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POST FLIGHT ANALYSES FOR DELTA PROGRAM MISSION NO. 113 - COS-B MISSION CONTRACT NAS7-832

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS CORPORATION

A3-262-AM00-M75-509
Date: FEB 2 0 1976

MEMORANDUM

Subject: POSTFLIGHT ANALYSES FOR DELTA PROGRAM MISSION NO. 113 - COS-B MISSION - CONTRACT NAS7-832*

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From: C. A. Ordahl, A3-262

1. This memorandum has been prepared in accordance with COM 15 of the subject contract.

2. On 8 August 1975, the COS-B spacecraft was launched successfully from the Western Test Range (Delta Program Mission No. 113). The launch vehicle was a three-stage Extended Long Tank Delta DSV-3P-11B vehicle, Serial No. 20018.

3. Postflight analyses performed in connection with Delta Program Mission No. 113 (COS-B Mission) are presented in the attachments to this memorandum (Attachments 1 through 10). These attachments consist of the following:

Attachment Number		Title	Pages
1	Section 1.	System Performance - COS-B Mission	1-1 through 1-26
2	Section 2.	Propulsion Systems - COS-B Mission	2-1 through 2-28
3	Section 3.	Guidance System - COS-B Mission	3-1 through 3-15
4	Section 4.	Flight Control System - COS-B Mission	4-1 through 4-29
5	Section 5.	Electronics System - COS-B Mission	5-1 through 5-11
6	Section 6.	Mechanical Systems - COS-B Mission	6-1 through 6-10

O. 3360-1114; EWO 54173; COM 15

TRACTUAL DOCUMENT

Attachment Number	Title	Pages
7	Section 7. Structural Systems - COS-B Mission	7-1 through 7-6
8	Section 8. Reliability	8-1 through 8-2
9	Definitions of Performance Parameters [Tables 2-3 and 2-4 of Attachment 2 (Section 2)]	9-1 through 9-2
10	Vehicle Performance Telemetry Plots - COS-B Mission	10-1 through 10-73

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Attachments: As Noted

ATTACHMENT 1:

SECTION 1. SYSTEM PERFORMANCE - COS-B MISSION

Attachment 1 to:
A3-262-AM00-M75-509

MISSION ANALYSIS - COS-B MISSION

INTRODUCTION AND SUMMARY

Delta Mission Number 113, COS-B, was launched from Pad SLC-2W of the Western Test Range (WTR) at a flight azimuth of 196 degrees from true north at 0147:59.595 Greenwhich Mean Time (GMT) on August 8, 1975.

This section provides a discussion of the mission analysis aspects of the COS-B spacecraft launch and a description of the trajectory flown by the Delta vehicle from liftoff to third-stage burnout; data pertaining to the experimental second stage restart are included. This section also presents a comparison between (1) the actual trajectory flown by the vehicle, (2) the guided nominal trajectory (Reference 1), and (3) the latest predicted or Best Estimate Trajectory with launch-day winds and atmosphere (BET-with-winds). The actual trajectory flown by the first and second stage is based on Federal Electric Corporation (FEC) radar tracking data and NASA-provided hardpoint position and velocity vectors (Reference (2). PCM telemetry data was utilized to support the determination of trajectory data at the time points specified in the subsections to follow. The following table compares the achieved orbit at spacecraft injection (TECO) to the nominal orbit given in the Orbit Accuracy Incentive TWX (Reference 3). Incentive flight requirements may be seen to have been met; that is, all fall within allowable tolerances.

Parameter	Nominal (Reference 3)	Achieved	Achieved Minus Nominal	Incentive Tolerance
Apogee Altitude (n.mi.)* (Integrated)	53,992	54,433	+441	+2115
Perigee Altitude (n.mi.)*	188.19	187.17	-1.02	-10.0
Inclination (deg)	90.000	90.155	+0.155	+0.82

Table 1 summarizes the orbit parameters of all Delta missions to date and, where applicable, includes the corresponding three-sigma deviations. Table 2 presents the guided nominal, BET-with-winds, and actual sequence of events for the COS-B mission.

VEHICLE DESCRIPTION

The launch vehicle used for the COS-B mission consists of a DSV-3P-1A Extended Long Tank Booster No. 602 (Serial No. 20020) powered by a Rocketdyne RS-27 liquid propellant engine and nine strap-on Thiokol TX-354-5 (Castor II) solid propellant rockets with low-drag nose cones. The second stage is a DSV-3P-4B (Serial No. 20023) having a TRW engine (light quartz nozzle with Expansion Ratio = 43:1) with restart capability and a DSV-3P-7A fairing (Serial No. 20023). The third stage consists of a TE-364-3 engine (Serial No. 00025).

* Based on an earth radius of 3442.62 n.mi.

METEOROLOGICAL CONDITIONS

Figures 1, 2, and 3 present the launch day temperature, pressure, and wind speed and direction from ground level to 100,000 feet measured at WTR at the time of launch. Figure 1 shows the atmospheric temperature was hotter than the reference temperature until approximately 42,000 feet, colder between 42,000 feet and 70,000 feet and hotter above 70,000 feet. The atmospheric pressure (Figure 2) is generally higher than the reference atmosphere. Figure 3 indicates that the wind speed was significantly lower than the 90 percent IRIG wind reference until approximately 65,000 feet and increasingly higher above 65,000 feet. The maximum wind speed was 49 knots at 100,000 feet. The wind direction changed from a north-westerly direction to an easterly direction with increasing altitude.

PERFORMANCE ANALYSIS

First and second stage performance up to second stage cutoff (SECO) is based on the radar tracking data and NASA SECO hardpoint. PCM telemetry data was utilized to determine the vehicle velocity at second stage burnout. Reconstruction of the third stage is based on the SECO I PCM data and NASA hardpoint data at third stage burnout.

FIRST STAGE PERFORMANCE

An analysis of pertinent data indicates that the first-stage flight was near nominal with respect to the vehicle's instantaneous impact point (IIP) and present position traces, which remained well within the three-sigma boundaries. Table 3 presents comparison of the guided nominal, BET-with-winds, and actual trajectory at significant times. The actual inertial velocity at MECO may be seen to be 2.1 ft/sec higher than the guided nominal and 59 ft/sec lower than the BET-with-winds.

SECOND STAGE PERFORMANCE

Table 4 presents trajectory comparisons of second stage performance parameters at significant event times during the first burn period of the second stage. Actual SECO I was determined from PCM telemetry data.

Figure 4 compares the tag second stage thrust history with the actual reconstructed thrust based on DIGS acceleration data, flowmeter weight-flow data (Reference 4), weights (Reference 5), and actual event times (Reference 6). The reconstructed thrust curve is higher than the tag an average of 48 pounds over the first burn. The higher than tag thrust level resulted in a 1.5 second shorter burn while the low (-71 ft/sec) velocity at ignition results in a 1.4 second longer burn, thus the first burn of the second stage was within 0.1 seconds of nominal.

THIRD STAGE PERFORMANCE

PCM position and velocity vectors at SECO were used in the following manner to reconstruct third stage performance. An MDAC-W predicted orbit was generated utilizing a PCM position and velocity vector at second stage burnout, vehicle attitude as defined in the BET-with-winds, actual third stage ignition time, and the latest predicted third stage performance and burn time. A reconstructed orbit was then generated using the same initial PCM position and velocity vectors and coast time as those for the predicted orbit in order to determine the third stage performance parameters required to match the NASA orbit parameters at a time after third stage burnout. The following table presents a summary of third stage predicted and reconstructed performance.

Parameter	Unit	Predicted Value	Reconstructed Value
Effective Specific Impulse	sec	287.93 ±1.10 3σ	288.39
Total Impulse	lb-sec	417678.9	418338.82
Impulsive Velocity	ft/sec	9497.10	9512.09
Vehicle Attitude Error; Pitch Component, Nose-Up Positive	deg	0 ± 3.90 3σ	0.699
Vehicle Attitude Error; Yaw Component, Nose Right Positive	deg	0 ± 3.90 3σ	0.649

Table 5 presents comparison of the MDAC-W predicted, BET-with-winds, and reconstructed third-stage trajectory parameters at third stage ignition and burnout.

POSTFLIGHT STATISTICS

Statistical information for pertinent performance and trajectory parameters are presented in Tables 6 and 7. Table 6 provides data as compared to nominal predictions, while Table 7 compares to tag (BET) predictions.

REFERENCES

1. Memorandum A3-200-AAC3-M-75-417, "Guided Nominal Trajectory for the COS-B Spacecraft Mission," dated 18 July 1975.

2. NASA Memorandum, "Tracking Data for COS-B Mission (Delta 113)," dated 11 September 1975.

3. TWX A3-130-Delta/AAC3-750137, "Orbit Accuracy Incentive Criteria for the COS-B Spacecraft Mission - Contract NAS7-832," dated 11 July 1975.

4. Memorandum A3-226-AD03-75293, "Propulsion Postflight Reconstruction for COS-B Delta Mission No. 113, Second Stage, DSV-3P-4B (Light Quartz), S/N 20020," dated 29 September 1975.

5. Memorandum A3-224-ABE2-75-169, "COS-B (Configuration 2913) - Final Postflight Weight Summary," dated 2 October 1975.

6. AVI A3-230-AEFO-AVI-75-234, "COS-B Sequence of Events," dated 7 October 1975.

TABLE 1-1

COMPARISON OF ORBIT PARAMETERS

MISSION *	LAUNCH NUMBER	LAUNCH DATE	CONF	NOMINAL APOGEE	NOMINAL PERIGEE	NOMINAL INCLIN	NOMINAL ECC	ACTUAL APOGEE	DELTA APOGEE	3σ Δha	ACTUAL PERIGEE	DELTA PERIGEE	3σ Δhp	ACTUAL INCLIN	DELTA INCLIN	3σ Δi	ACTUAL ECC	DELTA ECC	3σ Δe	COMMENTS
ECHO I	1	5-13-60	DM-19	900	900	48.0	0 0													COAST PHASE ATTITUDE FAILURE THIRD STAGE DID NOT IGNITE
ECHO IA	2	8-12-60	DM-19	900	900	47 1	0.0	907	7	110	818	82	110	47.2	0.1	0.5	0 0103	0.0103	0 0240	SUCCESS
TIROS A2	3	11-23-60	DM 19	380	380	48 3	0 0	395	15	86	334	46	86	48 5	0.2	0.5	0.0080	0 0080	0 0156	SUCCESS
P-14	4	3-25-61	DM-19	120000	94	33 0	0 9442	128611	8611	65000	90	4	2	329	0.1	0.3	0 9479	0.0037	0 0200	SUCCESS
TIROS A3	5	7-12-61	DM 19	380	380	48 3	0 0	442	62	81	398	18	81	47 9	0.4	0.5	0.0067	0 0057	0 0153	SUCCESS
S-3	6	8-15-61	DM-19	47000	160	33 0	0 8666	41762	5238	9252	159	1	2	33 0	0	0 6	0 8524	0 0142	0 0204	SUCCESS
TIROS D	7	2-8-62	DM-19	380	380	48 3	0 0	462	82	82	389	9	81	48 3	0	0 5	0.0094	0 0094	0 0153	SUCCESS
S-16	8	3-7-62	DM-19	300	300	32 9	0 0	322	22	53	299	1	53	32 9	0	0 5	0.0030	0 0030	0 0112	SUCCESS
S-51	9	4-26 62	DM-19	550	200	55 0	0 0458	656	106	365	211	11	60	53.9	1.1	1.5	0 0574	0.0116	0 0463	SUCCESS
TIROS E	10	6-19-62	DM-19	350	350	58 4	0 0	525	175	76	319	31	76	58 1	0.3	0 5	0 0266	0 0266	0 0146	PDS (BTL FAILURE)
TSX-1	11	7-10-62	DM-19	3000	500	45 0	0 2407	3042	42	321	512	12	23	44 8	0.2	1.1	0.2424	0 0017	0 0232	SUCCESS
TIROS F	12	9-18-62	DM-19	350	350	58 4	0 0	384	34	76	370	20	76	58 3	0.1	0 5	0.0019	0 0019	0.1460	SUCCESS
S-3A	13	10-2-62	DSV-3A	47000	160	33 0	0 8667	53204	6204	8000	152	8	28	33 0	0	1 6	0 8806	0 0139	0.0201	SUCCESS
S-3B	14	10 27-62	DSV-3A	9000	150	17 8	0 5519	9520	520		170	20		18 0	0.2		0 5642	0 0123		SUCCESS' FIRST [illegible] X-258 MOTOR
RELAY A-15	15	12-13-62	DSV-3B	4000	700	47 8	0 2848	4014	14	375	713	13	23	47 5	0 3	1.5	0 2848	0 0006	0 0259	SUCCESS' FIRST DUAL SQUIB SPIN ROCKETS
SYNCOM A-25	16	2-13-63	DSV 3B	19559	131	33 0	0 7311	18793	766	1676	130	1		33 1	0.1	0 9	0 7230	0 0081		SUCCESS
S-6	17	4-2-63	DSV 3B	485	135	57 8	0 0470	495	10	57	138	3	4	57 6	0.2	0 7	0.0479	0.0009	0 0070	SUCCESS
TSX-2	18	5-7-63	DSV 3B	5700	500	43 0	0 3938	5833	133	475	525	25	18	42 7	0 3		0.4007	0.0069	0 0202	SUCCESS
TIROS G	19	6-19-63	DSV 3B	355	355	58 3	0 0	350	5	76	355	0	76	58 2	0 1	0.5	0.0020	0 0020	0 0140	SUCCESS
SYNCOM A-26	20	7-26-63	DSV-3B	20016	120	33 0	0 7363	19647	369	2925	118	2		33.1	0 1	0.8	0 7327	0 0036		SUCCESS
IMP A	21	11-26-63	DSV-3C	50000	105	33 0	0 9548	106712	43288	52590	103	2	9	33 3	0 3	1.9	0.9376	0 0172	0 0239	SUCCESS; [illegible] FIRST X-258 MOTOR
TIROS H	22	12-21-63	DSV-3B	370	370	58 6	0.0	407	37	84	378	8	84	58 5	0 1	0.5	0 0038	0 0038	0 0175	SUCCESS
RELAY A-16	23	1-21-64	DSV-3B	4200	1150	46 5	0 2366	4003	3	376	1128	22	77	46 3	0.2	1.5	0 2392	0 0026	0 0231	SUCCESS
S-66	24	3-19-64	DSV-3B	647	642	70 7	0 0007													DID NOT OBTAIN [illegible] INJECTION LAST X-248 MOTOR
SYNCOM A-27	25	8-19-64	DSV-3D	20029	608	16 5	0 7056	20487	458	4242	610	2	17	16 7	0 2	3 2	0.7103	0 0047	0.0443	SUCCESS
IMP-B	26	10 3-64	DSV-3C	110011	105	33 0	0 9394	51114	58897	52590	102	3	9	33 6	0.6	1 9	0.8780	0 0604	0 0239	PARTIAL SUCCESS, DID NOT REACH DESIRED ORBITAL ALTITUDE
S-3C	27	12-21-64	DSV 3C	13782	174	20 0	0.6529	14148	366	6184	165	9	30	20 1	0 1	1.8	0 6595	0.0066	0.0854	SUCCESS
TIROS I	28	1-22-65	DSV-3C	400	400	98 4	0 0002	1392	992	103	379	21	103	96 4	2 0	0.8	0.1171	0 1169	0 0169	PARTIAL SUCCESS BTL ANTENNA INSTALLED INCORRECTLY
OSO-B	29	2-3-65	DSV 3C	300	300	32.9	0 0001	342	42	80	297	3	80	32.9	0	0 4	0.0059	0 0058	0 0182	SUCCESS
COMSAT #1	30	4-6-65	DSV-3D	20155	775	18 5	0 6967	19705	450	4199	778	3	77	18.1	0.4	1.5	0.6915	0 0052	0.0443	SUCCESS
IMP-C	31	5-29-65	DSV-3C	30000	102	33 0	0 9577	142681	22681	52590	105	3	9	33 9	0 9	1 9	0 9626	0 0129	0.0239	SUCCESS
TIROS OT-1	32	7-1-65	DSV 3C	432	430	98 6	0 0001	453	21	103	406	24	103	98 6	0	0 8	0.0061	0 0060	0 0182	SUCCESS
OSO-C	33	8-25-65	DSV 3C	300	300	32 9	0 0001													THIRD STAGE [illegible] PRIOR TO SEPARATION
GEOS A	34	11-6-65	DSV-3E	801	600	59.0	0 0243	1237	436	123	601	1	24	59 4	0.4	0 5	0 0729	0 0486	0 0140	SUCCESS' POS (WTL/[illegible] FAILURE) FIRST IMPROVED DELTA
PIONEER A	35	12-16-65	DSV 3E	0.984 a.u.	0 824 a.u.	0.147	0085	0 984 a.u.	0		0 814 a.u.	0 015 a.u.		0.176	0 029		0.0940	0.0090	0 0182	SUCCESS
TIROS OT-3**	36	2-3-66	DSV-3C	408	398	98 2	0 0014	457	49	106	385	13	106	97.9	0 3	0 7	0 0093	0 0078	0 0143	SUCCESS
TIROS OT-2***	37	2-28-66	DSV-3E	743	715	101.3	0 0034	768	25	142	735	20	142	101.0	0.3	0.7	0.0040	0 0006	0 0166	SUCCESS

* THREE SIGMA VALUES OBTAINED FROM MISSION ORBIT ERROR ANALYSIS

** THREE SIGMA VALUES ARE POINT ESTIMATE VALUES GENERATED FOR THE MISSION INCENTIVE CRITERIA

*** THREE SIGMA VALUES ARE 50% CONFIDENCE LEVEL VALUES GENERATED FOR THE MISSION INCENTIVE CRITERIA

TABLE 1-1 (CONTINUED)

COMPARISON OF ORBIT PARAMETERS

MISSION	LAUNCH NUMBER	LAUNCH DATE	CONF	NOMINAL APOGEE	NOMINAL PERIGEE	NOMINAL INCLIN.	NOMINAL ECC.	ACTUAL APOGEE	DELTA APOGEE	3σ Δha	ACTUAL PERIGEE	DELTA PERIGEE	3σ Δhp	ACTUAL INCLIN	DELTA INCLIN	3σ Δi	ACTUAL ECC.	DELTA ECC.	3σ Δe	COMMENTS
AE-B ***	38	5-25-66	DSV-3C	650	146	64 0	0 0657	1474	824	305	156	10	16	64 7	0.7	1.0	0 1550	0 0893	0.0656	SUCCESS FOS (BRIWCCO FAILURE) FIRST FW-4 MOTOR
AIMP-D	39	7-1-66	DSV-3E	299836	3600	28.8	0.9763	468207	168371		3602	2		28.9	0.1		0 9847	0 0084		SUCCESS ACHIEVED ALTERNATE MISSION
PIONEER-B	40	8-17-66	DSV-3E	1.134 a.u.	1.011 a.u.	0 0099	0.05820	1.124 a.u.	0.010 a.u.		1.009 a.u.	0 002 a.u.		0.1037	0 0938		0 05379	0 0441		SUCCESS
TOS WTR #1	41	10-2-66	DSV-3E	767	756	101.2	0 0014	813	46	148	749	7	148	101.0	0.2	1.0	0.0076	0 0062	0 0145	SUCCESS
INTELSAT II (F-1)	42	10-26-66	DSV 3E	20165	171	26 7	0 7344	20436	271	714	161	10	53	26.4	0.3	0.7	0.7377	0 0033	0 0083	SUCCESS
BIOS-A	43	12-14-66	DSV-3G	170.8	169 4	33.5	0 00019	171.5	0.7		66 1	3.3	21 1	33.5	0.0		0 00074	0 00055	0 005	SUCCESS
INTELSAT II (F-2)	44	1-11-67	DSV-3E	20165	171	26 7	0 7344	19958	207	714	160	11	53	26.2	0 5	0 7	0 7331	0 0013	0 0083	SUCCESS
TOS WTR #2	45	1-26-67	DSV-3E	777.1	772.6	101 6	0.0005	785	12	148	718	59	148	102.0	0.4	1 0	0.0080	0 0075		SUCCESS
OSO-E1	46	3-8-67	DSV-3C	300 6	299 3	32 91	0 0002	312 7	12 1	52 0	291	8 3	52 0	32.87	0.04	0.39	0 0029	0 0027	0.0081	SUCCESS
INTELSAT II (F-3)	47	3-22-67	DSV-3E	20165	171	26 7	0 7344	20188 7	23 7	1063 8	158 2	12.8	64 0	26.57	0.13	0.96	0.7355	0.0011	0 0111	SUCCESS
TOS D/NASA TOS C	48	4-20-67	DSV-3E	777 4	773.8	101.5	0 0004	769 4	8 0	113.5	732.3	41 5	113.5	101.9	0.4	1 0	0.0044	0 0040		SUCCESS
IMP-F	49	5-24-67	DSV-3E	121902	141	66.49	0 9446	13854	8048	27827	130 17	11 1	18 7	67 17	0.68	1.74	0.9409	0 0035	0 0100	SUCCESS
AIMP-E	50	7-19-67	DSV 3E	294076	355	29.36	0.9748	325106	31030		348	7.3		29 61	0 25		0.9772	0 0024		SUCCESS
BIOS-B	51	9-7-67	DSV-3G	170 8	169 4	33 50	0 0002	175 6	4.8	25	161 8	7 6	25	33 47	0 03		0 0019	0 0017	0 005	SUCCESS
INTELSAT II (F-4)	52	9-27-67	DSV-3E	20165	171	26 7	0 7344	20028	137	1163 7	162	9 0	63 7	26 44	0.26	1 095	0 7336	0 0008	0 0168	SUCCESS
OSO-D	53	10-18-67	DSV-3C	305.4	299 3	32 91	0 0002	311 5	6 1	34 3	295 9	3 4	34 3	33 00	0.09	0.34	0.0021	0.0019	0.0080	SUCCESS
TOS-C/NASA TOS D	54	11-10-67	DSV-3E	790.9	788 6	101 76	0.000259	809 8	18 7	76 04	760.0	26 8	76 04	102 1326	0.37	1.03	0 0058	0.0056	0 0116	SUCCESS
PIONEER-C	55	12-13-67	DSV-3E	1.100 a.u.	0.987 a.u.	0 0249	0.0541	1.090 a.u.	0.010 a.u.		0.969 a.u.	0.001 a.u.		0 0588	0.0339		0 0489	0 0052		SUCCESS
GEOS-B	56	1-11-68	DSV 3E	849.9	594.2	105 98	0 0307	858.3	8 4	79 5	584 6	9.6	27 4	105.80	0.18	0 97	0 0329	0.0022	0 0099	SUCCESS
RAE-A	57	7-4-68	DSV-3E	3174 5	345.2	121 01	0 2756	3176 6	2 1	104 94	344 5	0.7	15 64	120 63	0.38	1.05	0 2720	0 0036	0 0125	SUCCESS
TOS-E	58	8-16-68	DSV-3L	789 8	788 8	101.72	0.0001	796 3	6.5	21.4	779.1	9.7	21.6	101.73	0.01	0 37	0.0020	0 0019		SUCCESS
INTELSAT III-A	59	9-18 68	DSV-3L	19823	143 3	29.8	0 7288													FIRST STAGE FAILURE
PIONEER-D	60	11-8-68	DSV-3E	0.991 a.u.	0.755 a.u.	0 080	0 1352	0.991 a.u.	0.000 a.u.	0.001 a.u.	0.754 a.u.	0.001 a.u.	0.015 a.u.	0 0903	0.010	0 084	0.1357	0 0005		SUCCESS
GEOS-A	61	12-5-68	DSV-3E	114 750	239 8	28 29	0 9397	120552	5802	22218	2298	10 0	20.14	28 28	0 010	0.12	0 9425	0 0028	0 0088	SUCCESS
TOS-F	62	12-15-68	DSV-3L	789 55	785.29	101 729	0.0001	796.75	7 20	21.4	764.92	20 37	-21 9	101 801	0 072	0 37	0 0038	0 0037		SUCCESS
INTELSAT III-C	63	12-18 68	DSV-3L	19835	143 1	29.80	0 7330	19642	-193	-972	1453	2.2	20.7	29.86	0.06	0 65	0 7309	0.0021	0 0124	SUCCESS
OSO-F	64	1-22-69	DSV-3C	300 8	299.6	32 91	0 00017	307 2	6.4	49 4	296 6	-2 9	54.18	32 99	0.08	0.58	0 0014	0.0012		SUCCESS
SIS-A	65	1 30-69	DSV-3E	1895.1	304 7	88 5	0.1750089	1912 8	17.7	68.7	311.9	7.2	28 92	88.42	-0 08	1 32	0 1755	0 00067	0 0064	SUCCESS
INTELSAT III-B	66	2-5-69	DSV-3L	19835	143.1	29 80	0 7330	19563	-272	-972	143 1	0 0	-21.0	29 86	0 06	0 65	0.7303	0 0027	0.0124	SUCCESS
TOS-G	67	2 26 69	DSV-3E	773 71	786.43	101.73	0 000299	800 477	26 77	74.9	769.16	-17 27	-79 0	101 785	0 06	0 89	0.0006053	0 00575		SUCCESS
INTELSAT III-D	68	5-21 69	DSV-3L	19956	150	28.87	0.7337	19911	-45	-1251	152 3	2 3	19 9	28 61	0.26	0 78	0 7330	0.0007	0 0126	SUCCESS
IMP-G	69	6-21-69	DSV-3E	113960	184.9	83 792	0 9401	96296	-17665	-20414	205 2	20.3	21.8	86 793	3 001	1.684	0 9294	0.0107	0 0122	SUCCESS
BIOS-D	70	6-29-69	DSV-3L	207.9	199.7	33 498	0 0011	212.5	4.6	17.8	196.5	-3 2	-14 3	33 560	0 062	0 063	0 0022	0.0011	0.0034	SUCCESS
INTELSAT III-E	71	7-26-69	DSV-3L	19940	149.7	28 81	0 7336	2913	-17027	-1251	1470	-2.7	-21.6	30.30	1.49	0 78	0 2781	0 4555	0 0126	THIRD STAGE FAILURE
OSO-G	72	8-9-69	DSV-3L	300.458	299 251	32 944	0.000323	299.447	-1.017	-5 93	273 911	-24.84	-26.62	32 967	0 023	0.124	0 00349	0.003167	0 00385	SUCCESS
PIONEER-E	73	8-27-69	DSV-3L	1.03 a.u.	0.98 a.u.	0.025	0.03													FIRST STAGE FAILURE
IDCSP/A-A	74	11-22-69	DSV-3L	19731.8	150 2	28.0	0.7325	20023 2	291.4	778.3	141 46	-8.7	-13 1	27 56	-0 44	0 85	0.7360	0 0035	0.0079	SUCCESS

*** THREE SIGMA VALUES ARE 90% CONFIDENCE LEVEL VALUES GENERATED FOR THE MISSION INCENTIVE CRITERIA

TABLE 1-1 (CONTINUED)

COMPARISON OF ORBIT PARAMETERS

MISSION	LAUNCH NUMBER	LAUNCH DATE	CONF	NOMINAL APOGEE	NOMINAL PERIGEE	NOMINAL INCLIN	NOMINAL ECC.	ACTUAL APOGEE	DELTA APOGEE	3σ Δha	ACTUAL PERIGEE	DELTA PERIGEE	3σ Δhp	ACTUAL INCLIN	DELTA INCLIN	3σ Δi	ACTUAL ECC.	DELTA ECC.	3σ Δe	COMMENTS
INTELSAT III F	75	1-14-70	DSV-3L	19544 3	147 6	28.03	0 7308	19399 3	-145.0	-728.4	143 4	-4.2	-25.0	28 05	0.02	0.99	0.7285	-0.0023	-0.0079	SUCCESS
TIROS-M	76	1-23-70	DSV-3L	792 2	784 5	101 746	0 00088	798.3	6.1	26 64	782.32	-2.18	-27.671	101 982	0.236	0 496	0.00188	0.001	0 0052	SUCCESS
NATO-A	77	3-20-70	DSV 3L	20116	153 2	25.90	0 7360	19896	-220 2	-864 6	152.53	-0.10	-25.0	25.68	-0.22	-0 85	0.7339	0.0021	-0.0090	SUCCESS
INTELSAT III G	78	4-22-70	DSV-3L	19544.3	147.6	28.03	0.7308	17923.9	-2220.4	-713.7	153.7	6.1	25.0	27 21	-0.82	-0 97	0.7047	-0.0261	-0.0079	SUCCESS FIRST STAGE LOW VELOCITY 2ND STG POS
INTELSAT III H	79	7-23-70	DSV-3L	19532 6	147.2	28.03	0.7297	19572.8	40.2	761.15	149 9	2.7	25.0	27 96	-0.07	-0 99	0 7299	0 0002	0.0091	SUCCESS
IDCSP/A-B	80	8-19-70	DSV-3L	20116.4	153.2	25.90	0.7360	20271 5	165.1	917.46	144 1	-9.1	-25.0	25 93	0.03	0 85	0.7382	0 0022	0.0090	SUCCESS
ITOS-A	81	12 11-70	DSV-3L	791.8	787 5	101.75	0 000504	795.0	3.2	27.5	776 9	-10.6	-29.1	101.944	0.194	0 472	0.00214	0 00164	0 00527	SUCCESS
NATO-B	82	2-3-71	DSV-3L	20116.4	153.2	25.90	0.7360	20388.5	272.1	917.45	146.3	-6.9	-25.0	25.78	-0.12	-0.85	0.7382	0.0022	0.0090	SUCCESS
IMP-I	83	3-13-71	DSV-3L	114912	127.6	28.78	0.9415	111424	-3548	74760	132.9	5.3	25.0	28.69	-0.09	-0 40	0.9396	-0.0019	-0.0069	SUCCESS
ISIS-B	84	4-1-71	DSV-3E	757.1	756.2	88.73	0 00011	782 7	25.60	62.7	737.7	-18 54	-68.3	88.15	-0.58	-1.00	0 00537	0 00526	0 012911	SUCCESS
OSO-H	85	9-29-71	DSV-3L	300.5	297.5	32 96	0.0004	310.2	9.7	29.5	204.8	-92.7	-29.5	33 095	0.135	0.138	0.0142	0 0138	0.0052	SUCCESS: STAGE 2 HYDRAULIC SYSTEM FAILURE
ITOS-B	86	10 21-71	DSV-3L	791.0	788.0	101 60	0 0003	(IMPACTING			TRAJECTORY			AT SECOND II)			—	—	—	SECOND STAGE FAILURE
HEOS-A2	87	1-31-72	DSV-3L	132370	220.98	90 01	0 94754	132210+	-100	5767	214+	-6.98	7.3	89 95+	-0 06	0 23	0.94751	-0.00003	-	SUCCESS + QUICK LOOK DATA
TD-1	88	3-11-72	DSV-3L	295.84	295.25	97.62	0.000018	294.7	-1.14	8.76	291.1+	-4.15	8 8	97.55+	-0 07	0 10	0.00248	0 0024	—	SUCCESS + QUICK LOOK DATA
ERTS-A	89	7-23 72	900	497.4	491.0	99.10	0.0009	499.1	1.7	3.4	489.6	-1.4	-5.6	99 08	-0.02	0 045	0.0012	0 0003	0.001	SUCCESS: FIRST DIGS
IMP-H	90	9-22-72	1604	130873	133.9	28 81	0.94812	129162 4	1710	75262	134.3	0.4	3.11	28 646	-0.16	-0.670	0 94746	0 00066	-0 0067	SUCCESS: FIRST ELT
ITOS-D	91	10-15-72	300	790.4	789 0	101.77	0.0002	789.3	-1.1	-8.9	784.7	-4.3	-8.9	101 74	-0.03	0.043	0.0005	0.0003	0.0012	SUCCESS
TELESAT-A	92	11-10-72	1914	19524	105 0	27.00	0.7338	19699.	175	498	104.2	-0.8	-2.3	27.00	0	0.382	0.7356	0 0018	0 0049	SUCCESS: FIRST 8 FT SECOND STAGE
NIMBUS-E	93	12-10-72	900	597.5	596.0	99.96	0.0002	597.6	+0.1	+8.3	594.7	-1.3	-7.0	99.92	-0.02	0.041	0.00005	0.00015	0.0011	SUCCESS
TELESAT-B	94	4-20-73	1914	19533	115.1	26.80	0.7328	19596.	+63	485	114.8	-0.3	-2.2	26.73	-0 07	-0.33	0.7334	0 0006	0 0048	SUCCESS
RAE-B	95	6-10-73	1913	211275	99.1	29 31	0.9684	209110	-8165	-26040	99.0	-0.1	-2.15	29.11	-0.20	-0.66	0 9673	-0 0011	-0.0055	SUCCESS
ITOS-E	96	7-16-73	300	805.6	805.5	101.91	0 00001	—	—	—	—	—	—	—	—	—	—	—	—	SECOND STAGE FAILURE
IMP-J	97	10-26-73	1604	127396	106.6	28.8	0 94647	123591	-3805	-19609	107 2	0.6	6.78	28.77	-0.03	-0.51	0 94706	0.00059	0.0081	SUCCESS
ITOS-F	98	11-6-73	300	820.8	820.2	102.05	0.00001	817.6	-3.2	-8.2	816.3	-3.9	-8.2	102 07	0.02	0.05	0 00015	0.00014	0 00146	SUCCESS
AE-C	99	12-16-73	1900	2330.3	84.6	68.1	0.24140	2335.5	5.2	12.9	83.6	-1.0	-1.0	68.131	0.031	0.048	0 24196	0.00056	0.00113	SUCCESS
SKYNET IIA	100	1-19-74	2313	20054	100.9	24.6	0.7379	—	—	—	—	—	—	—	—	—	—	—	—	SECOND STAGE FAILURE
WESTAR-A	101	4-13-74	2914	19506	125.0	24.765	0.7319	19579	+73	593	124.3	-0.7	-3.1	24.734	-0.031	-0.35	0.7326	0.0007	0.0058	SUCCESS ONE SOLID MOTOR CARRIED TO MECO
SMS-A	102	5-17-74	2914	19524	99.9	23.800	0 7337	17757	-1767	-688	94.9	-5.0	-3.0	24.531	0.731	0.343	0.7150	-0.0813	-0.0070	SUCCESS LOW FIRST STAGE VELOCITY
WESTAR-B	103	10-10-74	2914	19506	125.0	24.765	0.7319	19484	-22.	593	124.5	-0.5	-3.1	24.764	-0.001	-0.35	0.7317	-0.0002	0 0059	SUCCESS
ITOS-G	104	11 15-74	2310	789 7	789.3	101.73	0.00004	789 6	-0.1	-3.6	785 3	-4.0	-8 3	101.73	0.000	0.05	0 0005	0.0005	0 0012	SUCCESS
SKYNET-IIB	105	11-22-74	2313	19949	100	24.6	0.7379	19948	-1.0	-621	99.96	-0.04	-2.3	24 594	-0.006	-0.33	0.7379	0.0	0.0053	SUCCESS
SYMPHONIE-A	106	12-18-74	2914	20519	216.0	13.156	0 7360	20548	+29	+1686	217.0	+1.0	+2.7	13.205	+0.049	-0.34	0 7359	-0.0001	-0 0159	SUCCESS
ERTS-B	107	1-22-75	2910	498.0	492 2	99.094	0.00073	496.6	-1.4	-2.9	493.9	+1.7	+4 6	99.074	-0.020	-0 033	0 0003	-0 0004	-0 0005	SUCCESS
SMS-B	108	2-06-75	2914	19784	100.0	23.800	0 7363	19770	-14	-661	99.4	-0 6	-3 0	23.815	+0.015	0.323	0.7362	-0.0001	-0.0067	SUCCESS
GEOS-C	109	4-09-75	1410	458.2	457.8	114.996	0.00008	458.4	+0.2	+9.56	457.8	-1.5	-9.09	114.982	-0.014	+0.049	0.00025	0.0002	0.001	SUCCESS
TELESAT-C	110	5-07-75	2914	19506	125.0	24.765	0.7319	19408	-98	-666	125.0	0.0	2.9	24.751	-0.014	-0.366	0.7309	-0.001	-0.0069	SUCCESS
NIMBUS-F	111	6-12-75	2910	599.2	597.5	99.960	0.00022	598.3	-0.9	-3.3	596.6	-0.9	-6.0	99.960	0.0	0.046	0.00022	0	0.0010	SUCCESS

TABLE 1-1 (CONTINUED)

COMPARISON OF ORBIT PARAMETERS

MISSION	LAUNCH NUMBER	LAUNCH DATE	CONF.	NOMINAL APOGEE	NOMINAL PERIGEE	NOMINAL INCLIN	NOMINAL ECC.	ACTUAL APOGEE	DELTA APOGEE	3σ Δha	ACTUAL PERIGEE	DELTA PERIGEE	3σ Δhp	ACTUAL INCLIN	DELTA INCLIN	3σ Δi	ACTUAL ECC.	DELTA ECC.	3σ Δe	COMMENTS
OSO-I	112	6-21-75	1910	300.2	299.9	32.959	0.00001	300.3	+0.1	+4.8	299.3	-0.6	-4.8	32.963	+0.004	+0.029	0.00013	±0.00012	0.00067	SUCCESS
COS-B	113	8-08-75	2913	53992	188.19	90.000	0.88113	54433	+441	+2135.0	187.17	-1.02	-9.5	90.155	+0.155	+0.822	0.88276	±0.00163	±0.00397	SUCCESS
	114																			
	115																			
	116																			
	117																			
	118																			
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	120																			
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Table 2

SEQUENCE OF EVENTS - COS-B MISSION

Event	Time From Liftoff (sec) Guided Nominal Value	BET-With-Winds Value	Actual Value
FIRST STAGE			
1. Solid-Motor Ignition Arm	-0.90	----	-1.14
2. Solid-Motor Ignition Command	-0.20	----	-0.38
3. Telemetry Liftoff	----	----	-0.18
4. Solid-Motor Burnout (6)	38.62	38.61	38.47
5. Solid-Motor Ignition (3)	39.00	39.08	38.58
6. Solid Motor Burnout (3)	77.81	77.81	77.61
7. Solid-Motor Separation (9)	87.00	87.00	87.34
8. MECO Enable	230.942	223.653	222.32
9. Sensed MECO (0.5g)	230.322	231.033	227.281
10. Vernier-Engine Cutoff (VECO)	236.322	237.033	233.800
11. First-Stage/Second-Stage Separation Command	238.322	239.033	235.880
SECOND STAGE - FIRST BURN			
13. Second-Stage Ignition Command No. 1	243.322	244.073	240.81
14. Second-Stage Engine Start No. 1 (Steady State)	243.662	244.373	241.18
15. Fairing Separation (Actual)	273.332	274.033	270.35
16. Second-Stage Engine Cutoff Command (SECOM) No. 1 (DIGS Velocity Cutoff)	530.121	533.919	530.563
17. Sensed Second-Stage Engine Cutoff (SECO) No. 1 (.5g)	530.832	534.662	530.873

Table 2 (Continued)

SEQUENCE OF EVENTS - COS-B MISSION

Event	Time From Liftoff (Sec) Guided Nominal Value	BET-With-Winds Value	Actual Value
THIRD STAGE			
18. Fire Spin Rockets, Start Third-Stage Ignition Time Delay, and Start Third-Stage Timer	3026.621	3027.439	3025.30
19. Second-Stage/Third-Stage Separation Second-Stage Retro Initiation	3028.621	3029.439	3027.32
20. Third-Stage Ignition	3070.121	3070.939	3071.2
21. Third-Stage Burnout	3114.921	3115.739	3115.7
22. Spacecraft Separation	3187.00	3187.439	3185.32

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Table 3

SUMMARY OF FIRST STAGE PERFORMANCE PARAMETERS
(COS-B MISSION)

Item	Unit	Guided Nominal Value	BET-With-Winds Value	Actual Value
LIFTOFF WEIGHT (LB)		291,785.71	291,288.85	291,290.0
SOLID MOTOR BURNOUT (6)				
Time (Average)	sec	38.62	38.61	38.97
Inertial Velocity	ft/sec	1660.03	1677.0	1668.89
Velocity (Relative to Launch Point)	ft/sec	1,259.8	1,274.5	1,264.1
Inertial Flight Path Elevation Angle	deg	42.67	42.99	43.05
Flight Path Elevation Angle*	deg	63.12	63.62	64.15
Inertial Flight Path Azimuth Angle	deg	116.37	116.17	115.51
Flight Path Azimuth Angle*	deg	196.61	195.93	196.42
Range	ft	6530.9	6604.3	6680.2
Altitude	ft	19,624.4	19,759.2	20,533.4
SOLID MOTOR BURNOUT (3)				
Time (Average)	sec	77.81	77.81	77.61
Inertial Velocity	ft/sec	2,657.7	2,643.5	2,679.0
Velocity (Relative to Launch Point)	ft/sec	2,640.4	2,628.5	2,664.3
Inertial Flight Path Elevation Angle	deg	37.34	37.47	38.27
Flight Path Elevation Angle*	deg	37.46	37.55	38.35
Inertial Flight Path Azimuth Angle	deg	161.60	161.60	161.66
Flight Path Azimuth Angle*	deg	196.48	196.71	196.67
Range	ft	52,668	52,499	51,723
Altitude	ft	71,030	71,649	72,573

* Angle is with respect to the relative velocity vector.

Table 3 (Continued)

SUMMARY OF FIRST STAGE PERFORMANCE PARAMETERS
(COS-B MISSION)

Item	Unit	Guided Nominal Value	BET With Winds Value	Actual Value
SOLID-MOTOR SEPARATION (8)				
Time (Average)	sec	87.00	87.00	87.34
Inertial Velocity	ft/sec	2853.1	2833.1	2891.0
Velocity (Relative to Launch Point)	ft/sec	2878.3	2864.8	2926.4
Inertial Flight Path Elevation Angle	deg	33.11	33.19	33.85
Flight Path Elevation Angle*	deg	32.61	32.60	33.22
Inertial Flight Path Azimuth Angle	deg	166.10	166.33	166.75
Flight Path Azimuth Angle*	deg	196.50	196.93	196.93
Range	n.mi.	12.06	12.00	12.12
Altitude	n.mi.	14.08	14.17	14.56
GUIDANCE INITIATION				
Time	sec	125.0	125.0	125.0
Inertial Velocity	ft/sec	4486.2	4465.7	4528.9
Velocity (Relative to Launch Point)	ft/sec	4609.7	4594.5	4674.9
Inertial Flight Path Elevation Angle	deg	20.52	20.43	21.24
Flight Path Elevation Angle*	deg	19.77	19.66	20.38
Inertial Flight Path Azimuth Angle	deg	177.35	177.58	178.53
Flight Path Azimuth Angle*	deg	194.38	194.65	195.40
Range	n.mi.	23.66	23.68	24.43
Altitude	n.mi.	23.66	23.68	24.43

Table 3 (Concluded)

SUMMARY OF FIRST STAGE PERFORMANCE PARAMETERS
(COS-B MISSION)

Item	Unit	Guided Nominal Value	BET-With-Winds Value	Actual Value
MAIN ENGINE CUTOFF SIGNAL				
Time	sec	229.942	230.653	226.835
Inertial Velocity	ft/sec	16443.9	16505.0	16446.0
Velocity (Relative to Launch Point)	ft/sec	16486.4	16547.5	16482.6
Inertial Flight Path Elevation Angle	deg	11.31	11.30	11.18
Flight Path Elevation Angle *	deg	11.11	11.10	10.99
Inertial Flight Path Azimuth Angle	deg	179.53	179.54	179.28
Flight Path Azimuth Angle*	deg	184.22	184.21	183.96
Longitude	deg	121.19	121.19	121.18
Geodetic Latitude	deg	31.71	31.69	31.78
Range	n.mi.	184.64	185.67	180.40
Altitude	n.mi.	58.58	58.78	57.81
IIP Time	sec	659.52	663.15	652.30
IIP Range	n.mi.	1297.21	1309.7	1283.0
Weight	lb	26924.4	26833.4	26833.4
Liquid Propellant Utilization	%	99.81	99.81	99.84

* Angle is with respect to the relative velocity vector.

Table 4

SUMMARY OF SECOND STAGE PERFORMANCE PARAMETERS
(COS-B MISSION)

Item	Unit	Guided Nominal Value	BET With Winds Value	Actual Value
SECOND STAGE START				
Time (Steady State)	sec	243.662	244.373	240.811
Inertial Velocity	ft/sec	16426.6	16487.9	16416.5
Velocity (Relative to Launch Point)	ft/sec	16470.0	16531.4	16460.1
Inertial Flight-Path Elevation Angle	deg	10.47	10.47	10.60
Flight-Path Elevation Angle*	deg	10.27	10.27	10.40
Inertial Flight-Path Azimuth Angle	deg	179.54	179.55	179.55
Flight-Path Azimuth Angle*	deg	184.26	184.25	184.26
Range	n.mi.	220.5	221.66	216.9
Altitude	n.mi.	65.5	65.72	64.9
Weight	lb	15744.6	15706.0	15708.7
NOSE FAIRING JETTISON				
Time	sec	273.32	274.033	270.35
Weight of Fairing	lb	1320.0	1305.0	1305.0

* Angle is with respect to the relative velocity vector.

Table 4 (Continued)

SUMMARY OF SECOND STAGE PERFORMANCE PARAMETERS

Item	Unit	Guided Nominal Value	BET With Winds Value	Actual Value
SECOND STAGE FIRST BURNOUT (SECO) 1				
Time	sec	530.832	534.662	530.873
Inertial Velocity	ft/sec	25636.8	25639.3	25636.2
Velocity (Relative to Launch Point)	ft/sec	25678.2	25680.8	25677.7
Inertial Flight Path Elevation Angle	deg	-0.98	-0.97	-0.97
Flight Path Elevation Angle*	deg	-1.07	-1.07	-1.07
Inertial Flight Path Azimuth Angle	deg	179.86	179.86	179.86
Flight Path Azimuth Angle*	deg	183.26	183.26	183.26
Range	n.mi.	1140.6	1154.5	1152.64
Altitude	n.mi.	121.4	121.2	121.54
Weight	lb	5170.0	5194.4	5143.62
Longitude	deg	122.36	122.37	122.36
Geodetic Latitude	deg	15.75	15.52	15.55
Radius of Apogee	n.mi.	3678.4	3679.0	3677.5
Radius of Perigee	n.mi.	3531.4	3531.6	3531.2
Inclination	deg	89.869	89.869	89.869
Eccentricity	---	0.02039	0.02044	0.02029

* Angle is with respect to the relative velocity vector.

Table 4 (Concluded)

SUMMARY OF SECOND STAGE PERFORMANCE PARAMETERS
(COS-B MISSION)

Item	Unit	Guided Nominal Value	BET-With-Winds Value	Actual Value
PROPULSIVE PERFORMANCE PARAMETERS (FIRST BURN)				
Burn Period (Steady State to SECOM 1)		286.459	289.546	289.42
Thrust (Average)	lb	9,707.09	9,548.36	9,596.9
Specific Impulse (Average)	sec	301.77	300.63	300.66
Total Second Stage Impulse	lb-sec	2,780,681.9	2,764,689.6	2,777,539.2
Total Propellant Consumed (Steady State to $SECOM_1$)	lb	9,236.4	9,196.45	9,238.0
Propellant Consumption (Steady State to $SECOM_1$)	%	92.01	91.81	92.37

Table 5

SUMMARY OF THIRD STAGE PERFORMANCE PARAMETERS

(COS-B MISSION)

Item	Unit	Pre-dicted Value	BET-With-Winds Value	Recon-structed Value
THIRD STAGE IGNITION				
Time	sec*	3,068.82	3,070.94	3,068.82***
Inertial Velocity	fps	25,159.8	25,152.8	25,159.8
Velocity (Relative to Launch Point)	fps	25,199.8	25,192.7	25,199.8
Inertial Flight Path Elevation Angle*	deg	1.09	1.10	1.09
Flight Path Elevation Angle*	deg	0.97	0.97	0.96
Inertial Flight Path Azimuth Angle	deg	0.14	0.14	0.14
Flight Path Azimuth Angle*	deg	356.77	356.77	356.77
Longitude	deg	-47.01	-47.01	-47.00
Geodetic Latitude	deg	-23.19	-23.19	-22.91
Euler Attitude Angles*				
Pitch (θ_{PB})	deg	169.56	169.56	170.37
Yaw (ψ_{PB})	deg	15.57	15.57	15.01
Roll (ϕ_{PB})	deg	-79.09	-78.79	-79.00
Range	n.mi.	9,849.9	9,862.7	9,849.9
Altitude	n.mi.	189.2	190.7	189.2
Weight	lb	2,262	2,262	2,262

*Angle is with respect to the relative velocity vector.

**Euler angles θ_{PB}, ψ_{PB}, and ϕ_{PB} are the angles specifying the orientation of the vehicle axes (X_{PB}, Y_{PB}, and Z_{PB}) with respect to an inertial reference platform. The order of rotation is: Pitch, θ_{PB} about Y_{PB} (positive turning Z_{PB} into X_{PB}); yaw, ψ_{PB} about Z_{PB} (positive turning X_{PB} into Y_{PB}); and roll, ϕ_{PB} about X_{PB} (positive turning Y_{PB} into Z_{PB}), in degrees.

***41.5 seconds after stage II/III separation.

Table 5 (Continued)

SUMMARY OF THIRD STAGE PERFORMANCE PARAMETERS

(COS-B MISSION)

Item	Unit	Predicted Value	BET-With-Winds Value	Reconstructed Value
THIRD STAGE BURNOUT				
Time	sec	3,113.62	3,115.739	3,113.62
Inertial Velocity	ft/sec	34,615.3	34,609.8	34,622.8
Velocity (Relative to Launch Point	ft/sec	34,648.7	34,643.1	34,660.5
Inertial Flight Path Elevation Angle	deg	2.56	2.49	2.76
Flight Path Elevation Angle*	deg	2.44	2.37	2.64
Inertial Flight Path Azimuth Angle	deg	360.00	360.00	359.84
Flight Path Azimuth Angle*	deg	357.48	357.49	357.32
Longitude	deg	-46.82	-46.83	-46.82
Geodetic Latitude	deg	-19.52	-19.79	-19.52
Euler Attitude Angles**				
Pitch (θ_{PB})	deg	169.56	169.56	170.37
Yaw (ψ_{PB})	deg	15.57	15.57	15.01
Roll (ϕ_{PB})	deg	-78.79	-78.79	-79.00

*Angle is with respect to the relative velocity vector.

**Euler angles Θ_{PB}, ψ_{PB}, and ϕ_{PB} are the angles specifying the orientation of the vehicle axes (X_{PB}, Y_{PB}, and Z_{PB}) with respect to an inertial reference platform. The order of rotation is pitch, Θ_{PB} about Y_{PB} (positive turning Z_{PB} into X_{PB}); yaw, ψ_{PB} about Z_{PB} (positive turning X_{PB} into Y_{PB}); and roll, ϕ_{PB} and X_{PB} (positive turning Y_{PB} into Z_{PB}), in degrees.

Table 5 (Concluded)

SUMMARY OF THIRD STAGE PERFORMANCE PARAMETERS

(COS-B MISSION)

Item	Unit	Predicted Value	BET-With-Winds Value	Reconstructed Value
Inertial Attitude Angles*				
Elevation Angle (Θ'_L)	deg	5.30	5.03	6.04
Azimuth Angle (ϕ'_L)	deg	359.62	359.63	359.02
Roll Angle (ϕ'_L)	deg	-82.11	-82.10	-82.16
Range	n.mi.	9,681.5	9,695.4	9,681.4
Altitude	n.mi.	194.79	196.2	195.2
Weight	lb	811.5	811.6	811.5
Total Third Stage Impulse	lb-sec	417,678.9	417,678.9	418338.8
Spacecraft Weight	lb	612.0	614.15	614.15
Radius of Apogee	n.mi.	57,670.8	57,732.8	58,204.6
Radius of Perigee	n.mi.	3,629.7	3,631.4	3,628.8
Inclination Angle	deg	90.000	90.000	90.155
Eccentricity	---	.8816	.8816	.8826
Argument of Perigee	deg	335.13	335.009	334.7

*The vehicle centerline elevation angle Θ'_L is the angle between the vehicle centerline and the plane perpendicular to the radius vector from the center of the earth to the vehicle (positive for the vehicle nose pointing away from the earth), in degrees. Vehicle centerline azimuth angle ψ'_L is the angle between the local meridian and the projection of the vehicle centerline onto a plane perpendicular to the radius vector from the center of the earth to the vehicle (positive clockwise from true north), in degrees. The vehicle instantaneous geocentric roll angle ϕ'_L is in degrees.

Table 6

SUMMARY OF POSTFLIGHT STATISTICS

NOMINAL PREDICTIONS

(COS-B MISSION)

BOOSTER: DSV-3P-1A Extended Long Tank

SECOND STAGE: DSV-3P-4B (Quartz)

Parameter	COS-B Deviation from Guided Nominal	No. of Samples	Mean Deviation	Sigma About Mean
SOLID MOTORS (6)				
Drop Time	+0.34	12	-0.235	0.686
GUIDANCE INITIATION				
Altitude (n.mi.)	+0.77	10	0.623	0.527
Inertial Velocity (ft/sec)	+92.7	10	60.7	97.7
Inertial Flight-Path Elevation Angle (deg)	+0.72	10	0.948	0.360
Inertial Flight-Path Azimuth Angle (deg)	+1.18	10	-0.018	0.621
MECO				
Time (sec)	-3.107	10	-1.555	2.825
Altitude (n.mi.)	-0.77	10	0.037	0.523
Inertial Velocity (ft/sec)*	154	10	179.2	110.7
Inertial Flight-Path Elevation Angle (deg)	-0.12	10	0.040	0.130
Inertial Flight-Path Azimuth Angle (deg)	-0.15	10	0.016	0.079

* Based on DIGS telemetry data and predicted nominal MECO velocity.

TABLE 6 (Concluded)

SUMMARY OF POSTFLIGHT STATISTICS

NOMINAL PREDICTIONS

COS-B MISSION

BOOSTER: DSV-3P-1A Extended Extended Long Tank

SECOND STAGE: DSV-3P-4B (Quartz)

Parameter	COS-B Deviation from Guided Nominal	No. of Samples	Mean Deviation	Sigma About Mean
SECOND STAGE				
First Burn Time (sec)	2.892	10	0.488	2.902
Propellant Consumption Through End of Primary Mission (%PU/σPU)	0.66	10	-0.771	1.320
SECO 1				
Altitude (n.mi.)	+0.10	11	0.014	0.242
Inertial Velocity (ft/sec)	0.6	11	-0.493	3.644
Inertial Flight-Path Elevation Angle (deg)	0.01	11	0.0004	-0.010
Inertial Flight-Path Azimuth Angle (deg)	0.00	11	0.063	0.090

Table 7

SUMMARY OF POSTFLIGHT STATISTICS

TAG PREDICTIONS

COS-B MISSION

BOOSTER: DSV-3P-1A Extended Long Tank

SECOND STAGE: DSV-3P-4B (Quartz)

Parameter	COS-B Deviation from Tag	No. of Samples	Mean Deviation	Sigma About Mean
BOOSTER				
Burn Time (sec)	-3.497	10	-1.736	1.820
MECO Inertial Velocity (ft/sec)*	+92	10	176.9	121.2
MECO Altitude (n.mi.)	-0.98	10	0.021	0.533
SECOND STAGE				
First Burn Time (sec)	-0.227	10	-4.988	2.867
Propellant Consumption Through End of Primary Mission (%PU/σPU)	0.035	10	0.035	1.066
Tailoff Impulse (lb-sec)	147	10	44.778	102.404

* Based on DIGS telemetry data and predicted nominal MECO velocity.

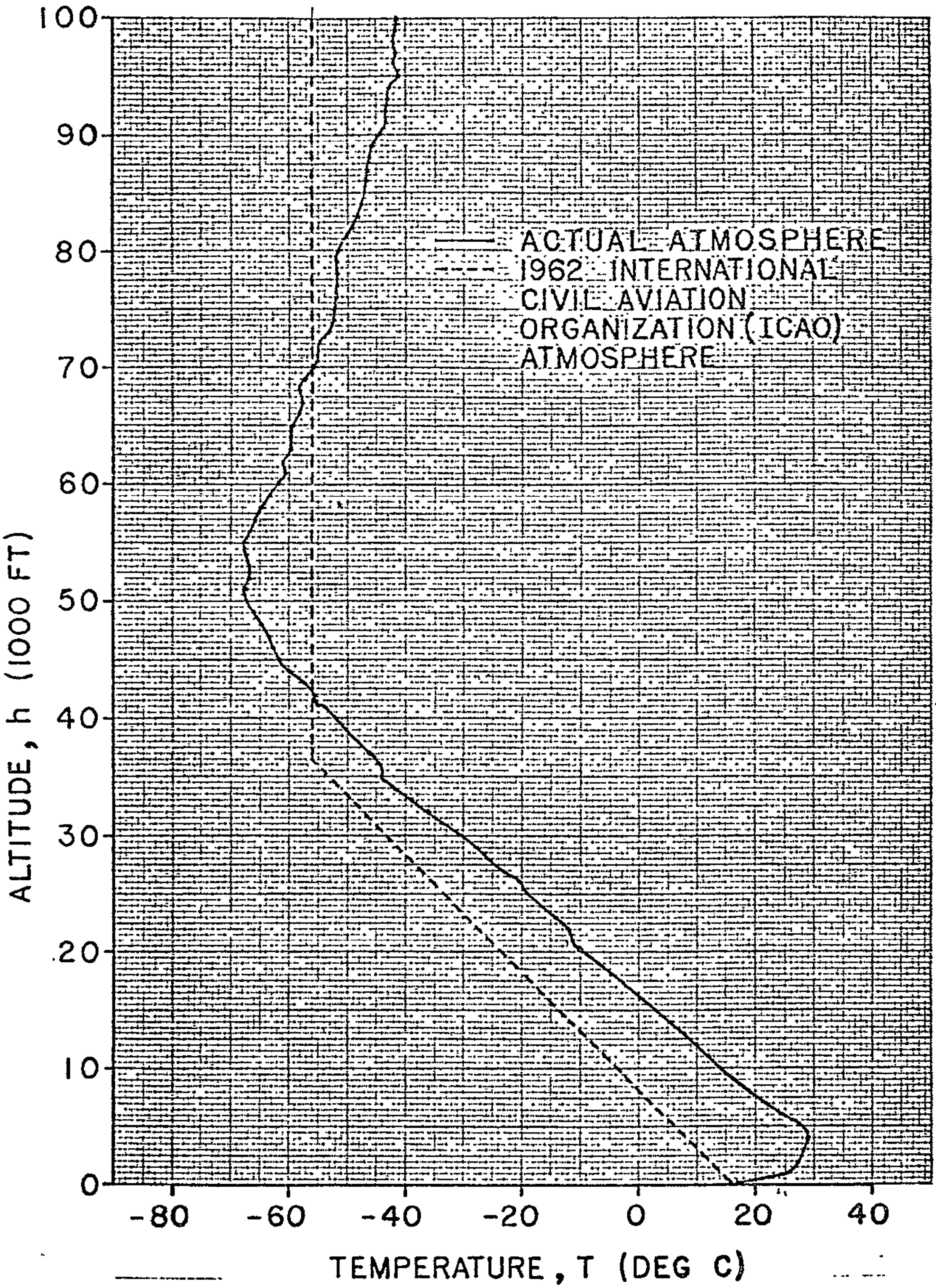
EXTENDED LONG TANK DELTA COS-B MISSION

UPPER AIR TEMPERATURE DATA

WESTERN TEST RANGE, VANDENBERG AFB

8 AUGUST 1975 0147 GMT (1847 PDT)

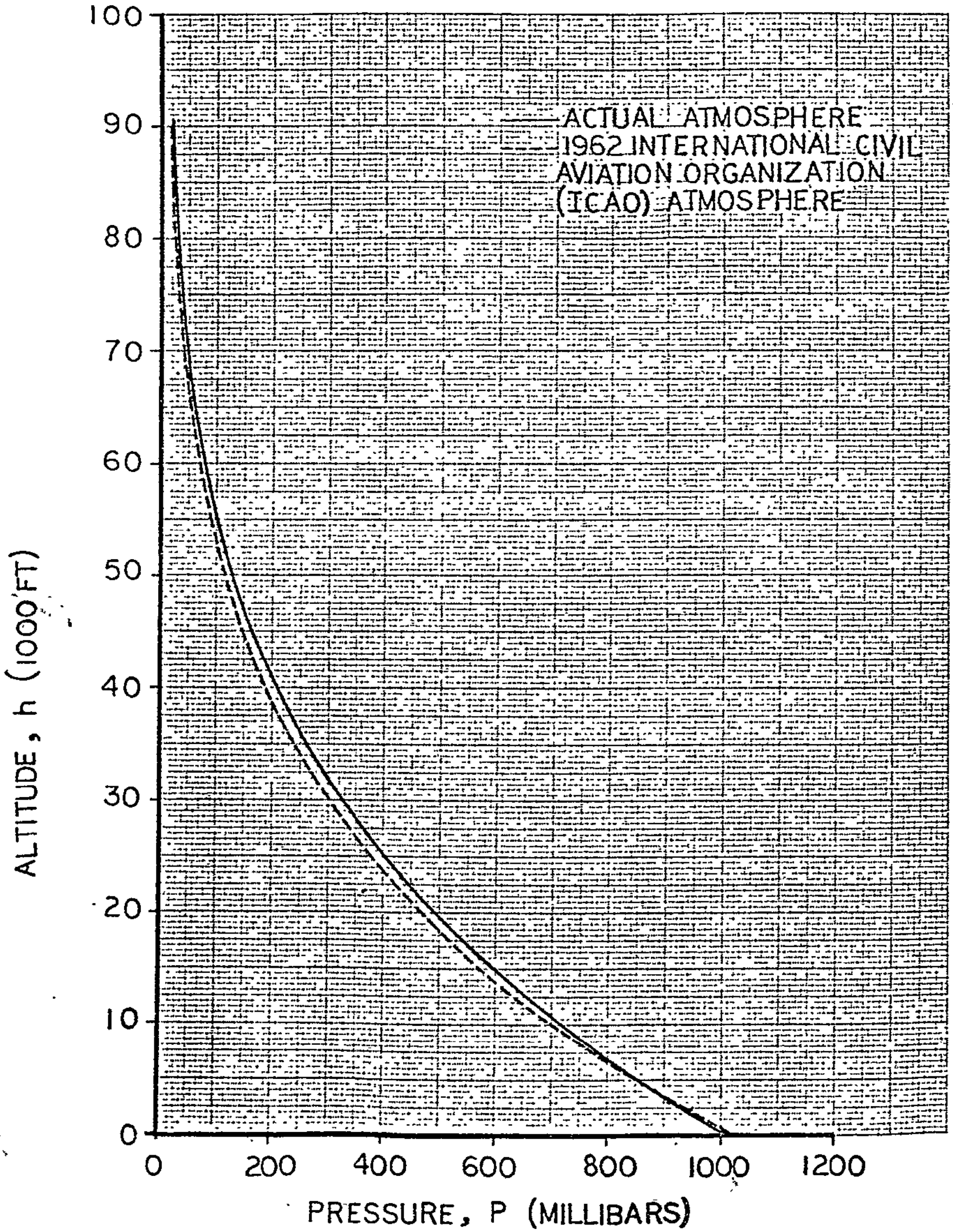
FIGURE 1



C.L. SMITH/MS
30 OCT 1975

EXTENDED LONG TANK DELTA COS-B MISSION
PRESSURE DATA
WESTERN TEST RANGE, VANDENBERG AFB
8 AUGUST 1975 0147 GMT (1847 PDT)

FIGURE 2



C.C. SMITH/MS
30 OCT 1975

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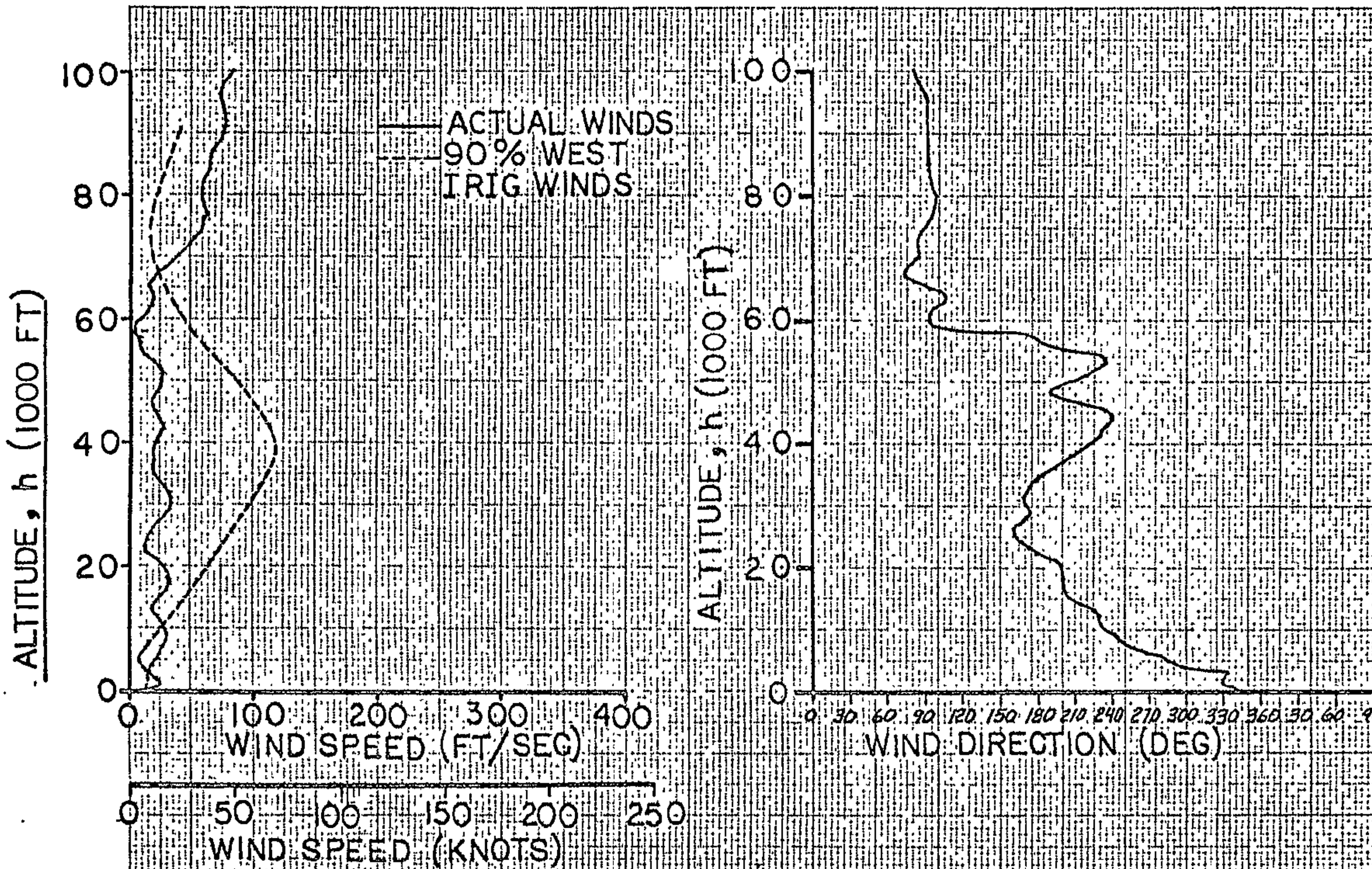
30 OCT 1975



METEOROLOGICAL CONDITIONS
UPPER WIND DATA
WESTERN TEST RANGE, VANDENBERG AFB
8 AUGUST 1975, 0147 GMT, (1847 PDT)

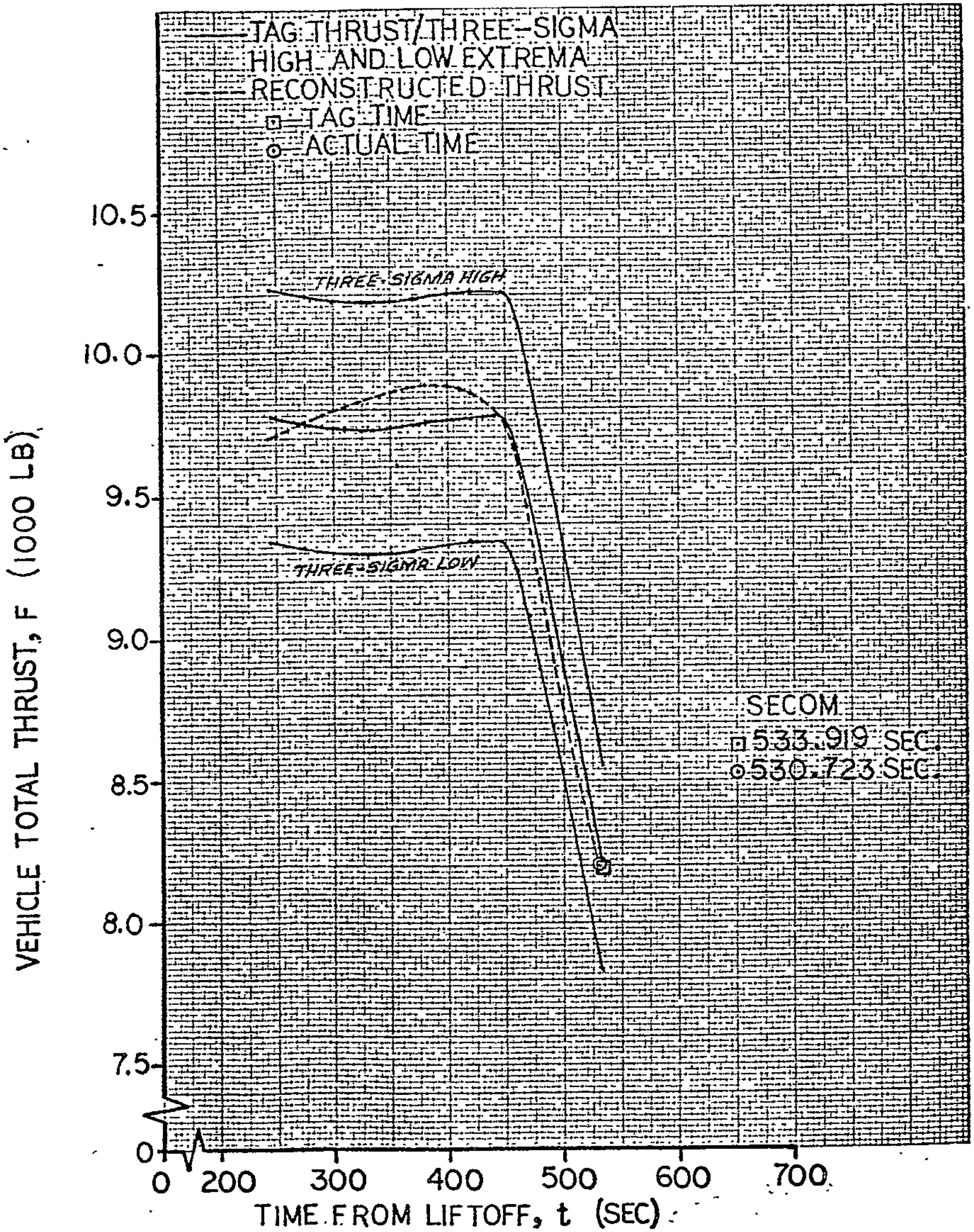
FIGURE 3

EXTENDED LONG TANK DELTA COS-B MISSION — FIGURE 4

VEHICLE TOTAL THRUST

SECOND STAGE

S/N 20020



C.C. Si H/Lou 31 OCT 1975

ATTACHMENT 2:

SECTION 2. PROPULSION SYSTEMS - COS-B MISSION

SECTION 2

PROPULSION SYSTEMS - COS-B MISSION

2.1 INTRODUCTION

Overall performance of the COS-B launch vehicle propulsion systems was satisfactory throughout first, second, and third stage flight. All data returned by telemetry channels used to monitor propulsion systems performance were satisfactory with two exceptions. The LOX pump inlet pressure transducer failed at approximately 74 seconds from liftoff, and the second stage chamber pressure exhibited the same anomalous characteristics observed on previous SSPU flights.

A summary of vehicle model and serial numbers is provided in Table 2-1. There were seven first flight items on this flight. These first flight items are listed in Table 2-2. All flight times in the text are given in seconds after DIGS indicated liftoff unless otherwise noted. The "DIGS Liftoff" time for this flight was defined as the time at which the vehicle achieved approximately 37.5 ft/sec^2 acceleration (about 5.3 ft/sec^2 off the pad) for four consecutive 20-millisecond time intervals. The propulsion system sequence of events is summarized in Table 2-3.

Reconstructed booster and second stage performance parameters are compared in Table 2-4 with corresponding values from the latest booster nominal simulation (Reference 2-1) and the Detailed Test Objectives Report (DTO, Reference 2-2). Values from both reports are referred to as nominal values since results of the nominal simulation are used to generate the DTO.

First and second stage reconstructed values are compared also with values from the Best Estimate Trajectory without winds (BET, Reference 2-3) and the Propulsion preflight tag predictions (References 2-4 and 2-5) in Table 2-4. Cumulative statistics for all comparisons in Table 2-4 are presented in Table 2-5.

In this section, the word "predicted" refers to preflight predictions of performance for the Propulsion systems utilized on this vehicle (References 2-4 and 2-5) and does not denote nominal or DTO values. The word "reconstructed" refers to postflight reconstructions of performance generated using telemetered system pressures, temperatures, event times, acceleration, and (for the second stage) flowrates. The term "internal" refers to reconstructions based on pressures, temperatures, and events. The term "external" refers to reconstructions using acceleration and the internally reconstructed vehicle mass history.

2.2 FIRST STAGE PERFORMANCE

Performance of the first stage propulsion systems is described in the following paragraphs.

2.2.1 Main Engine

All valid telemetry data indicated that the main engine flight performance was satisfactory, as summarized in Table 2-4.

Figure 2-1 shows the nominal and actual start sequence times. The agreement observed between the nominal and actual sequence times indicates a normal start sequence based on available engine statistics. The main engine start sequence was initiated 2.338 seconds prior to liftoff (DIGS).

Main engine cutoff (MECO) occurred 226.835 seconds after liftoff due to actuation of the fuel injector pressure switches (FIPS). The propellant residual at MECO was 281 pounds of fuel or 19 pounds less than the loaded bias of 300 pounds. The residual corresponds to a propellant consumption and a propellant utilization (PU) of 99.84 percent and mixture ratio variations of -0.0007 mixture ratio units (mru) from the preflight prediction and -0.0187 mru from the ground test tag prediction.

Figures 2-2 and 2-3 present the internal reconstructed liquid engine thrust and flowrate histories, respectively. The overall performance was good and generally verified the performance model.

The DIGS thrust acceleration measurements, together with preflight predicted drag and postflight internal reconstructed vehicle mass, were used to compute total external booster thrust and specific impulse. Figure 2-4 depicts the internal and external reconstructed thrust histories which agree very closely from liftoff to MECO.

Table 2-6 presents a comparison of averages for total vehicle altitude thrust and specific impulse between 120 seconds and MECO and the average mixture ratio over the entire flight. The internal reconstruction indicates first stage Isp was about 0.52 seconds higher than predicted; the external reconstruction shows a decrease of about 1.45 seconds from the predicted value. The preflight predicted and internal and external reconstructed values are compared with the ground test tag prediction in Table 2-6. Cumulative statistics for these parameters are also tabulated in Table 2-6.

2.2.2 POGO Suppression System (PSS)

The PSS was pressurized from a 464 psia regulated AGE source until liftoff. No inflight pressurization was provided, thus the inflight LOX volume was a function of the ullage gas mass and temperature and of the LOX pump inlet pressure. The two temperature probes in the PSS showed that the PSS performed satisfactorily and the LOX and ullage gas volume constraints were satisfied throughout the flight. The upper probe may have been covered momentarily by splashing at liftoff.

2.2.3 Vernier Engines

Vernier engine performance appeared satisfactory based on telemetered chamber pressure data from vernier engine No. 2. Reconstruction indicates that the engine was operating at a thrust level of 977 pounds during vernier engine solo, which is less than the nominal thrust of 1002 pounds.

2.2.4 Solid Motors

Based on telemetered data and reconstructed performance values, the performance of the solid motors was satisfactory. Table 2-4 summarizes solid motor performance and Table 2-5 presents cumulative statistics for Castor II motors.

The reconstructed solid motor performance is based on event times and the chamber pressure histories. Total burn times for both the ground-ignited and altitude-ignited motor sets were generally slightly less than predicted. Web times were slightly greater than predicted. All burn and web times were well within the allowable dispersion band of the Castor II motors.

All of the solid motor start and thrust buildup transients were normal. Total thrust and flowrate histories for the solid motors plus the main engine are shown in Figures 2-4 and 2-5, respectively.

2.3 SECOND STAGE PERFORMANCE

The second stage engine operated normally for the first burn of 289.75 seconds, which was 0.75 seconds shorter than the BET prediction. The experimental restart had a duration of 25.06 seconds for a total burn time about 6.1 seconds less than the predicted depletion burn time of 320.6 seconds. A fuel depletion was observed. A summary of second stage first burn engine performance is presented in Table 2-4 while specific impulse, thrust, and flowrate histories are depicted in Figures 2-6, 2-7, and 2-8, respectively. Table 2-5 presents statistical data for values in Table 2-4.

2.3.1 First Burn

During first burn operation, the second stage temperatures and pressures were nominal. The propellant tanks pre-pressurization signal occurred at 229.83 seconds, 3.00 seconds after MECO (FIPS) command. During the pre-pressurization, the helium bottle, helium regulator, and propellant tank pressures were as expected.

2.3.1.1 First Burn Transient Performance

The total start transient impulse calculated using chamber pressure data was 346 pound-seconds compared to the previous average flight value of 383 pound-seconds. The total propellant consumed during the start transient was 2.31 pounds compared to the average value experienced of 2.43 pounds. The shutdown propellant flow to propellant valves closure was 6.36 pounds compared to the average value experienced of 6.23 pounds.

DIGS accelerometer data indicate a shutdown impulse of 3187 pound-seconds, compared to the 3040 pound-seconds prediction derived from analysis of data from previous flights. The shutdown transient performance is summarized in Table 2-4.

