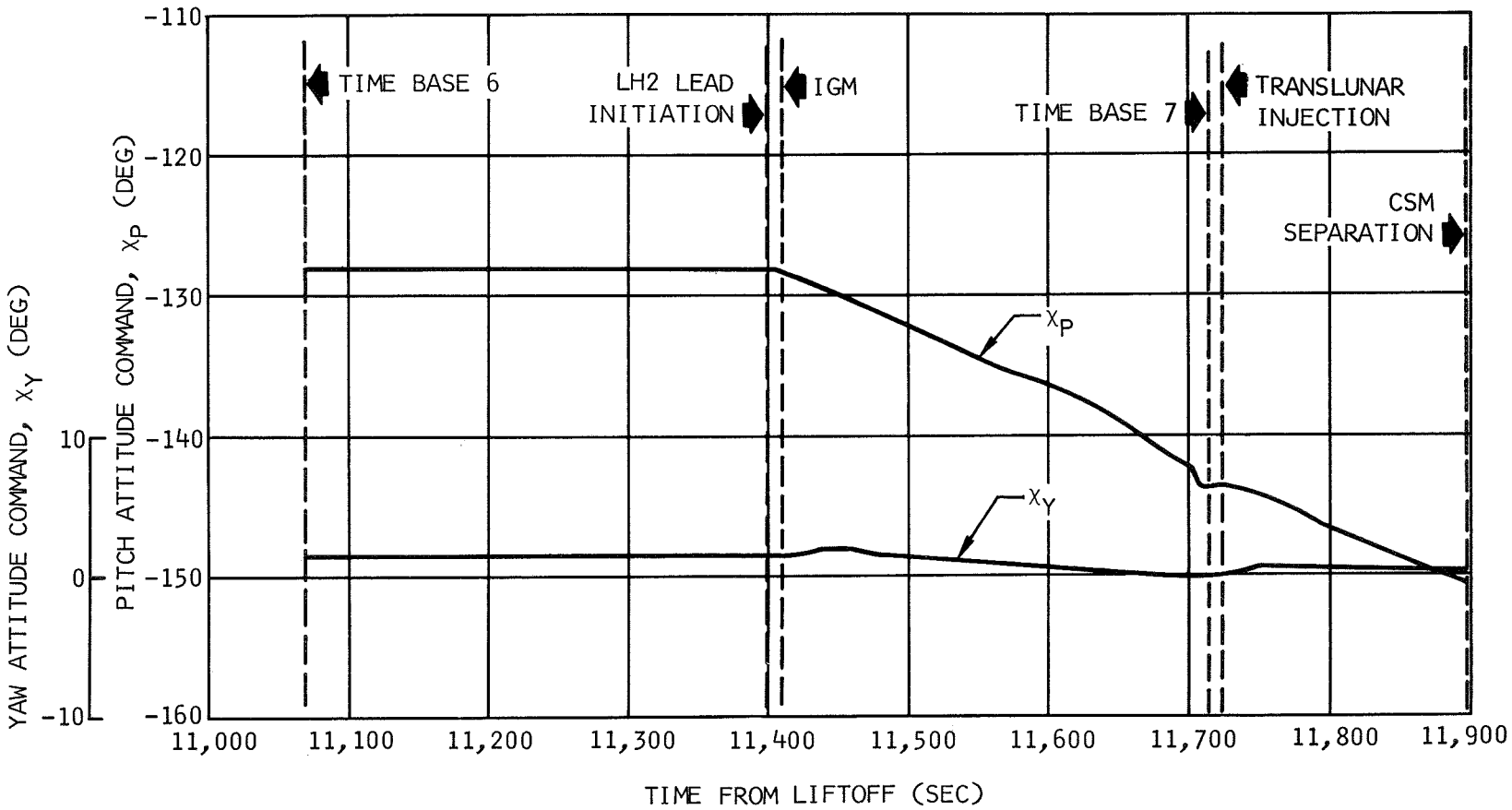


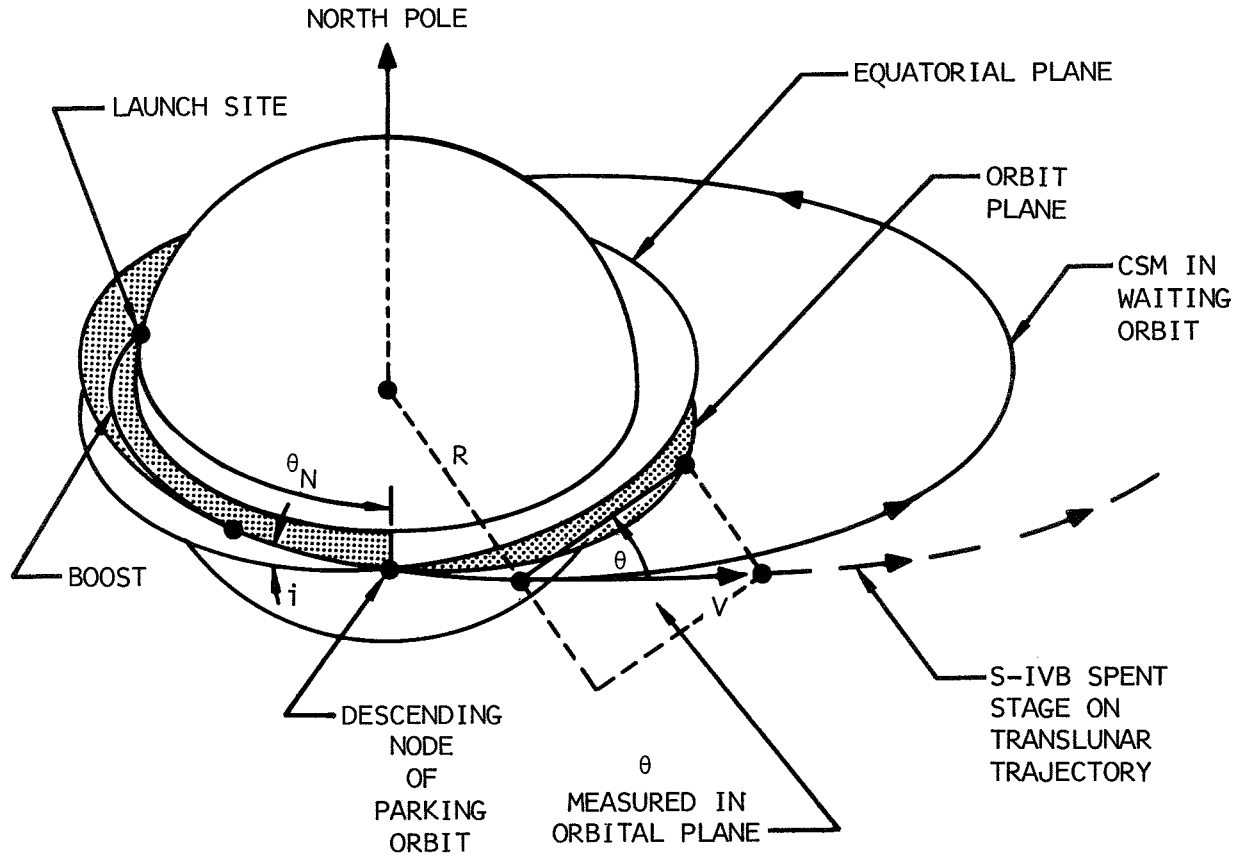
Figure 2-15. Predicted AS-502 Yaw and Pitch Attitude Commands During Restart Preparations and Second Burn

PARKING ORBIT INSERTION:

R	=	21,533,287 FT
V	=	25,568.0344 FT/SEC
θ	=	-0.0003 DEG
i	=	32.5611 DEG
θ_N	=	123.1741 DEG

TRANSLUNAR INJECTION:

R	=	21,956,483 FT
V	=	35,581.168 FT/SEC
θ	=	6.7725 DEG
i	=	32.4851 DEG
θ_N	=	122.4878 DEG
C_3	=	-16,202,139 FT^2/SEC^2
e	=	0.975084



(FIGURE NOT TO SCALE)

Figure 2-16. AS-502 Flight Conditions

SECTION 3

STAGE OBJECTIVES

3. STAGE OBJECTIVES

This section defines the S-IVB-502 stage flight objectives and evaluation criteria in support of the vehicle mission objectives presented in section 2. The S-IVB stage research and development objectives are designed to verify the performance of the S-IVB stage airframe, stage systems, S-II/S-IVB and S-IVB/IU interfaces, and to determine and evaluate the internal/external stage environments. It should be noted that the stage objectives describe the evaluation efforts to be accomplished only by Douglas, and do not completely satisfy the mission objectives. The mission objectives will be satisfied by the cumulative evaluation efforts of MSFC, Douglas, and the other Saturn program contractors and the results will be reported in the MSFC vehicle report.

For convenience of the evaluation and reporting tasks, the mission has been divided into the following four major phases:

(A) Launch Phase* - The period from liftoff to S-IVB first J-2 engine cutoff +10 sec.

(B) Parking Orbit Phase - The period from S-IVB first J-2 engine cutoff +10 sec to initiation of S-IVB restart preparations.

(C) Pre-ignition Sequencing and S-IVB Second Burn Phase - The period from initiation of S-IVB restart preparations to S-IVB second burn to second J-2 engine cutoff +10 sec.

(D) Active Waiting Orbit Phase - The period from second J-2 engine cutoff +10 sec until loss of S-IVB attitude control, or until planned LV/SC separation.

3.1 Airframe Structural Integrity (Phases A, B, C, D)

Verify the structural integrity of the S-IVB stage during all phases of the mission. This objective will be achieved by the evaluation of the structural integrity of the following airframe components:

*This phase may be considered to encompass the prelaunch activities where required.

a. Forward skirt assembly

b. LH2 tank assembly

c. LOX tank assembly

d. Engine thrust structure

e. Aft skirt assembly

f. Aft interstage assembly

g. Common bulkhead.

3.2 Main Propulsion System (Phases A, B, C, D)

Verify the propulsion system operations during flight. This objective will be achieved by evaluation of the performance of the J-2 engine system, the LH2 and LOX systems, and the stage pneumatic control and purge system. Predicted propulsion system performance data are presented in appendix 5.

3.2.1 J-2 Engine Performance and Conditioning (Phases A, C)

Determine the J-2 engine chilldown, start, steady-state, and cutoff performance characteristics. Evaluation of the following will verify this objective:

a. Thrust buildup characteristics during engine start transient

b. Thrust characteristics during steady-state operation

c. Thrust decay characteristics during engine cutoff

d. Total impulse

e. Start impulse

f. Cutoff impulse

g. The J-2 engine thrust chamber chilldown time, thermal gradients, response of the structure to chilldown, S-II/S-IVB interstage environment, and retro and ullage rocket plume impingement during stage separation

h. The J-2 engine start sphere chilldown and loading, the conditions in the sphere at liftoff and Engine Start Command, the mass used for engine start, and the sphere warmup rate from pressurization to liftoff and during S-IC and S-II boost

i. The J-2 engine start sphere refill during S-IVB first burn, the condition of the sphere at first burn cutoff and second burn Engine Start Command, the mass used for second burn engine start, and sphere warmup rate during orbital coast

j. The J-2 engine control helium sphere prepressurization and loading, sphere conditions at liftoff and at Engine Start Command (ESC), and the sphere warmup rate from loading to liftoff, during S-IC and S-II boost, and during orbital coast

k. The J-2 engine sequencing

l. Propellant consumption using flow integration and the thrust profile for flight performance reconstruction.

3.2.2 LH2 System (Phases A, B, C, D)

Satisfactory operation of the LH2 system will be verified by the proper operation of the LH2 propellant feed system and the LH2 vent systems.

3.2.2.1 LH2 Propellant Feed System (Phases A, C)

Demonstrate the capability of the LH2 system to provide sufficient LH2 and net positive suction head (NPSH) to the J-2 engine for satisfactory operation. Evaluation of the following will verify this objective:

a. LH2 temperature and pressure and tank ullage pressure during loading operations and at liftoff

b. Prepressurization of the LH2 tank prior to launch

c. Transition from ground prepressurization to onboard flight pressurization system to provide tank ullage pressure during engine operation

d. Conditions of propellant supplied to the J-2 engine LH2 pump inlet during prestart and steady-state operation

e. LH2 recirculation chilldown

f. Repressurization of the LH2 tank prior to second burn

g. Fuel lead thrust chamber chilldown

h. Orbital boiloff mass (obtained during phase B)

3.2.2.2 LH2 Vent Systems (Phases B, D)

Demonstrate the capability of the vent systems to provide the required LH2 tank pressures, and to provide sufficient acceleration after J-2 engine cutoff to settle the LH2 and LOX.

Evaluation of the following will verify this objective:

a. Continuous vent system thrust, thrust imbalance, and flowrate
b. Nonpropulsive vent system thrust, thrust imbalance, and flowrate (phase D only)
c. Tank depressurization rate
d. Tank self-pressurization rate (phase D only)
e. Heat input rates.

3.2.3 LOX System (Phases A, B, C, D)

Satisfactory operation of the LOX system will be verified by the proper operation of the LOX feed system, LOX vent system, and pneumatic control and purge system.

3.2.3.1 LOX Feed System (Phases A, C)

Demonstrate the capability of the LOX system to provide sufficient LOX and NPSH to the J-2 engine for satisfactory operation. Evaluation of the following will verify this objective:

a. LOX temperature, LOX pressure, and tank ullage pressure during loading operations and at liftoff
b. Prepressurization of the LOX tank prior to launch
c. Transition from ground prepressurization to onboard flight pressurization and operation of the onboard LOX tank pressurization to provide tank ullage pressure during engine operation
d. Pressurization control module operation
e. Pressure and temperature of the cold helium supply
f. J-2 heat exchanger performance
g. LOX pump chilldown and recirculation
h. Conditions of LOX supplied to the J-2 engine LOX pump inlet during prestart and steady-state operation.

3.2.3.2 LOX Vent System (Phases B, D)

Demonstrate the capability of the vent system to provide required tank pressures after J-2 engine cutoff. Evaluation of the following will verify this objective:

a. Propulsive vent system thrust, flowrate, and total vented impulse

b. Tank depressurization rate

c. Tank self-pressurization rate

d. Heat input rates.

3.2.4 Pneumatic Control and Purge System (Phases A, B, C, D)

Verify the capability of the pneumatic control and purge system to provide pneumatic power and purge gas throughout the mission.

Performance evaluation will include the following:

a. Pressure and temperature of the ambient helium supply

b. The regulation of control pressure

c. Actuation of pneumatic valves

d. Helium purge pressure and flow for the APS, and LH2 and LOX turbopump purges during prelaunch operations

e. LOX recirculation chilldown pump motor container purge pressure.

3.3 Auxiliary Propulsion System (Phases A, B, C, D)

Verify the ability of the auxiliary propulsion system (APS) to provide thrust on demand for roll control during the S-IVB J-2 engine first and second burn; for roll, pitch, and yaw control following J-2 engine cut-off, and for propellant settling. Performance evaluation will include the following:

a. Propellant temperatures and pressures and the ullage pressures during prelaunch operations and at liftoff

b. Temperature and pressure of the helium supply sphere

c. Pressurization of the propellant tanks to flight pressure

d. Response of the engines to stage commands during preflight checkouts and flight

e. Value of the minimum impulse bit

f. Performance of the helium pressurization, fuel supply, oxidizer supply, and engine systems in a space environment.

3.4 Ullage Rockets (Phase A)

Verify the capability of the ullage rockets to provide sufficient thrust for propellant stabilization during S-II/S-IVB separation and the J-2 engine start transient.

Performance evaluation will include the following:

a. Response of ullage rockets to ignition signal

b. Chamber pressure versus time.

3.5 Retrorockets (Phase A)

Verify the capability of the retrorockets to provide sufficient thrust for S-II/S-IVB separation. This will be done by determining (1) response of retrorockets to ignition signal, and (2) chamber pressure as a function of time.

3.6 Hydraulic System (Phases A, B, C, D)

Verify the ability of the hydraulic system to supply pressurized fluid to the servo system, and verify that the servo system gimbals the engine in response to signals from the instrument unit (IU).

3.6.1 Power System (Phases A, B, C, D)

The evaluation of the power system will include the following:

a. Verification that adequate pressurized fluid flow is available to the servo-actuator and that hydraulic system pressures are maintained within expected limits (figure AP 8-1)

b. Verification that fluid temperature is maintained within expected limits during system operation (figure AP 8-1)

c. Verification that auxiliary hydraulic pump motor pressurization is maintained

d. Verification of engine positioning capability prior to restart.

3.6.2 Servo System (Phases A, B, C, D)

The evaluation of the servo system will include the following:

a. Verify the adequacy of actuator artificial damping mechanism performance

b. Verify the adequacy of present compensation for thrust vector deflection errors caused by gimbal "slop" and thrust structure compression effects

c. Evaluate the effects of thrust misalignment and thrust eccentricity errors on actuator performance

d. Determine and evaluate actuator start transient loads during initial start and restart

e. Determine and evaluate gimbal friction during engine burn after gimbal bearing has been exposed to space environment

f. Compare critical actuator component temperatures with predicted values

g. Verify proper pitch and yaw actuator responses to commands

h. Evaluate the effects of IU command errors in the non-S-IVB burn modes on actuator performance

i. Evaluate actuator deflections during non-S-IVB burn modes.

3.7 Flight Control System (Phases A, B, C, D)

Verify the proper operation of the flight control system during flight. This objective will be achieved by: verification of the proper operation of the thrust vector control system and the auxiliary attitude control system; comparison of inflight body bending frequencies and propellant sloshing frequencies with those predicted (figure AP 7-1).

3.7.1 Thrust Vector Control System (Phases A, C)

Demonstrate proper performance of the main engine control system during S-IVB flight. This objective will be achieved by evaluation of the following:

a. Response of the thrust vector control system to commands from the

instrument unit

b. Response of the control system sensors and networks

c. Verification of control system stability during S-IVB flight, including controlability immediately after separation

d. Simulation of transient regions of flight (e.g., separation, guidance initiation)

e. Demonstrate proper main engine positioning prior to engine restart.

3.7.2 Auxiliary Attitude Control System (AACS) (Phases A, B, C, D)

Verification of control system stability and evaluation of performance during S-IVB flight. This objective will be achieved by consideration of the following:

a. Response of the APS and relays to commands from the instrument unit

b. Response of the control system sensors and networks

c. Comparison between theoretical and actual control system behavior and simulation of transient regions of flight

d. Comparison between actual and allocated impulse usage for vehicle maneuvers and disturbances.

3.8 Trajectory/Propulsion Compatibility (Phases A, C)

Verify compatibility of the observed trajectory and S-IVB propulsion system performance. This objective will be achieved by determining the following from trajectory data:

a. S-IVB stage thrust, specific impulse, and mass flow

b. Vehicle mass at ignition and cutoff

c. S-IVB stage thrust vector misalignment.

3.9 Stage Sequence of Events (Phases A, B, C, D)

Verify proper S-IVB acknowledgement of sequence commands issued from the IU. This objective will be verified by comparing IU command times to stage monitored command times.

3.10 Stage Separation (Phase A)

Verify clearance distance between S-II/S-IVB stages during separation. Predicted stage clearance is presented in figures AP 7-2 and AP 7-3.

This objective will be achieved by determining the following:

a. Lateral clearance between stages

b. Separation distance history between stages

c. Causes of observed motion by simulation of stage attitude rates and accelerations.

3.11 Data Acquisition System (Phases A, B, C, D)

Verify that the data acquisition system is within design tolerances. Satisfactory completion of this objective shall be the demonstration of the data acquisition system to properly assimilate, condition, and translate stage information into proper telemetry format for transmission to a ground station. This includes evaluating the items listed in the following paragraphs.

3.11.1 RF System (Phases A, B, C, D)

Verify the proper operation of the RF system.

The achievement of this objective will be verified by evaluation of the following:

a. RF signal strength at ground stations, horizontal and vertical polarization energy of each of the RF frequencies to determine radiated power

b. RF power output of all transmitter power amplifiers measured by means of directional couplers and RF power detectors

c. RF insertion loss during flight between RF amplifiers and the applicable antenna inputs

d. Voltage standing wave ratio (VSWR) computed from forward and reflected power data for each antenna obtained from the bi-directional coupler and RF power detectors

e. Effect of flame attenuation by measuring transmitted power out the antenna arrays during separation, measuring signal strength

at ground stations, and computing the signal attenuation.

3.11.2 Telemetry System (Phases A, B, C, D)

Verify the telemetry system performance. The achievement of this objective will be verified by consideration of the following:

a. Examination of output of the data reduction system for proper reference channel levels, synchronization pulses, etc.

b. Examination of PAM wave-train stripouts for proper format

c. Examination of PCM data channels and synchronization words to verify consistency

d. Evaluation of FM/FM telemetry system accuracy from inflight calibration data. The input to the vehicle SCO's is compared with the output of the ground station receiver

e. Correlation of PAM/FM and PCM/FM data by comparing selected measurements telemetered by both systems

f. Evaluation of the SSB by demodulating the composite signal and checking the data, pilot tone, and reference channels (phases A and C only).

3.11.3 Instrumentation System (Phases A, B, C, D)

Verify the performance of the instrumentation system. The achievement of this objective will be verified by evaluating the following:

a. FM system data for expected ranges and frequencies. Examination of inflight calibration of subcarrier oscillator (SCO) assemblies to determine proper operation and linearity

b. PAM system data for proper format, proper reference channels, and consistency of data channels from frame to frame

c. PCM data for proper format

d. Single sideband (SSB) data, calibration signals, and format of vibration multiplexer and its marker pulses present on the service channel (phases A and C only).

3.11.4 Tape Recorder (Phases A, B)

Verify proper performance of the inflight tape recorder. Verification of this objective will be achieved by evaluation of the following:

a. Tape recorder stabilization time determined from the time for data stabilization observed from oscillograph recordings

b. Wow and flutter during fast record and playback determined by discrimination of the 120 kc tape speed compensation signal

c. Data received from tape recorder compared to realtime data

d. Indication of ready-to-record event.

3.11.5 Data Acquisition System Electromagnetic Interference (Phases A,B,C,D)

Verify the following:

a. The data acquisition system does not interfere with the other stage systems

b. The other stage systems do not interfere with the data acquisition system .

3.11.6 Data Validity (Phases A, B, C, D)

Verify the validity of data from the data acquisition system. The achievement of this objective will be established by determination of data validity on a channel-by-channel basis from the following systems:

a. FM/FM systems No's. 1, 2, and 3

b. PAM/FM/FM systems (prime and subchannels of the model 270 time-division multiplexers)

c. PCM/DDAS system

d. SSB system (phases A and C only).

3.12 Electrical Control System (Phases A, B, C, D)

Verify the proper operation of the electrical control system, which includes the following:

a. Forward and aft control distribution assemblies

b. Forward power distribution assembly

c. Aft power distribution assemblies

d. Switch selector

e. Sequencer

f. Control pressure switches.

3.13 Electrical Power System (Phases A, B, C, D)

Verify that battery currents, voltages, temperatures, chilldown inverter frequencies, and voltages remain within acceptable limits during the flight.

3.14 Separation Exploding Bridgewire (EBW) System (Phase A)

Verify that the separation EBW system responds correctly to all commands.

3.15 Propellant Utilization (PU) System (Phases A, C)

Demonstrate the PU system performance in a propellant loading mode and for inflight propellant management as defined by the criteria listed herein. (S-IVB-502 propellant loading data are presented in appendix 6.)

a. Demonstrate that the PU system indicated propellant load is within 1.39 percent of the actual propellant load in each tank as determined by the statistical weighted average propellant mass history

b. Demonstrate the ability of the PU system to provide propellant management, and to deplete residuals within 575 lbm or less usable propellants as extrapolated to depletion from the conditions existing at second burn cutoff

c. Demonstrate closed-loop PU operation in the programmed mixture ratio (PMR) mode during first burn. Following a two-orbit coast and restart, control the EMR to a nominal reference mixture ratio of 5.00:1 during second burn.

3.16 Secure Range Safety Command System (Phase A)

The achievement of this objective will be verified by proper operation of the secure range safety command system for normal flight, or for the termination of an erratic flight.

a. Normal Flight

(1) An RF carrier should be received by the stage at all times, until after the systems have been safed.

(2) Indication of signal strengths from each range safety receiver should be a nominal 1.3v.

b. Abnormal Flight

The operation of the range safety system during an abnormal flight should include those operations described for normal flight (paragraph 3.16a) plus the following:

(1) Indication of receipt of the propellant dispersion (PD) EBW Firing Unit Arm and Engine Cutoff Command, from the range safety decoder. Tri-level signals should show a step increase from 1.27 $\pm$0.15v to 2.43 $\pm$0.15v

(2) The EBW firing units should show a charge of 2,300 $\pm$100v within 1 sec after the receipt of the EBW arm and engine cutoff signal

(3) After a predetermined time from the arm and engine cutoff signal, a propellant dispersion command will be given to the vehicle. At this time the range safety decoder tri-level signal should show a step increase to 4.16 $\pm$0.15v.

3.17 Stage Aero/Thermodynamics (Phases A, B, C, D)

Determine stage aero/thermodynamics during all phases of flight.

This objective will include the following:

a. Stage thermal environment and the response of structure and components subjected to cryogenics, aerodynamic heating, and plume impingement. Comparisons will be made between flight data and postflight simulations based on the actual trajectory, atmospheric parameters, stage operations, and ground test data. The following areas are to be investigated:

(1) Forward skirt

(2) LH2 tank

(3) Aft skirt

(4) Aft interstage

(5) APS

b. The propellant heat input during ground hold, boost, powered flight and orbital coast

c. The external static pressure distributions on the stage, as well as the internal pressure histories in the aft skirt and interstage compartments. Comparisons will be made between the flight data, preflight predictions, and postflight simulations.

3.18 Vibration and Acoustic Environment (Phases A, C)

This objective will be achieved by evaluation of the vibration environment of the stage basic structure, engine, stage components, and the internal and external acoustic environment of the forward and aft skirts.

a. Vibration

(1) The basic structure vibration will be measured at the gimbal point and on the separation and field splice ring frame

(2) The engine vibration will be measured at the LH2 and LOX turbopumps and at the combustion chamber dome

(3) The component vibration will be measured at the PU electronics panel, EBW range safety panel, battery installation in the forward skirt, sequencer panel, switch selector panel, and APS attach points in the aft skirt.

b. Acoustics (Phase A)

Internal and external sound pressures will be measured for the forward and aft skirt areas during liftoff along with the aerodynamic pressure fluctuations during S-IC flight.

Predicted envelopes of composite vibration and acoustic levels for the aforementioned areas of interest are presented in figure AP 8-6.

3.19 Ordnance System (Phase A)

Verify proper operation of the ordnance system during flight. The objective will be achieved by verification of the following:

a. Operation of the stage separation systems

b. Operation of the ullage rocket ignition and jettison systems

c. Operation of the retrorocket ignition system.

3.20 Environmental Control System (Phases A, B, C, D)

Verify proper environmental control system performance during all phases of flight. This objective will be achieved by verifying the following:

a. Proper S-IVB thermoconditioning fluid flowrate, supply pressure, and temperature were maintained by the IU thermoconditioning system

b. S-IVB thermoconditioning system fluid return pressure and temperature were within normal operating ranges.

3.21 Countdown Demonstration Test

The objective of the countdown demonstration test, relevant to flight will be to verify the propellant utilization system calibration data presented in appendix 6.

SECTION 4

STAGE CONFIGURATION

4. STAGE CONFIGURATION

This section presents the general configuration of the S-IVB-502 and significant stage configuration differences between S-IVB-502 and S-IVB-501.

4.1 S-IVB-502 Stage

The S-IVB-502 stage airframe (figure 4-1) consists of the following assemblies:

a. Forward skirt

b. Propellant tanks

c. Aft skirt

d. Engine thrust structure

e. Aft interstage

f. Supporting subsystems

A detailed description of these assemblies is presented in the DAC Drawing No. 1B63789B, *S-IVB-502 End Item Test Plan* (reference 10).

A propulsion system schematic diagram of the S-IVB-502 stage is presented in figure 4-2.

4.2 Stage Configuration Differences

The following paragraphs delineate significant configuration differences between the S-IVB-502 and S-IVB-501 stages.

4.2.1 LH2 and LOX Ullage Tanks Instrumentation Changes

The S-IVB-501 LH2 and LOX ullage tank pressure measurements for prelaunch checkout (D0576 and D0577) and flight (D0177 through D0180) were made from two pressure ports; one on the LH2 forward dome, and one on the LOX aft dome. The S-IVB-502 was modified by the installation of six pressure ports, thus providing one port for each of these six critical measurements.

4.2.2 Forward Skirt

The structural elements added to the forward skirt (referred to as the flutter kit) on the S-IVB-501 stage to arrest flutter, were not installed on the S-IVB-502 stage.

Special flutter instrumentation was added to the S-IVB-502 stage forward skirt.

These measurements are as follows:

S0086-426	S0094-426
S0087-426	S0095-426
S0088-426	S0096-426
S0089-426	S0097-426
S0090-426	S0098-426
S0091-426	S0099-426
S0092-426	S0100-426
S0093-426	S0101-426

4.2.3 Aft Interstage

In anticipation of a possible insulation problem during flight due to peeling of the Korotherm from the S-IVB-501 aft interstage, heat sink stringer caps and a silicon compound were added in the vicinity of the retro rockets and the fuel tank feedline fairing configuration was modified to have a blunt afterbody. These changes are not effective on the S-IVB-502 aft interstage.

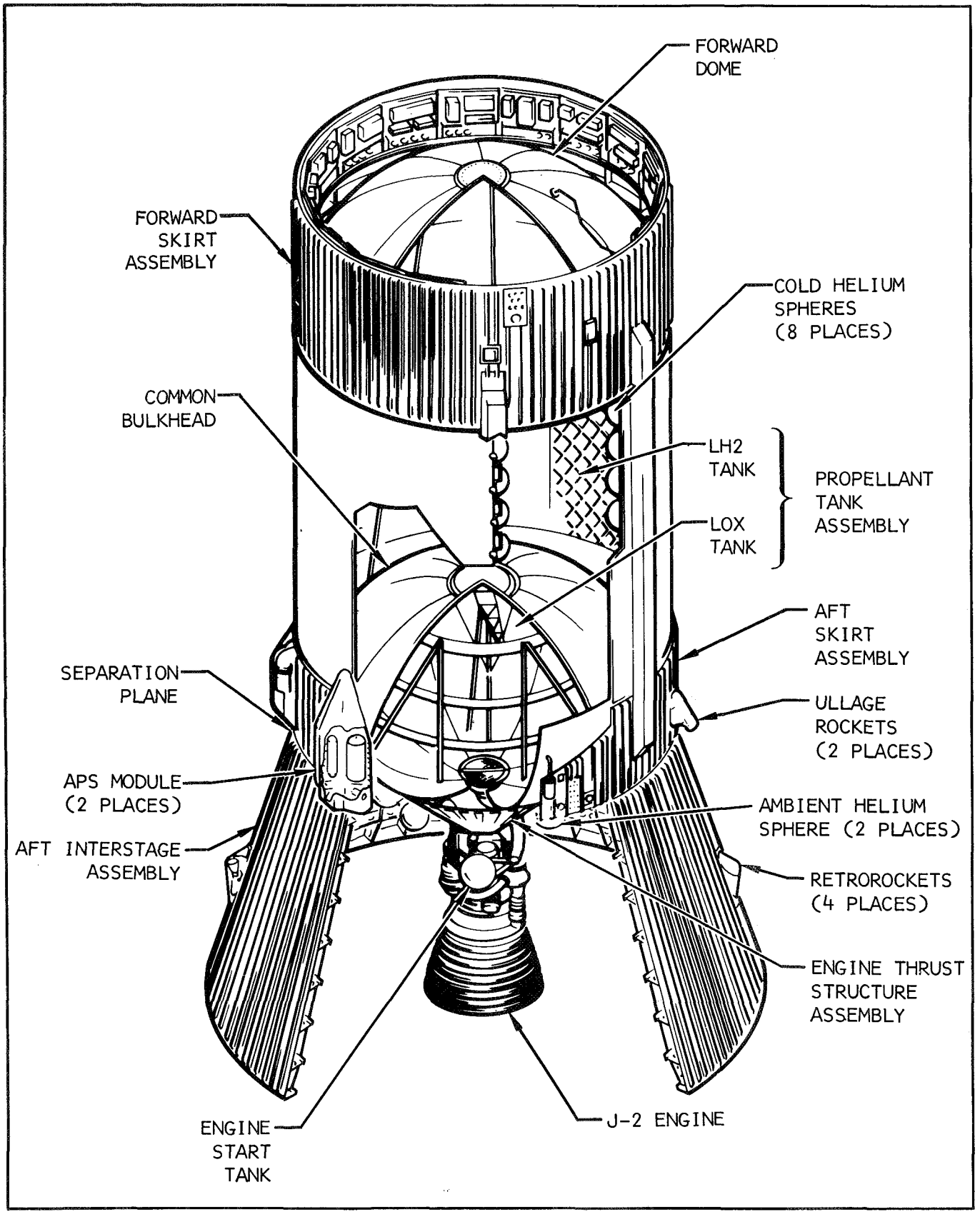
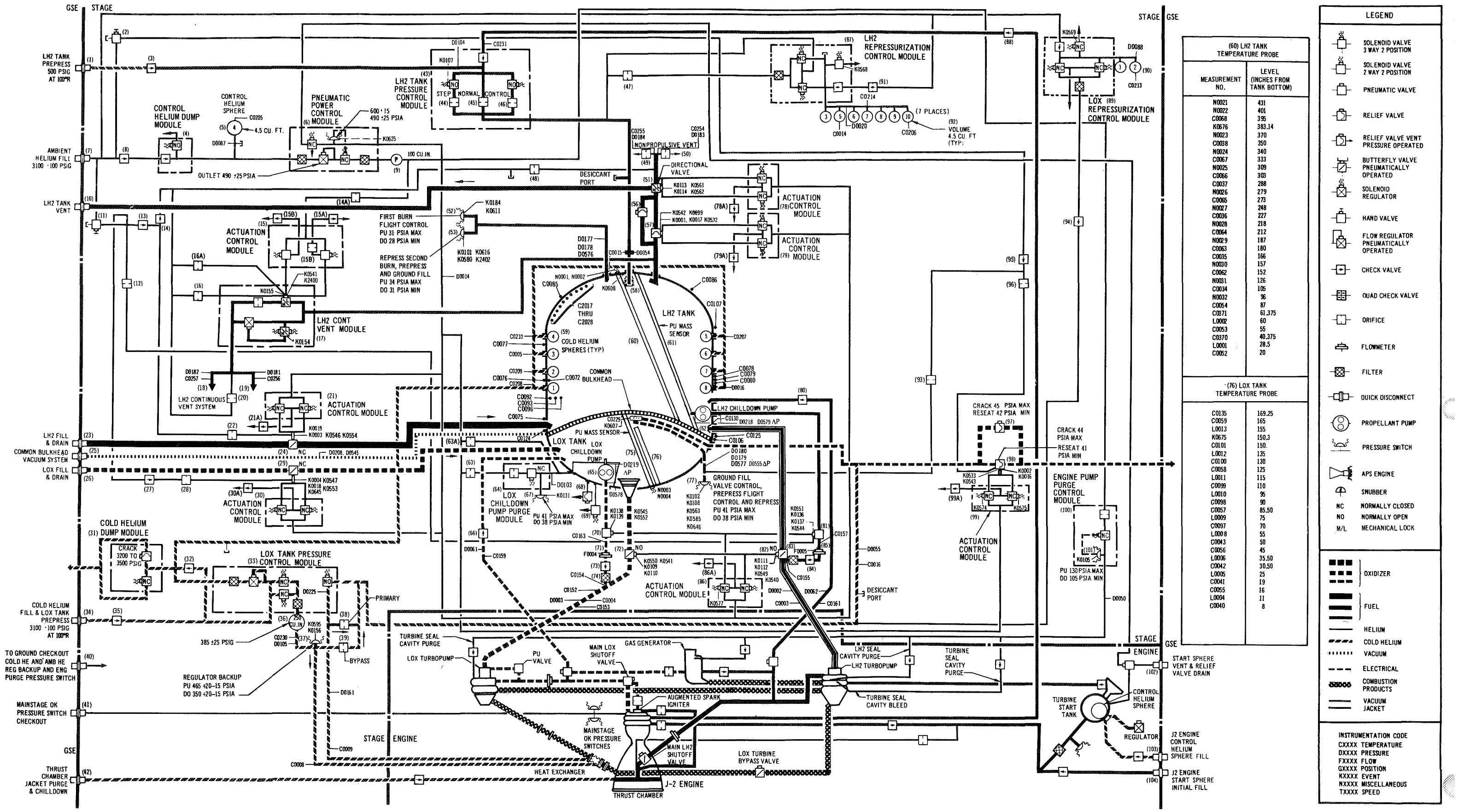


Figure 4-1. S-IVB-502 Stage Cutaway



(60) LH2 TANK TEMPERATURE PROBE	
MEASUREMENT NO.	LEVEL (INCHES FROM TANK BOTTOM)
N0021	431
N0022	401
C0068	395
K0676	383.14
N0023	370
C0038	350
N0024	340
C0067	333
N0025	309
C0066	303
C0037	288
N0026	279
C0065	273
N0027	248
C0036	227
N0028	218
C0064	212
N0029	187
C0063	180
C0035	166
N0030	157
C0062	152
N0031	126
C0034	105
N0032	96
C0054	87
C0371	61.375
L0002	60
C0053	55
C0370	40.375
L0001	28.5
C0052	20

(76) LOX TANK TEMPERATURE PROBE	
C0135	169.25
C0059	165
L0013	155
K0675	150.3
C0101	150.
L0012	135
C0100	130
C0058	125
L0011	115
C0099	110
L0010	95
C0098	90
C0057	85.50
L0009	75
C0097	70
L0008	55
C0043	50
C0056	45
L0006	35.50
C0042	30.50
L0005	25
C0041	19
C0055	16
L0004	11
C0040	8

Figure 4-2. S-IVB-502 Propulsion System Configuration and Instrumentation

SECTION 5

LAUNCH MISSION RULES AND REDLINES

5. LAUNCH MISSION RULES AND REDLINES

This section defines the launch mission rules pertaining to the S-IVB stage, redlines (which are a part of the launch mission rules), backup redlines, and bluelines. This information was submitted to NASA/MSFC prior to incorporating into this report.

5.1 Launch Mission Rules

Launch mission rules are launch vehicle, space vehicle, and spacecraft launch constraining requirements. These launch constraints are to be incorporated into the NASA/KSC Launch Mission Rules document (reference 5) prior to the AS-502 flight.

The Launch Mission Rules document is divided into five major areas as follows:

a. Mission Rules and Definitions

b. Launch Vehicle Requirements

c. Space Vehicle Requirements

d. Spacecraft Requirements

e. Technical Support.

The S-IVB stage is not affected by the spacecraft or technical support requirements.

The launch mission rules are effective during the prelaunch operations period. For the AS-502 flight, this period will begin with the completion of spacecraft fuel cell cryogenic topoff at T -13 hr 30 min, and will end at T -8.9 sec (S-IC ignition command).

5.1.1 Mission Rules and Definitions

The following mission rules and definitions extracted from the Launch Mission Rules document pertain directly to the S-IVB stage.

a. A mandatory item is a launch vehicle element or operational support element that is essential for accomplishment of the

primary mission, which includes prelaunch, flight, and recovery operations that assure crew safety and effective operational control as well as the attainment of the primary mission (redline parameters are mandatory).

b. If a mandatory item fails during the countdown, it will be corrected prior to launch during a hold, or recycle of the countdown as necessary. If the item cannot be corrected to permit liftoff within the launch window, the mission director will scrub the launch, following appropriate coordination with the launch and flight directors and the DOD manager for manned space flight support operations.

c. Any function that is interlocked on an automatic sequencing device is defined as mandatory and is not reiterated within the launch mission rules document.

d. A cutoff will not be initiated after T -8.9 sec (ignition command) except for failure of the launch vehicle to liftoff.

e. A scrub following the start of LOX loading requires a 48 hour launch delay.

5.1.2 Space Vehicle Requirements

The S-IVB stage launch constraints, as defined by the Launch Mission Rules document and applied to the space vehicle, are listed in the following paragraphs:

a. Surface Wind Restrictions - Surface wind restrictions referenced to 60 feet and based on a Cape Kennedy 95.0 percentile wind profile with a 1.4 gust factor are as follows:

	Steady State Wind (knots)	Peak Wind Gusts (knots)	(meters/sec)
MSS at Vehicle with Auxiliary Damper Attached	45.0	63.2	32.5
MSS Removed with Primary Damper Attached	45.0	63.2	32.5
Launch Vehicle Fully Loaded with Damper Released	45.0	63.2	32.5
Launch Release Winds	20.0	28.0	14.4

b. Space Vehicle Functional Sequence - During the time period specified in the following table, the listed failure will require the assigned action:

Time	Failure	Action
T-15 min to T-8 min	(1) Malfunction of the L/V guidance and control system. (mandatory) (2) Loss of any of the following telemetry links or multiplexers: TM link CP-1 (mandatory) CF-1 (mandatory) CF-2 (mandatory) CF-3 (mandatory) CS-1 (mandatory) Multiplexer A1 (mandatory) A2 (mandatory A3 (highly desirable) B0 (mandatory) (3) Malfunction of L/V propellant dispersion system. (all six transducers are mandatory) (4) Loss of ground ECS conditioned air and GN2 to the S/V. (mandatory) (5) Malfunction of the EDS. (mandatory) (6) Malfunction of the L/V hydraulic charging units (1 of 2 mandatory) (7) Failure to meet any S/V redline condition applicable to this time period. (mandatory) (8) Loss of any mandatory or more than one related highly desirable measurement applicable to this time period. (mandatory) (9) Malfunction of the L/V tape recorders. (all 5 are highly desirable)	Hold and repair. If a hold of an accumulated time of 5 min is exceeded, recycle to T-20 min for S-IVB thrust chamber warmup.
T-8 min to T-3 min 7 sec	Same as 1 through 9 above.	Hold and repair. If a hold of an accumulated time of 2 min is exceeded, recycle to T-20 min for S-II thrust chamber warmup.

Time	Failure	Action
T-3 min 7 sec to T-19 sec	(1) Malfunction of the L/V guidance and control system. (mandatory) (2) Loss of any of the following telemetry links or multiplexers: TM link CP-1 (mandatory) CF-1 (mandatory) CF-2 (mandatory) CF-3 (mandatory) CS-1 (mandatory) Multiplexer A1 (mandatory) A2 (mandatory) B0 (mandatory) (3) Malfunction of L/V propellant dispersion system. (all six transducers are mandatory) (4) Loss of ground ECS conditioned air and GN2 to the S/V. (mandatory) (5) Malfunction of the EDS. (mandatory) (6) Malfunction of the L/V hydraulic charging units. (1 of 2 mandatory) (7) Failure to meet any S/V redline condition applicable to this time period. (mandatory)	Cutoff, recycle to T-20 min and repair.
T-19 sec to T-11 sec	Same as 1 through 7 above.	Cutoff, scrub and repair.

c. Hold Criteria - During hold, the following restrictions must be imposed upon the space vehicle:

Time	Action
From T-15 min to T-8 min	An accumulated hold of 5 min maximum can be tolerated at the start of S-IVB thrust chamber chilldown. If the hold exceeds 5 min, recycle to T-20 min. A warmup period of 10 min is required if recycle is employed.

5.1.3 Launch Vehicle Requirements

The launch vehicle requirements as required by DAC are comprised of the following:

a. Redlines

b. Critical Flight Control Measurements

c. Critical Telemetry Systems.

These requirements are described in the following paragraphs.

5.1.3.1 Redlines

Redlines are minimum and/or maximum values that specify limits of acceptable operation. The prelaunch operations period or countdown cannot be completed if the conditions specified are not met. The launch mission rules define all redlines as mandatory. The measurements monitoring the parameters with redline limits are listed in table 5-1 with their limits, expected values and applicable time period. Each redline measurement must be monitored on a strip chart in the blockhouse.

5.1.3.2 Critical Flight Control Measurements

Critical flight control measurements (table 5-2) are implemented for realtime flight control of the mission. It is required that these elements be operational during the final part of the countdown, in compliance with the assigned category, or successful completion of the primary mission will be jeopardized.

5.1.3.3 Critical Telemetry Systems

The propulsion system performance analysis is considered a primary flight objective for the AS-502 mission, which emphasizes the importance of the postflight engine analysis. The S-IVB-502 stage instrumentation is configured such that certain key data, required for engine analysis, may be obtained only from the FM/FM portions of links CF-1 or CF-2. To be consistent with the requirement for engine analysis, Douglas requires that telemetry links CF-1 and CF-2 be mandatory for the S-IVB-502 stage, and link CF-3 be highly desirable.

The A1 and A2 multiplexers provide the majority of the data used for flight evaluation and therefore are mandatory. The A3 multiplexer is used primarily for ground checkout and therefore is not considered mandatory by the launch mission rules.

Douglas recommends that the tape recorder be categorized as highly desirable, based upon data requirements during flame attenuation effects at engine start, and the importance of continuous vent, maneuvering, APS, and boiloff data during orbital flight.

Total Douglas telemetry requirements for the S-IVB-502 stage are as follows:

a. The PCM/FM link CP-1 is mandatory

b. The PAM/FM links CF-1 and CF-2 are mandatory

c. The PAM/FM link CF-3 is highly desirable

d. The SSB/FM link CS-1 is highly desirable

e. The B0 multiplexer (via IU) is mandatory

f. The A1 and A2 multiplexers are mandatory

g. The A3 multiplexer is highly desirable

h. The tape recorder is highly desirable.

These requirements will continually be reviewed and coordinated with the cognizant MSFC laboratories. In the event that S-IVB stage or mission requirements should change, these requirements will be revised and updated as required.

5.2 Backup Redlines

Backup redlines are substitutions for redline measurements in the event the redline measurement becomes faulty. These measurements are to be used only after a careful investigation and assessment of data has established the primary measurement to be unacceptable. The backup measurements are not considered as alternates nor considered with the same confidence as primary redlines. The backup redline measurements are listed in table 5-3.

For redlines that have backups, at least one backup for each of these redlines should be monitored in the blockhouse at KSC or at the Central Instrumentation Facility (CIF).

If a redline value is exceeded during automatic sequence, a hold is imposed, the countdown is reverted to T -20 min and the decision to implement the backup redline is made.

5.3 Bluelines

Bluelines are maximum and/or minimum values of a parameter which, if exceeded, shall result in an engineering judgment as to whether the countdown will be completed without corrective action. The measurements monitoring bluelines are listed in table 5-4.

Bluelines have not been included in the Launch Mission Rules document in the past.

The blueline philosophy and limits are implemented by instructions from the design technologies to the instrumentation observers. Under no condition should exceeding a blueline result in a hold or scrub of a launch without the consent of the Launch Director.

It is planned to monitor all bluelines in the blockhouse at KSC or at the CIF by strip chart or "page format."

TABLE 5-1 (Sheet 1 of 7)
S-IVB-502 REDLINE REQUIREMENTS

MEASUREMENT NO.	TITLE	UNITS	LIMITS		EXPECTED VALUE	APPLICABLE TIME
			MINIMUM	MAXIMUM		
C0003-403	Temperature, Fuel Pump Outlet	deg R	Figure 5-1	Figure 5-1	Figure 5-1	Check from T-25 to T-11 sec. No check required prior to automatic sequence.
C0004-403	Temperature, Oxidizer Pump Inlet	deg R	None	165	164	Check immediately prior to initiation of automatic sequence to T-11 sec.
C0006-401	Temperature, GH2 Start Bottle	deg R	Figure 5-2	Figure 5-2	290	Check immediately prior to initiation of automatic sequence to T-11 sec.
C0007-401 minus C0006-401	Differential Temperature, Engine Control Bottle minus Engine Start Bottle*	deg R	None	±30	1,101	Check from initiation of automatic sequence to T-11 sec.
C0022-415	Temperature, Attitude Control Oxidizer Module 2 (APS)	deg R	535	560	550	Check at T-15 min. No check required after T-15 min.
C0023-414	Temperature Attitude Control He Pressure Tank, Module 1 (APS)	deg R	535	570	560	Check from T-15 min to immediately prior to initiation of automatic sequence.
C0050-401	Temperature, Hydraulic Pump Inlet Oil	deg F	None	160	30 to 110	From thermal (coast) mode ON to initiation of automatic sequence.
C0132-414	Temperature, Attitude Control Oxidizer Module 1 (APS)	deg R	535	560	550	Check at T-15 min. No check required after T-15 min.

*NASA recommended redline.

TABLE 5-1 (Sheet 2 of 7)
S-IVB-502 REDLINE REQUIREMENTS

MEASUREMENT NO.	TITLE	UNITS	LIMITS		EXPECTED VALUE	APPLICABLE TIME
			MINIMUM	MAXIMUM		
C0187-415	Temperature, Attitude Control He Pressure Tank, Module 2 (APS)	deg R	535	570	560	Check from T-15 min to immediately prior to initiation of automatic sequence.
C0199-401	Temperature, Thrust Chamber Jacket	deg R	None	290	280	Check immediately prior to initiation of automatic sequence and verify that thrust chamber jacket chill-down is continuing from initiation of automatic sequence to T-25 sec.
			None	265	250	Check from T-25 sec to T-11 sec.
D0014-403	Pressure, Control He Regulator Discharge	psia	465 (1)	615	515	Check from time of sphere pressurization to T-11 sec.
D0016-425	Pressure, Cold Helium Sphere	psia	2,800	3,200	3,000	Check from sphere pressurization to T-11 sec. (2)
D0017-401	Pressure, GH2 Start Bottle	psia	Figure 5-2	Figure 5-2	1,250	Check immediately prior to initiation of automatic sequence to T-11 sec.

NOTES: (1) Violation of the redline minimum for a period not to exceed 2 sec is expected and allowable during pneumatic valve actuations.

(2) The sequence of events shall be such that the fully pressurized (to D0016 redline limits) cold helium spheres are submerged in LH2 (LH2 tank at least 92 percent full) for at least the last 30 min of the countdown prior to liftoff.

TABLE 5-1 (Sheet 3 of 7)
S-IVB-502 REDLINE REQUIREMENTS

MEASUREMENT NO.	TITLE	UNITS	LIMITS		EXPECTED VALUE	APPLICABLE TIME
			MINIMUM	MAXIMUM		
D0019-401	Pressure, Engine Control Helium	psia	2,800	3,200	3,100	Check from sphere pressurization to initiation of automatic sequence.
		psia	2,800	3,280	3,150	Check from initiation of automatic sequence to T-11 sec.
D0020-403	Pressure, LH2 Tank Repressurition Spheres	psia	2,800	3,200	3,000	Check from sphere pressurization to T-11 sec.
D0035-414	Pressure, Attitude Control He Pressure Tank 1 (APS)	psia	2,800	3,200	3,000	Check from sphere pressurization to T-11 sec.
D0036-415	Pressure, Attitude Control He Pressure Tank 2 (APS)	psia	2,800	3,200	3,000	Check from sphere pressurization to T-11 sec.
D0041-403	Pressure, Hydraulic System (Auxiliary Pump ON)	psia	3,400	4,100	3,500 to 3,650	Check from auxiliary hydraulic pump thermal (coast) mode ON to T-11 sec.
D0042-403	Pressure, Reservoir Oil (Auxiliary Pump OFF)	psia	45	None	67 to 89	From thermal (coast) mode ON to flight mode ON.
D0071-414	Pressure, Oxidizer Supply Manifold, Module 1 (APS)	psia	203	222	211	Check from sphere pressurization to T-11 sec.
D0073-415	Pressure, Oxidizer Supply Manifold, Module 2 (APS)	psia	203	222	211	Check from sphere pressurization to T-11 sec.
D0087-403	Pressure, Pneumatic Control Helium Sphere 4 Gas	psia	2,800	3,200	3,000	Check from sphere pressurization to T-11 sec.

TABLE 5-1 (Sheet 4 of 7)
S-IVB-502 REDLINE REQUIREMENTS

MEASUREMENT NO.	TITLE	UNITS	LIMITS		EXPECTED VALUE	APPLICABLE TIME
			MINIMUM	MAXIMUM		
D0088-403	Pressure, LOX Tank Repressurization Spheres 1 and 2	psia	2,800	3,200	3,000	Check from T-15 min to T-11 sec.
D0223-403	Press - Auxiliary Hydraulic Pump Air Tank	psia	Figure 5-3	None	65 to 490	From auxiliary hydraulic pump air tank charging to T-11 sec.
D0576-408	Pressure, Fuel Tank Ullage	psia	None	16.7	16.5	Check from T-30 min to initiation of automatic sequence.
		psia	None	40	31 to 37	Check from LH2 tank pressurization to T-25 sec.
		psia	Figure 5-1	Figure 5-1	Figure 5-1	Check from T-25 sec to T-11 sec. No check required prior to automatic sequence.
D0577-406	Pressure, Oxidizer Tank Ullage	psia	38	44	40	Check from T-25 sec to T-11 sec. No check required prior to automatic sequence.
		psia	None	46	38 to 44	Check from LOX tank pressurization to T-25 sec.
D0577-406 minus D0576-408	Differential Pressure,* P_{LOX} Tank minus P_{LH2} Tank	psid	None	+30	--	Check from initiation of propellant loading until T-25 sec.
		psid	None	-23	--	
F0004-424	Flowrate, Oxidizer Recirculation Pump	gpm	35	50	42	Check from start of recirculation to T-11 sec.
F0005-404	Flowrate, Fuel Recirculation Pump	gpm	130	160	142 (3)	Check from T-97 sec to T-11 sec.

*NASA recommended redline.

NOTE: (3) While unpressurized and with the recirculation system operating, the fuel flowrate will be between 80 and 110 gpm. It should be noted that when prepressurization is initiated, sharp fluctuations in the flowrate may result; this is a normal condition and monitoring of this parameter should not be started until the flowrate has attained a steady-state value.

TABLE 5-1 (Sheet 5 of 7)
S-IVB-502 REDLINE REQUIREMENTS

MEASUREMENT NO.	TITLE	UNITS	LIMITS		EXPECTED VALUE	APPLICABLE TIME
			MINIMUM	MAXIMUM		
G0001-403	Position, Actuator Piston Position, Pitch	deg	None	+1-1/2	±1/2	From auxiliary hydraulic pump flight mode ON to T-11 sec.
G0002-403	Position, Actuator Piston Position, Yaw	deg	None	±1-1/2	±1/2	From auxiliary hydraulic pump flight mode ON to T-11 sec.
G0010-401	PU Valve Position*	deg	Null -2°	Null +2°	Null	Check from T-10 min to T-11 sec.
K0013-401	Event - Cutoff Signal		OFF	OFF	OFF	Observe drop from ON indication at Engine Ignition Power ON and monitor that the indication remains OFF.
K0151-411	Event - PU Oven ON Indication		ON	ON	ON	Immediately before initiation of propellant loading until T-11 sec.
L0007-403 C0051-403**	Level - Reservoir Oil					
	Auxiliary Pump ON	%	8	None	25 to 45	From thermal (coast) mode ON to T-11 sec.
	Auxiliary Pump OFF	%	Figure 5-4	None	84 to 99	From thermal (coast) mode ON until flight mode ON.
M0153-340	Voltage - Aft Bus No. 2	vdc	51	61	56	While buses are energized either from ground or internal power.
M0151-340	Voltage - Aft Bus No. 1	vdc	26	31 (4)	28	
M0152-340	Voltage - Fwd Bus No. 2	vdc	24.5	30.5	28	
M0154-340	Voltage - Fwd Bus No. 1	vdc	26	32	28	

*NASA recommended redline.

**Measurement C0051-403 is required to determine oil level as indicated in figure 5-4.

NOTE: (4) During the initial application of voltage to the engine buses, the maximum allowable voltage may be 32 vdc for a period not to exceed 60 sec.

TABLE 5-1 (Sheet 6 of 7)
S-IVB-502 REDLINE REQUIREMENTS

MEASUREMENT NO.	TITLE	UNITS	LIMITS		EXPECTED VALUE	APPLICABLE TIME
			MINIMUM	MAXIMUM		
M0015-404	Voltage - Aft Battery No. 2*	vdc	** (Loaded)	** (Loaded)	**	From battery installation to ignition command.
		vdc	** (Open Circuit)	** (Open Circuit)	**	
M0014-404	Voltage - Aft Battery No. 1*	vdc	** (Loaded)	** (Loaded)	**	
			** (Open Circuit)	** (Open Circuit)	**	
M0018-411	Voltage - Fwd Battery No. 2*	vdc	** (Loaded)	** (Loaded)	**	
			** (Open Circuit)	** (Open Circuit)	**	
M0016-411	Voltage - Fwd Battery No. 1*	vdc	** (Loaded)	** (Loaded)	**	
			** (Open Circuit)	** (Open Circuit)	**	

*NASA recommended redlines.

**Values for each battery will be determined by tests conducted during battery actuation and will be furnished to KSC by the Program Manager or his representative.

TABLE 5-1 (Sheet 7 of 7)
S-IVB-502 REDLINE REQUIREMENTS

MEASUREMENT NO.	TITLE	UNITS	LIMITS		EXPECTED VALUE	APPLICABLE TIME
			MINIMUM	MAXIMUM		
PTCS READOUT†	PU System - LOX Coarse Mass*	%	99.5	100.5	100.0	From T-15 min to initiation of LOX tank prepressurization (unpressurized).
		%	99.5	100.5	100.0	From T-30 sec to T-11 sec (pressurized).
PTCS READOUT†	PU System - LH2 Coarse Mass*	%	99.5	100.5	100.0	From T-15 min to initiation of LH2 tank prepressurization (unpressurized).
		%	99.5	100.5	100.0	From T-30 sec to T-11 sec (pressurized).
N0002-411	PU System LH2 Fine Mass:					
	Mass	lbm	TBD	TBD	TBD	From T-30 sec to T-11 sec.
	Indication - Pressurized(5)	legs	TBD	TBD	TBD	
N0004-411	PU System LOX Fine Mass:					
	Mass	lbm	TBD	TBD	TBD	From T-30 sec to T-11 sec.
	Indication - Pressurized(5)	legs	TBD	TBD	TBD	

*NASA recommended redlines.

†The maximum and minimum limits are percentage deviations from the nominal prescribed loads.

NOTE: (5) A leg unit represents approximately 5 percent of the full mass load.

TABLE 5-2 (Sheet 1 of 2)
CRITICAL FLIGHT CONTROL MEASUREMENTS

MEASUREMENT NO.	TITLE	CATEGORY
C0003-403	Temp, Fuel Pump Inlet	Highly Desirable
C0004-403	Temp, Oxidizer Pump Inlet	Highly Desirable
C0050-401	Temp, Hydraulic Pump Inlet Oil	Highly Desirable
C0051-403	Temp, Reservoir Oil	Highly Desirable
D0001-401	Press, Thrust Chamber	Highly Desirable
D0002-403	Press, Fuel Pump Inlet	Highly Desirable
D0003-403	Press, Oxidizer Pump Inlet	Highly Desirable
D0014-403	Press, Control He Reg Discharge	Mandatory
D0016-425	Press, Cold Helium Sphere	Highly Desirable
D0017-401	Press, GH2 Start Bottle	Highly Desirable
D0019-401	Press, Engine Control He Sphere	Highly Desirable
D0020-403	Press, Fuel Tank He Bottle Repress	Highly Desirable
D0035-414	Press, Att Control He Press Tank 1	Highly Desirable
D0036-415	Press, Att Control He Press Tank 2	Highly Desirable
D0041-403	Press, Hydraulic System	Highly Desirable
D0042-403	Press, Reservoir Oil	Highly Desirable
D0044-403	Press, Engine Actuator Pitch Differntial	Highly Desirable
D0045-403	Press, Engine Actuator Yaw Differential	Highly Desirable
D0087-403	Press, He Repress Sphere 4 Gas	Highly Desirable
D0088-403	Press, LOX Tank Repress Spheres	Highly Desirable
D0177-410	Press, Fuel Tank Ullage EDS 1	1 of 2 Mandatory
D0178-410	Press, Fuel Tank Ullage EDS 2	
D0179-424	Press, Oxid Tank Ullage EDS 1	1 of 2 Mandatory
D0180-424	Press, Oxid Tank Ullage EDS 2	

TABLE 5-2 (Sheet 2 of 2)
CRITICAL FLIGHT CONTROL MEASUREMENTS

MEASUREMENT NO.	TITLE	CATEGORY
D0181-409	Press, Fuel Tank Continuous Vent 1	1 of 2 Mandatory
D0182-409	Press, Fuel Tank Continuous Vent 2	
D0220-414	Press, U11 Control Chamber 1-4	Mandatory
D0221-414	Press, U11 Control Chamber 2-4	Mandatory
F0004-424	Flowrate, Oxidizer Recirculation Pump	Highly Desirable
F0005-424	Flowrate, Fuel Recirculation Pump	Highly Desirable
G0001-403	Posit, Actuator Piston Pot Pitch	Highly Desirable
G0002-403	Posit, Actuator Piston Pot Yaw	Highly Desirable
G0010-401	Posit, PU System Ratio Valve	Mandatory
K0001-410	Event, Fuel Tank Vent Valve - Closed	Highly Desirable
K0002-424	Event, Oxid Tank Vent Valve - Closed	Highly Desirable
K0151-411	Event, PU Oven ON Indication	Mandatory
K0154-411	Event, Relief OVRD SOV LH2 Tank - Closed	Highly Desirable
K0155-411	Event, Orifice SOV Cont Vt LH2 Tank - Closed	Highly Desirable
K0158-401	Event, M/S OK Press Sw 1 Depress	Highly Desirable
K0159-401	Event, M/S OK Press Sw 2 Depress	Highly Desirable
L0007-403	Level, Reservoir Oil	Highly Desirable
M0010-411	Volt - Fuel Boiloff Bias Signal	Mandatory
M0016-411	Volt - Output Fwd Battery No. 1	Highly Desirable
M0022-404	Current - Load Aft Battery No. 2	Highly Desirable

TABLE 5-3 (Sheet 1 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
C0003-403	Temperature, Fuel Pump Inlet	Recirculation system failure Excessive facility back pressure	Temperature - GG Fuel Bleed Valve (C0012-401) See figure 5-5	Measures LH2 temperature flowing through the bleed valve during chilldown. Bleed valve is located downstream of LH2 pump. If satisfactory chilldown has been accomplished, the LH2 bleed valve temperature will be approximately 1.0°R higher than the LH2 inlet temperature (C0003-403). Must satisfy requirements defined in figure 5-1 at T-15 sec (in conjunction with fuel ullage pressure, D0576-406).
D0576-406	Pressure, Fuel Tank Ullage	Vent valve open or excessive leakage Ground regulator malfunction Pressurization switch malfunction GSE pressurization valve malfunction	Pressure - Fuel Tank Ullage EDS 1 (D0177-410) or Pressure Fuel Tank Ullage EDS 2 (D0178-410) From LH2 tank pressurization to T-25 sec, use the following limits: Min: None Max: 40 psia Nom: 35 psia	Must satisfy the requirements as defined in figure 5-5 (in conjunction with GG fuel bleed valve temperature C0012-401).

TABLE 5-3 (Sheet 2 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
D0576-406 (Cont'd)			From T-30 min to initiation of automatic sequence, use the following limits: Min: None Max: 167 psia Nom: 16.5 psia From T-25 to T-11 sec, use the limits shown in figure 5-5	
C0004-403	Temperature, Oxidizer Pump Inlet	Recirculation system failure	Temperature - GG LOX Bleed Valve (C0013-401) Min: None Max: 167°R Nom: 166.5 °R	Measures LOX temperature flowing through the bleed valve during chilldown. Bleed valve is located downstream of LOX pump. If satisfactory chilldown has been accomplished, the LOX bleed valve temperature will be approximately 1.0°R higher than LOX pump inlet temperature (C0004-403) at T-3 min 7 sec; therefore, the LOX GG bleed valve temperature must be less than 169°R at start of automatic sequence.

TABLE 5-3 (Sheet 3 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
D0577-408	Pressure, Oxidizer Tank Ullage	Vent valve open or excessive leakage Ground regulator malfunction Pressurization switch malfunction GSE pressurization malfunction	Pressure-Oxidizer Tank Ullage EDS 1 (D0179-424) or Pressure-Oxidizer Tank Ullage EDS 2 (D0180-424) From LOX tank pressurization to T-25 sec, use the following limits: Min: None Max: 46 psia Nom: 40 psia From T-25 to T-11 sec, use the following limits: Min: 38 psia Max: 44 psia Nom: 40 psia	This parameter may be used directly as a backup for the ullage pressure. Ullage pressure must be between the limits of 37 to 44 psia at T-15 sec.
C0006-401	Temperature, GH2 Start Bottle	Improper chilldown Excessive hold time	Temperature-Engine Control Helium (C0007-401) See figure 5-6 Nom: 290°R	Start bottle chilldown is reflected by the temperature of the control helium sphere which is located within the GH2 start bottle. The two sphere temperatures will converge and stabilize after start bottle pressurization.

TABLE 5-3 (Sheet 4 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
C0006-401 (Cont'd)				The control helium sphere temperature may be used as a backup from T-3 min 7 sec on (see figure 5-6 for requirements).
D0017-401	Pressure, GH2 Start Bottle	Check valve between start bottle and LH injector fails open Vent and relief valve failed to close Excessive ground pressure Excessive hold time Excessive heating rate Excessive leakage	Pressure, GH2 Start Bottle Back-up Measurement (D0241-401) See figure 5-6	The backup requirements are the same as for primary redline when used in conjunction with temperature GH2 start bottle (C0006-401) (see figure 5-6). In the event the primary parameters (C0006-401 and D0017-401) are unavailable, the backup measurement (D0241-401) should be used in conjunction with C0007-401 (see figure 5-7).
D0019-401	Pressure, Engine Control He Sphere	Improper ground supply pressure Relief valve failure Excessive hold time Excessive start bottle temperature Excessive leakage	Pressure, Engine Control He Sphere Backup Measurement (D0242-401) Min: 2,800 psia Max: 3,300 psia Nom: 3,100 psia Min: 2,800 psia Max: 3,375 psia Nom: 3,150 psia	The backup requirements are the same as for the primary redline. Check from time of sphere pressurization to initiation of automatic sequence (IAS). Same comment as above. Check from IAS to T-11 min.

TABLE 5-3 (Sheet 5 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
C0199-401	Temperature, Thrust Chamber Jacket	Insufficient GSE performance	Temperature - LH2 Injection (C0200-401) From initiation of automatic sequence to T-25 sec, use the following limits: Min: None Max: 310°R Nom: 300°R From T-25 to T-11 sec, use the following limits: Min: None Max: 280°R Nom: 265°R	In the event of C0199 failure, C0200 can be used. The expected temperature will be higher than the thrust chamber injector jacket temperature. The temperature (C0200) shall be below 275°R at liftoff, allowing for boost heating, to prevent turbopump stall at J-2 engine ignition which would result from an excessively high thrust chamber jacket temperature.
D0014-403	Pressure, Control He Regulator Discharge	Regulator failure Excessive leakage	No backup	Although there is no backup measurement for this parameter, a system pressure switch interlock is provided to inhibit the countdown at initiation of automatic sequence start or S-IVB ignition command, if the regulator operates out of specifications in the high direction (which is the design fail-safe mode).

TABLE 5-3 (Sheet 6 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
D0016-425	Pressure, Cold He Sphere	Ground regulator failure Improper regulator setting Check valve failed closed Vent and/or dump relief valve failure Excessive leakage	No backup	Although there is no backup measurement for this parameter, it appears possible to determine if adequate bottle conditions exist by a controlled venting and refilling sequence of events. No such sequence has been established or verified at this time.
D0088-403	Pressure, LOX Tank Repress Spheres 1 and 2	Ground regulator failure Improper regulator setting Check valves closed failed Vent and/or relief valve failed open Excessive leakage	No backup	Same comments as for D0016-425.
D0087-403	Pressure, Pneumatic Control He Sphere 4 Gas	Ground regulator failure Improper regulator setting Check valve failed closed Excessive leakage Vent and/or dump relief valve failed	No backup	Same comments as for D0016-425.

TABLE 5-3 (Sheet 7 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
D0020-403	Pressure, LH2 Repressurization Spheres	Ground regulator failure Improper regulator setting Check valves failed closed Vent and/or relief valve failed open Excessive leakage	No backup	Same comments as for D0016-425.
C0132-414	Temperature, Attitude Control He Pressure Tank, Mod 1 (APS)	Failure of stage environmental control purge system	Temperature, Att. Cont Fuel Mod 1 (APS) (C0136-414) Min: 535°R Max: 560°R Nom: 550°R	LH2 and LOX temperatures will be stable and equal after approximately 3 hr of ECS operation. The LH2 temperature may then be monitored as a redline backup and must be between 535°R and 560°R at T-15 min.
C0022-415	Temperature, Attitude Control Oxidizer, Mod 2 (APS)	Failure of stage environmental control purge system	Temperature, Att. Cont Fuel Mod 2 (APS) (C0021-415) Min: 535°R Max: 560°R Nom: 550°R	Same comments as for C0132-414.

TABLE 5-3 (Sheet 8 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
D0035-414	Pressure, Attitude Control He Pressure Tank, Mod 1 (APS)	Ground regulator failure Check valves failed closed	No backup	Same comments as for D0016-425.
D0036-415	Pressure, Attitude Control He Pressure Tank, Mod 2 (APS)	Ground regulator failure Check valves failed closed	No backup	Same comments as for D0016-425.
D0071-414	Pressure, Oxidizer Supply Manifold, Mod 1 (APS)	Ground regulator failure Check valves failed closed	Pressure, Fuel Tank Ullage Volume Mod 1 (APS) (D0097-414) Min: 203 psia Max: 222 psia Nom: 211 psia Pressure, Oxid Tank Ullage Volume Mod 1 (APS) (D0098-414) Min: 203 psia Max: 222 psia Nom: 211 psia Pressure, Fuel Tank Supply Manifold Mod 1 (APS) (D0070-414) Min: 203 psia Max: 222 psia Nom: 211 psia	Primary and alternate pressures will be equal with the system pressurized and in a static condition. Alternate pressures must be between 203 and 222 psia at T-15 min.

TABLE 5-3 (Sheet 9 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
D0073-415	Pressure, Oxidizer Supply Manifold Mod 2 (APS)	He control module failure Quad check valves sticking	Pressure, Fuel Tank Ullage Volume Mod 2 (APS) (D0100-415) Min: 203 psia Max: 222 psia Nom: 211 psia Pressure, Oxid Tank Ullage Volume Mod 2 (APS) (D0099-415) Min: 203 psia Max: 222 psia Nom: 211 psia Pressure Fuel Tank Supply Manifold Mod 2 (APS) (D0072-415) Min: 203 psia Max: 222 psia Nom: 211 psia	Primary pressure and alternate pressures will be equal with the system pressurized and in a static condition. Alternate pressures must be between 203 and 222 psia at T-15 min.
VXC0050-401	Temperature-Hydraulic Pump Inlet Oil	Auxiliary pump overheating High pressure relief valve failed open	Temperature Reservoir Oil (VC0051-403) Nom: 70°F	Reservoir oil temperature usually lags pump inlet oil temperature by approximately 20°F. Auxiliary pump overheating may be due to excessive heat rejection of the electric motor which may be accompanied by higher than normal aft bus No. 2 current.

TABLE 5-3 (Sheet 10 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
VXC0050-401 (Cont'd)				High pressure relief valve failing open is accompanied by lower than normal hydraulic system pressure.
VXD0042-403	Pressure-Reservoir Oil (Aux Pump Off)	Accumulator gas leakage External oil leakage	Pressure - GN2 Accumulator (D0043-403) Nom: 2,350 psia	Required to insure adequate auxiliary pump inlet pressure at pump start. Reservoir oil pressure is developed through a piston powered by GN2 accumulator pressure.
VXL0007-403	Level-Reservoir Oil (Auxiliary Pump Off)	System leakage System underfilled	Pressure-Reservoir Oil (D0042-403) Nom: 170 psia (Auxiliary Pump On)	If auxiliary pump is OFF, turn ON and check alternative pressure measurement. If auxiliary pump is OFF, turn ON and observe low level light. Light indicates below 9.54 to 11.02%.
VXC0051-403	Temperature-Reservoir Oil	--	Temperature-Hydraulic Pump Inlet Oil (C0050-403) Nom: 70°F	This measurement is to be used to determine whether adequate reservoir oil level (L0007-403) exists at the indicated oil temperature.

TABLE 5-3 (Sheet 11 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
VXL0007-403	Level-Reservoir Oil (Auxiliary Pump On)	External leakage System underfilled	Pressure-Hydraulic System (D0041-403) Nom: 3,600 psia Pressure-Reservoir Oil (D0042-403) Nom: 170 psia	If reservoir oil level is too low, the pump will cavitate after start and hydraulic system pressure will not rise to minimum level. Observe low level light. Light indicates when oil level drops below 9.54 to 11.02%.
K0013-401	Event-Cutoff Signal	Loss of engine ready signal when engine cutoff is ON	No backup	The signal should drop from ON to OFF following engine ignition power ON and remain OFF. The following test can be conducted to verify if cutoff circuit is operative and in proper state. Verify that K0140 (Switch Selector Cutoff) is ON; cutoff indication on the C4EN panel is ON; non-programmed cutoff is OFF; engine control and ignition power are ON, and Engine Ready (K0012) is ON. a. Send remote automatic calibration system (RACS) and verify strip chart operation to check instrumentation. b. Remove ignition power (verify Engine Ready goes OFF). c. Remove K0140 (Switch Selector Cutoff OFF). (Verify cutoff indication on C4EN remains ON.)

TABLE 5-3 (Sheet 12 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
K0013-401 (Cont'd)				NOTE: If C4EN cutoff indication goes OFF with the removal of K0140, immediately turn OFF engine control power. d. Send Engine Ready Bypass. (Verify cutoff indication on C4EN goes OFF.) e. Send K0140 (Switch Selector Cutoff) to Safe Engine. A negative finding will require additional electronics analysis and disposition.
D0577-406 minus D0576-408	Differential Pressure P_{LOX} Tank - P_{LH2} Tank	Same as D0577-408	Diff Pressure - P_{LOX} Tank minus P_{LH2} Tank (D0179-424 minus D0178-410) Min: None Max: +30 psid & -23 psid Diff Pressure - P_{LOX} Tank minus P_{LH2} Tank (D0180-424 minus D0177-410) Min: None Max: +30 to -23	Same comments as for D0576-408 and D0577-408.

TABLE 5-3 (Sheet 13 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
G0010-401	Position, PU Valve	PU activate Off failure Mechanical failure in PU valve motor gear assembly	None	PU Activate is interlocked for start of automatic sequence.
VXD0041-403	Pressure-Hydraulic System	Aux hyd pump motor or pressure compensator failure Leak or break in hyd system High pressure relief valve setting drops to lower pressure	GN2 Accumulator Pressure (D0043-403) Nom: 3,600 psia Pressure - Reservoir Oil (D0042-403) Nom: 170 psia	Loss of excessive fluid from hydraulic lines or reservoir will cause auxiliary hydraulic pump to cavitate and fluctuate in pressure level. High pressure relief valve is set to relieve at 4,000 psia. If pressure setting of valve decays below setting of pump pressure compensator, the system pressure will decay proportionately.
VXD0223-403	Pressure-Auxiliary Pump Air Tank	External leakage System underfilled	No backup	Air pressure in auxiliary pump electric motor is required to prevent arcing of brushes, provide conduction of heat from motor to system oil, and act as lubricating media for brushes.

TABLE 5-3 (Sheet 14 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
K0151-411	Event-PU Oven On Indication	Temperature in PU oven drops below 80°C due to heater power failure	No backup	Measurement picks up and drops out at 80°C. Oven operating temperature is 100 ±0.30°C. A 6.7 min temperature decay time constant exists from oven heater power failure to K0151 OFF indication. A K0151 OFF indication at lift-off would indicate a propellant loading error and the possibility of a depletion cutoff in flight.
C0007-401 minus C0006-401	Temperature, Engine Control Bottle minus Engine Start Bottle	Improper chilldown	No backup	The two sphere temperatures will converge and stabilize after start bottle pressurization.
PTCS Readout	PU System - LOX Coarse Mass	Mass probe failure Potentiometer positioner failure PTCS failure	PU System LOX Fine Mass (N0002-411)	Both redline and its alternate measurement are ESE display and auxiliary display parameters.
PTCS Readout	PU System - LH2 Coarse Mass	Mass probe failure Potentiometer positioner failure PTCS failure	PU System LH2 Fine Mass (N0004-411)	Both redline and its alternate measurement are ESE and auxiliary display parameters.

TABLE 5-3 (Sheet 15 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
N0002-411	Misc, PU System LH2 Fine Mass	Mass probe failure Potentiometer positioner failure PTCS failure	Misc - PU Sys LH2 Coarse Mass Volt (as monitored by the PTCS) (N0001-411)	Both redline and its alternate measurement are ESE display parameters. A direct correspondence of 20:1 exists between fine and coarse mass data.
N0004-411	Misc, PU System LOX Fine Mass	Mass probe failure Potentiometer positioner failure PTCS failure	Misc - PU Sys LOX Coarse Mass Volt (as monitored by the PTCS) (N0003-411)	Both redline and its alternate measurement are ESE and auxiliary display parameters. A direct correspondence of 20:1 exists between fine and coarse mass data.
M0153-340	Voltage, Aft Bus No. 2	Ground power malfunction when on external power or battery malfunction when on internal power	Volt, Output, Aft Battery No. 2/56 vdc (M0015-404) Volt-Phase A-B, Fuel Chilldown Inv/56 vac (M0026-404) Volt-Phase A-B, LOX Chilldown Inv/56 vac (M0027-404) Volt-Phase A-C, LOX Chilldown Inv/56 vac (M0040-404)	With proper allowances for the potential difference between GSE and vehicle voltage buses, Meter M8 is a redline alternate when on external power and M0015-404 is a redline alternate when on internal power. During the time that chilldown inverters are energized, the inverter phase voltages will give a gross indication of whether aft bus No. 2 is ON or OFF. The design limits of the chilldown inverters established the redline limits of the bus.

TABLE 5-3 (Sheet 16 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
M0153-340 (Cont'd)			Volt-Phase A-C, Fuel Chilldown Inv/56 vac (M0041-404) Volt-Phase A1-B1, LOX Chilldown Inv/56 vac (M0044-404) Volt-Phase A1-C1, LOX Chilldown Inv/56 vac (M0045-404) Volt-Phase A1-B1, LH2 Chilldown Inv/56 vac (M0046-404) Volt-Phase A1-C1, LH2 Chilldown Inv/56 vac (M0047-404)	S-IVB ready for launch interlock is provided. S-IVB voltage malfunction interlock is provided.
M0151-340	Voltage, Aft Bus No. 1	Ground power malfunction when on external power or battery malfunction when on internal power	4D110 ESE Bus Volt/28 vdc (M0146-340) Volt, Output Aft Batt No. 1 28 vdc (M0014-404)	With proper allowances for the potential difference between GSE and vehicle voltage buses. M0146-340 is a redline alternate when on external power and M0014-404 is a redline alternate when on internal power.

