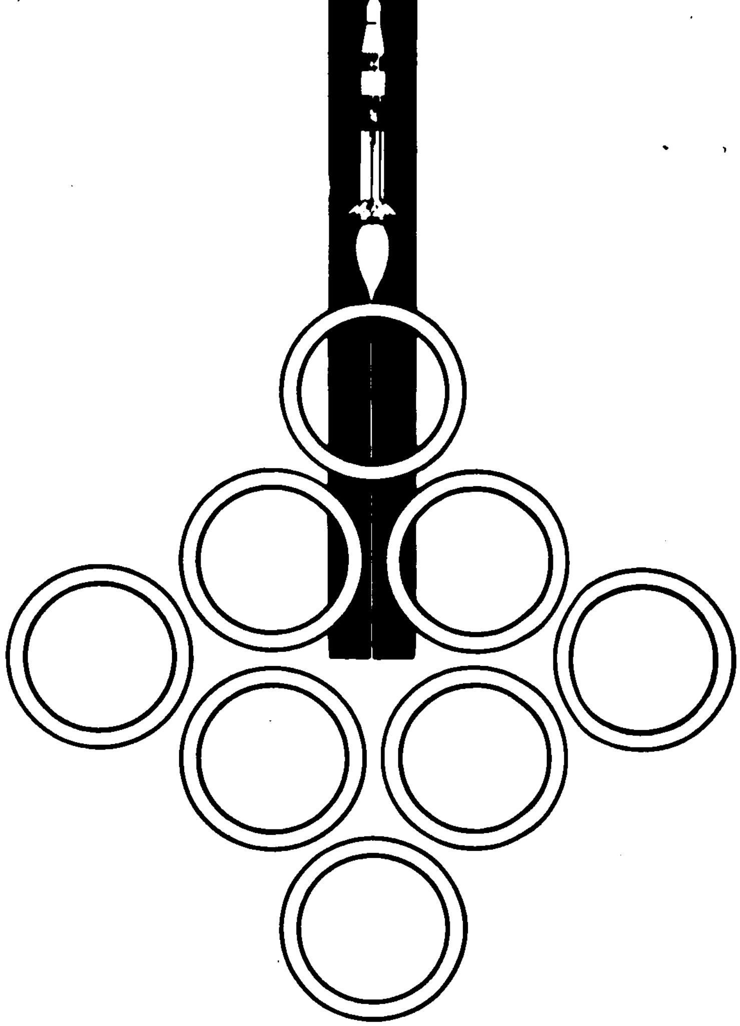

ENGINEERING DEPARTMENT

TECHNICAL REPORT

TR-P&VE-68-65

FINAL S-IB-5 PROPULSION SYSTEM FLIGHT PERFORMANCE PREDICTIONS FOR LAUNCH MONTHS AUGUST THROUGH DECEMBER

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SPACE DIVISION CHRYSLER CORPORATION

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FINAL S-IB-5 PROPULSION SYSTEM FLIGHT PERFORMANCE PREDICTIONS FOR LAUNCH MONTHS AUGUST THROUGH DECEMBER

June 15, 1968

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3848-8-14-68

ABSTRACT

Analysis of the revised final prediction data for the five launch months under consideration (August through December) indicate that inboard engine cutoff will occur between 140.05 and 142.22 seconds after first motion. Outboard engine cutoff is expected three seconds later than the respective inboard engine cutoff time. These times are based on the defined fuel and LOX load specific weights and stage propellant fill weights for each of the five months.

FOREWORD

This report presents the final flight performance prediction data for the Saturn AS-205 Propulsion System, S-IB-5 Stage, and is authorized by contract NAS8-4016 DRL 039, Revision ~~B~~ C, Item 35.

The final prediction data were determined by simulating the first stage powered flight of Saturn AS-205 with the Mark IV computation procedure. The data presented in this revised report supersedes the information in the previous document, reference A.

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Section 1

SUMMATION

1.1 INTRODUCTION

The mission and launch date for the AS-205 vehicle used in the previous prediction (reference A) have been revised. This report presents the nominal final flight performance prediction data for five launch months (August through December) for the S-IB-5 propulsion system and describes the data and methods used in making the predictions. Propulsion performance dispersion data for two representative months (September and December) are also included.

1.2 OBJECT

To present the predicted performance parameters of the S-IB-5 propulsion system.

1.3 CONCLUSIONS

The propellant liquid level sensor actuation times and the corresponding engine cutoff sequence were determined from the prediction data. A summary of pertinent prediction data for each month under consideration is presented in table VI.

The best engine characteristic data for the prediction were determined by an analysis of the engine performance data from Rocketdyne single engine acceptance tests and SA-34 and SA-35 stage static tests. An analysis comparing past flight data with Rocketdyne acceptance test data and stage test data showed that, although stage test data more often predicted flight with greater accuracy, the Rocketdyne data showed more consistent deviations. By applying biasing factors to the Rocketdyne thrusts and flowrates, past flights could have been predicted with a much higher degree of accuracy than could have been determined by using either stage test or Rocketdyne data. The engine data used for this prediction reflect Rocketdyne acceptance test data that were adjusted in accordance with the experience gained from the S-IB-1, S-IB-2, S-IB-3, and S-IB-4 stage flights.

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Section 2

DISCUSSION

2.1 VEHICLE DESCRIPTION

AS-205 will be the fifteenth Saturn vehicle, and the fifth of the Saturn IB series to be flight tested. The AS-205 vehicle will consist of the S-IB-5 first stage, S-IVB-5 second stage, the S-IU-205 instrument unit, and an Apollo command/service module payload. AS-205 is scheduled for launch during the last half of 1968.

2.2 PREDICTED PERFORMANCE

The Mark IV computer program was used to predict the flight performance of the S-IB-5 stage. The latest available table of the H-1 engine influence coefficients (reference B) was used in this prediction. Changes in criteria from that used in the last flight prediction (reference A) released for S-IB-5, are the launch date, aerodynamic and base drag, stage trajectory, and the engine performance biasing factors described in paragraph 2.2.3.

2.2.1 Nominal Prediction

The Mark IV computer program printouts, containing the detailed propulsion data for each launch month considered, are available for review. The specific performance data for each month were recorded on magnetic tapes and stored at the Slidell Computer Center tape library for use by cognizant organizations. Duplicate copies of B6 tapes, required by the Aero-Astrodynamics Laboratory (R-AERO-FMT) MSFC, were submitted to the Performance Analysis Section (R-P& VE-PPE) MSFC. Card decks were sent to CCSD Weight Control Group, Section 2733, for evaluation and the B5 and B6 tapes were made available to CCSD Flight Mechanics, Section 2783.

Pertinent final weights data are presented in tables I through V and the stage parameters, including predicted fill weights, ullage volumes, and engine cutoff times, are in table VI. Vehicle thrust, specific impulse, fuel flowrate, LOX flowrate, and the mixture ratio, as functions of flight time referenced from first motion, are shown in figures 1 through 5. Figures 6 through 8 show, as functions of flight time, the LOX and fuel tank ullage pressures, the ambient pressure, and the LOX pump inlet specific weight. The average values for several of the parameters, for each month considered, are shown on figures I through 5 and figure 8. The averages were calculated from first motion to Inboard Engine Cutoff (IECO).

2.2.2 Propellant Usage

The stage fill weights, listed in table II, were determined for a LOX volume of 66,990.4 gallons and corresponding amounts of fuel which are required for simultaneous depletion of the nominal consumable propellants. The propellant criteria is in reference C.

Variations from the predicted fuel densities will require adjustments to the predicted propellant loads to ensure simultaneous depletion of the propellant.

A fuel bias of 1,000 pounds is included in the fuel loads to minimize propellant residuals if there are deviations from the predicted propellant mixture ratios. The fuel bias is the same as that used for all the previous S-IB stage flights.

The LOX specific weights are based on the predicted environmental conditions at launch. The predicted nominal fuel temperatures were determined by using an estimated ambient air temperature and an approximate 8°F chilldown, due to LOX exposure, for each of the five months considered.

All the LOX in the tanks, sumps, and interchange lines, except approximately three gallons trapped in the center tank sump, will be consumed. Approximately 75 gallons of the LOX volume in the outboard engine suction line will also be consumed if the predicted LOX starvation mode of Outboard Engine Cutoff (OECO) occurs. The remaining LOX in the suction line is considered as unusable propellant and is listed as LOX residual in table VI.

It is predicted that the fuel level at the end of outboard engine thrust decay will be approximately at the bottom of the containers. The fuel in the sump, interchange lines, and the suction lines is listed as residual in table VI.

The 1,000-pound fuel bias is a portion of the predicted fuel residual and is available for consumption prior to IECO. Approximately 850 pounds more of the residual can be consumed prior to OECO if a significantly lower than predicted consumption mixture ratio is experienced. If all the fuel is consumed, the OECO signal would originate from the fuel depletion probes which are located approximately 11 inches below the theoretical bottom of fuel tanks F-2 and F-4. If the predicted performance occurs, this total of 1850 pounds of fuel will not be consumed.

