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Booster Systems Console Handbook

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STANDARD PROCEDURES

TABLE 1.1.1-II.- PASS TM INPUTS FOR LEFT ENGINE

Parameter no.	Parameter name	Units	MOC-computation MSID
E41M2003P	L-ENGINE STATUS WORD	hex	
E41M2005P	L-HARD FID	binary	
E41P2023B	L-ENGINE CHAMBER PRESSURE (AVERAGE)	psia	
E41R2021B	L-FUEL FLOW RATE	gpm	M02G3103C
E41R2022B	L-OXIDIZER FLOW RATE	gpm	M02G3101C
E41T2010B	L-HPFT TURBINE DISCHARGE TEMP A	°R	
E41T2011B	L-HPFT TURBINE DISCHARGE TEMP B	°R	
E41T2012B	L-HPOT TURBINE DISCHARGE TEMP A	°R	
E41T2013B	L-HPOT TURBINE DISCHARGE TEMP B	°R	
E41P2014B	L-HPOT ISP A	psia	
E41P2015B	L-HPOT ISP B	psia	
E41H2024B	L-MFV VALVE POSITION	percent	
E41H2025B	L-MOV VALVE POSITION	percent	
E41H2026B	L-CCV VALVE POSITION	percent	
E41H2027B	L-FPOV VALVE POSITION	percent	
E41H2028B	L-OPOV VALVE POSITION	percent	
E41W2004B	L-TIME REFERENCE	sec	
E41M2002P	L-IDENTIFICATION WORD 2	hex	
E41P2054B	L-ENGINE HYDRAULIC PRESSURE	psia	
E41P2051B	L-HPOT SECONDARY SEAL CAVITY PRESSURE A	psia	
E41P2053B	L-HPOT SECONDARY SEAL CAVITY PRESSURE B	psia	
E41P2008B	L-HPFP COOLANT LINER PRESSURE A	psia	
E41P2009B	L-HPFP COOLANT LINER PRESSURE B	psia	
E41P2016B	L-ENGINE CHAMBER PRESSURE A	psia	
E41P2017B	L-ENGINE CHAMBER PRESSURE B	psia	
E41T2019B	L-LPFT DISCHARGE TEMP	°R	
E41P2018B	L-LPFT DISCHARGE PRESSURE	psia	
E41P2030B	L-HPOT DISCHARGE PRESSURE	psia	

TABLE 1.1.1-III.- PASS TM INPUTS FOR RIGHT ENGINE

Parameter no.	Parameter name	Units	MOC-computation MSID
E41M3003P	R-ENGINE STATUS WORD	hex	
E41M3005P	R-HARD FID	binary	
E41P3023B	R-ENGINE CHAMBER PRESSURE (AVERAGE)	psia	
E41R3021B	R -FUEL FLOW RATE	gpm	M03G3103C
E41R3022B	R-OXIDIZER FLOW RATE	gpm	M03G3101C
E41T3010B	R-HPFT TURBINE DISCHARGE TEMP A	°R	
E41T3011B	R-HPFT TURBINE DISCHARGE TEMP B	°R	
E41T3012B	R-HPOT TURBINE DISCHARGE TEMP A	°R	
E41T3013B	R-HPOT TURBINE DISCHARGE TEMP B	°R	
E41P3014B	R-HPOT ISP A	psia	
E41P3015B	R-HPOT ISP B	psia	
E41H3024B	R-MFV VALVE POSITION	percent	
E41H3025B	R-MOV VALVE POSITION	percent	
E41H3026B	R-CCV VALVE POSITION	percent	
E41H3027B	R-FPOV VALVE POSITION	percent	
E41H3028B	R-OPOV VALVE POSITION	percent	
E41W3004B	R-TIME REFERENCE	sec	
E41M3002P	R-IDENTIFICATION WORD 2	hex	
E41P3054B	R-ENGINE HYDRAULIC PRESSURE	psia	
E41P3051B	R-HPOT SECONDARY SEAL CAVITY PRESSURE A	psia	
E41P3053B	R-HPOT SECONDARY SEAL CAVITY PRESSURE B	psia	
E41P3008B	R-HPFP COOLANT LINER PRESSURE A	psia	
E41P3009B	R-HPFP COOLANT LINER PRESSURE B	psia	
E41P3016B	R-ENGINE CHAMBER PRESSURE A	psia	
E41P3017B	R-ENGINE CHAMBER PRESSURE B	psia	
E41T3019B	R-LPFT DISCHARGE TEMP	°R	
E41P3018B	R-LPFT DISCHARGE PRESSURE	psia	
E41P3030B	R-HPOT DISCHARGE PRESSURE	psia	

TABLE 1.1.1-IV.- BFS TM INPUTS

Parameter no.	Parameter name	Units
V98M2200P	C-ENGINE STATUS WORD	hex
V98M2100C	C-ENGINE CHAMBER PRESSURE	percent
V98M2220P	L-ENGINE STATUS WORD	hex
V98P2110C	L-ENGINE CHAMBER PRESSURE	percent
V98M2240P	R-ENGINE STATUS WORD	hex
V98P2120C	R-ENGINE CHAMBER PRESSURE	percent

TABLE 1.1.1-V.- THRUST TABLE

Percent thrust	Pc (psia)	Sea level thrust(lb)	Vacuum thrust(lb)
109	3277	408,750	512,300
108	3246	405,000	507,600
107	3216	401,250	502,900
106	3186	397,500	498,200
105	3156	393,750	493,500
104	3126	390,000	488,800
103	3096	386,250	484,100
102	3066	382,500	479,400
101	3036	378,750	474,700
100	3006	375,000	470,000
99	2976	371,250	465,300
98	2946	367,500	460,600
97	2916	363,750	455,900
96	2886	360,000	451,200
95	2856	356,250	446,500
94	2826	352,500	441,800
93	2796	348,750	437,100
92	2766	345,000	432,400
91	2735	341,250	427,700
90	2705	337,500	423,000
89	2675	333,750	418,300
88	2645	330,000	413,600
87	2615	326,250	408,900
86	2585	322,500	404,200
85	2555	318,750	399,500
84	2525	315,000	394,800
83	2495	311,250	390,100
82	2465	307,500	385,400
81	2435	303,750	380,700
80	2405	300,000	376,000
79	2375	296,250	371,300
78	2345	292,500	366,600
77	2315	288,750	361,900
76	2285	285,000	357,200
75	2255	281,250	352,500
74	2224	277,500	347,800
73	2194	273,750	343,100
72	2164	270,000	338,400
71	2134	266,250	333,700
70	2104	262,500	329,000
69	2074	258,750	324,300
68	2044	255,000	319,600
67	2014	251,250	314,900
66	1984	247,500	310,200
65	1954	243,750	305,500

TABLE 1.1.1-VI.- ME VALVES C(L,R)

PHASES VALVES	PURGE SEQ 1	PURGE SEQ 2	PURGE SEQ 3	PURGE SEQ 4	SSME START	SRB IGNITION	MECO	ET SEP	LO2 DUMP	VACUUM INERTING	ON ORBIT	REPRESS		RTLS, TAL DUMPS
OPOV					—	—	—							
FPOV					—	—	—							
MOV					—	—	—		—					—
MFV					—	—	—							
CCV				—	—	—	—							
POGO PRCHG V				-	-		-							
POGO RIV (PAV)	—	—			—	—	—			—	—	—		—
GOX CONTROL V (PAV)				- -		—	-	—	—	—	—	—		—
HE PRECHARGE V (PAV)				-	-		-							
BLV CONTR V			—	- -				—	—					
OBV CONTROL V (PAV)			—	- -				—	—					
OBV (PAV)			—	- -				—	—					
FBV (PAV)			—	- -				—	—					
AFV					—	—	—							
EMER SHDN CONTROL V	—	—	—				-	—	—	—	—	—		
EMER SHDN (PAV)	—	—	—				-	—	—					
PREBURN SHDN PURGE CONTROL V							—							
OXIDIZER PREBURNER PURGE (PAV)							—							
FUEL PREBURNER PURGE (PAV)							—							
PURGE SEQUENCE (PAV)					—	—	—			—	—	—		
HPOT IMD SL PURGE CONTROL V				—	—	—	—							
HPOT IMD SEAL PURGE (PAV)				—	—	—	—							
FU SYS PURGE V		—	-	—										
FUEL SYSTEM PURGE (PAV)		—	-	—										
OXIDIZER DOMES GN_2 PURGE (PAV)	—	—	—											

TITLE

ME ACTIVITY TIMELINE/POSITION REPORTING

PURPOSE

This SCP describes the normal reporting and console operations required at the ME console.

DESCRIPTION

The timeline consists of five tables:

- TABLE 1.1.2-I.- PRELAUNCH TIMELINE - ME
- TABLE 1.1.2-II.- LAUNCH TIMELINE - ME
- TABLE 1.1.2-III.- POST MECO TIMELINE - ME
- TABLE 1.1.2-IV.- RTLS TIMELINE - ME
- TABLE 1.1.2-V.- TAL TIMELINE - ME

The timeline includes starting and updating the universal plots (UP's) and strip charts (SCR), taking history tabs (HT), and taking hardcopies (HC) of the booster ME MSK 1052. Time indicated is based on MET. Times associated with throttling are approximate. Flight specific times are provided by FIDO.

PROCEDURES

TABLE 1.1.2-I.- PRELAUNCH TIMELINE - ME

Time (min:sec)	Reports/operations
To - 20:00	"Purge 3"
To - 4:00	"Purge 4," CCV's open
To - 1:57	"3 engines ready;" start SCR's 622,623,624
To - :31	Auto sequence start
To - :06.6	"Ignition"
To - :01.6	"3 at 100 in mainstage"

TABLE 1.1.2-II.- LAUNCH TIMELINE - ME

Time (min:sec)	Reports/operations
To	Lift-off - start UP's 1821-26, 1830, 1831, HC
__:__	"3 at __" (mission power level)
__:__	"Throttle down"
__:__	"3 at __" (first half thrust bucket) HT, HC
__:__	"Throttle down"
__:__	"3 at __" (second half of thrust bucket) HT, HC
__:__	"Throttle up"
__:__	"3 at __" (mission power level), HT, HC
1:30	HC
2:08	SRB SEP, HT, HC
3:00	Restart UP 1824, 1825, 1826, 1831, HC
__:__	2-engine TAL
3:30	HC; Any suspect engine? (If yes, which engine and why?)
__:__	Negative return, HC, HT
__:__	Press-to-ATO
__:__	Press-to-MECO (normal throttles), HT, HC
__:__	Single-engine TAL
6:00	Restart UP 1824, 1825, 1826, 1831, HT, HC
__:__	Single-engine press, HT, HC
7:30	HC
__:__	"3g throttling all 3," HT, HC

TABLE 1.1.2-II.- Concluded

Time (min:sec)	Reports/operations
8:00	Manual shutdown calls (if req'd), HT, HC
8:28	"Fine count," HC
8:37	"MECO," HT, HC
	"MECO confirmed"

TABLE 1.1.2-III.- POST MECO TIMELINE - ME

Time (min:sec)	Reports/operations
ET Sep	"Three in post shutdown standby," HT, HC
9:00	HC
9:30	HC
10:00	HC
10:37	OMS-1 ignition, (MECO +2:00)
10:40	"LOX dump all three," HT, HC
11:00	HC
11:30	HC
11:55	BDA LOS
15:00	MPS powerdown
18:28	DAK AOS "All three controllers off"

TABLE 1.1.2-IV.- RTLS TIMELINE - ME

Time (min:sec)	Reports/operations
__:__	"C(L,R) engine out" (if required), HT, HC
2:30	RTLS initiate (mm 601), HT, HC "2 eng at __% power level," or "3 eng throttle down __%"
__:__	Powered pitcharound (PPA) "2 eng throttle down __%," or "3 eng throttle up __%" Report subsequent throttle changes and times.
PPA + 1:00	HT, HC
PPA + 1:30	HC
PPA + 2:00	HT, HC
PPA + 2:30	HC
PPA + 3:00	HT, HC
PPA + 3:30	HC
PPA + 4:00	HT, HC
PPA + 4:30	HC
PPA + __:__	Powered pitchdown (PPD) 2 eng - "2 at 91," or 3 eng - "3 at 65"
PPD + 00:20	"MECO", HT, HC
	"MECO confirmed"
MECO + 00:14	ET SEP
MECO + 00:15	"LOX dump - all three" MOV's (3) - open, HT, HC
__:__	V < 3800 ft/s + 2 sec, "LOX dump stop", MOV's (3) - close, HT, HC

TABLE 1.1.2-V.- TAL TIMELINE - ME

Time (min:sec)	Reports/operations
__:__	"C(L,R) engine out", HT, HC
4:05	TAL initiate, HT, HC
	Throttle down, HT, HC 2 eng - No throttle down 3 eng - __%
TBD	"MECO" (VI = 23.8K), HT, HC
	"MECO confirmed"
MECO + 00:18	ET SEP
MECO + 00:35	"LOX dump all three", HT, HC
MECO + 01:02	"LOX dump stop", HT, HC

TITLE

NOMINAL MPS ASCENT OPERATION

PURPOSE

This SCP describes the data used by the Main Propulsion System (MPS) console operator to monitor the nominal MPS operation during ascent.

PROCEDURES

A. The PASS TM downlink parameters used to monitor MPS operation are listed in tables 1.2.1-I and 1.2.1-II. These parameters can be found on MSK's 1054, 1055, 1056, 1057, and 1077 through 1086.

B. The BFS TM downlink parameters used to monitor MPS operation are listed in table 1.2.1-III. These parameters can be found on MSK's 1064, 1065, and 1089.

C. Those nominal MPS bilevel events that are observed and reported by the MPS console positions are detailed in SCP 1.2.3, MPS Activity Timeline/ Position Reporting.

D. Nominal operation of the external tank (ET) pressurization system is monitored using the following ET LO_2 and LH_2 data: ullage pressures and valve positions of the vent and pressurization valves. For off-nominal performance see SCP 2.2.1, ET LH_2 Ullage Pressurization Failures/NPSP Problem. The ET LH_2 ullage pressure, in psig, is used to monitor the possible operation of the ET LH_2 vent and relief valves, reference SCP 3.2.1.

E. The computed fuel net positive suction pressure (NPSP) for each Space Shuttle main engine (SSME) and the average fuel NPSP are monitored to ensure satisfactory SSME fuel pump operation. The expected LH_2 inlet NPSP margin for each SSME is shown in figure 2.2.1-I. Off-nominal NPSP operations are also described in SCP 2.2.1. The engine fuel inlet pressure and temperatures provide a coarse backup for detecting SSME fuel pump inlet problems.

F. The helium supply systems for each SSME and the pneumatic system are monitored to ensure that sufficient helium is available at a satisfactory pressure to perform nominal mission operations. These operations include pneumatic valve actuation during all phases of the mission and the following:

- SSME purge flow during engine starting and firing
- MPS pressurant gas for propellant dumps

- MPS purge flows for the prevention of contamination during reentry

The parameters used for monitoring the helium system include tank pressures, regulator pressures, tank temperatures, valve positions, and computation outputs for rate of depletion, time of depletion, and combined time of depletion. The use of the computation outputs are explained in SCP 3.2.2, SSME Helium Supply Computation. Off-nominal operations during SSME firing and propellant dump are covered in SCP 2.2.4, Helium Leak Isolation/Interconnection.

To determine the total helium mass in the three-engine tanks and the pneumatic tank use SCP 7.2.1, MPS On-Orbit Helium Remaining Computation. This total mass will determine the availability of helium for the entry purge.

G. ET propellant LO_2 and LH_2 5 percent, low level cutoff sensors, and the low level arm command are used to monitor the depletion of the propellants.

H. The LO_2 and LH_2 manifold pressures along with the LO_2 and LH_2 engine inlet pressures are monitored during powered flight and ET separation for possible line overpressurization or SSME inlet underpressurization conditions. These manifold and inlet pressures are also monitored during propellant dumps to help determine satisfactory dumps. During on orbit and entry, the same pressures are observed for indications of proper vacuum inerting and purging.

I. The master events controllers (MEC's) power switches and those events and switch positions associated with SRB and ET separation are monitored to ensure proper separations.

J. Various valve position and event indications are monitored throughout the mission to ensure proper performance of all automatic sequences and manual operations. Table 1.2.1-IV depicts the position of the main propulsion values during the various phases of prelaunch and flight. This information will serve as a reference in determining valve configuration problems. Those items that are observed and reported are listed in SCP 1.2.3, MPS Activity Timeline/Position Reporting.

TABLE 1.2.1-I.- PASS INPUTS FOR ET

Parameter no.	Parameter name	Units
T41P1700C	ET LH2 ULLAGE PRESS NO 1	psia
T41P1701C	ET LH2 ULLAGE PRESS NO 2	psia
T41P1702C	ET LH2 ULLAGE PRESS NO 3	psia
T41P1750C	ET LO2 ULLAGE PRESS NO 1	psia
T41P1751C	ET LO2 ULLAGE PRESS NO 2	psia
T41P1752C	ET LO2 ULLAGE PRESS NO 3	psia
T41X1712E	ET LH2 5 PCT LIQUID LVL SNSR NO 2	event
T41X1724E	ET LH2 VENT VLV NO 1 CLOSED IND	event
T41X1727E	ET LH2 VENT VLV NO 1 OPEN IND	event
T41X1730X	ET LH2 LOW LEVEL LIQ SENSOR NO 1	event
T41X1731X	ET LH2 LOW LEVEL LIQ SENSOR NO 2	event
T41X1732X	ET LH2 LOW LEVEL LIQ SENSOR NO 3	event
T41X1733X	ET LH2 LOW LEVEL LIQ SENSOR NO 4	event
T41X1762E	ET LO2 5 PCT LIQ LEVEL SENSOR NO 2	event
T41X1774E	ET LO2 VENT VLV NO 1 CLOSED IND	event

TABLE 1.2.1-II.- PASS INPUTS FOR ORBITER

Parameter no.	Parameter name	Units
V41P1100C	MPS-ENG NO 1 LH2 INLET PRESS	psia
V41T1101C	MPS-ENG NO 1 LH2 INLET TEMP	degF
V41X1104X	MPS-E-1 LH2 PREVALVE OPEN A	event
V41X1105E	MPS-ENG NO 1 LH2 PREVALVE CLOSED	event
V41P1130C	MPS-ENG NO 1 LOX INLET PRESS	psia
V41X1134X	MPS-ENG NO 1 LOX PREVALVE OPEN	event
V41X1135E	MPS-ENG NO 1 LOX PREVALVE CLOSED	event
V41P1150C	MPS-ENG NO 1 HELIUM SUPPLY PRESS	psia
V41T1151A	MPS-E-1 AFT FUSLG HE SUPPLY TEMP	degF
V41T1152A	MPS-E-1 MID FUSLG HE SUPPLY TEMP	degF
V41P1153A	MPS-E-1 HE REG B OUTLET PRESS	psia
V41P1154A	MPS-E-1 HE REG A OUTLET PRESS	psia
V41X1158E	MPS-E-1 HE ISLN VLV A OPEN PWR ON	event
V41X1159E	MPS-E-1 HE ISLN VLV B OPEN PWR ON	event
V41P1160A	MPS-ENG NO 1 GH2 OUTLET PRESS	psia
V41T1161A	MPS-ENG NO 1 GH2 PRESS OUTLET TEMP	degF
V41X1164E	MPS-E-1 HE INTCON IN/OPEN PWR ON	event
V41X1170E	MPS-E-1 HE INTCON OUT/OPEN PWR ON	event
V41T1171A	MPS-ENG NO 1 GOX PRESS OUTLET TEMP	degF
V41P1200C	MPS-ENG NO 2 LH2 INLET PRESS	psia
V41T1201C	MPS-ENG NO 2 LH2 INLET TEMP	degF
V41X1204X	MPS-E-2 LH2 PREVALVE OPEN A	event
V41X1205E	MPS-ENG NO 2 LH2 PREVALVE CLOSED	event
V41P1230C	MPS-ENG NO 2 LOX INLET PRESS	psia
V41X1234X	MPS-ENG NO 2 LOX PREVALVE OPEN	event
V41X1235E	MPS-ENG NO 2 LOX PREVALVE CLOSED	event
V41P1250C	MPS-ENG NO 2 HELIUM SUPPLY PRESS	psia
V41T1251A	MPS-E-2 AFT FUSLG HE SUPPLY TEMP	degF
V41T1252A	MPS-E-2 MID FUSLG HE SUPPLY TEMP	degF
V41P1253A	MPS-E-2 HE REG B OUTLET PRESS	psia
V41P1254A	MPS-E-2 HE REG A OUTLET PRESS	psia
V41X1258E	MPS-E-2 HE ISLN VLV A OPEN PWR ON	event
V41X1259E	MPS-E-2 HE ISLN VLV B OPEN PWR ON	event
V41P1260A	MPS-ENG NO 2 GH2 OUTLET PRESS	psia
V41T1261A	MPS-ENG NO 2 GH2 PRESS OUTLET TEMP	degF
V41X1264E	MPS-E-2 HE INTCON IN/OPEN PWR ON	event
V41X1270E	MPS-E-2 HE INTCON OUT/OPEN PWR ON	event
V41T1271A	MPS-ENGNO 2 GOX PRESS OUTLET TEMP	degF
V41P1300C	MPS-ENG NO 3 LH2 INLET PRESS	psia
V41T1301C	MPS-ENG NO 3 LH2 INLET TEMP	degF
V41X1304X	MPS-E-3 LH2 PREVALVE OPEN A	event
V41X1305E	MPS-ENG NO 3 LH2 PREVALVE CLOSED	event
V41P1330C	MPS-ENG NO 3 LOX INLET PRESS	psia
V41X1334X	MPS-ENG NO 3 LOX PREVALVE OPEN	event
V41X1335E	MPS-ENG NO 3 LOX PREVALVE CLOSED	event
V41P1350C	MPS-ENG NO 3 HELIUM SUPPLY PRESS	psia

TABLE 1.2.1-II.- Continued

Parameter no.	Parameter name	Units
V41T1351A	MPS-E-3 AFT FUSLG HE SUPPLY TEMP	degF
V41T1352A	MPS-E-3 MID FUSLG HE SUPPLY TEMP	degF
V41P1353A	MPS-E-3 HE REG B OUTLET PRESS	psia
V41P1354A	MPS-E-3 HE REG A OUTLET PRESS	psia
V41X1358E	MPS-E-3 HE ISLN VLV A OPEN PWR ON	event
V41X1359E	MPS-E-3 HE ISLN VLV B OPEN PWR ON	event
V41P1360A	MPS-ENG NO 3 GH2 OUTLET PRESS	psia
V41T1361A	MPS-ENG NO 3 GH2 PRESS OUTLET TEMP	degF
V41X1364E	MPS-E-3 HE INTCON IN/OPEN PWR ON	event
V41X1370E	MPS-E-3 HE INTCON OUT/OPEN PWR ON	event
V41T1371A	MPS-ENG NO 3 GOX PRESS OUTLET TEMP	degF
V41X1389X	MPS-LH2 OUTBD FILL VLV CLOSED	event
V41X1410X	MPS-LH2 INBOARD FILL VLV CLOSED	event
V41X1429X	MPS-LH2 FEED DISC VLV OPEN	event
V41X1430X	MPS-LH2 FEED DISC VLV CLOSED A	event
V41P1433C	MPS-LH2 ENG MANIFOLD PRESSURE	psia
V41X1434X	MPS-LH2 FEED DISC VLV CLOSED B	event
V41X1436E	MPS-LH2 MANF REPRESS 1 OPEN PWR ON	event
V41X1438E	MPS-LH2 MANF REPRESS 2 OPEN PWR ON	event
V41X1441E	MPS-LH2 FEEDLINE RELIEF SOV OPEN	event
V41X1456X	MPS-LH2 TOPPING VLV CLOSED	event
V41S1477E	MPS-LH2 TK PRESS HI FLOW	event
V41P1490A	MPS-GH2 DISCONNECT PRESSURE	psia
V41X1492E	MPS-GH2 PRESS LINE VENT OP PWR ON	event
V41X1509X	MPS-LOX INBD FILL VLV CLOSED	event
V41X1514X	MPS-LOX OUTBD FILL VLV CLOSED	event
V41X1529X	MPS-LOX FEED DISC VLV OPEN	event
V41X1530X	MPS-LO2 FEED DISC VLV CLOSED A	event
V41P1533C	MPS-LOX ENGINE MANIFOLD PRESSURE	psia
V41X1534X	MPS-LO2 FEED DISC VLV CLOSED B	event
V41X1555X	LO2 LEFT NO 1 ECO SENSOR	event
V41X1556X	LO2 LEFT NO 2 ECO SENSOR	event
V41X1557X	LO2 RIGHT NO 2 ECO SENSOR	event
V41X1558X	LO2 RIGHT NO 1 ECO SENSOR	event
V41X1538E	MPS-LOX MANF REPRESS 1 OPEN PWR ON	event
V41X1539E	MPS-LOX MANF REPRESS 2 OPEN PWR ON	event
V41X1541E	MPS-LOX FEEDLINE RELIEF SOV OPEN	event
V41X1580X	MPS-LO2 OVERBOARD B/V CLOSED A	event
V41P1590A	MPS-GOX DISCONNECT PRESSURE	psia
V41X1596E	MPS-GO2 PRESS SOV 1 CLOSE PWR ON	event
V41X1598E	MPS-GO2 PRESS SOV 2 CLOSE PWR ON	event
V41P1600A	MPS-PNEUMATIC VLV HE SUPPLY PRESS	psia
V41T1601A	MPS-PNEUMATIC VLV HE SUPPLY TEMP	degF
V41X1603E	MPS-GO2 PRESS SOV 3 CLOSE PWR ON	event
V41P1605A	MPS-PNEU VLV HE RGLTR OUTLET PRESS	psia
V41X1614E	MPS-PNEU CROSSOVER 2 OPEN PWR ON	event

TABLE 1.2.1-II.- Concluded

Parameter no.	Parameter name	Units
V41X1645E	MPS-PNEU HE ISLN VLV 1 OPEN PWR ON	event
V41X1646E	MPS-PNEU HE ISLN VLV 2 OPEN PWR ON	event
V41X1661E	MPS-GH2 PRESS SOV 1 CLOSE PWR ON	event
V41X1662E	MPS-GH2 PRESS SOV 2 CLOSE PWR ON	event
V41X1663E	MPS-GH2 PRESS SOV 3 CLOSE PWR ON	event
V41X1811X	MPS LO2 ACCUM RECIRC VLV 1 OPEN	event
V41X1821X	MPS LO2 ACCUM RECIRC VLV 2 OPEN	event
V41X1901E	MPS LH2 RTLS MANF REPRESS 1 PWR ON	event
V41X1902E	MPS LH2 RTLS MANF REPRESS 2 PWR ON	event
V41X1919X	MPS LH2 RTLS OTBD D/V CLOSE	event
V41X1929X	MPS LH2 RTLS INBD D/V CLOSE	event
V72X4526X	SYSTEM MANAGEMENT ALERT A CMD 1	event
V72X4533X	BU C&W CMD - FF4	event
V73X1567E	C/W MASTER ALARM TLM OUTPUT	event
V90W1941C	TIME TO GO TO VELOCITY CUTOFF	sec
V90X1942X	ET LEVEL SENSOR ARM CMD	event
V90U1948C	COMMANDED SSME THROTTLE SETTING	percent
V90W1970C	PREDICTED SSME C/O TIME IN MET	sec
V90X8250X	ET SEPARATION CMD FLAG	event
V90X8259X	ET AUTO SEP INHIBIT CREW ALERT	event
V90X8331X	SRB SEPARATION COMMAND FLAG	event
V90X8340X	SRB AUTO SEP INHIBIT CREW ALERT	event
V76S4601E	MEC PWR 1	event
V76S4605E	MEC PWR 2	event
V90X7570X	SRB SEP AUTO ENAB	event
V90X7554X	ET SET AUTO ENAB	event
V90X8333X	SRB SEP INIT	event
V90X8561X	MECO CONFIRMED	event
V90X8340X	SRB SEP INHIB	event
V90X8259X	ET SEP INHIB	event
V90X7571X	SRB SEP MAN ENAB	event
V90X7556X	ET SEP MAN ENAB	event
V90X7572X	SRB SEP INIT CMD	event
V90X7564X	ET SEP INIT CMD	event
V90X8331X	SRB SEP CMD	event
V90X8250X	ET SEP CMD	event

TABLE 1.2.1-III.- BFS INPUTS FOR ORBITER

Parameter no.	Parameter name	Units
V98P2140C	LH2 ULLAGE PRESS	psia
V98P2155C	C HELIUM SUPPLY PRESSURE	psia
V98P2156C	L HELIUM SUPPLY PRESSURE	psia
V98P2157C	R HELIUM SUPPLY PRESSURE	psia
V98P4997C	SSME HE TK PRESS 1 CHG RATE	lb/3 sec
V98P4998C	SSME HE TK PRESS 2 CHG RATE	lb/3 sec
V98P4999C	SSME HE TK PRESS 3 CHG RATE	lb/3 sec
V98X3532X	SRB SEP INIT	event
V98X3546X	MECO CONFIRMED	event
V98X0744X	SRB SEP ARM CMD	event
V98X0752X	ET ORB SEP ARM	event
V98X0742X	SRB SEP MNVA ENAB	event
V98X0748X	ET SEP MAN ENAB	event
V98X0743X	SRB SEP INIT CMD	event
V98X0752X	ET SEP INIT CMD	event
V98X3534X	SRB SEP CMD	event
V98X3550X	ET SEP CMD	event

TABLE 1.2.1-IV.- MPS VALVES

VALVES ▽ / PHASES ▷	PURGE SEQ 1	PURGE SEQ 2	PURGE SEQ 3	PURGE SEQ 4	SSME START	SRB IGNITION	MECO	ET SEP	LO_2 DUMP	LH_2 DUMP	VACUUM INERTING	ON ORBIT	REPRESS	RTLS DUMP
MPS LO_2 SYSTEM VALVES														
LO_2 ET/ORB FEEDLINE DISCONNECT VLV	—	—	—	—	—	—	—							
LO_2 POGO ACCUM RECIRC VLV NO. 1					—	—	—	—	—	—	—	—	—	—
LO_2 POGO ACCUM RECIRC VLV NO. 2					—	—	—	—	—	—	—	—	—	—
L LO_2 PREVALVE			—	—	—	—	—		—	—	—	—		—
C LO_2 PREVALVE			—	—	—	—	—		—	—	—	—		—
R LO_2 PREVALVE			—	—	—	—	—		—	—	—	—		—
LO_2 INBD FILL/DRAIN	—	—	—								×—	×—	—	—
LO_2 OUTBD FILL/DRAIN	—	—	—	—							×—	×		—
LO_2 OVBD BLEED VLV	—	—	—	—							—	—	—	—
LO_2 FEEDLINE RELIEF ISOLATION VLV								—	—	—	—	—	—	—
LO_2 MANIF REPRESS VLV NO. 1									—				—	
LO_2 MANIF REPRESS VLV NO. 2									—				—	
MPS LH_2 SYSTEM VALVES														
LH_2 ET/ORB FEEDLINE DISCONNECT VLV	—	—	—	—	—	—	—							
LH_2 RTLS INBD DUMP VLV								—						—
LH_2 RTLS OUTBD DUMP VLV								—						—
LH_2 ET/ORB RECIRC DISCONNECT VLV	—	—	—	—	—	—	—							
L LH_2 PREVALVE					—	—	—			—	—	—	—	—
C LH_2 PREVALVE					—	—	—			—	—	—	—	—
R LH_2 PREVALVE					—	—	—			—	—	—	—	—
LH_2 TOPPING VLV			—	—						—	×—	×	—	
LH_2 INBD FILL/DRAIN VLV	—	—	—							—	×—	×—	—	
LH_2 OUTBD FILL/DRAIN VLV	—	—	—	—						—	×—	×		
LH_2 FEEDLNE RELIEF SHUTOFF VLV								—	—	—	—	—	—	—
LH_2 FEED MANIF RTLS REPRESS VLV NO. 1														—
LH_2 FEED MANIF RTLS REPRESS VLV NO. 2														—
LH_2 MANIF REPRESS VLV NO. 1										—			—	
LH_2 MANIF REPRESS VLV NO. 2										—			—	
MPS HIGH POINT BLEED VLV			—	—							×—	×		
LH_2 RECIRC VLV			—	—										
L LH_2 RECIRC PUMP VLV			—	—										
C LH_2 RECIRC PUMP VLV			—	—										
R LH_2 RECIRC PUMP VLV			—	—										
GH_2 PRESS LINE VENT VLV											××			

× = MANUAL SWITCH THROW

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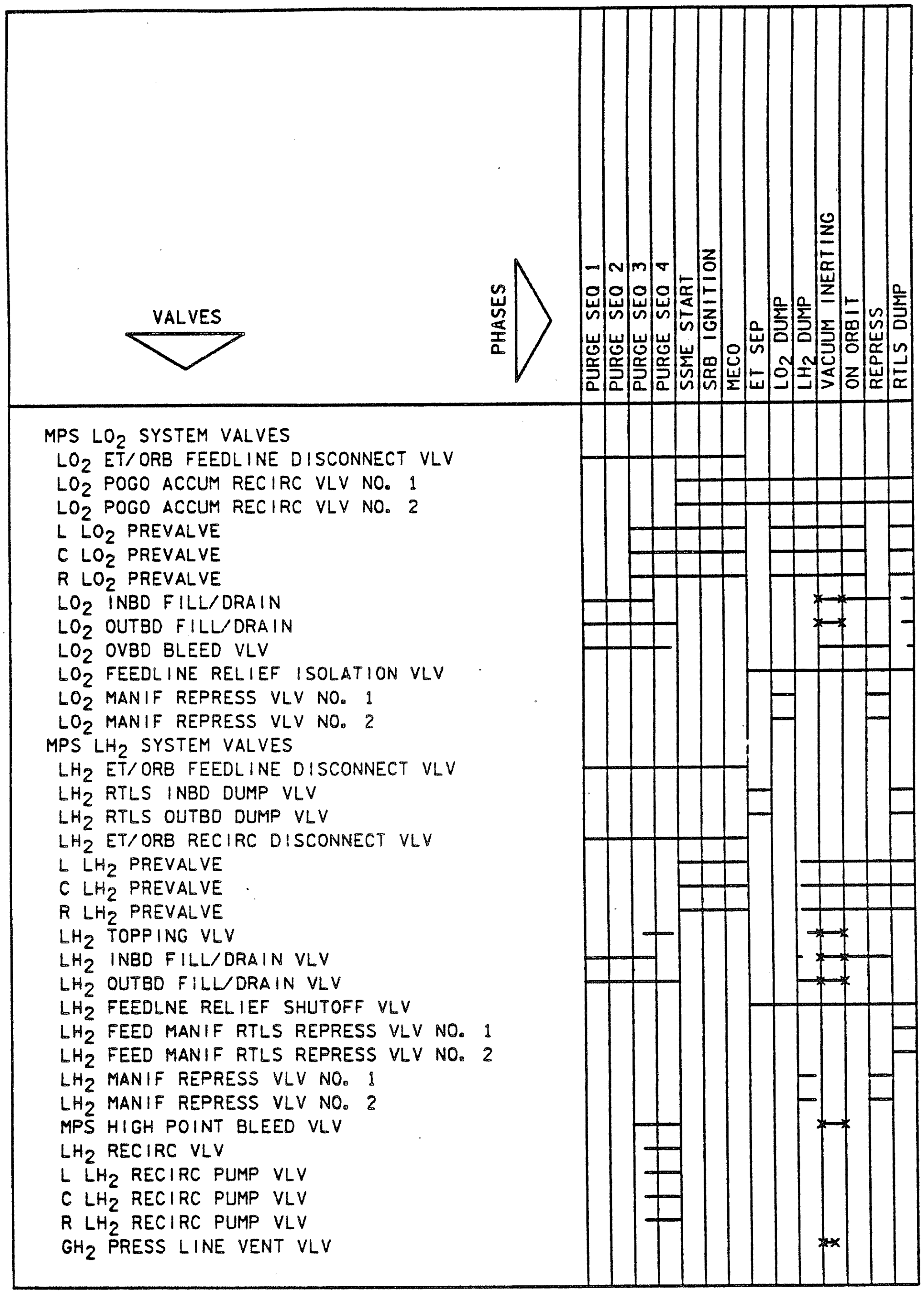
TABLE 1.2.1-III.- BFS INPUTS FOR ORBITER

Parameter no.	Parameter name	Units
V98P2140C	LH2 ULLAGE PRESS	psia
V98P2155C	C HELIUM SUPPLY PRESSURE	psia
V98P2156C	L HELIUM SUPPLY PRESSURE	psia
V98P2157C	R HELIUM SUPPLY PRESSURE	psia
V98P4997C	SSME HE TK PRESS 1 CHG RATE	lb/3 sec
V98P4998C	SSME HE TK PRESS 2 CHG RATE	lb/3 sec
V98P4999C	SSME HE TK PRESS 3 CHG RATE	lb/3 sec
V98X3532X	SRB SEP INIT	event
V98X3546X	MECO CONFIRMED	event
V98X0744X	SRB SEP ARM CMD	event
V98X0752X	ET ORB SEP ARM	event
V98X0742X	SRB SEP MNVA ENAB	event
V98X0748X	ET SEP MAN ENAB	event
V98X0743X	SRB SEP INIT CMD	event
V98X0752X	ET SEP INIT CMD	event
V98X3534X	SRB SEP CMD	event
V98X3550X	ET SEP CMD	event

TABLE 1.2.1-IV.- MPS VALVES



× = MANUAL SWITCH THROW

0426.ART, 10

TITLE

NOMINAL SRB OPERATIONS

PURPOSE

This SCP describes the MPS console operator's procedure for monitoring SRB operations.

PROCEDURES

A. The TM downlink parameters required for this procedure are listed in table 1.2.2-1.

B. Prior to launch, the propellant mean bulk temperature (PMBT), as reported by KSC SRB engineering, is noted in the console log along with the initial fuel supply module (FSM) pressure displayed on MSK 1054.

C. A representative graph of chamber pressure (Pc) versus MET for a value of PMBT = 70° F is plotted in figure 1.2.2-I. The corresponding values of vacuum thrust are plotted in figure 1.2.2-II. The predicted Pc and thrust profiles are subject to change and will be provided by MSFC before each flight. Parameters listed in sections I and II of table 1.2.2-I are displayed on MSK's 1054, 1083, and 1084 and limit sensed on the event light panels. The selected mid-value Pc for the left and right SRB's are displayed on the BFS display (MSK's 1064, 1089, and 1090). PC1, PC2, and PC3 for the left and right SRB's are plotted on strip chart recorders and UP 2773.

D. The SRB separation sequence begins at a mission elapsed time (MET) of 1:40. SRB separation sequence continues when two out of three Pc values on both SRB's are less than 50 psia. Both SRB's should reach 50 psia within 5.5 seconds (I-load-V97U9761C, max SRB SEP cue differential) of each other. If not, a delay is incurred until the I-loaded backup cue (V97U9751C) is reached. For flight 61-C, this value was 129.8 seconds. When any Pc on the left or right SRB reaches 50 psia, the corresponding event light is illuminated on the MPS event panel. If an MDM fails, it is commfaulted and the two remaining Pc's are averaged and used in the separation sequence. If two MDM's are commfaulted, the remaining Pc is used in the sequence. If two Pc's fail high or prematurely low (< 50 psia), the crew should be advised that SRB separation will be delayed (reference SCP 2.2.7 for the malfunction procedure). When SRB separation is commanded the SRB SEP CMD light is illuminated on the ME and MPS console event light panels. If SRB separation is inhibited due to excessive vehicle rates or dynamic pressure, the SRB SEP INH light will be illuminated on the event light panels and auto SEP is inhibited. The SRB's separate automatically if the vehicle rates and dynamic pressure return to the proper limits or if the crew initiates a manual separation by placing the SRB SEPARATION switch to MAN/AUTO and pushing the SEP pushbutton. The SRB SEP event lights on the event light panels are listed in area III and IV of table 1.2.2-I. See SRB Separation Sequence in the Booster Systems Software Handbook for more information.

E. FSM A and B pressures, as well as hydraulic supply's A and B pressures, are displayed on MSK's 1054, 1083, 1084, and 1087 and are limit sensed on the MPS event light panel. The nominal pressure decay rate for the FSM pressure is plotted in figure 1.2.2-III. Nominal hydraulic supply pressure will be maintained at 3200 ±50 psig. In case the hydraulic pressure drops below 2050 psig ±150 psig, the appropriate SRB switching valve automatically switches to the secondary position. The L TILT PRI P, L ROCK PRI P, R TILT PRI P, and R ROCK PRI P event lights on the MPS event light panel come on and provide a second cue that the left or right tilt or rock hydraulic power unit (HPU) has been isolated, and the actuator has been switched to operate on the remaining HPU. In this case, both the tilt and the rock actuators operate on the remaining HPU. HPU A supplies the rock actuator and HPU B supplies the tilt actuator. See figure 1.2.2-IV for rock and tilt axes orientation.

The FSM pressure normally decays from 375 psig at HPU startup to above 260 psig at SRB separation. The pressure should not decay below 80 psig or proper hydraulic pressure will not be maintained and switchover to the secondary HPU will occur. A switch back to the primary supply will occur if the primary supply pressure increases above 2600 psig or anytime the primary pressure is 700 psi below the secondary pressure. The flight director should be told if an HPU has been lost and if both SRB actuators are operating off the remaining HPU.

F. Upper and lower limits for all event light panels are listed in SCP 5.2.4.

G. SRB monitoring in BFS is limited to the left and right SRB mid-value Pc's. The SRB SEP sequence is the same as the PASS except for the absence of the 5.5 sec time compare limit for the decay of the mid-value Pc's below 50 psia (reference SCP 2.2.7 for the malfunction procedure).