TABLE 5-3 (Sheet 17 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
M0151-340 (Cont'd)			Volt-Eng Control Bus/28 vdc (M0006-401) Volt-Eng Ignition Bus/28 vdc	Within limitations of telemetry monitoring, the engine control and ignition bus measurements give an indication of aft bus No. 1 during engine power ON. The design limits of the engine control bus (Rocketdyne Specification R-3825-1) established the redline limits of the bus. S-IVB ready for launch interlock is provided. S-IVB voltage malfunction interlock is provided.
M0152-340	Voltage, Fwd Bus No. 2	Ground power malfunction when on external power or battery malfunction when on internal power	4D210 ESE Bus Volt/28 vdc (M147-307) Volt, Output Fwd Batt. No. 2/28 vdc (M0018-411) Volt-Static Inv-Conv/115 vac (M0001-411) Volt-Static Inv-Conv/5 vdc (M0004-411) Volt-Static Inv-Conv/21 vdc (M0023-411)	With proper allowances for the potential difference between GSE and vehicle voltage buses, M147-307 is a redline alternate when on external power and M0018-401 is a redline alternate when on internal power. During time that the inverter-converter is energized, it will give a gross indication of whether fwd bus No. 2 is ON or OFF. The design limits of the PU inverter-converter and PU electronics assembly established the redline limits of the bus.

TABLE 5-3 (Sheet 18 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
M0152-340 (Cont'd)				S-IVB ready for launch interlock is provided. S-IVB voltage malfunction interlock is provided.
M0154-340	Voltage, Fwd Bus No. 1	Ground power malfunction when on external power or battery malfunction when on internal power	4D310 ESE Bus Volt/28 vdc (M148-307) Volt, Output Fwd. Batt 1/28 vdc (M0016-411) Volt Excit Mod Fwd/5 vdc (M0024-411) Volt Excit Mod Aft/5 vdc (M0025-404)	With proper allowances for the potential difference between GSE and vehicle voltage buses, M148-307 is a redline alternate when on external power and M0016-411 is a redline alternate when on internal power. During time that fwd and aft 5 V excitation modules are energized, they will give a gross indication of whether fwd bus No. 1 is ON or OFF. S-IVB ready for launch interlock is provided. S-IVB voltage malfunction interlock is provided.
M0015-404	Voltage - Aft Batt. No. 2	Battery malfunction	TBD Meas of +4D40 Bus/56 vdc	The loaded redline limits apply when on internal power and the open circuit redline limits apply when on external power.

TABLE 5-3 (Sheet 19 of 19)
S-IVB-502 REDLINE BACKUP INFORMATION

MEASUREMENT NO.	TITLE	PROBABLE CAUSES OF EXCEEDING REDLINE LIMITS	ALTERNATIVE MEASUREMENTS AND NOMINALS	OTHER INFORMATION (SAFETY MARGINS, ETC)
M0014-404	Voltage - Aft Batt. No. 1	Battery malfunction	TBD Meas of +4D10 Bus/28 vdc	The loaded redline limits apply when on internal power and the open circuit redline limits apply when on external power.
M0018-411	Voltage - Fwd Batt. No. 2	Battery malfunction	TBD Meas of +4D20 Bus/28 vdc	
M0016-411	Voltage - Fwd Batt. No. 1	Battery malfunction	TBD Meas of +4D30 Bus/28 vdc	
C0023-414	Temperature, Attitude Control He Pressure Tank, Mod 1 (APS)	Failure of stage environmental control purge system	No backup	
C0187-415	Temperature, Attitude Control He Pressure Tank, Mod 2 (APS)	Failure of stage environmental control purge system	No backup	
F0004-424	Flowrate, Oxidizer Recirculation Pump	Recirculation system failure	Pressure, Oxid Pump Inlet minus Oxid Tank Ullage (D0003-403 minus D0577-408) Min: 13 psid Max: 18 psid Nom: 16 psid	In order to detect recirculation system failure, flowrate and pump inlet pressure were selected as new redline and backup redline.
F0005-404	Flowrate, Fuel Recirculation Pump	Recirculation system failure	Pressure, Fuel Pump Inlet minus Fuel Tank Ullage (D0002-403 minus D0516-406) Min: 6 psid Max: 10 psid Nom: 8 psid	Same comments as for F0004-424.

TABLE 5-4 (Sheet 1 of 3)
S-IVB-502 BLUELINE REQUIREMENTS

MEASUREMENT NO.	TITLE	UNITS	LIMITS		EXPECTED VALUE	APPLICABLE TIME
			MINIMUM	MAXIMUM		
C0102-411	Temp - Fwd Battery No. 1	deg F	60	140	90	After battery is stabilized.
C0103-411	Temp - Fwd Battery No. 2	deg F	60	140	90	
C0104-404	Temp - Aft Battery No. 1	deg F	60	140	90	
C0105-404	Temp - Aft Battery No. 2	deg F	60	140	90	
C0131-404	Temp - Aft Battery No. 1, Unit 2					
C0211-411	Temp - Fwd Battery No. 1, Unit 2	deg F	60	140	90	
C0212-404	Temp - Aft Battery No. 2, Unit 2					
D0545-407	Press - Common Bulkhead Internal	psia	None	5.5	<5.5	Anytime prior to liftoff.
M0001-411	Volt - Static Inverter-Converter	vac	110.5	119.5	115	From turn-on to T-3 sec during inverter-converter operation.
M0012-411	Freq - Static Inverter-Converter	cps	396	404	400	During inverter-converter operation.
M0014-404	Voltage - Output Aft Battery No. 1	vdc	29	36	29.5	Open circuit voltages from installation to transfer to internal power.
M0015-404	Volt - Output Aft Battery No. 2	vdc	64	75	72	
M0016-411	Volt - Output Fwd Battery No. 1	vdc	29	36	29.5	
M0018-411	Volt - Output Fwd Battery No. 2	vdc	29	36	29.5	

TABLE 5-4 (Sheet 2 of 3)
S-IVB-502 BLUELINE REQUIREMENTS

MEASUREMENT NO.	TITLE	UNITS	LIMITS		EXPECTED VALUE	APPLICABLE TIME
			MINIMUM	MAXIMUM		
M0019-411	Current - Load Fwd Battery No. 1	amp	None	70	40	From transfer to internal power until liftoff.
M0020-411	Current - Load Fwd Battery No. 2	amp	None	5	3.5	
M0021-404	Current - Load Aft Battery No. 1	amp	None	32	7	
M0022-404	Current - Load Aft Battery No. 2	amp	None	95	90	
M0026-404	Volt - Phase A-B Fuel Chilldown Inverter	vac	54	60	56	During inverter operation.
M0027-404	Volt - Phase A-B LOX Chilldown Inverter	vac	54	60	56	During inverter operation.
M0146-340	Volt - 4D110 Bus	vdc	27	30	28	Whenever power is on.
M0163-340	Current - 4D100 Bus	amp	None	20	10	
M0174-340	Current - 4D111 Bus	amp	None	32	7	
M0147-340	Volt - 4D210 Bus	vdc	27	30	28	
M0148-340	Volt - 4D310 Bus	vdc	27	30	28	

TABLE 5-4 (Sheet 3 of 3)
S-IVB-502 BLUELINE REQUIREMENTS

MEASUREMENT NO.	TITLE	UNITS	LIMITS		EXPECTED VALUE	APPLICABLE TIME
			MINIMUM	MAXIMUM		
M0164-340	Current - 4D200 Bus	amp	None	15 (1)	10	Whenever power is on.
M0175-340	Current - 4D211 Bus	amp	None	5	3.5	
M0176-340	Current - 4D311 Bus	amp	None	70	45	
TBD	Volt - 4D410 Bus	vdc	54	60	56	
M0177-340	Current - 4D411 Bus	amp	None	95	80	
M0153-340	Volt - 4D41 Bus	vdc	52	60	56	
M0151-340	Volt - 4D11 Bus	vdc	27	30	28	
M0152-340	Volt - 4D21 Bus	vdc	27	30	28	
M0154-340	Volt - 4D31 Bus	vdc	27	30	28	

(1) 40 amp on Remote Analog Calibration System (RACS).

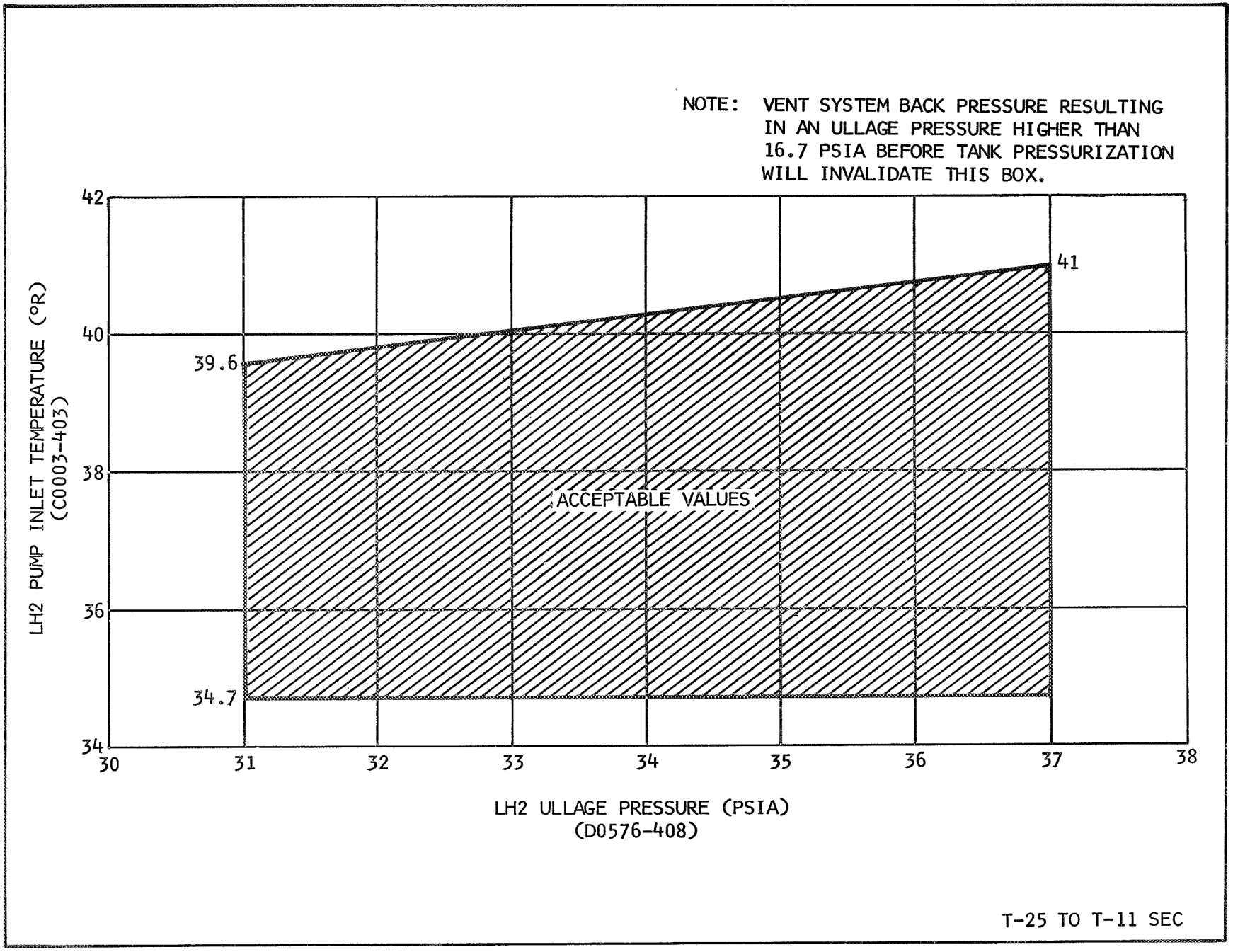
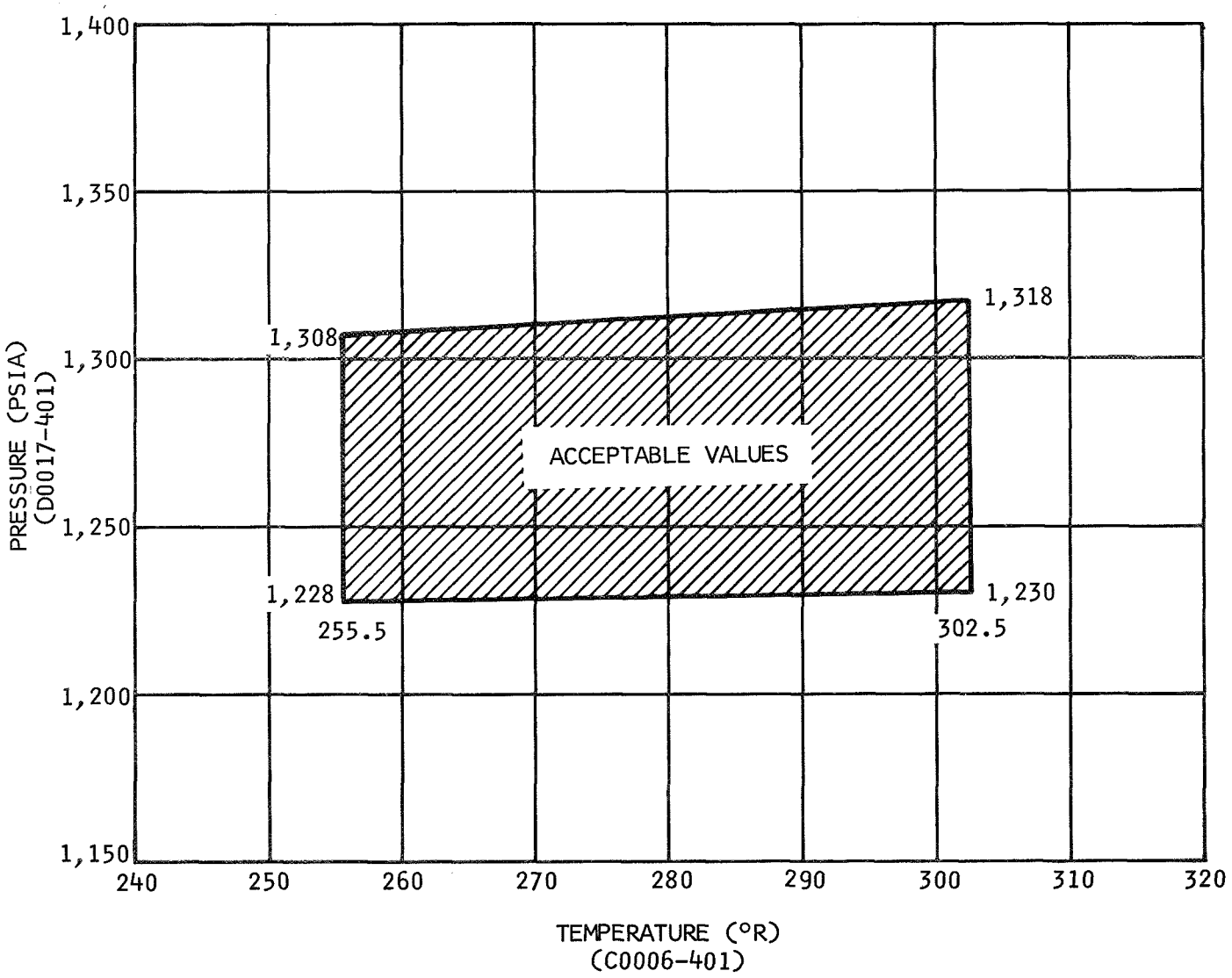
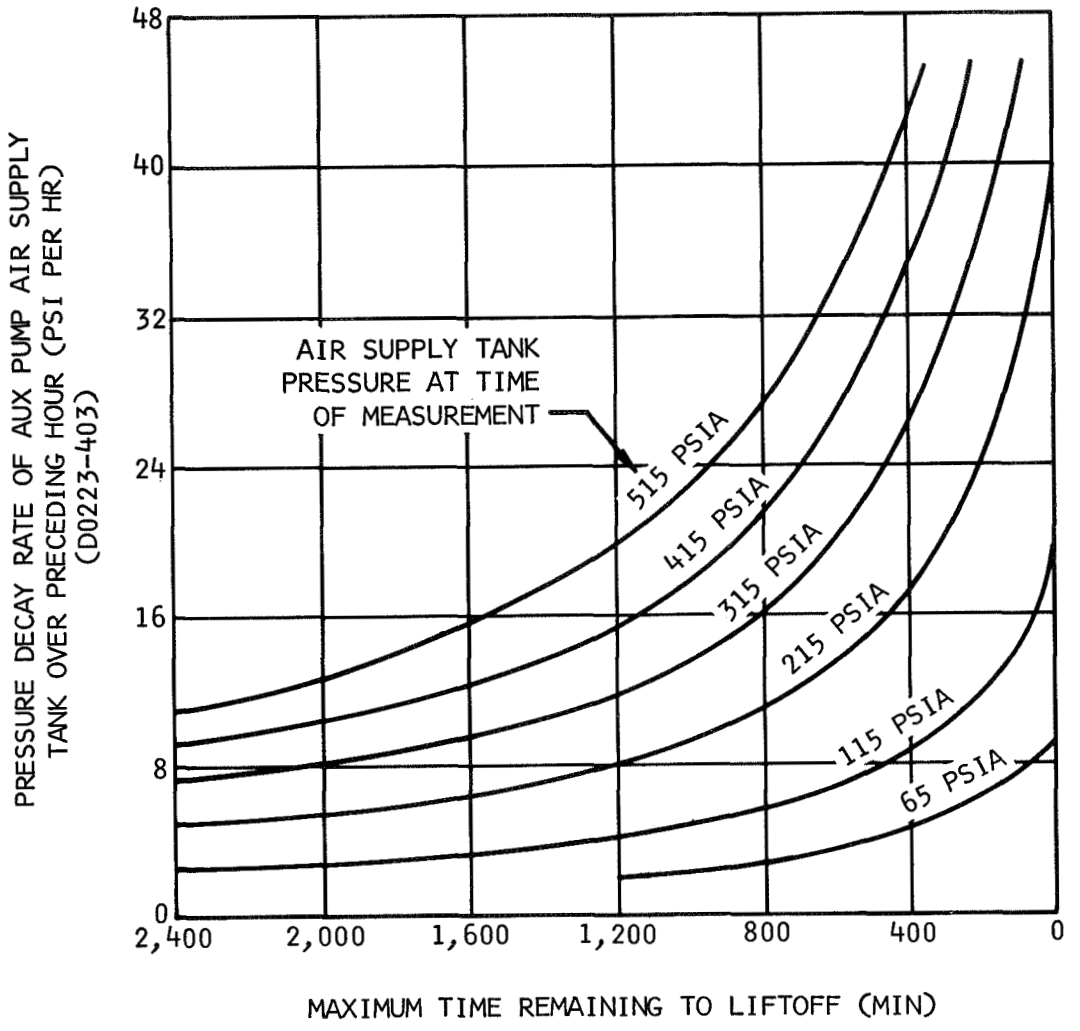


Figure 5-1. LH2 Critical Limits at Liftoff



CHECK IMMEDIATELY PRIOR TO INITIATION OF AUTOMATIC SEQUENCE TO T-11 SEC

Figure 5-2. GH2 Start Bottle Critical Limits at Liftoff

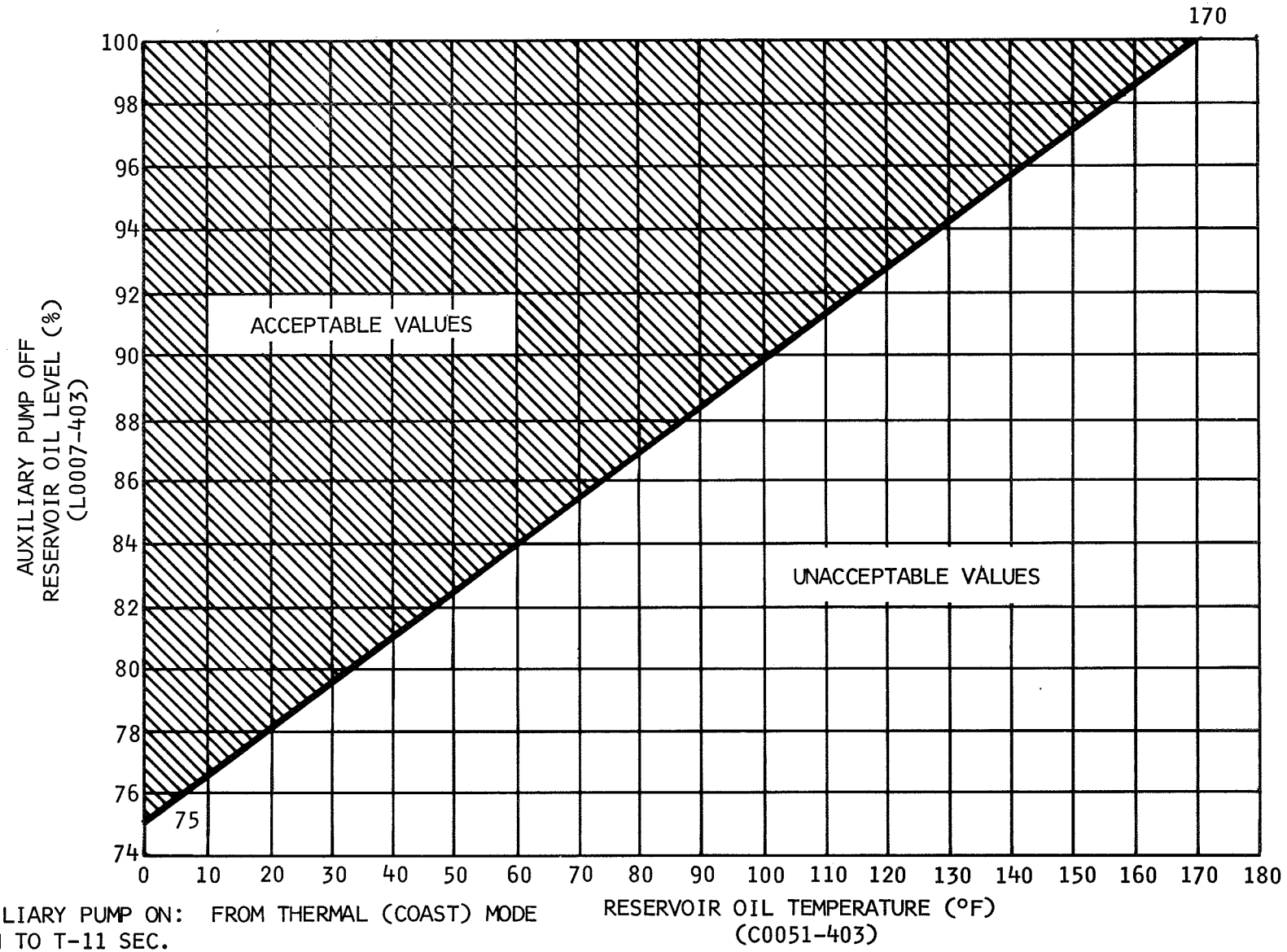


NOTE: PRESSURE MEASUREMENTS MUST BE MADE DURING A PERIOD IN WHICH THE AIR TEMPERATURE CAN BE ASSUMED RELATIVELY CONSTANT.

EXAMPLE - FOR A PRESSURE DECAY RATE OF 16 PSI/HR OVER THE PRECEDING HOUR, AND AN INDICATION AIR SUPPLY TANK PRESSURE OF 315 PSIG, A COUNTDOWN HOLD MUST BE IMPOSED IF THE SCHEDULED TIME TO LIFTOFF IS MORE THAN 800 MIN FROM THE TIME THE MEASUREMENT IS MADE.

FROM AUXILIARY HYDRAULIC PUMP AIR TANK CHARGING TO T-11 SEC

Figure 5-3. Auxiliary Hydraulic Pump Air Supply Tank Critical Limits



AUXILIARY PUMP ON: FROM THERMAL (COAST) MODE ON TO T-11 SEC.
AUXILIARY PUMP OFF: FROM THERMAL (COAST) MODE ON UNTIL FLIGHT MODE ON

Figure 5-4. Hydraulic Reservoir Level Critical Limits

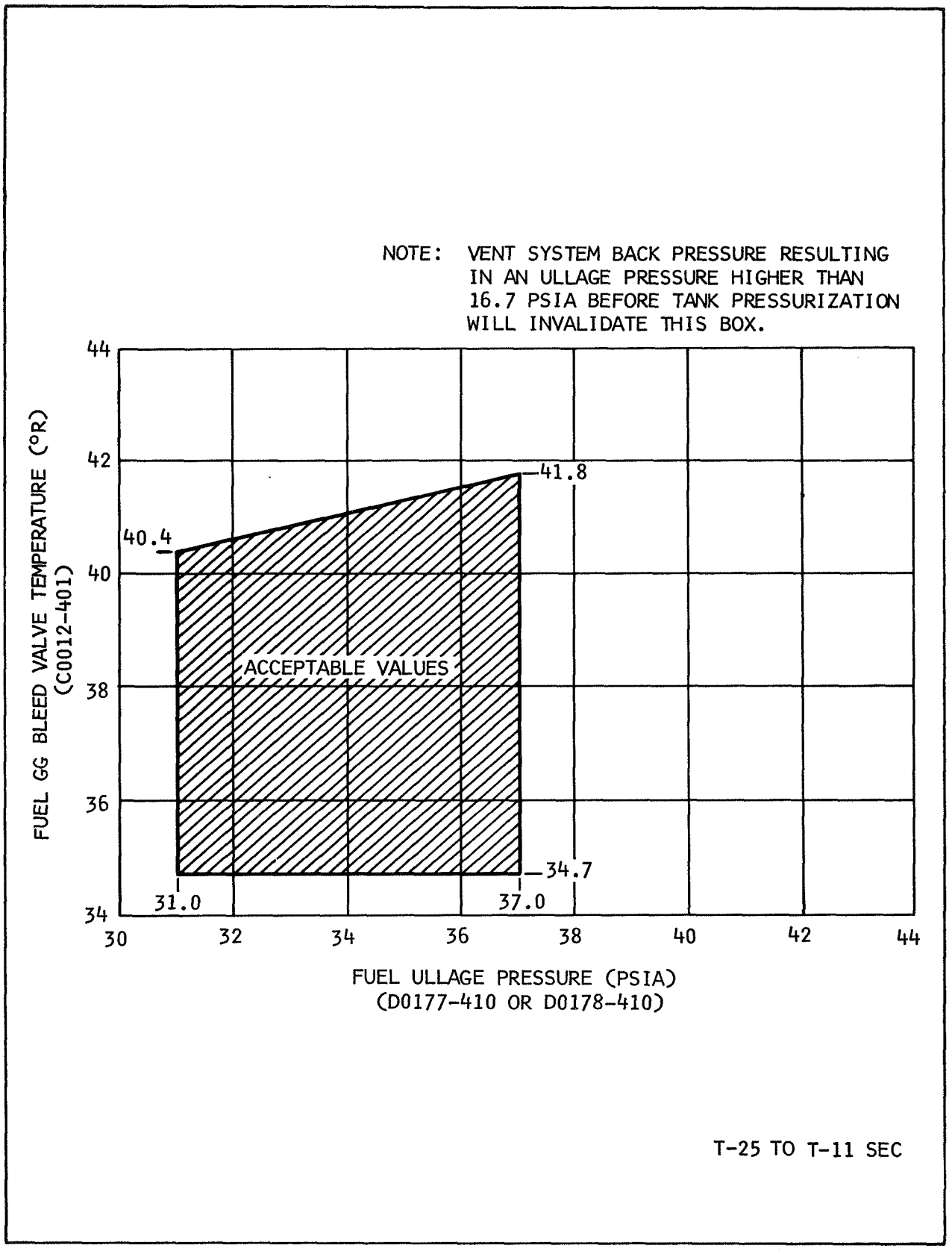


Figure 5-5. Fuel Liftoff Critical Limits (Backup)

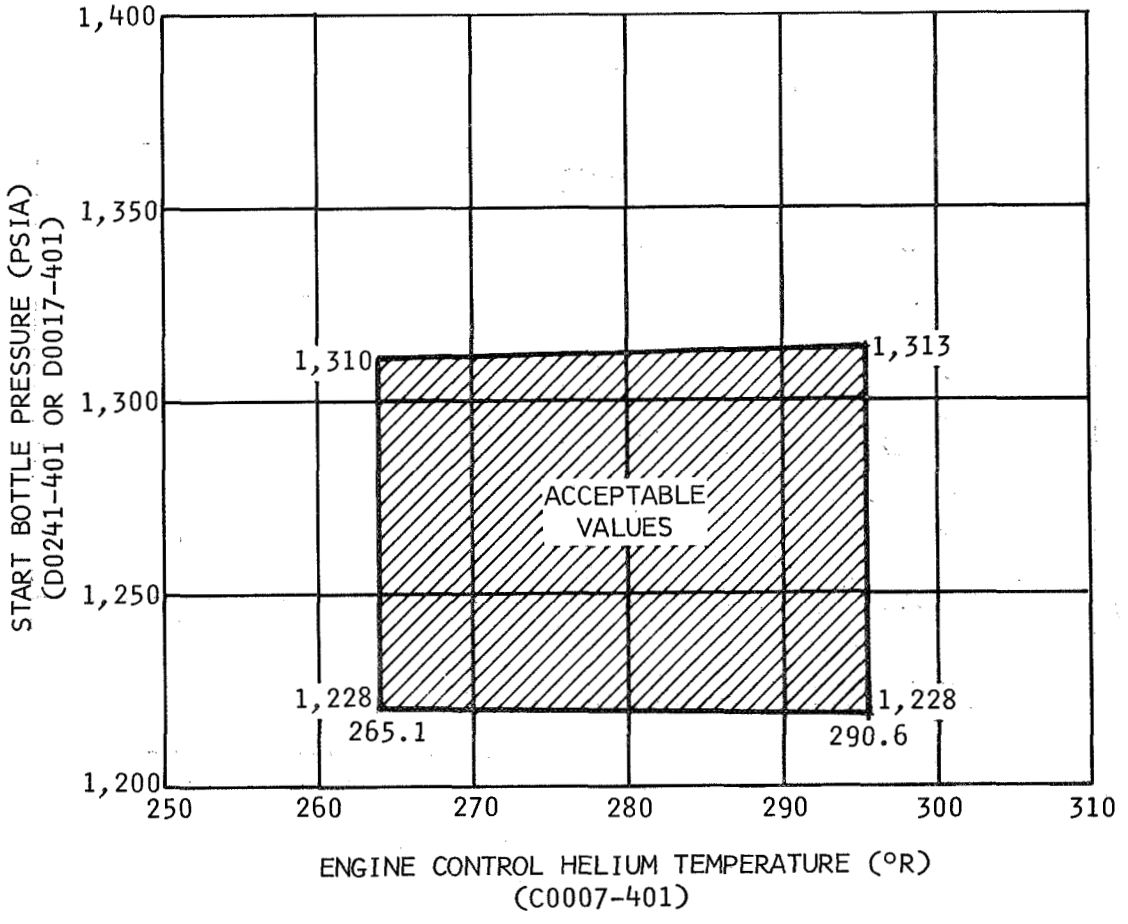


Figure 5-6. Engine Control Helium Bottle Liftoff Critical Limits (Backup)

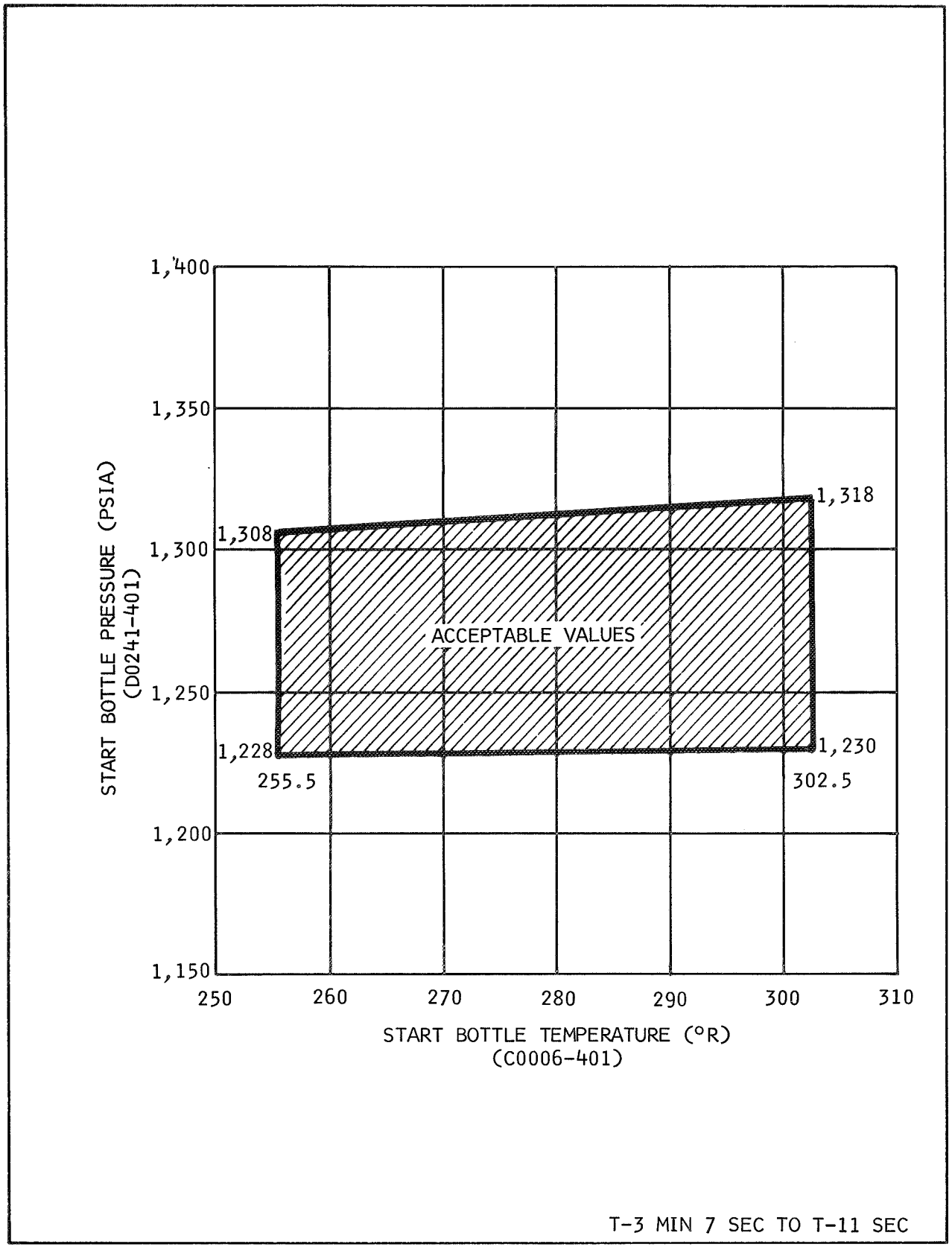


Figure 5-7. GH2 Start Bottle Liftoff Critical Limits (Backup)

SECTION 6

FLIGHT TEST MANAGEMENT

6. FLIGHT TEST MANAGEMENT

This section defines the responsibilities of the Douglas Aircraft Company (DAC) relative to the data flow, flight test evaluation, and documentation of the S-IVB-502 stage flight test.

6.1 Flight Test Responsibilities

Douglas Aircraft Company (DAC) personnel will perform postflight evaluations of the S-IVB-502 stage at the following locations:

a. Kennedy Space Center (KSC), Cape Kennedy, Florida

b. Marshall Space Flight Center (MSFC), Huntsville, Alabama

c. Douglas Missile & Space Systems Division (MSSD), Huntington Beach, California.

At KSC, DAC is represented by the Florida Test Center (FTC) Test Planning and Evaluation (TP&E) Committee; at Huntington Beach, DAC is represented by the DAC/HB TP&E Committee; and at MSFC, by the DAC/MSFC liaison team.

The DAC/HB and DAC/FTC TP&E Committees consist of personnel assigned from Saturn Engineering sections and branches. Their functions are to:

a. Coordinate postflight evaluation

b. Provide information for all contractual documentation

c. Coordinate test planning for future flights.

The onsite quick-look postflight evaluation, consisting primarily of analog data evaluation, is performed by the DAC/FTC TP&E Committee, and the results are transmitted to:

a. National Aeronautics and Space Administration (NASA), Kennedy Space Center

b. DAC/HB TP&E Committee

c. DAC/MSFC liaison team.

The major postflight evaluation is conducted at DAC/HB and consists primarily of analyses from digital data.

All analyses conducted at DAC/FTC and DAC/HB are transmitted to the DAC/MSFC liaison team. This liaison team transmits information between DAC and MSFC, provides the MSFC Flight Evaluation Working Group (FEWG) with required information, and performs rapid analyses in response to FEWG requests. In addition, the liaison team participates in many of the MSFC postflight evaluations which contribute to, or parallel, DAC postflight evaluation efforts.

6.2 Postflight Communication

The following means of communication (figure 6-1) have been established to expedite transmittal of evaluation information:

a. TWX communications between DAC/MSSD, DAC/MSFC, and DAC/FTC
b. Facsimile communications between DAC/MSSD, DAC/MSFC, and DAC/FTC
c. Data phone link between DAC/MSFC and DAC/MSSD

Transmittal of classified material between DAC facilities by any of the above means is not authorized. A standard format is used for transmission of unclassified data by TWX or facsimile.

To insure rapid and controlled data transmission between locations, it is highly desirable that all information be channeled through one coordinator of flight information at each location.

6.3 Documentation

DAC prepares and publishes certain documents for each S-IVB stage flight. The documents, listed in the approximate order in which they will be published, are as follows:

Preflight

a. DAC Drawing 1B43567, *Saturn S-IVB-502 Instrumentation Program and Components List* (reference 11)

b. DAC Report No. DAC-56334, *Douglas S-IVB Stage Data Acquisition Requirements Document for Saturn V Flights* (reference 12)

c. DAC Report No. SM-46999, *S-IVB-502 Stage Flight Test Plan*

Postflight

a. Quick-Look Assessment Report (second morning following launch)

b. FTC Ground Systems Evaluation Report (10 days)

c. FTC Preliminary Flight Evaluation Summary (2 wk)

d. Written Informal Evaluation Inputs to MSFC/FEWG (28 days)

e. DAC Report No. SM-47005, *S-IVB-502 Stage Flight Evaluation Report.* (60 days) (reference 14)

Descriptions of the contents are presented in the following paragraphs.

6.3.1 *Saturn S-IVB-502 Instrumentation Program and Components List - 1B43567* (reference 11)

This drawing contains all the telemetry measurements of the S-IVB-502 stage. A partial list of its contents is as follows:

a. Measurement numbers

b. Component part numbers

c. Reference designation numbers

d. Telemetry channel coding definitions

e. Measurement list

f. Measurement matrix by area and function

g. Measurement locations, illustrations, and index.

All sections of the Instrumentation Program and Components List are revised as necessary to reflect current instrumentation information. Revisions are controlled by the Saturn Project Office - Test at DAC/MSSD.

6.3.2 *Douglas S-IVB Stage Data Acquisition Requirements Document for Saturn V Flights - DAC-56334* (reference 12)

This document describes the detailed data requested by DAC/MSSD for evaluation of the S-IVB stage of the Saturn V flights. The requested data will be provided by KSC, Goddard Space Flight Center (GSFC), and MSFC.

6.3.3 S-IVB-502 Stage Flight Test Plan, SM-46999

The contents of the *S-IVB-502 Stage Flight Test Plan* are described in section 1, Introduction, of this document. This document is prepared by the DAC/MSSD TP&E Committee.

6.3.4 Quick-Look Assessment Report (Second Morning Following Launch)

Approximately forty-eight hours after launch or as soon as sufficient data are available, the DAC/FTC TP&E Committee will TWX to DAC/MSSD, DAC/MSFC, and DAC/Manned Spacecraft Center, Houston a quick-look evaluation which will include a brief description of system performance, mission objective accomplishments, and any malfunction which may have occurred. This will be for internal use only.

6.3.5 FTC Ground Systems Evaluation Report (10 days)

The DAC/FTC TP&E Committee will prepare an evaluation report of the performance of DAC/NASA-supplied GSE used in handling propellants for the S-IVB auxiliary propulsion system. This report will be transmitted to KSC.

6.3.6 FTC Preliminary Flight Evaluation Summary (2 wk)

The DAC/FTC TP&E Committee will compile, publish, and distribute the Preliminary Flight Evaluation Summary for internal use only approximately 2 weeks after launch. It will be the final FTC effort and will summarize test objectives, discuss possible causes of malfunctions, and recommend any corrective action required.

6.3.7 DAC Inputs to MSFC/FEWG

The DAC/MSFC liaison team will summarize the results of the DAC/FTC flight evaluations as they are completed during the four weeks subsequent to launch. These summaries, as they become available, will be input to the FEWG and will constitute the DAC input to the MSFC Saturn Vehicle Flight Evaluation Report.

In addition, 44 days after launch, DAC will review its portion of the FEWG report to ensure the technical accuracy and adequacy of evaluation.

6.3.8 S-IVB-502 Stage Flight Evaluation Report (60 days)

Sixty days after launch the DAC/MSSD TP&E Committee will write, publish and distribute DAC Report No. SM-47005, *S-IVB-502 Stage Flight Evaluation Report*. The data for evaluation will be required at DAC/MSSD 15 days after launch, thereby allowing 45 days for preparation of the report. Tentative evaluation meetings and documentation schedules are shown in tables 6-1 and 6-2. A flight evaluation report outline delineating the responsible design technologies is presented in table 6-3.

TABLE 6-1
TENTATIVE AS-502 FLIGHT EVALUATION MEETING SCHEDULE

DAYS AFTER LAUNCH	EVENT SCHEDULES	MEETING LOCATION
1	Flight Review Meeting	MSFC
6	First "How-Goes-It" Meeting	DAC/HB
7	First General Evaluation Meeting	MSFC
13	Second "How-Goes-It" Meeting	DAC/HB
14 & 15	Second General Evaluation Meeting	MSFC
20	Third "How-Goes-It" Meeting	DAC/HB
21	Third General Evaluation Meeting	MSFC
27	Fourth "How-Goes-It" Meeting	DAC/HB
28	Summary Meeting	MSFC
29	S-IVB Stage Instrumentation Splinter Meeting	MSFC

TABLE 6-2
EVALUATION AND DOCUMENTATION SCHEDULE FOR S-IVB-502
STAGE FLIGHT EVALUATION REPORT

DAYS AFTER LAUNCH	EVENT
0	Launch
1	Support FEWG Flight Review Meeting
7	Support FEWG First General Evaluation Meeting
14 & 15	Support FEWG Second General Evaluation Meeting
15	All Final Data Due at A3
21	Support FEWG Third General Evaluation Meeting
26	*First Inputs Due from Design Sections
28	Written Informal Evaluation Inputs to MSFC/FEWG Report Due: Support FEWG Summary Meeting
29	Support S-IVB Stage Instrumentation Splinter Meeting
40	*All Final Evaluation Inputs Due for 60-Day Report
44	Review of FEWG Flight Evaluation Report
45	Management Review Copy to Reproduction
47	Management Review Copy Distributed
50	Management Review Comments Due
53	Final Report to Reproduction
60	Final 60-Day Evaluation Report Distributed

* A detailed outline will be published immediately after launch, indicating when inputs are due during the 26 to 40 day period.

TABLE 6-3 (Sheet 1 of 4)
S-IVB-502 STAGE FLIGHT EVALUATION REPORT OUTLINE

SECTION	ENGINEERING SECTION
1. INTRODUCTION	S-IVB Project
2. SUMMARY	S-IVB Project*
3. TEST CONFIGURATION†	
3.1 Stage Configuration	Propulsion
3.2 Stage Modifications	S-IVB Project Office
3.3 Ground Support Equipment	S-IVB Project Office
4. SEQUENCE OF EVENTS	
4.1 Predicted and Monitored Times	FD&C
4.2 Time Bases	FD&C
4.3 Ground Sequence of Events	Electronics
5. COUNTDOWN OPERATIONS	
5.1 Propulsion System Checkouts	Propulsion
5.2 Launch Vehicle Tests	Propulsion
5.3 Propellant and Pneumatic Loading	Propulsion
5.4 Launch Countdown	Propulsion
5.5 Environmental Control Systems	Structural/Mechanical
5.6 Terminal Countdown	Propulsion and Electronics
5.7 Holds	Propulsion
5.8 Launch Environment	S-IVB Project Office
6. CPIF	S-IVB Project Office
6.1 Flight Mission Accomplishment	FD&C
6.2 Telemetry Performance	Electronics

*Each Design Technology will summarize its individual areas. The S-IVB TP&E Section will insure compatibility between the various analyses. A separate anomaly summary will be developed by the TP&E Committee.

†Includes serial numbers of significant stage end items, orifice sizes, nominal pressure switch settings, and nominal regulator settings. Significant modifications to the stage since acceptance firing are listed, if any.

TABLE 6-3 (Sheet 2 of 4)
S-IVB-502 STAGE FLIGHT EVALUATION REPORT OUTLINE

SECTION	ENGINEERING SECTION
7. TRAJECTORY	FD&C
7.1 Comparison Between Actual and Preflight Predicted Trajectories	
7.2 Trajectory Simulation Analysis	
8. MASS CHARACTERISTICS	Weight Control
9. ENGINE SYSTEM	
9.1 Engine Chilldown and Conditioning	Propulsion
9.2 Engine Performance	Propulsion
9.3 Sequence of Events	Propulsion
9.4 Component Operation	Propulsion
9.5 Flight Simulation Analysis	FD&C
10. SOLID ROCKET PERFORMANCE	Propulsion
10.1 Ullage Rockets	
10.2 Retrorockets	
11. OXIDIZER SYSTEM	Propulsion
11.1 Pressurization Control and Internal Environment	
11.2 Cold Helium Supply	
11.3 Heat Exchanger	
11.4 LOX Chilldown	
11.5 Engine LOX Supply	
12. FUEL SYSTEM	Propulsion
12.1 Pressurization Control and Internal Environment	
12.2 LH2 Chilldown	
12.3 Engine LH2 Supply	
13. AUXILIARY PROPULSION SYSTEM	Propulsion
13.1 APS Module No. 1	
13.2 APS Module No. 2	
13.3 Engine Performance	

TABLE 6-3 (Sheet 3 of 4)
S-IVB-502 STAGE FLIGHT EVALUATION REPORT OUTLINE

SECTION	ENGINEERING SECTION
14. PNEUMATIC CONTROL AND PURGE	Propulsion
14.1 Ambient Helium Supply	
14.2 Pneumatic Control	
14.3 Ambient Helium Purges	
15. PROPELLANT UTILIZATION	PU Analysis Panel
15.1 Propellant Mass History	
15.2 PU System Analysis	
15.3 PU Efficiency	
15.4 PU Valve Response	
16. S-II/S-IVB STAGE SEPARATION	FD&C
16.1 Separation Distance	
16.2 Stage Accelerations and Angular Velocities	
16.3 Relative Lateral Motion	
17. DATA ACQUISITION SYSTEM	Electronics
17.1 Instrumentation System	
17.2 Telemetry System	
18. ELECTRICAL SYSTEM	Electronics
18.1 Electrical Control System	
18.2 Electrical Power System	
19. RANGE SAFETY SYSTEM	Electronics
19.1 Controllers	
19.2 Firing Unit Monitors	
19.3 Receivers Signal Strength	
20. FLIGHT CONTROL	FD&C
20.1 Main Engine Control System	
20.2 Roll Control During S-IVB Powered Flight	
20.3 Sloshing	
20.4 Body Bending	

TABLE 6-3 (Sheet 4 of 4)
S-IVB-502 STAGE FLIGHT EVALUATION REPORT OUTLINE

SECTION	ENGINEERING SECTION
21. HYDRAULIC SYSTEM	Structural/Mechanical
21.1 Hydraulic Systems Operation	
21.2 Servo Systems Operation	
22. STAGE STRUCTURE AND ENVIRONMENT	Structural/Mechanical
22.1 Flight Load Conditions and Structural Integrity	
22.2 Explosive Ordnance Equipment	
23. FORWARD SKIRT THERMOCONDITIONING	Structural/Mechanical
23.1 Temperature	
23.2 Pressure	
23.3 Flowrate	
24. AERO/THERMODYNAMIC ENVIRONMENT	Aero/Thermodynamics
24.1 Thermodynamic Environment	
24.2 Aerodynamics	
24.3 Component Heating	

APPENDICES

1. MASS CHARACTERISTICS DATA (WS11)	Weight Control
2. ENGINE PERFORMANCE PROGRAM (AA89)	Propulsion
3. FLOWMETER RECONSTRUCTION (G105)	Propulsion
4. ENGINE PERFORMANCE PROGRAM (F823)	Propulsion
5. OBSERVED TRAJECTORY (AA83)	FD&C
6. FLIGHT SIMULATED DATA (AC77)	FD&C
7. METEOROLOGICAL DATA	DAC/FTC TP&E Committee
8. GLOSSARY AND ABBREVIATIONS	S-IVB Project

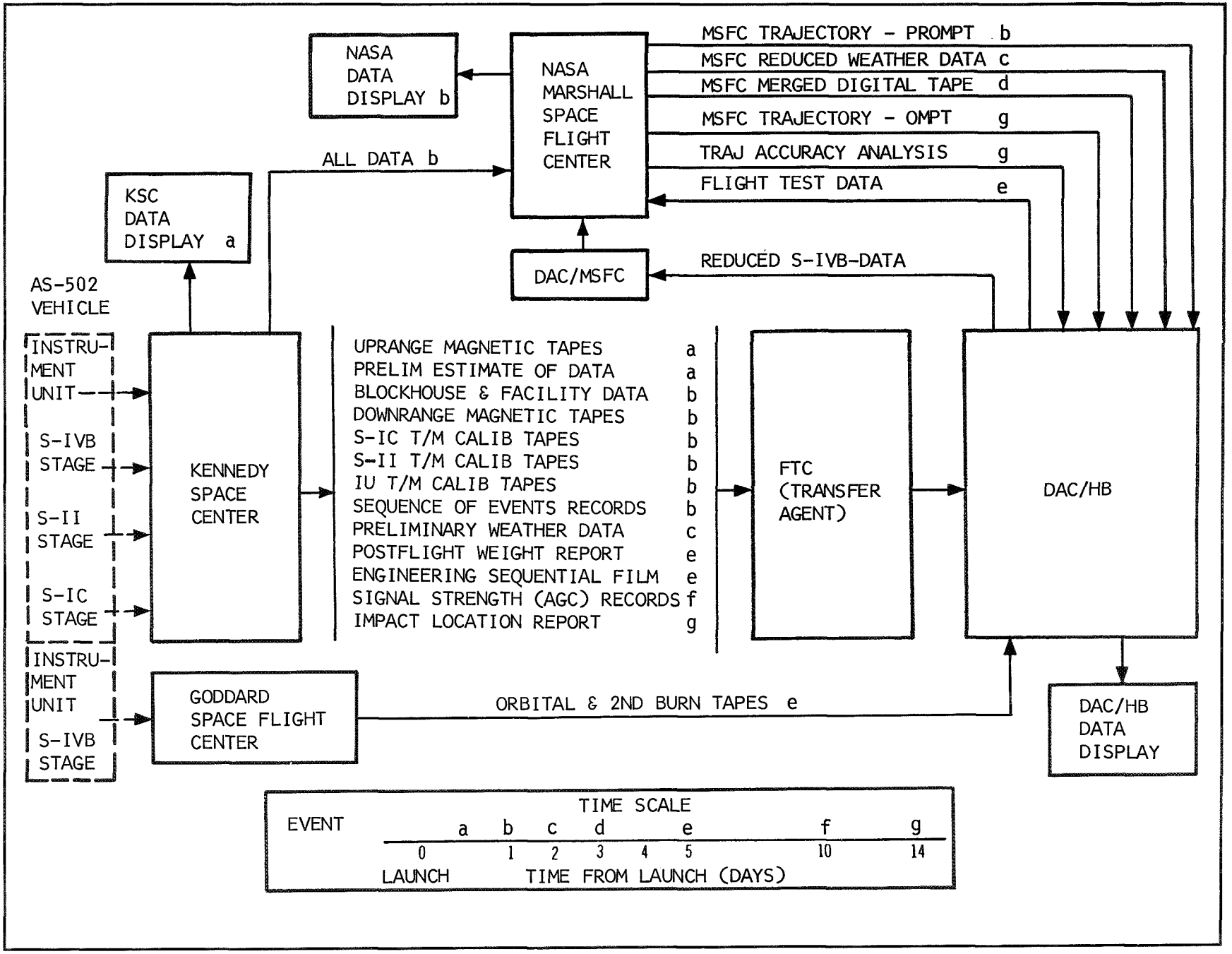


Figure 6-1. Data Flow Chart

APPENDIX 1

SEQUENCE OF EVENTS

1. SEQUENCE OF EVENTS

This appendix presents the predicted AS-502 flight sequence of events (table AP 1-1). Seven primary time bases and one alternate time base are programmed to achieve an optimum vehicle mission with suitable sequential operation and timing of flight events. Definitions of the time bases and symbols used are listed in table AP 10-1.

The sequence of events is based on the Marshall Space Flight Center sequence requirements as indicated in the Interface Control Document (reference 6), *Definition of Saturn SA-502 Flight Sequence Program*.

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 1 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Guidance Ref. Release	-00:00:16.7		-	-	
First Motion	00:00:00.0			-	
Liftoff - Start of Time Base No. 1 (T_1)	00:00:00.3	$(0.0)_1$	-517.0		Time base No. 1 is initiated by a liftoff signal provided by the deactivation of the liftoff relay in the IU at the umbilical disconnect.
Auto - Abort Enable Relays Reset	00:00:05.3	$(5.0)_1$	-512.0	IU	
Sensor Bias On	00:00:05.5	$(5.2)_1$	-511.8	IU	
Start Pitch Program	00:00:11.0	N/A	-506.0	-	The pitch program tilts the vehicle over for 133.5 sec in order to orient the vehicle for insertion into orbit.
Start Roll Program	00:00:11.0	N/A	-506.0	-	The roll program reorientates the roll attitude of the vehicle. The maneuver takes 18 sec.
Multiple Engine Cutoff Enable	00:00:14.3	$(14.0)_1$	-503.0	S-IC	Cutoff of any engine due to rough combustion or low thrust is enabled.
S-IC Telemeter Calibrate On	00:00:25.1	$(24.8)_1$	-492.2	S-IC	
Telemeter Calibrator In-Flight	00:00:27.3	$(27.0)_1$	-490.0	IU	
Achieve Programmed Roll Attitude	00:00:29.0	N/A	-489.0	-	
S-IC Telemeter Calibrate Off	00:00:30.1	$(29.8)_1$	-487.2	S-IC	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 2 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Enable Launch Vehicle Engines EDS Cutoff	00:00:30.3	$(30.0)_1$	-487.0	IU	
Telemeter Calibrator Stop In-Flight Calibrate	00:00:32.3	$(32.0)_1$	-485.0	IU	
Fuel Pressurizing Valve No. 2 Open and Tape Recorder Record	00:00:49.8	$(49.5)_1$	-467.5	S-IC	
Start Data Recorders	00:01:14.4	$(74.1)_1$	-442.9	S-II	
Cooling System Electrical Assembly Power Off	00:01:15.3	$(75.0)_1$	-442.0	IU	
Maximum Dynamic Pressure	00:01:17.2	N/A	-439.7	-	
Telemeter Calibrator In-Flight Calibrate	00:01:30.3	$(90.0)_1$	-427.0	IU	
Telemeter Calibrator Stop In-Flight Calibrate	00:01.35.3	$(95.0)_1$	-422.0	IU	
Fuel Pressurizing Valve No. 3 Open	00:01:35.6	$(95.3)_1$	-421.7	S-IC	
Flight Control Computer Switch Point No. 1	00:01:45.3	$(105.0)_1$	-412.0	IU	
S-IC Telemeter Calibrate On	00:01:55.3	$(115.0)_1$	-402.0	S-IC	
Regular Calibrate Relays On	00:01:59.5	$(119.2)_1$	-397.8	S-IVB	
S-IC Telemeter Calibrate Off	00:02:00.3	$(120.0)_1$	-397.0	S-IC	
Flight Control Computer Switch Point No. 2	00:02:00.5	$(120.2)_1$	-396.8	IU	
Regular Calibrate Relays Off	00:02:04.5	$(124.2)_1$	-392.8	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 3 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Start First PAM-FM/FM Calibration	00:02:10.0	$(129.7)_1$	-387.3	S-II	
Fuel Pressurizing Valve No. 4 Open	00:02:13.8	$(133.5)_1$	-383.5	S-IC	
Fast Record On	00:02:14.8	$(134.5)_1$	-382.5	S-IVB	The S-IVB tape recorder records during S-IC/S-II separation to prevent the possible loss of data during this time.
Stop First PAM-FM/FM Calibration	00:02:15.0	$(134.7)_1$	-382.3	S-II	
IU Tape Recorder Record On	00:02:15.2	$(134.9)_1$	-382.1	IU	
LOX Tank Strobe Lights Off	00:02:15.4	$(135.1)_1$	-381.9	S-IC	
S-IC Two Engine Out Auto-Abort Inhibit Enable	00:02:15.6	$(135.3)_1$	-381.7	IU	
S-IC Two Engine Out Auto-Abort Inhibit	00:02:15.8	$(135.5)_1$	-381.5	IU	
Excessive Rate (Pitch, Yaw and Roll) Auto-Abort Enable	00:02:16.0	$(135.7)_1$	-381.3	IU	
Excessive Rate (Pitch, Yaw and Roll) Auto-Abort Inhibit	00:02:16.2	$(135.9)_1$	-381.4	IU	
Two Adjacent Outboard Engines Out Enable	00:02:16.4	$(136.1)_1$	-380.9	S-IC	
Inboard Engine Cutoff Enable	00:02:16.6	$(136.3)_1$	-380.7	S-IC	
Inboard Engine Cutoff-Start Time Base No. 2 (T_2)	00:02:23.5	$(0.0)_2$	-373.5	S-IC	Computer time base will be reset.

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 4 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
S-II Ordnance Arm	00:02:23.6	$(0.1)_2$	-373.4	S-II	
Arm EBW Retro and Separation	00:02:23.8	$(0.3)_2$	-373.2	S-IC	
Separation Camera On	00:02:24.0	$(0.5)_2$	-373.0	S-IC	
Camera Lights On	00:02:24.1	$(0.6)_2$	-372.9	S-IC	
S-IC Telemetry Measurement Switch Over	00:02:24.3	$(0.8)_2$	-372.7	S-IC	
Enable Outboard Engine Cutoff	00:02:24.6	$(1.1)_2$	-372.4	S-IC	
Stop Pitch Program	00:02:24.5	N/A	-372.3		
Outboard Engine Cutoff - Start of Time Base No. 3 (T_3)	00:02:28.3	$(0.0)_3$	-368.7	-	Computer time base will be reset.
Camera Motor On	00:02:28.4	$(0.1)_3$	-368.6	S-II	
S-II LH2 Recirculation Pumps Off	00:02:28.6	$(0.3)_3$	-368.4	S-II	
S-II Ullage Rocket Trigger	00:02:28.8	$(0.5)_3$	-368.2	S-II	The S-II ullage rockets reach full thrust 0.17 sec after the command is given and will burn for 3.7 sec. Full thrust is required from separation to the S-II stage engine 30% thrust level.
Fire S-IC/S-II Separation Device; Fire S-IC Retrorockets	00:02:29.0	$(0.7)_3$	-368.0	S-IC	Separation is initiated when the F-1 outboard engines thrust has decayed to the 10% level.

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 5 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Camera Event Mark	00:02:29.1	$(0.8)_3$	-367.9	S-II	
Switch Engine Control to S-II Enable S-II Engine Out Second Separation Indication "A"	00:02:29.2	$(0.9)_3$	-367.8	IU	The IU switches flight control from the S-IC stage to the S-II stage.
S-II Engines Cutoff Reset	00:02:29.3	$(1.0)_3$	-367.7	S-II	
S-II Engines Ready Bypass	00:02:29.4	$(1.1)_3$	-367.6	S-II	
Prevalves Lockout Reset	00:02:29.5	$(1.2)_3$	-367.5	S-II	
S-II Engine Start	00:02:29.7	$(1.4)_3$	-367.3	S-II	The S-IC and S-II stages have separated a minimum of one foot. J-2 engine chilldown begins at this time.
Camera Event Mark	00:02:29.8	$(1.5)_3$	-367.2	S-II	
Enable S-II Engine Out Enable S-II Second Separation Indication "B"	00:02:30.0	$(1.7)_3$	-367.0	IU	
Engines Ready Bypass Reset	00:02:30.2	$(1.9)_3$	-366.8	S-II	
Q-Ball Power Off	00:02:30.7	$(2.4)_3$	-366.3	IU	
S-II Hydraulic Accumulators Unlock	00:02:31.3	$(3.0)_3$	-365.7	S-II	Gimbaling of the S-II stage engines is enabled.
Chilldown Valves Close	00:02:34.7	$(6.4)_3$	-362.3	S-II	
S-II Start Phase Limiter Cutoff Arm	00:02:35.0	$(6.7)_3$	-362.0	S-II	A start sequence halt will prevent the malfunction cutoff circuitry from being armed by the engine sequencer. This signal is a backup for arming the main stage OK switch to give cutoff if a malfunction in the engine sequence has occured.

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 6 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Activate PU System	00:02:35.2	$(6.9)_3$	-361.8	S-II	
S-II Start Phase Limiter Cutoff Arm Reset	00:02:36.0	$(7.7)_3$	-361.0	S-II	
Stop Data Recorders	00:02:39.7	$(11.4)_3$	-357.3	S-II	
Fast Record Off	00:02:39.9	$(11.6)_3$	-357.1	S-IVB	
IU Tape Recorder Record Off	00:02:40.1	$(11.8)_3$	-356.9	IU	
S-II Second Plane Separation	00:02:59.0	$(30.7)_3$	-338.0	S-II	
Camera Event Mark	00:02:59.1	$(30.8)_3$	-337.9	S-II	
Camera Event Mark	00:03:00.1	$(31.8)_3$	-336.9	S-II	
Water Coolant Valve Open	00:03:00.3	$(32.0)_3$	-336.7	IU	
Launch Escape Tower Jettison "A"	00:03:04.7	$(36.4)_3$	-332.3	IU	
Launch Escape Tower Jettison "B"	00:03:04.9	$(36.6)_3$	-332.1	IU	
Camera Eject No. 1	00:03:06.3	$(38.0)_3$	-330.7	S-II	
Camera Eject No. 2	00:03:06.9	$(38.6)_3$	-330.1	S-II	
Camera Eject No. 3	00:03:07.4	$(39.1)_3$	-335.4	S-II	
Flight Control Computer Switch Point No. 3	00:03:29.7	$(61.4)_3$	-307.3	IU	
Start Second PAM-FM/FM Calibration	00:05:30.2	$(181.9)_3$	-186.8	S-II	
Stop Second PAM-FM/FM Calibration	00:05:35.2	$(186.9)_3$	-181.8	S-II	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 7 of 27)

EVENT	TIME FROM FIRST MOTION (HR:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (SEC)	SSS	REMARKS
Flight Control Computer Switch Point No. 4	00:05:39.7	$(191.4)_3$	-177.3	IU	
Telemeter Calibrator In-Flight Calibrate	00:05:50.2	$(201.9)_3$	-166.8	IU	
Telemeter Calibrator Stop In-Flight Calibrate	00:05:55.2	$(206.9)_3$	-161.8	IU	
Measurement Control Switch No. 2 Activate	00:06:01.0	$(212.7)_3$	-156.0	S-II	
S-II LH2 Step Pressurization	00:06:39.2	$(250.9)_3$	-117.8	S-II	The LH2 pressurization regulator is locked open at this time.
Start Third PAM-FM/FM Calibration	00:07:00.9	$(272.6)_3$	-96.1	S-II	
Stop Third PAM-FM/FM Calibration	00:07:05.9	$(277.6)_3$	-91.1	S-II	
Regular Calibrate Relays On	00:08:00.2	$(331.9)_3$	-36.8	S-IVB	
Telemeter Calibrator In-Flight Calibrate	00:08:00.4	$(332.1)_3$	-36.6	IU	
Regular Calibrate Relays Off	00:08:05.2	$(336.9)_3$	-31.8	S-IVB	
Telemeter Calibrator Stop In-Flight Calibrate	00:08:05.4	$(337.1)_3$	-31.6	IU	
Charge Ullage Rocket Ignition On	00:08:05.8	$(337.5)_3$	-31.2	S-IVB	
S-II/S-IVB Ordnance Arm	00:08:06.0	$(337.7)_3$	-31.0	S-II	
IU Tape Recorder Record On	00:08:06.2	$(337.9)_3$	-30.8	IU	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 8 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Fast Record On	00:08:06.4	$(338.1)_3$	-30.6	S-IVB	S-IVB recorder records during separation to prevent the loss of data during this time.
Start Recorders	00:08:06.6	$(338.3)_3$	-30.4	S-II	
S-II LOX Depletion Sensor Cutoff Arm	00:08:06.8	$(338.5)_3$	-30.2	S-II	
S-II LH2 Depletion Sensor Cutoff Arm	00:08:07.0	$(338.7)_3$	-30.0	S-II	
S-II Stage J-2 Engine Cutoff-Start of Time Base No. 4 (T_4)	00:08:36.0	$(0.0)_4$	-1.0	-	S-II cutoff is initiated by depletion sensors. Computer time base is reset.
Start Recorder Timers	00:08:36.1	$(0.1)_4$	-0.9	S-II	
Prevalves Close Off	00:08:36.2	$(0.2)_4$	-0.8	S-IVB	
S-IVB Engine Cutoff Off	00:08:36.3	$(0.3)_4$	-0.7	S-IVB	
Engine Ready Bypass	00:08:36.5	$(0.5)_4$	-0.5	S-IVB	This signal resets the engine cutoff circuitry. It must be initiated prior to engine start command.
LOX Chilldown Pump Off	00:08:36.6	$(0.6)_4$	-0.4	S-IVB	
S-IVB Ullage Rocket Ignition On	00:08:36.7	$(0.7)_4$	-0.3	S-IVB	The ullage rockets with a burning time of 4 sec must burn until S-IVB J-2 engine thrust is sufficient to maintain propellants seated (approximately 3.1 sec).

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 9 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Fire S-II/S-IVB Separation Device; Fire S-II Retrorockets	00:08:36.8	$(0.8)_4$	-0.2	S-II	S-II stage J-2 engine thrust is at 10% level.
S-IVB Engine Start Interlock Bypass On	00:08:36.9	$(0.9)_4$	-0.1	S-IVB	The engine start interlocks will be bypassed for unmanned flights only. The interlocks prevent engine start in the event of an incomplete separation.
S-IVB Engine Start On	00:08:37.0	$(1.0)_4$	-0.0	S-IVB	The start sequence commanded by the J-2 engine sequencer is based around prechill of thrust chamber. J-2 engine chilldown is also initiated.
Flight Control Computer S-IVB Burn Mode On "A"	00:08:37.1	$(1.1)_4$	0.1	IU	The auxiliary propulsion system is activated to control roll and J-2 engine gimbaling is enabled.
Flight Control Computer S-IVB Burn Mode On "B"	00:08:37.2	$(1.2)_4$	0.2	IU	
S-IVB Engine Out Indication "A" Enable On	00:08:37.6	$(1.6)_4$	0.6	IU	
S-IVB Engine Out Indication "B" Enable On	00:08:37.8	$(1.8)_4$	0.8	IU	
Fuel Chilldown Pump Off	00:08:38.2	$(2.2)_4$	1.2	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 10 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
LOX Tank Flight Pressure System On	00:08:39.8	$(3.8)_4$	2.8	S-IVB	The control function of the LOX tank pressure switch is switched from the main pressurization shutoff valves to the heat exchanger bypass valve.
Fuel Injection Temperature OK Bypass	00:08:40.0	$(4.0)_4$	3.0	S-IVB	Fuel lead is terminated at this time by opening the start tank discharge valve.
Engine Start Off	00:08:40.2	$(4.2)_4$	3.2	S-IVB	
First Burn Relay On	00:08:41.8	$(5.8)_4$	4.8	S-IVB	
Emergency Playback Enable On	00:08:43.8	$(7.8)_4$	6.8	S-IVB	
Fast Record Off	00:08:44.0	$(8.0)_4$	7.0	S-IVB	
PU Activate On	00:08:45.0	$(9.0)_4$	8.0	S-IVB	
Charge Ullage Rocket Jettison On	00:08:45.8	$(9.8)_4$	8.8	S-IVB	
Fire Ullage Rocket Jettison On	00:08:48.8	$(12.8)_4$	11.8	S-IVB	
Fuel Injection Temperature OK Bypass Reset	00:08:50.0	$(14.0)_4$	13.0	S-IVB	
Ullage Rocket Charging Reset	00:08:51.6	$(15.6)_4$	14.6	S-IVB	
Ullage Rocket Firing Reset	00:08:51.8	$(15.8)_4$	14.8	S-IVB	
IU Tape Recorder Record Off	00:08:54.9	$(18.9)_4$	17.9	IU	
Emergency Playback Enable Off	00:08:57.3	$(21.3)_4$	20.3	S-IVB	
Telemeter Calibrator In-Flight Calibrate	00:08:58.4	$(22.4)_4$	21.4	IU	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 11 of 27)

EVENT	TIME FROM FIRST MOTION (hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Telmeter Calibrator Stop In-Flight Calibrate	00:09:03.4	$(27.4)_4$	26.4	IU	
Regular Calibrate Relays On	00:09:07.8	$(31.8)_4$	30.8	S-IVB	
Regular Calibrate Relays Off	00:09:12.8	$(36.8)_4$	35.8	S-IVB	
Chilldown Shutoff Pilot Valve Close On	00:10:20.9	$(103.5)_4$	102.5	S-IVB	
Engine Pump Purge Control Valve Enable On	00:10:38.9	$(-7.0)_5$	121.9	S-IVB	
S-IVB Engine Cutoff; Start of Time Base No. 5 (T_5)	00:10:45.9	$(0.0)_5$	128.9	-	J-2 engine cutoff will be at a predetermined velocity.
Maintain Cutoff Inertial Attitude	00:10:45.9	$(0.0)_5$	128.9		
Point Level Sensor Disarm	00:10:46.0	$(0.1)_5$	129.0	S-IVB	
70 lb Ullage Rocket Engines On No. 1	00:10:46.2	$(0.3)_5$	129.2	S-IVB	The ullage rockets serve to dampen out the cutoff transients.
70 lb Ullage Rocket Engines On No. 2	00:10:46.3	$(0.4)_5$	129.3	S-IVB	
Ullage Thrust Present On	00:10:46.5	$(0.6)_5$	129.5	IU	
First Burn Relay Off	00:10:46.6	$(0.7)_5$	129.6	S-IVB	
PU Activate Off	00:10:46.8	$(0.9)_5$	129.8	S-IVB	
Prevalves Close On	00:10:46.9	$(1.0)_5$	129.9	S-IVB	The main fuel and LOX valves must have sufficient time to close before the prevalves are closed. The minimum time between cutoff, and the command to close the LOX and LH2 prevalves is 0.425 sec.
LOX Tank Flight Pressure System Off	00:10:47.0	$(1.1)_5$	130.0	S-IVB	This signal sets the first burn relay which closes the main LOX pressurization shutoff valve.

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 12 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Coast Period On	00:10:47.2	$(1.3)_5$	130.2	S-IVB	
Engine Pump Purge Control Valve Enable On	00:10:47.4	$(1.5)_5$	130.4	S-IVB	The J-2 engine must be purged for 10 min after engine shutdown.
PU Fuel Boiloff Bias Cutoff On	00:10:47.6	$(1.7)_5$	130.6	S-IVB	
Flight Control Computer S-IVB Burn Mode Off "A"	00:10:49.4	$(3.5)_5$	132.4	IU	
Flight Control Computer S-IVB Burn Mode Off "B"	00:10:49.6	$(3.7)_5$	132.6	IU	
Auxiliary Hydraulic Pump Coast Mode On	00:10:49.8	$(3.9)_5$	132.8	S-IVB	
Auxiliary Hydraulic Pump Off	00:10:50.0	$(4.1)_5$	133.0	S-IVB	
S-IVB Engine Out Indication "A" Enable Off	00:10:55.9	$(10.0)_5$	138.9	IU	
S-IVB Engine Out Indication "B" Enable Off	00:10:56.1	$(10.2)_5$	139.1	IU	
Align Axis with Local Horizontal	00:11:00.9	$(15.0)_5$	143.8		
Single Sideband FM Transmitter Off	00:11:07.9	$(22.0)_5$	150.8	S-IVB	
Single Sideband FM Transmitter Group Off	00:11:08.1	$(22.2)_5$	151.0	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 13 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Continuous Vent Valve Open On	00:11:44.9	$(59.0)_5$	177.8	S-IVB	The LH2 continuous vent valves are opened at this time to provide ullage thrust during the coast mode. The 70-lb ullage engines are turned off after the vent valves are opened.
Prevalves Close Off	00:11:46.4	$(60.5)_5$	179.3	S-IVB	
Chilldown Shutoff Pilot Valve Close Off	00:11:46.6	$(60.7)_5$	179.5	S-IVB	
Continuous Vent Valve Open Off	00:11:46.9	$(61.0)_5$	179.8	S-IVB	
70-lb Ullage Rocket Engines No. 1 Off	00:12:13.9	$(88.0)_5$	206.8	S-IVB	
70-lb Ullage Rocket Engines No. 2 Off	00:12:14.0	$(88.1)_5$	206.9	S-IVB	
S-IVB Ullage Thrust Present Off	00:12:14.4	$(88.3)_5$	207.1	IU	
Roll 180° to Position III	00:12:15.1	$(90.0)_5$	208.8		
Emergency Playback Enable On	TBD	TBD	TBD	S-IVB	
IU Tape Recorder Playback Reverse On	TBD	TBD	TBD	IU	
Tape Recorder Playback Reverse Off	TBD	TBD	TBD	IU	
Emergency Playback Enable Off	TBD	TBD	TBD	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 14 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Engine Pump Purge Control Valve Enable Off	00:20:47.7	$(602.6)_5$	731.5	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	The recorder is turned on between ground stations to prevent the loss of data during this time. Playbacks are made when vehicle is over a ground station.
Slow Record Off	TBD	TBD	TBD	S-IVB	
Recorder Playback On	TBD	TBD	TBD	S-IVB	
Recorder Playback Off	TBD	TBD	TBD	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	
Telemetry Calibrator In-Flight Calibrate On	TBD	TBD	TBD	IU	
Regular Calibrate Relays On	TBD	TBD	TBD	S-IVB	
Telemetry Calibration In-Flight Calibrate Off	TBD	TBD	TBD	IU	
Regular Calibrate Relays Off	TBD	TBD	TBD	S-IVB	
Telemetry Calibrate In-Flight Calibrate On	TBD	TBD	TBD	IU	
Slow Record On	TBD	TBD	TBD	S-IVB	
Regular Calibrate Relays On	TBD	TBD	TBD	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 15 of 27)

EVENT	TIME FROM FIRST MOTION (Hr)Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Telemetry Calibrator In-Flight Calibrate Off	TBD	TBD	TBD	IU	
Regular Calibrate Relays Off	TBD	TBD	TBD	S-IVB	
Slow Record Off	TBD	TBD	TBD	S-IVB	
Recorder Playback On	TBD	TBD	TBD	S-IVB	
Recorder Playback Off	TBD	TBD	TBD	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	
Telemetry Calibrator In-Flight Calibrate On	TBD	TBD	TBD	IU	
Regular Calibrate Relays On	TBD	TBD	TBD	S-IVB	
Telemetry Calibrator In-Flight Calibrate Off	TBD	TBD	TBD	IU	
Regular Calibrate Relays Off	TBD	TBD	TBD	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	
Slow Record Off	TBD	TBD	TBD	S-IVB	
Recorder Playback On	TBD	TBD	TBD	S-IVB	
Recorder Playback Off	TBD	TBD	TBD	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	
Regular Calibrate Relays On	TBD	TBD	TBD	S-IVB	
Telemetry Calibrator In-Flight Calibrate On	TBD	TBD	TBD	IU	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 16 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB FIRST ENGINE START (Sec)	SSS	REMARKS
Regular Calibrate Relays Off	TBD	TBD	TBD	S-IVB	
Telemetry Calibrator In-Flight Calibrate Off	TBD	TBD	TBD	IU	
Slow Record On	TBD	TBD	TBD	S-IVB	
Slow Record Off	TBD	TBD	TBD	S-IVB	
Recorder Playback On	TBD	TBD	TBD	S-IVB	
Recorder Playback Off	TBD	TBD	TBD	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	
Slow Record On	TBD	TBD	TBD	S-IVB	
Telemetry Calibrator In-Flight Calibrate On	TBD	TBD	TBD	IU	
Regular Calibrate Relays On	TBD	TBD	TBD	S-IVB	
Telemetry Calibrate In-Flight Calibrate Off	TBD	TBD	TBD	IU	
Regular Calibrate Relays Off	TBD	TBD	TBD	S-IVB	
Initiate 20° Pitch Down Maneuver	00:51:45.1	$(2,460)_5$	2,588.5		
Initiate 20° Pitch Up Maneuver	00:55:25.1	$(4,680)_5$	4,808.9		
Roll 180° to Position I Down	11:00:25.1	$(5,040)_5$	5,168.9		

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 17 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB SECOND ENGINE START (Sec)	SSS	REMARKS
Begin Restart Preparations - Start of Time Base No. 6 (T_6)	03:04:32.0	$(0.0)_6$	-327.0		The computer in the IU will determine when to begin the restart sequence based on the mission and launch window. It will reset the time base and start automatic sequencing for restart.
70-lb Ullage Rocket Engine No. 1 On	03:04:32.2	$(0.2)_6$	-326.8	S-IVB	The ullage rockets serve to seat the propellant for S-IVB restart.
70-lb Ullage Rocket Engine No. 2 On	03:04:32.3	$(0.3)_6$	-326.7	S-IVB	
Auxiliary Hydraulic Pump Flight Mode On	03:04:32.4	$(0.4)_6$	-326.6	S-IVB	
S-IVB Ullage Thrust Present On	03:04:32.5	$(0.5)_6$	-326.5	IU	
Auxiliary Hydraulic Pump Coast Mode Off	03:04:32.6	$(0.6)_6$	-326.4	S-IVB	
LH2 Tank Vent Valve Boost Close On	03:04:32.8	$(0.8)_6$	-326.2	S-IVB	
LOX Tank Vent Valve Boost Close On	03:04:33.0	$(1.0)_6$	-326.0	S-IVB	
Continuous Vent Valve Close On	03:04:33.2	$(1.2)_6$	-325.8	S-IVB	
LH2 Repressurization Control Valve Open On	03:04:34.2	$(2.2)_6$	-324.8	S-IVB	
LH2 Tank Vent Valve Boost Close Off	03:04:34.8	$(2.8)_6$	-324.2	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 18 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB SECOND ENGINE START (Sec)	SSS	REMARKS
LOX Tank Vent Valve Boost Close Off	03:04:35.0	$(3.0)_6$	-324.0	S-IVB	
Continuous Vent Valve Close Off	03:04:35.2	$(3.2)_6$	-323.8	S-IVB	
Fuel Chilldown Pump On	03:04:38.0	$(6.0)_6$	321.0	S-IVB	The fuel system is conditioned for restart.
LOX Chilldown Pump On	03:04:43.0	$(11.0)_6$	-316.0	S-IVB	The LOX system is conditioned for restart.
Prevalves Close On	03:04:53.0	$(21.0)_6$	-306.0	S-IVB	
Telemetry Calibrator In-Flight Calibrate On	TBD	TBD	TBD	IU	
Regular Calibrate Relays On	TBD	TBD	TBD	S-IVB	
Telemetry Calibrator In-Flight Calibrate Off	TBD	TBD	TBD	IU	
Regular Calibrate Relays Off	TBD	TBD	TBD	S-IVB	
SSB/FM Group On	03:08:13.3	$(221.3)_6$	-105.7	S-IVB	
SSB/FM Transmitter On	03:08:13.5	$(221.5)_6$	-105.5	S-IVB	
LOX Repressurization Control Valve Open On	03:09:19.0	$(287.0)_6$	-40.0	S-IVB	
Prevalves Close Off	03:09:48.2	$(316.2)_6$	-10.8	S-IVB	LOX and LH2 prevalves are opened at this time to ensure against bubbles in the suction lines at engine start.
S-IVB Restart Alert	03:09:49.0	$(317.0)_6$	-10.0	IU	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 19 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB SECOND ENGINE START (Sec)	SSS	REMARKS
S-IVB Engine Cutoff Off	03:09:57.6	$(325.6)_6$	-1.4	S-IVB	
Engine Ready Bypass	03:09:57.8	$(325.8)_6$	-1.2	S-IVB	
LH2 Repressurization Control Valve Open Off	03:09:58.0	$(326.0)_6$	-1.0	S-IVB	The LH2 repressurization system is disabled at this time.
Fuel Chilldown Pump Off	03:09:58.2	$(326.2)_6$	-0.8	S-IVB	
LOX Chilldown Pump Off	03:09:58.4	$(326.4)_6$	-0.6	S-IVB	
LOX Tank Repressurization Control Valve Open Off	03:09:58.8	$(326.8)_6$	-0.2	S-IVB	
Engine Start On	03:09:59.0	$(327.0)_6$	0.0	S-IVB	J-2 engine chilldown begins at this time. The J-2 engine contains a sequencer which sequences the necessary commands to the engine for starting.
S-IVB Engine Out Indication "A" Enable On	03:09:59.8	$(327.8)_6$	0.8	IU	
S-IVB Engine Out Indication "B" Enable On	03:10:00.0	$(328.0)_6$	1.0	IU	
70-lb Ullage Engines No. 1 Off	03:10:02.0	$(330.0)_6$	3.0	S-IVB	
70-lb Ullage Engines No. 2 Off	03:10:02.1	$(330.1)_6$	3.1	S-IVB	
S-IVB Ullage Thrust Present Off	03:10:02.3	$(330.3)_6$	3.3	IU	
Flight Control Computer S-IVB Burn Mode On "A"	03:10:06.6	$(334.6)_6$	7.6	IU	
Flight Control Computer S-IVB Burn Mode On "B"	03:10:06.8	$(334.8)_6$	7.8	IU	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 20 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB SECOND ENGINE START (Sec)	SSS	REMARKS
Fuel Injection Temperature OK Bypass	03:10:07.0	$(335.0)_6$	8.0	S-IVB	
LOX Tank Flight Pressurization System On	03:10:07.2	$(335.2)_6$	8.2	S-IVB	
Coast Period Off	03:10:07.4	$(335.4)_6$	8.4	S-IVB	
Engine Start Off	03:10:07.6	$(335.6)_6$	8.6	S-IVB	
Second Burn Relay On	03:10:09.6	$(337.6)_6$	10.6	S-IVB	
PU Activate On	03:10:10.0	$(340.0)_6$	13.0	S-IVB	
Fuel Injection Temperature OK Bypass Reset	03:10:15.0	$(345.0)_6$	18.0	S-IVB	
Flight Control Computer Switch Point No. 5	03:14:27.0	$(597.0)_6$	270.0	IU	
Telemetry Calibrator In-Flight Calibrate On	TBD	TBD	TBD	IU	
Regular Calibrate Relays On	TBD	TBD	TBD	S-IVB	
Telemetry Calibrator In-Flight Calibrate Off	TBD	TBD	TBD	IU	
Regular Calibrate Relays Off	TBD	TBD	TBD	S-IVB	
Chilldown Shutdown Pilot Valve Close On	03:14:47.0	$(617.0)_6$	290.0	S-IVB	
Point Level Sensor Arming	03:15:12.2	$(642.2)_6$	315.2	S-IVB	The depletion sensors are activated prior to predicted energy cutoff. This provides a backup for S-IVB cutoff in the event of a failure in the energy cutoff.