There is a 19-inch diameter orifice located in the center LOX tank sump which causes the LOX liquid level in the center tank to be approximately three inches above the level of the outboard tanks at IECO. The liquid level height differential between the center LOX tank and the outboard LOX tank is an important factor when predicting stage shutdown criteria with a LOX pump starvation cutoff. This differential establishes the amount of LOX not yet consumed at the time of IECO. A larger than expected liquid level differential will cause an earlier than predicted liquid level sensor actuation; consequently, an earlier IECO and later OECO will result. A smaller than expected differential will cause the converse. Small deviations from the predicted height differentials are not too significant in the overall stage performance because the total impulse will be approximately the same as predicted, even though the engine cutoff times are different.

2.2.3 Engine Performance

Engine performance data from revised Rocketdyne acceptance test data logs (PAST-077) were compared with the actual flight data from S-IB-1, S-IB-2, S-IB-3, and S-IB-4 flights. The comparison revealed that the Rocketdyne acceptance tests offered consistently incorrect data; however, a statistical correlation could be drawn (table VII). Using this data as a basis, a series of multipliers for all reported Rocketdyne parameters were determined to correct the discrepancies. Utilizing this experience gained from the four S-IB flights, the following multipliers were computed: thrust, 1.00813; chamber pressure, 1.00727; pump speed, 1.00561; LOX flowrate, 1.01188; and fuel flowrate, 1.00314. A detailed analysis of these differences for the first four S-IB flights is presented in the "Launch-to-Launch Dispersion Analysis" (Reference D). Part of this presentation was extracted and is listed in table VIII.

Table VIII shows the Rocketdyne data to be significantly lower in magnitude than the flight data; however, the differences are consistent. If each of the four flights had been predicted with the flight multipliers used for this prediction, the engine performance data reduced to sea level and the rated conditions would have been predicted to within a high degree of accuracy (0.25 percent).

Table VII shows a comparison of the MSFC stage test data and the Rocketdyne single engine test data. On an average basis, the engine thrusts were 0.22 and 0.461 per cent higher for the short and long duration stage tests, respectively, than for the Rocketdyne data. Although the stage test data was not used in the prediction, it supports the assumption that the thrust levels will be significantly higher than the Rocketdyne data.

The flight multipliers account for the performance differences noted at 30 seconds. In addition, the previous S-IB flights exhibited a shift in engine performance referenced to sea level and rated pump inlet conditions throughout flight. This shift included a buildup to quasi-stable conditions at approximately 30 seconds with a slower buildup thereafter. The final AS-205 prediction includes a performance shift equivalent to that noted in the previous S-IB flight performances. Figure 10 shows this power level shift as a percentage of the predicted 30-second sea level thrust. The flight multipliers were used only to shift the curve upward. The shape of the curve was determined from an analysis of the first four S-IB flights.

2.2.4 Engine Cutoff Criteria

The time base T_2 cutoff sequencing will be initiated when any one of the four liquid level sensors is uncovered. The predicted actuation times are listed in table VI. Liquid level sensors are located in fuel tanks F-2 and F-4 and LOX tanks O-2 and O-4. IECO will be signaled by the launch vehicle digital computer (LVDC) 3.2 seconds after initiation of the T_2 cutoff sequence.

The OECO signal could be initiated by the thrust OK pressure switches on any of the outboard engines or by any of the fuel depletion probes located in the sumps of fuel tanks F-2 and F-4. The predicted performance is based on the assumption that LOX pump starvation of two of the four outboard engines will occur 3.0 seconds after the IECO signal, and that the OECO signal will be caused by deactuation of the thrust OK pressure switches. Time base T_2 sequencing is summarized below:

T_2 + 0.0 sec - LVDC activated by LSA or back-up timer.

T_2 + 3.2 sec - IECO signal given by LVDC.

T_2 + 4.7 sec - Outboard engine thrust OK pressure switches grouped.

T_2 + 5.7 sec - Fuel depletion sensors armed.

T_2 + 6.2 sec - OECO signal expected due to LOX starvation.

This T_2 sequence was determined for the predicted performance with the fuel and LOX liquid level sensors located as shown in figure 9. The locations are referenced from theoretical tank bottoms. The sequence separates the thrust OK pressure switch grouping from the fuel depletion sensor arming to minimize the possibility of OECO caused by a premature sensor signal.

2.2.5 Dispersions

In addition to the nominal predictions, five flights were simulated for two representative months to show the effects of various propulsion performance dispersions. These flights consist of fuel density dispersions due to ±3-sigma prelaunch ambient air temperature deviations, LOX density variations caused by ±3-sigma prelaunch environmental conditions, and the effect of a lower than expected propellant consumption ratio on stage performance. The data, obtained from the additional flight simulations, are shown in tables X and XI and were based on data in reference C. The results of the simulations are available from the tapes listed in table XII.

As a result of a premature fuel depletion cutoff during the S-IB-1 flight, the fuel level sensor heights were adjusted to make approximately 850 pounds of fuel available for consumption after IECO and prior to OECO if a significantly lower than predicted consumption ratio is experienced. Because of the possible consumption of this fuel, the time between IECO and OECO could be as long as four seconds which would result in significant differences in the S-IB-5 flight performance from that predicted. Since the nominal performance prediction assumes a LOX starvation mode OECO with a 3-second differential between IECO and OECO, the possibility of a 4-second differential must be accounted for in the propulsion performance dispersions.

The correct dispersion to include this effect of time between IECO and OECO is in the engine mixture ratio (EMR) residual propellant dispersion. The data on the dispersion tapes reflect an effective shift of -0.68 percent in the propellant mixture ratio while holding the thrust and specific impulse values the same as the respective nominal cases. The effective mixture ratio shift accounts for consumption of the 1000-pound fuel bias prior to IECO and the 850 pounds of fuel bias available prior to OECO. As a result, the 1850 pounds of additional fuel will be consumed with the nominal LOX consumption. This will result in the OECO signal being initiated simultaneously by the thrust OK pressure switches and the fuel depletion probes.

Table 1. Weight Breakdown For AS-205 Vehicle (August)

	Miscellaneous (lb)	LOX (lb)	Fuel (lb)	Total (lb)
Consumption During Ignition and Holddown		10,758	3136	13,894
Mainstage Consumption		613,983	264,560	878,543
Consumption During Inboard Engine Thrust Decay*		712	1378	2090
Consumption During Outboard Engine Thrust Decay*		604	1321	1925
Propellant Residual**		3046	4864	7910
Gear Box Fuel Consumption			718	718
GOX Generated During Flight		2620		2620
Ice	1100			1100
Initial LOX Tank Pressurant	33			33
Hydraulic Oil	28			28
Oronite (Fuel additive for lubrication)	32			32
Initial Weight of Helium in the Fuel Tanks	5			5
Initial Weight of Nitrogen and Helium in all Spheres (For fuel container pressurization, S-IB stage purge, etc.)	90			90
Total Upperstage Weight plus S-IB Stage Dry Weight	393,807			393,807
Total Weight at Ignition Command	395,095	631,723	275,977	1,302,795

* Thrust decay includes propellant below main valves that is not necessarily burned but ejected overboard after valves close.

** The fuel residual includes 1000 lb for biasing purposes. The bias is available to provide an equal propellant weight at the 3 sigma mixture ratio limits.

Table II. Weight Breakdown For AS-205 Vehicle (September)

	Miscellaneous (lb)	LOX (lb)	Fuel (lb)	Total (lb)
Consumption During Ignition and Holddown		10,750	3135	13,885
Mainstage Consumption		613,830	264,633	878,463
Consumption During Inboard Engine Thrust Decay*		771	1381	2152
Consumption During Outboard Engine Thrust Decay *		637	1323	1960
Propellant Residual**		2944	4858	7802
Gear Box Fuel Consumption			719	719
GOX Generated During Flight		2622		2622
Ice	1100			1100
Initial LOX Tank Pressurant	33			33
Hydraulic Oil	28			28
Oronite (Fuel additive for lubrication)	32			32
Initial weight of helium in the fuel tanks	5			5
Initial weight of nitrogen and helium in all spheres (For fuel container pressurization, S-IB stage purge, etc.)	90			90
Total upperstage weight plus S-IB stage dry weight	393,807			393,807
Total weight at ignition command	395,095	631,554	276,049	1,302,698

* Thrust decay includes propellant below main valves that is not necessarily burned but ejected overboard after valves close.

** The fuel residual includes 1000 lb for biasing purposes. The bias is available to provide an equal propellant weight at the 3 sigma mixture ratio limits.