REFERENCES

1. STS Operational Flight Rules, All Flights, Baseline, JSC-12820, September 1, 1987.

2. Solid Rocket Booster Thrust Vector Control Subsystem Description, NASA TM-82546, September 1983.

3. Booster Console Handbook, Final, Rev-C, JSC-17239, April 10, 1987.

4. Shuttle Operational Data Book, JSC-08934, October 1984.

5. DF65 Data Book.

6. Booster Systems Software Handbook, JSC-19395, Basic/Rev-3 (Prel), December 1, 1987.

TABLE 1.2.2-I.- SRB PERFORMANCE PARAMETERS

Type	MML	Parameter name	Normal operating range	Units	Remarks
I	B46P1305C	L FSM A P	135 - 400	psia	Hyd. press. will not be maintained if FSM press. < 80 psig.
	B46P1306C	L FSM B P	135 - 400	psia	
	B58P1303C	L HYD SUP A P	3000 - 3250	psig	
	B58P1304C	L HYD SUP B P	3000 - 3250	psig	
	B58X1859X	L TILT ACTR PRI P OK	primary	NA	PASS discrete
	B58X1860X	L ROCK ACTR PRI P OK	primary	NA	PASS discrete
	B47P1300C	L SRB Pc 1	0 - 950	psia	SEP SEQ starts at 50 psia
	B47P1301C	L SRB Pc 2	0 - 950	psia	SEP SEQ starts at 50 psia
	B47P1302C	L SRB Pc 3	0 - 950	psia	SEP SEQ starts at 50 psia
	V98P1740C	L SRB Pc	0 - 950	psia	selected Pc
	B46R1408C	L HPU A TURB SPD	0 - 85	krpm	
	B46R1409C	L HPU B TURB SPD	0 - 85	krpm	
II	B46P2305C	R FSM A P	135 - 400	psia	
	B46P2306C	R FSM B P	135 - 400	psia	
	B58P2303C	R HYD SUP A P	3000 - 3250	psig	
	B58P2304C	R HYD SUP B P	3000 - 3250	psig	
	B58X2859X	R TILT ACTR PRI P OK	primary	NA	PASS discrete
	B58X2860X	R ROCK ACTR PRI P OK	primary	NA	PASS discrete
	B47P2300C	R SRB Pc 1	0 - 950	psia	SEP SEQ starts at 50 psia
	B47P2301	R SRB Pc 2	0 - 950	psia	SEP SEQ starts at 50 psia
	B47P2302	R SRB Pc 3	0 - 950	psia	SEP SEQ starts at 50 psia
	V98P1741C	R SRB Pc	0 - 950	psia	selected Pc
	B46R2408C	R HPU A TURB SPD	0 - 85	krpm	
	B46R2409C	R HPU B TURB SPD	0 - 85	krpm	
III	V90X7570X	SRB SEP AUTO ENAB		NA	PASS discretes
	V90X7571X	SRB SEP MAN ENAB			
	V90X7572X	SRB SEP INIT CMD			
	V90X8331X	SRB SEP CMD			
	V90X8333X	SRB SEP INIT			
	V90X8340X	SRB SEP INHIB			

TABLE 1.2.2-I.- Concluded

Type	MML	Parameter name	Normal operating range	Units	Remarks
IV	V98X0742X V98X0743X V98X0744X V98X3532X V98X3534X	SRB SEP MNAU ENAB SRB SEP INIT CMD SRB SEP ARM CMD SRB SEP INIT SRB SEP CMD		NA	BFS discretes

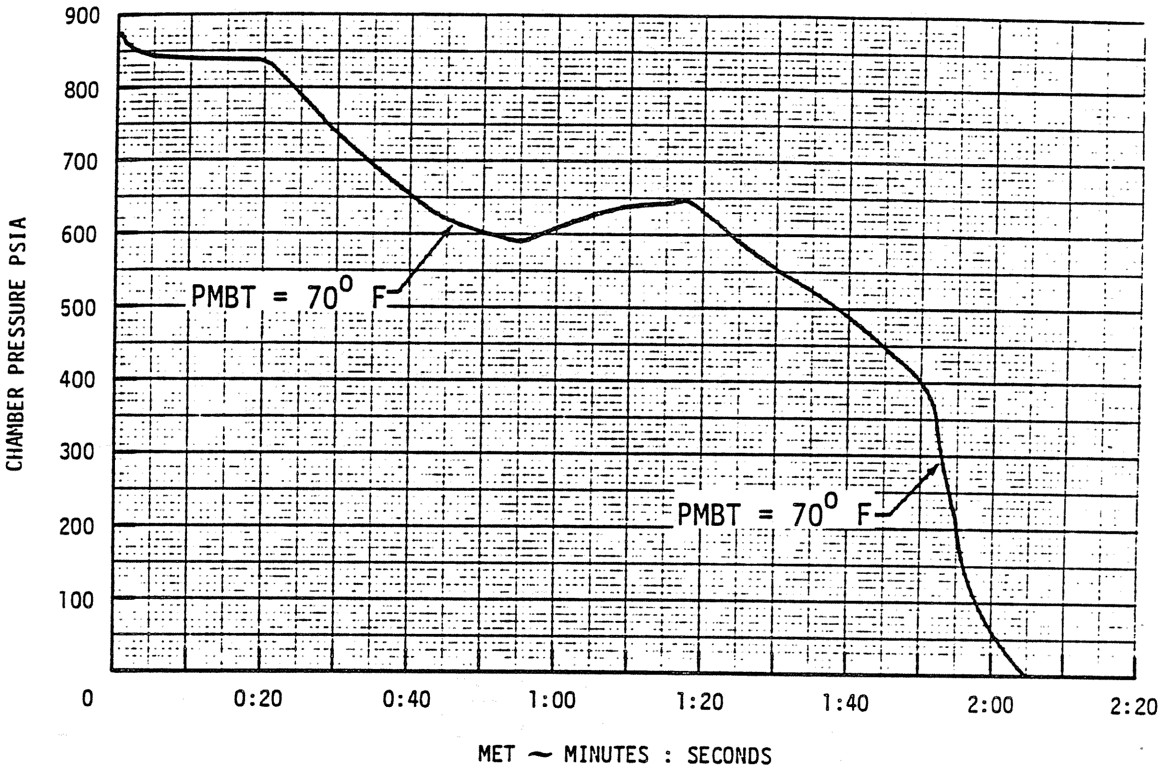


Figure 1.2.2-I.- Chamber pressure versus MET.

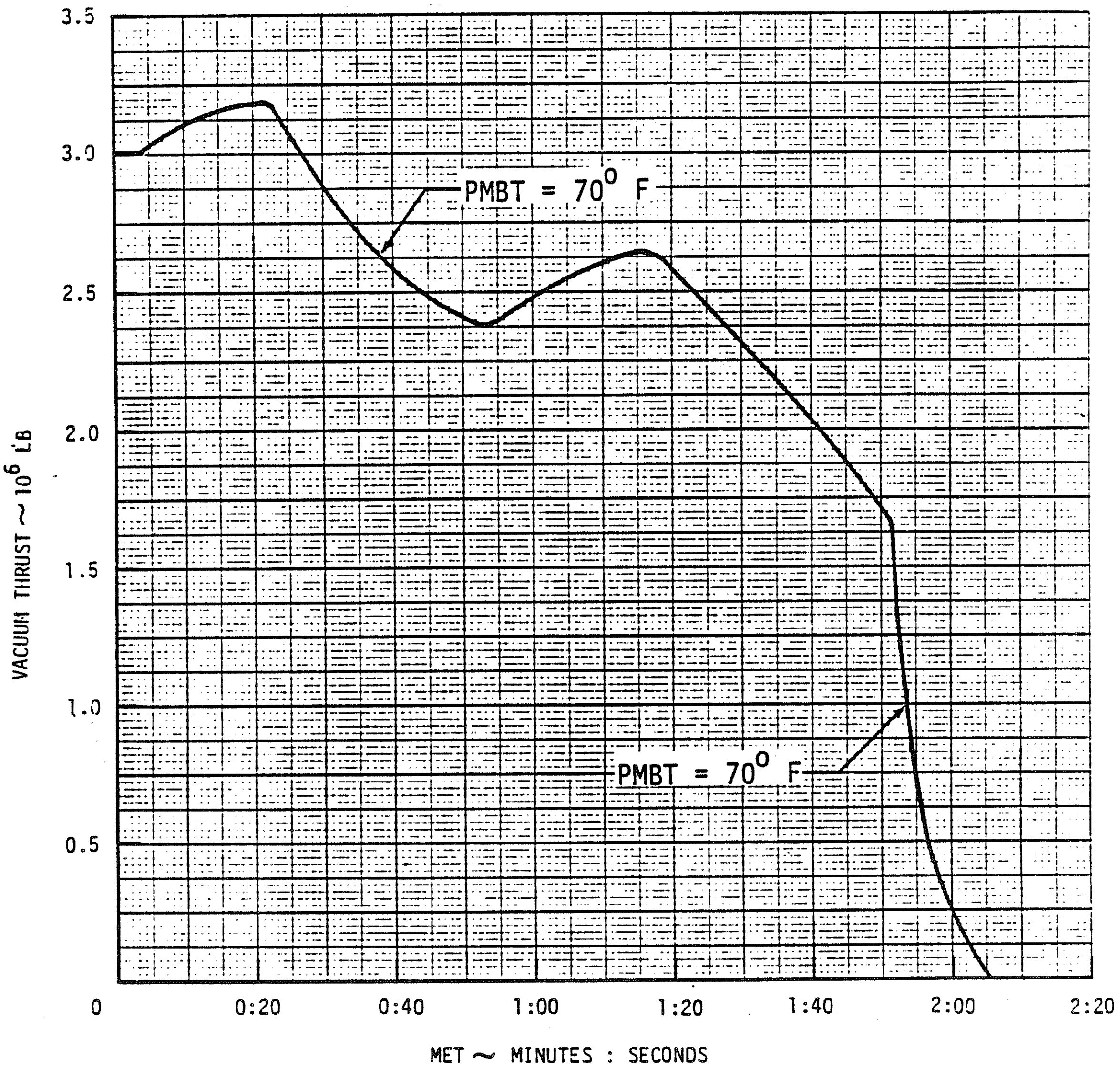


Figure 1.2.2-II.- Vacuum thrust versus MET.

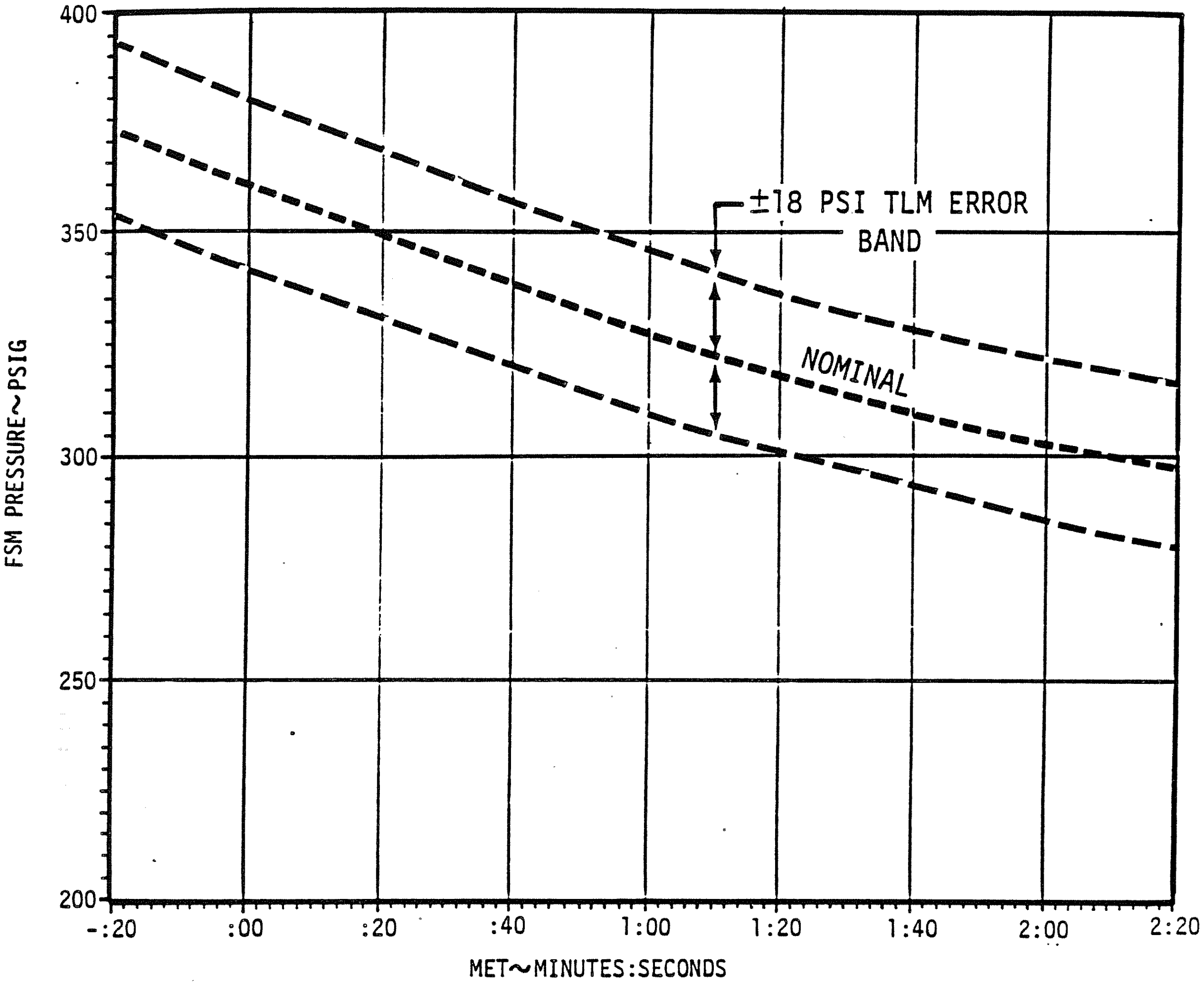


Figure 1.2.2-III.- Fuel supply module pressure versus MET.

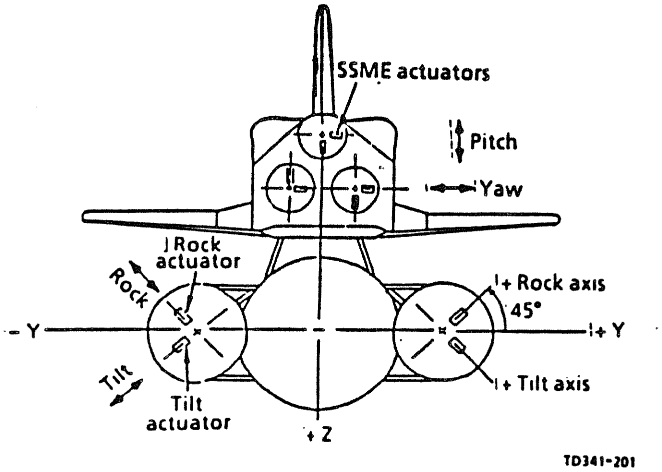


Figure 1.2.2-IV.- SRB actuator orientation.

TITLE

MPS ACTIVITY TIMELINE/POSITION REPORTING

PURPOSE

This SCP contains the timelines for MPS activity that occurs from prelaunch to rollout for nominal, RTLS, and TAL flights. MPS voice reports to the Booster position are shown in quotation marks.

DESCRIPTION

The timeline consists of six tables:

- TABLE 1.2.3-I.- PRELAUNCH TIMELINE - MPS (T_0-9 minutes to T_0)
- TABLE 1.2.3-II.- LAUNCH TIMELINE - MPS (T_0 through MPS dump)
- TABLE 1.2.3-III.- POST-MECO TIMELINE - MPS (covers first vacuum inerting)
- TABLE 1.2.3-IV.- ENTRY TIMELINE - MPS (on-orbit preparation for entry through rollout)
- TABLE 1.2.3-V.- RTLS TIMELINE - MPS (from RTLS call through rollout)
- TABLE 1.2.3-VI.- TAL INTEGRATED TIMELINE - MPS (from MECO through rollout)

The timelines include starting and updating the universal plots (UP), taking history tabs (HT), and taking hardcopies (HC) of the booster MPS MSK 1054 and 1055. Verify proper strip chart formats and start/stop times with the PROP MPSR.

PROCEDURES

TABLE 1.2.3-I.- PRELAUNCH TIMELINE - MPS

Time	Reports/operations
min:sec	
T_0 - 5:00	Left and Right SRB ignitors to Arm Position.
T_0 - 04:55	"LOX drainback started."* Verify LO_2 inboard fill/drain valve closed. Start drainback timer. Terminate LO_2 replenish @ T-6:40 if controlling with 100.15% sensor
T_0 - 02:55	"LOX vent closed"
T_0 - 02:20	"LO_2 tank pressurized." LO_2 manifold pressure reading ≈ 108 psia
T_0 - 02:00	HC MSK 1056
T_0 - 01:57	"LH_2 vent valve closed. LH_2 tank pressurized." Verify LH_2 topping valve closed and LH_2 manifold pressure receding ≃45 psia
T_0 - 00:48	"Outboard fill and drain valves closed"
T_0 - 00:28	"SRB hydraulics up," switchover valves in primary
T_0 - 00:12.5	"POGO valves open"
T_0 - 00:09.5	"Fuel prevalves open"
T_0 - 00:09.4	"Overboard bleed valve closed"
T_0 - 00:06.6	SSME ignition
T_0	"SRB ignition." HC MSK 1054 and 1055. On the SMEK panel EXECUTE - LAUNCH, and STOP HELIUM COMP. Start UP's 2767, 2768, 2769, 2770, 2771, 2772, 2773, 2774, and 2775.

*LO_2 drainback is not modeled in sims

TABLE 1.2.3-II.- LAUNCH TIMELINE - MPS

Time	Reports/operations
min:sec	
T_o	-
02:00	"Pc's less than 50." SRB sep initiate. HC MSK 1054 and MSK 2773
02:09	"SRB separation." On the SMEK panel EXECUTE - SRB SEP.
≃ 07:54	"LOX @ 5%"
≃ 08:02	"Fuel @ 5%"
≃ 08:20	"Arm command"
MECO	L, C, and R He interconnect in/open.* PNEU crossover open. Verify LO_2 and LH_2 feedline relief isolation valves open. "Relief ISO's open"
MECO + 1s	LO_2 prevalves closed
MECO + 6s	"Prevalves closed." Verify LH_2 prevalves closed. LH_2 recirculation disconnect valve closed
MECO + 7s	"Disconnects closed." HC MSK 1054, 1055
MECO + 10s	"RTLS dump valves open"
MECO + 18s	"ET SEP" On the SMEK panel EXECUTE - ET SEP, ON ORBIT HT, HC MSK 1054, and MSK 2773.

*Interconnect will occur only if tank pressure is less than 2000 psi.

TABLE 1.2.3-II - Concluded

Time Auto/Man	Reports/operations
T_o	-
MECO + 20s	L, C, and R He interconnect out/open
09:00	Report LO_2 and LH_2 manifold pressures. HC MSK 1054, 1055, 2767, 2768, 2769. Restart MSK 2774 and 2775
MECO + 90s	"RTLS dump valves closed"
Dump Start	LO_2 manifold repress 1 and 2 open LH_2 manifold repress 1 and 2 open LH_2 inboard and outboard fill and drain valves open LO_2 prevalves open SSME MOV's open
Dump +6s	LH_2 inboard fill and drain valve closed LH_2 topping valve open LH_2 prevalves open
Dump + 1:28/ 1:28	Verify LH_2 manifold repress 1 and 2 closed
Dump + 1:30/ 2:00	Verify LO_2 manifold repress 1 and 2 closed
Dump + 2:01/ 2:21	"Dump stop" LH_2 outboard fill and drain valve closed LH_2 topping valve closed. SSME MOV's closed HC MSK 1054, 1055 Compute He mass onboard
Dump + 2:11/ 2:31	L, C, and R He interconnect out/open close. PNEU crossover valve close

TABLE 1.2.3-III.- POST-MECO TIMELINE - MPS

Time (Approx)	Reports/operations
min:sec	
Vacuum Inert - 1m	MPS powerdown
Vacuum Inert Start	"Vacuum inert start." L, C, and R He isolation valves A and B closed H_2 press line vent valve open LO_2 and LH_2 inboard and outboard fill and drain valves open LH_2 topping valve open
Vacuum Inert + 1m	H_2 press line vent valve closed
TIG - 5m	"Vacuum inert stop" LO_2 and LH_2 outboard fill and drain valves closed LH_2 topping valve closed
TIG - 4:50	PNEU isolation valves closed

TABLE 1.2.3-IV.- ENTRY TIMELINE - MPS

Time (hr:min)	Reports/operations
TIG-1:38	Caution and warning reset Inhibit LO_2 and LH_2 manifold pressure (channels 69, 79) Reset all He REG A's low limit to 60 (channels 39, 49, 59)
TIG-0:30	HC MSK 1057 Compute He mass onboard Advise BSE of He mass
TIG-0:25	MPS reconfiguration Verify He Iso A L,C,R open, He Iso B L,C,R closed, Pneu He Iso closed, LO_2 and LH_2 outboard fill/drains closed
MM 304	Verify pneu crossover valve open, LH_2 RTLS dump valves open, LH_2 topping valve open, LH_2 inboard fill/drain powered open, L He interconnect in/open, C,R He interconnect out/open
Ground relative velocity < 4.5 kft/s	LO_2 prevalves closed. "Dump stop, repress initiated." Verify LO_2 and LH_2 manifold repress open, LH_2 RTLS dump valves closed, and He blowdown valves open. Start He blowdown timer
Ground relative velocity < 4.5 kft/s + 10:50	"He blowdown valves closed"
APU/HYD shutdown	Verify LO_2 and LH_2 outboard fill drains back to ground. "Switch configuration looks good"

TABLE 1.2.3-V.- RTLS TIMELINE - MPS

Time	Reports/operations
min:sec	
From MECO 00:00	L, C, and R He interconnect in/open* PNEU crossover valve open "Relief ISO's open"
00:01	LO_2 prevalves closed
00:06	"Prevalves closed." Verify LH_2 prevalves closed LH_2 recirculation disconnect valve closed
00:07	"Disconnects closed" HC MSK 1054
00:10	"RTLS dump valves open"
00:14	"ET SEP" On the SMEK panel EXECUTE - ET SEP
00:20	L, C, and R He interconnect out/close
MM602 ($\approx$00:25)	"Dump start" L, C, and R He interconnect out/open PNEU crossover valve open LH_2 RTLS manifold repress 1 and 2 open LO_2 and LH_2 prevalves open
$Q = 20$ lb/ft^2	"LO_2 fill and drain valves open"
MM602 + 80s ($\approx$01:45)	"LH_2 fill and drain valves open." Verify LH_2 topping valve open and LH_2 RTLS manifold repress 1 and 2 close
Ground relative velocity < 4500 ft/s	"He blowdown valves open." Start timer
Ground relative velocity < 3800 ft/s	"Repress initiated" LO_2 and LH_2 outboard fill and drain valves closed LO_2 prevalves closed LO_2 and LH_2 manifolds opened LO_2 overboard bleed closed LH_2 RTLS dump valves closed

*Interconnect will occur only if tank pressure is less than 2000 psi.

TABLE 1.2.3-V.- Concluded

Time	Reports/operations
Ground relative velocity < 3800 ft/s + 2s	"Dump stop" MOV's closed
Ground relative velocity < 4500 ft/s + 10:50	"He blowdown valves closed." Stop timer L, C and R He interconnect valves closed Pneu crossover valve closed

TABLE 1.2.3-VI.- TAL INTEGRATED TIMELINE - MPS

Time	Reports/operations
min:sec	
(From MECO) 00:00	L, C, and R He interconnect in/open* PNEU crossover valve open "Relief ISO's open"
00:01.16	LO_2 prevalves closed
00:06.06	"Prevalves closed." Verify LH_2 prevalves closed. LH_2 recirculation disconnect valve closed
00:07.14	"Disconnects closed" HC MSK 1054
00:10.14	"RTLS dump valves open"
00:16	SSME bleed valves open
00:18	"ET SEP" On the SMEK panel EXECUTE - ET SEP
00:20	L, C, and R He interconnect in/close L, C, and R He interconnect out/open
00:90	"RTLS dump valves closed"

*Interconnect will occur only if tank pressure is less than 2000 psi.

TABLE 1.2.3-VI.- Continued

Time	Reports/operations
min:sec	
MM304	"Dump start" L He interconnect in/open C and R He interconnect out/open L PNEU crossover open LH_2 fill and drain valves open LH_2 topping valve open LH_2 RTLS valves open SSME MOV's open
Ground relative velocity < 20000 ft/s	LO_2 fill and drain valves open
Ground relative velocity < 4500	"He blowdown valves open" LO_2 prevalves closed LO_2/LH_2 OUTBOARD fill and drain valves closed LH_2 RTLS dump valve closed LO_2 manifold repress 1 and 2 open LH_2 manifold repress 1 and 2 open Report He purge and He tank pressures
Ground relative velocity < 4500 + 10 min 50 sec	"He blowdown valves closed" Report He tank pressures He interconnect closed L Pneu crossover closed

TITLE

ON-ORBIT AND ENTRY MPS OPERATIONS

PURPOSE

This SCP describes the main propulsion system (MPS) and the Mechanical sections (MMAC's) console operators' procedures and responsibilities for monitoring the MPS during on-orbit and entry phases.

PROCEDURES

MPS OPERATOR RESPONSIBILITIES

A. Console Configuration

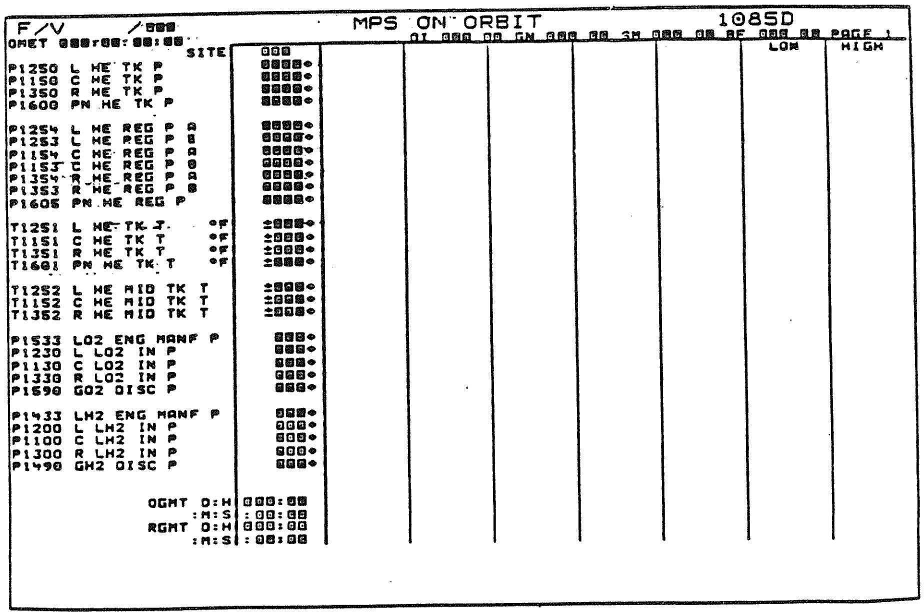
Following the MPS Vacuum Inert procedure, the MPS console will be configured for the on-orbit phase of the mission as follows:

1. Transmit the on-orbit limits to the MOC via the MED terminal or the MASSCOMP. This procedure includes a V31 menu to disable the low limits for the MPS helium regulators and LH_2/LO_2 manifold pressures. The on-orbit limits are given in table 1.2.4-I.
2. Select MSK 1085, MPS On-Orbit (fig. 1.2.4-I), to monitor MPS manifold and helium system pressures. On-orbit limits are to the far right on the display to allow operator verification.
3. Configure the DDD's with the on-orbit formats, 292 and 291, on the BSE, panels 1 and 2 respectively, and MPS, panels 1 and 2 respectively, consoles. MSK's 0071, 0075, and 0083 are used for verification for the FCR-1 BSE, MPS, and FCR-2 BSE, respectively.

Proper configuration of the limits and DDD's should result in only the three LO2 prevalve open DDD's being illuminated. If any other DDD light is illuminated during the on-orbit phase, an out-of-limits situation exists. This should be recorded in the log, and the booster should be notified. Once action is taken to correct the out-of-limits parameter, v31 menu may be required to extinguish the DDD light. This also will be noted in the flight log. Reference SCP 6.3 for MED terminal operation procedures, for how to disable a parameter.

TABLE 1.2.4-I.- BOOSTER ON-ORBIT LIMITS

MML no.	Parameter	Low	High
V41P1250C	L HE TANK PRESS, PSIA	2000	4500
V41P1150C	C HE TANK PRESS, PSIA	2000	4500
V41P1350C	R HE TANK PRESS, PSIA	2000	4500
V41P1600A	PN HE TANK PRESS, PSIA	2000	4500
V41P1254C	L HE REG PRESS, PSIA	0.00	800
V41P1154C	C HE REG PRESS, PSIA	0.00	800
V41P1354C	R HE REG PRESS, PSIA	0.00	800
V41P1605A	PN HE REG PRESS, PSIA	0.00	800
V41T1251A	L HE TANK TEMP, °F	-50	200
V41T1151A	C HE TANK TEMP, °F	-50	200
V41T1351A	R HE TANK TEMP, °F	-50	200
V41T1601A	PN HE TANK TEMP, °F	-50	200
V41P1533C	LO2 ENG MANF PRESS, PSIA	-1	40
V41P1230C	L LO2 INLET PRESS, PSIA	-1	20
V41P1130C	C LO2 INLET PRESS, PSIA	-1	20
V41P1330C	R LO2 INLET PRESS, PSIA	-1	20
V41P1590C	GO2 DISC PRESS, PSIA	0.00	25
V41P1433C	LH2 ENG MANF PRESS, PSIA	-1	45
V41P1200C	L LH2 INLET PRESS, PSIA	-1	30
V41P1100C	C LH2 INLET PRESS, PSIA	-1	30
V41P1300C	R LH2 INLET PRESS, PSIA	-1	30
V41P1490A	GH2 DISC PRESS, PSIA	0.00	25
V41T1252A	L HE MID TANK TEMP, °F	-50	200
V41T1152A	C HE MID TANK TEMP, °F	-50	200
V41T1352A	R HE MID TANK TEMP, °F	-50	200



```
F/V      /■■■              MPS  ON  ORBIT                 1085D
OMET ■■■/■■:■■:■■            01 ■■■ ■■ GN ■■■ ■■ 3M ■■■ ■■ BF ■■■ ■■ PAGE 1
                       SITE  ■■■                                 LOW   HIGH
P1250 L HE TK P               ■■■■◆
P1150 C HE TK P               ■■■■◆
P1350 R HE TK P               ■■■■◆
P1600 PN HE TK P              ■■■■◆

P1254 L HE REG P A            ■■■■◆
P1253 L HE REG P B            ■■■■◆
P1154 C HE REG P A            ■■■■◆
P1153 C HE REG P B            ■■■■◆
P1354 R HE REG P A            ■■■■◆
P1353 R HE REG P B            ■■■■◆
P1605 PN HE REG P             ■■■■◆

T1251 L HE TK T          °F   ±■■■◆
T1151 C HE TK T          °F   ±■■■◆
T1351 R HE TK T          °F   ±■■■◆
T1601 PN HE TK T         °F   ±■■■◆

T1252 L HE MID TK T           ±■■■◆
T1152 C HE MID TK T           ±■■■◆
T1352 R HE MID TK T           ±■■■◆

P1533 LO2 ENG MANF P           ■■■◆
P1230 L LO2 IN P               ■■■◆
P1130 C LO2 IN P               ■■■◆
P1330 R LO2 IN P               ■■■◆
P1590 GO2 DISC P               ■■■◆

P1433 LH2 ENG MANF P           ■■■◆
P1200 L LH2 IN P               ■■■◆
P1100 C LH2 IN P               ■■■◆
P1300 R LH2 IN P               ■■■◆
P1490 GH2 DISC P               ■■■◆

              OGMT D:H  ■■■:■■
                   :M:S  :■■:■■
              RGMT D:H  ■■■:■■
                   :M:S  :■■:■■
```

Figure 1.2.4-I.- MPS ON-ORBIT display.

B. Configuration Verification

MSK's 1053, 1054, and 1055 are used to verify the correct valve configuration. After termination of the Vacuum Inert procedure, the valves should be in the positions listed below:

VALVE	SW/POS
LO_2/LH_2 Prevalves (6)	GPC/OPEN
Rlf Isol (2)	GPC/OPEN
IB F/D (2)	GND/OPEN
Manf Press (2)	GPC/CLOSE
OB F/D (2)	GND/CLOSE
H_2 Press Ln Vt	GND/CLOSE *
LH_2 Topping	---/CLOSE**
LH_2 High Pe Bleed	---/CLOSE**
MPS Helium Isol (7)	GPC/CLOSE
Helium Xover	GPC/CLOSE
He Interconnect (3)	GPC/CLOSE

* Valve position is located on MSK 1053 only.
** Valve controlled by LH_2 IB F/D.

C. On-Orbit Operations

On a daily basis, the BSE or MPS operator will report to console to perform 1 and 2, below, and to remain cognizant of any failures that will impact the MPS entry procedures. A hard copy of MSK 1085 will be made for the flight log to use for daily comparisons. Prior to leaving console after ascent, the Booster On-Orbit Handover sheet, figure 1.2.4-II, is completed with one copy given to the MMAC operator and another filed in the flight log.

1. Helium Mass Tracking

Once the console is configured for orbit operations, the mass of MPS helium remaining is calculated on the MASSCOMP computer (ref. SCP 7.2.1). This calculation is used to monitor the health of the system and to determine if adequate helium, 74 lb_m, exists to perform entry functions. Nominally the mass remaining is in excess of 110 lb_m. These results are recorded in the flight log.

Note: Under zero-g conditions, the helium tank temperatures might vary from the actual gas temperatures; therefore, the calculated mass may vary from the previous calculations.

BOOSTER ON-ORBIT HANDOVER

FLIGHT ________

VEHICLE ________

	NAME	HOME PHONE #	BEEPER #
BOOSTER (PRIME CONTACT)			
MPS OPERATOR (2ND CONTACT)			
SECTION HEAD	TOM KWIATKOWSKI	486-8290	

HELIUM SYSTEM (MET) ________

	PRESSURE (PSI)	AFT HE TK TEMP (°F)	MID HE TK TEMP (°F)
LEFT ENGINE (#2)			
CENTER ENGINE (#1)			
RIGHT ENGINE (#3)			
PNEUMATIC SYSTEM			

MANIFOLD PRESSURE (MET) ________

	PREDICTED MANIFOLD PRESSURE (PSI)	MANIFOLD PRESSURE (PSI)	INLET PRESSURE (PSI)		
			LEFT (#2)	CENTER (#1)	RIGHT (#3)
LO2					
LH2					

ANOMALIES AFFECTING THIS MISSION: ________

Figure 1.2.4-II.- Booster on-orbit handover sheet.

2. Manifold Pressure Monitoring

The MPS LO_2 and LH_2 manifold pressures will be monitored to determine if a second vacuum inert is required, reference figure 1.2.4-III. This decision is based on transducer history and previous reading under noncryogenic conditions (prior to ET loading or previous flight). If a second vacuum inert is required, it will be coordinated with engineering support in the mission evaluation room (MER); however, if the LO_2 or LH_2 manifold pressure exceeds 249 or 60 psia, respectively, the crew will vacuum inert both MPS manifolds, reference the crew procedure, figure 1.2.4-IV. The above values are the caution and warning (C&W), upper limits to alert the crew to a manifold overpressure condition. In the event of a manifold pressure transducer failure, the inlet pressure readings (3) will be monitored, these are ground only measurements. On orbit the manifold pressures are the only MPS parameters monitored by the C&W system. One or both parameters can be disabled, if required, due to a transducer failing high. The procedure is described in section 4 of the FDF Reference Data book.

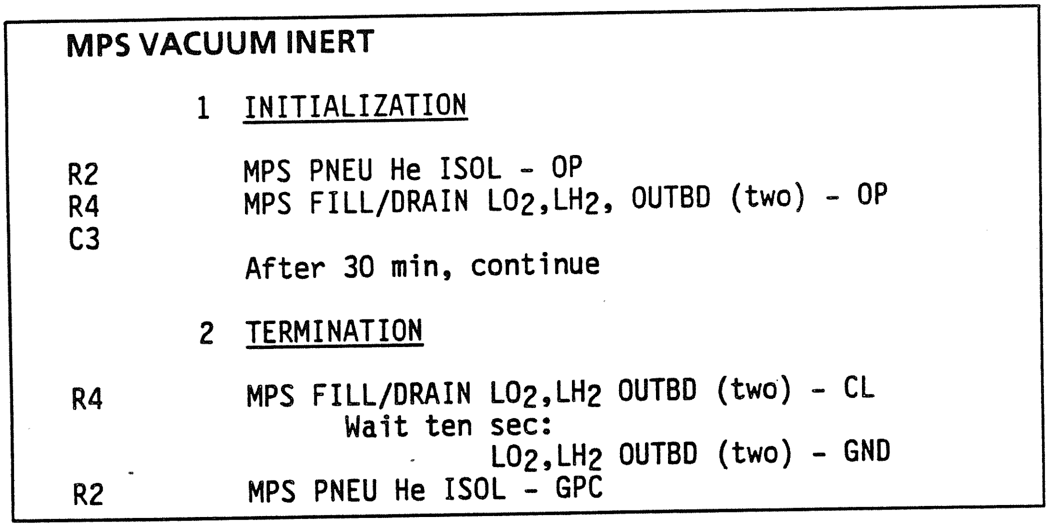
3. MPS Monitoring Handover Procedures And Responsibilities

Following on-orbit configuration of the BSE and MPS consoles, the MPS monitoring will be handed over to the MMAC's section for the orbit phase of the mission. The handover sheet will be used by the MMAC operator to look for changes in the MPS manifolds and helium system pressures. Manifold pressure increase and helium system pressure decreases are important conditions to monitor. MSK 1054 or 1085 can be used to monitor the parameters.

Handover will occur with the MPS in a stable configuration. The helium system will be isolated, such that if a leak occurs, there is no immediate action that can be taken. Deltas to the entry procedure may have to be worked to allow for adequate entry purging and manifold pressurizing. The MPS manifolds should have little if any propellant following the initial MPS vacuum inerting. If an actual increase in pressure is detected, the manifolds will vacuum inerted to avoid venting propellant during entry. As mentioned earlier, the manifold transducers are expected to drift in a noncryogenic environment.

The following list of figures is contained in the handover package.

1. Figure 1.2.4-II.- Booster on-orbit handover sheet.
2. Figure 1.2.4-III.- MPS vacuum inert procedure from the FDF, orbit operations checklist.
3. Figure 1.2.4-IV.- MPS C&W procedure from the FDF, orbit pocket checklist.
4. Figure 1.2.4-V.- Avionic failures affection the MPS system.
5. Figure 1.2.4-VI.- MPS helium supply system.
6. Figure 1.2.4-VII.- MPS propellant flow.



MPS VACUUM INERT

1 INITIALIZATION

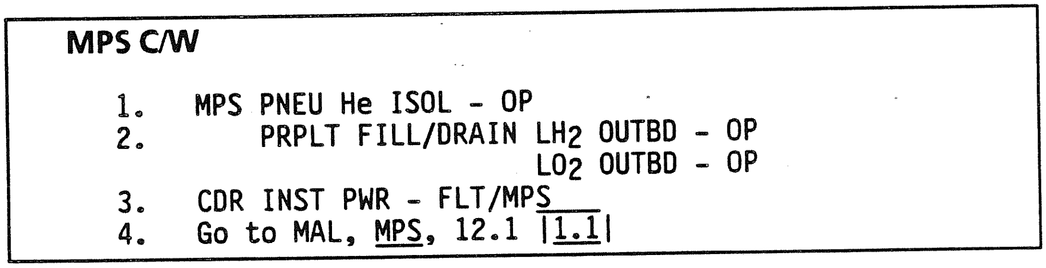
R2 MPS PNEU He ISOL - OP
R4 MPS FILL/DRAIN LO_2,LH_2, OUTBD (two) - OP
C3

After 30 min, continue

2 TERMINATION

R4 MPS FILL/DRAIN LO_2,LH_2 OUTBD (two) - CL
Wait ten sec:
LO_2,LH_2 OUTBD (two) - GND
R2 MPS PNEU He ISOL - GPC

Figure 1.2.4-III.- MPS vacuum inert procedure of orbit OPS checklist.



MPS C/W

1. MPS PNEU He ISOL - OP
2. PRPLT FILL/DRAIN LH_2 OUTBD - OP
   LO_2 OUTBD - OP
3. CDR INST PWR - FLT/MPS
4. Go to MAL, MPS, 12.1 |1.1|

Figure 1.2.4-IV.- MPS C&W procedure of orbit pocket checklist.

D. Deorbit Operations (Nominal).

At 1:38 (hour:minutes) prior to the deorbit burn, TIG -1:38, the MPS C&W is configured to monitor the MPS helium leg A regulators, only. At TIG -25 minutes, the MPS LO_2 and LH_2 outboard fill and drain and the helium isolation valves will be reconfigured. The fill and drain valves are configured to inhibit the entry dump, which is not required for a nominal entry. The switches (3) for the MPS helium A isolation valves will be positioned to the open position, and the B isolation (3) and pneumatic switches will be positioned to the close position. This action ensures that only the A regulators with C&W monitoring are opened. Illumination of the MPS C/W light will result in the crew closing all of the MPS helium isolation valves.

The MPS console operator should monitor valve operation during the procedures and should notify the BSE of any anomalies. Malfunction procedures associated with off-nominal entry purge and manifold repressurization are provided in detail in SCP 2.2.9.

VACUUM INERT - PNEU ISO VLVS (R2) - OUTBOARD FILL + DRAINS (R4)

COMPONENT	BUS			D.BUS			MNA FA				MNB FA				MNC FA				CONTROL BUS								
	A	B	C	AB	AC	BC	1	2	3	4	1	2	3	4	1	2	3	4	AB1	AB2	AB3	B4	BC2	BC3	CA1	CA2	CA3
PNEU ISO 1	●			●	●		●	●	●	●	G				G						M						
2		●		●		●				G	●	●	●	●				G						M			
LO2 OB F/D			●		●	●				G				G	●	●	●	●							M		
LH2 OB F/D		●		●		●		G			●	●	●	●		●						M					

ENTRY - LEFT HE ISO B (R2) - PNEU HE ISO (R2) - C + RT ME OUT/OPEN (R2)
L ME IN/OPEN (R2) - XOVER (R2) - LO2 AND LH2 OB FILL/DRAIN (R4)
TOPPING (LH2 IB R4) - RTLS DUMP VLVS (R2) - BLOWDOWN VLVS -
MANF REPRESS (R4) - L,C,R LO2 PREVALVE (R4)

COMPONENT	FA MDMS										BUSES			D. BUS			MNA FA				MNB FA				MNC FA				CONTROL BUS								
	1	2	3	4	12	13	14	23	24	34	A	B	C	AB	AC	BC	1	2	3	4	1	2	3	4	1	2	3	4	AB1	AB2	AB3	BC1	BC2	BC3	CA1	CA2	CA3
L ISO B							G								●					G					G												
PNEU ISO 1	G				G	G	G				●			●	●		●	●	●	●	G				G						M						
2				G			G		G	G		●		●		●				G	●	●	●	●				G						M			
C OUT/OP	G				G	G	G				●			●	●		●	●	●	●	G				G					M							
R OUT/OP				G			G		G	G			●		●	●				G				G	●	●	●	●							M		
L IN/OP								G								●							G			G											
XOVER		G			G			G	G				●		●	●		G				G			●	●	●	●								M	
LO2 OB F/D				G			G		G	G			●		●	●				G				G	●	●	●	●							M		
LH2 OB F/D		G			G			G	G			●		●		●		G			●	●	●	●		G						M					
TOPPING	G				G	G	G				●			●	●		●	●	●	●	G				G						M						
RTLS OB						●	●			●					●				●						●			●									
IB						●	●			●					●			●							●			●									
BLOWDN 1*			●			●		●		●	●			●	●		●	●	●	●			●				●										
2*				●			●		●	●	●			●	●		●	●	●	●				●				●									
MANF REP																																					
LO2 1			G			G		G		G			●		●	●			G				G		●	●	●	●							M		
2				G			G		G	G			●		●	●				G				G	●	●	●	●								M	
LH2 1	G				G	G	G					●		●		●	G				●	●	●	●	G								M				
2		G			G			G	G			●		●		●		G			●	●	●	●		G								M			
LO2 PV L					Go	Go	Go	Go	Go	Go						●						Go	Go	Go	Go	Go	Go										
C					Go	Go	Go	Go	Go	Go				●			Go	Go		Go	Go	Go	Go														
R					Go	Go	Go	Go	Go	Go					●		Go	Go		Go					Go		Go	Go									

* Software command only - No cockpit switch

Legend - ● - Total control loss
G - GPC control lost
Go - GPC control to open valve lost
M - Manual control of valve lost

Figure 1.2.4-V.- Avionic failures affecting the MPS system.