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 21 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB SECOND ENGINE START (Sec)	SSS	REMARKS
S-IVB Engine Cutoff-Start Time Base No. 7 (T_7)	03:15:17.2	$(0.0)_7$	320.2	S-IVB	
Maintain Cutoff Inertial Attitude	03:15:17.2	$(0.0)_7$	320.2		
LOX Tank Vent Valve Open	03:15:17.4	$(0.2)_7$	320.4	S-IVB	
Point Level Sensors Disarming	03:15:17.5	$(0.3)_7$	320.5	S-IVB	
LH2 Tank Vent Valve Open	03:15:17.6	$(0.4)_7$	320.6	S-IVB	
Second Burn Relay Off	03:15:18.0	$(0.8)_7$	321.0	S-IVB	
LOX Tank Flight Pressurization System Off	03:15:18.2	$(1.0)_7$	321.2	S-IVB	
Prevalves Close On	03:15:18.3	$(1.1)_7$	321.3	S-IVB	The main fuel and LOX valves must have sufficient time to close before the prevalves are closed. A minimum of 0.425 sec is required after engine cutoff to close the valves.
Coast Period On	03:15:18.4	$(1.2)_7$	321.4	S-IVB	This signal disables the control function of pressure switches D262 and D216, and closes the main LOX pressurization shutoff valves.
PU Activate Off	03:15:18.6	$(1.4)_7$	321.6	S-IVB	
PU Inverter and D.C. Power Off	03:15:18.7	$(1.5)_7$	321.7	S-IVB	
LOX Chilldown Pump Purge Control Valve Open Off	03:15:18.8	$(1.6)_7$	321.8	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 22 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB SECOND ENGINE START (Sec)	SSS	REMARKS
Flight Control Computer S-IVB Burn Mode Off "A"	03:15:20.7	$(3.5)_7$	323.7	IU	
Flight Control Computer S-IVB Burn Mode Off "B"	03:15:20.9	$(3.7)_7$	323.9	IU	
Auxiliary Hydraulic Pump Flight Mode Off	03:15:21.1	$(3.9)_7$	324.1	S-IVB	The capability for gimbaling the J-2 engine is removed at this time.
SSB/FM Group Off	03:15:22.2	$(5.0)_7$	325.2	S-IVB	
SSB/FM Group Off	03:15:22.4	$(5.2)_7$	325.4	S-IVB	
LOX Tank Vent Valve Close	03:15:27.2	$(10.0)_7$	330.2	S-IVB	
LOX Tank Vent Valve Boost Close On	03:15:29.2	$(13.0)_7$	333.2	S-IVB	
LOX Tank Vent Valve Boost Close Off	03:15:31.2	$(15.0)_7$	335.2	S-IVB	
Maneuver to Separation Inertial Attitude	03:15:36.2	$(20.0)_7$	340.2		
Prevalves Close Off	03:16:16.7	$(60.5)_7$	380.7	S-IVB	
Chilldown Shutoff Pilot Valve Close Off	03:16:16.9	$(60.7)_7$	380.9	S-IVB	
LH2 Tank Vent Valve Close	03:17:17.2	$(120.0)_7$	440.2	S-IVB	
LH2 Tank Vent Valve Boost Close On	03:17:20.2	$(123.0)_7$	443.2	S-IVB	
LH2 Tank Vent Valve Boost Close Off	03:17:22.2	$(125.0)_7$	445.2	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 23 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB SECOND ENGINE START (Sec)	SSS	REMARKS
LV/SC Separation Sequence Start	03:18:16.9	$(180.0)_7$	500.2	IU	This signal initiates charging and firing of separation devices between the launch vehicle and spacecraft.
Nominal CSM Separation	03:18:18.9	$(181.7)_7$	501.9		
CSM Ignition	03:19:57.2	$(280.0)_7$	600.2		
Maneuver to Post-Separation Inertial Attitude	03:25:17.2	$(600.0)_7$	920.2		
Switch PCM to Low Gain Antenna	03:35:17.2	$(1,200.0)_7$	1,520.2	IU	
Switch CCS to Low Gain Antenna	03:35:17.4	$(1,200.2)_7$	1,520.4	IU	
Telemeter Calibrator In-Flight Calibrate On	TBD	TBD	TBD	IU	
Regular Calibrate Relays On	TBD	TBD	TBD	S-IVB	
Telemeter Calibrator In-Flight Calibrate Off	TBD	TBD	TBD	IU	
Regulator Calibrate Relays Off	TBD	TBD	TBD	S-IVB	
Switch PCM to High Gain Antenna	04:45:17.2	$(5,400.0)_7$	5,720.2	IU	
Switch CCS to High Gain Antenna	04:45:17.4	$(5,400.2)_7$	5,720.4	IU	
Maneuver to Local Horizontal	05:15:17.2	$(7,200.0)_7$	7,520.2		
Initiate LOX Vent	06:05:17.2	$(7,500.0)_7$	7,820.2	S-IVB	
Initiate LH2 Vent	06:05:17.4	$(7,500.2)_7$	7,820.4	S-IVB	
Terminate LOX Vent	06:05:27.2	$(7,510.0)_7$	7,830.2	S-IVB	
Terminate LH2 Vent	06:05:57.4	$(7,540.2)_7$	7,860.4	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 24 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB SECOND ENGINE START (Sec)	SSS	REMARKS
S-II Engines Cutoff Start of Time Base No. 4a	Variable	$(0.0)_{4a}$	-5.7	S-II	This alternate time base and its sequence of events will be programmed for use in early S-II/S-IVB staging. T_{4a} will be initiated by RF Ground Command. The starting of T_{4a} will be inhibited until T_3 +1.3 sec.
Charge Ullage Ignition On	Variable	$(0.1)_{4a}$	-5.6	S-IVB	
S-II/S-IVB Separation Ordnance Arm	Variable	$(0.2)_{4a}$	-5.5	S-II	
Start Recorders	Variable	$(0.3)_{4a}$	-5.4	S-II	
S-IVB Engine Cutoff Off	Variable	$(0.4)_{4a}$	-5.3	S-IVB	
Engine Ready Bypass	Variable	$(0.5)_{4a}$	-5.2	S-IVB	
Tape Recorder Record On	Variable	$(0.7)_{4a}$	-5.0	IU	
Fast Record On	Variable	$(0.9)_{4a}$	-4.8	S-IVB	
Start Recorder Timers	Variable	$(1.1)_{4a}$	-4.6	S-II	
Prevalves Open	Variable	$(1.4)_{4a}$	-4.3	S-IVB	
Fire Ullage Ignition On	Variable	$(1.6)_{4a}$	-4.1	S-IVB	
S-II/S-IVB Separation	Variable	$(1.7)_{4a}$	-4.0	S-II	
S-IVB Engine Start Interlock Bypass On	Variable	$(1.9)_{4a}$	-3.8	S-IVB	
LOX Chilldown Pump Off	Variable	$(5.2)_{4a}$	-0.5	S-IVB	
S-IVB Engine Start On	Variable	$(5.7)_{4a}$	0	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 25 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB SECOND ENGINE START (Sec)	SSS	REMARKS
Flight Control Computer Burn Mode On "A"	Variable	$(6.1)_{4a}$	0.4	IU	
Flight Control Computer Burn Mode On "B"	Variable	$(6.3)_{4a}$	0.6	IU	
S-IVB Engine Out Indication "A" Enable	Variable	$(6.5)_{4a}$	0.8	IU	
S-IVB Engine Out Indication "B" Enable	Variable	$(6.7)_{4a}$	1.0	IU	
Fuel Chilldown Pump Off	Variable	$(6.9)_{4a}$	1.2	S-IVB	
LOX Tank Flight Pressure System On	Variable	$(8.5)_{4a}$	2.8	S-IVB	
Fuel Injection Temperature OK Bypass	Variable	$(8.7)_{4a}$	3.0	S-IVB	
S-IVB Engine Start Off	Variable	$(8.9)_{4a}$	3.2	S-IVB	
Fast Record Off	Variable	$(9.3)_{4a}$	3.6	S-IVB	
First Burn Relay On	Variable	$(10.5)_{4a}$	4.8	S-IVB	
Charge Ullage Jettison On	Variable	$(11.4)_{4a}$	5.7	S-IVB	
Emergency Playback Enable On	Variable	$(11.7)_{4a}$	6.0	S-IVB	
Launch Escape Tower Jettison "A" On	Variable	$(12.7)_{4a}$	7.0	IU	
Launch Escape Tower Jettison "B" On	Variable	$(12.9)_{4a}$	7.2	IU	
PU Activate On	Variable	$(13.7)_{4a}$	8.0	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 26 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB SECOND ENGINE START (Sec)	SSS	REMARKS
Fire Ullage Jettison On	Variable	(13.9)$_{4a}$	8.2	S-IVB	
Ullage Charging Reset	Variable	(17.1)$_{4a}$	11.4	S-IVB	
Ullage Firing Reset	Variable	(17.3)$_{4a}$	11.6	S-IVB	
Fuel Injection Temperature OK Bypass Reset	Variable	(18.7)$_{4a}$	13.0	S-IVB	
Tape Recorder Record Off	Variable	(22.0)$_{4a}$	16.3	IU	
Emergency Playback Enable Off	Variable	(23.0)$_{4a}$	17.3	S-IVB	
Telemetry Calibrator In-Flight Calibrate On	Variable	(23.2)$_{4a}$	17.5	IU	
Regular Calibrate Relays On	Variable	(23.4)$_{4a}$	17.7	S-IVB	
Water Coolant Valve Open	Variable	(25.1)$_{4a}$	19.4	IU	
Regular Calibrate Relays Off	Variable	(28.0)$_{4a}$	22.3	S-IVB	
Telemetry Calibrator In-Flight Calibrate Off	Variable	(28.2)$_{4a}$	22.5	IU	
Chilldown Shutoff Valves Close	Variable	(125.2)$_{4a}$	119.5	S-IVB	
Telemetry Calibration In-Flight Calibrate On	Variable	(200.0)$_{4a}$	194.3	IU	
Regular Calibrate Relays On	Variable	(200.2)$_{4a}$	194.5	S-IVB	
Regular Calibrate Relays Off	Variable	(204.8)$_{4a}$	199.1	S-IVB	
Telemetry Calibrator In-Flight Calibrate Off	Variable	(205.0)$_{4a}$	199.3	IU	
First Burn Relay Off	Variable	(305.7)$_{4a}$	300.0	S-IVB	

TABLE AP 1-1
PREDICTED AS-502 FLIGHT SEQUENCE OF EVENTS (Sheet 27 of 27)

EVENT	TIME FROM FIRST MOTION (Hr:Min:Sec)	TIME FROM BASE (Sec)	TIME FROM S-IVB SECOND ENGINE START (Sec)	SSS	REMARKS
Flight Control Computer Switch Point No. 5	Variable	(408.9)[4a]	403.2	IU	
Point Level Sensor Arming	Variable	(443.7)[4a]	438.0	S-IVB	
Engine Pump Purge Control Valve Enable On	Variable	(-7.0)[5]	Variable	S-IVB	
Return to Primary Time Base No. 5 S-IVB Engine Cutoff	Variable	(0)[5]	Variable	S-IVB	
C-Band Transponder					
C-Band Transponders No. 1 and No. 2 On	Variable	Variable	Variable	IU	
C-Band Transponder No. 1 Inhibit On	Variable	Variable	Variable	IU	
C-Band Transponder No. 2 Inhibit On	Variable	Variable	Variable	IB	
Water Coolant Valve Open	Variable	Variable	Variable	IU	
Water Coolant Valve Closed	Variable	Variable	Variable	IU	

APPENDIX 2

MASS CHARACTERISTICS DATA (WS11)

2. MASS CHARACTERISTICS DATA (WS11)

This appendix contains the mass characteristics of the S-IVB-502 stage. This information is presented on digital printouts which are outputs of the WS11 computer program.

Table AP 2-1 defines the terms and abbreviations used in the digital printouts.

Table AP 2-2 is an itemized listing of all major S-IVB stage components (including all propellants, gases, and components located above the S-IVB stage) and presents the mass breakdown, center of gravity, and moments of inertia, including the total mass for the indicated time. In addition, summaries of items jettisoned and items remaining are presented at the appropriate time intervals.

Table AP 2-3 is a time listing of the predicted S-IVB-502 stage mass characteristics.

Figure AP 2-1 presents the S-IVB-502 stage station numbers; figures AP 2-2 and AP 2-3 show the predicted S-IVB-502 stage mass and center of gravity and mass moment of inertia.

The information contained in this appendix was obtained from the following sources:

a. S-IVB-502 stage dry mass is based on the Weight and Balance Log AS-502, dated 16 February 1967.

b. S-IVB payload (IU, adapter, service module and propellants, common module, LM, and launch escape system) data as received from MSFC, *Saturn V/AS-502 Final Predicted Mass Characteristics, Depletion Cutoff,* (reference 7).

c. S-IVB-502 propellant loading is as presented in appendix 6.

d. Propellant mass flowrates are based on those presented in appendix 5.

e. The vehicle coordinate system used conforms to standard coordinate system 9, mass properties, as presented in Document SE008-001-1, *Project Apollo Coordinate System Standards*, (reference 8).

TABLE AP 2-1 (Sheet 1 of 2)
COMPUTER PROGRAM WS11 PRINTOUT
ABBREVIATIONS AND DEFINITIONS

TERM	DEFINITIONS	UNITS
DAC Station	Distance along the H axis from an arbitrary S-IVB stage reference zero. The zero station is located so that the S-IVB stage engine gimbal point is station 100.0. Positive values increase in the forward direction and negative values are aft of station zero.	In.
H Arm	Distance along the centerline of the S-IVB stage from the center of gravity of the item under consideration to DAC station zero.	In.
Items Jettisoned	A listing of all items being considered at the current computing time that will not be considered at the next computing time.	None
Items Remaining	A listing of all items being considered at the current computing time that will be considered at the next computing time.	None
L Arm	Distance from the center of gravity of the item under consideration to the centerline of the S-IVB stage along an axis perpendicular to the centerline and coinciding with position II and IV. Position II is positive and position IV is negative.	In.
Pitch MOI	Moment of inertia of any item or total about an axis through its own center of gravity and parallel to the V axis.	Lbm-in.^{2}

TABLE AP 2-1 (Sheet 2 of 2)
COMPUTER PROGRAM WS11 PRINTOUT
ABBREVIATIONS AND DEFINITIONS

TERM	DEFINITIONS	UNITS
Pound Inches Square	Moment of inertia about the center of gravity of each item or total of items.	Lbm/in.^{2}
SLF	Slug feet squared	None
SLG	Slugs	None
Time	Time is referenced to range time. All computing was done in the pounds, inches, and pound-inch squared system of units. (Items below the TOTAL REMAINING line were converted to other unit systems). Pound mass is defined as 1/32.174 slugs.	Sec
Total Jettisoned	A summation of the items being jettisoned at the current computing time.	None
Total Remaining	A summation of the items remaining at the current computing time.	None
V Arm	Distance from the center of gravity of item under consideration to the centerline of the S-IVB stage along an axis perpendicular to the H and L axes and coinciding with positions I and III. Position I is negative and position III	In.
Yaw MOI	Moment of inertia of any item or total, about an axis through its own center of gravity and parallel to the L axis.	Lbm-in.^{2}

TABLE AP 2-2 (Sheet 1 of 10)
PREDICTED MASS BREAKDOWN SUMMARY

S-IC LIFTOFF — TIME 0.000 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
1.	FRDST	300.00	420.40	0.0	0.0	.50778029 07	.43416269 07	.43416269 07
2.	LAUNCH ESCAPE	8660.00	1512.00	0.0	-0.5	.30380396 07	.11381257 09	.11377287 09
3.	AFT FRAME	47.71	200.70	0.0	0.0	.80258189 06	.56746671 06	.56746671 06
4.	DETONATION PKG	4.75	200.60	0.0	0.0	.79904924 05	.56496896 05	.56496896 05
8.	ULLAGE RKT GRN	122.00	225.80	0.0	0.0	.23912000 07	.24705000 06	.21450967 07
9.	ULLAGE RKT CSE	129.79	222.60	0.0	0.0	.25438840 07	.26282475 06	.22820663 07
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.42229576 08	.57211156 08	.55911367 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	39.80	318.26	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	192906.00	241.78	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049182 06	.60253674 05	.60253674 05
37.	LH2 ULLAGE GAS	57.60	646.79	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	42445.00	455.42	0.0	0.0	.00000000 00	.21962102 09	.21962102 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	10.00	72.20	0.0	0.0	.12082576 05	.55790439 04	.55790439 04
41.	COLD HE QUAD 1	165.00	494.30	86.3	-75.6	.00000000 00	.15168489 06	.15168489 06
42.	COLD HE QUAD 2	165.00	494.30	113.8	20.0	.00000000 00	.15168489 06	.15168489 06
43.	APS PROP FP 1	311.00	246.20	1.8	-140.3	.13715100 06	.11227100 06	.11227100 06
44.	APS PROP FP 3	311.00	246.20	-1.8	140.3	.13715100 06	.11227100 06	.11227100 06
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	81.00	153.50	0.0	0.0	.20250000 06	.99225000 05	.99225000 05
47.	GH2 IN STARTNK	5.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	362169.39	498.53	1.1	-0.4	.66217035 09	.52445398 11	.52442030 11
						SLF .14292289 06	SLF .11319818 08	SLF .11319091 08

SUMMARY PRINTOUT — TIME 184.500 — ITEMS JETTISONED

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
1.	FRDST	-0.00	420.40	0.0	0.0	-.00000000 00	-.00000000 00	-.00000000 00
2.	LAUNCH ESCAPE	8660.00	1512.00	0.0	-0.5	.30380396 07	.11381257 09	.11377287 09
	TOTAL JETTISONED	8660.00	1512.00	0.0	-0.5	.30380396 07	.11381257 09	.11377287 09
						SLF .65573068 03	SLF .24565313 05	SLF .24556743 05

SUMMARY PRINTOUT — TIME 184.500 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
3.	AFT FRAME	47.71	200.70	0.0	0.0	.80258189 06	.56746671 06	.56746671 06
4.	DETONATION PKG	4.75	200.60	0.0	0.0	.79904924 05	.56496896 05	.56496896 05
8.	ULLAGE RKT GRN	122.00	225.80	0.0	0.0	.23912000 07	.24705000 06	.21450967 07
9.	ULLAGE RKT CSE	129.79	222.60	0.0	0.0	.25438840 07	.26282475 06	.22820663 07
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.42229576 08	.57211156 08	.55911367 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	39.80	318.26	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	192906.00	241.78	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049182 06	.60253674 05	.60253674 05
37.	LH2 ULLAGE GAS	57.60	646.79	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	42445.00	455.42	0.0	0.0	.00000000 00	.21962102 09	.21962102 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	10.00	72.20	0.0	0.0	.12082576 05	.55790439 04	.55790439 04
41.	COLD HE QUAD 1	165.00	494.30	86.3	-75.6	.00000000 00	.15168489 06	.15168489 06
42.	COLD HE QUAD 2	165.00	494.30	113.8	20.0	.00000000 00	.15168489 06	.15168489 06
43.	APS PROP FP 1	311.00	246.20	1.8	-140.3	.13715100 06	.11227100 06	.11227100 06
44.	APS PROP FP 3	311.00	246.20	-1.8	140.3	.13715100 06	.11227100 06	.11227100 06
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	81.00	153.50	0.0	0.0	.20250000 06	.99225000 05	.99225000 05
47.	GH2 IN STARTNK	5.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	353209.39	473.75	1.1	-0.4	.65404300 09	.43213602 11	.43210263 11
						SLF .14116869 06	SLF .93272270 07	SLF .93265061 07

TABLE AP 2-2 (Sheet 2 of 10)
PREDICTED MASS BREAKDOWN SUMMARY

S-II/S-IVB SEPARATION — TIME 522.400 — ITEMS JETTISONED

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
3.	AFT FRAME	47.71	200.70	0.0	0.0	.80258189 06	.56746671 06	.56746671 06
4.	DETONATION PKG	4.75	200.60	0.0	0.0	.79904924 05	.56496896 05	.56496896 05
	TOTAL JETTISONED	52.46	200.69	0.0	0.0	.88248681 06	.62396366 06	.62396366 06
						SLF .19047602 03	SLF .13467636 03	SLF .13467636 03

S-II/S-IVB SEPARATION — TIME 522.400 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
8.	ULLAGE RKT GRN	118.79	225.80	0.0	0.0	.23282746 07	.24054878 06	.20886476 07
9.	ULLAGE RKT CSE	129.79	222.60	0.0	0.0	.25438840 07	.26282475 06	.22820663 07
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.42229576 08	.57211156 08	.55911367 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	39.80	318.26	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	192906.00	241.78	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049182 06	.60253674 05	.60253674 05
37.	LH2 ULLAGE GAS	57.60	646.79	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	42445.00	455.42	0.0	0.0	.00000000 00	.21962102 09	.21962102 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	10.00	72.20	0.0	0.0	.12082576 05	.55790439 04	.55790439 04
41.	COLD HE QUAD 1	165.00	494.30	86.3	-75.6	.00000000 00	.15168489 06	.15168489 06
42.	COLD HE QUAD 2	165.00	494.30	113.8	20.0	.00000000 00	.15168489 06	.15168489 06
43.	APS PROP FP 1	311.00	246.20	1.8	-140.3	.13715100 06	.11227100 06	.11227100 06
44.	APS PROP FP 3	311.00	246.20	-1.8	140.3	.13715100 06	.11227100 06	.11227100 06
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	81.00	153.50	0.0	0.0	.20250000 06	.99225000 05	.99225000 05
47.	GH2 IN STARTNK	5.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	353153.73	473.79	1.1	-0.4	.65309751 09	.43208863 11	.43205473 11
						SLF .14096461 06	SLF .93262040 07	SLF .93254722 07

S-IVB FIRST ENGINE START COMMAND — TIME 522.600 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
8.	ULLAGE RKT GRN	112.37	225.80	0.0	0.0	.22024191 07	.22754585 06	.19757452 07
9.	ULLAGE RKT CSE	129.79	222.60	0.0	0.0	.25438840 07	.26282475 06	.22820663 07
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.42229576 08	.57211156 08	.55911367 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	39.80	318.26	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	192906.00	241.78	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049182 06	.60253674 05	.60253674 05
37.	LH2 ULLAGE GAS	57.60	646.79	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	42445.00	455.42	0.0	0.0	.00000000 00	.21962102 09	.21962102 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	10.00	72.20	0.0	0.0	.12082576 05	.55790439 04	.55790439 04
41.	COLD HE QUAD 1	165.00	494.30	86.3	-75.6	.00000000 00	.15168489 06	.15168489 06
42.	COLD HE QUAD 2	165.00	494.30	113.8	20.0	.00000000 00	.15168489 06	.15168489 06
43.	APS PROP FP 1	311.00	246.20	1.8	-140.3	.13715100 06	.11227100 06	.11227100 06
44.	APS PROP FP 3	311.00	246.20	-1.8	140.3	.13715100 06	.11227100 06	.11227100 06
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	81.00	153.50	0.0	0.0	.20250000 06	.99225000 05	.99225000 05
47.	GH2 IN STARTNK	5.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	353147.30	473.79	1.1	-0.4	.65297165 09	.43208453 11	.43204964 11
						SLF .14093745 06	SLF .93261155 07	SLF .93253623 07

TABLE AP 2-2 (Sheet 3 of 10)
PREDICTED MASS BREAKDOWN SUMMARY

END OF FUEL LEAD — TIME 525.600 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
8.	ULLAGE RKT GRN	16.05	225.80	0.0	0.0	.31462972 06	.32506387 05	.28224789 06
9.	ULLAGE RKT CSE	129.79	222.60	0.0	0.0	.25438840 07	.26282475 06	.22820663 07
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.42229576 08	.57211156 08	.55911367 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	41.89	318.26	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	192904.88	241.78	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049182 06	.60253674 05	.60253674 05
37.	LH2 ULLAGE GAS	59.18	646.77	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	42441.15	455.40	0.0	0.0	.00000000 00	.21952970 09	.21952970 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	20.00	72.20	0.0	0.0	.24165151 05	.11158088 05	.11158088 05
41.	COLD HE QUAD 1	164.48	494.30	86.3	-75.6	.00000000 00	.15120811 06	.15120811 06
42.	COLD HE QUAD 2	164.48	494.30	113.8	20.0	.00000000 00	.15120811 06	.15120811 06
43.	APS PROP FP 1	310.97	246.20	1.8	-140.3	.13713562 06	.11225841 06	.11225841 06
44.	APS PROP FP 3	310.97	246.20	-1.8	140.3	.13713562 06	.11225841 06	.11225841 06
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	81.00	153.50	0.0	0.0	.20250000 06	.99225000 05	.99225000 05
47.	GH2 IN STARTNK	5.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	353058.58	473.85	1.1	-0.4	.65108091 09	.43203951 11	.43198958 11
						SLF .14052935 06	SLF .93251438 07	SLF .93240660 07

90 PERCENT THRUST — TIME 526.330 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
8.	ULLAGE RKT GRN	-0.00	225.80	0.0	0.0	-.18505096 01	-.19118786-00	-.16600544 01
9.	ULLAGE RKT CSE	129.79	222.60	0.0	0.0	.25438840 07	.26282475 06	.22820663 07
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.42229576 08	.57211156 08	.55911367 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	42.40	318.24	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	192885.98	241.77	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	138.00	72.20	0.0	0.0	.16673933 06	.76990707 05	.76990707 05
37.	LH2 ULLAGE GAS	59.57	646.66	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	42424.66	455.33	0.0	0.0	.00000000 00	.21913887 09	.21913887 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	20.00	72.20	0.0	0.0	.24165151 05	.11158088 05	.11158088 05
41.	COLD HE QUAD 1	164.36	494.30	86.3	-75.6	.00000000 00	.15109210 06	.15109210 06
42.	COLD HE QUAD 2	164.36	494.30	113.8	20.0	.00000000 00	.15109210 06	.15109210 06
43.	APS PROP FP 1	310.96	246.20	1.8	-140.3	.13713188 06	.11225535 06	.11225535 06
44.	APS PROP FP 3	310.96	246.20	-1.8	140.3	.13713188 06	.11225535 06	.11225535 06
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	81.00	153.50	0.0	0.0	.20250000 06	.99225000 05	.99225000 05
47.	GH2 IN STARTNK	1.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	353033.75	473.83	1.1	-0.4	.65079585 09	.43206501 11	.43201255 11
						SLF .14046782 06	SLF .93256942 07	SLF .93245620 07

TABLE AP 2-2 (Sheet 4 of 10)
PREDICTED MASS BREAKDOWN SUMMARY

SUMMARY PRINTOUT — TIME 534.400 — ITEMS JETTISONED

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
8.	ULLAGE RKT GRN	-0.00	225.80	0.0	0.0	-.18505096 01	-.19118786-00	-.16600544 01
9.	ULLAGE RKT CSE	129.79	222.60	0.0	0.0	.25438840 07	.26282475 06	.22820663 07
	TOTAL JETTISONED	129.79	222.60	0.0	0.0	.25438821 07	.26282462 06	.22820647 07
						SLF .54907169 03	SLF .56728084 02	SLF .49256100 03

SUMMARY PRINTOUT — TIME 534.400 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.42229576 08	.57211156 08	.55911367 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	48.04	315.95	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	190134.19	240.80	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	138.00	72.20	0.0	0.0	.16673954 06	.76990805 05	.76990805 05
37.	LH2 ULLAGE GAS	63.82	642.92	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	41828.26	452.96	0.0	0.0	.00000000 00	.20540268 09	.20540268 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	20.00	72.20	0.0	0.0	.24165151 05	.11158088 05	.11158088 05
41.	COLD HE QUAD 1	162.96	494.30	86.3	-75.6	.00000000 00	.14980956 06	.14980956 06
42.	COLD HE QUAD 2	162.96	494.30	113.8	20.0	.00000000 00	.14980956 06	.14980956 06
43.	APS PROP FP 1	310.86	246.20	1.8	-140.3	.13709051 06	.11222149 06	.11222149 06
44.	APS PROP FP 3	310.86	246.20	-1.8	140.3	.13709051 06	.11222149 06	.11222149 06
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	81.00	153.50	0.0	0.0	.20250000 06	.99225000 05	.99225000 05
47.	GH2 IN STARTNK	1.97	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	349563.65	474.97	1.1	-0.4	.64820764 09	.43126182 11	.43118898 11
						SLF .13990918 06	SLF .93083582 07	SLF .93067858 07

S-IVB FIRST ENGINE CUTOFF COMMAND — TIME 651.350 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.42229576 08	.57211156 08	.55911367 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	129.70	288.44	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	136374.72	223.97	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	138.00	72.20	0.0	0.0	.16673954 06	.76990805 05	.76990805 05
37.	LH2 ULLAGE GAS	125.51	594.83	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	32101.96	415.52	0.0	0.0	.00000000 00	.13577526 09	.13577526 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	20.00	72.20	0.0	0.0	.24165151 05	.11158088 05	.11158088 05
41.	COLD HE QUAD 1	142.74	494.30	86.3	-75.6	.00000000 00	.13122314 06	.13122314 06
42.	COLD HE QUAD 2	142.74	494.30	113.8	20.0	.00000000 00	.13122314 06	.13122314 06
43.	APS PROP FP 1	309.50	246.20	1.8	-140.3	.13649106 06	.11173078 06	.11173078 06
44.	APS PROP FP 3	309.50	246.20	-1.8	140.3	.13649106 06	.11173078 06	.11173078 06
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	81.00	153.50	0.0	0.0	.20250000 06	.99225000 05	.99225000 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	286183.11	507.44	1.4	-0.4	.64752071 09	.41016740 11	.41009140 11
						SLF .13976092 06	SLF .88530560 07	SLF .88514156 07

TABLE AP 2-2 (Sheet 5 of 10)
PREDICTED MASS BREAKDOWN SUMMARY

S-IVB FIRST END OF THRUST DECAY — TIME 652.750 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.42229576 08	.57211156 08	.55911367 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	130.68	288.38	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	136214.72	223.93	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049178 06	.60253656 05	.60253656 05
37.	LH2 ULLAGE GAS	126.25	594.71	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	32072.19	415.41	0.0	0.0	.00000000 00	.13559417 09	.13559417 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	10.00	72.20	0.0	0.0	.12082563 05	.55790380 04	.55790380 04
41.	COLD HE QUAD 1	142.50	494.30	86.3	-75.6	.00000000 00	.13100064 06	.13100064 06
42.	COLD HE QUAD 2	142.50	494.30	113.8	20.0	.00000000 00	.13100064 06	.13100064 06
43.	APS PROP FP 1	309.22	246.20	1.8	-140.3	.13636781 06	.11162988 06	.11162988 06
44.	APS PROP FP 3	309.22	246.20	-1.8	140.3	.13636781 06	.11162988 06	.11162988 06
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	81.00	153.50	0.0	0.0	.20250000 06	.99225000 05	.99225000 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	285954.02	507.63	1.4	-0.4	.64745437 09	.41000148 11	.40992556 11
						SLF .13974660 06	SLF .88494748 07	SLF .88478361 07

APS ULLAGE OFF — TIME 739.350 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.42229576 08	.57211156 08	.55911367 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	132.28	288.38	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	136212.31	223.93	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049178 06	.60253656 05	.60253656 05
37.	LH2 ULLAGE GAS	137.13	594.58	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	32040.70	415.28	0.0	0.0	.00000000 00	.13540336 09	.13540336 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	10.00	72.20	0.0	0.0	.12082563 05	.55790380 04	.55790380 04
41.	COLD HE QUAD 1	142.50	494.30	86.3	-75.6	.00000000 00	.13100064 06	.13100064 06
42.	COLD HE QUAD 2	142.50	494.30	113.8	20.0	.00000000 00	.13100064 06	.13100064 06
43.	APS PROP FP 1	287.50	246.20	1.8	-140.3	.12678751 06	.10378750 06	.10378750 06
44.	APS PROP FP 3	287.50	246.20	-1.8	140.3	.12678751 06	.10378750 06	.10378750 06
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	81.00	153.50	0.0	0.0	.20250000 06	.99225000 05	.99225000 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	285889.16	507.67	1.4	-0.4	.64657970 09	.40996575 11	.40989837 11
						SLF .13955781 06	SLF .88487035 07	SLF .88472492 07

TABLE AP 2-2 (Sheet 6 of 10)
PREDICTED MASS BREAKDOWN SUMMARY

RESTART PREPARATION — TIME 11,072.000 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.0	0.0	.43230353 08	.57215656 08	.00000000 00
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	366.00	288.32	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	135978.00	223.89	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049182 06	.60253674 05	.60253674 05
37.	LH2 ULLAGE GAS	267.50	583.88	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	29377.00	405.04	0.0	0.0	.00000000 00	.12168514 09	.12168514 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	10.00	72.20	0.0	0.0	.12082576 05	.55790439 04	.55790439 04
41.	COLD HE QUAD 1	117.20	494.30	86.3	-75.6	.00000000 00	.10774224 06	.10774224 06
42.	COLD HE QUAD 2	117.20	494.30	113.8	20.0	.00000000 00	.10774224 06	.10774224 06
43.	APS PROP FP 1	225.00	246.20	1.8	-140.3	.99225000 05	.81225000 05	.81225000 05
44.	APS PROP FP 2	225.00	246.20	-1.8	140.3	.99225000 05	.81225000 05	.81225000 05
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	81.00	153.50	0.0	0.0	.20250000 06	.99225000 05	.99225000 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	283179.65	507.66	1.4	-0.4	.64440818 09	.41003575 11	.40943034 11
						SLF .13908911 06	SLF .88502145 07	SLF .88371473 07

ENGINE START COMMAND - SECOND BURN — TIME 11,399.000 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.43230353 08	.57215656 08	.56645512 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	376.06	288.32	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	135978.00	223.89	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049182 06	.60253674 05	.60253674 05
37.	LH2 ULLAGE GAS	298.20	583.88	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	29377.00	405.04	0.0	0.0	.00000000 00	.12168514 09	.12168514 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	10.00	72.20	0.0	0.0	.12082576 05	.55790439 04	.55790439 04
41.	COLD HE QUAD 1	117.20	494.30	86.3	-75.6	.00000000 00	.10774224 06	.10774224 06
42.	COLD HE QUAD 2	117.20	494.30	113.8	20.0	.00000000 00	.10774224 06	.10774224 06
43.	APS PROP FP 1	197.26	246.20	1.8	-140.3	.86989457 05	.71209056 05	.71209056 05
44.	APS PROP FP 2	197.26	246.20	-1.8	140.3	.86989457 05	.71209056 05	.71209056 05
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	41.00	153.50	0.0	0.0	.10249749 06	.50223768 05	.50223768 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	283124.91	507.76	1.4	-0.4	.64318615 09	.40994262 11	.40991452 11
						SLF .13882534 06	SLF .88482042 07	SLF .88475978 07

TABLE AP 2-2 (Sheet 7 of 10)
PREDICTED MASS BREAKDOWN SUMMARY

END OF FUEL LEAD — TIME 11,407.000 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.43230353 08	.57215656 08	.56645512 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	378.60	288.32	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	135977.96	223.89	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049182 06	.60253674 05	.60253674 05
37.	LH2 ULLAGE GAS	303.83	583.75	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	29343.97	404.92	0.0	0.0	.00000000 00	.12154112 09	.12154112 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	17.62	72.20	0.0	0.0	.21288338 05	.98297396 04	.98297396 04
41.	COLD HE QUAD 1	115.93	494.30	86.3	-75.6	.00000000 00	.10657233 06	.10657233 06
42.	COLD HE QUAD 2	115.93	494.30	113.8	20.0	.00000000 00	.10657233 06	.10657233 06
43.	APS PROP FP 1	196.97	246.20	1.8	-140.3	.86861969 05	.71104696 05	.71104696 05
44.	APS PROP FP 2	196.97	246.20	-1.8	140.3	.86861969 05	.71104696 05	.71104696 05
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	41.00	153.50	0.0	0.0	.10249749 06	.50223768 05	.50223768 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	283104.50	507.75	1.4	-0.4	.64315070 09	.40996071 11	.40993256 11
						SLF .13881769 06	SLF .88485948 07	SLF .88479872 07

90 PERCENT THRUST — TIME 11,409.500 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.43230353 08	.57215656 08	.56645512 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	379.40	288.23	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	135725.10	223.81	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	138.00	72.20	0.0	0.0	.16673954 06	.76990805 05	.76990805 05
37.	LH2 ULLAGE GAS	305.59	583.33	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	29234.91	404.50	0.0	0.0	.00000000 00	.12106949 09	.12106949 09
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	20.00	72.20	0.0	0.0	.24165139 05	.11158082 05	.11158082 05
41.	COLD HE QUAD 1	115.53	494.30	86.3	-75.6	.00000000 00	.10620673 06	.10620673 06
42.	COLD HE QUAD 2	115.53	494.30	113.8	20.0	.00000000 00	.10620673 06	.10620673 06
43.	APS PROP FP 1	196.95	246.20	1.8	-140.3	.86854455 05	.71098544 05	.71098544 05
44.	APS PROP FP 2	196.95	246.20	-1.8	140.3	.86854455 05	.71098544 05	.71098544 05
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	41.00	153.50	0.0	0.0	.10249749 06	.50223768 05	.50223768 05
47.	GH2 IN STARTNK	1.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	282770.68	507.92	1.4	-0.4	.64317350 09	.40987485 11	.40984663 11
						SLF .13882261 06	SLF .88467415 07	SLF .88461323 07

TABLE AP 2-2 (Sheet 8 of 10)
PREDICTED MASS BREAKDWON SUMMARY

SUMMARY PRINTOUT — TIME 11,499.000 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.43230353 08	.57215656 08	.56645512 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	407.81	277.71	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	105271.31	214.59	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	138.00	72.20	0.0	0.0	.16673954 06	.76990805 05	.76990805 05
37.	LH2 ULLAGE GAS	368.54	557.22	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	22449.17	378.16	0.0	0.0	.00000000 00	.99053555 08	.99053555 08
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	20.00	72.20	0.0	0.0	.24165151 05	.11158088 05	.11158088 05
41.	COLD HE QUAD 1	101.29	494.30	86.3	-75.6	.00000000 00	.93118343 05	.93118343 05
42.	COLD HE QUAD 2	101.29	494.30	113.8	20.0	.00000000 00	.93118343 05	.93118343 05
43.	APS PROP FP 1	196.34	246.20	1.8	-140.3	.86585429 05	.70878322 05	.70878322 05
44.	APS PROP FP 2	196.34	246.20	-1.8	140.3	.86585429 05	.70878322 05	.70878322 05
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	41.00	153.50	0.0	0.0	.10249749 06	.50223768 05	.50223768 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	245598.82	539.58	1.6	-0.5	.64269550 09	.38890003 11	.38886938 11
						SLF .13871944 06	SLF .83940210 07	SLF .83933593 07

SUMMARY PRINTOUT — TIME 11,599.000 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.43230353 08	.57215656 08	.56645512 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	439.55	266.25	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	67783.01	202.08	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	138.00	72.20	0.0	0.0	.16673954 06	.76990805 05	.76990805 05
37.	LH2 ULLAGE GAS	438.87	526.18	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	14541.26	347.27	0.0	0.0	.00000000 00	.74640706 08	.74640706 08
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	20.00	72.20	0.0	0.0	.24165151 05	.11158088 05	.11158088 05
41.	COLD HE QUAD 1	85.38	494.30	86.3	-75.6	.00000000 00	.78494450 05	.78494450 05
42.	COLD HE QUAD 2	85.38	494.30	113.8	20.0	.00000000 00	.78494450 05	.78494450 05
43.	APS PROP FP 1	195.66	246.20	1.8	-140.3	.86284845 05	.70632265 05	.70632265 05
44.	APS PROP FP 2	195.66	246.20	-1.8	140.3	.86284845 05	.70632265 05	.70632265 05
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	41.00	153.50	0.0	0.0	.10249749 06	.50223768 05	.50223768 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.39060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	200271.51	600.19	1.9	-0.6	.64210619 09	.34689743 11	.34686364 11
						SLF .13859225 06	SLF .74874366 07	SLF .74867071 07

TABLE AP 2-2 (Sheet 9 of 10)
PREDICTED MASS BREAKDOWN SUMMARY

SUMMARY PRINTOUT — TIME 11,699.000 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.43230353 08	.57215656 08	.56645512 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	471.29	254.08	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	27614.81	184.57	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	138.00	72.20	0.0	0.0	.16673954 06	.76990805 05	.76990805 05
37.	LH2 ULLAGE GAS	509.21	494.40	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	6407.56	312.56	0.0	0.0	.00000000 00	.37679595 08	.37679595 08
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	20.00	72.20	0.0	0.0	.24165151 05	.11158088 05	.11158088 05
41.	COLD HE QUAD 1	69.48	494.30	86.3	-75.6	.00000000 00	.63870556 05	.63870556 05
42.	COLD HE QUAD 2	69.48	494.30	113.8	20.0	.00000000 00	.63870556 05	.63870556 05
43.	APS PROP FP 1	194.98	246.20	1.8	-140.3	.85984259 05	.70386208 05	.70386208 05
44.	APS PROP FP 2	194.98	246.20	-1.8	140.3	.85984259 05	.70386208 05	.70386208 05
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	41.00	153.50	0.0	0.0	.10249749 06	.50223768 05	.50223768 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	152038.51	714.03	2.5	-0.8	.64141490 09	.26319567 11	.26315789 11
						SLF .13844304 06	SLF .56808171 07	SLF .56800018 07

ENGINE CUTOFF COMMAND DEPLETION — TIME 11,767.378 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.43230353 08	.57215656 08	.56645512 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	492.99	244.65	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	166.63	158.14	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	138.00	72.20	0.0	0.0	.16673954 06	.76990805 05	.76990805 05
37.	LH2 ULLAGE GAS	557.30	473.03	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	847.41	272.18	0.0	0.0	.00000000 00	.64657526 07	.64657526 07
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	20.00	72.20	0.0	0.0	.24165151 05	.11158088 05	.11158088 05
41.	COLD HE QUAD 1	58.60	494.30	86.3	-75.6	.00000000 00	.53871030 05	.53871030 05
42.	COLD HE QUAD 2	58.60	494.30	113.8	20.0	.00000000 00	.53871030 05	.53871030 05
43.	APS PROP FP 1	194.51	246.20	1.8	-140.3	.85778725 05	.70217958 05	.70217958 05
44.	APS PROP FP 2	194.51	246.20	-1.8	140.3	.85778725 05	.70217958 05	.70217958 05
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	41.00	153.50	0.0	0.0	.10249749 06	.50223768 05	.50223768 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	119077.30	854.23	3.2	-1.0	.64082939 09	.15406210 11	.15402068 11
						SLF .13831666 06	SLF .33252774 07	SLF .33243835 07

TABLE AP 2-2 (Sheet 10 of 10)
PREDICTED MASS BREAKDOWN SUMMARY

END OF THRUST DECAY DEPLETION — TIME 11,768.778 — ITEMS REMAINING

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	850.30	0.7	-1.0	.43230353 08	.57215656 08	.56645512 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	492.99	244.60	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	30.63	157.63	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049178 06	.60253656 05	.60253656 05
37.	LH2 ULLAGE GAS	557.30	472.91	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	819.41	271.81	0.0	0.0	.00000000 00	.62512106 07	.62512106 07
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	10.00	72.20	0.0	0.0	.12082563 05	.55790380 04	.55790380 04
41.	COLD HE QUAD 1	58.60	494.30	86.3	-75.6	.00000000 00	.53871030 05	.53871030 05
42.	COLD HE QUAD 2	58.60	494.30	113.8	20.0	.00000000 00	.53871030 05	.53871030 05
43.	APS PROP FP 1	194.50	246.20	1.8	-140.3	.85774516 05	.70214513 05	.70214513 05
44.	APS PROP FP 2	194.50	246.20	-1.8	140.3	.85774516 05	.70214513 05	.70214513 05
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	41.00	153.50	0.0	0.0	.10249749 06	.50223768 05	.50223768 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	118873.28	855.42	3.2	-1.0	.64077838 09	.15306410 11	.15302267 11
						SLF .13830565 06	SLF .33037366 07	SLF .33028423 07

COMMAND SERVICE MODULE SEPARATION — TIME 11,948.000 — ITEMS JETTISONED

SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
24.	COMMAND MODULE	12200.00	1250.20	0.2	5.9	.28579231 08	.25826425 08	.21829338 08
25.	SERVICE MODULE	9600.00	1123.10	-0.6	1.3	.29240986 08	.49105059 08	.47457562 08
26.	SM PROPELLANT	39300.00	1114.90	4.9	-2.0	.93628951 08	.97935849 08	.13002603 09
27.	SLA RING	90.00	1047.70	0.6	-1.8	.50301517 06	.26830439 06	.23473304 06
	TOTAL JETTISONED	61190.00	1143.06	3.1	0.1	.15291197 09	.34958912 09	.37576519 09
						SLF .33004529 05	SLF .75455338 05	SLF .81105185 05

COMMAND SERVICE MODULE SEPARATION — TIME 11,948.000 — ITEMS REMAINING

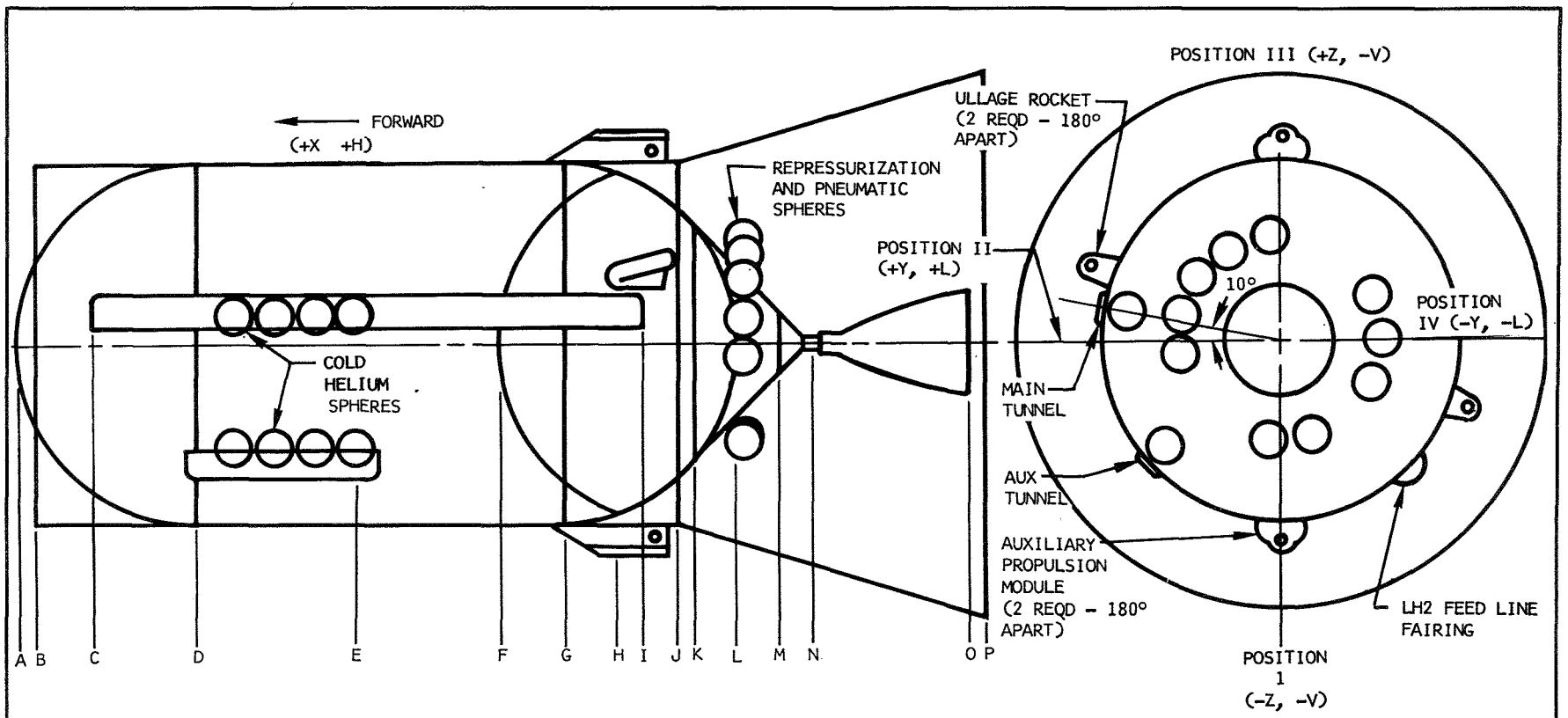
SEQ	DESCRIPTION	MASS (POUNDS)	STATION(INCHES) H. ARM	L.ARM	V.ARM	MOI (POUND INCHES SQUARE) ROLL	PITCH	YAW
28.	LUNAR MODULE	20000.00	790.90	0.5	0.0	.61206047 08	.82741246 08	.72504880 08
29.	ADAPTER (SLA)	3810.00	836.50	4.1	-2.9	.12352008 09	.86930233 08	.82939223 08
30.	VEH INST UNIT	4763.00	698.90	0.0	-9.9	.71498107 08	.38067610 08	.34843159 08
31.	S4B502 DRY STG	26164.75	324.85	6.4	-2.8	.30017645 09	.11498030 10	.11404976 10
32.	LOX ULLAGE GAS	492.99	244.60	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
33.	LOX IN TANK	30.63	157.63	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
34.	LOX IN PORTS	13.00	155.00	-25.0	10.0	.18720000 04	.29250000 04	.29250000 04
35.	LOX IN LINES	246.00	136.80	6.4	9.9	.22718616 05	.22718616 05	.22718616 05
36.	LOX IN ENGINE	108.00	72.20	0.0	0.0	.13049178 06	.60253656 05	.60253656 05
37.	LH2 ULLAGE GAS	557.30	472.91	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
38.	LH2 IN TANK	819.41	271.81	0.0	0.0	.00000000 00	.62512106 07	.62512106 07
39.	LH2 IN LINES	38.00	187.91	-59.9	-64.8	.44993827 05	.48051516 05	.48051516 05
40.	LH2 IN ENGINE	10.00	72.20	0.0	0.0	.12082563 05	.55790380 04	.55790380 04
41.	COLD HE QUAD 1	58.60	494.30	86.3	-75.6	.00000000 00	.53871030 05	.53871030 05
42.	COLD HE QUAD 2	58.60	494.30	113.8	20.0	.00000000 00	.53871030 05	.53871030 05
43.	APS PROP FP 1	192.01	246.20	1.8	-140.3	.84676833 05	.69315957 05	.69315957 05
44.	APS PROP FP 2	192.01	246.20	-1.8	140.3	.84676833 05	.69315957 05	.69315957 05
45.	APS HELIUM	3.00	246.20	0.0	0.0	.00000000 00	.00000000 00	.00000000 00
46.	HELIUM REPRESS	41.00	153.50	0.0	0.0	.10249749 06	.50223768 05	.50223768 05
47.	GH2 IN STARTNK	7.00	88.40	-22.0	14.6	.00000000 00	.00000000 00	.00000000 00
48.	SERVICE ITEMS	30.00	127.20	14.2	9.3	.43548299 05	.59060906 05	.25966092 05
49.	ENV CONT FLUID	43.00	662.70	0.0	0.0	.66116800 06	.33193332 06	.33193332 06
	TOTAL REMAINING	57678.30	549.41	3.5	-2.3	.56786695 09	.45217502 10	.44882412 10
						SLF .12256844 06	SLF .97597488 06	SLF .96874228 06

TABLE AP 2-3 (Sheet 1 of 2)
PREDICTED MASS CHARACTERISTICS SUMMARY

TIME (SECONDS)	MASS (POUNDS)	H.ARM (INCHES)	L.ARM (INCHES)	V.ARM (INCHES)	ROLL MOI (SLUG FT.SQ.)	PITCH MOI (SLUG FT.SQ.)	YAW MOI (SLUG FT.SQ.)
0.000	362169.39	498.53	1.1	-0.4	142923.02	11319828.13	11319101.13
60.000	362169.39	498.53	1.1	-0.4	142923.02	11319828.13	11319101.13
120.000	361869.39	498.59	1.1	-0.4	141826.94	11318495.38	11317768.38
184.500	361869.39	498.59	1.1	-0.4	141826.94	11318495.38	11317768.38
184.500	353209.39	473.75	1.1	-0.4	141168.81	9327235.00	9326514.25
522.300	353209.39	473.75	1.1	-0.4	141168.81	9327235.00	9326514.25
522.400	353206.18	473.75	1.1	-0.4	141155.23	9327190.75	9326459.13
522.400	353153.73	473.79	1.1	-0.4	140964.73	9326212.00	9325480.38
522.500	353150.52	473.79	1.1	-0.4	140951.15	9326168.00	9325425.50
522.600	353147.30	473.79	1.1	-0.4	140937.57	9326123.63	9325370.50
525.600	353058.58	473.85	1.1	-0.4	140529.47	9325151.88	9324074.13
526.100	353047.89	473.84	1.1	-0.4	140465.93	9325508.50	9324376.50
526.330	353033.75	473.83	1.1	-0.4	140467.94	9325702.38	9324570.13
534.400	349693.44	474.87	1.1	-0.4	140458.42	9310206.25	9309069.88
534.400	349563.65	474.97	1.1	-0.4	139909.30	9308366.38	9306794.00
540.000	346534.19	476.03	1.2	-0.4	139902.46	9293461.75	9291886.38
550.000	341132.59	478.03	1.2	-0.4	139890.19	9265092.50	9263511.50
560.000	335727.61	480.18	1.2	-0.4	139877.88	9234380.00	9232793.63
570.000	330316.02	482.49	1.2	-0.4	139865.51	9201264.50	9199672.25
576.330	326887.84	484.03	1.2	-0.4	139857.66	9179045.50	9177449.75
580.000	324898.84	484.95	1.2	-0.4	139853.02	9165692.75	9164095.00
590.000	319475.91	487.58	1.3	-0.4	139840.33	9127582.50	9125978.88
600.000	314048.13	490.36	1.3	-0.4	139827.59	9086880.50	9085271.00
610.000	308616.43	493.32	1.3	-0.4	139814.78	9043502.25	9041886.88
620.000	303195.09	496.44	1.3	-0.4	139801.90	8997485.00	8995863.75
630.000	297765.84	499.74	1.3	-0.4	139788.95	8965026.63	8963399.25
640.000	292341.68	503.23	1.4	-0.4	139775.92	8914276.88	8912643.38
650.000	286916.36	506.92	1.4	-0.4	139762.81	8860558.75	8858919.13
651.350	286183.11	507.44	1.4	-0.4	139761.04	8853063.63	8851423.25
651.650	286134.14	507.48	1.4	-0.4	139758.46	8852298.38	8850658.00
652.750	285954.02	507.63	1.4	-0.4	139746.72	8849482.63	8847843.88
710.350	285924.59	507.66	1.4	-0.4	139621.16	8848992.75	8847476.50
739.350	285889.16	507.67	1.4	-0.4	139557.93	8848711.25	8847256.88
-327.000	283179.65	507.66	1.4	-0.4	139089.23	8850222.25	8837155.13
-326.800	283179.65	507.66	1.4	-0.4	139089.23	8850222.25	8837155.13
-326.600	283179.61	507.66	1.4	-0.4	139089.08	8850221.38	8837154.38
-326.400	283179.58	507.66	1.4	-0.4	139088.93	8850220.75	8837154.00
-326.200	283179.54	507.66	1.4	-0.4	139088.79	8850219.88	8837153.13
-326.000	283179.51	507.66	1.4	-0.4	139088.64	8850219.13	8837152.63
-324.800	283179.30	507.66	1.4	-0.4	139087.75	8850215.75	8837150.00
-321.000	283178.65	507.66	1.4	-0.4	139084.76	8850194.13	8837131.00

TABLE AP 2-3 (Sheet 2 of 2)
PREDICTED MASS CHARACTERISTICS SUMMARY

TIME (SECONDS)	MASS (POUNDS)	H.ARM (INCHES)	L.ARM (INCHES)	V.ARM (INCHES)	ROLL MOI (SLUG FT.SQ.)	PITCH MOI (SLUG FT.SQ.)	YAW MOI (SLUG FT.SQ.)
-316.000	283177.81	507.66	1.4	-0.4	139080.82	8850166.13	8837106.75
-300.000	283175.09	507.67	1.4	-0.4	139068.21	8850074.75	8837026.75
-200.000	283158.11	507.70	1.4	-0.4	138989.44	8849509.50	8836533.63
-100.000	283141.13	507.73	1.4	-0.4	138910.66	8848942.50	8836039.00
-40.000	283130.94	507.74	1.4	-0.4	138863.40	8848603.50	8835743.25
-1.000	283124.32	507.76	1.4	-0.4	138827.39	8848217.50	8835383.38
-0.800	283124.42	507.76	1.4	-0.4	138827.21	8848215.13	8835383.13
-0.600	283124.53	507.76	1.4	-0.4	138827.04	8848214.00	8835382.13
-0.400	283124.63	507.76	1.4	-0.4	138826.86	8848212.88	8835381.00
-0.200	283124.74	507.76	1.4	-0.4	138826.69	8848211.63	8835380.00
-0.200	283124.74	507.76	1.4	-0.4	138826.69	8848211.63	8835380.00
0.000	283124.91	507.76	1.4	-0.4	138825.46	8848212.00	8847605.63
3.000	283123.46	507.76	1.4	-0.4	138821.33	8848341.13	8847735.63
8.000	283104.50	507.75	1.4	-0.4	138817.81	8848602.63	8847994.88
10.500	282770.68	507.92	1.4	-0.4	138822.73	8846749.25	8846140.13
20.000	278646.15	510.88	1.4	-0.4	138812.00	8804707.88	8804093.13
40.000	270368.98	517.19	1.4	-0.5	138789.44	8715159.38	8714533.38
60.000	262109.62	524.03	1.5	-0.5	138766.67	8617579.25	8616941.75
60.500	261903.46	524.21	1.5	-0.5	138766.09	8615031.38	8614393.50
80.000	253862.33	531.46	1.5	-0.5	138743.26	8511016.38	8510366.88
100.000	245598.82	539.58	1.6	-0.5	138719.56	8394028.38	8393366.75
120.000	237148.85	548.68	1.6	-0.5	138695.44	8261077.63	8260403.44
140.000	228328.80	559.13	1.7	-0.5	138670.73	8107110.50	8106423.25
160.000	219166.29	571.13	1.8	-0.6	138645.32	7928326.50	7927625.88
180.000	209792.67	584.76	1.8	-0.6	138619.22	7722892.81	7722177.88
200.000	200271.51	600.19	1.9	-0.6	138592.37	7487443.19	7486713.69
220.000	190679.47	617.59	2.0	-0.6	138564.70	7218674.19	7217929.25
240.000	181172.98	636.97	2.1	-0.7	138536.23	6916022.44	6915261.44
260.000	171569.78	659.09	2.2	-0.7	138506.66	6566360.31	6565587.38
280.000	161867.27	684.53	2.4	-0.8	138475.73	6159039.50	6158243.50
300.000	152038.51	714.03	2.5	-0.8	138443.16	5680822.06	5680006.69
320.000	142350.58	747.72	2.7	-0.9	138408.99	5128148.00	5127311.94
340.000	132697.68	786.69	2.9	-0.9	138372.74	4478562.69	4477704.19
360.000	123064.91	832.64	3.1	-1.0	138333.88	3698167.50	3697284.56
368.378	119077.30	854.23	3.2	-1.0	138316.78	3325280.28	3324386.44
369.778	118873.28	855.42	3.2	-1.0	138305.77	3303739.47	3302845.22
370.000	118873.27	855.42	3.2	-1.0	138305.74	3303738.13	3302843.91
540.000	118868.55	855.45	3.2	-1.0	138285.22	3303339.97	3302465.81
548.999	118868.30	855.45	3.2	-1.0	138284.13	3303318.09	3302445.03
549.000	118868.30	855.01	3.3	-1.1	155611.92	3310002.41	3308383.38
549.000	57678.30	549.41	3.5	-2.3	122568.55	975975.73	968743.13
550.000	57678.28	549.41	3.5	-2.3	122568.43	975975.16	968742.67



	INSTALLATION	STATION
A.	FWD BULKHEAD (FWD END)	684.6
B.	FWD SKIRT (FWD END)	676.7
C.	MAIN TUNNEL (FWD END)	647.7
D.	FWD SKIRT (AFT END)	554.7
	FWD BULKHEAD (AFT END)	553.0
E.	COLD HELIUM SPHERES (8 REQD - 269" ℄ TO ℄)	454.0
F.	COMMON BULKHEAD (FWD END)	335.2
	AUXILIARY PROPULSION MODULE (FWD END)	298.4
	AFT BULKHEAD (FWD END)	287.9
G.	AFT SKIRT (FWD END)	286.1
	LH2 FEED LINE FAIRING (FWD END)	286.1
	ULLAGE ROCKET (FWD END)	245.3
H.	COMMON BULKHEAD (AFT END)	244.4

	INSTALLATION	STATION
I.	MAIN TUNNEL (AFT END)	220.9
	ULLAGE ROCKET FAIRING (AFT END)	204.6
	AUXILIARY PROPULSION MODULE (AFT END)	203.6
	LH2 FEED LINE FAIRING (AFT END)	202.7
J.	AFT SKIRT (AFT END)	200.6
	INTERSTAGE (FWD END)	200.6
K.	THRUST STRUCTURE/AFT BULKHEAD TANGENT POINT	186.7
L.	AFT BULKHEAD (AFT END)	156.3
	AMBIENT HELIUM SPHERES	153.5
M.	THRUST STRUCTURE SKIN (AFT END)	121.4
N.	GIMBAL STATION	100.0
O.	ENGINE NOZZLE (AFT END)	-16.0
P.	INTERSTAGE (AFT END)	-26.9

Figure AP 2-1. S-IVB-502 Station List and Coordinate System

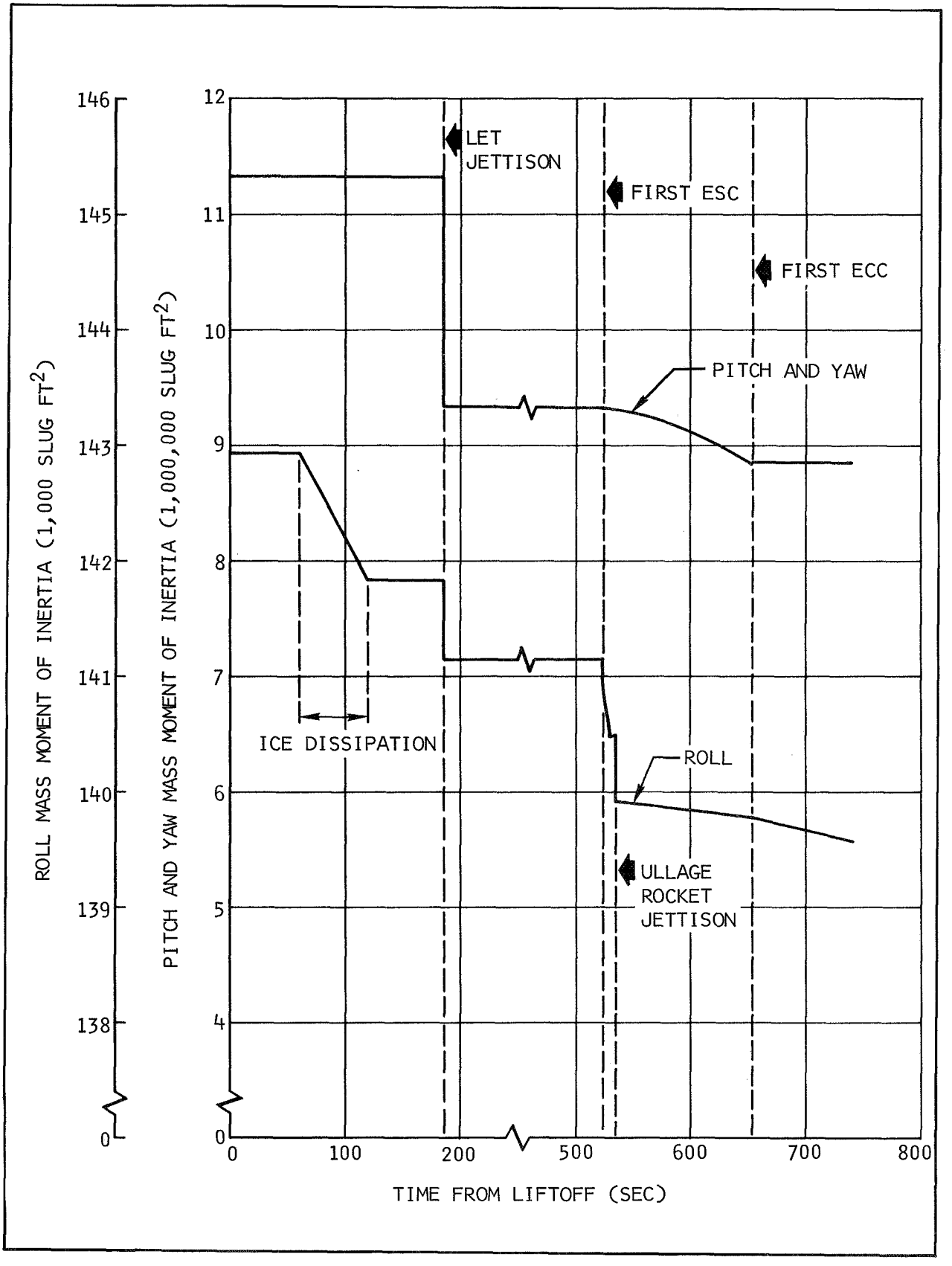


Figure AP 2-2. S-IVB-502 Stage Predicted Mass Moment of Inertia (Sheet 1 of 2)

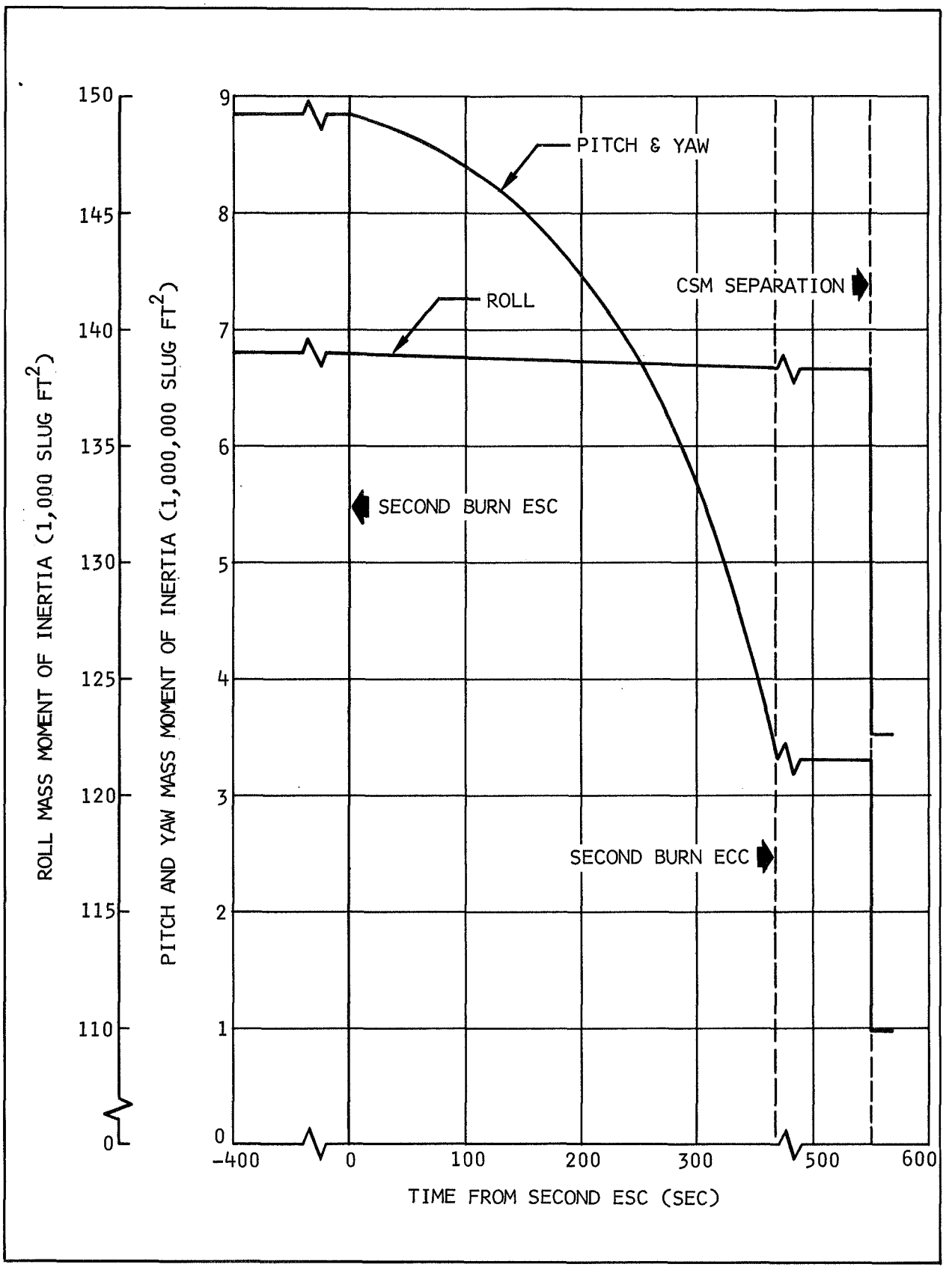


Figure AP 2-2. S-IVB-502 Stage Predicted Mass Moment of Inertia (Sheet 2 of 2)

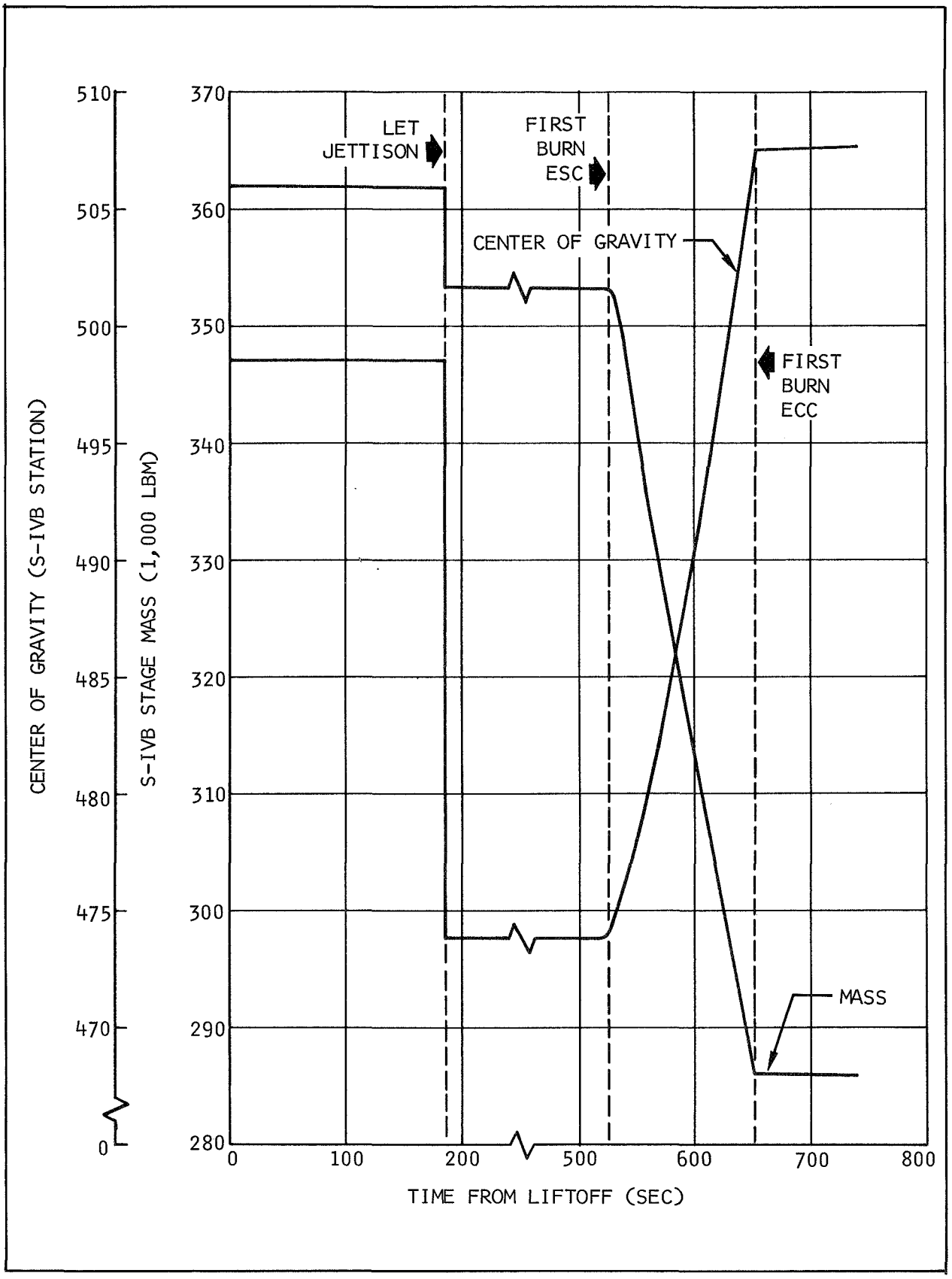


Figure AP 2-3. S-IVB-502 Stage Predicted Mass and Center of Gravity (Sheet 1 of 2)

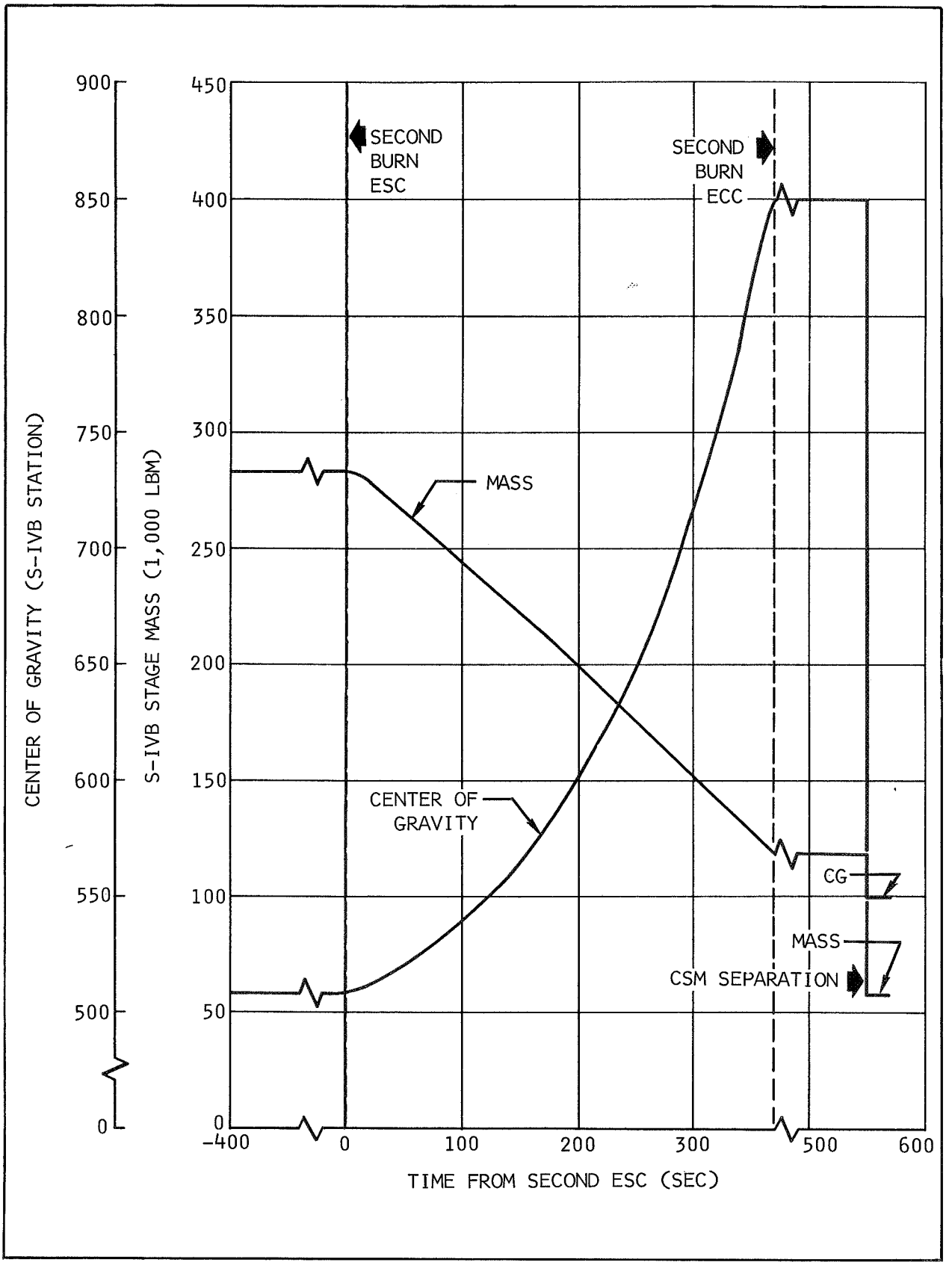


Figure AP 2-3. S-IVB-502 Stage Predicted Mass and Center of Gravity (Sheet 2 of 2)

APPENDIX 3

PREDICTED FLIGHT TRAJECTORY

3. PREDICTED FLIGHT TRAJECTORY

As of the publication date of this document, DAC has not been provided sufficient data to generate S-IC, S-II, or S-IVB trajectories. Therefore, this information will be supplied in a subsequent revision.