2.3.1.2 Steady-State Performance

Second Stage Ignition Command No. 1 (SSIC No. 1) occurred 240.81 seconds after liftoff and Engine Start No. 1 occurred 0.37 second later at 241.18 seconds. SECOM No. 1 occurred 530.56 seconds after liftoff as the result of a planned DIGS-initiated cutoff command. Therefore, the propulsion system first burn steady-state powered flight duration (from Engine Start No. 1 to SECOM No. 1) was 289.42 seconds. This time was 1.08 seconds shorter than the BET predicted duration. The reconstructed average thrust was higher than predicted, as was the average flowrate yielding an average specific impulse that was 1.75 seconds lower than the BET prediction.

Although it did not adversely affect the primary mission, the COS-B vehicle experienced an anomalous vibration which occurred from 165 to 212 seconds into second stage burn. This anomaly is discussed in detail in Anomaly Report No. T00166. The vibration had an acceleration level of approximately 2 g's zero to peak in the thrust axis at a frequency of approximately 130 Hz, as measured at the guidance section.

The fuel manifold used on COS-B was of a new buy, built especially for the Delta Program (previous fuel manifolds were designed for the Lunar Module Descent Engine or LMDE). The Delta fuel manifold incorporated minor production changes, including a weld bead at the inlet. Corrective measures being considered at this time include the removal of the weld bead and stiffening of the thrust mount.

Analysis is continuing as additional test data become available. During the interim, silica chambers are being flown on stages utilizing the Delta manifold to improve stability margins.

Another anomaly with respect to mixture ratio and specific impulse was identified and is discussed in detail in Anomaly Report No. T00168. Reconstruction of inflight performance indicated an approximate 0.010 mru shift in mixture ratio (M.R.) starting during the period of 130 Hz oscillations. The initial reconstruction also indicated an apparent 1% lower than expected specific impulse (Isp) throughout first burn engine operation.

The specific cause of the mixture ratio shift has not been determined, but is considered an effect of the 130 Hz oscillations due to the simultaneous onset times. Possible causes of the M.R. shift are: 1) cracks in the oxidizer pintle slots as a result of the oscillations, or 2) the effect of oscillations on flowmeter calibration (although the apparent increase in oxidizer flow rate is not consistent with postulated flowmeter failure modes).

The apparent low specific impulse has been attributed to flowmeter calibration error. A detailed evaluation of propellant depletion characteristics indicated a bias in the oxidizer flowmeter over the entire engine burn time. With the bias taken out of the flowmeter data, the calculated specific impulse is normal. Normal performance was also verified by stage velocity data; therefore, it is concluded that the engine specific impulse was normal. Information presented in this report reflects the corrected data.

Predicted and reconstructed values for propellant consumption were comparable. Approximately 808 pounds of usable propellant remained on board after SECOM No. 1 in reserve for the second and third burns. This represents a first burn propellant consumption (PC) of 92.37 percent. According to the integration of flowmeter data, the average first burn mixture ratio was 1.584 mru, less than the 1.598 predicted but within two sigma of the predicted value.

Reconstruction of thrust from acceleration data yields an average specific impulse of 300.66 seconds compared to a BET predicted specific impulse of 302.41 seconds. As depicted in Figure 2-6, from approximately ignition plus 200 seconds the reconstructed specific impulse decreases at a faster rate, moving farther away from the predicted level. The start of this decay in specific impulse (Isp) is coincident with the beginning of the tailoff portion of flight.

Based on chamber pressure data, the reconstructed throat erosion was -1.2 percent compared to a predicted value of 2.2 percent.

2.3.2 Coast

The second stage coasted for approximately 2688 seconds between the first and second burn. All monitored pressure and temperature values were acceptable during coast. The fuel tank pressure increased by about 15 psi and the oxidizer tank pressure rose about 27 psi during coast due to heating. Characteristics of the fuel tank pressure data indicate proper levels throughout the mission.

2.3.3 Second Burn (Experimental)

The second burn (as reconstructed) was initiated at 3218.3 seconds after liftoff. The burn was preceded by a settling period of approximately 15 seconds. No actual data were available for restart. Therefore, no conclusion can be made as to the adequacy of the settling period.

The restart steady-state burn duration was approximately 25.06 seconds which was 5.79 seconds shorter than the predicted value. Restart burn times usually are shorter than predicted because heating during coast increases the propellant tank pressures resulting in higher than predicted thrust and flowrate levels.

Approximately 55 pounds of propellant remained on board after SECOM No. 2. This corresponds to a propellant consumption value of 99.74 percent for the two burns.

2.3.6 Nitrogen Auxiliary Propulsion System (APS)

Predicted and actual impulse usages from the nitrogen APS for various events are tabulated below:

Event	Usage	Predicted	Actual-Predicted
First burn	18	16	2.3
First coast	297	430	-133
Separation and retro	54	44	10
Plume impingement	14	40	-26
Settling	125	115	10
Experimental burn	1	1	0
Total	509	646	-137

Overall APS performance was normal.

2.3.7 Second Stage Retro Initiation

Second stage retro initiation occurred at 3027.29 seconds after liftoff. During retro, bottle pressure decayed normally from 190 psia to approximately zero psia. Based on the DIGS system integrated velocity value, the separation distance at third stage ignition was approximately 42.3 feet, compared to the minimum required of 25 feet.

2.4 THIRD STAGE PERFORMANCE

2.4.1 Spin Motors

The spin table microswitch data indicate that the eight spin motors were fired at 3025.30 seconds after vehicle liftoff and produced a spin rate of approximately 39.3 rpm (versus predicted 39.8 rpm) at third stage/spin table separation. It is concluded that all eight spin motors performed satisfactorily.

2.4.2 Third Stage Motor

Performance of the third stage motor (TE-M-364-3, S/N 00025) was satisfactory based on the accuracy of the spacecraft orbit. The chamber pressure data exhibited a -10 psi shift at 23 seconds after ignition, and a complimentary

+10 psi shift at motor tailoff. The shape of the pressure-time curve appeared to be normal both prior to and after the pressure shifts. Accelerometer data did not exhibit corresponding shifts in the acceleration level, and it is therefore believed that the chamber pressure data shifts are not indicative of actual motor performance. Immediately after third stage motor tailoff, low level oscillations were noted on the spacecraft attach fitting accelerometers. The oscillations had a maximum amplitude of 2.3 G's 0-peak at a frequency of 800-1000 Hz, and lasted for 18 seconds. During this period of time, the motor chamber pressure did not register any activity. The cause of the oscillations is unknown at this time, but is under investigation. Predicted third stage solid motor performance parameters, obtained from Reference 2-6, are listed in Table 2-7.

REFERENCES

2-1 Memorandum A3-250-AD03-74090, dated 21 March 1974

2-2 Memorandum A3-200-AAC3-M-75-357, dated June 23, 1975

2-3 Memorandum A3-200-AAC3-M-75-454, dated 6 August 1975

2-4 Memorandum A3-226-AD03-75191, dated 10 July 1975

2-5 Memorandum A3-226-AD03-75190, dated 2 July 1975

2-6 Memorandum A3-226-AD03-75178, dated 23 June 1975

TABLE 2-1

VEHICLE AND VEHICLE COMPONENT IDENTIFICATION SUMMARY (COS-B)

Item	Manufacturer	Model	Serial No.
Launch Vehicle	MDAC	DSV-3P-11B	20018
First Stage	MDAC	DSV-3P-1A	20020 (602)
Main Engine	Rocketdyne/A Division of Rockwell International Corporation (RD)	RS2701A	0017
Vernier Engines (two)	RD	LR-101-NA-11	No. 1: 338180 No. 2: 338181
Solid Motors (Set No. 1 - three)	Thiokol Corporation (TC)	TX354-5 (Castor II)	No. 1: 473 No. 2: 474 No. 3: 475
Solid Motors (Set No. 2 - three)	TC	TX354-5 (Castor II)	No. 4: 480 No. 5: 535 No. 6: 489
Solid Motors (Set No. 3 - three)	TC	TX354-5 (Castor II)	No. 7: 494 No. 8: 498 No. 9: 548
Second Stage Propulsion System	MDAC	DSV-3P-4B	20020
Engine	TRW	TR-201	1016
Third Stage	TC	TE-M-364-3	00025
Spin Motors	Atlantic Research Corporation (ARC)	1D00399-529	- - -

TABLE 2-2

FIRST FLIGHT ITEMS (COS-B)

1. Castor II motors with bimodal oxidizer propellant: Castor II Motors, S/N's 473, 474, 475, 480, and 489, were loaded with bimodal oxidizer propellant aft of the aft propellant slot. This is a departure from the standard trimodal oxidizer propellant.

2. Castor II direct-mount pressure transducer: Previously, the solid motor chamber pressure transducer was mounted in the motor forward dome with a short hardline connection to the motor pressure port. The change to the direct-mount configuration was accomplished to reduce potential hardline leak paths and facilitate launch site installation.

3. Castor II solid motor aluminum wiring tunnel: The previous fiberglass tunnel cover has been replaced with a similar design fabricated of aluminum including cork sheet interior insulation. The change to the aluminum tunnel was implemented to reduce cost.

4. Over-age TE-M-364-3 third stage motor: This was the oldest third stage motor to be flown (44 months old at launch). The oldest motor previously flown was S/N 00026 on SKYNET-IIB (35 months old).

5. Second stage fuel and oxidizer tank shutoff valves: The Fuel Tank Shutoff Valve (FTSV), P/N 1B96916-1, and Oxidizer Tank Shutoff Valve (OTSV), P/N 1B96916-501, replace the FTSV, P/N 1B95417-507, and OTSV, P/N 1B95417-509, effective DSV-3P-4B, S/N 20020, and subsequent.

   The Pneudraulics, Inc., P/N 9386, restrictor check valve (PRCV) was replaced by the 1B97422-1 PRCV in order to obtain proper OTSV-FTSV differential opening time with the new TSV's. Physically, the two valves are identical except for the size of the restrictor flow orifice. The incorporation of the new TSV's also required minor modification of the interconnecting tubes between the PRCV and the TSV's, and a change in the pressurization sequence.

6. Second stage fuel pressurization fitting modification: The 1B94500-1 fuel tank pressurization fitting located on the forward dome of the SSPU fuel tank was modified by having its sense port increased from 0.098 inch diameter to 0.300 inch diameter. In addition, a 0.012 to 0.013 inch diameter hole was added between the fitting inlet pressure port and the fuel tank top pressure sense port.

7. POGO accumulator vendor change: The 1B89068-507 POGO accumulator (manufactured by Solar) was replaced by 1B96342 (manufactured by Coast Metal Craft). The vendor change was necessary because Solar no longer builds this part. The new accumulator is similar to the old part except for relocated transducer bosses and a slight decrease in internal volume as a result of different manufacturing techniques.

TABLE 2-3

PROPULSION SEQUENCE OF EVENTS (COS-B)

Events	Time from Liftoff (Seconds)
First Stage	
Main Engine Start Command	-2.518
Solid Motor Sets Nos. 2 and 3 Ignition Command	-0.38
Solid Motor Sets Nos. 2 and 3 Burnout	38.53
Solid Motor Set No. 1 Ignition Command	38.97
Solid Motor Set No. 1 Burnout	77.62
Solid Motors Separation	87.34
Fuel Floatswitch Actuation	217.555
LOX Floatswitch Actuation	220.285
Main Engine Cutoff Command (MECO) Enable	222.32
MECO (FIPS)	226.835
Sensed MECO	227.281
Vernier Engines Cutoff Command (VECO)	233.805
1st/2nd Stage Separation (Actual)	235.83
Second Stage	
First Burn	
Pressurize Tanks	229.83
Second Stage Ignition Command (SSIC) No. 1	240.811
First Chamber Pressure Rise	241.075
Engine Start No. 1 (Full Thrust)	241.15
Fairing Separation (Command)	270.35
Second Stage Engine Cutoff Command (SECOM) No. 1 (Velocity or Depletion, etc.)	530.563
Engine Stop (Valve Closure)	530.963
Second Burn	
Settling Jets On	3203.32
SSIC No. 2	LOS
First Chamber Pressure Rise	LOS
Engine Start No. 2 (Full Thrust)	LOS
Settling Jets Off	LOS
SECOM No. 2 (Fuel Depletion)	3247.514
Engine Stop (Valve Closure)	3247.914
Spacecraft or Third Stage Separation	3027.32

TABLE 2-3

PROPULSION SEQUENCE OF EVENTS (COS-B) CONTINUED

Events	Time from Liftoff (Seconds)
Third Stage (From Third Stage Telemetry Data)	
Spin Motor Initiation; Third Stage Delay Squib Initiation	3025.30
Second Stage Retro Initiation	3027.29
Third Stage Separation	3027.32
Third Stage Ignition	3071.2 *
Third Stage Burnout	3115.7 *
Spacecraft Separation	N/A

*Estimated from third stage chamber pressure data.

TABLE 2-4

SUMMARY OF PERFORMANCE PARAMETERS (COS-B)

Parameter	Unit	Nominal Value	Tag Value	Internal Reconstructed Value	Deviation From Nominal Value	Deviation From Tag Value
First Stage						
Liquid Engine System						
Average vacuum thrust	lbf	223,278	223,019	226,522	3,244	3,503
Average vacuum effective specific impulse	sec	291.55	292.61	292.37	0.82	-0.24
Propellant utilization	%	99.81	99.81	99.84	0.03	0.03
Solid Motors (4, 5, 6)						
Average vacuum thrust	lbf	166,119	166,119	168,311	2,192	2,192
Average vacuum effective specific impulse (Isp)	sec	258.80	258.80	260.81	2.01	2.01
Vacuum axial total impulse	lbf-sec	6,414,503	6,414,503	6,473,312	58,809	58,809
Solid Motors (7, 8, 9)						
Average vacuum thrust	lbf	166,119	166,119	167,117	998	998
Average vacuum effective Isp	sec	258.80	258.80	260.3	1.5	1.50
Vacuum axial total impulse	lb-sec	6,414,503	6,414,503	6,447,931	33,428	33,428
Solid Motors (1, 2, 3)						
Average vacuum thrust	lbf	166,296	166,296	168,072	1,776	1,776
Average vacuum effective Isp	sec	259.75	259.75	261.01	1.26	1.26
Vacuum axial total impulse	lbf-sec	6,454,599	6,454,599	6,494,323	39,724	39,724

TABLE 2-4.

SUMMARY OF PERFORMANCE PARAMETERS (COS-B)

(CONTINUED)

Parameter	Unit	Nominal Value	Tag Value	Internal Reconstructed Value	Deviation From Nominal Value	Deviation From Tag Value
<u>Second Stage</u>**						
Average thrust	lbf	9,650	9,432	9,597*	-53	165
Average specific impulse	sec	302.47	302.41	300.66*	-1.81	-1.75
Average mixture ratio	mru	1.595	1.598	1.584	-0.011	-0.014
Propellant consumption (SECO$_1$)	%	93.02	91.73	92.37	-0.65	0.64
Propellant utilization****	%	99.71	99.71	99.75	0.04	0.04
Total steady-state impulse	lbf-sec	2,822,434	2,777,874	2,777,885	-44,549	11
Total shutdown impulse (SECO$_1$)****	lbf-sec	3,040	3,040	3,187***	147.0	147.0

*Externally Reconstructed
**Nominal and Tag values are based on DTO and BET burn times, respectively
***Based on DIGS velocity data
****Latest Propulsion Nominal and Tag Values

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TABLE 2-5

INTERNAL RECONSTRUCTED PERFORMANCE PARAMETER CUMULATIVE STATISTICS

(COS-B)

Parameter	Unit	Number of Samples	Mean Deviation From Nominal*	Mean Deviation From Tag	Standard Deviation Nominal	Standard Deviation Tag
First Stage						
Liquid Engine System						
Average vacuum thrust	lbf	11	1,821	1,506	2,238	1,749
Average vacuum effective specific impulse	sec	11	0.176	-0.004	0.526	0.309
Propellant utilization	%	11	-0.020	0.010	-	-
Solid Motors (Sea-Level Ignition)						
Average vacuum thrust	lbf	29	1,117	1,189	2,446	2,450
Average vacuum specific impulse	sec	29	0.460	0.460	1.351	1.361
Total vacuum axial impulse	lbf-sec	29	11,712	11,766	33,343	33,601
Solid Motors (Altitude Ignition)						
Average vacuum thrust	lbf	11	-1,139	-1,134	2,741	2,749
Average vacuum specific impulse	sec	11	-1.610	-1.600	1.231	1.228
Total vacuum axial impulse	lbf-sec	11	-38,425	-38,221	34,847	34,884
Second Stage						
Average thrust**	lbf	13	-169	60.7	161	82.9
Average specific impulse**	sec	13	-1.59	-1.776	0.633	0.4246
Average mixture ratio	mru	13	0.0020	-0.0040	0.0093	0.0094
Propellant consumption	%	11	-0.114	-0.28	-	-

TABLE 2-5

INTERNAL RECONSTRUCTED PERFORMANCE PARAMETER CUMULATIVE STATISTICS

(CONTINUED) (COS-B)

Parameter	Unit	Number of Samples	Mean Deviation From Nominal*	Mean Deviation From Tag	Standard Deviation Nominal	Standard Deviation Tag
Second Stage (Continued)						
Propellant utilization	%	13	0.028	0.027	-	-
Total steady-state impulse**	lbf-sec	11	-28,312	-25,500	29,552	25,839
Total shutdown impulse***	lbf-sec	12	19.3	19.3	111.8	111.8

*Nominal values are based on DTO burn times

**Externally reconstructed

***Updated based on the latest Propulsion nominal and tag values

TABLE 2-6

SUMMARY OF PERFORMANCE PARAMETERS FOR FIRST STAGE LIQUID ENGINE

120 SECONDS TO MECO (COS-B)

Parameter	Units	Ground Test Tag	Preflight Predicted	Internal Reconstructed	External Reconstructed	Deviation from Ground Tag Preflight Predicted	Deviation from Ground Tag Internal Reconstructed	Deviation from Ground Tag External Reconstructed
Average total vehicle altitude thrust*	lbf	217,844	217,844	221,660	220,753	0	3,816	2,909
Average altitude specific impulse*	sec	291.79	291.79	292.31	290.34	0	0.52	-1.45
Average mixture ratio	mru	-	-	-	-	-0.01798	-0.01870	-

PERFORMANCE PARAMETERS CUMULATIVE STATISTICS

Parameter	Units	Number of Samples	Mean Deviation from Ground Tag Internal Reconstructed	Mean Deviation from Ground Tag External Reconstructed	Standard Deviation Internal Reconstructed	Standard Deviation External Reconstructed
Average total vehicle altitude thrust**	lbf	11	2,444	3,118	1,766	1,879
Average altitude specific impulse**	sec	11	0.007	0.9136	0.365	1.313
Average mixture ratio shift**	mru	11	-0.01780	-	0.0118	-

*Averages for vehicle between 120 seconds and MECO

**SMS-A not included

TABLE 2-7

THIRD STAGE SOLID MOTOR PREDICTED PERFORMANCE

(COS-B)

Parameter	Unit	Value
Total Loaded Weight	lbm	1580.33
Propellant Weight	lbm	1438.29
Inert Weight Loss During Burning	lbm	12.35
Burnout Weight (Motor Only)	lbm	129.69
Propellant Specific Impulse*	sec	290.4
Total Impulse*	lbf-sec	417,679
Action Time	sec	44.8
Nozzle Misalignment	degrees	0.005

MASS PROPERTIES

Moment of Inertia	Unit	Loaded Motor	Expended Motor
Pitch	slug-ft^2	48.32	6.63
Roll	slug-ft^2	49.62	4.29
Center of Gravity**	inches aft of the forward attach flange	16.05	21.80

*Values are for vacuum condition and 75°F

**Measured from the forward face of the 18-inch attach flange

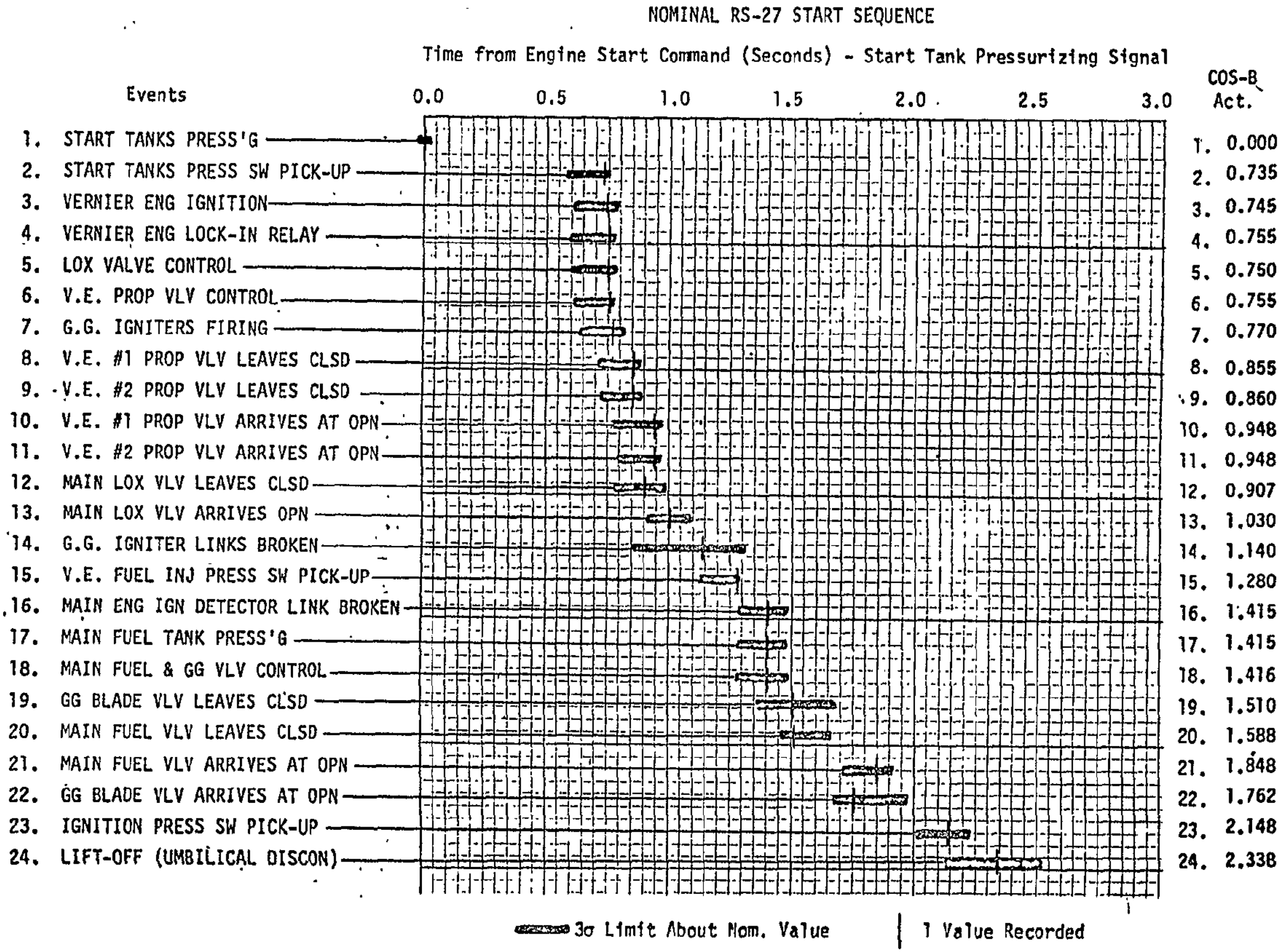

NOMINAL RS-27 START SEQUENCE
Time from Engine Start Command (Seconds) - Start Tank Pressurizing Signal
Events
0.0
0.5
1.0
1.5
2.0
2.5
3.0
COS-B Act.
1. START TANKS PRESS'G
2. START TANKS PRESS SW PICK-UP
3. VERNIER ENG IGNITION
4. VERNIER ENG LOCK-IN RELAY
5. LOX VALVE CONTROL
6. V.E. PROP VLV CONTROL
7. G.G. IGNITERS FIRING
8. V.E. #1 PROP VLV LEAVES CLSD
9. V.E. #2 PROP VLV LEAVES CLSD
10. V.E. #1 PROP VLV ARRIVES AT OPN
11. V.E. #2 PROP VLV ARRIVES AT OPN
12. MAIN LOX VLV LEAVES CLSD
13. MAIN LOX VLV ARRIVES OPN
14. G.G. IGNITER LINKS BROKEN
15. V.E. FUEL INJ PRESS SW PICK-UP
16. MAIN ENG IGN DETECTOR LINK BROKEN
17. MAIN FUEL TANK PRESS'G
18. MAIN FUEL & GG VLV CONTROL
19. GG BLADE VLV LEAVES CLSD
20. MAIN FUEL VLV LEAVES CLSD
21. MAIN FUEL VLV ARRIVES AT OPN
22. GG BLADE VLV ARRIVES AT OPN
23. IGNITION PRESS SW PICK-UP
24. LIFT-OFF (UMBILICAL DISCON)
1. 0.000
2. 0.735
3. 0.745
4. 0.755
5. 0.750
6. 0.755
7. 0.770
8. 0.855
9. 0.860
10. 0.948
11. 0.948
12. 0.907
13. 1.030
14. 1.140
15. 1.280
16. 1.415
17. 1.415
18. 1.416
19. 1.510
20. 1.588
21. 1.848
22. 1.762
23. 2.148
24. 2.338
3σ Limit About Nom. Value
1 Value Recorded

FIGURE 2-1

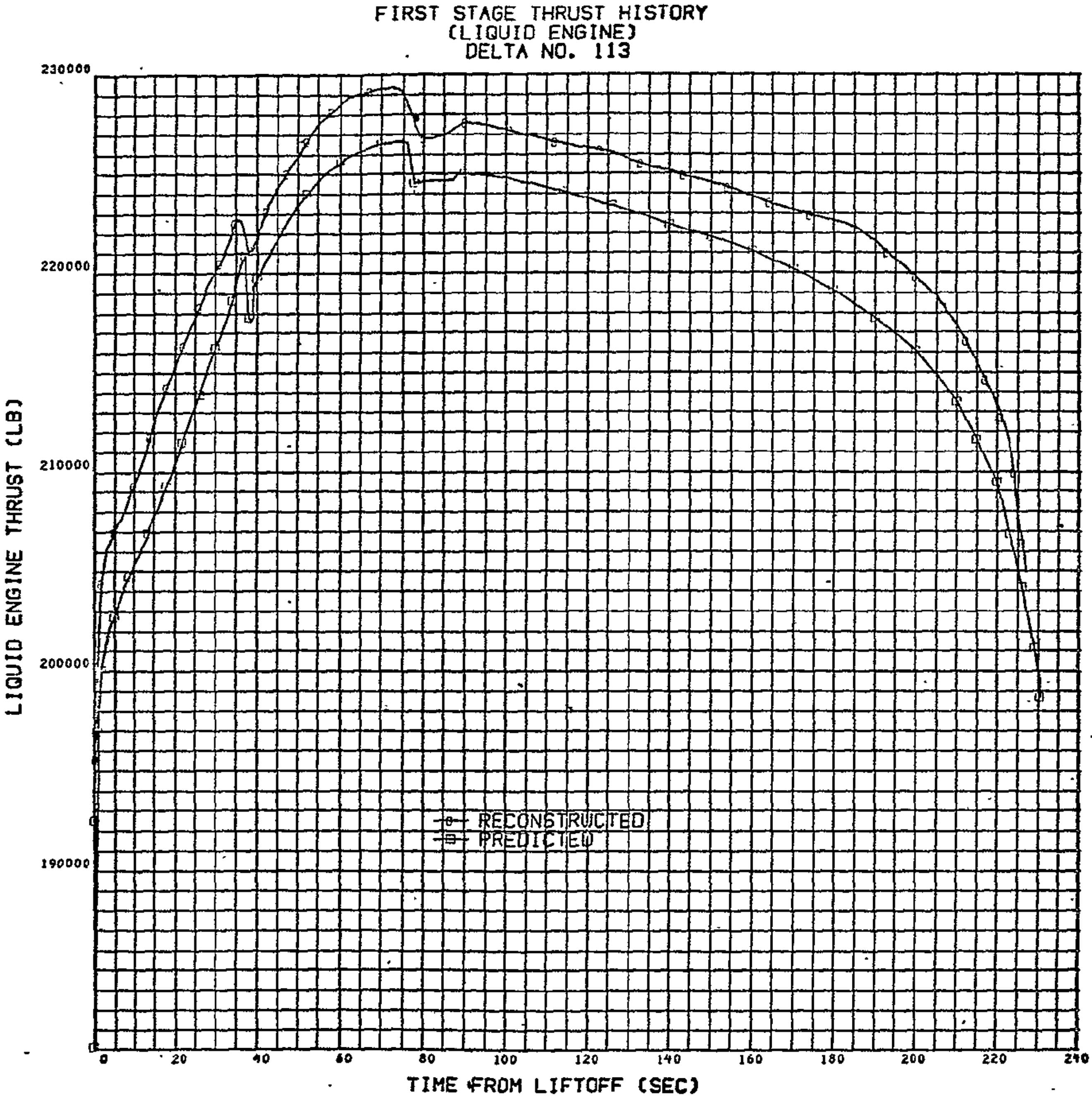
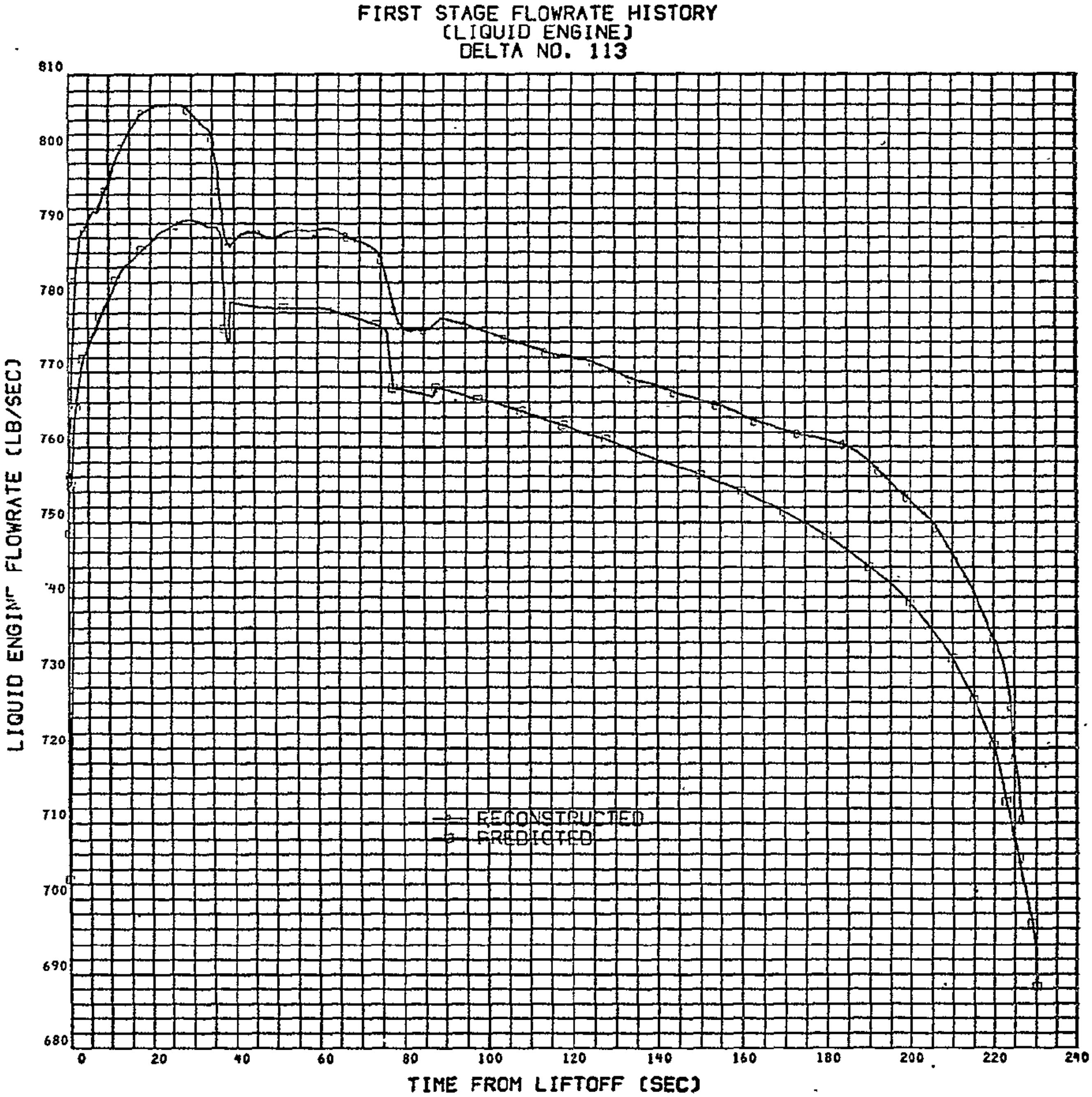

FIRST STAGE THRUST HISTORY
(LIQUID ENGINE)
DELTA NO. 113
LIQUID ENGINE THRUST (LB)
230000
220000
210000
200000
190000
0
20
40
60
80
100
120
140
160
180
200
220
240
TIME FROM LIFTOFF (SEC)
RECONSTRUCTED
PREDICTED

FIGURE 2-2



FIRST STAGE FLOWRATE HISTORY
(LIQUID ENGINE)
DELTA NO. 113
810
800
790
780
770
760
750
740
730
720
710
700
690
680
LIQUID ENGINE FLOWRATE (LB/SEC)
0
20
40
60
80
100
120
140
160
180
200
220
240
TIME FROM LIFTOFF (SEC)
RECONSTRUCTED
PREDICTED

FIGURE 2-3

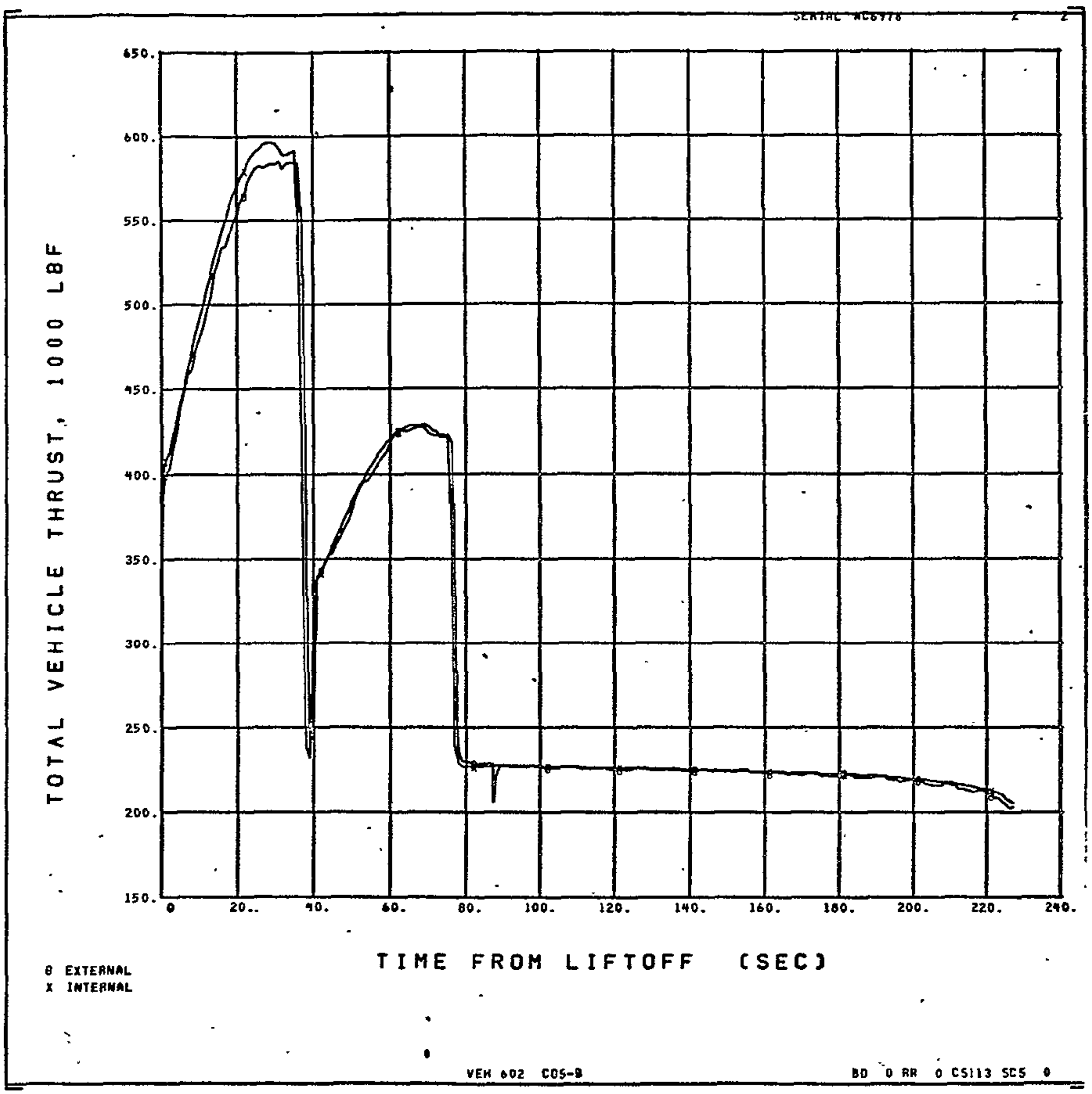

SERIAL AC6978
650.
600.
550.
500.
450.
400.
350.
300.
250.
200.
150.
0
20.
40.
60.
80.
100.
120.
140.
160.
180.
200.
220.
240.
TOTAL VEHICLE THRUST, 1000 LBF
TIME FROM LIFTOFF (SEC)
8 EXTERNAL
X INTERNAL
VEH 602 COS-B
BD 0 RR 0 CS113 SCS 0

FIGURE 2-4

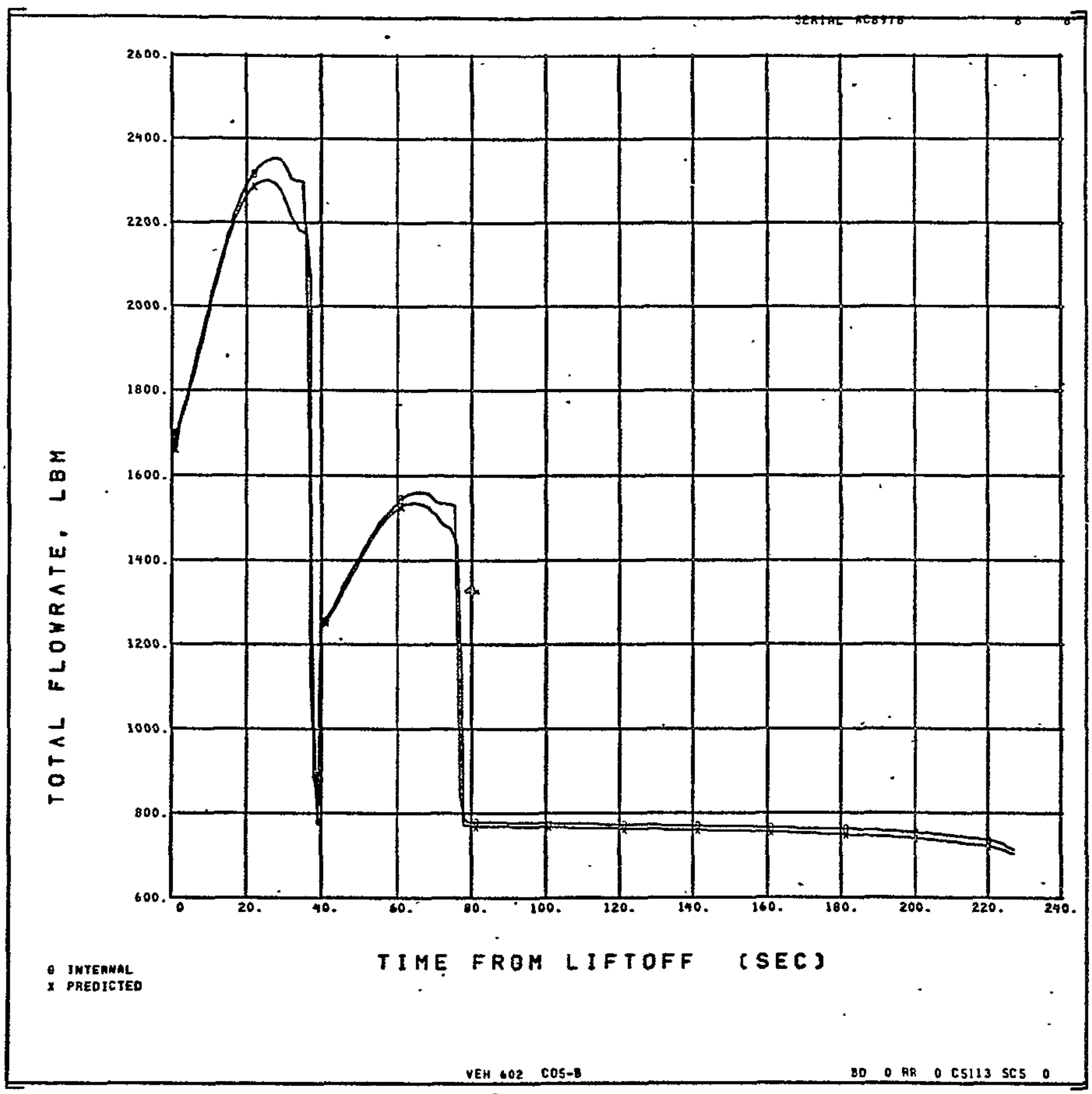

SERIAL AC8978
2600.
2400.
2200.
2000.
1800.
1600.
1400.
1200.
1000.
800.
600.
0
20.
40.
60.
80.
100.
120.
140.
160.
180.
200.
220.
240.
TOTAL FLOWRATE, LBM
TIME FROM LIFTOFF (SEC)
@ INTERNAL
X PREDICTED
VEH 602 COS-B
BD 0 RR 0 C5113 SCS 0

FIGURE 2-5

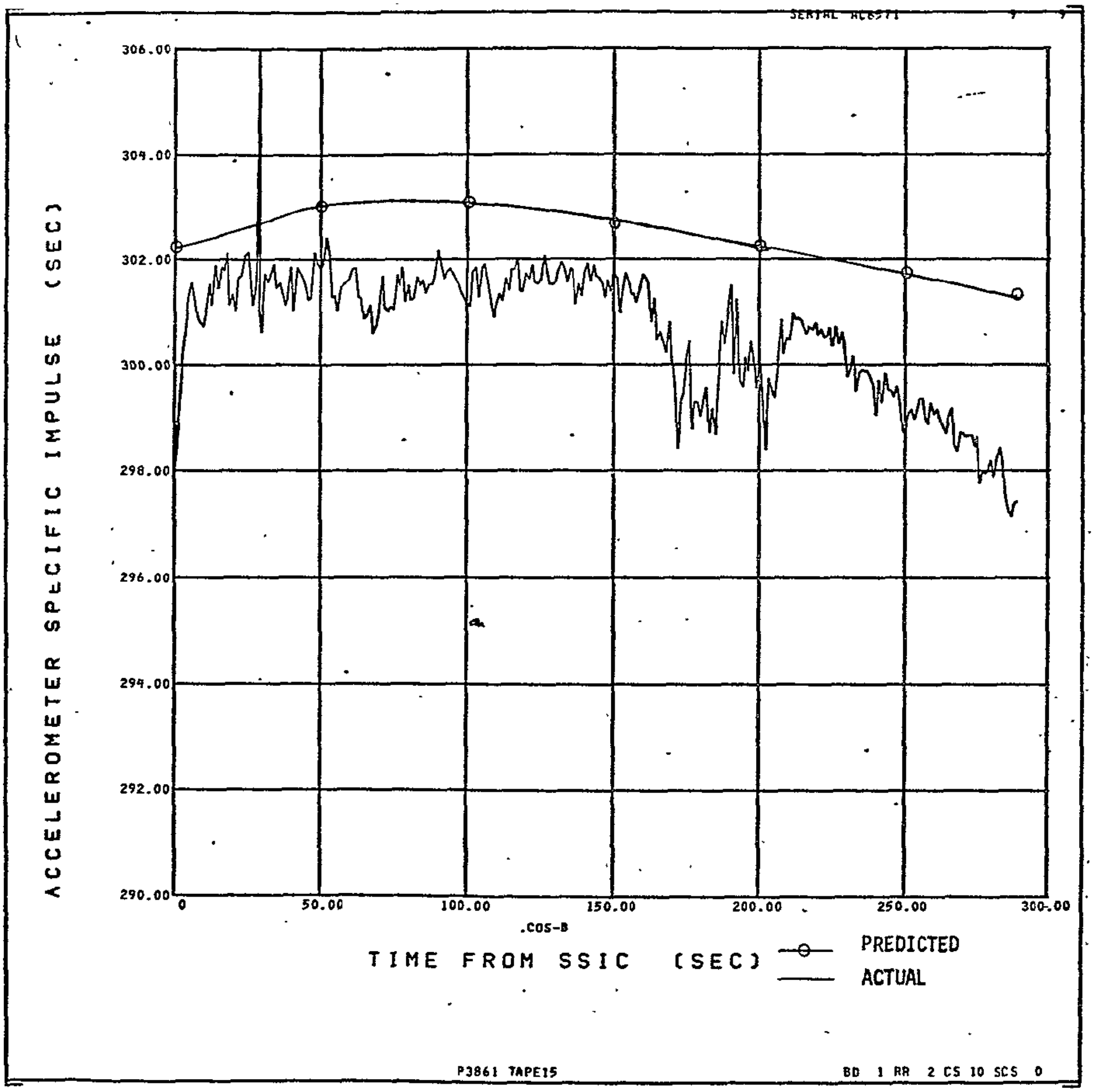
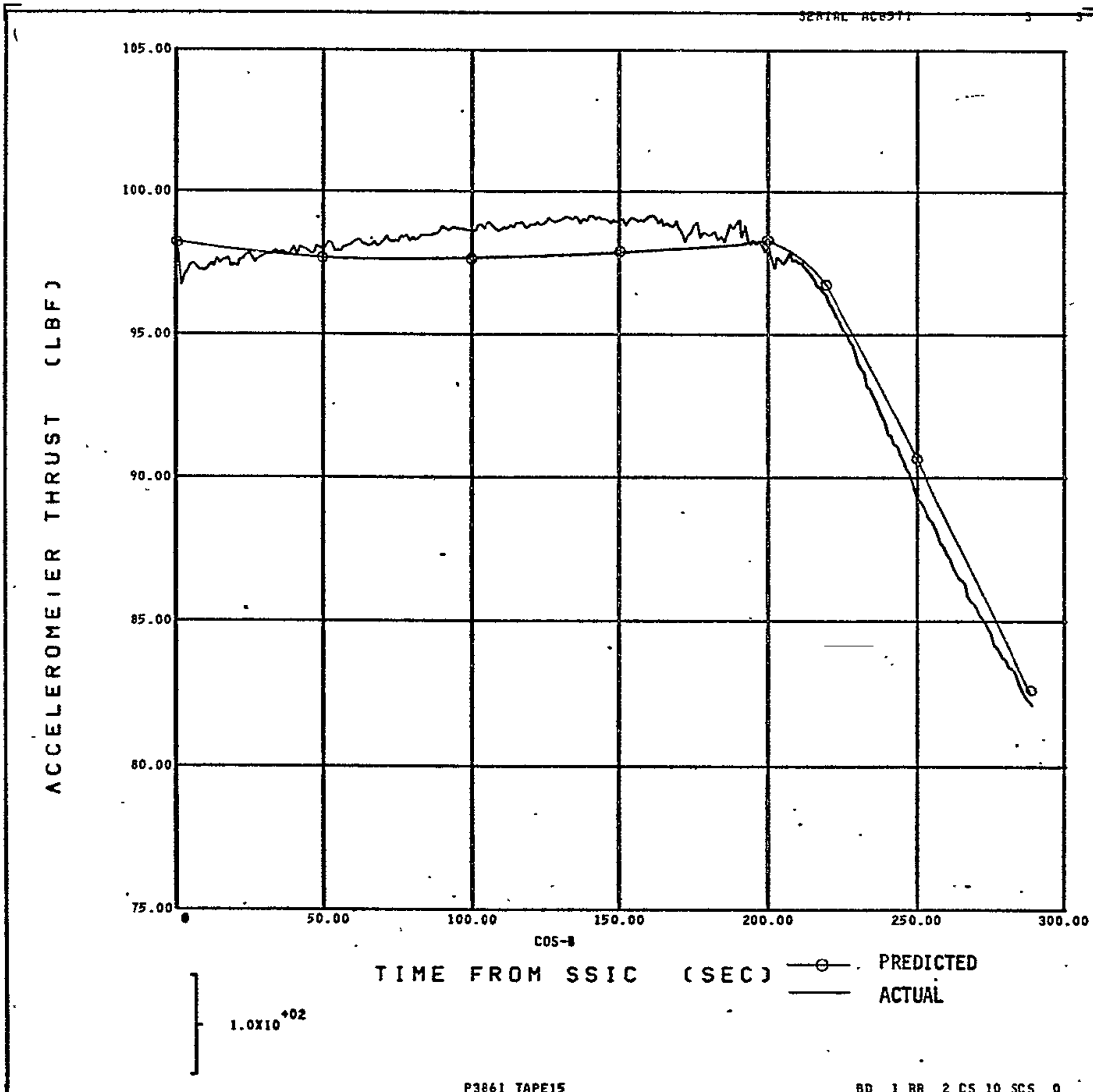
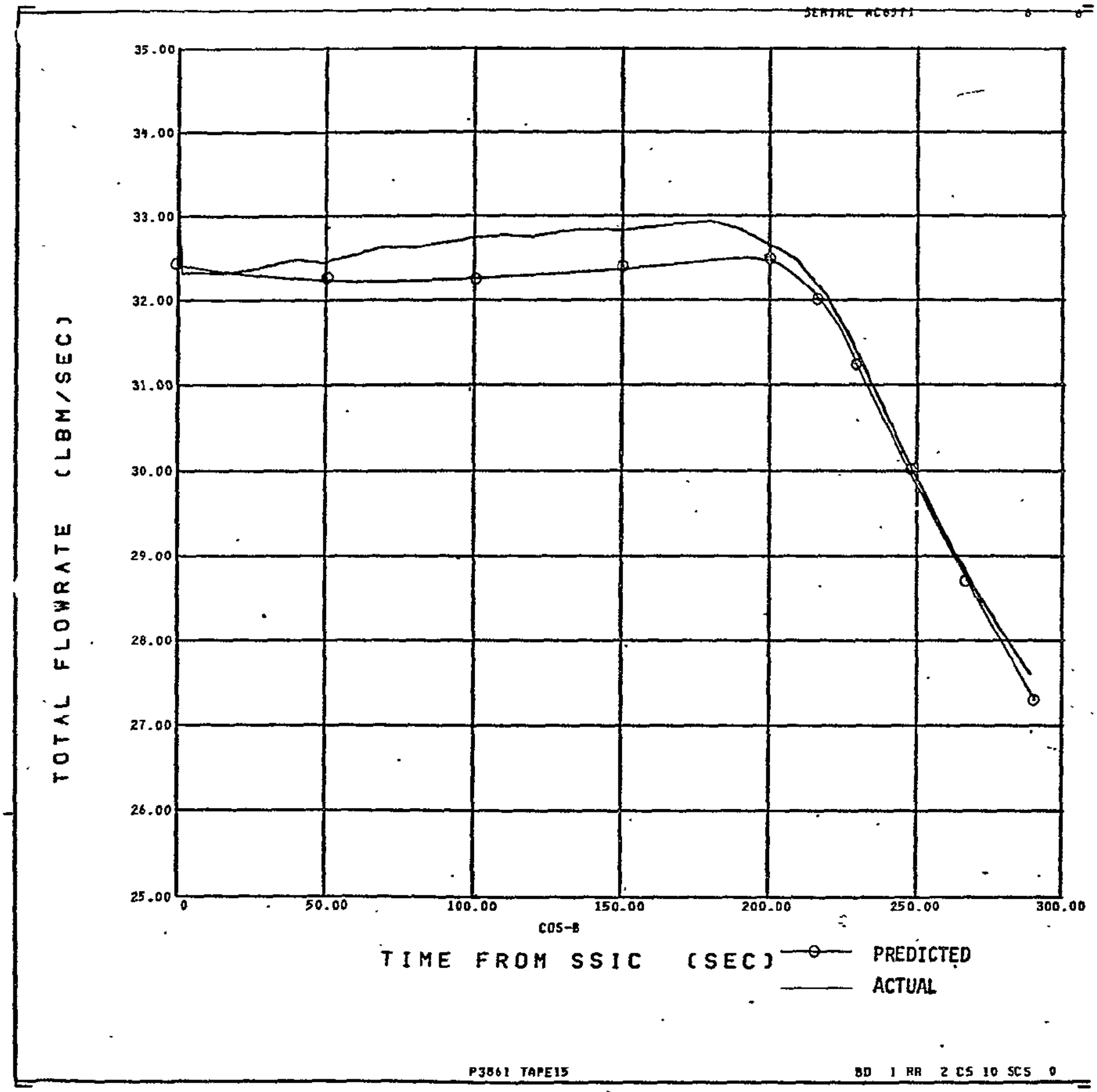

SERIAL AC6571
306.00
304.00
302.00
300.00
298.00
296.00
294.00
292.00
290.00
ACCELEROMETER SPECIFIC IMPULSE (SEC)
0
50.00
100.00
150.00
200.00
250.00
300.00
.COS-B
TIME FROM SSIC (SEC)
PREDICTED
ACTUAL
P3861 TAPE15
BD 1 RR 2 CS 10 SCS 0

FIGURE 2-6



ACCELEROMETER THRUST (LBF)
105.00
100.00
95.00
90.00
85.00
80.00
75.00
0
50.00
100.00
150.00
200.00
250.00
300.00
COS-8
TIME FROM SSIC (SEC)
PREDICTED
ACTUAL
1.0X10+02
P3861 TAPE15
BD 1 RR 2 CS 10 SCS 0

FIGURE 2-7



35.00
34.00
33.00
32.00
31.00
30.00
29.00
28.00
27.00
26.00
25.00
0
50.00
100.00
150.00
200.00
250.00
300.00
COS-8
TIME FROM SSIC (SEC)
TOTAL FLOWRATE (LBM/SEC)
PREDICTED
ACTUAL
P3861 TAPE15

FIGURE 2-8

ATTACHMENT 3:

SECTION 3. GUIDANCE SYSTEM - COS-B MISSION

Section 3

GUIDANCE SYSTEM - COS-B MISSION

The Delta Inertial Guidance System (DIGS) performed its functions properly throughout the COS-B mission. From the observed small off-nominal SECO orbit parameter deviations, the system navigation errors appear to be nominal. Postflight statistics and interpretations of key guidance, navigation, and trajectory parameters are provided in this section.

3.1 ALIGNMENT

The gyro update parameters were observed small and a continuous steady state solution to these existed long before liftoff during the terminal count as shown in Figure 3-2. This means that a minimum of vehicle sway occurred in each body coordinate. The system tracked this motion well since alignment had reached a converged solution. The gyro bias update parameters resolved into the IMU (X, Y, Z) frame are respectively (0.058, 0.007, -0.081) deg/hr.

3.2 CLOSED LOOP GUIDANCE PERFORMANCE

The observed response of the guidance system for the COS-B mission was as expected. Table 3-1 presents the significant mission trajectory event times and attitude errors. Figure 3-1 shows a continuous time history of guidance adjustments in vehicle sequencing time while Figures 3-3 through 3-6 present guidance system time adjustment and steering. As shown in Table 3-1 and the figures, all guidance time adjustments, attitude errors, and guidance steering commands were within the normal ranges. Figure 3-7 show the velocity gained after SECO 1 as a function of time. These can be used to compute actual tailoff impulse. Figure 3-8 presents the second stage thrust axis velocity and shows the change in velocity at third stage separation and ignition. Note that this figure is valid only for changes in velocity (not total velocity) since the range is -1024 to +1024 ft/sec with overflow allowed.

3.3 NAVIGATION AND PERFORMANCE

A total guidance system error can essentially be categorized as residual system errors and system navigation errors. Table 3-2 normally lists the MECO and SECO 1 orbital parameters extrapolated from data reflecting NASA hardpoint (tracking, SECO 1 only), guidance computed (telemetry) and the targeted nominal conditions. However, due to lack of NASA tracking data from before SECO 1 through experimental restart, no valid hardpoint SECO 1 orbital data is available. Errors due to less than perfect navigation normally can be computed as differences between NASA and telemetry data. The total guidance system performance as of SECO 1 normally can be observed in the difference between NASA hardpoint and the targeted (DTO) data. Even though no valid NASA hardpoint data is available, from the observed data presented in Table 3-2, it is evident that DIGS performed well throughout the second stage burn.

3.4 ANGLE OF ATTACK HISTORIES

A reference angle-of-attack profile was generated from PCM inertial velocity vector by subtracing the atmospheric rotational velocity due to the earth rate and transforming the resulting relative velocity vectory into the body coordinates using the T^c matrix. Note that the angle-of-attack values include the wind velocity effects which were measured prior to launch. The wind velocity vector was resolved into body coordinates and accounted for prior to computing the angles of attack. The true pitch, yaw and total angle-of-attack are defined from the wind coorected velocity vector in body coordinates using the equations

$$\alpha = \tan^{-1} (V_{ZRB}/V_{XRB})$$

$$\beta = \tan^{-1} (-V_{YRB}/V_{XRB})$$

$$\alpha^{*} = \tan^{-1} \left(\sqrt{V_{YRB}^2 + V_{ZRB}^2} \Big/ V_{XRB}\right)$$

Figures 3-9 and 3-10 provide the angle-of-attack histories up to 240 seconds of flight.

3.5 EXPERIMENTAL RESTART

From the guidance standpoint, no significant events occurred during the open-loop experimental restart (TM data was very poor during this period), except for the long burn time. This is discussed further in the Propulsion and System Performance sections of this report.

Table 3-1

COS-B

MAJOR EVENT TIMES AND VEHICLE INERTIAL ATTITUDE ERROR

Event	Time (Sec)	Vehicle Attitude From Nominal (Deg)
Liftoff	0	$\Delta\phi$ = 0.209 $\Delta\theta$ = 0.063 $\Delta\psi$ = 0.039
First-Stage Guidance Initiation	Nominal 125.000 Actual 125.232	$\Delta\phi$ = 0.343 $\Delta\theta$ = 2.206 $\Delta\psi$ = -1.559
MECO (DIGS Sensed)	Nominal 228.061 Actual 227.381	$\Delta\phi$ = -0.045 $\Delta\theta$ = 1.287 $\Delta\psi$ = 0.264
Second-Stage Guidance Initiation	Nominal 280.000 Actual 279.524	$\Delta\phi$ = 4.957 $\Delta\theta$ = 0.409 $\Delta\psi$ = 0.199
SECO 1 (DIGS Sensed)	Nominal 531.075 Actual 530.981	$\Delta\phi$ = -6.614 $\Delta\theta$ = 2.135 $\Delta\psi$ = -0.085
Start Coast Guidance #1	Nominal 630.000 Actual	$\Delta\phi$ = $\Delta\theta$ = No PCM data $\Delta\psi$ =
Stop Coast Guidance #1	Nominal 680.000 Actual	$\Delta\phi$ = $\Delta\theta$ = No PCM Dat… $\Delta\psi$ =
Start Coast Guidance #2	Nominal 2975.000 Actual 2973.395	$\Delta\phi$ = 0.038 $\Delta\theta$ = 0.066 $\Delta\psi$ = 2.143
Stop Coast Guidance #2	Nominal 3025.000 Actual 3023.204	$\Delta\phi$ = 0.047 $\Delta\theta$ = 0.092 $\Delta\psi$ = 0.099

Table 3-2

COS-B ORBITAL DATA

Trajectory Point	Trajectory Type	Apogee Altitude* (n.mi.)	Δh_a (n.mi.)	Perigee Altitude* (n.mi.)	Δh_p (n.mi.)	Inclination (deg)	Δi (deg)	ΔV (ft/sec)
MECO	Targeted Nominal	103.687	0	-2608.49	0	89.5930	0	0
	Telemetry (Guidance Computed)	106.104	2.417	-2585.08	23.41	89.6103	0.0173	192.593
SECO 1	Targeted Nominal**	238.710 ±4.660	0	91.849 ±2.071	0	89.8687 ±0.041	0	0
	Telemetry (Guidance Computed)	237.842	-0.868	91.615	-0.234	89.8688	0.0001	-1.892
	NASA (Hardpoint Data)	No NASA SECO 1 data available due to lack of tracking prior to SECO 2 (experimental burn SECO).						

* Based on earth radius of 3439.62 n.mi.

** Indicated tolerances are root sum square of 3σ contributions to orbit parameter dispersions. The value of Δt^{adj} calculated at the beginning of second stage guidance was -1.890 seconds.

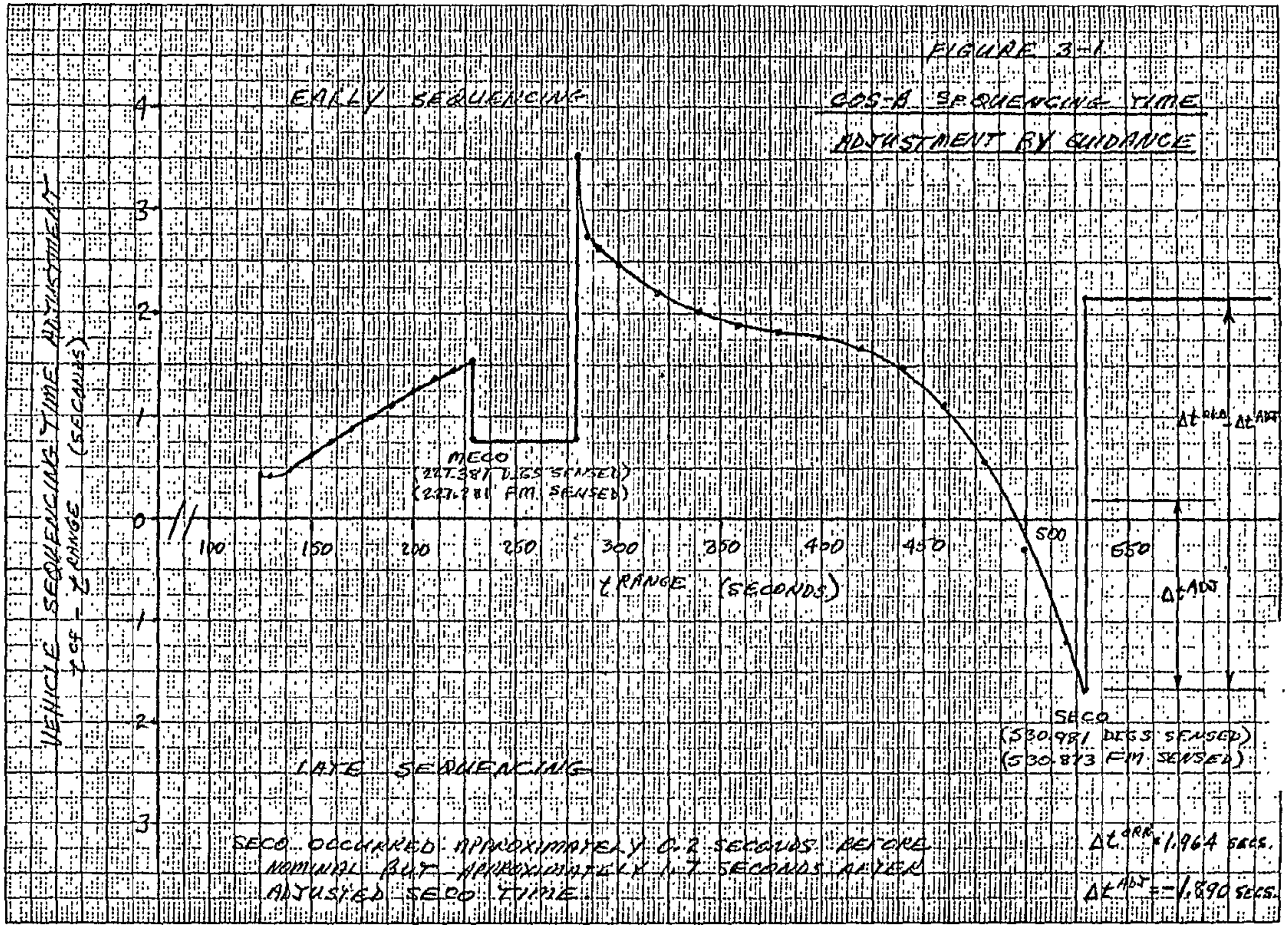
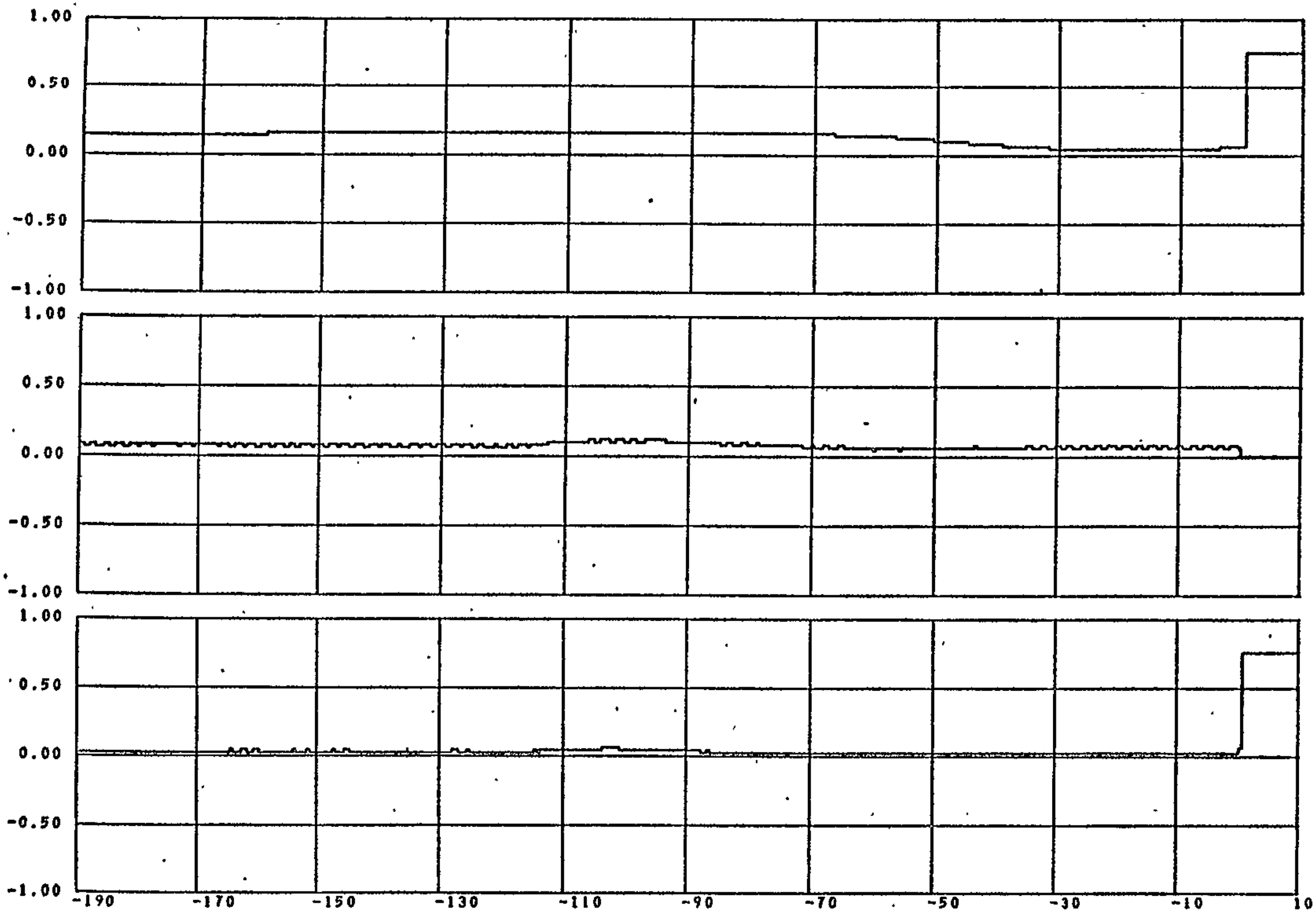


FIGURE 3-1
GOS-B SEQUENCING TIME
ADJUSTMENT BY GUIDANCE
EARLY SEQUENCING
LATE SEQUENCING
VEHICLE SEQUENCING TIME ADJUSTMENT
(SECONDS)
4
3
2
1
0
1
2
3
100
150
200
250
300
350
400
450
500
550
t RANGE (SECONDS)
MECO
(227.387 DIGS SENSED)
(227.281 FM SENSED)
SECO
(530.981 DIGS SENSED)
(530.873 FM SENSED)
Δt^ADJ
SECO OCCURRED APPROXIMATELY 0.2 SECONDS BEFORE
NOMINAL BUT APPROXIMATELY 1.7 SECONDS AFTER
ADJUSTED SECO TIME.
Δt^ORR = 1.964 SECS.
Δt^ADJ = -1.890 SECS.