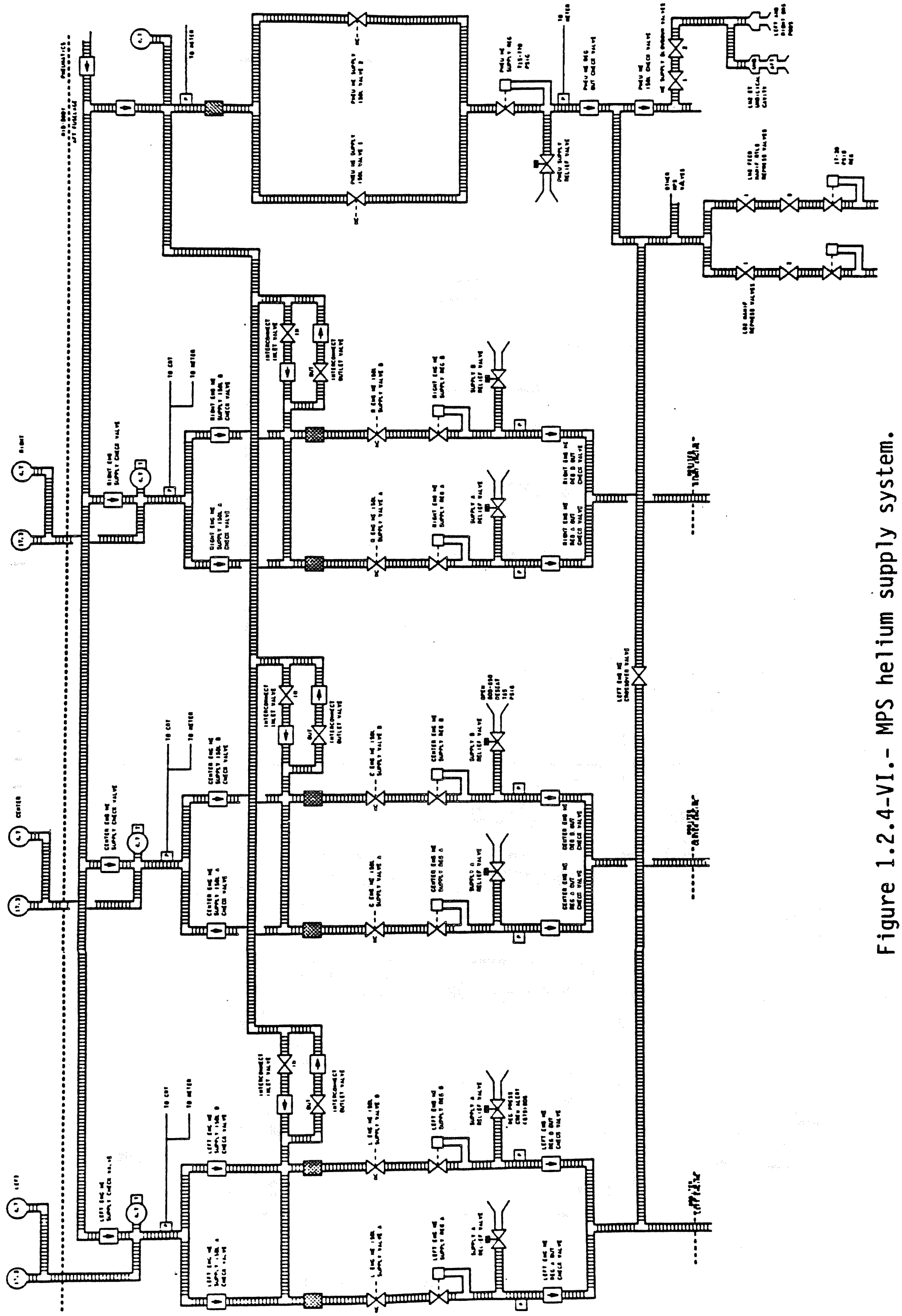


Figure 1.2.4-VI.- MPS helium supply system.

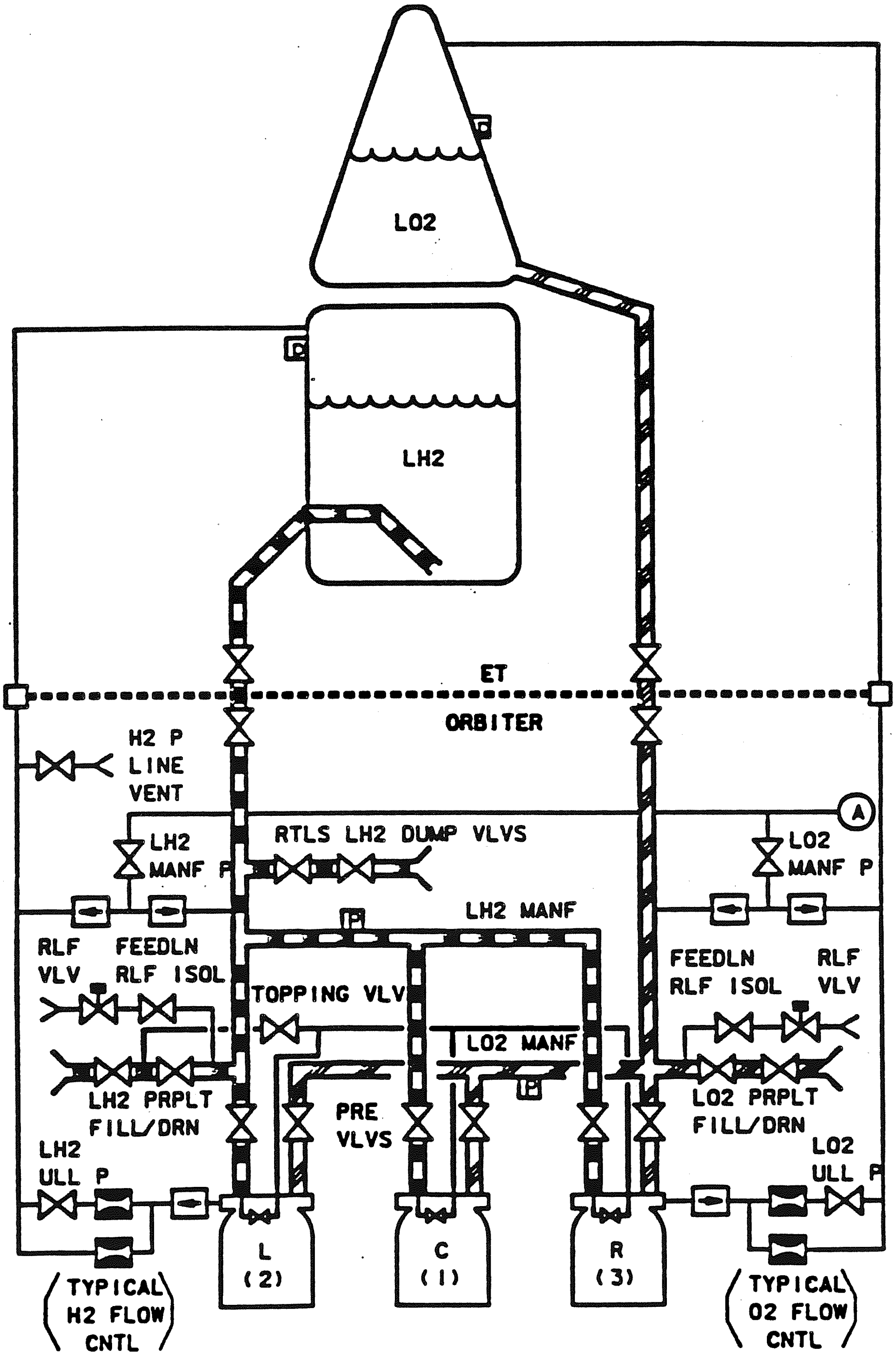


Figure 1.2.4-VII.- MPS propellant flow.

REFERENCES

1. Flight Data File Post Insertion
2. Flight Data File Orbit Operations Checklist
3. Flight Data File Deorbit Prep
4. Flight Data File Contingency Deorbit Prep
5. Flight Data File Reference Data
6. Flight Data File Orbit Pocket Checklist
7. STS Operational Flight Rules, All Flights, Baseline, JSC-12820, September 1, 1987

TITLE

BOOSTER CONSOLE ACTIVITY TIMELINE/POSITION REPORTING

PURPOSE

The purpose of this SCP is to describe the reporting and console operation required at the Booster MOCR console.

DESCRIPTION

The timeline consists of six tables:

- TABLE 1.3.1-I.- PRELAUNCH INTEGRATED TIMELINE-BOOSTER
- TABLE 1.3.1-II.- LAUNCH INTEGRATED TIMELINE-BOOSTER
- TABLE 1.3.1-III.- POST-MECO INTEGRATED TIMELINE-BOOSTER
- TABLE 1.3.1-IV.- RTLS INTEGRATED TIMELINE-BOOSTER
- TABLE 1.3.1-V.- TAL INTEGRATED TIMELINE-BOOSTER
- TABLE 1.3.1-VI.- ENTRY INTEGRATED TIMELINE-BOOSTER

Each timeline is an integrated timeline of the MPS and ME SSR position reports to the Booster, and the reports made by the Booster to the flight director. All voice communications are in quotation marks.

TABLE 1.3.1-I.- PRELAUNCH INTEGRATED TIMELINE-BOOSTER

Time T_0 ±	Reports/operations		
	Booster	ME	MPS
min:sec			
-20:00	Transition to MM101	"Engine data displayed Engines in purge seq 3"	
- 9:00	GLS start		
- 5:00	APU start		
- 4:55	"LO$_2$ drainback started"		"LO$_2$ inbd F/D-cl. Start LO2 drain-back. ET LO$_2$ vent valve-cl"
- 4:00		"Purge 4" CCV open	
- 2:55	"LO$_2$ tank pressurized"		"ET LO$_2$ tank pressurizing"
- 1:57	"LH$_2$ tank pressurized"	Monitor engine start conditions	"LH2 vent-cl and tank pressurizing. Topping valve- cl"
- 1:30	"3 engines ready"	"3 engines ready"	
- 0:48			"LO$_2$ and LH$_2$ outbd F/D-cl"
- 0:28		Auto seq start	"SRB hyd up"
- 0:12.5			"POGO vlv's - op"
- 0:09.5			"LH$_2$ pv's-op"
- 0:08			"LO$_2$ ovbd bleed-cl"
- 0:06.6		"Ignition"	
- 0:01.6		"3 at 100 in main stage"	

TABLE 1.3.1.-II.- LAUNCH INTEGRATED TIMELINE-BOOSTER

Time T_0 ±	Reports/operations		
	Booster	ME	MPS
min:sec + 0			"SRB ignition"
+ ____		"3 at ___" (mission power level)	
+ 0:30	FD status		Monitor He usage
+ ____	"Throttle down to __%"	"Throttle down to ___%"	
+ ____		"3 at ___" (thrust bucket)	
+ 0:52	"Throttle up -__%" (mission power level)	"Throttle up"	
+ 0:56	FD status	"3 at ___" (mission power level)	
+ 2:00			"SRB P_C's <50"
+ 2:09	"SRB SEP"		"SRB SEP cmd"
+ 2:30		Nominal or low first stage performance (FIDO) Performance limiting update (if req'd) Suspect engine status	
+ ____		2-eng TAL (FIDO)	
+ 3:00	FD status		
+ ____		Neg return (FIDO)	
+ ____		Press-to-ATO (FIDO)	
+ ____		Press-to-MECO Normal throttles (FIDO)	

TABLE 1.3.1-II.- Concluded

Time T_0 ±	Reports/operations		
	Booster	ME	MPS
min:sec			
+ ____		Single-eng TAL (FIDO)	
+ ____		Single-eng TAL RV (FIDO)	
+ 7:40	"3g throttling" all 3"	"3g throttling - all 3"	
+ 7.54			"LO_2 at 5%"
+ 8:00	Man shutdn calls (if req'd)	Man shutdn calls (if req'd)	
+ 8:02			"LH_2 at 5%"
+ 8:10	(V_I = 23K)	(V_I = 23K)	"Arm command"
+ 8:20			
+ 8:28		"Fine count"	
+ 8:33	"MECO" "MECO confirmed" LO_2 or LH_2 low level cutoff (if req'd)	"MECO" "MECO confirmed"	"LO_2 or LH_2 low level cutoff (if req'd)"

TABLE 1.3.1-III.- POST-MECO INTEGRATED TIMELINE-BOOSTER

Time To ±	Reports/operations		
	Booster	ME	MPS
MECO+ min:sec			
0:01	Note MECO velocity		"LO_2 and LH_2 fdln rlf isol vlv's - op" "LO_2 pv's (3) - cl"
0:05			"LH_2 pv's (3) - cl"
0:06	Fdln disc vlv status (auto ET sep inh if req'd)		"LO_2 and LH_2 fdln disc - cl"
0:10			"LH_2 RTLS dump valves open"
0:17		3 in post-shutdn standby	
0:18	"ET SEP"		"ET SEP" Report LO_2 and LH_2 manf pressures
0:37	FD status for OMS-1		
1:30			"LH_2 RTLS dump valves closed"

TABLE 1.3.1-III.- Continued

Time T_0 ±	Reports/operations		
	Booster	ME	MPS
MECO+ min:sec			
2:00	OMS-1 ignition (or manual dump start for direct insertion)	"LOX dump start - all 3" MOV's (3) - op Report dump start time	"LH_2 inbd and outbd F/D - op" "LO_2 pv's (3) - op"
OMS-1+ min:sec			
0:06			"LH_2 inbd F/D - cl" "LH_2 pv's (3) - op:"
0:27	FD status of OMS-1 and MPS dump		
1:22	BDA LOS		
2:00			"LH_2 outbd F/D - cl"
2:10		"Dump stop" MOV's (3) - cl	

TABLE 1.3.1-III.- Concluded

Time T_0 ±	Reports/operations		
	Booster	ME	MPS
min:sec Approx MET			
16:00			"Vacuum inerting started" Report on valve configuration
18:28		"All 3 controllers-off"- MPS powerdown	
40:00 (TIG-5m)			Vacuum inerting terminate Report on on-orbit valve configuration and manifold pressures

TABLE 1.3.1-IV.- RTLS INTEGRATED TIMELINE-BOOSTER

Time To ±	Reports/operations		
	Booster	ME	MPS
min:sec			
0 to press-to-MECO	"C(L,R) engine out" or other sys reason	"C(L,R) engine out (if req'd)"	
2:30 or 4:16	3 eng - "Throttle down - ___%"	RTLS initiate (MM 601) 2 eng - "at ___ power level" or 3 eng - "Throttle down - ___%"	
PPA (depends on RTLS select time)	2 eng - throttle down - ___% 3 eng - throttle up - ___% Report all post PPA fuel dissipation throttling to TRAJ (power level and time)	2 eng - "Throttle down - ___%" 3 eng - "Throttle up - ___%" Report all post PPA fuel dissi pation throttling to Booster (power level and time)	
PPD		2 eng - "2 at 91" or 3 eng - "3 at 65"	
PPD +20 sec	"MECO" "MECO confirmed" LO_2 or LH_2 low level cutoff (if req'd)	"MECO" "MECO confirmed"	"LO_2 or LH_2 low level cutoff (if req'd)"
MECO + 0:01			"LO_2 and LH_2 fdln rlf isol vlv's-op" "LO_2 pv's (3)-cl"
0:05.9			"LH_2 pv's (3)-cl"
0:6.9			"LO_2 and LH_2 fdln disc - cl"
0:9.9			LH2 RTLS dump valves (2) - op

TABLE 1.3.1-IV.- Concluded

Time T_o ±	Reports/operations		
	Booster	ME	MPS
MECO+ min:sec			
0:12.9	"ET SEP"		"ET SEP"
0:15		"LOX dump-all 3" MOV's (3) - op	
0:23 (MM602)			LH_2 RTLS manf repress 1 and 2 - op "LO_2 and LH_2 pv's (6) - op"
Q=20			"LO_2 F/D vlv's -op"
1:45 (MM602 + 80s)			"LH_2 F/D vlv's - op, LH_2 RTLS manf repress vlv's -cl
V_{REL}< 4500 ft/s	Dump status		"He blowdown vlv's - op"
V_{REL} 3800 ft/s			LO2/LH_2 outbrd F/D vlv's - cl LO_2 pv's - cl LO_2 overbrd bleed vlv - cl LH_2 RTLS dump vlv's - cl
V_{REL} 3800 ft/s +2 sec		"LOX dump stop" MOV's (3) - cl	
V_{REL} 4500 ft/s +10:50			"He blowdown valves - cl"
Post-landing	Report LH_2 and LO_2 relief condition Report any hazardous condition to FIDO to relay to grd convoy		Report any hazardous condition: High LH_2 manf P High LO_2 manf P

TABLE 1.3.1-V.- TAL INTEGRATED TIMELINE-BOOSTER

Time T_0 ±	Reports/operations		
	Booster	ME	MPS
min:sec			
SRB staging to Press-to MECO	"C(L,R) eng out"	"C(L,R) engine out"	
4:05	2 eng - "2 at __ power level" 3 eng - "Throttle down - 65%"	TAL initiate 2 eng - "at __ power level" 3 eng - Throttle down to 65%"	
MECO	"MECO" (VI = 23.8K) "MECO confirmed"	"MECO" (VI - 23.8K) "MECO confirmed"	
From MECO 00:00			
00:01			LO_2 and LH_2 fdln rlf shutoff valves - op "LO_2 PV's closed"
00:05.9			"LH_2 PV's - cl" LH_2 recirc disconnect valve - cl
00:06.9			"LO_2 and LH_2 fdln disconnect valve - cl"
00:09.9			"LH_2 RTLS D/V open"
00:16	"ET SEP"		"ET SEP"

TABLE 1.3.1-V.- Concluded

Time T_0 ±	Reports/operations		
	Booster	ME	MPS
Manual dump start (00:40)		"LOX dump start all three;" all MOV's open	LH_2 RTLS D/V - cl LO_2 manf repress 1 and 2 - open LH_2 inbd/outbd F/D vlvs - op
Manual dump start + 00:03			"LO_2 pv's - op"
00:06			"LH_2 inbd F/D vlv - cl. LH_2 topping vlv - op"
00:09			"LH_2 pv's - op"
00:30	Dump status	"Dump stop" All MOV's closed	LH_2 manf repress 1 and 2 - closed LO_2 manf repress 1 and 2 - closed LO_2 pvs - cl LH_2 outbd F/D - cl LH_2 topping vlv - cl
05:00			LO_2 and LH_2 manf repress 1 and 2 - open Report LO_2 and LH_2 manifold pressures
Ground relative velocity <4500			"He blowdown valves open" Report He purge and He tank pressures
Ground relative velocity <4500 + 14 min 48 sec			"He blowdown valves closed" Report He tank pressures

TABLE 1.3.1-VI.- ENTRY INTEGRATED TIMELINE-BOOSTER

Time OMS TIG-	Reports/operations		
	Booster	ME	MPS
hr:min		Not required	
Prior to MM304 transition			Compute Helium mass
At MM304 transition			Report on value configuration: RTLS IB and OB vlvs - op L,C, and R LO2 PV - op L,C, and R LH2 PV - op LH_2 IB and OB F/D - op LH_2 topping vlv - op L helium isol B - op L he interconn in - op C and R He interconn out - op Crossover vlv - op Pneu isol 1 and 2 - op "Valve config - good"
Ground relative velocity <20kft/s			"LO_2 IB and OB F/D - op"

TABLE 1.3.1-VI.- Concluded

Time OMS TIG-	Reports/operations		
	Booster	ME	MPS
Ground relative velocity <4500 ft/s			Report on valve configuration: LO_2 PV - cl LH_2 OB F/D - cl LO_2 OB F/D - cl LH_2 manf repress 1 and 2 - op LO_2 manf repress 1 and 2 - op RTLS IB and OB vlvs - cl He blowdown 1 and 2 - op "Blowdowns - op, valve config - good"
4500 ft/s +650s			He blowdown 1 and 2 - cl L,C, and R He interconn out - cl Crossover vlv - cl "Crossover vlv - cl "Blowdowns - cl, valve config - good" (Report any deltas)

TITLE

FLIGHT DATA FILE PROCEDURES

PURPOSE

This SCP lists the Booster procedures included in the flight data file (FDF) documents.

PROCEDURES

This SCP identifies the FDF documents that contain Main Propulsion System (MPS)/Space Shuttle Main Engine (SSME) procedures. The nominal crew procedures are found in the following FDF documents:

Ascent Checklist
Post-Insertion
Deorbit Prep
Orbit Operations Checklist
Entry Checklist

Off-nominal (emergency) procedures are found in the following FDF documents:

Ascent Pocket Checklist
Ascent/Entry Systems Procedures
Systems Abort-Once-Around (AOA) Procedures
Orbit Pocket Checklist
Contingency Deorbit Prep
Entry Pocket Checklist
Malfunction Procedures

All MPS/SSME-related procedures are listed in table 1.3.2-I which lists the FDF documents in which they are found and the applicable flight rules.

TABLE 1.3.2-I.- CREW PROCEDURE LISTING

FDF document	Crew procedures	Section	Flight rule (Section 5)
Ascent Checklist	Normal procedures - prelaunch	1	
	MPS helium reconfiguration (T-16:00)		
	Ascent flip book	FB 2	
	Ascent procedures		
	ET SEP		
	OMS 1 burn - dump switch check		10, 64
	RTLS PLT		
	AUTO TAL PLT		
	LATE TAL PLT		
	Contingency abort (MS)		64
	RTLS contingency (MS)		64
	Delayed burns	FB 2	
	Manual MPS dump		10, 64
	ET SEP (MECO +6 min) (feedline fail only)		60
	RTLS procedures	2	
	TAL procedures	2	
	Post-OMS 1	3	
	APU/HYD shutdown (not AOA)		
	HYD depress (AOA only)		
	MPS powerdown		
	MPS vacuum inerting actuate		10, 66, 68
	MPS vacuum inerting terminate		10, 66, 68
	AOA procedures	6	
	OPS 301 PRO		
	MPS vacuum inerting terminate		10, 66
	Entry switch checklist		
	Switch list for handover INGRESS	FS 9	
	Left seat - Panel F7, C3		
	Right seat - Panel O17, R2, R4		
	Ascent cue cards	FS CC 10,	
	Contingency abort	FS CC 11	64
	RTLS contingency		64
Ascent Pocket Checklist	MPS	9	
	MPS propellant schematic		
	MPS helium schematic		
	Powerdown	10	
	Loss of high load evap		
	Loss of two Freon loops		69
	Loss of second fuel cell		69

TABLE 1.3.2-I.- CREW PROCEDURE LISTING (continued)

FDF document	Crew procedures	Section	Flight rule (Section 5)
Ascent/Entry Systems Procedures	DPS Ascent	MS 3	
	PASS GPC fail		65
	FA MDM I/O error		65
	Multiple data path loss (nonrecov)		65
	EPS	5	
	MN A fail		10, 36, 65
	MN B fail		10, 36, 65
	MN C fail		36
	SUBBUS (APC 4, ALC 1, APC 5, ALC 2)		10, 65
	CNTL AB3		10, 65
	CNTL BC3		10, 65
	Loss of second fuel cell powerdown		69
	MPS	MS 9	
	MPS data		2, 4, 29, 30
	MPS CMD, HYD, or ELEC		3, 32 - 34
	Multi MPS CMD/DATA (No MECO confirm)		2 - 4, 32, 53
	ENG fail		2, 30, 36
	LH2 ET ULL press		5, 49
	Post-MECO LH2/LO2 manf press high		61
	MPS dummy OMS burn (PASS only)		10, 64, 65
	ET SEP man.		
	MPS C&W light		
	MPS He TK LK pre-ET SEP		5, 7, 28,45-48
	MPS He TK LK post-ET SEP (not RTLS)		7, 62
	Pneu He LK		8, 47, 48
	Multiphase systems cue cards	CC 10	
	MPS data		2, 4, 29, 30
	MPS CMD, HYD, or ELEC		3, 32 - 34
	Multi MPS CMD/data (No MECO confirm)		2 - 4, 32, 53
	ENG fail		2, 30, 36
	LH2 ET ULL press		5, 49
	Post-MECO LH2/LO2 manf press high		61
	MPS He TK LK pre-ET SEP		5, 7, 28,45-48
	MPS He TK LK post-ET SEP (not RTLS)		7, 62
	Pneu He LK		8, 47
	ET SEP man.		
	PLT overhead flip book	FB 11	
	MPS dummy OMS burn (PASS ONLY)		10, 64, 65
	PLT flip book	FB 12	
	PASS GPC fail		65
	FA MDM I/O error		65
	Multi data path loss		60, 65
	MN A fail		10, 36, 65

TABLE 1.3.2-I.- CREW PROCEDURE LISTING (continued)

FDF document	Crew procedures	Section	Flight rule (Section 5)
Ascent/Entry System Procedures (continued)	MN B fail		10, 36, 65
	MN C fail		36
	CNTL AB3		10, 65
	CNTL BC3		10, 65
	Loss of second fuel cell powerdown		69
	CDR flip book	FB 13	
	PASS GPC fail		65
	FA MDM I/O error		65
Systems AOA Procedures	Summary timeline for loss of two Freon loops (AOA) powerdown	1	69
	Loss of two Freon loops (AOA) powerdown	2	
	APU/HYD shutdown and powerdown		
	MPS powerdown/isolation		69
	MPS vacuum inerting actuate		10, 66, 68
	MPS vacuum inerting terminate		10, 66, 68
	Pre-EI and entry switch check	3	
	Summary timeline for loss of two H2O loops (AOA) powerdown	7	69
	Loss of two H2O loops (AOA) powerdown	8	
	Direct insertion (if no OMS 1)		
	MPS propellant dump seq - start		10, 64
	MPS powerdown/isolation		69
	MPS vacuum inerting actuate		10, 66, 68
	MPS vacuum inerting terminate		10, 66, 68
Post-Insertion	Post-insertion procedures	1	
	Reset C/W		
	EIU, MEC powerdown		
Orbit Operations Checklist	MPS	8	
	MPS vacuum inerting actuate		67
	MPS vacuum inerting terminate		67
Orbit Pocket Checklist	MPS	9	
	MPS C/W		61, 67
	Powerdowns	10	
	Loss of second fuel cell (on orbit)		69
	Loss of second fuel cell (deorbit prep)		69
	Loss of two Freon loops		69
	Priority powerdown procedures	11	
	Priority powerdown group A		69

TABLE 1.3.2-I.- CREW PROCEDURE LISTING (continued)

FDF document	Crew procedures	Section	Flight rule (Section 5)
Deorbit Prep	Nominal deorbit prep procedures	1	
	SSME HYD repress prep		70
	Reset C/W		
	Entry switch list/verification		
	Deorbit prep backout procedures	2	
	MPS helium reconfiguration		
	Entry switch list/verification	3	
	Left seat - Panel F7, C3		
	Right seat - Panel R2, R4 Panel O17	FS 3	
	BFS deorbit prep notes	4	
Contingency Deorbit Prep	Launch day deorbit prep (orbit 3)	2	
	Entry switch list/verification		
	Entry switch list/verification	3	
	Left seat - Panel F7, C3		
	Right seat - Panel O17, R2, R4		
	Loss of two fuel cells launch day (orbit 2 of 3)	4	
	P&I changes to entry checklist		
	Loss of two fuel cells deorbit prep	5	
	Switch verification		
	MPS/H2 purge prep		69
	P&I changes to entry checklist		
	Loss of two fuel cells switch list	6	
	Left seat - Panel F7, C3		
	Right seat - Panel O17, R2, R4		
	Loss of FES deorbit prep	7	
	Entry deltas pullout page		
	Loss of two H2O loops deorbit prep/entry	9	69
	Entry switch check		
	Emergency deorbit prep/entry	10	
	Entry switch check		
	Loss of two Freon loops deorbit prep/entry	11	
	MPS H2 purge prep		69
Entry Checklist	Deorbit burn procedures	3	
	MPS reconfiguration		
	SSME HYD repress		70

TABLE 1.3.2-I.- CREW PROCEDURE LISTING (continued)

FDF document	Crew procedures	Section	Flight rule (Section 5)
Entry Checklist (continued)	Postlanding procedures SSME repositioning (if PASS and OPS 9) APU/HYD shutdown	5	
	Switch list at wheels stop Left seat - Panel F7, C3 Right seat - Panel 017, R2, R4	8	
Entry Pocket Checklist	Powerdown	10	
	Loss of two Freon loops (Entry)		69
	Loss of two fuel cells		69
Malfunction Procedures	MPS	12	
	LH2 manifold pressure		61, 67
	LO2 manifold pressure		61, 67
Reference Data	EPDC	1	
	Fault messages ET SEP ME SHDN SW C(L,R) MPS CMD C(L,R) MPS DATA C(L,R) MPS ELEC C(L,R) MPS HYD C(L,R) MPS HE P C(L,R) MPS LH2/O2 MANF MPS LH2/O2 ULL SSME FAIL C(L,R)	3	
	C/W and FDA table MPS ET ULL P LH2 MPS ET ULL P LO2 MPS HE dP/dT MPS HE REG C(L,R) MPS HE TK P C(L,R) MPS MANF P LH2 MPS MANF P LO2	4	
	C/W parameter inhibit/enable (Used to inhibit C/W for LH2 MANF P and LO2 MANF P on orbit)	4	

TABLE 1.3.2-I.- CREW PROCEDURE LISTING (concluded)

FDF document	Crew procedures	Section	Flight rule (Section 5)
Data Processing System Dictionary	Fault displays	2	
	Trajectory displays	3	
	Override displays	3	
	BFS displays TRAJ 1, 2 GNC SYS SUMM 1 BFS OVERRIDE displays	5	
	System software Ascent/abort SSME throttling after IMU loss	6	

REFERENCES

1. Ascent Checklist, Baseline, JSC-18547
2. Ascent Pocket Checklist, Baseline, JSC-18537
3. Ascent/Entry System Procedures, Baseline, JSC-18768
4. Systems AOA Procedures, Baseline, JSC-22728
5. Post-Insertion, Baseline, JSC-22435-26
6. Orbit Operations Checklist, Baseline, JSC-18541
7. Orbit Pocket Checklist, Baseline, JSC-18538
8. Deorbit Prep, Baseline, JSC-18998
9. Contingency Deorbit Prep, Baseline, JSC-17871
10. Entry Checklist, Baseline, JSC-18540
11. Entry Pocket Checklist, Baseline, JSC-18539
12. Malfunction Procedures, Baseline, JSC-18691
13. Reference Data, Baseline, JSC-18546
14. Data Processing System Dictionary, JSC-17322
15. STS Operational Flight Rules, Baseline, JSC-12820, PCN-4, November 3, 1989

TITLE

BOOSTER PRELAUNCH ACTIVITY/REPORTING

PURPOSE

The purpose of this SCP is to describe the reporting and console operations required at the Booster FCR console and the MPS/ME MPSR positions for the period from on console to GLS auto sequence start (T_o - 9M00S).

DESCRIPTION

The prelaunch activities involve monitoring the vehicle loading to be cognizant of the status and evaluating the effect of any anomalous hardware operation or data. The flight director must be kept informed of the status of the loading and any problems that have developed. The prelaunch team will arrive on console at the assigned hour and prepare the consoles for launch including inputting the limits from the Megadata Terminal (MED) into the MOC and NRT computers, selecting the proper formats for the event lights, and calling up the displays to be monitored. Table 1.3.3-II identifies the prelaunch events of interest and the reports to be given. The sequence steps and times will vary from flight to flight. For this reason, Table 1.3.3-II should be used only as a guide to the events which will occur. All voice communications are in quotation marks.
Table 1.3.3-II includes references to the appropriate sequences in the following OMI's which describe the events during the countdown.

OMI No. S0007V2 - Launch countdown

OMI No. G3151 - LO_2 system preps for vehicle loading

OMI No. G3251 - LH_2 system preps for vehicle loading

OMI No. V9018 - SSME/MPS preps and securing for prop loading

OMI No. S1003 - MPS LO_2 system automatic load and drain operations

OMI No. S1004 - MPS LH_2 system automatic load and drain operations.

The table below lists the current configuration for the Booster console and the back room support consoles for pre-launch comm loops. If it becomes necessary to monitor an OIS loop not assigned to a keyset label, the Booster Console operator can request GC to patch the OIS loop to MCC*PATCH 2. Table 1.3.3-III lists all of the available OIS loops.

Two new comm loops have been added to the keysets for STS-28 and all subsequent flights. These loops allow the prelaunch MPSR personnel to monitor the MSFC engine and SRB project conference loops from the Huntsville Operation Support Center (HOSC). The ME operator will monitor the SSME HOSC loop and the MPS operator will monitor the SRB HOSC loop.

TABLE 1.3.3-I.- PRELAUNCH COMM LOOPS BY CONSOLE

OIS loop	Keyset label	Booster (right side)	MPSR-1		MPSR-2	
			MPS	ME	MPS	ME
132-OTC	OTC OIS 132	M	M		M	
156-LO2	OIS * PATCH 1	T/M	T/M	M	T/M	T/M
161-PE-1	SSR 2 CONF/PE-1 OIS	T/M	T/M	T/M	T/M	T/M
166-LH2	SSR 1 ** CONF/OIS PATCH	T/M	T/M	T/M	T/M	T/M
214-I-COMM A	PLBK 4 ICOM A&B 214	M			M	M
231-WX & TRBL	PLBK 1 WX/231	M			M	M
232-NTD INTG	PLBK 3 NTD/232 CONV	M	M		M	M
245-ESA	PLBK 2 ESA/245 COOL	M	M		M	M
Any OIS loop	MCC PATCH 2	T	T	T	T	T

* OIS*PATCH 1 comm loop can patch to the following OIS loops: 136,137,141,143,146,147,151,153,156,157,169,166,168,171,173,174, 182,183,245 OIS 156 is usually patched to OIS*PATCH 1

** SSR 1*CONF/OIS*PATCH comm loop can patch to the following OIS loops: 137,141,143,146,147,151,153,156,157,163,164,166,168,171,173,174, 182,183,245 OIS 166 is usually patched to SSR 1*CONF/OIS*PATCH

Note: T = Talk Capability, M = Monitor Capability

TABLE 1.3.3-II.- BOOSTER PRELAUNCH ACTIVITY

Time To -	Console	Activity/report	S0007 vol 2 seq no.
-10H00M		SRB aft skirt GN2 purge activation	15-0057
-9H30M		MPS recirculation pump power activation	15-0132
-9H00M		SRB powerup. SRB buses A and B power applied and MDM initialized SRB PC1 and PC2 are active	15-0192
	MPS	Report: "SRB Bus A and B powerup"	
-9H00M		Initiate Orbiter/ET Disconnect cavity purge	15-0278
-8H30M		ET sensor checks. Perform check of ET OI liquid level sensors and ullage pressure transducers	15-0267
-8H15M		Weather update ET tanking preps	15-0286
-8H00M		ET sensor checks complete	15-0292
-8H00M		SRB field joint heater power application	15-0293
-7H30M		LH_2 systems preparation for propellant loading complete (OMI G3251 complete)	15-0362
7H00M		LH_2 Pre-chilldown ops	15-0465
7H00M		LCC verify	15-0466
6H45M		SSME/MPS preps for loading per V9018 complete	15-0495
-6H20M		Verify go for LO_2 and LH_2 tanking	15-0590
-6H00M		Holding	15-0633
-6H00M		LH_2 pre-chilldown operations complete	15-0627
-6H00M		Initiate LO_2 transfer line chilldown	16-0009
-6H00M		Initiate LH_2 transfer line chilldown	16-0010
-6H00M		Verify SRB nozzle flex bearing and SRB nozzle to case joint meets OMRS temp requirements	16-0033
-5H50M		LH_2 facility/Orbiter chilldown complete Start LH_2 slow fill to ECOS	16-0035
-5H50M		LO_2 transfer line chilldown complete Starting Orbiter LO_2/MPS chilldown	16-0036

TABLE 1.3.3-II.- BOOSTER PRELAUNCH ACTIVITY (continued)

Time To -	Console	Activity/report	S0007 vol 2 seq no.
-5H20M		Orbiter LO_2 MPS chilldown complete Proceeding to slow fill of LO_2	16-0037
-5H15M		LH_2 slow fill to ECOS complete Proceed to LH_2 fast fill to 98 percent	16-0040
-5H15M	MPS	Report: "LO_2 and LH_2 ECOS sensors wet"	
-5H10M		Transition to LO_2 fast fill complete	16-0044
-4H55M		Begin LH_2 recirculation. LH_2 recirculation pumps on, recirc valves open, prevalves closed	16-0056
-4H55M	MPS	Report: "LH_2 recirc pumps on"	
-4H00M	BSE	Report: "Go for ET ullage transducer switch out"	
-4H00M		Spare ET ullage transducer switched out	16-0088
-4H00M	BSE	Report: "No anomalies after transducer switch out"	
-3H45M		LH_2 fast fill to 98 percent complete Starting LH_2 topping to 100 percent Close inboard fill and drain valve Terminate vent valve cycling ET vent valve open	16-0092
-3H05M		LH_2 topping complete. Begin replenish	16-0121
-3H05M		LO_2 in stable replenish	16-0122
-3H05M		LH_2 in stable replenish	16-0123
-3H05M	MPS	Report: "LO_2 and LH_2 100 percent sensors wet"	
-3H00M		Holding	16-0163
-3H00M		SRB RGA powerup. Remaining SRB bus C is powered up. PC3 active	16-0231
-3H00M	MPS	Report: "SRB Bus C powerup"	
-3H00M		Proceed with pressurization of MPS helium bottles to flight pressure	16-0320
-3H00M	MPS	Report: "Helium bottle pressurization complete"	

TABLE 1.3.3-II.- BOOSTER PRELAUNCH ACTIVITY (continued)

Time To -	Console	Activity/report	S0007 vol 2 seq no.
-3H00M	MPS	Report: "No LCC violations"	
-2H45M		Launch commit criteria verification	16-0348
-2H30M		MPS helium pressurization to flight pressures complete	16-0388
-2H30M		ET liquid level sensor checks	16-0392
-2H30M		Flight crew ingress begins	16-0409
-1H30M		SRM chamber pressure calibration and GPC update	16-0559
-1H30M	MPS	Report: "SRB PC calibration check in progress"	
-1H00M		SRM PC transducer calibration complete	16-0620
-32M00S		Perform PASS/BFS transfer prep	16-0714
-25M00S		Weather briefing	16-0762
-20M00S		10-minute hold	16-0773
-20M00S	ME	Report: "SSME data available. No LCC violations"	
-16M00S		MPS Helium reconfiguration complete	16-0908
-16M00S	MPS	Report: "Switch config is good"	
-09H00S		10-minute hold	16-0960
-5M00S		APU start - Orbiter hydraulics up	16-1034
-5M00S	ME	Report: "Three good engine hydraulics"	
-4M55S		Terminate LOX replenish (Start timer)	16-1052
-4M55S	MPS	Report: "Drain back started"	
-4M00S		Purge sequence 4	16-1056
-4M00S	ME	Report: "Purge 4, all three engines"	
-4M00S		Verify SSME valve movement in close direction	16-1058
-2M55S		ET LO_2 pressurization	16-1062
-2M55S	MPS	Report: "LOX vent closed"	

TABLE 1.3.3-II.- BOOSTER PRELAUNCH ACTIVITY (concluded)

Time To -	Console	Activity/report	S0007 vol 2 seq no.
-2M30S		Clear C & W memory	16-1065
-1M57S		ET LH_2 pressurization	16-1074
-1M57S	MPS	Report: "Fuel vent closed"	
-10S		GLS go for main engine start	16-1085
-6.6S		SSME ignition - all three	16-1088
To		SRB ignition	16-1089

TABLE 1.3.3-III.- KSC OIS CHANNELS AVAILABLE AT JSC

No.	Channel name	Description
117	OIS control	Used by NASA and LSOC/comm personnel for incoming trouble reports, (OIS) voice coordination, validation, and OIS troubleshooting
132	OTC	Used by the Orbiter test conductor (OTC) from pickup of test until crew ingress to coordinate and direct Orbiter testing. OTC coordination channel used by the assistant OTC from crew ingress to T-9 minutes to coordinate and direct Orbiter subsystem testing. From T-9 minutes through T-0, the assistant OTC continues to monitor CHNL 132 to discuss nonrelated launch commit criteria problems, as required. This channel is not used to communicate with the Orbiter. (see CHNL 211 through 215)
133	CTD	Used by the cargo test director for overall operational direction of integrated cargo activities. Also used for intercenter/agency coordination between KSC and payload operations control centers. This channel is not used to communicate with the Orbiter Used by the air force test director during DOD missions
134	CTC	Used by the cargo test conductor to direct operational activities of cargo element test teams. This channel will be extended off-site for coordination with payload ground stations and satellite control centers. This channel is not used to communicate with the Orbiter Used by the air force during DOD missions
135	LRD	Used by the NASA landing and recovery director as a primary command channel to off-site landing areas at DFRF and WSMR (space harbor). Provides coordination and status of KSC deployed OPS team with KSC/LCC. Also used for prelaunch coordination of SRB retrieval operations
136	TTC	Used by the contractor test conductor to direct the activities directly associated with the checkout and preparation of the external tank