APPENDIX 4

TELEMETRY LOOK ANGLES AND TELEMETRY POWER MARGINS

4. TELEMETRY LOOK ANGLES AND TELEMETRY POWER MARGINS

Data relating to the telemetry coverage for parking orbit and S-IVB second burn has been derived from the *Tracking and Telemetry Design Analysis for Apollo-Saturn V Flight AS-502 document*, (reference 15).

Table AP 4-1 presents a parking orbit time line summary and figures AP 4-1 and AP 4-2 present launch phase telemetry coverage at a 5 deg elevation angle and pre-ignition sequencing and S-IVB second-burn coverage at a 5 deg elevation angle, respectively.

TABLE AP 4-1
PARKING ORBIT TIME LINE SUMMARY

SYSTEM	REVO-LUTION	STATION	STATION ACQUISITION TIME			MAXIMUM ELEVATION ANGLE (deg)	RANGE AT ELEVATION MAX (km)	TIME OF ELEVATION MAX (H:M:S)	STATION LOSS TIME			TRACKING TIME ABOVE		
			0 deg (H:M:S)	2 deg (H:M:S)	5 deg (H:M:S)				5 deg (H:M:S)	2 deg (H:M:S)	0 deg (H:M:S)	5 deg (H:M:S)	2 deg (H:M:S)	0 deg (H:M:S)
Telemetry	1	Bermuda	(00:04:03)	(00:04:42)	(00:05:33)	73.3	198.6	(00:08:49)	00:11:27	00:12:02	00:12:31	00:05:54	00:07:20	00:08:28
	1	Insertion Ship	(00:08:32)	(00:09:05)	(00:09:46)	22.6	461.4	00:12:10	00:14:28	00:15:06	00:15:36	00:04:42	00:06:01	00:07:04
	1	Canary Island	00:16:19	00:16:48	00:17:23	71.2	200.0	00:19:50	00:22:22	00:22:58	00:23:26	00:04:59	00:06:10	00:07:07
	1	Tananarive	00:36:48	00:37:25	00:38:21	7.2	941.6	00:39:40	00:40:53	00:41:49	00:42:27	00:02:32	00:04:24	00:05:39
	1	Carnarvon	00:51:58	00:52:39	00:53:25	8.6	890.9	00:55:00	00:56:32	00:57:24	00:58:00	00:03:07	00:04:45	00:06:02
	1	Guaymas	01:28:05	01:28:34	01:29:10	47.4	267.4	01:31:40	01:34:16	01:34:52	01:35:21	00:05:06	00:06:18	00:07:16
	1	Corpus Christi	01:30:59	01:31:28	01:32:04	35.7	333.3	01:34:40	01:37:07	01:37:44	01:38:14	00:05:03	00:06:16	00:07:15
	1	Cape Tel 4	01:34:53	01:35:23	01:36:02	21.9	494.1	01:38:30	01:40:49	01:41:27	01:41:57	00:04:47	00:06:04	00:07:04
	1	MILA-CIF	01:34:53	01:35:23	01:36:02	22.4	486.0	01:38:30	01:40:49	01:41:28	01:41:58	00:04:47	00:06:05	00:07:05
	1	Grand Bahama	01:35:35	01:36:07	01:36:50	13.6	701.9	01:39:00	01:41:02	01:41:44	01:42:17	00:04:12	00:05:37	00:06:42
	1	Grand Turk	01:38:24	01:39:19	*	3.3	1281.5	01:40:40	*	01:41:57	01:42:54	*	00:02:38	00:04:30
	2	Bermuda	01:38:20	01:38:49	01:39:24	87.8	200.0	01:42:00	01:44:35	01:45:11	01:45:40	00:05:11	00:06:22	00:07:20
	2	Insertion Ship	01:41:43	01:42:12	01:42:48	52.7	247.5	01:45:20	01:47:55	01:48:31	01:49:00	00:05:07	00:06:19	00:07:17
	2	Canary Island	01:49:56	01:50:37	01:51:42	6.3	1037.6	01:52:40	01:53:42	01:54:47	01:55:27	00:02:00	00:04:10	00:05:31
	2	Tananrive	02:09:01	02:09:30	02:10:07	32.2	352.1	02:12:30	02:15:01	02:15:38	02:16:08	00:04:54	00:06:08	00:07:07
	2	Carnarvon	02:25:14	02:25:47	02:26:31	12.8	733.0	02:28:30	02:30:36	02:31:20	02:31:53	00:04:05	00:05:33	00:06:39
	2	Hawaii	02:50:37	02:51:12	02:51:59	10.2	847.2	02:53:50	02:55:37	02:56:24	02:56:59	00:03:38	00:05:12	00:06:22
	2	Guaymas	03:01:21	03:01:51	03:02:30	24.4	467.1	(03:05:00)	(03:07:27)	(03:08:05)	(03:08:35)	00:04:57	00:06:14	00:07:14

NOTE: Numbers in parenthesis indicate coverage has begun before or extended beyond the parking orbit phase of flight.

* Vehicle does not track at this elevation angle.

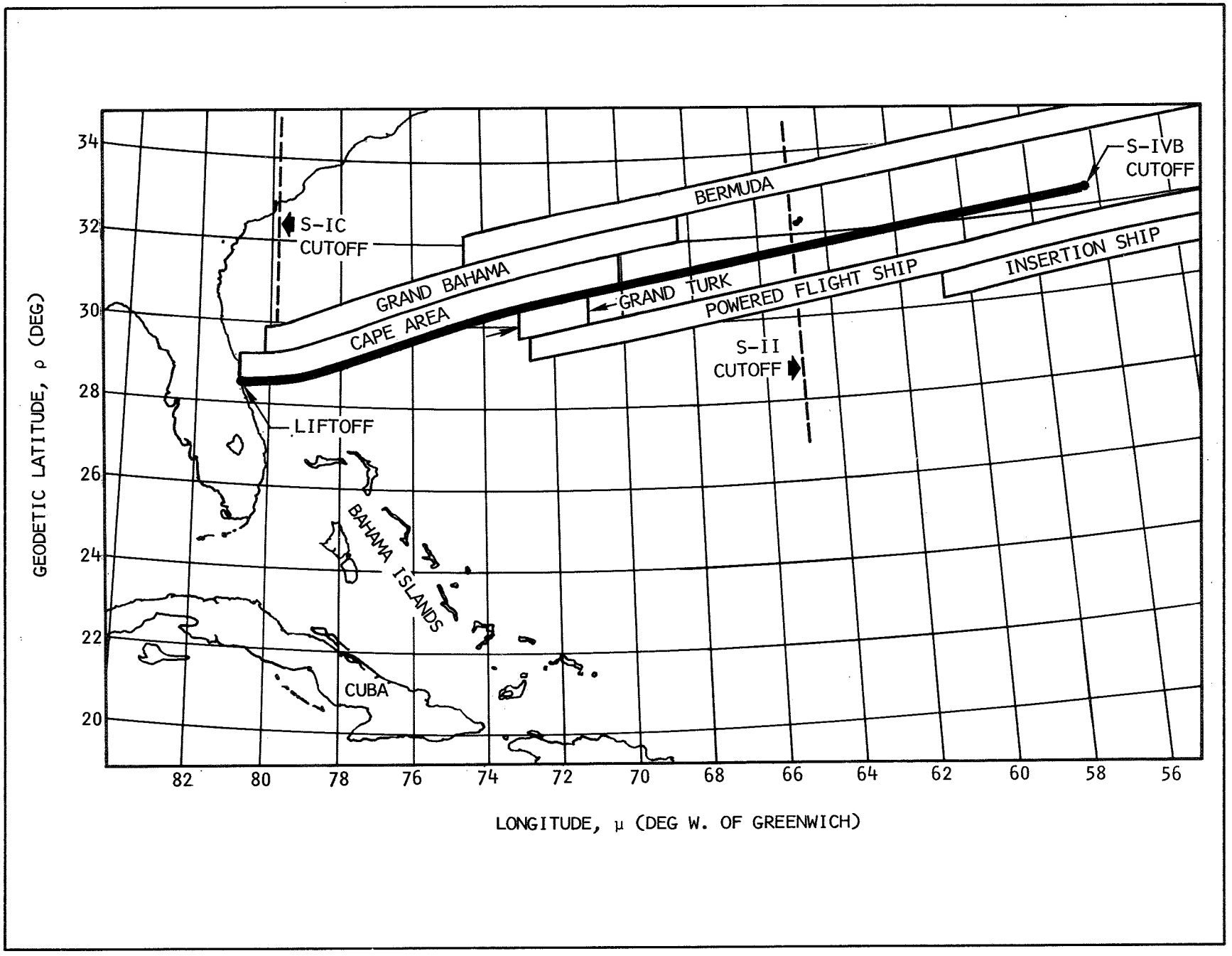


Figure AP 4-1. Launch Phase Telemetry Coverage at a 5-Degree Elevation Angle

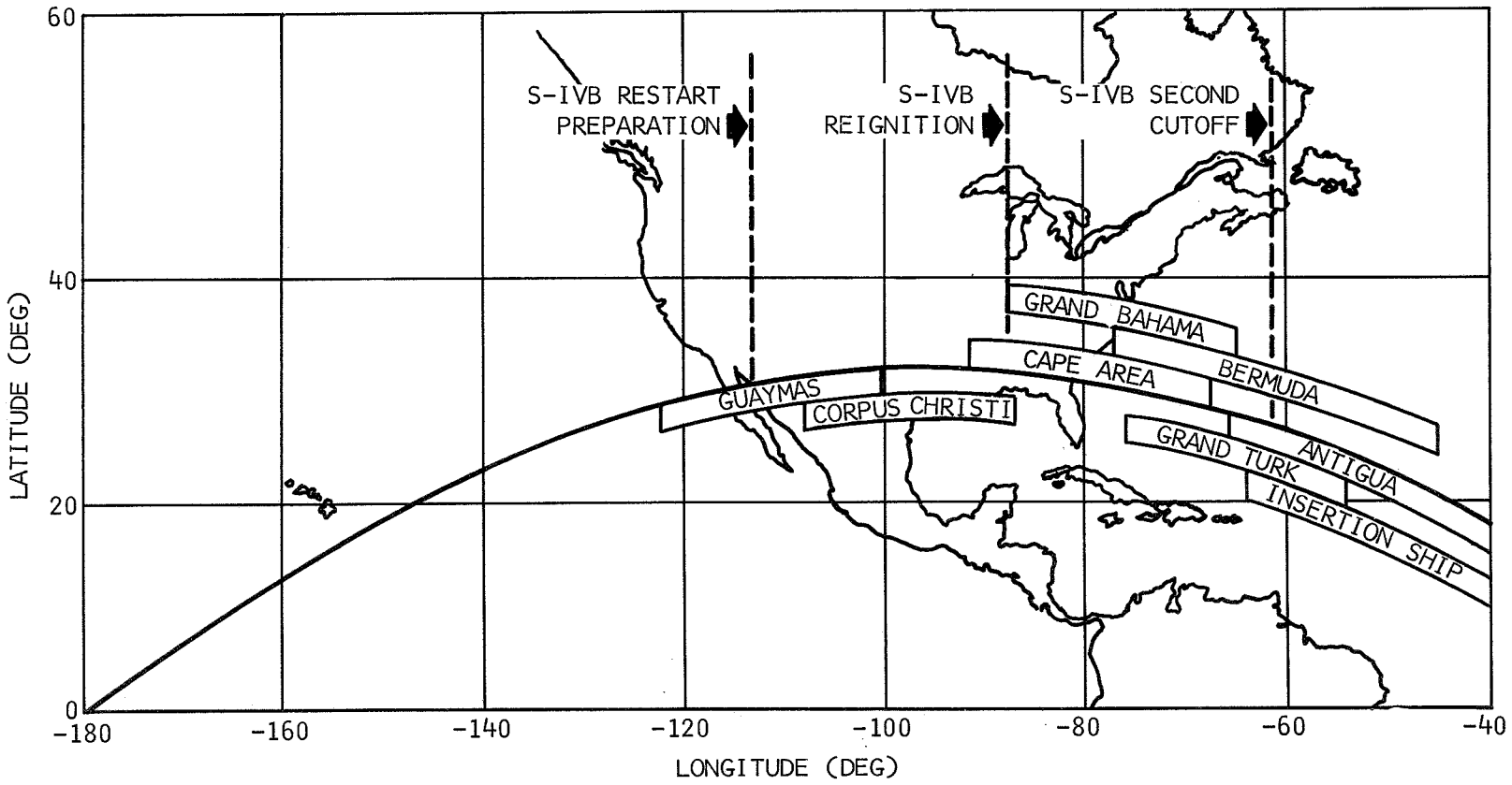


Figure AP 4-2. Pre-ignition Sequencing and S-IVB Second Burn Coverage at a 5-Degree Elevation Angle

Saturn V Space Vehicle

APPENDIX 5

PREDICTED PROPULSION SYSTEM PERFORMANCE

5. PREDICTED PROPULSION SYSTEM PERFORMANCE

This appendix contains predicted propulsion system performance data in support of the stage objectives presented in section 3. The data are submitted in accordance with the requirements of the *MSFC S-IVB Stage Test Information and Propulsion System Performance Prediction Requirements for Flight Test Planning document*, (reference 9).

Table AP 5-1 contains the predicted performance of selected S-IVB-502 parameters and their associated 3 sigma dispersion limits. Table AP 5-2 presents the J-2 engine tag values which were used as a basis for computing the predictions shown in table AP 5-1. Table AP 5-3 is a list of symbols, with their definitions, used in the tabulated summaries of the predicted propulsion system performance as derived from the AA89 computer program (tables AP 5-4 and AP 5-5). Graphical representations of the tabulated data are shown in figures AP 5-1 through AP 5-42.

The propulsion system prediction as presented in this appendix is based on propellant utilization (PU) activate to occur at Engine Start Command (ESC) +8 sec for first burn. Propellant management will maintain the engine performace at the high mixture ratio of 5.5:1 for the remainder of the first burn. Second burn will occur after a two-orbit coast period. The J-2 engine will start with the PU valve in the full open position (4.5:1), and at ESC +13 sec the PU valve will move to the null position in approximately one sec. The remainder of the burn will operate in the closed loop mode with a PU system reference mixture ratio of 5.0:1. Propellant management will nominally maintain a low EMR (4.5:1) until approximately ESC +100 sec to correct for the excessive fuel load, which is a result of the mission criterion to load LH2 for three orbits of boiloff and restart after two orbits.

The propulsion prediction is based on a nominal first burn time of 128.8 sec from ESC; second burn depletion will occur at ESC +368.4 sec.

TABLE AP 5-1 (Sheet 1 of 4)
PREDICTED PROPULSION SYSTEM PERFORMANCE PARAMETERS

PARAMETER	UNIT	VALUE	DISPERSION 3 sigma	REMARKS
FIRST BURN				
Average Stage Longitudinal Thrust	lbf	229,137	±5,250	
Average LOX Flowrate	lbm/sec	456.22	±10.7	
Average LH2 Flowrate	lbm/sec	83.52	±2.6	Determined from 90 percent thrust to ECC. Does not include ullage rocket operation.
Average Stage Mass Flowrate	lbm/sec	539.74	±11.0	
Average Stage Longitudinal Specific Impulse	sec	424.53	±2.8	
Engine Total Impulse	lbf/sec	2.8×10^7	TBD	
Start Impulse	lbf/sec	165,439	±30,000	Determine for the time period of ESC to 90 percent thrust buildup.
Cutoff Impulse	lbf/sec	70,110	±9,000	Determined for the time period of ECC as monitored on the S-IVB stage until thrust decay to zero.
Time from 90 Percent Thrust to ECC	sec	123.25	TBD	First burn ECC is a guidance command cutoff.
Total Loaded Propellants				
LOX	lbm	193,273	±2,686	Total propellant above engine main valves.
LH2	lbm	42,222	±590	
Total	lbm	234,495	±2,750	

TABLE AP 5-1 (Sheet 2 of 4)
PREDICTED PROPULSION SYSTEM PERFORMANCE PARAMETERS

PARAMETER	UNIT	VALUE	DISPERSION 3 sigma	REMARKS
Engine Propellant Consumption at ECC				
LOX	lbm	56,230	±1,319	Does not include thrust buildup or cutoff consumption
LH2	lbm	10,294	±320	
Total	lbm	66,524	±1,355	
SECOND BURN				
Average Stage Longitudinal Thrust	lbf	196,607	±16,000	
Average LOX Flowrate	lbm/sec	378.77	±33.3	
Average LH2 Flowrate	lbm/sec	79.34	±3.9	Determined from 90 percent thrust buildup to ECC. Does not include ullage rocket operation.
Average Stage Mass Flowrate	lbm/sec	458.11	±33.5	
Average Stage Longitudinal Specific Impulse	sec	429.16	±3.6	
Engine Total Impulse	lbf/sec	7.0×10^7	TBD	
Start Impulse	lbf/sec	143.097	±30,000	Determined for the time period of ESC to 90 percent thrust buildup.
Cutoff Impulse	lbf/sec	70,110	±9,000	Determined for the time period of ECC as monitored on the S-IVB stage until thrust decay to zero.

TABLE AP 5-1 (Sheet 3 of 4)
PREDICTED PROPULSION SYSTEM PERFORMANCE PARAMETERS

PARAMETER	UNIT	VALUE	DISPERSION 3 sigma	REMARKS
Time from 90 Percent Thrust to ECC	sec	357.9	TBD	First burn ECC is a guidance command cutoff. Second burn ECC refers to simultaneous propellant depletion cutoff and not guidance command cutoff. Since the time of first burn cutoff is velocity dependent, this prediction presents only a nominal time and as a result, depletion cutoff on second burn will be perturbed as a function of the variation of first burn cutoff.
Total Depletion Burntime (ESC to ECC)	sec	368.4	TBD	
Propellants on Board at second ESC (assuming nominal first burn and orbital propellant boiloff)				
LOX	lbm	136,345	TBD	Total propellant above main engine values.
LH2	lbm	29,425	TBD	Assumes nominal first burn run for dispersions.
Total	lbm	165,770	TBD	
Engine Propellant Consumption at ECC				First burn ECC is a guidance command cutoff. Second burn ECC refers to simultaneous propellant depletion cutoff and not guidance command cutoff. Since the time of first burn cutoff is velocity dependent, this prediction presents only a nominal time and as a result, depletion cutoff on second burn will be perturbed as a function of the variation of first burn cutoff.
LOX	lbm	135,556	TBD	
LH2	lbm	28,395	TBD	
Total	lbm	163,951	TBD	

TABLE AP 5-1 (Sheet 4 of 4)
PREDICTED PROPULSION SYSTEM PERFORMANCE PARAMETERS

PARAMETERS	UNIT	VALUE	DISPERSION 3 sigma	REMARKS
Total Engine Propellant Consumption (Includes First Burn and Second Burn)				
LOX	lbm	191,786	±2,686	
LH2	lbm	38,689	±573	
Total	lbm	230,475	±2,746	

TABLE AP 5-2
J-2 ENGINE TAG VALUES (ENGINE 2042)

PARAMETER	UNITS	PU VALVE POSITION (MAXIMUM EXCURSION)
Thrust	lbf	229,187
Engine Mixture Ratio	LOX/LH2	5.4846
Specific Impulse	sec	425.2
Total Propellant Flowrate	lbm/sec	539.60
Fuel Flowrate	lbm/sec	83.21
LOX Flowrate	lbm/sec	456.39

TABLE AP 5-3 (Sheet 1 of 3)
DEFINITION OF SYMBOLS USED WITH COMPUTER PROGRAM AA89

PRINTOUT SYMBOL	DEFINITION
ASUBM	Stage axial acceleration, (g)
CSUBFEV	Vacuum thrust coefficient
DEL	PU valve position (deg)
DRAG	Atmospheric resistance to the motion of the vehicle
EMR	Total engine propellant mixture ratio. The ratio of the total engine LOX mass flowrate to the total engine LH2 mass flowrate
ENGINE ISP	Engine specific impulse (sec). Engine thrust divided by engine mass flowrate
FPS	LH2 pump speed (rpm)
FSUBAUX	Auxiliary thrust (lbf)
FSUBE	Stage thrust (lbf)
FUEL OVB	LH2 passed overboard through engine and vents (lbm)
GGMR	Gas generator mixture ratio
HSUBF	Height of LH2 above pump inlet (in.); computed from height versus volume polynominal
HSUBO	Height of LOX above pump inlet (in.); computed from height versus volume polynominal
IMPSUBT	Stage total impulse (lbf-sec)
LPS	LOX pump speed (rpm)
OXID OVB	LOX passed overboard through engine and vents (lbm)
PCC	Thrust chamber pressure (psia) (injector static pressure)
PFPI	LH2 pump inlet pressure, total (psia)
POPI	LOX pump inlet pressure, total (psia)
RHOSUBF	LH2 bulk density (lbm/ft^3); calculated from pump inlet temperature plus a bias

TABLE AP 5-3 (Sheet 2 of 3)
DEFINITION OF SYMBOLS USED WITH COMPUTER PROGRAM AA89

PRINTOUT SYMBOL	DEFINITION
RHOSUBO	LOX bulk density (lbm/ft^3); calculated from pump inlet temperature plus a bias
TFPI	LH2 pump inlet temperature (deg R)
TIME	Time from S-IVB stage engine start (sec)
TOPI	LOX pump inlet temperature (deg R)
TTFHE	GHE in LH2 tank ullage (lbm)
TTFLH2	GH2 in LH2 tank ullage (lbm)
TTMF	Total mass in LH2 tank ullage (lbm)
TTMO	Total mass in LOX tank ullage (lbm)
TTOHE	GHE in LOX tank ullage (lbm)
TTOLOX	GOX in LOX tank ullage (lbm)
TTPSUBF	LH2 tank ullage pressure (psia)
TTPSUBO	LOX tank ullage pressure (psia)
VSUBF	LH2 volume in tank (ft^3)
VSUBO	LOX volume in tank (ft^3)
WDOTFBO	Rate of LH2 boiloff (lbm/sec)
WDOTFGG	Gas generator LH2 flowrate (lbm/sec)
WDOTFPR	LH2 tank pressurant flowrate (lbm/sec)
WDOTFVO	Rate of GH2 vented overboard (lbm/sec)
WDOTHE	LOX tank pressurant (GHe) flowrate (lbm/sec)
WDOTOBO	Rate of LOX boiloff (lbm/sec)
WDOTOGG	Gas generator LOX flowrate (lbm/sec)
WDOTOVO	Rate of GOX vented overboard (lbm/sec)
WDOTSUBF	Engine LH2 flowrate (lbm/sec)

TABLE AP 5-3 (Sheet 3 of 3)
DEFINITION OF SYMBOLS USED WITH COMPUTER PROGRAM AA89

PRINTOUT SYMBOL	DEFINITION
WDOTSUBO	Engine LOX flowrate (lbm/sec)
WDOTSUBT	Total propellant consumption, includes auxiliary flows (lbm/sec)
WFBOT	Accumulated LH2 boiloff (lbm)
WF IN TANK	Weight of LH2 in tank (lbm)
WFPRT	Accumulated LH2 tank pressurant (lbm)
WF PU	PU indicated LH2 weight (lbm)
WFPU USABLE	PU indicated usable LH2 weight (lbm)
WF USABLE	Usable LH2 in tank (lbm)
WFVOT	Total GH2 vented overboard (lbm)
WOBOT	Accumulated LOX boiloff (lbm)
WO IN TANK	Weight of LOX in tank (lbm)
WO PU	PU indicated LOX weight (lbm)
WOPU USABLE	PU indicated usable LOX weight (lbm)
WO USABLE	Usable LOX in tank (lbm)
WOVOT	Total GOX vented overboard (lbm)
WSUBFT	Total LH2 onboard (lbm)
WSUBHE	Weight of helium in cold helium spheres (lbm)
WSUBO ERROR	Equivalent LOX weight error, defined as LH2 weight (PU indicated) times reference mixture ratio of PU system, subtracted from LOX weight (PU indicated) (lbm)
WSUBOT	Total LOX onboard (lbm)
WSUBV	Total weight of S-IVB plus payload (lbm)

TABLE AP 5-4 (Sheet 1 of 3)
PREDICTED S-IVB-502 PROPULSION SYSTEM PERFORMANCE (FIRST BURN)
COMPUTER PROGRAM AA89

1	TIME	WDOTSUBO	WDOTSUBF	WDOTSLBT	OEL
2	FSUBE	TTPSUBO	TTPSUBF	HSUBO	HSUBF
3	EMR	POPI	PFPI	VSUBO	VSUBF
4	ENGINE ISP	TOPI	TFPI	WO PU	WF PU
5	CSUBFEV	RHOSUBO	RHOSUBF	WOPU USABLE	WFPU USABLE
6	PCC	WDOTOBO	WDOTFBO	WO USABLE	WF USABLE
7	LPS	WDOTWE	WDOTFPR	WO IN TANK	WF IN TANK
8	FPS	TTOWE	TTFWE	WSUBOT	WSUBFT
9	FSUBAUX	TTOLOX	TTFLH2	OXIO OVB	FUEL OVB
10	WSUBO ERROR	WOBOT	WFBOT	WOOTOVO	WOOTFVO
11	WSUBWE	TTMO	TTMF	WOVOT	WFVOT
12	GGMR	WDOTOGG	WDOTFGG	DRAG	WSUBV
13	ASUBM		WFPRT		IMPSUBT

1	0.000	0.000	0.000	0.000	0.000	1	5.500	324.540	70.258	394.799	0.000
2	0.00	39.740	32.700	199.281	505.819	2	176000.44	39.978	34.405	198.486	510.554
3	0.000	39.740	32.700	2720.672	9826.571	3	4.619	42.769	34.213	2716.477	9747.111
4	0.000	164.000	38.200	0.000	0.000	4	445.797	164.001	38.208	191315.766	33139.793
5	1.699	70.904	4.319	192756.000	42220.000	5	1.699	70.903	4.342	191630.744	33331.446
6	0.000	0.350	0.000	192906.000	42445.000	6	606.505	0.350	0.000	191780.744	33556.446
7	0.000	0.000	0.000	192906.000	42445.000	7	6788.527	0.225	0.379	192607.699	42323.580
8	0.000	5.300	17.400	193273.000	42493.000	8	22942.009	5.581	17.400	192974.699	42371.580
9	0.000	34.300	40.200	0.000	0.000	9	0.000	36.425	40.673	296.375	120.946
10	0.000	0.000	0.000	0.000	0.000	10	12.986	1.925	0.000	0.000	0.000
11	330.000	39.800	57.600	0.000	0.000	11	329.719	42.006	58.073	0.000	0.000
12	0.000	0.000	0.000	0.000	342113.000	12	0.875	2.642	3.018	0.000	341491.277
13	0.000		0.000		0.000	13	0.515		0.473		149439.162

1	0.500	0.000	2.564	2.564	0.000	1	10.000	407.407	80.291	487.698	4.732
2	181.51	39.762	32.855	198.832	511.850	2	209369.54	38.750	35.800	196.185	506.682
3	0.000	39.766	32.855	2720.670	9776.229	3	5.074	41.644	35.491	2692.856	9644.184
4	70.791	164.000	38.201	191793.576	33256.799	4	429.712	164.001	38.214	189945.361	32790.268
5	1.699	70.904	4.342	191925.191	33449.018	5	1.707	70.902	4.343	189955.996	32979.499
6	0.626	0.350	0.000	192075.191	33674.018	6	719.076	0.350	0.000	190105.996	33204.499
7	0.000	0.000	0.000	192905.824	42443.758	7	8324.560	0.272	0.547	190929.641	41969.288
8	819.564	5.300	17.400	193272.824	42491.758	8	25829.881	6.789	17.400	191296.641	42017.288
9	0.000	34.675	40.200	0.000	1.242	9	0.000	38.000	43.013	1972.859	472.898
10	12.831	0.175	0.000	0.000	0.000	10	13.075	3.500	0.000	0.000	0.000
11	330.000	39.975	57.600	0.000	0.000	11	328.511	44.789	60.413	0.000	0.000
12	0.000	0.000	0.110	0.000	342113.582	12	0.949	3.290	3.466	0.000	339458.926
13	0.001		0.000		87.726	13	0.617		2.813		1055113.328

1	1.000	0.000	2.564	2.564	0.000	1	15.000	458.741	82.810	541.551	32.400
2	181.52	39.783	33.010	198.832	511.830	2	230541.73	37.188	36.200	193.283	502.447
3	0.000	39.788	33.010	2720.668	9775.766	3	5.540	39.985	35.899	2661.014	9568.573
4	70.786	164.000	38.201	191793.777	33255.780	4	425.707	164.002	38.221	187773.516	32391.798
5	1.699	70.904	4.342	191925.383	33447.994	5	1.729	70.901	4.343	187697.789	32586.921
6	0.626	0.350	0.000	192075.383	33672.994	6	780.554	0.350	0.000	187847.789	32791.921
7	0.000	0.000	0.000	192905.648	42442.473	7	8691.457	0.274	0.547	188667.756	41554.105
8	819.581	5.300	17.400	193272.648	42490.473	8	26723.300	8.154	17.400	189034.756	41602.105
9	0.000	34.850	40.200	0.000	2.527	9	0.000	39.750	45.751	4232.994	885.344
10	12.834	0.350	0.000	0.000	0.000	10	12.985	5.250	0.000	0.000	0.000
11	330.000	40.150	57.600	0.000	0.000	11	327.146	47.904	63.131	0.000	0.000
12	0.000	0.000	0.110	0.000	342112.121	12	1.004	3.617	3.604	0.000	336781.859
13	0.001		0.000		178.482	13	0.685		5.551		2194297.750

1	1.500	0.000	2.565	2.565	0.000	1	20.000	458.130	82.819	540.949	32.400
2	181.53	39.805	33.165	198.852	511.806	2	230280.32	35.625	36.000	190.611	498.403
3	0.000	39.809	33.165	2720.666	9775.302	3	5.532	38.392	35.697	2628.719	9473.472
4	70.781	164.000	38.202	191793.982	33254.763	4	425.697	164.003	38.227	185529.100	31986.248
5	1.699	70.904	4.342	191925.576	33446.970	5	1.729	70.899	4.342	185407.492	32182.666
6	0.626	0.350	0.000	192075.576	33671.970	6	779.774	0.350	0.000	185557.492	32377.666
7	0.000	0.000	0.000	192905.475	42441.189	7	8688.895	0.276	0.547	186473.781	41137.245
8	819.599	5.300	17.400	193272.475	42489.189	8	26730.427	9.530	17.400	186740.781	41185.245
9	0.000	35.025	40.200	0.000	3.811	9	0.000	41.500	48.488	6525.219	1299.467
10	12.837	0.525	0.000	0.000	0.000	10	12.876	7.000	0.000	0.000	0.000
11	330.000	40.325	57.600	0.000	0.000	11	325.770	51.030	65.888	0.000	0.000
12	0.000	0.000	0.110	0.000	342110.660	12	1.002	3.613	3.605	0.000	334071.023
13	0.001		0.000		269.242	13	0.689		8.288		3346356.406

1	2.000	0.000	2.565	2.565	0.000	1	25.000	457.769	82.809	540.578	32.400
2	181.53	39.827	33.320	198.852	511.784	2	230100.95	34.700	35.400	188.131	494.516
3	0.000	39.831	33.320	2720.664	9774.839	3	5.528	37.440	35.097	2596.460	9378.953
4	70.775	164.000	38.203	191794.186	33253.746	4	425.657	164.004	38.234	183304.740	31581.824
5	1.699	70.904	4.342	191925.770	33445.947	5	1.729	70.897	4.342	183115.873	31738.484
6	0.626	0.350	0.000	192075.770	33670.947	6	779.213	0.350	0.000	183269.873	31963.484
7	0.000	0.000	0.000	192905.299	42439.905	7	8687.056	0.279	0.547	184082.482	40720.457
8	819.616	5.300	17.400	193272.299	42487.905	8	26739.174	10.918	17.400	184449.482	40768.457
9	0.000	35.200	40.200	0.000	5.095	9	0.000	43.250	51.226	8014.768	1713.517
10	12.839	0.700	0.000	0.000	0.000	10	12.769	8.750	0.000	0.000	0.000
11	330.000	40.500	57.600	0.000	0.000	11	324.382	54.168	68.628	0.000	0.000
12	0.000	0.000	0.110	0.000	342109.203	12	1.002	3.611	3.605	0.000	331362.938
13	0.001		0.000		360.007	13	0.694		11.026		4497208.000

1	2.500	0.046	2.565	2.611	0.000	1	30.000	457.688	82.836	540.524	32.400
2	181.54	39.848	33.475	198.831	511.760	2	230035.46	34.500	34.800	185.896	490.737
3	0.018	39.853	33.475	2720.662	9774.375	3	5.525	37.216	34.496	2564.212	9284.388
4	69.527	164.000	38.203	191794.385	33252.729	4	425.579	164.004	38.241	181109.630	31197.091
5	1.699	70.904	4.342	191925.957	33444.923	5	1.729	70.896	4.341	180833.168	31324.229
6	0.626	0.350	0.000	192075.957	33669.923	6	778.986	0.350	0.000	180983.168	31549.229
7	0.962	0.000	0.000	192905.119	42438.621	7	8686.310	0.281	0.547	181792.100	40303.597
8	819.634	5.300	17.400	193272.119	42486.621	8	26760.626	12.317	17.400	182159.100	40351.597
9	0.000	35.375	40.200	0.006	6.379	9	0.000	45.000	53.963	11103.400	2127.640
10	12.842	0.875	0.000	0.000	0.000	10	12.637	10.500	0.000	0.000	0.000
11	330.000	40.675	57.600	0.000	0.000	11	322.982	57.317	71.363	0.000	0.000
12	0.003	0.000	0.110	0.000	342107.738	12	1.001	3.610	3.607	0.000	328655.695
13	0.001		0.000		450.776	13	0.700		13.763		5647523.875

1	3.000	0.046	2.566	2.611	0.000	1	35.000	458.496	82.910	541.406	32.400
2	181.55	39.870	33.630	198.831	511.738	2	230187.31	34.671	34.250	183.578	487.055
3	0.018	39.874	33.630	2720.659	9773.911	3	5.530	37.361	33.945	2531.918	9189.651
4	69.522	164.000	38.204	191794.589	33251.711	4	425.166	164.005	38.248	178910.348	30793.077
5	1.699	70.904	4.342	191926.119	33443.899	5	1.728	70.894	4.340	178543.264	30909.656
6	0.626	0.350	0.000	192076.119	33668.899	6	779.805	0.350	0.000	178693.264	31134.656
7	0.962	0.000	0.000	192904.914	42437.336	7	8692.931	0.369	0.547	179498.518	39886.418
8	819.651	5.300	17.400	193271.914	42485.336	8	26798.789	14.094	17.400	179865.518	39934.418
9	0.000	35.550	40.200	0.035	7.664	9	0.000	46.750	56.701	13395.232	2342.081
10	12.845	1.050	0.000	0.000	0.000	10	12.547	12.250	0.000	0.000	0.000
11	330.000	40.850	57.600	0.000	0.000	11	321.206	60.844	74.101	0.000	0.000
12	0.003	0.000	0.110	0.000	342004.250	12	1.001	3.615	3.611	0.000	325944.934
13	0.001		0.000		341.550	13	0.706		16.501		6798350.313

1	4.000	59.400	46.724	106.125	0.000	1	40.000	458.700	82.955	541.635	32.400
2	39040.78	39.913	33.940	198.808	511.476	2	230226.66	35.025	33.700	181.501	483.481
3	1.271	40.580	33.681	2720.130	9767.333	3	5.529	37.698	33.395	2499.606	9094.830
4	367.876	164.001	38.205	191759.611	33223.630	4	425.043	164.006	38.255	176705.293	30379.712
5	1.699	70.904	4.342	191889.213	33415.697	5	1.729	70.893	4.340	176452.134	30494.848
6	134.547	0.350	0.000	192038.213	33640.697	6	779.926	0.350	0.000	176402.134	30719.848
7	1244.934	0.090	0.151	192867.271	42408.613	7	8693.703	0.381	0.547	177203.730	39469.005
8	14954.641	5.345	17.400	193234.271	42456.613	8	26825.672	15.970	17.400	177370.730	39517.005
9	0.000	35.900	40.276	37.328	36.311	9	0.000	48.500	59.438	15688.270	2956.757
10	12.898	1.400	0.000	0.000	0.000	10	12.478	14.000	0.000	0.000	0.000
11	329.955	41.245	57.676	0.000	0.000	11	319.329	64.470	76.838	0.000	0.000
12	0.242	0.484	2.002	0.000	341835.883	12	1.000	3.616	3.614	0.000	323232.734
13	0.114		0.076		8607.843	13	0.712		19.238		7949383.625

1	5.000	223.599	59.800	283.399	0.000	1	45.000	458.891	83.007	541.898	32.400
2	133046.64	39.957	34.250	198.664	510.902	2	230271.93	35.379	33.329	179.422	479.957
3	3.739	42.149	34.086	2718.453	9754.775	3	5.528	38.034	33.023	2467.278	8999.675
4	469.468	164.001	38.207	191647.843	33172.064	4	424.936	164.007	38.262	174494.916	29962.149
5	1.699	70.904	4.342	191770.721	33363.875	5	1.729	70.891	4.339	173960.047	30079.791
6	438.492	0.350	0.000	191920.721	33588.875	6	780.069	0.350	0.000	174110.047	30304.791
7	4679.774	0.180	0.303	192748.043	42356.270	7	8694.486	0.389	0.547	174907.945	39051.343
8	19169.994	5.480	17.400	193115.043	42404.270	8	26851.464	17.901	17.400	175274.945	39099.343
9	0.000	36.250	40.503	138.207	88.427	9	0.000	50.250	62.176	17982.305	3371.681
10	12.971	1.750	0.000	0.000	0.000	10	12.416	15.750	0.000	0.000	0.000
11	329.820	41.730	57.903	0.000	0.000	11	317.399	68.151	79.573	0.000	0.000
12	0.709	1.821	2.566	0.000	341684.313	12	1.000	3.617	3.617	0.000	320519.285
13	0.389		0.303		83502.093	13	0.718		21.976		9100629.625

TABLE AP 5-4 (Sheet 2 of 3)
PREDICTED S-IVB-502 PROPULSION SYSTEM PERFORMANCE (FIRST BURN)
COMPUTER PROGRAM AA89

1	50,000	459.105	83.057	542.162	32.400
2	230331.88	35.860	32.957	177.536	476.487
3	5.528	38.503	32.651	2434.934	8904.440
4	424.840	164.007	38.269	172278.379	29366.517
5	1.729	70.889	4.339	171666.951	29664.485
6	780.240	0.350	0.000	171816.951	29889.485
7	8693.209	0.395	0.547	172611.170	38633.431
8	26876.527	19.862	17.400	172978.170	38681.431
9	0.000	52.000	64.913	20277.330	3786.855
10	12.296	17.500	0.000	0.000	0.000
11	315.437	71.862	82.313	0.000	0.000
12	0.999	3.618	3.620	0.000	317804.598
13	0.725		24.713		10232127.875

1	55,000	459.323	83.105	542.428	32.400
2	230395.27	36.372	32.586	175.649	473.092
3	5.527	39.003	32.280	2402.574	8809.124
4	424.748	164.008	38.276	170060.779	29152.597
5	1.729	70.888	4.338	169372.736	29248.929
6	780.416	0.350	0.000	169522.756	29473.929
7	8695.915	0.401	0.547	170313.297	38215.270
8	26900.880	21.852	17.400	170680.297	38263.270
9	0.000	53.750	67.651	22573.453	4202.279
10	12.222	19.250	0.000	0.000	0.000
11	313.447	75.602	85.050	0.000	0.000
12	0.999	3.619	3.623	0.000	315088.566
13	0.731		27.451		11403943.500

1	60.000	459.534	83.139	542.673	32.400
2	230459.81	36.885	32.267	173.814	469.824
3	5.527	39.505	31.962	2370.197	8713.668
4	424.675	164.009	38.282	167816.285	28738.485
5	1.729	70.886	4.338	167077.492	28833.179
6	780.595	0.350	0.000	167227.492	29058.179
7	8696.591	0.404	0.547	168014.355	37796.915
8	26919.736	23.866	17.400	168381.355	37844.915
9	0.000	55.500	70.388	24870.645	4617.896
10	12.134	21.000	0.000	0.000	0.000
11	311.433	79.366	87.788	0.000	0.000
12	0.999	3.620	3.625	0.000	312371.270
13	0.738		30.188		12556074.250

1	65.000	459.736	83.176	542.911	32.400
2	230524.98	37.397	32.000	172.078	466.638
3	5.527	40.010	31.696	2337.804	8618.080
4	424.609	164.010	38.289	165365.979	28332.016
5	1.729	70.885	4.337	164781.188	28417.249
6	780.773	0.350	0.000	164931.188	28642.249
7	8697.206	0.407	0.547	165714.373	37378.379
8	26938.528	25.896	17.400	166081.373	37426.379
9	0.000	57.250	73.126	27168.877	5033.695
10	12.025	22.750	0.000	0.000	0.000
11	309.403	83.146	90.525	0.000	0.000
12	0.998	3.622	3.627	0.000	309652.750
13	0.744		32.926		13708535.750

1	70.000	459.941	83.212	543.154	32.400
2	230593.32	37.940	31.733	170.341	463.449
3	5.527	40.544	31.430	2305.395	8522.429
4	424.545	164.010	38.296	163314.695	27944.294
5	1.729	70.883	4.337	162483.885	28001.135
6	780.956	0.350	0.000	162633.885	28226.135
7	8697.801	0.409	0.547	163413.391	36959.660
8	26957.404	27.937	17.400	163780.391	37007.660
9	0.000	59.000	75.863	29468.109	5449.677
10	11.867	24.500	0.000	0.000	0.000
11	307.361	86.937	93.263	0.000	0.000
12	0.998	3.623	3.630	0.000	306933.047
13	0.751		35.663		14861325.750

1	75.000	460.151	83.250	543.400	32.400
2	230663.09	38.490	31.467	168.660	460.258
3	5.527	41.088	31.164	2272.971	8426.716
4	424.481	164.011	38.303	161062.385	27529.708
5	1.729	70.881	4.336	160185.533	27584.835
6	781.144	0.350	0.000	160335.533	27809.835
7	8698.409	0.410	0.547	161111.361	36540.755
8	26976.349	29.986	17.400	161478.361	36588.755
9	0.000	60.750	78.600	31768.389	5865.844
10	11.777	26.250	0.000	0.000	0.000
11	305.313	90.735	96.000	0.000	0.000
12	0.998	3.624	3.632	0.000	304212.113
13	0.758		38.401		16014463.125

1	80.000	460.360	83.287	543.647	32.400
2	230733.17	39.040	31.200	167.044	457.065
3	5.527	41.634	30.898	2240.530	8330.940
4	424.417	164.012	38.310	158809.047	27112.175
5	1.729	70.880	4.336	157886.135	27168.350
6	781.332	0.350	0.000	158036.135	27393.350
7	8699.021	0.411	0.547	158808.285	36121.665
8	26995.313	32.040	17.400	159175.285	36169.665
9	0.000	62.500	81.338	34069.715	6282.197
10	11.694	28.000	0.000	0.000	0.000
11	303.259	94.540	98.738	0.000	0.000
12	0.998	3.625	3.634	0.000	301489.949
13	0.765		41.138		17167949.500

1	85.000	460.569	83.323	543.893	32.400
2	230807.21	39.590	31.020	165.427	453.867
3	5.527	42.179	30.719	2208.072	8234.990
4	424.362	164.012	38.317	156554.686	26696.761
5	1.729	70.878	4.335	155583.691	26751.679
6	781.537	0.350	0.000	155735.691	26976.679
7	8699.685	0.413	0.547	156504.164	35702.388
8	27012.482	34.101	17.400	156871.164	35750.388
9	0.000	64.250	84.075	36372.086	6698.736
10	11.605	29.750	0.000	0.000	0.000
11	301.198	98.350	101.475	0.000	0.000
12	0.997	3.626	3.636	0.000	298766.551
13	0.773		43.876		18321794.250

1	90.000	459.390	83.291	542.681	32.400
2	230505.04	39.020	30.840	163.830	450.668
3	5.515	41.614	30.541	2175.659	8139.029
4	424.753	164.013	38.324	154303.441	26283.470
5	1.730	70.877	4.335	153288.426	26335.034
6	780.116	0.350	0.000	153438.426	26560.034
7	8689.959	0.296	0.547	154203.221	35283.137
8	27003.429	35.756	17.400	154570.221	35331.137
9	0.000	66.000	86.813	38671.279	7115.250
10	11.512	31.500	0.000	0.000	0.000
11	299.342	101.756	104.213	0.000	0.000
12	0.996	3.619	3.635	0.000	296046.355
13	0.779		46.613		19474954.000

1	95.000	459.063	83.299	542.363	32.400
2	230360.88	38.170	30.660	162.337	447.468
3	5.511	40.764	30.362	2143.286	8043.056
4	424.736	164.014	38.331	152055.154	25869.640
5	1.730	70.875	4.333	150994.180	25918.412
6	779.681	0.350	0.000	151144.180	26143.412
7	8688.527	0.297	0.547	151905.295	34863.910
8	27010.444	37.240	17.400	152272.295	34911.910
9	0.000	67.750	89.550	40967.455	7531.739
10	11.422	33.250	0.000	0.000	0.000
11	298.058	104.990	106.950	0.000	0.000
12	0.995	3.617	3.633	0.000	293329.203
13	0.785		49.351		20627112.250

1	100.000	460.121	83.376	543.496	32.400
2	230590.79	38.425	30.480	160.822	444.267
3	5.519	41.011	30.182	2110.875	7947.010
4	424.273	164.015	38.337	149802.584	25460.565
5	1.729	70.873	4.334	148897.348	25501.546
6	780.866	0.350	0.000	148847.348	25726.546
7	8697.464	0.416	0.547	149604.785	34444.439
8	27043.450	39.257	17.400	149971.785	34492.439
9	0.000	69.500	92.288	43266.215	7948.473
10	11.317	35.000	0.000	0.000	0.000
11	296.041	108.757	109.688	0.000	0.000
12	0.996	3.623	3.639	0.000	290609.223
13	0.793		52.088		21779600.500

1	105.000	460.324	83.408	543.732	32.400
2	230662.43	38.956	30.300	159.312	441.062
3	5.519	41.542	30.003	2078.429	7850.889
4	424.221	164.015	38.344	147537.895	25062.781
5	1.729	70.872	4.334	146398.115	25084.437
6	781.063	0.350	0.000	146548.115	25309.437
7	8698.106	0.416	0.547	147301.875	34024.724
8	27059.412	41.336	17.400	147668.875	34072.724
9	0.000	71.250	95.025	45567.375	8365.450
10	11.179	36.750	0.000	0.000	0.000
11	293.962	112.586	112.425	0.000	0.000
12	0.995	3.624	3.641	0.000	287886.398
13	0.801		54.826		22932727.250

1	110.000	459.567	83.393	542.960	32.400
2	230535.50	39.487	30.174	157.880	437.856
3	5.511	42.081	29.879	2046.028	7754.698
4	424.590	164.016	38.351	145276.463	24645.216
5	1.730	70.870	4.334	144102.188	24667.381
6	780.159	0.350	0.000	144252.188	24892.381
7	8690.072	0.417	0.547	145002.270	33605.063
8	27055.468	43.419	17.400	145369.270	33653.063
9	0.000	73.000	97.763	47865.230	8782.374
10	11.091	38.500	0.000	0.000	0.000
11	291.879	116.419	115.163	0.000	0.000
12	0.994	3.620	3.641	0.000	285167.332
13	0.808		57.563		24085312.750

1	115.000	459.453	83.407	542.860	32.400
2	230480.58	39.190	30.048	156.449	434.648
3	5.509	41.786	29.755	2013.647	7658.467
4	424.567	164.017	38.358	143014.971	24222.082
5	1.730	70.868	4.333	141806.201	24250.221
6	779.989	0.350	0.000	141956.201	24475.221
7	8689.506	0.299	0.547	142702.604	33185.297
8	27063.682	45.091	17.400	143069.604	33233.297
9	0.000	74.750	100.500	50163.146	9199.402
10	11.018	40.250	0.000	0.000	0.000
11	290.206	119.841	117.900	0.000	0.000
12	0.994	3.619	3.641	0.000	282447.898
13	0.816		60.301		25237976.500

1	120.000	459.127	83.409	542.537	32.400
2	230339.35	38.340	29.922	155.019	431.439
3	5.505	40.939	29.630	1981.287	7362.215
4	424.560	164.018	38.363	140747.125	23799.081
5	1.730	70.865	4.333	139511.629	23833.037
6	779.566	0.350	0.000	139661.629	24058.037
7	8688.111	0.300	0.547	140404.354	32765.508
8	27067.934	46.589	17.400	140771.354	32813.508
9	0.000	76.500	103.238	52459.646	9616.454
10	10.941	42.000	0.000	0.000	0.000
11	288.709	123.089	120.638	0.000	0.000
12	0.993	3.617	3.642	0.000	279729.859
13	0.823		63.038		26390020.000

1	125.000	460.057	83.474	543.531	32.400
2	230519.96	38.257	29.796	153.689	428.229
3	5.511	40.855	29.505	1948.907	7465.914
4	424.116	164.018	38.372	138470.697	23391.538
5	1.729	70.863	4.332	137215.846	23415.706
6	780.609	0.350	0.000	137365.846	23640.706
7	8696.583	0.419	0.547	138104.893	32345.572
8	27095.831	48.387	17.400	138471.893	32393.572
9	0.000	78.250	105.975	54757.337	10033.653
10	10.821	43.750	0.000	0.000	0.000
11	286.911	126.636	123.375	0.000	0.000
12	0.994	3.622	3.645	0.000	277010.461
13	0.832		65.776		27542041.750

1	126.000	460.091	83.479	543.370	32.400
2	230531.85	38.343	29.771	153.437	427.586
3	5.511	40.942	29.480	1942.423	7440.643
4	424.107	164.019	38.373	138013.627	23307.361
5	1.729	70.862	4.332	136756.145	23332.202
6	780.642	0.350	0.000	136906.145	23557.202
7	8696.690	0.420	0.547	137644.435	32261.546
8	27098.524	48.806	17.400	138011.435	32309.546
9	0.000	78.600	106.523	55217.443	10117.130
10	10.803	44.100	0.000	0.000	0.000
11	286.491	127.406	123.923	0.000	0.000
12	0.994	3.623	3.645	0.000	276466.000
13	0.834		66.323		27772566.750

1	127.000	460.124	83.485	543.609	32.400
2	230543.83	38.429	29.746	153.185	426.711
3	5.511	41.030	29.457	1935.939	7406.060
4	424.099	164.019	38.375	137556.525	23223.179
5	1.729	70.862	4.345	136296.412	23248.692
6	780.675	0.350	0.000	136446.412	23473.692
7	8696.798	0.420	0.547	137183.988	32177.516
8	27101.222	49.226	17.400	137550.988	32225.516
9	0.000	78.950	107.070	55677.561	10200.614
10	10.785	44.450	0.000	0.000	0.000
11	286.071	128.176	124.470	0.000	0.000
12	0.994	3.623	3.645	0.000	275921.504
13	0.836		66.871		28003103.000

TABLE AP 5-4 (Sheet 3 of 3)
PREDICTED S-IVB-502 PROPULSION SYSTEM PERFORMANCE (FIRST BURN)
COMPUTER PROGRAM AA89

1	128.000	460.157	83.491	543.648	32.400
2	230555.68	38.514	29.720	152.933	425.592
3	5.511	41.117	29.431	1929.434	7386.840
4	424.090	164.019	38.376	137099.395	23138.991
5	1.729	70.861	4.345	135836.630	23165.176
6	780.708	0.350	0.000	135986.630	23390.176
7	8696.904	0.420	0.547	136723.490	32093.479
8	27103.915	49.646	17.400	137090.490	32141.479
9	0.000	79.300	107.618	56137.709	10284.103
10	10.766	44.800	0.000	0.000	0.000
11	285.651	128.946	125.018	0.000	0.000
12	0.994	3.623	3.646	0.000	275376.969
13	0.837		67.418		28233631.750

1	128.750	460.182	83.495	543.677	32.400
2	230564.61	38.579	29.701	152.731	425.080
3	5.511	41.183	29.412	1924.590	7372.424
4	424.083	164.019	38.377	136756.654	23075.813
5	1.729	70.861	4.345	135491.805	23102.536
6	780.733	0.350	0.000	135641.805	23327.536
7	8696.984	0.420	0.547	136378.094	32030.448
8	27105.936	49.961	17.400	136745.094	32078.448
9	0.000	79.562	108.028	56482.864	10346.724
10	10.753	45.062	0.000	0.000	0.000
11	285.336	129.524	125.428	0.000	0.000
12	0.994	3.623	3.646	0.000	274968.539
13	0.839		67.829		28406570.500

1	128.850	460.182	83.495	543.678	32.400
2	231712.13	38.587	29.699	152.706	425.015
3	5.511	41.191	29.410	1923.942	7370.502
4	426.194	164.019	38.377	136710.938	23067.394
5	1.729	70.861	4.345	135445.824	23094.184
6	785.156	0.350	0.000	135595.824	23319.184
7	8741.862	0.420	0.547	136332.039	32022.043
8	26853.753	50.003	17.400	136699.039	32070.043
9	0.000	79.597	108.083	56528.863	10355.073
10	10.751	45.097	0.000	0.000	0.000
11	285.294	129.601	125.483	0.000	0.000
12	0.997	3.630	3.642	0.000	274914.082
13	0.843		67.883		28429626.500

1	128.950	396.568	71.948	468.516	32.400
2	199790.58	38.596	29.696	152.681	424.946
3	5.512	41.735	29.688	1923.322	7368.501
4	426.433	164.019	38.377	136667.309	23059.354
5	1.729	70.861	4.345	135401.934	23086.211
6	676.990	0.350	0.000	135551.934	23311.211
7	7533.410	0.420	0.547	136288.074	32014.019
8	23139.835	50.045	17.400	136655.074	32062.019
9	0.000	79.632	108.138	56572.793	10363.043
10	10.749	45.132	0.000	0.000	0.000
11	285.252	129.678	125.538	0.000	0.000
12	0.997	3.128	3.139	0.000	274862.090
13	0.727		67.938		28451744.000

1	129.050	243.118	44.131	287.249	32.400
2	122218.43	38.604	29.694	152.660	424.879
3	5.509	41.364	29.994	1922.869	7366.788
4	425.480	164.019	38.377	136635.387	23053.463
5	1.729	70.861	4.345	135369.787	23080.377
6	414.137	0.350	0.000	135519.787	23305.377
7	4618.393	0.420	0.547	136255.855	32008.132
8	14193.348	50.087	17.400	136622.855	32056.132
9	0.000	79.667	108.193	56604.977	10368.875
10	10.748	45.167	0.000	0.000	0.000
11	285.210	129.755	125.592	0.000	0.000
12	0.996	1.918	1.925	0.000	274823.984
13	0.445		67.993		28467950.000

1	129.150	92.486	16.866	109.352	32.400
2	46530.49	38.613	29.691	152.646	424.844
3	5.484	40.336	29.955	1922.639	7366.058
4	425.510	164.019	38.378	136619.264	23050.457
5	1.729	70.861	4.345	135353.525	23077.406
6	157.669	0.350	0.000	135503.525	23302.406
7	1756.918	0.420	0.547	136239.520	32005.110
8	5424.412	50.130	17.400	136606.520	32053.110
9	0.000	79.702	108.247	56621.277	10371.842
10	10.748	45.202	0.000	0.000	0.000
11	285.168	129.832	125.647	0.000	0.000
12	0.992	0.730	0.736	0.000	274804.629
13	0.169		68.048		28476122.250

1	129.250	39.717	6.873	46.589	32.400
2	19085.66	38.621	29.689	152.641	424.836
3	5.779	39.201	29.783	1922.558	7365.975
4	409.656	164.019	38.378	136613.652	23049.417
5	1.729	70.861	4.345	135347.859	23076.382
6	64.672	0.350	0.000	135497.859	23301.382
7	754.478	0.420	0.547	136233.779	32004.033
8	2210.422	50.172	17.400	136600.779	32052.033
9	0.000	79.737	108.302	56626.982	10372.864
10	10.747	45.237	0.000	0.000	0.000
11	285.126	129.909	125.702	0.000	0.000
12	1.045	0.313	0.300	0.000	274797.813
13	0.069		68.102		28478968.500

1	129.350	29.314	5.198	34.512	32.400
2	13872.08	38.630	29.686	152.639	424.831
3	5.639	38.982	29.744	1922.510	7365.878
4	401.944	164.019	38.378	136610.334	23048.810
5	1.729	70.861	4.345	135344.518	23075.781
6	47.006	0.350	0.000	135494.518	23300.781
7	556.869	0.420	0.547	136230.365	32003.380
8	1671.852	50.214	17.400	136597.365	32051.380
9	0.000	79.772	108.357	56630.361	10373.463
10	10.747	45.272	0.000	0.000	0.000
11	285.084	129.986	125.757	0.000	0.000
12	1.020	0.231	0.227	0.000	274793.742
13	0.050		68.157		28480578.750

1	129.450	23.231	4.457	29.688	32.400
2	11827.59	38.639	29.684	152.637	424.828
3	5.660	38.918	29.729	1922.472	7365.781
4	398.392	164.019	38.378	136607.693	23048.325
5	1.729	70.861	4.345	135341.859	23075.301
6	40.078	0.350	0.000	135491.859	23300.301
7	479.299	0.420	0.547	136227.633	32002.848
8	1433.598	50.256	17.400	136594.633	32050.848
9	0.000	79.807	108.412	56633.059	10373.940
10	10.747	45.307	0.000	0.000	0.000
11	285.042	130.063	125.811	0.000	0.000
12	1.024	0.199	0.194	0.000	274790.480
13	0.043		68.212		28481847.250

1	129.550	23.090	4.069	27.159	32.400
2	10756.50	38.647	29.681	152.636	424.825
3	5.675	38.897	29.722	1922.437	7365.689
4	396.050	164.019	38.378	136605.330	23047.893
5	1.729	70.861	4.345	135339.482	23074.872
6	36.448	0.350	0.000	135489.482	23299.872
7	438.639	0.421	0.547	136225.182	32002.367
8	1308.660	50.298	17.400	136592.182	32050.367
9	0.000	79.842	108.466	56635.475	10374.366
10	10.747	45.342	0.000	0.000	0.000
11	285.000	130.140	125.866	0.000	0.000
12	1.026	0.182	0.178	0.000	274787.347
13	0.039		68.267		28482975.000

1	129.650	20.263	3.556	23.819	32.400
2	9339.60	38.656	29.679	152.634	424.822
3	5.699	38.881	29.716	1922.406	7365.605
4	392.114	164.019	38.378	136603.201	23047.503
5	1.729	70.861	4.345	135337.340	23074.486
6	31.647	0.350	0.000	135487.340	23299.486
7	384.923	0.421	0.547	136222.967	32001.929
8	1143.611	50.340	17.400	136589.967	32049.929
9	0.000	79.877	108.521	56637.634	10374.750
10	10.747	45.377	0.000	0.000	0.000
11	284.958	130.217	125.921	0.000	0.000
12	1.030	0.160	0.155	0.000	274784.893
13	0.034		68.321		28483985.250

1	129.750	16.045	2.791	18.836	32.400
2	7225.06	38.664	29.676	152.633	424.819
3	5.750	38.851	29.707	1922.380	7365.539
4	383.384	164.019	38.378	136601.424	23047.177
5	1.729	70.861	4.345	135335.551	23074.164
6	24.482	0.350	0.000	135485.551	23299.164
7	304.801	0.421	0.547	136221.104	32001.555
8	897.502	50.382	17.400	136588.104	32049.555
9	0.000	79.912	108.576	56639.482	10375.069
10	10.747	45.412	0.000	0.000	0.000
11	284.916	130.294	125.976	0.000	0.000
12	1.040	0.127	0.122	0.000	274782.656
13	0.026		68.376		28484818.250

1	129.850	11.330	1.935	13.265	32.400
2	4861.70	38.673	29.674	152.632	424.817
3	5.855	38.809	29.697	1922.360	7365.494
4	366.494	164.019	38.378	136600.104	23046.936
5	1.729	70.861	4.345	135334.221	23073.925
6	16.474	0.350	0.000	135484.221	23298.925
7	215.233	0.421	0.547	136219.699	32001.264
8	622.422	50.424	17.400	136586.699	32049.264
9	0.000	79.947	108.631	56640.852	10375.305
10	10.747	45.447	0.000	0.000	0.000
11	284.874	130.371	126.030	0.000	0.000
12	1.059	0.089	0.084	0.000	274780.961
13	0.018		68.431		28485421.250

1	129.950	7.623	1.263	8.886	32.400
2	3004.91	38.681	29.671	152.632	424.816
3	6.037	38.768	29.686	1922.346	7365.468
4	338.179	164.019	38.379	136599.213	23046.774
5	1.729	70.861	4.345	135333.324	23073.765
6	10.182	0.350	0.000	135483.324	23298.765
7	144.809	0.421	0.547	136218.730	32001.051
8	406.099	50.466	17.400	136585.730	32049.051
9	0.000	79.982	108.685	56641.787	10375.463
10	10.747	45.482	0.000	0.000	0.000
11	284.831	130.448	126.083	0.000	0.000
12	1.092	0.060	0.055	0.000	274779.781
13	0.011		68.486		28485807.750

1	130.050	5.266	0.835	6.100	32.400
2	1825.64	38.690	29.679	152.631	424.815
3	6.308	38.744	29.688	1922.337	7365.438
4	299.275	164.019	38.379	136598.615	23046.666
5	1.729	70.861	4.345	135332.721	23073.658
6	6.186	0.350	0.000	135482.721	23298.658
7	100.027	0.421	0.546	136218.053	32000.892
8	268.451	50.508	17.400	136585.053	32048.892
9	0.000	80.017	108.740	56642.430	10375.567
10	10.747	45.517	0.000	0.000	0.000
11	284.789	130.525	126.140	0.000	0.000
12	1.141	0.042	0.036	0.000	274778.941
13	0.007		68.540		28486046.500

1	130.150	0.000	0.000	0.000	32.400
2	0.00	38.699	29.698	152.631	424.814
3	0.000	38.723	29.702	1922.332	7365.409
4	0.000	164.019	38.379	136598.305	23046.611
5	1.729	70.861	4.345	135332.408	23073.604
6	0.000	0.350	0.000	135482.408	23298.604
7	0.000	0.421	0.543	136217.666	32000.786
8	0.000	50.550	17.400	136584.666	32048.786
9	0.000	80.052	108.794	56642.781	10375.619
10	10.747	45.552	0.000	0.000	0.000
11	284.747	130.602	126.194	0.000	0.000
12	0.000	0.000	0.000	0.000	274778.449
13	0.000		68.595		28486143.750

1	130.250	0.000	0.000	0.000	0.000
2	0.00	38.707	29.717	152.631	424.813
3	0.000	38.707	29.717	1922.331	7365.390
4	0.000	164.019	38.379	136598.344	23046.607
5	1.729	70.861	4.343	135332.445	23073.602
6	0.000	0.350	0.000	135482.445	23298.602
7	0.000	0.421	0.541	136217.631	32000.732
8	0.000	50.592	17.400	136584.631	32048.732
9	0.000	80.087	108.849	56642.781	10375.619
10	10.747	45.587	0.000	0.000	0.000
11	284.705	130.679	126.249	0.000	0.000
12	0.000	0.000	0.000	0.000	274778.359
13	0.000		68.649		28486143.750

1	150.000	0.000	0.000	0.000	-27.700
2	0.00	38.900	33.400	152.743	405.529
3	0.000	38.900	33.400	1925.211	6786.331
4	0.000	165.300	38.800	137094.814	28458.922
5	1.729	70.630	4.329	135827.545	28235.126
6	0.000	0.000	0.000	135977.545	28480.126
7	0.000	0.000	0.000	135977.545	29377.126
8	0.000	0.000	44.995	136344.545	29425.126
9	0.000	320.173	252.738	56642.781	12855.335
10	-2.615	285.673	2618.267	0.000	0.000
11	234.328	376.142	297.493	0.000	2498.346
12	0.000	0.000	0.000	0.000	271914.668
13	0.000		73.988		28486143.750

TABLE AP 5-5 (Sheet 1 of 5)
PREDICTED S-IVB-502 PROPULSION SYSTEM PERFORMANCE (SECOND BURN)
COMPUTER PROGRAM AA89

1	150.000	0.000	1.585	1.585	-27.700
2	0.00	38.900	33.400	152.743	405.509
3	0.000	38.900	33.400	1925.211	6786.331
4	0.000	165.300	38.800	137094.814	28458.922
5	1.698	70.630	4.329	135827.545	28255.126
6	0.000	0.000	0.000	135977.545	28480.126
7	0.000	0.000	0.000	135977.545	29377.126
8	509.112	0.000	44.995	136344.545	29425.126
9	0.000	320.173	252.738	56642.781	12855.335
10	-2.615	285.673	2618.267	0.000	0.000
11	234.328	376.142	297.495	0.000	2498.346
12	0.000	0.000	0.068	0.000	271914.668
13	0.000		73.988		28486143.750

1	151.000	0.000	1.844	1.844	-27.700
2	243.21	38.908	33.400	152.743	405.505
3	0.000	38.914	33.400	1925.223	6785.989
4	131.859	165.302	38.801	137094.814	28457.849
5	1.666	70.629	4.329	135827.545	28254.007
6	0.855	0.000	0.000	135977.545	28479.007
7	0.000	0.000	0.000	135977.545	29375.449
8	588.370	0.000	44.995	136344.545	29423.449
9	0.000	320.173	252.738	56642.781	12857.013
10	-2.613	285.673	2618.267	0.000	0.000
11	234.328	376.142	297.495	0.000	2498.346
12	0.000	0.000	0.078	0.000	271912.992
13	0.001		73.988		28486380.750

1	152.000	0.000	2.190	2.190	-27.700
2	243.21	38.917	33.400	152.743	405.491
3	0.000	38.922	33.400	1925.235	6785.570
4	111.044	165.305	38.801	137094.814	28456.417
5	1.666	70.629	4.329	135827.545	28252.546
6	0.855	0.000	0.000	135977.545	28477.546
7	0.000	0.000	0.000	135977.545	29373.431
8	698.667	0.000	44.995	136344.545	29421.431
9	0.000	320.173	252.738	56642.781	12859.031
10	-2.609	285.673	2618.267	0.000	0.000
11	234.328	376.142	297.495	0.000	2498.346
12	0.000	0.000	0.092	0.000	271910.973
13	0.001		73.988		28486623.000

1	153.000	0.000	2.536	2.536	-27.700
2	243.21	38.925	33.400	152.744	405.475
3	0.000	38.931	33.400	1925.247	6785.070
4	95.904	165.307	38.802	137094.814	28454.643
5	1.666	70.629	4.329	135827.545	28250.740
6	0.855	0.000	0.000	135977.545	28475.740
7	0.000	0.000	0.000	135977.545	29371.066
8	808.965	0.000	44.995	136344.545	29419.066
9	0.000	320.173	252.738	56642.781	12861.395
10	-2.605	285.673	2618.267	0.000	0.000
11	234.328	376.142	297.495	0.000	2498.346
12	0.000	0.000	0.107	0.000	271908.609
13	0.001		73.988		28486865.250

1	154.000	0.000	2.882	2.882	-27.700
2	243.21	38.933	33.400	152.744	405.456
3	0.000	38.939	33.399	1925.259	6784.490
4	84.397	165.310	38.803	137094.814	28452.528
5	1.666	70.628	4.329	135827.545	28248.587
6	0.855	0.000	0.000	135977.545	28473.587
7	0.000	0.000	0.000	135977.545	29368.356
8	919.264	0.000	44.995	136344.545	29416.356
9	0.000	320.173	252.738	56642.781	12864.106
10	-2.599	285.673	2618.267	0.000	0.000
11	234.328	376.142	297.495	0.000	2498.346
12	0.000	0.000	0.121	0.000	271905.898
13	0.001		73.988		28487107.500

1	155.000	0.000	3.227	3.227	-27.700
2	243.21	38.942	33.400	152.745	405.434
3	0.000	38.947	33.399	1925.272	6783.831
4	75.356	165.312	38.803	137094.814	28450.073
5	1.666	70.628	4.329	135827.545	28246.089
6	0.855	0.000	0.000	135977.545	28471.089
7	0.000	0.000	0.000	135977.545	29365.300
8	1029.563	0.000	44.995	136344.545	29413.300
9	0.000	320.173	252.738	56642.781	12867.161
10	-2.593	285.673	2618.267	0.000	0.000
11	234.328	376.142	297.495	0.000	2498.346
12	0.000	0.000	0.136	0.000	271902.844
13	0.001		73.988		28487349.750

1	156.000	0.000	3.845	3.845	-27.700
2	243.21	38.950	33.400	152.745	405.402
3	0.000	38.956	33.395	1925.284	6782.833
4	41.611	165.315	38.804	137094.814	28446.155
5	1.666	70.627	4.329	135827.545	28242.110
6	0.855	0.000	0.000	135977.545	28467.110
7	0.000	0.000	0.000	135977.545	29360.763
8	1864.517	0.000	44.995	136344.545	29408.763
9	0.000	320.173	252.738	56642.781	12871.699
10	-2.583	285.673	2618.267	0.000	0.000
11	234.328	376.142	297.495	0.000	2498.346
12	0.000	0.000	0.246	0.000	271898.303
13	0.001		73.988		28487592.000

1	157.000	0.000	6.652	6.652	-27.700
2	243.21	38.958	33.400	152.746	405.355
3	0.000	38.964	33.393	1925.296	6781.436
4	36.564	165.317	38.805	137094.814	28440.550
5	1.666	70.627	4.329	135827.545	28236.417
6	0.855	0.000	0.000	135977.545	28461.417
7	0.000	0.000	0.000	135977.545	29354.512
8	2121.914	0.000	44.995	136344.545	29402.512
9	0.000	320.173	252.738	56642.781	12877.949
10	-2.569	285.673	2618.267	0.000	0.000
11	234.328	376.142	297.495	0.000	2498.346
12	0.000	0.000	0.280	0.000	271892.055
13	0.001		73.988		28487834.250

1	158.000	0.039	7.458	7.498	-27.700
2	243.21	38.967	33.400	152.746	405.303
3	0.005	38.972	33.391	1925.307	6779.854
4	32.437	165.320	38.805	137094.781	28434.150
5	1.666	70.626	4.329	135827.512	28229.920
6	0.855	0.000	0.000	135977.512	28454.920
7	0.917	0.000	0.000	135977.512	29347.457
8	2379.313	0.000	44.995	136344.512	29395.457
9	0.000	320.173	252.738	56642.814	12885.005
10	-2.553	285.673	2618.267	0.000	0.000
11	234.328	376.142	297.495	0.000	2498.346
12	0.001	0.000	0.314	0.000	271884.965
13	0.001		73.988		28488076.500

1	139.000	51.003	44.051	93.084	-27.700
2	34355.81	38.975	33.400	152.731	405.114
3	1.158	39.734	33.199	1924.867	6773.769
4	361.435	165.322	38.806	137062.902	28407.661
5	1.665	70.626	4.328	135795.463	28203.073
6	120.791	0.000	0.000	135943.463	28428.073
7	1187.072	0.071	0.000	135945.463	29320.052
8	14055.150	0.036	44.995	136312.463	29368.052
9	0.000	320.173	252.738	56674.863	12912.410
10	-2.503	285.673	2618.267	0.000	0.000
11	234.293	376.177	297.495	0.000	2498.346
12	0.232	0.430	1.854	0.000	271825.512
13	0.126		73.988		28526256.500

1	160.000	189.105	56.472	245.577	-27.700
2	117131.49	38.983	33.400	152.679	404.739
3	3.349	41.064	33.269	1923.433	6762.371
4	476.964	165.324	38.807	136962.366	28389.725
5	1.665	70.625	4.328	135694.590	28154.457
6	411.819	0.000	0.000	135844.590	28379.457
7	4396.442	0.142	0.000	135844.590	29270.878
8	18018.004	0.143	44.995	136211.590	29318.878
9	0.000	320.173	252.738	56775.736	12961.584
10	-2.433	285.673	2618.267	0.000	0.000
11	234.186	376.284	297.495	0.000	2498.346
12	0.671	1.595	2.377	0.000	271675.465
13	0.431		73.988		28593940.250

1	160.500	278.589	66.404	344.992	-27.700
2	154974.99	38.987	33.400	152.616	404.508
3	4.195	41.347	33.224	1921.765	6759.340
4	449.213	165.326	38.807	136843.311	28329.706
5	1.665	70.625	4.328	135574.674	28124.014
6	544.885	0.000	0.000	135724.674	28349.014
7	6474.234	0.178	0.000	135724.674	29240.157
8	21187.805	0.223	44.995	136091.674	29288.157
9	0.000	320.173	252.738	56895.652	12992.305
10	-2.417	285.673	2618.267	0.000	0.000
11	234.106	376.364	297.495	0.000	2498.346
12	0.841	2.350	2.795	0.000	271524.828
13	0.571		73.988		28664300.750

1	161.000	304.073	71.754	375.827	-27.700
2	164621.55	38.992	33.400	152.537	404.246
3	4.238	41.606	33.137	1919.697	6747.419
4	438.025	165.327	38.807	136697.369	28295.662
5	1.665	70.625	4.328	135427.902	28089.487
6	578.849	0.000	0.000	135577.902	28314.487
7	7066.500	0.214	0.000	135577.902	29205.351
8	22896.537	0.321	44.995	135944.902	29253.351
9	0.000	320.173	252.738	57042.424	13027.111
10	-2.405	285.673	2618.267	0.000	0.000
11	234.008	376.462	297.495	0.000	2498.346
12	0.849	2.565	3.021	0.000	271343.250
13	0.607		73.988		28744649.500

1	162.000	315.528	73.559	389.087	-27.700
2	171546.75	39.000	33.533	152.367	403.680
3	4.289	41.692	33.253	1915.321	6730.396
4	440.896	165.329	38.808	136388.611	28223.149
5	1.666	70.624	4.328	135117.373	28016.705
6	603.073	0.000	0.000	135267.373	28241.705
7	7325.536	0.285	0.510	135267.373	29132.010
8	23625.220	0.570	44.995	135634.373	29180.010
9	0.000	320.173	253.111	57352.953	13100.078
10	-2.378	285.673	2618.267	0.000	0.000
11	233.758	376.712	297.869	0.000	2498.346
12	0.853	2.657	3.116	0.000	270939.383
13	0.633		74.362		28913151.250

1	163.000	323.469	74.419	397.888	-27.700
2	176856.89	38.938	33.667	152.192	403.102
3	4.347	41.689	33.384	1910.814	6713.055
4	444.489	165.332	38.809	136070.639	28146.179
5	1.666	70.623	4.328	134797.576	27942.636
6	621.754	0.000	0.000	134947.576	28167.636
7	7510.489	0.285	0.510	134947.576	29057.383
8	23899.087	0.855	44.995	135314.576	29105.383
9	0.000	320.173	253.621	57672.750	13174.194
10	-2.344	285.673	2618.267	0.000	0.000
11	233.473	376.997	298.379	0.000	2498.346
12	0.864	2.724	3.152	0.000	270564.957
13	0.654		74.872		29087351.250

1	163.200	337.910	75.823	413.734	-16.620
2	184370.15	38.925	33.693	152.157	402.986
3	4.457	41.708	33.407	1909.897	6709.569
4	445.625	165.332	38.809	136006.008	28130.690
5	1.675	70.623	4.328	134732.574	27927.729
6	646.395	0.000	0.000	134882.574	28152.729
7	7626.456	0.285	0.510	134882.574	29042.365
8	24403.194	0.912	44.995	135249.574	29090.365
9	0.000	320.173	253.723	57737.752	13189.110
10	-2.338	285.673	2618.267	0.000	0.000
11	233.416	377.054	298.481	0.000	2498.346
12	0.872	2.818	3.230	0.000	270484.938
13	0.682		74.974		29122938.250

1	163.400	356.150	77.125	433.276	-5.540
2	193177.62	38.912	33.720	152.120	402.868
3	4.618	41.751	33.433	1908.932	6706.009
4	445.854	165.333	38.809	135937.891	28114.885
5	1.686	70.623	4.329	134664.070	27912.517
6	670.736	0.000	0.000	134814.070	28137.517
7	7769.379	0.285	0.510	134814.070	29027.042
8	24870.566	0.969	44.995	135181.070	29075.042
9	0.000	320.173	253.825	57806.236	13204.332
10	-2.332	285.673	2618.267	0.000	0.000
11	233.359	377.111	298.582	0.000	2498.346
12	0.889	2.936	3.303	0.000	270401.109
13	0.714		75.076		29160296.750