Table III. Weight Breakdown For AS-205 Vehicle (October)

	Miscellaneous (lb)	LOX (lb)	Fuel (lb)	Total (lb)
Consumption During Ignition and Holddown		10,712	3,130	13,842
Mainstage Consumption		614,089	265,447	879,536
Consumption During Inboard Engine Thrust Decay*		709	1377	2086
Consumption During Outboard Engine Thrust Decay*		603	1328	1924
Propellant Residual**		2989	4867	7856
Gear Box Fuel Consumption			721	721
GOX Generated During Flight		2633		2633
Ice	1100			1100
Initial LOX Tank Pressurant	33			33
Hydraulic Oil	28			28
Oronite (Fuel additive for lubrication)	32			32
Initial Weight of Helium in the Fuel Tanks	5			5
Initial Weight of Nitrogen and Helium in all Spheres (For fuel container pressurization, S-IB stage purge, etc.)	90			90
Total Upperstage Weight Plus S-IB Stage Dry Weight	393,807			393,807
Total Weight at Ignition Command	395,095	631,734	276,864	1,303,693

* Thrust decay includes propellant below main valves that is not necessarily burned but ejected overboard after valves close.

** The fuel residual includes 1000 lb for biasing purposes. The bias is available to provide an equal propellant weight at the 3 sigma mixture ratio limits.

Table IV. Weight Breakdown For AS-205 Vehicle (November)

	Miscellaneous (lb)	LOX (lb)	Fuel (lb)	Total (lb)
Consumption During Ignition and Holddown		10,669	3124	13,793
Mainstage Consumption		614,387	266,399	880,786
Consumption During Inboard Engine Thrust Decay*		713	1378	2091
Consumption During Outboard Engine Thrust Decay*		603	1322	1925
Propellant Residual**		2922	4871	7793
Gear Box Fuel Consumption			7246	7246
GOX Generated During Flight		2646		2646
Ice	1100			1100
Initial LOX Tank Pressurant	33			33
Hydraulic Oil	28			28
Oronite (Fuel additive for lubrication)	32			32
Initial Weight of Helium in the Fuel Tanks	5			5
Initial Weight of Nitrogen and Helium in all Spheres (For fuel container pressurization, S-IB Stage Purge, etc.)	90			90
Total Upperstage Weight Plus S-IB Stage Dry Weight	393,807			393,807
Total Weight at Ignition Command	395,095	631,940	277,820	1,304,855

* Thrust decay includes propellant below main valves that is not necessarily burned but ejected overboard after valves close.

** The fuel residual includes 1000 lb for biasing purposes. The bias is available to provide an equal propellant weight at the 3 sigma mixture ratio limits.

Table V. Weight Breakdown For AS-205 Vehicle (December)

	Miscellaneous (lb)	LOX (lb)	Fuel (lb)	Total (lb)
Consumption During Ignition and Holddown		10,601	3116	13,717
Mainstage Consumption		614,422	267,693	882,115
Consumption During Inboard Engine Thrust Decay*		766	1381	2147
Consumption During Outboard Engine Thrust Decay*		632	1323	1955
Propellant Residual**		2742	4912	5654
Gear Box Fuel Consumption			729	729
GOX Generated During Flight		2664		2664
Ice	1100			1100
Initial LOX Tank Pressurant	33			33
Hydraulic Oil	28			28
Oronite (Fuel additive for lubrication)	32			32
Initial Weight of Helium in the Fuel Tanks	5			5
Initial Weight of Nitrogen and Helium in all spheres (For fuel container pressurization, S-IB stage purge, etc.)	90			90
Total Upperstage Weight Plus S-IB Stage Dry Weight	393,807			393,807
Total Weight at Ignition Command	395,095	631,827	279,154	1,306,076

* Thrust decay includes propellant below main valves that is not necessarily burned but ejected overboard after valves close.

** The fuel residual includes 1000 lb for biasing purposes. The bias is available to provide an equal propellant weight at the 3 sigma mixture ratio limits.

Table VI. Stage Parameters for Various Launch Months

Parameters	August	September	October	November	December
Fuel Density (lb/ft^3)	49.99	49.99	50.11	50.24	50.41
LOX Density (lb/ft^3)	70.549	70.531	70.551	70.573	70.561
Average Thrust (kips)	1750.1	1749.0	1743.4	1737.2	1727.2
Average Specific Impulse (sec)	281.65	281.62	281.49	281.33	281.08
Average LOX Flowrate (lb/sec)	4339.4	4336.5	4321.1	4304.2	4277.1
Average Fuel Flowrate (lb/sec)	1874.5	1874.2	1872.5	1871.0	1868.1
Average Mixture Ratio	2.3150	2.2137	2.3076	2.3005	2.2895
Predicted L.S.A. Times	136.85	136.91	137.47	138.10	139.02
IECO (sec)	140.05	140.11	140.67	141.30	142.22
OECO (sec)	143.05	143.11	143.67	144.30	145.22
Fuel Load (lb)	275977	276050	276864	277820	279154
LOX Load (lb)	631723	631554	631734	631940	631827
Fuel Ullage At Fill (%)	3.48	3.46	3.42	3.34	3.23
LOX Ullage at Fill (%)	1.5	1.5	1.5	1.5	1.5

Table VII. Comparison of Rocketdyne, Stage Static Test, and Predicted Thrust Levels.

Engine Position	Rocketdyne PAST-077	Short Test (SA-34)	Long Test (SA-35)	Flight Prediction*
1	200.75	201.08	201.18	202.38
2	196.20	197.28	197.88	197.80
3	198.44	199.28	198.77	200.05
4	195.31	196.19	197.74	196.90
5	196.44	194.41	194.99	198.04
6	198.34	199.72	198.58	199.95
7	196.18	196.72	197.86	197.77
8	197.57	197.99	199.48	199.18
Avg.	197.40	197.83	198.31	199.01
Delta	--	+0.43	+0.91	+1.60
Multiplier	--	1.00218	1.00461	1.00813

* See paragraph 2.2.3

Table VIII. Comparison of Average S-IB Stage Flight and Rocketdyne Sea Level Data

Parameter	Vehicle	Difference	Pct Difference
Engine Thrust (lbf)	S-IB-1	1598	0.80
	S-IB-3	1170	0.59
	S-IB-2	1596	0.80
	S-IB-4	2153	1.07
		1629 Avg	0.82 Avg
Engine LOX Flowrate (lbm/sec)	S-IB-1	7.06	1.35
	S-IB-3	4.99	0.95
	S-IB-2	6.22	1.19
	S-IB-4	6.59	1.25
		6.22 Avg	1.19 Avg
Engine Fuel Flowrate (lbm/sec)	S-IB-1	0.58	0.24
	S-IB-3	0.57	0.24
	S-IB-2	0.80	0.34
	S-IB-4	1.03	0.43
		0.75 Avg	0.31 Avg
Engine Specific Impulse (sec)	S-IB-1	-0.53	-0.20
	S-IB-3	-0.38	-0.14
	S-IB-2	-0.32	-0.12
	S-IB-4	+0.16	+0.06
		-0.27 Avg	-0.10 Avg
Engine Mixture Ratio (O/F)	S-IB-1	0.0242	1.01
	S-IB-3	0.0157	0.71
	S-IB-2	0.0181	0.82
	S-IB-4	0.0185	0.83
		0.0191 Avg	0.84 Avg
Chamber Pressure (psi)	S-IB-1	4.92	0.71
	S-IB-3	3.52	0.52
	S-IB-2	4.92	0.71
	S-IB-4	6.64	0.96
		5.02 Avg	0.73 Avg

Difference = Flight - Rocketdyne
Pct Difference = (Difference/Rocketdyne) 100

NOTE: All values derived using latest gain table and revised Rocketdyne acceptance test data (PAST-077).

Table IX. Sea-Level Performance of S-IB-5 Stage at 30 Seconds Flight Time

Parameter	Nominal Value	Engine H-7066 Pos. 1	Engine H-7067 Pos. 2	Engine H-7068 Pos. 3	Engine H-7069 Pos. 4	Engine H-4063 Pos. 5	Engine H-4064 Pos. 6	Engine H-4065 Pos. 7	Engine H-4066 Pos. 8	Vehicle Parameters
Engine Thrust (kips)	200.00	202.21	197.63	199.88	196.73	197.87	199.78	197.61	199.01	1,585.27*
Engine Specific Impulse (sec)	262.88	262.49	261.26	262.26	261.45	262.43	261.98	261.20	262.14	260.80**
Chamber Pressure (psia)	689.31	699.45	683.54	692.74	678.91	681.77	688.05	684.27	686.18	
Engine LOX Flowrate (lbm/sec)	525.27	533.39	524.44	527.55	523.30	521.34	527.08	523.51	525.76	4,206.4
Engine Fuel Flowrate (lbm/sec)	235.54	236.95	231.99	234.57	229.15	232.66	235.48	233.01	233.40	1,872.2**
Engine Mixture Ratio	2.2301	2.2511	2.2606	2.2490	2.2836	2.2408	2.2383	2.2467	2.2526	2.2468**
Turbopump Speed (rpm)	6,716.5	6,794.9	6,655.7	6,734.5	6,644.3	6,626.8	6,725.3	6,636.8	6,631.4	
Engine Throat Area (in^2)	204.35	204.35	204.35	204.35	204.35	204.35	204.35	204.35	204.35	
Engine Expansion Ratio	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	

* Thrust along longitudinal axis

** Includes fuel used as lubricant

Table X. Stage Parameters for Various Environmental Conditions (September)