TABLE 1.3.3-III.- Continued

No.	Channel name	Description
137	BTC	Utilized by the contractor test conductor to direct the activities directly associated with the preparation and checkout of the solid rocket booster
141	G&N-1	Prime channel for systems testing of GN&C including IMU, star tracker, and air data systems
143	ECLSS-1	ECLSS prime-channel for control and testing of Orbiter ECLSS systems including, coolant loops, CM air, ARS, ground cooling units, etc
144	INT test	Used for Orbiter cargo integrated testing
145	ORB INST-1	Prime channel for testing and monitoring of the Orbiter OI and DFI systems including PCMMU, MUT, caution and warning, and tape
146	SSME-1/ SSMEC-1	Prime channel for testing and monitoring of the main engine systems and the SSME controllers. Used to monitor engines during FRF and prelaunch
147	HYGL FUEL-1	A prime channel used for testing and servicing of Orbiter OMS and RCS fuel systems. Also used for installation and removal of OMS pods and RCS modules
151	EPDC-1	Prime channel for systems monitoring and testing of the Orbiter AC and DC buses and electrical systems. This channel is also used for coordinating power to SRB and ET buses. At arrival of Orbiter in deservice area this channel is tied to DFRF SPA to coordinate ground turnaround procedures
152	DPS-1	One of two channels used by data processing engineers to monitor, test, and troubleshoot functions involving the Orbiter GPC's. Also used to perform SRB MDM checkout and to unlock MDM's as part of SRB powerup
153	F/C-1	Prime channel for duel cell control and testing including PRSD systems. Coordination channel for fuel fell operations including bus load sharing, fuel cell purges, activation, deactivation, etc
154	INTEG test	Used for orbiter cargo integrated testing. This channel can be interfaced, as required, for specific testing

TABLE 1.3.3-III.- Continued

No.	Channel name	Description
155	COMM-1	Prime channel for testing and monitoring of the Orbiter communications systems including voice, commands, TV, data, etc. This channel is used for test coordinations with MILA STDN station and comm and tracking station. This channel is not used to communicate with the Orbiter
156	LO 2	Prime channel for testing and monitoring ground, Orbiter and ET LO systems. The main function will be tank loading in preparation for FRF and flight. Parallel loading is planned
157	HYGL OXID-1	Prime channel used for testing and servicing of Orbiter OMS and RCS oxidizer systems
161	PE-1	Project engineering channel used to coordinate systems integration and troubleshooting by the engineers in the firing room. Engineering point-of-contact between test directors and engineering and the ESA. Prime channel for GLS coordination
163	BIOMED	Prime channel for testing the biomedical systems and for use by the medical personnel for prelaunch coordination with JSC medical personnel
164	P/L-1	Used by payloads during payload processing and coordination with NASA-wide nets
166	LH 2	Prime channel for testing and monitoring ground, Orbiter and ET LH systems. The main function will be tank loading in preparation for FRF and flight. Parallel loading is planned
168	MPS-1	Prime channel for main propulsion systems testing, purging, servicing, etc.
171	FLIGHT CONT-1	Prime channel for systems monitoring and testing of the shuttle flight control systems including aero surfaces, controllers, and ATVS. SRB rate GYROS and actuator checkout will be performed/monitored
173	NAV aids	Prime channel for testing and monitoring of Orbiter navaids including MSBLS, TACAN, and radar altimeter. Serves as channel for coordination with OPF comm and tracking stations of navaid functions
174	P/L-2	Used by payloads during payload processing and coordination with NASA-wide nets

TABLE 1.3.3-III.- Continued

No.	Channel name	Description
182	HYD/ORB-1	Prime channel for testing and control of the Orbiter hydraulic systems and APU's. Coordination channel for application/removal of ground hydraulics and control of ground hydraulics units
183	SM TRBL	Used as SM troubleshooting channel. This channel will be assigned as required by the NTD for troubleshooting hardware/software problems
184	P/L-3	Used by payloads during payload processing and coordination with NASA-wide nets
214	I-COMM A	Used by the STS test team to coordinate onboard activities involving the flight crew during preparation of the shuttle for launch. This circuit is switched at the OTC (Orbiter test conductor) console into the IC-A astrocomm circuit that goes to the ORB via hardlines, however the IC-A circuit may be used by the flight crew in a "private" configuration for flight crew onboard communications After lift-off and when scheduled, this channel is used to monitor convoy CDR RF net At arrival of Orbiter in deservice area, this channel is used to coordinate ground turnaround procedures (Reference sketches in longlines comm guide - section 1)
215	I-COMM B	Used by the STS test team to coordinate onboard activities involving the flight crew during preparation of the shuttle for launch. This circuit is switched at the OTC (Orbiter test conductor) console into the IC-B astrocomm circuit that goes to the Orbiter via hardlines, however the IC-B circuit may be used by the flight crew in A "private" configuration for flight crew onboard communications Upon request, also used for communications when Orbiter has arrived at deservice area

TABLE 1.3.3-III.- Continued

No.	Channel name	Description
217	GSFC GCN-1 (MON)	Used by KSC to monitor Orbiter-to ground conversations involving the GSFC worldwide tracking nets. This circuit is monitor only for air-to-ground S-band or UHF conversations between the flight crew and control centers during flight JSC refers to the GSFC GNC-2 net as A/G-2 (monitor) The JSC A/G-1 is not to be confused with OIS channel 212 or the A/G-1 astrocomm During integrated tests when astrocomm is not up and if the Orbiter is not in orbit, this channel will be tied (monitor only) to OIS channel 212 Note: OIS-212 is used by the STS test team (primarily OTC) to coordinate onboard activities involving the flight crew. This channel (212 will be tied (monitor only) into OIS 217
231	WX and TRBL	Used for communications with cape meteorologist Tied to OIS-A (chnl 8) for weather briefing of chase/weather pilots and SLF tower operator Also used for SM troubleshooting. This channel will be assigned as required by the NTD for hardware/software problems
232	NTD INTG	Used by the NASA test director (NTD) to integrate all flight hardware and its ESE/GSE. The reporting of flight hardware/ESE/GSE problems to the NTD is also done on this channel. Monitoring and responding to procedure callouts to start and complete test items include SPE, OTC, BTC, TTC, STM, and CITS The channel is also used by SM (NASA and contractor personnel) for communication with the CT/MLP during the STS move to or from the pad This channel is not used to communicate with the Orbiter CHNL 131 is used as NTD backup if 232 becomes inoperable

TABLE 1.3.3-III.- Concluded

No.	Channel name	Description
234	P/L-4	Used by payloads during payload processing and coordination with NASA-wide nets
242	MECH-2, ECS-2 and HYD/ORB-2	Back up channel for 182 After lift-off "purge" at DFRF and KSC will be patched to this channel to coordinate ground turnaround procedures
243	ECLSS-2	Back up channel for 143 After lift-off "cooling net" at DFRF and KSC will be patched to this channel
244	TRBL	This channel will be assigned as required by the CTD/CTC for troubleshooting hardware/software
245	ESA	Coordination channel for use by JSC/MSFC/KSC engineering personnel located in the ESA room at KSC At arrival of Orbiter in deservice area this channel is tied to DFRF and KSC to coordinate ground turnaround procedures
247	HYGL FUEL-2	Back channel for channel 147 When required, by KSC, this channel will be patched to L/F-1 or L/F-2 (monitor only)
254	P/L-5	Used by payloads during payload processing and coordination with NASA-wide nets
264	P/L-6	Used by payloads during payload processing and coordination with NASA-wide nets
172	ECS-1	Prime channel for testing and control of the conditioned purge systems, ECS air, payload bay purge control, PV&D systems etc. Note: Requested by the JSC MER

Additional information concerning the OIS channel descriptions is available in the KSC operational launch and landing voice communications systems document (KSC comm ACD) (KSC-HB-2520.3).

TITLE

MPS/ME PRELAUNCH OPERATIONS

PURPOSE

The purpose of this SCP is to describe the responsibilities and actions of the MPS and ME operator during prelaunch activities in the MPSR. This SCP is to be used in conjunction with the SCP 1.3.3 BOOSTER PRELAUNCH. This SCP will cover:

- Prelaunch checklists and activities
- MPS and ME limit and comp loading
- Problem corrections
- Operations and maintenance instructions (OMI's) usage
- Prelaunch cue card for proper MPS valve configuration

PRELAUNCH CHECKLISTS AND ACTIVITIES

At least a week before the flight date, the prelaunch team should verify that all their goodie books and documentation are complete and up-to-date by having the Ascent team leads review their books.

A sample copy of the MPS and ME prelaunch checklist is shown as table 1.3.4-I. The prelaunch team arrives on console about T-10 hours (L - 12 hours). After arrival they log the flight number and launch attempt date on the checklist and fill out the flight manning list.

The first step to bring up the console is to assign the right flight to the console. The thumbwheel is set to the right number (e.g., 0036 for flight 36) and the flight select key is pushed, then left monitor enter is pushed. You can verify this was done properly by checking the flight number on the upper left of any of your displays.

The MSID parameter limits, MOC constants, and universal plots (UP's) can be assigned to the flight by one of three procedures. They can be loaded by either a MEGADATA disk, MASSCOMP, or, if a previous launch attempt was done, by recalling the load from a checkpoint if one was stored. It is important that the limit sets for mission-specific times (i.e., prelaunch, launch, SRB sep, ET sep, and abort throttle (>104 percent power)) not be sent at the same time between MPS and ME. First one operator should send all their limits, then the other operator should send their set. If both sets are sent at the same time, either on different MEGADATA's or MASSCOMP's, the limits will not be assigned to the proper mission time. For example, launch limits may be assigned to ET sep limits MSID's.

A listing of the procedures used in the loading limits/comps via the MEGADATA is listed in SCP 6.3.

After loading all the limits, MOC constants, and UP's, these numbers should be verified against the numbers specified in SCP 5.2.4 (MPS) and 5.1.4 (ME). If any MSID parameters were displaced by overridden constants these should be noted in the prelaunch checklist.

To verify the limits and MOC constants use the following procedure:

Step (1)	Assign prelaunch limit set.
Step (2)	Call up MSK's 2100, 2101, and 2102.
Step (3)	Produce hard copies of these limit/comp sets. Numeral 1 will be printed on these three hard copies in the upper left to signify they belong to the "prelaunch set".
Step (4)	Change limit set to launch and produce hard copies of 2100, 2101, and 2102 again. Limit set 2 will be placed in the upper left to signify "launch set"
Step (5)	Repeat this procedure for SRB sep - limit set 3 ET sep - limit set 4 Abort throttle - limit set 5

Note that abort throttle only refers to throttle setting, not abort mode. Abort throttle may be used in a nominal/AOA/TAL or RTLS Abort.

Step (6)	Compare the limits/constants from these 15 pages (5 launch sets times 3 displays each) to those provided by SCP 5.1.4 and 5.2.4 unless instructed otherwise by the MPS/ME lead Ascent operator.
Step (7)	GPC MED constants can also be called up on hard copies via MSK 2064 and MSK 2065. These values can be verified against values provided by the prime MPSR operators.

A light check should be done to insure twin bulbs are burning for all DDD lights. A light check can be done either via the MASSCOMP, MEGADATA, or from the console using the MSK select buttons. To do a light check via the console select 777 left adjusted via the thumbwheel and insert the DDD panel number as the fourth digit, right adjusted. Then press left monitor enter for single digit panels, or right monitor enter for double digit panels. For example, 7772 followed by left monitor enter would light panel 2. 7775 followed by right monitor enter would light panel 15. Only the last digit of a two-digit panel number is listed on the thumbwheel. In this latter case 5 represents 15. Each DDD MSID light is single-fault tolerant as they all contain 2 lights per MSID.

To verify the right DDD panels are assigned to the right display sets call up MSK 0075 for the second floor MPSR. On the third floor (DOD) call up MSK 0087.

The prelaunch "L minus" and "T minus" times should be placed on the overhead TV. This can be done by assigning TV channel 0171 for the second floor MPSR or channel 0065 for the third floor.

The Near Real Time (NRT) numbers should also be sent via the MASSCOMP or MEGADATA. Unlike the limit sets, NRT numbers are not saved through checkpoints and must be resent every launch attempt.

Voice loops, SMEK panel buttons, and displays should be checked to insure they are working properly.

Listings of any LCC violations, equipment malfunctions, and other anomalies should be noted. FRR data pack items should be thoroughly reviewed and understood. Interim Problem Reports (IPR's) should be reviewed after every revision. IPR updates are sent to each console in box several times a day.

The availability of all required documentation to support the flight in the MPSR and FCR should be verified. Any documentation in the MPSR in-boxes should be reviewed.

MPS AND ME LIMIT AND COMP LISTINGS

The MSK displays of the limits and comps will list the variables in the order shown in table 1.3.4-II for MPS and 1.3.4-III for ME. The respective MSID's for all variables are shown in these two tables.

PROBLEM CORRECTION

If problems arise in getting the console up, limits in, or lights and buttons working there are always a series of people on call to help troubleshoot the system and make repairs.

If problems arise getting the CRT's/SMEK panel working or adjusted, or replacing burned out DDD lights call "DISPLAY".

If the MEGADATA will not function properly or accept inputs contact "GC CALL".

If some of the telemetry appears poor quality or certain parameters appear missing verify you have the right telemetry downlink (listed in the upper right of your display). If that appears correct call "TLM/MITS".

If your headset is bad it can be replaced at the STSOC supply room in building 30. Before replacing it, plug it in to another outlet on the console to insure the console connection is not bad.

OMI'S

The OMI books, located in the MPSR and FCR, are followed during the entire prelaunch countdown by both the prelaunch team and later, by the ascent team prior to liftoff. They are also used following any pad abort situations, if they occur.

The OMI's are published by KSC for four basic purposes. These are:

- To provide the sequence of operations required to prepare the Shuttle for launch
- To service certain propellants and gasses to the Shuttle for launch
- To launch the Shuttle
- To perform initial pad safing after launch and provide for turnaround operations

There are several OMI volumes. S0007, volumes 1 through 5, are the primary controlling task documents. A number of subtask OMI documents are called by S0007 to perform various specialized tasks. For the Booster section, these subtask OMI's are G3151, G3251, S1003, S1004, and V9018. The subtask OMI's run concurrently with the S0007 series, VL1 - VL5. In addition, there is one OMI dedicated to Terminal Countdown Demonstration Tests (TCDT's), not used for flight launches, known as S0017.

These OMI sets are composed of 7 OMI's, or 11 volumes, counting S0007 as 5 volumes. S0007VL2 is the principal OMI used by both the MPS and ME operator in prelaunch.

The flow of prelaunch activities from S0007 is shown in figure 1.3.4-I. S0007 subtask OMI flows are shown in figure 1.3.4-II. A description of the information in each S0007, VL1-VL5, is shown in table 1.3.4-IV.

Prelaunch Cue Card

When you arrive on console, you can verify the MPS valves and switches are in the right configuration by comparing them to figure 1.3.4-III. These switch positions and valve states are displayed on MSK 1056, 1055, and 1054.

TABLE 1.3.4-I.- MPS AND ME PRELAUNCH CHECKLIST (1 OF 3)

****
ONLY UNCLASSIFIED DATA IS TO BE WRITTEN
ON THIS CHECKLIST SHEET
****

FLIGHT ______________________________

DATE/LAUNCH ATTEMPT # ______________________________

	PRELAUNCH	LAUNCH	ENTRY
BOOSTER			
MPS PRIME			
MPS OJT			
ME PRIME			
ME OJT			

SET UP / INITIALIZE CONSOLE

CONSOLE SET UP VIA (CHECK ONE) _____ MEGADATA _____ MASSCOMP

_____ CHECKPOINT FROM PREVIOUS LAUNCH ATTEMPT

****
** NOTE: BE SURE ME AND MPS LIMITS **
** ARE NOT SENT AT THE SAME TIME **
****

- IF MEGADATA USED ----

  WHICH MOC # __________ WHICH NRT # __________

- LIMITS LOADED __________ LIMITS VERIFIED __________

  WERE ANY TELEMETRY OVERRIDE PARAMETERS SENT?

  YES _____ NO _____

  IF YES, WHICH ONES? ______________________________

  ____

TABLE 1.3.4-I.- (2 OF 3)

● MOC CONSTANTS LOADED ____________	MOC CONSTANTS VERIFIED ____________
● COMPS LOADED ____________	COMPS VERIFIED ____________
● PLOTS LOADED ____________	PLOTS VERIFIED ____________
● DDD'S LOADED ____________	DDD ASSIGNMENT VERIFIED ____________ (right panel to displays)
	DDD LIGHT CHECK PERFORMED ____________

- NRT LOADED ________________

  (NOTE: NRT CANNOT BE SAVED THROUGH CHECKPOINTS LIKE LIMITS CAN, AND MUST BE RESET EVERY EVERY LAUNCH ATTEMPT)

- VOICE LOOPS OK ________________
- SMEK PANEL KEYS OK ________________
- DISPLAYS OK ________________

MPS & ME DISPLAYS

1056 PRELAUNCH ________
1057 ENTRY ________
1064 (1065) BFS ________

MPS ONLY

0606 PYROS/PICS ________
1054 PRIME ASCENT ________
1055 BILEVEL ________
HELIUM PLOTS ________

ME ONLY

1052 PRIME ASCENT ________
1069 SSME FID ________
UP 2759-2766 ________

- RTDS OK ________________
- STRIP CHARTS OK ________________

DID YOU CALL IN ANY PROBLEMS WITH CONSOLE SET UP?

CHECK VEHICLE STATUS AFTER ARRIVAL ON CONSOLE

LCC VIOLATIONS -------------------

FLIGHT EQUIPMENT MALFUNCTIONS -----------

ANOMALIES/OTHER ------------------

TABLE 1.3.4-I.- (3 OF 3)

REVIEW RELEVANT FRR DATA PAK ITEMS

REVIEW IPR LIST

ARE ALL THE FOLLOWING DOCUMENTS AVAILABLE

SODB -
OMI'S -
FLIGHT RULES -

FDF -
PHONE LIST -
MPS COMPONENTS MANUAL -

SYSTEM'S BRIEFS -
SCP'S -
SOFTWARE HANDBOOK -

LCC LIST -
ET BOOKS (BLUE BOOKS) -
STS LOG BOOKS (FROM THE LAST FLIGHT OF THAT VEHICLE AND THE LAST FLIGHT) -

STS MPS BLUE BOOKS -
SSME CONTROLLER S/W BOOK -
PART I/II CEI SPEC -

TABLE 1.3.4-II.- MPS LIMITS

			PRELAUNCH		LAUNCH		SRB SEP		ET SEP		ABORT	
			LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
1	B46P1305C	L FUEL SUP MOD PR A										
2	B46P1306C	L FUEL SUP MOD PR B										
3	B46P2305C	R FUEL SUP MOD PR A										
4	B46P2306C	R FUEL SUP MOD PR B										
5	B46R1406C	L HPU A TURB SP 1										
6	B46R1407C	L HPU B TURB SP 1										
7	B46R1408C	L HPU A TURB SP 2										
8	B46R1409C	L HPU B TURB SP 2										
9	B46R2406C	R HPU A TURB SP 1										
10	B46R2407C	R HPU B TURB SP 1										
11	B46R2408C	R HPU A TURB SP 2										
12	B46R2409C	R HPU B TURB SP 2										
13	B47P1300C	L SRB PC 1										
14	B47P1301C	L SRB PC 2										
15	B47P1302C	L SRB PC 3										
16	B47P2300C	R SRB PC 1										
17	B47P2301C	R SRB PC 2										
18	B47P2302C	R SRB PC 3										
19	B58P1303C	L HYD SUP PR A										
20	B58P1304C	L HYD SUP PR B										
21	B58P2303C	R HYD SUP PR A										

TABLE 1.3.4-II.- Continued

			PRELAUNCH		LAUNCH		SRB SEP		ET SEP		ABORT	
			LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
22	B58P2304C	R HYD SUP PR B										
23	M01G3111C	NPSP C										
24	M01G3706C	LH2 ULL PR C										
25	M01G3800C	HE DEPL RATE C										
26	M02G3111C	NPSP L										
27	M02G3706C	LH2 ULL PR L										
28	M02G3800C	HE DEPL RATE L										
29	M03G3111C	NPSP R										
30	M03G3706C	LH2 ULL PR R										
31	M03G3800C	HE DEPL RATE R										
32	M04G3111C	NPSP AVE										
33	M04G3800C	HE DEPL RATE PN										
34	M05G3800T	HE TOD C										
35	M06G3800T	HE TOD L										
36	M07G3800T	HE TOD R										
37	M08G3800T	HE TOD PN										
38	M09G3800T	TOD WITH PNUE C										
39	M10G3800T	TOD WITH PNUE L										
40	M11G3800T	TOD WITH PNUE R										
41	M12G3800T											
42	M13G3800T											

TABLE 1.3.4-II.- Continued

			PRELAUNCH		LAUNCH		SRB SEP		ET SEP		ABORT	
			LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
43	M14G3800T											
44	T41P1700C	LH2 ULL PR C										
45	T41P1701C	LH2 ULL PR L										
46	T41P1702C	LH2 ULL PR R										
47	T41P1750C	LO2 ULL PR C										
48	T41P1751C	LO2 ULL PR L										
49	T41P1752C	LO2 ULL PR R										
50	V41P1100C	LH2 INLET PR C										
51	V41P1130C	LO2 INLET PR C										
52	V41P1150C	HE TANK PR C										
53	V41P1153A	HE REG B PR C										
54	V41P1154A	HE REG A PR C										
55	V41P1160A	GH2 OUTLET PR C										
56	V41P1200C	LH2 INLET PR L										
57	V41P1230C	LO2 INLET PR L										
58	V41P1250C	HE TANK PR L										
59	V41P1253A	HE REG B PR L										
60	V41P1254A	HE REG A PR L										
61	V41P1260A	GH2 OUTLET PR L										
62	V41P1300C	LH2 INLET PR R										
63	V41P1330C	LO2 INLET PR R										

TABLE 1.3.4-II.- Continued

			PRELAUNCH		LAUNCH		SRB SEP		ET SEP		ABORT	
			LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
64	V41P1350C	HE TANK PR R										
65	V41P1353A	HE REG B PR R										
66	V41P1354A	HE REG A PR R										
67	V41P1360A	GH2 OUTLET PR R										
68	V41P1433C	LH2 MANI PR										
69	V41P1490A	GH2 DISC PR										
70	V41P1533C	LO2 MANI PR										
71	V41P1590A	GO2 DISC PR										
72	V41P1600A	HE TANK PR PN										
73	V41P1605A	HE REG A PR PN										
74	V41P1650A	PN ACC PR										
75	V41T1101C	LH2 INLET TEMP C										
76	V41T1131C	LO2 INLET TEMP C										
77	V41T1151A	HE TANK TEMP AFT C										
78	V41T1152A	HE TANK TEMP MID C										
79	V41T1161A	GH2 OUT TEMP C										
80	V41T1171A	GO2 OUT TEMP C										
81	V41T1201C	LH2 IN TEMP L										
82	V41T1231C	LO2 INLET TEMP L										
83	V41T1251A	HE TANK TEMP AFT L										
84	V41T1252A	HE TANK TEMP MID L										

TABLE 1.3.4-II.- Concluded

			PRELAUNCH		LAUNCH		SRB SEP		ET SEP		ABORT	
			LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
85	V41T1261A	GH2 OUT TEMP L										
86	V41T1271A	GO2 OUT TEMP L										
87	V41T1301C	LH2 IN TEMP L										
88	V41T1331C	LO2 INLET TEMP R										
89	V41T1351A	HE TANK TEMP AFT R										
90	V41T1352A	HE TANK TEMP MID R										
91	V41T1361A	GH2 OUT TEMP R										
92	V41T1371A	GO2 OUT TEMP R										
93	V41T1601A	HE TANK TEMP MID PN										
94	V98P1740C	BFS-L SRB PC										
95	V98P1741C	BFS-R SRB PC										
96	V98P2130C	LOX ULL PR #1 IN BFS										
97	V98P2140C	BFS-LH2 V11 PRESS										
98	V98P2155C	BFS-HE TK PRESS C										
99	V98P2156C	BFS-HE TK PRESS L										
100	V98P2157C	BFS-HE TK PRESS R										
101	V98P4997C	TANK CHG RATE C										
102	V98P4998C	TANK CHG RATE L										
103	V98P4999C	TANK CHG RATE R										

TABLE 1.3.4-III.- ME LIMITS

ME LIMITS STS-XX *			PRELAUNCH		LAUNCH		SRB SEP		ET SEP		ABORT	
			LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
1	E41P1008B	C HPFP COOLANT PA										
2	E41P1009B	C HPFP COOLANT PB										
3	E41P1014B	C HPOT ISP PA										
4	E41P1015B	C HPOT ISP PB										
5	E41P1016B	C PC A										
6	E41P1017B	C PC B										
7	E41P1018B	C LPFT DSCH P										
8	E41P1023B	C PC AVG										
9	E41P1030B	C HPOT D P *										
10	E41P1051B	C HPOT SSL PA										
11	E41P1053B	C HPOT SSL PB										
12	E41P1054B	C HYD SYS P										
13	E41P2008B	L HPFP COOLANT PA										
14	E41P2009B	L HPFP COOLANT PB										
15	E41P2014B	L HPOT ISP PA										
16	E41P2015B	L HPOT ISP PB										
17	E41P2016B	L PC A										
18	E41P2017B	L PC B										
19	E41P2018B	L LPFT DSCH P										
20	E41P2023B	L PC AVG										

TABLE 1.3.4-III.-Continued

ME LIMITS STS-XX			*	PRELAUNCH		LAUNCH		SRB SEP		ET SEP		ABORT	
				LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
21	E41P2030B	L HPOT D P	*										
22	E41P2051B	L HPOT SSL PA											
23	E41P2053B	L HPOT SSL PB											
24	E41P2054B	L HYD SYS P											
25	E41P3008B	R HPFP COOLANT PA											
26	E41P3009B	R HPFP COOLANT PB											
27	E41P3014B	R HPOT ISP PA											
28	E41P3015B	R HPOT ISP PB											
29	E41P3016B	R PC A											
30	E41P3017B	R PC B											
31	E41P3018B	R LPFT DSCH P											
32	E41P3023B	R PC AVG											
33	E41P3030B	R HPOT D P	*										
34	E41P3051B	R HPOT SSL PA											
35	E41P3053B	R HPOT SSL PB											
36	E41P3054B	R HYD SYS P											
37	E41R1021B	C FU FLOW GPM											
38	E41R1022B	C OX FLOW GPM											
39	E41R2021B	L FU FLOW GPM											
40	E41R2022B	L OX FLOW GPM											

TABLE 1.3.4-III.- Continued

ME LIMITS		STS-XX	*	PRELAUNCH		LAUNCH		SRB SEP		ET SEP		ABORT	
				LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
41	E41R3021B	R FU FLOW GPM											
42	E41R3022B	R OX FLOW GPM											
43	E41T1010B	C HPFT TD TA	*										
44	E41T1011B	C HPFT TD TB	*										
45	E41T1012B	C HPOT TD TA	*										
46	E41T1013B	C HPOT TD TB	*										
47	E41T1019B	C LPFT DSCH T											
48	E41T1020B	C POP DISCHT											
49	E41T2010B	L HPFT TD TA	*										
50	E41T2011B	L HPFT TD TB	*										
51	E41T2012B	L HPOT TD TA	*										
52	E41T2013B	L HPOT TD TB	*										
53	E41T2019B	L LPFT DSCH T											
54	E41T2020B	L POP DISCHT											
55	E41T3010B	R HPFT TD TA	*										
56	E41T3011B	R HPFT TD TB	*										
57	E41T3012B	R HPOT TD TA	*										
58	E41T3013B	R HPOT TD TB	*										
59	E41T3019B	R LPFT DSCH T											
60	E41T3020B	R POP DISCHT											

TABLE 1.3.4-III.- Continued

ME LIMITS STS-XX *			PRELAUNCH		LAUNCH		SRB SEP		ET SEP		ABORT	
			LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
61	M01G3101C	C OX FLOW RT										
62	M01G3103C	C FU FLOW RT										
63	M01G3107C	OVERALL MIX RATIO										
64	M01G3111C	*** MPS ***										
65	M01G3701C	C PWLV-CM										
66	M01G3702C	C HPFT TD TDELTA										
67	M01G3706C	*** MPS ***										
68	M01G3800C	*** MPS ***										
69	M02G3101C	L OX FLOW RT										
70	M02G3103C	L FU FLOW RT										
71	M02G3107C	C MIX RATIO										
72	M02G3110T	*** NO LONGER USED ***										
73	M02G3111C	*** MPS ***										
74	M02G3701C	L PWLV-CM										
75	M02G3702C	L HPFT TD TDELTA										
76	M02G3706C	*** MPS ***										
77	M02G3800C	*** MPS ***										
78	M03G3101C	R OX FLOW RT										
79	M03G3103C	R FU FLOW RT										
80	M03G3107C	L MIX RATIO										

TABLE 1.3.4-III.- Continued

	ME LIMITS	STS-XX *	PRELAUNCH		LAUNCH		SRB SEP		ET SEP		ABORT	
			LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
81	M03G3110T	*** NO LONGER USED ***										
82	M03G3111C	*** MPS ***										
83	M03G3701C	R PWLV-CM										
84	M03G3702C	R HPFT TD TDELTA										
85	M03G3706C	*** MPS ***										
86	M03G3800C	*** MPS ***										
87	M04G3101C	TOT OX FLOW RT										
88	M04G3103C	TOT FU FLOW RT										
89	M04G3107C	R MIX RATIO										
90	M04G3111C	*** MPS ***										
91	M04G3702C	C HPOT TD TDELTA										
92	M04G3800C	*** MPS ***										
93	M05G3702C	L HPOT TD TDELTA										
94	M05G3800T	*** MPS ***										
95	M06G3702C	R HPOT TD TDELTA										
96	M06G3800T	*** MPS ***										
97	M07G3702C	C HPOT ISP PDELTA										
98	M07G3800T	*** MPS ***										
99	M08G3702C	L HPOT ISP PDELTA										
100	M08G3800T	*** MPS ***										

TABLE 1.3.4-III.- Concluded

ME LIMITS STS-XX *		PRELAUNCH		LAUNCH		SRB SEP		ET SEP		ABORT	
		LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
101 M09G3702C	R HPOT ISP PDELTA										
102 M09G3800T	*** MPS ***										
103 M10G3702C	C HPOT SEC SL PDELTA										
104 M10G3800T	*** MPS ***										
105 M11G3702C	L HPOT SEC SL PDELTA										
106 M11G3800T	*** MPS ***										
107 M12G3702C	R HPOT SEC SL PDELTA										
108 M12G3800T	*** MPS ***										
109 M13G3702C	C PC DELTA										
110 M13G3800T	*** MPS ***										
111 M14G3702C	L PC DELTA										
112 M14G3800T	*** MPS ***										
113 M15G3702C	R PC DELTA										
114 M16G3702C	C HPFT C LN PDELTA										
115 M17G3702C	L HPFT C LN PDELTA										
116 M18G3702C	R HPFT C LN PDELTA										
117 V98P2100C	C PC										
118 V98P2110C	L PC										
119 V98P2120C	R PC										

* - These parameters are flight dependent

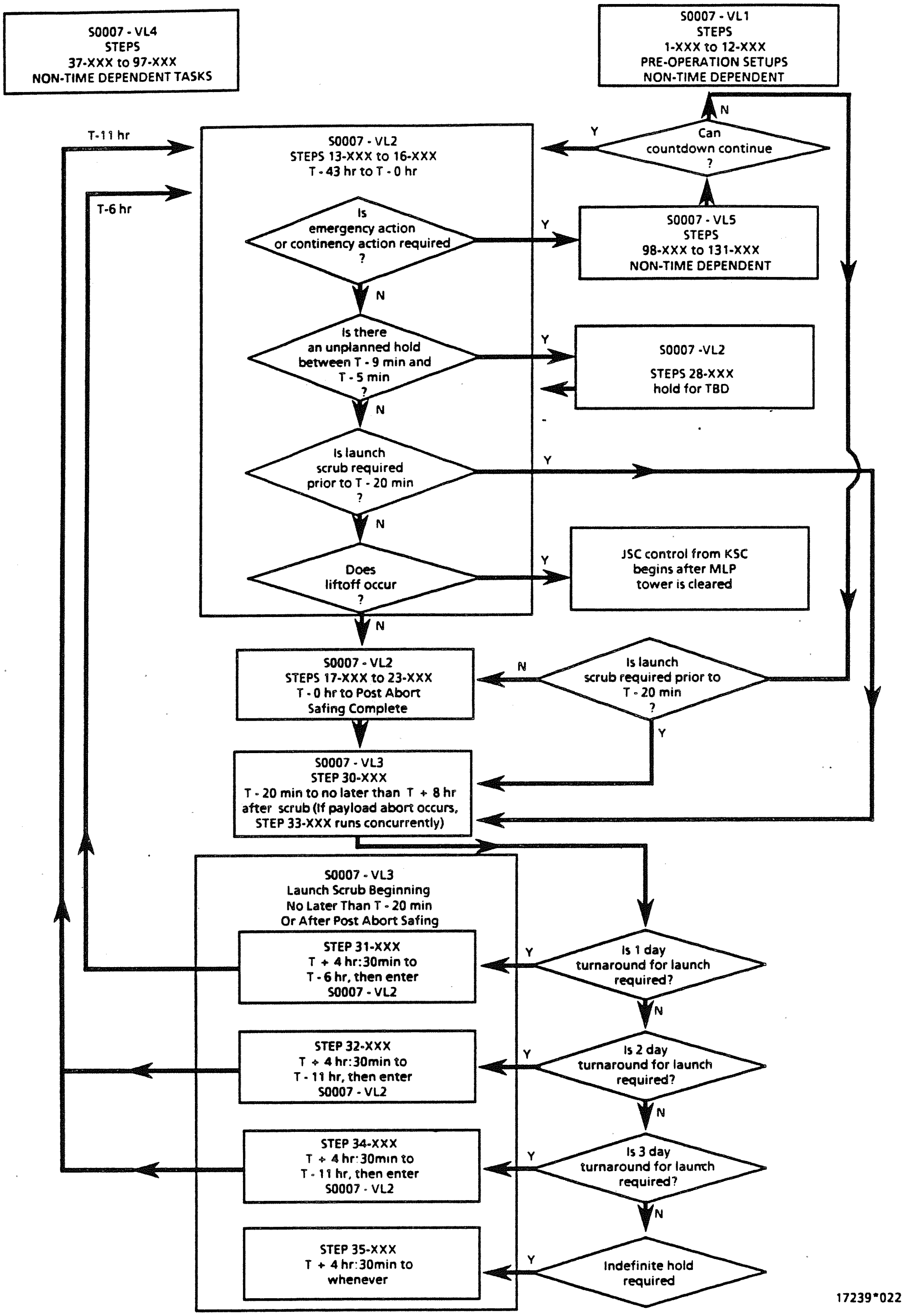


Figure 1.3.4-I.- S0007 launch flow.

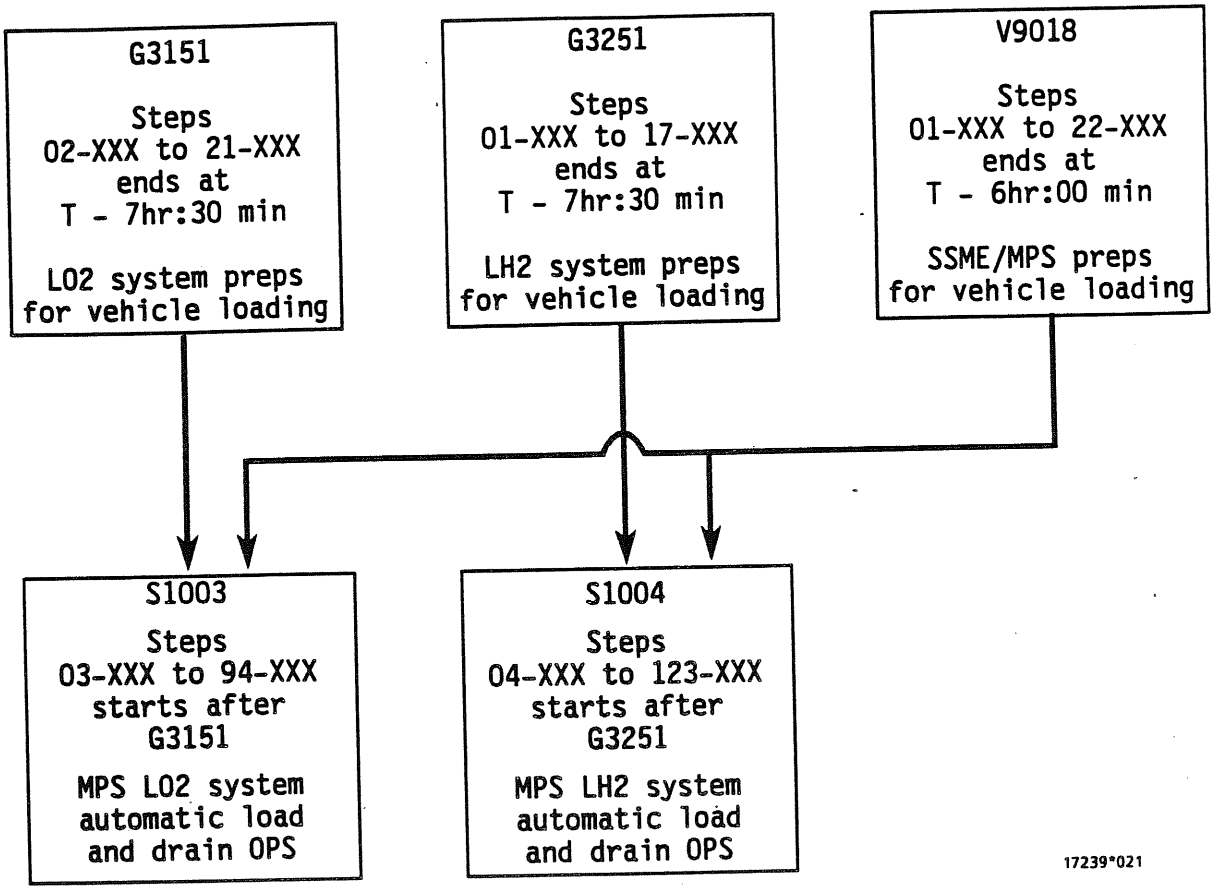


Figure 1.3.4-II.- S0007 subtask OMI flows.

TABLE 1.3.4-IV.- S0007 DESCRIPTIONS

S0007 - VL1

Pre-Operation Setups For GSE,
Orbiter, ET, SRB, Payloads

Steps		Function	Time Period
Begin	End		
1-XXX	12-XXX	Generic Pre-Operation	N/A

S00007 - VL2

Operation Timeline for GSE,
Orbiter, ET, SRB, Payloads.
Launch Timeline, RSLS Abort,
RSLS Hold, BFS Engaged Abort,
SRB Holdfire, Unplanned Hold
Before T - 5 minutes, Recycle
Control Sequence

Steps		Function	Time Period
Begin	End		
13-XXX	16-XXX	Nominal Launch Timeline	T - 43 hours to T - 0
17-XXX	23-XXX	Launch Abort Or Post Launch	T - 0 to Post Launch/Abort Safing
24-XXX	27-XXX	Reserved	N/A
28-XXX	28-XXX	Prelaunch Hold Option 1 - Unplanned Long Hold	T - 9 Minutes to T - 5 minutes
29-XXX	29-XXX	Reserved	N/A

S0007 - VL3

Launch Abort Scrub And Turnaround

Steps Begin	Steps End	Function	Time
30-XXX	30-XXX	Nominal Launch Scrub	T - 20 Minutes to T + 8 Hours
31-XXX	31-XXX	Launch Scrub And 24 Hour Turnaround	T + 4hr:30min to T - 6 Hours
32-XXX	32-XXX	Launch Scrub And 48 Hour Turnaround	T + 4hr:30min to T - 11 Hours
33-XXX	33-XXX	Launch Scrub For Payload Reasons Only - 24, 48, 72 Hour Turnarounds	N/A - Whenever It Happens
34-XXX	34-XXX	Launch Scrub And 72 Hour Turnaround	T - 4hr:30min to T - 11 Hours
35-XXX	35-XXX	Launch Scrub - Indefinite Hold	T - 4hr:30min to Whenever
36-XXX	36-XXX	Reserved	N/A

S0007 VL4

PreLaunch And PostLaunch System And Subsystem Tests. Tests Outside Standard Timelines With No Attached Time Tags.

Steps Begin	Steps End	Function	Time
37-XXX	97-XXX	System And Subsystem Tests	N/A

Specifics Of Interest:

Step	Function
41	ET level sensor cal. checks
44	MPS helium tank load GSE and LH2/LO2 prepress
48	SRB/ET PIC resistance tests
57	ice frost inspection
60	ET GH2 vent retract system config
71	SRB power on/off contingency
74	SRB aft skirt GN2 purge

S0007 - VL5

Preplanned Contingency Actions To Provide Workarounds To Enable A Launch To Continue
&
Emergency Instructions To Safe And Secure Vehicle, MLP, GSE, And Flight Crew

Steps		Function	Time
Begin	End		
98-XXX	131-XXX	Contingency Actions & Safe & Secure Functions	N/A

PRELAUNCH 02-26-90

PRE-CRYO LOADING

RTLS V	HELIUM	L	C	R	P
IB O	ISO A O	O	O	O	O
OB O	ISO B O	O	O	O	O
	INT IN O				
P1 O	INT OT O				
P2 O	XVR/BD12				

Q	LO2			LH2		
PV OP O				O	O	O
PV CL X	X	X	X			
FD DSC	OO			OO		
FD LATCH	**			**		
FD RIS O						
IB F/D X						
OB F/D X		X			X	
MN P1/2O		/			/	
OVB/TOPX					X	
R DSC X						
P LN V O						
POGO1/2O						

MNA → APC4 → ALC1
MNB → APC5 → ALC2
MNC → APC6 → ALC3

COCKPIT SWITCH LIST
(Pre-Ingress)

Manifold Repress (2) - GPC
F/D Valves (4) - GND
Prevalves (6) - GPC
Feedline Rel Iso (2) - GPC
He Iso Valves (7) - GPC
Pneu Xover Valve - GPC
He Interconnect Valves (3) - GPC
Eng He Bottles @ 1800-2200 psia
Eng He Reg Out Press @ 730-785 psia
Pneu He Reg Out Press @ 715-785 psia

SUBSEQUENT TO PURGE SEQ. 3
LO2 P/V - OPEN

LO2 CHILLDOWN
LO2 Outboard F/D - OPEN
LO2 ECO Sensors Wet

LO2 DRAINBACK TO END OF FLUSH
LO2 ECO Sensors - Wet to Dry

LH2 CHILLDOWN & SLOW FILL TO ECOS
LH2 Outboard F/D - OPEN

LO2 SLOW FILL - ABOVE 2% (LO2 ULLAGE 2.0-8.0 PSIG)
LO2 ECO Sensors Wet

LH2 FAST FILL TO 85% - (WHEN 3 OF 4 ECO SENSORS WET)
LH2 ECO Sensors Wet
LH2 Topping Valve - OPEN
LH2 Ullage Press Band - (43.7-46.7 psia)
Temporarily Switch LH2 Ullage Press Trans 3 & 4 During Fast Fill

LO2 FAST FILL TO 98% - INITIATED 11 MINUTES AFTER 2%

(25 Min AFTER START OF LH2 FAST FILL)
LH2 Recirc Valves - OPEN
Start LH2 Recirc Pumps (10800-11800 RPM)
LH2 P/V's - CLOSE
LH2 Ullage Press Band - (37.2-48.2 psia)

FAST FILL PHASE COMPLETE - TRANSITION TO REDUCED FAST-FILL
LH2 Inboard F/D - CLOSE

LO2/LH2 TOPPING PHASE
98% Sensors Wet
Ullage Press Band - (LO2 - 00.0-17.1 psig; LH2 - 14.7-37.5 psia)

LO2/LH2 STABLE REPLENISH
100% Sensors Wet

SRB RGA BUS C POWER UP

LEGEND
X = Closed
O = Open
* = Latched closed
"blank" = Valve is not in the configuration specified in the nomenclature to the left of the valve state

Figure 1.3.4 - III.- MPS prelaunch.