1	163.300	377.327	78.758	456.086	0.000
2	202419.12	38.906	33.733	152.100	402.808
3	4.791	41.766	33.440	1908.425	6704.206
4	443.818	165.333	38.809	135902.152	28106.851
5	1.699	70.623	4.329	134628.133	27904.784
6	697.817	0.000	0.000	134778.133	28129.784
7	7926.485	0.285	0.510	134778.133	29019.252
8	25457.419	0.998	44.995	135145.133	29067.252
9	0.000	320.173	253.876	57842.193	13212.070
10	-2.330	285.673	2618.267	0.000	0.000
11	233.331	377.139	298.633	0.000	2498.346
12	0.905	3.071	3.394	0.000	270337.383
13	0.749		75.127		29179748.000

TABLE AP 5-5 (Sheet 2 of 5)
PREDICTED S-IVB-502 PROPULSION SYSTEM PERFORMANCE (SECOND BURN)
COMPUTER PROGRAM AA89

1	163,600	377,808	78,763	456,570	-0,000
2	202418,33	38,900	33,747	152,080	402,748
3	4,797	41,770	33,447	1907,893	6702,371
4	443,345	165,333	38,809	135864,607	28098,674
5	1,699	70,623	4,329	134590,375	27896,913
6	697,815	0,000	0,000	134740,375	28121,913
7	7936,596	0,285	0,510	134740,375	29011,325
8	25458,647	1,026	44,995	135107,375	29059,325
9	0,000	320,173	253,927	57879,951	13219,946
10	-2,328	285,673	2618,267	0,000	0,000
11	233,302	377,168	298,684	0,000	2498,346
12	0,906	3,075	3,394	0,000	270311,699
13	0,749		75,178		29199989,750

1	163,800	378,756	78,771	437,527	-0,001
2	202412,14	38,887	33,773	152,039	402,625
3	4,808	41,748	33,474	1906,826	6698,688
4	442,404	165,334	38,809	135789,379	28082,313
5	1,699	70,622	4,329	134514,715	27881,168
6	697,799	0,000	0,000	134664,715	28106,168
7	7936,773	0,285	0,510	134664,715	28995,470
8	25460,887	1,083	44,995	135031,715	29043,470
9	0,000	320,173	254,029	57955,611	13235,700
10	-2,325	285,673	2618,267	0,000	0,000
11	233,245	377,225	298,786	0,000	2498,346
12	0,908	3,083	3,394	0,000	270220,184
13	0,749		75,280		29240472,500

1	164,000	380,233	78,779	439,012	-0,007
2	202400,67	38,875	33,800	151,997	402,502
3	4,827	41,722	33,500	1905,756	6695,004
4	440,949	165,334	38,809	135713,926	28065,950
5	1,699	70,622	4,329	134438,828	27865,423
6	697,766	0,000	0,000	134588,828	28090,423
7	7988,217	0,285	0,510	134588,828	28979,612
8	25462,821	1,140	44,995	134955,828	29027,612
9	0,000	320,173	254,131	58031,498	13251,455
10	-2,322	285,673	2618,267	0,000	0,000
11	233,188	377,282	298,888	0,000	2498,346
12	0,912	3,095	3,395	0,000	270128,438
13	0,749		75,382		29280954,000

1	164,200	381,914	78,784	460,698	-0,024
2	202377,36	38,862	33,827	151,955	402,379
3	4,848	41,693	33,527	1904,681	6691,320
4	439,284	165,335	38,809	135638,139	28049,586
5	1,699	70,622	4,329	134362,607	27849,675
6	697,699	0,000	0,000	134512,607	28074,675
7	8024,333	0,285	0,510	134512,607	28963,753
8	25464,046	1,197	44,995	134879,607	29011,753
9	0,000	320,173	254,233	58107,719	13267,213
10	-2,319	285,673	2618,267	0,000	0,000
11	233,131	377,339	298,990	0,000	2498,346
12	0,916	3,109	3,395	0,000	270036,359
13	0,749		75,484		29321432,250

1	164,400	383,548	78,787	462,335	-0,059
2	202334,16	38,850	33,853	151,914	402,256
3	4,868	41,664	33,553	1903,602	6687,636
4	437,636	165,335	38,810	135562,021	28033,221
5	1,698	70,622	4,329	134286,053	27833,927
6	697,574	0,000	0,000	134436,053	28058,927
7	8060,121	0,285	0,510	134436,053	28947,893
8	25464,073	1,254	44,995	134803,053	28995,893
9	0,000	320,173	254,335	58184,273	13282,971
10	-2,316	285,673	2618,267	0,000	0,000
11	233,074	377,396	299,092	0,000	2498,346
12	0,920	3,122	3,395	0,000	269943,945
13	0,750		75,586		29361905,250

1	164,600	385,429	78,784	464,214	-0,119
2	202263,71	38,838	33,880	151,871	402,134
3	4,892	41,632	33,580	1902,518	6683,951
4	435,712	165,336	38,810	135485,574	28016,856
5	1,698	70,622	4,329	134209,166	27818,178
6	697,369	0,000	0,000	134359,166	28043,178
7	8102,015	0,285	0,510	134359,166	28932,033
8	25462,440	1,311	44,995	134726,166	28980,033
9	0,000	320,173	254,437	58261,160	13298,729
10	-2,313	285,673	2618,267	0,000	0,000
11	233,017	377,453	299,194	0,000	2498,346
12	0,924	3,138	3,394	0,000	269851,199
13	0,750		75,688		29402368,500

1	164,800	388,466	78,776	467,242	-0,210
2	202156,66	38,825	33,907	151,829	402,011
3	4,931	41,588	33,606	1901,426	6680,267
4	432,659	165,336	38,810	135408,609	28000,491
5	1,698	70,622	4,329	134131,760	27802,431
6	697,057	0,000	0,000	134281,760	28027,431
7	8169,461	0,285	0,510	134281,760	28916,174
8	25458,603	1,369	44,995	134648,760	28964,174
9	0,000	320,173	254,539	58338,566	13314,486
10	-2,311	285,673	2618,267	0,000	0,000
11	232,960	377,510	299,296	0,000	2498,346
12	0,932	3,163	3,394	0,000	269757,934
13	0,749		75,790		29442815,750

1	165,000	390,210	78,760	468,971	-0,338
2	202008,23	38,813	33,933	151,787	401,888
3	4,954	41,556	33,633	1900,327	6676,584
4	430,748	165,337	38,810	135331,129	27984,129
5	1,698	70,621	4,329	134053,834	27786,685
6	696,623	0,000	0,000	134203,834	28011,685
7	8211,098	0,285	0,510	134203,834	28900,316
8	25452,237	1,426	44,995	134570,834	28948,316
9	0,000	320,173	254,641	58416,492	13330,241
10	-2,309	285,673	2618,267	0,000	0,000
11	232,903	377,567	299,398	0,000	2498,346
12	0,937	3,178	3,393	0,000	269664,148
13	0,749		75,892		29483240,000

1	170,000	356,779	76,393	433,173	-16,186
2	187564,08	38,500	34,300	150,756	398,866
3	4,670	41,231	34,009	1873,835	6585,969
4	433,001	165,349	38,813	133463,094	27580,317
5	1,679	70,617	4,329	132175,055	27398,098
6	654,315	0,000	0,000	132325,055	27623,098
7	7974,384	0,286	0,510	132325,055	28508,940
8	24588,973	2,854	44,995	132692,055	28556,940
9	0,000	320,173	257,191	60295,271	13719,068
10	-2,233	285,673	2618,267	0,000	0,000
11	231,474	378,996	301,948	0,000	2498,346
12	0,910	2,965	3,258	0,000	267393,992
13	0,701		78,442		30462185,500

1	180,000	338,055	74,778	412,833	-27,700
2	178874,71	38,142	34,200	148,893	393,066
3	4,521	40,847	33,918	1825,891	6412,022
4	433,286	165,373	38,820	130106,832	26816,999
5	1,664	70,609	4,328	128774,780	26648,662
6	629,367	0,000	0,000	128924,780	26873,662
7	7843,870	0,364	0,510	128924,780	27753,926
8	24009,560	5,843	44,995	129291,780	27801,926
9	0,000	320,173	262,291	63695,546	14468,982
10	-2,001	285,673	2618,267	0,000	0,000
11	228,485	381,984	307,048	0,000	2498,346
12	0,899	2,846	3,166	0,000	263238,703
13	0,680		83,542		32262040,750

1	190,000	338,312	74,873	413,186	-27,700
2	178940,62	38,850	33,467	147,040	387,300
3	4,518	41,568	33,183	1778,196	6239,068
4	433,075	165,398	38,827	126771,446	26048,490
5	1,664	70,601	4,328	125392,895	25900,871
6	629,517	0,000	0,000	125542,895	26125,871
7	7844,518	0,402	0,510	125542,895	27000,556
8	24055,782	9,739	44,995	125909,895	27048,556
9	0,000	320,173	267,391	67077,432	15217,252
10	-1,746	285,673	2618,267	0,000	0,000
11	224,589	385,880	312,148	0,000	2498,346
12	0,898	2,847	3,172	0,000	259103,449
13	0,691		88,642		34051100,500

1	200,000	338,570	74,969	413,539	-27,700
2	179009,66	39,558	32,800	145,186	381,523
3	4,516	42,289	32,515	1730,454	6065,767
4	432,872	165,422	38,833	123413,626	25307,121
5	1,665	70,593	4,327	122008,433	25152,121
6	629,680	0,000	0,000	122158,433	25377,121
7	7845,208	0,406	0,510	122158,433	26246,227
8	24101,016	13,780	44,995	122525,433	26294,227
9	0,000	320,173	272,491	70461,894	15966,481
10	-1,570	285,673	2618,267	0,000	0,000
11	220,547	389,921	317,248	0,000	2498,346
12	0,897	2,848	3,177	0,000	254964,658
13	0,702		93,742		35840820,000

1	210,000	337,430	74,989	412,419	-27,700
2	178702,64	39,133	32,200	143,334	375,738
3	4,500	41,881	31,914	1682,792	5892,233
4	433,304	165,447	38,840	120077,370	24569,292
5	1,666	70,585	4,326	118630,354	24402,879
6	628,221	0,000	0,000	118780,354	24627,879
7	7835,520	0,291	0,510	118780,354	25491,405
8	24116,378	16,973	44,995	119147,354	25539,405
9	0,000	320,173	277,591	73839,972	16716,203
10	-1,393	285,673	2618,267	0,000	0,000
11	217,355	393,114	322,348	0,000	2498,346
12	0,894	2,841	3,179	0,000	250831,758
13	0,712		98,842		37629028,500

1	220,000	337,143	75,018	412,161	-27,700
2	178555,39	38,425	31,644	141,485	369,947
3	4,494	41,186	31,358	1635,191	5718,529
4	433,217	165,471	38,847	116724,131	23815,493
5	1,666	70,577	4,326	115257,439	23653,309
6	627,756	0,000	0,000	115407,439	23878,309
7	7834,150	0,291	0,510	115407,439	24736,256
8	24137,229	19,884	44,995	115774,439	24784,256
9	0,000	320,173	282,691	77212,887	17466,251
10	-1,184	285,673	2618,267	0,000	0,000
11	214,444	396,024	327,448	0,000	2498,346
12	0,893	2,839	3,181	0,000	246703,695
13	0,724		103,942		39415293,000

1	233,000	338,095	74,856	412,952	-27,700
2	178525,26	38,340	31,212	139,635	364,147
3	[illegible],517	41,108	30,930	1587,566	5544,552
4	433,315	165,496	38,853	113363,365	23080,232
5	1,665	70,569	4,325	111883,492	22903,267
6	627,949	0,000	0,000	112033,492	23128,267
7	7840,110	0,410	0,757	112033,492	23980,636
8	24175,041	23,215	44,995	112400,492	24028,636
9	0,000	320,173	288,161	80586,834	18216,402
10	-1,025	285,673	2618,267	0,000	0,000
11	211,112	399,356	332,918	0,000	2498,346
12	0,893	2,842	3,184	0,000	242574,127
13	0,736		109,412		41200712,500

1	240,000	338,400	74,951	413,351	-27,700
2	178650,11	39,190	31,271	137,779	358,324
3	4,515	41,974	30,987	1539,809	5369,882
4	432,199	165,520	38,860	109989,293	22327,498
5	1,665	70,561	4,325	108500,963	22152,214
6	628,315	0,000	0,000	108650,963	22377,214
7	7841,455	0,411	0,757	108650,963	23224,003
8	24206,587	27,324	44,995	109017,963	23272,003
9	0,000	320,173	295,731	83969,363	18965,464
10	-0,829	285,673	2618,267	0,000	0,000
11	207,004	403,464	340,488	0,000	2498,346
12	0,892	2,844	3,188	0,000	238434,965
13	0,749		116,982		42986568,000

1	250,000	337,979	75,043	413,022	-27,401
2	178698,77	39,473	31,329	135,924	352,495
3	4,504	42,278	31,045	1492,063	5195,027
4	432,662	165,548	38,867	106388,774	21590,351
5	1,666	70,553	4,325	105119,130	21400,438
6	627,935	0,000	0,000	105269,130	21625,438
7	7836,474	0,294	0,757	105269,130	22466,649
8	24236,016	31,029	44,995	105636,130	22514,649
9	0,000	320,173	303,301	87351,196	19715,249
10	-0,686	285,673	2618,267	0,000	0,000
11	203,298	407,169	348,058	0,000	2498,346
12	0,890	2,842	3,193	0,000	234295,777
13	0,763		124,552		44772809,000

1	260,000	346,368	76,146	422,514	-22,311
2	182632,92	38,907	31,388	134,048	346,615
3	4,549	41,750	31,091	1443,749	5018,638
4	432,253	165,576	38,873	103160,590	20829,716
5	1,672	70,544	4,324	101697,922	20642,067
6	639,463	0,000	0,000	101847,922	20867,067
7	7896,968	0,295	0,757	101847,922	21702,699
8	24630,962	33,975	44,995	102214,922	21750,699
9	0,000	320,173	310,871	90772,404	20471,628
10	-0,497	285,673	2618,267	0,000	0,000
11	200,352	410,115	355,628	0,000	2498,346
12	0,890	2,895	3,254	0,000	230110,619
13	0,794		132,122		46579382,500

TABLE AP 5-5 (Sheet 3 of 5)
PREDICTED S-IVB-502 PROPULSION SYSTEM PERFORMANCE (SECOND BURN)
COMPUTER PROGRAM AA89

1	270,000	354.963	76.740	431.702	-16.961
2	186407.12	38.340	31.457	132.123	340.672
3	4.626	41.216	31.160	1394.211	4840.367
4	431.796	165.603	38.880	99686.901	20075.580
5	1.678	70.535	4.324	98191.131	19875.711
6	650.324	0.000	0.000	98341.131	20100.711
7	7958.945	0.296	0.757	98341.131	20930.764
8	24842.527	36.927	44.995	98708.131	20978.764
9	0.000	320.173	318.441	94279.195	21235.994
10	-0.348	285.673	2618.267	0.000	0.000
11	197.400	413.067	363.198	0.000	2498.346
12	0.898	2.950	3.286	0.000	225831.895
13	0.825		139.692		48424635.500

1	280,000	363.799	77.375	441.174	-11.925
2	190029.50	38.378	31.529	130.152	334.682
3	4.702	41.281	31.229	1343.443	4660.676
4	430.736	165.631	38.887	96140.615	19301.609
5	1.682	70.528	4.324	94600.000	19103.296
6	661.660	0.000	0.000	94750.000	19328.296
7	8023.736	0.415	0.762	94750.000	20152.770
8	25072.375	40.303	44.995	95117.000	20200.770
9	0.000	320.173	326.034	97870.326	22006.395
10	-0.185	285.673	2618.267	0.000	0.000
11	194.024	416.442	370.791	0.000	2498.346
12	0.905	3.006	3.321	0.000	221462.770
13	0.858		147.285		50306003.500

1	290,000	372.736	78.201	450.938	-7.257
2	193937.74	39.322	31.600	128.129	328.637
3	4.766	42.258	31.295	1291.378	4479.354
4	430.077	165.659	38.893	92449.219	18526.453
5	1.687	70.522	4.324	90919.979	18323.895
6	673.110	0.000	0.000	91069.979	18548.895
7	8086.251	0.416	0.766	91069.979	19367.790
8	25369.415	44.457	44.995	91436.979	19415.790
9	0.000	320.173	333.674	101550.348	22783.735
10	-0.092	285.673	2618.267	0.000	0.000
11	189.869	420.597	378.431	0.000	2498.346
12	0.910	3.063	3.366	0.000	216997.768
13	0.894		154.925		52224498.500

1	300,000	379.340	78.766	458.105	-4.111
2	197002.16	39.504	31.733	126.061	322.531
3	4.816	42.475	31.427	1238.137	4296.199
4	430.037	165.687	38.900	88634.193	17743.217
5	1.693	70.515	4.324	87157.622	17536.839
6	681.567	0.000	0.000	87307.622	17761.839
7	8131.274	0.298	0.771	87307.622	18575.155
8	25570.030	47.968	44.995	87674.622	18623.155
9	0.000	320.173	341.360	105312.704	23568.683
10	-0.041	285.673	2618.267	0.000	0.000
11	186.359	424.107	386.117	0.000	2498.346
12	0.914	3.105	3.398	0.000	212442.775
13	0.927		162.611		54180051.500

1	310,000	385.377	79.252	464.630	-1.946
2	199586.11	39.177	31.867	123.958	316.399
3	4.863	42.177	31.559	1184.012	4112.242
4	429.559	165.714	38.917	84761.083	16955.044
5	1.696	70.509	4.323	83233.569	16744.545
6	689.136	0.000	0.000	83483.569	16969.545
7	8174.737	0.299	0.776	83483.569	17777.282
8	25746.570	50.951	44.995	83850.569	17825.282
9	0.000	320.173	349.093	109136.757	24358.823
10	-0.007	285.673	2618.267	0.000	0.000
11	183.376	427.090	393.850	0.000	2498.346
12	0.918	3.143	3.425	0.000	207820.850
13	0.960		170.343		56163155.500

1	320,000	389.112	79.565	468.677	-0.590
2	201180.35	38.850	32.000	121.829	310.233
3	4.891	41.879	31.692	1129.188	3927.280
4	429.251	165.749	38.933	80852.939	16159.055
5	1.698	70.502	4.322	79459.613	15948.138
6	693.805	0.000	0.000	79609.613	16173.138
7	8201.903	0.299	0.780	79609.613	16975.296
8	25860.618	53.938	44.995	79976.613	17023.296
9	0.000	320.173	356.873	113010.713	25153.029
10	0.029	285.673	2618.267	0.000	0.000
11	180.388	430.077	401.630	0.000	2498.346
12	0.920	3.167	3.442	0.000	203144.908
13	0.990		178.125		58167585.000

1	330,000	392.732	79.867	472.599	0.578
2	202726.15	38.523	32.171	119.680	304.042
3	4.917	41.582	31.864	1073.878	3741.570
4	428.960	165.784	38.950	76927.662	15364.635
5	1.700	70.494	4.322	75551.903	15148.821
6	698.334	0.000	0.000	75701.903	15373.821
7	8228.290	0.299	0.783	75701.903	16170.400
8	25970.077	56.929	44.995	76068.903	16218.400
9	0.000	320.173	364.699	116918.423	25950.098
10	0.053	285.673	2618.267	0.000	0.000
11	177.397	433.068	409.456	0.000	2498.346
12	0.922	3.190	3.458	0.000	198432.303
13	1.022		185.951		60186423.000

1	340,000	395.650	80.112	475.763	1.421
2	203976.00	38.196	32.343	117.419	297.827
3	4.939	41.283	32.036	1018.045	3555.153
4	428.735	165.820	38.967	72984.712	14563.422
5	1.701	70.487	4.321	71609.204	14346.588
6	701.999	0.000	0.000	71759.204	14571.588
7	8249.750	0.300	0.785	71759.204	15362.588
8	26057.934	59.925	44.995	72126.204	15410.588
9	0.000	320.173	372.549	120861.122	26750.060
10	0.084	285.673	2618.267	0.000	0.000
11	174.401	436.063	417.306	0.000	2498.346
12	0.924	3.209	3.471	0.000	193681.791
13	1.053		193.801		62220224.000

1	350,000	399.852	80.422	480.273	2.297
2	205558.99	38.378	32.514	115.125	291.590
3	4.972	41.489	32.208	961.714	3368.047
4	428.004	165.856	38.983	68978.975	13767.125
5	1.702	70.482	4.321	67633.878	13541.749
6	707.165	0.000	0.000	67783.878	13766.749
7	8281.587	0.420	0.785	67783.878	14552.170
8	26170.383	63.344	44.995	68150.878	14600.170
9	0.000	320.173	380.399	124836.448	27552.628
10	0.072	285.673	2618.267	0.000	0.000
11	170.982	439.483	425.156	0.000	2498.346
12	0.928	3.235	3.488	0.000	188896.047
13	1.088		201.651		64267247.000

1	360,000	399.786	80.440	480.226	2.182
2	205527.29	39.322	32.662	112.742	285.335
3	4.970	42.458	32.359	904.989	3180.441
4	427.980	165.891	39.000	64876.400	12959.064
5	1.702	70.477	4.320	63631.367	12734.845
6	707.074	0.000	0.000	63781.367	12959.845
7	8280.290	0.420	0.785	63781.367	13739.687
8	26176.906	67.544	44.995	64148.367	13787.687
9	0.000	320.173	388.249	128838.999	28357.261
10	0.041	285.673	2618.267	0.000	0.000
11	166.782	443.683	433.006	0.000	2498.346
12	0.927	3.235	3.488	0.000	184081.053
13	1.117		209.501		66324477.500

1	370,000	396.353	80.228	476.582	1.492
2	204271.49	39.535	32.787	110.338	279.095
3	4.940	42.698	32.488	848.563	2993.252
4	428.618	165.930	39.022	60802.418	12160.026
5	1.702	70.472	4.319	59649.986	11929.177
6	702.869	0.000	0.000	59799.986	12154.177
7	8254.059	0.300	0.785	59799.986	12928.440
8	26101.628	71.084	44.995	60166.986	12976.440
9	0.000	320.173	396.099	132820.340	29160.659
10	0.001	285.673	2618.267	0.000	0.000
11	163.242	447.223	440.856	0.000	2498.346
12	0.924	3.213	3.477	0.000	179288.424
13	1.139		217.351		68373806.000

1	380,000	394.334	80.099	474.432	0.986
2	203412.60	39.261	32.912	107.877	272.868
3	4.923	42.444	32.616	792.603	2806.460
4	428.750	165.980	39.044	56862.994	11348.587
5	1.701	70.465	4.318	55700.371	11125.542
6	700.351	0.000	0.000	55850.371	11350.542
7	8240.465	0.300	0.785	55850.371	12119.226
8	26037.367	74.085	44.995	56217.371	12167.226
9	0.000	320.173	403.949	136769.955	29962.023
10	0.060	285.673	2618.267	0.000	0.000
11	160.241	450.223	448.706	0.000	2498.346
12	0.922	3.200	3.469	0.000	174529.596
13	1.165		225.201		70410543.000

1	390,000	396.777	80.291	477.068	1.701
2	204454.65	38.987	33.028	105.365	266.635
3	4.942	42.192	32.735	736.577	2619.497
4	428.565	166.030	39.067	52904.785	10547.896
5	1.702	70.457	4.317	51746.974	10321.471
6	703.403	0.000	0.000	51896.974	10546.471
7	8258.563	0.300	0.785	51896.974	11309.577
8	26129.070	77.086	44.995	52263.974	11357.577
9	0.000	320.173	411.799	140723.352	30763.823
10	0.083	285.673	2618.267	0.000	0.000
11	157.239	453.224	456.556	0.000	2498.346
12	0.924	3.216	3.480	0.000	169766.549
13	1.204		233.050		72448901.000

1	400,000	399.629	80.510	480.139	2.324
2	205667.99	38.713	33.123	102.740	260.383
3	4.964	41.938	32.832	680.139	2431.968
4	428.351	166.080	39.089	48916.003	9736.984
5	1.704	70.450	4.317	47765.682	9515.242
6	706.955	0.000	0.000	47915.682	9740.242
7	8279.553	0.300	0.785	47915.682	10497.769
8	26210.862	80.087	44.995	48282.682	10545.769
9	0.000	320.173	419.649	144704.645	31567.780
10	0.116	285.673	2618.267	0.000	0.000
11	154.238	456.225	464.406	0.000	2498.346
12	0.926	3.234	3.492	0.000	164973.449
13	1.247		240.900		74499141.000

1	410,000	402.410	80.717	483.128	3.325
2	206847.75	38.439	33.217	100.036	254.115
3	4.985	41.681	32.929	623.233	2243.950
4	428.143	166.131	39.116	44924.931	8940.202
5	1.705	70.446	4.315	43754.554	8706.745
6	710.408	0.000	0.000	43904.554	8931.745
7	8300.027	0.299	0.785	43904.554	9683.692
8	26289.742	83.081	44.995	44271.554	9731.692
9	0.000	320.173	427.498	148715.771	32374.007
10	0.113	285.673	2618.267	0.000	0.000
11	151.244	459.219	472.256	0.000	2498.346
12	0.928	3.252	3.504	0.000	160148.246
13	1.292		248.750		76562058.000

1	420.000	403.763	80.811	484.574	3.742
2	207418.37	38.165	33.311	97.174	247.837
3	4.996	41.416	33.027	566.070	2055.634
4	428.043	166.189	39.148	40914.716	8117.352
5	1.706	70.442	4.314	39725.109	7896.926
6	712.074	0.000	0.000	39875.109	8121.926
7	8310.388	0.298	0.785	39875.109	8868.294
8	26329.351	86.069	44.995	40242.109	8916.294
9	0.000	320.173	435.348	152745.217	33181.555
10	0.165	285.673	2618.267	0.000	0.000
11	148.256	462.206	480.105	0.000	2498.346
12	0.929	3.260	3.509	0.000	155303.402
13	1.336		256.600		78632721.000

1	430.000	408.895	81.163	490.058	4.730
2	209402.88	38.378	33.406	94.235	241.539
3	5.038	41.634	33.125	508.462	1866.707
4	427.302	166.246	39.180	36838.223	7301.033
5	1.707	70.438	4.313	35664.870	7084.969
6	718.406	0.000	0.000	35814.870	7309.969
7	8348.896	0.416	0.785	35814.870	8050.758
8	26462.954	89.462	44.995	36181.870	8098.758
9	0.000	320.173	443.198	156805.455	33991.241
10	0.168	285.673	2618.267	0.000	0.000
11	144.862	465.600	487.955	0.000	2498.346
12	0.933	3.292	3.528	0.000	150425.627
13	1.392		264.450		80715788.000

1	440,000	410.650	81.283	491.933	5.066
2	210138.95	39.322	33.500	91.046	235.216
3	5.052	42.573	33.224	450.293	1677.036
4	427.170	166.310	39.212	32695.379	6475.432
5	1.708	70.432	4.311	31565.007	6270.304
6	720.556	0.000	0.000	31715.007	6495.304
7	8360.715	0.415	0.785	31715.007	7230.514
8	26512.116	93.614	[illegible]	32082.007	7278.514
9	0.000	320.173	[illegible]	160905.318	34803.635
10	0.160	285.673	2618.267	0.000	0.000
11	140.711	469.751	495.805	0.000	2498.346
12	0.934	3.304	3.535	0.000	145305.521
13	1.444		272.300		82814349.000

TABLE AP 5-5 (Sheet 4 of 5)
PREDICTED S-IVB-502 PROPULSION SYSTEM PERFORMANCE (SECOND BURN)
COMPUTER PROGRAM AA89

1	450.000	408.182	81.117	489.299	4.715
2	209288.42	39.526	33.567	87.715	228.906
3	5.032	42.765	33.298	392.139	1487.264
4	427.731	166.385	39.244	28489.121	5665.620
5	1.708	70.424	4.310	27466.140	5455.674
6	717.532	0.000	0.000	27616.140	5680.674
7	8341.657	0.296	0.785	27616.140	6410.306
8	26457.053	97.342	44.995	27983.140	6458.306
9	0.000	320.173	458.898	165004.186	35615.994
10	0.081	285.673	2618.267	0.000	0.000
11	136.982	473.479	503.655	0.000	2498.346
12	0.932	3.288	3.527	0.000	140586.445
13	1.489		280.150		84913524.000

1	460.000	402.615	80.704	483.320	3.397
2	206903.70	39.237	33.633	84.257	222.640
3	4.989	42.444	33.272	334.629	1298.127
4	428.089	166.460	39.276	24348.614	4827.724
5	1.705	70.418	4.309	23413.815	4644.440
6	710.536	0.000	0.000	23563.815	4869.440
7	8303.095	0.294	0.785	23563.815	5593.493
8	26315.266	100.291	44.995	23930.815	5641.493
9	0.000	320.173	466.748	169056.512	36424.957
10	0.106	285.673	2618.267	0.000	0.000
11	134.033	476.429	511.505	0.000	2498.346
12	0.928	3.252	3.504	0.000	135717.307
13	1.525		288.000		86993696.000

1	470.000	401.914	80.652	482.565	3.269
2	206602.21	38.947	33.700	80.474	216.313
3	4.983	42.103	33.445	277.568	1109.431
4	428.133	166.538	39.308	20269.156	4013.701
5	1.705	70.411	4.308	19393.744	3835.569
6	709.644	0.000	0.000	19543.744	4060.569
7	8299.148	0.292	0.785	19543.744	4779.043
8	26302.692	103.225	44.995	19910.744	4827.043
9	0.000	320.173	474.598	173076.582	37231.557
10	0.101	285.673	2618.267	0.000	0.000
11	131.099	479.362	519.355	0.000	2498.346
12	0.927	3.248	3.502	0.000	130882.786
13	1.579		295.850		89060078.000

1	480.000	401.993	80.654	482.648	3.359
2	206632.47	38.658	33.767	76.345	209.361
3	4.984	41.736	33.516	220.534	920.672
4	428.123	166.629	39.340	16119.064	3179.231
5	1.705	70.401	4.306	15375.847	3026.884
6	709.725	0.000	0.000	15525.847	3251.884
7	8300.903	0.290	0.785	15525.847	3964.778
8	26310.206	106.139	44.995	15892.847	4012.778
9	0.000	320.173	482.448	177094.479	38037.972
10	0.112	285.673	2618.267	0.000	0.000
11	128.185	482.276	527.205	0.000	2498.346
12	0.927	3.248	3.502	0.000	126050.625
13	1.639		303.699		91125498.000

1	490.000	402.188	80.665	482.854	3.478
2	206711.53	38.400	33.833	71.709	201.548
3	4.986	41.359	33.583	163.432	731.718
4	428.104	166.720	39.372	11965.802	2347.116
5	1.705	70.392	4.305	11354.227	2217.963
6	709.948	0.000	0.000	11504.227	2442.963
7	8303.486	0.288	0.785	11504.227	3150.278
8	26320.673	109.032	44.995	11871.227	3198.278
9	0.000	320.173	490.298	181116.098	38844.622
10	0.116	285.673	2618.267	0.000	0.000
11	125.292	485.169	535.055	0.000	2498.346
12	0.928	3.249	3.503	0.000	121214.506
13	1.705		311.549		93192471.000

1	500.000	401.880	80.640	482.520	3.464
2	206576.89	38.150	33.900	66.251	192.324
3	4.984	40.920	33.645	105.311	542.662
4	428.121	166.811	39.404	7735.353	1523.817
5	1.705	70.382	4.304	7332.411	1409.059
6	709.544	0.000	0.000	7482.411	1634.059
7	8302.562	0.286	0.785	7482.411	2335.795
8	26318.419	111.903	44.995	7849.411	2383.795
9	0.000	320.173	498.147	185137.914	39651.255
10	0.058	285.673	2618.267	0.000	0.000
11	122.421	488.040	542.904	0.000	2498.346
12	0.927	3.247	3.502	0.000	116378.206
13	1.775		319.399		95259488.000

1	510.000	397.655	80.333	477.988	2.346
2	204776.03	38.340	33.967	59.292	180.984
3	4.950	40.794	33.697	49.496	353.889
4	428.413	166.902	39.436	3497.715	692.875
5	1.703	70.372	4.303	3333.148	601.794
6	704.257	0.000	0.000	3483.148	826.794
7	8273.430	0.284	0.785	3483.148	1522.952
8	26214.847	114.751	44.995	3850.148	1570.952
9	0.000	320.173	505.997	189137.178	40456.248
10	0.017	285.673	2618.267	0.000	0.000
11	119.573	490.888	550.754	0.000	2498.346
12	0.924	3.220	3.485	0.000	111566.100
13	1.835		327.249		97316889.000

1	518.378	393.851	80.052	473.903	1.333
2	203150.54	39.052	34.023	47.838	168.437
3	4.920	40.792	33.725	2.384	196.276
4	428.675	166.978	39.463	19.817	-34.393
5	1.701	70.364	4.303	17.716	-71.932
6	699.485	0.000	0.000	167.716	153.068
7	8247.011	0.282	0.785	167.716	844.552
8	26120.105	117.120	44.995	534.716	892.552
9	0.000	320.173	512.574	192452.609	41128.072
10	0.096	285.673	2618.267	0.000	0.000
11	117.204	493.256	557.331	0.000	2498.346
12	0.921	3.196	3.470	0.000	107572.268
13	1.889		333.825		99025547.000

1	518.450	391.580	80.052	471.632	1.329
2	203150.79	39.058	34.023	47.835	168.435
3	4.892	40.820	33.726	1.980	194.918
4	430.740	166.979	39.463	-8.581	-40.201
5	1.701	70.364	4.303	-10.677	-77.736
6	688.376	0.000	0.000	139.323	147.264
7	7438.655	0.282	0.785	139.323	838.707
8	25746.498	117.140	44.995	506.323	886.707
9	0.000	320.173	512.630	192481.002	41133.860
10	0.097	285.673	2618.267	0.000	0.000
11	117.183	493.277	557.387	0.000	2498.346
12	0.890	3.107	3.492	0.000	107538.029
13	1.889		333.882		99040234.000

1	518.478	391.580	80.001	471.582	1.328
2	204161.87	39.061	34.023	47.579	168.312
3	4.895	40.804	33.726	1.826	194.398
4	432.930	166.979	39.463	-19.782	-42.684
5	1.701	70.364	4.303	-21.524	-79.960
6	691.802	0.000	0.000	128.476	145.040
7	7438.658	0.282	0.785	128.476	836.468
8	25730.062	117.148	44.995	495.476	884.468
9	0.000	320.173	512.652	192491.850	41136.077
10	0.097	285.673	2618.267	0.000	0.000
11	117.175	493.285	557.409	0.000	2498.346
12	0.890	3.107	3.490	0.000	107524.943
13	1.899		333.904		99045861.000

1	518.578	337.449	68.572	406.021	1.323
2	176035.75	39.069	34.024	47.481	168.265
3	4.921	41.317	34.020	1.294	192.605
4	433.563	166.980	39.463	-57.321	-50.433
5	1.701	70.364	4.303	-58.927	-87.610
6	596.497	0.000	0.000	91.073	137.390
7	6410.358	0.282	0.785	91.073	828.763
8	22054.222	117.176	44.995	458.073	876.763
9	0.000	320.173	512.731	192529.252	41143.704
10	0.098	285.673	2618.267	0.000	0.000
11	117.147	493.313	557.488	0.000	2498.346
12	0.895	2.677	2.991	0.000	107479.836
13	1.638		333.982		99065362.000

1	518.678	206.875	38.201	245.075	1.318
2	107686.82	39.078	34.025	47.014	168.102
3	5.415	41.678	34.425	0.906	191.295
4	439.403	166.981	39.464	-85.122	-56.303
5	1.701	70.364	4.303	-86.261	-93.137
6	364.897	0.000	0.000	63.739	131.863
7	3929.900	0.282	0.785	63.739	823.179
8	12286.073	117.205	44.995	430.739	871.179
9	0.000	320.173	512.809	192556.586	41149.209
10	0.099	285.673	2618.267	0.000	0.000
11	117.119	493.341	557.566	0.000	2498.346
12	0.985	1.641	1.666	0.000	107446.918
13	1.002		334.061		99079628.000

1	518.778	78.699	9.907	88.606	1.313
2	40998.08	39.086	34.025	46.650	167.984
3	7.944	40.913	34.428	0.709	190.732
4	462.703	166.982	39.464	-99.330	-58.900
5	1.701	70.364	4.303	-100.126	-95.486
6	138.922	0.000	0.000	49.874	129.514
7	1495.003	0.282	0.785	49.874	820.775
8	3186.204	117.233	44.995	416.874	868.775
9	0.000	320.173	512.888	192570.451	41151.535
10	0.098	285.673	2618.267	0.000	0.000
11	117.091	493.369	557.645	0.000	2498.346
12	1.445	0.624	0.432	0.000	107430.648
13	0.382		334.139		99086825.000

1	518.878	33.796	0.000	33.796	1.310
2	16816.40	39.095	34.026	46.465	167.934
3	0.000	39.802	34.185	0.641	190.655
4	497.588	166.983	39.464	-104.302	-59.808
5	1.701	70.364	4.303	-104.926	-95.787
6	56.982	0.000	0.000	45.074	129.213
7	642.004	0.282	0.785	45.074	820.418
8	0.000	117.261	44.995	412.074	868.418
9	0.000	320.173	512.966	192575.252	41151.813
10	0.097	285.673	2618.267	0.000	0.000
11	117.063	493.397	557.723	0.000	2498.346
12	0.000	0.268	0.000	0.000	107425.492
13	0.157		334.218		99089333.000

1	518.978	24.944	4.984	29.928	1.306
2	12222.71	39.103	34.027	46.388	167.927
3	5.005	39.391	34.088	0.600	190.533
4	408.403	166.983	39.465	-107.236	-59.809
5	1.701	70.364	4.303	-107.799	-96.272
6	41.417	0.000	0.000	42.201	128.728
7	473.853	0.282	0.785	42.201	819.877
8	1602.917	117.289	44.995	409.201	867.877
9	0.000	320.173	513.045	192578.125	41152.276
10	0.096	285.673	2618.267	0.000	0.000
11	117.035	493.425	557.802	0.000	2498.346
12	0.910	0.198	0.217	0.000	107422.077
13	0.114		334.296		99090752.000

1	519.078	21.470	4.274	25.743	1.303
2	10421.31	39.112	34.027	46.314	167.915
3	5.024	39.320	34.072	0.567	190.410
4	404.818	166.984	39.465	-109.565	-60.314
5	1.701	70.363	4.303	-110.093	-96.752
6	35.313	0.000	0.000	39.907	128.248
7	407.847	0.282	0.785	39.907	819.341
8	1374.487	117.317	44.995	406.907	867.341
9	0.000	320.173	513.123	192580.418	41152.733
10	0.097	285.673	2618.267	0.000	0.000
11	117.006	493.454	557.880	0.000	2498.346
12	0.914	0.170	0.186	0.000	107419.248
13	0.097		334.375		99091870.000

1	519.178	19.648	3.901	23.549	1.301
2	9477.57	39.120	34.028	46.236	167.904
3	5.036	39.298	34.066	0.538	190.297
4	402.454	166.985	39.465	-111.648	-60.768
5	1.701	70.363	4.303	-112.147	-97.184
6	32.115	0.000	0.000	37.853	127.816
7	373.248	0.282	0.785	37.853	818.854
8	1254.700	117.345	44.995	404.853	866.854
9	0.000	320.173	513.202	192582.473	41153.142
10	0.097	285.673	2618.267	0.000	0.000
11	116.978	493.482	557.959	0.000	2498.346
12	0.916	0.156	0.170	0.000	107416.707
13	0.088		334.453		99092863.000

1	519.278	17.242	3.409	20.651	1.299
2	8229.14	39.129	34.029	46.203	167.894
3	5.058	39.291	34.063	0.512	190.194
4	398.481	166.986	39.466	-113.528	-61.180
5	1.701	70.363	4.303	-114.001	-97.574
6	27.884	0.000	0.000	35.999	127.426
7	327.540	0.282	0.785	35.999	818.408
8	1096.457	117.374	44.995	402.999	866.408
9	0.000	320.173	513.280	192584.326	41153.509
10	0.097	285.673	2618.267	0.000	0.000
11	116.950	493.510	558.037	0.000	2498.346
12	0.920	0.137	0.149	0.000	107414.406
13	0.077		334.532		99093733.000

TABLE AP 5-5 (Sheet 5 of 5)
PREDICTED S-IVB-502 PROPULSION SYSTEM PERFORMANCE (SECOND BURN)
COMPUTER PROGRAM AA89

1	519.378	13.653	2.675	16.329	1.297
2	6366.01	39.137	34.029	46.155	167.885
3	5.103	39.279	34.060	0.490	190.106
4	389.868	166.987	39.466	-115.104	-61.529
5	1.701	70.363	4.303	-115.534	-97.903
6	21.571	0.000	0.000	34.446	127.097
7	259.362	0.282	0.785	34.446	818.024
8	860.495	117.402	44.995	401.446	866.024
9	0.000	320.173	513.359	192585.879	41153.815
10	0.097	285.673	2618.267	0.000	0.000
11	116.922	493.538	558.116	0.000	2498.346
12	0.928	0.108	0.117	0.000	107412.469
13	0.059		334.610		99094487.000

1	519.478	9.641	1.855	11.497	1.296
2	4283.65	39.146	34.030	46.116	167.877
3	5.196	39.256	34.054	0.473	190.036
4	372.603	166.988	39.466	-116.286	-61.795
5	1.701	70.363	4.303	-116.717	-98.151
6	14.515	0.000	0.000	33.283	126.849
7	183.147	0.282	0.785	33.283	817.719
8	596.758	117.430	44.995	400.283	865.719
9	0.000	320.173	513.437	192587.043	41154.042
10	0.097	285.673	2618.267	0.000	0.000
11	116.894	493.566	558.194	0.000	2498.346
12	0.945	0.076	0.081	0.000	107411.002
13	0.040		334.689		99095018.000

1	519.578	6.487	1.211	7.697	1.296
2	2647.63	39.154	34.031	46.086	167.870
3	5.358	39.228	34.047	0.462	189.983
4	343.977	166.989	39.467	-117.096	-61.982
5	1.701	70.363	4.303	-117.512	-98.325
6	8.971	0.000	0.000	32.488	126.675
7	123.221	0.282	0.785	32.488	817.489
8	389.354	117.458	44.995	399.488	865.489
9	0.000	320.173	513.516	192587.838	41154.192
10	0.097	285.673	2618.267	0.000	0.000
11	116.866	493.594	558.273	0.000	2498.346
12	0.974	0.051	0.053	0.000	107409.978
13	0.025		334.767		99095358.000

1	519.678	4.481	0.800	5.281	1.296
2	1608.58	39.163	34.031	46.065	167.866
3	5.599	39.209	34.041	0.454	189.943
4	304.606	166.990	39.467	-117.650	-62.115
5	1.701	70.362	4.303	-118.056	-98.447
6	5.451	0.000	0.000	31.944	126.553
7	85.115	0.282	0.785	31.944	817.311
8	257.382	117.486	44.995	398.944	865.311
9	0.000	320.173	513.594	192588.381	41154.292
10	0.097	285.673	2618.267	0.000	0.000
11	116.837	493.622	558.351	0.000	2498.346
12	1.018	0.036	0.035	0.000	107409.255
13	0.015		334.846		99095568.000

1	519.778	0.000	0.000	0.000	1.296
2	0.00	39.171	34.032	46.051	167.862
3	0.000	39.199	34.038	0.430	189.914
4	0.000	166.991	39.467	-117.954	-62.194
5	1.701	70.362	4.303	-118.353	-98.519
6	0.000	0.000	0.000	31.647	126.481
7	0.000	0.282	0.785	31.647	817.184
8	0.000	117.514	44.995	398.647	865.184
9	0.000	320.173	513.673	192588.678	41154.341
10	0.097	285.673	2618.267	0.000	0.000
11	116.809	493.651	558.430	0.000	2498.346
12	0.000	0.000	0.000	0.000	107408.830
13	0.000		334.924		99095657.000