FIGURE 3-2

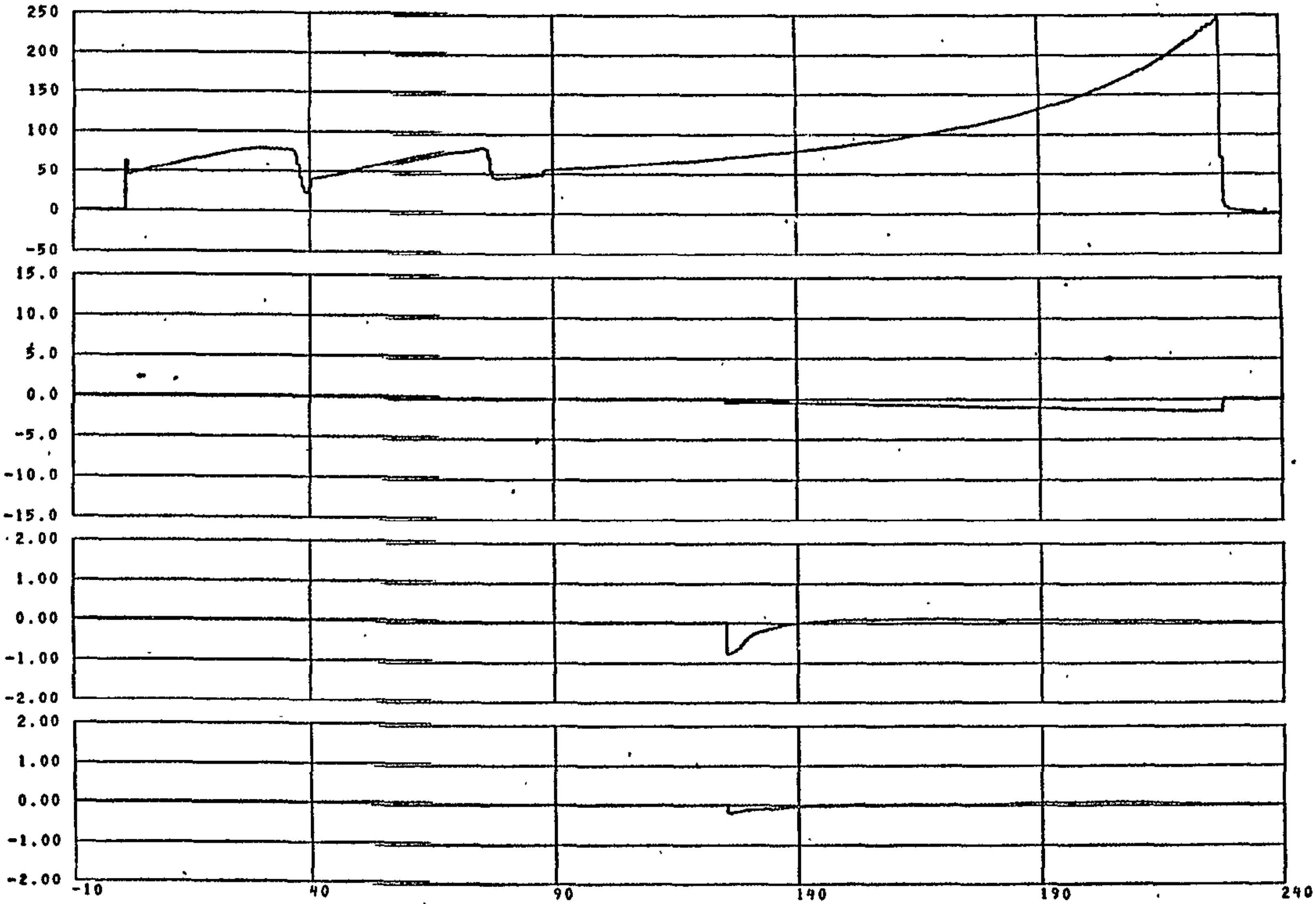
TEST ID 046619 780000 COS-B GROUP 2 PLOT NO 1 REVISION 1 REFERENCE TIME 01 47 59.795



MEAS. NUMBER	CHANNEL ASGN.		TITLE	RANGE	UNITS	GRID-SYM
PCM-2G-69L	1-69-03	X	Gyro Bias Update	-1.00 TO 1.00	DEG/HR	A
PCM-2G-70L	1-70-03	Y		-1.00 TO 1.00	DEG/HR	B
PCM-2G-71L	1-71-03	Z		-1.00 TO 1.00	DEG/HR	C

FIGURE 3-3

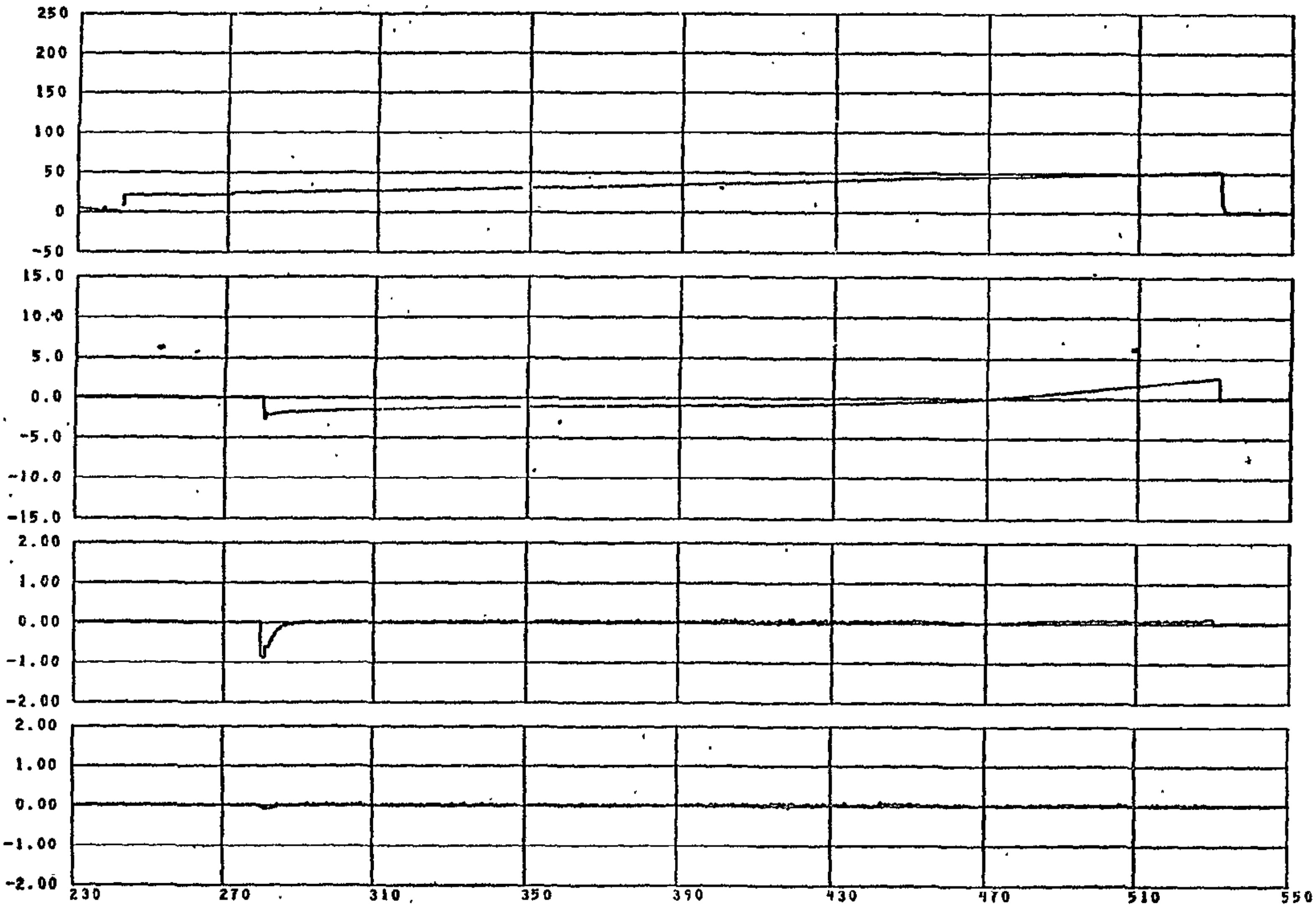
TEST ID 096619 780000 COS-B GROUP 3 PLOT NO 1A REVISION 1 REFERENCE TIME 01 47 59.795



RELATIVE TIME IN SEC

MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PCM-2G-39	1-39-01	THRUST ACCELERATION	0 TO 500	FT/SEC2	A
PCM-2G-61	1-61-02	TIME-TO-GO CORRECTION	-50 TO 50	SECONDS	B
PCM-2G-67	1-67-03	C/LOOP GUID STEERING PITCH RATE	-2.86 TO 2.86	DEG/SEC	C
PCM-2G-68	1-68-03	C/LOOP GUID STEERING YAW RATE	-2.86 TO 2.86	DEG/SEC	D

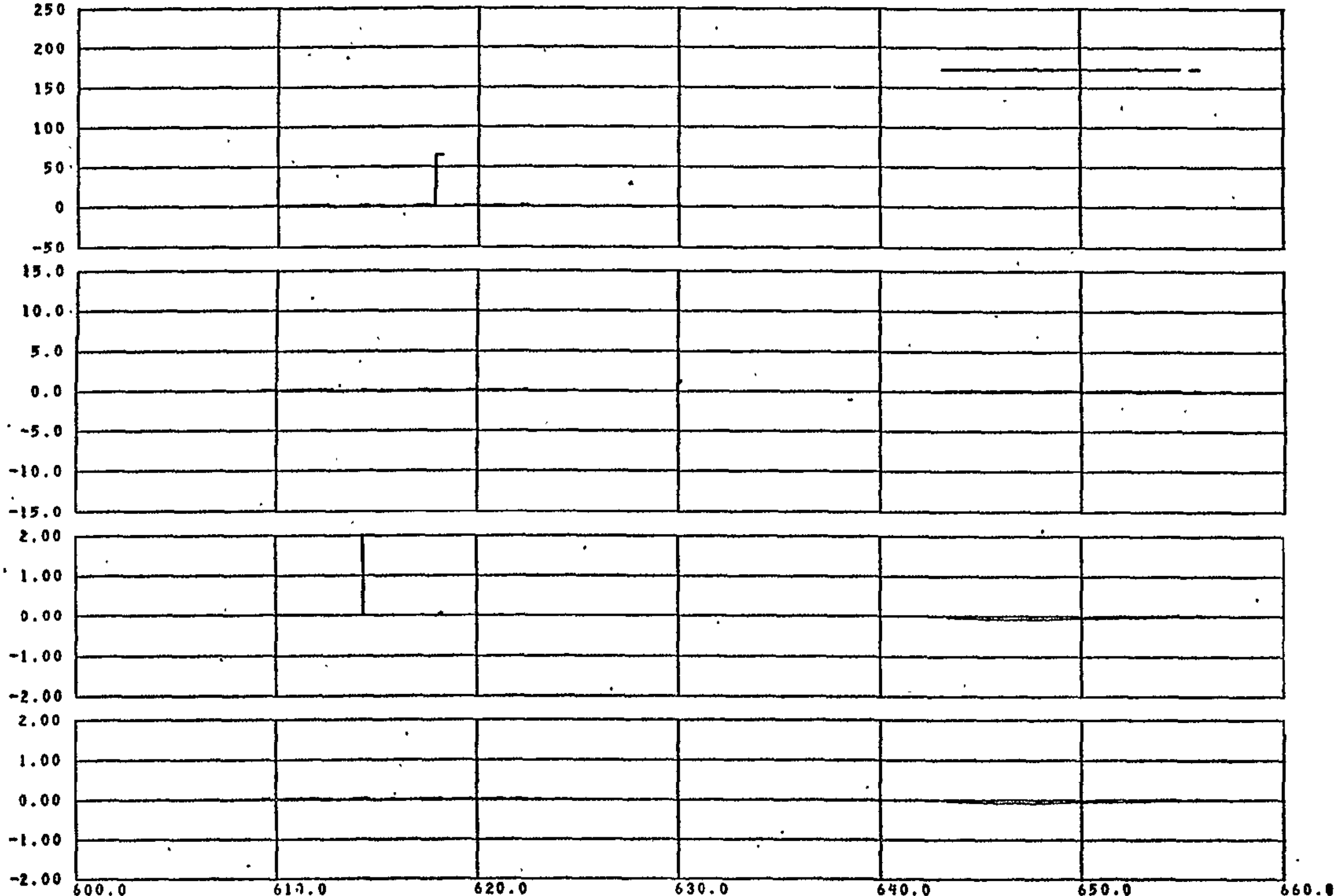
FIGURE 3-4



MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SVR
PCM-2G-39	1-39-01	THRUST ACCELERATION	0 TO 500	FT/SEC2	A
PCM-2G-61	1-61-02	TIME-TO-GO CORRECTION	-50 TO 50	SECONDS	B
PCM-2G-67	1-67-03	C/LOOP GUID STEERING PITCH RATE	-2.86 TO 2.86	DEG/SEC	C
PCM-2G-68	1-68-03	C/LOOP GUID STEERING YAW RATE	-2.86 TO 2.86	DEG/SEC	D

FIGURE 3-5

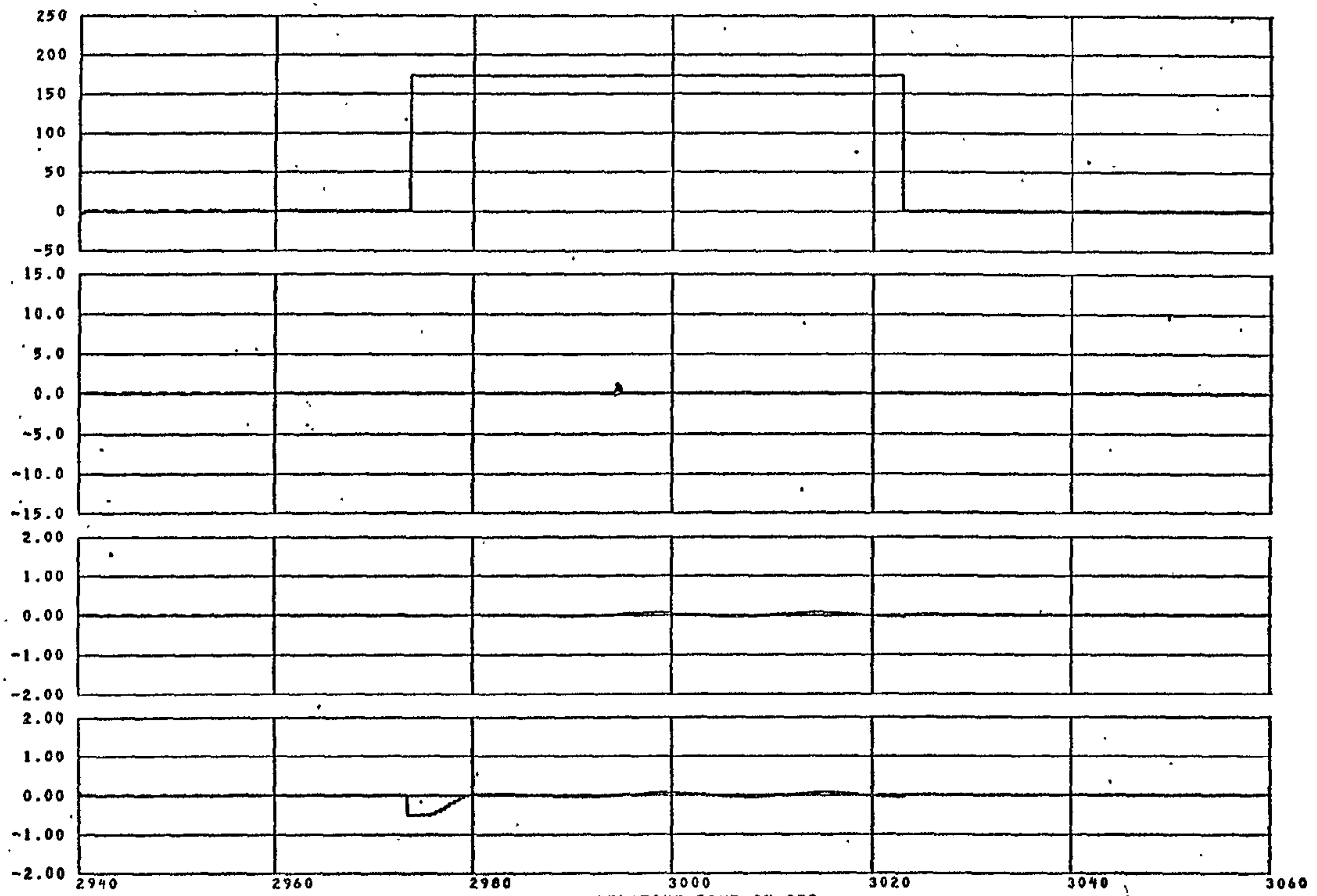
TEST ID 046619 780001 COS-B GROUP 3 PLOT NO 1C REVISION 1 REFERENCE TIME 01 47 59.799



MEAS. NUMBER	CHANNEL ASGN	TITLE	RANGE	UNITS	GRID-SYM
PCM-2G-39	1-39-01	THRUST ACCELERATION	0 TO 500	FT/SEC2	A
PCM-2G-61	1-61-02	TIME-TO-GO CORRECTION	-50 TO 50	SECONDS	B
PCM-2G-67	1-67-03	C/LOOP GUID STEERING PITCH RATE	-2.86 TO 2.86	DEG/SEC	C
PCM-2G-68	1-68-03	C/LOOP GUID STEERING YAW RATE	-2.86 TO 2.86	DEG/SEC	D

FIGURE 3-6

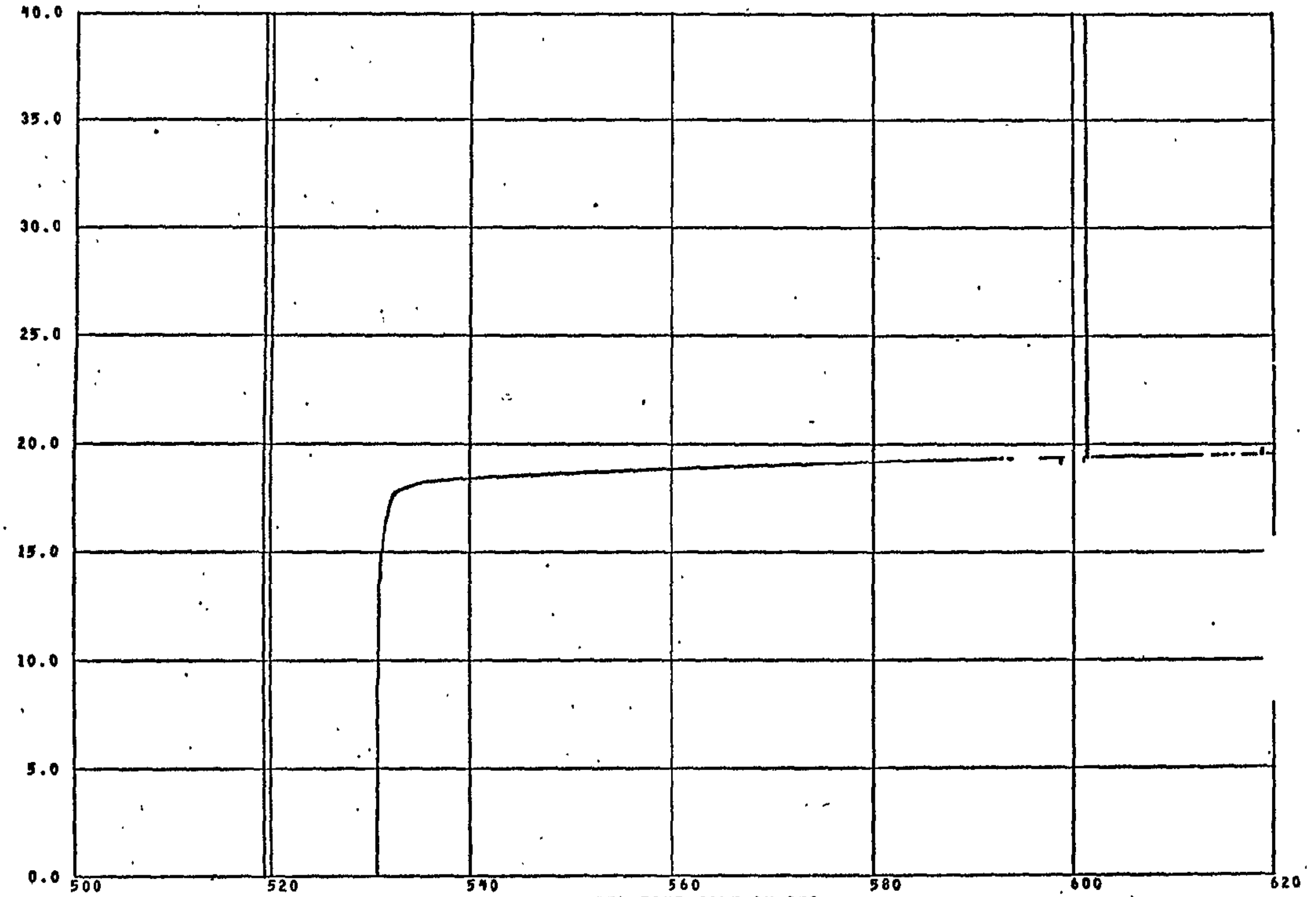
TEST ID 046619 780001 COS-B GROUP 3 PLOT NO 1C REVISION 1 REFERENCE TIME 01 47 59.795



MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PCM-2G-39	1-39-01	THRUST ACCELERATION	0 TO 500	FT/SEC2	A
PCM-2G-61	1-61-02	TIME-TO-GO CORRECTION	-50 TO 50	SECONDS	B
PCM-2G-67	1-67-03	C/LOOP GUID STEERING PITCH RATE	-2.86 TO 2.86	DEG/SEC	C
PCM-2G-68	1-68-03	C/LOOP GUID STEERING YAW RATE	-2.86 TO 2.86	DEG/SEC	D

FIGURE 3-7

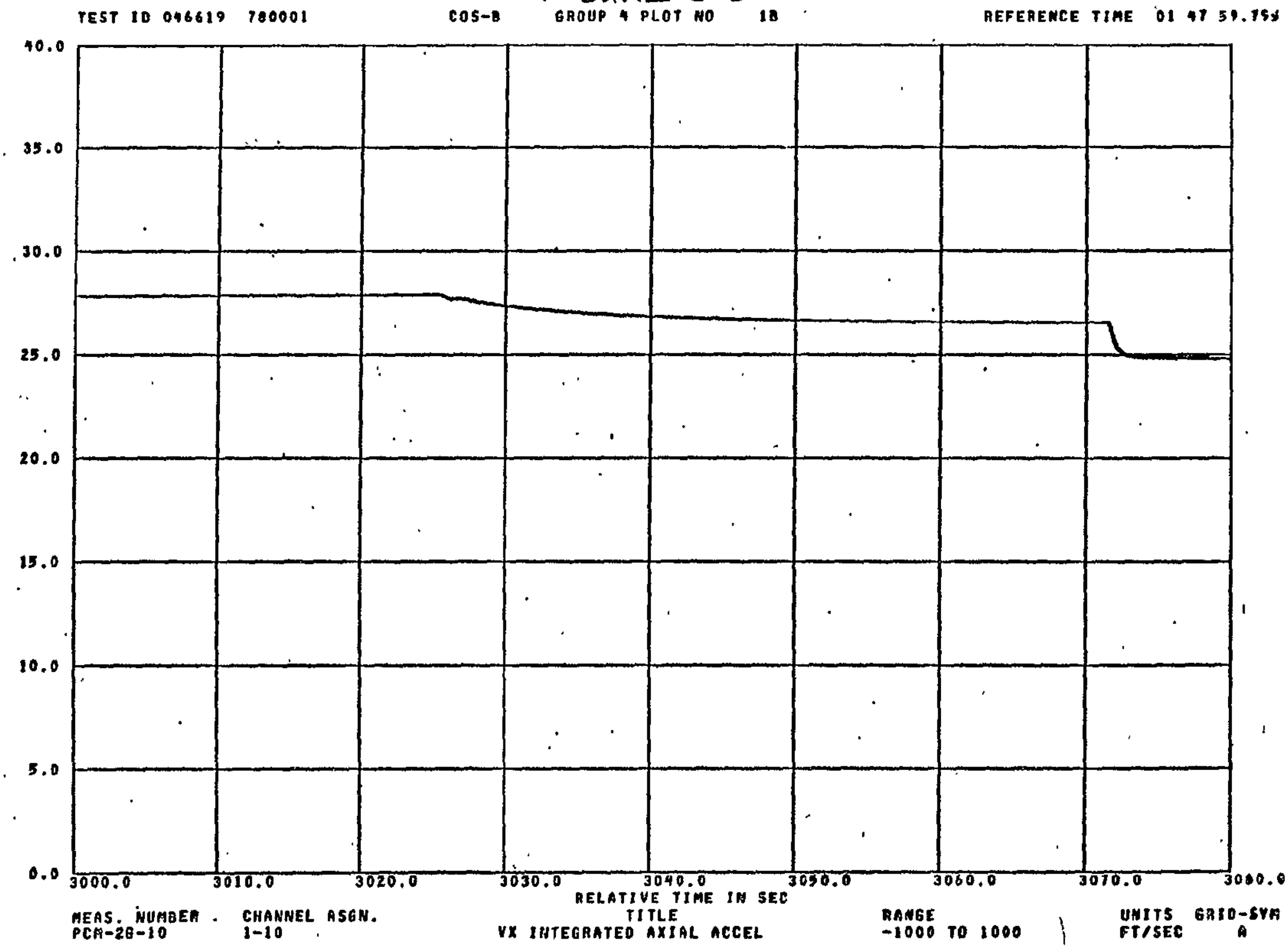
TEST ID 046619 780000 COS-B GROUP 4 PLOT NO 1A REVISION 1 REFERENCE TIME 01 47 59.795



RELATIVE TIME IN SEC

MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-S
PCM-26-10	1-10	VX INTEGRATED AXIAL ACCEL	-1000 TO 1000	FT/SEC	A

FIGURE 3-8



TEST ID 046619 780001
COS-B
GROUP 4 PLOT NO 18
REFERENCE TIME 01 47 59.75
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
3000.0
3010.0
3020.0
3030.0
3040.0
3050.0
3060.0
3070.0
3080.0
RELATIVE TIME IN SEC
MEAS. NUMBER
PCM-28-10
CHANNEL ASGN.
1-10
TITLE
VX INTEGRATED AXIAL ACCEL
RANGE
-1000 TO 1000
UNITS
FT/SEC
GRID-SYM
A

FIGURE 3-9

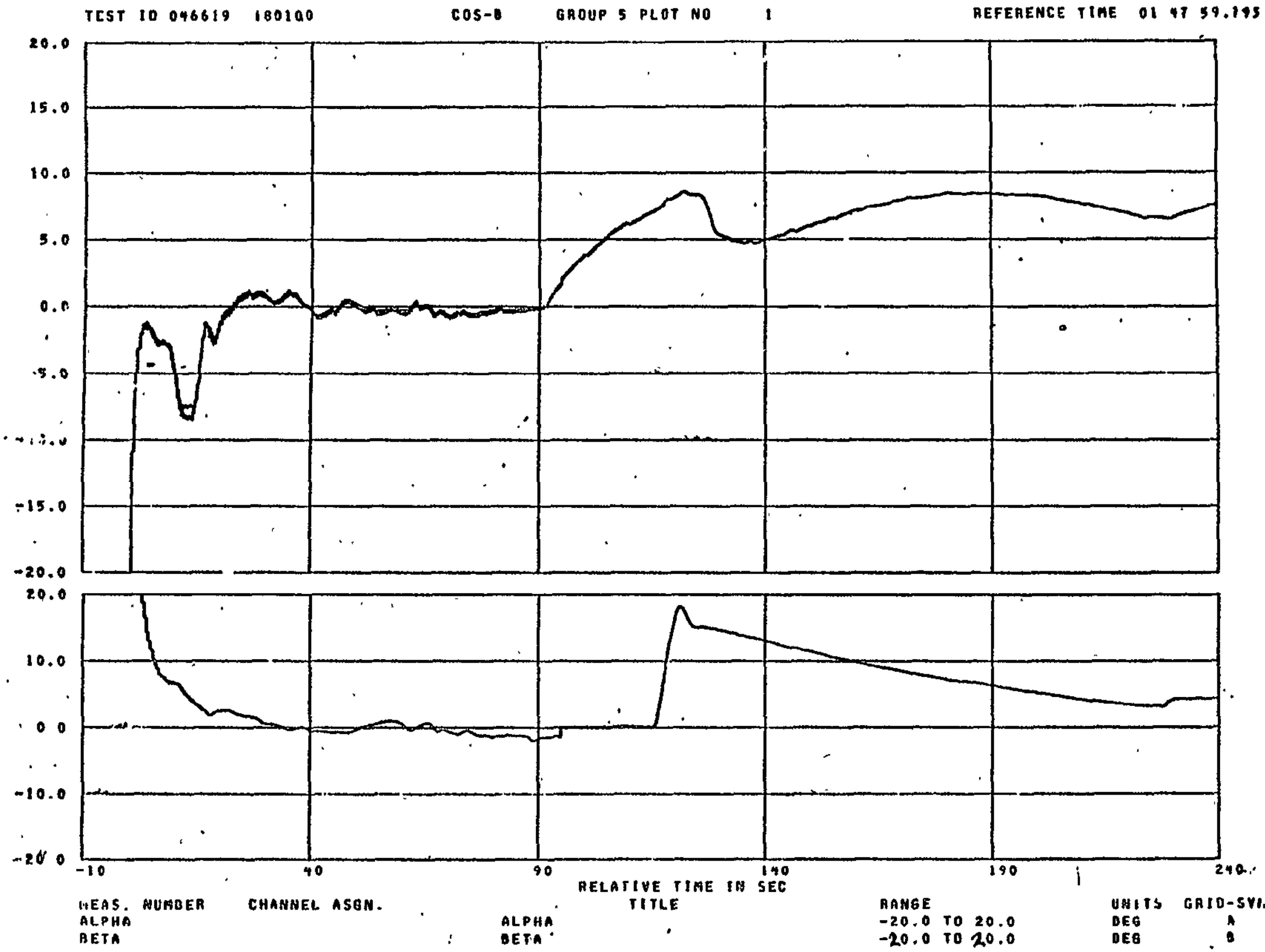
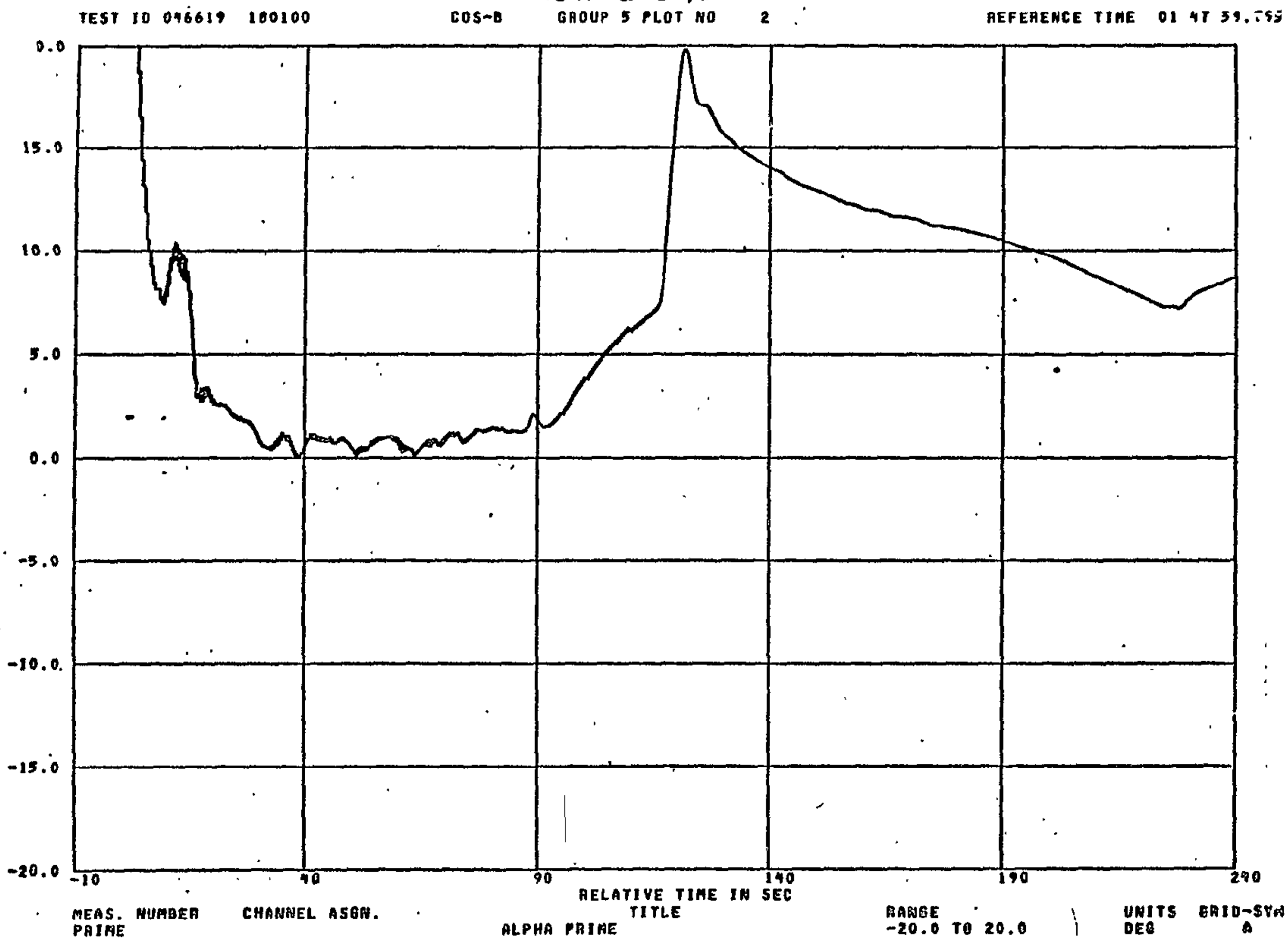

TEST ID 046619 180100
COS-B
GROUP 5 PLOT NO 1
REFERENCE TIME 01 47 59.195
20.0
15.0
10.0
5.0
0.0
-5.0
-15.0
-20.0
20.0
10.0
0 0
-10.0
-20 0
-10
40
90
140
190
240
RELATIVE TIME IN SEC
MEAS. NUMBER
CHANNEL ASGN.
TITLE
RANGE
UNITS
GRID-SYM
ALPHA
ALPHA
-20.0 TO 20.0
DEG
A
BETA
BETA
-20.0 TO 20.0
DEG
B

FIGURE 3-10


TEST ID 096619 180100
COS-B
GROUP 5 PLOT NO 2
REFERENCE TIME 01 47 59.795
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-10
40
90
140
190
240
RELATIVE TIME IN SEC
MEAS. NUMBER
PRIME
CHANNEL ASGN.
TITLE
ALPHA PRIME
RANGE
-20.0 TO 20.0
UNITS
DEG
GRID-SYM
A

ATTACHMENT 4:

SECTION 4. FLIGHT CONTROL SYSTEM - COS-B MISSION

FLIGHT CONTROL SYSTEM - COS-B

4.0 FLIGHT CONTROL SYSTEM

All flight control systems operated nominally throughout the first and second stage flight for the COS-B mission. First-second and second-third stage separations occurred satisfactorily. This was the first DIGS mission to use a modified second stage propulsion fuel manifold system. An unexpected pogo resonance of significant duration was observed during powered flight. This anomaly had no impact on the successful completion of primary and secondary mission objectives. Maneuvers to shield the payload from the sun and to reorient the vehicle prior to third stage separation were adequately performed. The nitrogen gas usage through third stage separation was well within the predicted three-sigma deviations.

4.1 FIRST STAGE

The first stage control system maintained vehicle stability and performed the required functions throughout first stage flight.

4.1.1 <u>First Stage Statistical Record</u>

Table 4-1 provides a compilation of some of the control system characteristics for this flight and the corresponding statistics generated from past flights.

4.1.1.1 Thrust Misalignment

The first stage main engine positions required to direct the thrust vector through the vehicle center of gravity are shown in Figures 4-1 and 4-2 for liftoff and MECO, respectively. Data points of previously flown 2914 vehicle configurations and the mean values applicable for each plot are also shown. Note that the engine positions for COS-B were within one-sigma deviations from their respective mean values.

4.1.1.2 Maximum Aero Moment Region

Peak roll rate and pitch attitude error with their respective peak engine deflections occurred at the maximum dynamic pressure time of about T+36 seconds. All other peak values of attitude errors, rates and engine deflections occurred between T+67 and T+79 seconds. Large engine deflections prior to 20 seconds were primarily due to programmed pitch maneuvers. Figure 4-3 shows that the peak pitch and yaw engine deflections after 20 seconds were -1.2 and 1.5 degrees, respectively. These deflections were primarily caused by the combined effects of wind shear and dynamic pressure.

4.1.1.3 Roll Moments

External roll moments were computed at liftoff, maximum dynamic pressure, MECO and vernier engine solo times of flight. The roll moments shown in Table 4-1 are the total external moments (includes thrust misalignments and aerodynamics) which are computed from the vernier engine deflections. A vernier engine thrust of 1000 pounds was used for all calculations.

4.1.1.4 Peak Vernier Solo Engine Deflection

Rates and attitude errors from just before MECO to just after stage II (second stage engine) ignition are shown in Figures 4-4 and 4-5. Note that attitude errors and body rates present at MECO are zeroed out by the vernier solo control system prior to first-second stage (I/II) separation. The peak vernier engine deflections occurred shortly after MECO. The largest deflection was in the yaw channel due to the large attitude error existing at MECO in that plane.

4.1.1.5 Maximum Guidance Rate Commands

The maximum guidance rate commands occurred at guidance initiation (T+125 seconds). The pitch command was very close to the mean value observed over 12 missions. The yaw command of -0.20 deg/sec was less than one standard deviation from its mean value.

4.1.1.6 Conditions Before and After First-Second Stage Separation

Rate and attitude errors in the pitch and yaw planes were essentially zero prior to stage I/II separation. The roll rate and attitude error before separation were close to mean values. Figures 4-4 and 4-5 show the rate and attitude error changes during separation were very slight indicating a smooth separation event.

4.1.2 First Stage Control System Response

4.1.2.1 Vehicle Bending

The shock of liftoff excited the first and possibly the second bending mode. Figure 4-6 shows the pitch and yaw angular rates while Figure 4-7 shows the DAC outputs following liftoff. Second mode bending oscillations can be observed in the angular rate data. Due to the heavy attenuation of these high frequencies by the rate and attitude feedback digital filters, the DAC output trace shows only the first mode oscillations. As opposed to most DIGS missions, the first mode oscillations were larger in yaw than pitch and were quite mild. The first bending frequency was ≃2.3 Hertz at liftoff while the predicted was 2.0 Hertz. The second mode frequency was 4.5 Hertz compared to 4.3 Hertz predicted. During vernier engine solo, starting immediately after MECO, bending transients were observed in pitch and yaw. The DAC output transients shown in Figure 4-8 include first bending mode oscillations at 4.8 Hertz versus the predicted frequency of 4.4 Hertz. Similar bending mode oscillations have been seen on prior missions and cause no problems to the control system.

4.1.2.2 Pogo Resonance

Just prior to MECO, Pogo resonance effects sensed by the rate gyros were about 2 deg/sec peak-to-peak in roll and about 1.5 deg/sec peak-to-peak in pitch and yaw (Figure 4-4). The Pogo resonant frequency was approximately 19 Hertz. Pogo resonance also occurred earlier in flight (T+140 seconds) as shown in Figure 4-9. The resonant frequency at that region of time was about 21 Hertz. Note that as expected, attitude error history of that figure show no trace of these high frequency oscillations.

4.1.2.3 Roll Limit Cycle

Roll limit cycling was observed in the attitude error, rate and vernier engine position traces from solid drop until MECO. The rate and attitude error histories of Figure 4-9 show that the oscillations were at a frequency of 0.35 Hertz. Peak-to-peak amplitudes were approximately 1.0 degree per second in rate and 0.5 degree in attitude error. The limit cycle is due to the non-linearities in the vernier engine linkage and actuator combined with DAC granularities. All past DIGS flights have exhibited this limit cycle.

4.2 SECOND STAGE

The second stage control systems maintained stability and satisfactorily controlled the vehicle throughout powered and coast phase flight.

4.2.1 Second Stage Statistical Record

Table 4-2 provides a compilation of some of the control system characteristics of this flight.

4.2.1.1 Second Stage Thrust Misalignment

At ignition, all attitude errors and body rates as well as pitch and yaw thrust misalignment for the SSPU were well within one-sigma of the mean values recorded for the TRW second stage. An increase in pitch thrust misalignment at SECO 1 over that observed at ignition was observed. However, these (as well as yaw) misalignments were less than one standard deviation from the mean values. Engine positions required to counter the disturbing moments generated by the thrust misalignment errors are shown in Figures 4-10 and 4-11 for the first ignition and cutoff times, respectively. As was done for the first stage engine, data from prior TRW missions and the mean values are also shown. Note that based on 14 samples, there exists a general tendency of increased misalignment effect at SECO compared to engine ignition.

4.2.1.2 Roll Impulse at Fairing Jettison

The roll impulse imparted to the second stage by the successful separation of the fairing was 0.99 foot-pound-seconds clockwise looking forward. The induced roll rate transient was +0.15 degree per second. This roll impulse was within one-sigma deviation from the mean value. Figure 4-12 presents the relative sequencing of roll attitude error and rate transients with roll control jet activations and triaxial accelerator excitations. Despite an apparent second excitation of the triaxial accelerometer, the lack of the usual high frequency content in this data plus the analysis of the jet actuation and body roll rate data made vehicle recontact by a fairing section doubtful.

4.2.1.3 Powered Flight Roll Moment

From the control jet actuation data, the gas impulse used to counter the external roll moments induced during second stage engine burn was 28 lb-sec. This impulse was calculated using an assumed jet on-time of 13 milliseconds for a 20 millisecond "on" signal. Shortly after ignition, a clockwise external roll moment developed. This moment changed direction at T+340 seconds and remained counterclockwise until SECO. The average roll moment was about one sigma higher than the mean for light quartz nozzle liners.

4.2.1.4 SECO Transients

Pitch and yaw switchlines with 0.5 degree deadzone were used at second engine first cutoff. In the roll axis, switchlines with a deadzone of 6.5 degrees were used. Impulse usage to reduce or maintain attitude errors within the switchlines were within one-sigma deviations from mean values for the pitch and yaw axes. The unusually large roll rate transient (1.6 deg/sec) is attributed to the absence of a rate deadzone of the spinup switchlines. The roll impulse was about two-sigma higher than the mean value for 20 data samples.

4.2.1.5 Ratio of Actual to Predicted Acceleration

The roll-pitch orientation meaneuvers for sun shielding (see Figures 4-13 and 4-14) were used to determine to actual control acceleration capability of the vehicle in the two planes. During the zeroing of the roll rate command, a two-jet, full-on condition prevailed. During this period, the roll acceleration was 3.08 deg/sec^2 which was almost exactly the predicted nominal. For a similar jet full-on period, the pitch acceleration was 0.48 deg/sec^2 (7 percent higher than the predicted nominal). The actual value calculations were based on nominal thrust and mass property conditions. These accelerations are within one-sigma deviations of the mean achieved-to-predicted acceleration ratios.

4.2.2 Coast Control System

4.2.2.1 Coast Control System Impulse Usage

Figure 4-15 shows the COS-B coast control system impulse usage as a function of time. The predicted mean and three-sigma high usage from Reference 4-1 are also shown. Actual usage was much less than that of the predicted mean through third-stage separation. The actual impulse usage (solid curve) was computed by using the combination of observing the achieved body rates (PCM data), NTOT (software data of total jet firing counts) and nitrogen bottle pressure data. The primary source of the difference is the much lower gas actually used for the convergence to the fine switchlines at SECO 1 and for the coast guidance periods. Predictions assumed ultra conservative rate commands corresponding to the pitch and yaw rate ledges for these events.

4.2.2.2 Coast Control Limit Cycling

Periods of coast control limit cycling was observed at various times of flight. Closed loop limit cycles just prior to stage II-III separation were present in the pitch and yaw axes. The frequencies of the limit cycles were about 0.07 Hertz. Open loop (without guidance) limit cycles developed shortly after the second burn of the second stage engine. These frequencies appeared to be more than an order of magnitude lower (0.003 Hertz) than those with guidance.

4.2.2.3 Pogo Resonance

On COS-B, the propulsion fuel manifold system was of a modified configuration. About 150 seconds after second stage engine ignition, pogo resonance started to develop. By T+425 seconds, the resonance grew to 1 deg/sec peak-to-peak in yaw and roll whereas in the pitch axis, the magnitude was about 2 deg/sec. The frequency initially was about 100 Hertz and increased with time to 130 Hertz. From F/M data, peak magnitudes were observed when the resonance was at 125 Hertz.

Figure 4-16 shows the effects of foldback due to the difference between the increasing pogo resonant frequencies and the telemetry data sampling rate of 25 per second. Note that, as expected, none of the high frequency oscillations are observable in the filtered attitude error data of Figure 4-17. The resonance did not hamper satisfactory second stage operation and subsequent successful mission completion.

4.2.2.4 Third-Stage Separation Transients

Angular rate and attitude error transients were observed in all axes following third stage spinup and separation (Figures 4-18 and 4-19). The roll transients are due to: (1) the impulse required to break the spin table retention cord, (2) the roll-control-moment correction effect, and (3) the spin table bearing friction. This friction increases when the spin table petals fully open at the height of the spin and the crush blocks make contact with the spin rockets. The shock of the contact and of the detonation of the separation bolts cause the pitch and yaw transients shown on the figures. Also shown in the figures are rate and attitude error transients resulting from impingement effects due to third stage engine ignition.

The spin rate was 47.1 rpm versus the predicted 45.7 rpm. To counter the disturbing moments and suppress the separation transients, a total gas impulse of 73 pound-seconds was used. The above transients and gas usage were similar to those achieved on prior missions and caused no problem to the control system.

4.2.2.5 Experimental Restart

An experimental restart of the second stage engine was performed. Data dropout during most of this flight period made a thorough analysis impossible. This burn commenced after about 16 seconds of ullaging and continued on to fuel depletion about 29 seconds later. One cycle of an oxidizer tank sloshing oscillation occurring just prior to SECO 2 was observed. The oscillation frequency was about 1.5 Hertz (predicted was 1.4 Hertz). Oscillations like these for the
ated second stage in the powered flight mode were observed on prior
ons and are not detrimental to the satisfactory performance of restart

guidance. After SECO 2, the desired switchover to pitch and yaw bang-bang control was clearly evident from flight data. The SECO 2 transients of the depletion burn were relatively mild. A gas impulse usage of 2.3 lb-sec was spent during the burn for control moment purposes.

TABLE 4-1

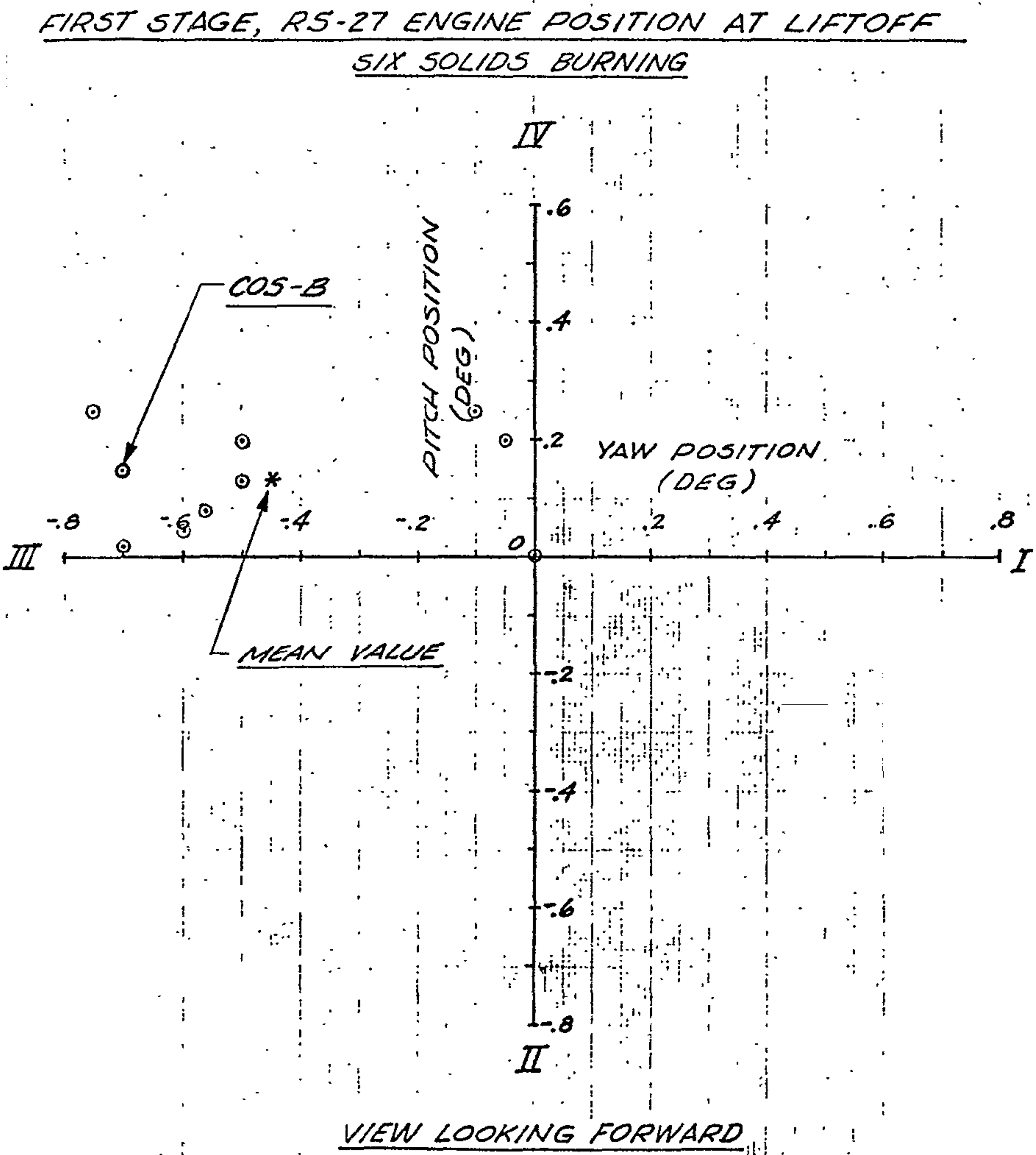
FIRST STAGE CONTROL SYSTEM PARAMETERS

COS-B

PARAMETER	TIME OF FLIGHT	VALUE			MEAN	STANDARD DEVIATION	SAMPLE NUMBER
Thrust Misalignment	Liftoff	Pitch	-.15	deg	-.13	.09	10
		Yaw	.70	deg	.45	.29	10
Thrust Misalignment	MECO	Pitch	.18	deg	.16	.09	11
		Yaw	.54	deg	.38	.20	11
Peak Attitude Error	Maximum Aero Moment Region	Pitch	.85	deg	.12	.87	13
		Yaw	1.0	deg	.24	.86	13
		Roll	.62	deg	.20	.58	10
Peak Rate		Pitch	-1.2	deg/sec	-1.1	.16	13
		Yaw	.95	deg/sec	.10	.64	13
		Roll	.8	deg/sec	.36	.45	10
Peak Engine Deflection		Pitch	-1.15	deg	1.5	1.4	13
		Yaw	-1.47	deg	-.13	1.6	13
		Roll	8.4	deg	-3.1	11.6	10
Equivalent Roll Moment (External)	Liftoff		242	ft-lb	59	252	17
	Max Q		-959	ft-lb	209	1315	9
	MECO		210	ft-lb	192	121	13
	Vern. Solo		55	ft-lb	14	174	13
Peak Vernier Engine Deflection	Vernier Solo	Pitch	-.18	deg	1.7	2.1	12
		Yaw	-11	deg	-14.6	5.5	12
		Roll	-3.8	deg	.61	2.1	13
Maximum Guidance Rate Command	Guidance Initiation	Pitch	-.75	deg/sec	-.78	.31	13
		Yaw	-.20	deg/sec	-.0022	.24	13
Attitude Error	MECO Plus 8 Sec (Before Separation)	Pitch	0	deg	.0073	.043	15
		Yaw	0	deg	.021	.030	15
		Roll	.35	deg	.058	.30	15
Rate		Pitch	0	deg/sec	-.0003	.0090	15
		Yaw	0	deg/sec	-.0007	.0026	15
		Roll	.15	deg/sec	-.043	.18	15
Rate Change Due To Separation	First-Second Separation	Pitch	.02	deg/sec	.0085	.056	15
		Yaw	.05	deg/sec	.00053	.070	15
		Roll	0	deg/sec	.011	.18	15

FORM 25 BP (REV 3 54)

PREPARED BY
CHECKED BY 4/5/76
DATE 6-26-74 (REV. B 3-18-75)
TITLE 3 FEB 76



NOTE: ENGINE POSITION IS PLOTTED; THRUST MISALIGNMENT IS OPPOSITE IN SIGN.

FIGURE 4-1

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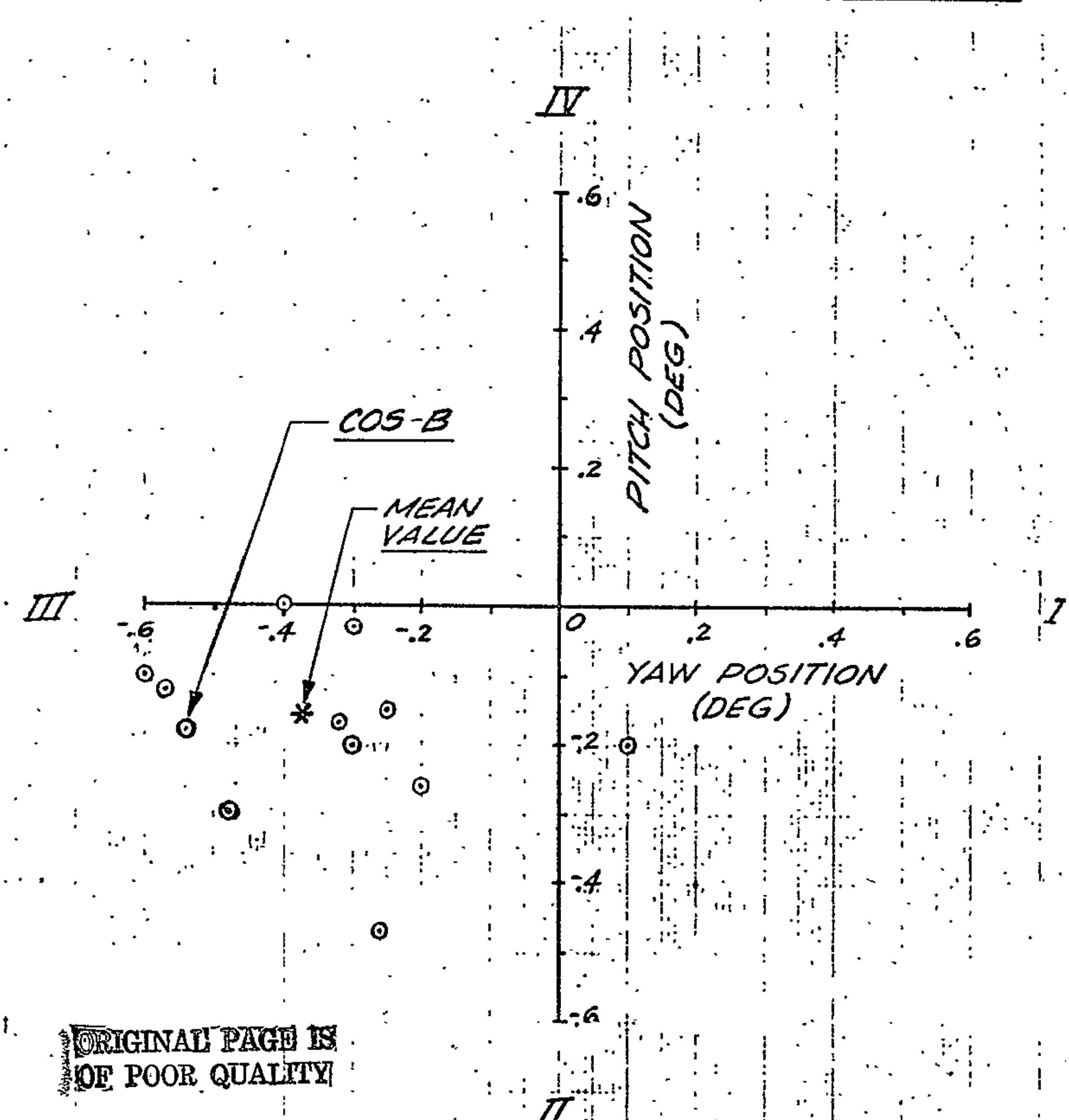
(REV 3-54)

PREPARED BY: [illegible]
CHECKED BY: [illegible] 3/5/76
DATE 6-26-74 (REV. B 3-18-75)
TITLE 3 FEB 76

FIRST STAGE, RS-27 ENGINE POSITION AT MECO



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NOTE: ENGINE POSITION IS PLOTTED; THRUST MISALIGNMENT IS OPPOSITE IN SIGN.

FIGURE 4-2

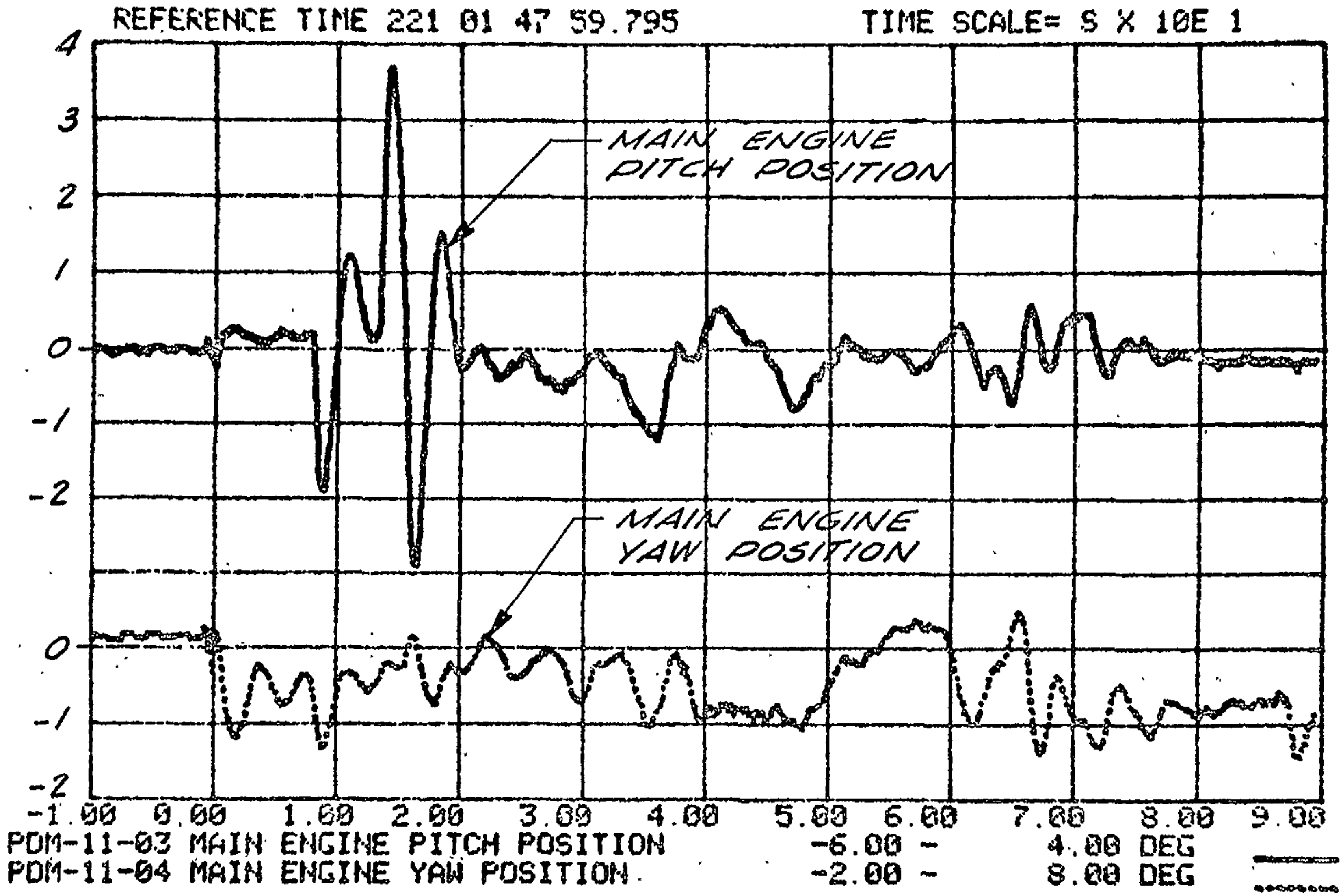


FIGURE 4-3

MAIN ENGINE POSITIONS AT LIFTOFF

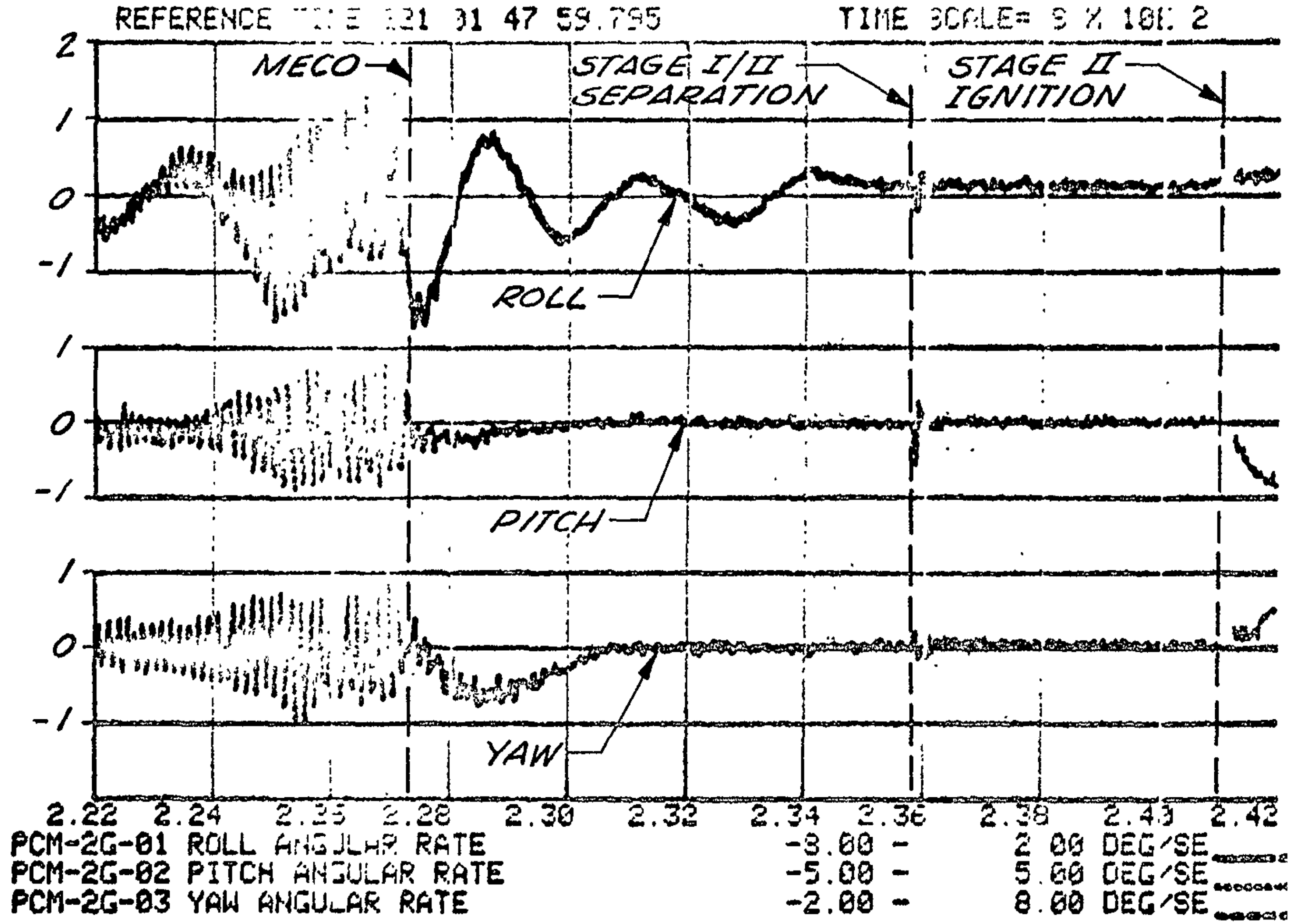
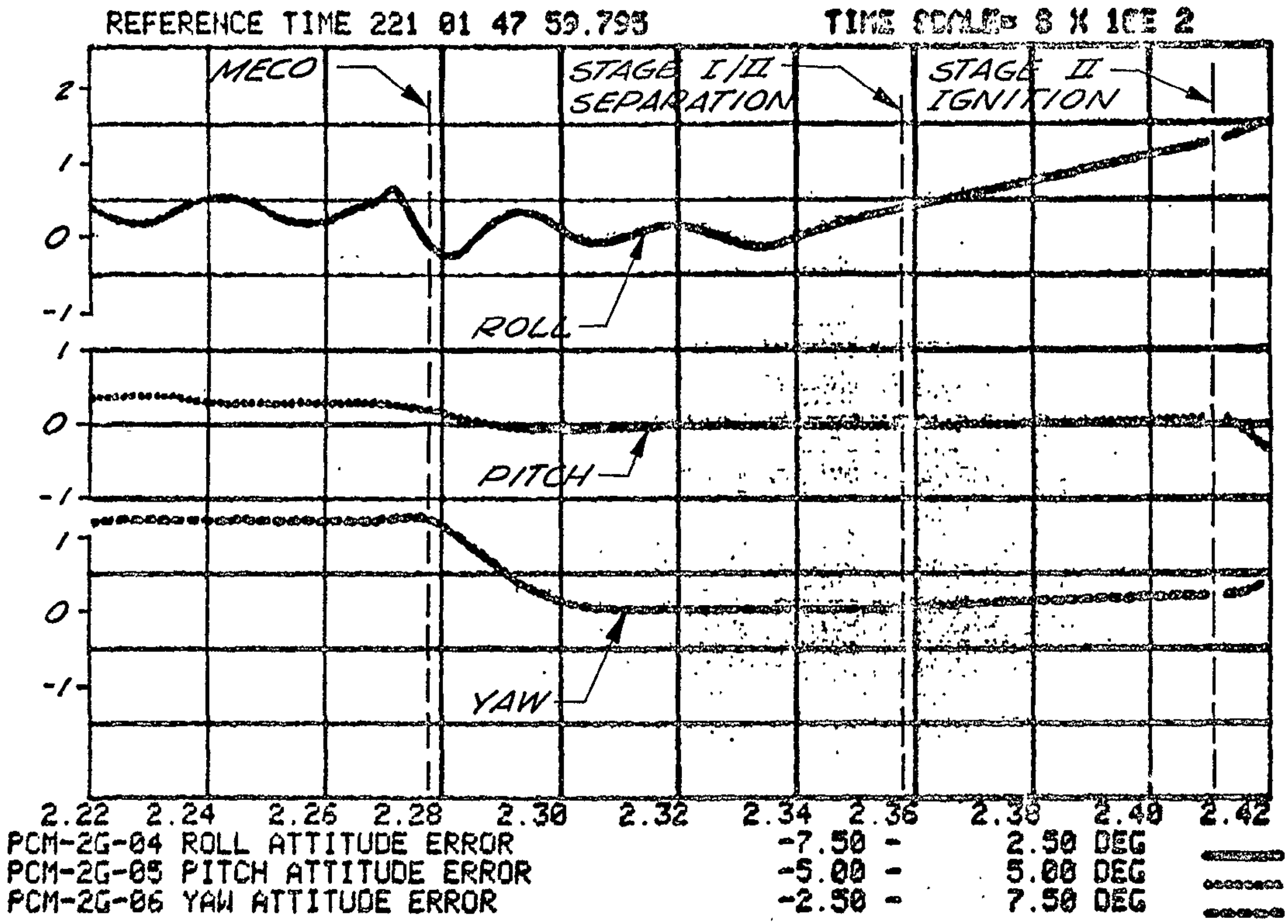


FIGURE 4-4

ANGULAR RATES FROM MECO TO STAGE II IGNITION



ATTITUDE ERRORS FROM MECO TO STAGE II IGNITION

FIGURE 4-5

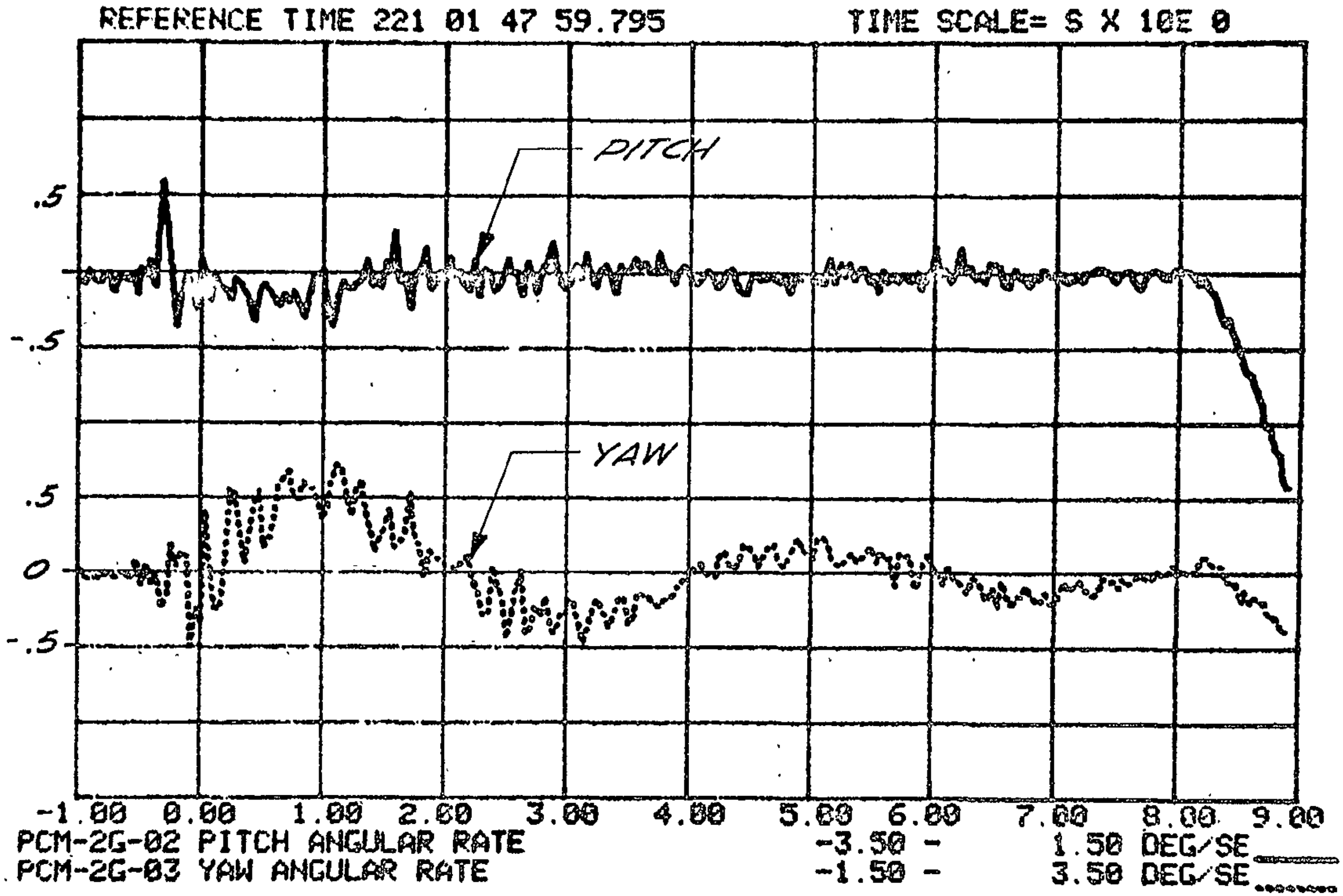
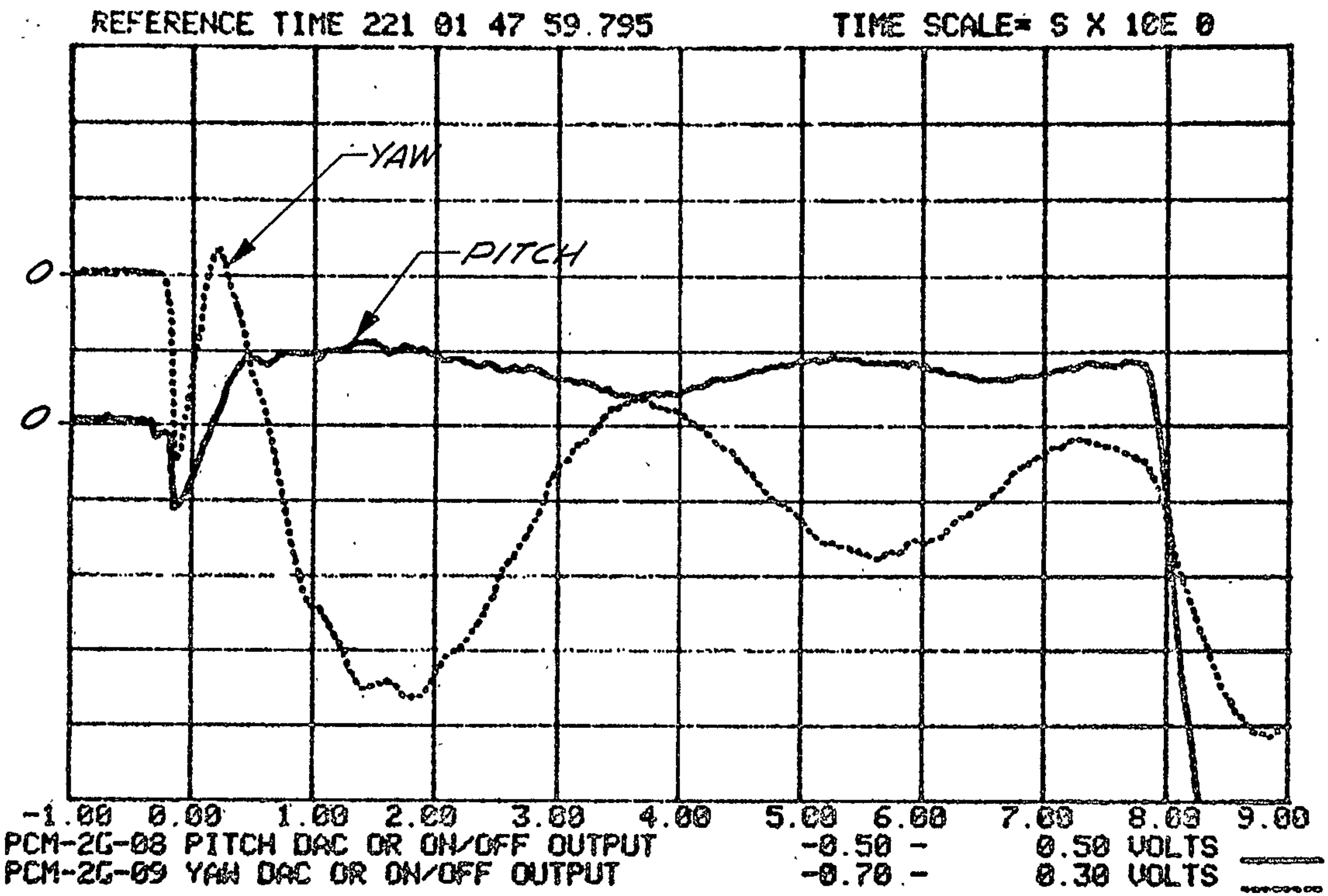


FIGURE 4-6

ANGULAR RATES AT LIFTOFF



DAC OUTPUTS AT LIFTOFF

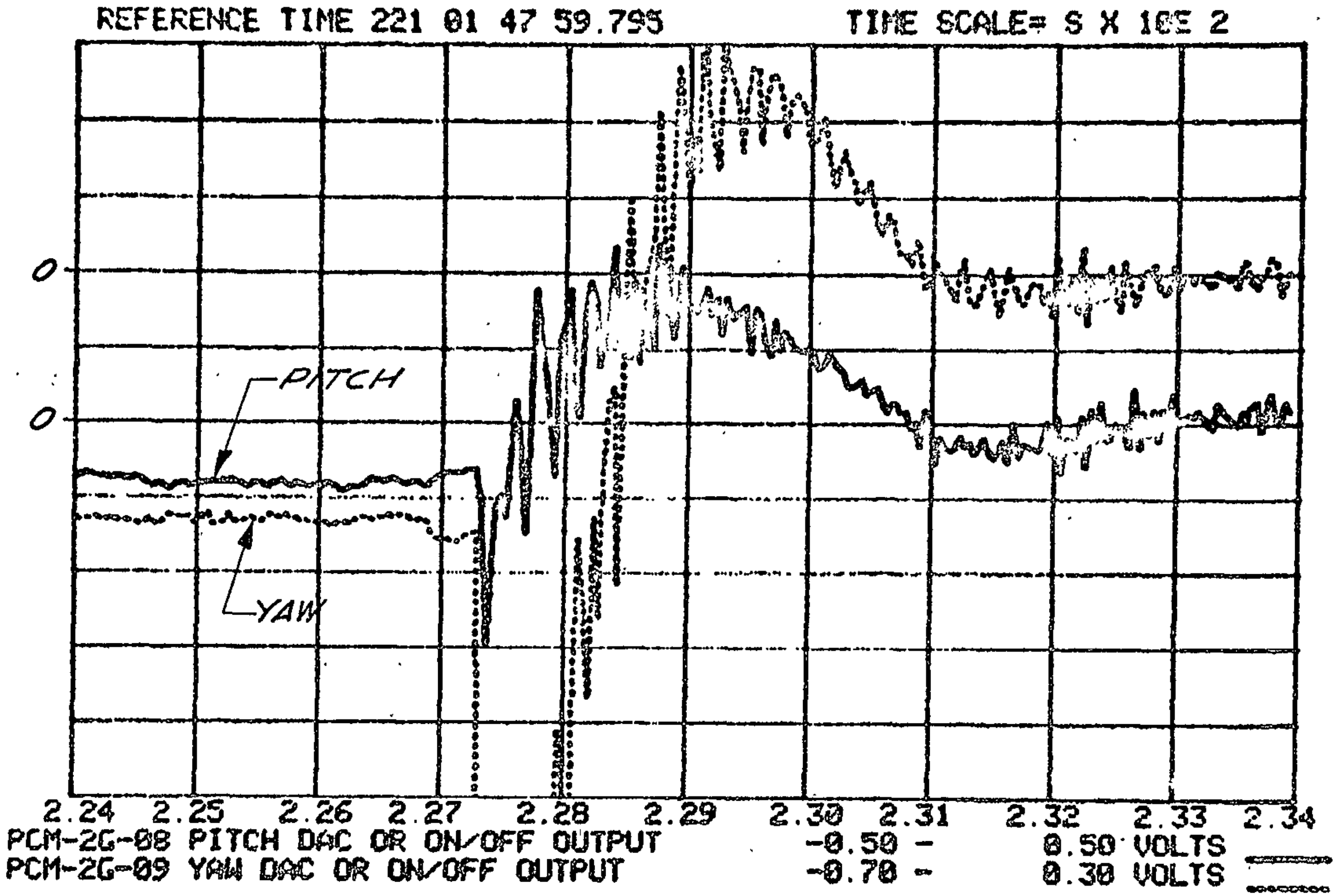
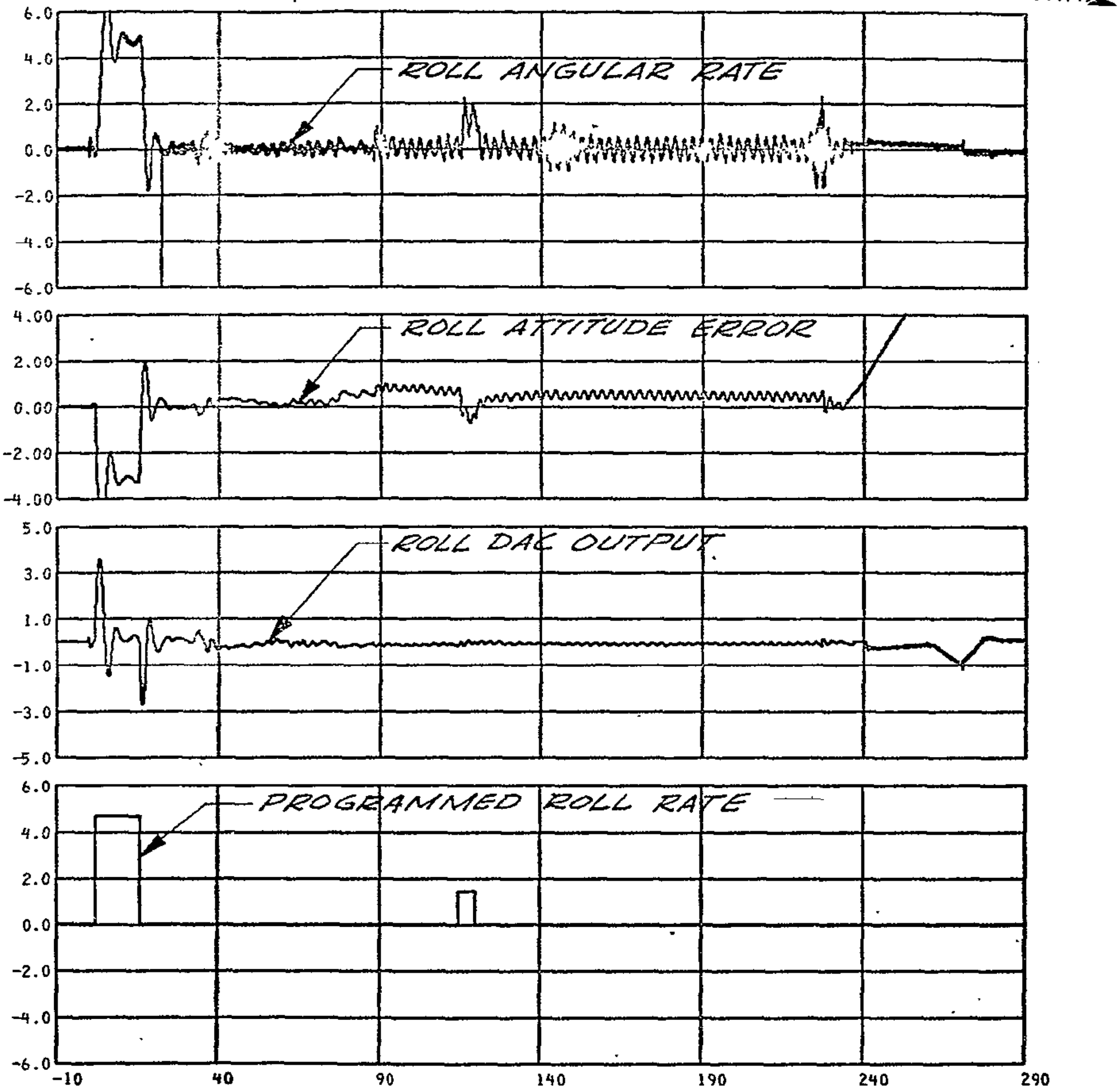


FIGURE 4-8

DAC OUTPUTS AT MECO

TEST ID 046619 880100 COS-B VAFB PLOT NO G600 REFERENCE TIME 01 47 59.795



MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PCM-2G-01	1-01S	ROLL ANGULAR RATE	-43.0 TO 43.0	DEG/SEC	A
PCM-2G-04	1-04S	ROLL ATTITUDE ERROR	-30.1 TO 30.1	DEG	B
PCM-2G-07	1-07S	ROLL DAC OR ON/OFF OUTPUT	-10.1 TO 10.1	VOLTS	C
PCM-2G-17	1-17	PROGRAMMED ROLL RATE	-30.1 TO 30.1	DEG/SEC	D

ROLL AXIS PARAMETERS DURING FIRST STAGE FLIGHT

FIGURE 4-9

TABLE 4-2

SECOND STAGE CONTROL SYSTEM PARAMETERS
COS-B

PARAMETER	TIME OF FLIGHT	VALUE			MEAN	STANDARD DEVIATION	SAMPLE NUMBER
Attitude Error	Second Stage	Pitch	.10	deg	.69	1.1	14
		Yaw	.20	deg	.06	.21	14
		Roll	1.25	deg	.05	.72	14
Rate	First Ignition	Pitch	0	deg/sec	.26	.38	14
		Yaw	0	deg/sec	.00	.12	14
		Roll	.15	deg/sec	.00	.09	14
Thrust Misalignment	Second Stage First Ignition	Pitch	-.28	deg	-.30	.15	14
		Yaw	.33	deg	.34	.079	14
Thrust Misalignment	SECO 1	Pitch	-.40	deg	-.42	.18	14
		Yaw	.33	deg	.41	.10	14
Roll Impulse	Fairing Jettison		.99	ft-lb-sec	-.71	3.28	12
Average External Roll Moment	Powered Flight		-.32	ft-lb	-.15	.17	8
Average External Roll Moment]	Powered Flight		.32	ft-lb	.21	.11	8
Roll Gas Usage	Powered Flight		13.1	lb-sec / 100 sec	7.7	4.1	8
SECO Impulse	SECO	SECO #	1 / 2 / 3		1 / 2	1 / 2	
		Pitch	7.3 / - / -	lb-sec	14.2 / -	10.2 / -	11
		Yaw	3.2 / - / -	lb-sec	8.9 / -	5.7 / -	11
		Roll	3.7 / - / -	lb-sec	1.4 / -	1.2 / -	20
Ullage Moment Disturbance Impulse	Prior to Restart		N/A	lb-sec / sec	-	-	-
Ratio of Actual to Predicted Angular Acceleration	Coast Phase	Pitch	1.07	N.D.	1.1	.13	15
		Yaw	-		-	-	-
		Roll	.99		1.1	.045	8

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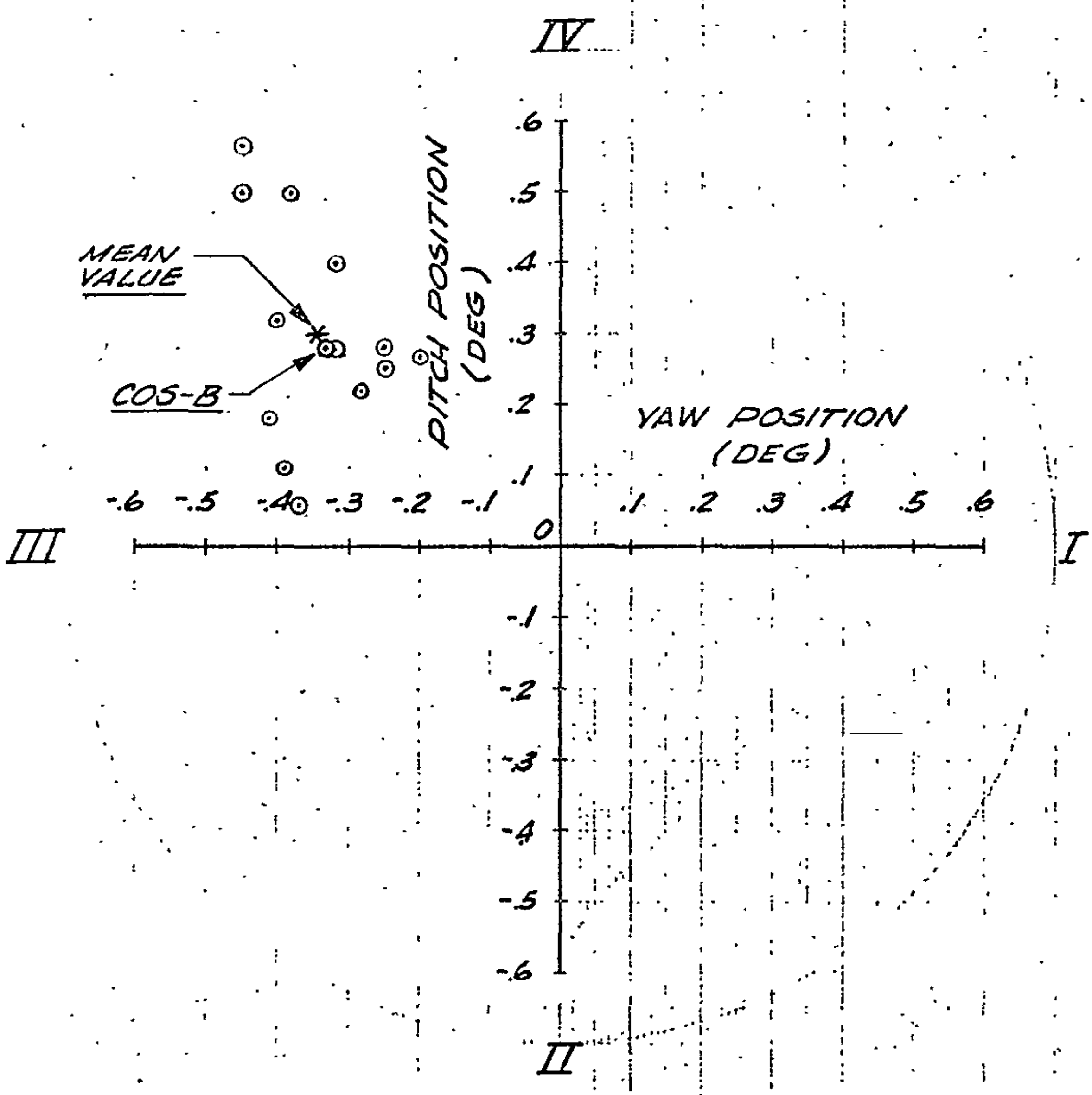
FORM 25-BP
(REV 3 54)

SECOND STAGE (TRW SSPU) ENGINE POSITION AT IGNITION #1



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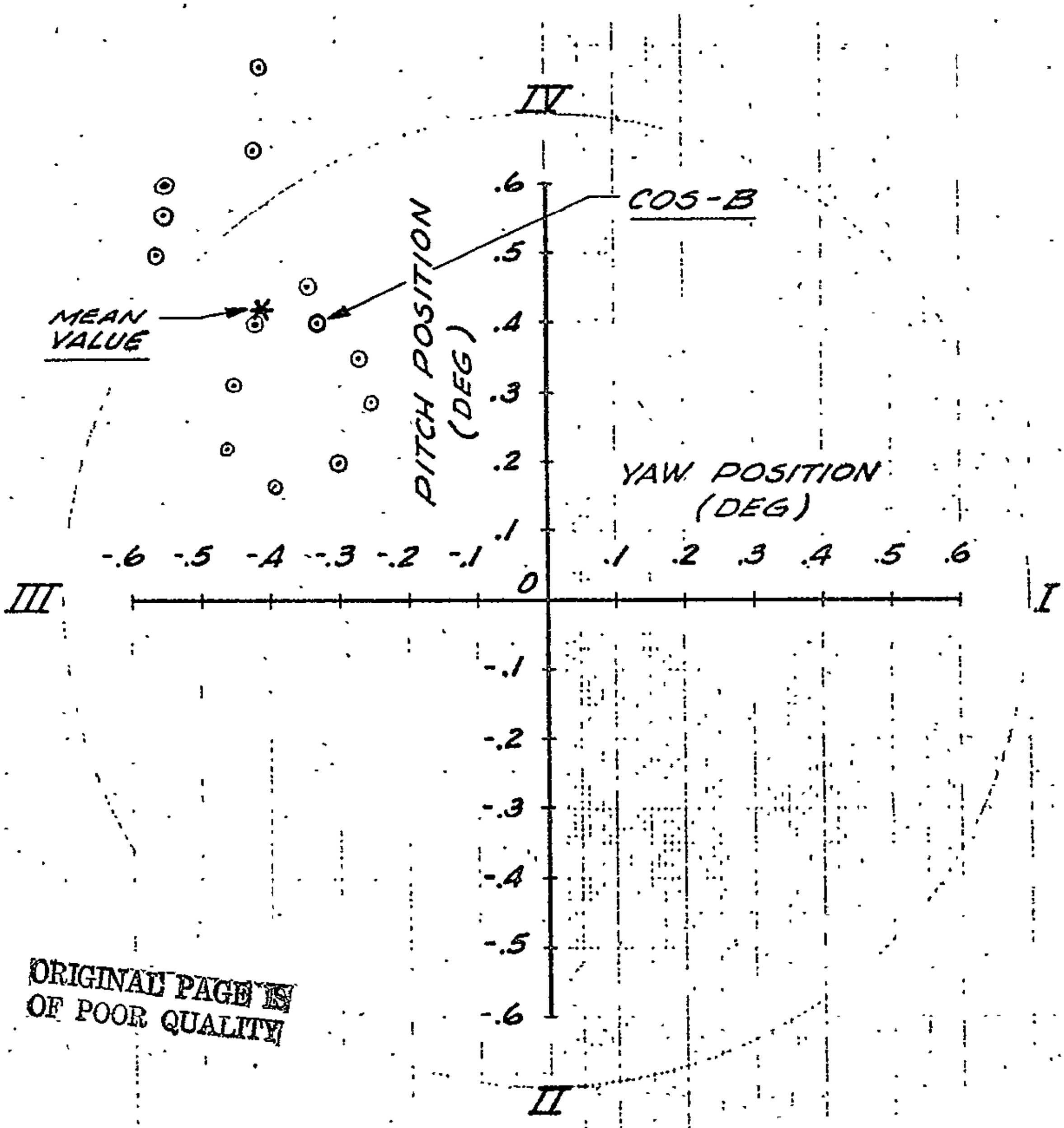
NOTE: ENGINE POSITION IS PLOTTED; THRUST MISALIGNMENT IS OPPOSITE IN SIGN.