MALFUNCTION
PROCEDURES/
RATIONALE

2

TITLE

PERFORMANCE LIMITING FAILURE CONDITIONS EVALUATION

CONDITION

Off-nominal space shuttle main engine (SSME) performance as indicated in the primary avionics software system (PASS) and backup flight system (BFS) downlists.

SUMMARY

This SCP describes the SSME performance dispersion failures and monitoring procedures required to evaluate off-nominal SSME performance. The corrected values for mixture ratio, specific impulse, and power level will be provided to the Flight Dynamics Officer (FDO) to adjust the abort region determinator (ARD) in the flight control room (FCR). The ARD is used by the FDO to evaluate the impact of off-nominal SSME performance on the abort boundaries, uphill capability, and second-stage performance.

The specific off-nominal levels given to the FDO are obtained from tables generated by the main engine table program. (Refer to SCP's 6.8 and 7.1.2.)

PROCEDURES

MAIN COMBUSTION CHAMBER PRESSURE (MCC Pc) SENSOR SHIFT LOW, ACTUAL HIGH

The MCC of the SSME contains four pressure sensing elements. These elements are installed as two sensor pairs.

An MCC Pc sensor shift low, actual high is caused by a shift low of one of the two MCC Pc sensor pairs. Typically, this will be caused by a shift low of a single sensing element of one pair. The SSME controller's Pc average is an overall average of both Pc pairs and is used in the thrust control loop. In the thrust control loop, the oxidizer preburner oxidizer valve (OPOV) is used to control Pc average. When valid Pc commands are received by the controller, the reference Pc is updated to the Pc commanded, and then compared to the measured Pc average. The controller matches Pc average to the reference Pc by sending position commands to the OPOV. For a Pc sensor shift low, the OPOV is commanded further open, the LO_2 flowrate increases. Because the combustion in the oxidizer preburner (OPB) is fuel rich (OPB mixture ratio is about 0.76), the increased LO_2 flow will allow more combustion with the fuel. As a result, the energy released by the combustion is increased which is converted into increased shaft power output of the turbine. The additional shaft power increases the volumetric output of the high pressure oxidizer pump causing more oxidizer to be injected into the MCC. This increases the actual MCC Pc. In this case, the actual power level and MCC mixture ratio are higher than nominal.

The SSME controller's engine status word (ESW) is used in many failure cases as a primary cue. It is important to note that Pc sensor shifts will not be reflected in the ESW. That is, the ESW <u>will not</u> change. Also, the crew has no insight into this failure mode.

The following example describes the failure effect of a Pc shift low, actual high. (Similar arguments can be made for a Pc shift high, actual low.) If the engine is operating nominally in a steady state condition at 104 percent power level, Pc average will equal 3126 psia. If one pair shifts low by 70 psia (Pc pair average = 3056 psi), that pair passes the sensor reasonableness test which requires each pair to be within ±75 psia of Pc reference for steady state conditions above 75-percent power level. All SSME sensors are required to pass a reasonableness test to qualify for use by the controller. Therefore, in this example, the shifted sensor pair is qualified and is then averaged with the good pair. The average in this case becomes

$$\frac{\overset{(Pc\,A)}{3126} + \overset{(Pc\,B)}{3056}}{2} = 3091\,psia$$

Notice that because the pairs are averaged, Pc average is below Pc reference by 35 psia or one-half of the sensor pair shift.

The engine should be in a steady state condition at the nominal mission power level in order to properly evaluate an MCC Pc shift. The nominal mission power level will usually be 104 percent (3126 psia). For this case, where the actual average Pc is below the reference Pc, the controller will command the OPOV to open further. As the OPOV opens, both Pc sensor pair averages will increase. When Pc average reaches 3126 psia (for 104 percent), the good pair will indicate 3161 psia (3126 + 35), and the shifted pair will indicate 3091 psia (3056 + 35). Therefore, Pc average will indicate a nominal value:

$$\frac{\overset{(Pc\,A)}{3161} + \overset{(Pc\,B)}{3091}}{2} = 3126\,psia$$

However, the engine will actually be operating at 3161 psia which is about 105 percent power level. Table 2.1.1-I (from the main engine table program) is used to determine the level of the off-nominal engine performance. The valid Pc is used to determine the level of the Pc shift. In this example, the valid Pc is 3161 psia; this falls between levels 1 and 2 in the table. For conservatism, level 2 is selected. The failure mode, the time the failure occurred, and the level number is given to the Flight Director and the FDO so that the ARD can be updated with the off-nominal engine performance.

This type of Pc shift is a high mixture ratio case. Therefore, the values for the actual power level and mixture ratio will be higher than the nominal values. The high mixture ratio is due to the increased LO_2 usage caused by increasing the open position of the OPOV. The fuel flowrate will remain constant because the SSME controller's mixture ratio control loop uses Pc

TABLE 2.1.1-I.- MCC PC SENSOR SHIFT LOW, ACTUAL HIGH

Pc Sensor(s) Shift Low, Actual High - 104 pct for STS-43

A. Recognition of failure (MR high, thrust high)
   1. | PcA - PcB | > 50
      (For single Pc sensor shift, use high Pc for level)
   2. HPOT DP increases (45 psia/25 psia Pc shift)
      (If both Pc sensors shift low, use HPOT for level)
   3. Case number - One Pc shift low N = 3
      - Both Pc's shift N = 11 (RIDS only)
   4. HPOT TD T increases (60° R/25 psia Pc shift)
   5. FPOV position does not change

Pc SHIFT TABLE - LEFT SSME

Level	Good Pc (psia)	HPOT DP	HPOT TD T		OPOV (pct)	MR	ISP (sec)	Power level (pct)	WDOTO (lb/sec)	Pc err
			A	B						
NOM	3126	3999	1331	1333	67.0	6.041	452.66	104.0	927.73	0
1	3151	4045	1389	1391	68.1	6.111	452.45	105.0	938.59	25
2	3176	4092	1453	1455	69.4	6.182	452.22	106.0	949.55	50
3	3201	4133	1518	1520	70.6	6.254	451.97	107.0	960.60	75
4	3226	4170	1536	1538	71.0	6.273	451.90	107.3	963.62	100

Pc SHIFT TABLE - CENTER SSME

Level	Good Pc (psia)	HPOT DP	HPOT TD T		OPOV (pct)	MR	ISP (sec)	Power level (pct)	WDOTO (lb/sec)	Pc err
			A	B						
NOM	3126	4020	1337	1327	66.7	6.041	452.66	104.0	927.73	0
1	3151	4066	1405	1385	67.8	6.111	452.45	105.0	938.59	25
2	3176	4113	1469	1449	69.1	6.182	452.22	106.0	949.55	50
3	3201	4154	1534	1514	70.3	6.254	451.97	107.0	960.60	75
4	3226	4191	1552	1532	70.7	6.273	451.90	107.3	963.62	100

Pc SHIFT TABLE - RIGHT SSME

Level	Good Pc (psia)	HPOT DP	HPOT TD T		OPOV (pct)	MR	ISP (sec)	Power level (pct)	WDOTO (lb/sec)	Pc err
			A	B						
NOM	3126	4033	1400	1410	68.1	6.041	452.66	104.0	927.73	0
1	3151	4079	1458	1468	69.2	6.111	452.45	105.0	938.59	25
2	3176	4126	1522	1532	70.5	6.182	452.22	106.0	949.55	50
3	3201	4167	1587	1597	71.7	6.254	451.97	107.0	960.60	75
4	3226	4204	1605	1615	72.1	6.273	451.90	107.3	963.62	100

average and LH_2 flowrate to calculate LO_2 flowrate (there is no LO_2 flowmeter). Since Pc average has been adjusted by the engine controller back to a nominal value, the calculated LO_2 flowrate and mixture ratio will be nominal. Remember, these <u>calculated</u> values are nominal, but the <u>actual</u> values will be higher than nominal. Failures resulting in high mixture ratios generally do not adversely affect the overall vehicle performance. The reason is that LO_2 is used at a higher than nominal rate which causes the vehicle weight to decrease at a faster than nominal rate. Thrust is also slightly increased with the higher actual power level.

In the mixture ratio control loop, the controller computes the inlet mixture ratio which is the ratio of the calculated inlet oxidizer mass flowrate to the inlet fuel mass flowrate. The nominal mixture ratio is approximately 6.0. The actual value loaded into the controller software may be changed preflight to optimize performance. The controller has LH_2 volumetric flow data from the LH_2 flowmeter, as well as the low pressure fuel pump (LPFP) discharge temperature and LPFP discharge pressure (DP). These LPFP measurements are upstream of the fuel flowmeter and are used to calculate the LH_2 density. This density is used with the volumetric flowrate to calculate the LH_2 mass flowrate. The LO_2 mass flowrate is calculated as a function of Pc and LH_2 flowrate. There is no LO_2 flowmeter because the high momentum flow environment has prevented the successful development of an LO_2 flowmeter. The LO_2 mass flowrate is divided by the LH_2 mass flowrate to determine the mixture ratio. If the calculated mixture ratio does not agree with the mixture ratio loaded into the controller, the controller will send commands to the fuel preburner oxidizer valve (FPOV) for mixture ratio correction. Normally, when the OPOV is opened to increase thrust, the FPOV will open slightly to increase the LH_2 flowrate to adjust mixture ratio back to the targeted value. In this case, with the Pc sensor shift, the calculated mixture ratio remains in agreement with the target mixture ratio. This is because the LH_2 mass flowrate and Pc average used to calculate LO_2 mass flowrate remain unchanged. Therefore, the FPOV will not be commanded open and the true mixture ratio will increase.

The engine data must be carefully assessed to identify a Pc sensor shift case. The primary data path (the first 32 words of the engine vehicle data table) must be available. Performance assessment is not possible if only the secondary engine data is available, or if the BFS is engaged. The engine must be in a steady state condition (i.e., not throttling) at the mission power level when the assessment is made. As discussed earlier, Pc average will be displayed as a nominal value, but one of the sensor pairs will be high, and the other low. The operator must evaluate the SSME operational data to determine which pair has shifted and in what direction. The operational data evaluated includes the HPOT DP, parameters are compared with the preflight predicted values to determine the actual Pc value.

In the above example, the actual Pc is higher than nominal. Increased HPOT turbine discharge (TD) temperatures (T's) are a cue, indicating increased MCC mixture ratio. Based upon Shuttle Operational Data Book (SODB) data, this temperature will increase 50° to 60° R for each 25-psia error (increase) in Pc. However, the operator must be aware that HPOT temperature is not always a dependable cue because if either high pressure pump or the low pressure oxidizer turbopump (LPOT) has been replaced prior to the flight, the preflight HPOT TD T predictions may be in error as much as 100° R (as seen on STS 51-C).

The HPOT DP is more predictable than the HPOT TD T's, since it is primarily a function of the resistance in the MCC. This measurement can be used to determine if the actual thrust is higher or lower than nominal. The actual engine power level can also be determined with this measurement. In the previous example, the HPOT DP and the actual power level will increase, indicating that the Pc is actually higher than normal; therefore, the low Pc pair is the erroneous pair. The HPOT DP increases approximately 45 psia for each 25-psia error (increase) in Pc. Table 2.1.1-II (from the main engine table program) can be used to determine the actual power level from HPOT DP.

Comparisons of the OPOV and FPOV positions with the preflight predictions are made to confirm the actual Pc value. However, just as with the HPOT turbine temperature, the preflight predictions of the valves may be in error. The error may indicate nominal performance or a 'worse-than-actual' off-nominal condition. For a Pc shift low, actual high, the OPOV will be open more than the nominal value. The OPOV will open an additional 1 percent, approximately, for each 25-psia error (decrease) in Pc. The FPOV position will not be influenced by a shift in the Pc transducer.

A good rule of thumb in evaluating MCC Pc sensor shifts is:

> The good Pc pair, HPOT DP, OPOV position, HPOT TD T, actual mixture ratio, and actual power level will all shift in the same direction.

A computation in the mission operations computer (MOC) calculates an absolute delta between the two Pc pairs. When the delta exceeds 40 psia, an event light illuminates to alert the console operator of possible off-nominal SSME operation. The 40-psia delta corresponds to a 20-psia error in Pc, which is just below the level-1 condition (25 psia). A 25-psia error was determined to be the smallest error that could be accurately identified. Since this is a relatively small error, the SSME operational parameters previously discussed must be used to determine which of the Pc pairs is erroneous. There is also a performance case computation in the MOC that determines what performance limiting case is present and displays a failure mode number for each case. This computation will help the operator in the initial analysis. Refer to SCP 3.1.6 for a detailed discussion.

Another function of this computation in the MOC uses the HPOT DP and HPOT TD T's to identify the Pc sensor shift low case from the high case. For the Pc shift low case all three parameters, HPOT DP and TD T's, must be indicating higher values than the preflight predicted values. The HPOT DP must be 20 psia and the HPOT TD T's must be 55° higher than the preflight predicted values. The computation determines the failure mode number and the mission elapsed time (MET) when the failure occurred. These are displayed on MSK's 1051 and 1052 to alert the operator of the failure mode.

TABLE 2.1.II LOCKUP TABLE

Lockup table - 104 for STS-43

Power level	Pc (psia)	MR	ISP (sec)	HPOT DP 2	HPOT DP 1	HPOT DP 3	HPPT CLIN R/L	MCC Pc R/L
109	3277	6.041	452.84	4221.8	4242.8	4255.8	3849	2877
108	3246	6.041	452.80	4177.2	4198.2	4211.2	3814	2846
107	3216	6.041	452.77	4132.7	4153.7	4166.7	3779	2816
106	3186	6.041	452.73	4088.1	4109.1	4122.1	3745	2786
105	3156	6.041	451.70	4043.6	4064.6	4077.6	3710	2756
104	3126	6.041	452.66	3999.0	4020.0	4033.0	3675	2726
103	3096	6.041	452.62	3954.4	3975.4	3988.4	3640	2696
102	3066	6.041	452.59	3909.9	3930.9	3943.9	3605	2666
101	3036	6.041	452.55	3865.3	3886.3	3899.3	3570	2636
100	3006	6.041	452.52	3820.8	3841.8	3854.8	3536	2606
99	2976	6.041	452.48	3776.2	3797.2	3810.2	3501	2576
98	2946	6.041	452.45	3731.6	3752.6	3765.6	3466	2546
97	2916	6.040	452.41	3687.1	3708.1	3721.1	3431	2516
96	2886	6.040	452.38	4642.5	3663.5	3676.5	3396	2486
95	2856	6.040	452.34	3597.9	3618.9	3631.9	3362	2456
94	2826	6.040	452.31	3553.4	3574.4	3587.4	3327	2426
93	2796	6.040	452.27	3508.8	3529.8	3542.8	3292	2396
92	2766	6.040	452.24	3464.3	3485.3	3498.3	3257	2366
91	2735	6.040	452.20	3419.7	3440.7	3453.7	3222	2335
90	2705	6.040	452.17	3375.1	3396.1	3409.1	3187	2305
------ Power levels 89 to 81 not shown ------								
80	2405	6.039	451.81	2929.5	2950.5	2963.5	2839	2005
79	2375	6.039	451.78	2885.0	2906.0	2919.0	2804	1975
78	2345	6.039	451.74	2840.4	2861.4	2874.4	2770	1945
77	2315	6.039	451.71	2795.8	2816.8	2829.8	2735	1915
76	2285	6.039	451.67	2751.3	2772.3	2785.3	2700	1885
75	2255	6.039	451.64	2706.7	2727.7	2740.7	2665	1855
74	2224	6.039	451.60	2662.1	2683.1	2696.1	2630	1824
73	2194	6.039	451.57	2617.6	2638.6	2651.6	2596	1794
72	2164	6.039	451.53	2573.0	2594.0	2607.0	2561	1764
71	2134	6.038	451.50	2528.5	2549.5	2562.5	2526	1734
70	2104	6.038	451.46	2483.9	2504.9	2517.9	2491	1704
69	2074	6.038	451.43	2439.3	2460.3	2473.3	2456	1674
68	2044	6.038	451.39	2394.8	2415.8	2428.8	2421	1644
67	2014	6.038	451.35	2350.2	2371.2	2384.2	2387	1614
66	1984	6.038	451.32	2305.7	2326.7	2339.7	2352	1584
65	1954	6.038	451.28	2261.1	2281.1	2295.1	2317	1554
64	1924	6.038	451.25	2216.5	2237.5	2250.5	2282	1524
63	1894	6.038	451.21	2172.0	2193.0	2206.0	2247	1494
62	1864	6.038	451.18	2127.4	2148.4	2161.4	2213	1464
61	1834	6.038	451.14	2082.8	2103.8	2116.8	2178	1434
60	1804	6.038	451.11	2038.3	2059.3	2072.3	2143	1404

TABLE 2.1.1-III.- PASS RECOGNITION OF FAILURE - Pc SENSOR SHIFT LOW, ACTUAL HIGH

Parameter no.	Failure value/trend	Displayed on
(PCΔ) (C) M13G3702C (L) M14G3702C (R) M15G3702C	Pc Δ light C(L,R) SSME - ON (limits set for 50-psia delta)	DDD (C) 281 (L) 282 (R) 283
(HPOT DP) (C) E41P1030B (L) E41P2030B (R) E41P3030B	HPOT DP increases 40 to 50 psia for each 25-psia discrepancy in Pc	MSK 1051 1052
(HPOT TD T A/B) (C) E41T1012/13B (L) E41T2012/13B (R) E41T3012/13B	HPOT TD T A/B increase 50° to 60° R for each 25-psia error in Pc (high mixture ratio)	MSK 1051 1052 2759 2760 2761
(OPOV) (C) E41H1028B (L) E41H2028B (R) E41H3028B	OPOV position will open further by approximately 1 percent for each 25-psia discrepancy in Pc	MSK 1051 1052
(N) (C) M02G3112C (L) M04G3112C (R) M06G3112C	MOC performance case number equals 3	MSK 1051 1052
(TN) (C) M08G3112C (L) M10G3112C (R) M12G3112C	MET the MOC performance case identified	MSK 1051 1052
(OMET) M40H0107J	Note time of failure	MSK 1051 1052
(Pc A, Pc B) (C) E41P1016/17B (L) E41P2016/17B (R) E41P3016/17B	Note higher Pc pair and determine performance level from table 2.1.1-I	MSK 1051 1052 2759 2760 2761

Note: There are no BFS failure recognitions.

A Pc shift, in one Pc pair, can be eliminated by powering off the erroneous Pc pair's channel (the bad channel). Once the failure mode, the time the failure occurred, and the failure level are given to the FDO, the Booster and the ME operators will determine if the bad channel can be powered off to improve engine performance. Powering off the bad channel will eliminate the bad Pc pair in the controller's Pc average calculation. Therefore, the remaining Pc pair average will become the controller's overall Pc average and the control loop will continue as previously discussed. The bad channel cannot be powered off if this will cause the engine to shut down or the engine to go into hydraulic or electric lockup. Causing an engine to go into lockup under these conditions will not improve performance because the engine will be stuck at the erroneous Pc level. If the Booster and the ME operators determine that the bad channel can be turned off, the off-nominal performance caused by the Pc shift will be eliminated. Once the bad channel is turned off, that engine will have only one channel remaining, and therefore, has lost redundancy. The AC bus sensors should then be taken "OFF" by the crew. Refer to SCP 2.1.2 for AC bus sensor procedure. A short on the AC bus could cause the remaining channel to halt, resulting in a pneumatic shutdown of the engine.

It is acceptable to create a command path failure by powering off the bad channel if nominal engine performance can be regained. This is due to the internal control loop of the SSME controller. Prior to turning off the bad channel, the controller has a valid command within its registers. Suppose, that a command path failure occurs when the bad channel is powered off. The last valid command is still present, therefore, the controller will use its internal control loop to maintain the proper mixture ratio and Pc. In this case, even though there is a command path failure, the engine is operating at the nominal Pc and mixture ratio. However, the command path failure will require additional activity. Refer to SCP 2.1.4 for these procedures.

It is important to emphasize that if the controller side containing the correct Pc pair is powered off instead of the side having the erroneous Pc pair, the Pc error will double and cannot be corrected. The crew has no insight into Pc shifts, so the bad channel to be powered down must be stated clearly. If the good channel is powered down, the engine will be using the erroneous Pc pair in the thrust control loop. Recall the previously discussed example. One sensor pair shifted low by 70 psia, but because the pair is averaged with the other good pair, the net error was 35 psia. The engine was actually operating at 35 psia above nominal with the erroneous pair at 3091 psia. Therefore, if the good pair is eliminated by turning off that side of the controller, the controller only has the erroneous pair to use in its control loop processing. Because that pair is indicating 3091 psia, the OPOV is adjusted to increase MCC Pc by another 35 psia to obtain the value of 3126 psia, doubling the Pc error. As a result, the level obtained in the table will also change, and the ARD must be updated with the new level. The effect on performance could result in requiring a manual shutdown of that engine. A summary of the Mission Control Center calls and the activity required for this case is presented in table 2.1.1-IV.

TABLE 2.1.1-IV.- Pc SENSOR SHIFT LOW, ACTUAL HIGH ACTIVITY

Step	Activity	Position
1	Report: "Pc shift low, actual high on C (L, R) engine; we are evaluating"	ME/BSE/FDO FD
2	Determine level of shift from table 2.1.1-I. After evaluation, report: "Pc shift low, actual high; level ______, at ______ (time); that is a high mixture ratio case."	ME/BSE/FDO FD/crew
3	Verify erroneous Pc pair, identify AC switch that powers the erroneous side of the controller, and determine if AC powerdown is acceptable. Report: "Bad channel is C (L, R) AC _____; we can/cannot turn the bad channel off"	ME/BSE/FDO FD/crew
4	If bad channel can be powered down, Report/verify: "C (L, R) engine, AC ____" If bad channel cannot be powered down, Report: "Engine will _____ (S/D, lockup, etc.)"	ME/BSE/FDO FD/crew
5	If FDO predicts loss of ATO capability, and requests channel power down, Report: "C (L, R) engine, AC _____, OFF"	ME/BSE FD/crew
6	If controller channel powered off, Report: "Loss of controller redundancy, AC bus sensors - OFF"	ME/BSE FD/crew

Additional facts concerning how different levels of Pc average errors occur should be reviewed. Recall that Pc average is the average of two sensor pairs that must pass reasonableness tests. There is actually one sensor per channel and two sense bridges per sensor. These two bridges are commonly referred to as a Pc pair. The two bridges in a Pc pair must be within ±75 psia of each other. This is known as the Pc comparison test. Therefore, the worst shift allowed for a single bridge in a pair is 75 psia. Because four bridges (two pairs) are averaged together, Pc average will be in error by only 18.75 psia, or one-fourth of the shift:

delta average:

$$\frac{\underset{75/2}{Pc\,A} + \underset{0/2}{Pc\,B}}{2} = 18.75\,psia$$

As a result, level 1 in table 2.1.1-I is the worst case level for a shift in a single bridge of a pair. When the individual bridges in both pairs are qualified, the pairs must pass a qualification test. Both pair averages must be within ±75 psia of the reference Pc for steady state operation at power levels above 75 percent. If the engine is throttling or is in steady state operation at less than 75-percent power level, both pair averages must be within 200 psia of the reference Pc. If both pairs pass the reasonableness tests, the pairs are averaged to determine Pc average for use in the thrust control loop. If one Pc pair shifts 75 psia, Pc average will be in error by 37.5 psia, or one-half of the shift:

delta from Pc ref:

$$\frac{\underset{75}{Pc\,A} + \underset{0}{Pc\,B}}{2} = 37.5\,psia$$

As a result, level 2 in table 2.1.1-I is the worst case level for a single pair that has shifted and passed the reasonableness test. A level-3 shift could occur when the erroneous pair is active with the good pair eliminated (AC bus failure) or if both sensor pairs shift in the same direction (both Pc pairs shift 75 psia). Lower levels are possible if the shift occurs slowly, giving the controller time to react to the shift by adjusting the performance. If both Pc pairs fail the reasonableness test, the engine will go into electrical lockup. This situation is discussed later in this SCP under ELECTRICAL LOCKUP.

Recall that failures resulting in high mixture ratios, such as a Pc sensor shift low, actual high do not adversely affect the overall vehicle performance since the weight decreases at a faster than nominal rate. The thrust will also be higher in these cases.

The relevant Flight Rules for this section are

<u>Flight Operation Rules - Ascent</u>
2-27, ARD UPDATE CRITERIA

<u>Booster, SSME Systems Management</u>
5-35, ENGINE PERFORMANCE DISPERSION

MCC PC SENSOR SHIFT HIGH, ACTUAL LOW

This failure is is due to both Pc sensor pairs shifting low. The failure signature for this failure is identical to the case described above (one Pc sensor shift low) except the HPOT DP must be used to determine the operating power level of the SSME and the level number. The HPOT TD T's and OPOV readings are used in conjunction with the HPOT DP to determine the level number. Tables 2.1.1-I through IV are to be used to evaluate and report the SSME operation. Steps 3 through 6 in table 2.1.1-IV, powering an SSME AC down, are not performed for this case, since both Pc sensors have shifted. Flight rules for the previous section apply for this section.

MCC PC SENSOR SHIFT HIGH, ACTUAL LOW

This failure is caused by a shift high of one Pc sensor pair. The thrust and mixture ratio control logic for this failure is similar to the Pc shift low case. The only difference is that, in the shift high case, the relevant parameters required for the evaluation, such as OPOV position, HPOT TD T's, HPOT DP, and the good Pc pair, are lower than nominal (shift high, actual low). While in the shift low case, the actual values for these parameters were higher than nominal (shift low actual high). Therefore, the actual values for mixture ratio and power level in the shift high, actual low case will be less than their nominal values. In the shift high, actual low case, low mixture ratio means that LO_2 is consumed at a lower than nominal rate. Therefore, more LO_2 than normal remains in the tank and the vehicle must carry this weight longer during ascent. With this in mind, it is evident that a Pc shift high, actual low (low mixture ratio) can result in significant loss of vehicle performance.

As stated earlier a good rule of thumb in evaluating MCC Pc sensors shifts is:

> The good Pc pair, HPOT DP, OPOV position, HPOT TD temperatures, actual mixture ratio, and actual power level will all shift in the same direction.

Table 2.1.1-V (from the main engine table program) is used in evaluating this type of Pc shift. This table is used in the same manner as described for the Pc shift low case. The performance degradation from a level 1 or 2 case generally does not affect vehicle performance enough to require any action. A level-3 Pc shift can sometimes require the controller channel with the erroneous Pc pair to be powered off to correct the performance degradation (significance of the * in table 2.1.1-V). Because of the reasonableness and comparison test, the engine will probably lockup electrically before a level 4 shift can be reached. Either table 2.1.1-V or table 2.1.1-II can be used to obtain the actual power level using HPOT DP. A summary of the failure signature for this case is presented in table 2.1.1-VI.

Remember, the crew has no insight into this type of failure and the SSME controller's ESW will not change. A summary of the Mission Control Center calls and the activity required for this case is presented in table 2.1.1-VII.

The relevant Flight Rules for this section are

Flight Operation Rules - Ascent
2-27, ARD UPDATE CRITERIA

Booster, SSME Systems Management
5-35, ENGINE PERFORMANCE DISPERSION

TABLE 2.1.1-V.- MCC Pc SENSOR SHIFT HIGH, ACTUAL LOW

Pc Sensor(s) Shift High, Actual Low - 104 percent for STS-43

A. Recognition of failure (MR low, thrust low)
   1. | PcA - PcB | > 50 ;
      (For single Pc sensor shift, use low Pc for level)
   2. HPOT DP decreases (45 psia/25 psia Pc shift)
      (If both Pc sensors shift high, use HPOT DP for level)
   3. Case number - One Pc shift high N = 4
      - Both Pc's shift N = 12 (RIDS only)
   4. HPOT TD T decreases (50° R/25 psia Pc shift)
   5. FPOV position does not change

Pc SHIFT TABLE - LEFT SSME

Level	Good Pc (psia)	HPOT DP	HPOT TD T		OPOV (pct)	MR	ISP (sec)	Power level (pct)	WDOTO (lb/sec)	Pc err
			A	B						
NOM	3126	3999	1331	1333	67.0	6.041	452.66	104.0	927.73	-0
1	3101	3953	1279	1281	66.2	5.971	452.85	103.0	916.96	-25
2	3076	3909	1229	1231	65.4	5.903	453.02	102.0	906.35	-50
*3	3051	3863	1182	1184	64.7	5.835	453.15	101.0	895.83	-75
4	3026	3819	1136	1138	64.0	5.768	453.25	100.1	885.47	-100
5	3001	3775	1093	1095	63.3	5.702	453.29	99.1	875.29	-125
6	2976	3732	1052	1054	62.7	5.636	453.30	98.1	865.20	-150
7	2951	3689	1013	1015	62.0	5.571	453.30	97.2	855.17	-175
8	2926	3646	977	979	61.4	5.507	453.28	96.2	845.19	-200

Pc SHIFT TABLE - CENTER SSME

Level	Good Pc (psia)	HPOT DP	HPOT TD T		OPOV (pct)	MR	ISP (sec)	Power level (pct)	WDOTO (lb/sec)	Pc err
			A	B						
NOM	3126	4020	1347	1333	66.7	6.041	452.66	104.0	927.73	-0
1	3101	3974	1295	1275	65.9	5.971	452.85	103.0	916.96	-25
2	3076	3930	1245	1225	65.1	5.903	453.02	102.0	906.35	-50
*3	3051	3884	1198	1178	64.4	5.835	453.15	101.0	895.83	-75
4	3026	3840	1152	1132	63.7	5.768	453.25	100.1	885.47	-100
5	3001	3796	1109	1089	63.0	5.702	453.29	99.1	875.29	-125
6	2976	3753	1068	1048	62.4	5.636	453.30	98.1	865.20	-150
7	2951	3710	1029	1009	61.7	5.571	453.30	97.2	855.17	-175
8	2926	3667	993	973	61.1	5.507	453.28	96.2	845.19	-200

TABLE 2.1.1-V.- Concluded

Pc SHIFT TABLE - RIGHT SSME

Level	Good Pc (psia)	HPOT DP	HPOT TD T		OPOV (pct)	MR	ISP (sec)	Power level (pct)	WDOTO (lb/sec)	Pc err
			A	B						
NOM	3126	4033	1400	1410	68.1	6.041	452.66	104.0	927.73	-0
1	3101	3987	1348	1358	67.3	5.971	452.85	103.0	916.96	-25
2	3076	3943	1298	1308	66.5	5.903	453.02	102.0	906.35	-50
*3	3051	3897	1251	1261	65.8	5.835	453.15	101.0	895.83	-75
4	3026	3853	1205	1215	65.1	5.768	453.25	100.1	885.47	-100
5	3001	3809	1162	1172	64.4	5.702	453.29	99.1	875.29	-125
6	2976	3766	1121	1131	63.8	5.636	453.30	98.1	865.20	-150
7	2951	3723	1082	1092	63.1	5.571	453.30	97.2	855.17	-175
8	2926	3680	1046	1056	62.5	5.507	453.28	96.2	845.19	-200

TABLE 2.1.1-VI.- PASS RECOGNITION OF FAILURE - Pc SENSOR SHIFT HIGH, ACTUAL LOW

Parameter no.	Failure value/trend	Displayed on
(Pc Δ) (C) M13G3702C (L) M14G3702C (R) M15G3702C	Pc Δ light C (L, R) SSME - ON (limits set for 50-psia delta)	DDD (C) 281 (L) 282 (R) 283
(HPOT DP) (C) E41P1030B (L) E41P2030B (R) E41P3030B	HPOT DP decreases 40 to 50 psia for 25-psia discrepancy in Pc	MSK 1052
(HPOT TD T A/B) (C) E41T1012/13B (L) E41T2012/13B (R) E41T3012/13B	HPOT TD T A/B decrease 50° to 60° R for each 25-psia discrepancy in Pc (low mixture ratio)	MSK 1052 2759 2760 2761
(OPOV) (C) E41H1028B (L) E41H2028B (R) E41H3028B	OPOV position will close further by approximately 1 percent for each 25-psia discrepancy in Pc	MSK 1052
(N) (C) M02G3112C (L) M04G3112C (R) M06G3112C	MOC performance case number equals 4	MSK 1052
(TN) (C) M08G3112C (L) M10G3112C (R) M12G3112C	MET the MOC performance case identified	MSK 1052
(OMET) M40H0107J	Note time of failure	MSK 1052
(Pc A, Pc B) (C) E41P1016/17B (L) E41P2016/17B (R) E41P3016/17B	Note lower Pc pair and determine performance level from table 2.1.1-V	MSK 1052 2759 2760 2761

Note: There are no BFS failure recognitions.

TABLE 2.1.1-VII.- Pc SENSOR SHIFT HIGH, ACTUAL LOW ACTIVITY

Step	Activity	Position
1	Report: "Pc shift high, actual low on C (L, R) engine; we are evaluating"	ME/BSE/FDO FD
2	Determine level of shift from table 2.1.1-V. After evaluation, report: "Pc shift high, actual low; level ______, at ______ (time); that is a low mixture ratio case."	ME/BSE/FDO FD/crew
3	Verify erroneous Pc pair, identify AC switch that powers the erroneous side of the controller and determine if AC powerdown is acceptable. Report: "Bad channel is C (L, R) AC _____; we can/cannot turn the bad channel off"	ME/BSE/FDO FD/crew
4	If bad channel can be powered down, Report/verify: "C (L, R) engine, AC ____" If bad channel cannot be powered down, Report: "Engine will _____ (S/D, lockup, etc.)"	ME/BSE/FDO FD/crew
5	If FDO predicts loss of ATO capability, and requests channel power down, Report: "C (L, R) engine, AC _____, OFF"	ME/BSE FD/crew
6	If controller channel powered off, Report: "Loss of controller redundancy, AC bus sensors - OFF"	ME/BSE FD/crew

MCC PC SENSORS SHIFT HIGH, ACTUAL LOW

This failure is due to both Pc sensor pairs shifting high. The failure signature for this failure is identical to the case described above (one Pc sensor shift high) except the HPOT DP must be used to determine the operating power level of the SSME and the level number. The HPOT TD T's and OPOV readings are used in conjunction with the HPOT DP to determine the level number. Table 2.1.1-II, and tables 2.1.1-V through 2.1.1-VII are used to evaluate and report the SSME operation. Steps 3 through 6 in table 2.1.1-VII, powering an SSME AC down, are not performed for this case since both Pc sensors have shifted. Flight rules for the previous section apply for this section.

ELECTRICAL LOCKUP

The SSME controller uses the LH_2 flowmeter transducers in the mixture ratio control loop, and the average of the MCC Pc transducer pairs are used in the thrust control loop. The LH_2 flowmeter and the MCC Pc operate with two channels for redundancy. The loss of both sensor channels of either the flowmeter or Pc will result in electrical lockup. The controller initiates lockup by deactivating the mixture ratio and thrust control loops. This is accomplished by maintaining the SSME valve actuators in closed loop control. The valves are controlled or maintained to the last valid commanded position. This action minimizes SSME valve drift. Valve drift is more likely to occur in the hydraulic lockup case, as is discussed later in this SCP under HYDRAULIC LOCKUP. An electrical lockup will be indicated in the ESW. The cause of the lockup (LH_2 flowmeter or MCC Pc) will be identified by the hard failure identifiers (FID's) displayed on MSK's 1051, 1052, 1069, and 1070.

When an engine is operating in electrical lockup, variations in engine performance can occur due to the effect of thermal stabilization and vehicle acceleration. Vehicle acceleration has the greater influence on performance. Three hot-fire tests were performed to evaluate SSME operation in electrical lockup. These tests are summarized in table 2.1.1-VIII.

TABLE 2.1.1-VIII.- SSME HOT-FIRE TEST RESULTS, ELECTRICAL LOCKUP CASES

Engine	Test no.	Power level (%)	Lockup time (sec)	Test duration (sec)	MR change
0005	901-206	95	250	300	unknown
0007	750-112	100	130	300	-0.02
2010	902-287	106	9.7	500	unknown

If the Pc sensors or flowmeter sensors fail slowly, it is possible that the sensors could be in error by a significant amount prior to being disqualified by the controller. Since the controller uses the last valid value reported by the sensor prior to disqualification, the engine could be locked up at an erroneous Pc or flowmeter value. This will result in off-nominal performance. Evaluation procedures of electrical lockups due to flowmeter and MCC Pc sensor failures are discussed in the following sections.

The relevant Flight Rules for this section are

<u>Flight Operation Rules - Ascent</u>
2-27, ARD UPDATE CRITERIA

<u>Booster, SSME Systems Management</u>
5-27B, LIMIT SHUTDOWN CONTROL
5-33, MANUAL SHUTDOWN FOR HYDRAULIC AND ELECTRICAL LOCKUP
5-34, MANUAL SHUTDOWN FOR TWO STUCK THROTTLES
5-35, ENGINE PERFORMANCE DISPERSION

1. Electrical Lockup Due To MCC Pc Sensor Error

An electrical lockup due to MCC Pc sensor failure occurs when the sensors have been disqualified by the controller. Refer to part A of this SCP for the qualification limit discussion. Recognition of this failure in the PASS is summarized in table 2.1.1-IX. Recognition in the BFS will be discussed later.

Once an engine goes into electrical lockup, a MOC performance computation will use HPOT DP to compute the actual Pc. The computation will use this calculation to compute the instantaneous mixture ratio and specific impulse. Refer to SCP 3.1.3 for details on this computation. Another MOC computation, known as main engine drift (MEDRIFT), adjusts the mixture ratio and power level for any SSME valve drift and vehicle acceleration effects. Outputs from the MEDRIFT computation represents the average flight performance values. Outputs from both these MOC computations are displayed on MSK 1052. The data used in the MEDRIFT computation are found in the SODB. The data consist of the performance parameters over a range of LO_2 inlet conditions that simulate acceleration effects.

When an engine is in lockup, variation in vehicle acceleration affects the overall performance because the valves cannot be repositioned to adjust Pc and flowrates. Also, because of the changing LO_2 inlet conditions, the HPOT efficiency may degrade which will further contribute to the performance drift.

Just as with MCC Pc sensor shifts, the ARD is updated for electrical lockup to account for any performance dispersions. The performance level is determined from table 2.1.1-X (from the main engine table program). Notice, there are three ranges of power levels: low, mid, and high. This is because the ME specific impulse varies with mixture ratio and power level. The engine power level must be determined from table 2.1.1-II using the HPOT DP. This is an important step because the average Pc displayed on

MSK's 1051 and 1052 will be the reference Pc at the time of lockup and may not reflect the actual Pc.

If the engine performance is changing with time (drifting), the MEDRIFT computation is used to predict the flight average performance level and is obtained from table 2.1.1-XI (from the main engine table program). The flight average performance level and flight average power level are given to the FDO for overall flight evaluation.

The Mission Control Center calls and the activity required for electrical lockups due to MCC Pc sensor failure in the PASS are summarized in table 2.1.1-XII.

TABLE 2.1.1-IX.- PASS RECOGNITION OF FAILURE - ELECTRICAL LOCKUP DUE TO Pc SENSOR FAILURES

Parameter no.	Failure value/trend	Displayed on
(ESW) (C) E41M1003P (L) E41M2003P (R) E41M3003P (ELEC HOLD) (C) M19G3708E (L) M20G3708E (R) M21G3708E	Electrical lockup flag set HEX ESW MCF ELE Last 2 digits 8E 8F	MSK 1052 DDD (C) 281 (L) 282 (R) 283 284
	MPS ELEC C (L, R) (class 3 alarm)	FML
(HARD FID) (C) E41M1005B (L) E41M2005B (R) E41M3005B	Hard failure ID R SEN FAIL - Pc (A OR B) PAIR	MSK 1052 1069 1070
(T FAIL) (C) M13G3000T (L) M14G3000T (R) M15G3000T	Note time of failure (T FAIL - 7 sec)	MSK 1052 1069 1070
(HPOT DP) (C) E41P1030B (L) E41P2030B (R) E41P3030B	Use HPOT DP for power level determination	MSK 1052
(N) (C) M02G3112C (L) M04G3112C (R) M06G3112C	MOC performance case number (N) equals 6	MSK 1052
(TN) (C) M08G3112C (L) M10G3112C (R) M12G3112C	MET the MOC performance case identified	MSK 1052
(MR) (C) M02G3107C (L) M03G3107C (R) M04G3107C (ISP) (C) M01G3112C (L) M03G3112C (R) M05G3112C	Note performance levels: Instantaneous: Table 2.1.1-X Flight average: Table 2.1.1-XI and MEDRIFT output	MSK 1052

TABLE 2.1.1-X.- LOCKUP TABLE

Electrical lockup - Pc sensor failure

A. Recognition of failure
   1. N = 6
   2. FML = MPS ELEC C(L,R)
   3. ESW ends in '8E' or '8F'
   4. FID: 011 'R SENS FAIL'
      (013 thru 016 - Pc A, B, or pair)

Hydraulic lockup

A. Recognition of failure
   1. N = 7
   2. FML = MPS HYD C(L,R)
   3. ESW ends in '92' or '93'
   4. FID: 015 ' SERVO ACT FAIL-'
      (01-12)

Flight average performance level

A. Recognition of failure

   1. N = 1, 2, 3, 4, 5, 6, 7
   2. Engine performance is drifting

Average level	SSME power level*						Delta MR
	Low (<80)		mid (80 - 90)		High (>94)		
	MR	ISP	MR	ISP	MR	ISP	
12	6.881	446.90	6.881	447.42	6.881	448.02	0.840
11	6.811	447.43	6.811	447.96	6.811	448.56	0.770
10	6.741	447.93	6.741	448.46	6.741	449.06	0.700
9	6.671	448.41	6.671	448.94	6.671	449.54	0.630
8	6.601	448.86	6.601	449.39	6.601	449.99	0.560
7	6.531	449.29	6.531	449.82	6.531	450.42	0.490
6	6.461	449.69	6.461	449.22	6.461	450.82	0.420
5	6.391	450.06	6.391	450.59	6.391	451.19	0.350
4	6.321	450.41	6.321	450.94	6.321	451.54	0.280
3	6.251	450.73	6.251	450.26	6.251	451.86	0.210
2	6.181	451.02	6.181	451.55	6.181	452.15	0.140
1	6.111	451.29	6.111	451.82	6.111	452.42	0.070
0	6.041	451.53	6.041	451.06	6.041	452.66	0.000
-1	5.971	451.74	5.971	452.27	5.971	452.87	-0.070
-2	5.901	451.93	5.901	452.46	5.901	453.06	-0.140
-3	5.831	452.09	5.831	452.62	5.831	453.22	-0.210
-4	5.761	452.23	5.761	452.76	5.761	453.36	-0.280
-5	5.691	452.34	5.691	452.87	5.691	453.47	-0.350
-6	5.621	452.42	5.621	452.95	5.621	453.55	-0.420
-7	5.551	452.47	5.551	452.00	5.551	453.60	-0.490
-8	5.481	452.50	5.481	453.03	5.481	453.63	-0.560
-9	5.411	452.50	5.411	453.03	5.411	453.63	-0.630
-10	5.341	452.48	5.341	453.01	5.341	453.61	-0.700
-11	5.271	452.43	5.271	453.96	5.271	453.56	-0.770
-12	5.201	452.35	5.201	453.88	5.201	453.48	-0.840

* ISP = fcn (MR and pwr lvl); where power levels of 72, 87, and 104 pct are used for the low, mid, and high calculations respectively.