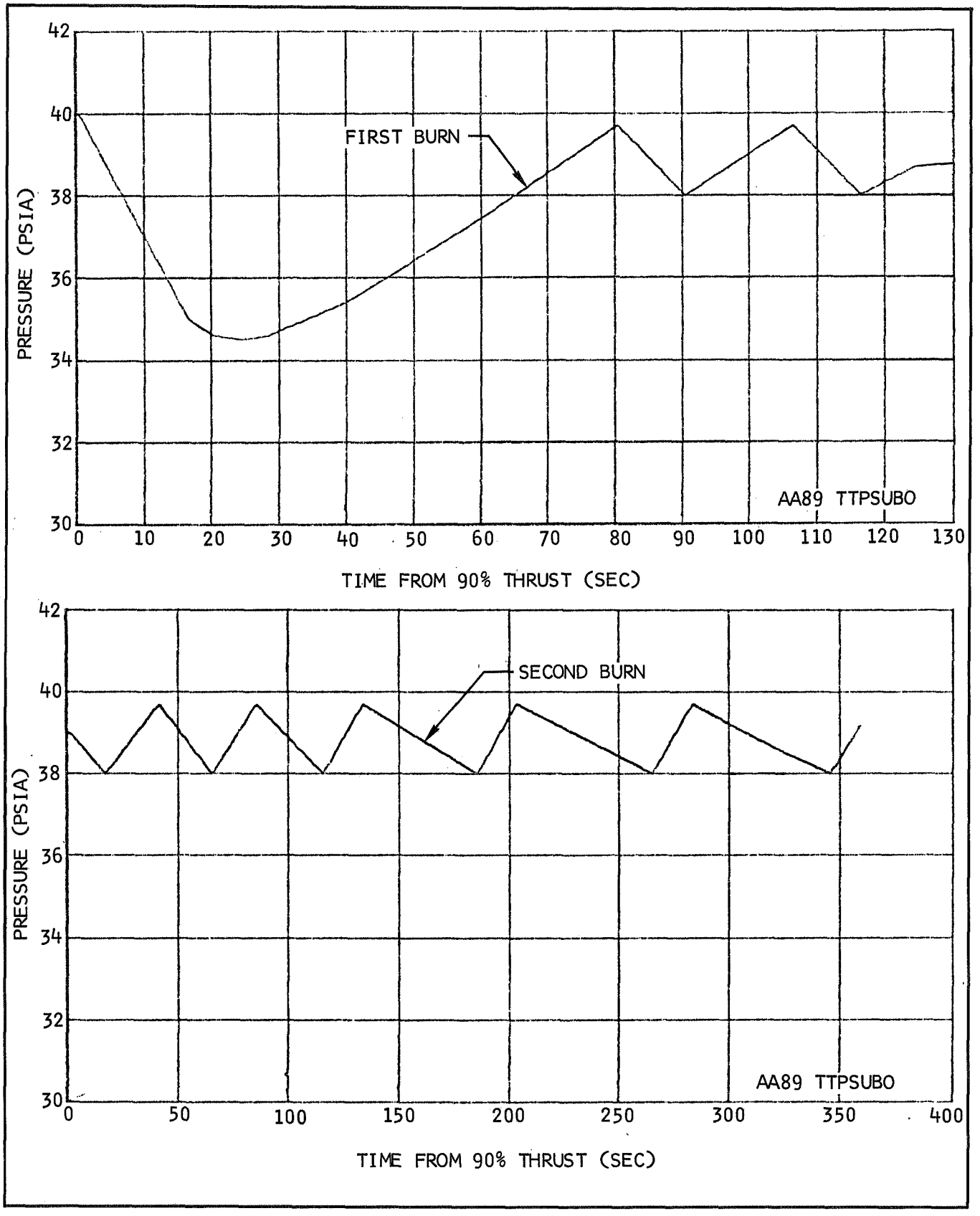


Figure AP 5-1. LOX Tank Ullage Pressures

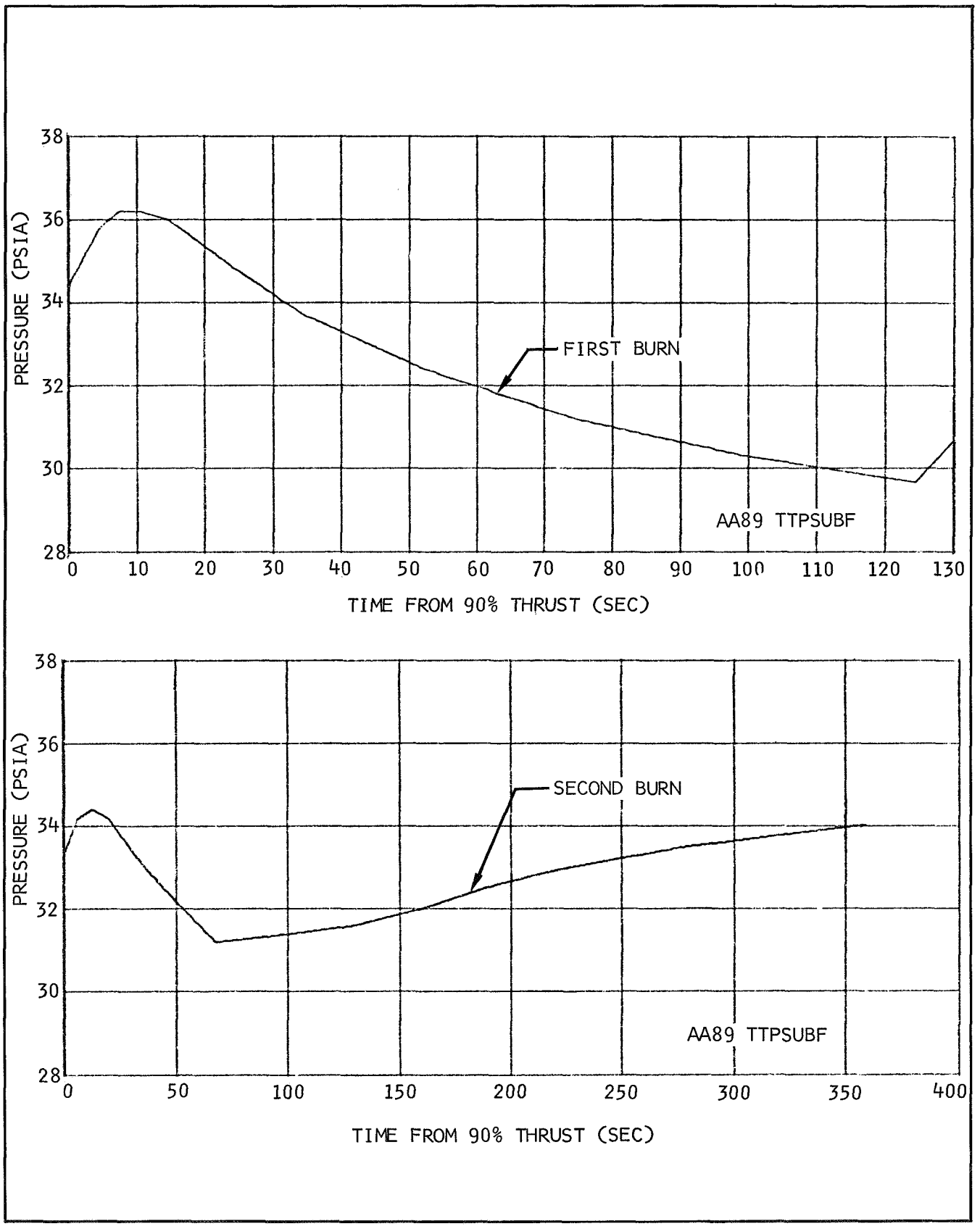


Figure AP 5-2. LH2 Tank Ullage Pressures

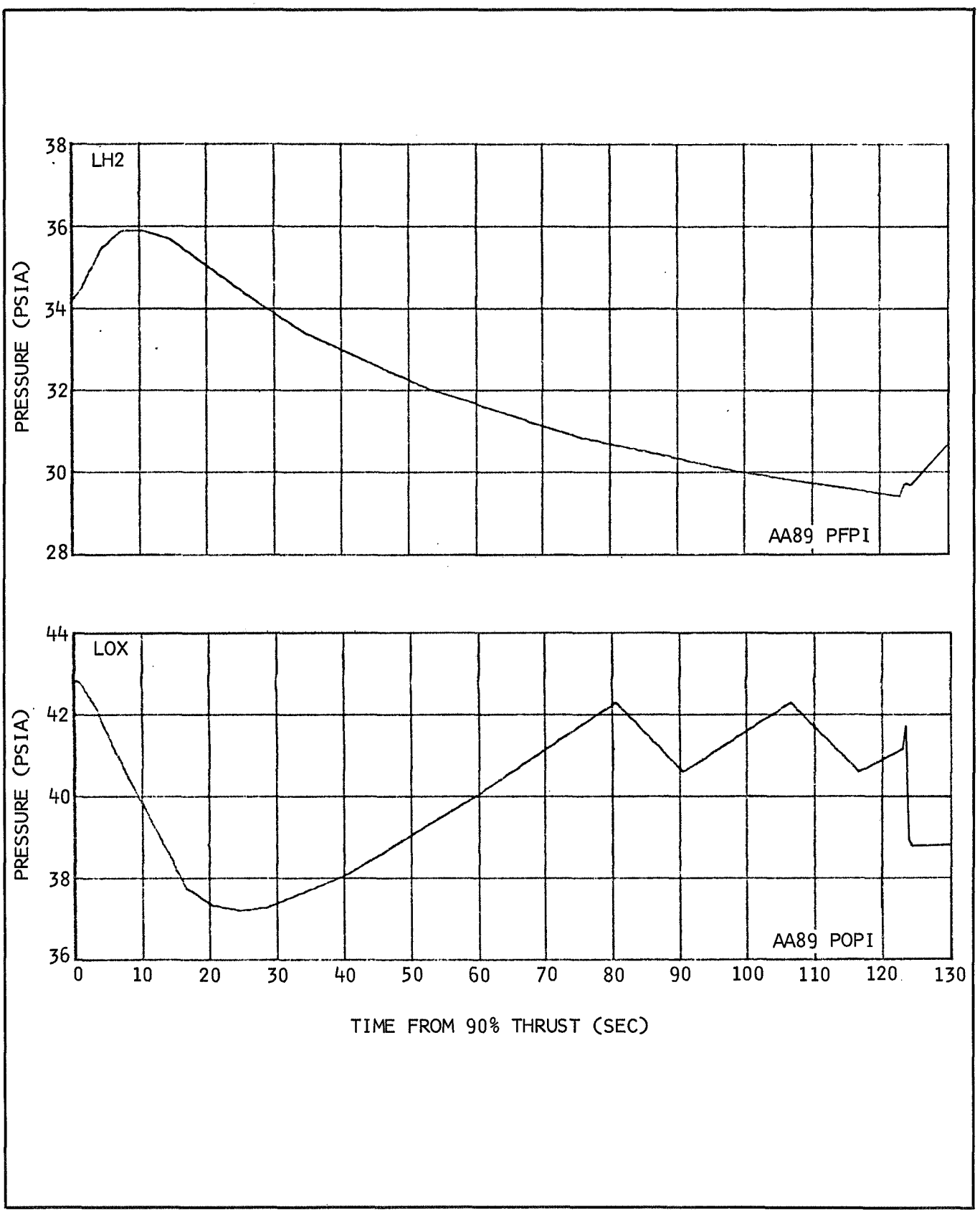


Figure AP 5-3. First Burn: LH2 and LOX Pump Inlet Pressures

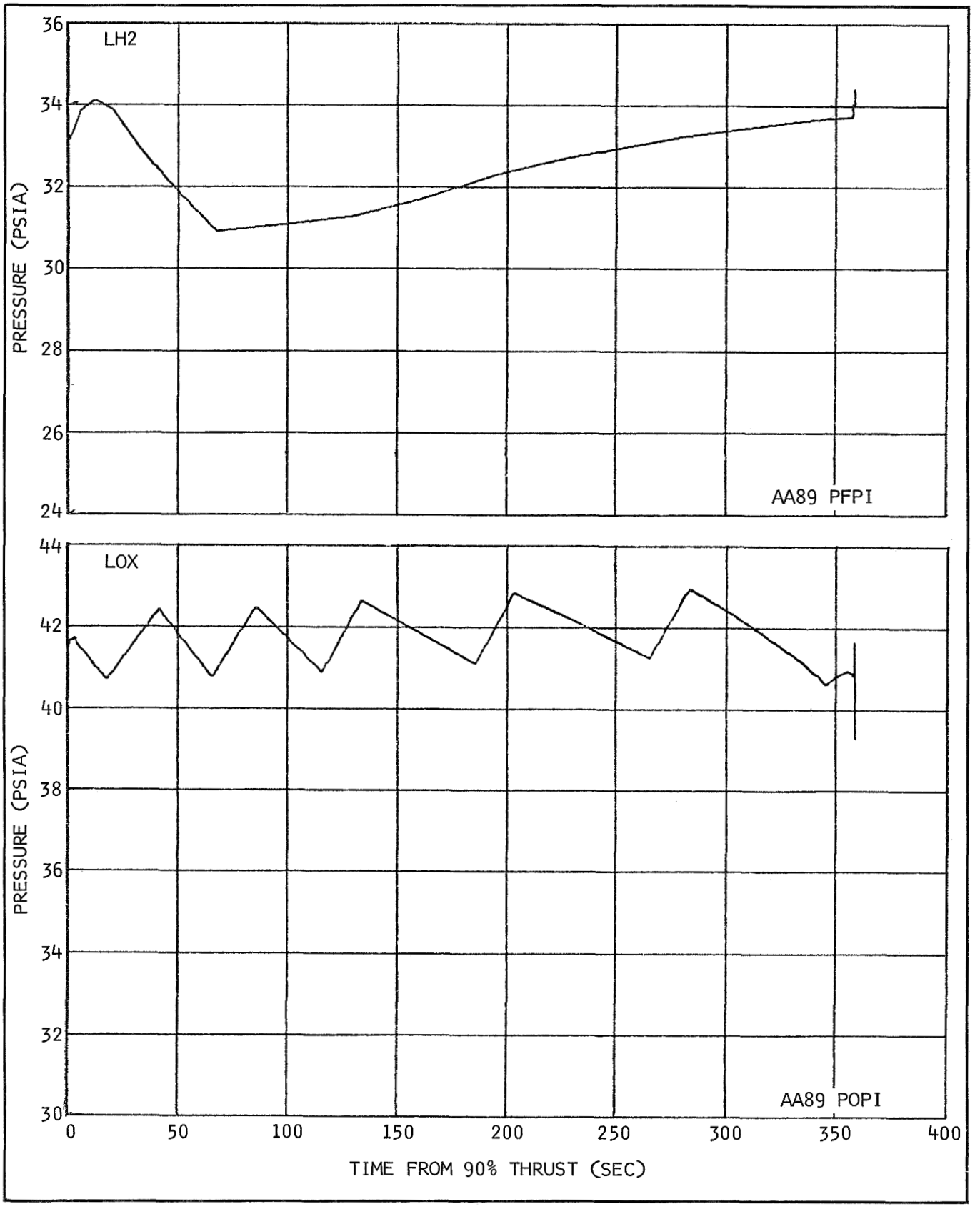


Figure AP 5-4. Second Burn: LH2 and LOX Pump Inlet Pressures

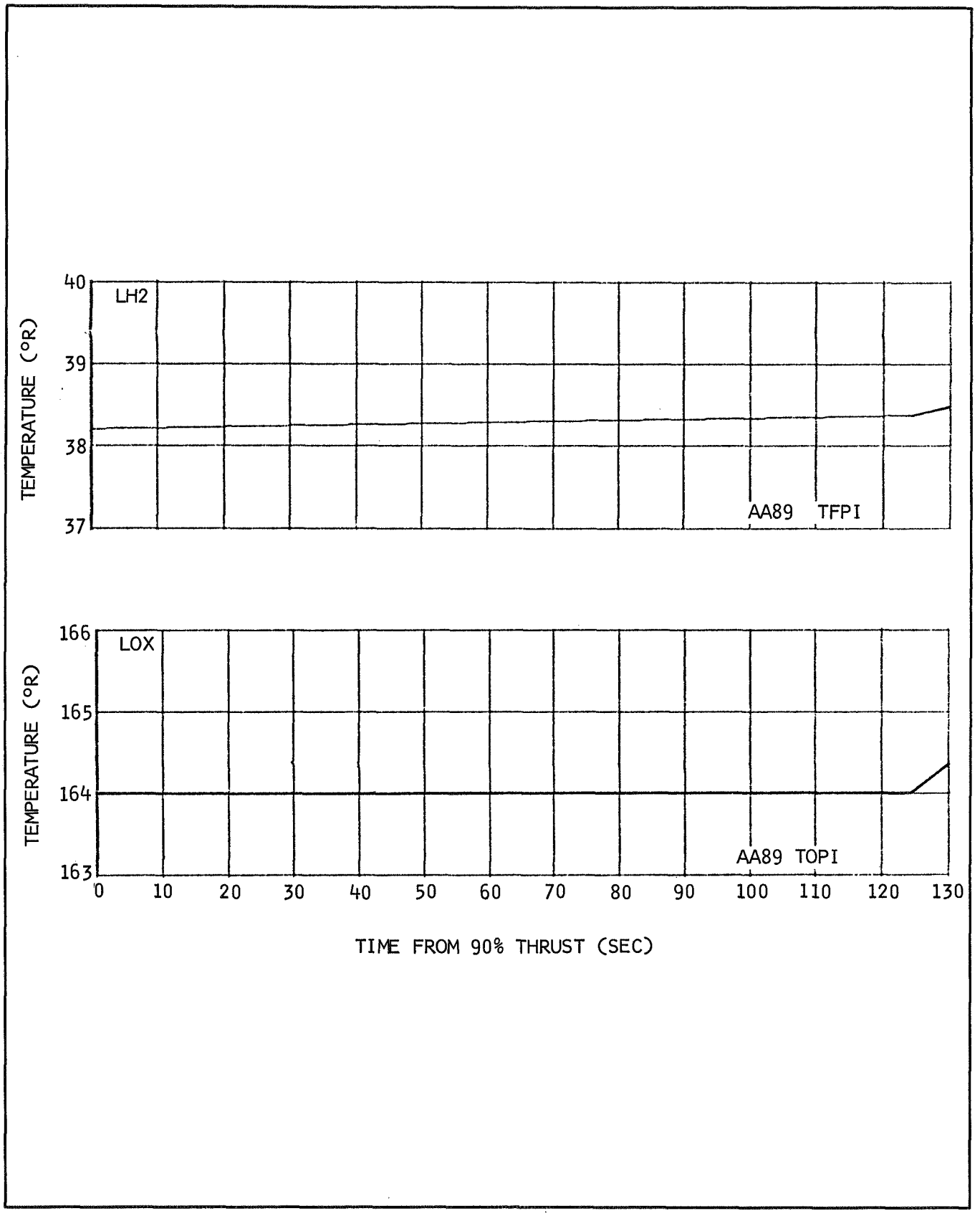


Figure AP 5-5. First Burn: LH2 and LOX Pump Inlet Temperatures

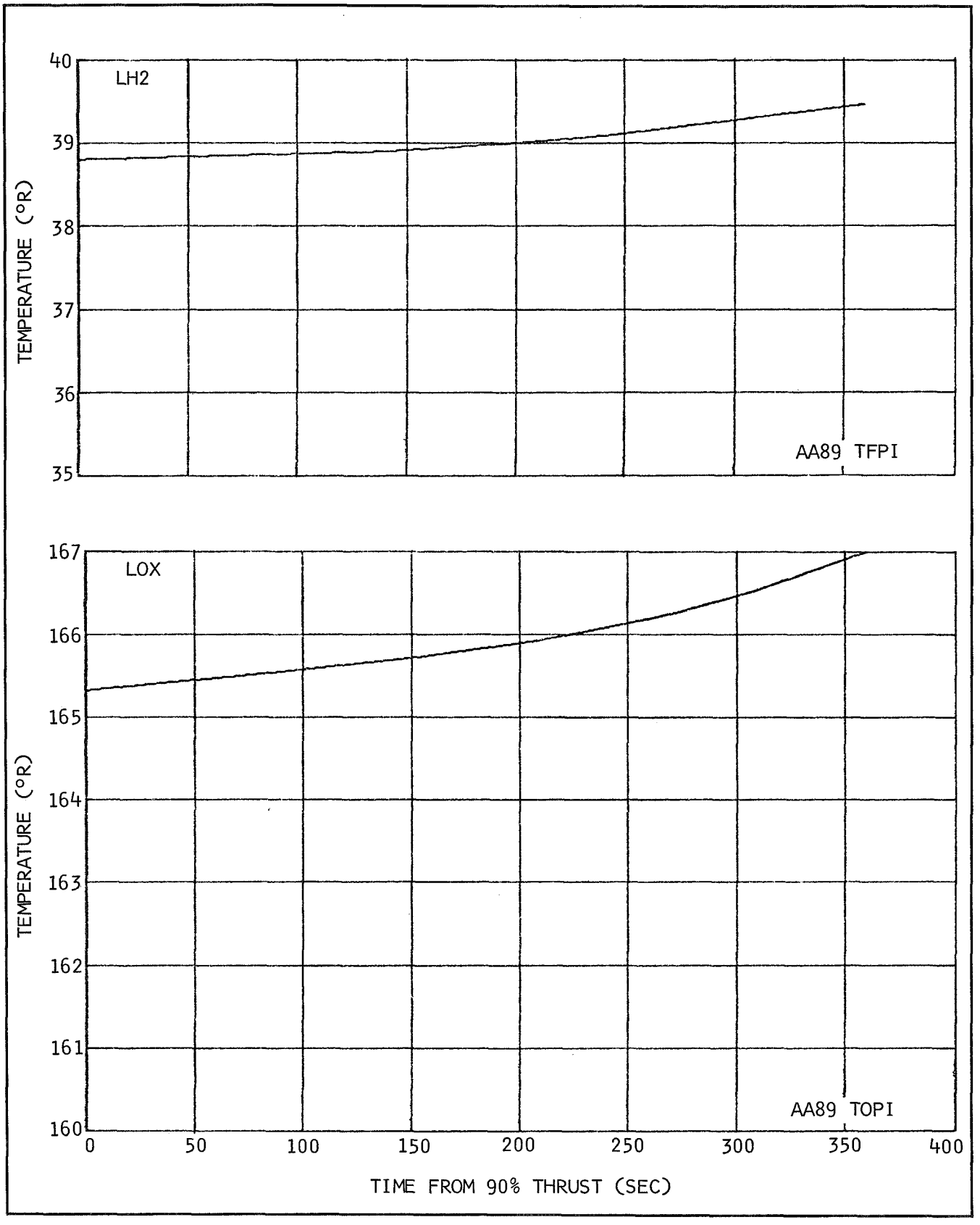


Figure AP 5-6. Second Burn: LH2 and LOX Pump Inlet Temperatures

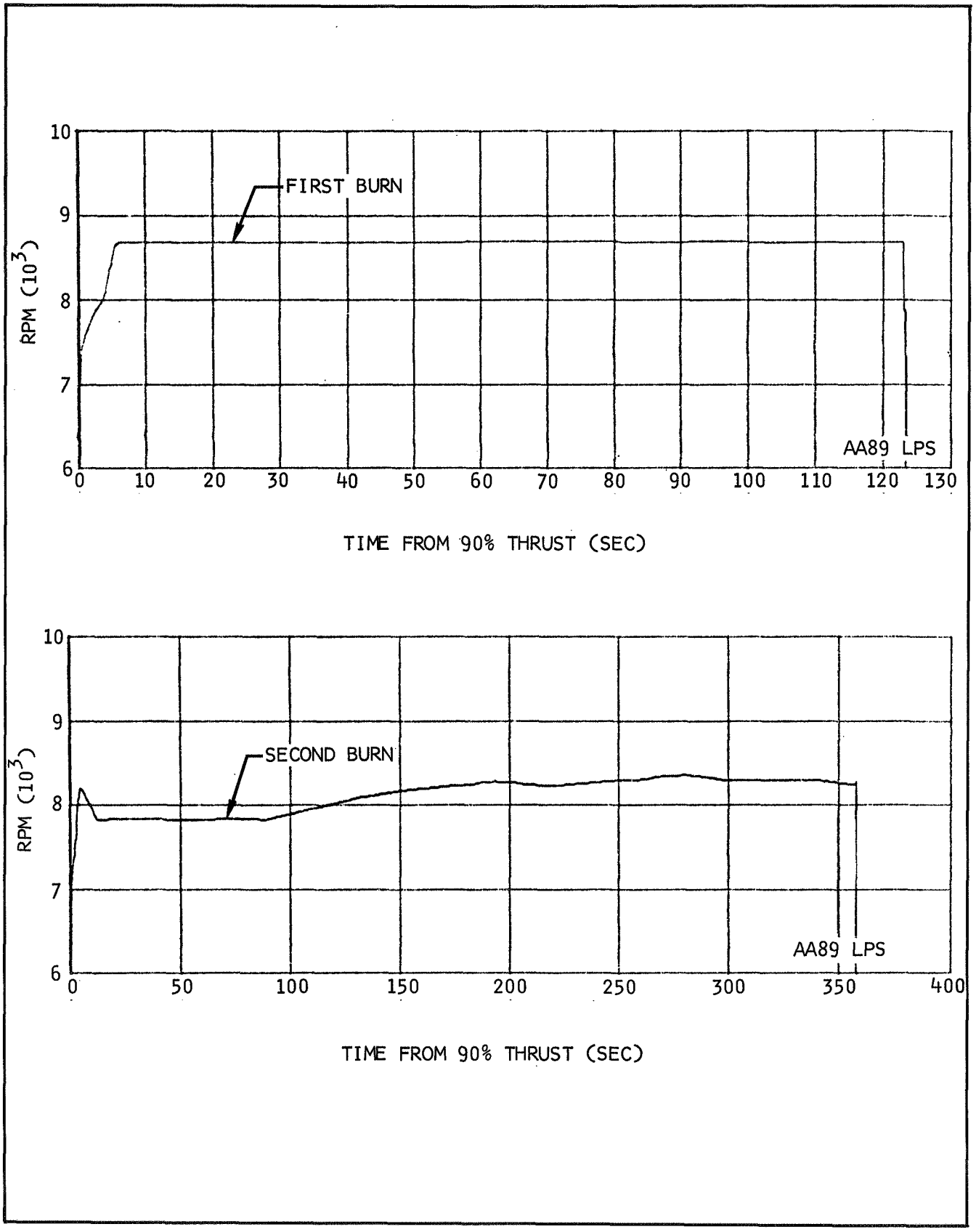


Figure AP 5-7. LOX Pump Speed

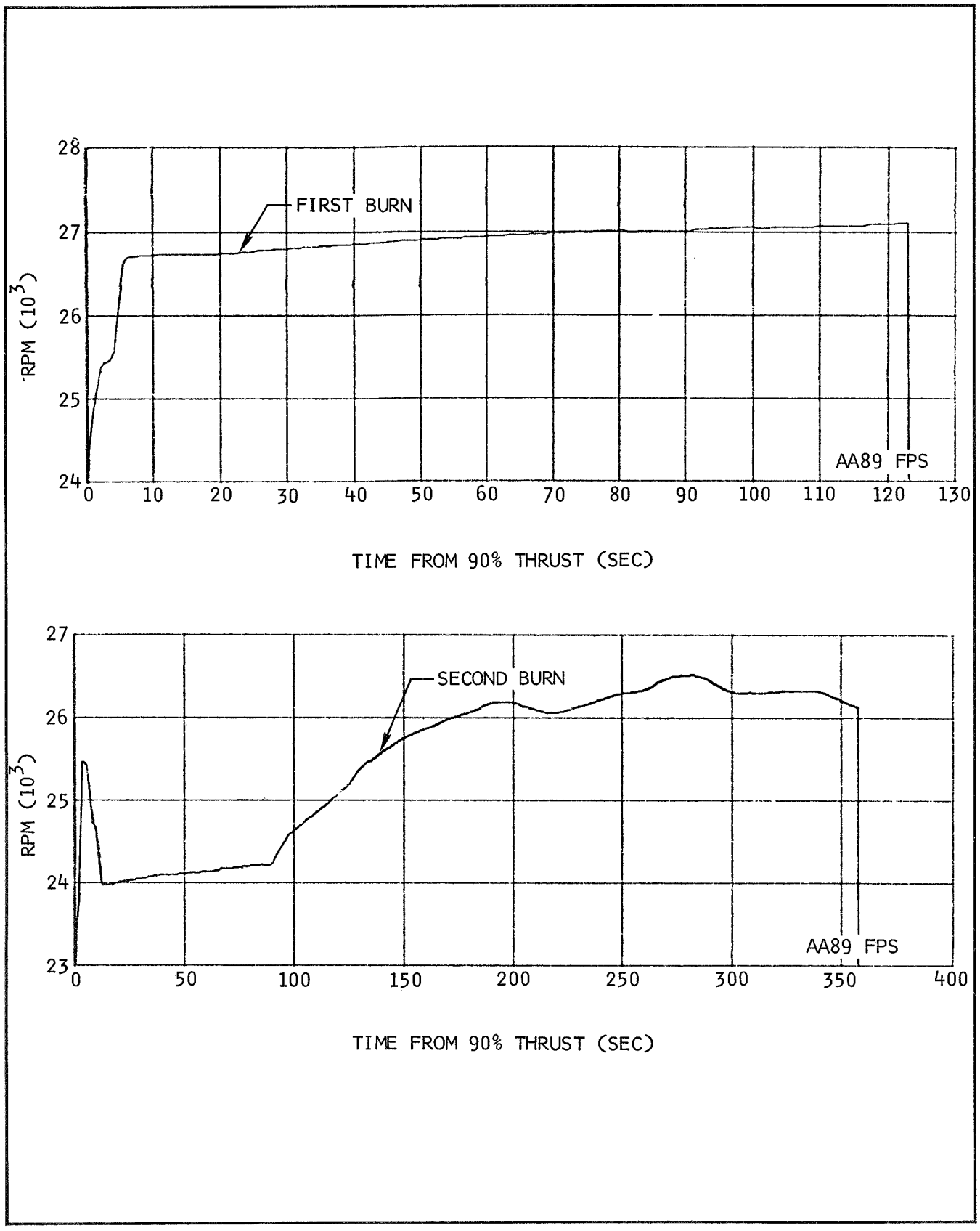


Figure AP 5-8. LH2 Pump Speed

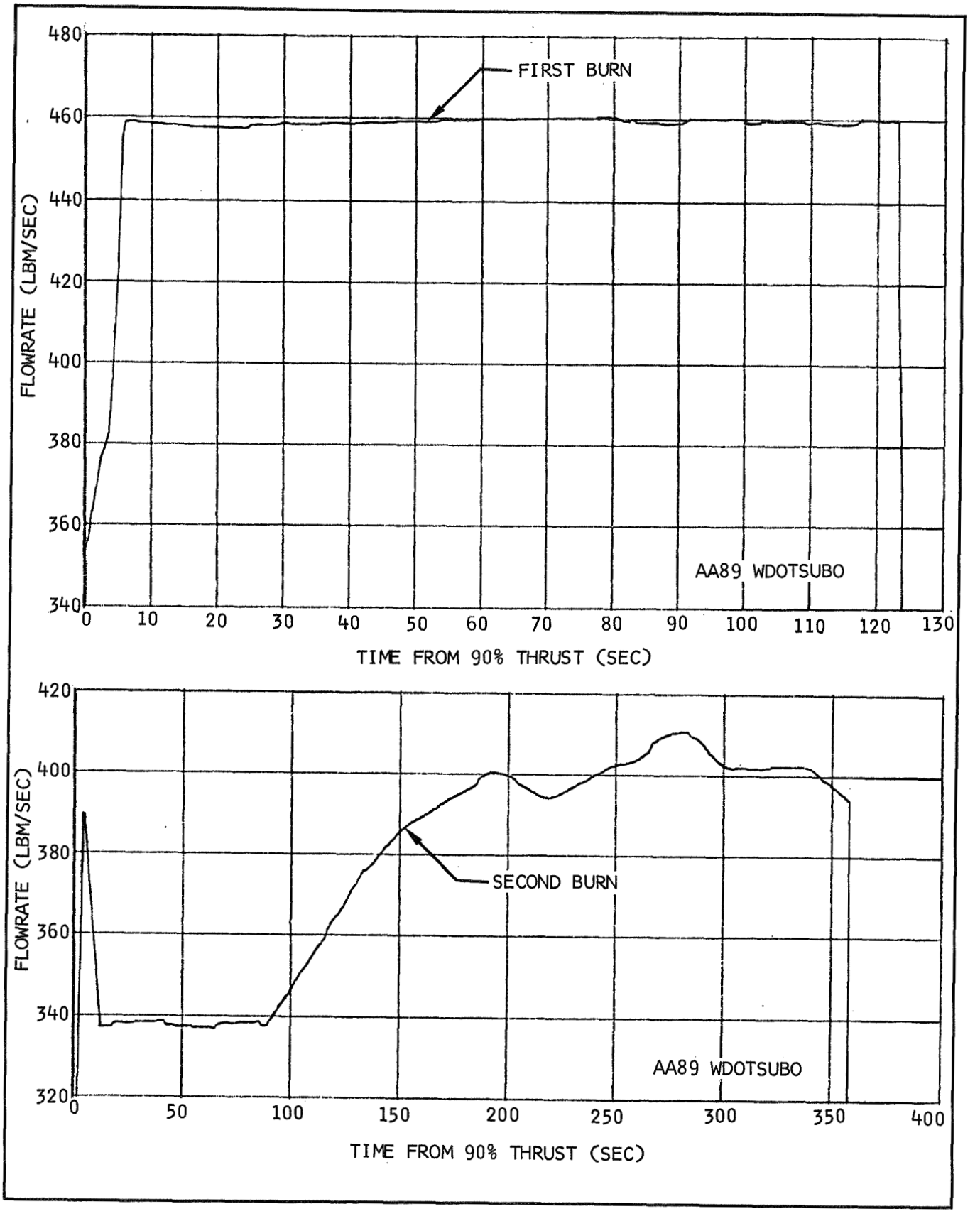


Figure AP 5-9. LOX Flowrates, Pump Inlet

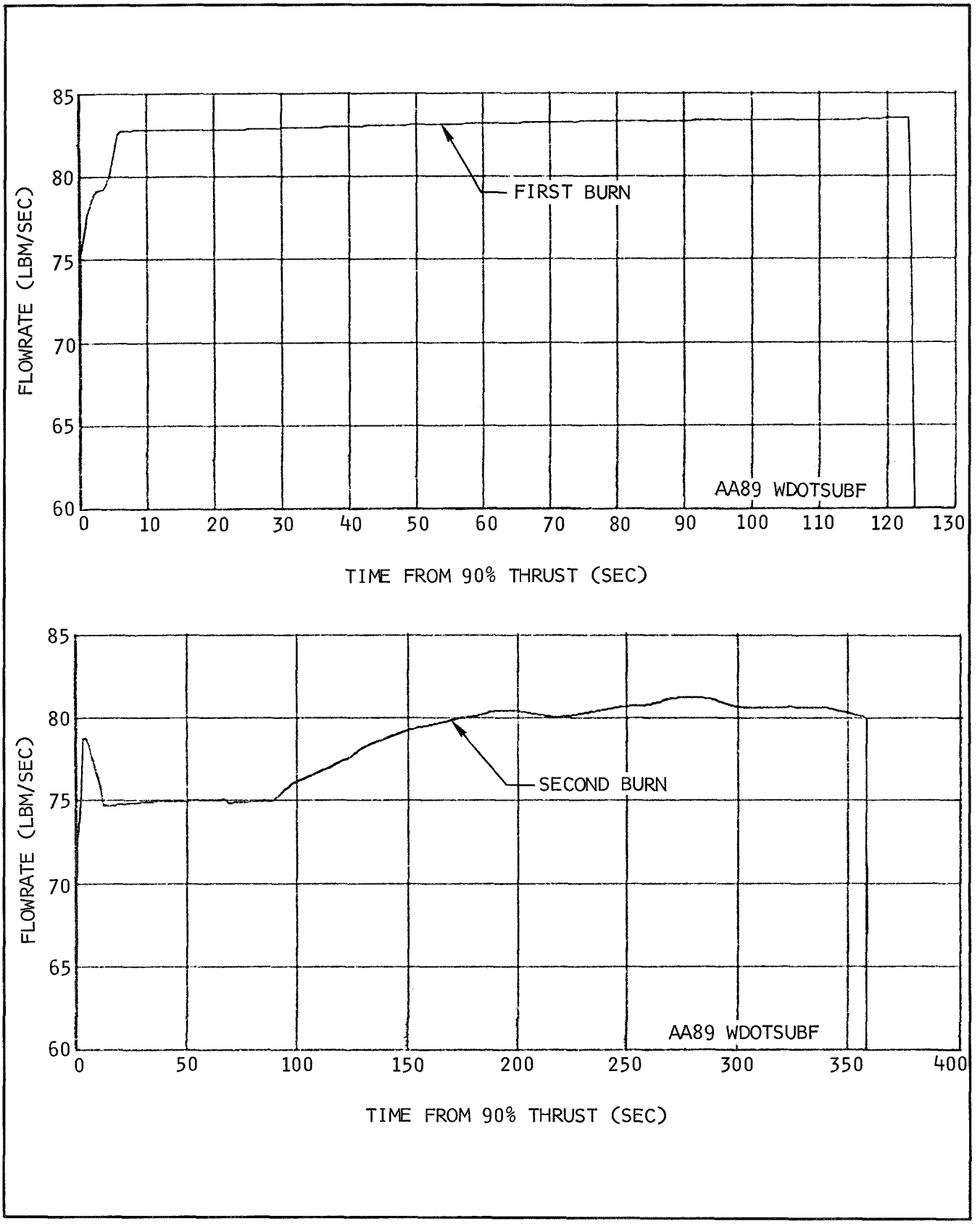


Figure AP 5-10. LH2 Flowrates, Pump Inlet

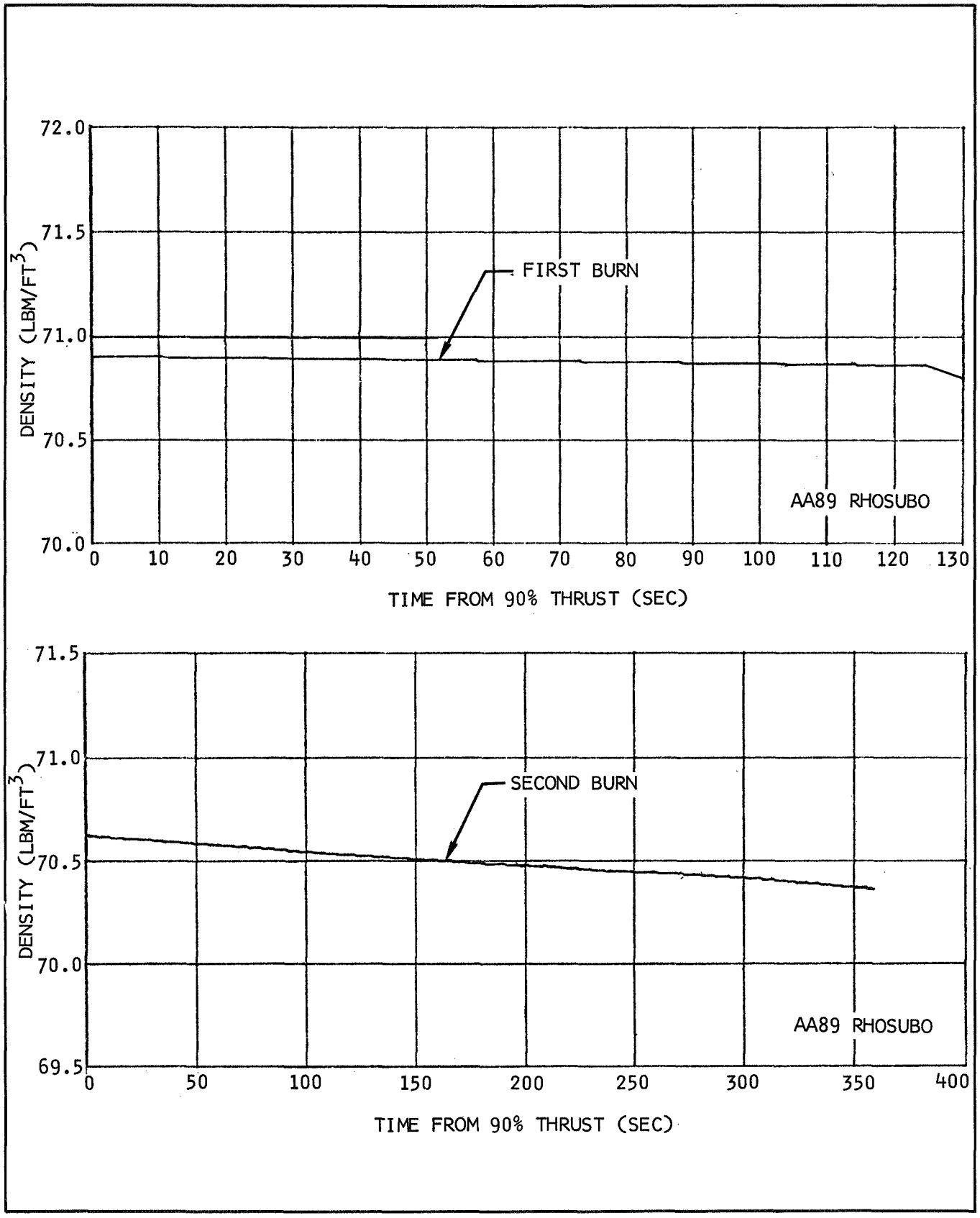


Figure AP 5-11. LOX Bulk Densities

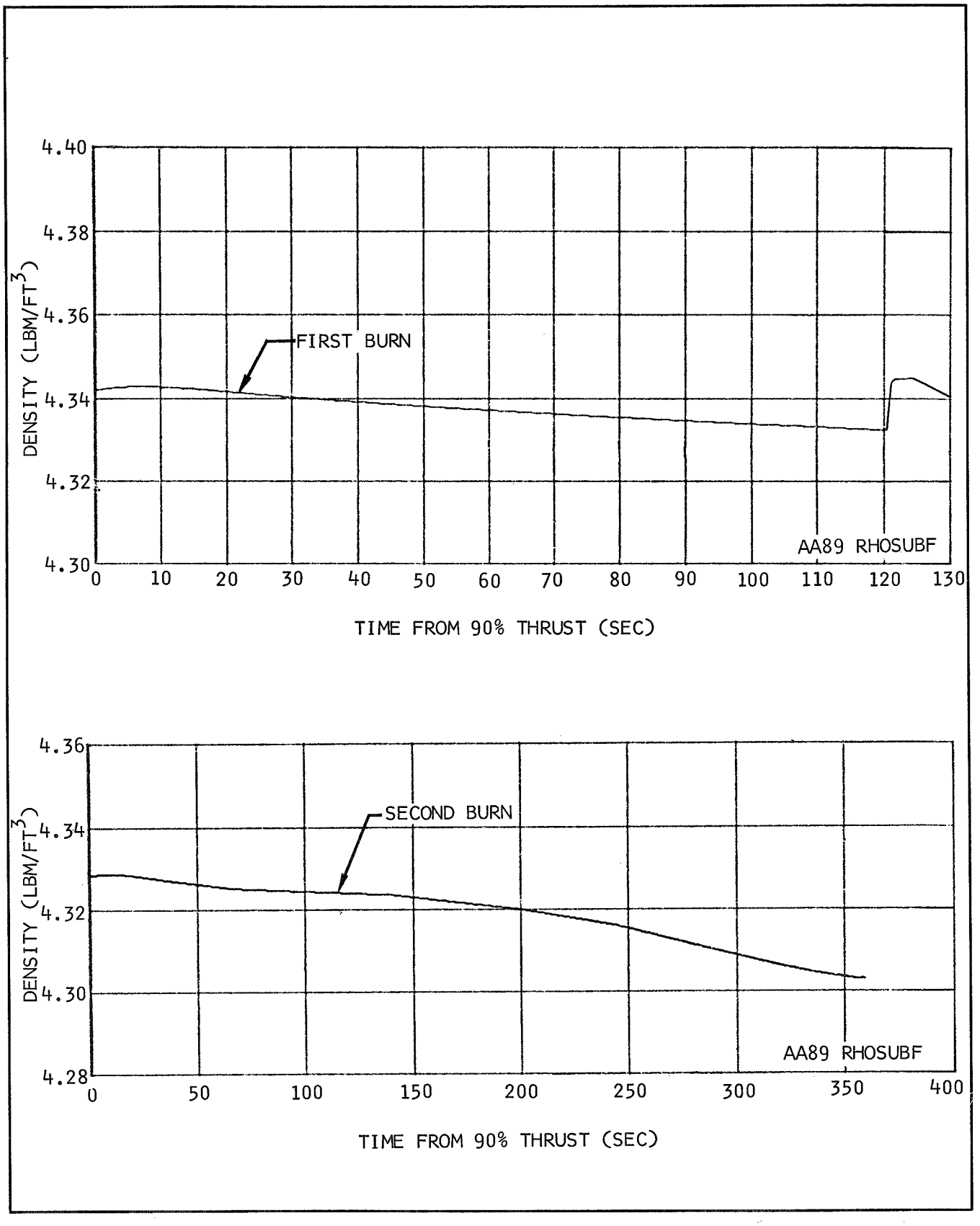


Figure AP 5-12. LH2 Bulk Densities

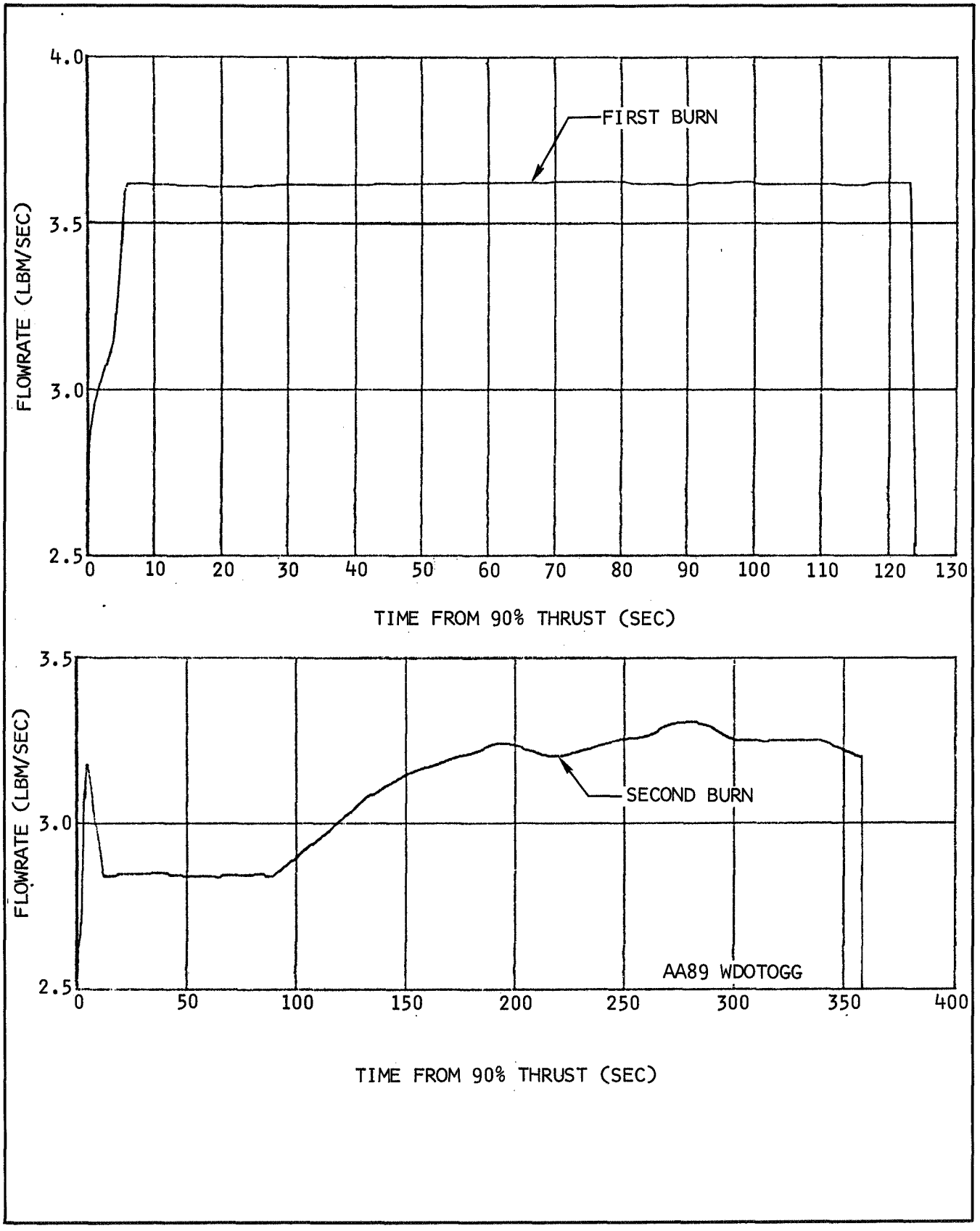


Figure AP 5-13. Gas Generator LOX Flowrates

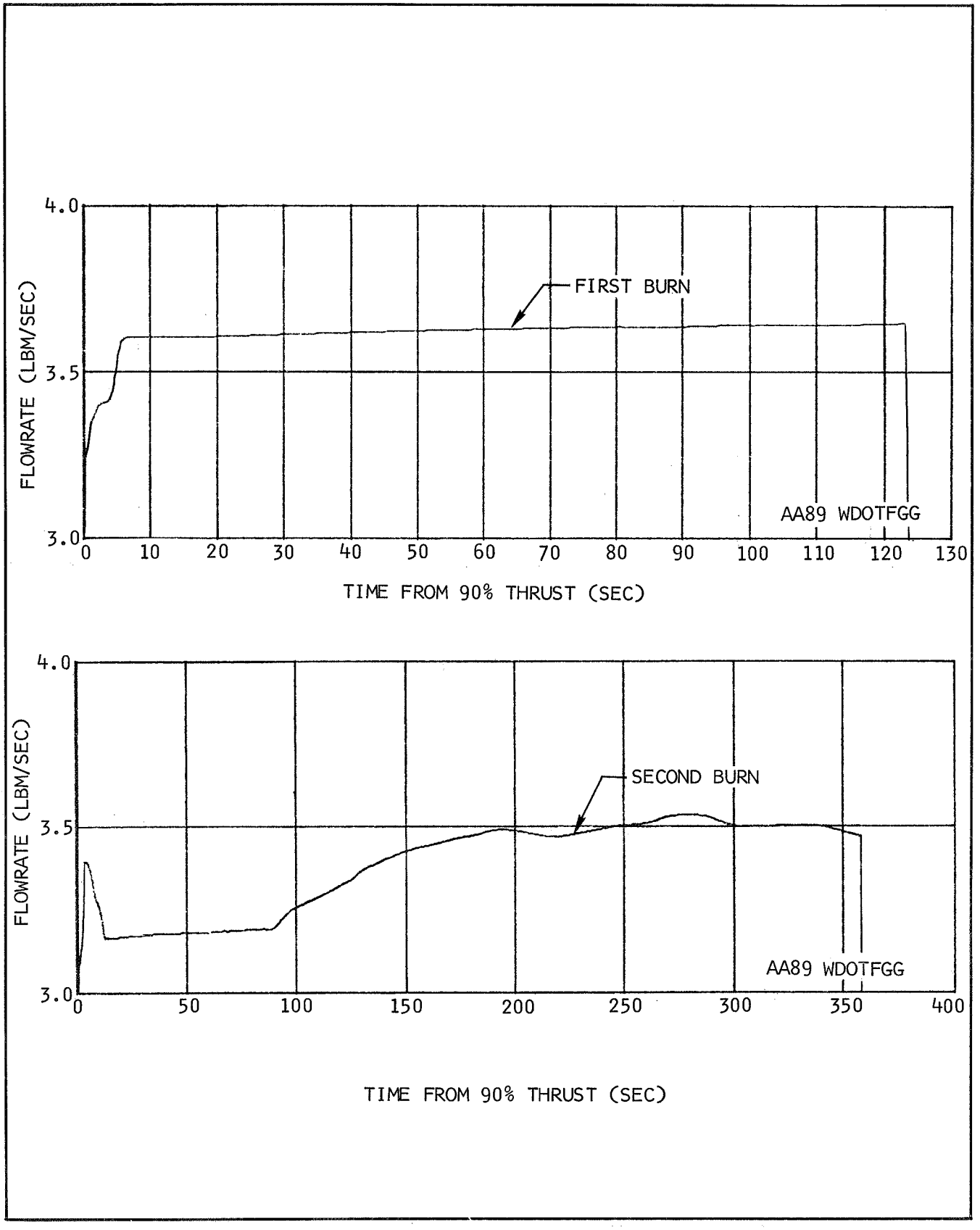


Figure AP 5-14. Gas Generator LH2 Flowrates

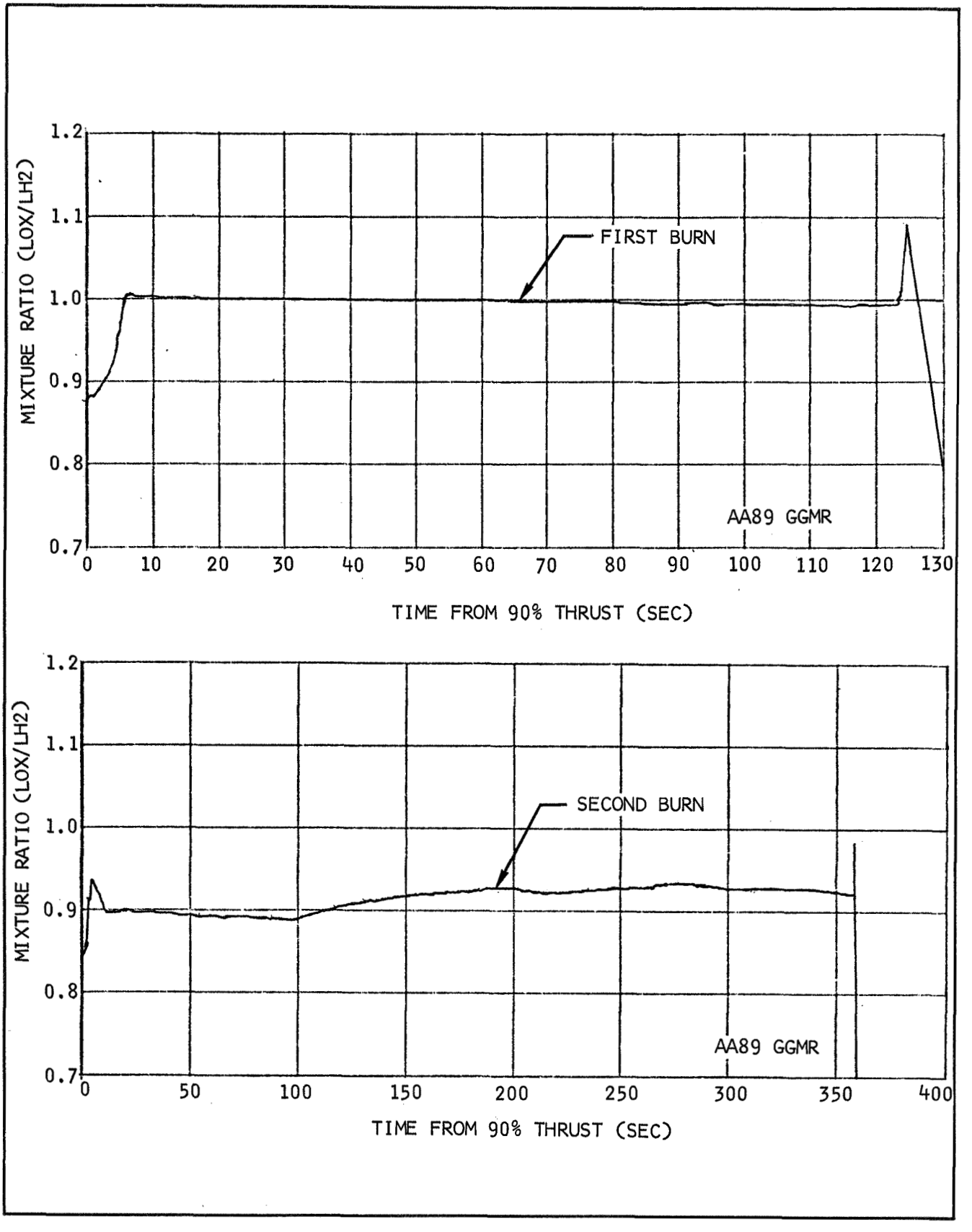


Figure AP 5-15. Gas Generator Mixture Ratio

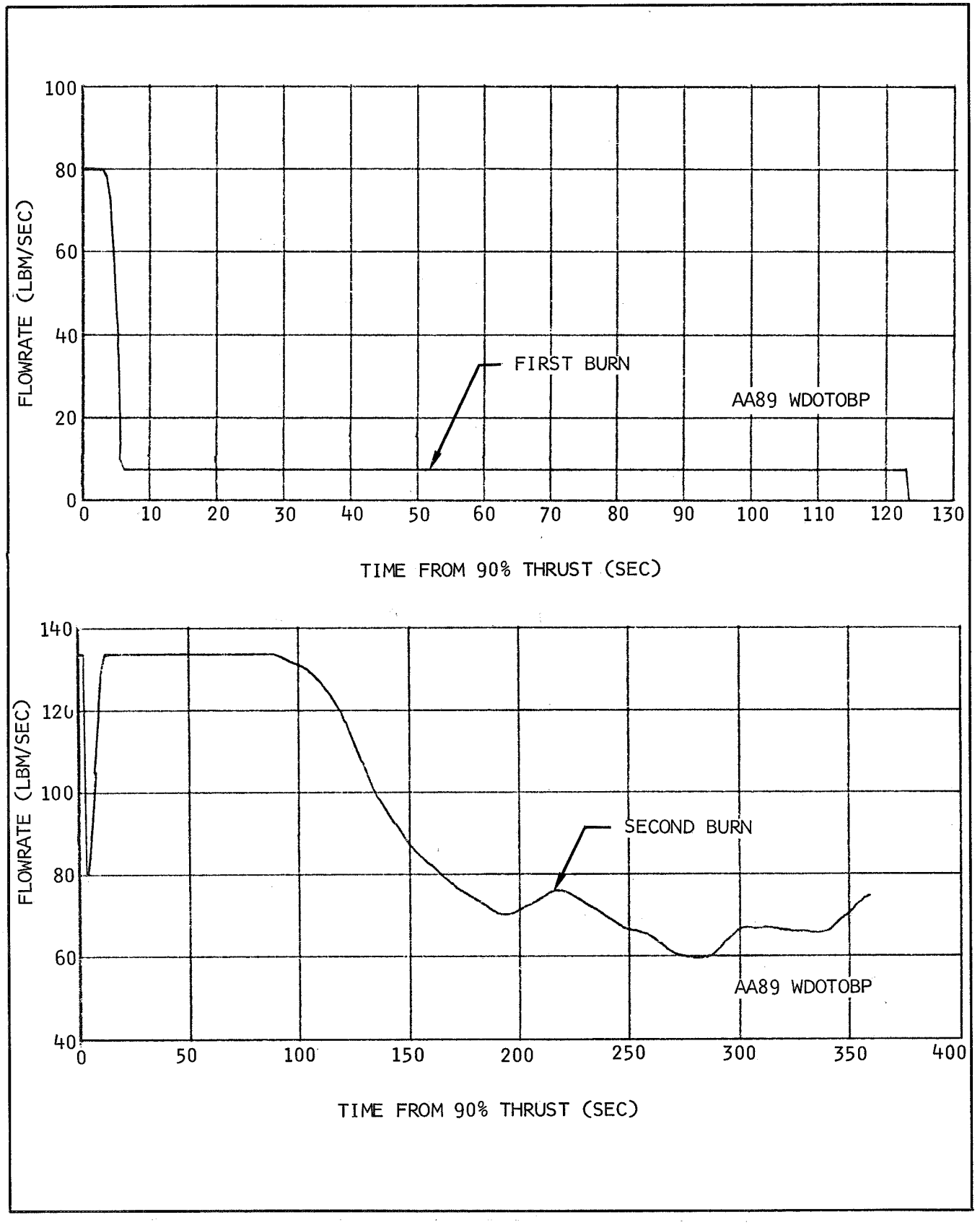


Figure AP 5-16. LOX Bypass Flowrates

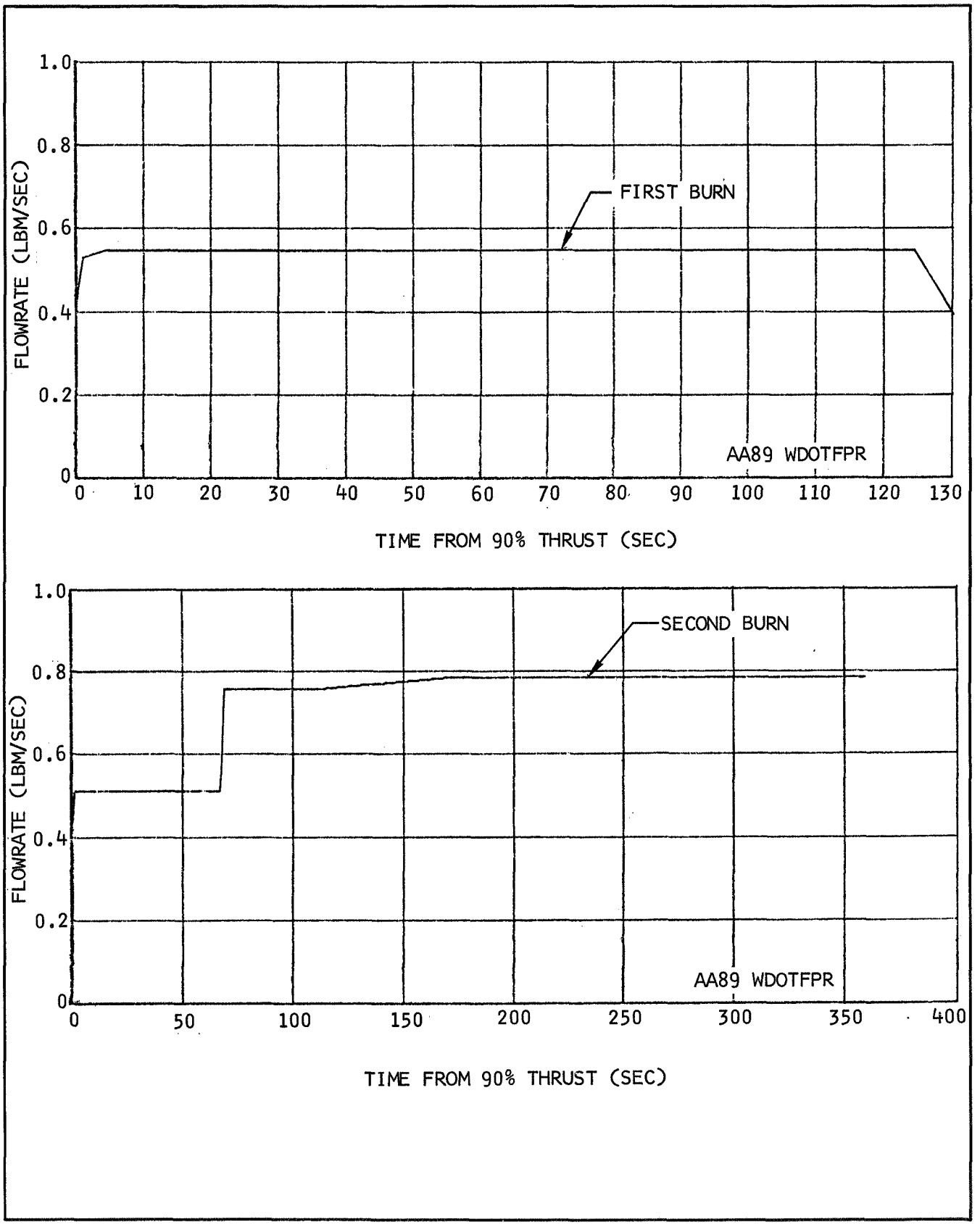


Figure AP 5-17. LH2 Tank GH2 Pressurant Flowrates

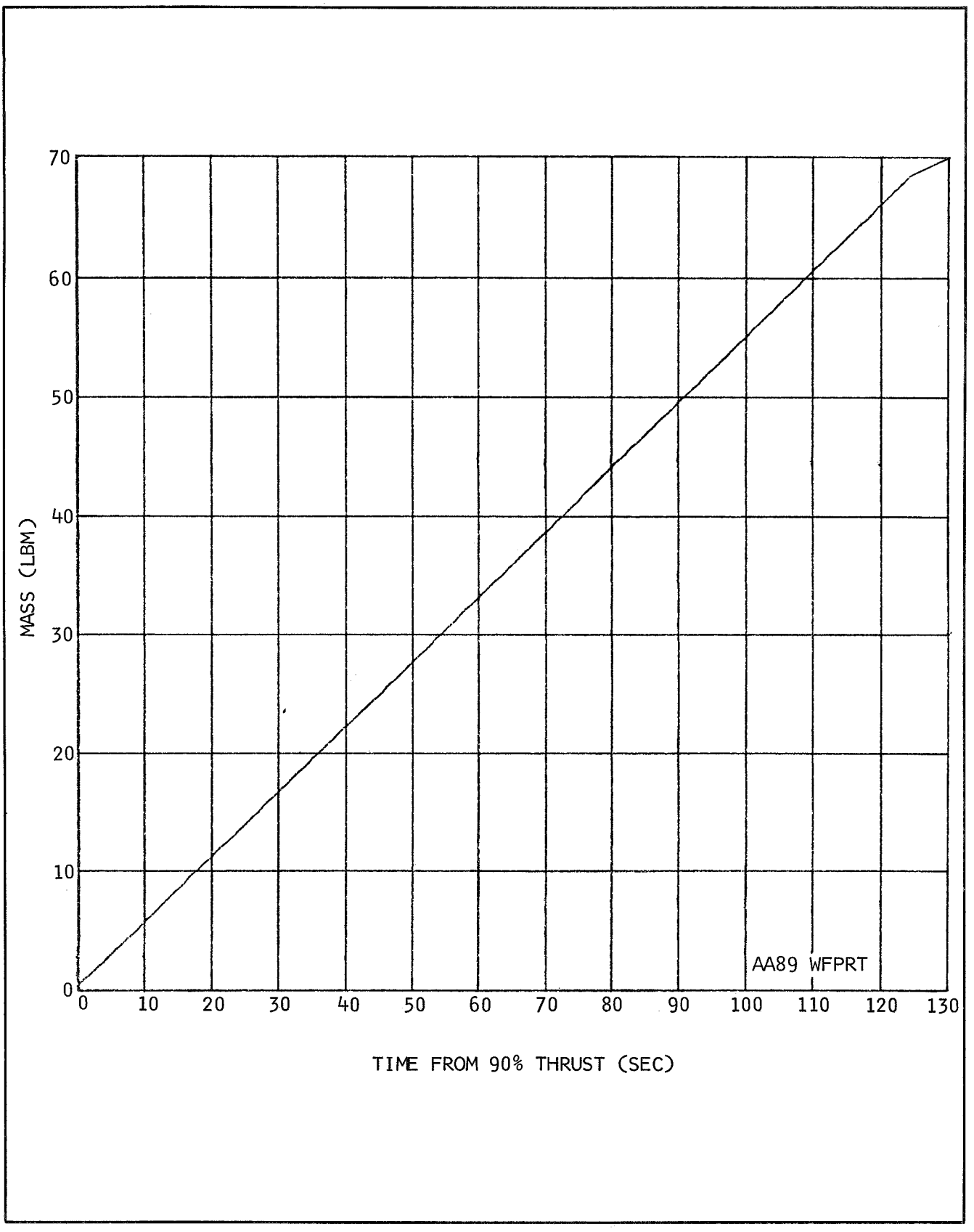


Figure AP 5-18. First Burn: LH2 Pressurant Mass in Ullage

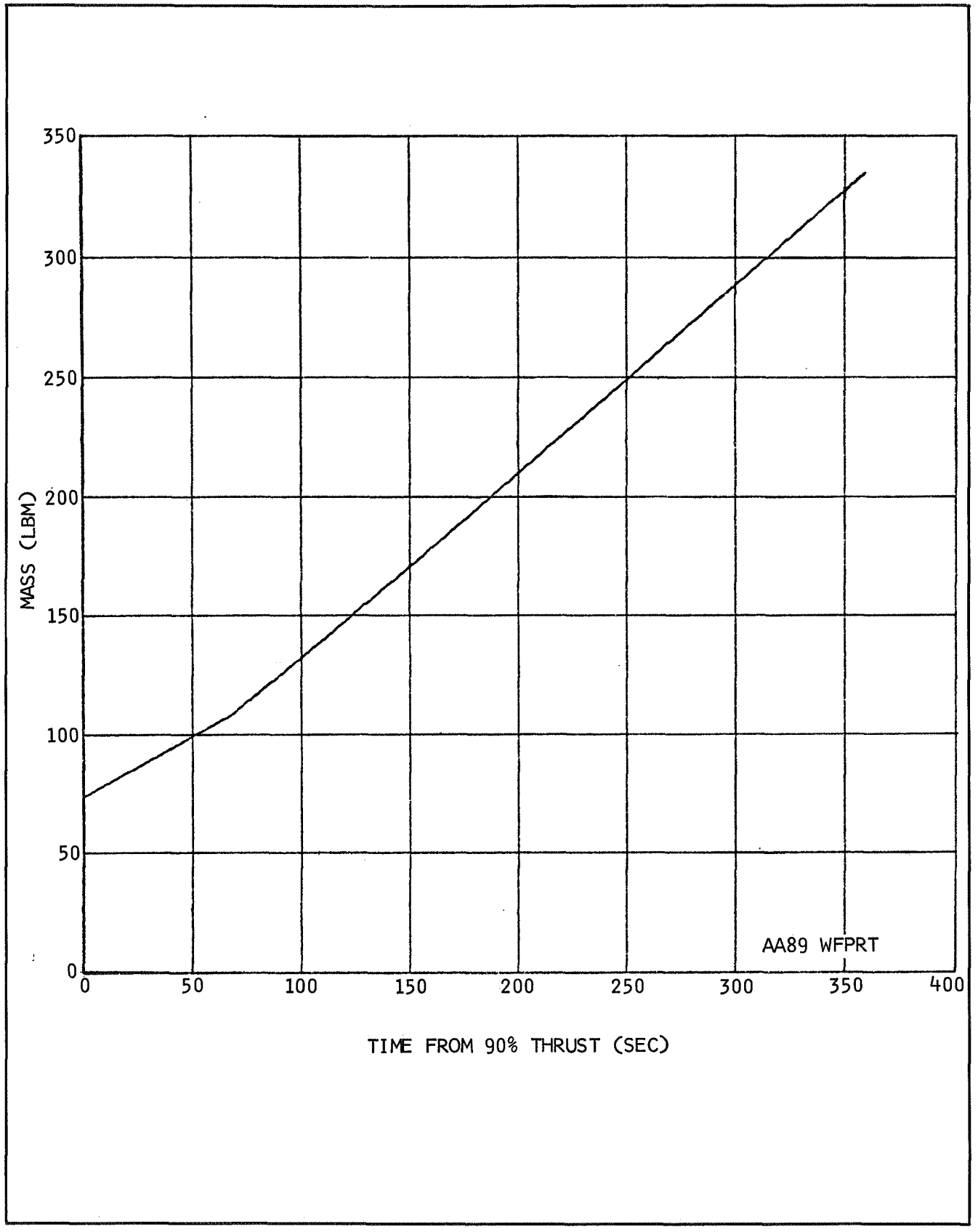


Figure AP 5-19. Second Burn: LH2 Pressurant Mass in Ullage

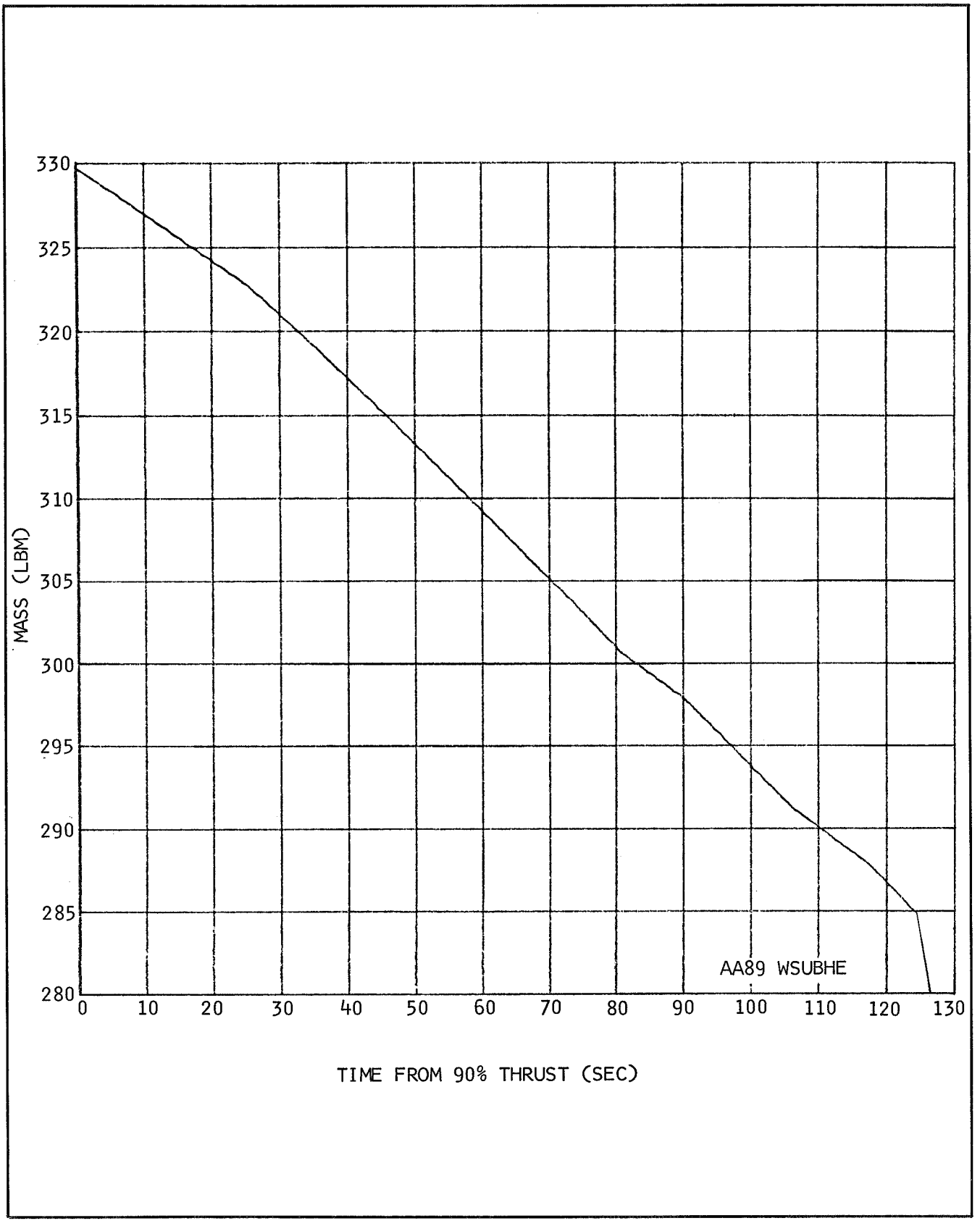


Figure AP 5-20. First Burn: Helium Mass in Cold Spheres

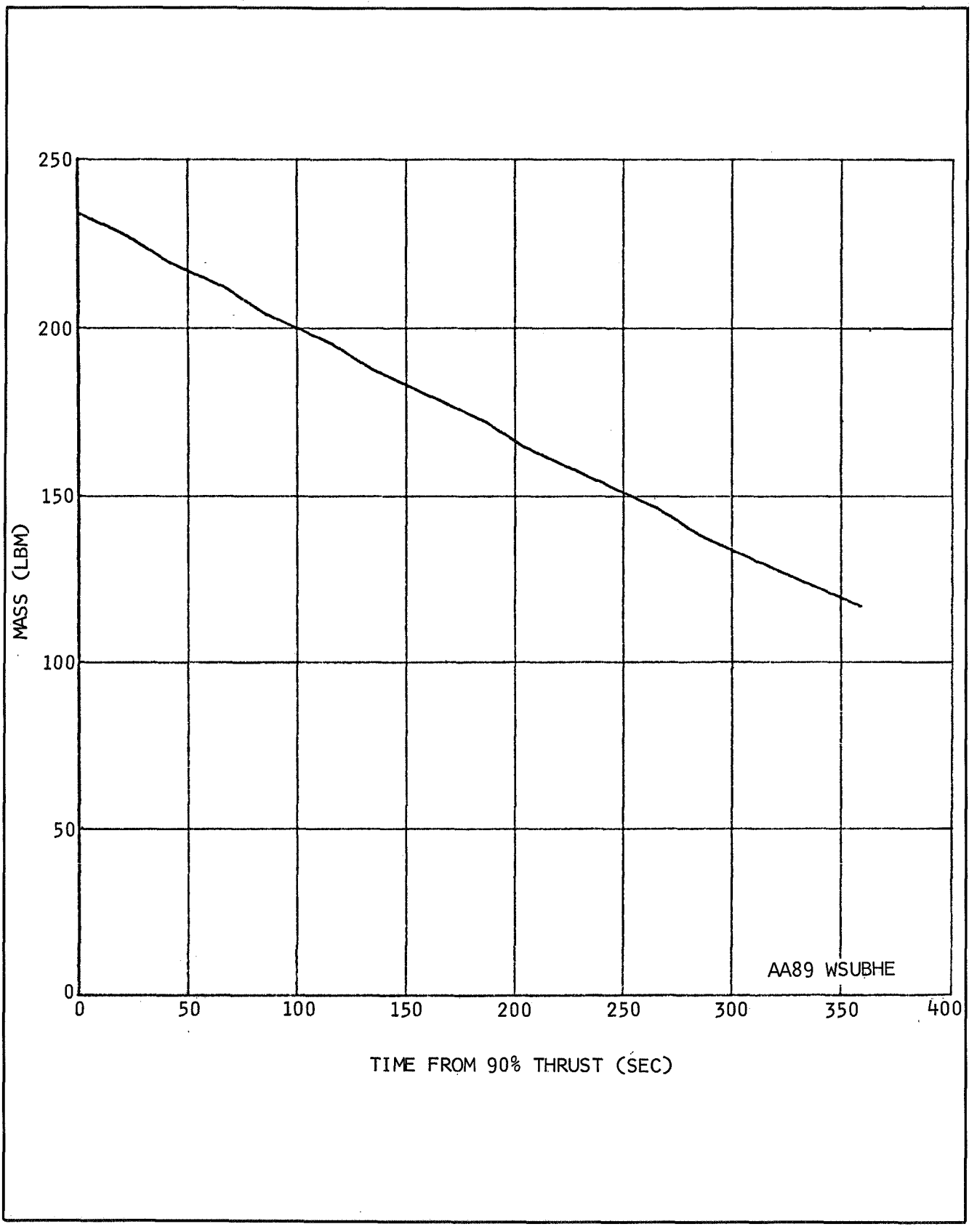


Figure AP 5-21. Second Burn: Helium Mass in Cold Spheres

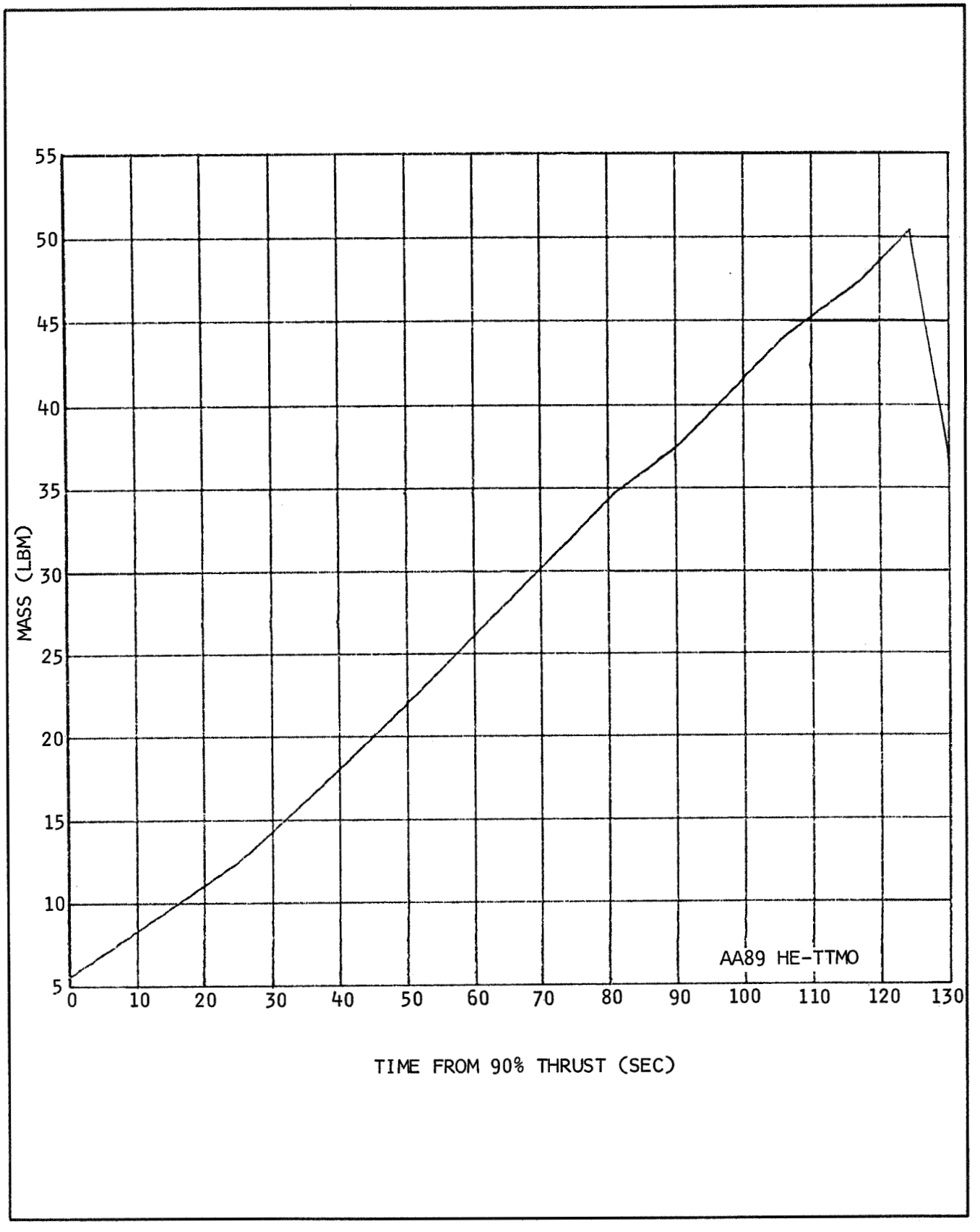


Figure AP 5-22. First Burn: Helium Mass in LOX Ullage

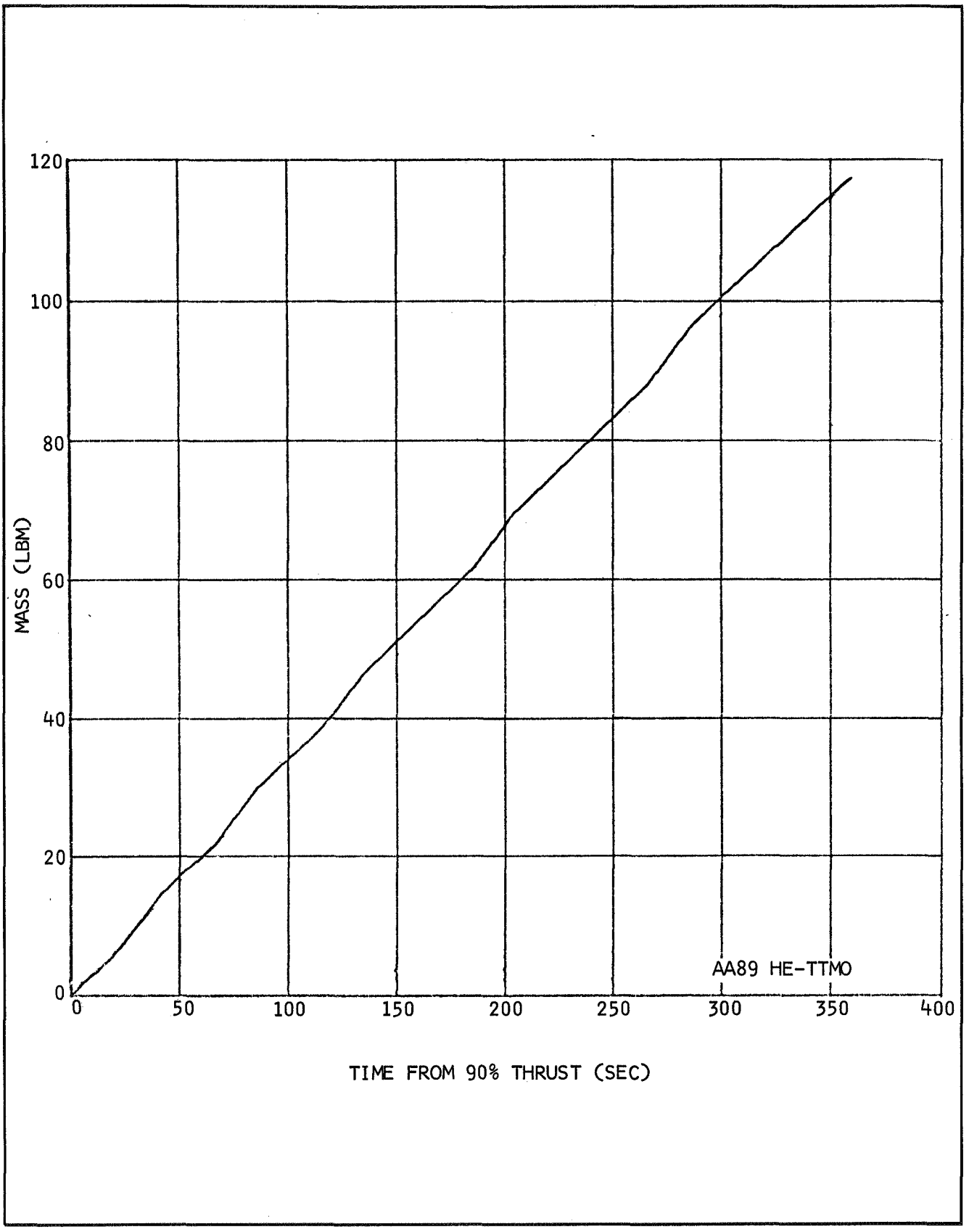


Figure AP 5-23. Second Burn: Helium Mass in LOX Ullage

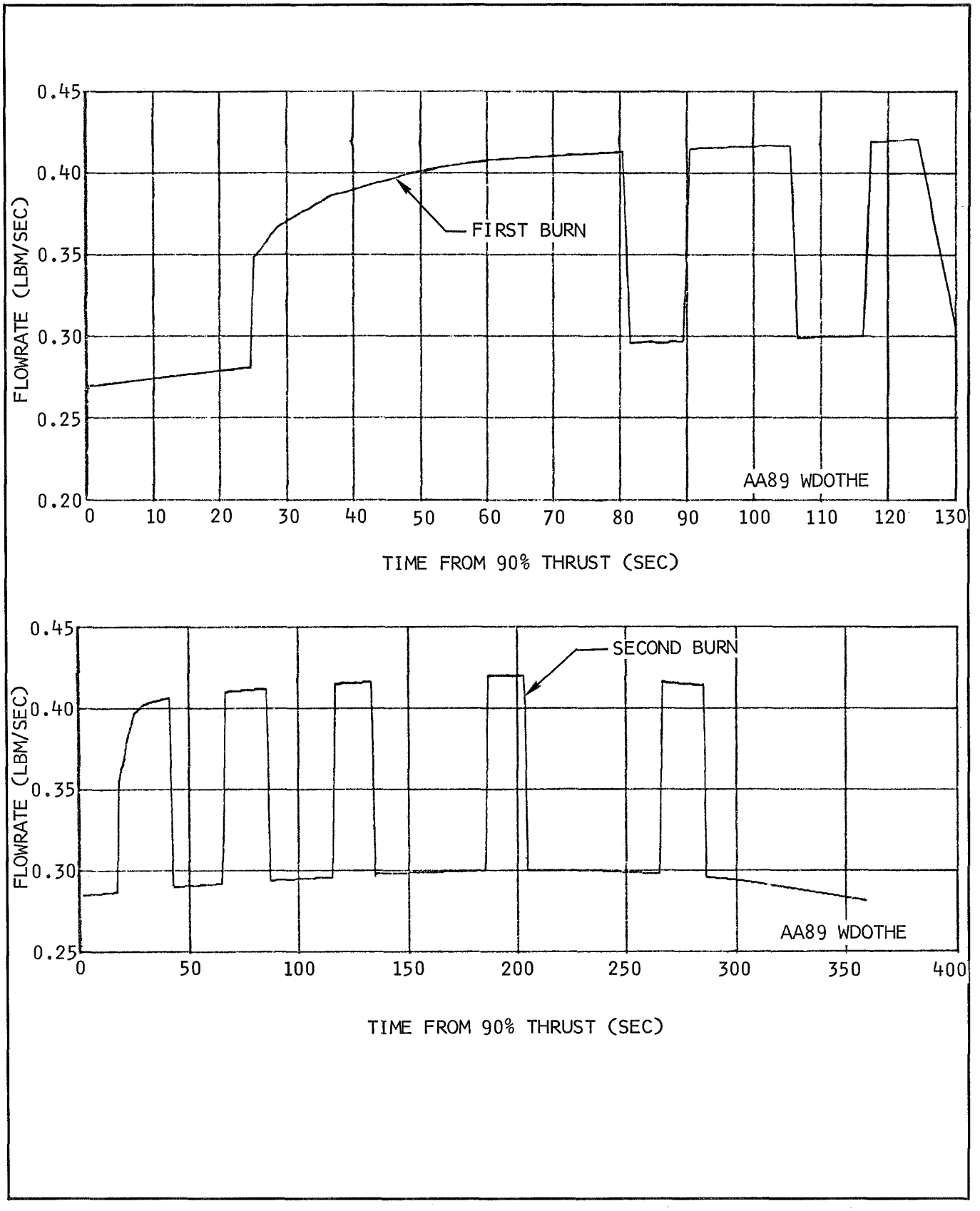


Figure AP 5-24. Total Helium Flowrates

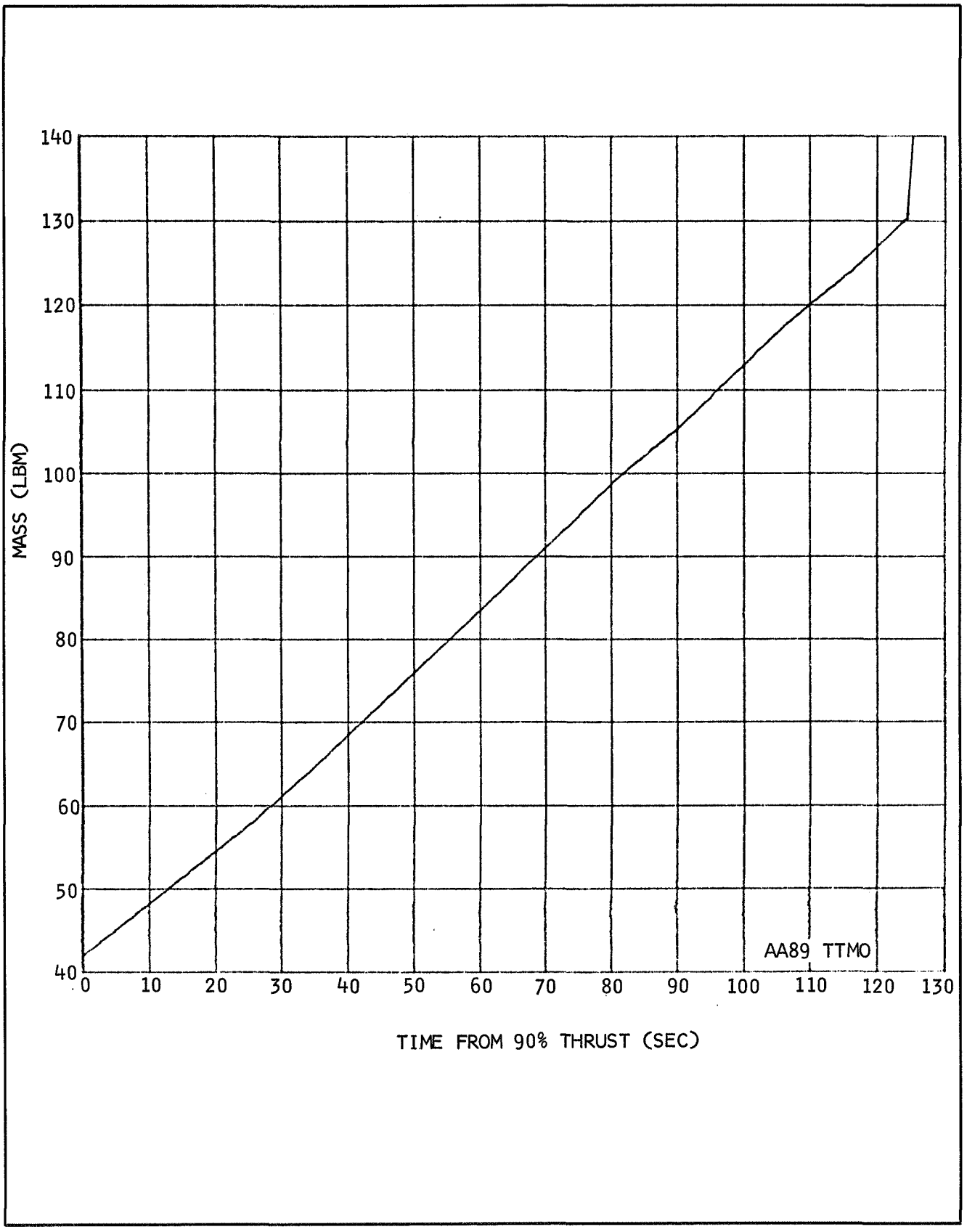


Figure AP 5-25. First Burn: LOX Tank Ullage Mass

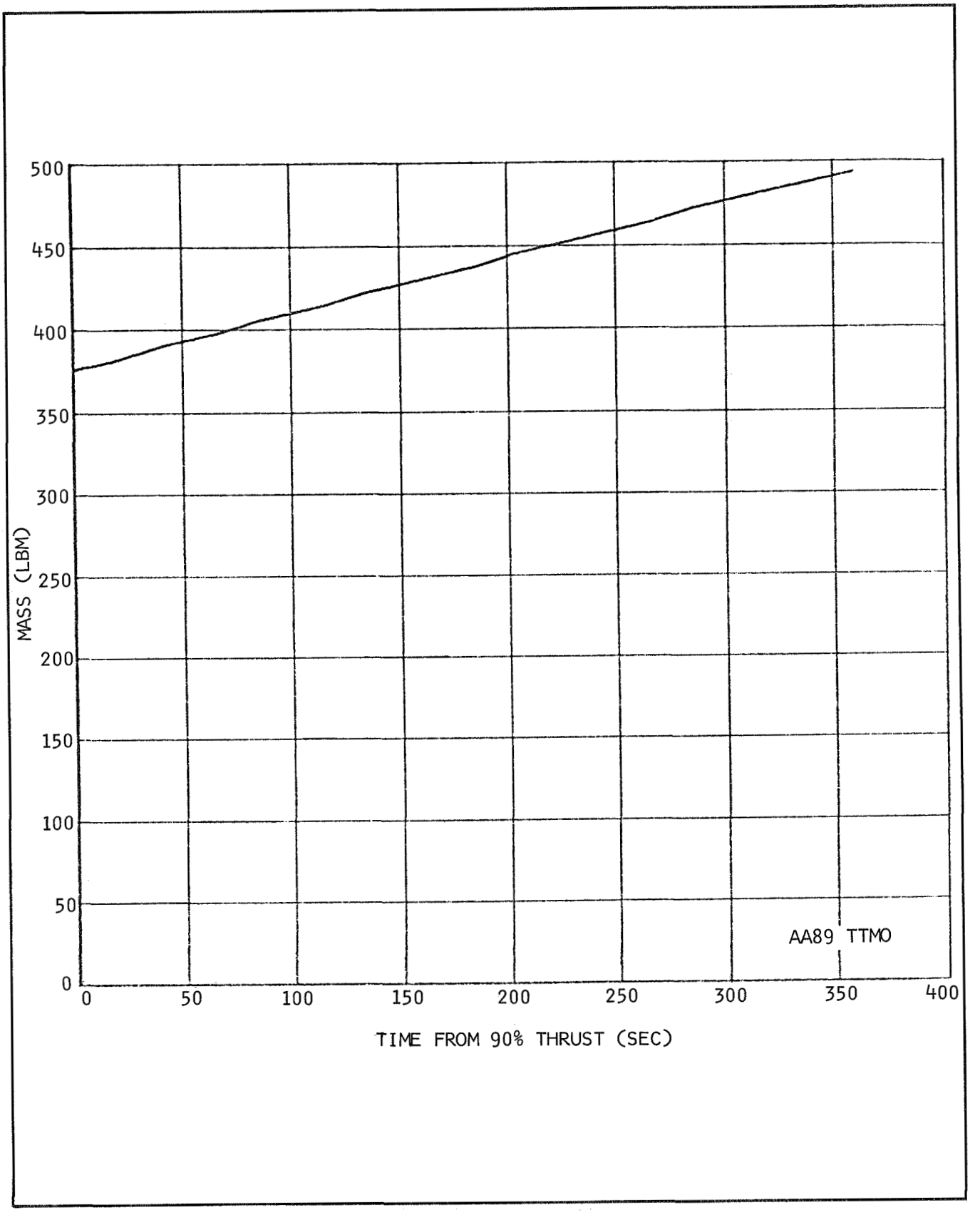


Figure AP 5-26. Second Burn: LOX Tank Ullage Mass

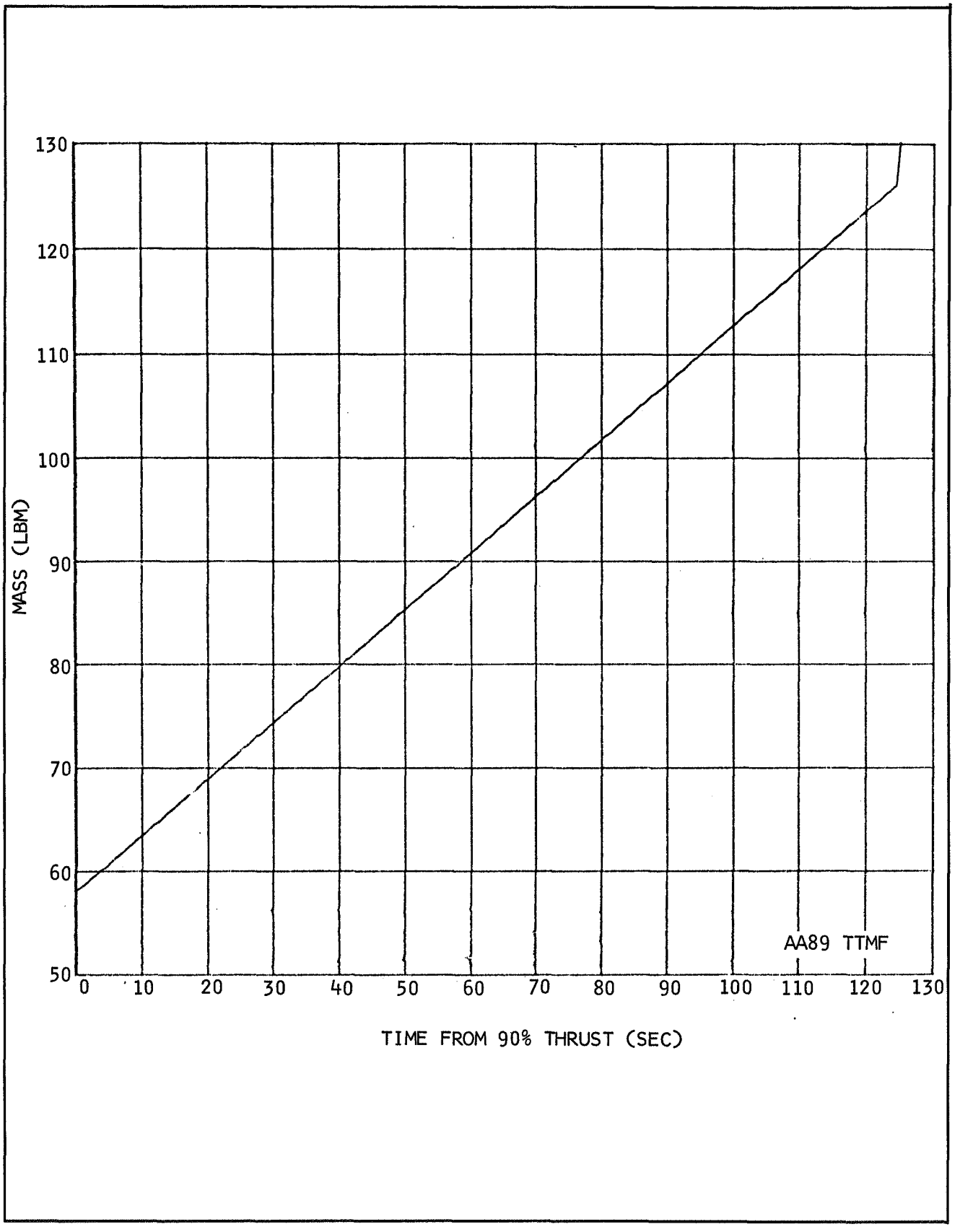


Figure AP 5-27. First Burn: LH2 Tank Ullage Mass

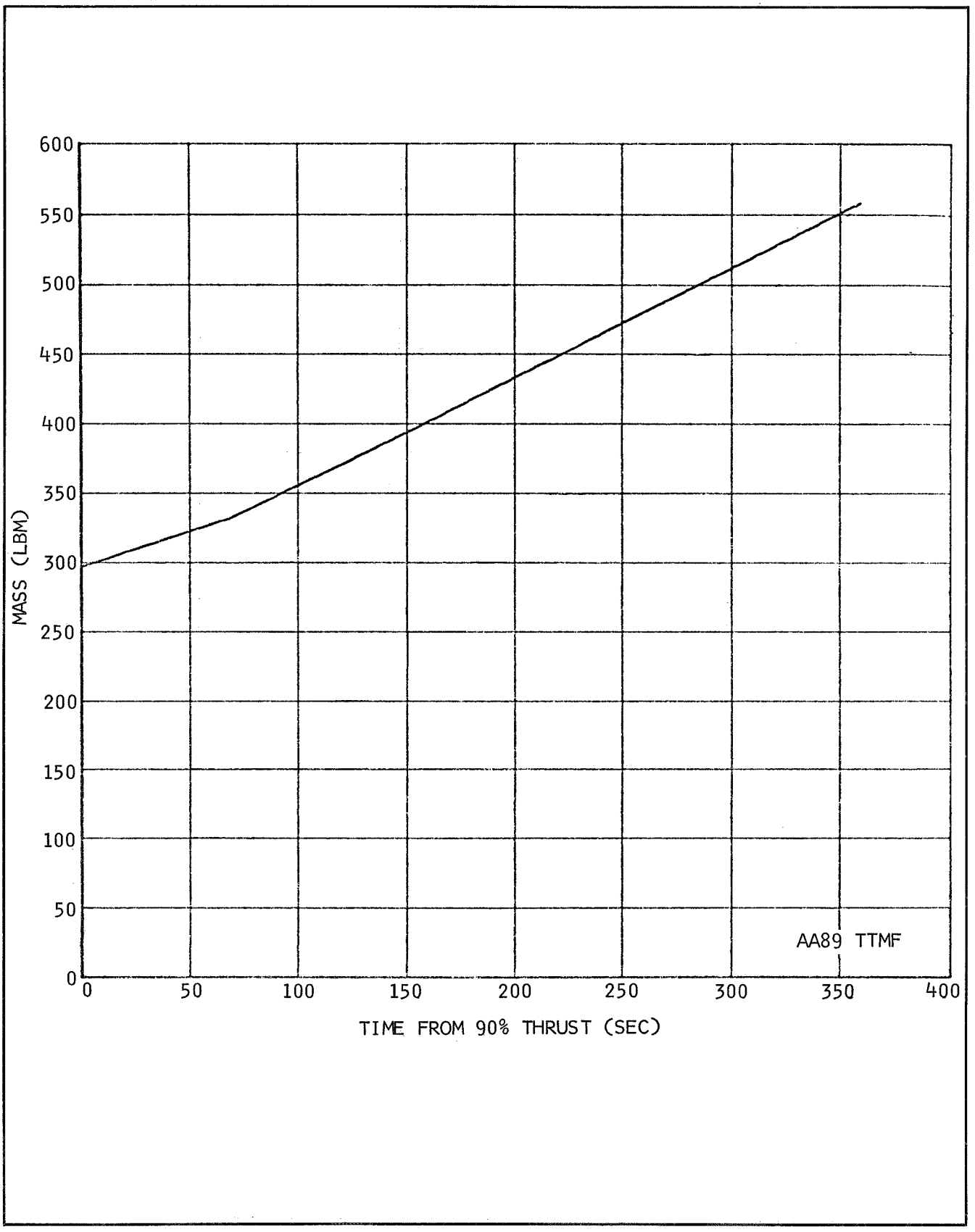


Figure AP 5-28. Second Burn: LH2 Tank Ullage Mass

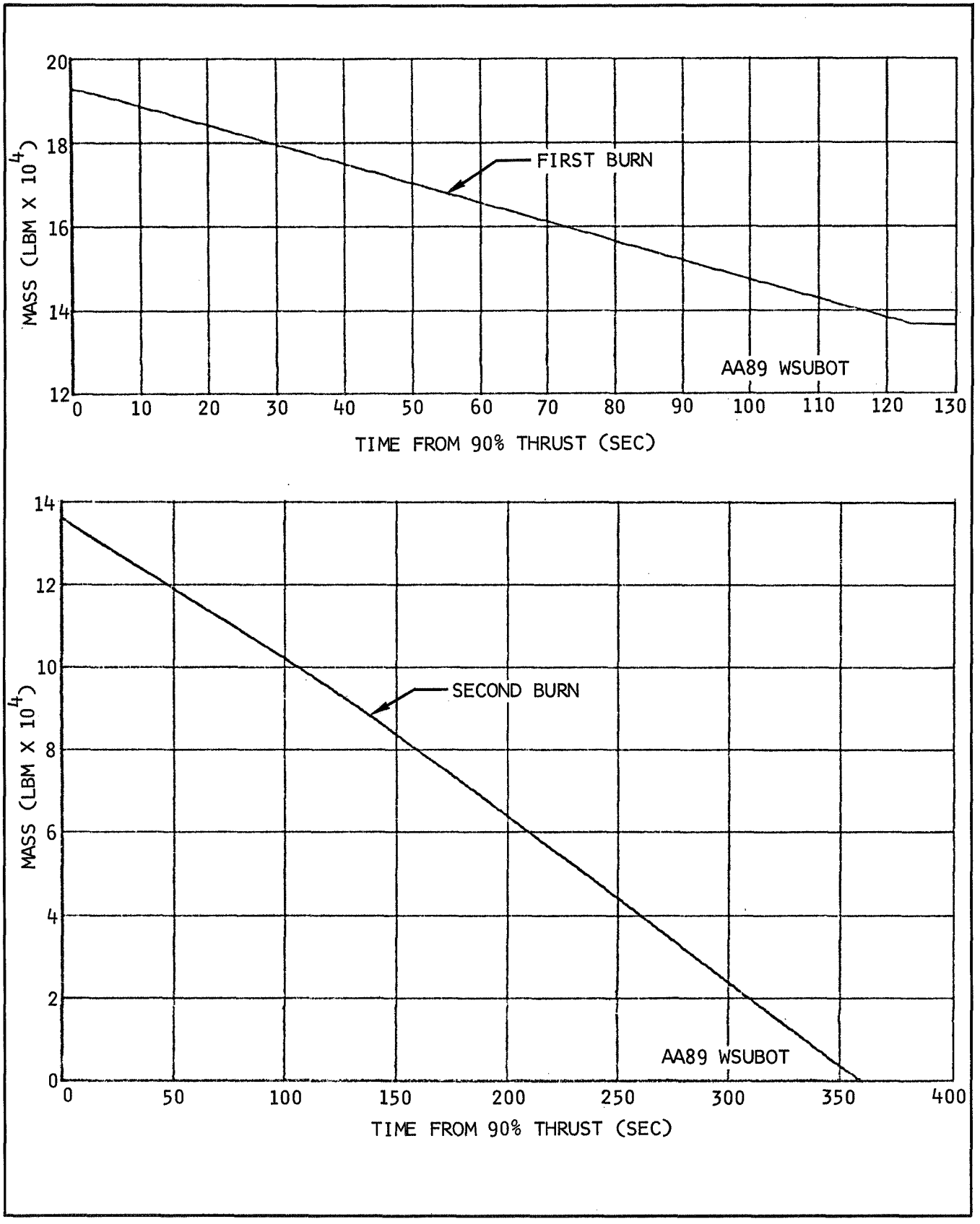


Figure AP 5-29. LOX Mass Onboard

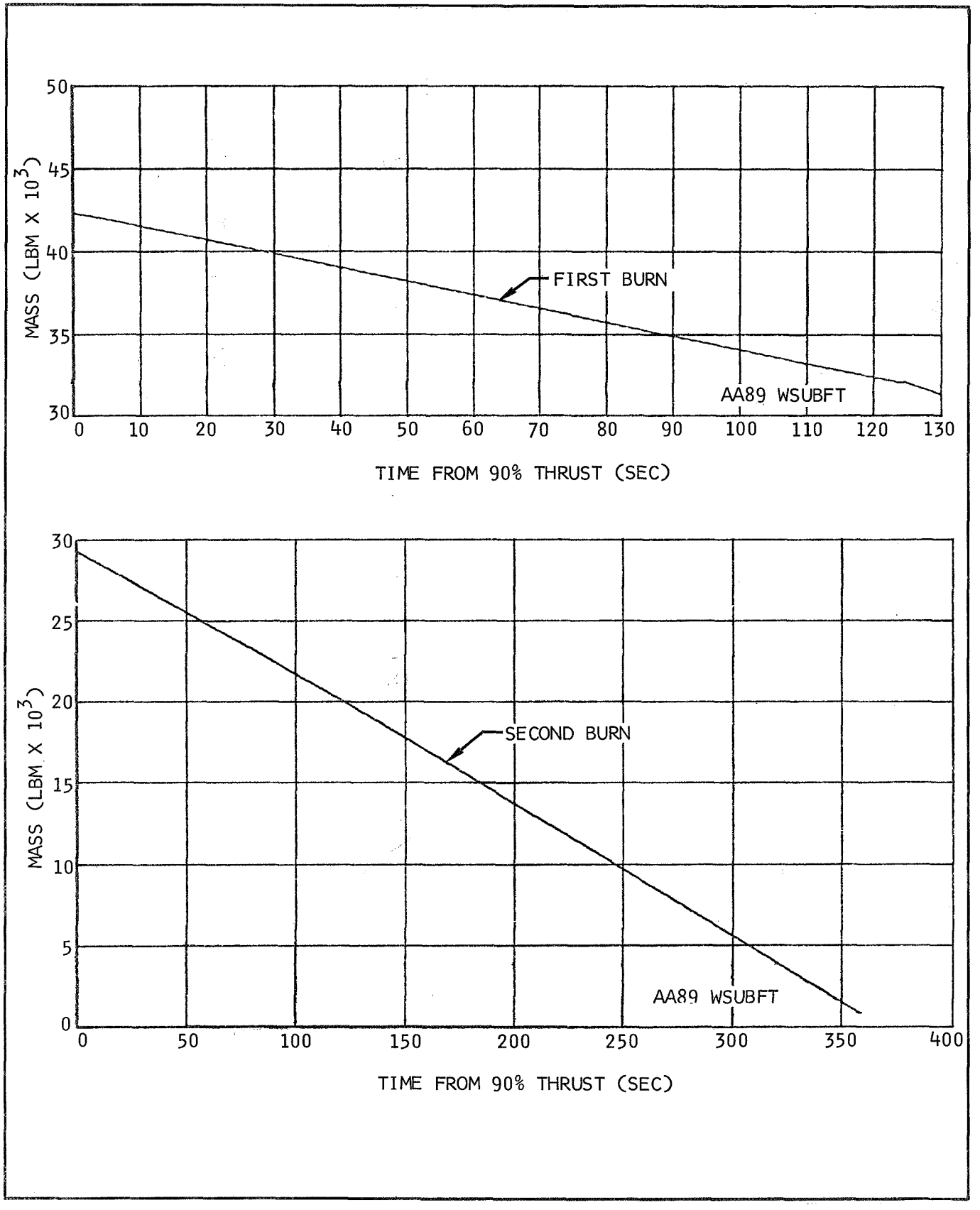


Figure AP 5-30. LH2 Mass Onboard

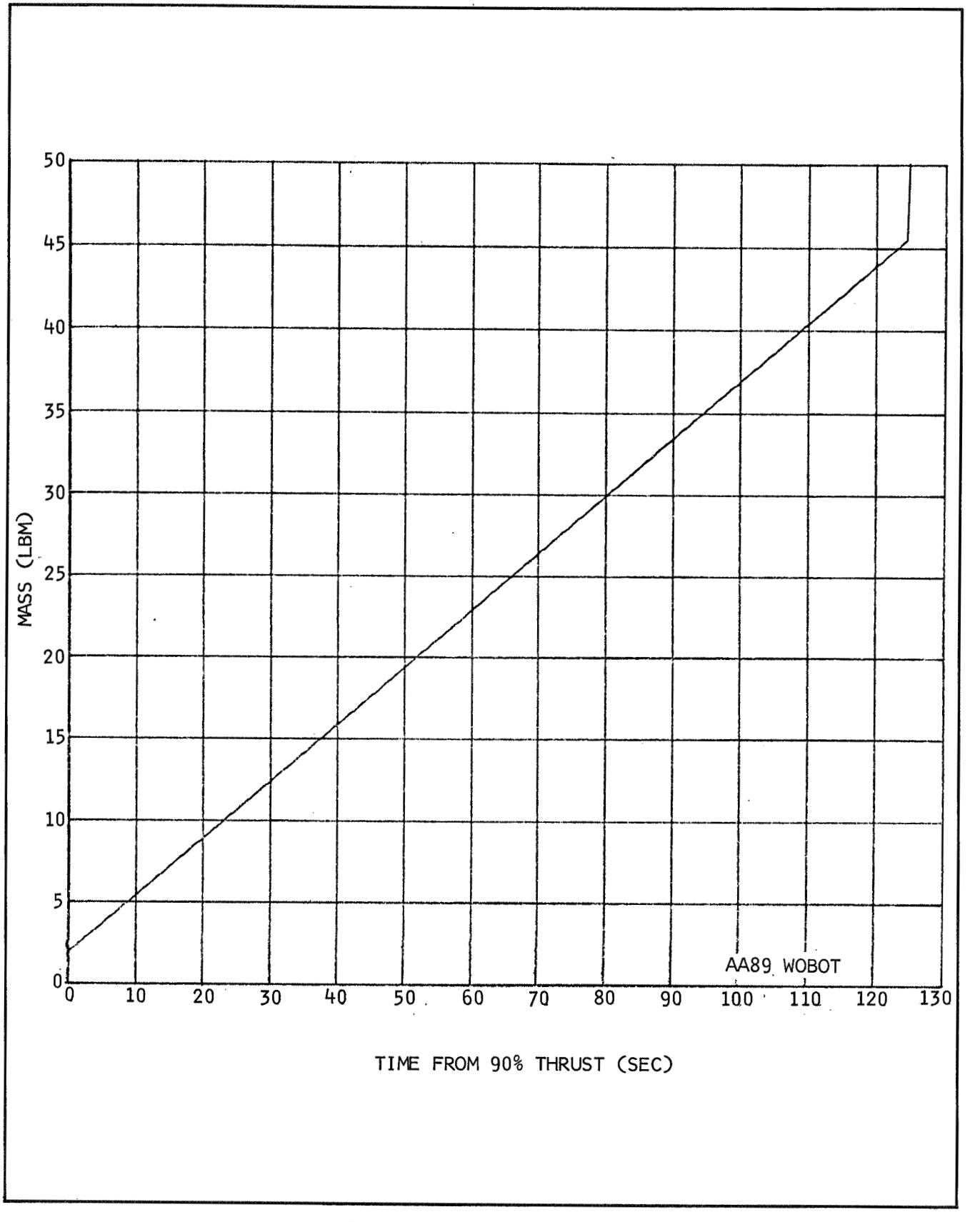


Figure AP 5-31. First Burn: LOX Mass Boiled-off

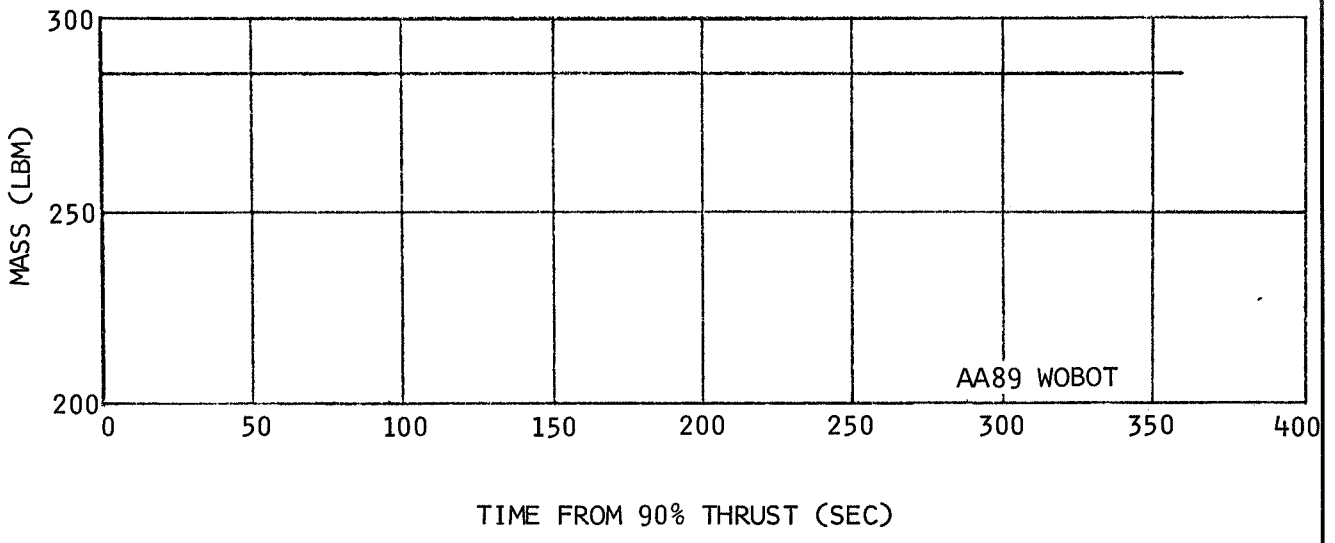


Figure AP 5-32. Second Burn: LOX Mass Boiled-off

DAC HAS PREDICTED THAT
LH2 BOILOFF FOR THE FIRST
BURN WILL BE ZERO.