	Case 1	Case 2	*Case 3	Case 4	Case 5	Case 6
Wind Speed (probability limit)	(+3σ)	(-3σ)	Nominal	Nominal	Nominal	Special Mixture Ratio Case
Ambient Temperature (probability limit)	Nominal	Nominal	Nominal	(+3σ)	(-3σ)	
Fuel Density (lb/ft^3)	49.99	49.99	49.99	49.82	50.21	49.99
LOX Density (lb/ft^3)	70.278	70.729	70.531	70.531	70.531	70.531
Average Thrust (kips)	1737.0	1761.3	1749.0	1758.2	1737.1	1749.3
Average Specific Impulse (sec)	281.34	2818.9	281.62	281.84	281.33	281.64
Average LOX Flowrate (lb/sec)	4303.2	4370.4	4336.5	4361.5	4304.0	4328.8
Average Fuel Flowrate (lb/sec)	1870.7	1877.7	1874.2	1876.8	1871.0	1882.4
Average Mixture Ratio	2.3002	2.3275	2.3137	2.3238	2.3006	2.2996
IECO (sec)	140.886	139.131	140.110	139.265	141.218	140.023
OECO (sec)	144.438	142.034	143.110	142.265	144.218	143.744
Fuel Load (lb)	276050	276050	276050	274841	277638	276050
LOX Load (lb)	631029	631842	631554	631554	631554	631554
Minimum Allowable Fuel Ullage (%)	2.0	2.0	2.0	2.0	2.0	2.0
Nominal Allowable LOX Ullage (%)	1.5	1.5	1.5	1.5	1.5	1.5
Fuel Ullage at Fill (%)	3.46	3.46	3.46	3.55	3.35	3.46
LOX Ullage at Fill (%)	1.22	1.71	1.5	1.5	1.5	1.5

Table XI. Stage Parameters for Various Environmental Conditions (December)

Parameter	Case 1	Case 2	*Case 3	Case 4	Case 5	Case 6
Wind Speed (probability limit)	(+3σ)	(-3σ)	Nominal	Nominal	Nominal	Special Mixture Ratio Case
Ambient Temperature (probability limit	Nominal	Nominal	Nominal	(+3σ)	(-3σ)	
Fuel Density (lb/ft^3)	50.41	50.41	50.41	50.02	51.02	50.41
LOX Density (lb/ft^3)	70.280	70.766	70.561	70.561	70.561	70.561
Average Thrust (kips)	1712.8	1739.6	1727.2	1748.4	1693.6	1727.0
Average Specific Impulse (sec)	280.70	281.35	281.08	281.60	280.04	281.07
Average LOX Flowrate (lb/sec)	4237.8	4311.4	4277.1	4334.7	4188.8	4268.3
Average Fuel Flowrate (lb/sec)	1864.0	1871.7	1868.1	1874.2	1858.8	1876.2
Average Mixture Ratio	2.2734	2.3034	2.2895	2.3128	2.2534	2.2750
IECO (sec)	142.988	141.078	142.215	140.233	143.965*	142.071
OECO (sec)	146.812	144.114	145.215	143.233	149.111	145.905
Fuel Load (lb)	279154	279154	279154	276277	283762	279154
LOX Load (lb)	631215	632092	631827	631827	631827	631827
Minimum Allowable Fuel Ullage (%)	2.0	2.0	2.0	2.0	2.0	2.0
Nominal Allowable LOX Ullage (%)	1.5	1.5	1.5	1.5	1.5	1.5
Fuel Ullage at Fill (%)	3.23	3.23	3.23	3.44	2.86	3.23
LOX Ullage at Fill (%)	1.18	1.71	1.5	1.5	1.5	1.5

*T_2 Back-up Timer Signaled IECO

Table XII. Output Tapes

Case	A-5 Tape Reel No.	B-5 Tape Reel No.	B-6 Tape Reel No.	B-6 Copy Reel No.
Nominal Cases:*				
August	0995	3829	3130	6049 (File I)
September	3880	3612	3876	6049 (File II)
October	10876	0240	1152	6049 (File III)
November	0497	1443	3879	6049 (File IV)
December	5260	4415	1706	6049 (File V)
High Fuel Density				
3 Sigma Cases:				
September	1329	1467	2707	5226 (File II)
December	8584	1489	8333	8758 (File II)
Low Fuel Density				
3 Sigma Cases:				
September	8720	1042	1089	5226 (File III)
December	8651	10482	10529	8758 (File III)
High LOX Density				
3 Sigma Cases:				
September	8233	6187	6319	5226 (File IV)
December	7348	6493	5104	8758 (File IV)
Low LOX Density				
3 Sigma Cases:				
September	7732	9331	9285	5226 (File V)
December	8608	6351	6378	8758 (File V)
-3 Sigma Mixture Ratio Cases:				
September	1229	0232	0381	5226 (File VI)
Decmber	6715	1426	3041	8758 (File VI)
Delivered to Section No.	2733	2783	Library	R-P&VE-PPE (MSFC)