TABLE 2.1.1-XI.- FLIGHT AVERAGE PERFORMANCE

Flight average performance level

Recognition of failure

A. N = 1, 2, 3, 4, 5, 6, and 7
B. Engine performance is drifting

Average level	Low (<80)		Average SSME power level* Mid (80 - 90)		High (>94)		Delta MR
	MR	ISP	MR	ISP	MR	ISP	
12	6.875	446.544	6.875	447.058	6.875	447.641	0.840
11	6.805	447.064	6.805	447.579	6.805	448.161	0.770
10	6.735	447.562	6.735	448.076	6.735	448.659	0.700
9	6.665	448.036	6.665	448.550	6.665	449.133	0.630
8	6.595	448.487	6.595	449.001	6.595	449.584	0.560
7	6.525	448.915	6.525	449.429	6.525	450.012	0.490
6	6.455	449.320	6.455	449.834	6.455	450.417	0.420
5	6.385	449.702	6.385	450.216	6.385	450.799	0.350
4	6.315	450.061	6.315	450.575	6.315	451.158	0.280
3	6.245	450.397	6.245	450.911	6.245	451.493	0.210
2	6.175	450.709	6.175	451.223	6.175	451.806	0.140
1	6.105	450.999	6.105	451.513	6.105	452.095	0.070
0	6.035	451.265	6.035	451.779	6.035	452.362	0.000
-1	5.965	451.508	5.965	452.022	5.965	452.605	-0.070
-2	5.895	451.728	5.895	452.243	5.895	452.825	-0.140
-3	5.825	451.926	5.825	452.440	5.825	453.022	-0.210
-4	5.755	452.100	5.755	452.614	5.755	453.196	-0.280
-5	5.685	452.250	5.685	452.765	5.685	453.347	-0.350
-6	5.615	452.378	5.615	452.892	5.615	453.475	-0.420
-7	5.545	452.483	5.545	452.997	5.545	453.580	-0.490
-8	5.475	452.565	5.475	453.079	5.475	453.661	-0.560
-9	5.405	452.623	5.405	453.137	5.405	453.720	-0.630
-10	5.335	452.659	5.335	453.173	5.335	453.755	-0.700
-11	5.265	452.671	5.265	453.185	5.265	453.768	-0.770
-12	5.195	452.660	5.195	453.174	5.195	453.757	-0.840

* ISP = fcn (MR and pwr lvl); where power levels of 72, 87, and 104 percent are used for the low, mid, and high calculations respectively.

TABLE 2.1.1-XII.- PASS ACTIVITY FOR ELECTRICAL LOCKUP DUE TO Pc SENSOR FAILURE

Step	Activity	Position
1	Report: "C (L, R) engine in electrical lockup due to Pc's"	ME/BSE/ FD/crew
2	Monitor instantaneous mixture ratio and specific impulse on MSK 1052. Determine the actual power level from table 2.1.1-II and performance level from table 2.1.1-X Report: "C (L, R) engine is ____ range, at ____% (actual power level); level ____, at ____ (time)"	ME/BSE FDO/FD
3	Monitor SSME valves and MEDRIFT. If performance is drifting determine flight average level from table 2.1.1-XI Report: "C (L, R) engine is drifting flight average level _____ at _____ percent"	ME/BSE FDO/FD
4	If first-stage vehicle performance is low, Report: Shut down C (L, R) engine at 23K due to low performance" If first-stage vehicle performance is nominal, Report: "Nominal performance, no action required on C (L, R) engine" (Refer to SCP 21.8 for this procedure.)	ME/BSE FD/crew

If the BFS is engaged and the engine is in lockup, the only two cues available are the ESW and the fault summary message. This is presented in table 2.1.1-XIII. The crew's indications of a lockup are the same for both PASS and BFS. These are presented in table 2.1.1-XIV.

TABLE 2.1.1-XIII.- MCC BFS FAILURE RECOGNITIONS - ELECTRICAL LOCKUP

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(ESW)
(C) V98M2200P
(L) V98M2220P
(R) V98M2240P</td><td>Electrical lockup flag set<table><tr><td>HEX ESW</td><td>MCF</td><td>ELE</td></tr><tr><td>Last 2 digits</td><td>8E</td><td>8F</td></tr></table></td><td>MSK 1052
1089
1064
1065</td></tr>
<tr><td></td><td>MPS ELEC C (L, R)
(class 3 alarm)</td><td>FML</td></tr>
<tr><td>(Pc percent)
(C) V98P2100C
(L) V98P2110C
(R) V98P2120C</td><td>Note Pc percent: If lockup occurred during throttle down/up, Pc percent indicates 6 percent lower/higher than actual.</td><td>MSK 1052
1089
1064
1065</td></tr>
<tr><td>(OMET)
M40H0107J</td><td>Note time</td><td>MSK 1052
1064
1065</td></tr>
</table>

TABLE 2.1.1-XIV.- CREW PASS/BFS RECOGNITION OF FAILURE - ELECTRICAL LOCKUP*

Parameter no.	Failure value/trend	Displayed on
(C) V72X0035X (L) V72X0036X (R) V72X0037X	C (L, R) amber MAIN ENGINE STATUS light	PNL F7
	MPS ELEC C (L, R) (class 3 alarm)	FML
(C) V72P0040C (L) V72P0041C (R) V72P0042C	Pc meter indicates no throttling	PNL F7

* Crew cannot determine what caused lockup.

If the MOC computations are judged to be incorrect or the BFS is engaged, alternate means of evaluation are required. Tables 2.1.1-II and 2.1.1-XV (from the main engine table programs) are used in this analysis. Table 2.1.1-XV is used to determine the performance level. Notice, there are three levels. A level 1 is valid if lockup occurs in the interval between throttle up out of the thrust bucket through SRB tailoff when the vehicle acceleration is greater than 1.5g. In this case, at the higher g level, the SSME control valves will be partially closed to maintain the proper Pc and flowrates. Since the valves cannot be adjusted, the overall performance is lower than nominal with respect to mixture ratio and Pc.

TABLE 2.1.1-XV.- BACKUP LOCKUP

Backup hydraulic lockup - 104 percent for STS-43

A. Recognition of failure
   1. N not = 7 or BFS engaged
   2. FML = MPS HYD C (L,R)
   3. ESW ends in '92' or '93'
   4. FID 015

Backup electrical lockup - 104 percent for STS-43

A. Recognition of failure
   1. N = 6 or BFS engaged
   2. FML = MPS ELEC C (L,R)
   3. ESW ends in '8E' or '8F'
   4. FID 011, DLM's 0-6 (FFM) or 13-16 (Pc)

From	To	Level	Pc (psia)	MR	ISP (sec)	Power level (percent)
Liftoff	Throttle down	(User power level only)				
Throttle up	SRB tail (g > 1.5)	1	3113	5.974	452.49	103.44
SRB tail (g < 1.5)	SRB sep (g > 1.5)	2	3136	6.068	452.23	104.4
In the bucket		3	(See lockup tables)			

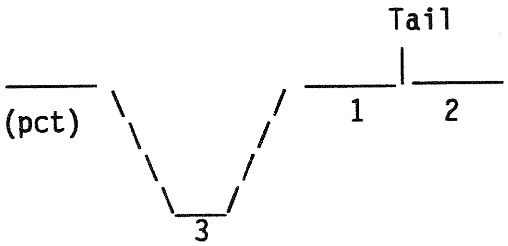


TABLE 2.1.1-XVI.- LOCKUP TABLE
Lockup table - 104 FOR FLIGHT S34

CMD (pct)	Pc (psia)	MR	ISP (sec)	Power level (percent)
109	3277	6.036	452.51	109
108	3246	6.035	452.47	108
107	3216	6.035	452.44	107
106	3186	6.035	452.40	106
105	3156	6.034	452.37	105
104	3126	6.034	452.34	104
103	3096	6.034	452.30	103
102	3066	6.033	452.27	102
101	3036	6.033	452.23	101
100	3006	6.033	452.20	100
99	2976	6.032	452.17	99
98	2946	6.032	452.13	98
97	2916	6.032	452.10	97
96	2886	6.031	452.06	96
95	2856	6.031	452.03	95
94	2826	6.031	451.99	94
93	2796	6.031	451.96	93
92	2766	6.030	451.93	92
91	2735	6.030	451.89	91
90	2705	6.030	451.86	90
89	2675	6.029	451.82	89
88	2645	6.029	451.79	88
87	2615	6.029	451.76	87
86	2585	6.028	451.72	86
85	2555	6.028	451.69	85
84	2525	6.028	451.65	84
83	2495	6.027	451.62	83
82	2465	6.027	451.59	82
81	2435	6.027	451.55	81
80	2405	6.026	451.52	80
79	2375	6.026	451.48	79
78	2345	6.026	451.45	78
77	2315	6.025	451.41	77
76	2285	6.025	451.38	76
75	2255	6.025	451.35	75
74	2224	6.025	451.31	74
73	2194	6.024	451.28	73
72	2164	6.024	451.24	72
71	2134	6.024	451.21	71
70	2104	6.023	451.18	70
69	2074	6.023	451.14	69
68	2044	6.023	451.11	68
67	2014	6.022	451.07	67
66	1984	6.022	451.04	66
65	1954	6.022	451.01	65

The second level (level 2) is valid when the lockup occurs in the interval during SRB tailoff when the g is less than 1.5. During this interval, the SSME valves are normally opened more to maintain the proper Pc and flowrates. In this case, the overall performance is higher than nominal with respect to mixture ratio and Pc.

Level 3 corresponds to lockup occurring when the SSME's have throttled down into the thrust bucket during first stage. Table 2.1.1-II is used by the FDO to adjust the ARD for the actual mixture ratio and specific impulse. Remember the actual Pc must be obtained from table 2.1.1-II using the HPOT DP.

The Mission Control Center calls and the activity required for BFS scenarios is presented in table 2.1.1-XVII.

2. Electrical Lockup Due To LH_2 Flowmeter Sensor Error

The LH_2 flowmeter logic uses the average of two sensor pairs in the mixture ratio control loop. The qualification limits are as follows:

Channel A: A1 - A2 ≤ 1800 gallons per minute (GPM)
Channel B: B1 - B2 ≤ 1800 gpm
Interchannel: Channel A average - channel B average ≤ 1800 gpm

The failure of both pairs results in electrical lockup. Since the valves are commanded to the last position prior to sensor disqualification, it is possible that the last valid sensor readings were in error. This error could cause the actual mixture ratio and power level to be off-nominal.

If the fuel flowmeter shifts low or is "biased" low, a fuel flowmeter shift low, actual high exists. That is, the fuel flowrate is actually high. In this case, the controller mixture ratio calculation will be erroneously high. Therefore, the controller will erroneously compensate by increasing the fuel flowrate. This is accomplished by increasing the FPOV open position. When the FPOV open position is increased, the HPFT turbine temperatures will also increase. The actual mixture ratio will decrease when fuel flow in increased. The MCC Pc will increase a small amount due to the FPOV increasing oxidizer flow to the fuel preburner (FPB). Therefore, to reduce the Pc to the proper level, the controller will decrease the OPOV open position a small amount. This action will cause the HPOT turbine discharge temperature to decrease. The HPOT DP may also decrease a very small amount. The engine will still be operating at the commanded power level, however, it will be operating at an off-nominal low mixture ratio.

The mixture ratio level can be obtained from table 2.1.1-XVIII (from the main engine table program). The level is obtained using the SSME operational parameters shown in table XVIII. This level and the time the failure occurred are then given to the FDO to adjust the ARD.

TABLE 2.1.1-XVII.- BACKUP ELECTRICAL LOCKUP ACTIVITY

Step	Activity	Position
1	Report: "C (L, R) engine in electrical lockup; we are evaluating."	ME/BSE FDO/FD Crew
2	Determine level from tables 2.1.1-XV and 2.1.1-XVI Report: "C (L, R) engine lockup is level ____, at ____ percent, at ____ (time)."	ME/BSE FDO/FD
3	If first-stage vehicle performance is low, Report: "Shut down C (L, R) engine at 23K due to low performance If first-stage vehicle performance is nominal, Report: "Nominal performance, no action required on C (L, R) engine." (Refer to SCP 2.1.8 for this procedure.)	ME/BSE FD/Crew

TABLE 2.1.1-XVIII.- FUEL FLOWMETER SENSOR SHIFT LOW, ACTUAL HIGH

ELECTRICAL LOCKUP (FM FAILURE)

A. Recognition of failure
1. N = 6 (MOC), N = 9 (RIDS)
2. FML = 'MPS ELEC C (L, R)
3. ESW ends in '8E' or '8F'
4. FID: 011 'R SEN FAIL-'
   DEL: 0-6, FFM
5. HPOT TD T decreases > 130° R
6. FPOV increases > 2 pct
7. QPOV decreases > 1 pct
8. HPOT DP decreases > 25 psi

LH2 FM GPM SENSOR SHIFT LOW (ACT HIGH)

A. Recognition of failure
1. N = 9 (RIDS only)
2. HPOT TD T decreases > 130° R
3. FPOV increases > 2 pct
4. OPOV decreases > 1 pct
5. HPOT DP decreases > 25 psi

LEFT SSME - FLOWMETER GPM SENSOR SHIFT LOW (ACTUAL HIGH)

Level	OPOV (pct)	FPOV (pct)	HPOT TD T		HPOT DP	MR	ISP (sec)	Power level (pct)	WDOTO (lb/sec)	WDOTF (lb/sec)	GPM err
			A	B							
NOM	67.0	79.3	1331	1333	3999	6.041	452.66	104.0	927.73	153.57	0
1	65.8	81.3	1192	1194	3977	5.820	453.24	103.5	917.03	157.58	413
2	65.7	81.5	1181	1183	3974	5.800	453.28	103.4	916.12	157.94	450
3	65.3	82.3	1137	1139	3965	5.726	453.35	103.3	912.72	159.39	600
4	64.9	83.2	1094	1096	3956	5.654	453.37	103.1	909.48	160.85	750
5	64.6	84.2	1055	1057	3946	5.583	453.36	102.9	906.29	162.34	900

CENTER SSME - FLOWMETER GPM SENSOR SHIFT LOW (ACTUAL HIGH)

Level	OPOV (pct)	FPOV (pct)	HPOT TD T		HPOT DP	MR	ISP (sec)	Power level (pct)	WDOTO (lb/sec)	WDOTF (lb/sec)	GPM err
			A	B							
NOM	66.7	79.0	1347	1327	4020	6.041	452.66	104.0	927.73	153.57	0
1	65.5	81.0	1208	1188	3998	5.820	453.24	103.5	917.03	157.58	413
2	65.4	81.2	1197	1177	3995	5.800	453.28	103.4	916.12	157.94	450
3	65.0	82.0	1153	1133	3986	5.726	453.35	103.3	912.72	159.39	600
4	64.6	82.9	1110	1090	3977	5.654	453.37	103.1	909.48	160.85	750
5	64.3	83.9	1071	1051	3967	5.583	453.36	102.9	906.29	162.34	900

TABLE 2.1.1-XVIII.- Concluded

RIGHT SSME - FLOWMETER GPM SENSOR SHIFT LOW (ACTUAL HIGH)

Level	OPOV (pct)	FPOV (pct)	HPOT TD T		HPOT DP	MR	ISP (sec)	Power level (pct)	WDOTO (lb/ sec)	WDOTF (lb/ sec)	GPM err
			A	B							
NOM	68.1	79.4	1400	1410	4033	6.041	452.66	104.0	927.73	153.57	0
1	66.9	81.4	1261	1271	4011	5.820	453.24	103.5	917.03	157.58	413
2	66.8	81.6	1250	1260	4008	5.800	453.28	103.4	916.12	157.94	450
3	66.4	82.4	1206	1216	3999	5.726	453.35	103.3	912.72	159.39	600
4	66.0	83.3	1163	1173	3990	5.654	453.37	103.1	909.48	160.85	750
5	65.7	84.3	1124	1134	3980	5.583	453.36	102.9	906.29	162.34	900

If the fuel flowmeter shifts high or is "biased" high, a fuel flowmeter shift high, actual low exists. That is, the fuel flowrate is actually low. In this case, the controller mixture ratio calculation will be erroneously low. Therefore, the controller will erroneously compensate by decreasing the fuel flowrate. This is done by decreasing the FPOV open position. When the FPOV open position is decreased, the HPFT turbine temperatures will also decrease. The actual mixture ratio will increase when fuel flow is decreased. The MCC Pc will decrease a small amount due to the FPOV decreasing oxidizer flow to the FPB. Therefore, to increase the Pc to the proper level, the controller will increase the OPOV open position a small amount. This causes the HPOT turbine discharge temperature to increase. The HPOT DP may also increase a very small amount. The engine will still be operating at the commanded power level, however, it will be operating at an off-nominal high mixture ratio.

The mixture ratio level can be obtained from table 2.1.1-XIX (from the main engine table program), using the SSME operational parameters on the table. This level, and the time the failure occurred, are then given to FDO to adjust the ARD. The PASS recognition of electrical lockup due to failure of the fuel flowmeters is presented in table 2.1.1-XX, for a flowmeter shift the ESW and FID (failure ID) may not be present. The Mission Control Center calls and the activity required for fuel flowmeter shifts is presented in table 2.1.1-XXI.

For an SSME operating with a flowmeter shift (error) prior to the ESW indicating Electrical Lockup due to the failure of the flowmeter sensor pairs, the appropriate performance information will be given to the FDO.

The minimum detectable flowmeter error corresponds to a delta of ±130° between the predicted HPOT TD T's and the actual value, a delta of ±1 percent on the OPOV, a delta of ±2 percent on the FPOV and a delta of ±25 psi on the HPOT DP. The values given for the HPOT TD T's, HPOT DP, FPOV and OPOV in table 2.1.1-XVIII and 2.1.1-XIX are the predicted values for an MET of 194 seconds (200 seconds after SSME ignition) and an LO_2 inlet pressure of 63 psia. The effect of increasing the LO_2 inlet pressure by 100 psi is shown in the table below. The LO_2 inlet pressure is approximately 55 psia after SRB staging and 160 at 3-g throttling.

Operational parameter	LO_2 inlet pressure gain (1 sigma)
HPOT TD T	-91.2 (+/- 28.0)
HPOT DP	0.0
OPOV	-1.44 (+/- 0.41)
FPOV	2.54 (+/- 0.49)

TABLE 2.1.1-XIX.- FUEL FLOWMETER SENSOR SHIFT HIGH, ACTUAL LOW

ELECTRICAL LOCKUP (FM FAILURE)

A. Recognition of failure
   1. N = 6 (MCC), N = 8 (RIDS)
   2. FML = 'MPS ELEC C (L, R)
   3. ESW ends in '8E' or '8F'
   4. FID: 011 'R SEN FAIL-'
      DEL: 0-6, FFM
   5. HPOT TD T increases > 130° R
   6. FPOV decreases > 2 pct
   7. QPOV increases > 1 pct
   8. HPOT DP increases > 25 psi

LH2 FM GPM SENSOR SHIFT HIGH (ACT LOW)

A. Recognition of failure
   1. N = 8 (RIDS only)
   2. HPOT TD T increases > 130° R
   3. FPOV decreases > 2 pct
   4. OPOV increases > 1 pct
   5. HPOT DP increases > 25 psi

LEFT SSME - FLOWMETER GPM SENSOR SHIFT HIGH (ACTUAL LOW)

Level	OPOV (pct)	FPOV (pct)	HPOT TD T		HPOT DP	MR	ISP (sec)	Power level (pct)	WDOTO (lb/ sec)	WDOTF (lb/ sec)	GPM err
			A	B							
NOM	67.0	79.3	1331	1333	3999	6.041	452.66	104.0	927.73	153.57	0
1	69.1	77.5	1530	1532	4021	6.306	451.69	104.6	940.87	149.15	-450
2	69.8	77.1	1602	1604	4028	6.400	451.28	104.8	945.60	147.68	-600
3	70.4	76.6	1676	1678	4034	6.497	450.83	105.1	950.50	146.20	-750
4	71.2	76.1	1763	1765	4040	6.597	450.34	105.3	955.56	144.74	-900

CENTER SSME - FLOWMETER GPM SENSOR SHIFT HIGH (ACTUAL LOW)

Level	OPOV (pct)	FPOV (pct)	HPOT TD T		HPOT DP	MR	ISP (sec)	Power level (pct)	WDOTO (lb/ sec)	WDOTF (lb/ sec)	GPM err
			A	B							
NOM	66.7	79.0	1347	1327	4020	6.041	452.66	104.0	927.73	153.57	0
1	68.8	77.2	1546	1526	4042	6.306	451.69	104.6	940.87	149.15	-450
2	69.5	76.8	1618	1598	4049	6.400	451.28	104.8	945.60	147.68	-600
3	70.1	76.3	1692	1682	4055	6.497	450.83	105.1	950.50	146.20	-750
4	70.9	75.8	1779	1759	4061	6.597	450.34	105.3	955.56	144.74	-900

RIGHT SSME - FLOWMETER GPM SENSOR SHIFT HIGH (ACTUAL LOW)

Level	OPOV (pct)	FPOV (pct)	HPOT TD T		HPOT DP	MR	ISP (sec)	Power level (pct)	WDOTO (lb/ sec)	WDOTF (lb/ sec)	GPM err
			A	B							
NOM	68.1	79.4	1400	1410	4033	6.041	452.66	104.0	927.73	153.57	0
1	70.2	77.6	1599	1609	4055	6.306	451.69	104.6	940.87	149.15	-450
2	70.9	77.2	1671	1681	4062	6.400	451.28	104.8	945.60	147.68	-600
3	71.5	76.7	1745	1755	4068	6.497	450.83	105.1	950.50	146.20	-750
4	72.3	76.2	1832	1842	4074	6.597	450.34	105.3	955.56	144.74	-900

TABLE 2.1.1-XX.- PASS RECOGNITION OF FAILURE - FLOWMETER SENSOR FAILURES

Parameter no.	Failure value/trend	Displayed on
(ESW) (C) E41M1003P (L) E41M2003P (R) E41M3003P (ELEC LOCK) (C) M19G3708E (L) M20G3708E (R) M21G3708E	Electrical lockup flag set	MSK 1051 1052 DDD (C) 281 (L) 282 (R) 283 284
	MPS ELEC C (L, R) (class 3 alarm)	FML
(HARD FID) (C) E41M1005B (L) E41M2005B (R) E41M3005B	Hard failure ID R SEN FAIL - FU FLW RTE (A, B, or A&B)	MSK 1051 1052 1069 1070
(N) (C) M02G3112C (L) M04G3112C (R) M06G3112C	Performance case number equals 6 in the MOC, and 10 or 11 in RTDS for shift low or high	MSK 1051 1052
(TN) (C) M08G3112C (L) M10G3112C (R) M12G3112C	MET the MOC performance case identified	MSK 1051 1052
(HPOT TD T A/B) (C) E41T10128/13B (L) E41T2012B/13B (R) E41T3012B/13B	HPOT TD T A/B ● Increases ˜ 70°/-150 GPM error ● Decreases ˜ 50°/+150 GPM error	MSK 1051 1052
(HPOT DP) (C) E41T1030B (L) E41T2030B (R) E41T3030B	HPOT DP ● Increases - 7 psi/+150 GPM error ● Decreases - 9 psi/+150 GPM error	MSK 1051 1052
(OPOV) (C) E41H1028B (L) E41H1028B (R) E41H1028B	Note performance levels from table 2.1.1-XVIII or 2.1.1-XIX OPOV position will ● Open ~ 0.7%/-150 GPM error ● Close ~ 0.4%/+150 GPM error	MSK 1051 1052
(FPOV) (C) E41H1027B (L) E41H1027B (R) E41H1027B	Note performance levels from table 2.1.1-XVIII or 2.1.1-XIX FPOV position will ● Close ~ 0.6%/-150 GPM error ● Open ~ 0.7%/+150 GPM error	MSK 1051 1052

TABLE 2.1.1-XX.- Concluded

Parameter no.	Failure value/trend	Displayed on
(MR) (C) M02G3107C (L) M03G3107C (R) M04G3107C	Note performance levels: instantaneous: table 2.1.1-X	MSK 1051 1052
(ISP) (C) M01G3112C (L) M03G3112C (R) M05G3112C	Flight average: table 2.1.1-XI and MEDRIFT OUTPUT	MSK 1051 1052

TABLE 2.1.1-XXI.- PASS ACTIVITY FOR ELECTRICAL LOCKUP DUE TO FUEL FLOWMETER SENSOR FAILURE

Step	Activity	Position
1	a. If engine is in lockup Report: "C (L, R) engine in electrical lockup due to flowmeter; we are evaluating" b. If engine is not in lockup Report: "Fuel flowmeter shift on C (L, R) engine; we are evaluating"	ME/BSE/FDO FD/crew
2	Monitor instantaneous mixture ratio and specific impulse on MSK 1052. Determine the actual power level from table 2.1.1-II and performance level from table 2.1.1-XVIII or table 2.1.1-XIX Report: "C (L, R) engine flowmeter shift low/high, actual high/low and is at _____ percent (actual power level); level _____, at ______ (time)"	ME/BSE FDO/FD
3	Monitor SSME valves and MEDRIFT. If performance is drifting determine flight average level from table 2.1.1-XI Report: "C (L, R) performance is drifting, flight average level _____ at _____ percent"	ME/BSE FDO/FD

TABLE 2.1.1-XXI.- Concluded

Step	Activity	Position
4.	If first-stage vehicle performance is low, Report: "Shut down C (L, R) engine at 23K due to low performance" (Not RTLS or TAL) If first-stage vehicle performance is nominal, Report: "Nominal performance, no action required on C (L, R) engine" (Refer to SCP 2.1.8 for this procedure.)	ME/BSE FD/crew

D. Hydraulic Lockup

The SSME valves are hydraulically actuated valves. An engine will be hydraulically locked up if one of the SSME valve actuators fails or the hydraulic supply pressure is lost (APU failure). The valves are hydraulically isolated at their last position when the qualification or error limits are violated. The error limits are 6 percent for channel A, and 10 percent for channel B. The error limits are based on the comparison between the actual and the Actuator Model positions. After a valve is commanded, the actual position is compared to the Actuator Model position. If the valve did not move, then subsequent commands would be sent until the error limits are violated. In the case of an APU failure, the valve error can take 20 to 60 seconds to violate the error limits during nonthrottling periods. During throttling, the error limits are violated almost instantly. PASS recognition for hydraulic lockup is presented in table 2.1.1-XXII.

Several hot-fire tests have been conducted with the engine in hydraulic lockup. This testing was performed to evaluate engine performance while in lockup and has shown that significant valve drift is possible. The SSME valve that historically drifts the most is the FPOV. A summary of SSME hot-fire hydraulic lockup test is presented in table 2.1.1-XXIII.

Performance variations on a locked up engine are dependent on the amount of valve drift and vehicle acceleration. As described earlier, the MOC performance computation will compute the instantaneous mixture ratio and specific impulse for hydraulic lockup. Table 2.1.1-XXIV (from the main engine table program) is used to determine the level of the performance dispersion. Notice there are three power levels: low, mid, and high. This range is because the ME specific impulse varies with mixture ratio and power level. The affected engine, power level range, power level, performance level, and time the failure occurred are given to the FDO to update the ARD. If the engine performance is changing with time (i.e., valve drift), the MEDRIFT program will predict the average mixture ratio and specific impulse for the flight. Refer to SCP 3.1.6 for details on MEDRIFT. Table 2.1.1-XI is used to obtain the flight average performance level. A summary of the Mission Control Center calls and the activity required for this case is presented in table 2.1.1-XXV.

If the BFS is engaged and the engine is in lockup, the only two cues available are the ESW and the fault summary message. This is presented in table 2.1.1-XXVI. The crew indications of a lockup occurring are the same for both PASS and BFS. These are presented in table 2.1.1-XXVII.

If the MOC computations are judged to be incorrect or the BFS is engaged, alternate means of evaluation are required. Tables 2.1.1-XXV and 2.1.1-II are used in this analysis. (These pages are from the main engine table program.) Table 2.1.1-XV is used to determine the performance level. Notice, there are three levels. The rationale for these levels is presented in the Electrical Lockup section of this SCP. The Mission Control Center calls and the activity required for lockups using the backup tables is presented in table 2.1.1-XVII.

The relevant Flight Rules for this section are

Flight Operation Rules - Ascent
2-27, ARD UPDATE CRITERIA

Booster, SSME Systems Management
5-27B, LIMIT SHUTDOWN CONTROL
5-33, MANUAL SHUTDOWN FOR HYDRAULIC AND ELECTRICAL LOCKUP
5-34, MANUAL SHUTDOWN FOR TWO STUCK THROTTLES
5-35, ENGINE PERFORMANCE DISPERSION

TABLE 2.1.1-XXII.- PASS RECOGNITION OF FAILURE - HYDRAULIC LOCKUP

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(ESW)
(C) E41M1003P
(L) E41M2003P
(R) E41M3003P
(HYD LOCK)
(C) M22G3708E
(L) M23G3708E
(R) M24G3708E</td><td>Hydraulic lockup flag set<table><tr><td>HEX ESW</td><td>MCF</td><td>ELE</td></tr><tr><td>Last 2 digits</td><td>92</td><td>93</td></tr></table></td><td>MSK 1051
1052
DDD
(C) 281
(L) 282
(R) 283
284</td></tr>
<tr><td></td><td>MPS HYD C (L, R)
(class 3 alarm)</td><td>FML</td></tr>
<tr><td>(HARD FID)
(C) E41M1005B
(L) E41M2005B
(R) E41M3005B</td><td>HARD FAIL ID
Refer to SCP 4.1 for failures causing hydraulic lockup</td><td>MSK 1051
1052
1069</td></tr>
<tr><td>(T FAIL)
(C) M13G3000T
(L) M14G3000T
(R) M15G3000T</td><td>Note time of failure
(T FAIL - 7 sec)</td><td>MSK 1070
1051
1052
1069</td></tr>
<tr><td>(N)
(C) M02G3112C
(L) M04G3112C
(R) M06G3112C</td><td>Performance case number (N) equals 7</td><td>MSK 1070
1051
1052</td></tr>
<tr><td>(TN)
(C) M08G3112C
(L) M10G3112C
(R) M12G3112C</td><td>MET the MOC performance case identified</td><td>MSK 1051
1052</td></tr>
<tr><td>(Hyd P)
(C) E41P1054B
(L) E41P2054B
(R) E41P3054B</td><td>Monitor to determine if lockup caused by low hydraulic pressure (< 1200 psi)</td><td>MSK 1051
1052</td></tr>
<tr><td>(MR)
(C) M02G3107C
(L) M03G3107C
(R) M04G3107C
(ISP)
(C) M01G3112C
(L) M03G3112C
(R) M05G3112C</td><td>Note performance levels
Instantaneous: Table 2.1.1-XXIV
Flight average: Table 2.1.1-XI</td><td>MSK 1051
1052</td></tr>
</table>

TABLE 2.1.1-XXIII.- SSME HOT-FIRE HYDRAULIC LOCKUP TEST HISTORY

Engine	Test ①	Lockup		Maximum change in performance		
		Power level (%)	Duration (Sec) ②	FPOV drift (%)	Pc (psi)	Mixture ratio (MRU)
0105	750-053	RPL④	44-300	-0.55	-35	+0.150
0007	750-110	MPL⑤	30-450	-0.24	-85	-0.050
0007	750-111	RPL④	130-300	-0.30	-20	+0.030
0007	750-121	92.5	10-20	—	—	—
0110	750-135	FPL⑥	250-300	-0.50	-4	+0.020
2005	STS-3	82⑦	491-520	—	—	—
2105	901-526	104	330-520	-2.20	-40	+0.150
2105	901-532	104	330-520	0	-11	+0.020
2105	901-537	104	20-657	-6.30	-121	+0.720
0211	901-564	104	20-520	-3.20	-90	+0.320
0211	901-571	104	20-520	-3.70	-80	+0.260
0211	901-583	104	20-300	-0.50	+37	+0.075
2106	902-420	104	330-520	0	-15	+0.015
2106	902-427③	104	20-127	-0.40	-40	~ 0
2106	902-428③	104	20-204	-0.50	—	—

① Lockup induced by closing hydraulic supply valve

② "Engine start plus time" to pneumatic shutdown time

③ Software induced lockup (hydraulic pressure not affected)

④ Rated power level (RPL) = 100 percent

⑤ Minimum power level (MPL) = 65 percent

⑥ Full power level (FPL) = 109 percent

⑦ Lockup caused by APU failure

TABLE 2.1.1-XXIV.- PASS ACTIVITY FOR HYDRAULIC LOCKUP

Step	Activity	Position
1	Report: "C (L, R) engine in hydraulic lockup due to actuator problem/APU 1 (2,3); we are evaluating"	ME/BSE/ FD/crew
2	Monitor instantaneous mixture ratio and specific impulse on MSK 1052. Determine the actual power level from table 2.1.1-II and performance level from table 2.1.1-X Report: "C (L, R) engine is _____ range, at ______ % (actual power level); level _____, at ______ (time)"	ME/BSE FDO/FD
3	Monitor SSME valves and MEDRIFT. If performance is drifting determine flight average level from table 2.1.1-X Report: "C (L, R) engine is drifting flight average level _____ at _____ percent"	ME/BSE FDO/FD
4	If first-stage vehicle performance is low, Report: "Shut down C (L, R) engine at 23K due to low performance" (Not RTLS or TAL) If first-stage vehicle performance is nominal, Report: "Nominal performance, no action required on C (L, R) engine" (Refer to SCP 2.1.8 for this procedure.)	ME/BSE FD/crew

TABLE 2.1.1-XXV.- MCC BFS FAILURE RECOGNITION - HYDRAULIC LOCKUP

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(ESW)
(C) V98M2200P
(L) V98M2220P
(R) V98M2240P</td><td>Hydraulic lockup flag set<table><tr><td rowspan="2">HEX ESW Last 2 digits</td><td>MCF</td><td>ELE</td></tr><tr><td>92</td><td>93</td></tr></table></td><td>MSK 1051
1052
1089
1064
1065</td></tr>
<tr><td></td><td>MPS HYD C (L, R)
(class 3 alarm)</td><td>FML</td></tr>
<tr><td>(Pc percent)
(C) V98M2100C
(L) V98M2110C
(R) V98M2120C</td><td>Note Pc percent. If lockup occurred during throttle down/up, Pc percent indicates 6 percent lower/higher than actual</td><td>MSK 1051
1052
1089
1064
1065</td></tr>
<tr><td>(OMET)
M40H0107J</td><td>Note time</td><td>MSK 1052
1064
1065</td></tr>
</table>

TABLE 2.1.1-XXVI.- CREW PASS/BFS FAILURE RECOGNITION - HYDRAULIC LOCKUP

Parameter no.	Failure value/trend	Displayed on
(C) V72X0035X (L) V72X0036X (R) V72X0037X	C (L, R) amber MAIN ENGINE STATUS light	PNL F7
	MPS HYD C (L, R) (class 3 alarm)	FML
(C) V72P0040C (L) V72P0041C (R) V72P0042C	Pc meter indicates no throttling	PNL F7

E. OPOV Limiting (Thrust Limiting)

When an anomaly occurs that causes the measured MCC Pc to drop below the reference Pc, the SSME controller will increase the OPOV open position to increase Pc to the proper value. This action causes the HPOT turbine discharge temperatures to increase. If the temperatures exceed their redline limits, the controller will command the engine to shut down. In an attempt to keep an engine running, OPOV limiting was developed. During the engine start sequence, the controller calculates the maximum open position the OPOV is allowed to achieve. Currently, this limit is approximately 4 percent greater than the nominal position. When this limit is reached, the engine will enter the OPOV limiting mode, which is identified in the ESW. At this point, the OPOV will not be commanded to open any further. If the engine is commanded to a lower power level, the engine may get out of OPOV limiting due to the controller commanding the OPOV to close a small amount to accommodate the lower power level. There are two OPOV limiting cases that require ARD updates: nozzle leaks and HPOT efficiency loss. OPOV limiting must be reached to distinguish between these two failure modes.

The relevant Flight Rules for this section are

<u>Flight Operation Rules - Ascent</u>
2-27, ARD UPDATE CRITERIA

<u>Booster - SSME Systems Management</u>
5-35, ENGINE PERFORMANCE DISPERSION

Nozzle Leaks

A nozzle leak is any fuel leak downstream of the fuel flowmeter. The flow-rate measured by the flowmeter is used by the controller to calculate the engine's mixture ratio. The controller maintains the mixture ratio by adjusting the FPOV. Any fuel leak downstream of the flowmeter will be transparent to the controller (i.e., the flowmeter measurement remains constant). Therefore, the controller calculated mixture ratio does not change, and the FPOV is not opened to compensate for the leak. In the nozzle leak case, the mixture is fuel lean at the MCC combustion chamber, and the Pc decreases a small amount. Since the OPOV is the thrust control valve, the controller will command the OPOV to increase its open position. This action will increase the oxidizer flow while the fuel flow remains constant and a high mixture ratio condition will exist. The increase in OPOV position is accompanied by an increase in the HPOT turbine discharge temperatures. After OPOV limiting is reached, the turbine temperatures will continue to increase. The rate of increase (after limiting) will be less than when the valve is actually (moving) increasing its open position. This occurs because the engine is operating slightly oxidizer rich. There is less fuel in the OPB for combustion with the oxidizer. Another factor causing HPOT temperatures to increase (to a lesser extent) is that, with the nozzle leak there is less fuel (coolant) flow in the coolant jackets or liners. PASS recognition of this failure mode is summarized in table 2.1.1-XXVII. With the BFS engaged, the ESW will indicate OPOV limiting, but

TABLE 2.1.1-XVII.- MCC PASS RECOGNITION OF FAILURE - NOZZLE TUBE LEAKAGE

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(ESW)
(C) E41M1003P
(L) E41M2003P
(R) E41M3003P</td><td>OPOV limiting flag set<table><tr><td rowspan="2">HEX ESW
Last 2 digits</td><td>MCF</td><td>ELE</td></tr><tr><td>8A</td><td>8B</td></tr></table></td><td>MSK 1051
1052</td></tr>
<tr><td>(TH-LIM)
(C) M49G3708E
(L) M50G3708E
(R) M51G3708E</td><td>OPOV limiting mode</td><td>DDD
(C) 281
(L) 282
(R) 283</td></tr>
<tr><td>(OPOV)
(C) E41H1028B
(L) E41H2028B
(R) E41H3028B</td><td>OPOV position will be opened about 4 percent more than nominal</td><td>MSK 1051
1052</td></tr>
<tr><td>(HPOT TD T A/B)
(C) E41T1012/13B
(L) E41T2012/13B
(R) E41T3012/13B</td><td>HPOT TD T A/B increase will be greater than about 250° at 104 percent power level (fig. 2.1.1-I)</td><td>MSK 1051
1052</td></tr>
<tr><td>(N)
(C) M02G3112C
(L) M04G3112C
(R) M06G3112C</td><td>Performance case number equals 1</td><td>MSK 1051
1052</td></tr>
<tr><td>(TN)
(C) M08G3112C
(L) M10G3112C
(R) M12G3112C</td><td>MET the MOC performance case identified</td><td>MSK 1051
1052</td></tr>
<tr><td>(OMET)
M40H0107J</td><td>Time of failure</td><td>MSK 1051
1052</td></tr>
<tr><td>(AVG Pc)
(C) E41P1023B
(L) E41P2023B
(R) E41P3023B

(MR)
(C) M02G3107C
(L) M03G3107C
(R) M04G3107C</td><td>Note performance level on table 2.1.1- XXVII</td><td>MSK 1051
1052</td></tr>
</table>

detailed analysis of a nozzle leak is not possible. Also, the crew has no insight into this failure mode in either the PASS or BFS.

There are 1080 tubes in the nozzle to provide cooling for the nozzle. These tubes are located downstream of the LH_2 flowmeter. A nozzle tube split is an example of a downstream leak. It should be pointed out that this failure mode is declared a "nozzle leak," but the source of the hydrogen loss may be at some other location downstream of the fuel flowmeter. The rationale for this is that there were numerous cases of nozzle tube leaks early in the ground test program. The tube walls have been thickened which has reduced the probability of tube splits.

Nozzle tube leakage can only be quantified after the engine enters OPOV limiting. The ARD will then be updated with the level of the leakage. Prior to entering OPOV limiting, the signatures for a nozzle leak and HPOT efficiency loss are the same. After entering OPOV limiting, the HPOT turbine temperatures will be used to determine the proper failure mode. If the turbine temperatures continue to increase as stated earlier, the failure mode is a nozzle leak. If the temperatures decrease after the OPOV limit is reached, the failure mode is an HPOT efficiency loss. HPOT efficiency loss is discussed in the following section. A comparison of these two failure modes with respect to HPOT turbine discharge temperatures is presented in figure 2.1.1-I.