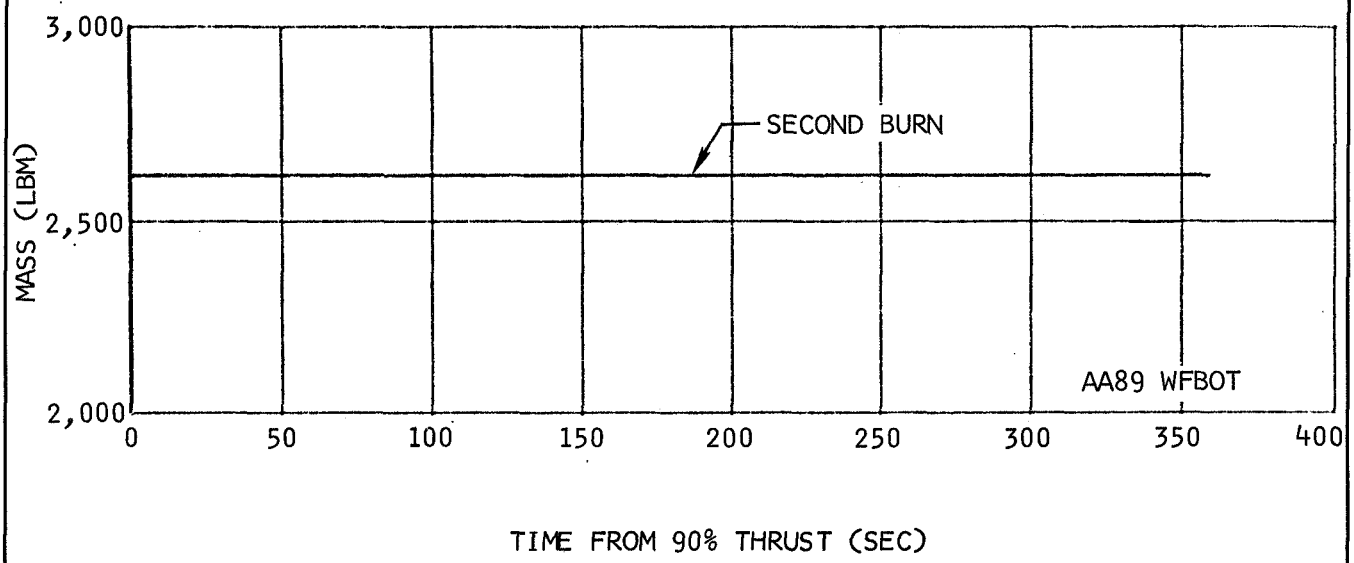


Figure AP 5-33. LH2 Mass Boiled-off

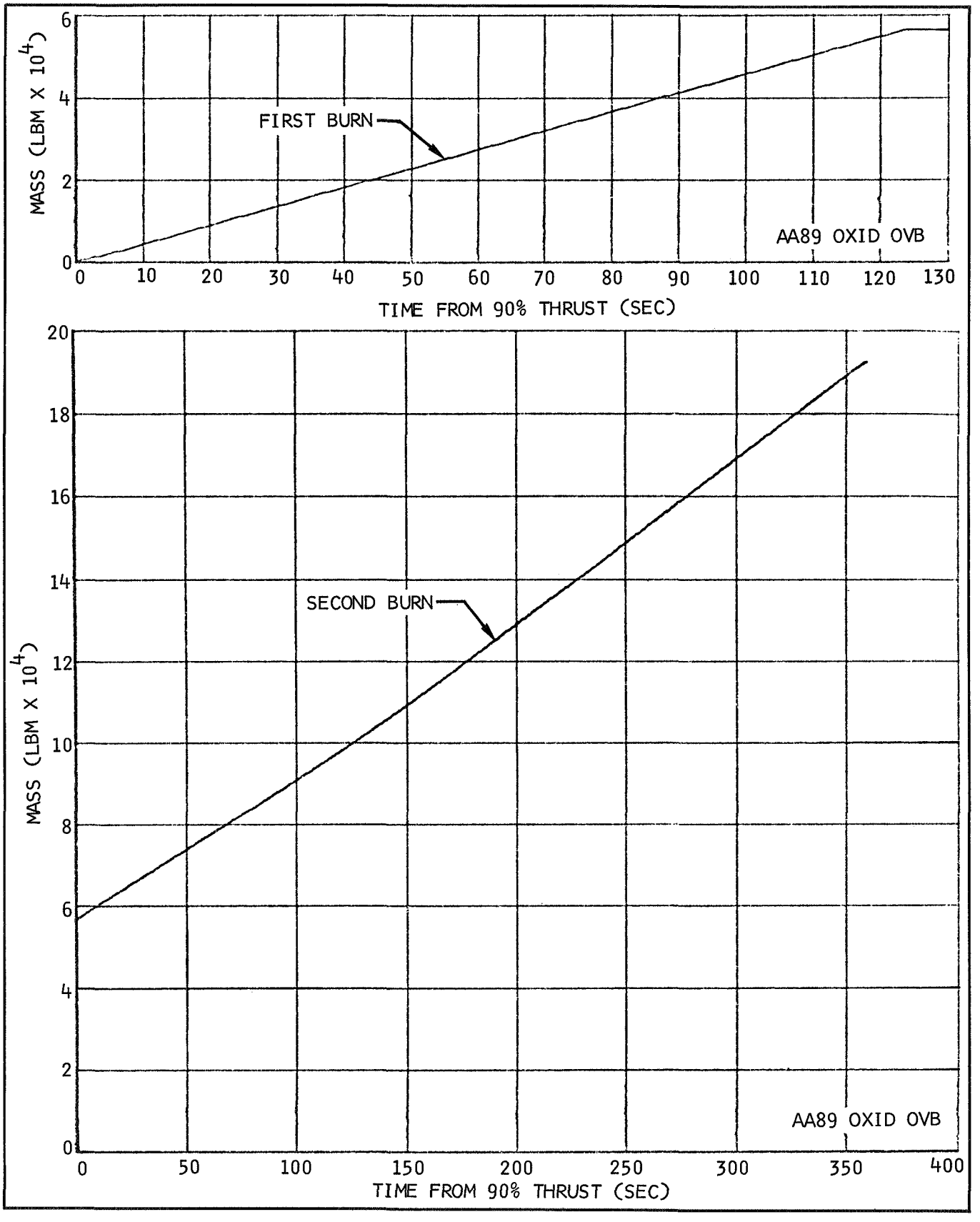


Figure AP 5-34. LOX Mass Overboard

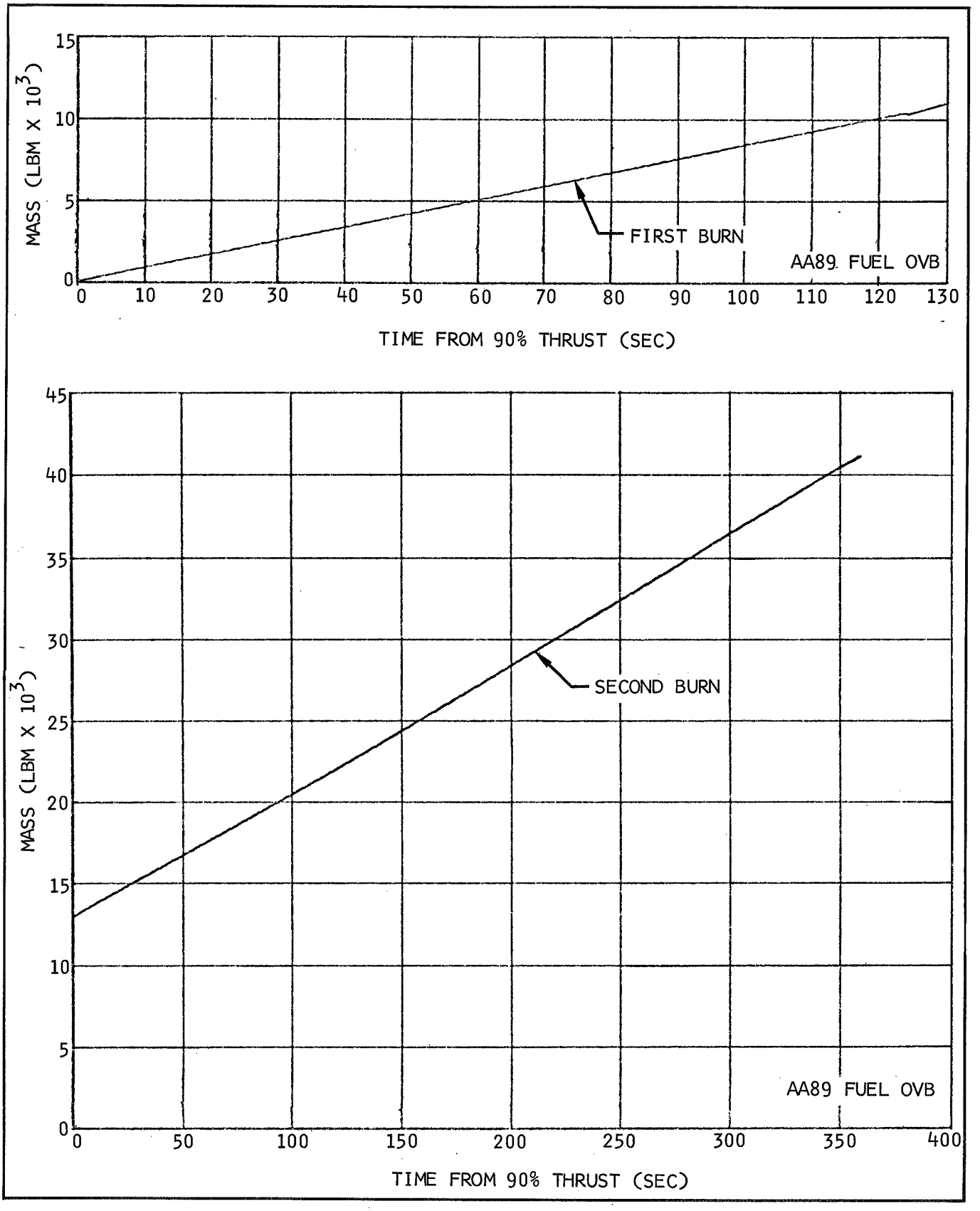


Figure AP 5-35. LH2 Mass Overboard

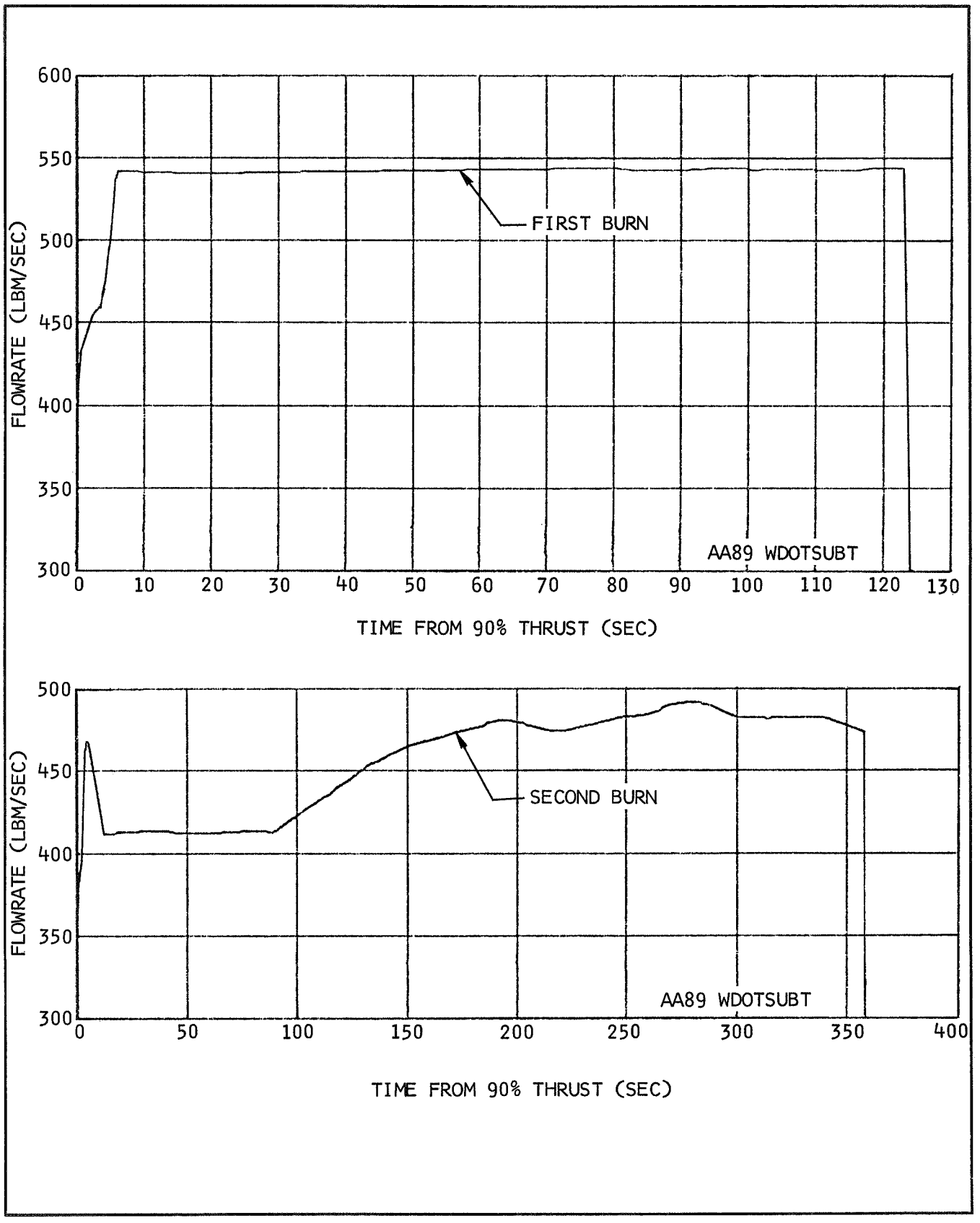


Figure AP 5-36. Total Propellant Flowrates

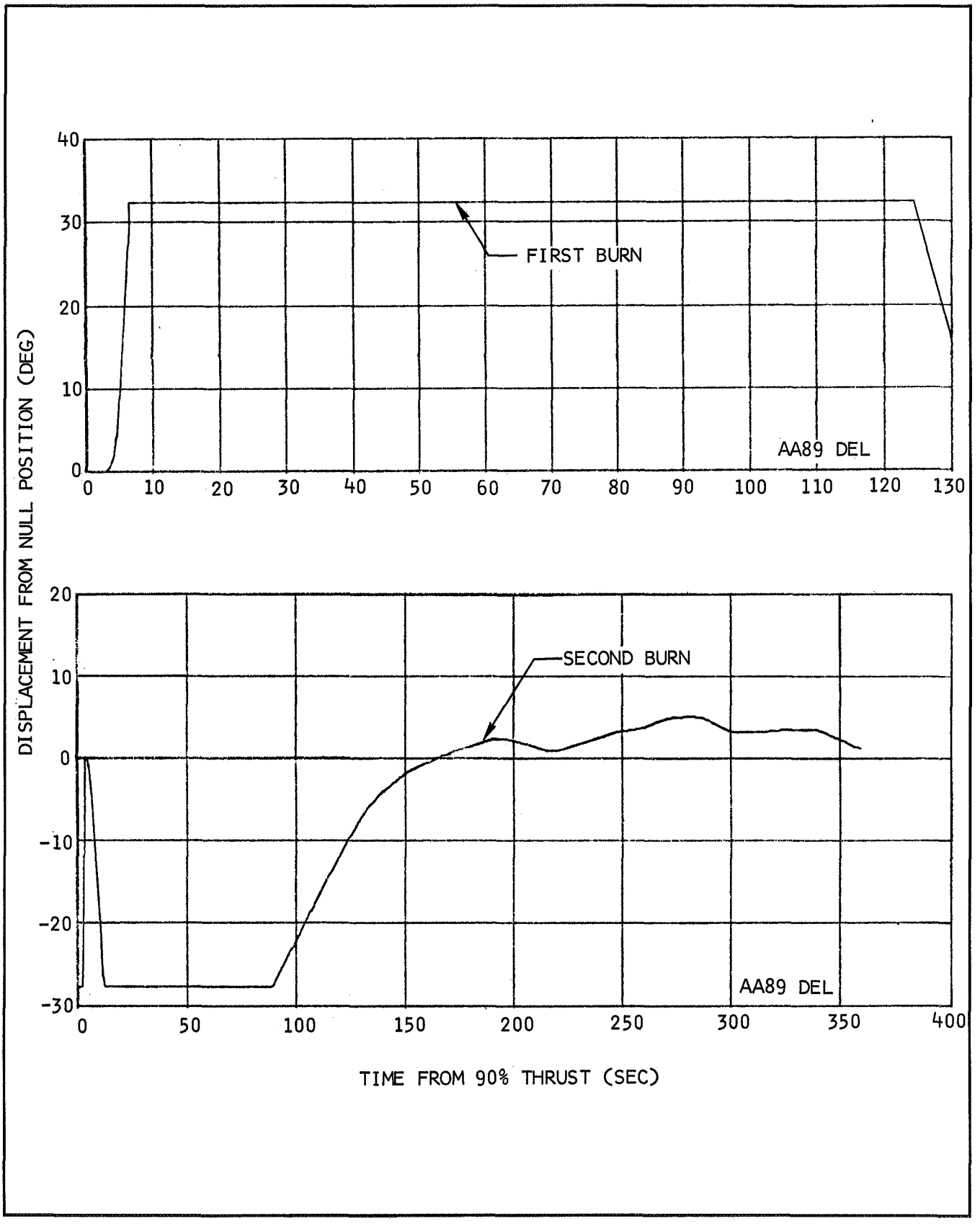


Figure AP 5-37. PU Valve Positions

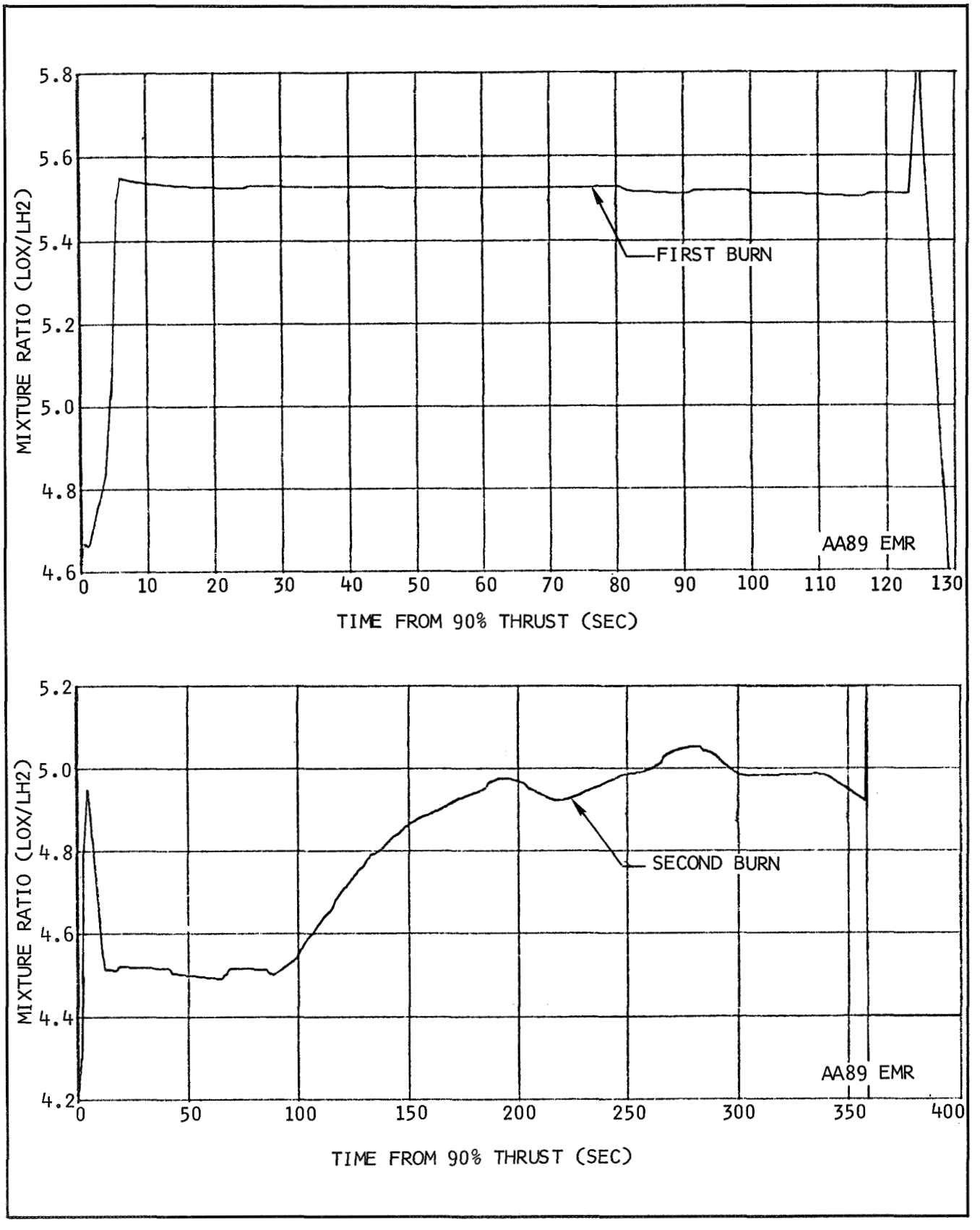


Figure AP 5-38. Engine Mixture Ratio

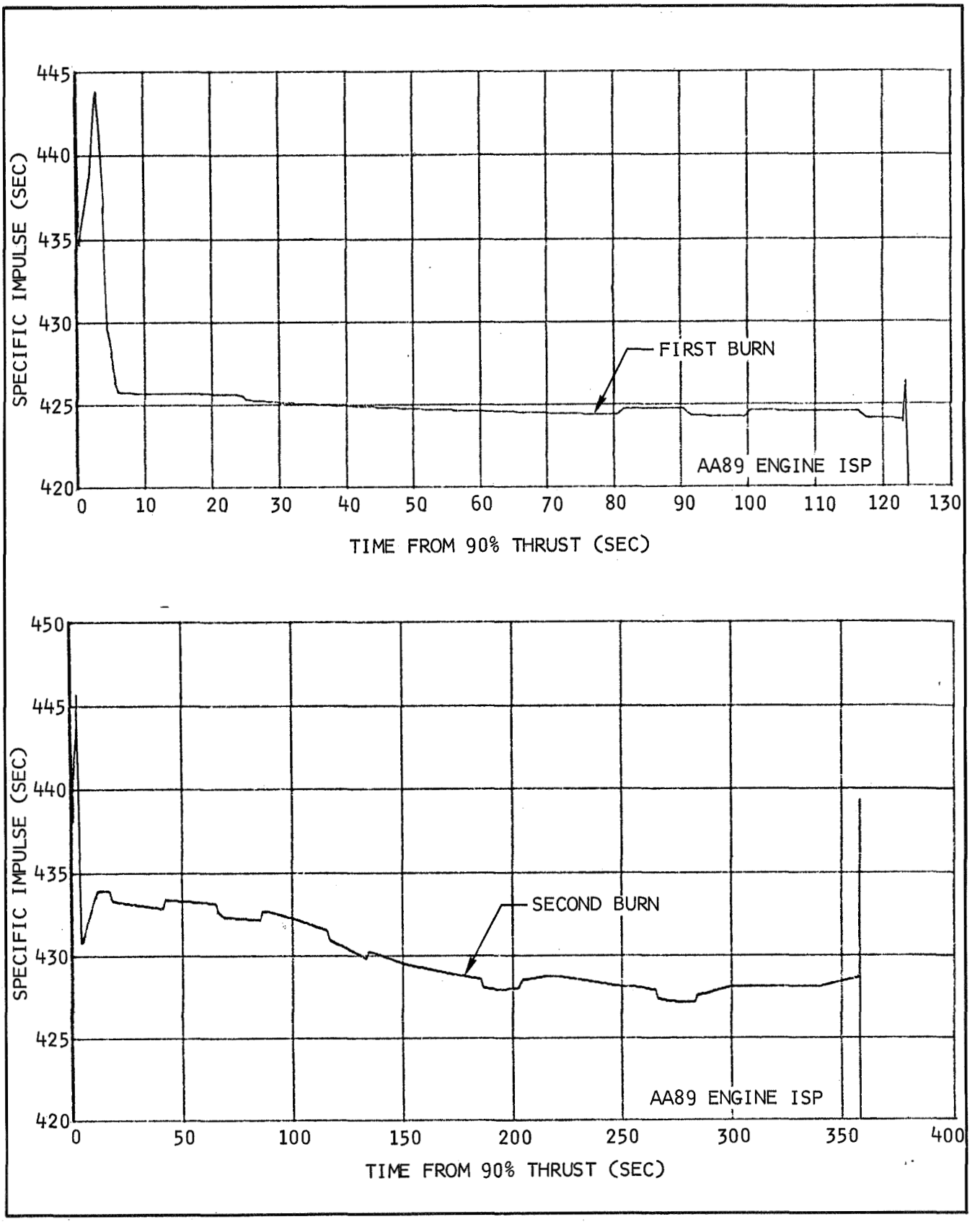
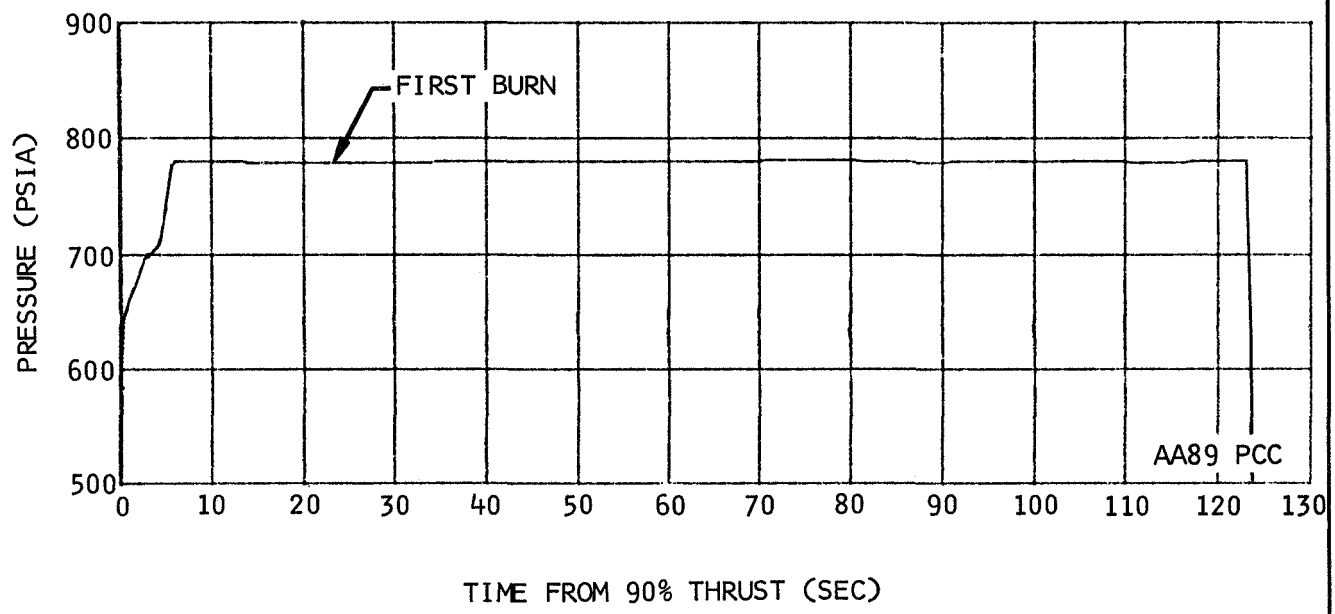


Figure AP 5-39. Engine Specific Impulse



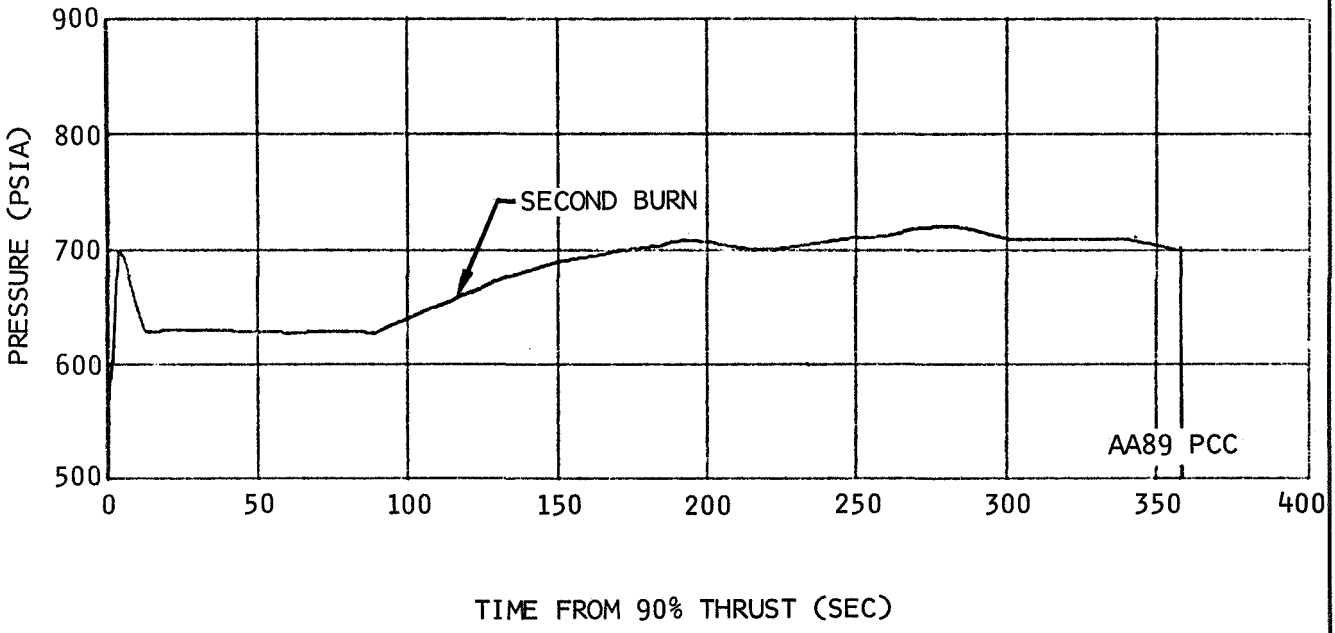


Figure AP 5-40. Thrust Chamber Pressures (Injector)

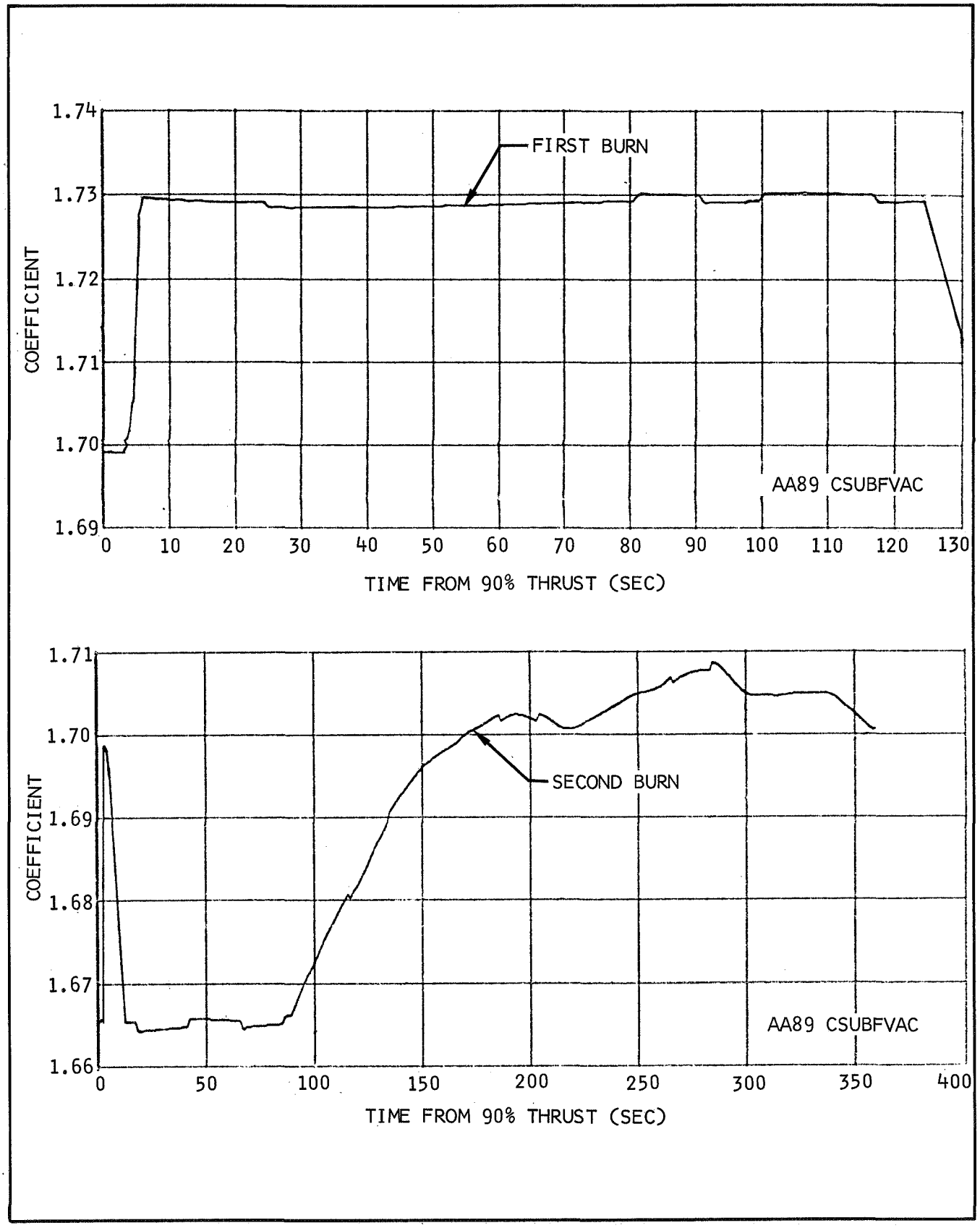


Figure AP 5-41. Vacuum Thrust Coefficients (Injector)

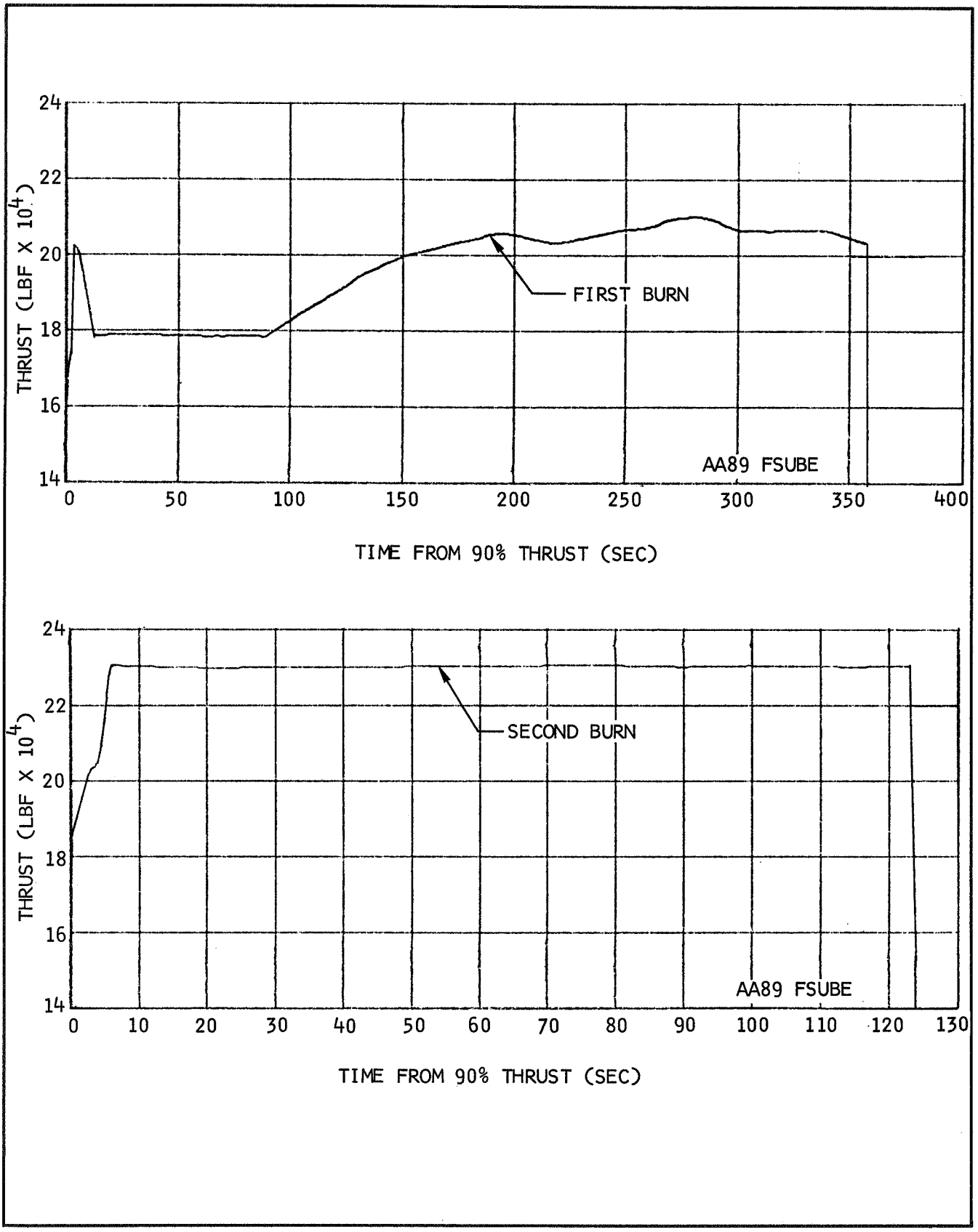


Figure AP 5-42. Engine Thrust

APPENDIX 6

PROPELLANT UTILIZATION DATA

6. PROPELLANT UTILIZATION DATA

This appendix presents the data required for S-IVB stage propellant loading as well as data for flight control and evaluation. The propellant loading requirements for the S-IVB-502 stage are summarized in table AP 6-1. These requirements are based on the S-IVB final propulsion performance predictions (appendix 5) and on a programmed mixture ratio mode of operation with depletion cutoff.

Propellant utilization (PU) system calibration data is presented in table AP 6-2. Figure AP 6-1 is a block diagram of the S-IVB-502 PU system. The motor, bridge, and feedback shaping network dynamics have been omitted as their effect on overall system response is negligible.

The estimated PU analysis accuracies for ground loading and flight, based on the inflight mass characteristics (appendix 2), are presented in table AP 6-3; table AP 6-4 presents estimated flight propellant residual accuracies.

Tabulations of the LH2 and LOX tank unique volume versus height data during ground loading, based on tank measurement data, are presented in tables AP 6-5 and AP 6-6. The predicted LOX and LH2 level histories for flight are shown in figures AP 6-2 and AP 6-3.

Mass sensor nonlinearities resulting from tank-to-sensor mismatch including mass sensor manufacturing nonlinearities are presented in figure AP 6-4 for both the flow integral and volumetric calibrations. These corrections are based on acceptance firing data and unique tank measurements. The flow integral nonlinearities were used in the predictions presented in this report.

Predicted mass corrections for flight dynamics effects are presented in figure AP 6-5. These corrections compensate for tank geometry changes caused by variations in tank skin temperature, vehicle acceleration, and differential tank pressures. Figure AP 6-6 provides the flight corrections for vehicle tilt caused by cg offset.

The actual propellant mass onboard is determined by adding the appropriate corrections to the indicated mass values. During loading operations,

tank-to-sensor mismatch and manufacturing nonlinearities are added to the indicated value. During powered flight, tank-to-sensor mismatch, manufacturing nonlinearities, flight dynamics, and vehicle tilt corrections must all be added to determine actual mass. Figure AP 6-7 presents the total predicted mass sensor corrections for flight using both the flow integral and volumetric calibration results. Again it should be pointed out that the flow integral values were used in the predictions presented in this report. The volumetric data will be used in conjunction with the stage and interstage weight and balance logs, to provide vehicle mass evaluation within 24 hr after launch.

TABLE AP 6-1 (Sheet 1 of 2)
PROPELLANT LOADING REQUIREMENTS SUMMARY

DESCRIPTION	LH2 (lbm)	LOX (lbm)	REMARKS
Usable Propellants			
Total Usable Propellants	38,484	191,747	The propellant load for the S-IVB-502 flight was defined using a nominal first burntime of 129 sec, a three-orbit coast (See Note 2), and a nominal second burntime (to depletion) of 368 sec.
Nominal Propellant Consumption	Note 3	Note 3	This quantity will normally be burned by the J-2 engine between the 90 percent thrust level at ignition and predicted guidance cutoff.
Total Available Flight Performance Reserve	Note 3	Note 3	This quantity is the nominal flight performance reserve and flight geometry reserve available following a predicted guidance cutoff.
LH2 Bias	197	--	The bias is included as a straight line bias to the empty and full calibration points to minimize residuals at depletion.
LH2 Bias to Support PMR	910	--	This is an electrical bias included in the orbital boiloff bias to ensure high EMR during first burn. After first burn cutoff this bias is removed and the LH2 becomes part of the normal propellant consumption for flight.
Unusable Propellants			
Total Unusable Propellants	4,009	1,526	The total unusable mainstage propellant is 5,634 lbm.
Orbital Boiloff	2,613	200	
Engine Chilldown Boiloff	5	40	

TABLE AP 6-1 (Sheet 2 of 2)
PROPELLANT LOADING REQUIREMENTS SUMMARY

DESCRIPTION	LH2 (lbm)	LOX (lbm)	REMARKS
LH2 Tank Pressurant	343	0	This quantity is required to pressurize the LH2 tank during burn and to refill the engine start sphere.
J-2 Start Transient	259	550	These are the propellants consumed during both J-2 engine start transients, from Engine Start Command to 90 percent thrust.
J-2 Cutoff Transient	56	296	These are the propellants consumed during both J-2 engine cutoff transients, from Engine Cutoff Command to zero thrust.
J-2 Trapped	10	108	These are the propellants trapped in the J-2 engine following the cutoff transient.
Unavailable	723	286	These are the unavailable propellants trapped in the tanks and lines, based upon depletion sensor cutoff and thrust decay.
Total Desired Load	42,493	193,273	

NOTE:

1. The allowable indicated-to-desired propellant load mismatch is ±0.5 percent of the desired propellant load in each tank, and the indicated-to-actual mass accuracy is ±1.3 percent. The RSS of these accuracies yields a desired-to-actual loading accuracy of 1.39 percent of the desired propellant load for each tank.
2. One of the mission criterion is to load for three orbits of propellant boil-off and restart at the end of two orbits.
3. To be determined after the trajectory simulation has established the predicted cutoff times.

TABLE AP 6-2 (Sheet 1 of 3)
PROPELLANT UTILIZATION CALIBRATION DATA

PROPELLANT LEVEL	CAPACITANCE (pf)	MASS (lbm)	COARSE MASS RATIO	FINE MASS RATIO (λ)
LOX MASS SENSOR (E-9)				
Helium Calibration Point (1)	282.71	1,788	0.02036	Tap +0.01996
Air Calibration Point (GN2)	282.86	2,001	0.02132	Tap +0.02089
Probe Bottom (Cryogenic)	282.36	1,270	0.01805	Tap +0.01769
Empty Calibration Point	279.62	-2,774	0.0	Tap
Full Calibration Point (2)	411.77	192,011	0.86956	Tap +0.85217
Probe Calibration Point	412.76	193,470	0.87607	Tap +0.85855
Full Load (Pressurized) (3)	412.63	193,273	0.87519	Tap +0.85769
Full Load (Unpressurized) (4)	413.07	193,273	0.87812	Tap +0.86056
RMR Calibration Point	411.77	192,011	0.86956	Tap +0.85217

The above data are valid only when probe is immersed in GHe at ambient room conditions.

NOTES:

(1) When LOX tank is empty of propellant and filled only with GHe at one atmosphere.

(2) The delta capacitance (full calibration point minus the helium calibration point) is 129.96 pf, which is equal to a coarse mass ratio (CMR) of 0.86956 and a LOX mass of 192,011 lbm.

(3) The loading computer (L/C) will be programmed to load to a CMR of 0.87519, which is equal to a LOX mass of 193,273 lbm (pressurized). The maximum acceptable deviation from the nominal load is ±0.5 percent; i.e., a minimum CMR of 0.87086 and a maximum of 0.87949.

(4) The L/C will be programmed to load to a CMR of 0.87812, which is equal to a LOX mass of 193,273 lbm (unpressurized). An L/C tolerance of ±0.5 percent of the desired load will yeild a minimum CMR of 0.87382 and a maximum of 0.88242. The nominal CMR of 0.87812 will be used as the initial 100 percent value for the KSC propellant loading test. This value was based upon data obtained from the AS-201 and AS-203 propellant loading tests and launch countdowns. Additional adjustments to the CMR (unpressurized) may be required after the AS-502 Countdown Demonstration Test.

TABLE AP 6-2 (Sheet 2 of 3)
PROPELLANT UTILIZATION CALIBRATION DATA

PROPELLANT LEVEL	CAPACITANCE (pf)	MASS (lbm)	COARSE MASS RATIO	FINE MASS RATIO (λ)
LH2 MASS SENSOR (E-9)				
Helium Calibration Point(5)	973.30	-8	-0.00661	Tap -0.00648
Air Calibration Point (GN2)	973.80	95	-0.00432	Tap -0.00424
Probe Bottom (Cryogenic)	974.34	206	-0.00187	Tap -0.00183
Empty Calibration Point	974.75	291	0.0	Tap
Full Calibration Point(6)	1,165.87	39,587	0.86956	Tap +0.85217
Probe Calibration Point	1,170.38	40,515	0.89010	Tap +0.87229
Full Load (Pressurized)(7)	1,180.00	42,493	0.93386	Tap +0.91519
Full Load (Unpressurized)(8)	1,181.39	42,493	0.94017	Tap +0.92137
Reference Mixture Ratio Calibration Point	1,165.87	39,587	0.86957	Tap +0.85217

The above data are valid only when probe is immersed in GHe at ambient room conditions.

NOTES:

(5) When LH2 tank is empty of propellant and filled only with GHe at one atmosphere.

(6) The delta capacitance (full calibration point minus the helium calibration point) is 192.57 pf, which is equal to a coarse mass ratio (CMR) of 0.86956 and an LH2 mass of 39,587 lbm.

(7) The loading computer (L/C) will be programmed to load to a CMR of 0.93386, which is equal to an LH2 mass of 42,493 lbm (pressurized). The maximum acceptable deviation from the nominal load is ±0.5 percent; i.e., a minimum CMR of 0.92918 and a maximum of 0.93857.

(8) The L/C will be programmed to load to a CMR of 0.94071, which is equal to an LH2 mass of 42,493 lbm (unpressurized). An L/C tolerance of ±0.5 percent of the desired load will yield a minimum CMR of 0.93600 and a maximum of 0.94542. The nominal CMR of 0.88270 will be used as the initial 100 percent value for the KSC propellant loading test. This value was based upon data obtained from the AS-201 and AS-203 propellant loading tests and launch countdowns. Additional adjustments to the CMR (unpressurized) may be required after the AS-502 Countdown Demonstration Test.

TABLE AP 6-2 (Sheet 3 of 3)
PROPELLANT UTILIZATION CALIBRATION DATA

MASS AND CAPACITANCE REDUCTION FORMULAE

LOX Mass = $\lambda(228{,}575) - 7{,}345$

LH2 Mass = $\lambda(46{,}113) - 632$

LOX Capacitance = $\lambda(155.08) + 276.52$

LH2 Capacitance = $\lambda(224.27) + 970.27$

$$\lambda = \frac{LEG}{20}$$

LEG = Total integral number plus fractional part of fine mass LEGS traversed expressed as a decimal. Example: LEG = 18.49 indicates that 18 full LEGS have been traversed plus 49/100 of the nineteenth LEG.

REFERENCE MIXTURE RATIO ADJUSTMENT TO 5.00

a. Calibrate bridges as shown in table

b. Put in ΔC = 192.57 pf on LH2 bridge

c. Put in ΔC = 129.06 pf on LOX bridge

d. Adjust bias potentiometers for 0.00 $\pm$0.01 volts at the empty calibration point and with the above ΔC's in the bridges.

TABLE AP 6-3
ESTIMATED PU ANALYSIS ACCURACIES

ITEM	DESCRIPTION	TEST	LOX TANK (± lbm)								LH2 TANK (± lbm)											
			LEVEL SENSOR NO.								LEVEL SENSOR NO.											
			L0012	L0011	L0010	L0009	L0008	L0006	L0005	L0004	N0023	N0024	N0025	N0026	N0027	N0028	N0029	N0030	N0031	N0032	L0002	L0001
1.	Predicted accuracies of level sensors	FLIGHT	1,245	1,223	1,186	1,021	783	538	385	176	251	241	228	211	196	181	167	157	146	139	84	45
		CDDT*	1,136	1,014	868	673	475	305	213	100	230	209	189	168	148	128	107	91	70	56	37	29
2.	Predicted accuracy of PU mass sensor at level sensor activation	FLIGHT and CDDT	1,780	1,550	1,260	940	670	460	390	320	415	385	350	315	280	250	215	182	150	115	82	70
3.	Probable deviation between level sensor and PU mass sensor (RSS of items 1 and 2)	FLIGHT	2,172	1,974	1,730	1,388	1,031	708	548	365	485	454	418	379	342	309	272	240	209	180	117	83
		CDDT	2,112	1,852	1,530	1,156	821	552	444	335	474	438	398	357	317	281	240	203	166	160	90	76
4.	Predicted accuracy of propellant residuals at ECC as determined by individual level sensor	FLIGHT	TO BE INCLUDED IN LATER REVISION																			
5.	Probable deviation between mass sensor and level sensor determined residuals at ECC (RSS of item 4 and item 1 in table AP 6-2A)	FLIGHT	TO BE INCLUDED IN LATER REVISION																			

* Countdown demonstration test (CDDT) predictions are valid only if propellant is maintained at a minimum of 2 deg R below saturation and at nominal tank pressurization.

TABLE AP 6-4
ACCURACY OF DETERMINING PROPELLANT RESIDUALS

ITEM	DESCRIPTION	FIRST BURN			SECOND BURN		
		LOX (± lbm)	LH2 (± lbm)	TOTAL (± lbm)	LOX (± lbm)	LH2 (± lbm)	TOTAL (± lbm)
1.	PU system mass sensor accuracy of propellant residuals at ECC based on a predicted residual, above the main propellant valves, of TBD lbm LOX and TBD lbm LH2 (first burn) and TBD lbm LOX and TBD lbm LH2 (second burn)	TBD	TBD	TBD	TBD	TBD	TBD
2.	Estimated overall level sensor accuracy of propellant residuals at ECC as determined by the weighted average technique based on predicted residuals noted in item 1.	TBD	TBD	TBD	TBD	TBD	TBD
3.	Combining the estimated level sensor residual accuracy (item 2) with the mass sensor residual accuracy (item 1) using the weighted average technique, the stage estimated residual accuracy at ECC is:	TBD	TBD	TBD	TBD	TBD	TBD

NOTE: Totals represent RSS (root-sum-square) values of individual propellant tank accuracies.

TABLE AP 6-5 (Sheet 1 of 3)
SATURN S-IVB-502 HEIGHT VERSUS VOLUME
LH2 TANK-GROUND LOADING CONDITION

HEIGHT* (in.)	VOLUME (ft^3)	HEIGHT* (in.)	VOLUME (ft^3)	HEIGHT* (in.)	VOLUME (ft^3)
1.00	0.000	51.00	382.606	101.00	1608.605
2.00	0.000	52.00	398.104	102.00	1638.766
3.00	0.000	53.00	413.953	103.00	1668.933
4.00	.506	54.00	430.156	104.00	1699.106
5.00	1.550	55.00	446.717	105.00	1729.284
6.00	2.955	56.00	463.640	106.00	1759.468
7.00	4.710	57.00	480.926	107.00	1789.656
8.00	6.804	58.00	498.581	108.00	1819.848
9.00	9.230	59.00	516.607	109.00	1850.044
10.00	11.981	60.00	535.007	110.00	1880.244
11.00	15.049	61.00	553.786	111.00	1910.447
12.00	18.430	62.00	572.945	112.00	1940.653
13.00	22.119	63.00	592.490	113.00	1970.862
14.00	26.112	64.00	612.422	114.00	2001.073
15.00	30.406	65.00	632.746	115.00	2031.287
16.00	34.999	66.00	653.465	116.00	2061.502
17.00	39.889	67.00	674.582	117.00	2091.719
18.00	45.076	68.00	696.101	118.00	2121.938
19.00	50.558	69.00	718.024	119.00	2152.158
20.00	56.335	70.00	740.356	120.00	2182.379
21.00	62.407	71.00	763.099	121.00	2212.601
22.00	68.775	72.00	786.257	122.00	2242.823
23.00	75.440	73.00	809.834	123.00	2273.046
24.00	82.402	74.00	833.832	124.00	2303.270
25.00	89.662	75.00	858.256	125.00	2333.494
26.00	97.221	76.00	883.108	126.00	2363.717
27.00	105.081	77.00	908.391	127.00	2393.941
28.00	113.241	78.00	934.110	128.00	2424.164
29.00	121.703	79.00	960.268	129.00	2454.387
30.00	130.467	80.00	986.867	130.00	2484.609
31.00	139.533	81.00	1013.912	131.00	2514.831
32.00	148.901	82.00	1041.405	132.00	2545.053
33.00	158.570	83.00	1069.350	133.00	2575.273
34.00	168.540	84.00	1097.751	134.00	2605.493
35.00	178.808	85.00	1126.611	135.00	2635.711
36.00	189.372	86.00	1155.932	136.00	2665.929
37.00	200.230	87.00	1185.719	137.00	2696.146
38.00	211.377	88.00	1215.975	138.00	2726.361
39.00	222.789	89.00	1247.317	139.00	2756.575
40.00	234.336	90.00	1277.368	140.00	2786.788
41.00	246.195	91.00	1307.431	141.00	2817.000
42.00	258.367	92.00	1337.505	142.00	2847.211
43.00	270.857	93.00	1367.591	143.00	2877.420
44.00	283.668	94.00	1397.687	144.00	2907.628
45.00	296.803	95.00	1427.792	145.00	2937.834
46.00	310.265	96.00	1457.907	146.00	2968.040
47.00	324.058	97.00	1488.031	147.00	2998.243
48.00	338.185	98.00	1518.163	148.00	3028.446
49.00	352.650	99.00	1548.303	149.00	3058.647
50.00	367.456	100.00	1578.450	150.00	3088.846

*NOTE: Height is the distance above the LH2 tank reference station 248.574

TABLE AP 6-5 (Sheet 2 of 3)
SATURN S-IVB-502 HEIGHT VERSUS VOLUME
LH2 TANK-GROUND LOADING CONDITION

HEIGHT* (in.)	VOLUME (ft^3)	HEIGHT* (in.)	VOLUME (ft^3)	HEIGHT* (in.)	VOLUME (ft^3)
151,00	3119,044	201,00	4627,576	251,00	6131,649
152,00	3149,241	202,00	4657,723	252,00	6161,617
153,00	3179,436	203,00	4687,869	253,00	6191,578
154,00	3209,630	204,00	4718,014	254,00	6221,534
155,00	3239,823	205,00	4748,158	255,00	6251,483
156,00	3270,014	206,00	4778,300	256,00	6281,427
157,00	3300,204	207,00	4808,440	257,00	6311,364
158,00	3330,393	208,00	4838,579	258,00	6341,295
159,00	3360,580	209,00	4868,716	259,00	6371,220
160,00	3390,766	210,00	4898,852	260,00	6401,139
161,00	3420,951	211,00	4928,986	261,00	6431,051
162,00	3451,135	212,00	4959,118	262,00	6460,958
163,00	3481,318	213,00	4989,247	263,00	6490,859
164,00	3511,499	214,00	5019,375	264,00	6520,753
165,00	3541,679	215,00	5049,501	265,00	6550,642
166,00	3571,858	216,00	5079,624	266,00	6580,525
167,00	3602,036	217,00	5109,745	267,00	6610,403
168,00	3632,213	218,00	5139,864	268,00	6640,275
169,00	3662,389	219,00	5169,980	269,00	6670,142
170,00	3692,564	220,00	5200,093	270,00	6700,004
171,00	3722,738	221,00	5230,204	271,00	6729,860
172,00	3752,911	222,00	5260,312	272,00	6759,712
173,00	3783,084	223,00	5290,416	273,00	6789,559
174,00	3813,255	224,00	5320,518	274,00	6819,403
175,00	3843,425	225,00	5350,616	275,00	6849,242
176,00	3873,595	226,00	5380,711	276,00	6879,077
177,00	3903,764	227,00	5410,802	277,00	6908,909
178,00	3933,932	228,00	5440,890	278,00	6938,738
179,00	3964,099	229,00	5470,974	279,00	6968,564
180,00	3994,265	230,00	5501,055	280,00	6998,388
181,00	4024,431	231,00	5531,131	281,00	7028,210
182,00	4054,596	232,00	5561,203	282,00	7058,031
183,00	4084,760	233,00	5591,271	283,00	7087,850
184,00	4114,923	234,00	5621,335	284,00	7117,670
185,00	4145,086	235,00	5651,394	285,00	7147,489
186,00	4175,247	236,00	5681,449	286,00	7177,308
187,00	4205,409	237,00	5711,499	287,00	7207,129
188,00	4235,569	238,00	5741,544	288,00	7236,952
189,00	4265,728	239,00	5771,584	289,00	7266,777
190,00	4295,887	240,00	5801,620	290,00	7296,605
191,00	4326,045	241,00	5831,650	291,00	7326,438
192,00	4356,202	242,00	5861,675	292,00	7356,274
193,00	4386,359	243,00	5891,694	293,00	7386,116
194,00	4416,514	244,00	5921,709	294,00	7415,965
195,00	4446,669	245,00	5951,717	295,00	7445,820
196,00	4476,823	246,00	5981,720	296,00	7475,684
197,00	4506,975	247,00	6011,718	297,00	7505,557
198,00	4537,127	248,00	6041,709	298,00	7535,440
199,00	4567,278	249,00	6071,695	299,00	7565,334
200,00	4597,427	250,00	6101,675	300,00	7595,240

*NOTE: Height is the distance above the LH2 tank reference station 248.574

TABLE AP 6-5 (Sheet 3 of 3)
SATURN S-IVB-502 HEIGHT VERSUS VOLUME
LH2 TANK-GROUND LOADING CONDITION

HEIGHT* (in.)	VOLUME (ft^3)	HEIGHT* (in.)	VOLUME (ft^3)	HEIGHT* (in.)	VOLUME (ft^3)
301.00	7625.159	347.00	8975.355	392.00	10009.834
302.00	7655.093	348.00	9002.617	393.00	10027.077
303.00	7685.043	349.00	9029.735	394.00	10044.008
304.00	7715.009	350.00	9056.704	395.00	10060.622
305.00	7744.994	351.00	9083.522	396.00	10076.916
306.00	7775.000	352.00	9110.186	397.00	10092.885
307.00	7805.026	353.00	9136.691	398.00	10108.524
308.00	7835.074	354.00	9163.035	399.00	10123.830
309.00	7861.318	355.00	9189.215	400.00	10138.797
310.00	7891.938	356.00	9215.227	401.00	10153.422
311.00	7922.518	357.00	9241.068	402.00	10167.700
312.00	7953.056	358.00	9266.734	403.00	10181.626
313.00	7983.549	359.00	9292.223	404.00	10195.197
314.00	8013.996	360.00	9317.530	405.00	10208.407
315.00	8044.393	361.00	9342.652	406.00	10221.251
316.00	8074.739	362.00	9367.586	407.00	10233.727
317.00	8105.030	363.00	9392.328	408.00	10245.827
318.00	8135.264	364.00	9416.875	409.00	10257.549
319.00	8165.439	365.00	9441.222	410.00	10268.888
320.00	8195.552	366.00	9465.368	411.00	10279.838
321.00	8225.601	367.00	9489.307	412.00	10290.395
322.00	8255.583	368.00	9513.037	413.00	10300.555
323.00	8285.495	369.00	9536.553	414.00	10310.312
324.00	8315.335	370.00	9559.853	415.00	10319.662
325.00	8345.100	371.00	9582.932	416.00	10328.600
326.00	8374.787	372.00	9605.786	417.00	10337.121
327.00	8404.394	373.00	9628.413	418.00	10345.220
328.00	8433.919	374.00	9650.807	419.00	10352.893
329.00	8463.357	375.00	9672.966	420.00	10360.135
330.00	8492.707	376.00	9694.886	421.00	10366.939
331.00	8521.966	377.00	9716.562	422.00	10373.303
332.00	8551.131	378.00	9737.991	423.00	10379.220
333.00	8580.199	379.00	9759.169	424.00	10384.686
334.00	8609.168	380.00	9780.092	425.00	10389.695
335.00	8638.034	381.00	9800.756	426.00	10394.243
336.00	8666.794	382.00	9821.158	427.00	10398.323
337.00	8695.446	383.00	9841.293	428.00	10401.933
338.00	8723.987	384.00	9861.157	429.00	10405.065
339.00	8752.414	385.00	9880.746	430.00	10407.715
340.00	8780.724	386.00	9900.056	431.00	10409.878
341.00	8808.913	387.00	9919.084	432.00	10411.549
342.00	8836.979	388.00	9937.825	433.00	10412.721
343.00	8864.919	389.00	9956.274	434.00	10413.391
344.00	8892.730	390.00	9974.428	435.00	10413.552
345.00	8920.408	391.00	9992.283	436.00	10413.713
346.00	8947.951				

*NOTE: Height is the distance above the LH2 tank reference station 248.574

TABLE AP 6-6 (Sheet 1 of 2)
SATURN S-IVB-502 HEIGHT VERSUS VOLUME
LOX TANK-GROUND LOADING CONDITION

HEIGHT* (in.)	VOLUME (ft^3)	HEIGHT * (in.)	VOLUME (ft^3)	HEIGHT* (in.)	VOLUME (ft^3)
1.00	.052	51.00	531.388	101.00	1750.412
2.00	.682	52.00	550.803	102.00	1775.407
3.00	1.787	53.00	570.498	103.00	1800.203
4.00	3.365	54.00	590.472	104.00	1824.794
5.00	5.408	55.00	610.719	105.00	1849.178
6.00	7.912	56.00	631.237	106.00	1873.351
7.00	10.873	57.00	652.022	107.00	1897.309
8.00	14.286	58.00	673.071	108.00	1921.050
9.00	18.146	59.00	694.378	109.00	1944.568
10.00	22.449	60.00	715.942	110.00	1967.861
11.00	27.190	61.00	737.758	111.00	1990.925
12.00	32.365	62.00	759.823	112.00	2013.757
13.00	37.969	63.00	782.133	113.00	2036.352
14.00	43.999	64.00	804.683	114.00	2058.708
15.00	50.451	65.00	827.472	115.00	2080.820
16.00	57.319	66.00	850.494	116.00	2102.685
17.00	64.601	67.00	873.747	117.00	2124.300
18.00	72.293	68.00	897.227	118.00	2145.660
19.00	80.389	69.00	920.929	119.00	2166.763
20.00	88.888	70.00	944.851	120.00	2187.604
21.00	97.783	71.00	968.988	121.00	2208.180
22.00	107.073	72.00	993.338	122.00	2228.487
23.00	116.753	73.00	1017.896	123.00	2248.522
24.00	126.820	74.00	1042.659	124.00	2268.281
25.00	137.269	75.00	1067.623	125.00	2287.761
26.00	148.097	76.00	1092.784	126.00	2306.957
27.00	159.300	77.00	1118.140	127.00	2325.867
28.00	170.875	78.00	1143.686	128.00	2344.486
29.00	182.818	79.00	1169.418	129.00	2362.811
30.00	195.126	80.00	1195.334	130.00	2380.838
31.00	207.794	81.00	1221.429	131.00	2398.564
32.00	220.819	82.00	1247.701	132.00	2415.985
33.00	234.198	83.00	1274.144	133.00	2433.097
34.00	247.927	84.00	1300.756	134.00	2449.897
35.00	262.003	85.00	1327.534	135.00	2466.380
36.00	276.421	86.00	1354.473	136.00	2482.544
37.00	291.178	87.00	1381.570	137.00	2498.385
38.00	306.271	88.00	1408.822	138.00	2513.899
39.00	321.696	89.00	1436.146	139.00	2529.081
40.00	337.450	90.00	1463.266	140.00	2543.930
41.00	353.528	91.00	1490.228	141.00	2558.441
42.00	369.928	92.00	1517.030	142.00	2572.609
43.00	386.645	93.00	1543.667	143.00	2586.433
44.00	403.677	94.00	1570.136	144.00	2599.907
45.00	421.019	95.00	1596.433	145.00	2613.029
46.00	438.668	96.00	1622.555	146.00	2625.794
47.00	456.620	97.00	1648.498	147.00	2638.199
48.00	474.872	98.00	1674.259	148.00	2650.240
49.00	493.419	99.00	1699.834	149.00	2661.913
50.00	512.260	100.00	1725.220	150.00	2673.216

*NOTE: Height is the distance above the LOX tank reference station 156.416.

TABLE AP 6-6 (Sheet 2 of 2)
SATURN S-IVB-502 HEIGHT VERSUS VOLUME
LOX TANK-GROUND LOADING CONDITION

HEIGHT* (in.)	VOLUME (ft^3)	HEIGHT* (in.)	VOLUME (ft^3)	HEIGHT* (in.)	VOLUME (ft^3)
151.00	2684.143	160.00	2764.998	169.00	2812.453
152.00	2694.691	161.00	2771.970	170.00	2815.544
153.00	2704.857	162.00	2778.526	171.00	2818.186
154.00	2714.637	163.00	2784.663	172.00	2820.374
155.00	2724.027	164.00	2790.375	173.00	2822.104
156.00	2733.024	165.00	2795.661	174.00	2823.373
157.00	2741.623	166.00	2800.515	175.00	2824.176
158.00	2749.821	167.00	2804.934	176.00	2824.511
159.00	2757.614	168.00	2808.915		

*NOTE: Height is the distance above the LOX tank reference station 156.416.