* September Nominal Case B-6 Copy is also File I of Tape 5226

December Nominal Case B-6 Copy is also File I of Tape 8758

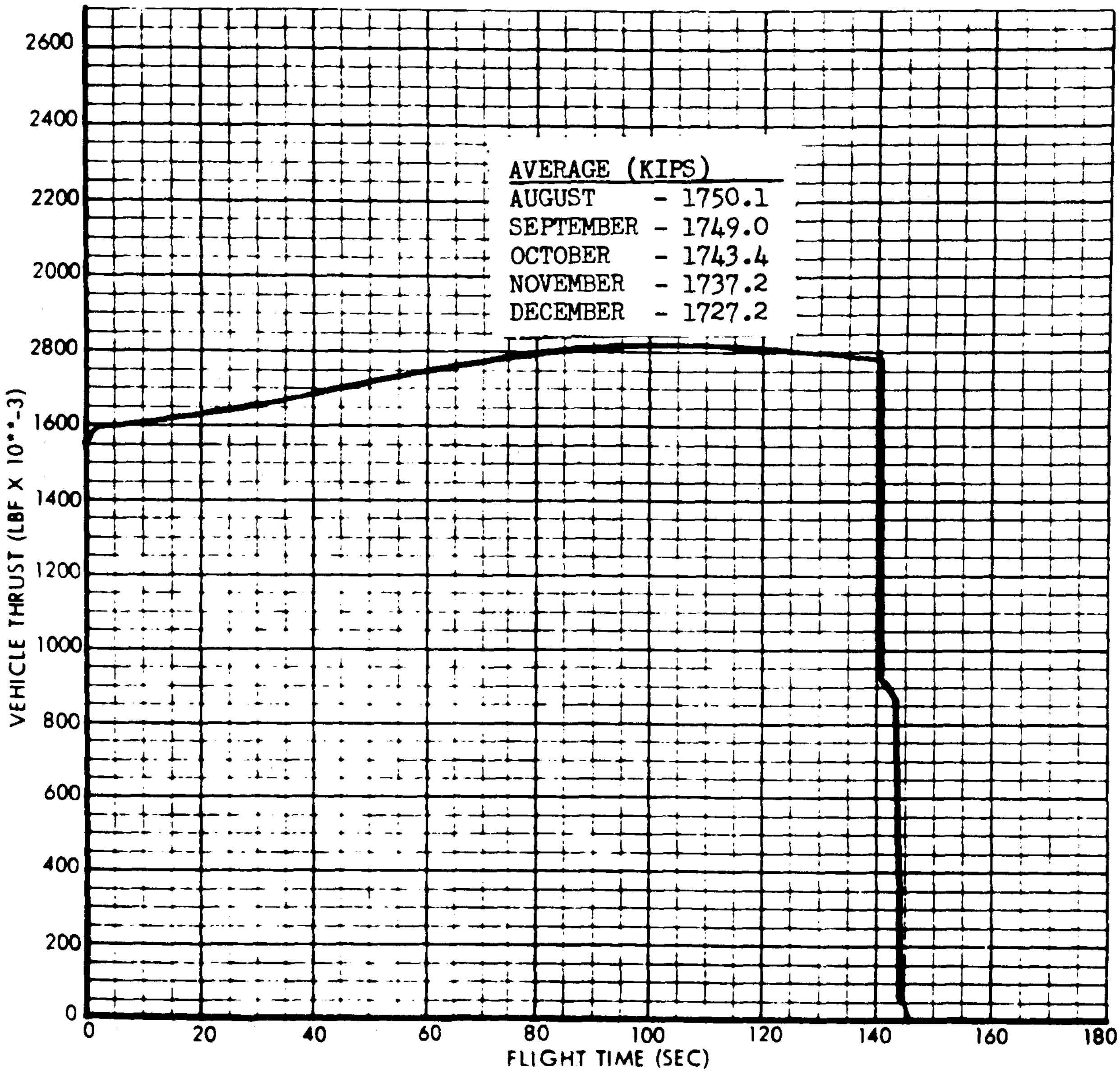

Figure 1. Vehicle Longitudinal Thrust vs Flight Time

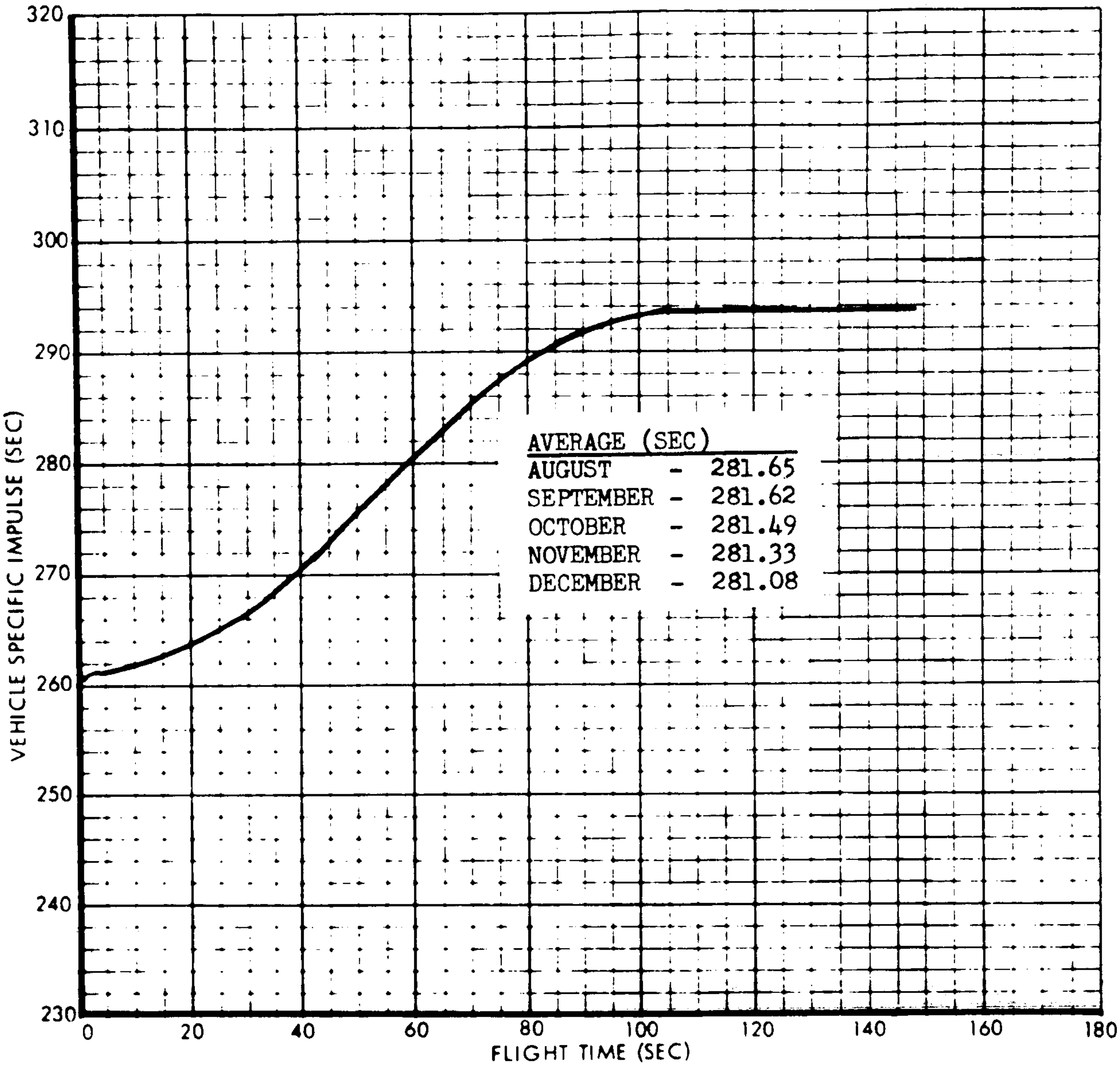