Table 2.1.1-XXVIII (from the main engine table program) is used to determine the level of the leak. For nozzle leaks, the MCC Pc is the primary cue used to determine the level. A summary of the Mission Control Center calls and the activity required for this case is presented in table 2.1.1-XXIX.

HPOT Efficiency Loss

A reduction in HPOT efficiency reduces the output from the pump and the MCC Pc will decrease. The SSME controller will command the OPOV to increase its open position to increase the oxidizer flowrate and increase Pc to the reference Pc. As stated earlier, the increased OPOV position will cause the HPOT turbine discharge temperature to increase. At this point, the engine is operating at the proper performance level. If the efficiency loss is such that the OPOV is required to open a greater amount and reaches OPOV limiting, the Pc cannot be maintained and will begin to decrease.

As with a nozzle leak, HPOT efficiency loss can be quantified only after the engine enters OPOV limiting. The HPOT TD T's will increase as the OPOV is opened. When OPOV limiting is reached, the HPOT TD Ts will have increased approximately 110°. After entering OPOV limiting, the HPOT turbine discharge temperatures will begin to decrease. Refer to figure 2.1.1-I. The inefficient HPOT pumps less LO_2, less oxidizer reaches the preburners, and the engine is operating at a slightly lower mixture ratio. PASS recognition of this failure mode is summarized in table 2.1.1-XXX. With the BFS engaged, the ESW will indicate OPOV limiting, but detailed analysis of an HPOT efficiency loss is not possible. Also, the crew has no insight into this failure mode in either the PASS of BFS.

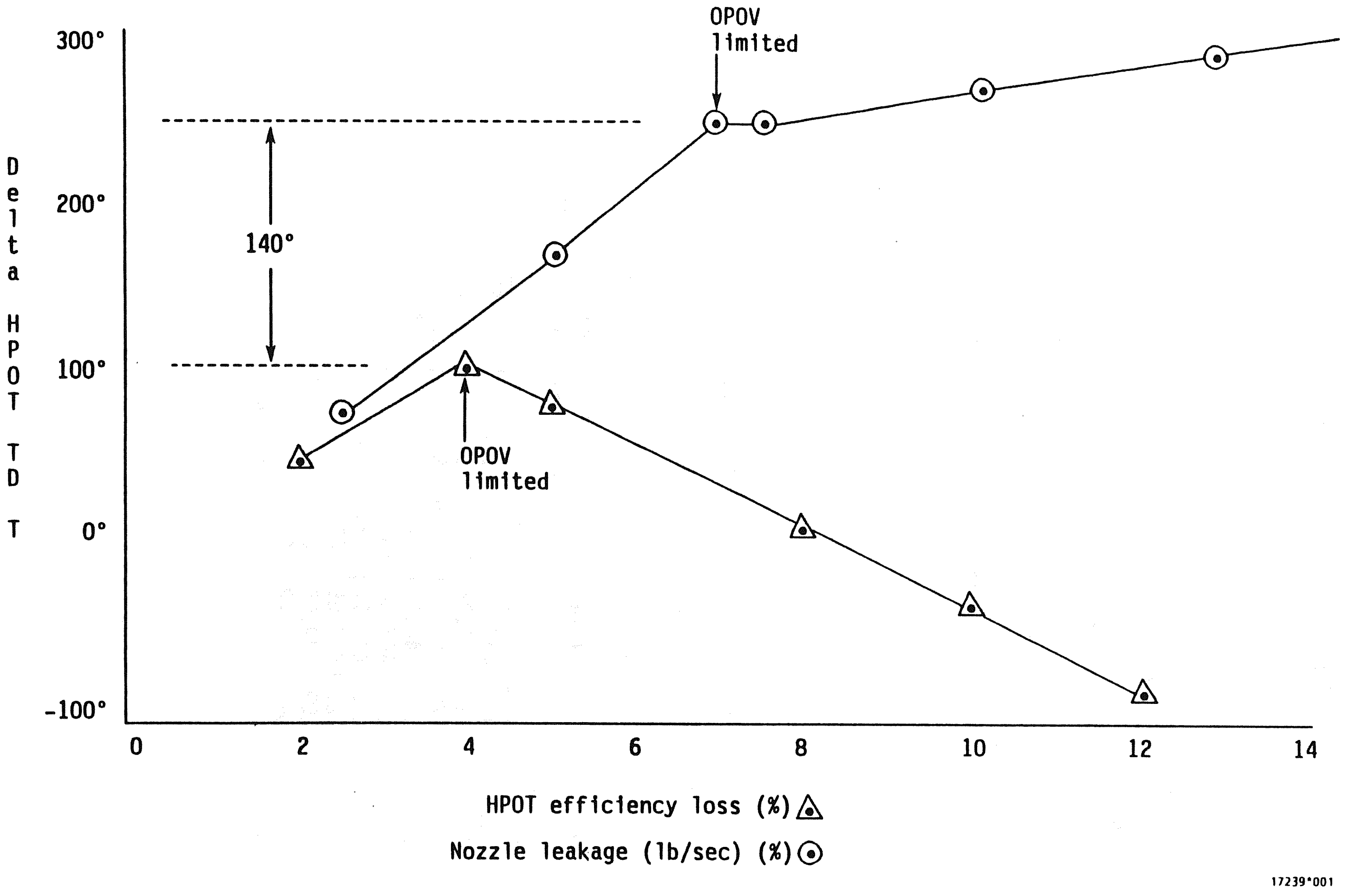


Figure 2.1.1-I.- Comparison of temperature effect for HPOT efficiency loss and nozzle leakage.

TABLE 2.1.1-XXVIII.- NOZZLE LEAK

Nozzle leak

A. Recognition of failure

1. Case number N = 1
   If TL flag set (1:45 - 2:00)
   assume time of throttle up
2. TL flag set (ESW = 8A)

3.

	L	C	R
HPOT TD T A >	1579	1648	1581
B >	1581	1575	1658

--- or ---
Pc Av Drop < 12 psia

4. HPOT TD TA and TB continues to increase

B. Activity

1. 'Thrust limiting C (L, R) SSME AT: ______ time'

2. After SRB SEP (sooner if possible):

   'Nozzle leak C (L, R) SSME level ____ at ____ time'

Level	Avg Pc (psia)	Performance			WDOTO (lb/sec)	WDOTF (lb/sec)	Leak (lb/sec)
		MR	ISP	PL			
NOM	3126	6.041	452.66	104.0	927.73	153.57	0
1	3126	6.183	447.85	105.0	949.74	153.57	7 TL set
2	3113	6.170	447.20	104.6	947.60	153.57	8
3	3100	6.157	446.60	104.3	945.68	153.57	9
4	3088	6.145	446.00	104.0	943.75	153.57	10
5	3077	6.133	445.37	103.7	941.88	153.57	11
6	3066	6.120	444.65	103.3	940.01	153.57	12
7	3054	6.109	444.08	103.0	938.20	153.57	13
8	3043	6.097	443.42	102.7	936.44	153.57	14
9	3031	6.086	442.76	102.4	934.68	153.57	15

TABLE 2.1.1-XXIX.- NOZZLE LEAK ACTIVITY

Step	Activity	Position
1	Report: "HPOT turbine temps are increasing and the OPOV position is increasing on the C (L, R) engine"	ME/BSE
2	After OPOV limiting is reached, Report: "C (L, R) engine is in OPOV limiting and the HPOT turbine temps are increasing; confirm a nozzle leak; we are evaluating"	ME/BSE FDO/FD crew
3	Determine performance level from table 2.1.1- XXVIII. Report: "C (L, R) engine nozzle leak, level _____, at ____ (time)"	ME/BSE FDO/FD

TABLE 2.1.1-XXX.- MCC PASS RECOGNITION OF FAILURE - HPOT EFFICIENCY LOSS

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(ESW)
(C) E41M1003P
(L) E41M2003P
(R) E41M3003P</td><td>OPOV limiting flag set<table><tr><td>HEX ESW</td><td>MCF</td><td>ELE</td></tr><tr><td>Last 2 digits</td><td>8A</td><td>8B</td></tr></table></td><td>MSK 1051
1052</td></tr>
<tr><td>(TH-LIM)
(C) M49G3708E
(L) M50G3708E
(R) M51G3708E</td><td>OPOV limiting mode</td><td>DDD
(C) 281
(L) 282
(R) 283</td></tr>
<tr><td>(N)
(C) M02G3112C
(L) M04G3112C
(R) M06G3112C</td><td>MOC performance case number (N) equals 2</td><td>MSK 1051
1052</td></tr>
<tr><td>(TN)
(C) M08G3112C
(L) M10G3112C
(R) M12G3112C</td><td>MET the MOC performance case identified</td><td>MSK 1051
1052</td></tr>
<tr><td>(OPOV)
(C) E41H1028B
(L) E41H2028B
(R) E41H3028B</td><td>OPOV position will be opened about 4 percent more than nominal</td><td>MSK 1051
1052</td></tr>
<tr><td>(HPOT TD T A/B)
(C) E41T1012/13B
(L) E41T2012/13B
(R) E41T3012/13B</td><td>HPOT TD T A/B will increase prior to entering OPOV limiting. After OPOV limit is reached, temps will decrease (fig. 2.1.1-I); temps will be no greater than 111° above nominal</td><td>MSK 1051
1052</td></tr>
<tr><td>(OMET)
M40H0107J</td><td>Time of failure</td><td>MSK 1051</td></tr>
<tr><td>(AVG Pc)
(C) E41P1023B
(L) E41P2023B
(R) E41P3023B
(ISP)
(C) M02G3107C
(L) M03G3107C
(R) M04G3107C</td><td>Note performance level on table 2.1.1-XXXI</td><td>MSK 1051
1052</td></tr>
</table>

Table 2.1.1- XXXI (from the main engine table program) is used to determine the level of the efficiency loss. For HPOT efficiency loss cases, the MCC PC is the primary cue used to determine the level. A summary of the Mission Control Center calls and the activity required for this case is presented in table 2.1.1-XXXII.

TABLE 2.1.1-XXXI.- HPOT EFFICIENCY LOSS

HPOT efficiency loss

A. Recognition of failure (MR low, thrust low)

1. TL flag set (ESW = 8A)

2. HPOT TD T

	L	C	R
A <	1442	1458	1511
B <	1444	1438	1521

--- and ---
Pc avg drop > 22 psia

3. HPOT TD TA and TB starts to decrease

4. Case number N = 2

B. Activity

1. 'Thrust limiting C (L, R) SSME AT: ______ time'

2. After SRB SEP (sooner if possible):

'HPOT Efficiency off C (L, R) SSME level ____ at ____ time'

3. If FDO determines ATO capability lost, shut down bad engine

Level	Avg Pc (psia)	Performance			WDOTO (lb/sec)	WDOTF (lb/sec)	Leak (lb/sec)
		MR	ISP	PL			
NOM	3126	6.041	452.66	104.0	927.73	153.57	0
1	3125	6.037	452.67	104.0	927.17	153.57	4 T/L set
2	3104	5.978	452.85	103.1	917.97	153.57	5
3	3082	5.918	452.99	102.3	908.79	153.57	6
4	3060	5.859	453.13	101.4	899.62	153.57	7
5	3039	5.800	453.27	100.6	890.44	153.57	8
6	3015	5.738	453.30	99.6	880.85	153.57	9
7	2992	5.676	453.34	98.7	871.25	153.57	10
8	2968	5.613	453.34	97.8	861.54	153.57	11
9	2943	5.550	453.34	96.9	851.82	153.57	12

TABLE 2.1.1-XXXII.- HPOT EFFICIENCY LOSS ACTIVITY

Step	Activity	Position
1	Report: "HPOT turbine temps are increasing and the OPOV position is increasing on the C (L, R) engine"	ME/BSE
2	After OPOV limiting is reached, Report: "C (L, R) engine is in OPOV limiting and the HPOT turbine temps are dropping; confirm an HPOT efficiency loss; we are evaluating"	ME/BSE FDO/FD crew
3	Determine performance level from table 2.1.1- XXXI Report: "C (L, R) engine HPOT efficiency loss, level _____, at _____ (time)"	ME/BSE FDO/FD

F. Low Pressure Fuel Turbopump (LPFT) Discharge Temperature Shift Low

The LPFT discharge temperature sensors are used by the controller to calculate the fuel density. This density is used in the calculation of the fuel mass flowrate, which is used in the mixture ratio calculation. The average LPFT discharge temperature is 43° R. The qualification limits for this sensor are 40° R minimum and 45° R maximum, respectively. The minimum detectable shift is 1.5° to ensure proper failure recognition. It is physically impossible for this temperature to be lower. The fuel inlet conditions are the same for all engines (i.e., the source is the same: the external tank). Therefore, if the LPFT discharge temperature is lower than the other two engines, the sensor has shifted low. If the LPFT discharge temperature is higher than nominal (or the other two engines), it is likely that this is an indication of a real engine problem and not a sensor failure. There is no console procedure to cover a sensor that has shifted high.

The LPFT discharge temperature shift low will cause the value of the calculated density to increase, which will cause the value of the calculated flowrate to increase. The controller calculated fuel flowrate will be greater than the actual flowrate, and the controller calculated mixture ratio will be lower than the actual mixture ratio. The controller response is to increase mixture ratio (decrease the fuel flowrate) by decreasing the FPOV open position. The MCC Pc and HPOT DP will then decrease a small amount. Next, the controller will command the OPOV to increase its open position to maintain the average Pc to the reference Pc. This will cause the HPOT turbine discharge temperature and the HPOT DP to increase a small amount as well. The engine will be operating at the commanded power level, but at an off-nominal high mixture ratio. A summary of PASS recognition of this failure mode is presented in table 2.1.1-XXXIII. Evaluation of this failure mode is not possible if the BFS is engaged. Also, the crew has no insight into this failure mode in either the PASS of BFS.

This is an off-nominal, high-mixture ratio failure mode that requires an ARD input. Table 2.1.1-XXXIV (from the main engine table program) is used to determine the level of the temperature shift. A summary of the Mission Control Center calls and activity required for this case is presented in table 2.1.1-XXXV.

The relevant Flight Rules for this section are

<u>Flight Operation Rules - Ascent</u>
2-27, ARD UPDATE CRITERIA

<u>Booster - SSME Systems Management</u>
5-35, ENGINE PERFORMANCE DISPERSION

TABLE 2.1.1-XXXIII.- MCC PASS RECOGNITION OF FAILURE - LPFT DT SENSOR SHIFT LOW

Parameter no.	Failure value/trend	Displayed on
(LPFT DT) (C) E41T1019B (L) E41T2019B (R) E41T3019B	LPFT DT is 2° lower than the other two engines	MSK 1051 1052
(HPOT TD T A/B) (C) E41T1012/13B (L) E41T2012/13B (R) E41T3012/13B	HPOT TD T A/B will increase about 75° for each 1° of LPFT DT error	MSK 1051 1052
(HPOT D P) (C) M41P1030B (L) M41P2030B (R) M41P3030B	HPOT DP will increase about 10 psia for each 1° of LPFT DT error	MSK 1051 1052
(OPOV) (C) E41H1028B (L) E41H2028B (R) E41H3028B	OPOV position will increase about 0.7 percent for each 1° of LPFT TD error	MSK 1051 1052
(FPOV) (C) E41H1027B (L) E41H2027B (R) E41H3027B	FPOV position will decrease about 0.6 percent for each 1° of LPFT TD error	MSK 1051 1052
(OMET) M40H0107J	Time of failure	MSK 1051 1052
(N) (C) M02G3112C (L) M04G3112C (R) M06G3112C	MOC performance case number (N) equals	MSK 1051 1052
(TN) (C) M08G3112C (L) M10G3112C (R) M12G3112C	MET the MOC performance case identified	MSK 1051 1052
(LPFT DT) (C) E41T1019B (L) E41T2019B (R) E41T3019B	Note performance level on table 2.1.1-XXXVII	MSK 1051 1052

TABLE 2.1.1-XXXIV.- LPFT DISCHARGE TEMPERATURE SHIFT LOW

Console cue card: LPFT DISCH T shift low

A. Recognition of failure

1. N = S
2. LPFT DISCH T < 42° R
   Qualified range: 40° to 45° R
3. Temp shift of 2° R from other SSME's
4. 70° R HPOT TD T increase per 1° R LPFT DT shift
5. MR high

B. Activity

'LPFT DT shift low C (L, R) SSME

level _____ at _____ time.'

LPFT DISCH T Shift Low - 104 pct

Level	Temp error	Pc (psia)	MR	ISP (sec)	Power level (percent)	WDOTO (lb/sec)	WDOTF (lb/sec)
NOM	0	3126	6.041	452.66	104.0	927.73	153.57
1	-1	3126	6.130	452.36	104.2	932.13	152.04
2	-2	3126	6.227	451.00	104.4	936.95	150.42
3	-3	3126	6.325	451.61	104.7	941.81	148.85
4	-4	3126	6.443	450.09	104.9	947.77	147.02
5	-5	3126	6.563	450.51	105.2	953.82	145.24

TABLE 2.1.1-XXXV.- LPFT DISCHARGE TEMPERATURE SHIFT LOW ACTIVITY

STEP	ACTIVITY	POSITION
1	Report: "The LPFT temp has shifted low on the C (L, R) engine; we are evaluating"	ME/BSE FDO/FD crew
2	Determine performance level from table 2.1.1-XXXIV Report: "C (L, R) engine LPFT discharge temp shift low, level _____, at ___ (time)"	ME/BSE FDO/FD

REFERENCES

1. STS Operational Flight Rules, All Flights, Final, PCN-4
November 3, 1989

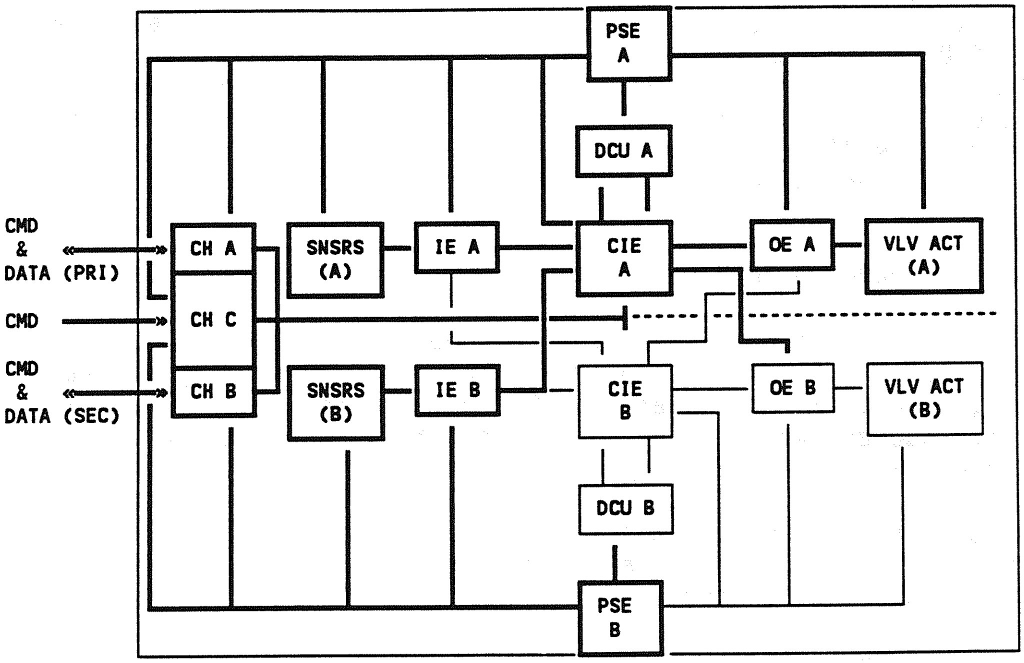
TITLE

SSME CONTROLLER REDUNDANCY LOSS

CONDITION

Controller redundancy loss is defined as loss of input electronics (IE), output electronics (OE), digital computer unit (DCU)/computer interface electronics (CIE), or power supply electronics (PSE) in channel A or B of any engine, such that the affected engine is one failure away from a pneumatic shutdown. See figure 2.1.2-I for the SSME controller redundancy management scheme. Figure 2.1.2-III provides the failure matrix for SSME failures resulting in shutdown or lockup (hydraulic or electric).

DESCRIPTION



NOTES:

PSE = DCU/CIE
IE (SENSORS)
OE (VALVE ACTUATORS)

IE = SENSORS
OE (VALVE ACTUATORS)
DCU (MAYBE - √ID WD 2)

OE = VALVE ACTUATORS

DCU/CIE A (NOT PSE) = DCU/CIE A
OE A (VALVE ACTUATORS)

DCU/CIE B = DCU/CIE ONLY (LOSS OF REDUNDANCY)

	CH	
ENG	A	B
L	AC 2	AC 3
C	AC 1	AC 2
R	AC 3	AC 1

Figure 2.1.2-I.- SSME controller redundancy management scheme.

I. LOSS OF PSE CHANNEL A OR B

Loss of either channel's power supply electronics causes disqualification of all functions on that channel: it's DCU, CIE, IE, and OE. Only functions/sensors on the remaining channel are used for engine control. Disqualification reporting is under either failure identification (FID) 1 or 2, delimiter (DLM) 001. If either channel's DCU/CIE pair is disqualified due to a non-power-related problem and power is subsequently lost on that channel, another FID (001(2)-002) is issued. No FID's are reported for loss of the other functions/channels/sensors on the failed side of the controller.

II. LOSS OF DCU/CIE CHANNEL A OR B

Loss of either DCU also results in loss of that channel's CIE. If the DCU and CIE were halted due to loss of power, then that channel's IE and OE will also be disqualified (redundancy effects are discussed later in this SLP). If DCU/CIE A were disqualified due to a non-power-related problem, then IE A can still be used by the remaining DCU. If DCU/CIE B were disqualified due to a non-power-related problem, then IE B and OE B can still be used by the remaining DCU. If DCU/CIE A is disqualified after a rotational variable differential transformer (RVDT) miscompare, the channel B actuators are also disqualified and the engine placed in hydraulic lockup (see figure 2.1.2-V).

III. LOSS OF IE CHANNEL A OR B

Loss of either IE channel results in disqualifying all sensors used in control, ignition confirmation, or engine limit monitoring on that channel, as well as that channel's OE and actuators. If either IE fails its address and data bus self test, the in-charge DCU will also be disqualified. The FID only reports the IE disqualification (FID 003 or 004 with DLM 001, 002, 012, or 013). If DCU A was disqualified due to this failure mode, then switchover to DCU B can be detected by monitoring ID word 2. Failure of this test while DCU B is in charge results in a pneumatic shutdown.

IV. LOSS OF OE CHANNEL A OR B

Loss of either OE channel results in commanding the solenoid power off and the OE registers to the fail-safe configuration in the respective OE channel. The fail-safe configuration includes: all ON/OFF valves and ignitors deactivated and all internal functions deactivated. All ON/OFF valves, propellant valve actuators, and LVDT/RVDT excitations on the failed channel are also disqualified. Actuator control will be via the remaining OE.

A criticality 1R/2 scenario has been identified in OE part of the controller that results in the engine going into hydraulic lockup mode and being unable to accomplish a pneumatic shutdown (fig. 2.1.2-II). The first failure is the +36 V dc power switch in OE B failing closed after final checkout prelaunch (approximately T-34h in Redundancy Checkout). This failure will be undetected following the Redundancy Checkout. The second failure is bit 11 in storage register B in OE B failing to the ON state. This causes OE B to be disqualified (FID 006-000). The solenoid power switch (+36 V dc) is commanded open, but it remains failed closed (due to the first failure). This causes all on/off devices to be commanded OFF, but with bit 11 failed ON, the emergency shutdown (EMSD) solenoid power B is left ON and the CCV fail-operate servoswitch is commanded ON. The CCV switches from channel A control to channel B, but since OE B is disqualified, no new commands are issued from channel B. DCU A does not know that OE A no longer has control of the CCV, which was left in its last commanded position. Hydraulic lockup eventually occurs (probably not until a new throttle command is issued) due to SEII detection of 6 percent error (FID 015-031) between commanded and actual position on the CCV and the inability to switch to B actuators due to the OE B disqualification. When the GPC's command shut down, the pneumatic shutdown cannot be accomplished due to EMSD B solenoid remaining powered, resulting in failure to close the valves and no shutdown purges (catastrophic failure resulting in loss of crew and vehicle). Preliminary numbers provided by Mr. R. Biggs/Rocketdyne indicate the probability of both failures occurring during a flight to be approximately 2.2222 x 10^{-10}. If the signature of this failure mode is seen by the ground, the MCC will request that the crew turn off the ac power to channel B of the affected engine at Vrel = 23K (or whatever the appropriate boundary is, depending on the abort). The engine will continue to run in hydraulic lockup until shutdown is commanded. The ac bus sensor switches are taken to OFF at the time of the OE B failure. The only indications to the crew are the fault message "MPS HYD C (L,R)" and the amber status light. This case is shown on the cue card in figure 2.1.2-IV.

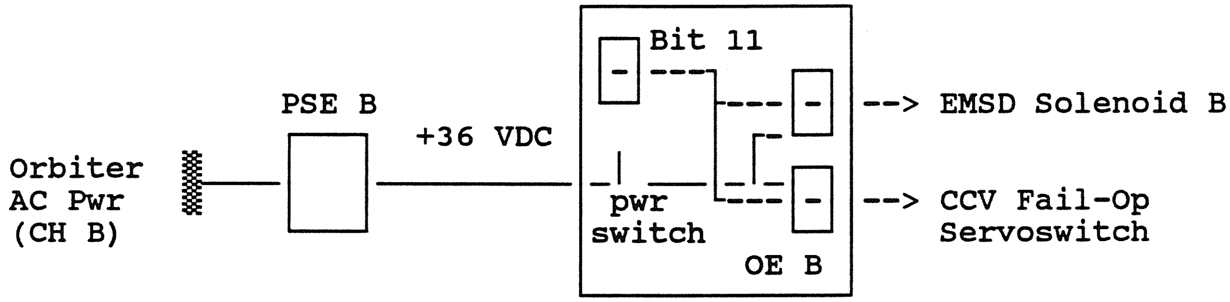


Figure 2.1.2-II.- OE B critically 1R failure diagram.

V. NONDISQUALIFYING FAILURE OF OE A OR OE B

The controller performs self tests on the on/off devices by verifying their current states with their last commanded states. Since the OE is used to command and read back these values, these tests can be considered part of the OE self tests, even though failure of these tests does not necessarily result in loss of the OE. Failure of these tests are reported using FID's 7 and 10. Since these failures are nondisqualifying, the normal action of taking the ac bus sensors to OFF for loss of controller redundancy is not required (engine is not one failure away from an immediate pneumatic shutdown). There are two cases worth noting. The first one is the failure of the EMSD solenoid bit failed on (part of FID 007/010-100). If this failure occurs, then the OE is disqualified at shutdown and FID 005/006-101 is issued. When the OE is disqualified, the EMSD solenoid is commanded off and should allow the other channel to control the solenoid's status. The second failure worth noting is that if any of the fail-safe bits have failed OFF (FID 007/101-300), the engine will go into hydraulic lockup if the other channel's fail-safe on that actuator also fails OFF. These two special cases are documented in the cue card shown in figure 2.1.2-IV.

CHANNEL A	CHANNEL B																
	DCU/ CIE B D/QUAL	IE B D/QUAL	OE B D/QUAL	PSE B D/QUAL	HPFT TDT B EX LIM	HPOT TDT B EX LIM	HPOT IMSL B EX LIM	HPOT SCSL B EX LIM	HPFT CLLNRB EX LIM	MCC Pc B EX LIM	MOVB D/QUAL	MFVB D/QUAL	CCVB D/QUAL	FPOVB D/QUAL	OPOVB D/QUAL	MCC Pc B D/QUAL	FFMB D/QUAL
DCU/CIE A D/QUAL	PSD	PSD*	PSD	PSD							HL	HL	HL	HL	HL		
IE A D/QUAL	PSD*	PSD	PSD	PSD	RL	RL	RL	RL	RL	RL	HL	HL	HL	HL	HL	EL	EL
OE A D/QUAL		PSD	PSD	PSD							HL	HL	HL	HL	HL		
PSE A D/QUAL	PSD	PSD	PSD	PSD	RL	RL	RL	RL	RL	RL	HL	HL	HL	HL	HL	EL	EL
HPFT TDT A EXCDG LIM		RL		RL	RL												
HPOT TDT A EXCDG LIM		RL		RL		RL											
HPOT IMSL A EXCDG LIM		RL		RL			RL										
HPOT SEC SL A EXCDG LIM		RL		RL				RL									
HPFT CL LNR A EXCDG LIM		RL		RL					RL								
MCC Pc A EXCDG LIM		RL		RL						RL							
MOVA D/QUAL		HL	HL	HL							HL	HL	HL	HL	HL		
MFVA D/QUAL		HL	HL	HL							HL	HL	HL	HL	HL		
CCVA D/QUAL		HL	HL	HL							HL	HL	HL	HL	HL		
FPOVA D/QUAL		HL	HL	HL							HL	HL	HL	HL	HL		
OPOVA D/QUAL		HL	HL	HL							HL	HL	HL	HL	HL		
MCC Pc A D/QUAL		EL		EL												EL	
FFM A D/QUAL		EL		EL													EL

PSD = SHUTDOWN DUE TO LOSS OF CONTROLLER REDUNDANCY
PSD* = SHUTDOWN DUE TO LOSS OF CONTROLLLER REDUNDANCY IF IE FAILURE ALSO DISQUALIFIED DCU (CHECK ID WORD)
RL = SHUTDOWN DUE TO REDLINE (MAY BE INHIBITED BY LIMIT SWITCH)
HL = HYDRAULIC LOCKUP
EL = ELECTRICAL LOCKUP

Figure 2.1.2-III.- SSME shutdown/lockup failure matrix.

VI. PROCEDURES

A. Flight Rules

1. 5-2, SSME ENGINE OUT
2. 5-3, STUCK THROTTLE
3. 5-36, AC BUS SENSOR ELECTRONICS CONTROL

B. Crew Operations

1. Recognition of Failure - None
2. Crew Procedure - None in FDF
3. Activity - Ground call only

TABLE 2.1.2-I.- CREW ACTIVITY (PASS/BFS) FOR LOSS OF SSMEC REDUNDANCY

Step	Activity	Panel
1	AC BUS SENSORS (three) - OFF	R1

C. MCC Operations

1. Recognition of Failure

TABLE 2.1.2-II.- RECOGNITION OF FAILURE (PASS)

Parameter no.	Failure value/trend		Displayed on MSK
(FID)	FID-DLM (octal)	Syntax	
(C) E41M1005P	003-001	IE A D/QUAL - & OE & ACTRS	1051, 1052,
(L) E41M2005P	003-002	IE A D/QUAL - & OE & ACTRS	1069, 1070
(R) E41M3005P	003-012	IE A D/QUAL - & OE & ACTRS	
	003-013	IE A D/QUAL - & OE & ACTRS	
	003-201	IE A D/QUAL - & OE & ACTRS	
	003-202	IE A D/QUAL - & OE & ACTRS	
	003-203	IE A D/QUAL - & OE & ACTRS	

TABLE 2.1.2-II.- Continued

Parameter no.	Failure value/trend		Displayed on MSK
(FID)	FID-DLM (octal)	Syntax	
(C) E41M1005P	003-204	IE A D/QUAL - & OE & ACTRS	1051, 1052
(L) E41M2005P	003-205	IE A D/QUAL - & OE & ACTRS	1069, 1070
(R) E41M3005P	003-206	IE A D/QUAL - & OE & ACTRS	
	003-207	IE A D/QUAL - & OE & ACTRS	
	003-210	IE A D/QUAL - & OE & ACTRS	
	003-211	IE A D/QUAL - & OE & ACTRS	
	003-501	IE A D/QUAL - & OE & ACTRS	
	004-001	IE B D/QUAL - & OE & ACTRS	
	004-002	IE B D/QUAL - & OE & ACTRS	
	004-012	IE B D/QUAL - & OE & ACTRS	
	004-013	IE B D/QUAL - & OE & ACTRS	
	004-201	IE B D/QUAL - & OE & ACTRS	
	004-202	IE B D/QUAL - & OE & ACTRS	
	004-203	IE B D/QUAL - & OE & ACTRS	
	004-204	IE B D/QUAL - & OE & ACTRS	
	004-205	IE B D/QUAL - & OE & ACTRS	
	004-206	IE B D/QUAL - & OE & ACTRS	
	004-207	IE B D/QUAL - & OE & ACTRS	
	004-210	IE B D/QUAL - & OE & ACTRS	
	004-211	IE B D/QUAL - & OE & ACTRS	
	004-501	IE B D/QUAL - & OE & ACTRS	

TABLE 2.1.2-II.- Continued

Parameter no.	Failure value/trend		Displayed on MSK
(FID)	FID-DLM (octal)	Syntax	
(C) E41M1005P	005-000	OE A D/QUAL - & ACTUATORS	1051, 1052,
(L) E41M2005P	005-100	OE A D/QUAL - & ACTUATORS	1069, 1070
(R) E41M3005P	005-101	OE A D/QUAL - EMER S/D ON	
	005-102	OE A D/QUAL - IGN FAIL ON	
	005-200	OE A D/QUAL - & ACTUATORS	
	005-300	OE A D/QUAL - & ACTUATORS	
	005-400	OE A D/QUAL - & ACTUATORS	
	005-401	OE A D/QUAL - & ACTUATORS	
	005-402	OE A D/QUAL - & ACTUATORS	
	005-403	OE A D/QUAL - & ACTUATORS	
	005-404	OE A D/QUAL - & ACTUATORS	
	005-405	OE A D/QUAL - & ACTUATORS	
	004-406	OE A D/QUAL - & ACTUATORS	
	004-407	OE A D/QUAL - & ACTUATORS	
	006-000	OE B D/QUAL - & ACTUATORS	
	006-100	OE B D/QUAL - & ACTUATORS	
	006-101	OE B D/QUAL - EMER S/D ON	
	006-102	OE B D/QUAL - IGN FAIL ON	
	006-300	OE B D/QUAL - & ACTUATORS	
	006-400	OE B D/QUAL - & ACTUATORS	
	006-401	OE B D/QUAL - & ACTUATORS	

TABLE 2.1.2-II.- Concluded

<table>
<tr><th>Parameter no.</th><th colspan="2">Failure value/trend</th><th>Displayed on MSK</th></tr>
<tr><td>(FID)</td><td>FID-DLM
(octal)</td><td>Syntax</td><td></td></tr>
<tr><td>(C) E41M1005P</td><td>006-404</td><td>OE B D/QUAL - & ACTUATORS</td><td>1051, 1052</td></tr>
<tr><td>(L) E41M2005P</td><td>006-405</td><td>OE B D/QUAL - & ACTUATORS</td><td>1069, 1070</td></tr>
<tr><td>(R) E41M3005P</td><td>006-406</td><td>OE B D/QUAL - & ACTUATORS</td><td></td></tr>
<tr><td></td><td>006-407</td><td>OE B D/QUAL - & ACTUATORS</td><td></td></tr>
<tr><td></td><td>001-000</td><td>DCU A D/QUAL-& OE & ACTRS</td><td></td></tr>
<tr><td></td><td>001-001</td><td>DCU A D/QUAL - CHAN PWR</td><td></td></tr>
<tr><td></td><td>001-002</td><td>DCU A D/QUAL - CHAN PWR</td><td></td></tr>
<tr><td></td><td>002-000</td><td>DCU B D/QUAL-DCU/CIE ONLY</td><td></td></tr>
<tr><td></td><td>002-001</td><td>DCU B D/QUAL - CHAN PWR</td><td></td></tr>
<tr><td></td><td>002-002</td><td>DCU B D/QUAL - CHAN PWR</td><td></td></tr>
<tr><td>E41MX003P (ESW)
X = 1 (C)
X = 2 (L)
X = 3 (R)</td><td colspan="2"><table><tr><td rowspan="2">HEX
ESW
LAST 2 DIGITS</td><td>MCF</td><td>ELE</td></tr><tr><td>86</td><td>87</td></tr></table></td><td>1051
1052</td></tr>
</table>

TABLE 2.1.2-III.- BFS RECOGNITION OF FAILURE

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on MSK</th></tr>
<tr><td>(ESW)
V98M2200P (C)
V98M2220P (L)
V98M2240P (R)</td><td><table><tr><td rowspan="2">HEX
ESW
LAST 2 DIGITS</td><td>MCF</td><td>ELE</td></tr><tr><td>86</td><td>87</td></tr></table></td><td>1051
1052
1064
1065
1089</td></tr>
</table>

SPECIAL CASE OE FAILURE (BLK II)

CASE 1: OE B STORAGE REGISTER FAILURE

SIGNATURE: FID = 6-000, "OE B D/QUAL -& ACTUATORS"
FID = 15-031, "SRVO ACT FAIL-SEII-CCV CH A
ESW = HYD L/U (92)

RESPONSE: TURN OFF CH B POWER @
V_{REL} = 23K (NOM, ATO, AOA)
V_{REL} = 22.5K (TAL)
α = -4 (RTLS)
ENGINE SHOULD REMAIN IN HYD L/U
UNTIL MECO

CASE 2: EMERGENCY SHUTDOWN SOLENOID FAILS ON IN MAINSTAGE

SIGNATURE: (during mainstage)
FID = 007(010)-100, "OE A(B), NOT DQL-REGISTER 1"

(during shutdown)
FID = 005(006)-101, "OE A(B) D/QUAL-EMER S/D ON"

RESPONSE: NONE BY MCC
CONTROLLER WILL DISQUALIFY OE DURING S/D

CASE 3: ALTHOUGH FID's 007 AND 010 ARE NONDISQUALIFYING, BE AWARE OF THE FOLLOWING FAILURE RESPONSE:

DLM 300: 2ND FAILURE RESULTS IN HYDRAULIC LOCKUP

03/25/92

Figure 2.1.2-IV.- Special case OE failures cue card.

2. MCC Activity

TABLE 2.1.2-IV.- MCC ACTIVITY

Step	Activity	Position
1	Report "Loss of controller redundancy on C(L,R) engine, channel A(B)"	ME/BSO/FD
2	"AC BUS SENSORS - OFF" Verify on DDD panel 293	ME/BSO/FD ME
3	Report "Critical to AC 1(2,3)"	ME/BSO/FD
4	Review specific redundancy loss and criticality of subsequent failures (as time permits)	

D. Supporting Data

1. Figures

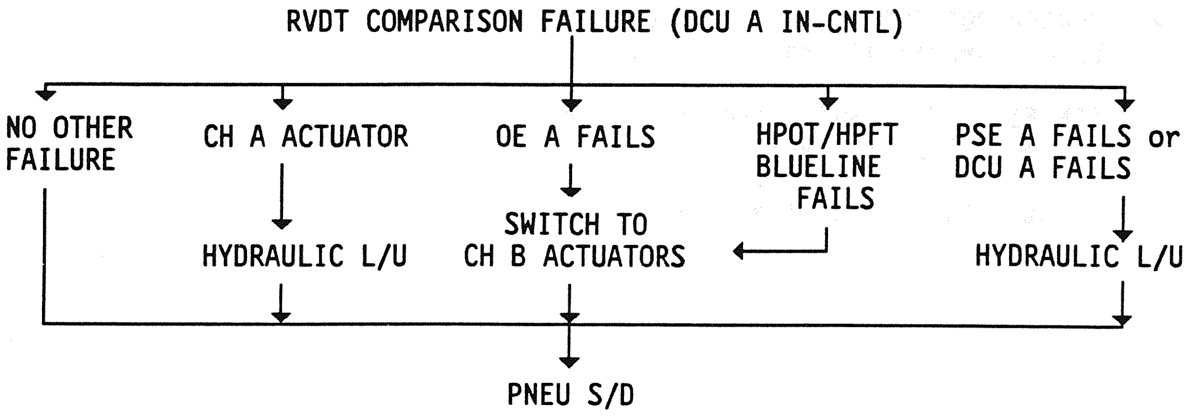


Figure 2.1.2-V.- SSME RVDT miscompare fault tree (Blk II).

2. Tables - None.

3. Notes

a. Subsequent loss of the redundant element will result in a DCU halt, failsafe pneumatic shutdown, and the fault message "MPS DATA C(L,R)." See SCP 2.1.3, DATA PATH FAIL, for more information.

b. The ground FAILURE VALUE/TREND in table 2.1.2-II represents a decoded syntax of word 5 from each engine's VDT. The MSID's for these parameters are input into a computation, documented in SCP 3.1.2, which generates the syntax and time of failure. The syntax is displayed on MSK's 1051, 1052, 1069, and 1070. The octal values of the FID and DLM numbers are displayed on MSK 1069. The hexadecimal values are displayed on MSK's 1071/1072, 1073/1074, and 1075/1076, which are the history tabs for the center, left, and right engines, respectively. For more information on VDT word 5, reference SCP's 3.1.2 and 4.1, and SSMEC software brief 1.4.

c. Switching the ac bus sensors to OFF is required due to possible single point failures in the bus sensor monitor electronics that could inadvertently turn off a remaining ac power bus.

REFERENCES

1. STS Operational Flight Rules, All Flights, final, PCN-12, JSC-12820, Feb. 27, 1992.

2. CP406R0002 (V2.5), Part, I, Computer Program Contract End Item, Block II SSME Operational Program, Jan. 10, 1992.

3. RCN 5193, "DCU Switchover Following Channel A Actuator Disqualification," Feb. 5, 1992.

4. Booster Systems Software Handbook, vols. I and II, JSC-19395.

TITLE

DATA PATH FAILURE

CONDITION

Loss of data from the SSME to the GPC's.

DESCRIPTION

The data from the monitored engine parameters are arranged into a vehicle data table (VDT) in the main engine controller (ref. SCP 4.1). The controller transmits the VDT, consisting of 128 words, to the controller interface adapter (CIA) 1 and CIA 2 of the engine interface unit (EIU). The data transmitted to CIA 1 and CIA 2 is called primary data and secondary data, respectively. Refer to figure 2.1.3-I for EIU data flow. In the EIU, the first 32 words of the VDT are loaded into a status register for transmission upon request by the GPC's. The remaining words of the VDT are not available to JSC flight controllers in real time. Upon GPC request by the mid frequency executive, the first 32 words are transmitted to multiplexer interface adapter (MIA) 1 and the first 6 words are transmitted to MIA 4. The high frequency executive requests the six words from MIA's 1 and 4 every 40 msec. The primary data and secondary data are output through MIA 1 and MIA 4, respectively. The secondary data includes identification (ID) word 1, ID word 2, the engine status word (ESW), reference time (T-REF), hard failure identification (FID), and average main chamber combustion pressure.