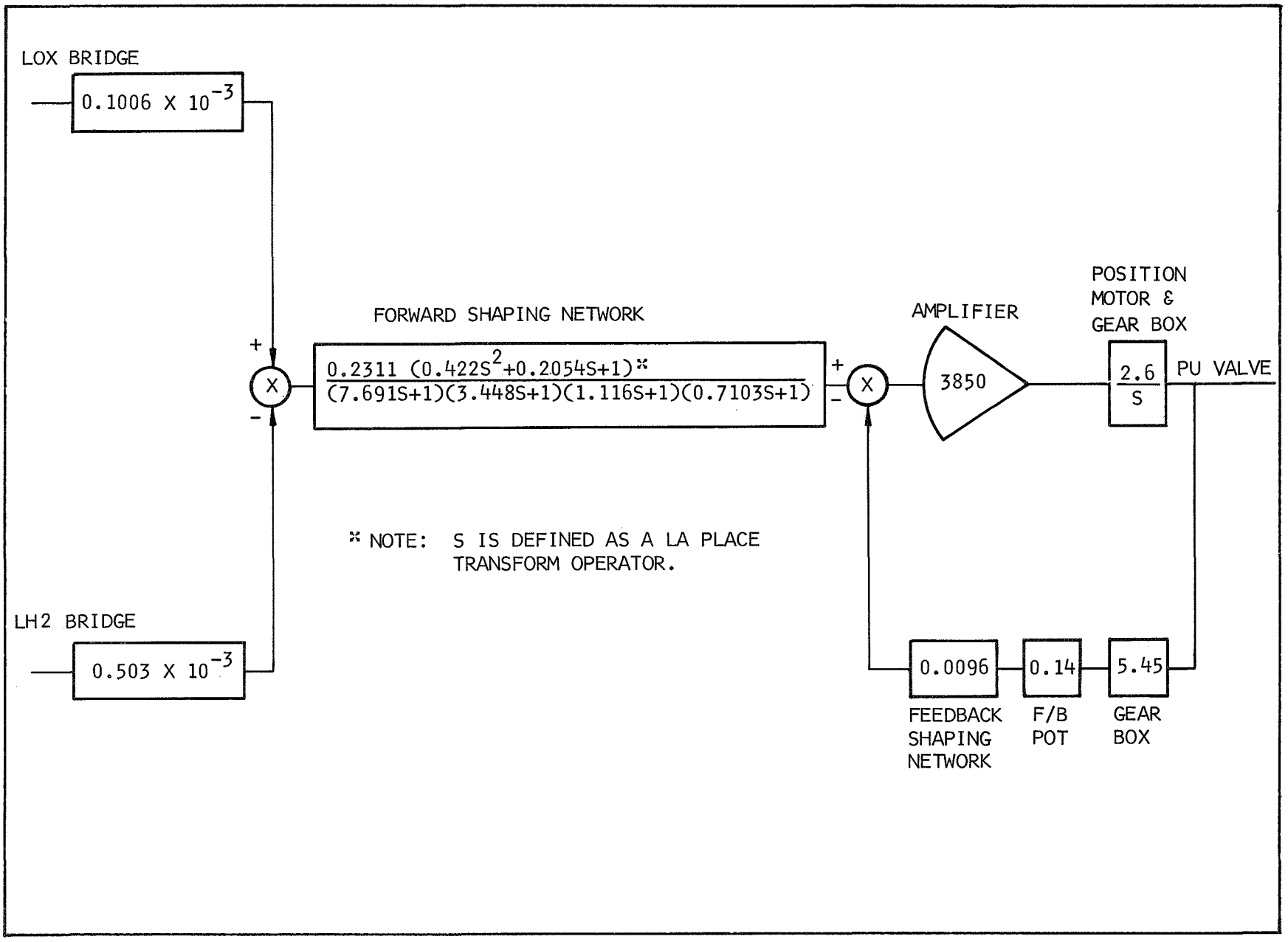


Figure AP 6-1. S-IVB-502 PU System Block Diagram

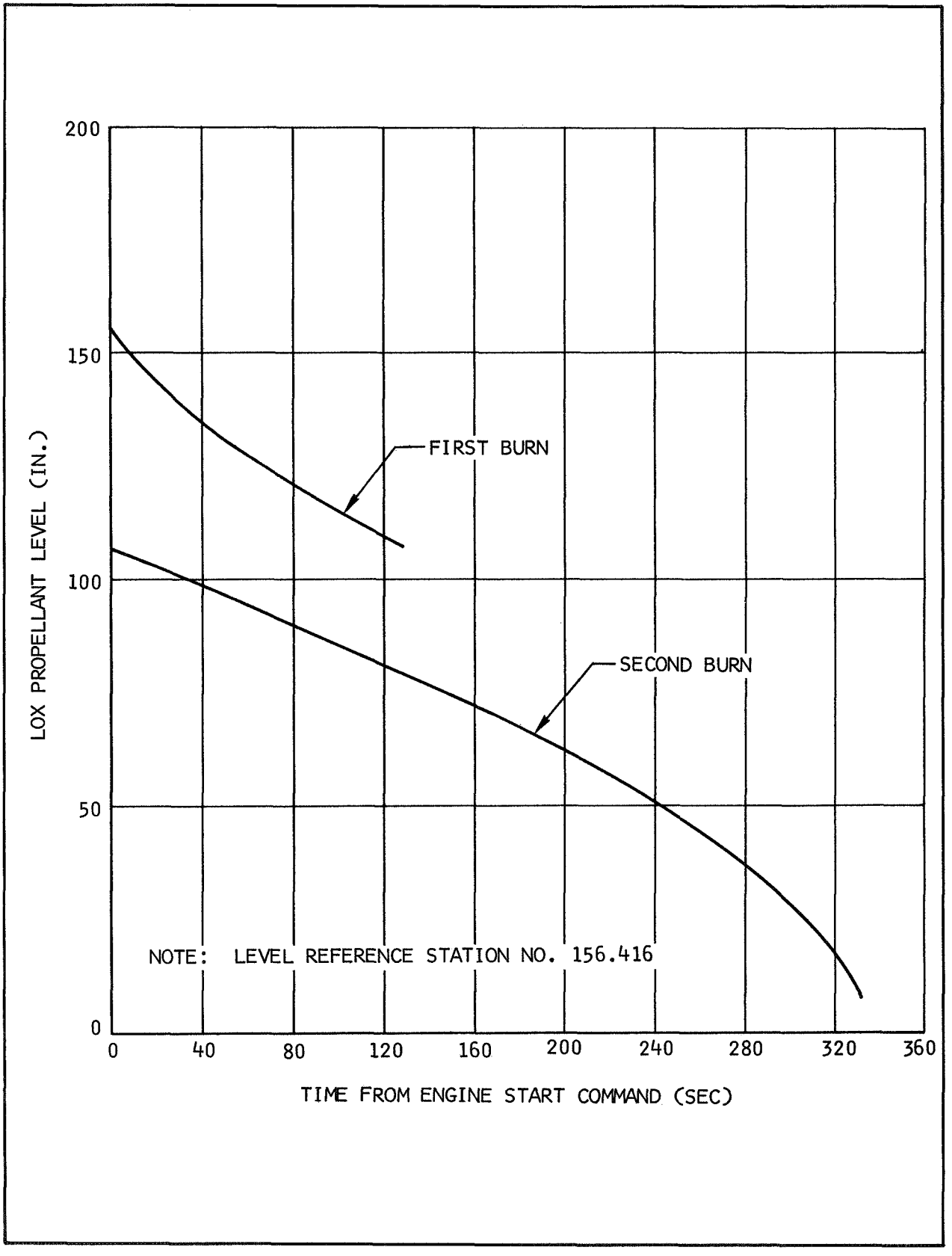


Figure AP 6-2. Predicted LOX Level History

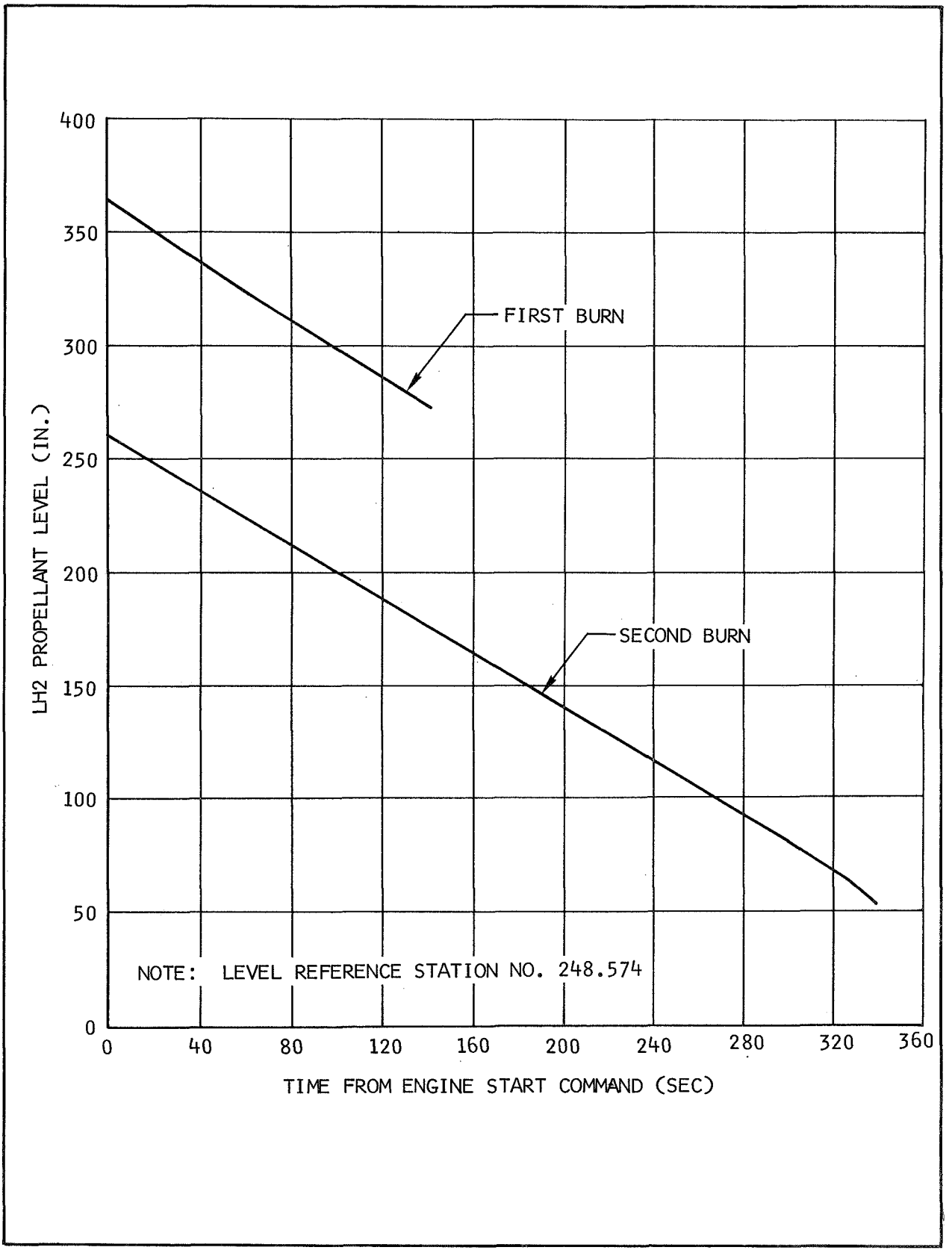


Figure AP 6-3. Predicted LH2 Level History

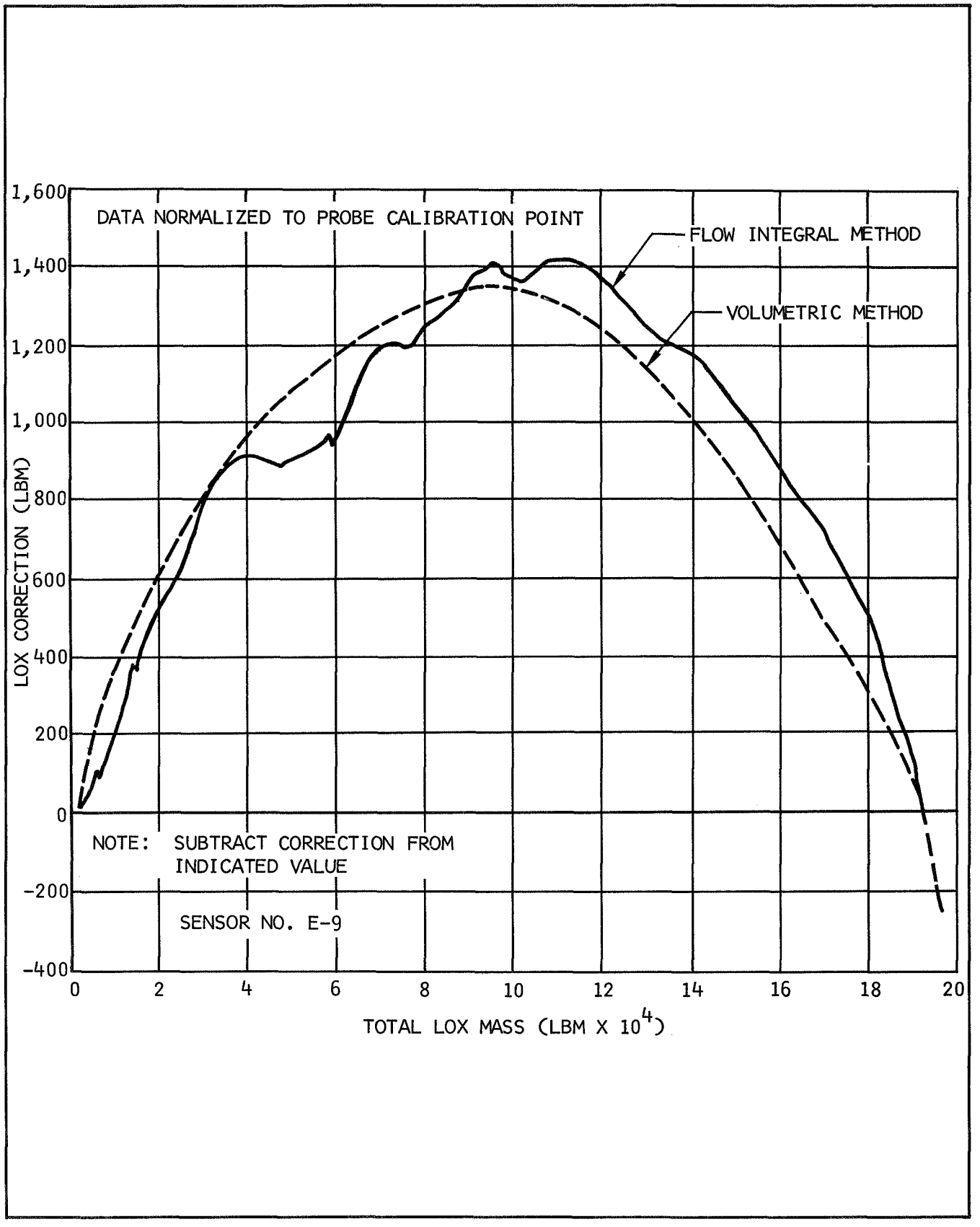


Figure AP 6-4. Tank-To-Sensor Mismatches Including Manufacturing Nonlinearities (Sheet 1 of 2)

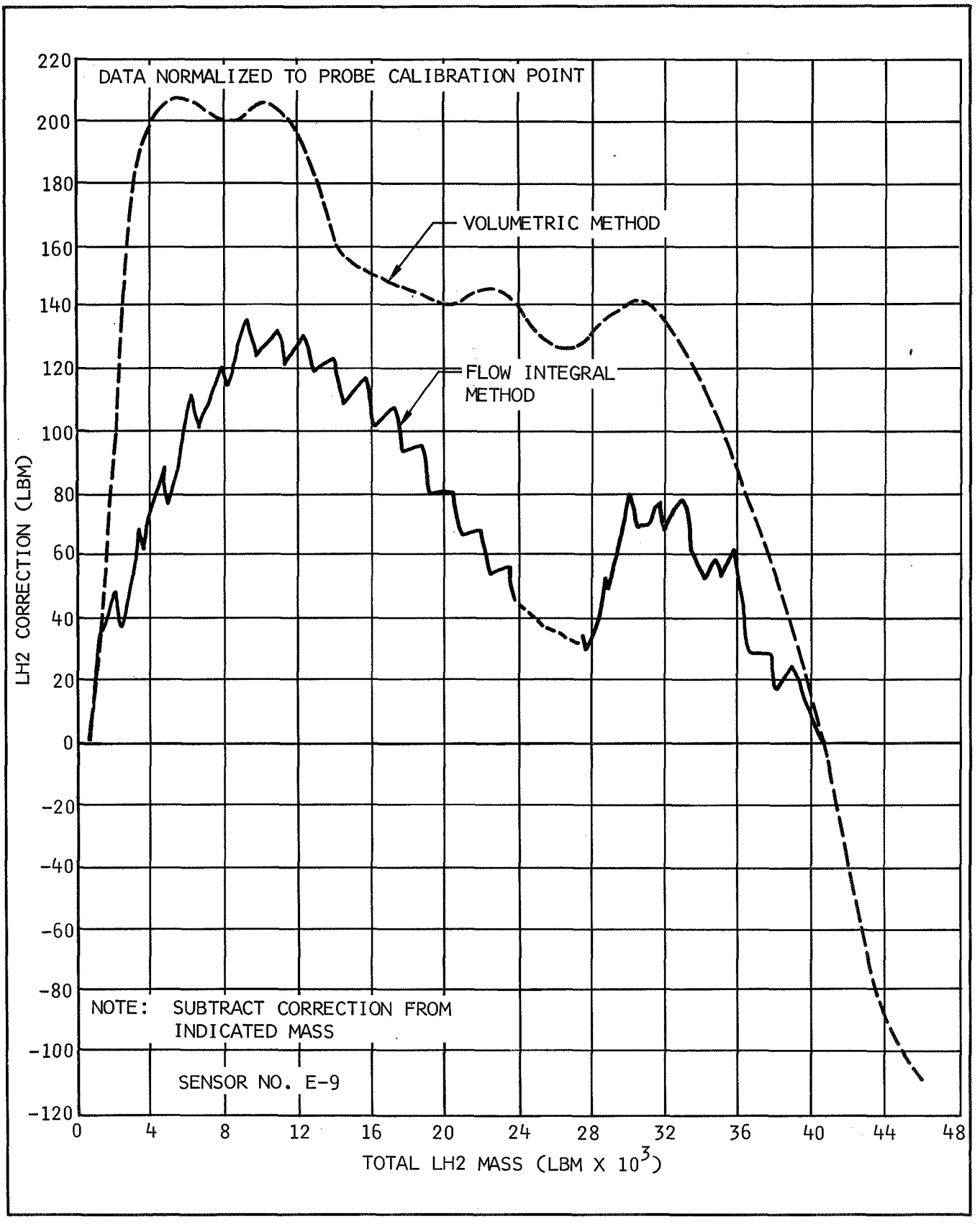


Figure AP 6-4. Tank-To-Sensor Mismatches Including Manufacturing Nonlinearities (Sheet 2 of 2)

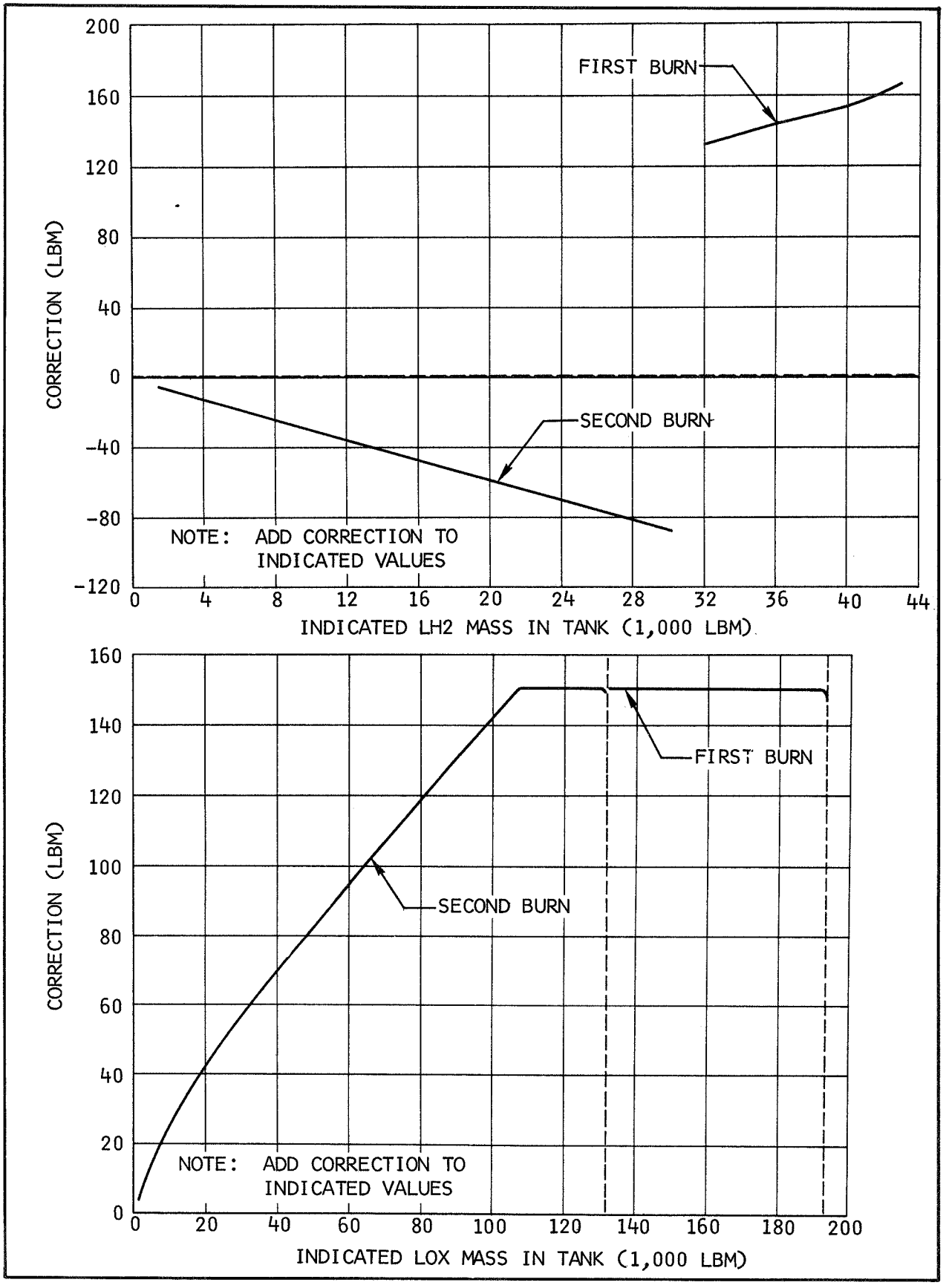


Figure AP 6-5. Predicted Sensor Correction for Flight Dynamics Effects

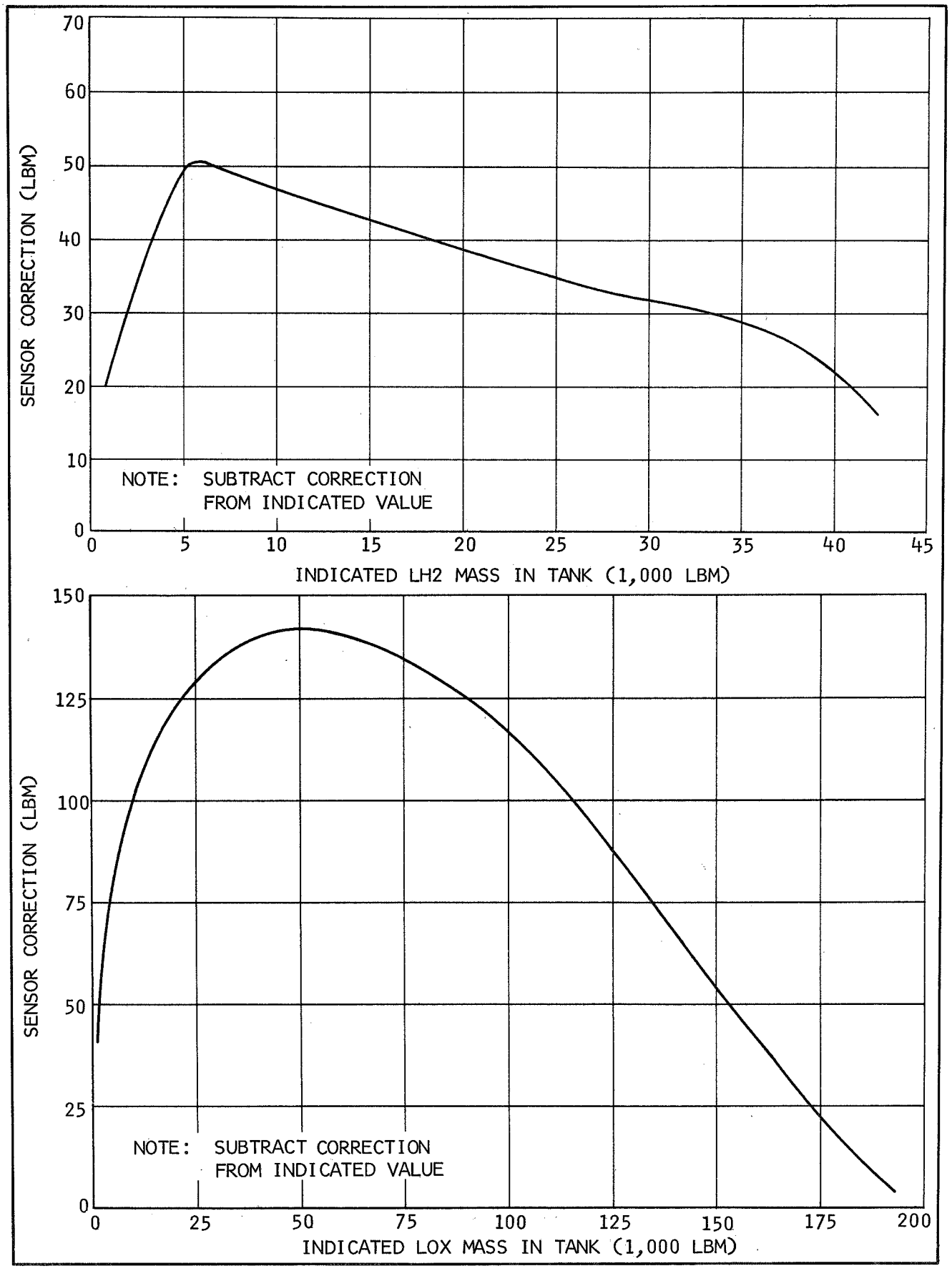


Figure AP 6-6. Mass Sensor Correction for Center-of-Gravity Offset

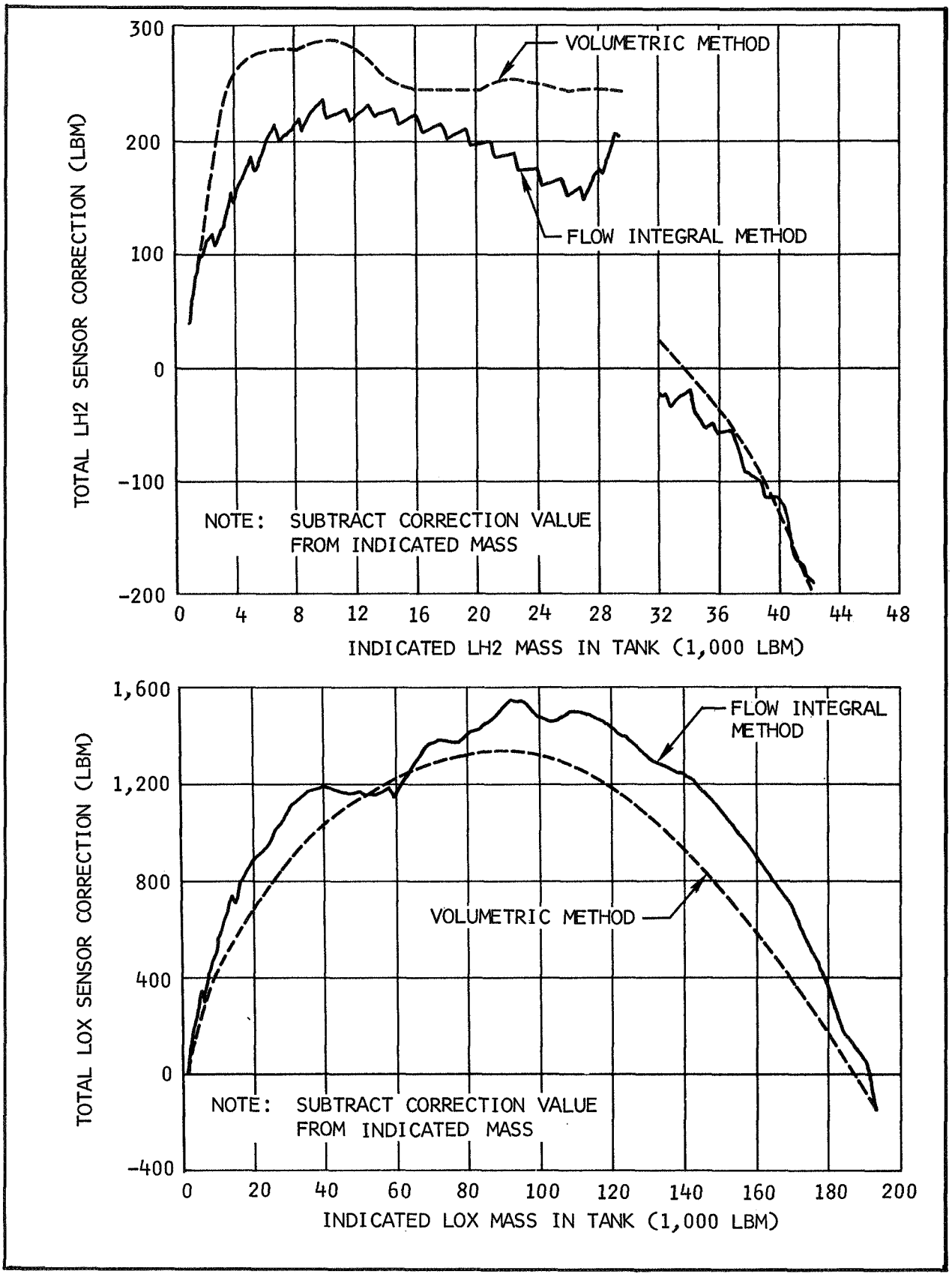


Figure AP 6-7. Total Flight LH2 and LOX Sensor Corrections

APPENDIX 7

PREDICTED SEPARATION AND CONTROL PERFORMANCE

7. PREDICTED SEPARATION AND CONTROL PERFORMANCE

7.1 General

This appendix contains predicted stage separation, preflight control transient simulations, and control performance curves (figures AP 7-1 through AP 7-3).

Nominal relative motion and predicted separation history between the S-II and the S-IVB stages (figures AP 7-2 and AP 7-3) were derived by using the results of J-2 engine performance on Saturn IB flights.

7.2 Predicted Preflight Control Transient Simulation

Body attitude transients of varying magnitude are expected following S-II/S-IVB separation, and active guidance initiation. The nominal transients expected during these periods of flight will be simulated and graphs of the resulting attitude errors, APS firings, and engine deflections will be included in a revision to this document. The simulation program solves the vehicle equations of motion for three rotational degrees of freedom. The equations of motion include the main engine control system equations (with servo-loop non-linearities), roll control system equations, ST-124M stable platform equations (with transport delays), and the equations representing aerodynamic forces, propellant sloshing forces, and ullage rocket and main engine thrust vector misalignment.

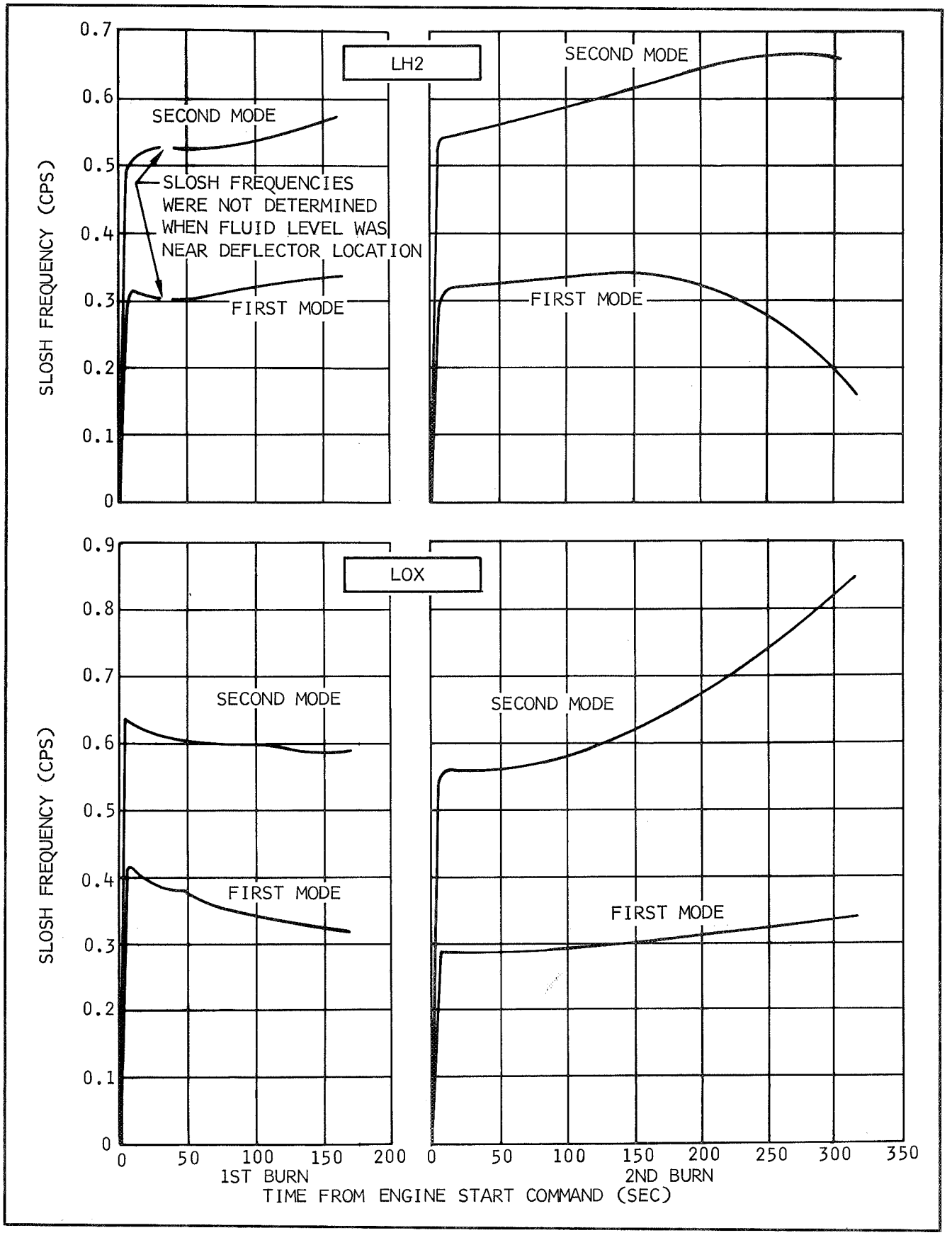


Figure AP 7-1. Propellant Slosh Frequency

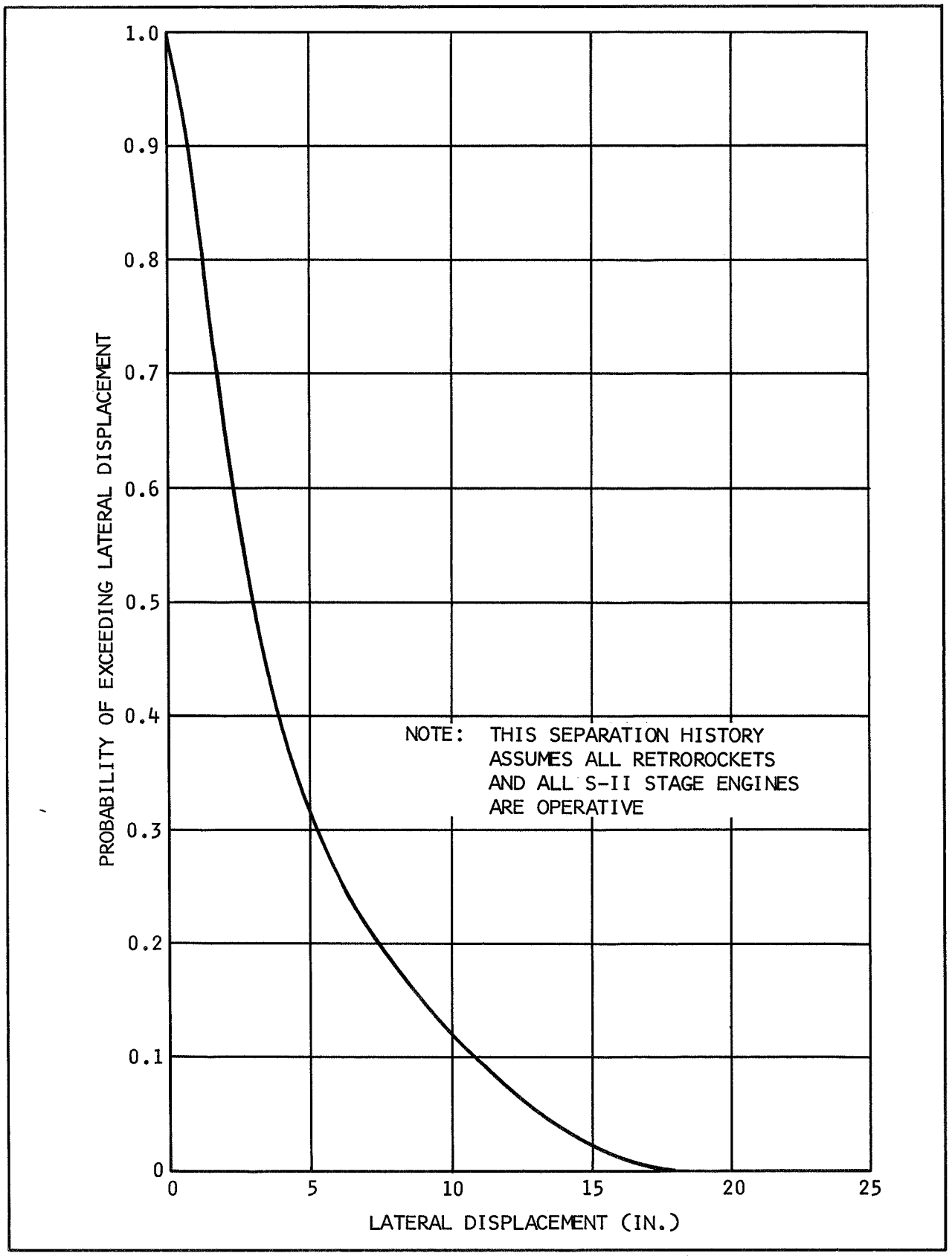


Figure AP 7-2. Predicted S-II/S-IVB Separation Probability of Lateral Displacement Exceeding a Specified Value

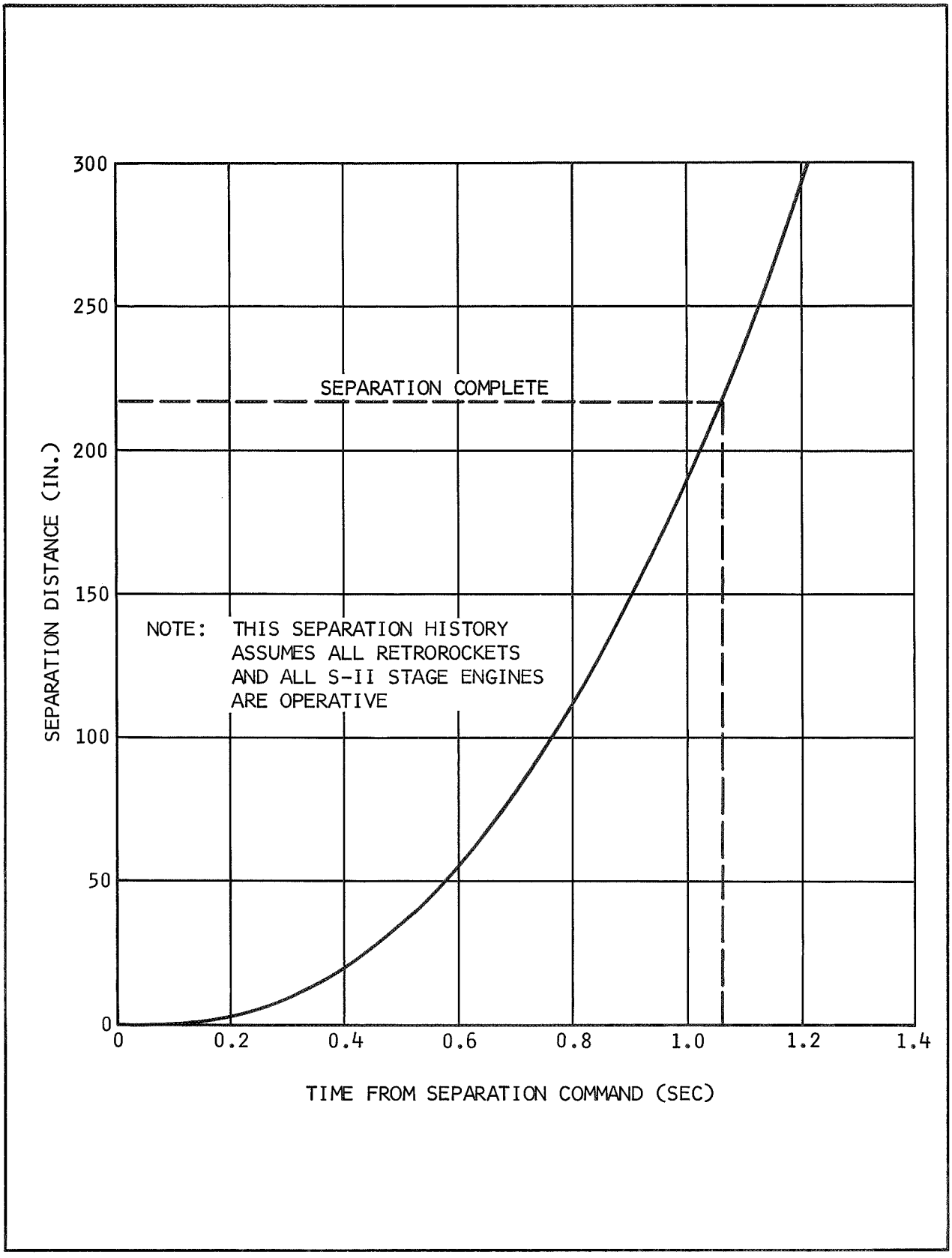


Figure AP 7-3. Predicted S-II/S-IVB Separation History

APPENDIX 8

ADDITIONAL PREDICTED PERFORMANCE DATA

8. ADDITIONAL PREDICTED PERFORMANCE DATA

This appendix presents additional predicted performance data and design performance levels not presented in other areas of the test plan.

Figure AP 8-1 presents predicted S-IVB-502 hydraulic system operating levels, which are based on acceptance firing data. Figures AP 8-2 through AP 8-5 show the predicted load profiles for the forward and aft batteries, based on S-IVB-502 acceptance firing data. Figures AP 8-6 and AP 8-7 depict the predicted envelope of composite vibration and acoustic levels established on data obtained from Saturn I and IB flights, and S-IVB acceptance firings.

The data acquisition system design tolerances are as follows:

a. Radio frequency:

(1) The signal strength of each RF link shall be greater than five microvolts at the receiver of one or more ground stations during the following time intervals:

(a) FM links 1, 2, and 3 T_1 to engine cutoff +80 sec

(b) Single sideband line T_1 to engine cutoff +29 sec

(c) PCM link T_1 to engine cutoff +82.1 sec

(2) The output of all RF amplifiers shall be 15 watts, minimum under all operative and environmental conditions

(3) The RF insertion loss between the power amplifier output and the input to any of the applicable antennas shall not exceed 7.5 db

(4) The VSWR, as computed from forward and reflected power of the antenna elements, shall not exceed 1.7:1.

b. Accuracy of FM/FM telemetry systems Nos. 1, 2, 3 and SSB/FM system:

(1) Each FM/FM telemetry system shall be ± 1.5 percent from the input to the translator through the ground station receiver

(2) The SSB/FM system shall be ±15 percent from the input to the translator through the ground station receiver.

c. Correlation of PAM and PCM data (between the PAM/FM/FM and PCM/FM systems) shall be within three percent.

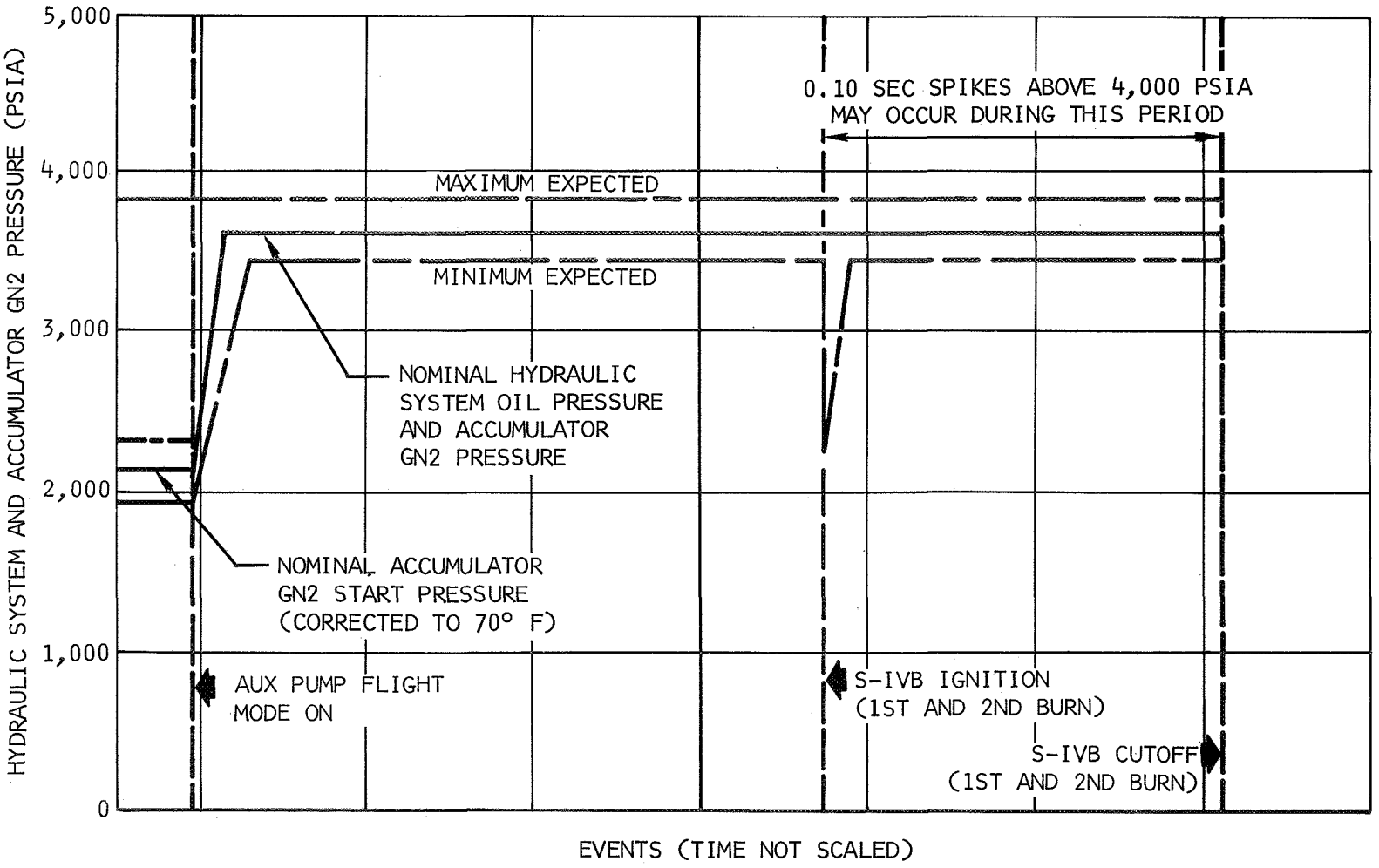
d. Flight tape recorder:

(1) The tape recorder fast-record and playback speed shall become stabilized to design tolerance within 4 sec after turn-on

(2) Wow and flutter, after stabilization of tape speed, shall be within the design tolerance of 1 percent, RMS (root-mean-square) of mean speed under any and all environmental conditions encountered

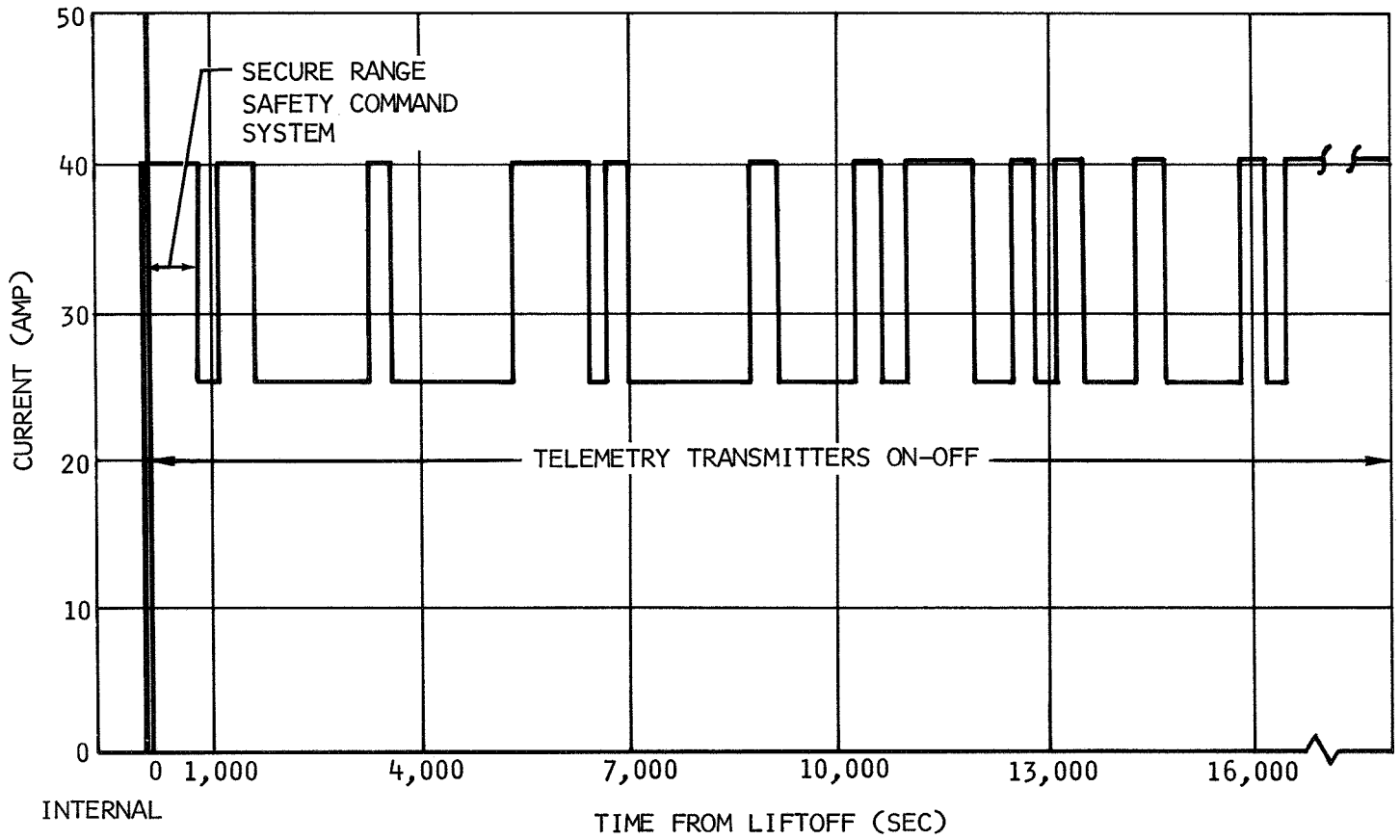
(3) Recovered recorded data after tape speed compensation shall agree with real time data within the tolerance:

1.5 percent of full scale	FM/FM
0.5 percent of full scale	PAM/FM/FM
3.0 percent of full scale	PCM/FM



NOTE: AUXILIARY PUMP
STARTS PRIOR TO LIFTOFF
AND PRIOR TO RESTART

Figure AP 8-1. Predicted S-IVB-502 Hydraulic System Operating Limits



NOTE: BATTERY HEATER CURRENTS ARE NOT INCLUDED IN THE ABOVE PROFILE DUE TO UNPREDICTABILITY OF HEATER OPERATION.

Figure AP 8-2. Predicted Load Profile For Forward Battery No. 1

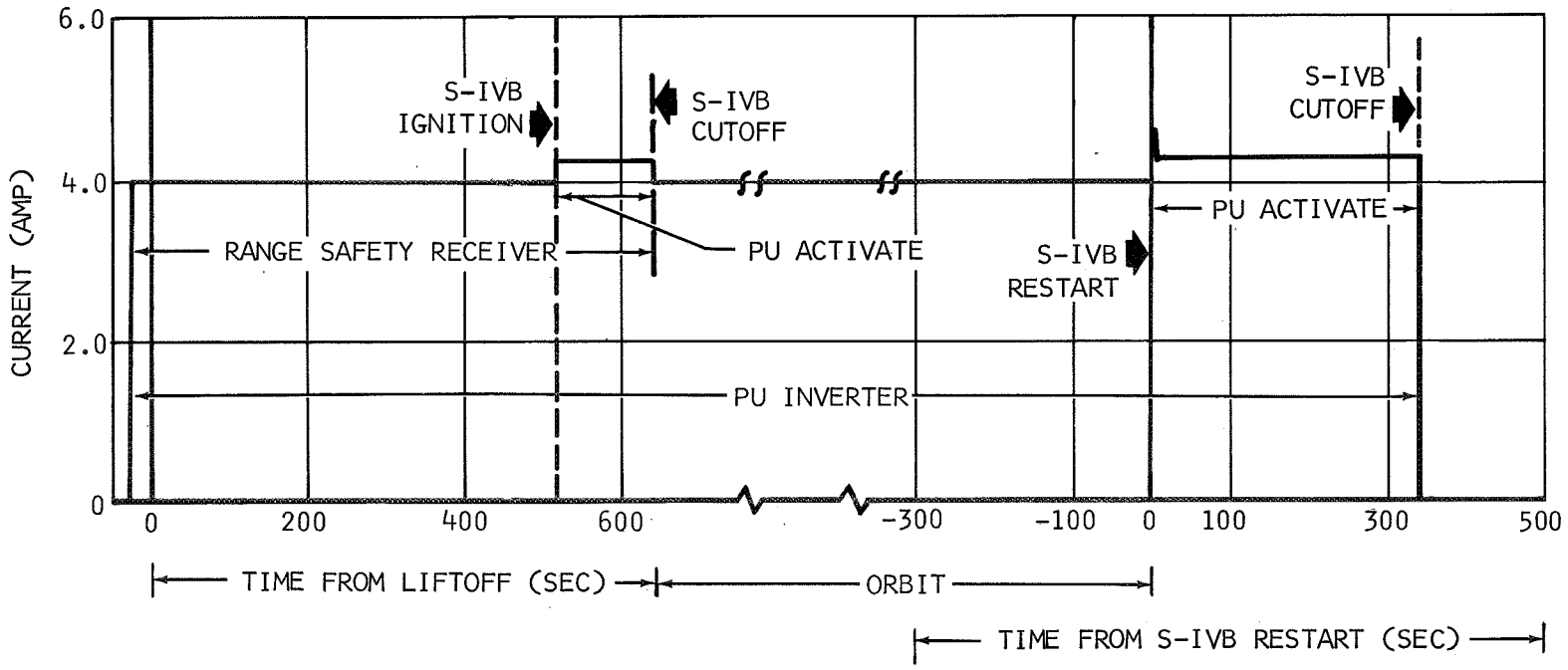
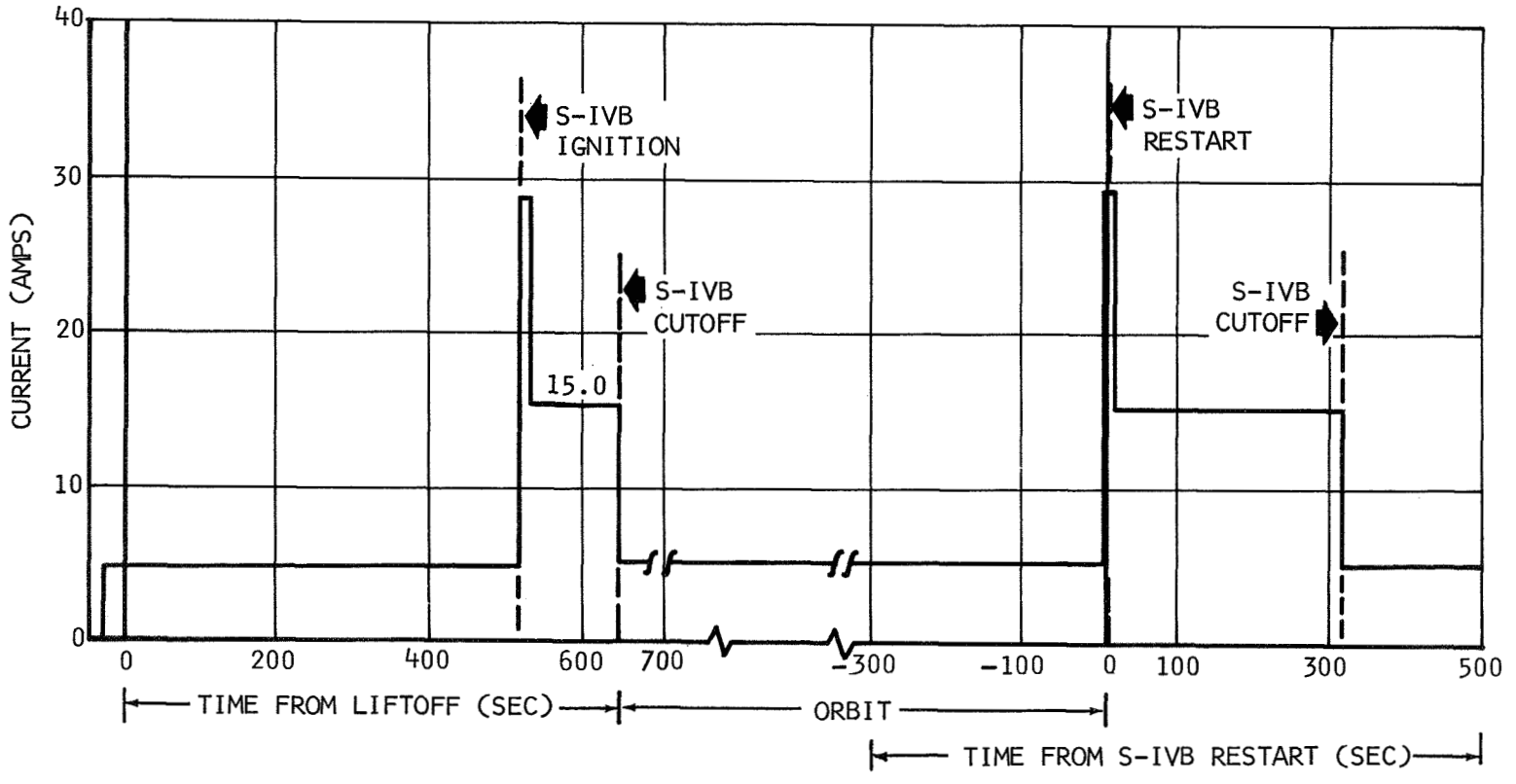


Figure AP 8-3. Predicted Load Profile For Forward Battery No. 2



NOTE: BATTERY HEATER CURRENTS ARE NOT INCLUDED IN THE ABOVE PROFILES DUE TO UNPREDICTABILITY OF HEATER OPERATION.

Figure AP 8-4. Predicted Load Profile For Aft Battery No. 1

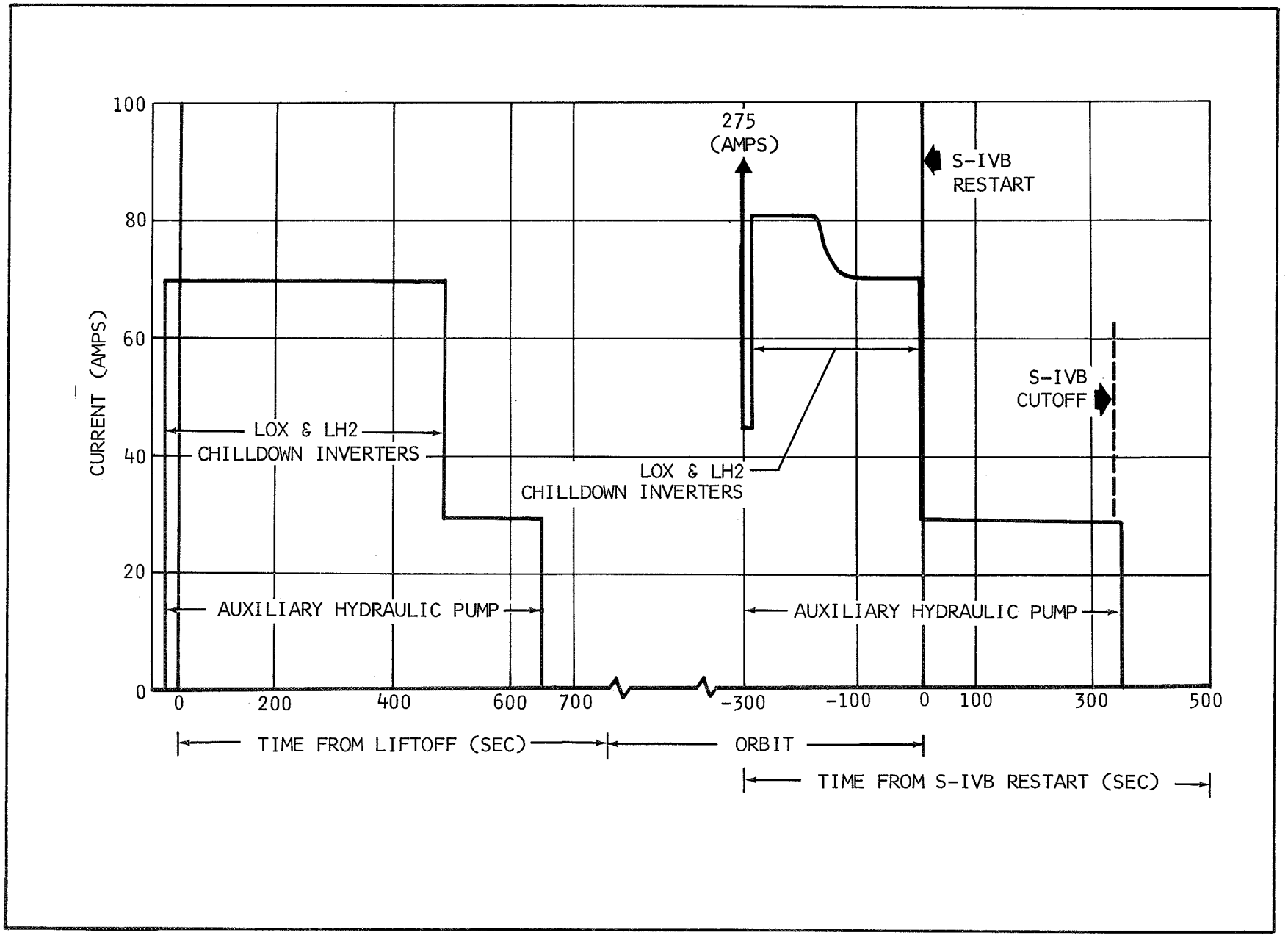


Figure AP 8-5. Predicted Load Profile For Aft Battery No. 2

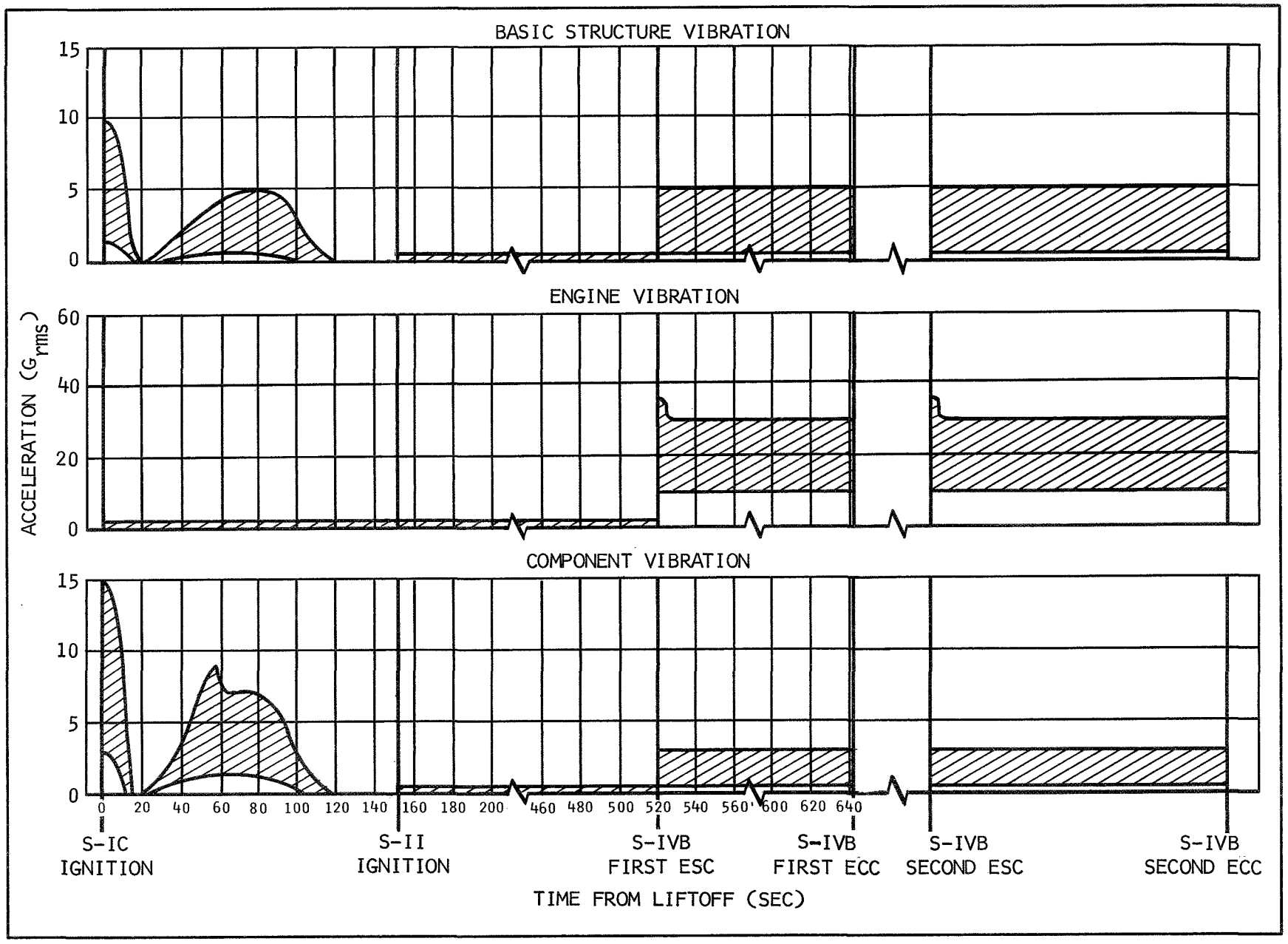


Figure AP 8-6. Predicted Envelopes of Composite Vibration During AS-502 Flight

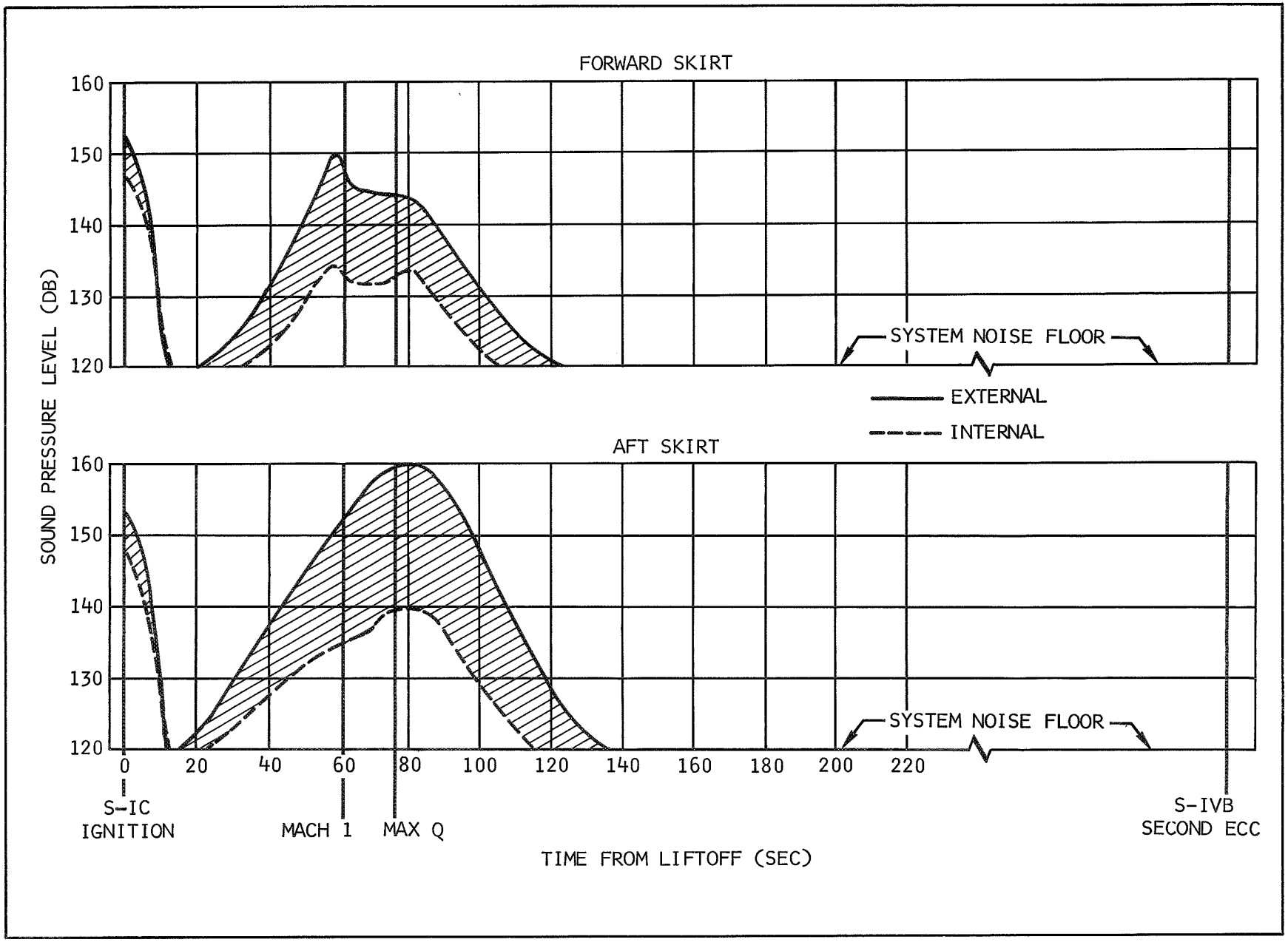


Figure AP 8-7. Predicted Envelopes of Overall Sound Pressure Level During AS-502 Flight

APPENDIX 9

RADIO FREQUENCY ALLOCATION

9. RADIO FREQUENCY ALLOCATION

The following radio frequencies will be used for S-IVB-502 telemetry and range safety transmitters:

USAGE	FREQUENCY
SSB/FM	226.2 Mc
PCM/FM	232.9 Mc
PAM/FM No. 1	258.5 Mc
PAM/FM No. 2	246.3 Mc
PAM/FM No. 3	253.8 Mc
Secure Range Safety	450 Mc

APPENDIX 10

GLOSSARY AND ABBREVIATIONS

TABLE AP 10-1 (Sheet 1 of 9)
GLOSSARY AND ABBREVIATIONS

ABBREVIATION	TERM	DEFINITION
AA89	--	Designation of DAC propulsion system performance computer program
AACS	--	Auxiliary attitude control system
AB77	--	Designation of DAC S-IB trajectory simulation computer program
AB79	--	Designation of DAC Saturn S-IVB radar look angle computer program
ac	--	Alternating current
AC77	--	Designation of DAC S-IVB trajectory simulation computer program
AGC	--	Apollo guidance computer
amp	--	Ampere
APS	--	Auxiliary propulsion system
AS	--	Apollo Saturn
--	Average Mixture ratio	The time average of the propellant mixture ratio over 1-sec time intervals between 90 percent thrust buildup and Engine Cutoff Command
--	Average thrust or specific impulse	Determined between the time of 90 percent thrust and Engine Cutoff Command
CCS	--	Command communication system
°C	--	Degree centigrade
CECO	--	S-IC stage Center Engine Cutoff Command
cg	--	Center of gravity
CIF	--	Central Instrumentation Facility
CM	--	Command module
CMR	--	Coarse mass ratio
--	Composite data (acoustic and vibration)	The total energy of the oscillatory phenomenon, consisting of all frequencies and amplitudes sensed by the transducers, and represents the phenomenon at the point of measurement within the limitations of the data acquisition and reduction systems
cont	--	Control
cps	--	Cycles per second

TABLE AP 10-1 (Sheet 2 of 9)
GLOSSARY AND ABBREVIATIONS

ABBREVIATION	TERM	DEFINITION
CSM	--	Command Service Module
CVS	--	Continuous vent system
D	--	Drag
DAC	--	Douglas Aircraft Company
DAC/FTC	--	Douglas Aircraft Company, Florida Test Center
DAC/HB	--	Douglas Aircraft Company, Huntington Beach
DAC/STC	--	Douglas Aircraft Company, Sacramento Test Center
db	--	Decibel
deg	--	Degree
--	Depletion Engine Cut-off Command	The time that engine cutoff was, or would be, initiated by the depletion level sensors
DDAS	--	Digital data acquisition system
DOD	--	Department of defense
EBW	--	Exploding bridgewire
ECC	--	Engine Cutoff Command
ECS	--	Environmental control system
EDS	--	Emergency detection system
--	Effective burntime	The engine burntime from 90 percent thrust buildup to Engine Cutoff Command
EMR	Engine propellant mixture ratio	The ratio of engine LOX mass flowrate to LH2 mass flowrate. Includes gas generator operations
eng	--	Engine
--	Engine cutoff (applicable for original issue of flight test plans only)	The guidance cutoff time referred to in this issue of the test plan is intended to be a representative event time and should not be construed as the DAC predicted guidance cutoff time. The DAC predicted guidance cutoff time is undetermined at this date due to lack of trajectory information.

TABLE AP 10-1 (Sheet 3 of 9)
GLOSSARY AND ABBREVIATIONS

ABBREVIATION	TERM	DEFINITION
--	Engine cutoff transient	Engine operation during the period from the Engine Cutoff Command until the end of thrust decay
ESC	--	Engine Start Command
ESE	--	Electrical Support Equipment
--	Engine start transient	Engine operation during the period from the Engine Start Command until the time of 90 percent thrust (approximately a 3-sec period)
--	Engine steady-state operation	Engine operation during the period from the time of 90 percent thrust until Engine Cutoff Command
ETD	--	End of thrust decay
°F	--	Degree fahrenheit
F823	--	Designation of DAC propulsion system performance computer program
--	Flow integral propellant mass history	That propellant mass history determined by combining independent engine analyses by a statistical method
FD&C	--	Flight Dynamics and Control
FM	--	Frequency modulation
FPR	Flight performance reserve	Usable mass onboard at predicted guidance cutoff
fps	--	Feet per second
FTA	--	Flight test article
ft	--	Foot
FTC	--	Florida Test Center
g	Gravitational acceleration	The acceleration produced by the force of gravity, which varies with the altitude and elevation of the point of observation. The value 32.1739 ft/sec^2 has been chosen as the standard by international agreement for sea level at 45° north latitude
GG	--	Gas generator
GH2	--	Gaseous hydrogen
GHe	--	Gaseous helium
GN2	--	Gaseous nitrogen
GOX	--	Gaseous oxygen

TABLE AP 10-1 (Sheet 4 of 9)
GLOSSARY AND ABBREVIATIONS

ABBREVIATION	TERM	DEFINITION
gpm	--	Gallons per minute
GSE	--	Ground support equipment
GSFC	--	Goddard Space Flight Center, Greenbelt, Maryland
h	--	Altitude
HB	--	Huntington Beach, California
He	--	Helium
H:M:S	--	Hours, minutes, seconds
HOSC	--	Huntsville Operations Support Center
hr	--	Hour
H/W	--	Hardwire
IAS	--	Initiation of automatic sequence
IECO	--	S-IB stage Inboard Engine Cutoff Command
IGM	--	Iterative guidance mode
INT	--	Internal
IP&CL	--	Instrumentation Program and Components List
I_{sp}	--	Specific impulse
IU	--	Instrument Unit
kc	--	Kilocycles
km	--	Kilometer
KSC	--	Kennedy Space Center
lbf	--	Pounds force
lbm	Pounds mass	1/32.1739 slug
L/C	--	Loading computer
LEM or L.E.M.	--	(See LM)
LET	--	Launch escape tower
LH2	--	Liquid hydrogen
LLM	--	Lunar landing mission
LM	--	Lunar Module
LOX	--	Liquid oxygen

TABLE AP 10-1 (Sheet 5 of 9)
GLOSSARY AND ABBREVIATIONS

ABBREVIATION	TERM	DEFINITION
LV	--	Launch vehicle
Mc	--	Milicycle
LVDC	--	Launch Vehicle Digital Computer
Mod	--	Module
MOI	--	Moment of inertia
MOV	--	Main oxidizer valve
m	--	Mach number
M/S	--	Mainstage
MSC	--	Manned Spacecraft Center, Houston, Texas
MSFC	--	Marshall Space Flight Center
MSS	--	Mobile service structure
MSSD	--	Missile and Space Systems Division
mvdc	--	Millivolt - direct current
N/A	--	Not applicable
NASA	--	National Aeronautics and Space Administration
NC	--	Normally closed
--	Ninety percent thrust buildup	Time from Engine Start Command until the last engine chamber pressure (injector end) reaches 618 psia
nmi	--	Nautical mile
NO	--	Normally open
No.	--	Number
NOM	--	Nominal
NPSH	--	Net positive suction head
NPV	--	Nonpropulsive vent
OECO	--	S-IB or S-IC stage Outboard Engine Cutoff Command
OVRD	--	Override
oxid	--	Oxidizer
PAM	--	Pulse amplitude modulation
--	Payload	All portions of the vehicle above the S-IVB/IU

TABLE AP 10-1 (Sheet 6 of 9)
GLOSSARY AND ABBREVIATIONS

ABBREVIATION	TERM	DEFINITION
PCM	--	Pulse code modulation
PD	--	Propellant dispersion
pf	--	Capacitance
PMR	Programmed mixture ratio	A method of controlling the PU valve mixture ratio to obtain maximum efficiency of the stage. The propellant loading is provided to cause the PU system to command the PU valve against the LOX rich stop for the initial portion of flight and then decrease to a lower mixture ratio during the final portion of flight
--	Propellant residuals	The sum of LOX and LH2 remaining onboard at Engine Cutoff Command. The residuals include both usable and trapped propellants
P/S	--	Pulse sensor
psia	--	Pounds per square inch absolute
psid	--	Pounds per square inch differential
psig	--	Pounds per square inch gauge
psi/hr	--	Pounds per square inch hour
PTCS	--	Propellant tanking computer system
PU	--	Propellant utilization
--	PU system propellant mass history	That propellant mass history determined for flight by the PU system
--	PU system residuals	Those propellant residuals above the main propellant valves determined by the PU system
q	--	Dynamic pressure
°R	--	Degree rankine
RACS	--	Remote automatic calibration system
RCS	--	Reaction control system
reg	--	Regulator
RF	--	Radio frequency
rms	--	Root mean square
RMR	--	Reference mixture ratio

TABLE AP 10-1 (Sheet 7 of 9)
GLOSSARY AND ABBREVIATIONS

ABBREVIATION	TERM	DEFINITION
rpm	--	Revolutions per minute
R/S	--	Range safety
rss	--	Root sum square
S	--	Surface range (ft)
SC	Spacecraft	Includes Apollo command and service module and LM adapter
sco	--	Sub-carrier oscillator
sec	--	Second
S-II	--	Second stage of the Saturn V (500) series of vehicles
S-IB	Saturn IB	First stage of the Saturn IB (200) series of vehicles
S-IC	--	First stage of the Saturn V (500) series of vehicles
S-IVB	--	Second stage of the Saturn IB (200) series of vehicles and third stage of the Saturn V (500) series of vehicles
SLA	--	Spacecraft LEM adapter
SLG	--	Slug
SLF	--	Slug feet squared
--	Slug	Engine system unit of mass
SPS	--	Service propulsion system
SOV	--	Shutoff valve
SSB/FM	--	Single sideband modulation
SSB	--	Single sideband
SSS	--	Stage switch selector
STC	--	Sacramento Test Center
t	--	Time
T	--	Countdown time from prospective liftoff or as specifically defined in the text
T_1	--	Time base No. 1: Initiated at liftoff by umbilical disconnect
T_2	--	Time base No. 2: At S-IC center engine cutoff time base is activated if vehicle has sufficient downrange velocity

TABLE AP 10-1 (Sheet 8 of 9)
GLOSSARY AND ABBREVIATIONS

ABBREVIATION	TERM	DEFINITION
T_3	--	Time base No. 3: Initiated at S-IC outboard engines cutoff
T_4	--	Time base No. 4: Initiated at S-II engines cutoff
T_5	--	Time base No. 5: Initiated by S-IVB engine first burn cutoff
T_6	--	Time base No. 6: Initiated by an LVDC command based on an equation or by ground command
T_7	--	Time base No. 7: Initiated by S-IVB engine second burn cutoff
TBD	--	To be determined
TLI	--	Translunar injection
T/M	--	Telemetry
TWX	--	Teletype
--	Total depletion burn-time	The engine burntime from Engine Start Command to the time that the depletion Engine Cutoff Command would have been initiated
--	Total propellants consumed	That amount of liquid propellants consumed from Engine Start Command to Engine Cutoff Command. Includes engine consumption, boiloff, and LH2 tank pressurant
--	Total stage burntime	The engine burntime from Engine Start Command to Engine Cutoff Command
--	Total stage mass history	A compilation of all final hardware, propellant, and gas masses. The measured and computed mass of each constituent is adjusted within its accuracy band so that the total stage mass at Engine Start Command and Engine Cutoff Command agrees with the total stage mass as determined by the Statistical Weighted Average mass determination method
TP&E	--	Test Planning and Evaluation
--	Unusable propellants	Those propellants remaining after a propellant depletion cutoff. This includes the propellants in the tank

TABLE AP 10-1 (Sheet 9 of 9)
GLOSSARY AND ABBREVIATIONS

ABBREVIATION	TERM	DEFINITION
-- (Continued)	Unusable propellants	below the depletion sensor, propellants in the feed duct, and trapped propellants. It does not include sensor lag time or the propellant consumed during engine cutoff but does include sensor time delay
UMB	--	Umbilical
U/R	--	Ullage rocket
--	Usable residuals	Propellants in excess of trapped propellants left onboard a stage after powered flight has been terminated by some specified cutoff criteria
v	--	Volt
V_E	--	Earth-fixed velocity
V_I	--	Inertial velocity
VAB	--	Vehicle Assembly Building, KSC, Florida
vac	--	Voltage, alternating current
vdc	--	Voltage, direct current
VHF	--	Very high frequency
VSWR	--	Voltage standing wave ratio
w	--	Watt
WS11	--	Designation of DAC mass characteristics computer program
α	--	Angle of Attack
α'	--	Total Angle of Attack
α_{xm}	--	Axial acceleration
X_Y	--	Yaw attitude command
X_P	--	Pitch attitude command
γ_1	--	Earth fixed flight path elevation angle
γ_{1_I}'	--	Inertial flight path elevation angle
γ_{2_I}'	--	Inertial flight path azimuth angle
μ	--	Longitude
ρ	--	Geodetic lattitude

APPENDIX 11

REFERENCES

11. REFERENCES

The references used in this document are divided into three general groups; those issued and maintained by the National Aeronautics and Space Administration, those issued and maintained by Douglas Aircraft Company (DAC), and one issued and maintained by Boeing Aircraft. The intended use of the references are applicable only to those portions of the documents relative to the performance or qualification of the S-IVB stage. Generally, the documents are listed in the same order as mentioned in either the text of the report or in the appendices.

a. NASA Documentation:

(1) *SA-502 Launch Vehicle Mission Directive*, (prepared by Saturn V Test Office), Marshall Space Flight Center, Huntsville, Alabama, dated April 26, 1966.

(2) *Apollo Flight Mission Assignments* (U), (prepared by Office of Manned Space Flight, Apollo Program), M-D MA 500-11, SE 010-000-1, Washington, D.C., dated September 10, 1965.

(3) *Apollo Saturn V Program Support Requirements*, (prepared by Office of Manned Space Flight, Apollo Program), Z2NPX, Revision 8, Washington, D.C., dated September 26, 1966.

(4) *MSFC/MSC AS-502/CSM-020 Joint Reference Trajectory*, (Trajectory Document No. 66-FMP-10), Marshall Space Flight Center, Huntsville, Alabama, dated June 28, 1966.

(5) *Apollo/Saturn V Launch Mission Rules, AS-502*, (Prepared by KSC. Document number and date of publication to be determined.)

(6) *Definition of Saturn SA-502 Flight Sequence Program*, Interface control document No. 40M33622A (prepared by Airborne Electrical Systems Branch, Astrionics Laboratory) Marshall Space Flight Center, Huntsville, Alabama, dated May 13, 1966; and Interface Revision notices No. 1, 2, 3, 4, 5, and 7, dated August 4, 1967, and Revision A, dated February 15, 1967.

(7) *"Saturn V AS-502 Projected Mass Characteristics"* (Memorandum), R-P&VE-VAW-66-40, Marshall Space Flight Center, Huntsville, Alabama, dated April 27, 1966.

(8) *Project Apollo Coordinate Standards*, Standard Coordinate System 9, Mass Properties (prepared by Office of Manned Space Flight), Washington, D.C., dated June, 1965.

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(14) S-IVB-502 Stage Flight Evaulation Report, report No. SM 47005 (Date of publication to be determined).

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(15) *Tracking and Telemetry Design Analysis for Apollo-Saturn V Flight AS-502*, volume I, (Boeing document D5-15697-502), dated April 12, 1967.

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