Figure 2. Vehicle Specific Impulse vs Flight Time

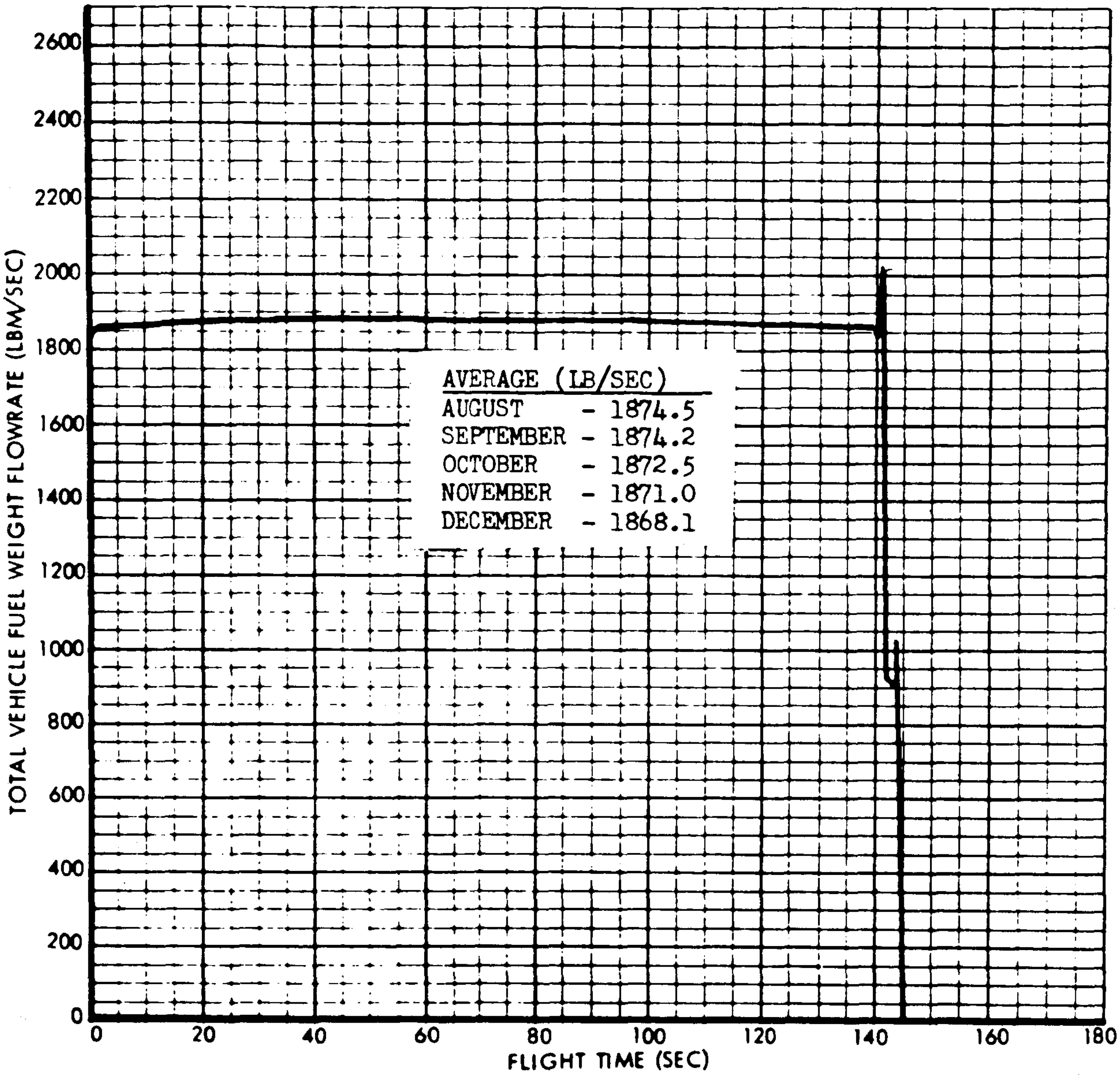

Figure 3. Total Vehicle Fuel Flowrate vs Flight Time

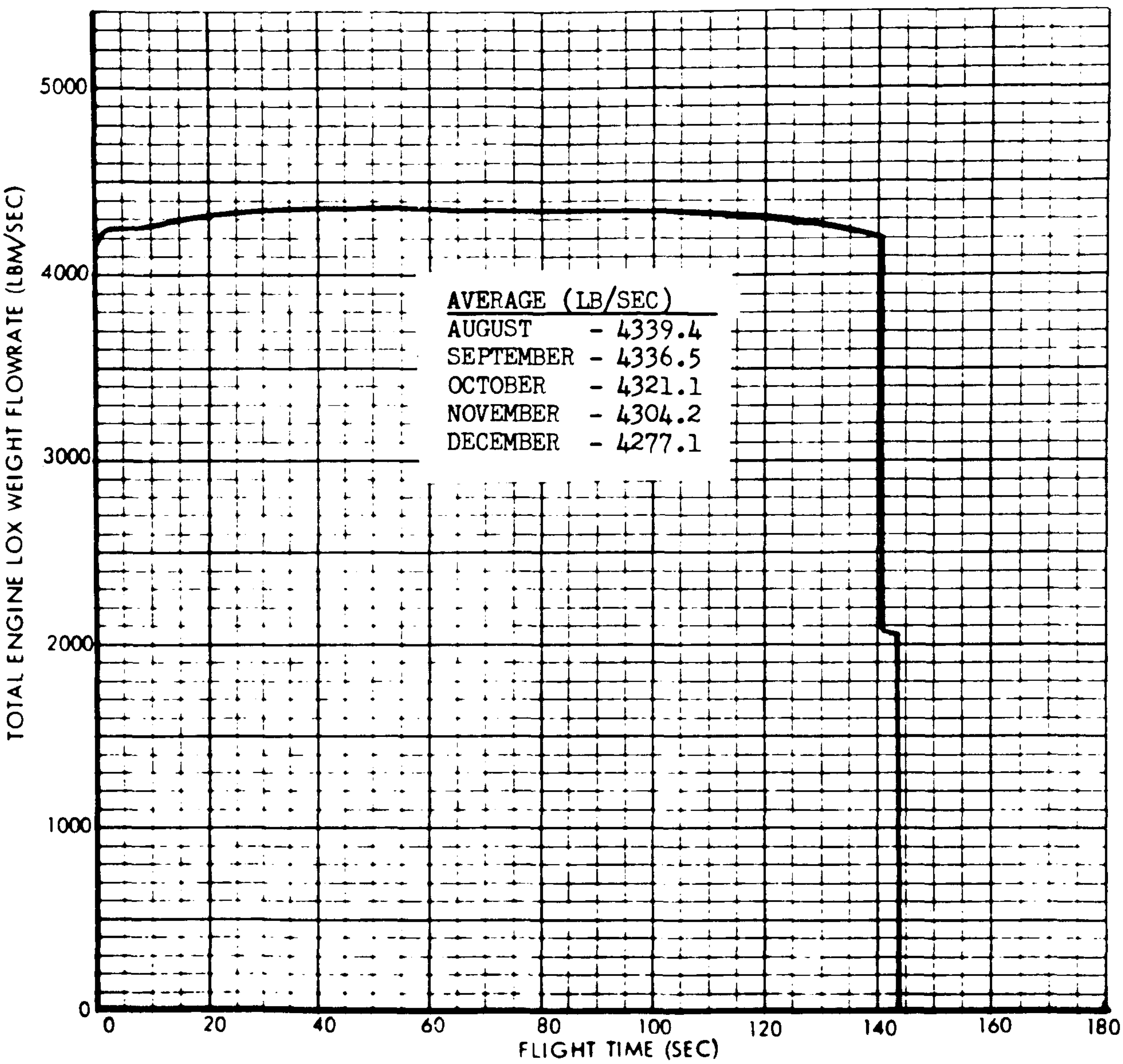

Figure 4. Total Engine LOX Flowrate vs Flight Time

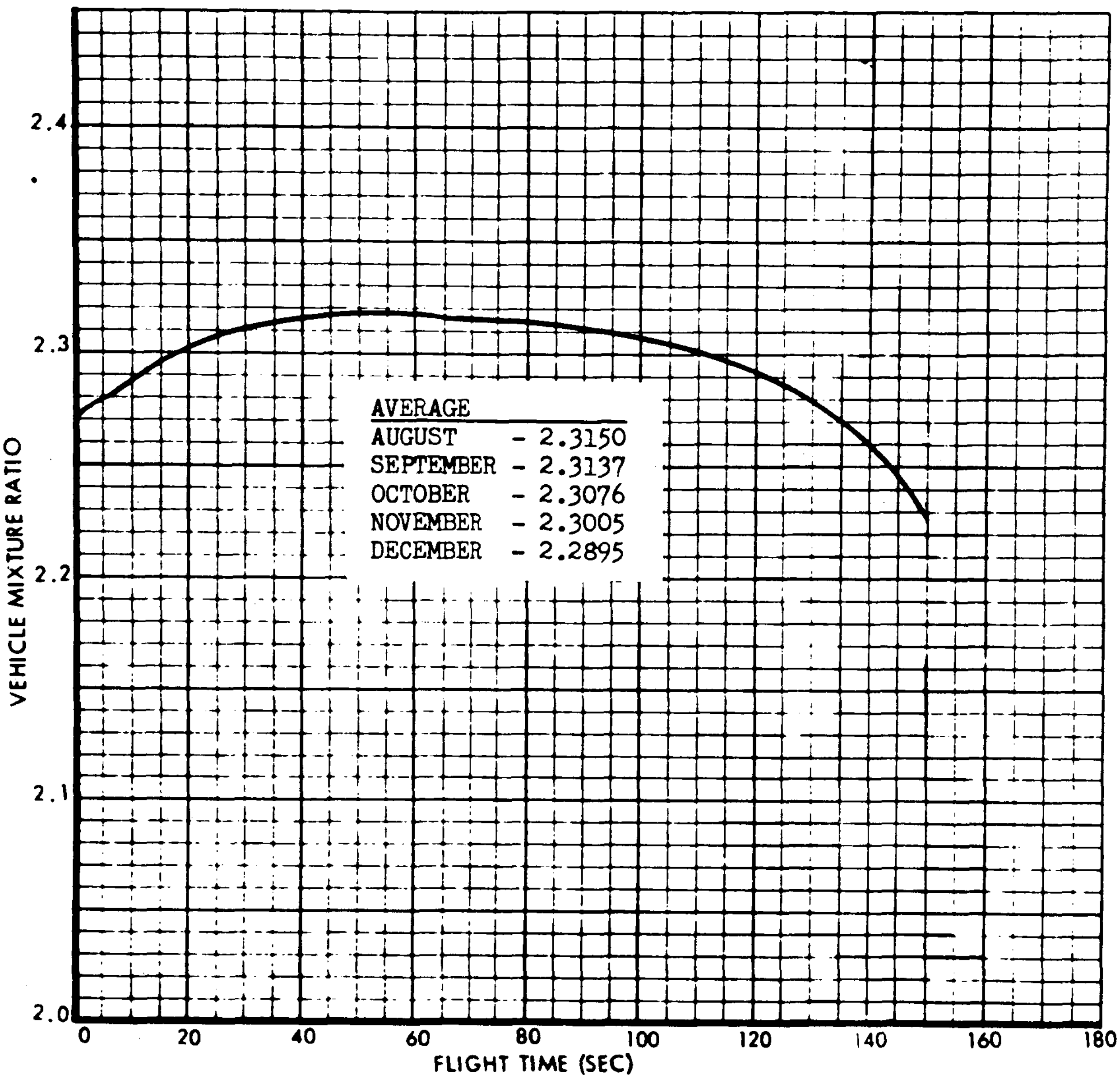