FIGURE 4-10

SECOND STAGE (TRW SSPU) ENGINE POSITION AT SECO #1



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NOTE: ENGINE POSITION IS PLOTTED; THRUST MISALIGNMENT IS OPPOSITE IN SIGN.

FIGURE 4-11

COS-B ROLL RESPONSE AT FAIRING SEPARATION

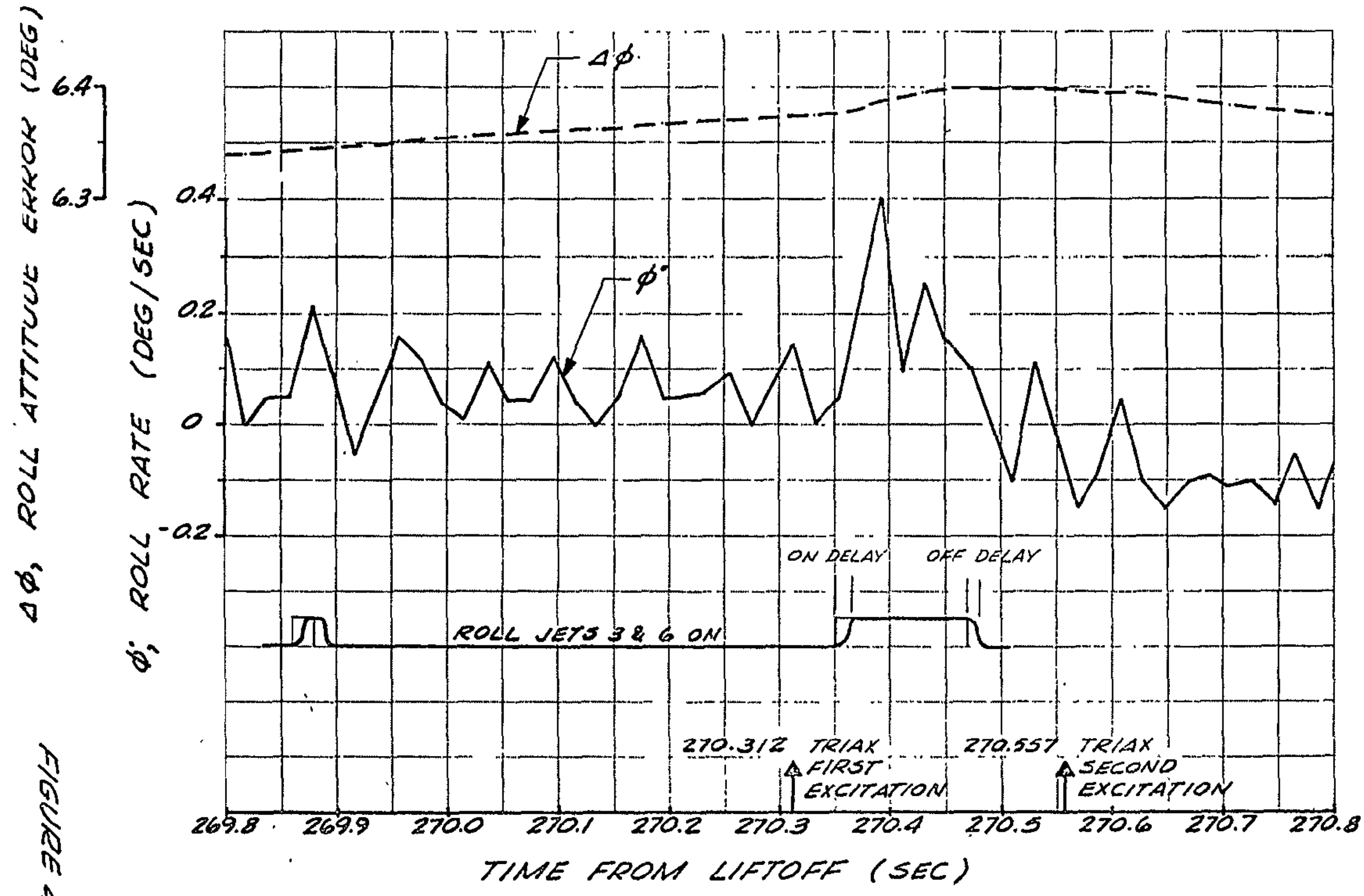

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FIGURE 4-12

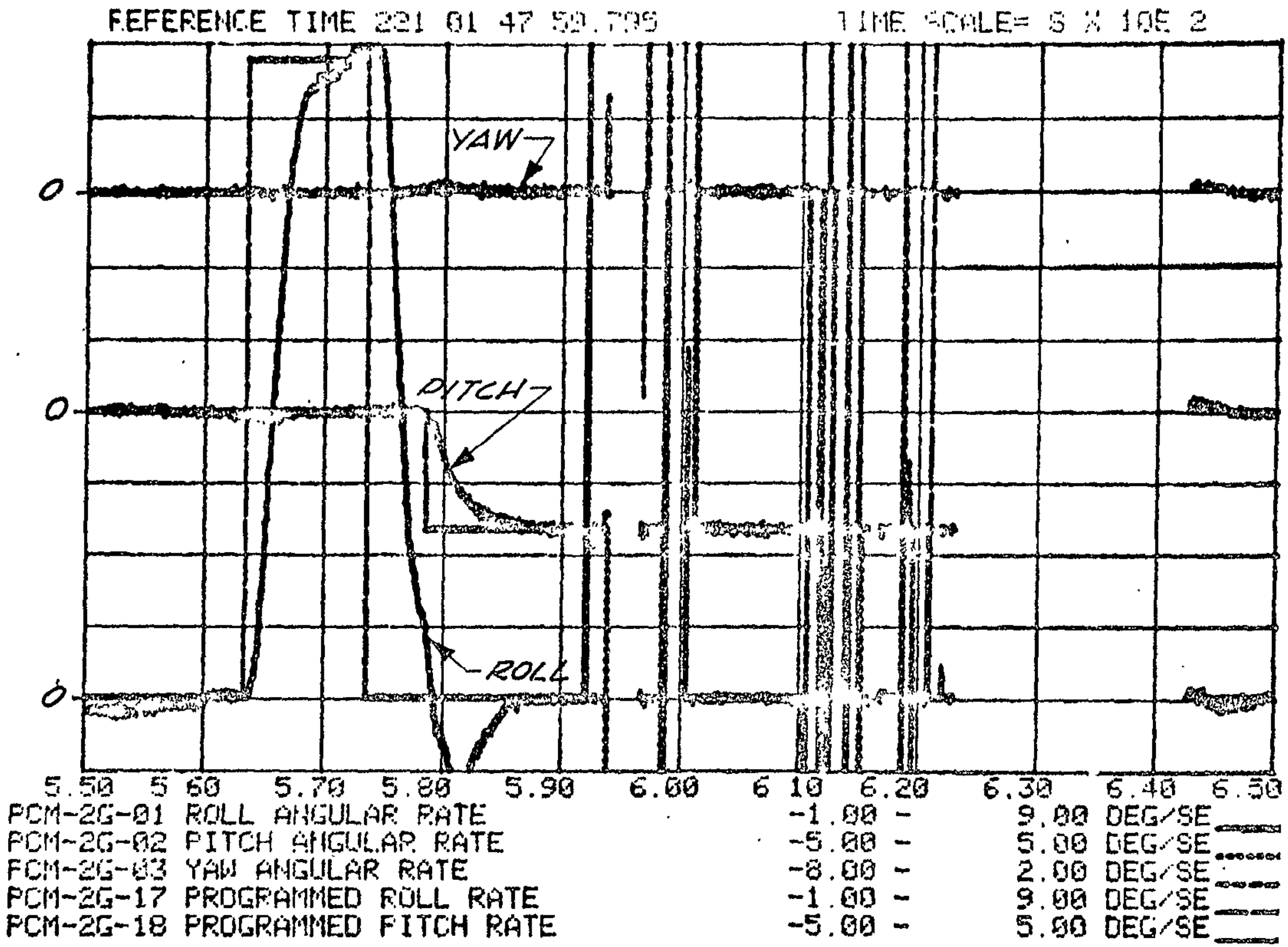

FIGURE 4-13

ANGULAR RATES DURING SUN SHIELDING MANEUVERS

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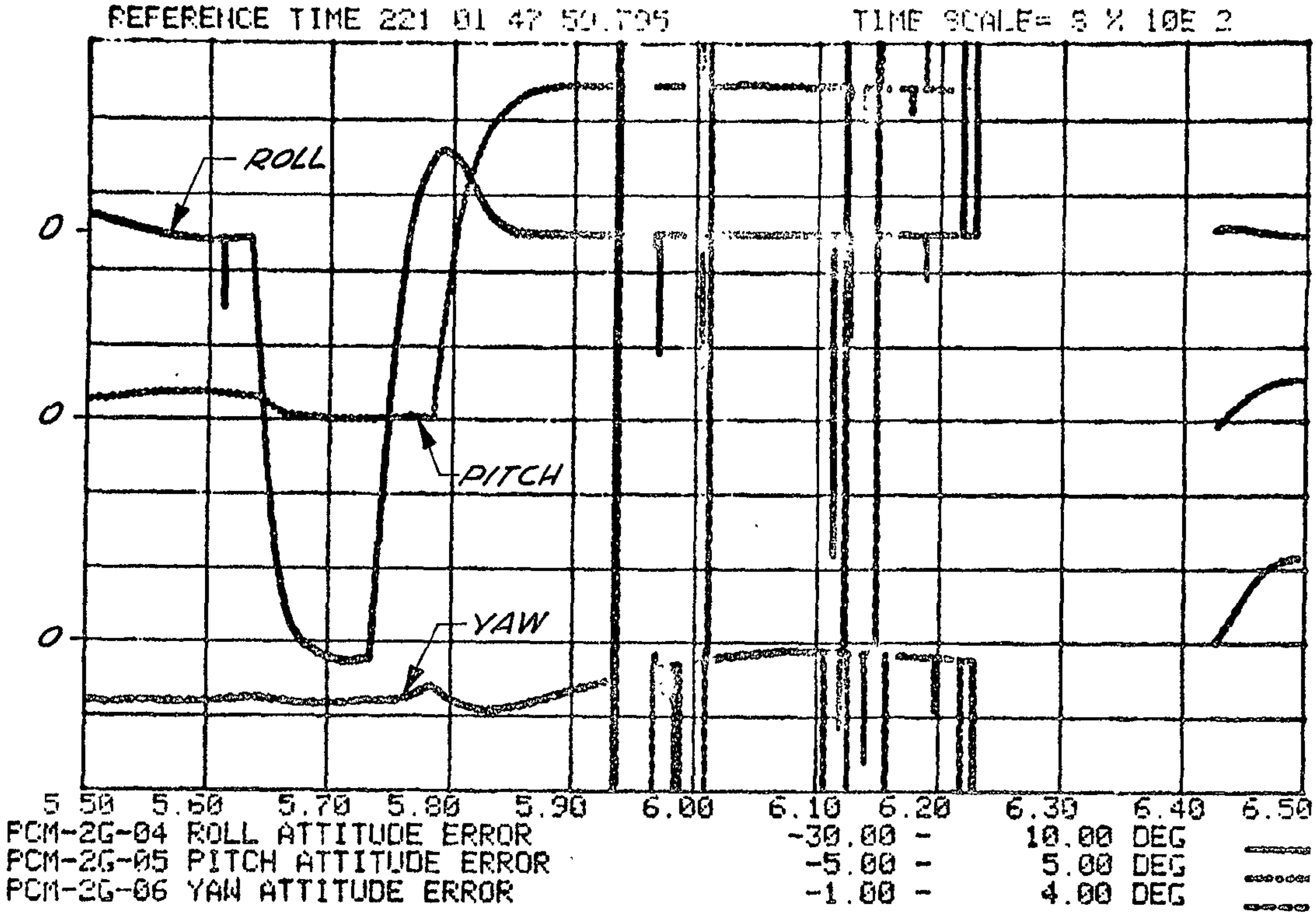


ATTITUDE ERRORS DURING SUN SHIELDING MANEUVERS

FIGURE 4-14

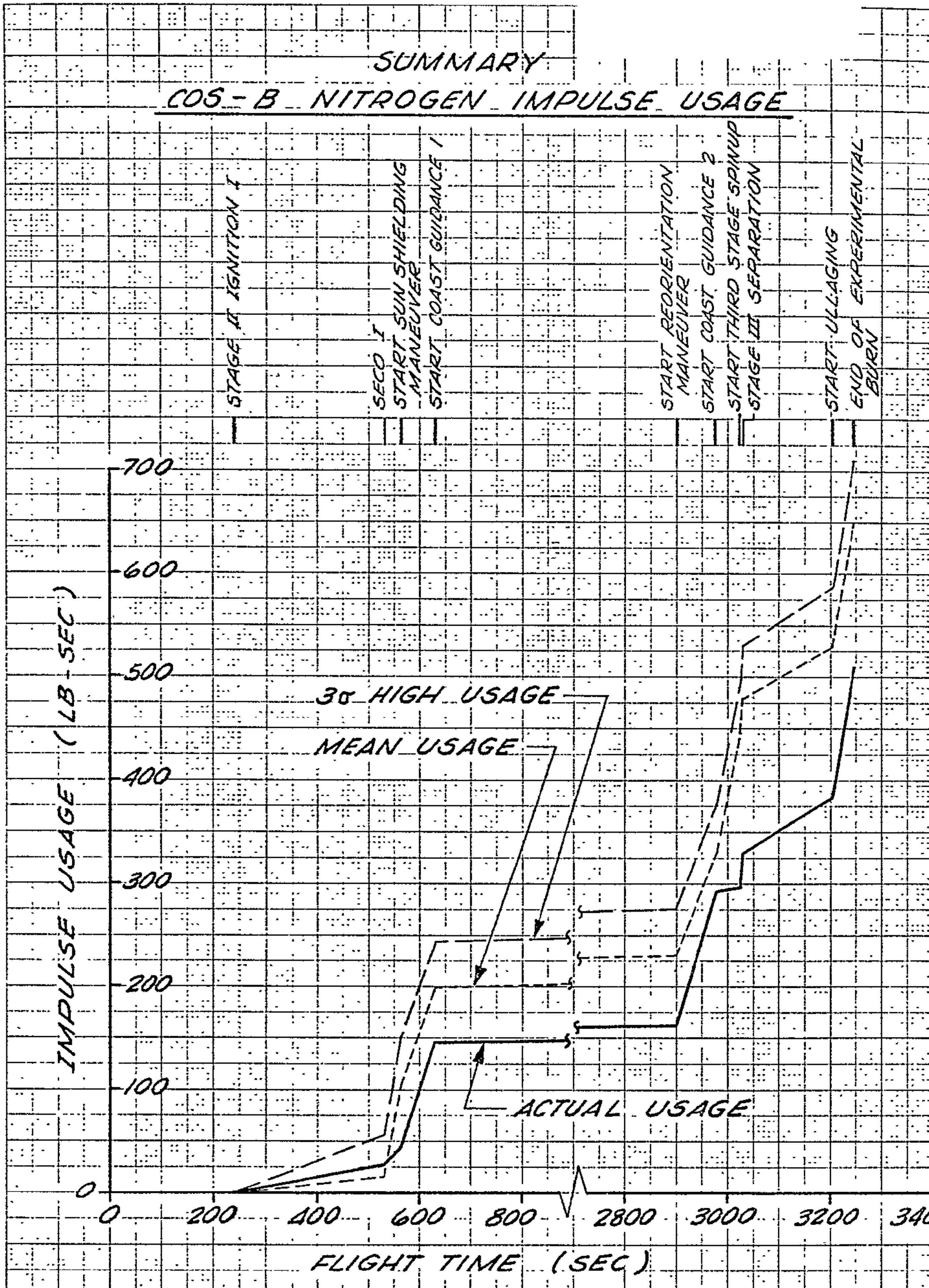

SUMMARY
COS-B NITROGEN IMPULSE USAGE
STAGE II IGNITION I
SECO I
START SUN SHIELDING MANEUVER
START COAST GUIDANCE 1
START REORIENTATION MANEUVER
START COAST GUIDANCE 2
START THIRD STAGE SPINUP
STAGE III SEPARATION
START ULLAGING
END OF EXPERIMENTAL BURN
IMPULSE USAGE (LB-SEC)
0
100
200
300
400
500
600
700
3σ HIGH USAGE
MEAN USAGE
ACTUAL USAGE
0
200
400
600
800
2800
3000
3200
3400
FLIGHT TIME (SEC)
F VENTURA
5 FEB 76

FIGURE 4-15

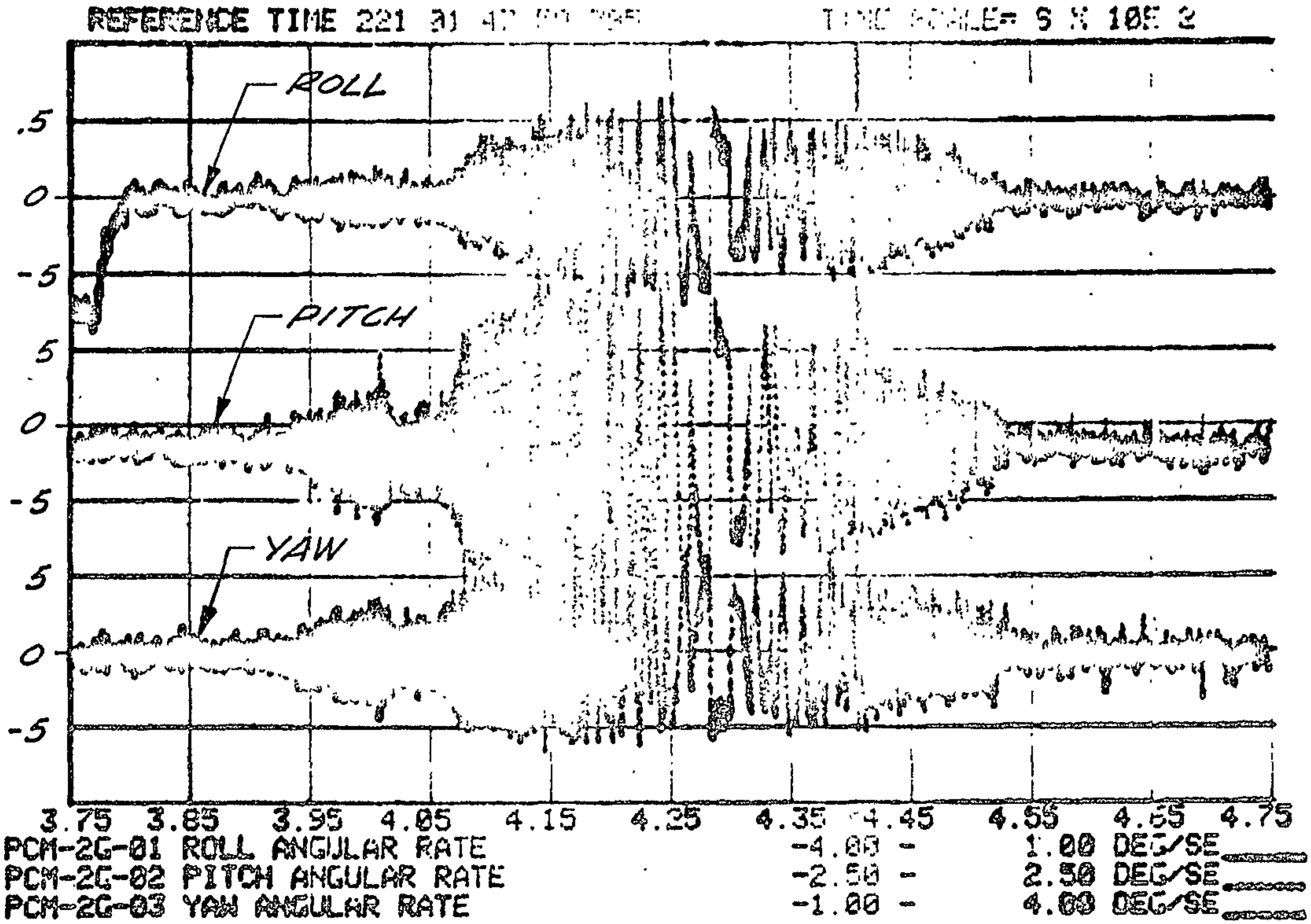


FIGURE 4-16

ANGULAR RATES DURING SECOND STAGE POWERED FLIGHT

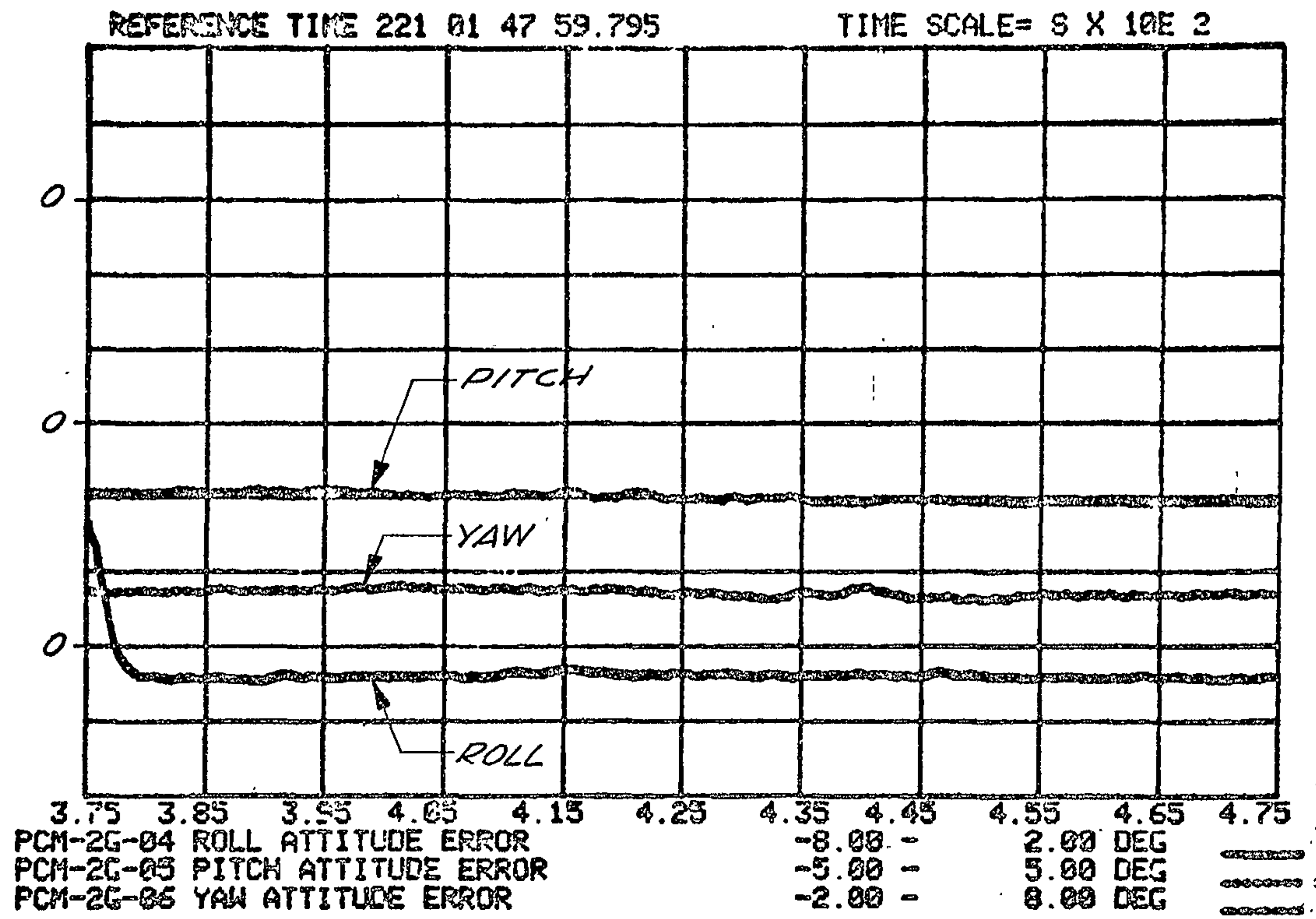
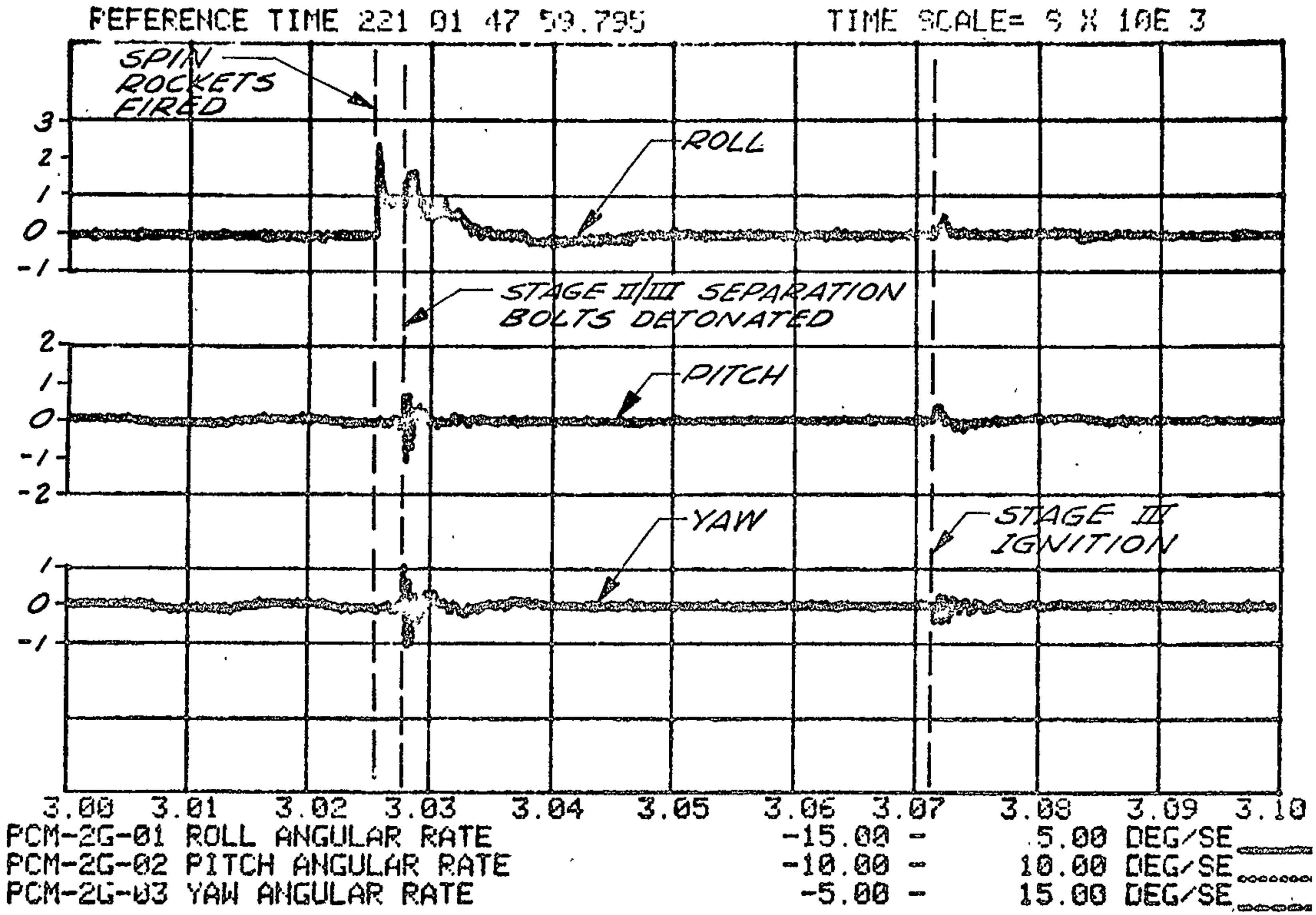


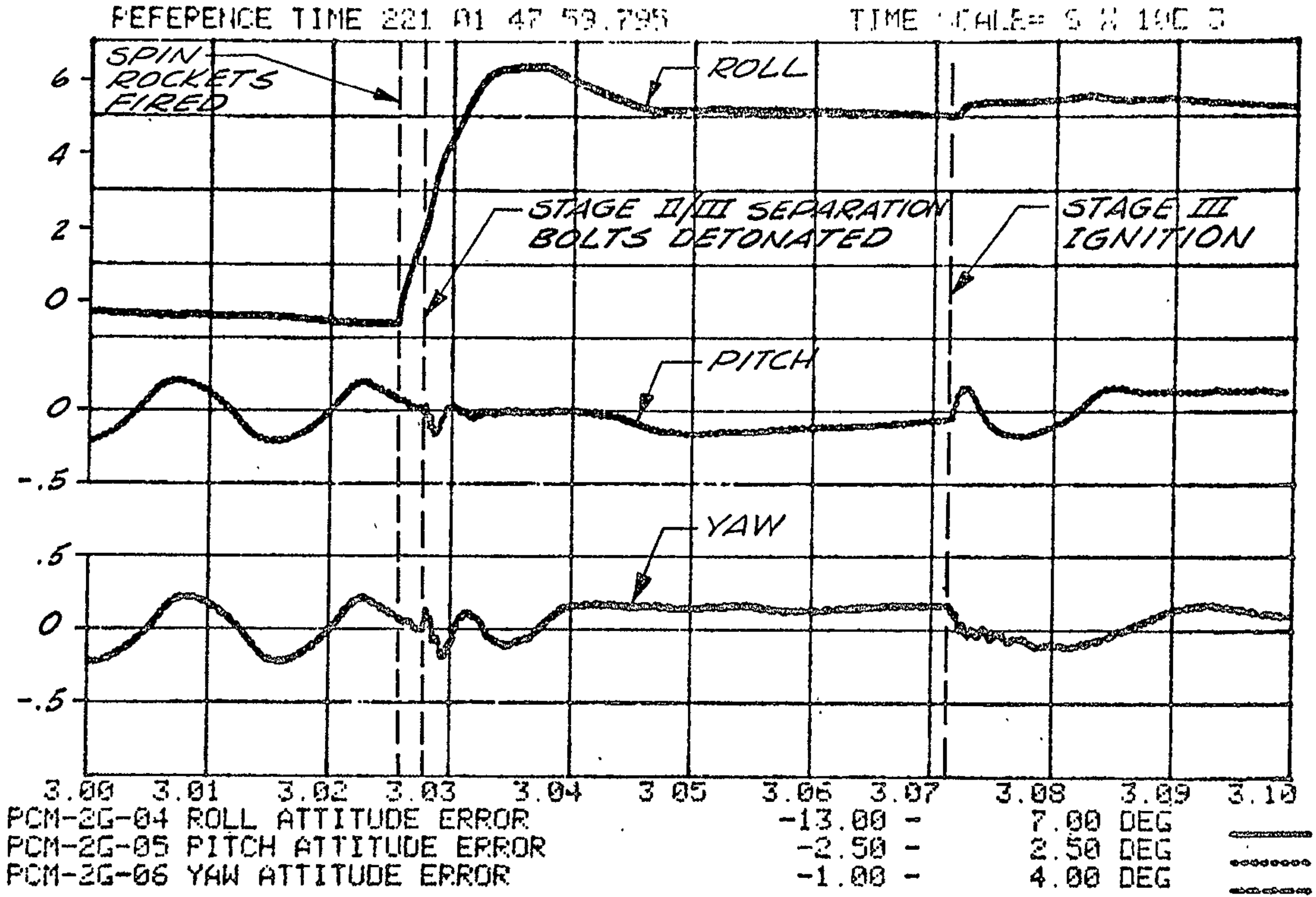
FIGURE 4-17

ATTITUDE ERRORS DURING SECOND STAGE POWERED FLIGHT



ANGULAR RATES AT STAGE II/III SEPARATION

FIGURE 4-18



ATTITUDE ERRORS AT STAGE II/III SEPARATION

FIGURE 4-19

ATTACHMENT 5:

SECTION 5: ELECTRONICS SYSTEM - COS-B MISSION

SECTION 5

ELECTRONICS SYSTEM - COS-B

5.1 FIRST STAGE PERFORMANCE

The first stage event times for the COS-B flight are tabulated in Table 5-1 and are satisfactory. The first stage electronics system voltages are tabulated in Table 5-2 and are normal. The first stage electronics system performed normally throughout the period of first stage operation except for the instrumentation anomaly indicated in subsection 5.3

5.2 SECOND STAGE PERFORMANCE

The second stage event times for the COS-B flight are tabulated in Table 5-1 and are satisfactory. Second stage electronics system voltages and steady-state parameters are listed in Table 5-3 and are normal. Table 5-4 tabulates sequence times obtained from PCM data which indicates the guidance computer discrete output activity. The second stage electronics system performed normally throughout the flight except for the instrumentation anomaly indicated in subsection 5.3

5.3 ANOMALIES

5.3.1 First Stage LOX Pump Inlet Pressure - FM11-09

The LOX pump inlet pressure transducer returned data until approximately 75 seconds at which time the unit failed. The transducer is located in the LOX pump inlet elbow and has repeatedly failed in this position. Due to the repeated failures in this position, a change has been implemented to relocate the transducer to the LOX Accumulator for all vehicles. The relocation did not carry COS-B effectivity.

5.3.2 Second Stage Thrust Chamber Pressure - FM21-09

The Second Stage Chamber Pressure measurement indicated a 50 second duration pressure transient beginning approximately 25 seconds after second stage ignition. Analysis of other propulsion parameters revealed that the chamber pressure could not respond as the data indicates. Analysis indicates that the transducer is probably being affected by a thermal gradient.

TABLE 5-1

SEQUENCE OF EVENTS - COS-B

EVENT	NOMINAL TIME	ACTUAL TIME #	SYSTEM RESPONSE TIME #	SYSTEM RESPONSE PARAMETER
IGNITION ARM, SETS #2 & #3	-0.900	-1.14	N/A	N/A
IGNITION CMD. SETS #2 & #3	-0.200	-0.38	-0.35	CHAMBER PRESS.
TM LIFTOFF IND.	-------	-0.18	N/A	N/A
ACCEL. SENSE	0.000	-0.199	N/A	N/A
FEEDBACK GAIN CHANGE	38.000	37.84	N/A	N/A
IGNITION, SET #1	39.000	38.97	39.07	CHAMBER PRESS.
SEP. CMD, SET #1	87.000	87.34	87.39	CHAMBER PRESS.
SEP. CMD, SET #2	87.000	87.34	87.37	CHAMBER PRESS.
SEP. CMD, SET #3	87.000	87.33	87.37	CHAMBER PRESS.
FUEL FLOAT SWITCH	-------	217.555	N/A	N/A
LOX FLOAT SWITCH	-------	220.285	N/A	N/A
MECO ENABLE	224.061	222.32	N/A	N/A
FUEL LEVEL SENSOR ENABLE	224.061	222.305	N/A	N/A

TABLE 5-1 (Continued)

SEQUENCE OF EVENTS - COS-B

EVENT	NOMINAL TIME	ACTUAL TIME #	SYSTEM RESPONSE TIME #	SYSTEM RESPONSE PARAMETER
MECO	228.061	226.835	*	ME CHAM. PRESS.
DECEL. SENSE	##	227.281	N/A	N/A
VE ENABLE/ME LOCKOUT	##	227.31	227.35	ME POSITION
ARM STAGE II BUS	##	227.33	N/A	N/A
PRESS TANKS-ON	230.061	229.83	229.86	HEL. REG. PRESS.
VECO	234.061	233.805	233.94	CHAMBER PRESS.
STAGE I/II SEP.	236.061	235.83	235.88	RELAY DEACT.
REMOVE SEP. DISCRETES	240.061	239.85	N/A	N/A
START STAGE II	241.061	240.811	241.101	CHAMBER PRESS.
ACCEL SENSE	##	241.181	N/A	N/A
FAIRING UNLATCH	270.000	269.33	N/A	N/A
FAIRING SEPARATION	271.000	270.35	270.35	SEP. MONITOR CKT.
FAIRING UNLATCH OFF	271.000	270.32	N/A	N/A
FAIRING SEP. OFF	273.000	272.34	N/A	N/A

TABLE 5-1 (Continued)

SEQUENCE OF EVENTS - COS-B

EVENT	NOMINAL TIME	ACTUAL TIME #	SYSTEM RESPONSE TIME #	SYSTEM RESPONSE PARAMETER
SECO I	531.075	530.563	530.723	CHAMBER PRESS.
DECEL SENSE	##	530.873	N/A	N/A
HYD. PUMP OFF	##	530.92	531.14	HYD. SYS. PRESS.
CDR OFF	592.075	N/A	590.32	CDR AGC
SPIN ROCKETS/3RD STAGE IGNITION T.D.	3027.000	3025.30	3025.764	SPIN RATE SWITCH
3RD STAGE WIRE CUTTERS	3028.000	3026.29	N/A	N/A
SPIN ROCKET CMD OFF	3028.000	3026.29	3026.29	ENG. BATT. CUR.
WIRE CUTTER CMD OFF	3029.000	3027.33	N/A	N/A
STAGE II/III SEP.	3029.000	3027.32	3027.294Δ	TRIAXIAL ACCEL.
FIRE RETROS	3029.000	3027.29	3027.31	HEL. REG. PRESS.
REMOVE SEP. DISCRETE	3031.000	3029.30	N/A	N/A
RETRO CMD OFF	3031.000	3029.32	N/A	N/A
HYD PUMP ON	3199.000	LOS	LOS	HYD. SYS. PRESS.
INIT. ULLAGE JETS	3205.000	3203.32	3203.31Δ	N_2 REG. PRESS.
ENGINE RESTART I	3220.000	LOS	LOS	CHAMBER PRESS.

TABLE 5-1 (Continued)

SEQUENCE OF EVENTS - COS-B

EVENT	NOMINAL TIME	ACTUAL TIME #	SYSTEM RESPONSE	
			TIME #	PARAMETER
ACCEL SENSE	##	LOS	N/A	N/A
ULLAGE JETS OFF	3221.000	LOS	LOS	N_2 REG. PRESS.
DECEL SENSE ***	3250.000	3247.514	N/A	N/A
SECO II	##	3247.514	N/A	N/A

TABLE 5-1 (Concluded)

SEQUENCE OF EVENTS - COS-B

NOTES

In this report all times are referenced to DS23 which is issued by the guidance computer upon sensing acceleration at liftoff. The actual zero reference time is obtained manually from an oscillograph plot of channel FM 21-08 versus time. The zero reference time was misread by 200 milliseconds and thus to obtain the true time relative to liftoff 200 milliseconds must be added to the relative times of the data. The times in this table and Table 5-4 have been taken directly from the data without the 200 millisecond correction being added. The TM liftoff indication comes from PDM 11-30 when the liftoff switches in the vehicle are activated by the vehicle's motion away from the liftoff pins on the pad.

Times listed as XX.XX are from PDM data with a time resolution of 50 msec. Times listed as XX.XXX are from FM data and have a time resolution of 10 msec.

These events occur due to the sensing of acceleration or deceleration.

* N/A if MECO due to fuel injector pressure switches (FIPS).

** Event did not occur.

*** SECO II was due to a planned propellant depletion. The SECO command was issued due to the sensing of deceleration.

N/A Not applicable. An observable system response does not (or did not) occur.

LOS Loss of signal, either due to noise or out of range of ground station.

Δ System response and event occur simultaneously and response time prior to event time is due to sampling time between channels during event occurrence.

TABLE 5-2

1ST STAGE SYSTEM VOLTAGES - COS-B

PARAMETER	NOMINAL (VDC)	ACTUAL (VDC)
+5 VDC REFERENCE	+5.0 ± 0.1	5.00
INSTRUM. GROUND	0.00 ± 0.1	0.00
SOLID MOTOR POT. EXCIT.	+4.5 ± 0.25	4.50*
F/B POT. EXCIT. (+)	+25.0 ± 1.3	25.4
F/B POT. EXCIT. (-)	-25.0 ± 1.3	-25.2
ACTUATOR EXCIT. (+)	+50.0 ± 3.0	49.5
ACTUATOR EXCIT. (-)	-25.0 ± 1.5	-25.0
+12.35 V BIAS	+12.35 ± 0.15	12.2
+10 VDC TRANSDUCER	+10.0 ± 0.25	9.8
-10 VDC TRANSDUCER	-10.0 ± 0.25	-10.2

* VOLTAGE ROSE TO 5.0 VDC AT SOLID MOTOR SEPARATION WHICH IS NORMAL

TABLE 5-3

2ND STAGE SYSTEM PARAMETERS - COS-B

PARAMETER	NOMINAL	ACTUAL
+5 VDC REFERENCE	+5.0 ± 0.1 VDC	5.00 VDC
INSTRUM. GROUND	0.0 ± 0.1 VDC	0.00 VDC
+5 VDC POT. EXCIT.	+5.0 ± 0.1 VDC	5.00 VDC
F/B POT. EXCIT. (+)	+20.0 ± 1.0 VDC	19.7 VDC
F/B POT. EXCIT. (-)	-20.0 ± 1.0 VDC	-20.0 VDC
VALVE EXCIT. (+)	+35.0 ± 2.0 VDC	34.7 VDC
VALVE EXCIT. (-)	-35.0 ± 2.0 VDC	-34.5 VDC
GC LOGIC VOLTS	+5.0 ± 0.3 VDC	4.90 VDC
GC MEMORY VOLTS	-30 ± 2.1 VDC	-29.6 VDC
IMU LOGIC VOLTS	+5.0 ± 0.5 VDC	5.2 VDC
IMU GYRO EXCIT.	22.0 ± 2.2 VRMS	20.5 VRMS
GYRO WHEEL FREQ.	388.0 ± 3.9 HZ	389.0 HZ
IMU BLOCK TEMP.	+160 ± 2.0°F	160.4°F

TABLE 5-4

SEQUENCE TIMES - PCM DATA - COS-B

The following tabulation includes all computer discrete activity to show compliance to the Sequence of Events 1B96808. This data was taken from the PCM data. The mission times tabulated in Table 5-1 were obtained from the PDM/FM telemetry data with a time resolution of 10 ms (FM) and 50 ms (PDM). The PCM times are listed here separately since the PCM time resolution is 0.125 seconds and would not accurately correlate to the PDM/FM times. This tabulation includes some events not tabulated in the PDM/FM data due to the limited monitoring capability of the PDM/FM system.

EVENT	NOMINAL TIME	ACTUAL TIME	FUNCTION
Accel Sense	0.000	-0.083	DS23
Feedback Shaping Network Gain Change	38.000	37.867	DS30
Enable MECO	224.061	222.400	DS31
Decel. Sense	228.061	227.381	DS23 Off
VE Enable/ME Lockout	228.061	227.381	DS29
Stage II Hydraulic Pump On (Backup)	228.061	227.381	DS7
Arm Stage II Ignition and Pyrotechnic Power	228.061	227.381	DS12 DS13
Pressurize Tanks	230.061	229.871	DS22
VE Cutoff (VECO)	234.061	233.903	DS32
Blow Stage I/II Separation Bolts	236.061	235.919	DS2 DS18
Remove Stage I Discretes	237.061	236.868	DS29 Off DS30 Off DS31 Off DS32 Off
Remove Separation Discretes	240.061	239.952	DS2 Off DS18 Off

SEQUENCE TIMES - PCM DATA - COS-B

VENT	NOMINAL TIME	ACTUAL TIME	FUNCTION
tart Stage II Engine	241.061	240.900	DS3
ccel Sense	##	241.258	DS23
emove Tank Pressurization and ngine Start Discretes	242.061	241.849	DS22 Off DS3 Off
airing Unlatch	270.000	269.363	DS4
airing Unlatch Off	271.000	270.431	DS4 Off
Fairing Separation	271.000	270.431	DS19
Fairing Separation Off	273.000	272.447	DS19 Off
SECO I	531.075	530.625	DS5
Decel Sense	##	530.981	DS23 Off
Turn Off Hydraulic Pump	##	530.981	DS7 Off DS6
Enable CDR Turnoff	591.075	589.448	DS27 DS28
Turn Off CDR's	592.075	590.397	DS27 Off
RACS Enable	--------	**	DS17
Remove RACS Enable	--------	**	DS17 Off
Fire Spin Rockets & 3rd Stage Ign Comm	3027.000	3025.377	DS10
Fire 3rd Stage Wire Cutters	3028.000	3026.326	DS11
Remove Spin Rocket Discrete	3028.000	3026.326	DS10 Off

TABLE 5-4 (Continued)

SEQUENCE TIMES - PCM DATA - COS-B

EVENT	NOMINAL TIME	ACTUAL TIME	FUNCTION
Remove Wire Cutter Discrete	3029.000	3027.393	DS11 Off
Stage II/III Separation Command	3029.000	3027.393	DS15
Fire Retros	3029.000	3027.393	DS14
Remove Separation Discrete	3031.000	3029.409	DS15 Off
Remove Retro Discrete	3031.000	3029.409	DS14 Off
Hydraulic Pump - On	3199.000	LOS	DS7 DS6 Off
Initiate Ullage Jets	3205.000	3203.387	DS8
Engine Restart #1	3220.000	LOS	DS3 DS5 Off
Acceleration Sense	##	LOS	DS23
Ullage Jets Off	3221.000	LOS	DS9 DS8 Off
Deceleration Sense****	3250.000	3247.743	DS23 Off
SECO II***	##	3247.624	DS5 DS3 Off
Turn Off Hydraulic Pump On Discrete (Pump Remains On)	##	3247.624	DS7 Off

*** SECO II was commanded as a result of sensed deceleration due to a planned propellant depletion.

**** FM data indicated the acceleration sense discrete, DS 23, went off at 3247.514 long enough to command SECO II, however went on again before it could be sampled by the PCM telemetry. DS 23 went off and remained off at 3247.694 and was then sampled by the PCM telemetry at 3247.743 as being off.

ATTACHMENT 6:

SECTION 6. MECHANICAL SYSTEMS - COS-B MISSION

6.1 First Stage Hydraulic System

Hydraulic power is supplied to the six first stage gimbal actuators by a pressure compensated variable displacement pump and an integrated accumulator/reservoir. The hydraulic system functioned normally throughout main and vernier engine operation. Quantitative data is presented in Table 6-1 and Figures 6-1 and 6-2.

6.1.1 Supply Pressure

All supply pressure measurements were within the TRD limits for steady state and transient operation. The system was supplied by HTS power at a pressure of 2955 psia until one second before liftoff when the assessory drive accelerated the pump to 4036 RPM at T-0. The pump pressure peaked at 3268 psia, 0.45 seconds after liftoff, then stabilized at 3175 psia at T + 1.5 seconds.

Supply pressure oscillations occurred from T-0.6 seconds to T-0.3 seconds in a pump speed range of 3208 to 3587 RPM. A survey of these startup oscillations on missions back to Skynet IIB showed that "blossoming" occurred on all pumps including those used with MB-3 engines. Also, the RPM at first indication of amplitude increase varied from 1600 to 3108 while the RPM at the end of the "blossoming" varied from 3000 to 3621. Peak amplitudes measured between 175 and 240 psi peak-to-peak. Documented test results show that resonances occur at frequencies corresponding to speeds of 2184 RPM to 2726 RPM, however, resonance frequencies have been accurately recorded up to 3400 RPM (Westar A, simulated flight test). Large datum errors are possible when using T/M measurements because of the low datum sample rate, therefore, the above flight test results are approximations. The pump oscillations do not degrade hydraulic system performance and overtests have verified ample margin against a malfunction during this transient period.

The supply pressure decreased normally until MECO when it was measured at 3135 psia. The rate of decrease was 0.11 psi/second in a flight experience band of 0.06 to 0.18 psi/second. The pressure decrease is primarily due to decreasing oil viscosity and change in pump pressure compensator spring force with increasing temperature. The accumulator bleeddown required 73.5 seconds measured from first piston motion (at MECO) to the time the accumulator was empty (supply pressure corner). The corner pressure was 1610 psia which is the lowest corner measurement since Delta 92, and is indicative of low accumulator precharge and long bleeddown time. A leaking accumulator fill valve was found which had a pressure decay rate of 24 psi/day after the last of three accumulator fill procedures had been performed at VTC. At the pre-launch slew check 30 minutes before launch, the accumulator pressure measured 2070 psia at 92 degrees F or 1984 psi at 70 degrees F, which is below the TRD limit, but well above the 1715 psia precharge launch redline. This is calculated to yield the observed bleeddown corner, and an increase in bleeddown time of 5.1 seconds over the bleeddown time with nominal precharge. The hydraulic system responded normally at this precharge.

The reservoir began filling at T + 227 seconds (MECO) and was full at T + 234.7 seconds. The pump spun down and stopped at T + 234.2 seconds. Decompression of the supply side of the system required 1.6 seconds.

6.1.2 Accumulator GN2 Pressure

The average piston friction was measured at 26 psi using the differential supply - GN2 pressures. A volume of 66.5 cubic inches of oil was transferred to the accumulator due to the low precharge and represents an operating level of 65 percent full.

6.1.3 Return Pressure

Before liftoff, return pressure is the relief pressure of the low pressure relief valves and measured 233 psia on COS-B which is nominal. At pump startup, the relief valves closed and the return pressure went to a bootstrap level of 163 psia. The bootstrap return pressure permits T/M verification of the accuracy of supply and return pressures, since they differ by the bootstrap ratio which is nearly constant at 21.39 ± .04. The transient dip in pressure went to 144 psia during startup while the low pressure relief valves were closing. This verified the nominal response time of the valves and reservoir piston

At MECO the return pressure was 147 psia. At the reservoir full point, the return pressure became independent of supply pressure and peaked at 220 psia, the cracking point of the relief valves. The steady state relief pressure during bleeddown was 213 psia. All return pressure measurements were within TRD limits.

6.1.4 Reservoir Piston Position and Temperature

The piston position measurement for the reservoir full condition was measured at 98.4 percent. At pump startup the reservoir gave up 10.5 cubic inches of fluid to the accumulator due to differential increase in supply pressure, and at this point the piston position measured 93.7 percent. The piston gradually settled to a 93 percent position at T + 90 seconds as the GN2 temperature gradually recovered from the compression heating at pump startup. The reservoir oil temperature had remained stable at 87 degrees since liftoff. After T + 90 seconds the temperature gradually climbed to 98 degrees at MECO as the oil picked up compression energy from the pump.

6.1.5 Hydraulic Servo

The six servo valves and actuators functioned normally throughout flight. The summation of the actuator rates was a maximum at T + 16 seconds at which time the flow was calculated to be 1.6 gpm. Therefore, no fluid was required from the accumulator to meet servo demands during the mission. Drift and balance shift were well within TRD limits for all servo valves.

6.2 Second Stage Hydraulic System

The second stage hydraulic system provides the hydraulic power for the second stage engine gimballing and bi-propellant flow control valve actuation. The hydraulic system comprises an electric motor dirven fixed displacement piston

6.2 Second Stage Hydraulic System - Continued

pump, and a separate precharged accumulator and precharged reservoir. Performance of the system was nominal during the first duty cycle from T - 45 seconds to SECO 1 at T + 531 seconds. Recorded T/M data from the subsequent experimental restart failed to include the pump startup transient and loss of battery power. However, all steady state data on the run were normal.

6.2.1 First Duty Cycle

Prior to pump turn on the return pressure measured 67 psia at a temperature of 60 degrees F, and reflects the reservoir precharge which was 3 psi above nominal in a tolerance band of 10 psi. At turn on the supply pressure transient peak prior to accumulator piston first motion was 915 psia interpolated between datum points with a TRD allowable of 1135 psia. Accumulator piston first motion occurred at a pressure of 650 psia. The steady state supply pressure of 1100 psia was attained in 1.30 seconds, then slowly decreased to 1080 psia at SECO 1 due to oil heating. At turn on the return pressure decreased to a steady state value of 49.5 psia at completion of accumulator filling.

The motor pump temperature increased from a turn on value of 60 degrees F to 194 degrees F at SECO-I and peaked at 202 degrees F at 610 seconds. Accumulator bleeddown required 11.0 seconds to a precharge corner of 565 psia. All measurements were within TRD limits during the run.

6.2.2 Experimental Restart

Datum coverage started at 3202 seconds, whereas pump restart was scheduled for 3199 seconds. Usefull data amounted to 1.5 seconds during which time the supply pressure was 1095, the return pressure 58, and the motor case temperature 125 degrees F. Data coverage began again at 3242 seconds while the hydraulic system was operating and was lost for the last time at 3465 seconds. The system responded normally during the restart.

6.2.3 Hydraulic Servo

Servo valves and actuators functioned satisfactorily during both hydraulic duty cycles. At initial pump start, the engine was snapped to zero deflection angle for a total oil useage of 0.9 cubic inches which was supplied by the pump during the transient rise in pressure as the accumulator was empty at this time. This increased the duration of the pressure transient to 1.60 seconds in a prior experience band of 1.0 to 1.6 seconds. Bi-propellant valve actuation caused a dip of 80 psi in system pressure and a dip to 47 psia in return pressure.

6.3 Ordnance and Mechanical Devices

All ordnance and mechanical devices functioned satisfactorily to complete a successful launch.

6.4 Environmental Control Aerospace Ground Equipment (AGE)

All environmental control AGE equipment performed satisfactorily during the countdown and launch.

6.5 Hydraulic Control Aerospace Ground Equipment

All hydraulic control AGE performed satisfactorily during the countdown and launch.

TABLE 6-1

FIRST STAGE HYDRAULIC SYSTEM

PERFORMANCE SUMMARY

COS-B

Event	Time from Liftoff (sec)	Supply Pressure (psia)	Return Pressure (psia)
HTS power	-5.0	2955	233
Peak pressure	0.4	3268	-
Steady state	5.0	3175	163
Solid motor separation	87	3150	150
Reference point	120	3145	148
MECO	227	3135	147
Pump stall	234.24	2990	141
Reservoir full	234.76	2964	141
LPRV crack	234.9	2953	220
Accumulator empty	300.6	1610	213
Bleed down + 5 sec		200	212
Accumulator bleed down time	73.5 seconds		
Decompression time	1.6 seconds		

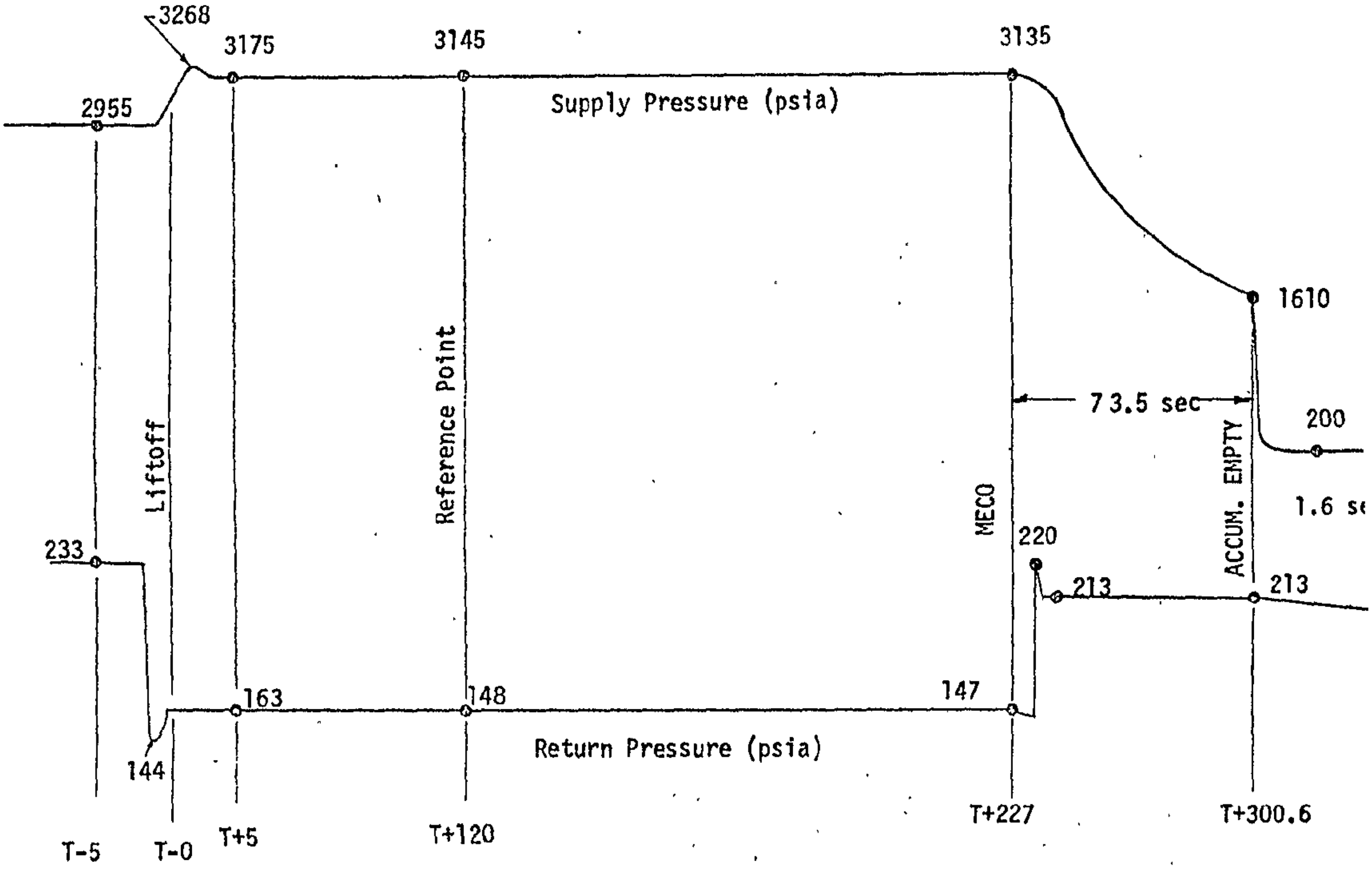


FIGURE 6-1 COS-B FIRST STAGE HYDRAULIC SYSTEM PERFORMANCE

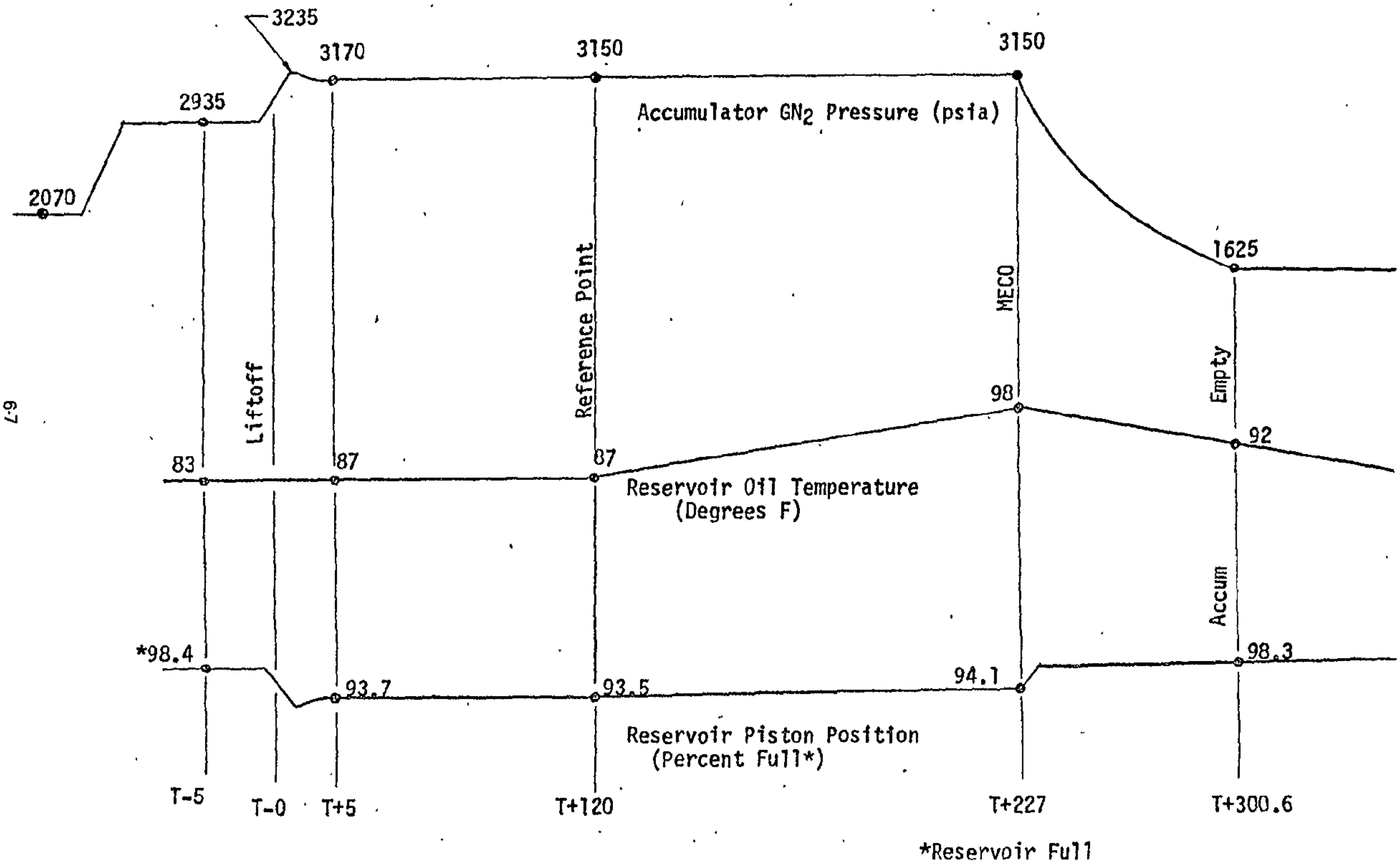


FIGURE 6-2 COS-B FIRST STAGE HYDRAULIC SYSTEM PERFORMANCE

TABLE 6-2

SECOND STAGE HYDRAULIC

SYSTEM PERFORMANCE SUMMARY

COS-B

Event	Time from Liftoff (sec)	Supply Pressure (psia)	Return Pressure (psia)
Prior to pump on	-46	60	67
Pressure knee	-45.4	680	-
Steady state	-40	1100 (actual)	49.5
Liftoff	0	1100	53
At engine ignition	241	1090	59/47
SECO-1	531	1080	62
Accumulator empty	542	565	87
Prior to restart	Data not available		
Pressure knee	Data not available		
Steady state	3203	1095	58
SECO-2	3247.5	1090	57
Accumulator bleed down time (1st cycle)	11.0 seconds		
Accumulator bleed down time (restart)	N/A - Pump remained on		

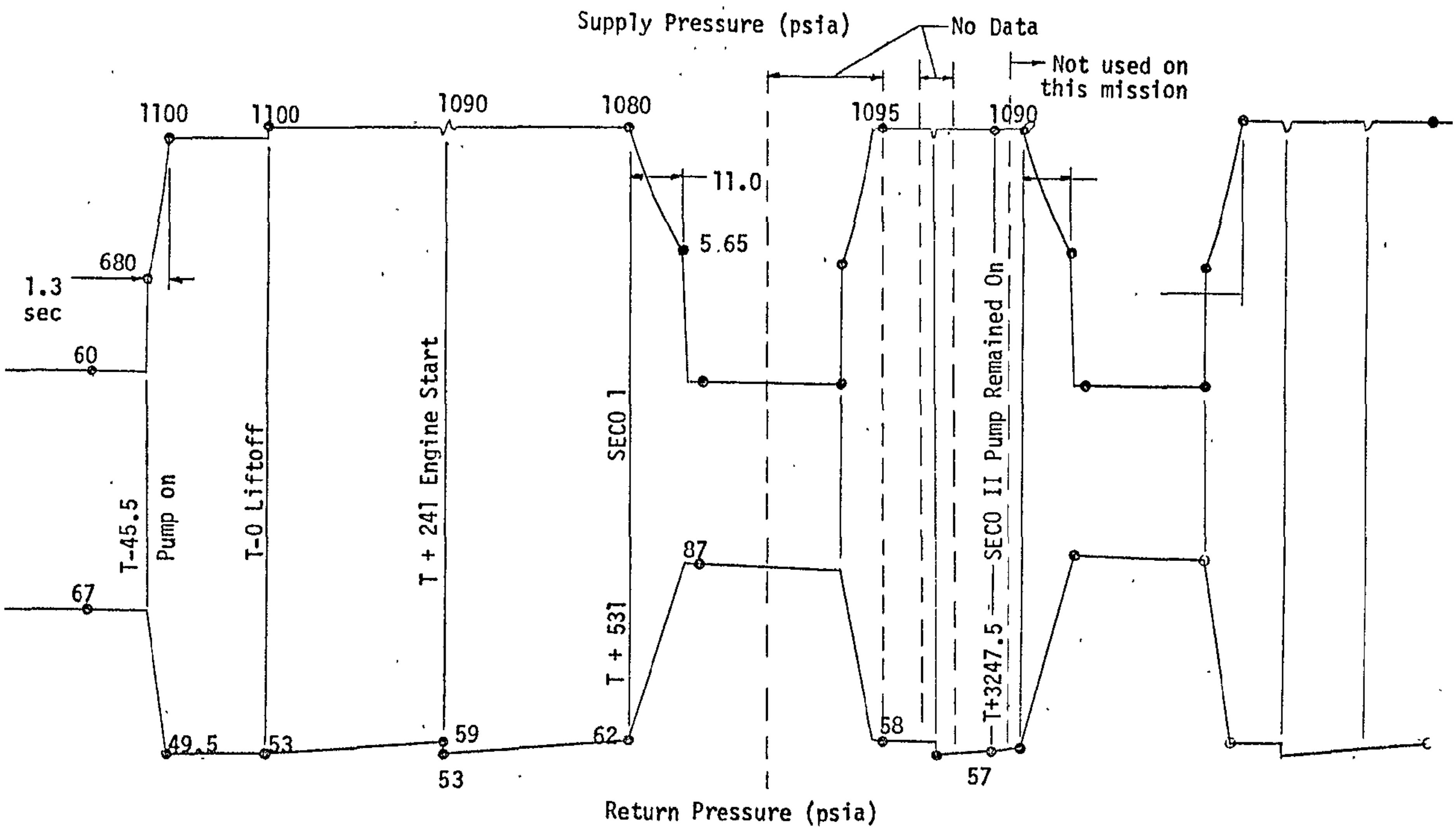


FIGURE 6-3 COS-B SECOND STAGE HYDRAULIC SYSTEM PERFORMANCE

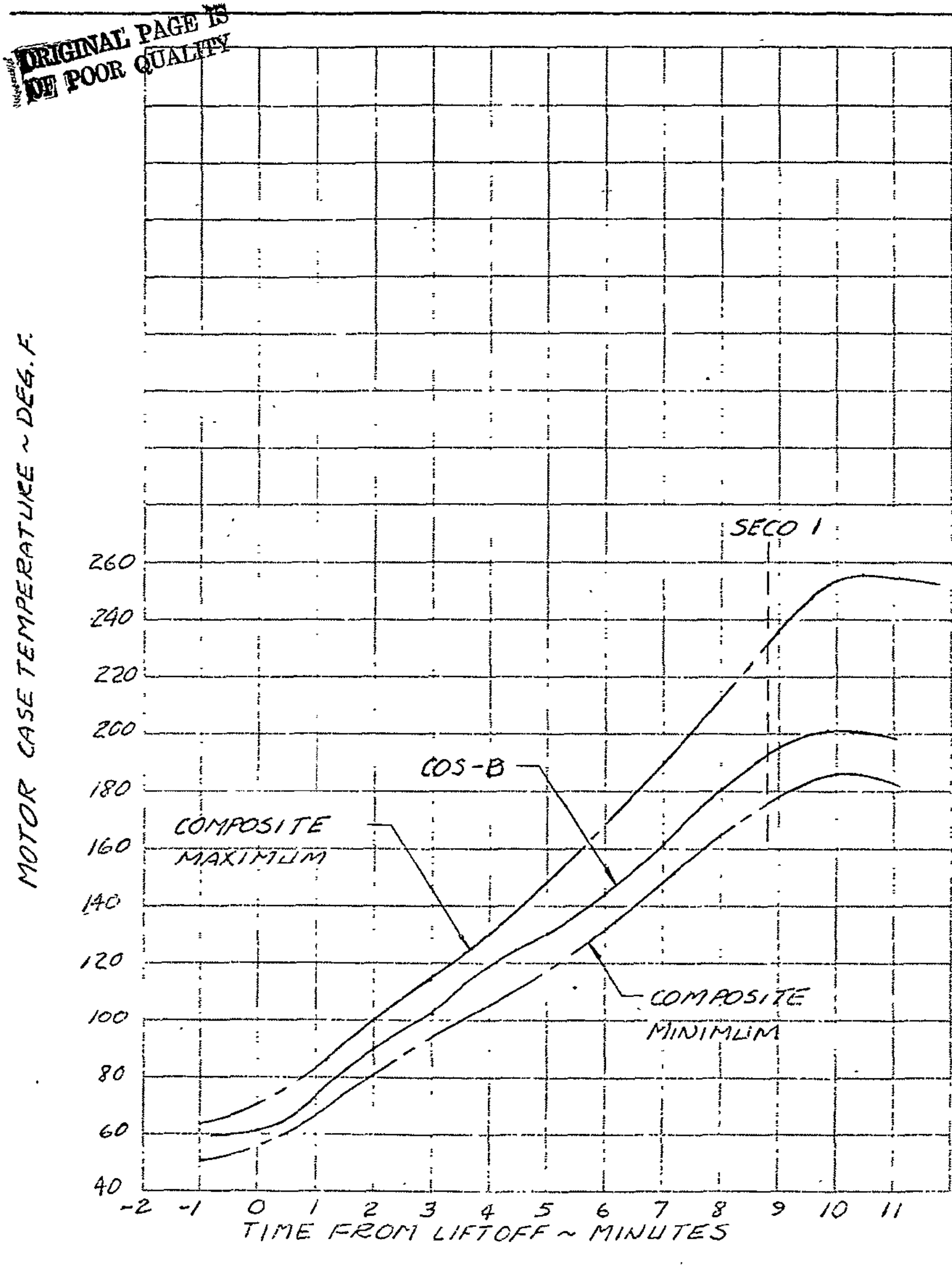


FIGURE 6-4 MOTOR CASE TEMPERATURE

ATTACHMENT 7:

SECTION 7. STRUCTURAL SYSTEMS - COS-B MISSION

Section 7

STRUCTURAL SYSTEMS - COS-B MISSION

7.1 STRUCTURAL PERFORMANCE

The COS-B first and second stage and fairing structural subsystems and associated components satisfactorily provided the launch vehicle with the strength and rigidity required to withstand all design conditions during handling and throughout all phases of the flight. A secondary transient was noted during fairing jettison. Reference T00164, "Fairing Separation and Roll Moment", unreleased at this time. A second stage POGO was noted and will be covered by T00166, "COS-B Anomaly Investigation", unreleased at this time.

7.2 VIBRATION MEASUREMENT DATA

Vibration data analysis results for COS-B will be documented under separate cover at a later date.

7.3 WEIGHT DATA

Actual inflight weight data for the COS-B launch vehicle and its various components are provided in Table 7-1. Included in this table are actual dry weights, propellant liftoff weights and densities, and pressurization and control gas weights.

7.4 SUPPORT EQUIPMENT AND FACILITIES

All support equipment performed satisfactorily during countdown and launch. Damage to the facilities at Launch Complex SLC 2W at the Vandenberg Test Center was light. Recycle time to support the next launch was normal.