Figure 5. Vehicle Mixture Ratio vs Flight Time

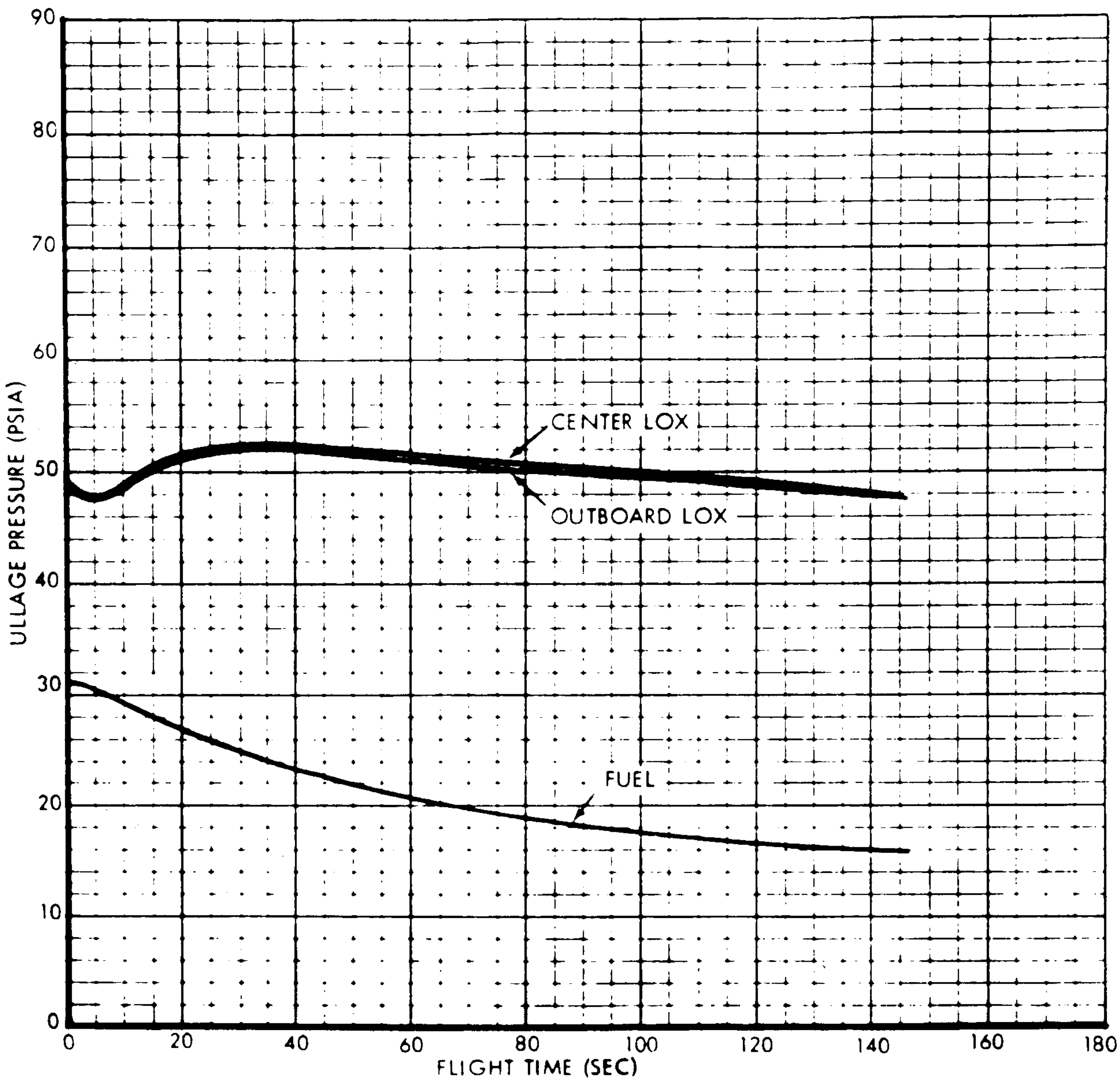

Figure 6. LOX and Fuel Tank Ullage Pressure vs Flight Time

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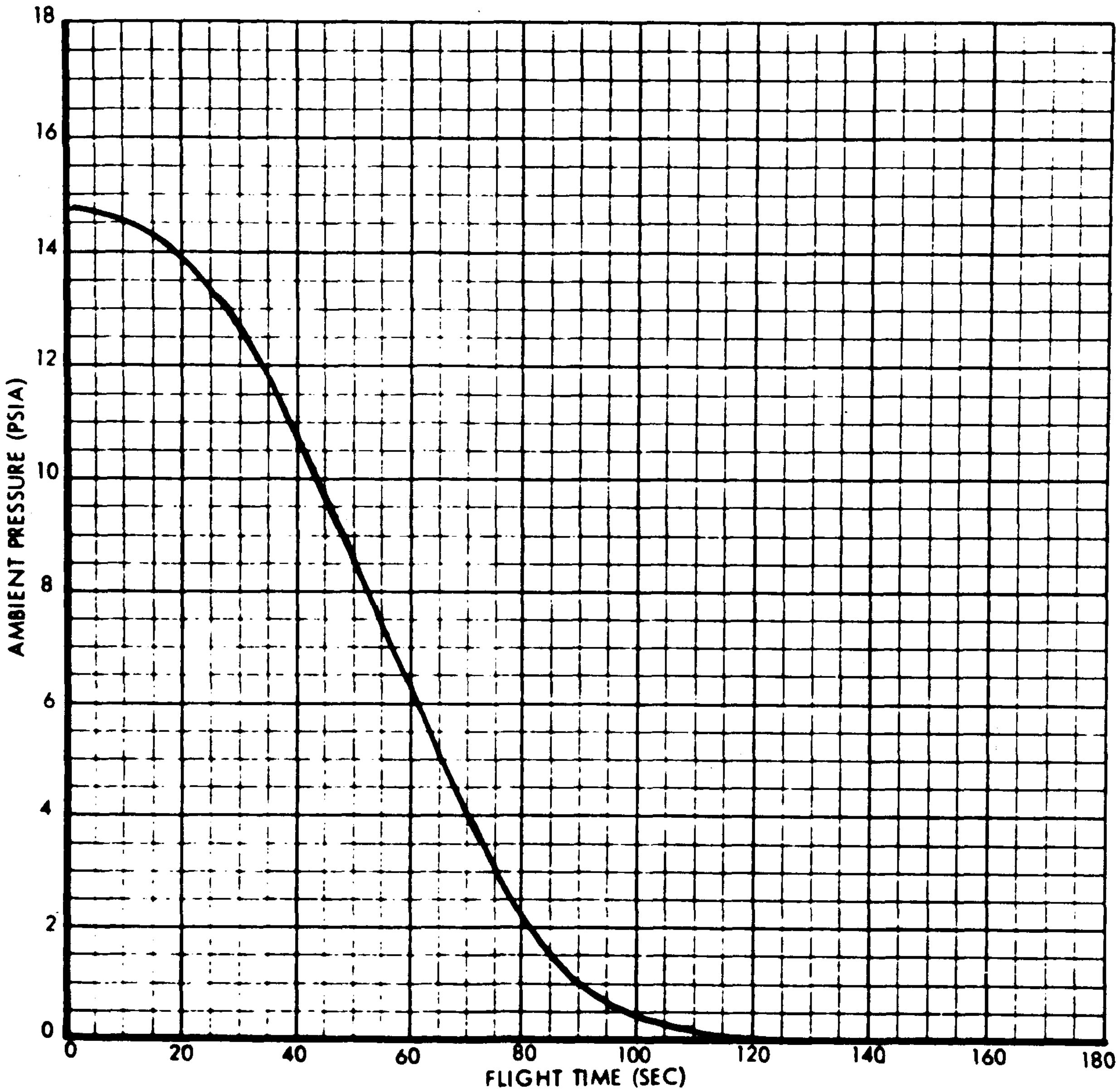

Figure 7. Ambient Pressure vs Flight Time

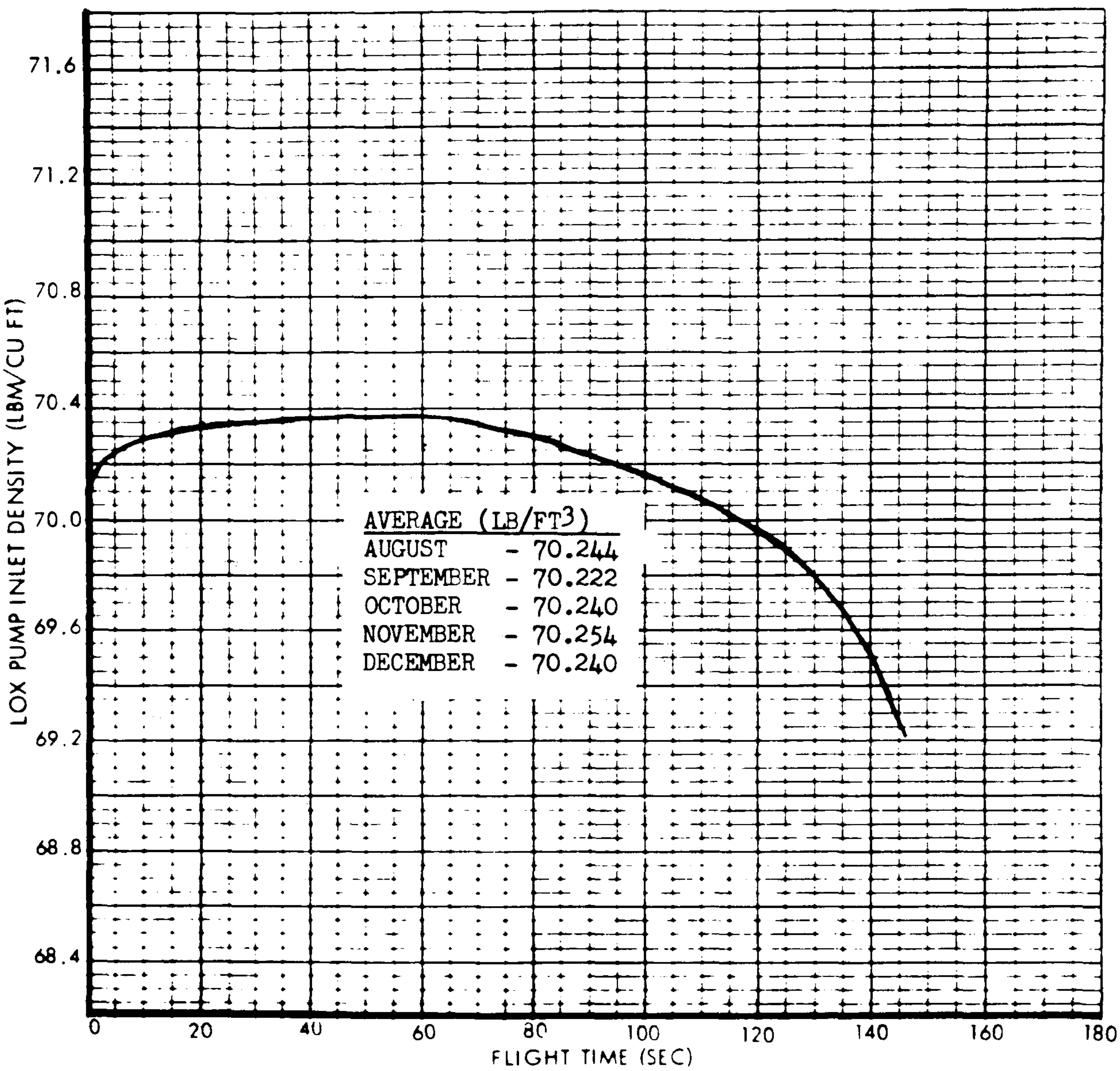

Figure 8. Engine LOX Pump Inlet Specific Weight vs Flight Time

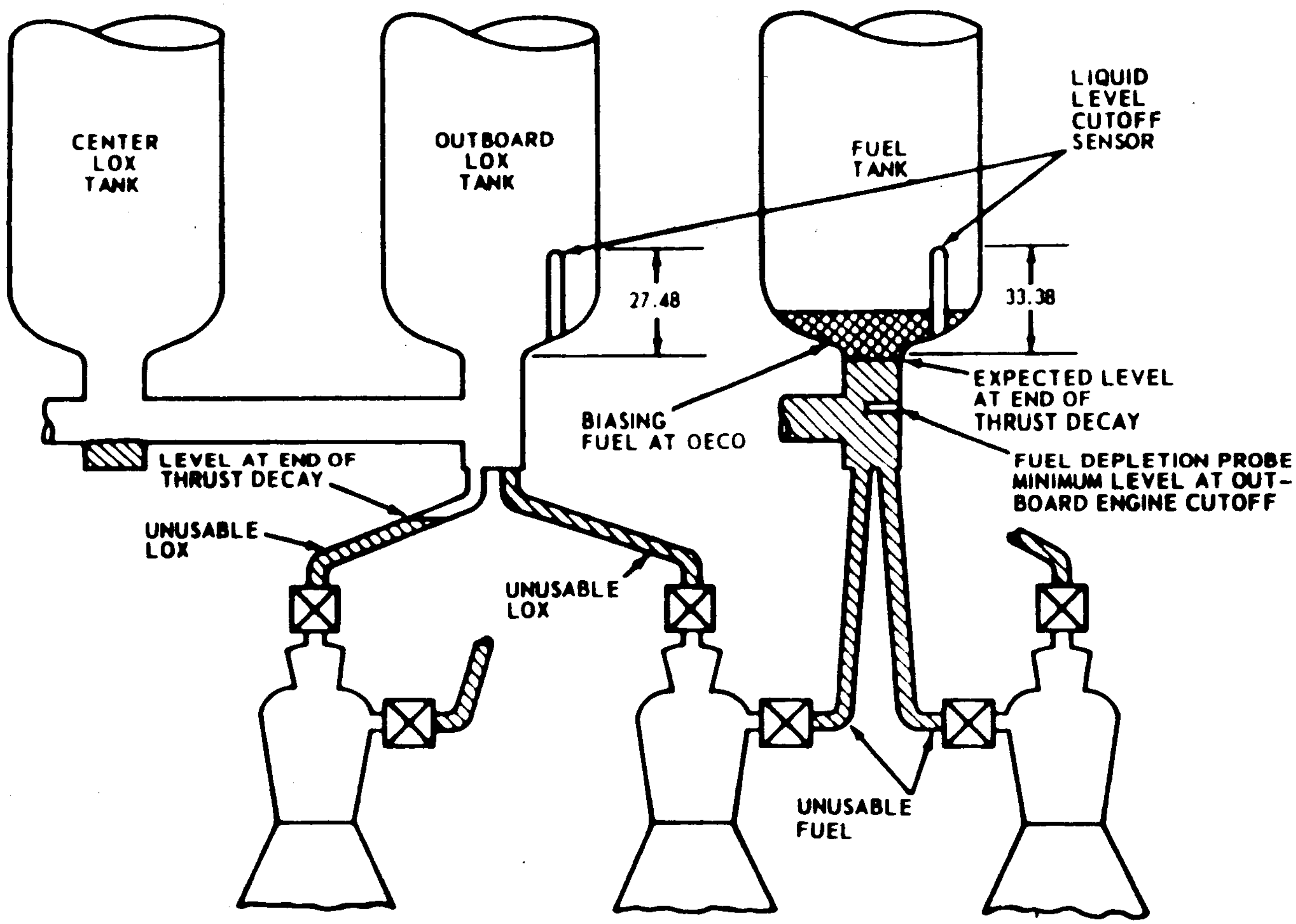

Figure 9. Propellant Depletion Requirements for S-IB-5 Stage

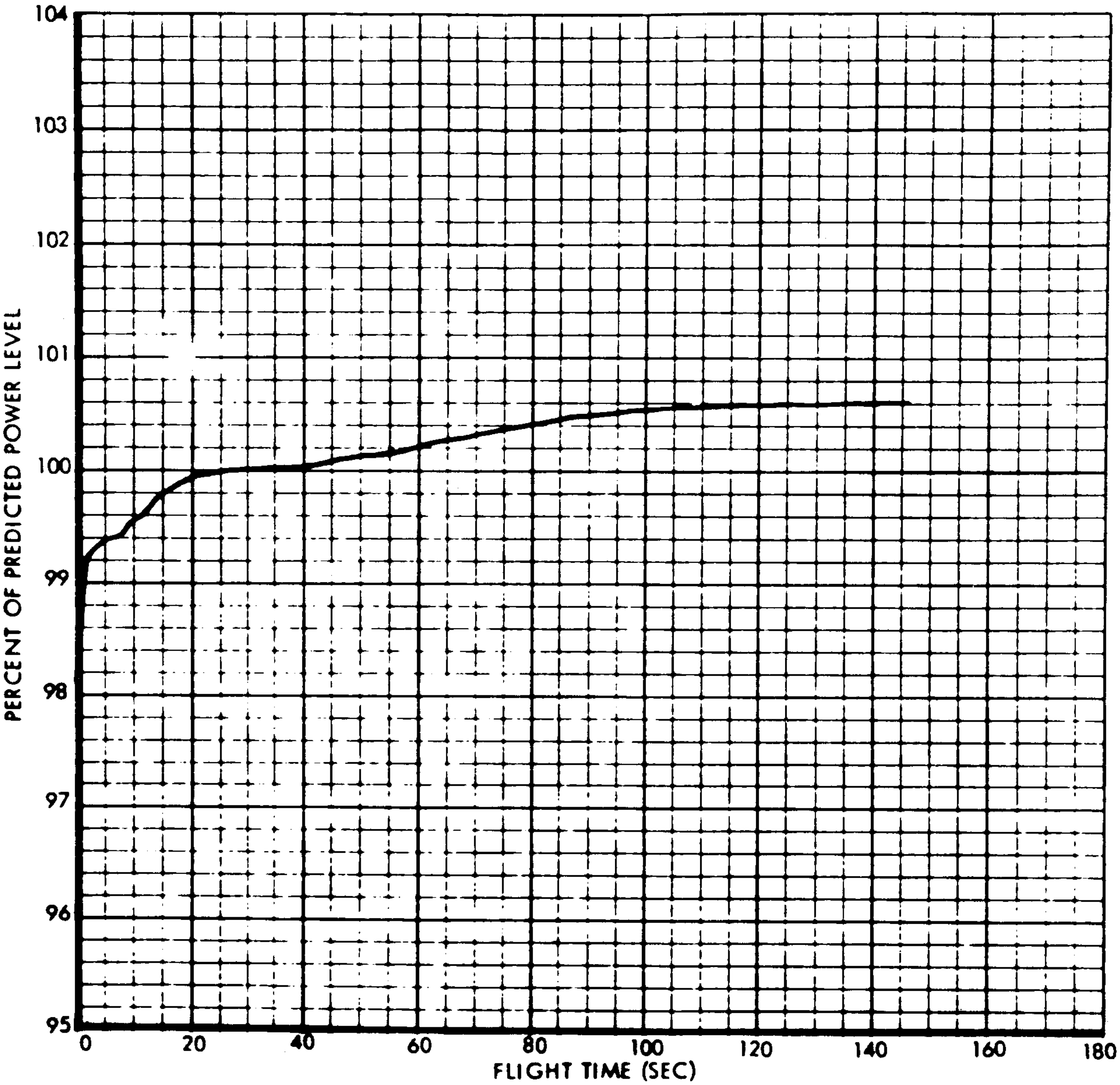

Figure 10. Predicted Power Level Shift vs Flight Time

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A. Final Flight Performance Prediction for Saturn AS-205 Propulsion System S-IB-5 Stage (Revision B), TR-P&VE-66-34, April, 1968.

B. Influence Coefficients for the 200K H-1, Rocketdyne Program Office Letter 166, dated June 2, 1967.

C. Revised S-IB Criteria for AS-205 Final Flight Prediction (Revision B), TB-P&VE-68-284, April 23, 1968 CCSD.

D. Launch to Launch Vehicle Systems Dispersions Analysis for Saturn IB Vehicles SA-201, -202, -203, and -204, HSM-R305-68, May 22, 1968.

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