TABLE 7-1

FINAL POST FLIGHT WEIGHT SUMMARY

COS-B CONFIGURATION 2913

	ITEM	WEIGHT (LBS)	WEIGHT (LBS)
1.	THIRD STAGE USEFUL LOAD		681.81
	COS-B Spacecraft	614.15	
	Payload Attach Fitting, MDAC Mods and Telemetry	63.31	
	Ballast	4.35	
2.	BURNED OUT THIRD STAGE (TE-364-3 S/N 00025)		129.69
3.	THIRD STAGE BURNOUT		811.50
4.	PROPELLANTS AND INERTS CONSUMED		1,450.64
5.	THIRD STAGE IGNITION		2,262.14
7.	SPINTABLE ASSEMBLY DSV-3E-17C (S/N 20236)		214.83
8.	SECOND STAGE USEFUL LOAD		2,476.97
9.	DRY SECOND STAGE - DSV-3P-4B (S/N 20020) (LESS 8.0 LBS. ABLATIVE EXPENDABLES)		1,815.47
10.	TRAPPED PROPELLANTS		29.34
	Fuel	5.24	
	Oxidizer (Liquid)	11.10	
	Oxidizer (Vapor)	13.00	
11.	HELIUM (2 BOTTLE SYSTEM)		20.34
12.	NITROGEN RESERVE - 1 BOTTLE SYSTEM		18.25
13.	PROPELLANT RESERVE		778.40
	Fuel	288.04	
	Oxidizer	490.36	

TABLE 7-1 (CONTINUED)

FINAL POST FLIGHT WEIGHT SUMMARY

COS-B CONFIGURATION 2913

	ITEM	WEIGHT (LBS)	WEIGHT (LBS)
22.	NITROGEN USED DURING COAST AND FIRST BURN		4.85
25.	SECOND STAGE ENGINE CUTOFF - FIRST BURN		5,143.62
4. & 26.	STOP TRANSIENT & TCA BOILOFF		11.72
	Fuel	5.10	
	Oxidizer	6.62	
23.	ABLATIVE EXPENDABLES		8.00
27.	PROPELLANT CONSUMED		9,238.02
	Fuel	3,575.54	
	Oxidizer	5,662.48	
28.	FAIRING DSV-3P-7A (S/N 20023)		1,305.00
29.	START TRANSIENT		2.31
	Fuel	.62	
	Oxidizer	1.69	
30.	SECOND STAGE IGNITION		15,708.67
31.	FIRST TO SECOND STAGE ADAPTER - DSV-3P-2A (S/N 20019)		986
32.	DRY BOOSTER DSV-3P-1A (20020) (602)		8,948
33.	TRAPPED PROPELLANTS AND GASES		670
	Fuel	142	
	Liquid Oxygen	70	
	Gaseous Oxygen	335	
	Gaseous Nitrogen	117	
	FABU Lube and/or Fuel	6	

TABLE 7-1 (CONTINUED)

FINAL POST FLIGHT WEIGHT SUMMARY

COS-B CONFIGURATION 2913

	ITEM	WEIGHT (LBS)	WEIGHT (LBS)
34.	RESIDUAL PROPELLANTS		282
	Fuel	282	
	Liquid Oxygen	0	
35.	RESIDUAL VERNIER PROPELLANTS		54
	Fuel (Includes 18 pounds vernier refill)	25	
	Liquid Oxygen (Includes 12 pounds vernier refill)	29	
36.	VERNIER ENGINE CUTOFF		26,649
37.	VERNIER PROPELLANT CONSUMED		44
	Fuel	16	
	Liquid Oxygen	28	
38.	MAIN ENGINE STOP LOSSES		140
	Fuel	47	
	Liquid Oxygen	93	
39.	MAIN ENGINE CUTOFF		26,833
40.	LIQUID PROPELLANTS CONSUMED		175,388
	Fuel	55,590	
	Liquid Oxygen	119,798	
41.	LIQUID PROPELLANTS & GASES VENTED		364
	Fuel Overflow	8	
	Liquid Oxygen Overflow	29	
	Gaseous Oxygen Vented	327	

TABLE 7-1 (CONTINUED)

FINAL POST FLIGHT WEIGHT SUMMARY

COS-B CONFIGURATION 2913

	ITEM	WEIGHT (LBS)	WEIGHT (LBS)
42.	SOLID MOTOR CASES (6) (FIRST BURN)		9,530
	Solid Motor Cases (6)	8,797	
	MDAC Modifications	413	
	Cork Insulation	320	
43.	SOLID MOTOR CASES (3) (SECOND BURN)		4,725
	Solid Motor Cases (3)	4,373	
	MDAC Modifications	207	
	Cork Insulation	145	
44.	SOLID MOTOR PROPELLANT & INERTS CONSUMED (6) (FIRST BURN)		49,591
	Propellants	49,233	
	Inert Loss During Burning	358	
45.	SOLID MOTOR PROPELLANTS & INERTS CONSUMED (SECOND BURN)		24,837
	Propellants	24,652	
	Inert Loss During Burning	179	
	Pyrogen	6	
47.	SOLID MOTOR NOZZLE PLUGS (3) (SEOND BURN)		22
48.	LIFTOFF		291,290

TABLE 7-1 (CONTINUED)

FINAL POST FLIGHT WEIGHT SUMMARY

COS-B CONFIGURATION 2913

PROPELLANT DATA		
ITEM	WEIGHT (LBS)	DENSITY (LBS/FT^3)
FIRST STAGE		
Oxidizer in tank at liftoff	120,501	70.589
Fuel in tank at liftoff	55,898	50.496
SECOND STAGE		
Oxidizer loaded	6,185.25	90.843
Fuel loaded	3,874.54	56.504

ATTACHMENT 8:

SECTION 8. RELIABILITY

Section 8

RELIABILITY

The reliability point estimates and 90 percent lower confidence limits for the various Delta vehicle configurations flown to date, considering 113 flights, are furnished in Table 8-1. The indicated reliability point estimate values were obtained by dividing the number of flight successes by the total number of flights. Using these values, applicable standard probability tables were then utilized to obtain the 90 percent confidence limit values that are shown.

Table 8-1

RELIABILITY SUMMARY (COS-B)

Item	Trials	Failures	Reliability Point Estimate	90% Lower Confidence Limit
Complete Vehicle				
Delta	38	3	0.921	0.833
Improved Delta	26	0	1.000	0.915
Long Tank Delta	29a	5	0.828	0.704
Extended Long Tank Delta	20b	1	0.950	0.819
Total Vehicles	113	9	0.920	0.877
First Stage Booster				
Thor	64	0	1.000	0.965
Long Tank Thor	29a	2	0.931	0.827
Extended Long Tank Thor	8b	0	1.000	0.750
RS-27 (E.L.T.)	12b	0	1.000	0.825
Total Boosters	113	2	0.982	0.954
Second Stage				
Delta	38	1	0.974	0.901
Improved Delta	48c	1	0.979	0.921
Transtage Delta	12	2	0.833	0.614
SSPU (TRW)	13	0	1.000	0.838
Total Second Stages	111	4	0.964	0.929
Third Stage Motor				
X-248 Motor	22d	1	0.955	0.834
X-258 Motor	18	1	0.944	0.801
FW-4D Motor	21d	0	1.000	0.896
TE-364-3 Motor	17e	1	0.941	0.790
TE-364-4 Motor	10	0	1.000	0.794
Total Third Stages	88f	3	0.966	0.926

a. Long Tank Thor/Delta: Includes four six-solid-motor booster configurations (IMP-I, TIROS-M, ITOS-A, ITOS-B) and two nine-solid-motor booster configurations (ERTS-A, NIMBUS-E).

b. Extended Long Tank Thor/Delta: Includes three three-solid-motor booster configurations (SKYNET-IIA, SKYNET-IIB, ITOS-G), one four-solid motor booster configuration (GEOS-C), two six-solid-motor booster configurations (IMP-H, IMP-J), and fourteen nine-solid-motor booster configurations (TELESAT-A, AEC, TELESAT-B, RAE-B, WESTAR-A, WESTAR-B, SMS-A, SYMPHONIE-A, ERTS-B, SMS-B, TELESAT-C, NIMBUS-F, OSO-I, and COS-B).

c. Two improved Delta vehicles were not considered trials.

d. One motor of this model was not considered a trial.

e. One motor of this model was not considered a trial, and the one flown on the INTELSAT-III-E mission (Delta Program Mission No. 71) was considered a failure.

f. Twenty-two launch vehicles did not have a third stage.

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ATTACHMENT 9:

DEFINITIONS OF PERFORMANCE PARAMETERS
[TABLES 2-4 THROUGH 2-6 OF ATTACHMENT 2 (SECTION 2)]

Attachment 9

DEFINITIONS OF PERFORMANCE PARAMETERS [TABLES 2-4 THROUGH 2-6 OF ATTACHMENT 2 (SECTION 2)]

This attachment provides the performance parameter definitions on which the values given in Tables 2-4 through 2-6 of Attachment 2 (Section 2) are based.

9.1 First Stage

First stage performance parameters for the liquid engine system and for the solid motors are defined in the following paragraphs.

9.1.1 Liquid Engine System

Parameter	Definition
Average Altitude Thrust:	The liquid engine thrust for altitude conditions averaged from liftoff to MECO.
Average Vacuum Thrust:	The liquid engine thrust for vacuum conditions averaged from liftoff to MECO.
Average Altitude Effective Specific Impulse:	The liquid engine effective specific impulse for altitude conditions averaged from liftoff to MECO.
Average Vacuum Effective Specific Impulse:	The liquid engine effective specific impulse for vacuum conditions averaged from liftoff to MECO.
Propellant Utilization:	The ratio of the weight of propellant consumed during steady-state burn (from liftoff to depletion at MECO) to the weight of total propellant available for the steady-state burn.

9.1.2 Solid Motors

Parameter	Definition
Average Altitude Thrust:	The total thrust of the solid motors for altitude conditions averaged from liftoff to burnout.
Average Vacuum Thrust:	The total thrust of the solid motors for vacuum conditions averaged from liftoff to burnout.

Average Altitude Specific Impulse:	The specific impulse for altitude conditions averaged for the solid motors from liftoff to burnout.
Average Vacuum Specific Impulse:	The specific impulse for vacuum conditions averaged for the solid motors from liftoff to burnout.

9.2 Second Stage

Second stage performance parameters are defined as follows:

Parameter	Definition
Average Thrust (ACC):	The thrust of the second stage engine averaged from start* to SECOM. The reconstructed value is based on a flight kinetic reconstruction using DIGS acceleration, flow rates, and actual vehicle weight data.
Average Thrust (Pc):	The thrust of the second stage engine averaged from start* to SECOM. The reconstructed value is based on a propulsion reconstruction using chamber pressure (Pc), flow rates, nozzle throat area, thrust coefficients, and acceptance test data.
Average Specific Impulse (ACC):	The specific impulse of the second stage engine averaged from start* to SECOM. The reconstructed value is based on the flight kinetic reconstruction.
Average Specific Impulse (Pc):	The specific impulse of the second stage engine averaged from start* to SECOM. The reconstructed value is based on the propulsion reconstruction.
Propellant Consumption:	The ratio of the weight of propellant consumed during steady-state burn (from start* to SECOM) to the weight of total propellant available for a steady-state burn.
Propellant Utilization:	The ratio of the weight of propellant that would have been consumed during steady-state burn if the engine had burned to depletion to the weight of the total propellant available for a steady-state burn.

*Start and restart are defined as the time at which chamber pressure reaches a steady-state level.

ATTACHMENT 10:

VEHICLE PERFORMANCE TELEMETRY PLOTS - COS-B MISSION

Attachment 10

VEHICLE PERFORMANCE TELEMETRY PLOTS - COS-B MISSION

A series of telemetry plots relating to COS-B launch vehicle inflight performance is furnished in this attachment. Included are all of the PDM and FM data; the first-stage plots cover the period from -300 seconds to 500 seconds (pages 10-6 through 10-29); the second-stage plots cover the period from -300 seconds to 3,600 seconds (pages 10-30 through 10-59); and the third stage plots cover the period from -300 seconds to 3,600 seconds (pages 10-68 through 10-73). Also included in this attachment are data for fourteen selected PCM channels from the second-stage T/M; the PCM data plots cover the period from -300 seconds to 3,600 seconds (pages 10-60 through 10-67). An index to the PDM, FM, and PCM data plots is provided on pages 10-2 through 10-5 of this attachment.

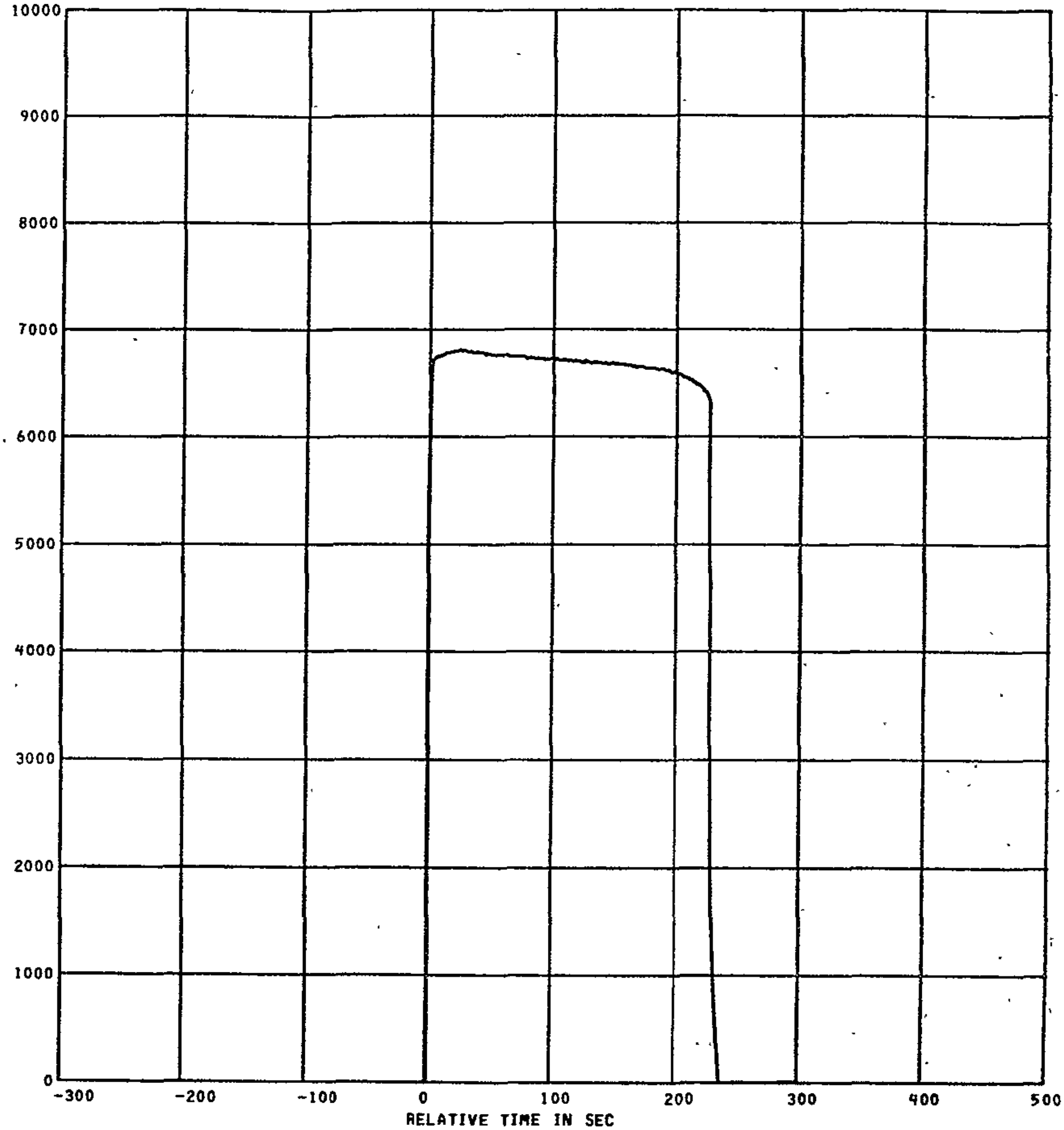
MEASUREMENT	CHANNEL NO.	MEASUREMENT NAME	CAT=21 PLOT NUMBERS	
FM-11-07	CF11-07	FUEL DEPLETION	101	
FM-11-08	CF11-08	SEQUENCE NO.1	101	
FM-11-09	CF11-09	LOX ACCUMULATOR PRESSURE	102	
FM-11-10	CF11-10	CONTROL BATTERY CURRENT	101	
FM-11-11	CF11-11	MAIN ENGINE CHAMBER PRESSURE	101	
FM-11-12	CF11-12	TURBOPUMP SPEED	100	
FM-11-13	CF11-13	FUEL PUMP INLET PRESSURE	102	
FM-21-A	CF21-A	TRIAXIAL ACCEL THRUST AXIS (X)	400	
FM-21-01	CF21-01	GYRO WHEEL SUPPLY FREQUENCY	401	
FM-21-05	CF21-05	CONTROL BATTERY CURRENT	401	
FM-21-06	CF21-06	YAW JET ACTUATION-PRIMARY	402	
FM-21-07	CF21-07	PITCH/ROLL JET ACTUATION-PRIMARY	402	
FM-21-08	CF21-08	ROLL/PITCH JET ACTUATION-PRIMARY	402	
FM-21-09	CF21-09	THRUST CHAMBER PRESSURE	401	
FM-21-10	CF21-10	2ND STAGE YAW CONTROL SIGNAL	402	
FM-21-11	CF21-11	2ND STAGE PITCH CONTROL SIGNAL	401	
FM-21-12	CF21-12	TRIAXIAL ACCEL YAW AXIS (Z)	400	
FM-21-13	CF21-13	TRIAXIAL ACCEL PITCH AXIS (Y)	400	
FM-31-14	CF31-14	BATTERY MONITOR VOLTAGE	701	
FM-31-15	CF31-15	PITCH ACCELEROMETER	702	
FM-31-16	CF31-16	YAW ACCELEROMETER	702	
FM-31-17	CF31-17	THRUST ACCELEROMETER	702	
FM-31-18	CF31-18	THIRD STAGE CHAMBER PRESSURE	700	
PCM-2G-01	1-01S	ROLL ANGULAR RATE	600	Q600
PCM-2G-02	1-02S	PITCH ANGULAR RATE	601	Q601
PCM-2G-03	1-03S	YAW ANGULAR RATE	602	Q602
PCM-2G-04	1-04S	ROLL ATTITUDE ERROR	600	Q600
PCM-2G-05	1-05S	PITCH ATTITUDE ERROR	601	Q601
PCM-2G-06	1-06S	YAW ATTITUDE ERROR	602	Q602
PCM-2G-07	1-07S	ROLL DAC OR ON/OFF OUTPUT	600	Q600
PCM-2G-08	1-08S	PITCH DAC OR ON/OFF OUTPUT	601	Q601
PCM-2G-09	1-09S	YAW DAC OR ON/OFF OUTPUT	602	Q602
PCM-2G-11	1-11	RACS CTR	R100	R200
PCM-2G-17	1-17	PROGRAMMED ROLL RATE	600	Q600
PCM-2G-18	1-18	PROGRAMMED PITCH RATE	601	Q601
PCM-2G-19	1-19	PROGRAMMED YAW RATE	602	Q602
PCM-2G-25	1-25	X BODY COORD ACCEL	603	Q603
PCM-2G-39	1-39-01	THRUST ACCELERATION	603	Q603
PDM-11-01	CG11-01	5 VOLT REFERENCE	200	
PDM-11-02	CG11-02	INSTRUMENTATION GROUND	200	
PDM-11-03	CG11-03	MAIN ENGINE PITCH POSITION	204	
PDM-11-04	CG11-04	MAIN ENGINE YAW POSITION	204	
PDM-11-05	CG11-05	V.E. NO.1 PITCH/ROLL POSITION	205	
PDM-11-06	CG11-06	V.E. NO.1 YAW POSITION	205	
PDM-11-07	CG11-07	V.E. NO.2 PITCH/ROLL POSITION	206	
PDM-11-08	CG11-08	V.E. NO.2 YAW POSITION	206	
PDM-11-09	CG11-09	PITCH SUMMING AMP OUTPUT	204	
PDM-11-10	CG11-10	YAW SUMMING AMP OUTPUT	204	
PDM-11-11	CG11-11	ROLL SUMMING AMP OUTPUT VE NO.2	206	

MEASUREMENT	CHANNEL NO.	MEASUREMENT NAME	DAT*21 PLOT NUMBERS
PDM-11-12	CG11-12	ROLL SUMMING AMP OUTPUT VE NO.1	205
PDM-11-13	CG11-13	SEQUENCE NO.9	203
PDM-11-14	CG11-14	SOLID MOTOR NO.4 CHAMBER PRESS	210
PDM-11-15	CG11-15	SOLID MOTOR NO.5 CHAMBER PRESS	210
PDM-11-16	CG11-16	SOLID MOTOR NO.6 CHAMBER PRESS	210
PDM-11-17	CG11-17	FEEDBACK POT EXCITATION (POS)	201
PDM-11-18	CG11-18	FEEDBACK POT EXCITATION (NEG)	201
PDM-11-19	CG11-19	SOLID MOTOR NO.7 CHAMBER PRESS	211
PDM-11-20	CG11-20	SOLID MOTOR NO.8 CHAMBER PRESS	211
PDM-11-21	CG11-21	ACTUATOR EXCITATION (NEG)	201
PDM-11-22	CG11-22	V.E. NO.2 CHAMBER PRESSURE	206
PDM-11-23	CG11-23	CONTROL BATTERY VOLTAGE	200
PDM-11-24	CG11-24	INSTRUMENTATION BATTERY VOLTAGE	200
PDM-11-25	CG11-25	HYDRAULIC SUPPLY PRESSURE	207
PDM-11-26	CG11-26	HYDRAULIC RETURN PRESSURE	207
PDM-11-27	CG11-27	HYDRAULIC ACCUM PISTON POSITION	207
PDM-11-28	CG11-28	SEQUENCE NO.2 S.M. SET NO.2 + 3	202
PDM-11-29	CG11-29	SOLID MOTOR POT EXCITATION	200
PDM-11-30	CG11-30	SEQUENCE NO.4	202
PDM-11-31	CG11-31	SEQUENCE NO.3 S.M. SET NO.3	202
PDM-11-32	CG11-32	SEQUENCE NO.6 S.M. SET NO.2	203
PDM-11-33	CG11-33	ENGINE PNEUMATIC BOTTLE PRESS	208
PDM-11-34	CG11-34	ACTUATOR EXCITATION (POS)	201
PDM-11-35	CG11-35	SEQUENCE NO.7 S.M. SET NO.1	203
PDM-11-36	CG11-36	SEQUENCE NO.5	202
PDM-11-37	CG11-37	SOLID MOTOR NO.1 CHAMBER PRESS	209
PDM-11-38	CG11-38	SOLID MOTOR NO.2 CHAMBER PRESS	209
PDM-11-39	CG11-39	SEQUENCE NO.8 S.M. SET NO.1	203
PDM-11-40	CG11-40	MAIN FUEL TANK TOP PRESSURE	208
PDM-11-41	CG11-41	SOLID MOTOR NO.3 CHAMBER PRESS	209
PDM-11-42	CG11-42	LOX TANK TOP PRESSURE	208
PDM-11-43	CG11-43	SOLID MOTOR NO.9 CHAMBER PRESS	211
PDM-12-01	CG12-01	5 VOLT REFERENCE	300
PDM-12-02	CG12-02	INSTRUMENTATION GROUND	300
PDM-12-03	CG12-03	FUEL PUMP INLET TEMPERATURE	308
PDM-12-07	CG12-07	MAIN ENGINE CHAMBER PRESSURE	308
PDM-12-08	CG12-08	GG COMBUSTION TEMPERATURE	306
PDM-12-10	CG12-10	GG LOX INJECTOR PRESSURE	306
PDM-12-11	CG12-11	LOX PUMP INLET TEMPERATURE	305
PDM-12-12	CG12-12	12.35 VOLT BIAS	300
PDM-12-13	CG12-13	V.E. NO.1 HOUSING TEMPERATURE	301
PDM-12-14	CG12-14	V.E. NO.2 HOUSING TEMPERATURE	301
PDM-12-15	CG12-15	M.E. PITCH ACTUATOR TEMPERATURE	302
PDM-12-16	CG12-16	AIR CONDITIONING INLET TEMP	301
PDM-12-17	CG12-17	SKIRT SECTION TEMPERATURE	301
PDM-12-21	CG12-21	CENTER BODY SKIN TEMPERATURE	307
PDM-12-23	CG12-23	M.E. PITCH SERVO DIFF. SIGNAL	302
PDM-12-24	CG12-24	VE 1 PITCH/ROLL SERVO DIFF SGNL	303
PDM-12-25	CG12-25	VE 2 PITCH/ROLL SERVO DIFF SGNL	303

MEASUREMENT	CHANNEL NO.	MEASUREMENT NAME	CAT-21 PLOT NUMBERS
PDM-12-26	CG12-26	M.E. YAW SERVO DIFF. SIGNAL	302
PDM-12-27	CG12-27	VE 1 YAW SERVO DIFF. SIGNAL	303
PDM-12-28	CG12-28	VE 2 YAW SERVO DIFF. SIGNAL	303
PDM-12-29	CG12-29	+10 VDC TRANSDUCER POWER	300
PDM-12-30	CG12-30	-10 VDC TRANSDUCER POWER	300
PDM-12-31	CG12-31	HYDRAULIC ACCUM TEMPERATURE	304
PDM-12-32	CG12-32	HYDRAULIC ACCUM GN2 PRESSURE	304
PDM-12-33	CG12-33	HELIUM BOTTLE PRESSURE	305
PDM-12-36	CG12-36	CENTER BODY AIR TEMPERATURE	307
PDM-12-37	CG12-37	THRUST CHAMBER DOME OXID PRESS	305
PDM-12-38	CG12-38	LUBE SYSTEM PRESSURE	308
PDM-12-39	CG12-39	GG FUEL INLET PRESSURE	306
PDM-12-40	CG12-40	THRUST CHMBR DOME FUEL INJ PRESS	308
PDM-12-42	CG12-42	POGO NO. 2 LOX ACCUMULATOR TEMP	307
PDM-12-43	CG12-43	POGO NO. 1 LOX ACCUMULATOR TEMP	307
PDM-21-01	CG21-01	5 VOLT ABSOLUTE	500
PDM-21-02	CG21-02	INSTRUMENTATION GROUND	500
PDM-21-03	CG21-03	YAW SUMMING AMP OUTPUT	502
PDM-21-04	CG21-04	VALVE EXCITATION (POS)	503
PDM-21-05	CG21-05	EVENT GROUP NO.1	506
PDM-21-06	CG21-06	VALVE EXCITATION (NEG)	503
PDM-21-07	CG21-07	G.C. LOGIC VOLTAGE	508
PDM-21-08	CG21-08	ROLL/PITCH JET ACT - SECONDARY	504
PDM-21-09	CG21-09	PITCH ACTUATOR POSITION	505
PDM-21-10	CG21-10	CDR NO. 1 AGC	507
PDM-21-11	CG21-11	IMU BLOCK TEMPERATURE	508
PDM-21-12	CG21-12	ENGINE BATTERY CURRENT	501
PDM-21-13	CG21-13	YAW ACTUATOR POSITION	502
PDM-21-14	CG21-14	EVENT GROUP NO.4	506
PDM-21-15	CG21-15	EVENT GROUP NO.5	506
PDM-21-16	CG21-16	NITROGEN BOTTLE PRESSURE	510
PDM-21-17	CG21-17	5 VOLT POT EXCITATION	500
PDM-21-18	CG21-18	PITCH SUMMING AMP OUTPUT	505
PDM-21-19	CG21-19	PITCH SERVO DIFFERENTIAL SIGNAL	505
PDM-21-20	CG21-20	CONTROL BATTERY VOLTAGE	501
PDM-21-21	CG21-21	INSTRUMENTATION BATTERY VOLTAGE	500
PDM-21-22	CG21-22	OXIDIZER TANK PRESSURE	510
PDM-21-23	CG21-23	HYDRAULIC SYSTEM PRESSURE	509
PDM-21-24	CG21-24	FEEDBACK POT EXCITATION (POS)	503
PDM-21-25	CG21-25	FEEDBACK POT EXCITATION (NEG)	503
PDM-21-26	CG21-26	HYD MOTOR PUMP TEMPERATURE	509
PDM-21-27	CG21-27	NITROGEN REGULATOR PRESSURE	510
PDM-21-28	CG21-28	OXIDIZER LINE TEMPERATURE	510
PDM-21-29	CG21-29	HYDRAULIC SYSTEM RETURN PRESSURE	509
PDM-21-30	CG21-30	CDR NO. 2 AGC	507
PDM-21-31	CG21-31	GC MEMORY VOLTAGE	508
PDM-21-32	CG21-32	IMU GYRO EXCITATION	508
PDM-21-33	CG21-33	1ST STAGE ROLL CONTROL SIGNAL	504
PDM-21-34	CG21-34	EVENT GROUP NO.2	506

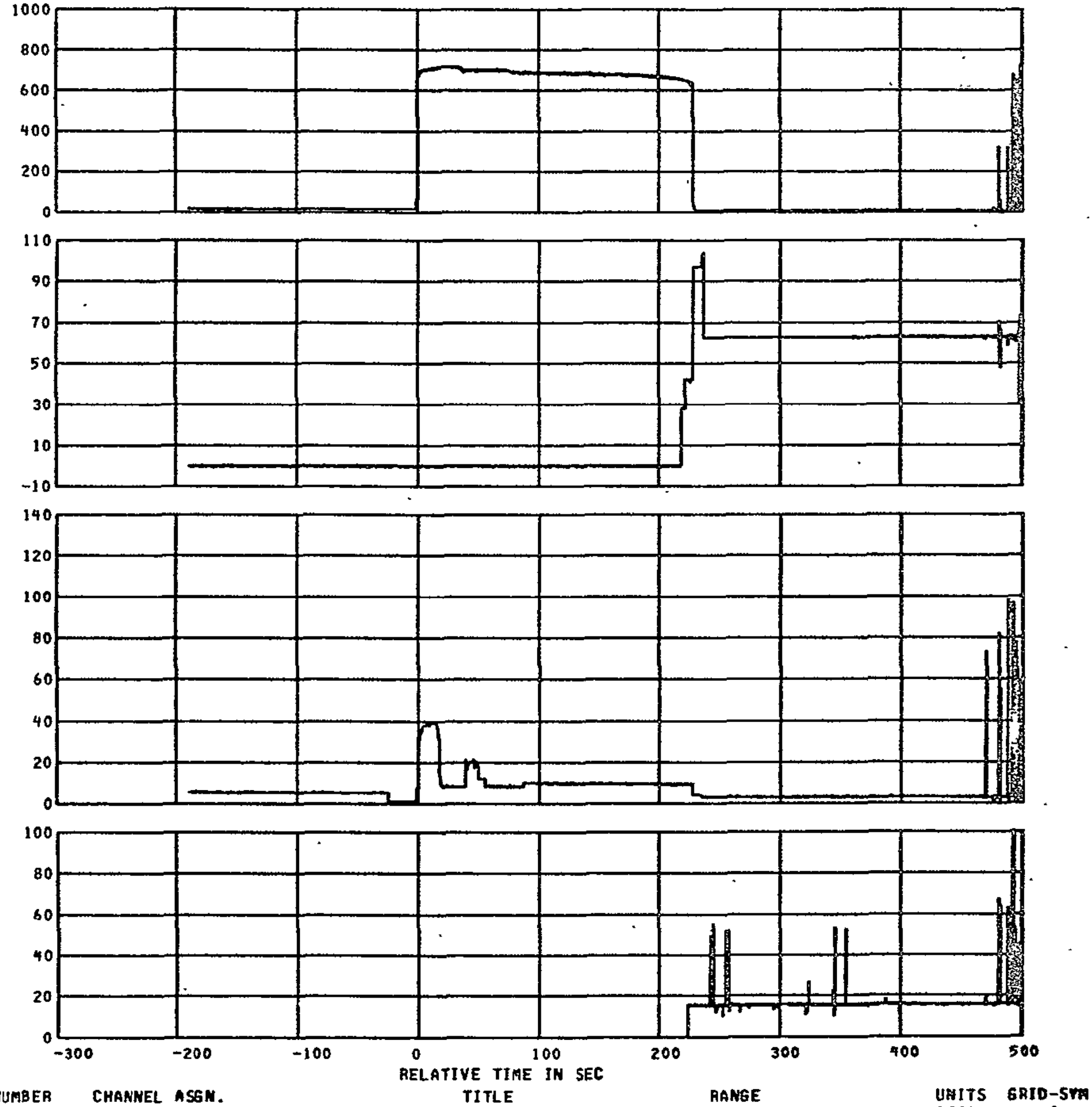
MEAS REMT	CHANNEL NO.	MEASUREMENT NAME	CAT-21 PLOT NUMBERS
PDM-21-35	CG21-35	IMU LOGIC VOLTAGE	508
PDM-21-36	CG21-36	YAW SERVO DIFFERENTIAL SIGNAL	502
PDM-21-37	CG21-37	HELIUM BOTTLE PRESSURE	511
PDM-21-38	CG21-38	HELIUM REGULATED PRESSURE	511
PDM-21-39	CG21-39	FUEL LINE TEMPERATURE	511
PDM-21-40	CG21-40	PITCH/ROLL JET ACT - SECONDARY	504
PDM-21-41	CG21-41	YAW JET ACTUATION-SECONDARY	502
PDM-21-42	CG21-42	FUEL TANK PRESSURE	511
PDM-21-43	CG21-43	ENGINE BATTERY VOLTAGE	501

TEST ID 046619 511100 COS-B DRETS PLOT NO 100 REFERENCE TIME 01 47 59.795

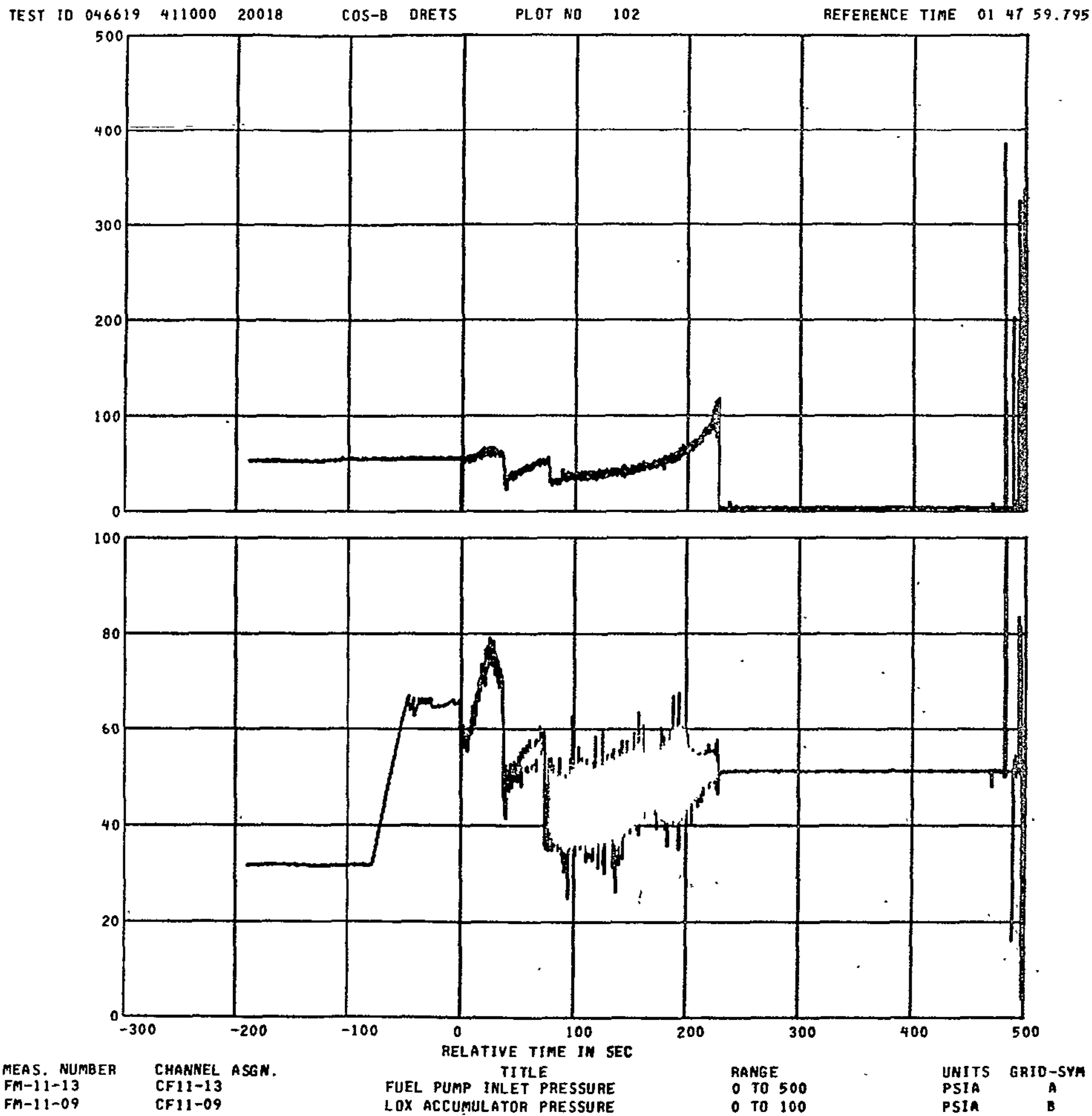


MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-11-12	CF11-12	TURBOPUMP SPEED	0 TO 100	PCT	

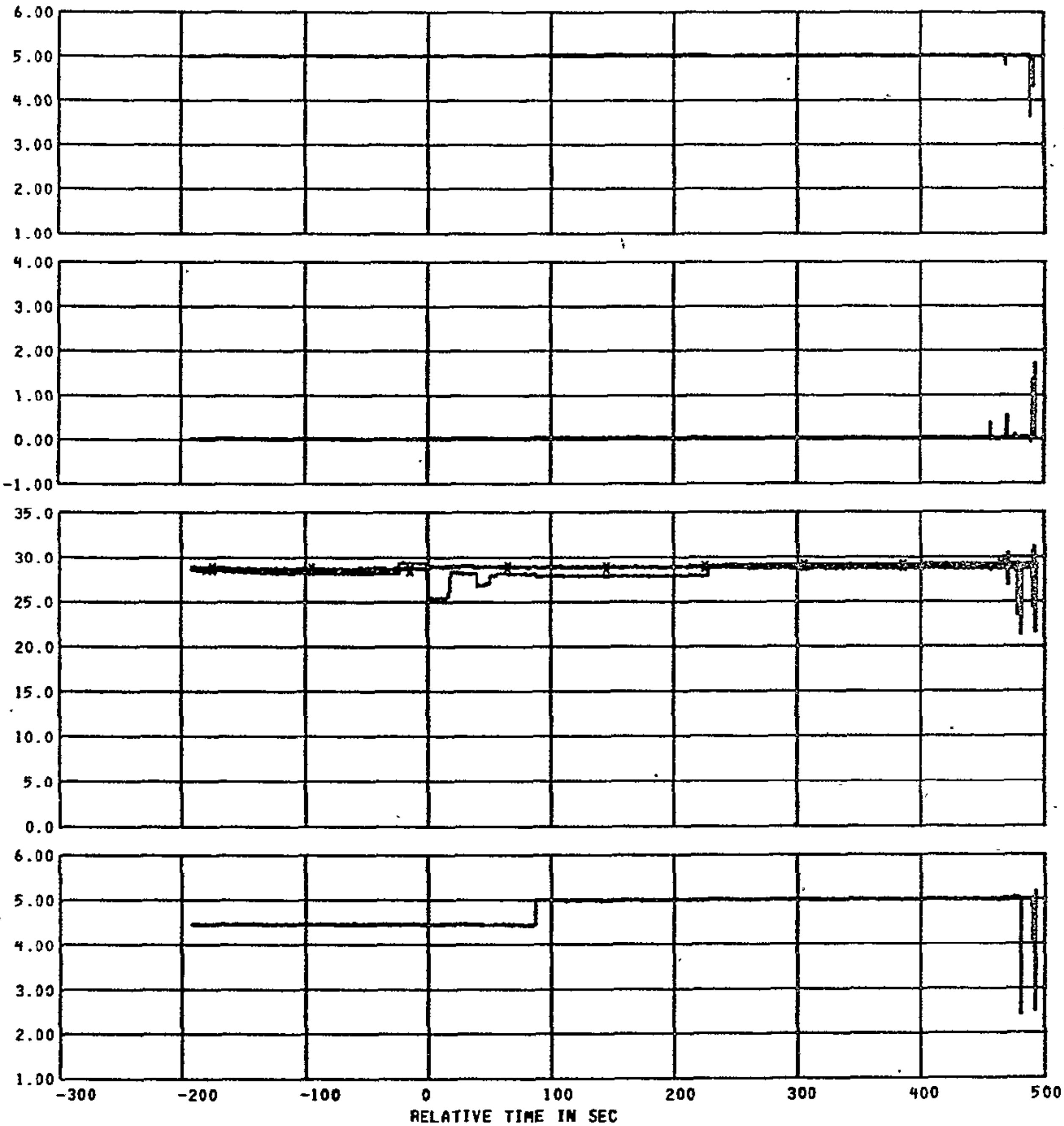
T ID 046619 411000 20018 COS-B DRETS PLOT NO 101 REFERENCE TIME 01 47 59.795



MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-11-11	CF11-11	MAIN ENGINE CHAMBER PRESSURE	0 TO 1000	PSIA	A
FM-11-08	CF11-08	SEQUENCE NO.1	0 TO 100	PCT	B
FM-11-10	CF11-10	CONTROL BATTERY CURRENT	0 TO 140	AMPS	C
FM-11-07	CF11-07	FUEL DEPLETION	0 TO 100	PCT	D

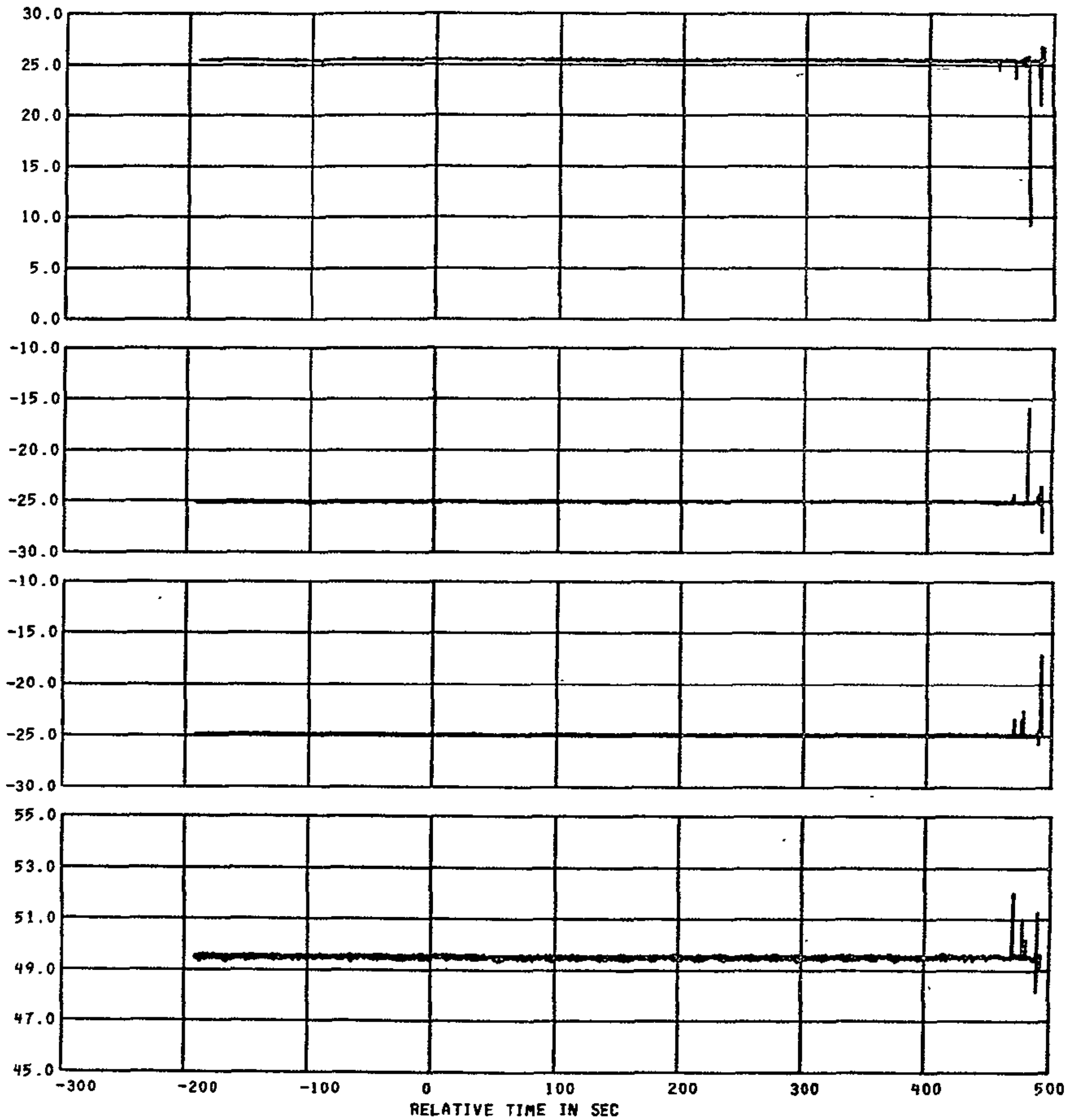

TEST ID 046619 411000 20018 COS-B DRETS PLOT NO 102 REFERENCE TIME 01 47 59.795
500
400
300
200
100
0
100
80
60
40
20
0
-300 -200 -100 0 100 200 300 400 500
RELATIVE TIME IN SEC
MEAS. NUMBER CHANNEL ASGN. TITLE RANGE UNITS GRID-SYM
FM-11-13 CF11-13 FUEL PUMP INLET PRESSURE 0 TO 500 PSIA A
FM-11-09 CF11-09 LOX ACCUMULATOR PRESSURE 0 TO 100 PSIA B

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 200 REFERENCE TIME 01 47 59.795



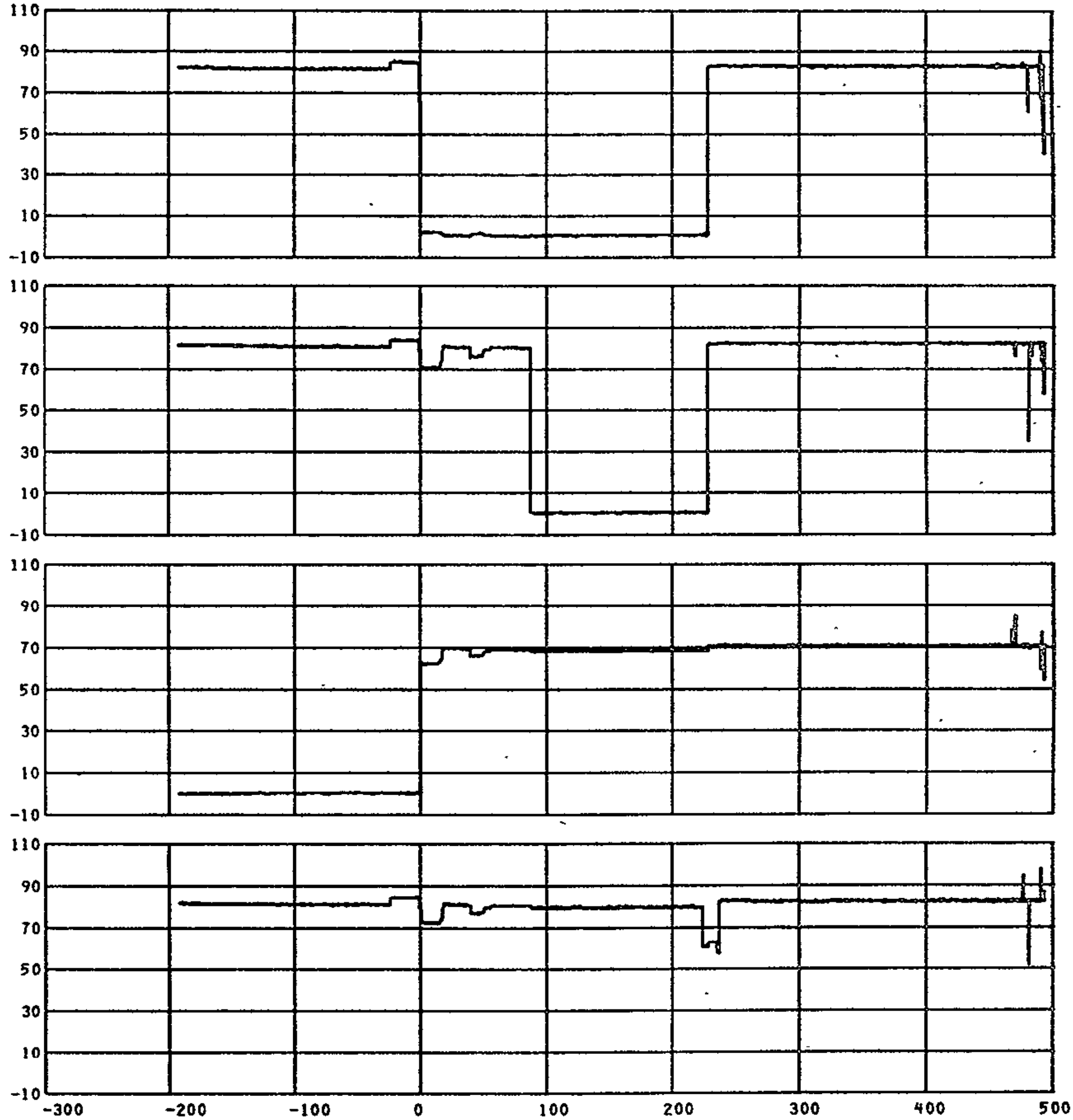
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-01	CG11-01	5 VOLT REFERENCE	0.00 TO 5.00	VDC	A
PDM-11-02	CG11-02	INSTRUMENTATION GROUND	0.00 TO 5.00	VDC	B
PDM-11-23	CG11-23	CONTROL BATTERY VOLTAGE	0.0 TO 35.0	VDC	C
PDM-11-24	CG11-24	INSTRUMENTATION BATTERY VOLTAGE	0.0 TO 32.0	VDC	CX
PDM-11-29	CG11-29	SOLID MOTOR POT EXCITATION	0.00 TO 5.00	VDC	D

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 201 REFERENCE TIME 01 47 59.795



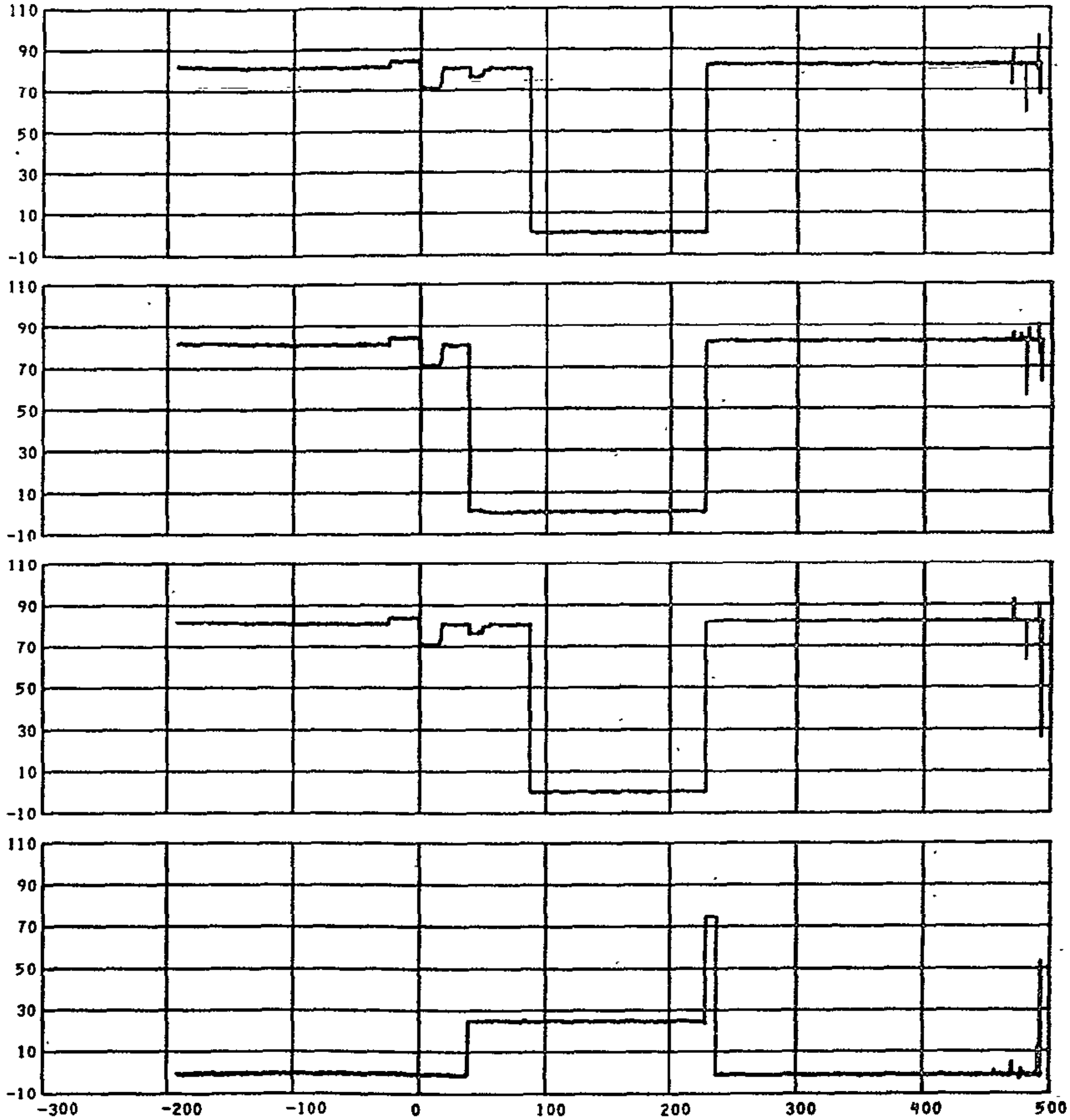
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-17	CG11-17	FEEDBACK POT EXCITATION (POS)	0.0 TO 30.0	VDC	A
PDM-11-18	CG11-18	FEEDBACK POT EXCITATION (NEG)	-30.0 TO -13.0	VDC	B
PDM-11-21	CG11-21	ACTUATOR EXCITATION (NEG)	-30.0 TO -13.0	VDC	C
PDM-11-34	CG11-34	ACTUATOR EXCITATION (POS)	45.0 TO 55.0	VDC	D

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 202 REFERENCE TIME 01 47 59.795



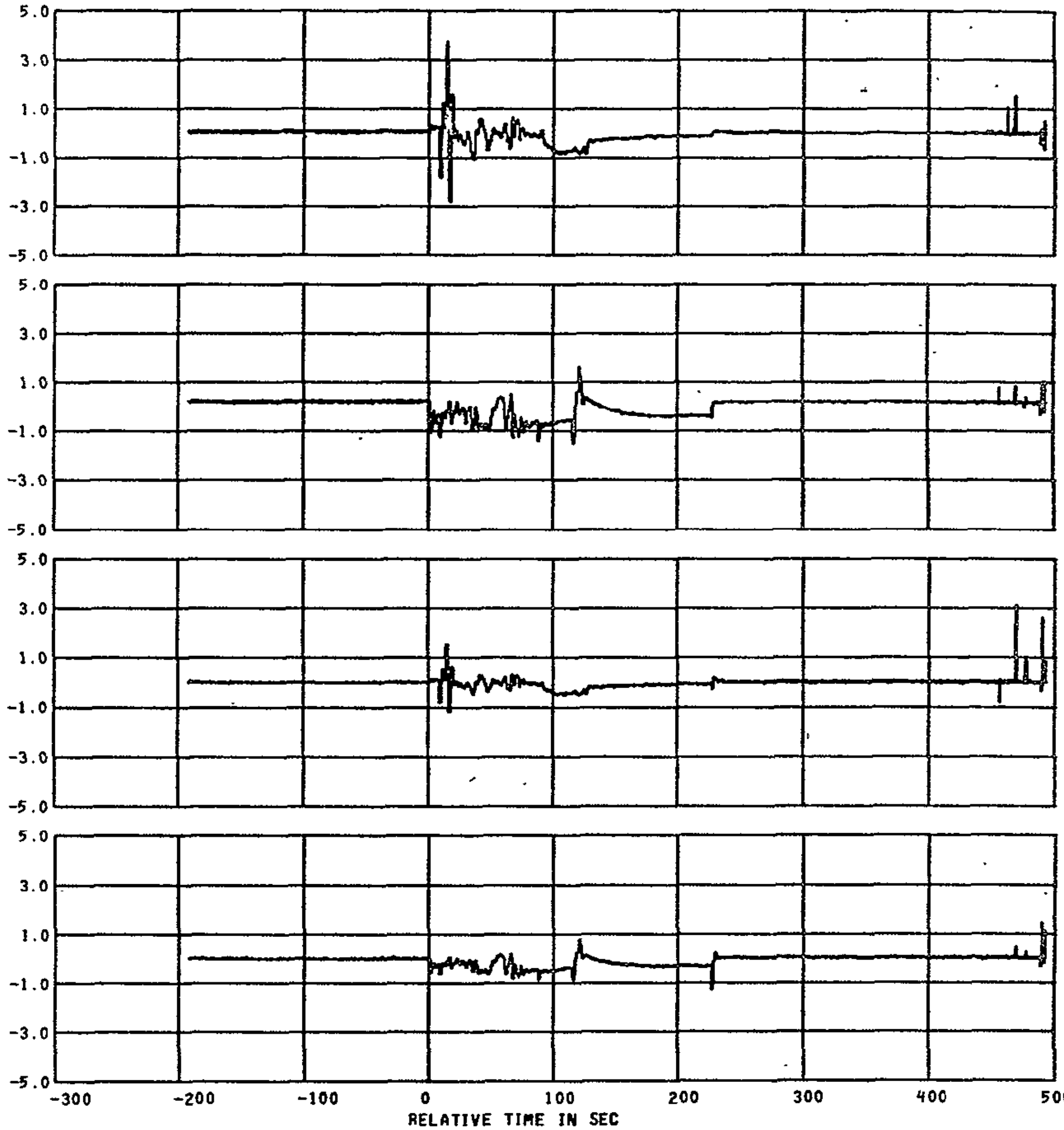
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-28	CG11-28	SEQUENCE NO.2 S.M. SET NO.2 + 3	0 TO 100	PCT	A
PDM-11-31	CG11-31	SEQUENCE NO.3 S.M. SET NO.3	0 TO 100	PCT	B
PDM-11-30	CG11-30	SEQUENCE NO.4	0 TO 100	PCT	C
PDM-11-36	CG11-36	SEQUENCE NO.5	0 TO 100	PCT	D

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 203 REFERENCE TIME 01 47 59.795



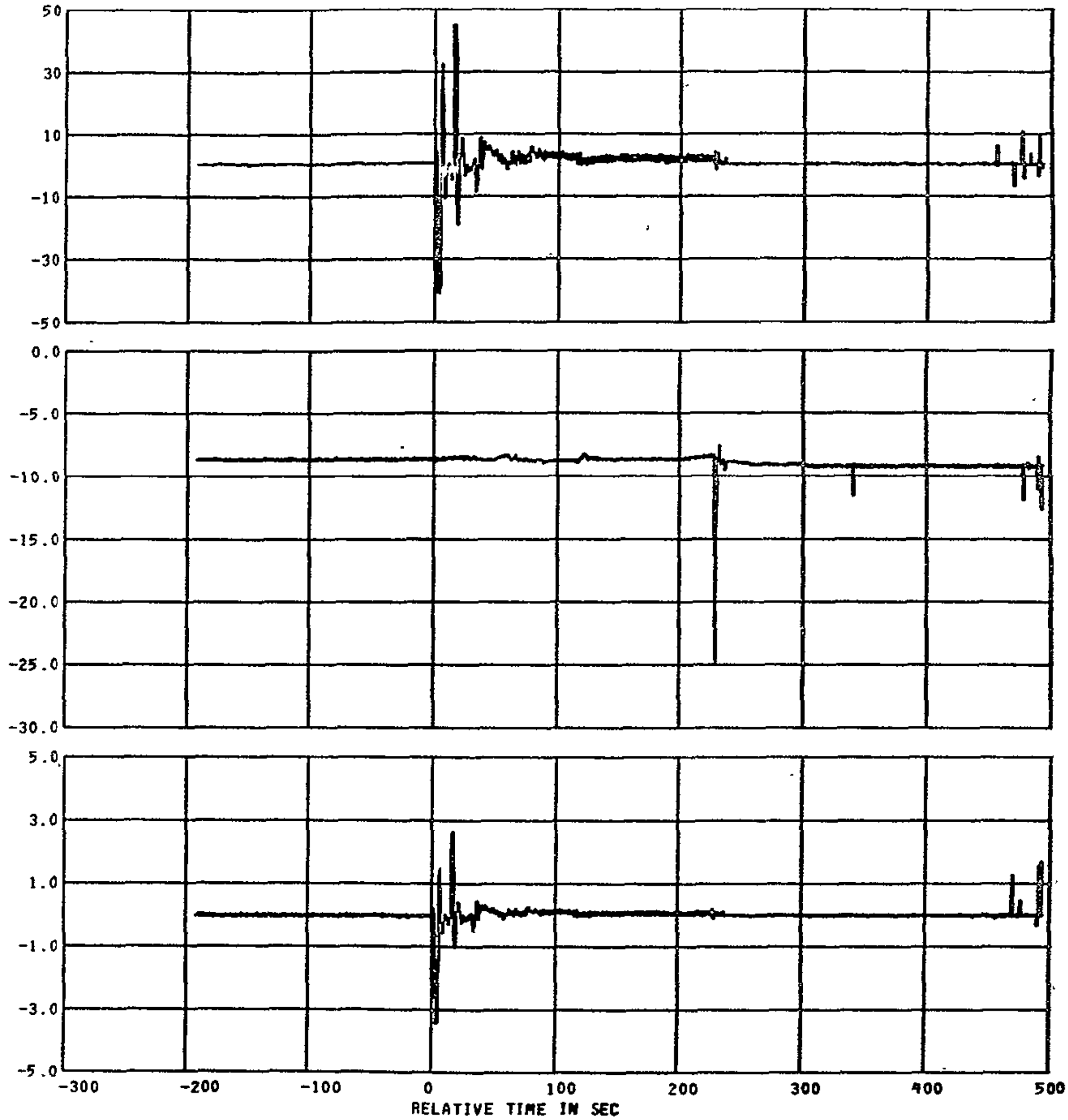
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-32	CG11-32	SEQUENCE NO.6 S.M. SET NO.2	0 TO 100	PCT	A
PDM-11-35	CG11-35	SEQUENCE NO.7 S.M. SET NO.1	0 TO 100	PCT	B
PDM-11-39	CG11-39	SEQUENCE NO.8 S.M. SET NO.1	0 TO 100	PCT	C
PDM-11-13	CG11-13	SEQUENCE NO.9	0 TO 100	PCT	D

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 204 REFERENCE TIME 01 47 59.795



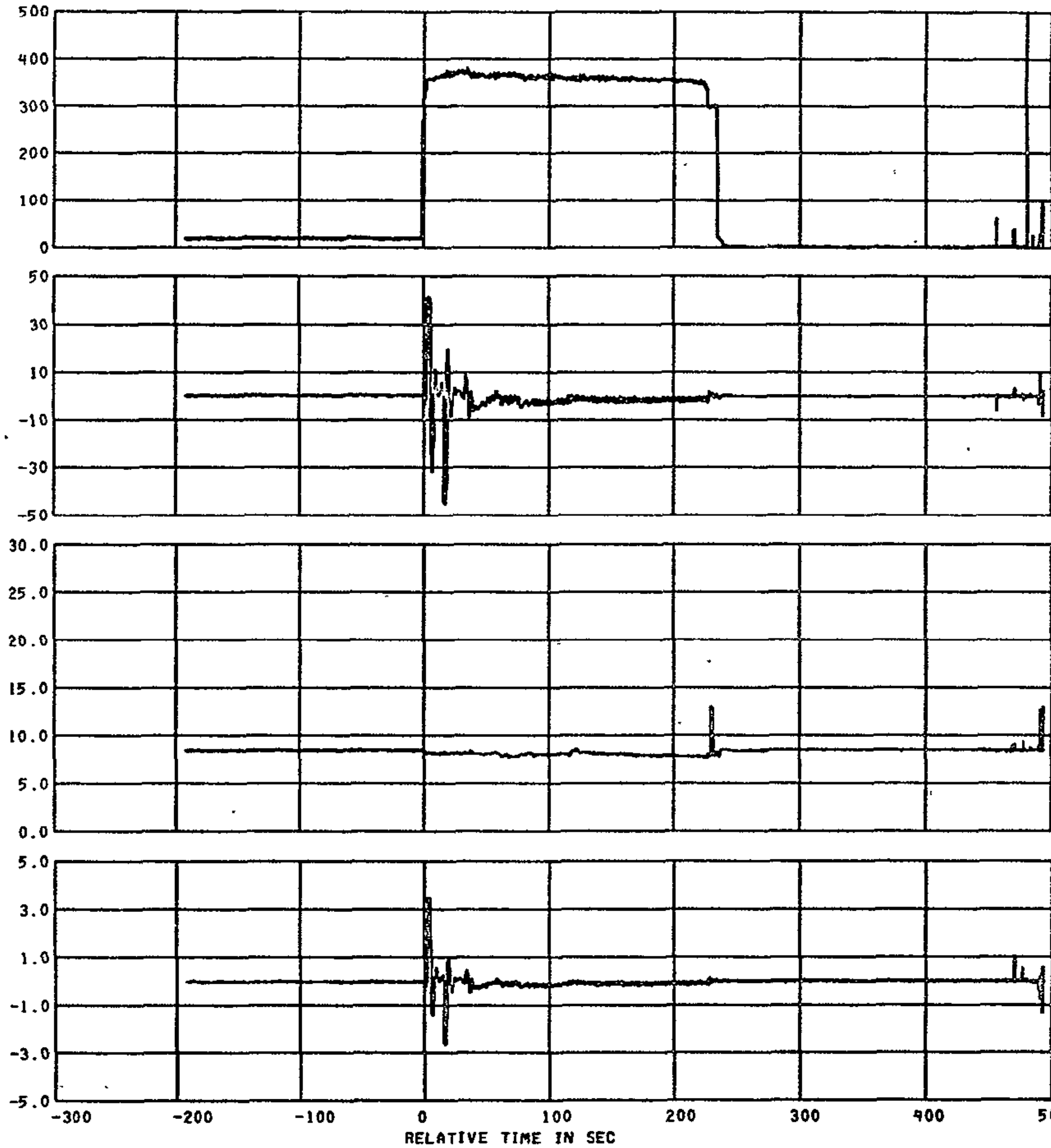
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-03	CG11-03	MAIN ENGINE PITCH POSITION	-5.0 TO 5.0	DEG	A
PDM-11-04	CG11-04	MAIN ENGINE YAW POSITION	-5.0 TO 5.0	DEG	B
PDM-11-09	CG11-09	PITCH SUMMING AMP OUTPUT	-4.50 TO 4.50	VDC	C
PDM-11-10	CG11-10	YAW SUMMING AMP OUTPUT	-4.50 TO 4.50	VDC	D

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 205 REFERENCE TIME 01 47 59.795



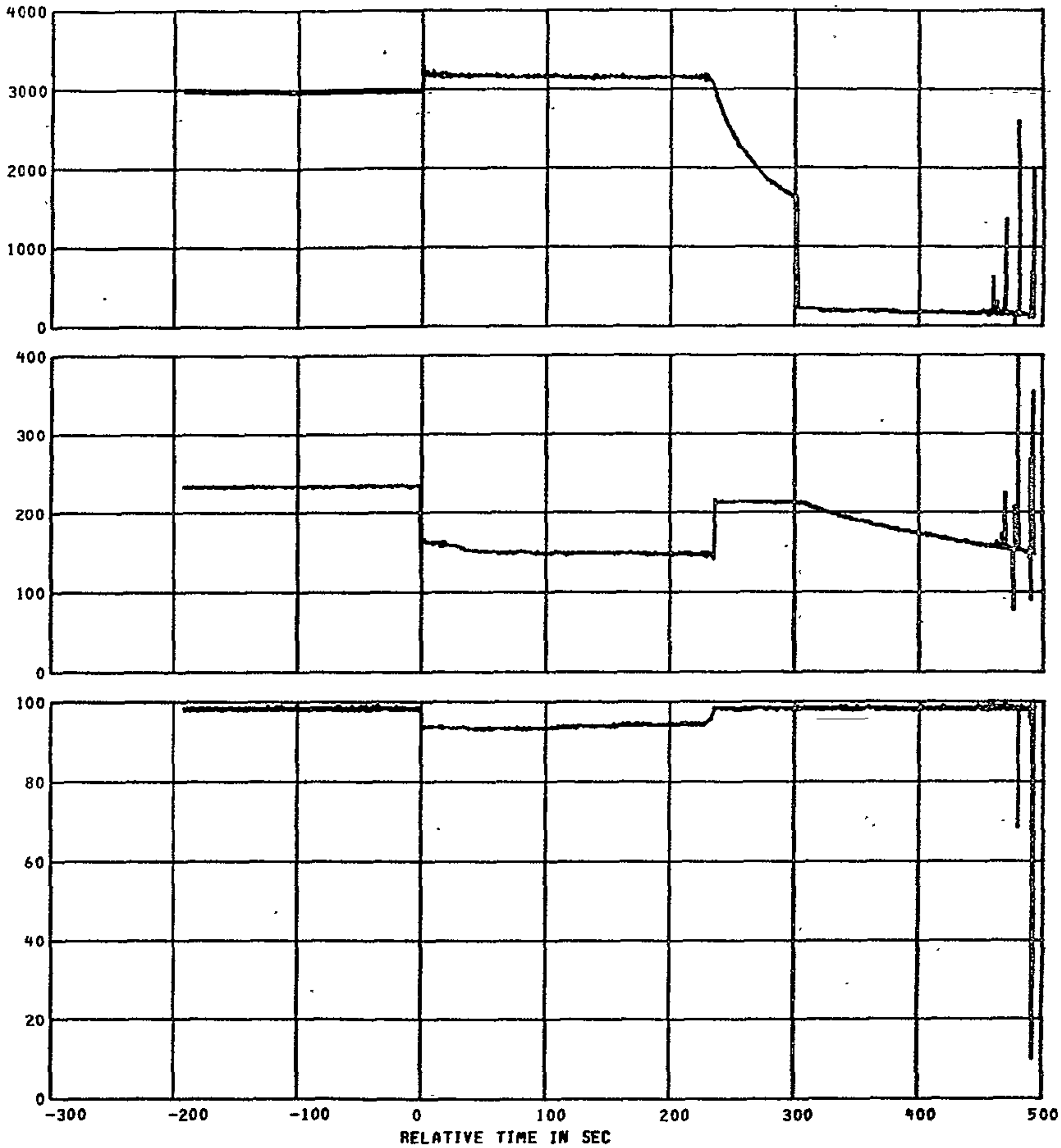
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-05	CG11-05	V.E. NO.1 PITCH/ROLL POSITION	-45.0 TO 45.0	DEG	A
PDM-11-06	CG11-06	V.E. NO.1 YAW POSITION	-29.0 TO -9.0	DEG	B
PDM-11-12	CG11-12	ROLL SUMMING AMP OUTPUT VE NO.1	-4.50 TO 4.50	VDC	C

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 206 REFERENCE TIME 01 47 59.795



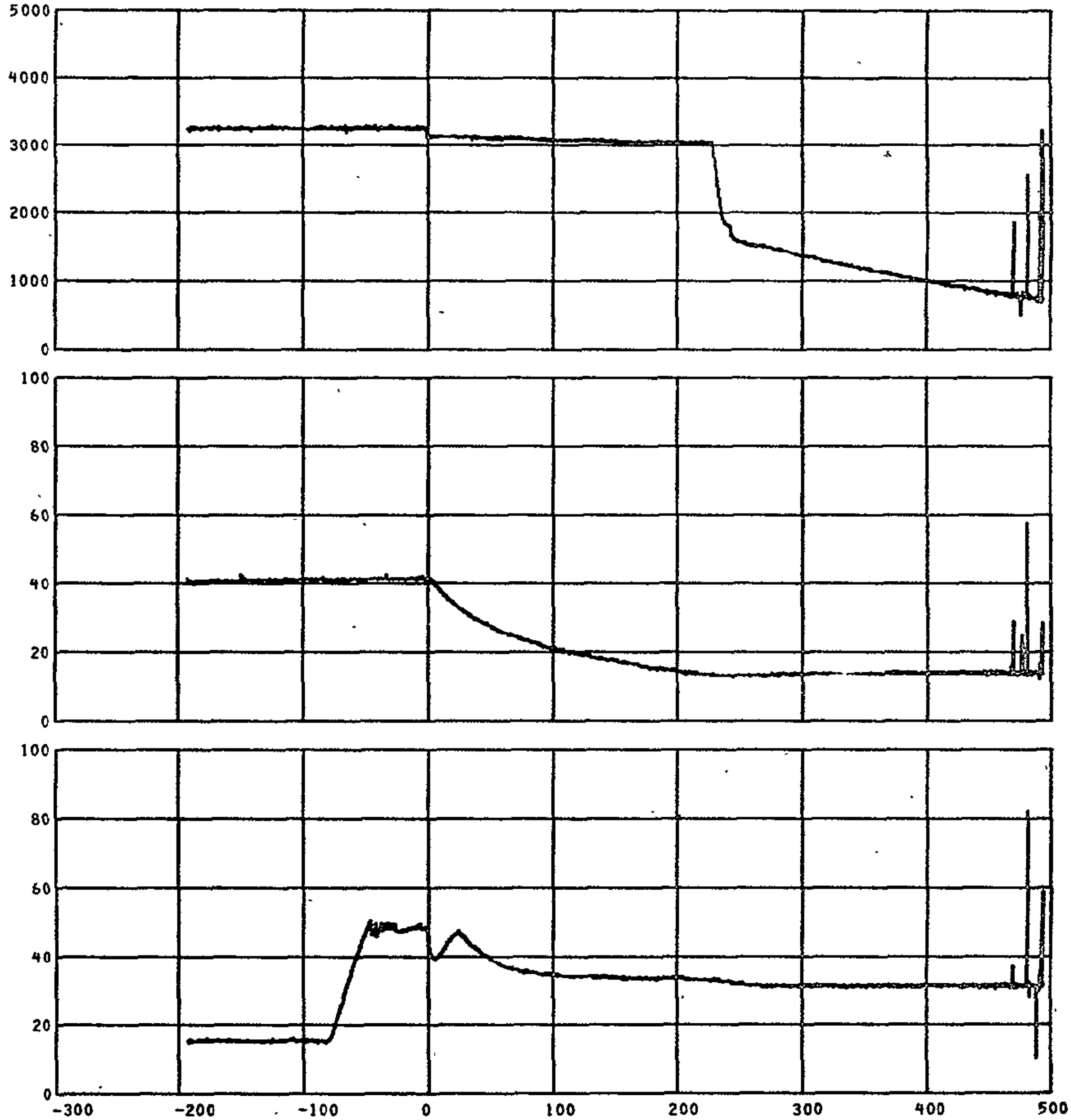
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-22	CG11-22	V.E. NO.2 CHAMBER PRESSURE	0 TO 500	PSIA	A
PDM-11-07	CG11-07	V.E. NO.2 PITCH/ROLL POSITION	-45.0 TO 45.0	DEG	B
PDM-11-08	CG11-08	V.E. NO.2 YAW POSITION	9.0 TO 29.0	DEG	C
PDM-11-11	CG11-11	ROLL SUMMING AMP OUTPUT VE NO.2	-4.50 TO 4.50	VDC	D

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 207 REFERENCE TIME 01 47 59.795



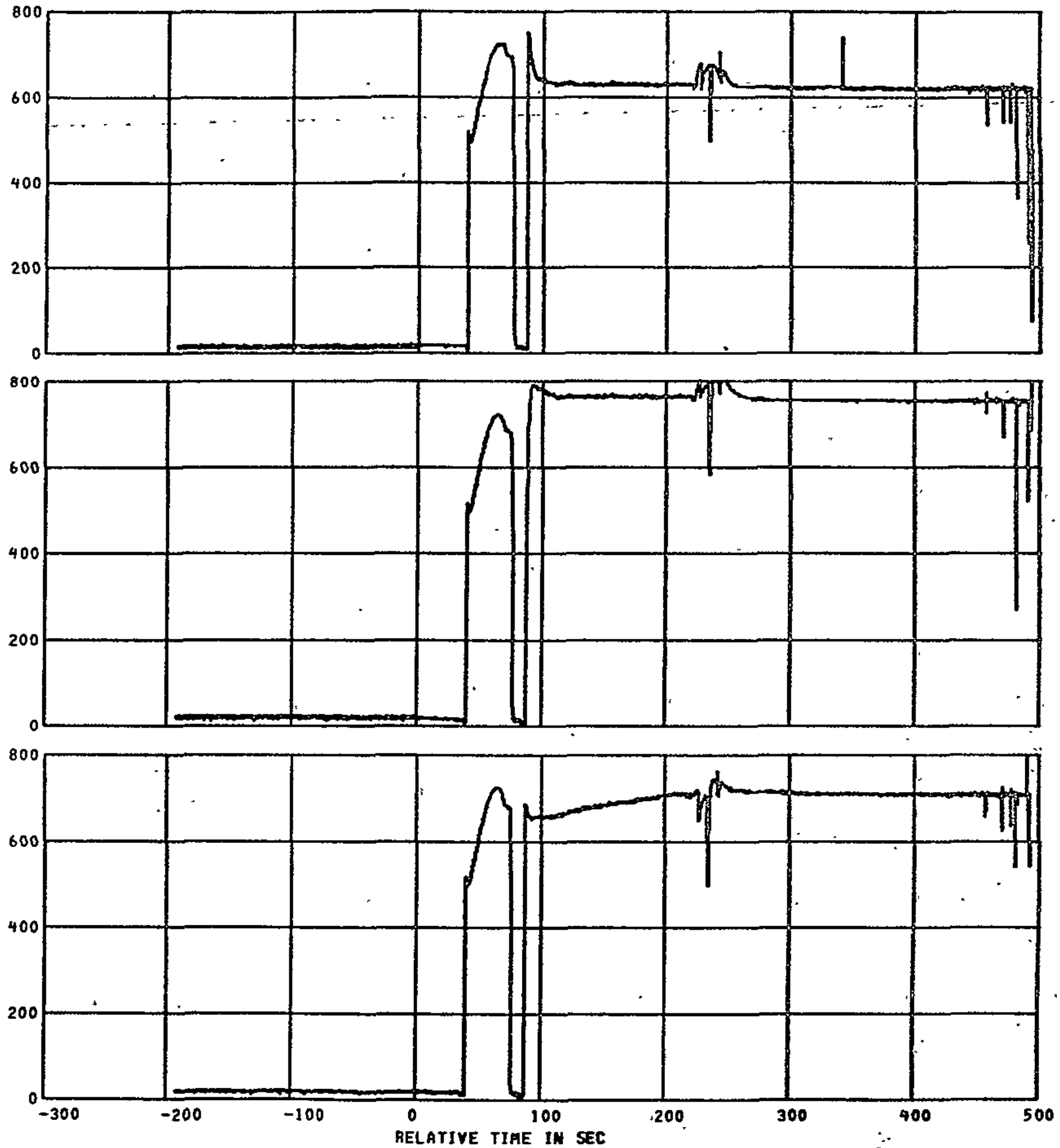
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-25	CG11-25	HYDRAULIC SUPPLY PRESSURE	0 TO 4000	PSIA	A
PDM-11-26	CG11-26	HYDRAULIC RETURN PRESSURE	0 TO 400	PSIA	B
PDM-11-27	CG11-27	HYDRAULIC ACCUM PISTON POSITION	0 TO 100	PCT	C

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 208 REFERENCE TIME 01 47 59.795



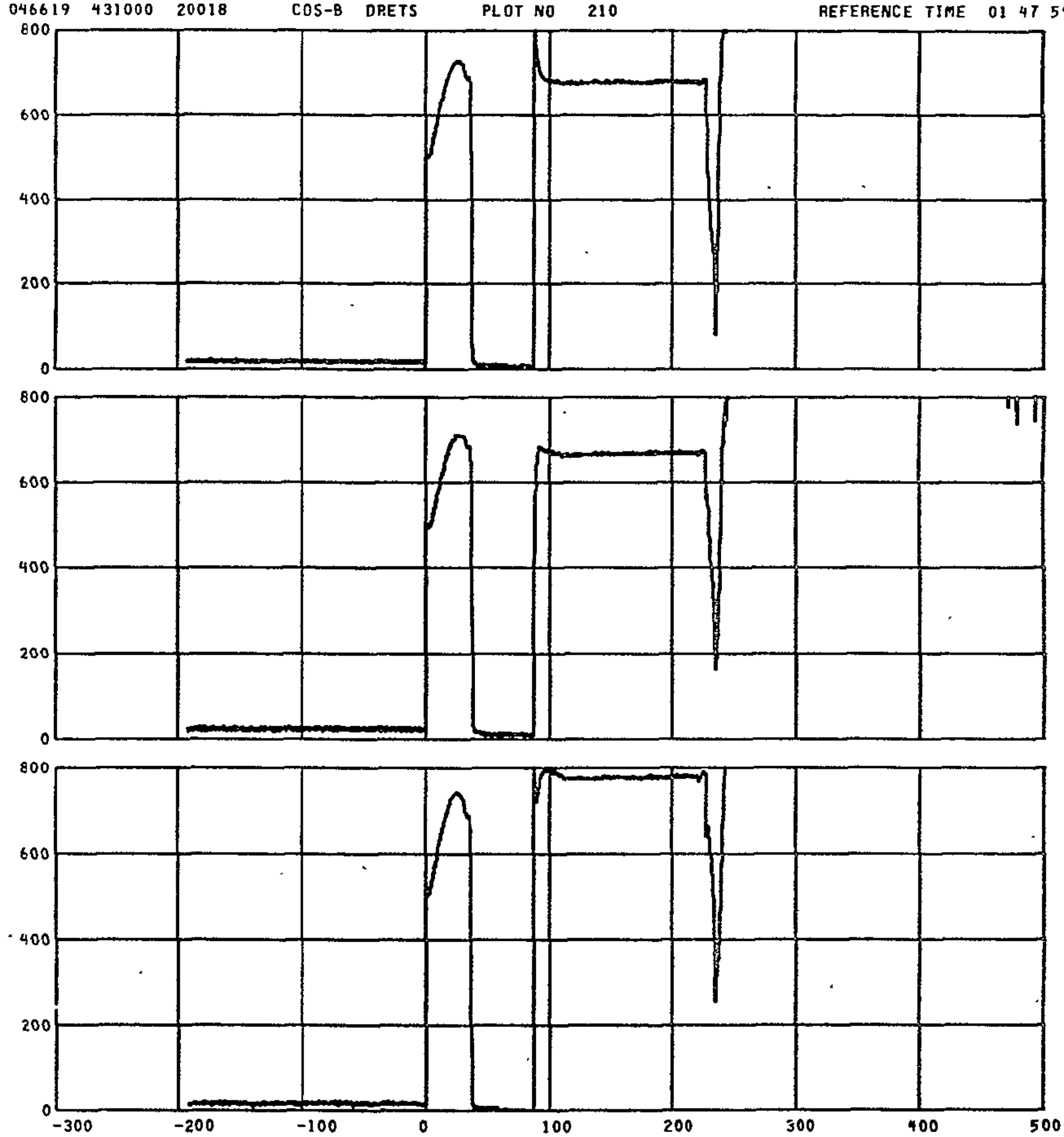
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-33	CG11-33	ENGINE PNEUMATIC BOTTLE PRESS	0 TO 5000	PSIA	A
PDM-11-40	CG11-40	MAIN FUEL TANK TOP PRESSURE	0 TO 100	PSIA	B
PDM-11-42	CG11-42	LOX TANK TOP PRESSURE	0 TO 100	PSIA	C

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 209 REFERENCE TIME 01 47 59.795



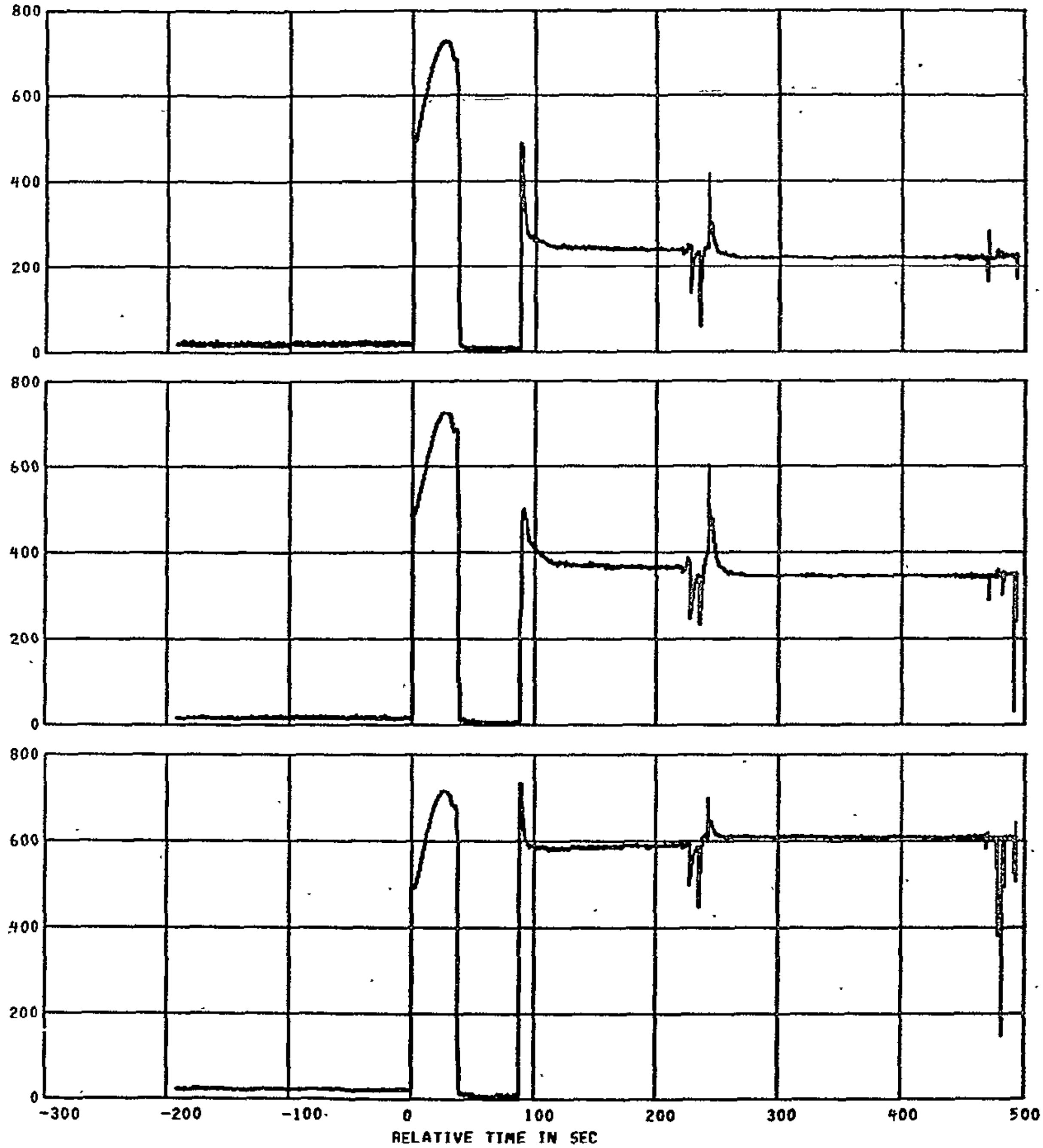
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-37	CG11-37	SOLID MOTOR NO.1 CHAMBER PRESS	0 TO 800	PSIA	A
PDM-11-38	CG11-38	SOLID MOTOR NO.2 CHAMBER PRESS	0 TO 800	PSIA	B
PDM-11-41	CG11-41	SOLID MOTOR NO.3 CHAMBER PRESS	0 TO 800	PSIA	C

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 210 REFERENCE TIME 01 47 59.795



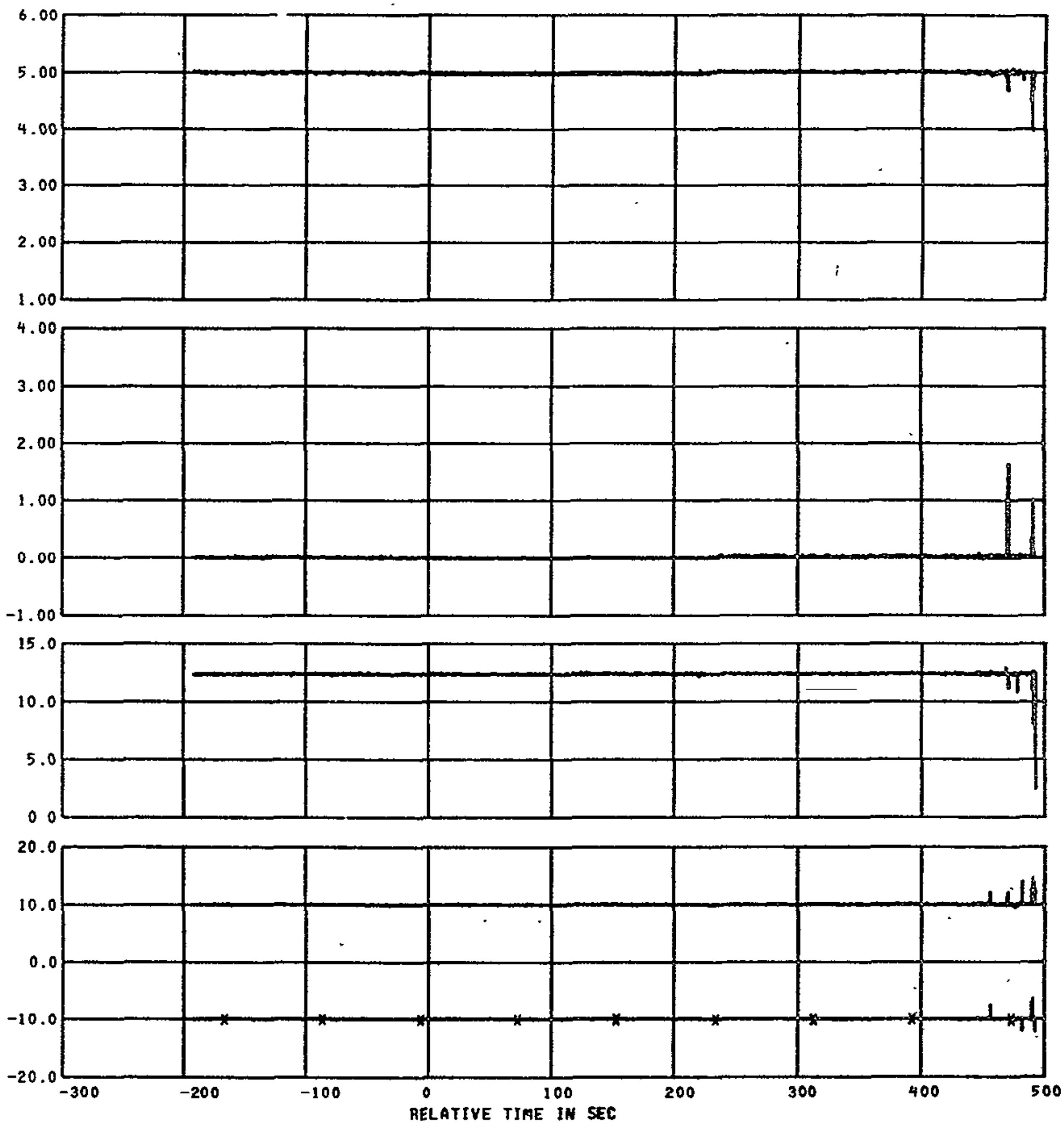
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-14	CG11-14	SOLID MOTOR NO.4 CHAMBER PRESS	0 TO 800	PSIA	A
PDM-11-15	CG11-15	SOLID MOTOR NO.5 CHAMBER PRESS	0 TO 800	PSIA	B
PDM-11-16	CG11-16	SOLID MOTOR NO.6 CHAMBER PRESS	0 TO 800	PSIA	C

TEST ID 046619 431000 20018 COS-B DRETS PLOT NO 211 REFERENCE TIME 01 47 59.795



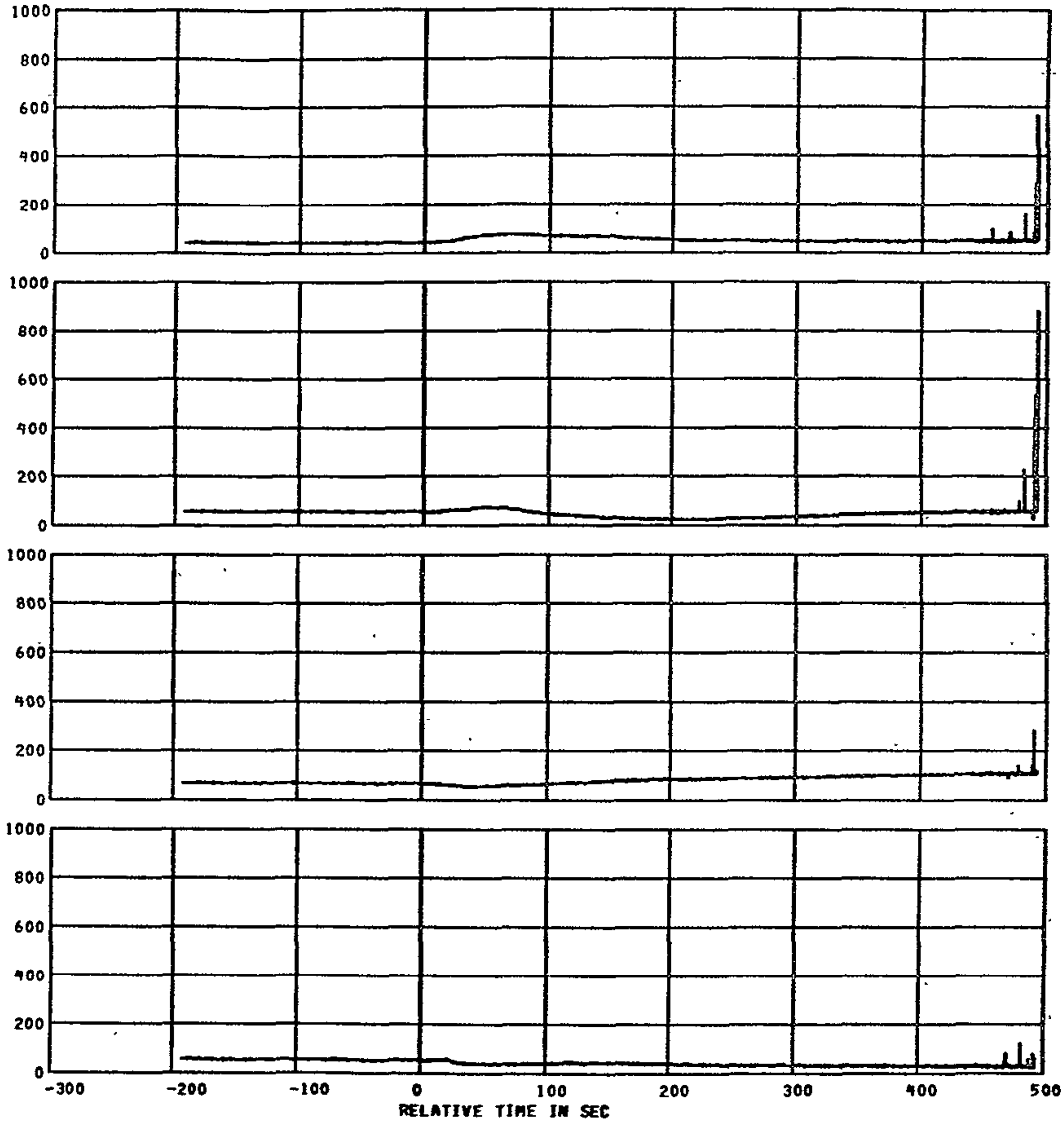
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-11-19	CG11-19	SOLID MOTOR NO.7 CHAMBER PRESS	0 TO 800	PSIA	A
PDM-11-20	CG11-20	SOLID MOTOR NO.8 CHAMBER PRESS	0 TO 800	PSIA	B
PDM-11-43	CG11-43	SOLID MOTOR NO.9 CHAMBER PRESS	0 TO 800	PSIA	C

TEST ID 046619 432000 20018 COS-B DRETS PLOT NO 300 REFERENCE TIME 01 47 59.795



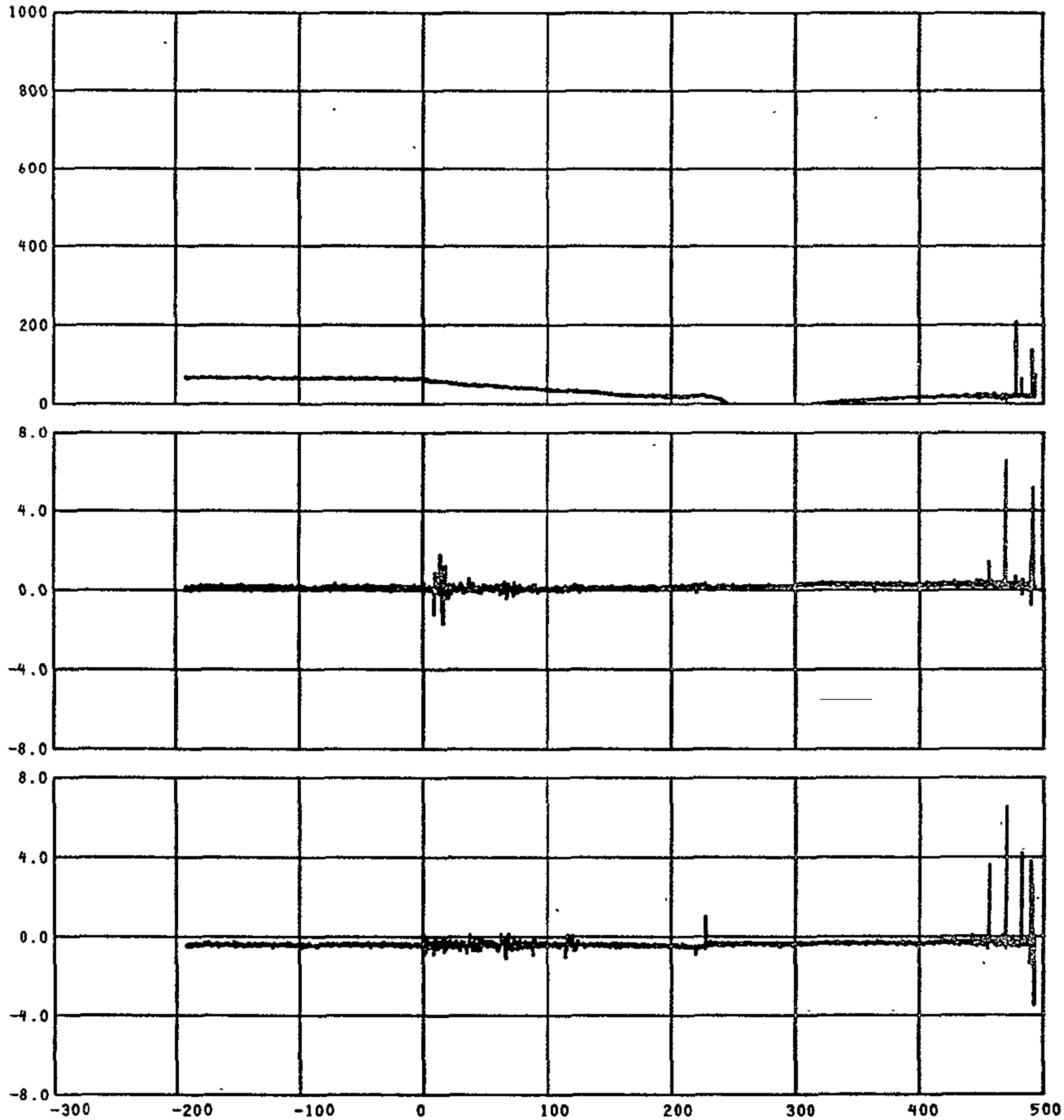
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-12-01	CG12-01	5 VOLT REFERENCE	0.00 TO 5.00	VDC	A
PDM-12-02	CG12-02	INSTRUMENTATION GROUND	0.00 TO 5.00	VDC	B
PDM-12-12	CG12-12	12.35 VOLT BIAS	0.0 TO 12.4	VDC	C
PDM-12-29	CG12-29	+10 VDC TRANSDUCER POWER	0.0 TO 20.0	VDC	D
PDM-12-30	CG12-30	-10 VDC TRANSDUCER POWER	-20.0 TO 0.0	VDC	DX

TEST ID 046619 432000 20018 COS-B DRETS PLOT NO 301 REFERENCE TIME 01 47 59.795



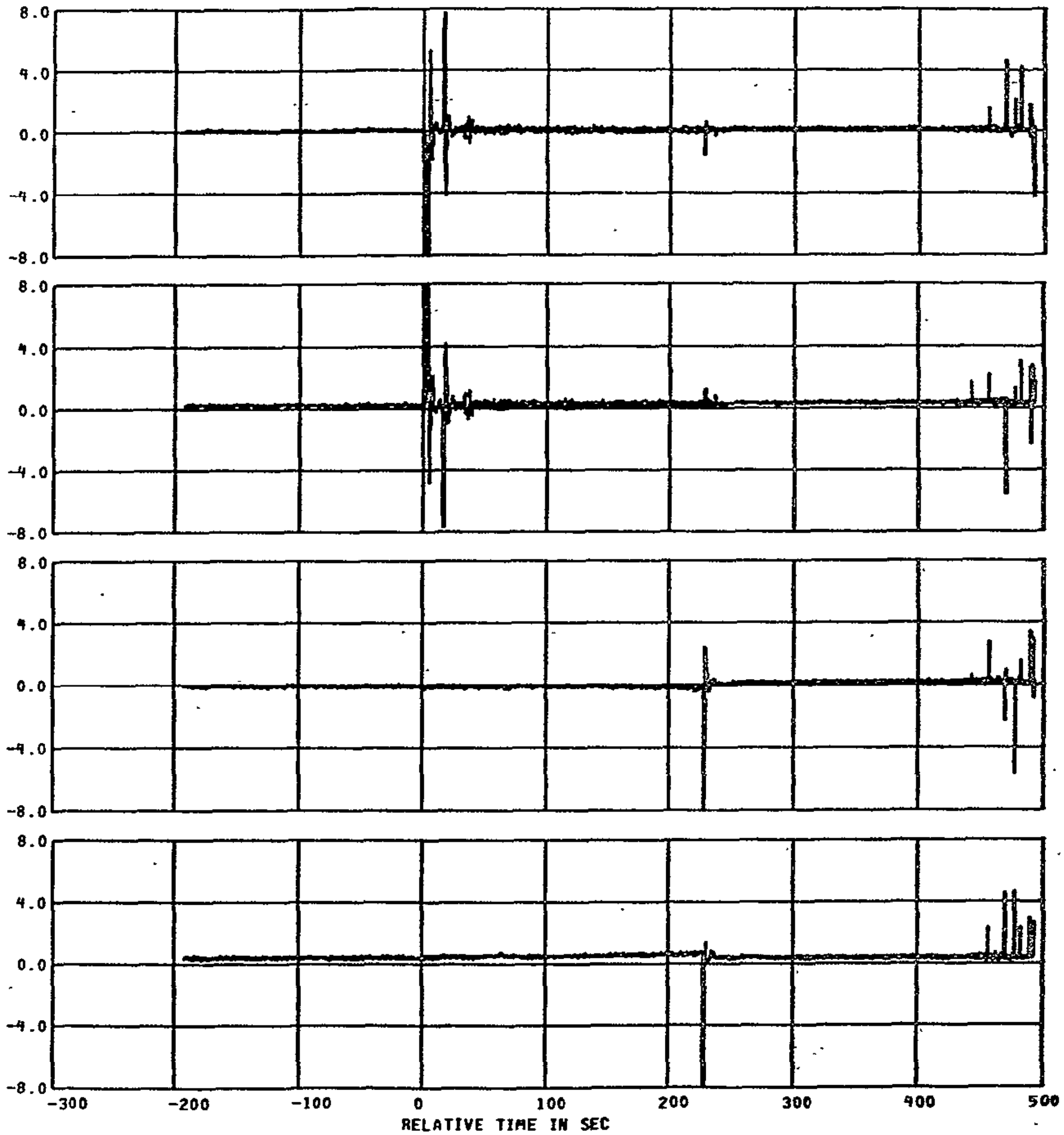
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-12-13	CG12-13	V.E. NO.1 HOUSING TEMPERATURE	32 TO 1000	DEG F	A
PDM-12-14	CG12-14	V.E. NO.2 HOUSING TEMPERATURE	32 TO 1000	DEG F	B
PDM-12-16	CG12-16	AIR CONDITIONING INLET TEMP	32 TO 1000	DEG F	C
PDM-12-17	CG12-17	SKIRT SECTION TEMPERATURE	32 TO 1000	DEG F	D

TEST ID 046619 432000 20018 COS-B DRETS PLOT NO 302 REFERENCE TIME 01 47 59.795



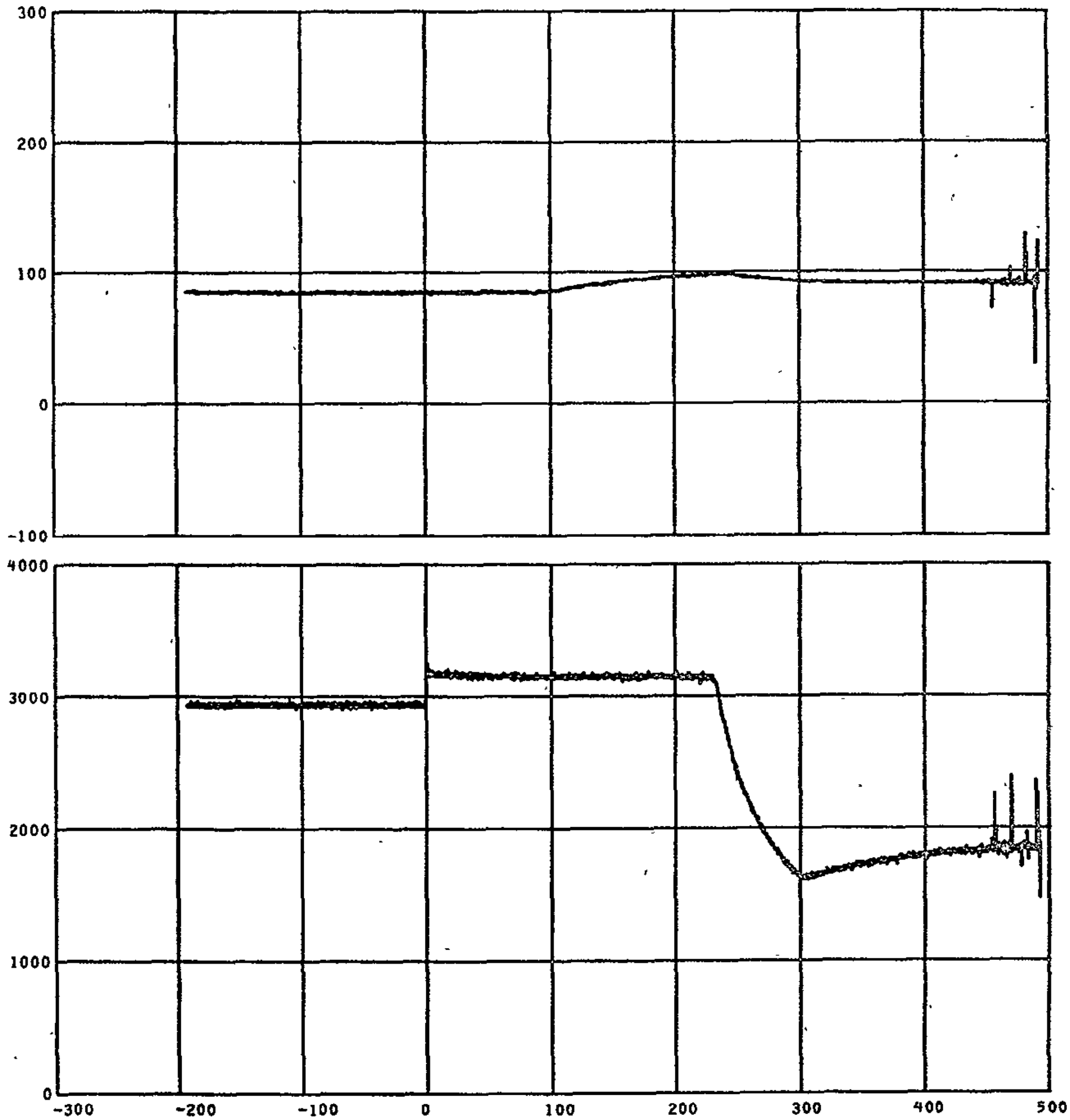
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-12-15	CG12-15	M.E. PITCH ACTUATOR TEMPERATURE	32 TO 1000	DEG F	A
PDM-12-23	CG12-23	M.E. PITCH SERVO DIFF. SIGNAL	-8.0 TO 8.0	MA	B
PDM-12-26	CG12-26	M.E. YAW SERVO DIFF. SIGNAL	-8.0 TO 8.0	MA	C

TEST ID 046619 432000 20018 COS-B DRETS PLOT NO 303 REFERENCE TIME 01 47 59.795



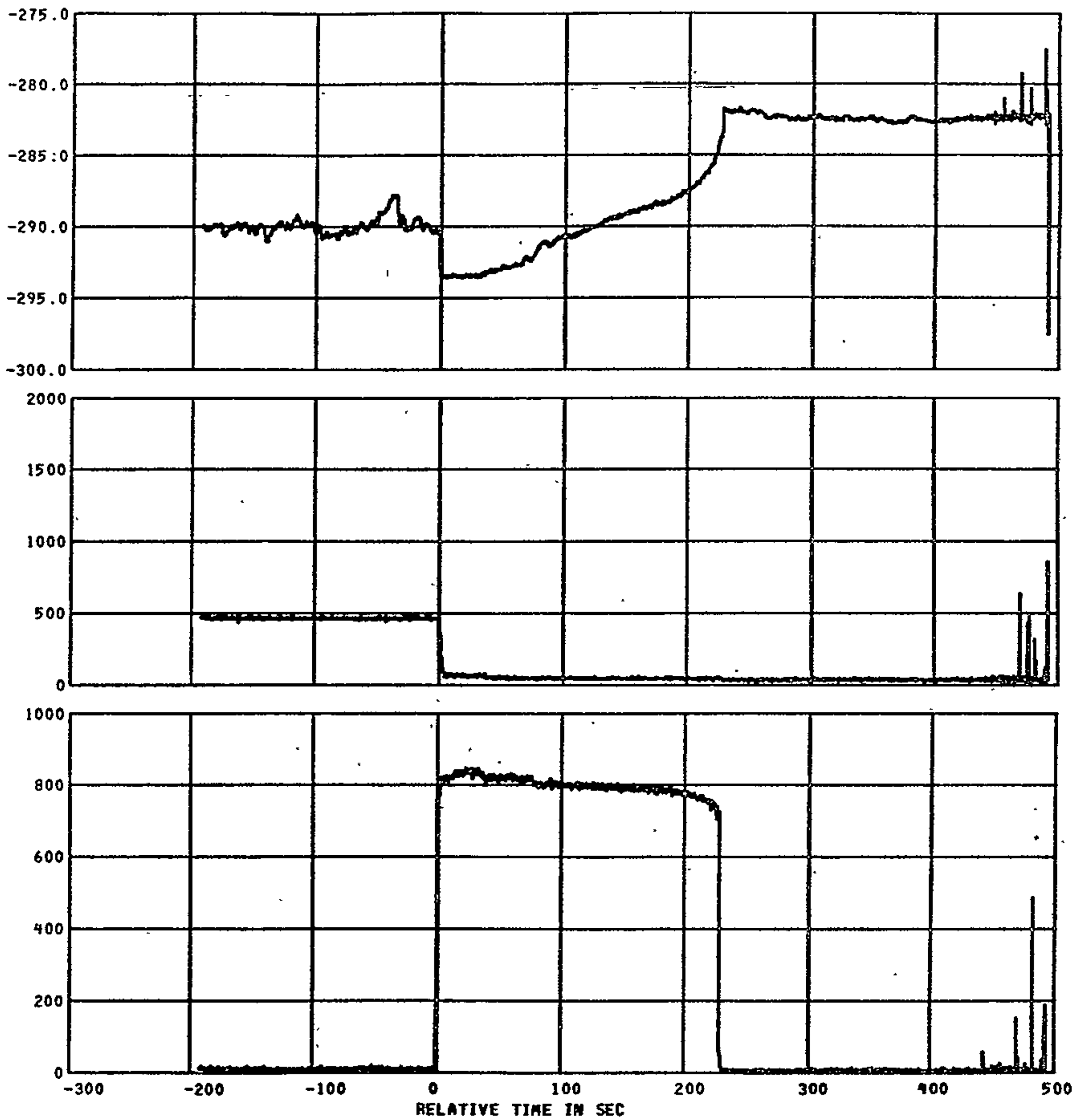
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-12-24	CG12-24	VE 1 PITCH/ROLL SERVO DIFF SGNL	-8.0 TO 8.0	MA	A
PDM-12-25	CG12-25	VE 2 PITCH/ROLL SERVO DIFF SGNL	-8.0 TO 8.0	MA	B
PDM-12-27	CG12-27	VE 1 YAW SERVO DIFF. SIGNAL	-8.0 TO 8.0	MA	C
PDM-12-28	CG12-28	VE 2 YAW SERVO DIFF. SIGNAL	-8.0 TO 8.0	MA	D

TEST ID 046619 432000 20018 COS-B DRETS PLOT NO 304 REFERENCE TIME 01 47 59.795



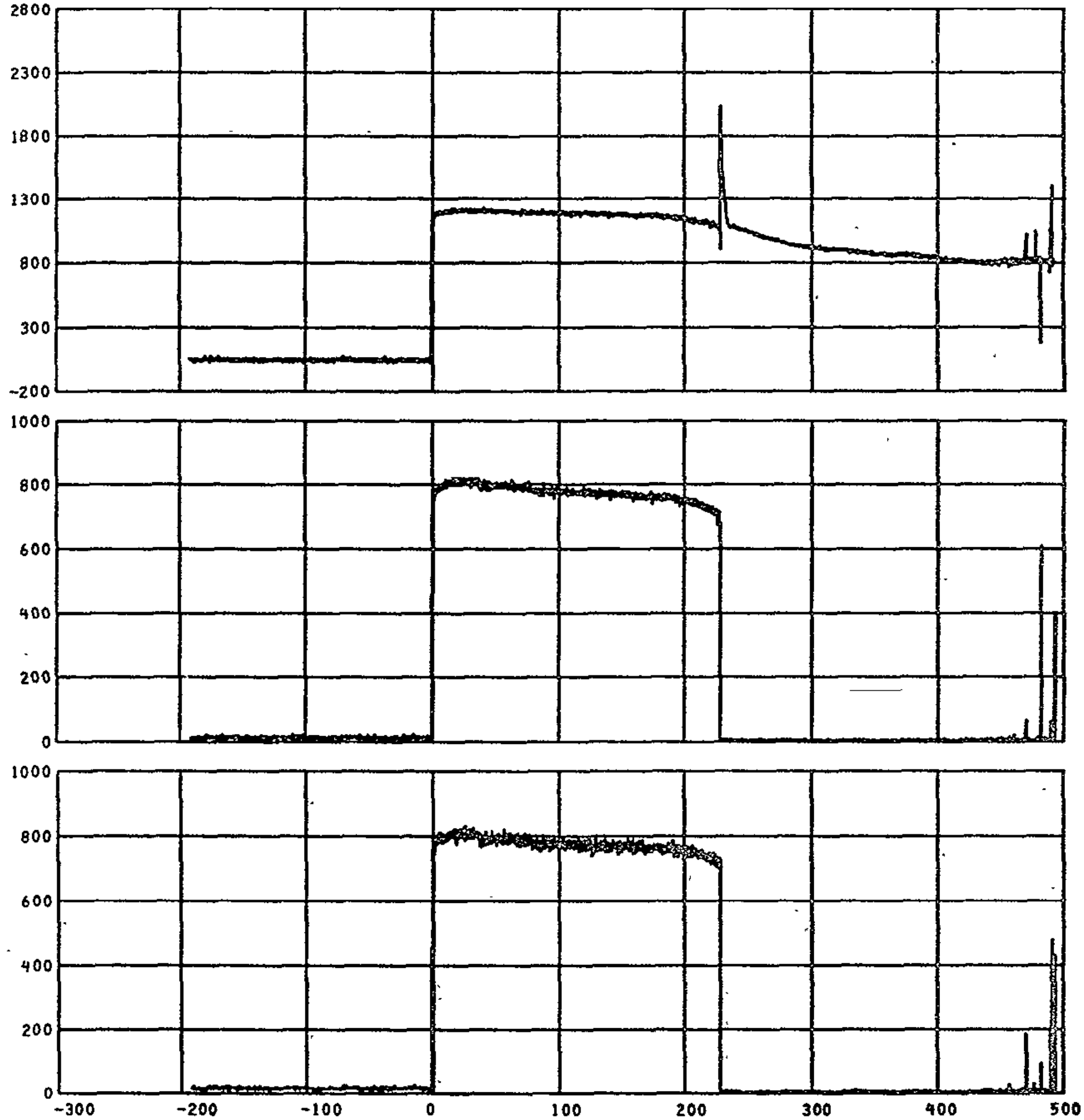
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-12-31	CG12-31	HYDRAULIC ACCUM TEMPERATURE	-20 TO 300	DEG F	A
PDM-12-32	CG12-32	HYDRAULIC ACCUM GN2 PRESSURE	0 TO 4000	PSIA	B

TEST ID 046619 432000 20018 COS-B DRETS PLOT NO 305 REFERENCE TIME 01 47 59.795



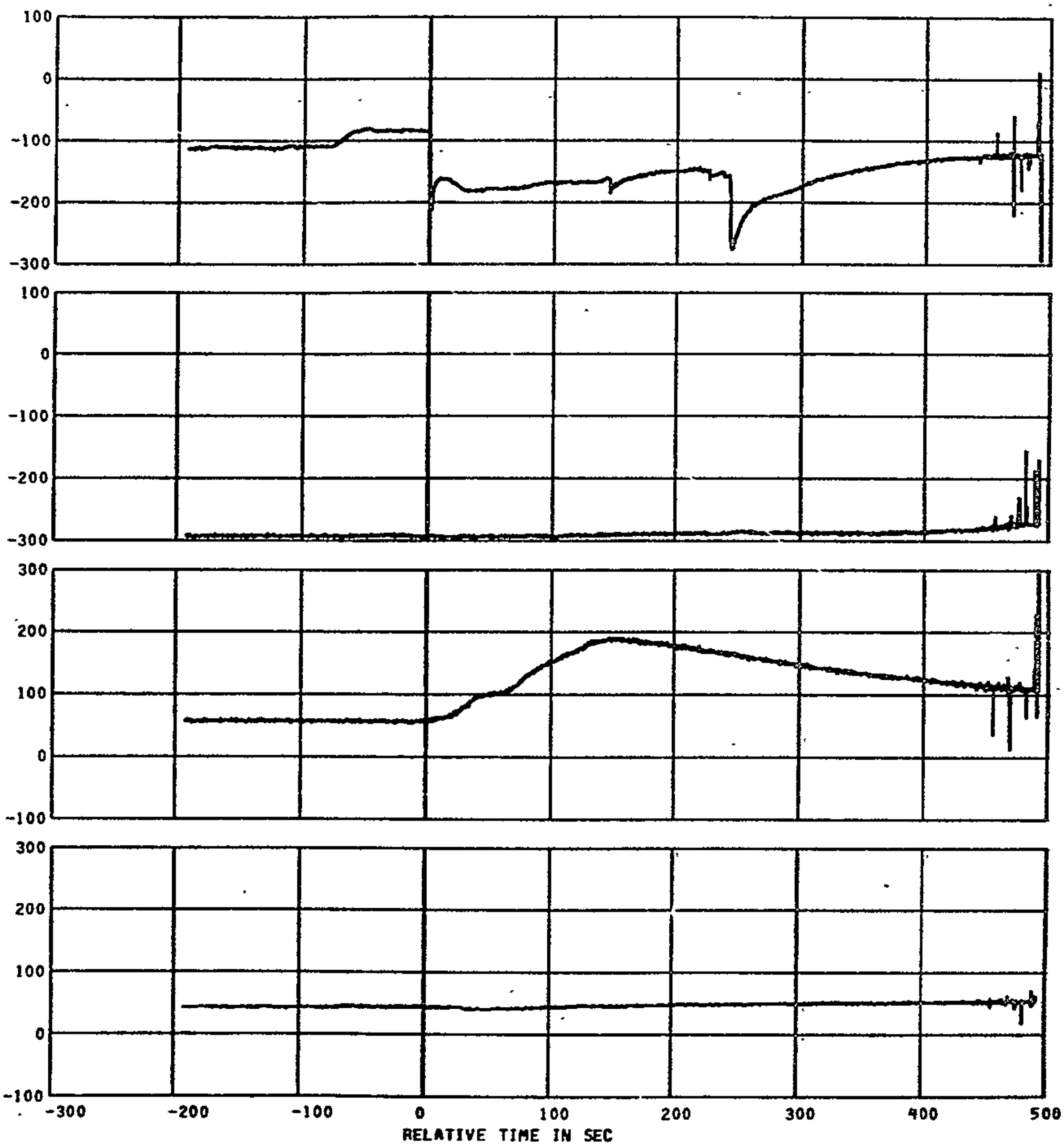
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-12-11	CG12-11	LOX PUMP INLET TEMPERATURE	-300.0 TO -275.0	DEG F	A
PDM-12-33	CG12-33	HELIUM BOTTLE PRESSURE	0 TO 2000	PSIA	B
PDM-12-37	CG12-37	THRUST CHAMBER DOME OXID PRESS	0 TO 1000	PSIA	C

TEST. ID 046619 432000 20018 COS-B DRETS PLOT NO 306 REFERENCE TIME 01 47 59.795



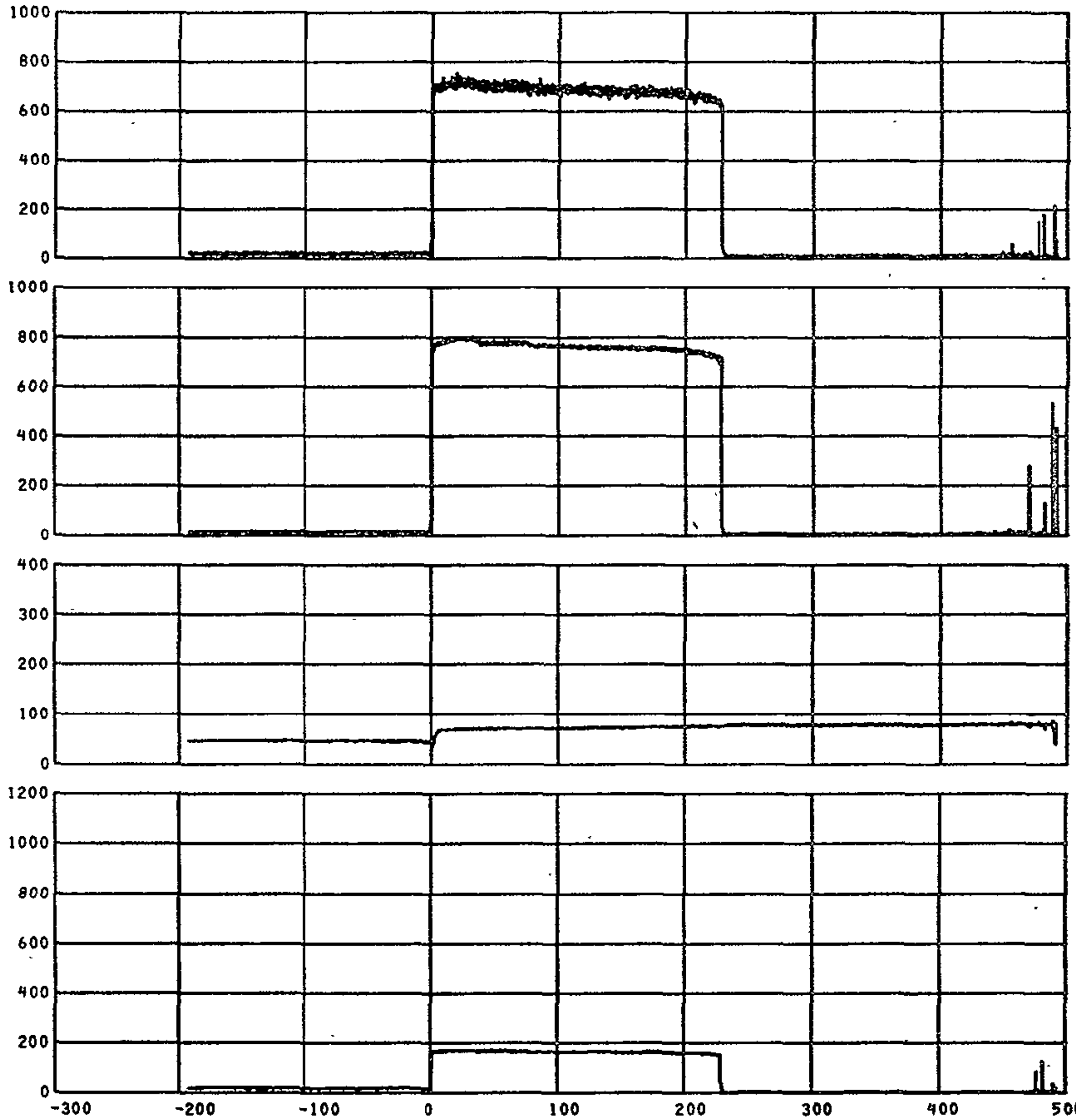
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-12-08	CG12-08	GG COMBUSTION TEMPERATURE	-30 TO 2200	DEG F	A
PDM-12-10	CG12-10	GG LOX INJECTOR PRESSURE	0 TO 1000	PSIA	B
PDM-12-39	CG12-39	GG FUEL INLET PRESSURE	0 TO 1000	PSIA	C

TEST ID 046619 432000 20018 COS-B DRETS PLOT NO 307 REFERENCE TIME 01 47 59.795



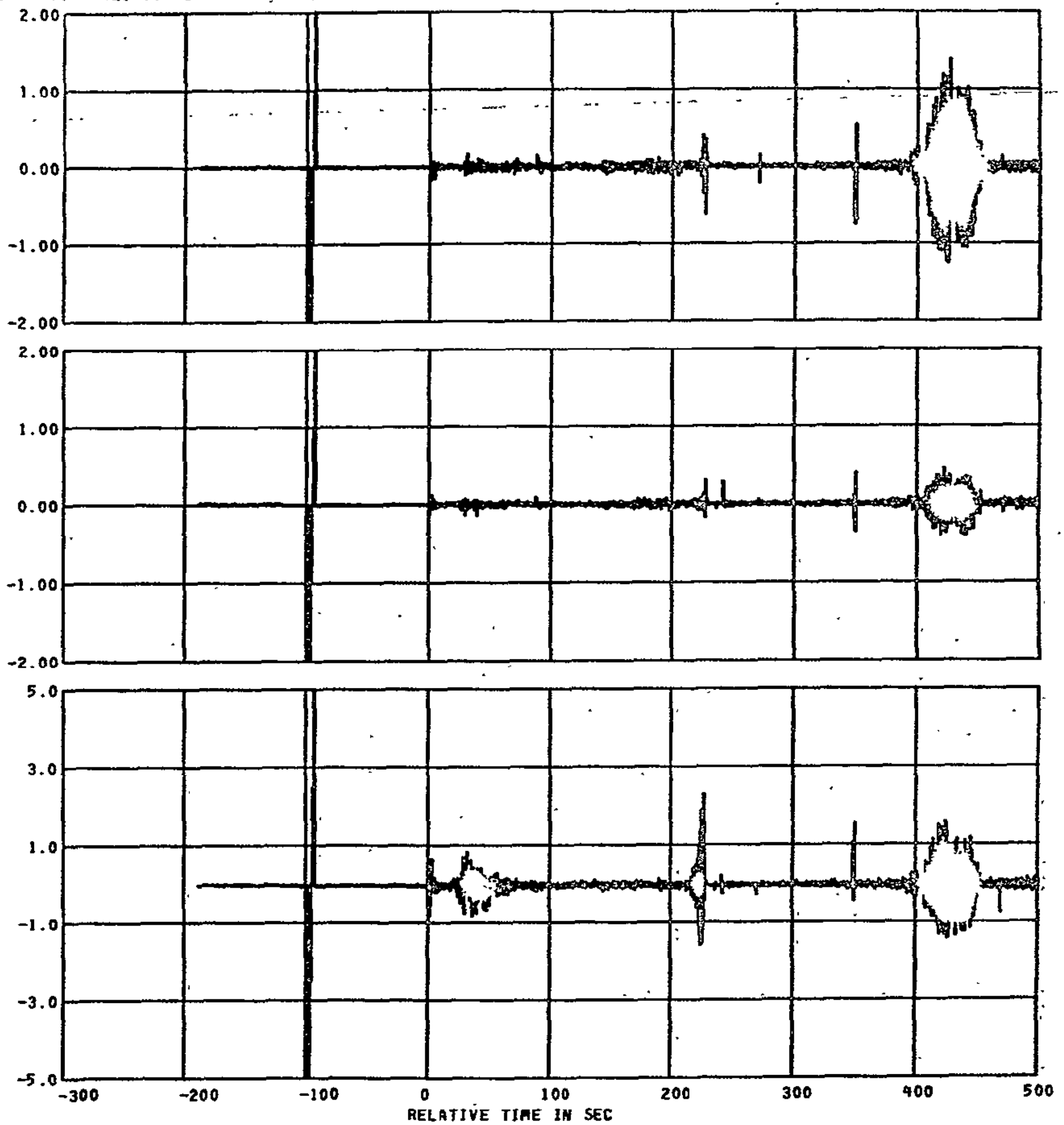
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-12-42	CG12-42	POGO NO. 2 LOX ACCUMULATOR TEMP	-300 TO 60	DEG F	A
PDM-12-43	CG12-43	POGO NO. 1 LOX ACCUMULATOR TEMP	-300 TO 60	DEG F	B
PDM-12-21	CG12-21	CENTER BODY SKIN TEMPERATURE	-100 TO 475	DEG F	C
PDM-12-36	CG12-36	CENTER BODY AIR TEMPERATURE	-40 TO 150	DEG F	D

TEST ID 046619 432000 20018 COS-B DRETS PLOT NO 308 REFERENCE TIME 01 47 59.795



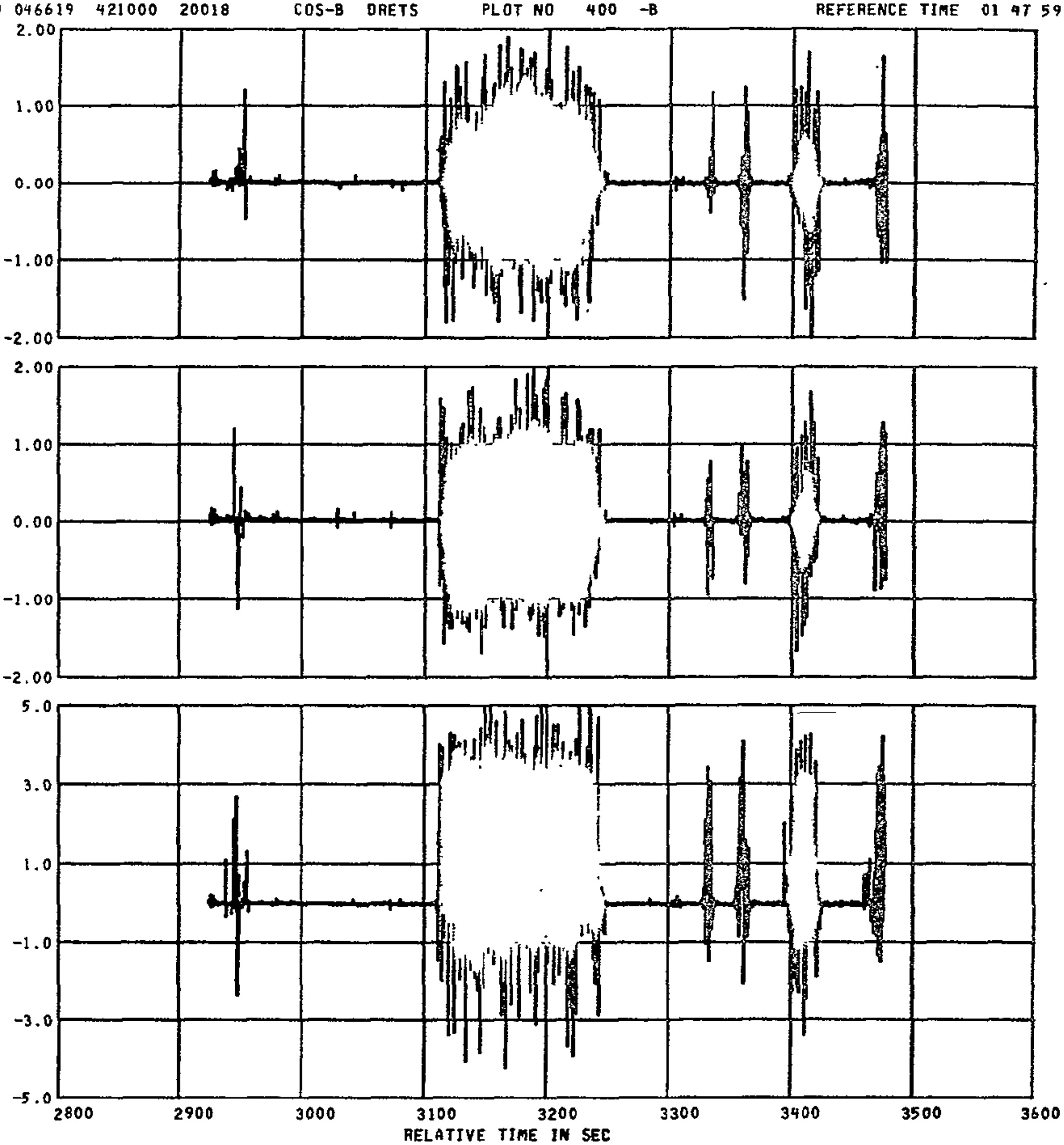
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-12-07	CG12-07	MAIN ENGINE CHAMBER PRESSURE	0 TO 1000	PSIA	A
PDM-12-40	CG12-40	THRUST CHMBR DOME FUEL INJ PRESS	0 TO 1000	PSIA	B
PDM-12-03	CG12-03	FUEL PUMP INLET TEMPERATURE	0 TO 150	DEG F	C
PDM-12-38	CG12-38	LUBE SYSTEM PRESSURE	0 TO 200	PSIA	D

TEST ID 046619 421000 20018 COS-B DRETS PLOT NO 400 -A REFERENCE TIME 01 47 59.795



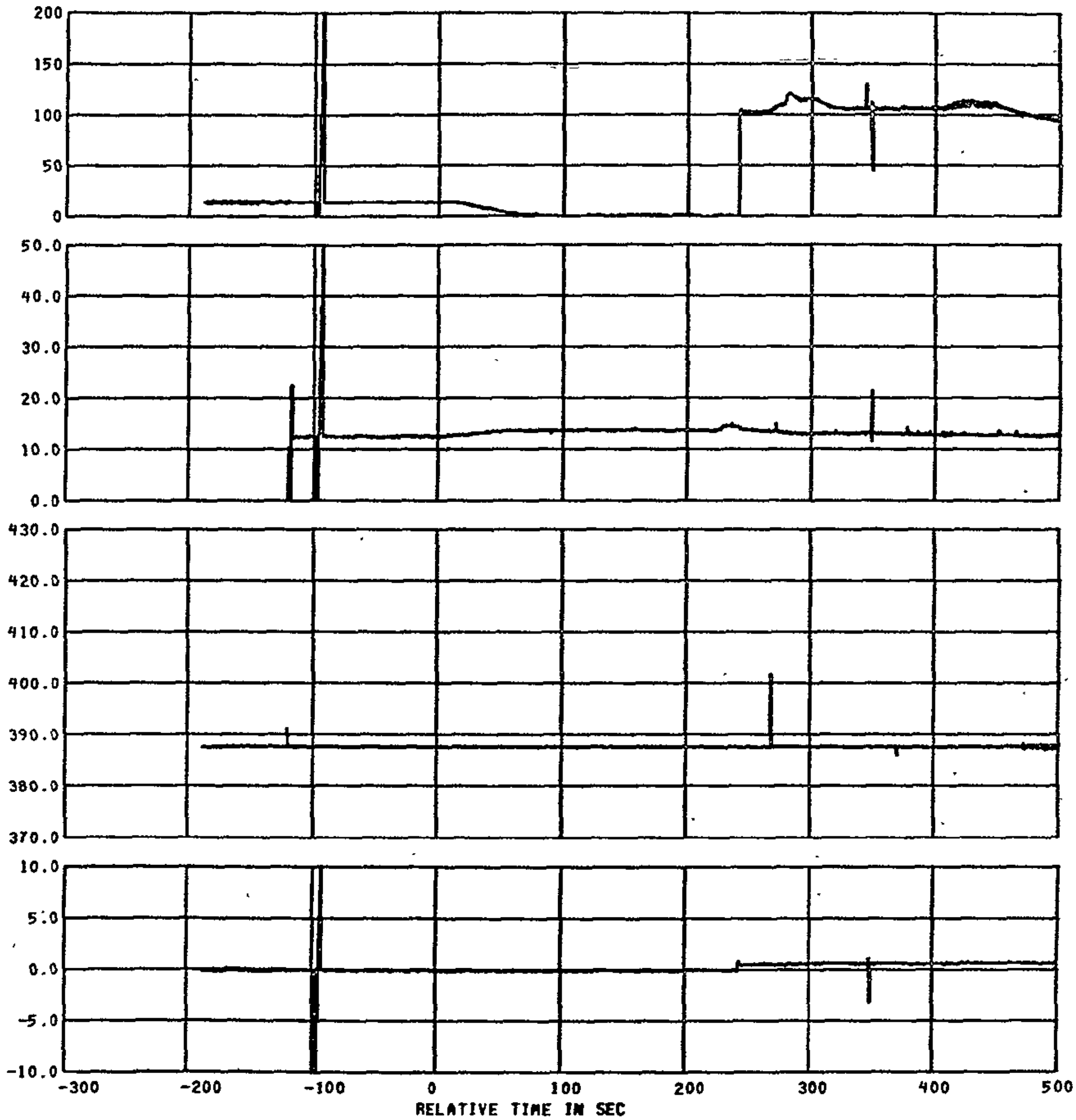
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-21-12	CF21-12	TRIAXIAL ACCEL YAW AXIS (Z)	-2.00 TO 2.00	G	A
FM-21-13	CF21-13	TRIAXIAL ACCEL PITCH AXIS (Y)	-2.00 TO 2.00	G	B
FM-21-A	CF21-A	TRIAXIAL ACCEL THRUST AXIS (X)	-5.0 TO 5.0	G	C

TEST ID 046619 421000 20018 COS-B DRETS PLOT NO 400 -B REFERENCE TIME 01 47 59.795



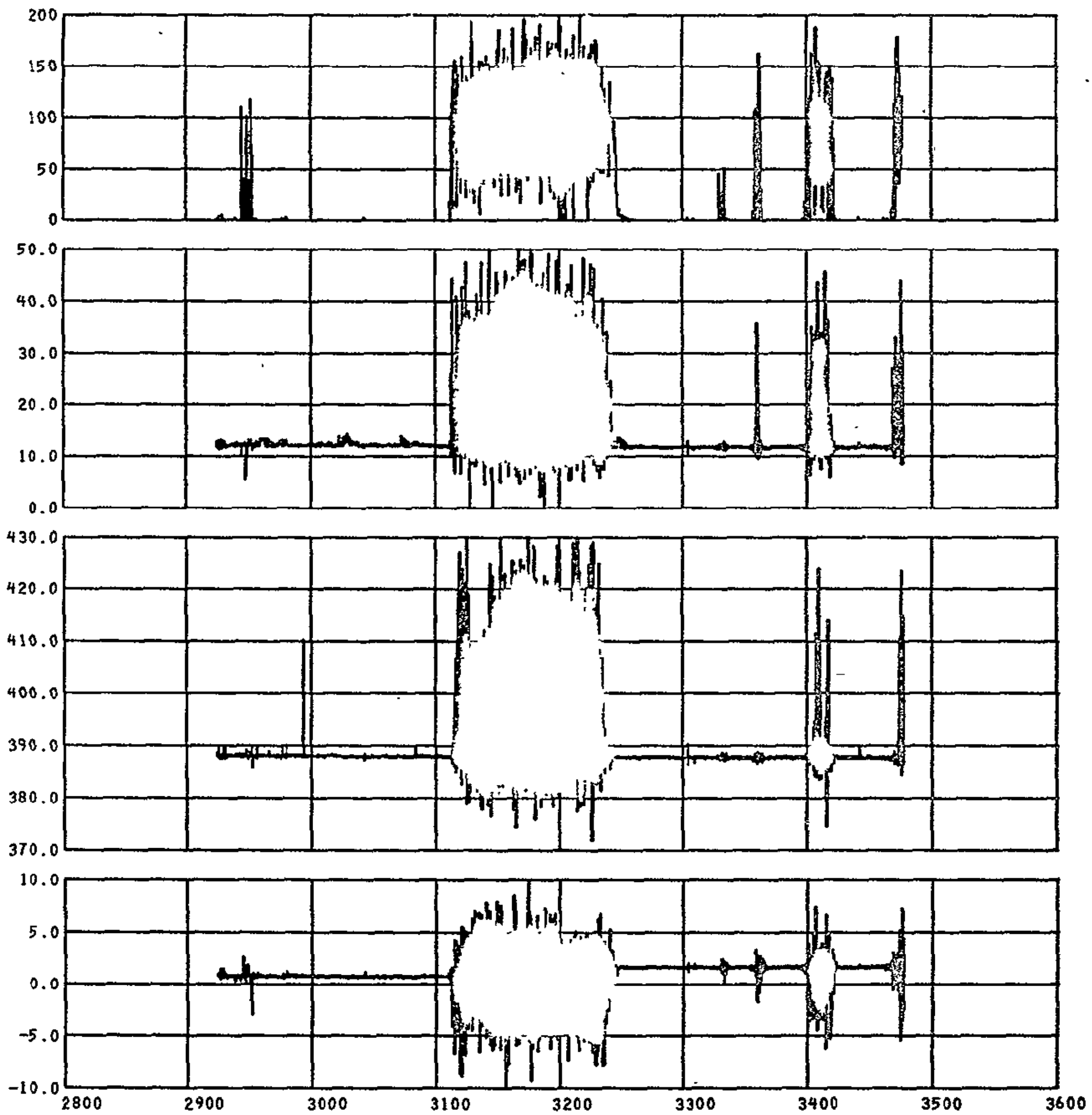
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-21-12	CF21-12	TRIAXIAL ACCEL YAW AXIS (Z)	-2.00 TO 2.00	G	A
FM-21-13	CF21-13	TRIAXIAL ACCEL PITCH AXIS (Y)	-2.00 TO 2.00	G	B
FM-21-A	CF21-A	TRIAXIAL ACCEL THRUST AXIS (X)	-5.0 TO 5.0	G	C

TEST ID 046619 421000 20018 COS-B DRETS PLOT NO 401 -A REFERENCE TIME 01 47 59.795



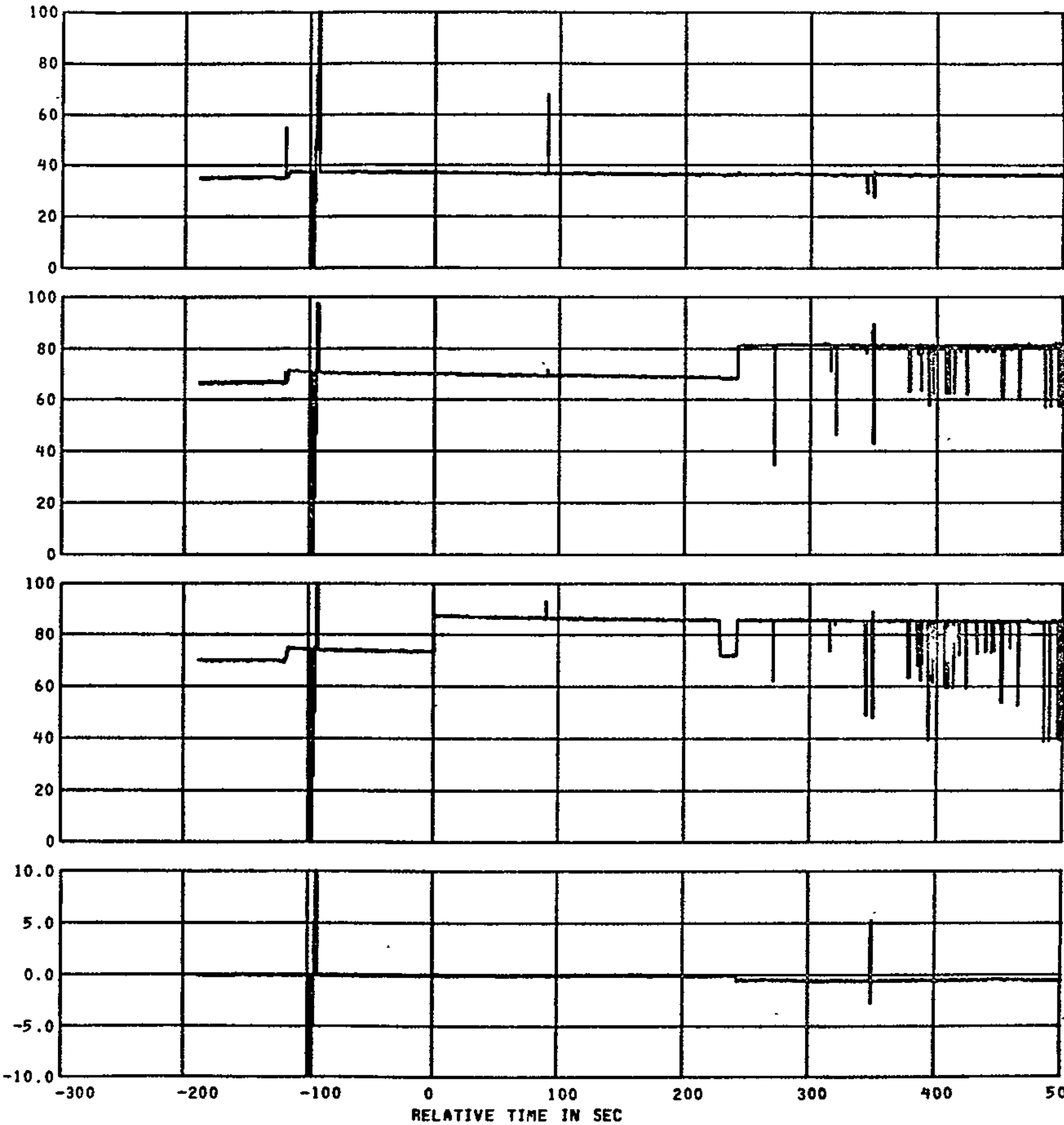
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-21-09	CF21-09	THRUST CHAMBER PRESSURE	0 TO 200	PSIA	A
FM-21-05	CF21-05	CONTROL BATTERY CURRENT	0.0 TO 50.0	AMPS	B
FM-21-01	CF21-01	GYRO WHEEL SUPPLY FREQUENCY	370.0 TO 430.0	HZ	C
FM-21-11	CF21-11	2ND STAGE PITCH CONTROL SIGNAL	-10.0 TO 10.0	VDC	D

TEST ID 046619 421000 20018 COS-B DRETS PLOT NO 401 -B REFERENCE TIME 01 47 59.795



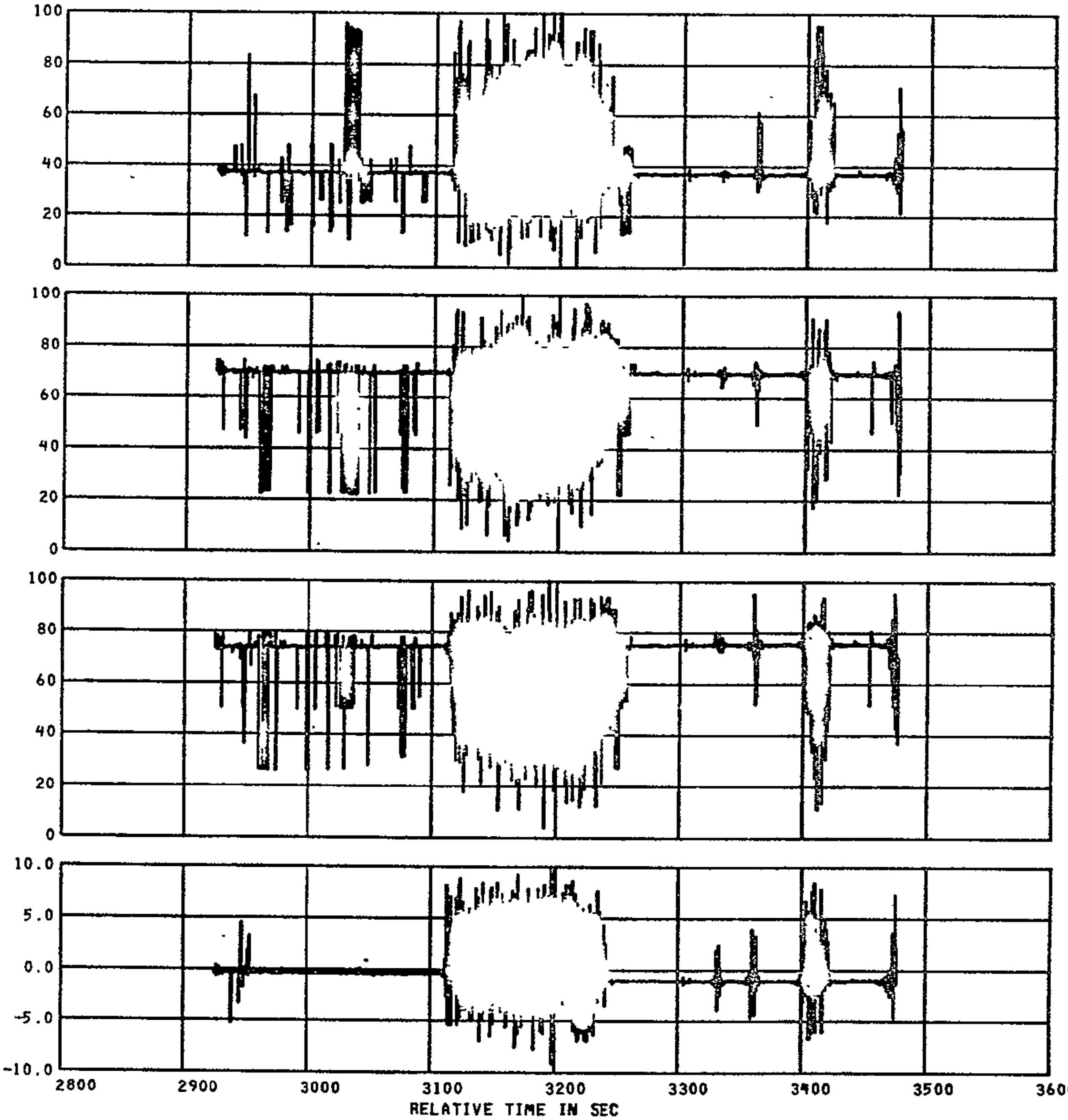
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-21-09	CF21-09	THRUST CHAMBER PRESSURE	0 TO 200	PSIA	A
FM-21-05	CF21-05	CONTROL BATTERY CURRENT	0.0 TO 50.0	AMPS	B
FM-21-01	CF21-01	GYRO WHEEL SUPPLY FREQUENCY	370.0 TO 430.0	HZ	C
FM-21-11	CF21-11	2ND STAGE PITCH CONTROL SIGNAL	-10.0 TO 10.0	VDC	D

TEST ID 046619 421000 20018 COS-B DRETS PLOT NO 402 -A REFERENCE TIME 01 47 59.795



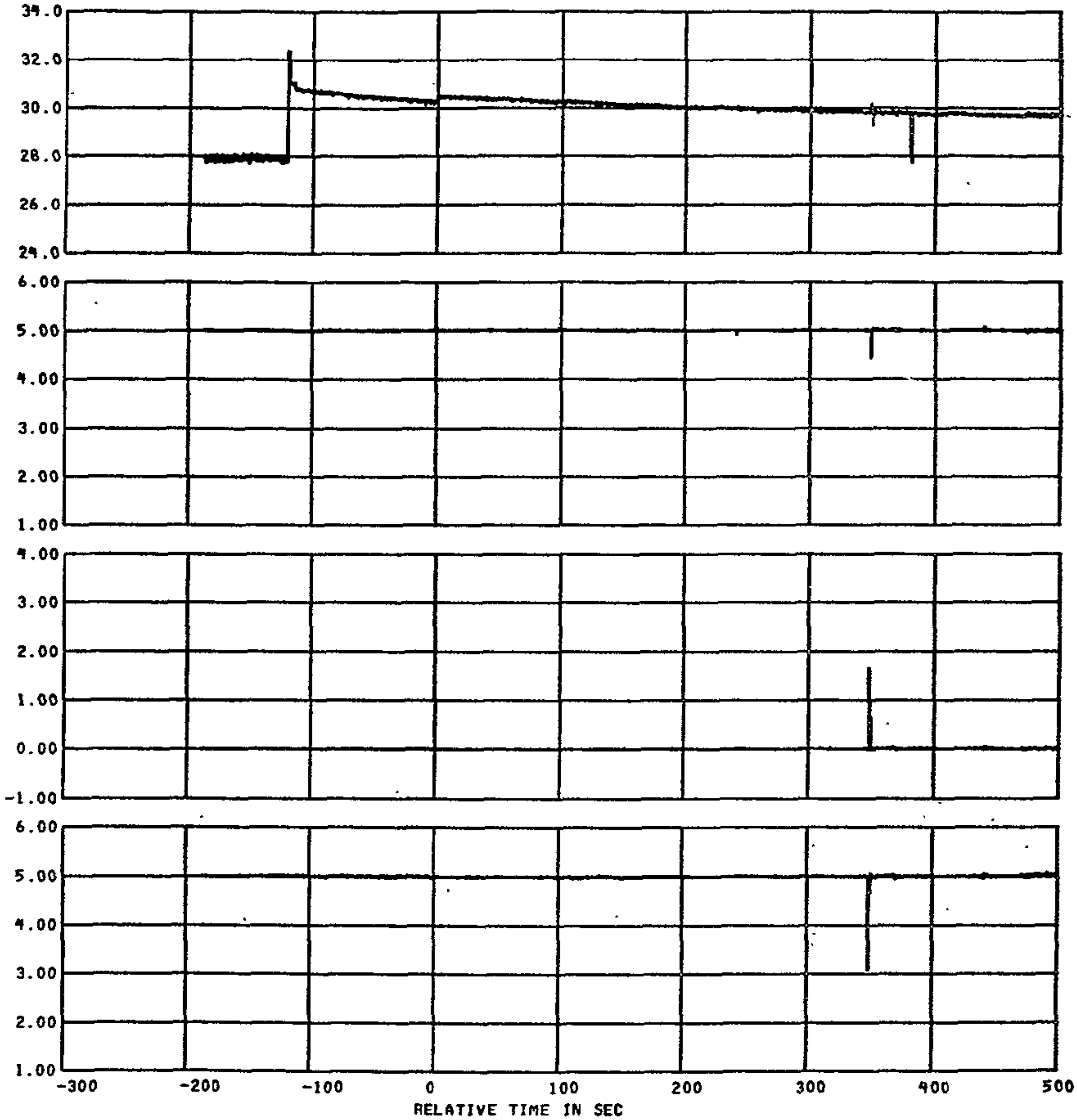
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-21-06	CF21-06	YAW JET ACTUATION-PRIMARY	0 TO 100	PCT	A
FM-21-07	CF21-07	PITCH/ROLL JET ACTUATION-PRIMARY	0 TO 100	PCT	B
FM-21-08	CF21-08	ROLL/PITCH JET ACTUATION-PRIMARY	0 TO 100	PCT	C
FM-21-10	CF21-10	2ND STAGE YAW CONTROL SIGNAL	-10.0 TO 10.0	VDC	D

TEST ID 046619 421000 20018 COS-B DRETS PLOT NO 402 -B REFERENCE TIME 01 47 59.795



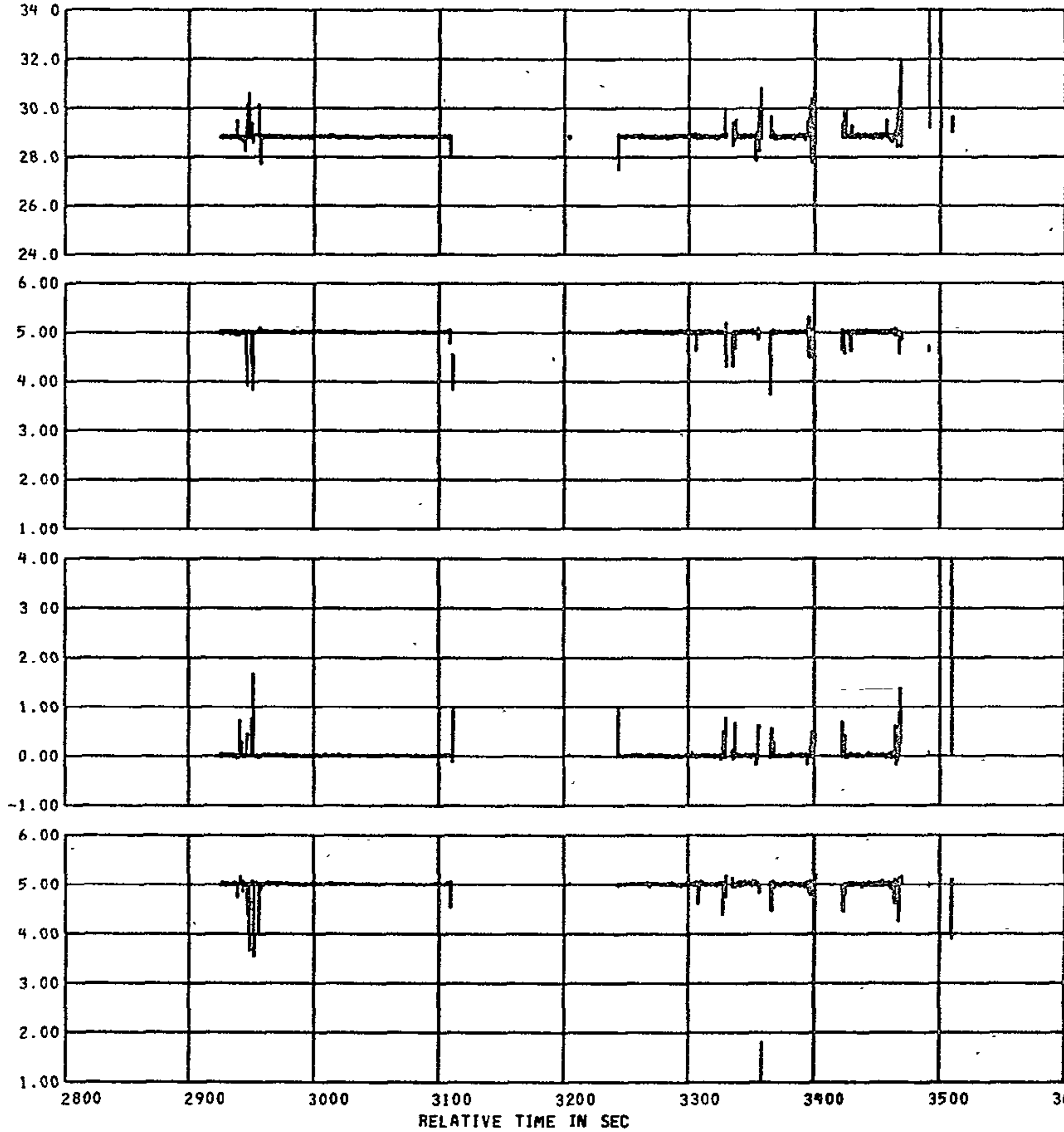
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-21-06	CF21-06	YAW JET ACTUATION-PRIMARY	0 TO 100	PCT	A
FM-21-07	CF21-07	PITCH/ROLL JET ACTUATION-PRIMARY	0 TO 100	PCT	B
FM-21-08	CF21-08	ROLL/PITCH JET ACTUATION-PRIMARY	0 TO 100	PCT	C
FM-21-10	CF21-10	2ND STAGE YAW CONTROL SIGNAL	-10.0 TO 10.0	VDC	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 500 -A REFERENCE TIME 01 47 59.795



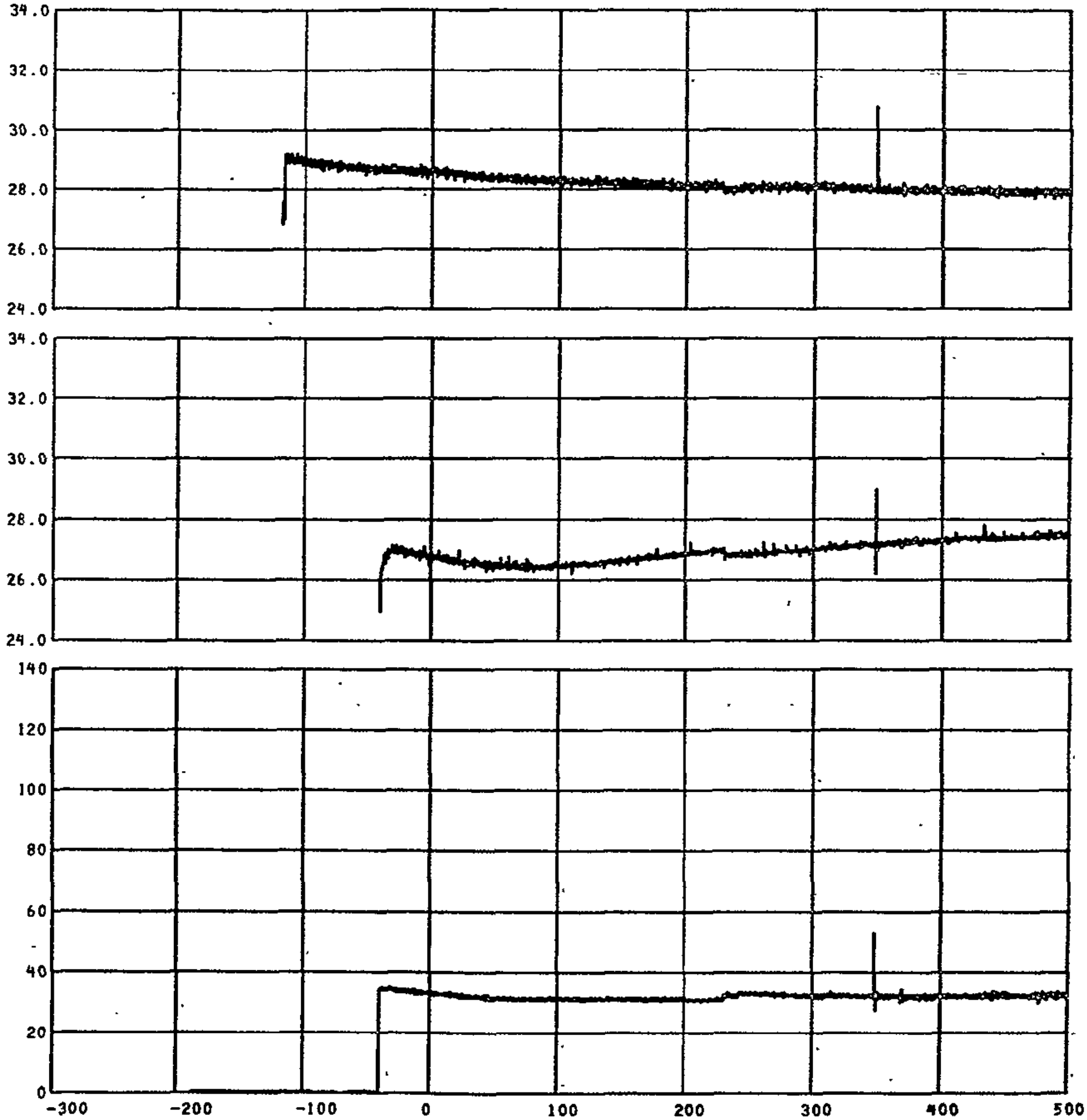
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-21	CG21-21	INSTRUMENTATION BATTERY VOLTAGE	24.0 TO 34.0	VDC	A
PDM-21-01	CG21-01	5 VOLT ABSOLUTE	0.00 TO 5.00	VDC	B
PDM-21-02	CG21-02	INSTRUMENTATION GROUND	0.00 TO 5.00	VDC	C
PDM-21-17	CG21-17	5 VOLT POT EXCITATION	0.00 TO 5.00	VDC	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 500 -B REFERENCE TIME 01 47 59.795



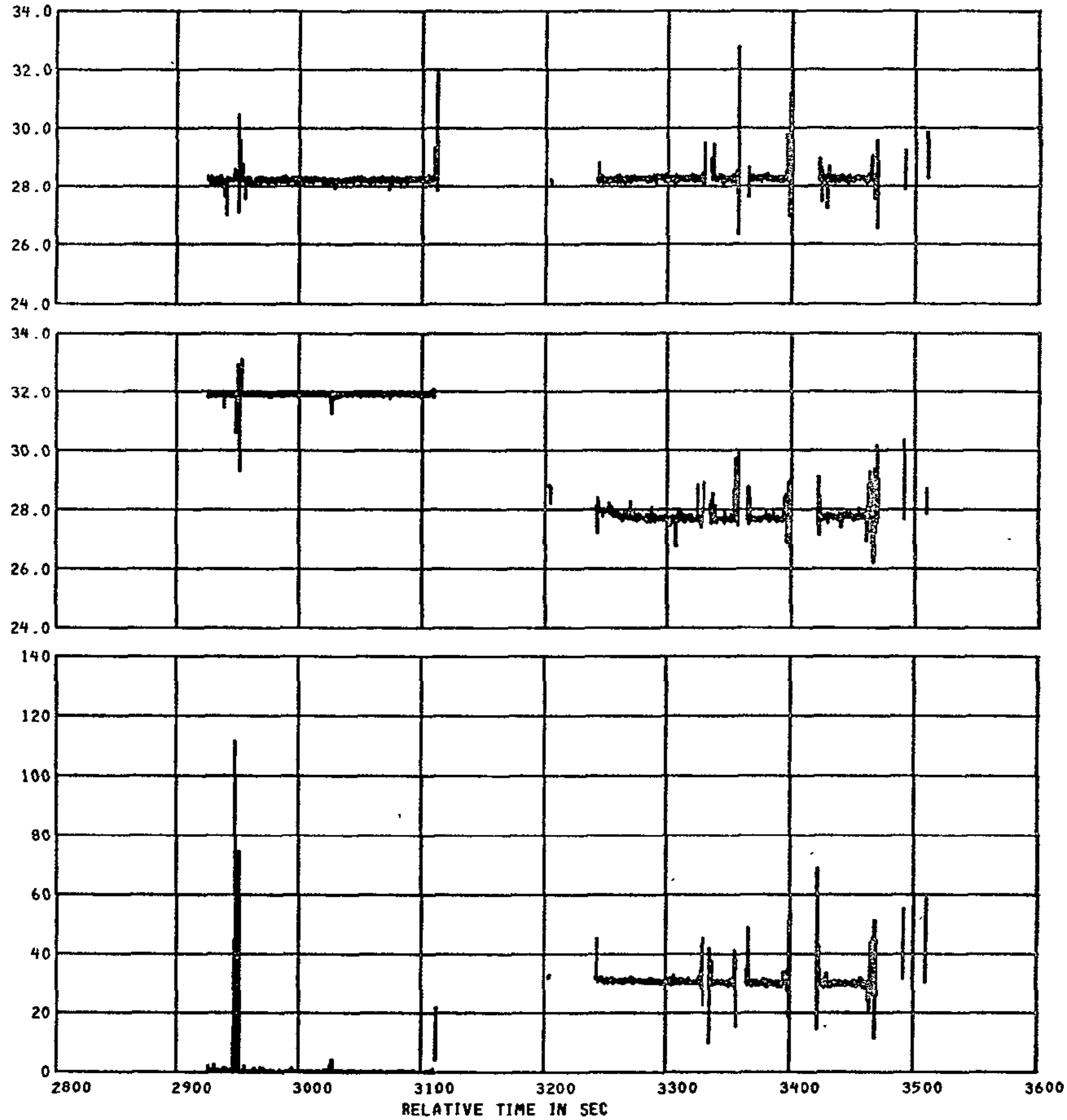
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-21	CG21-21	INSTRUMENTATION BATTERY VOLTAGE	24.0 TO 34.0	VDC	A
PDM-21-01	CG21-01	5 VOLT ABSOLUTE	0.00 TO 5.00	VDC	B
PDM-21-02	CG21-02	INSTRUMENTATION GROUND	0.00 TO 5.00	VDC	C
PDM-21-17	CG21-17	5 VOLT POT EXCITATION	0.00 TO 5.00	VDC	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 501 -A REFERENCE TIME 01 47 59.795



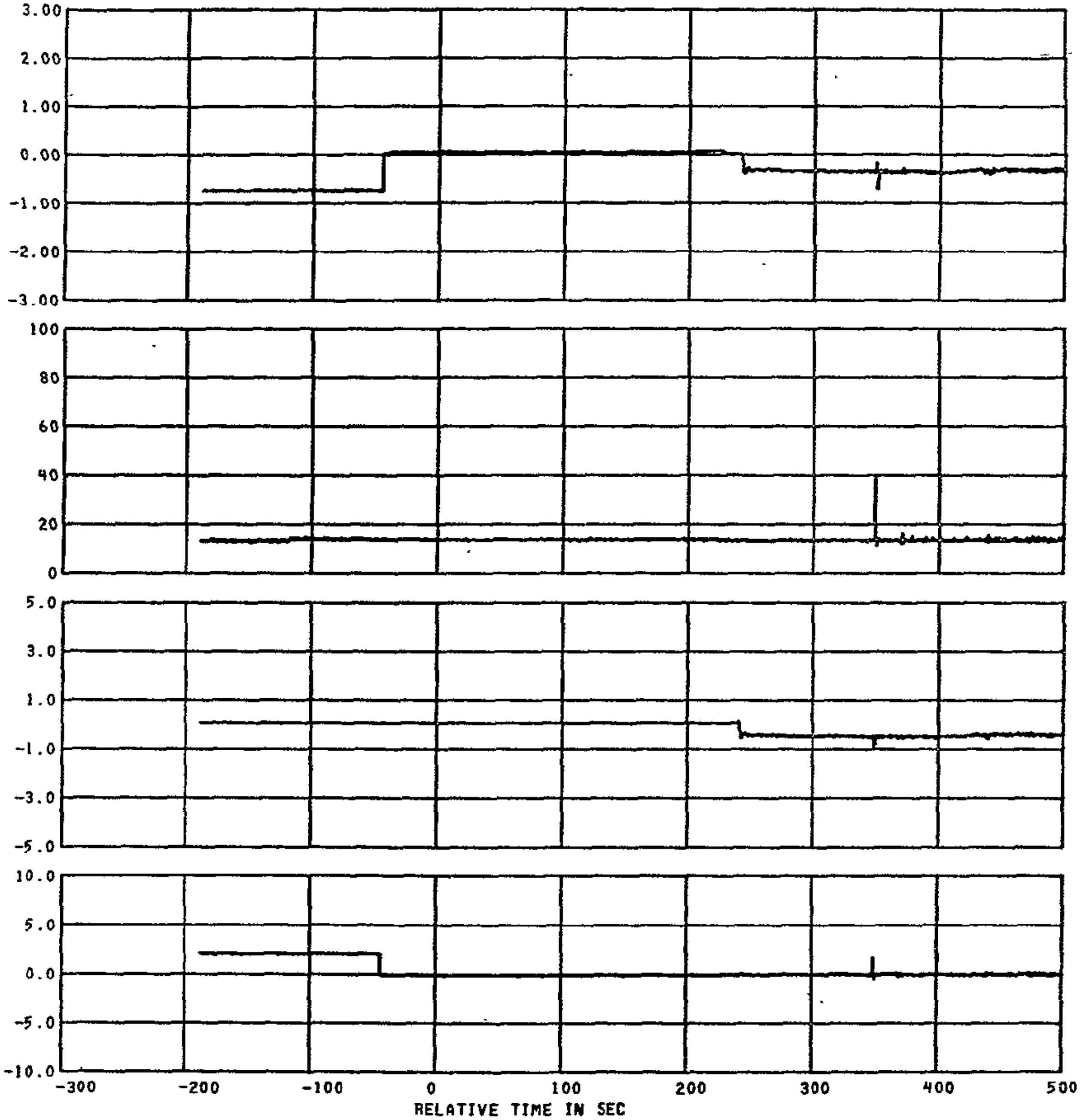
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-20	CG21-20	CONTROL BATTERY VOLTAGE	24.0 TO 34.0	VDC	A
PDM-21-43	CG21-43	ENGINE BATTERY VOLTAGE	24.0 TO 34.0	VDC	B
PDM-21-12	CG21-12	ENGINE BATTERY CURRENT	0 TO 140	AMPS	C

TEST ID 046619 441000 20018 COS-B ORETS PLOT NO 501 -B REFERENCE TIME 01 47 59.795



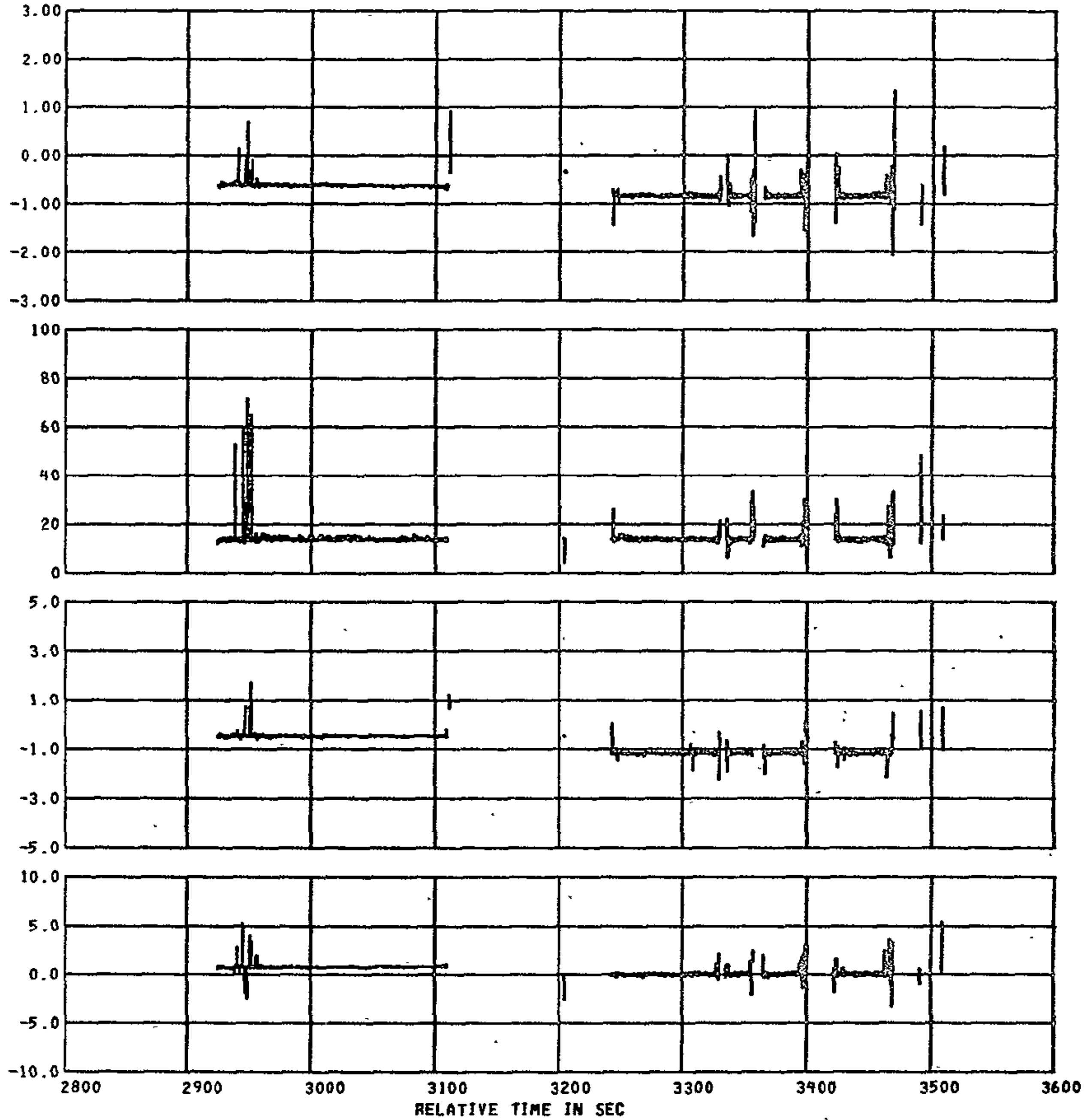
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-20	CG21-20	CONTROL BATTERY VOLTAGE	24.0 TO 34.0	VDC	A
PDM-21-43	CG21-43	ENGINE BATTERY VOLTAGE	24.0 TO 34.0	VDC	B
PDM-21-12	CG21-12	ENGINE BATTERY CURRENT	0 TO 140	AMPS	C

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 502 -A REFERENCE TIME 01 47 59.795



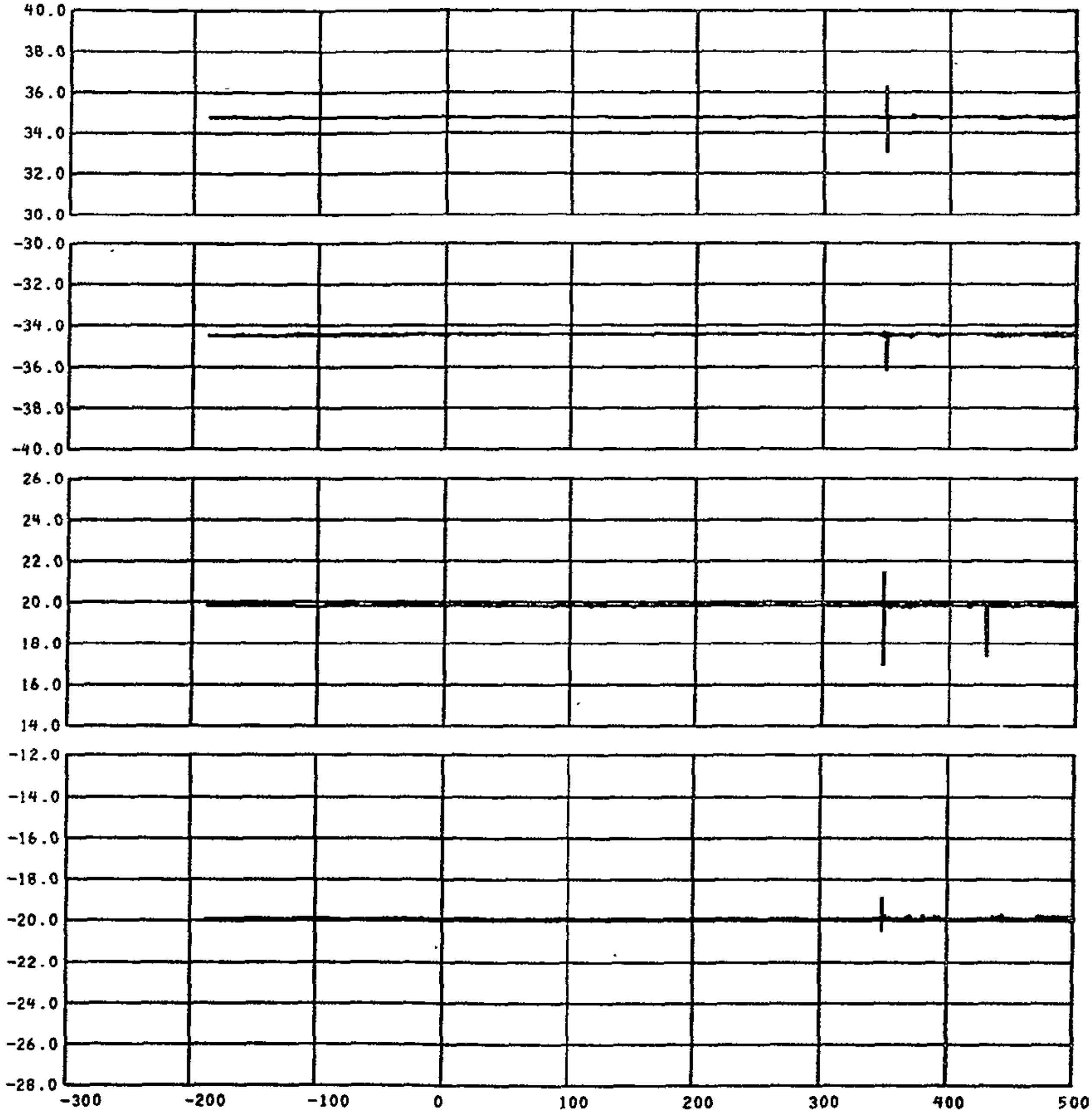
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-13	CG21-13	YAW ACTUATOR POSITION	-3.00 TO 3.00	DEG	A
PDM-21-41	CG21-41	YAW JET ACTUATION-SECONDARY	0 TO 100	PCT	B
PDM-21-03	CG21-03	YAW SUMMING AMP OUTPUT	-4.50 TO 4.50	VDC	C
PDM-21-36	CG21-36	YAW SERVO DIFFERENTIAL SIGNAL	-10.0 TO 10.0	MA	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 502 -B REFERENCE TIME 01 47 59.795



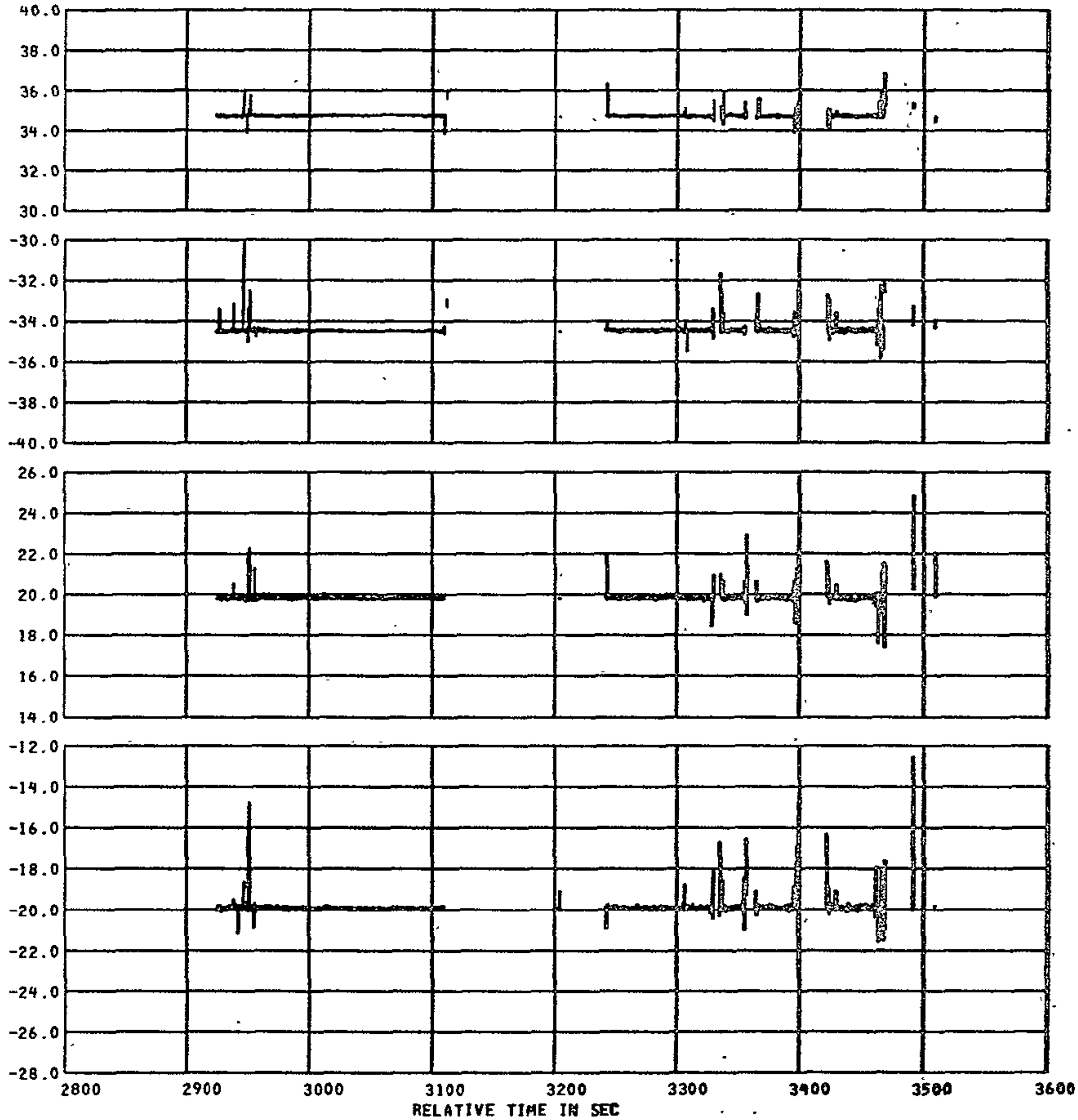
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-13	CG21-13	YAW ACTUATOR POSITION	-3.00 TO 3.00	DEG	A
PDM-21-41	CG21-41	YAW JET ACTUATION-SECONDARY	0 TO 100	PCT	B
PDM-21-03	CG21-03	YAW SUMMING AMP OUTPUT	-4.50 TO 4.50	VDC	C
PDM-21-36	CG21-36	YAW SERVO DIFFERENTIAL SIGNAL	-10.0 TO 10.0	MA	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 503 -A REFERENCE TIME 01 47 59.795



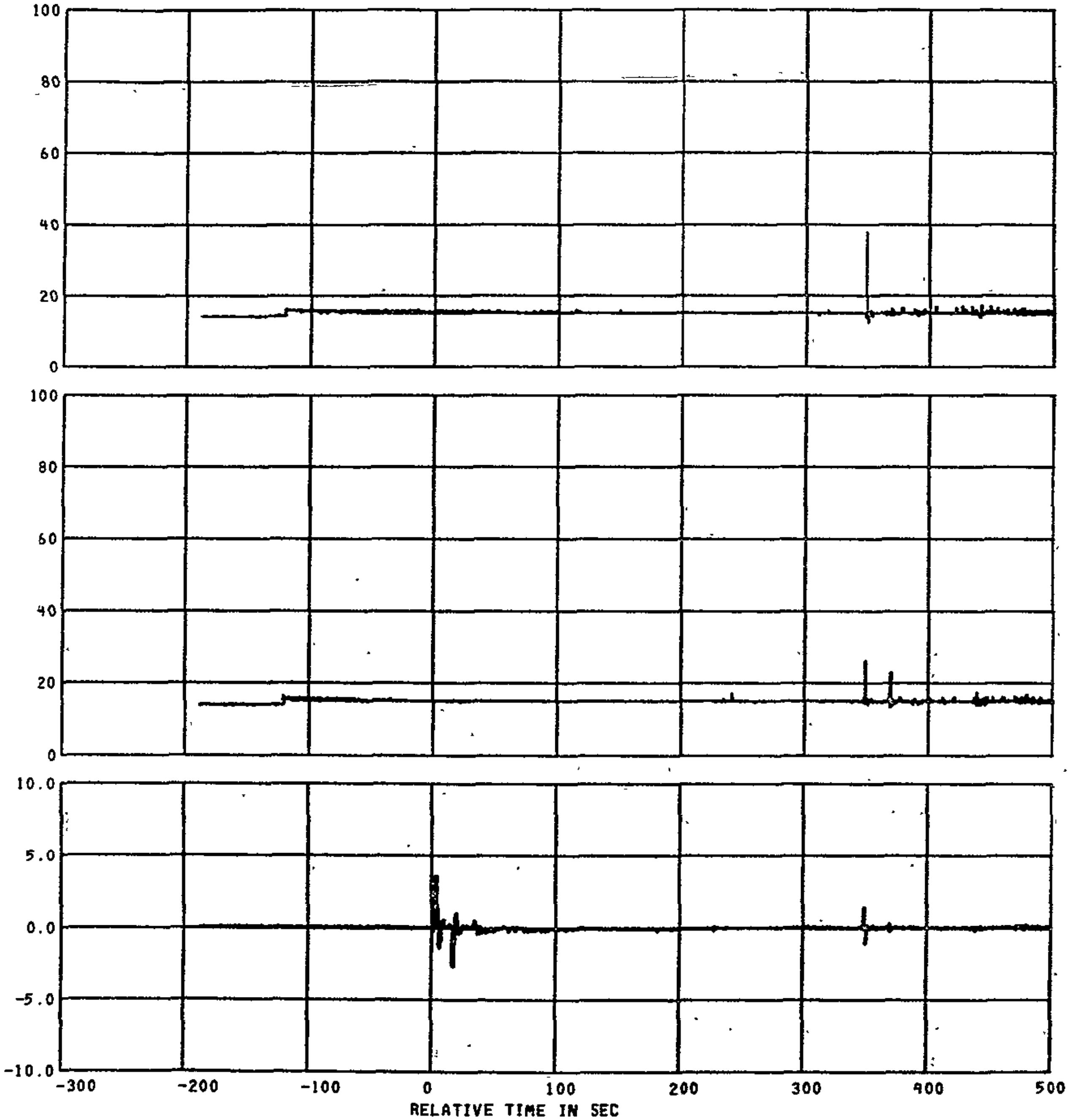
EAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
]M-21-04	CG21-04	VALVE EXCITATION (POS)	30.0 TO 40.0	VDC	A
]M-21-06	CG21-06	VALVE EXCITATION (NEG)	-40.0 TO -30.0	VDC	B
]M-21-24	CG21-24	FEEDBACK POT EXCITATION (POS)	14.0 TO 26.0	VDC	C
]M-21-25	CG21-25	FEEDBACK POT EXCITATION (NEG)	-28.0 TO -12.0	VDC	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 503 -B REFERENCE TIME 01 47 59.795



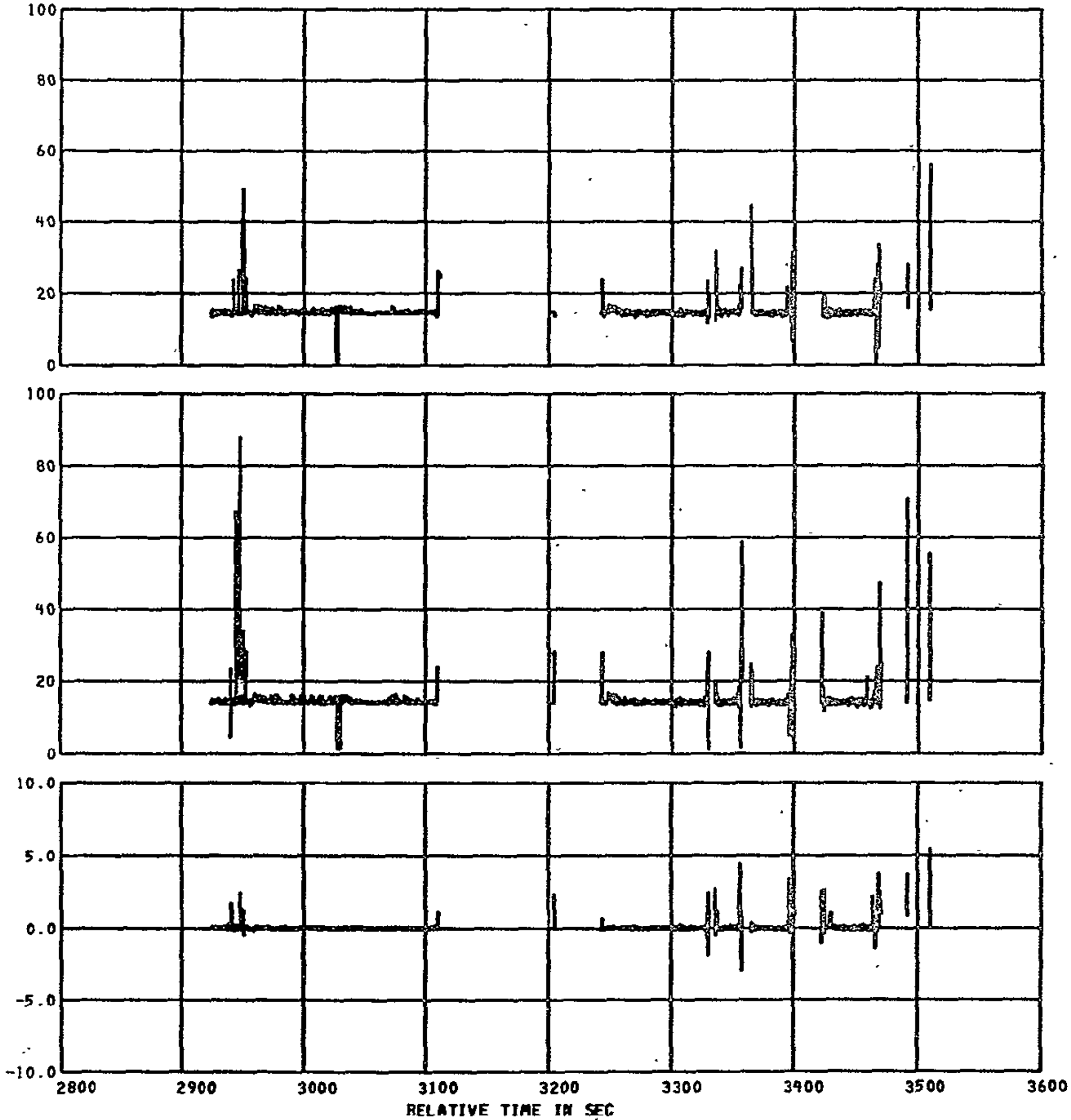
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-04	CG21-04	VALVE EXCITATION (POS)	30.0 TO 40.0	VDC	A
PDM-21-06	CG21-06	VALVE EXCITATION (NEG)	-40.0 TO -30.0	VDC	B
PDM-21-24	CG21-24	FEEDBACK POT EXCITATION (POS)	14.0 TO 26.0	VDC	C
PDM-21-25	CG21-25	FEEDBACK POT EXCITATION (NEG)	-28.0 TO -12.0	VDC	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 504 - -A REFERENCE TIME 01 47 59.795



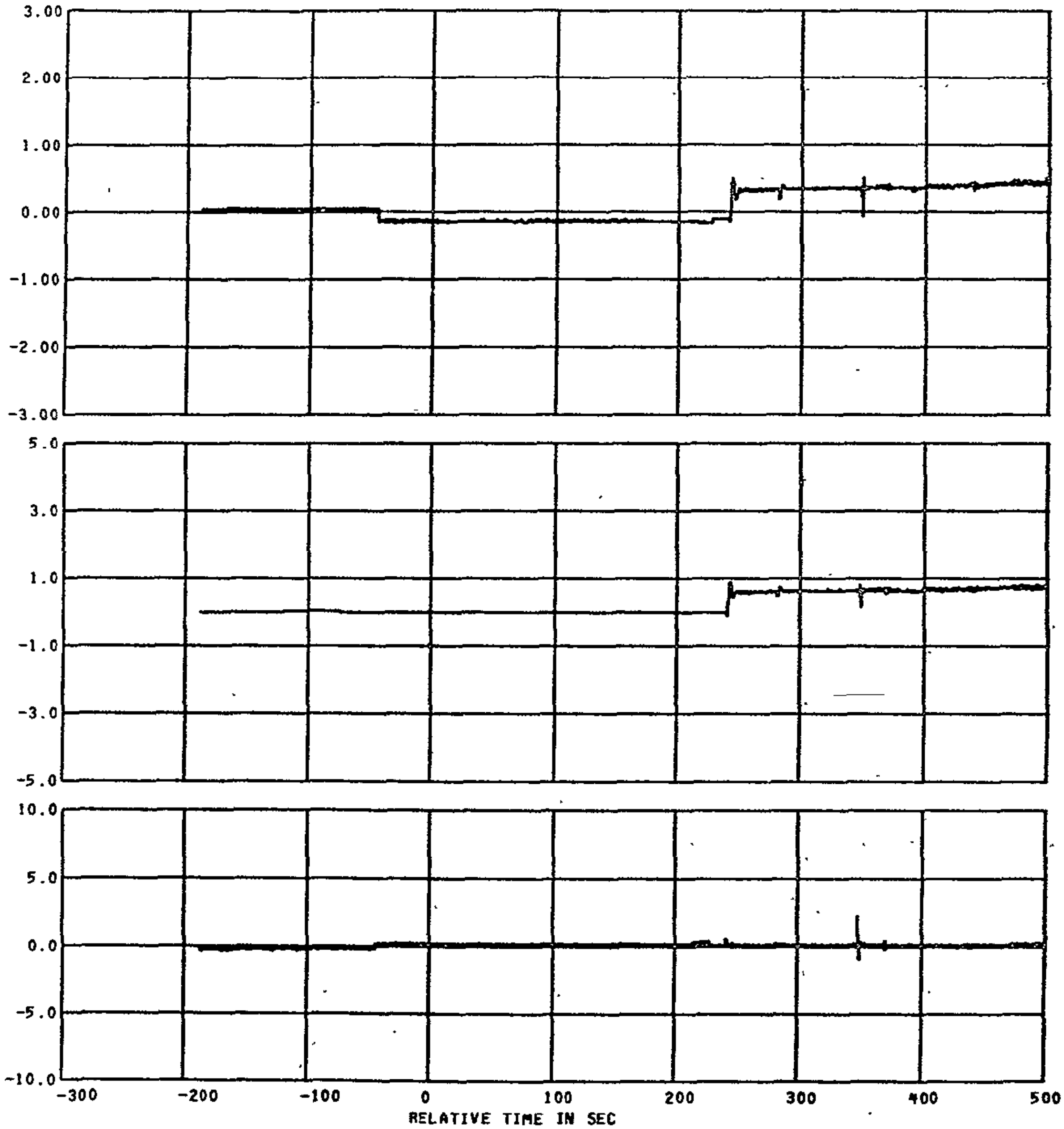
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-08	CG21-08	ROLL/PITCH JET ACT - SECONDARY	0 TO 100	PCT	A
PDM-21-40	CG21-40	PITCH/ROLL JET ACT - SECONDARY	0 TO 100	PCT	B
PDM-21-33	CG21-33	1ST STAGE ROLL CONTROL SIGNAL	-10.0 TO 10.0	VDC	C

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 504 -B REFERENCE TIME 01 47 59.795



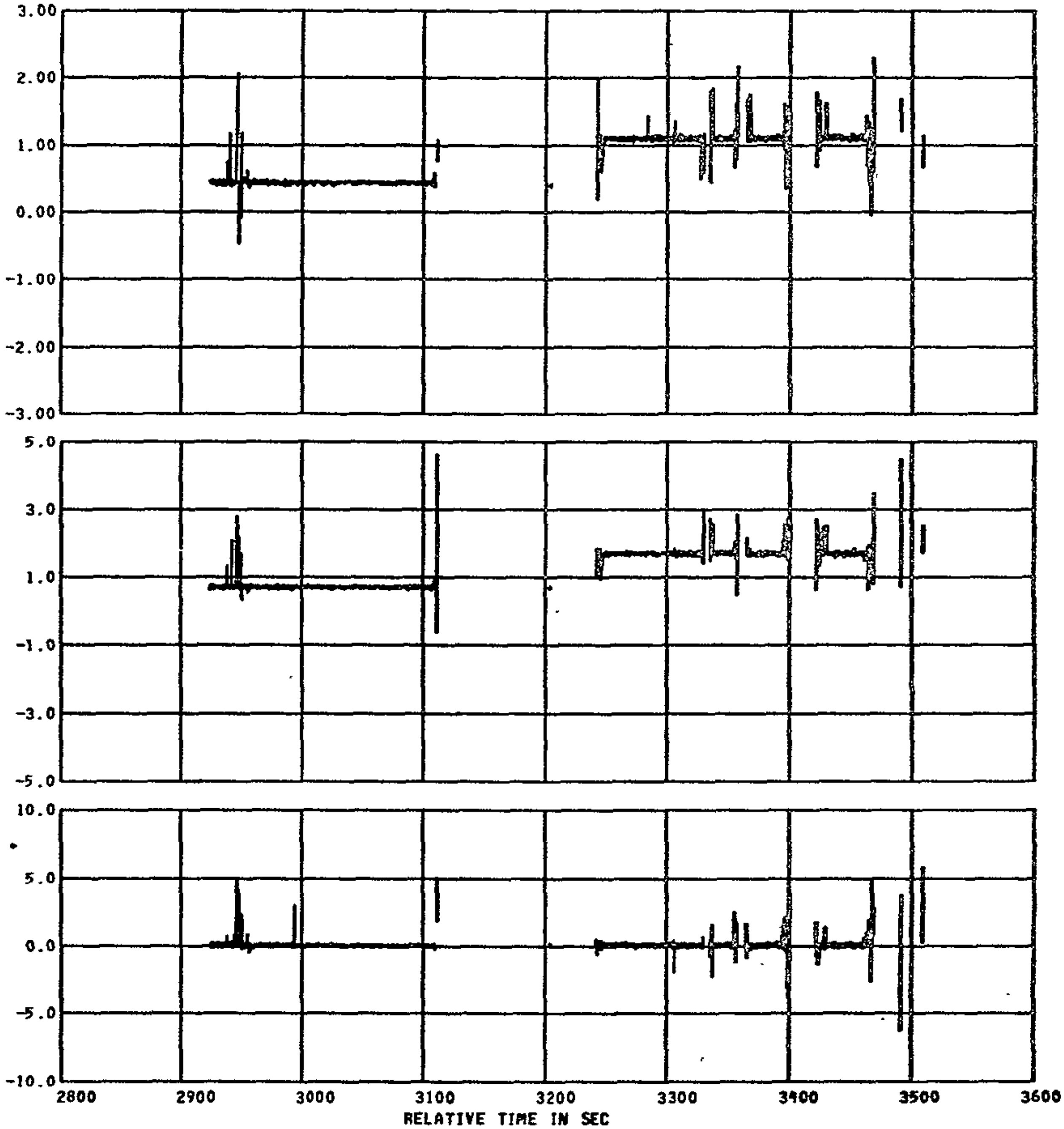
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-08	CG21-08	ROLL/PITCH JET ACT - SECONDARY	0 TO 100	PCT	A
PDM-21-40	CG21-40	PITCH/ROLL JET ACT - SECONDARY	0 TO 100	PCT	B
PDM-21-33	CG21-33	1ST STAGE ROLL CONTROL SIGNAL	-10.0 TO 10.0	VDC	C

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 505 -A REFERENCE TIME 01 47 59.795



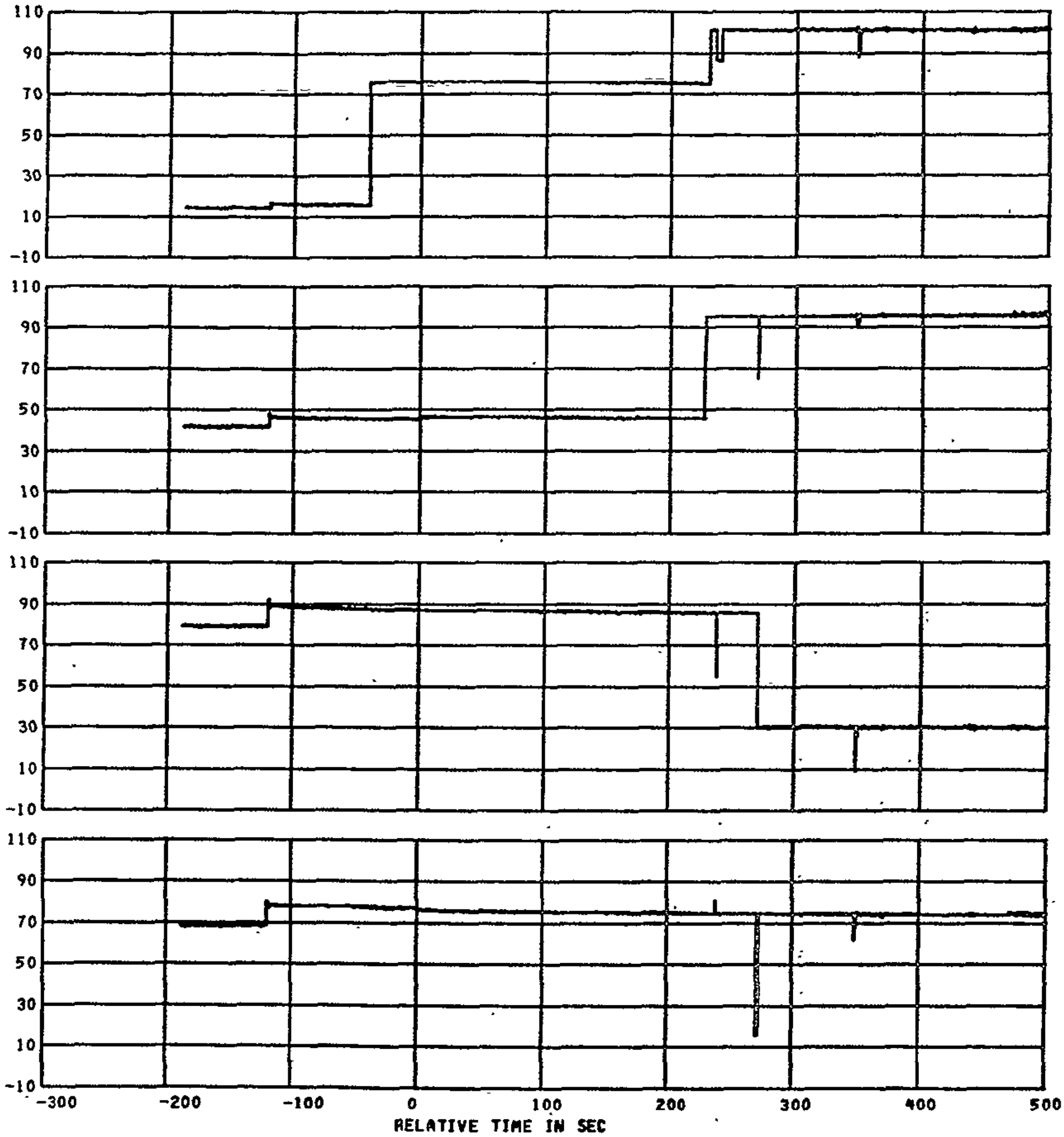
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-09	CG21-09	PITCH ACTUATOR POSITION	-3.00 TO 3.00	DEG	A
PDM-21-18	CG21-18	PITCH SUMMING AMP OUTPUT	-4.50 TO 4.50	VDC	B
PDM-21-19	CG21-19	PITCH SERVO DIFFERENTIAL SIGNAL	-10.0 TO 10.0	MA	C

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 505 -B REFERENCE TIME 01 47 59.795



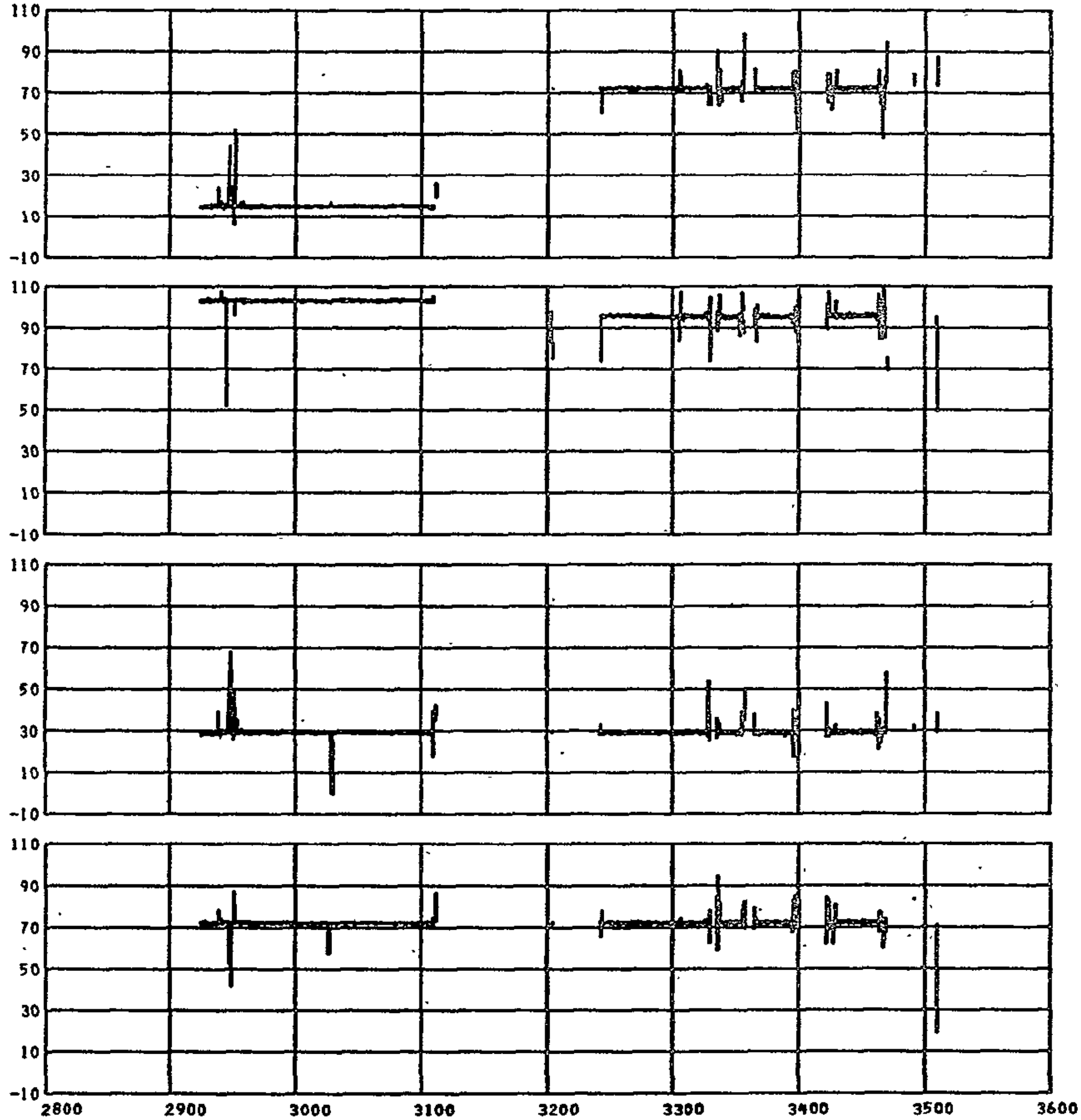
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-09	CG21-09	PITCH ACTUATOR POSITION	-3.00 TO 3.00	DEG	A
PDM-21-18	CG21-18	PITCH SUMMING AMP OUTPUT	-4.50 TO 4.50	VDC	B
PDM-21-19	CG21-19	PITCH SERVO DIFFERENTIAL SIGNAL	-10.0 TO 10.0	MA	C

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 506 -A REFERENCE TIME 01 47 59.795



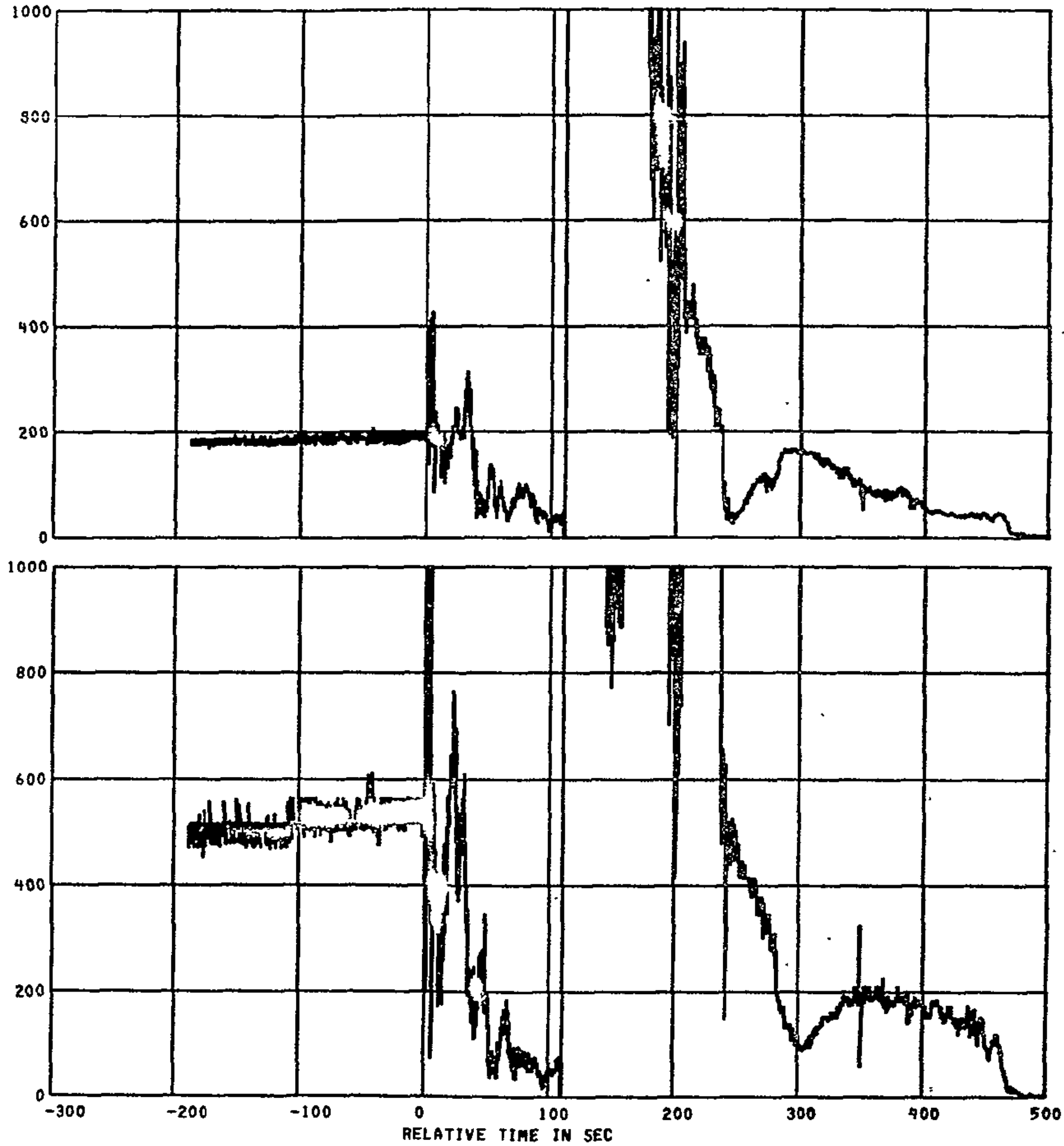
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-05	CG21-05	EVENT GROUP NO.1	0 TO 100	PCT	A
PDM-21-34	CG21-34	EVENT GROUP NO.2	0 TO 100	PCT	B
PDM-21-14	CG21-14	EVENT GROUP NO.4	0 TO 100	PCT	C
PDM-21-15	CG21-15	EVENT GROUP NO.5	0 TO 100	PCT	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 506 -B REFERENCE TIME 01 47 59.795



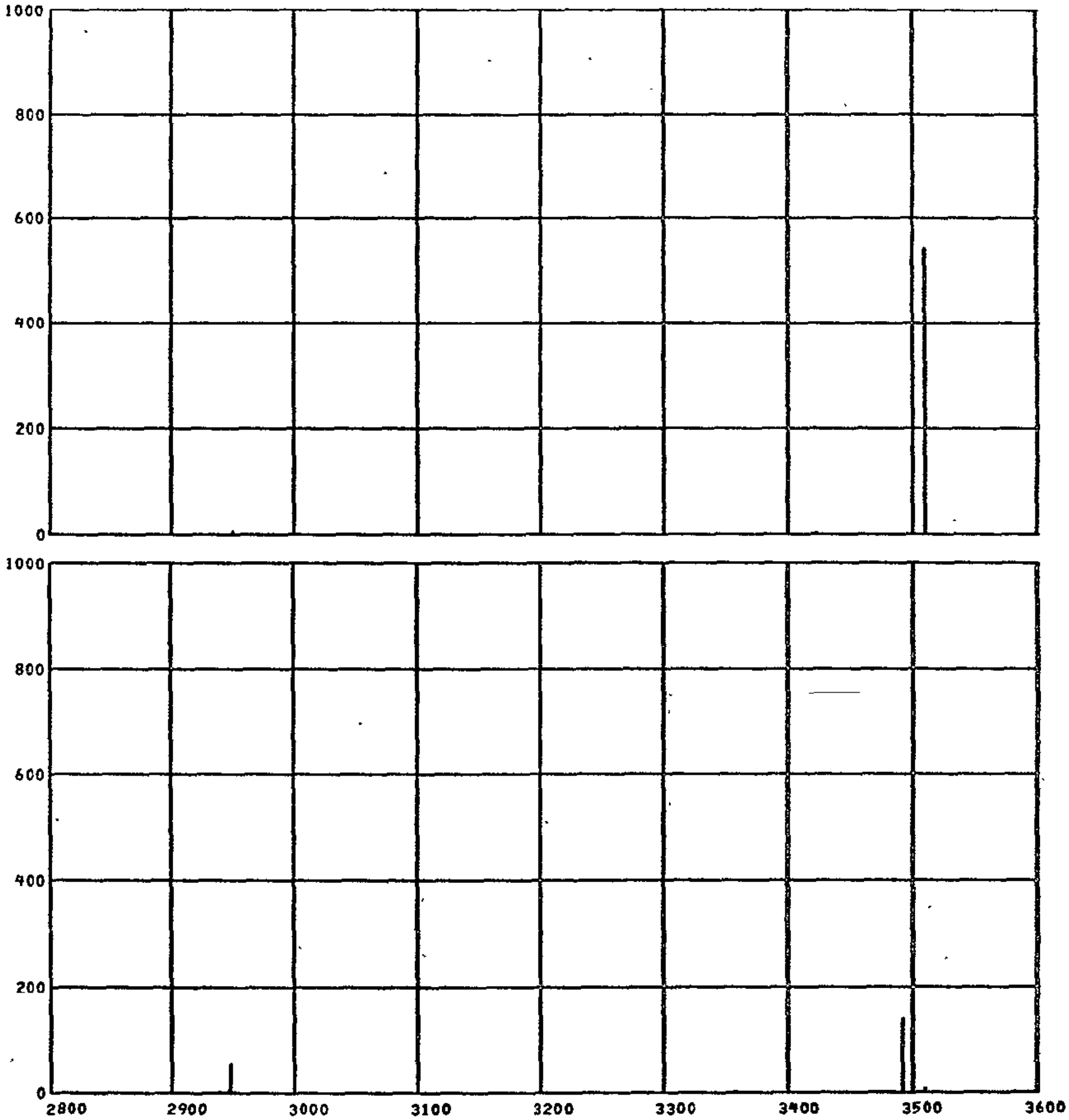
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-05	CG21-05	EVENT GROUP NO.1	0 TO 100	PCT	A
PDM-21-34	CG21-34	EVENT GROUP NO.2	0 TO 100	PCT	B
PDM-21-14	CG21-14	EVENT GROUP NO.4	0 TO 100	PCT	C
PDM-21-15	CG21-15	EVENT GROUP NO.5	0 TO 100	PCT	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 507 -A REFERENCE TIME 01 47 59.795



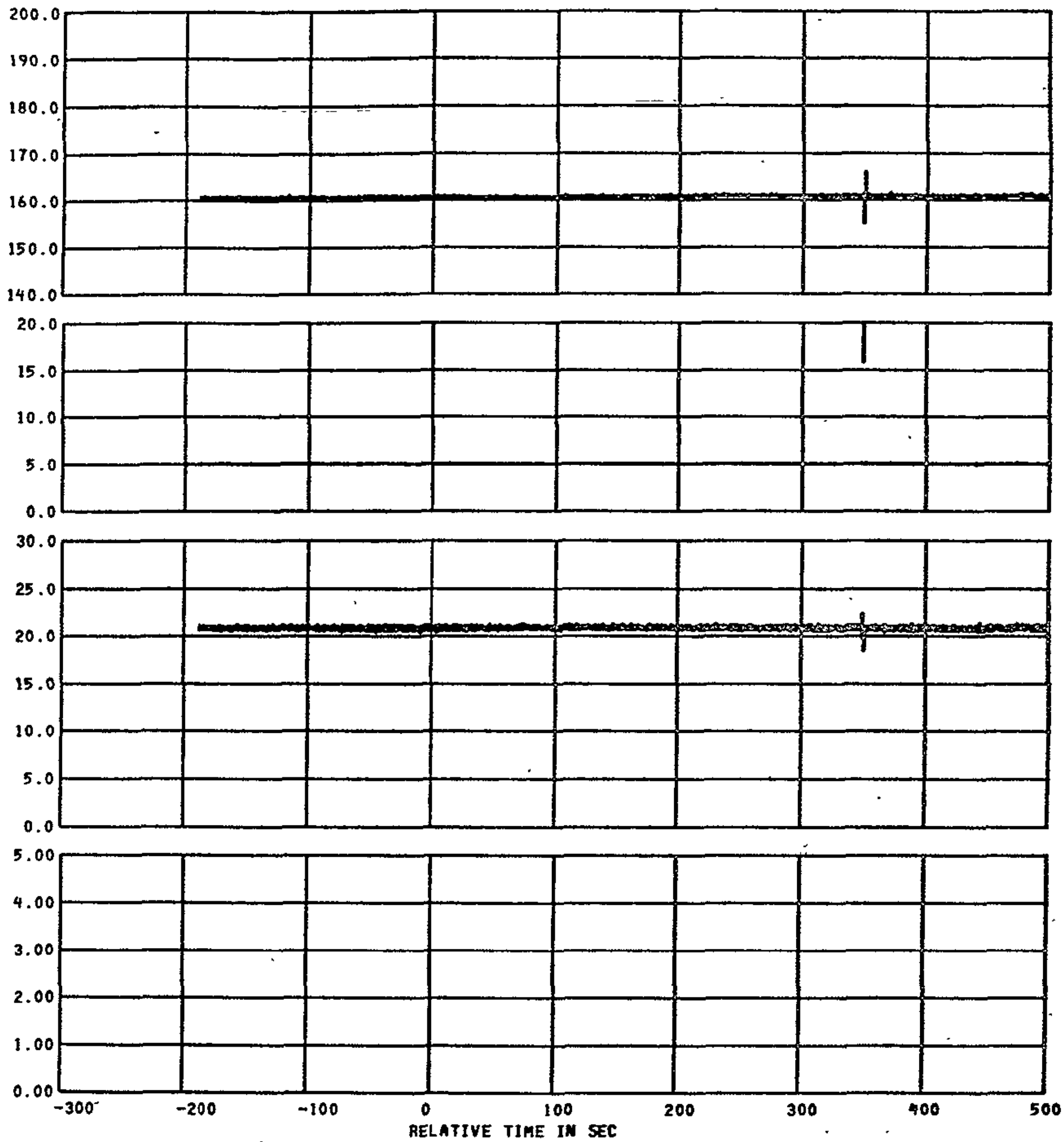
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-10	CG21-10	CDR NO. 1 AGC	0 TO 1000	MCRVOLTS	A
PDM-21-30	CG21-30	CDR NO. 2 AGC	0 TO 1000	MCRVOLTS	B

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 507 -B REFERENCE TIME 01 47 59.795



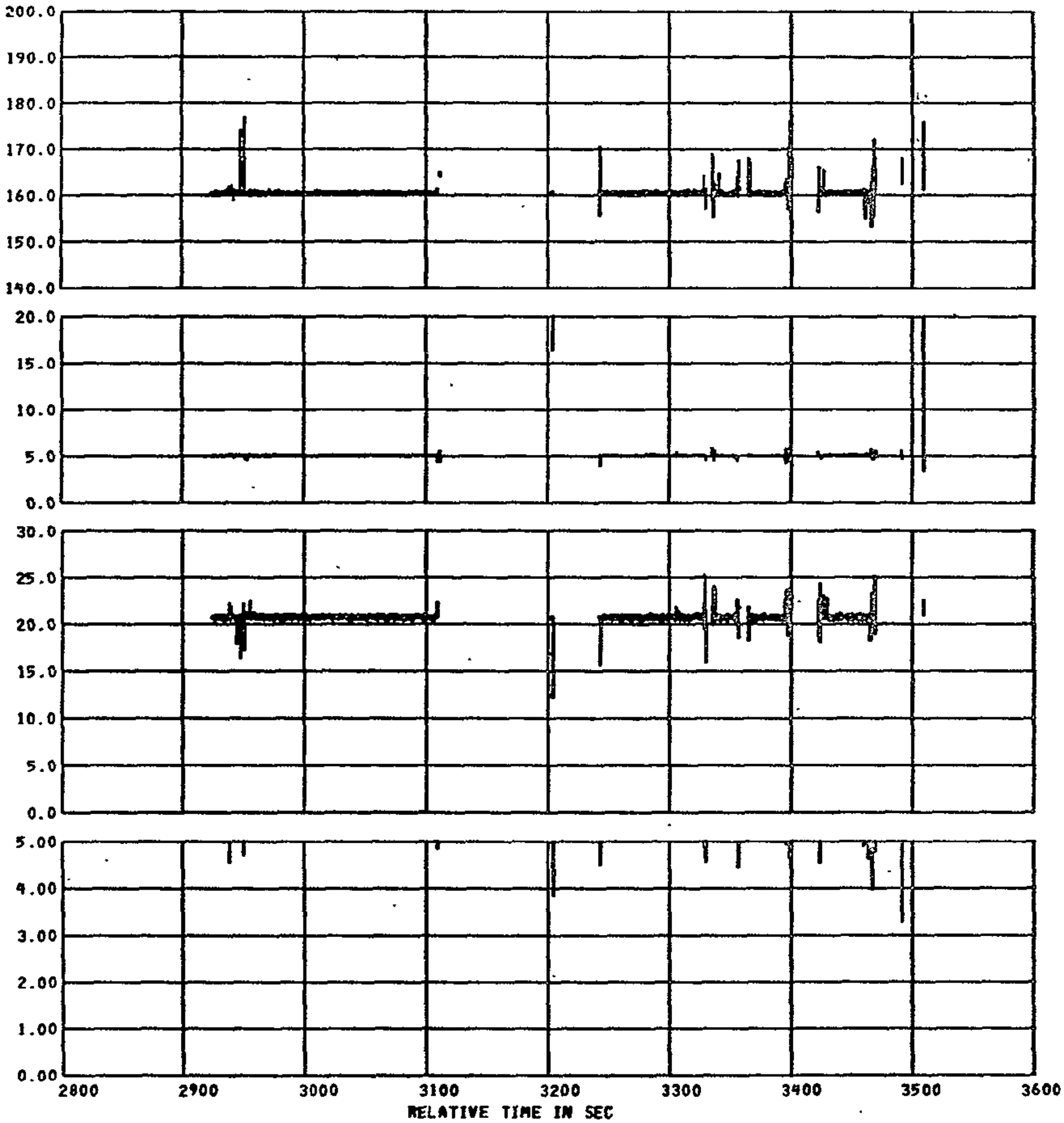
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-10	CG21-10	CDR NO. 1 AGC	0 TO 1000	MCRVOLTS	A
PDM-21-30	CG21-30	CDR NO. 2 AGC	0 TO 1000	MCRVOLTS	B

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 508 -A REFERENCE TIME 01 47 59.795



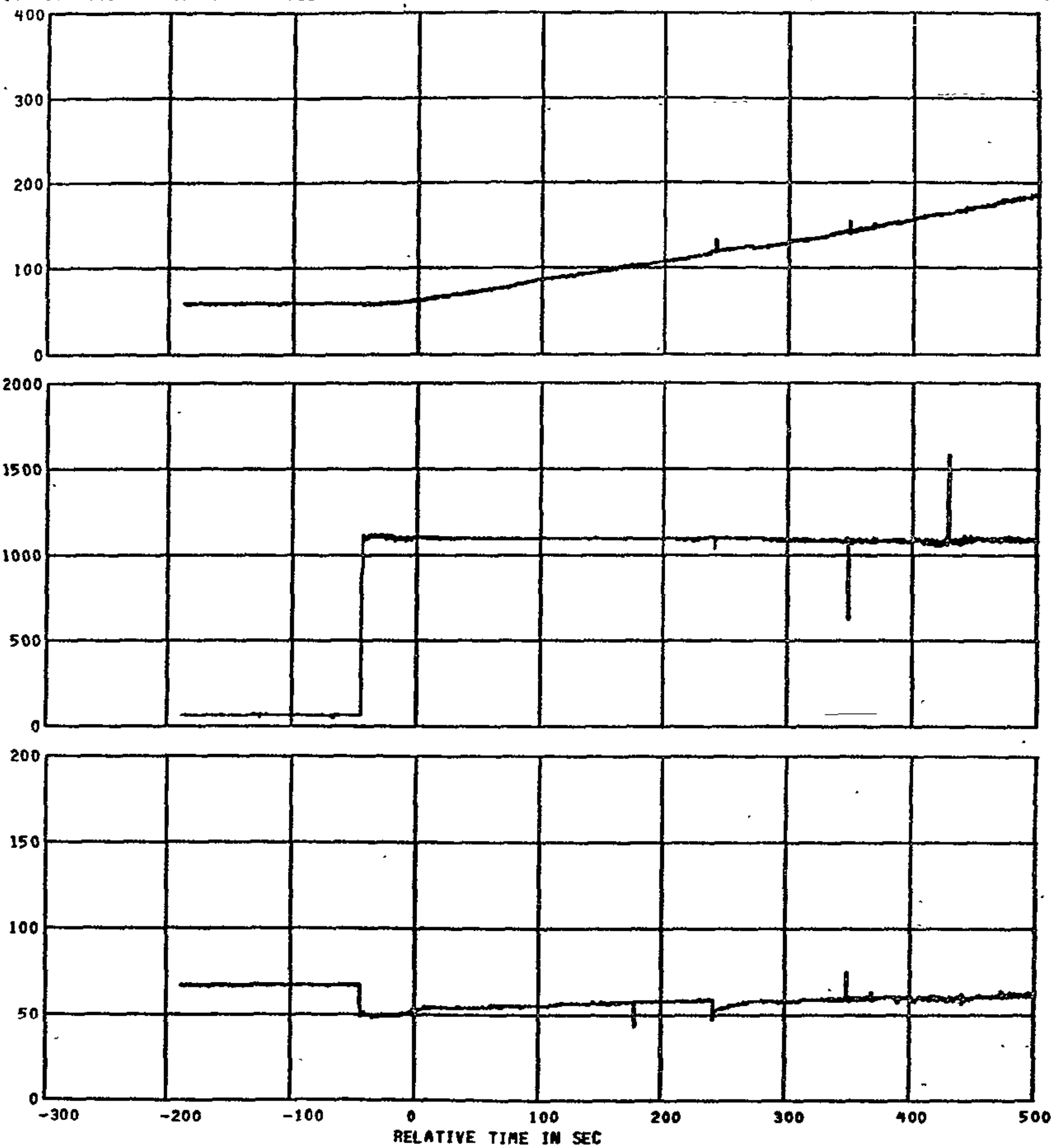
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-11	CG21-11	IMU BLOCK TEMPERATURE	140.0 TO 200.0	DEG F	A
PDM-21-07	CG21-07	G.C. LOGIC VOLTAGE	0.00 TO 5.00	VDC	B
PDM-21-31	CG21-31	GC MEMORY VOLTAGE	0.0 TO 30.0	VDC	BX
PDM-21-32	CG21-32	IMU GYRO EXCITATION	0.0 TO 27.5	VRMS	C
PDM-21-35	CG21-35	IMU LOGIC VOLTAGE	0.00 TO 5.00	VDC	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 508 -B REFERENCE TIME 01 47 59.795



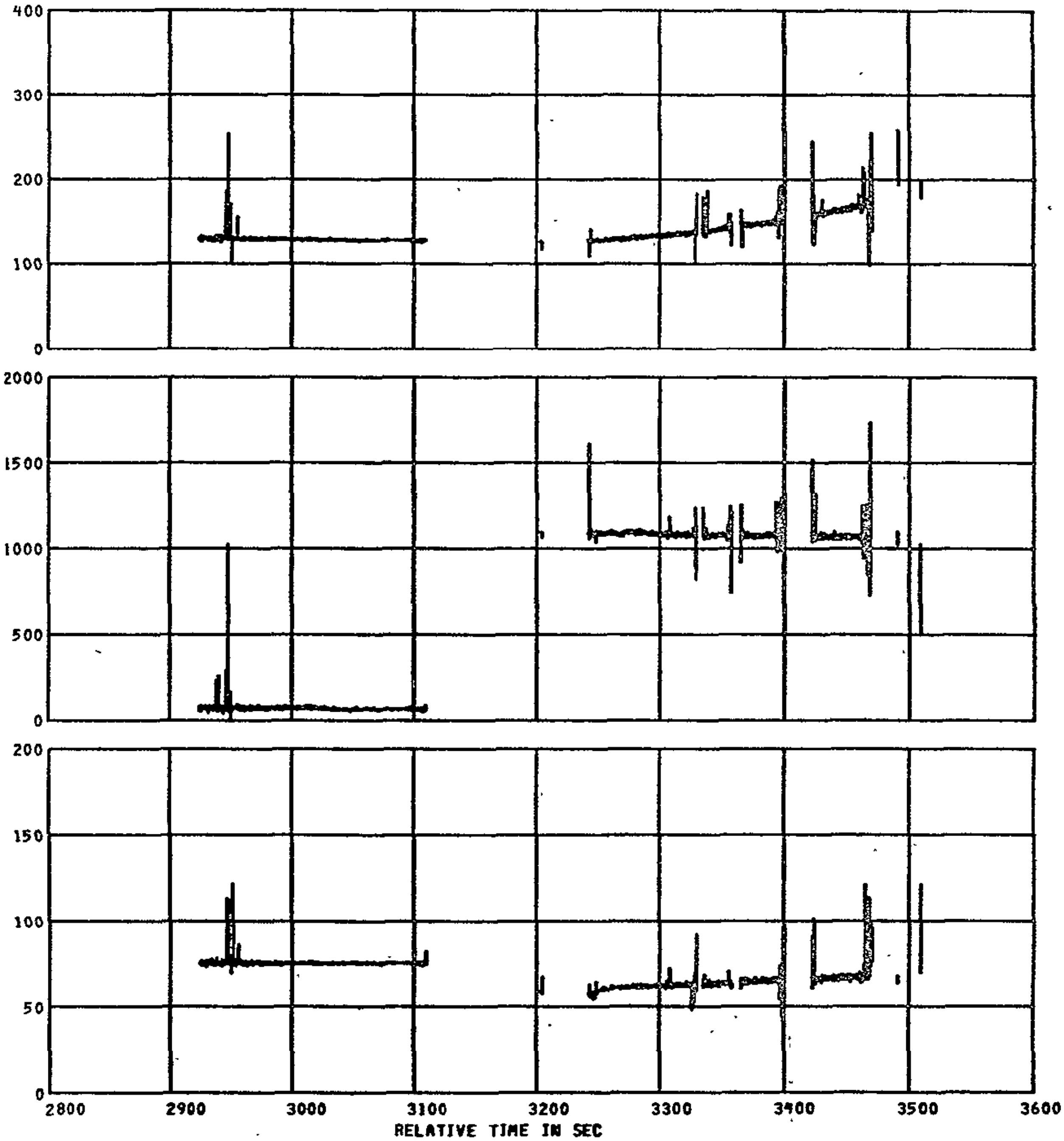
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-11	CG21-11	IMU BLOCK TEMPERATURE	140.0 TO 200.0	DEG F	A
PDM-21-07	CG21-07	G.C. LOGIC VOLTAGE	0.00 TO 5.00	VDC	B
PDM-21-31	CG21-31	GC MEMORY VOLTAGE	0.0 TO 30.0	VDC	BX
PDM-21-32	CG21-32	IMU GYRO EXCITATION	0.0 TO 27.5	VRMS	C
PDM-21-35	CG21-35	IMU LOGIC VOLTAGE	0.00 TO 5.00	VDC	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 509 -A REFERENCE TIME 01 47 59.795



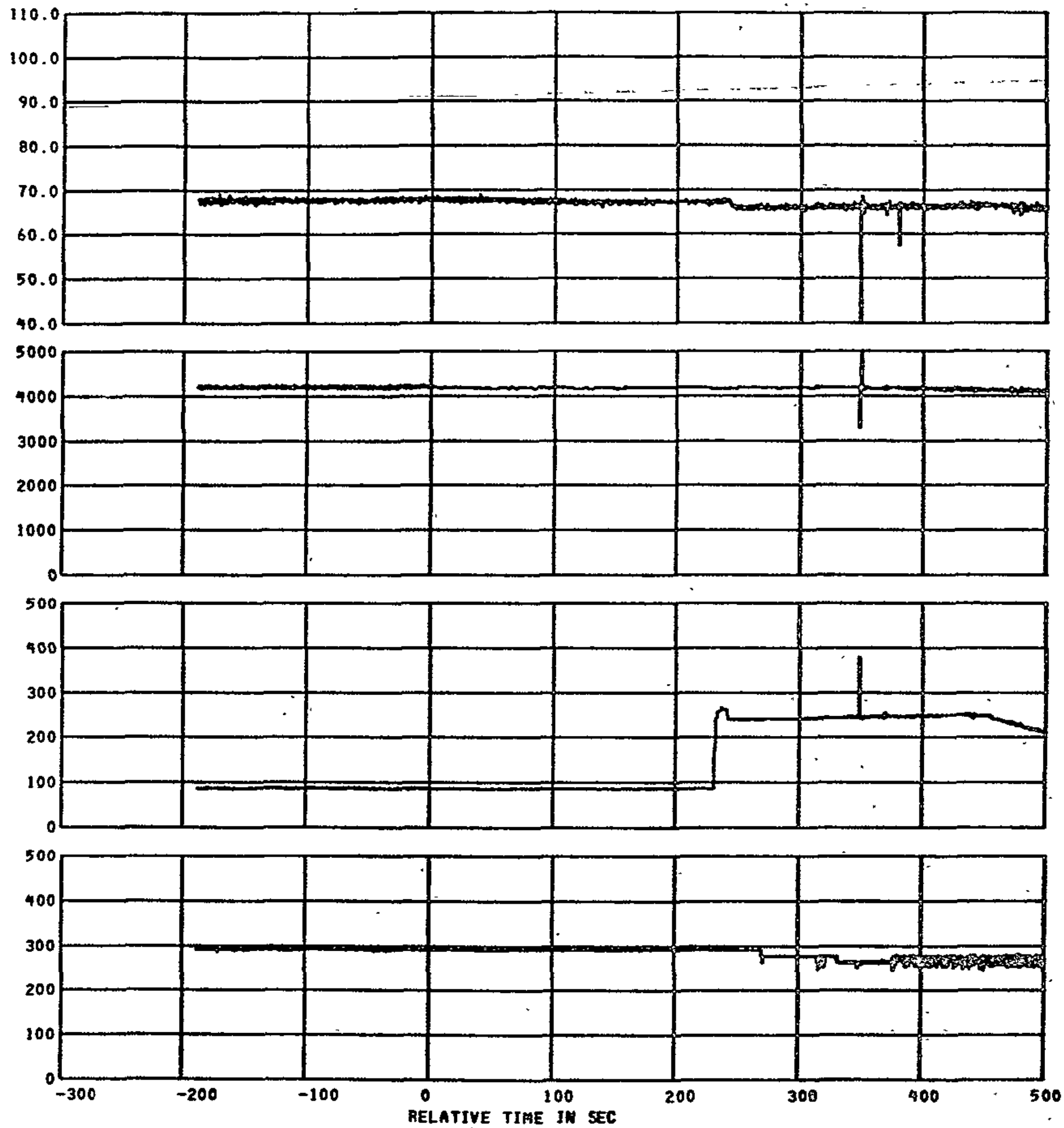
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-26	CG21-26	HYD MOTOR PUMP TEMPERATURE	32 TO 400	DEG F	A
PDM-21-23	CG21-23	HYDRAULIC SYSTEM PRESSURE	0 TO 2000	PSIA	B
PDM-21-29	CG21-29	HYDRAULIC SYSTEM RETURN PRESSURE	0 TO 200	PSIA	C

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 509 -B REFERENCE TIME 01 47 59.795



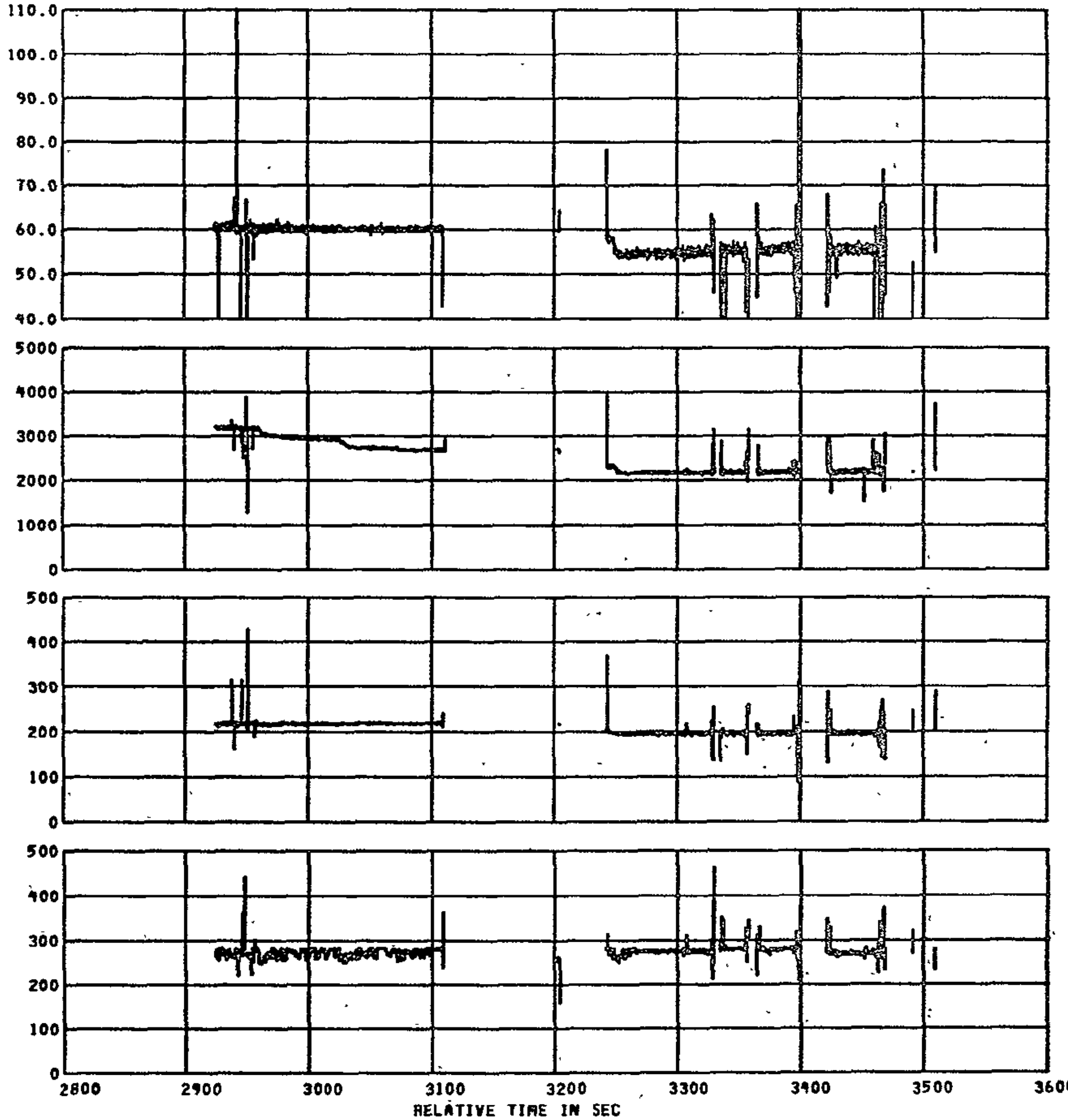
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-26	CG21-26	HYD MOTOR PUMP TEMPERATURE	32 TO 400	DEG F	A
PDM-21-23	CG21-23	HYDRAULIC SYSTEM PRESSURE	0 TO 2000	PSIA	B
PDM-21-29	CG21-29	HYDRAULIC SYSTEM RETURN PRESSURE	0 TO 200	PSIA	C

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 510 -A REFERENCE TIME 01 47 59.795



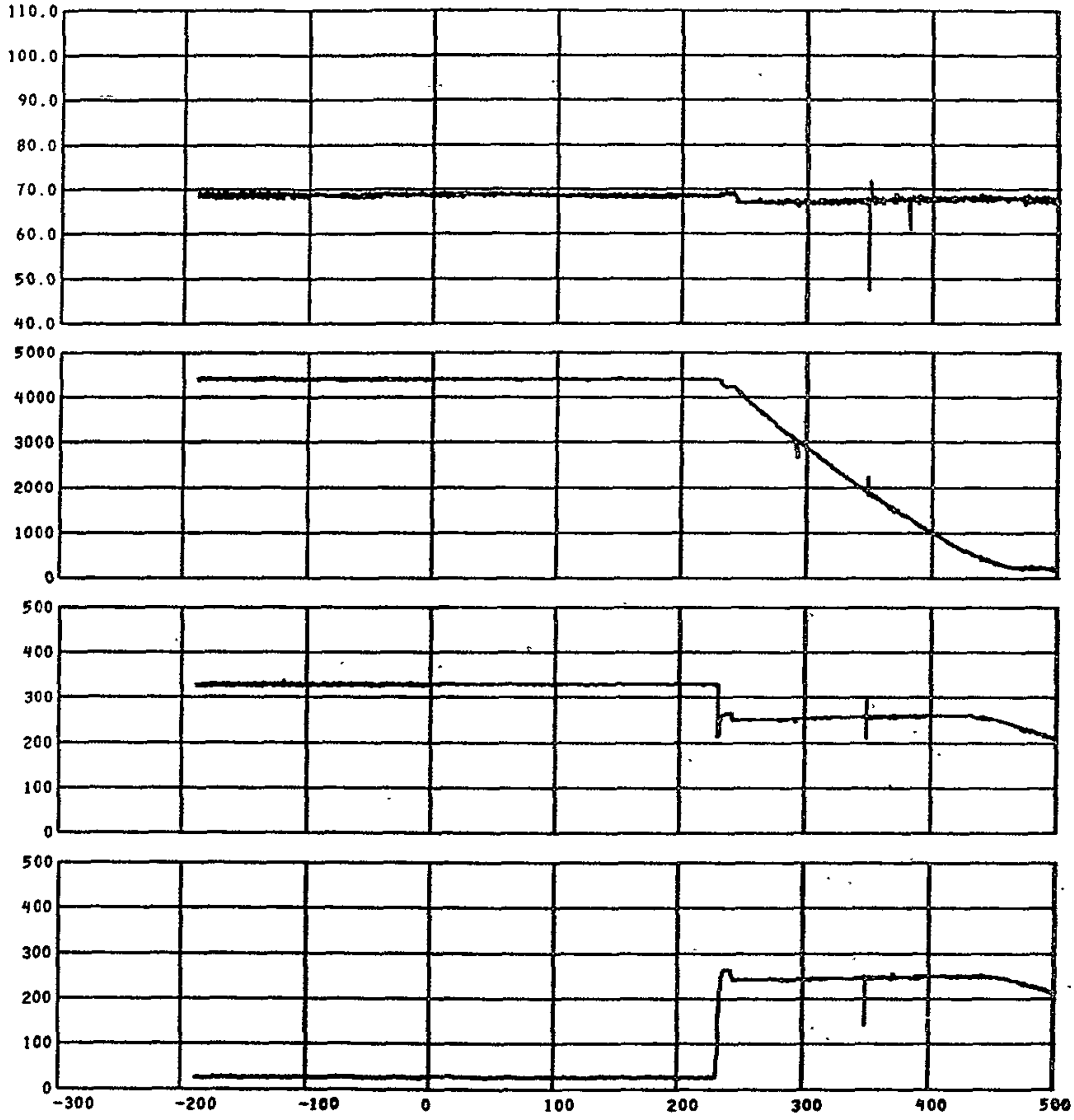
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-28	CG21-28	OXIDIZER LINE TEMPERATURE	40.0 TO 110.0	DEG F	A
PDM-21-16	CG21-16	NITROGEN BOTTLE PRESSURE	0 TO 5000	PSIA	B
PDM-21-22	CG21-22	OXIDIZER TANK PRESSURE	0 TO 500	PSIA	C
PDM-21-27	CG21-27	NITROGEN REGULATOR PRESSURE	0 TO 500	PSIA	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 510 -B REFERENCE TIME 01 47 59.795



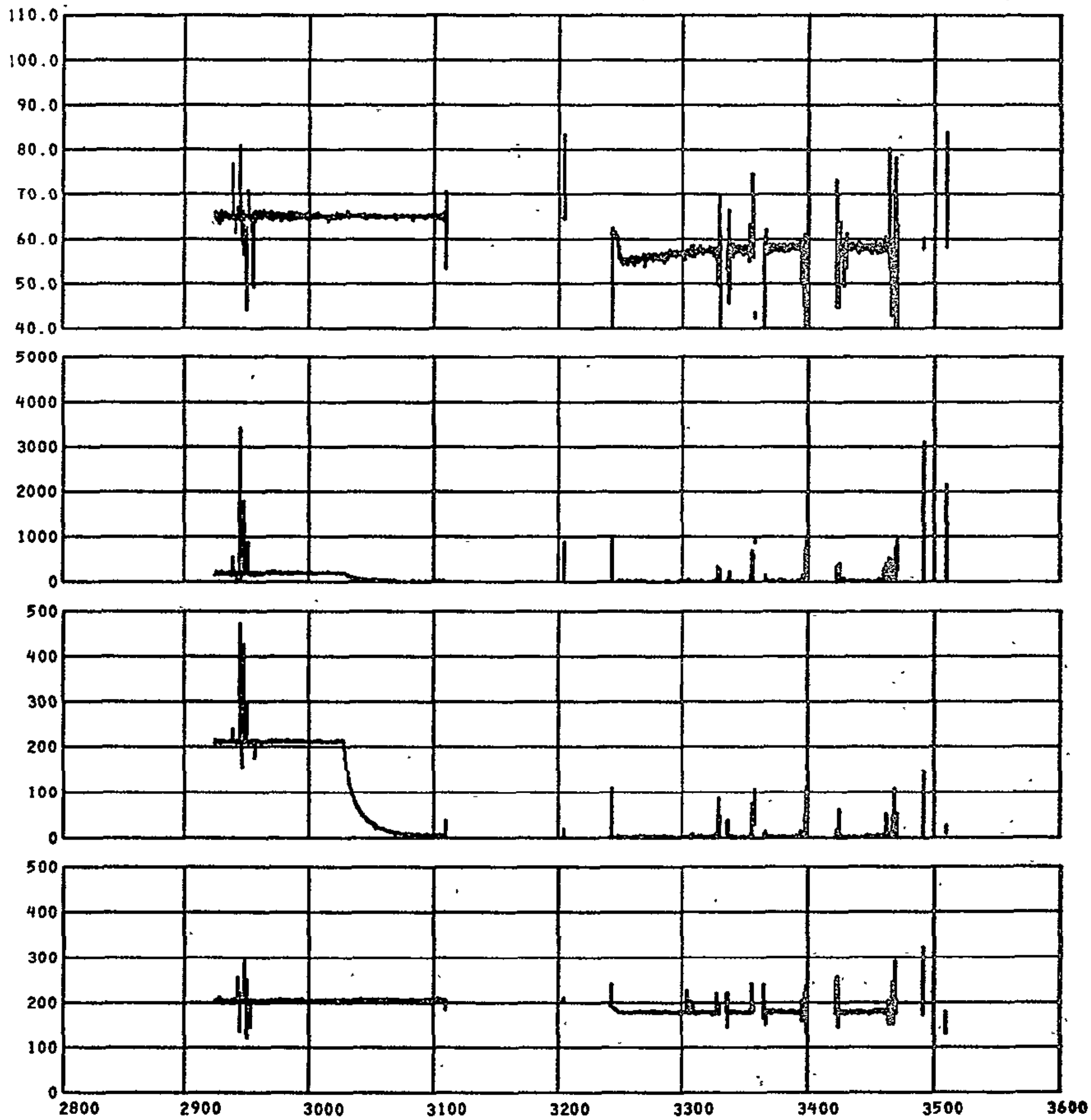
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-28	C621-28	OXIDIZER LINE TEMPERATURE	40.0 TO 110.0	DEG F	A
PDM-21-16	C621-16	NITROGEN BOTTLE PRESSURE	0 TO 5000	PSIA	B
PDM-21-22	C621-22	OXIDIZER TANK PRESSURE	0 TO 500	PSIA	C
PDM-21-27	C621-27	NITROGEN REGULATOR PRESSURE	0 TO 500	PSIA	D

TEST ID 046619 441000 20018 COS-B DRETS PLOT NO 511 -A REFERENCE TIME 01 47 59.795



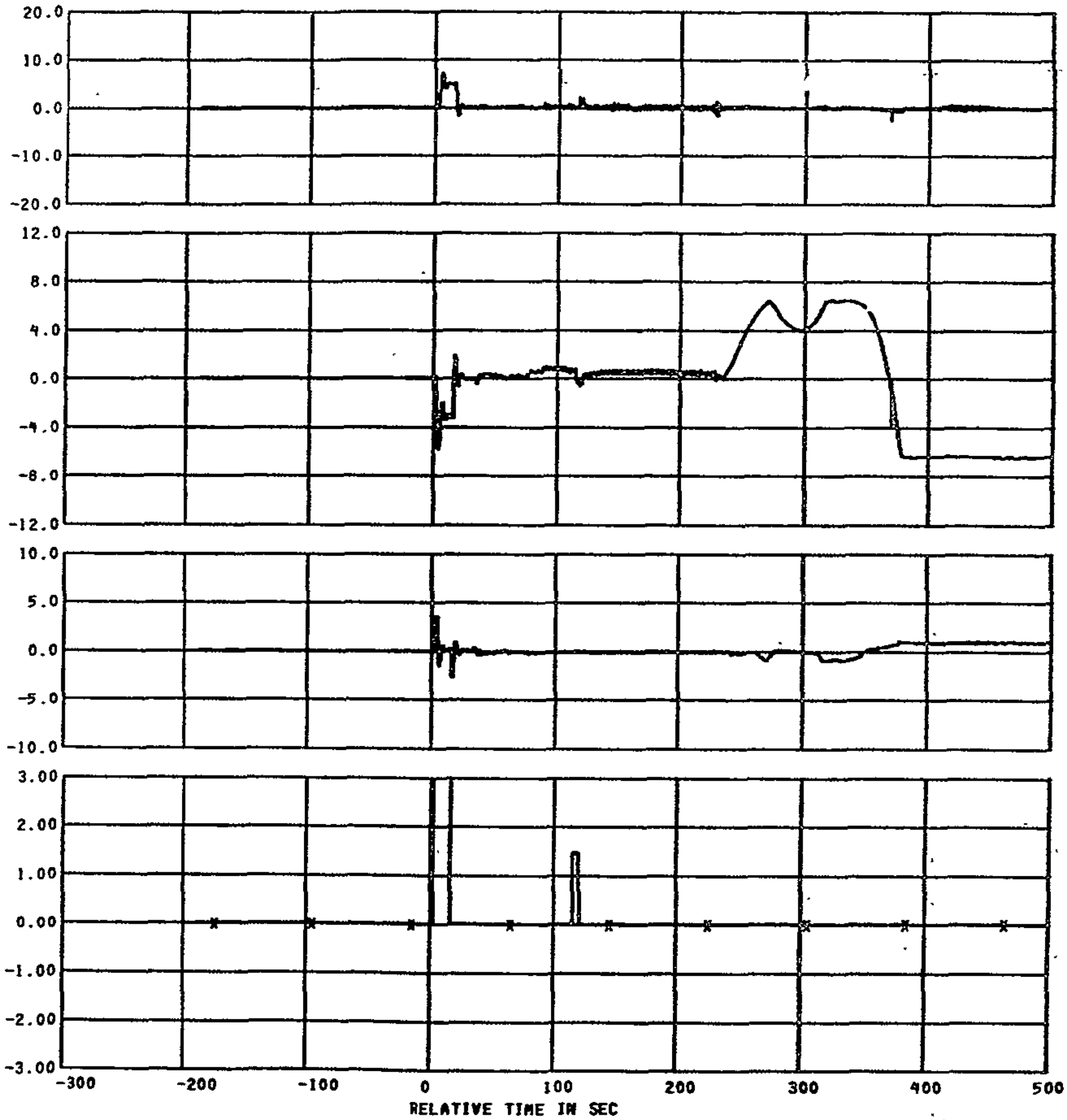
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-39	CG21-39	FUEL LINE TEMPERATURE	40.0 TO 110.0	DEG F	A
PDM-21-37	CG21-37	HELIUM BOTTLE PRESSURE	0 TO 5000	PSIA	B
PDM-21-38	CG21-38	HELIUM REGULATED PRESSURE	0 TO 500	PSIA	C
PDM-21-42	CG21-42	FUEL TANK PRESSURE	0 TO 500	PSIA	D

TFST ID 046619 441000 20018 COS-B DRETS PLOT NO 511 -B REFERENCE TIME 01 47 59.795



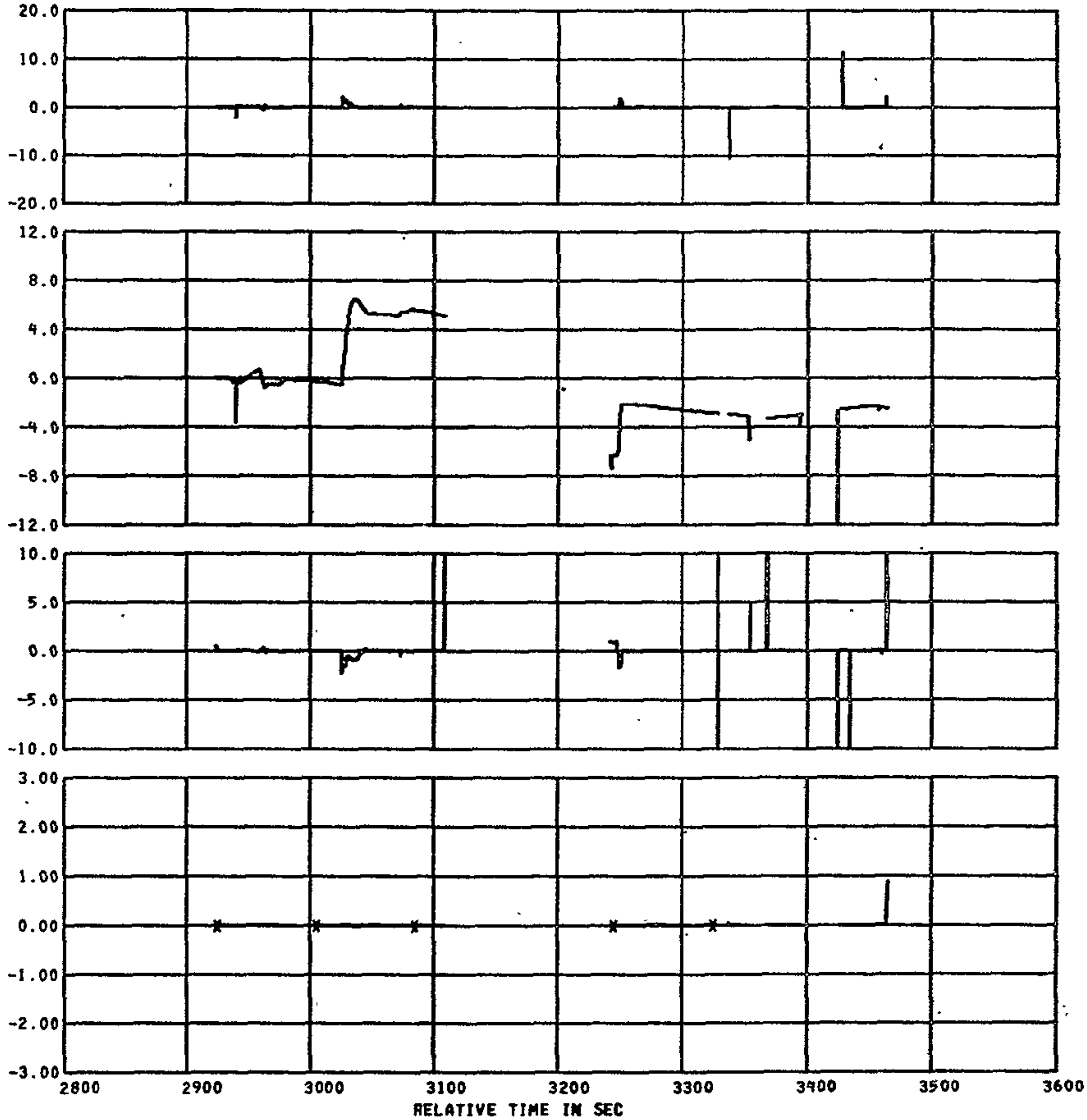
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PDM-21-39	CG21-39	FUEL LINE TEMPERATURE	40.0 TO 110.0	DEG F	A
PDM-21-37	CG21-37	HELIUM BOTTLE PRESSURE	0 TO 5000	PSIA	B
PDM-21-38	CG21-38	HELIUM REGULATED PRESSURE	0 TO 500	PSIA	C
PDM-21-42	CG21-42	FUEL TANK PRESSURE	0 TO 500	PSIA	D

TEST ID 046619 480000 COS-B DRETS PLOT NO 600 -A REFERENCE TIME 01 47 59.795



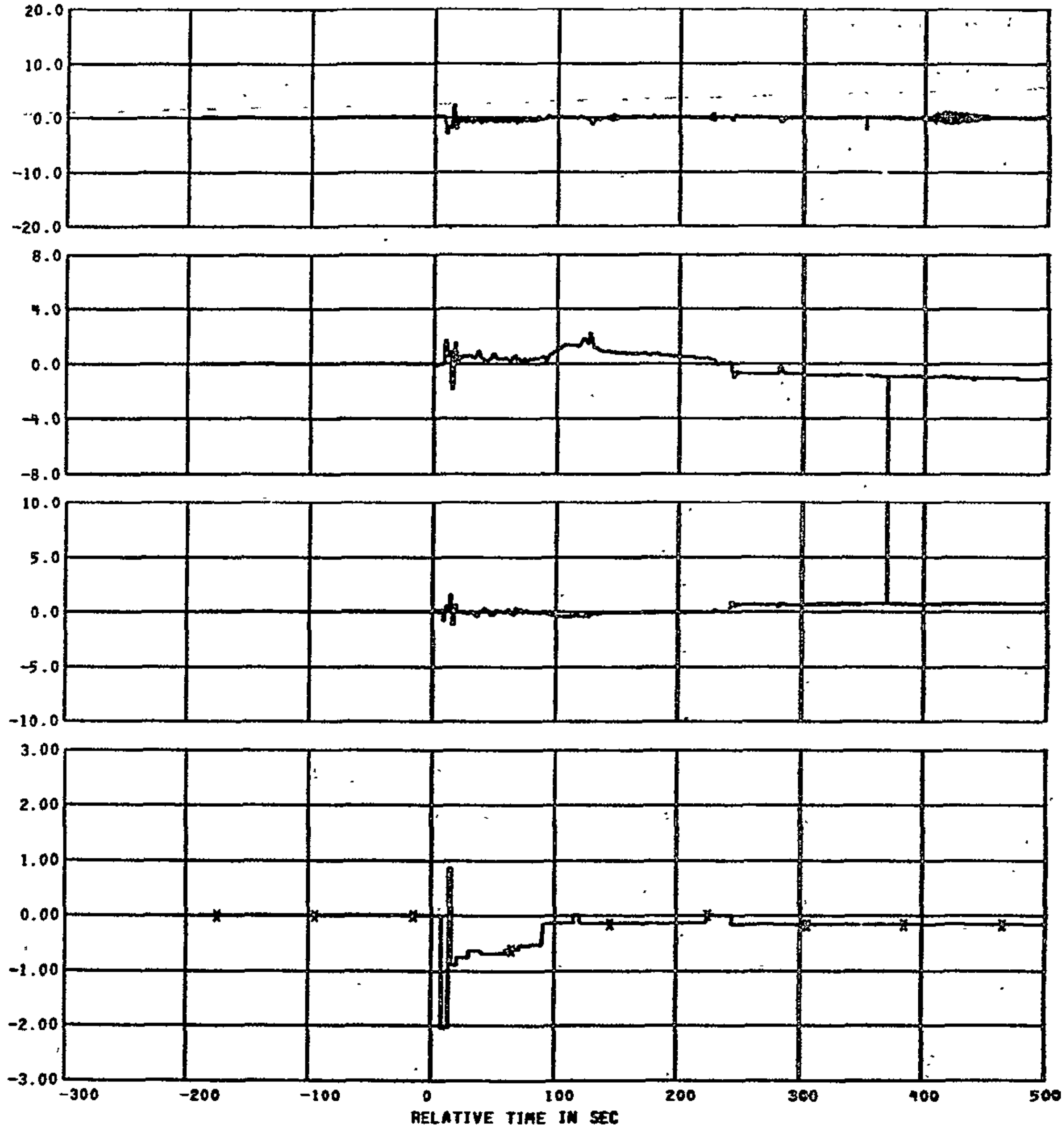
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PCM-2G-01	1-01S	ROLL ANGULAR RATE	-43.0 TO 43.0	DEG/SEC	A
PCM-2G-04	1-04S	ROLL ATTITUDE ERROR	-30.1 TO 30.1	DEG	B
PCM-2G-07	1-07S	ROLL DAC OR ON/OFF OUTPUT	-10.1 TO 10.1	VOLTS	C
PCM-2G-17	1-17	PROGRAMMED ROLL RATE	-30.1 TO 30.1	DEG/SEC	DX

TEST ID 046619 480000 COS-B DRETS PLOT NO 600 -B REFERENCE TIME 01 47 59.795



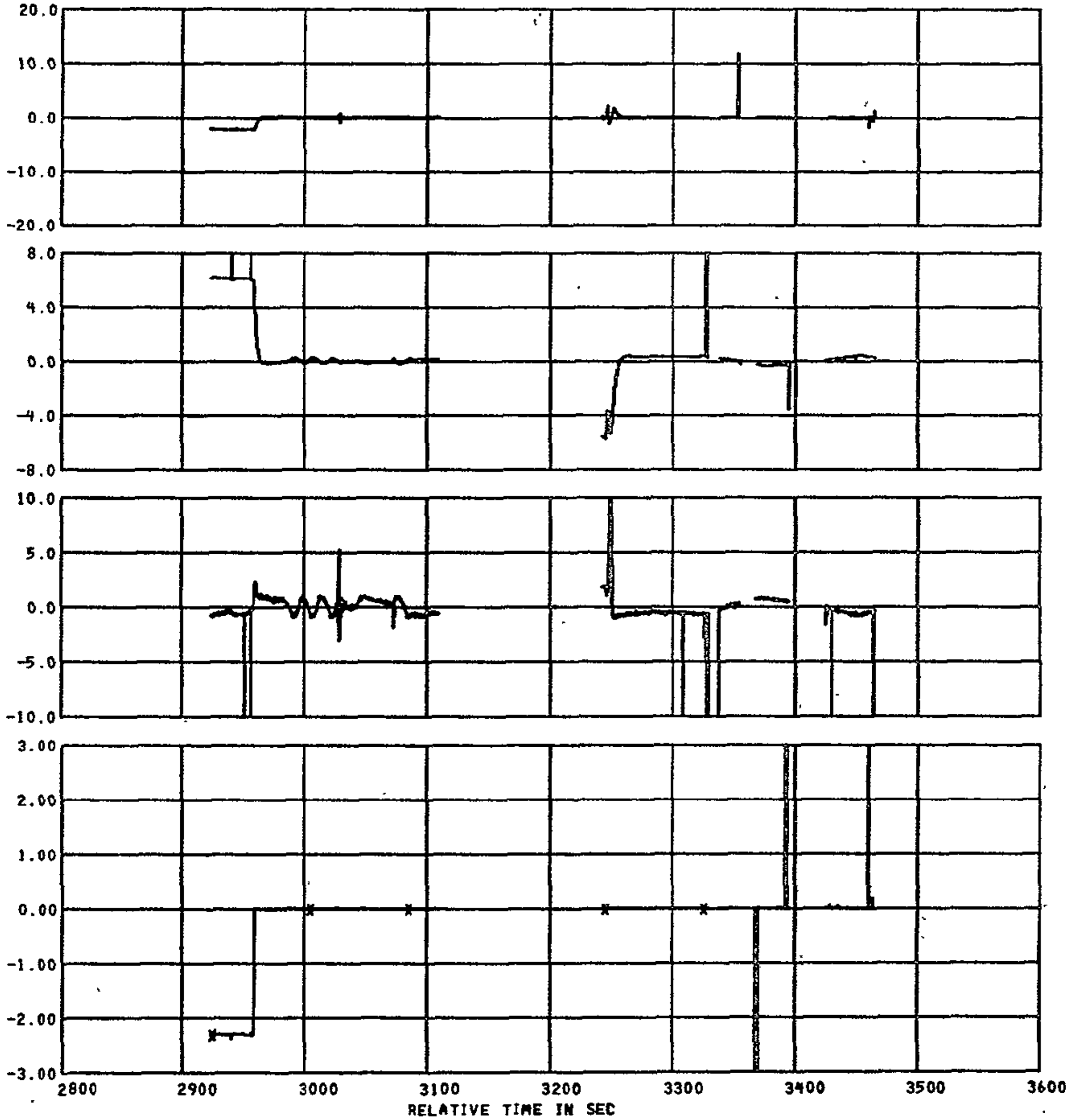
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PCM-2G-01	1-01S	ROLL ANGULAR RATE	-43.0 TO 43.0	DEG/SEC	A
PCM-2G-04	1-04S	ROLL ATTITUDE ERROR	-30.1 TO 30.1	DEG	B
PCM-2G-07	1-07S	ROLL DAC OR ON/OFF OUTPUT	-10.1 TO 10.1	VOLTS	C
PCM-2G-17	1-17	PROGRAMMED ROLL RATE	-30.1 TO 30.1	DEG/SEC	DX

TEST ID 046619 480000 COS-B DRETS PLOT NO 601 -A REFERENCE TIME 01 47 59.795



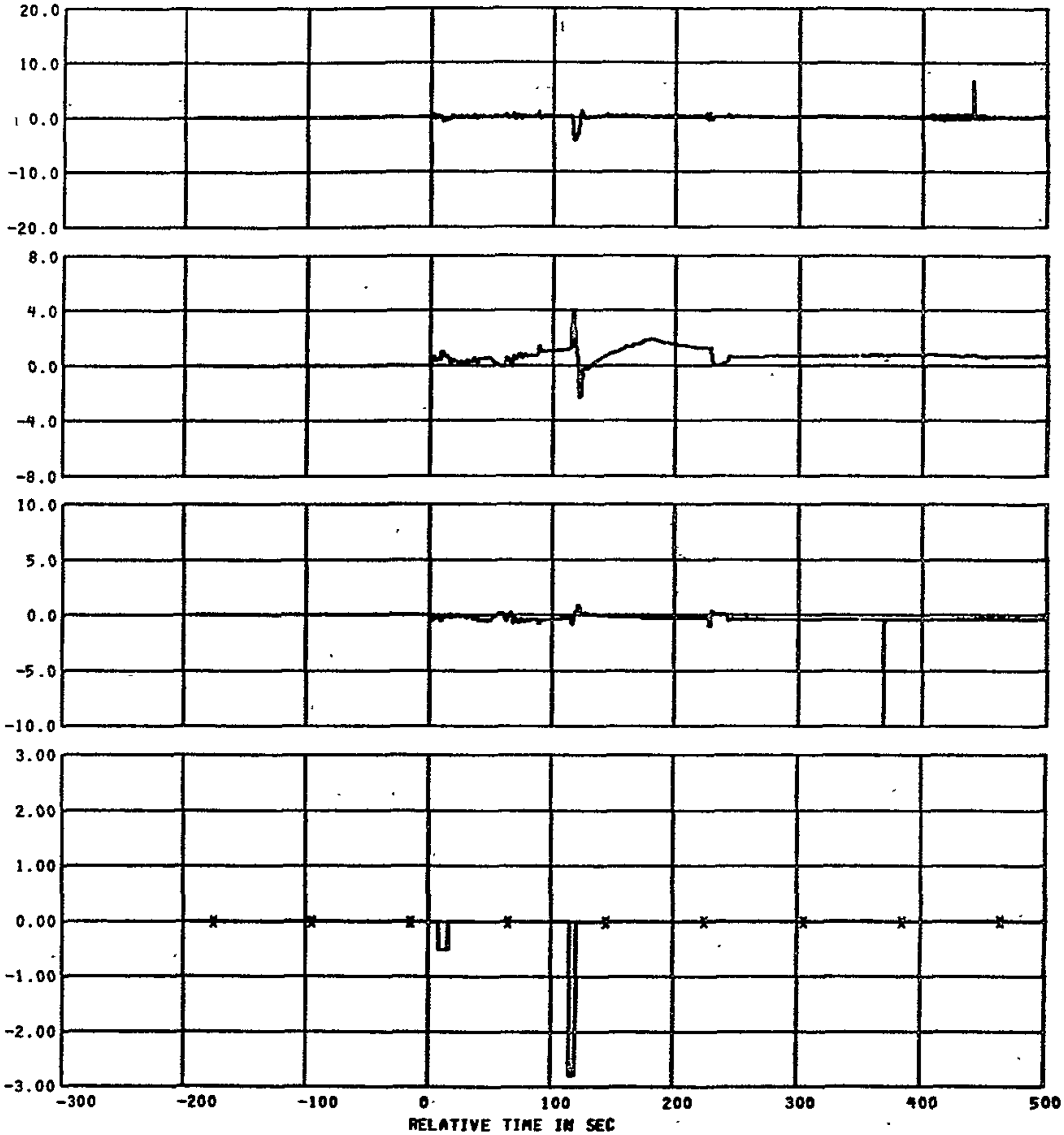
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PCM-2G-02	1-025	PITCH ANGULAR RATE	-43.0 TO 43.0	DEG/SEC	A
PCM-2G-05	1-055	PITCH ATTITUDE ERROR	-30.1 TO 30.1	DEG	B
PCM-2G-08	1-085	PITCH DAC OR ON/OFF OUTPUT	-10.1 TO 10.1	VOLTS	C
PCM-2G-18	1-18	PROGRAMMED PITCH RATE	-30.1 TO 30.1	DEG/SEC	DX

TEST ID 046619 480000 COS-B DRETS PLOT NO 601 -B REFERENCE TIME 01 47 59.795



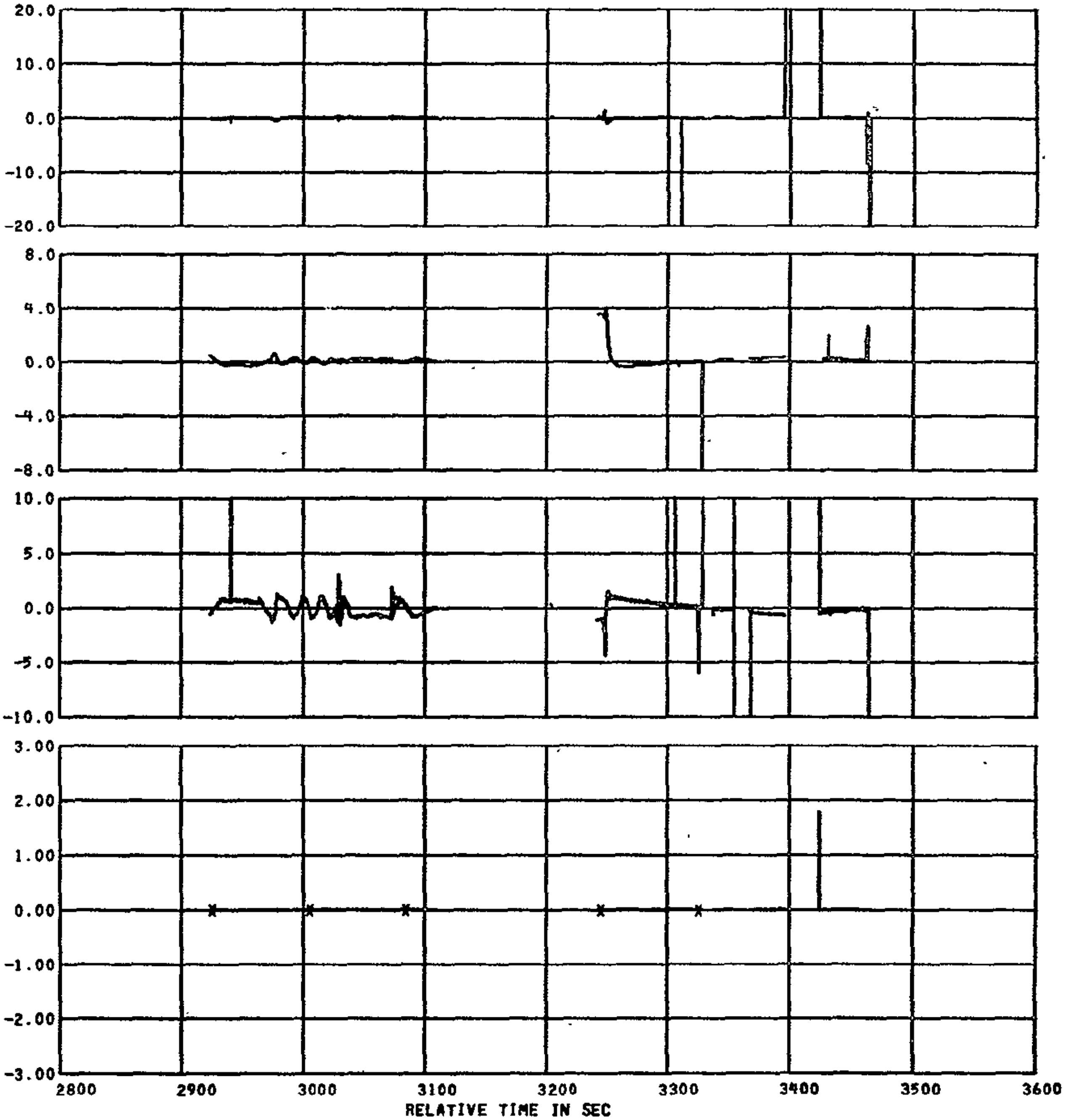
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PCM-2G-02	1-025	PITCH ANGULAR RATE	-43.0 TO 43.0	DEG/SEC	A
PCM-2G-05	1-055	PITCH ATTITUDE ERROR	-30.1 TO 30.1	DEG	B
PCM-2G-08	1-085	PITCH DAC OR ON/OFF OUTPUT	-10.1 TO 10.1	VOLTS	C
PCM-2G-18	1-18	PROGRAMMED PITCH RATE	-30.1 TO 30.1	DEG/SEC	DX

TEST ID 046619 480000 COS-B DRETS PLOT NO 602 -A REFERENCE TIME 01 47 59.795



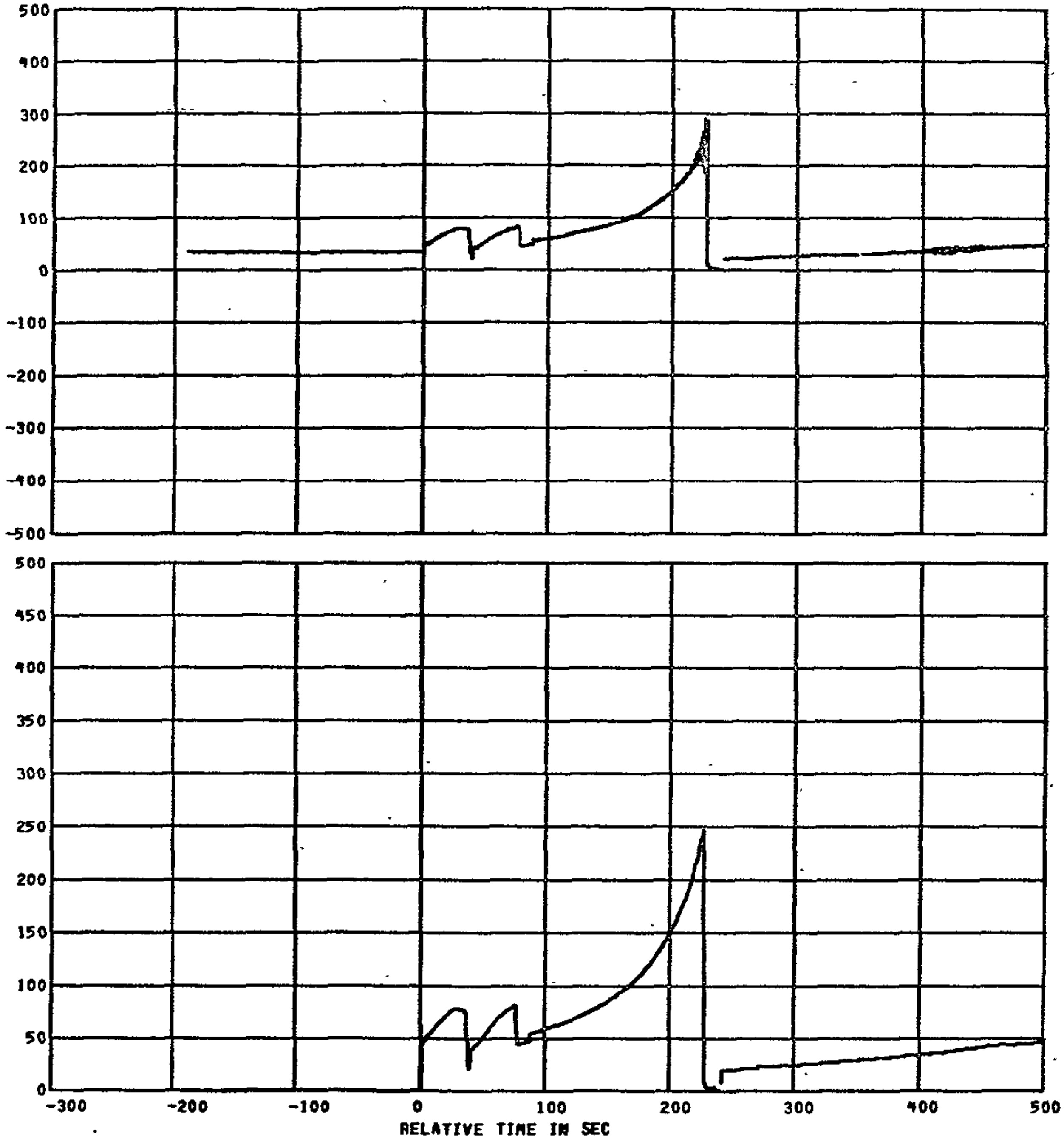
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PCM-2G-03	1-03S	YAW ANGULAR RATE	-43.0 TO 43.0	DEG/SEC	A
PCM-2G-06	1-06S	YAW ATTITUDE ERROR	-30.1 TO 30.1	DEG	B
PCM-2G-09	1-09S	YAW DAC OR ON/OFF OUTPUT	-10.1 TO 10.1	VOLTS	C
PCM-2G-19	1-19	PROGRAMMED YAW RATE	-30.1 TO 30.1	DEG/SEC	DX

TEST ID 046619 480000 COS-B DRETS PLOT NO 602 -B REFERENCE TIME 01 47 59.795



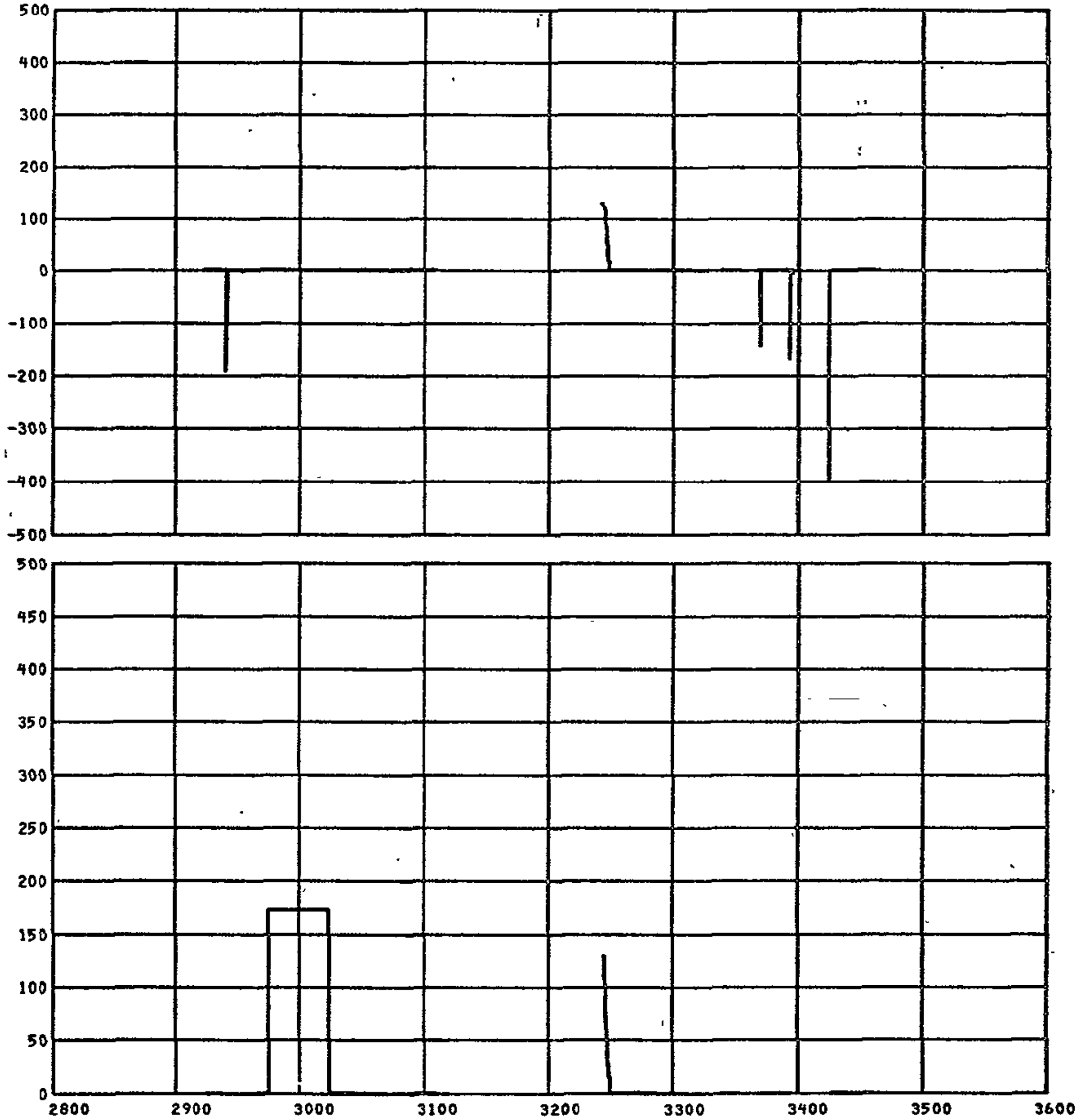
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PCM-2G-03	1-03S	YAW ANGULAR RATE	-43.0 TO 43.0	DEG/SEC	A
PCM-2G-06	1-06S	YAW ATTITUDE ERROR	-30.1 TO 30.1	DEG	B
PCM-2G-09	1-09S	YAW DAC OR ON/OFF OUTPUT	-10.1 TO 10.1	VOLTS	C
PCM-2G-19	1-19	PROGRAMMED YAW RATE	-30.1 TO 30.1	DEG/SEC	DX

TEST ID 046619 480000 COS-B DRETS PLOT NO 603 -A REFERENCE TIME 01 47 59.795



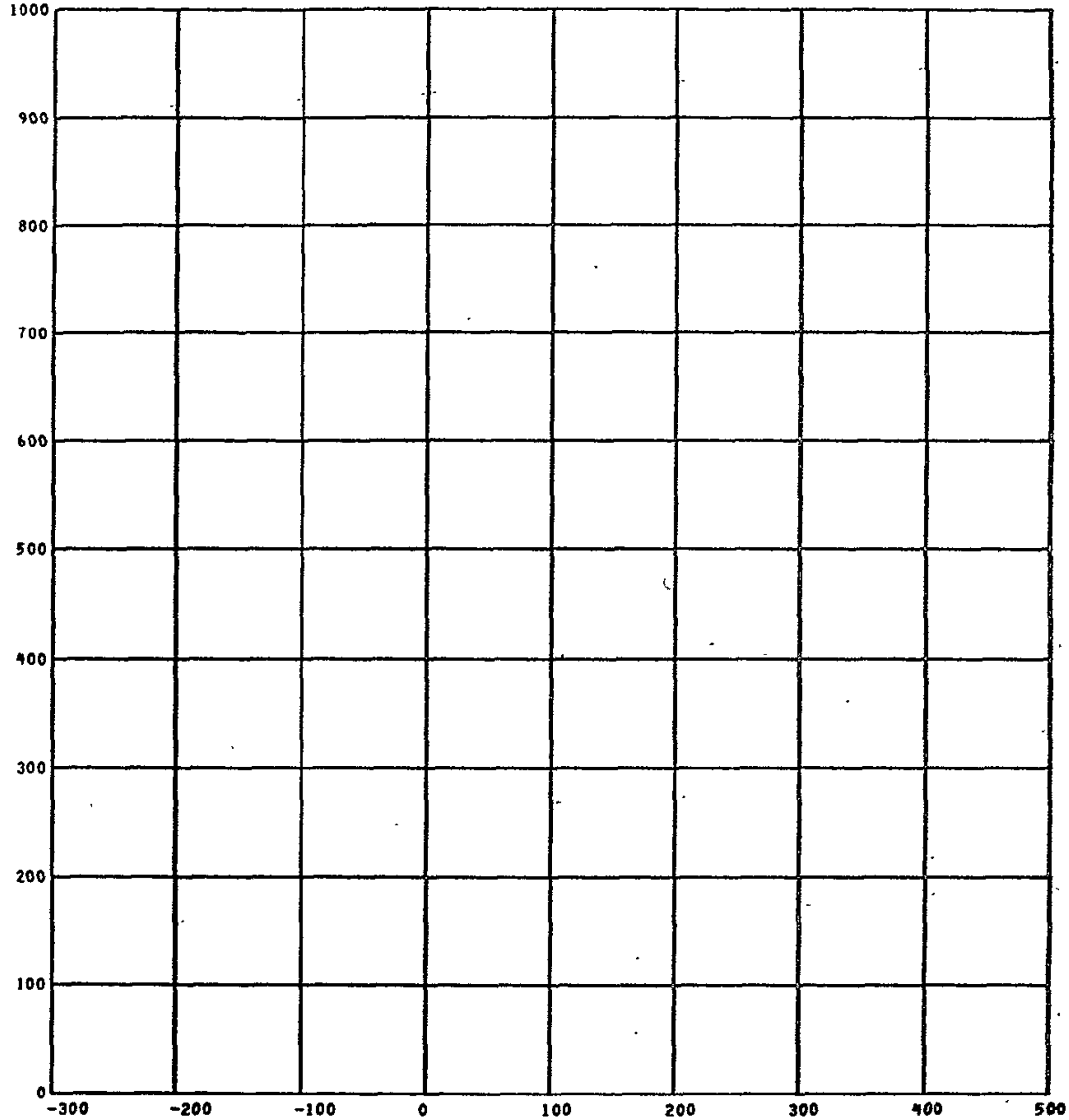
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PCM-26-25	1-25	X BODY COORD ACCEL	-500 TO 500	FT/SEC2	A
PCM-26-39	1-39-01	THRUST ACCELERATION	0 TO 500	FT/SEC2	B

TEST ID 046619 480000 COS-B DRETS PLOT NO 603 -B REFERENCE TIME 01 47 59.795



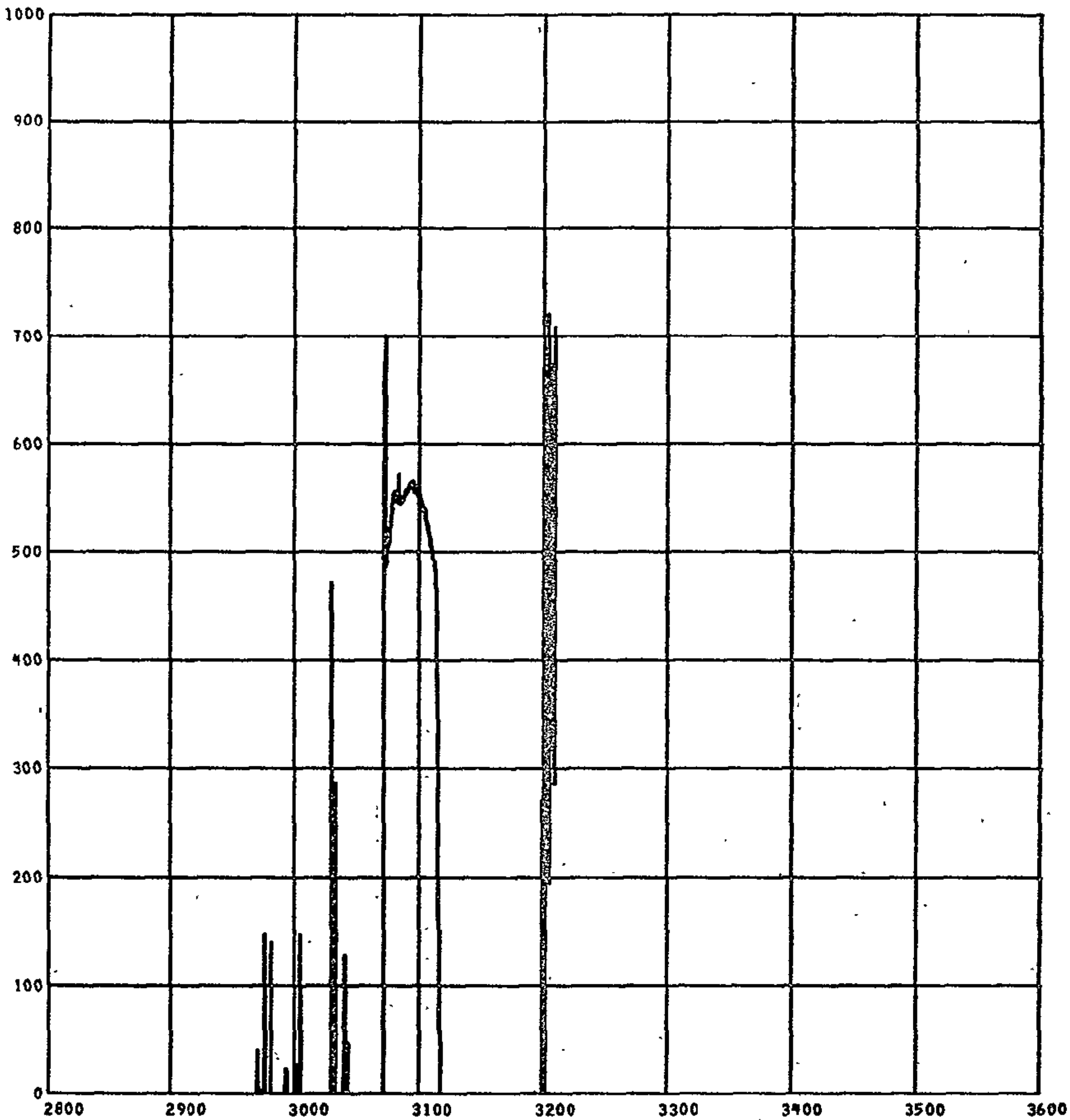
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
PCM-26-25	1-25	X BODY COORD ACCEL	-500 TO 500	FT/SEC2	A
PCM-26-39	1-39-01	THRUST ACCELERATION	0 TO 500	FT/SEC2	B

TEST ID 046619 461000 20018 COS-B DRETS PLOT NO 700 -A REFERENCE TIME 01 47 59.795



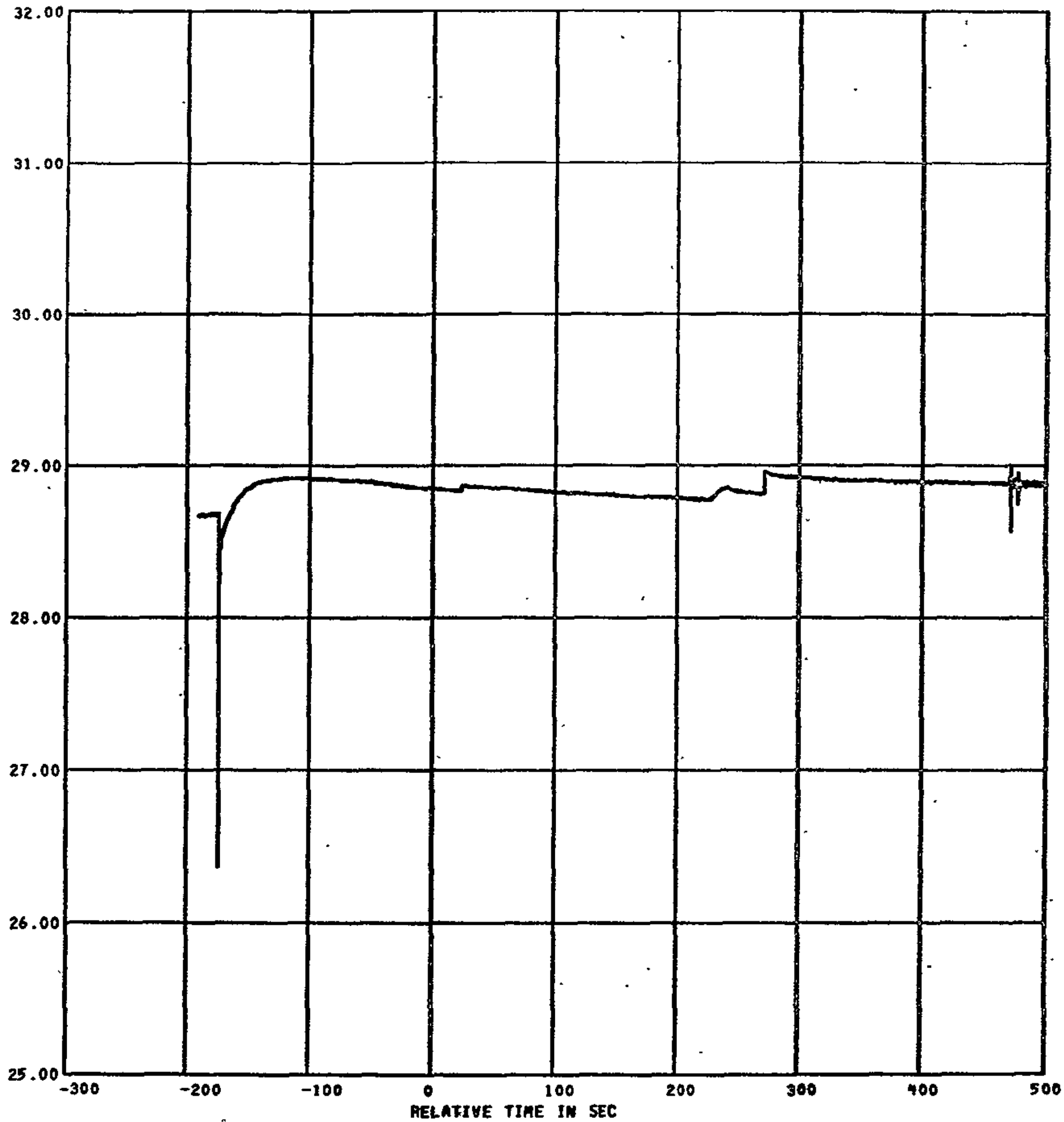
MEAS. NUMBER	CHANNEL ASSN.	TITLE	RANGE	UNITS	GRID-SYM
FM-31-18	CF31-18	THIRD STAGE CHAMBER PRESSURE	0 TO 1000	PSIA	A

TEST ID 046619 461000 20018 COS-B DRETS PLOT NO 700 -B REFERENCE TIME 01 47 59.795



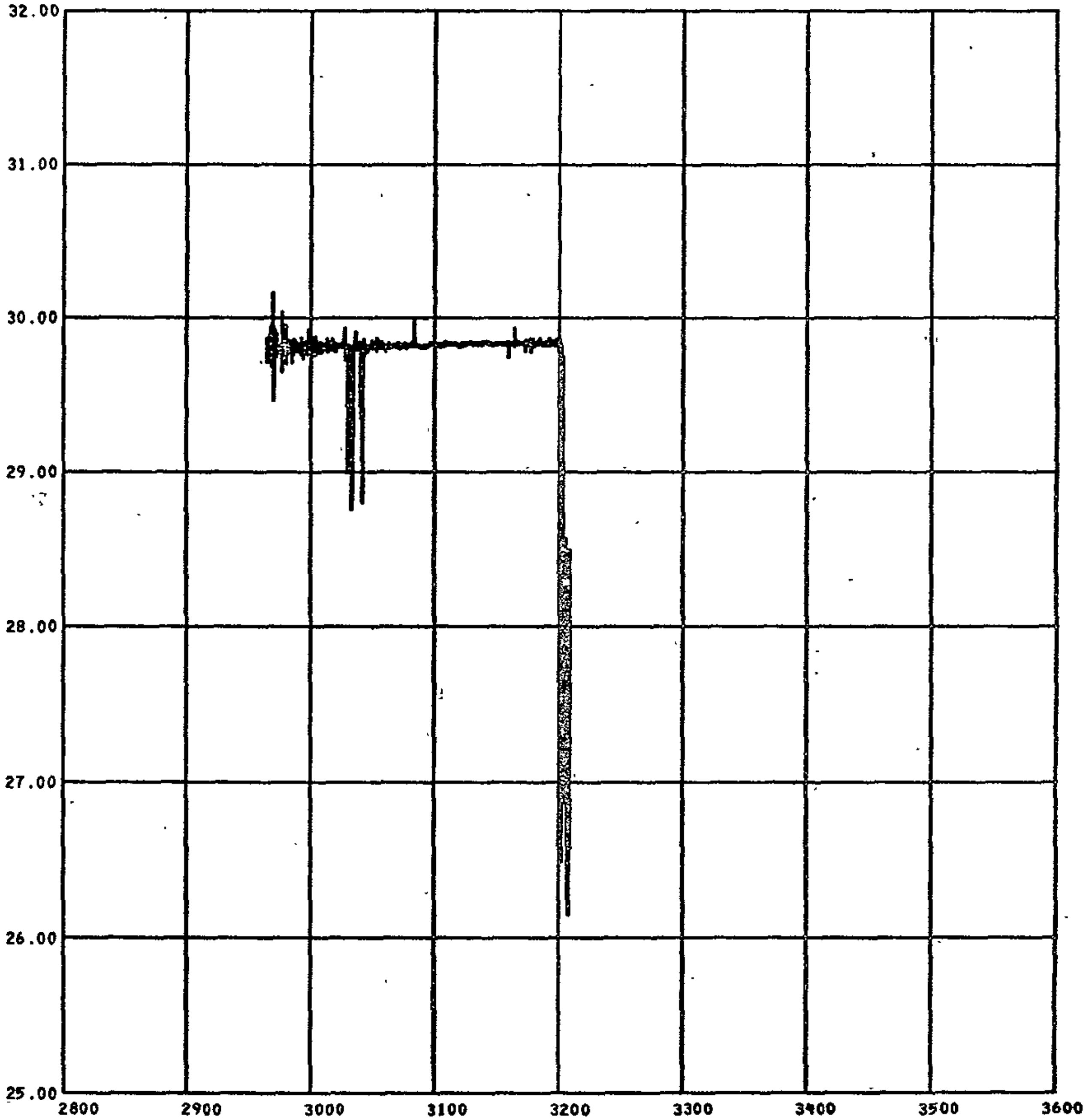
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-31-18	CF31-18	THIRD STAGE CHAMBER PRESSURE	0 TO 1000	PSIA	A

TEST ID 046619 461000 20018 COS-B DRETS PLOT NO 701 -A REFERENCE TIME 01 47 59.795



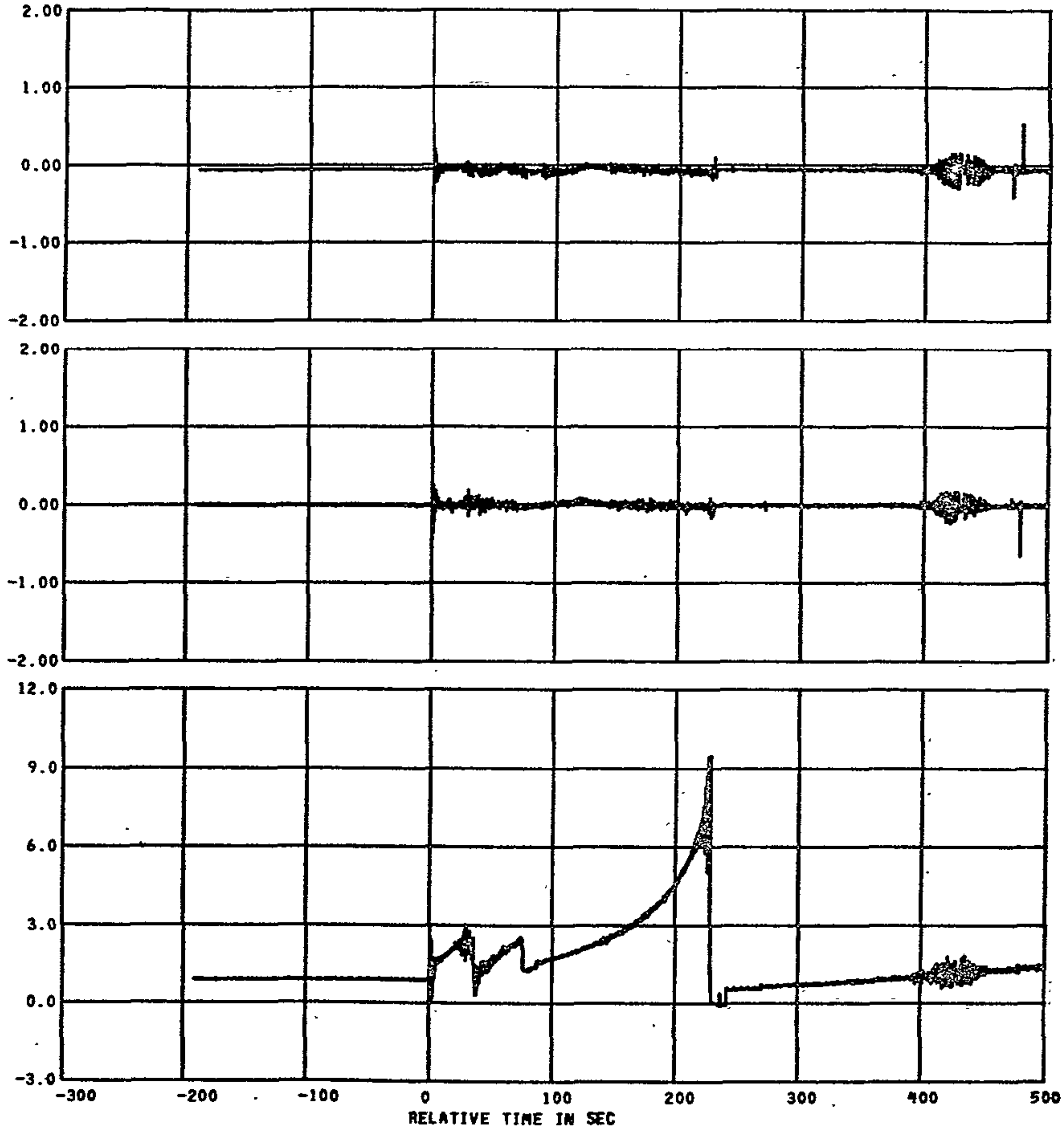
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-31-14	CF31-14	BATTERY MONITOR VOLTAGE	25.00 TO 32.00	VDC	A

TEST ID 046619 461000 20018 COS-B DRETS PLOT NO 701 -B REFERENCE TIME 01 47 59.795



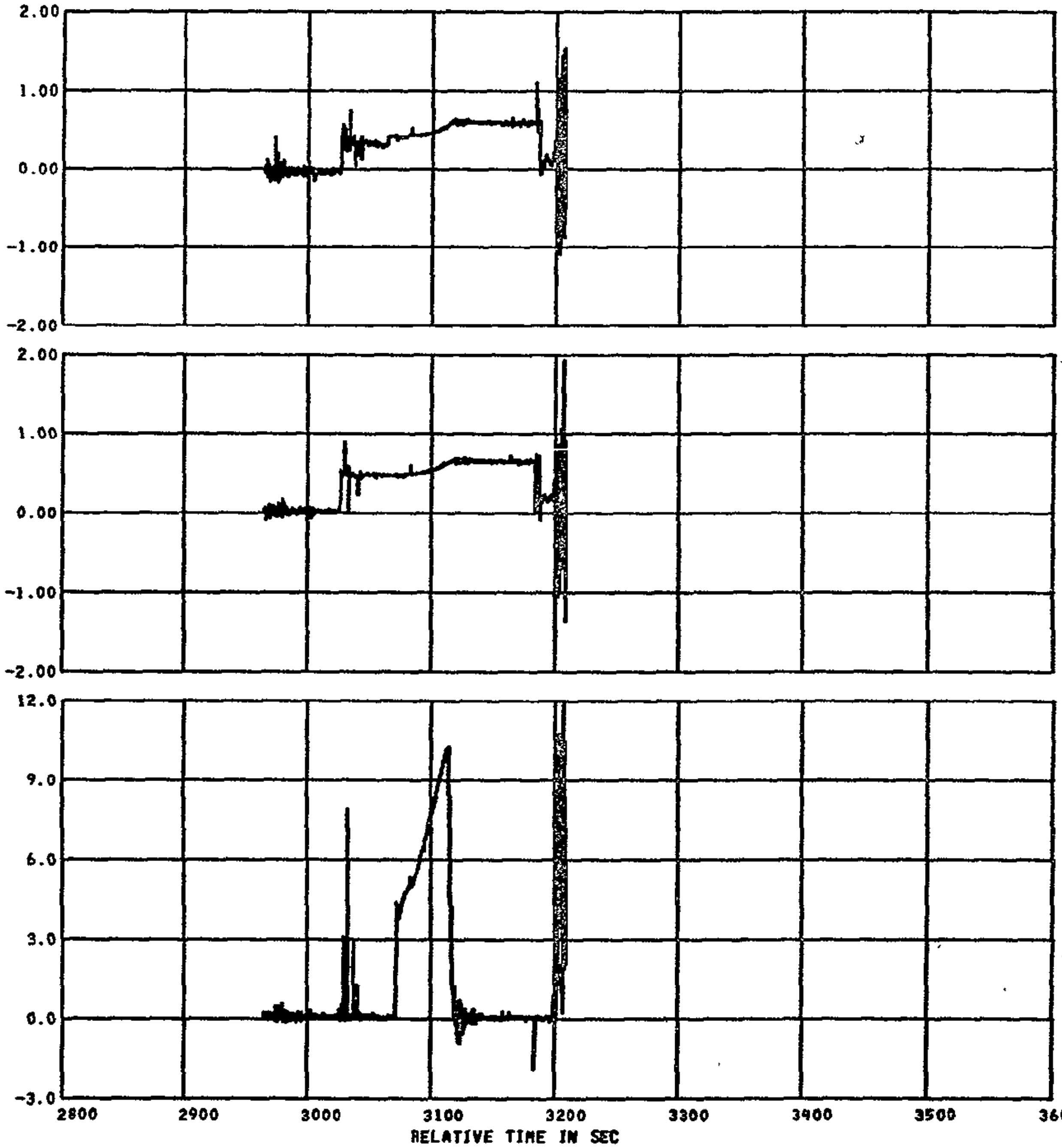
MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-31-14	CF31-14	BATTERY MONITOR VOLTAGE	25.00 TO 32.00	VDC	A

TEST ID 046619 461000 20018 COS-B DRETS PLOT NO 702 -A REFERENCE TIME 01 47 59.795



MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-31-15	CF31-15	PITCH ACCELEROMETER	-2.00 TO 2.00	G	A
FM-31-16	CF31-16	YAW ACCELEROMETER	-2.00 TO 2.00	G	B
FM-31-17	CF31-17	THRUST ACCELEROMETER	-3.0 TO 12.0	G	C

TEST ID 046619 461000 20018 COS-B DRETS PLOT NO 702 -B REFERENCE TIME 01 47 59.795



MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
FM-31-15	CF31-15	PITCH ACCELEROMETER	-2.00 TO 2.00	G	A
FM-31-16	CF31-16	YAW ACCELEROMETER	-2.00 TO 2.00	G	B
FM-31-17	CF31-17	THRUST ACCELEROMETER	-3.0 TO 12.0	G	C

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