A data path failure is defined as the loss of both primary and secondary data streams from the SSME's to the GPC's. This type of anomaly will exist after the occurrence of any of the following failures:

1. The failures of the GPC's (or FA MDM's) associated with MIA's 1 and 4. Refer to SCP 2.1.4 for MDM failures.
2. The failures of MIA's 1 and 4.
3. The failures of CIA's 1 and 2.
4. The failures of an ac power bus and a failed-to-sync GPC that affects the primary and secondary data streams.
5. Combinations of GPC, CIA, MIA, and ac power bus failures that affects the primary and secondary data streams.
6. A two-on-two GPC set split can cause loss of data from an engine to one set of computers.

As a result of the data path failure for causes 1 through 5, the crew does not know the status of that SSME. A data path failure will cause the associated cockpit Pc meter to indicate zero. If that engine has shut down prematurely, the shutdown will be masked to both the crew and the GPC's (guidance and flight control). However, the BSE, ME, and MPS operators use other parameters, such as the GH2 outlet pressure, the GO2 outlet temperature, engine helium usage, thrust factor (PASS only; second stage only) and vehicle acceleration (second stage only) to determine if the SSME is still operating. These parameters are also used to verify 3-g throttling and the status of the command path to that SSME. Summaries of the crew failure recognition and MCC failure recognition are presented in tables 2.1.3-I and 2.1.3-II, respectively. Mission Control Center recognition while on the BFS is presented in table 2.1.3-III. For a "pseudo" data path, which occurs after a two-on-two GPC set split, the crew will probably receive one data path message and at least one command path message. All Pc's should still be valid on the meters and the status lights should not be illuminated. It should also be noted that the ground may not receive engine data.

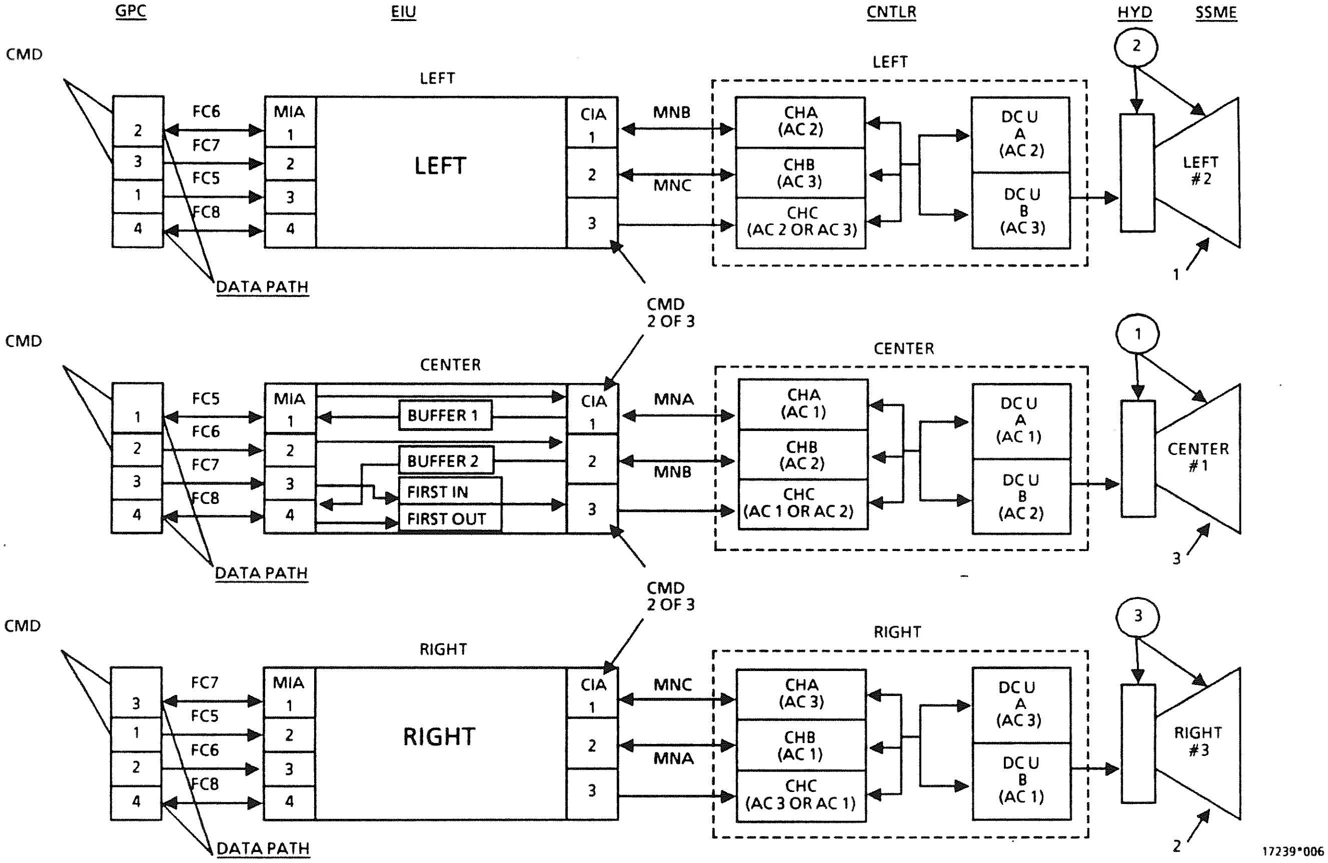


Figure 2.1.3-I.- EIU data flow.

If the command path is good to the SSME with the data path failure, no crew action is required pre-MECO because the engine can accept the shutdown command. However, in a no-comm situation, the crew assumes the SSME has both a command path failure and a data path failure and shuts down the engine prior to MECO (refer to Flight Rule 5-32, MANUAL SHUTDOWN FOR COMMAND/DATA PATH FAILURES).

If the SSME with the data path failure is determined by the BSE, ME, and MPS console operators not to be operating, the shutdown pushbutton for that engine must be pushed as soon as possible. This will inform guidance that the engine has shut down and command the prevalves on that engine closed. Engine shutdown behind a data path is presented in table 2.1.3-V. If the safing function of the shutdown pushbutton is inoperative due to a control bus problem, the appropriate flight critical forward (FF) multiplexer/demultiplexer (MDM) will be commfaulted (power cycle). The SSME shutdown pushbutton is a two-contact switch (refer to systems brief 1.12, SSME CREW CONTROLS). There is one FF MDM and one control bus associated with each contact. The FF MDM that is associated with the same switch contact as the control bus is the MDM that is commfaulted. This will allow the safing command to be processed when the shutdown pushbutton is engaged. The commfaulted MDM may be regained via an input/output (I/O) reset after the safing command is processed (refer to Flight Rule 5-30, DATA PATH FAIL/ENGINE OUT ACTION).

When an SSME has a data path failure due to causes 1 through 5, the shutdown limits on the other engines are automatically inhibited. If all three SSME's are still operating nominally, the limits are re-enabled as soon as possible. This is accomplished by putting the limit shutdown switch in the ENABLE position, then taking the switch back to the AUTO position. If two SSME's are operating and the engine with the data path failure was the one that shut down, the limits are not re-enabled, when on the PASS, until single engine capability is reached. If the BFS is engaged, the shutdown limits are not re-enabled. A second engine cannot be allowed to shut down because there is no single engine flight control capability in the BFS (refer to Flight Rules 5-27, LIMIT SHUTDOWN CONTROL and 5-29, DATA PATH FAIL/ENGINE ON LIMIT SHUTDOWN CONTROL). When a "pseudo" data path occurs after a two-on-two GPC set split, the shutdown limits on one or two engines will be automatically inhibited and the crew should take the limits switch to enable.

It should be noted that the PASS SSME OPS sequence uses the last valid data from the engine prior to the data path when it performs its MECO confirm logic. Therefore, if an engine shuts down and subsequently has a data path failure, the Pc < 30 will be used in the MECO confirm logic. If an engine shuts down "behind" a data path, the Pc when the data path was incurred will be used (i.e., Pc > 30). The BFS MECO confirm logic is located in the backup events control S/W and does not use engine data if a data path fail flag is latched.

If an SSME has a data path failure but is still operating and another SSME has shut down, the limits cannot be re-enabled (refer to Flight Rule 5-29, DATA PATH FAIL/ENGINE ON LIMIT SHUTDOWN CONTROL). If the limits were re-enabled and the remaining good engine shut down, then MECO would immediately occur. This would result in an unacceptable underspeed. The reason that this would happen is found in the SSME OPS sequence. In this sequence, if the main combustion Pc on two SSME's is less than 30 percent and the third engine has a data path failure with Pc > 30, the MECO command flag is set.

However, if multiple data path failures exist, this early MECO concern might be eliminated. For example, if an engine with a data path failure is confirmed on (Pc > 30 latched), limits will be re-enabled as described earlier. However, if a subsequent engine experiences a command path failure, a manual shutdown of this engine will be required at a velocity of 23K. This manual shutdown will create another data path failure (refer to SCP 2.1.4) with Pc > 30. The software will then inhibit limits. There are now two data path failures with Pc > 30, (1) one engine operating and (2) the manually shutdown engine. Since there are two data path failures with Pc > 30, the MECO confirmed software as described will never be satisfied. In this type of case, it is preferable to re-enable limits after the manual shutdown.

One additional case requires explanation. As before, an engine with a data path failure is confirmed operating and the limits are reconfigured. A subsequent engine experiences a redline shutdown (not behind a data path failure), guidance is moded and the engine is safed. If this failed engine experiences a data path failure after this has occurred, limits should not be re-enabled due to the early MECO confirmed concern (one engine's Pc < 30 with a data path and another data path).

Suppose a data path failure has occurred. The engine is determined to be operating and the shutdown limits are enabled with the switch in the AUTO position. Subsequently, the engine with the data path failure shuts down prematurely. In this case, the auto function on the limit switch will not work. The limits must be manually inhibited (switch to INHIBIT position). The Mission Control Center activity required for a data path failure is presented in table 2.1.3-IV.

For multiple command and data path failures, all three shutdown pushbuttons must be pushed simultaneously at MECO. This action must be taken to set the MECO CONFIRMED flag in the SSME OPS sequence. This flag is required to initiate the ET separation sequence. In the event of pushbutton failures, the crew can also set the MECO CONFIRMED flag by moding the GPC's to major mode (MM) 104 (refer to Flight Rule 5-53).

There can be a false indication of a data path or a command path failure. This will occur when a GPC has failed synchronization (failed-to-sync) with the redundant set. A discussion of this is presented in SCP 2.1.4.

The last case to be discussed involves recovering data on an engine that has had a data path fail flag latched through a restring. The amber status light will be on due to the latched data path flag and the Pc meter will remain at 0 percent. Since DCU B will be supplying data (DCU switch command will have been sent) it is only limited. If DCU B is not in charge it will be performing sensor logic and will probably be unaware of redline violations. However, mode and phase changes could cause fault messages and red status lights. Lastly, the Pc values should be available to the SSME SOP and SSME OPS for MECO confirm logic (i.e., treat as Pc < 30).

A. Crew Operations

TABLE 2.1.3-I.- FAILURE RECOGNITION (PASS/BFS)

Parameter no.	Failure value/trend	Displayed on
(C) V72X0035X (L) V72X0036X (R) V72X0037X	C(L,R) amber MAIN ENGINE STATUS light on	PNL F7
	MPS DATA C(L,R) (class 3 alarm)	FML
(C) V72P0040C (L) V72P0041C (R) V72P0042C	Pc meter drops to zero on C(L,R)	PNL F7

Note: A "pseudo" data path caused by a GPC set split will cause a fault message but not affect that engine's status light or Pc.

MPS ASC

MN ENG FAIL/SHUTDN

If 'MPS DATA':
  Aff MN ENG SHUTDN
  pb - push
AC BUS SNSR (three) - OFF
If 1 ENG:
  When MPS PRPLT = 2%:
    MAN THROT Pc → 67%,
     At CO: Shut dn MN ENG (pb)

MPS DATA

✓MCC, accel, He dP/dT
If no comm: Assume MPS CMD
If multi (No MECO Confirm):
  Post MECO:
    MN ENG SHUTDN pb
    (three) - push (simo)

MPS LH2 ULL

✓MCC
Post SRB Sep:
  If 2,3 Ps < 31.6 or
  > 34.5:
    MPS LH2 ULL PRESS - OP
  When all Ps > 34.5:
    MPS LH2 ULL PRESS - AUTO

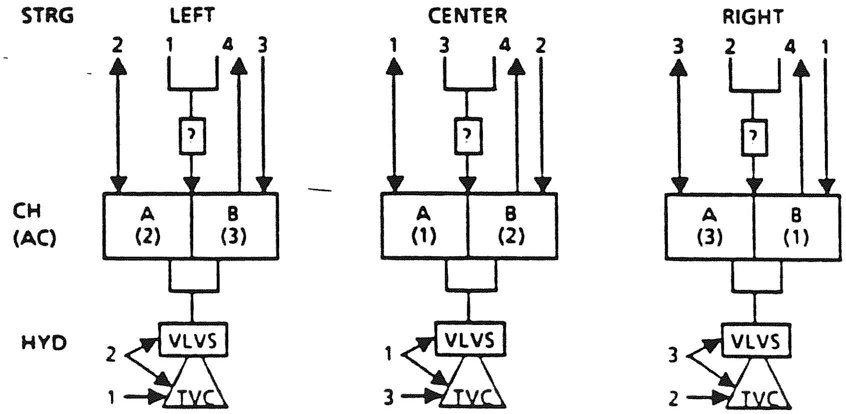
------------- POST MECO -------------

MPS LH2/O2 MANF

MPS PRPLT DUMP SEQ - START

MPS DUMP INHIBIT

Aff MPS ENG PWR (two) - OFF
        LO2(H2) PRE VLV - CL



B. MCC Operations

TABLE 2.1.3-II.- MCC PASS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
First stage recognition		
(ESW) (C) E41M1003P (L) E41M2003P (R) E41M3003P	ESW still indicates normal mainstage and other two ESW's indicate limits inhibited (first two bits of ESW = 00)	MSK 1052
(T-REF) (C) E41W1004P (L) E41W2004P (R) E41W3004P	T-REF will not update	MSK 1052
(Pc) (C) E41P1023P (L) E41P2023P (R) E41P3023P	Pc will not change	MSK 1052
(GH_2 OUT P) (C) V41P1160A (L) V41P1260A (R) V41P1360A	GH_2 outlet pressure will not change Note: If GH_2 OUT P > 1050 psia, SSME ON If GH_2 OUT P < 1050 psia, SSME S/D	MSK 1052 DDD 281 282 283
(GO_2 OUT T) (C) V41T1171A (L) V41T1271A (R) V41T1371A	GO_2 outlet temperature will not change Note: If GO2 OUT T > 300° F, SSME ON If GO2 OUT T < 300° F, SSME S/D	MSK 1052 1054
(He TK dP/dt)) (C) V98P4997C (L) V98P4998C (R) V98P4999C	Helium tank change rate will not change Note: If an SSME shutdown, helium usage will increase and generate a BFS He dp/dt fault message and go to 0 psi/3 sec within 20 sec of shutdown	MSK 1054

TABLE 2.1.3-II.- Concluded

Parameter no.	Failure value/trend	Displayed on
Second-stage recognition	Use first-stage recognition with: vehicle acceleration and thrust factor	
(Accel) V95U0163C	Vehicle acceleration will decrease by one-third if SSME has S/D	MSK 1052 2762
(Thrust factor) V90U1979C	Thrust factor will decrease to 0.67 if engine has S/D. After guidance is moded it will return to 1.00	MSK 1052

Note: During a two-on-two GPC set split, the MCC may not have any data, but must rely on the DPS officer to determine that the set split occurred.

TABLE 2.1.3-III.- BFS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
First-stage recognition		MSK
(ESW) (C) V98M2200P (L) V98M2220P (R) V98M2240P	ESW still indicates normal mainstage and other two ESW's indicate limits inhibited (first two bits of ESW = 00)	1064 1089
(TREF) (C) E41W1004P (L) E41W2004P (R) E41W3004P	T-REF will not update	MSK 1064 1089
(% Pc) (C) V98P2100C (L) V98P2110C (R) V98P2120C	Percent Pc will not change	MSK 1064 1089

TABLE 2.1.3-III.- Concluded

Parameter no.	Failure value/trend	Displayed on
(GH2 OUT P) (C) V41P1160A (L) V41P1260A (R) V41P1360A	GH_2 outlet pressure will not change Note: If GH_2 out P > 1050 psia, SSME ON If GH_2 out P < 1050 psia, SSME S/D	MSK 1064 1052 DDD 281 282 283
(GO_2 OUT T) (C) V41T1171A (L) V41T1271A (R) V41T1371A	GO_2 outlet temperature will not change Note: If GO_2 out T > 300° F, SSME ON If GO_2 out T < 300° F, SSME S/D	MSK 1064 1052 1054
(Helium tank change rate) (C) V98P4997C (L) V98P4998C (R) V98P4999C	Helium tank change will not change Note: If SSME is out, tank change rate will go to 0 psi/sec	MSK 1064 1054
	MPS DATA C (L,R) (class 3 alert)	FML
Second-Stage Recognition	Same as first-stage recognition	

1. Console Cue Cards

Recognition of failure:

- T-REF not updating (PASS only)
- ESW still indicates mainstage and other two ESW indicate limits inhibited
- Pc, GH_2 outlet press unchanged
- "MPS DATA C(L,R)" message

2. MCC Activity

TABLE 2.1.3-IV.- DATA PATH (CAUSES 1-5) AND SSME ON (GH_2 OUTLET PRESSURE > 1050 PSIA) (GO_2 OUTLET TEMP > 300° F)

Step	Activity	Position
1	Report: "Data path failure on the C(L,R) engine"	ME/BSE/FD/crew
2	Report: If three engines operating, report: "C(L,R) engine confirmed running, Limits - ENABLE/AUTO" ASAP	ME/BSE/FD/crew
	If engine with data path S/D at time of data path failure, report: "C(L,R) engine out, push S/D pushbutton	ME/BSE/FD/crew
3	Report: If engine with data path failure S/D after limits re-enabled <u>and</u> prior to single engine droop capability, report: "C(L,R) engine out, push S/D pushbutton and inhibit limits"	ME/BSE/FD/crew
	If engine with data path failure S/D after limits re-enabled <u>and</u> after single engine droop capability <u>and</u> all redline sensors are qualified, report: "C(L,R) engine out, push S/D pushbutton and ENABLE/AUTO limits"	ME/BSE/FD/crew
	If engine with data path failure S/D after limits re-enabled <u>and</u> after single engine droop capability <u>and</u> one redline sensor has been disqualified report: "C(L,R) engine out, push S/D pushbutton" (Re-enable limits at single engine limits)	ME/BSE/FD/crew

TABLE 2.1.3-IV.- Concluded

Step	Activity	Position
3	If engine with data path S/D and two or more similar redline sensors have been disqualified, report: "C(L,R) engine out, push S/D pushbutton" "Limits remain inhibited due to sensor failures" (Refer to Flight Rule 5-27, Limit S/D Control)	ME/BSE/FD/crew

TABLE 2.1.3-V.- DATA PATH (CAUSES 1-5) AND SSME S/D (GH_2 OUTLET PRESSURE < 1050 PSIA)(GO_2 OUTLET TEMP < 300° F)

Step	Activity	Position
1	Report: "C(L,R) MN ENG S/D pb - push"	BSE/FD/crew
2	Report: "Both prevalves closed"	MPS
3	Report: (two engines operating) "LIM S/D - ENABLE, then AUTO" per Flight Rule 5-27	BSE/FD/crew

TABLE 2.1.3-VI.- "PSEUDO" DATA PATH CAUSED BY GPC SET SPLIT

Step	Activity	Position
1	Report: "Data path caused by GPC set split - limits to enable" per Flight Rule 5-27	ME/BSE/FD/crew

3. Supporting Data

   a. Figures - None

   b. Tables - None

   c. Notes:

      (1) Reference SCP 2.1.6 for ENG FAIL procedures

      (2) Reference SCP 2.1.4 for CMD FAIL procedures

REFERENCES

1. STS Operational Flight Rules, All Flights, FINAL, PCN-9, JSC-12820, June 20, 1991.

2. Cue Cards

3. Booster System Briefs

4. Flight Data File

TITLE

COMMAND PATH FAILURE

CONDITION

Loss of command capability from the GPC's to an SSME.

DESCRIPTION

A command path failure will result when two of the three controller channel command paths fail. If at least two of the three commands (which reside in the controller channels) are in agreement, the command is considered valid. Otherwise, a command path failure will result.

Commands are sent from the GPC's (redundant set), through the engine interface unit (EIU), to the SSME controller. Refer to figure 2.1.4-I for SSME command channels. The commands that pass through the multiplexer interface adapter (MIA) 1 and MIA 2 pass through the EIU and proceed directly to the engine controller channels A and B, respectively. The commands that pass through MIA 3 and MIA 4 of the EIU pass through a first in/first out buffer. Only one of these commands will pass through to controller channel C.

The main engine controller will compare the commands which are present in each channel. If two of the three commands are in agreement, the command will be accepted. A command acceptance bit in the engine status word (ESW) will be set and sent back to the GPC's. If a GPC does not see this acceptance bit from the controller, or if a command reject bit is set, the SSME SOP sequence will set a command path failure discrete. If the GPC that sets the discrete is also driving an onboard crew display CRT and engine status light, the GPC will issue a command path fail message and illuminate the appropriate amber status light. The onboard recognition of a command path failure is summarized in table 2.1.4-II. The PASS and BFS MCC recognitions are summarized in tables 2.1.4-III and 2.1.4-IV, respectively.

The following is a discussion on how a command path failure can manifest itself. The center engine will be the focal point for these examples; however, similar arguments can also be made for the other engines (fig. 2.1.4-I).

GPC's 1 and 2 are associated with EIU ports 1 and 2 (MIA's 1 and 2), so their commands will pass directly through the EIU to controller channels A and B, respectively. If these two computers fail-to-halt (stop operating), they will no longer be able to send commands. Therefore, the controller will only see one command which will be in channel C. The two of three requirements for the controller to accept the command are not satisfied, so a command path failure will exist.

The commands pass from the GPC's to the EIU via a flight critical (FC) data bus. These buses transfer data to flight critical aft (FA) MDM's and the

EIU's. The FC 5, 6, 7, and 8 buses transfer data to FA MDM's 1, 2, 3, and 4, respectively. If an FA MDM fails at the GPC (i.e., a string failure), commands cannot pass from the GPC to the EIU either. This situation has the same effect on the engine as a GPC failure. Therefore, a command path failure can result not only from multiple GPC failures, but also from multiple FA MDM failures that occur at the GPC. For example, if FA 1 and FA 2 fail at the GPC, commands cannot be sent through the EIU to the controller. The two of three requirement for the controller to accept the command is not satisfied, so a command path failure will exist.

The previous example dealt with MDM's failing at the GPC. If the FA MDM fails at the MDM, commands can still pass from the GPC to the EIU on the FC data bus. This type of failure will not yield a command path failure.

A command path failure will also occur if MIA's 1 and 2 of the EIU fail. When a MIA fails, commands are not able to pass through the EIU to the SSME controller. The two of three requirement is not satisfied, and a command path failure will exist.

The EIU interfaces with the SSME controller via controller interface adapters (CIA) which reside in the EIU. Each of the CIA's in the EIU is associated with a controller channel. Commands pass through the CIA's prior to going to the controller. When a CIA fails, the command cannot pass to the controller. If any two CIA's fail, the two of three requirement is not satisfied in the controller, and a command path failure will exist.

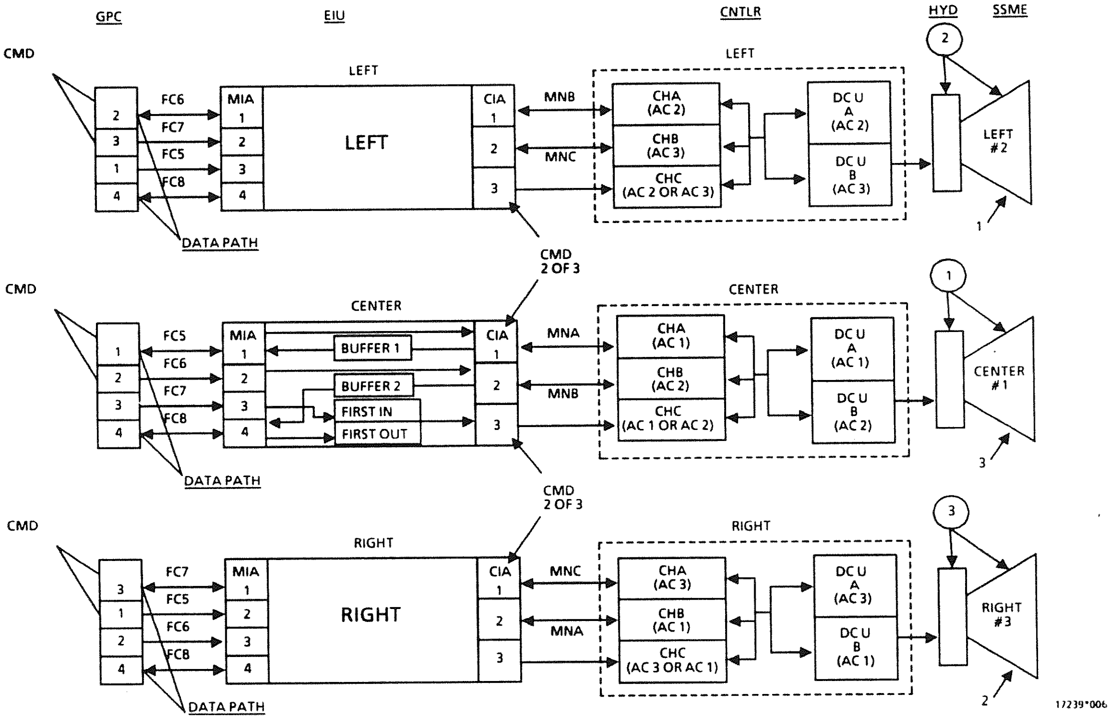


Figure 2.1.4-I.- EIU command/data flow.

A command path failure can occur due to combinations of GPC, CIA, and MIA failures. The failures of MIA 2 and CIA 3 will yield a command path failure. Alternately, if GPC 2 and MIA 1 fail, the same result will occur. In these cases, the two of three requirement is not satisfied in the controller and a command path failure will exist.

A command path failure will also occur if one of these failures is coupled with an AC bus or a main power bus failure. Failures of main and power buses can also affect the command path of an engine. Figure 2.1.4-I shows the power buses associated with each channel and the digital control unit (DCU) of the SSME controller. When an AC bus fails, two engines are affected. For example, if AC 1 fails, DCU A of the center main engine controller and DCU B of the right main engine controller will fail. Also, channels A and B of the center and right engine controller will fail, respectively. If a main bus failure occurs, the result is the same as above, except the interface string between the CIA and the controller channel will also fail. In the above example, main A powers AC 1. Therefore, if main A fails, AC 1 will fail. The string between center engine CIA 1 and controller channel A will fail, and the string between the right engine CIA 2 and controller channel B will fail. Also, the effects of AC 1 are felt as previously described.

The following is an example of a command path failure using an AC bus failure (fig. 2.1.4-I). If AC 2 and center engine EIU MIA 1 fail, channel A and B of the center SSME controller will not be able to host commands. Therefore, the two of three requirement is not satisfied in the controller, and a command path failure will exist. In this case, a data path failure will also occur. The data path failure will mask the command path failure. For more details, refer to SCP 2.1.3.

When a command failure occurs on an engine, that engine must be shut down prior to MECO to prevent propellant depletion through an engine. Also, shutdown should occur in a timeframe that will allow sufficient time to mode guidance. Refer to Booster Flight Rule 5-32, MANUAL SHUTDOWN FOR COMMAND/DATA PATH FAILURES, for shutdown velocities. Sometimes another failure will require the shutdown of another engine prior to shutting down the command path engine. One such case is when one engine has a helium leak and will not support MECO shutdown requirements. This engine has a higher shutdown priority than the command path engine and therefore the command path engine is shut down second at the appropriate two-engine on boundary.

In the event that a command path failure occurs in the thrust bucket, SSME shutdown limits will be manually inhibited until intact abort or crew bail out capability is reached. If the command path failure was caused by data processing system (DPS) failures (GPC's, FA MDM's), command capability may be recovered by GPC reassignment (i.e., restringing). The Booster Systems Engineer (BSE) will contact the DPS officer and provide the DPS officer with the desired strings to be recovered. The DPS officer will determine whether restringing will recover the strings the BSE requires. If restringing will regain command capability to the engine, the DPS officer will provide a nominal bus assignment table (NBAT) for the crew to perform. Once the restringing is complete, the crew will select manual throttles, throttle back to 2 percent below the commanded (mission) power level, then return the throttles to the mission power level. The crew will then return to auto throttles and re-enable SSME shutdown limits when abort capability is confirmed. If this procedure is successful, uphill capability should be regained.

The controller software requires that two of the three controller channels are in agreement, except for the START and START ENABLE commands which require three out of three channels. Agreement means that the commands are exactly the same. If a command, other than START or START ENABLE, does not achieve a three-of-three vote, it will still be accepted, but the first occurrence will cause the engine status word (ESW) to indicate a major component fail (MCF) and a hard failure identification (FID) (FID 042-DLM's 000, 001, 002, or 004) will be posted (ref. SCP 4.1). If either the START ENABLE or START command does not achieve a three-out-of three vote, the command will be rejected, an INHIBIT will be set, the ESW will indicate an MCF, and FID 42 will be issued. The Mission Control Center calls and activity required for command path failures are summarized in table 2.1.4-V.

Erroneous Command/Data Path Failure Indications

If a PASS GPC has failed synchronization (failed-to-sync) with the redundant set, the flight crew and the MCC will receive erroneous indications of data and command path failures. When a GPC has failed-to-sync, the other GPC's stop listening to the failed computer and vice versa. Therefore, the failed GPC does not have any data on the other two engines (the computer can still see data on the SSME that has it on its primary data path). The other PASS GPC's now use the secondary data from the engine whose primary data path has failed. These data are obtained from GPC 4. Since the failed GPC (if numbers 1, 2, or 3) can only see data on one engine, it believes there is a data path failure on two engines and will issue MPS data path messages on two engines. The failed GPC will try to send a command to inhibit main engine shutdown limits. The engine is still responding nominally to the other "good" GPC's, and the command sent by the failed computer will not be accepted. The failed GPC now believes there is a command path failure on the engine and will issue an MPS command path message for that engine and illuminate the main engine amber status light. If the failed GPC does not drive a CRT, the crew will not see the erroneous messages (unless the fault summary page is displayed); however, they will see the amber status light which is also an erroneous indication of engine health. A summary of the erroneous messages and status lights is contained in table 2.1.4-I.

When this failure occurs, the flight director and the flight crew should be notified that no action is required when the indications appear. If the crew sees any indication of an engine problem during 3g throttling (i.e., MPS data/command path or engine status light) and time is not available for the MCC to evaluate and make a recommendation, the engine should be shut down manually. Refer to Booster Flight Rule 5-32, MANUAL SHUTDOWN FOR COMMAND/DATA PATH FAILURES, for shutdown velocities.

TABLE 2.1.4-I.- GPC FAIL-TO-SYNC FAULT MESSAGE SUMMARY

GPC fail-to-sync	Erroneous fault summary message
1	MPS DATA L MPS DATA R MPS CMD C C amber light
2	MPS DATA C MPS DATA R MPS CMD L L amber light
3	*MPS DATA C *MPS DATA L *MPS CMD R R amber light
4	All secondary data static

*These messages are not displayed to the crew because GPC 3 does not drive a CRT. These messages will be displayed on the fault summary page.

A. Crew Operations

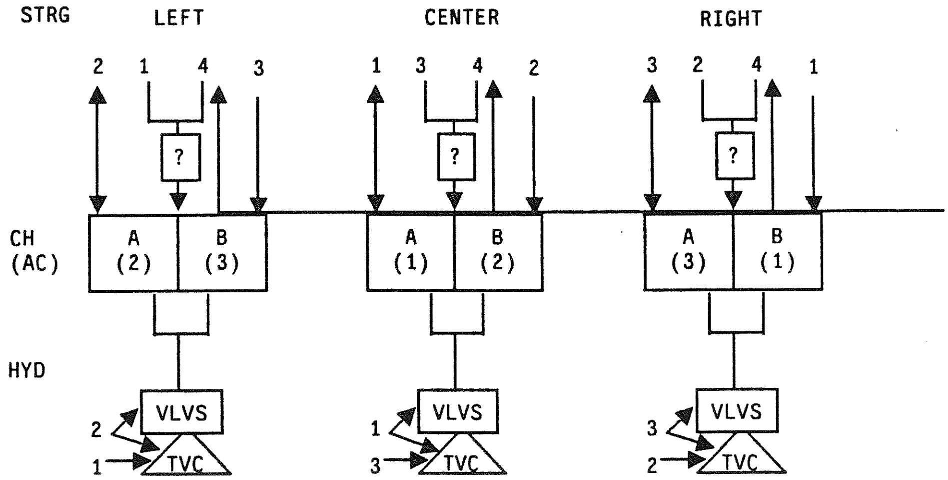
TABLE 2.1.4-II.- FAILURE RECOGNITION (PASS/BFS)

Parameter no.	Failure value/trend	Displayed on
(C) V72X0035X (L) V72X0036X (R) V72X0037X	C(L,R) amber MAIN ENGINE STATUS light	PNL F7
	MPS CMD C(L,R) (class 3 alarm)	FML
(C) V72P0040C (L) V72P0041C (R) V72P0042C	Pc meter indicates no throttling	PNL F7

MPS CMD/HYD/ELEC

If in bucket (Pc < 104%) or 2 HYD SYS failed:
MN ENG LIMIT SHUTDN - INH

If:	When:	Shut down:
2 HYD SYS failed & 3 ENG	Nom/ATO:SE PRESS TAL: SE TAL RTLS & 2 Pcs > 85%: MECO-2:00	MN ENG (AC/pb): ENG(HYD) | S/D C(1) & R(3) | C L(2) & C(1) | L L(2) & R(3) | R
He lk S/D reqd	Nom/ATO and: 3 ENG: V > 23K 2 ENG: V > 24.5K TAL: V 22.5K RTLS and: 3 ENG & 2 Pc's >85%: MECO-2:00 HE lk: α = -4 CMD: ΔR = CO	Aff MN ENG (pb)
MPS CMD(s)		Aff MN ENG (AC/pb) If 2 CMD: repeat
2 MPS ELEC/HYD & 3 ENG		1 aff MN ENG (AC/pb) If 1 each: HYD
1 MPS ELEC/HYD & 3-ENG Nom/ATO & Perf Low or no comm	V > 23K	Aff MN ENG (AC/pb)



B. MCC Operations

TABLE 2.1.4-III.- PASS FAILURE RECOGNITION
(Engine will not throttle when commanded)

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(Pc)
(C) E41P1023P
(L) E41P2023P
(R) E41P3023P</td><td>Engine will not throttle. Pc does not change</td><td>MSK
1052</td></tr>
<tr><td>(GH_2 OUT P)
(C) V41P1160A
(L) V41P1260A
(R) V41P1360A</td><td>GH_2 outlet pressure will not change</td><td>MSK 1052
2762
DDD 281
282
283</td></tr>
<tr><td>(GO_2 OUT T)
(C) V41T1171A
(L) V41T1271A
(R) V41T1371A</td><td>GO_2 outlet temperature will not change</td><td>MSK
1052
1054</td></tr>
<tr><td>(ESW)
(C) E41M1003P
(L) E41M2003P
(R) E41M3003P</td><td>ESW indicates normal mainstage
<table><tr><th rowspan="2">HEX bits last 2 digits</th><th>OK</th><th>MCF</th><th>ELE</th></tr><tr><td>85</td><td>86</td><td>87</td></tr></table></td><td>MSK
1052</td></tr>
<tr><td></td><td>MPS CMD C(L,R)
(class 3 alarm)</td><td>FML</td></tr>
</table>

TABLE 2.1.4-IV.- BFS FAILURE RECOGNITION
(Engine will not throttle when commanded)

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(percent Pc)
(C) V98P2100C
(L) V98P2110C
(R) V98P2120C</td><td>Engine will not throttle.
% Pc does not change</td><td>MSK 1052
1064
1065
1089</td></tr>
<tr><td>(GH_2 OUT P)
(C) V41P1160A
(L) V41P1260A
(R) V41P1360A</td><td>GH_2 outlet pressure will not change</td><td>MSK 1052
1064
1065
1089
2762
DDD 281
282
283</td></tr>
<tr><td>(GO_2 OUT T)
(C) V41T1171A
(L) V41T1271A
(R) V41T1371A</td><td>GO_2 outlet temperature will not change</td><td>MSK
1052
1054
1064
1065</td></tr>
<tr><td>(ESW)
(C) V98M2200P
(L) V98M2220P
(R) V98M2240P</td><td>ESW indicates normal mainstage<table><tr><th rowspan="2">HEX bits last 2 digits</th><th>OK</th><th>MCF</th><th>ELE</th></tr><tr><td>85</td><td>86</td><td>87</td></tr></table></td><td>MSK 1052
1064
1065
1089</td></tr>
<tr><td></td><td>MPS CMD C(L,R)
(class 3 alarm)</td><td>FML</td></tr>
</table>

1. Console Cue Card

   a. Recognition of failure

      Engine does not throttle
      Pc, GH_2 outlet press, GO_2 outlet temp unchanged
      "MPS CMD C(L,R)" message

b. Activity

Report "C(L,R) engine cmd path fail at ____ %"

MPS CMD

1. If in bucket, ME LIMIT SHUTDN - INH

2. Approaching MECO, shut down engine at:
   NOM: $V_I > 23K$
   TAL: $V_I > 22.5K$
   RTLS: MECO
   MPS ENG PWR (two) - OFF
   MN ENG SHUTDN pb - push

MULTI MPS CMD/DATA (no MECO confirmed)
Post MECO: MN ENG SHUTDN
pb (three) - push (simo)

If two engines have stuck throttles and one or both command paths reference SCP 2.1.5 for applicable procedures.

2. MCC Activity

TABLE 2.1.4-V.- MCC ACTIVITY (Command path failure)

Step	Activity	Position
1	Report: "C(L,R) engine command path failure at ____ %" For affected engine: MPS ENG PWR (two) - OFF at 23K (24.5 with two engines on) (at 22.5K for TAL or MECO for RTLS)	ME/BSE/ FD/crew
2	If SSME stuck in thrust bucket report: "C(L,R) engine command path failure at ____ %; Limits - INHIBIT"	ME/BSE/ FD/crew
	If restringing will regain command capability to SSME, report: "Regaining string(s) _____ will restore command capability. Is restringing possible?	ME/BSE/DPS
	If restringing is possible, report: "Restringing will regain command capability"	BSE/FD
	If restringing is not possible or restringing will not regain command capability to SSME, report: "Restringing will not regain command capability"	ME/BSE/FD

TABLE 2.1.4-V.- MCC ACTIVITY (Continued)

Step	Activity	Position
3	After restring is complete, report: "Engage manual throttles, throttle down to _____%" (2% below mission power level) "Then throttle up to __%." (mission power level) After throttling: If engine responds to manual throttle commands, report: "C(L,R) engine throttled up, three engines at _____% (mission power level) "Limits - ENABLE/AUTO; return to auto throttles" "No manual shutdown required" If engine does not respond to manual throttle commands, report: "C(L,R) engine did not respond to throttle commands, return to step 1. "Limits - ENABLE/AUTO" when achieve first abort capability with loss of good engine	ME/BSE/ FD/crew ME/BSE/ FD/crew ME/BSE/ FD/crew ME/BSE/ FD/crew

REFERENCES

1. STS Operational Rules, All Flights, Final, PCN-9, JSC-12820, June 20, 1991.
2. Cue Cards
3. Booster Systems Briefs, JSC-19041.
4. Flight Data File
5. Mission Operations Directorate Note of Interest, DF6/85-112-NOI

TITLE

TWO STUCK THROTTLES

CONDITION

Two SSME's are unable to throttle.

DESCRIPTION

An SSME that does not throttle is referred to as a stuck throttle. A stuck throttle can be caused by any of the following failures: a command path failure, a hydraulic lockup, or an electrical lockup.

First consider if only one SSME has a stuck throttle. An SSME with a command path failure must always be manually shut down prior to MECO due to the loss of command capability (refer to SCP 2.1.4). An SSME in hydraulic or electrical lockup normally will not require a manual shutdown. When the GPC's command MECO, an SSME in hydraulic lockup pneumatically shuts down, and an SSME in electrical lockup hydraulically shuts down. However, if the first-stage vehicle performance is low, three SSME's are operating, and one of the three SSME's is in hydraulic or electrical lockup, the engine in lockup must be manually shut down prior to MECO (refer to SCP 2.1.8).

Now, consider if two SSME's have stuck throttles. In most circumstances an engine must be shut down in order to avoid exceeding 3.5g near MECO. The case where two APU's have failed not only causes two engines to be hydraulically locked up, but also causes one engine's TVC to be nonfunctional. The stuck TVC case also has the concern that an engine with good TVC will shut down and cause loss of control. In many high-fidelity simulators the case always causes loss of control. This is the rationale for maintaining limits inhibited until the nongimballing engine is shut down. If the procedures below call for the nongimballing engine to be shut down prior to MECO, then limits can be reenabled at the appropriate boundary: SE PRESS for NO/ATO/AOA, SE TAL for TAL, and SE RTLS for RTLS. The discussion for two stuck throttles will be broken into three separate topics: nominal/ATO/AOA, RTLS, and TAL.

A. NOMINAL/ATO/AOA

If three SSME's are gimballing (i.e., GOOD TVC) during a nominal, ATO, or AOA flight condition and two of these engines are unable to throttle, only one engine (the one not in lockup) throttles in response to the 3g throttle commands. As a result, the vehicle acceleration will exceed 3g. To prevent the excessive g, one of the nonthrottling engines must be manually shutdown prior to MECO. The stuck engine to be manually shut down is shutdown at V_I = 23K ft/s and is selected according to the following failure priority: command path failure, hydraulic lockup, and electrical lockup. This priority was established to cover the case in which the causes for the stuck throttles on the two engines are not the same. For example, if one engine is in electrical lockup and the other is in hydraulic lockup, the engine in hydraulic lockup will be the engine selected for manual shutdown. The rationale for the shutdown priorities is: the command path failure has the highest priority for shutdown because the engine is unable to accept any commands, such as shutdown command, and must always be manually shut down. The hydraulic lockup has the second priority because the valves could drift and result in off-nominal performance. The electrical lockup has the lowest priority for shutdown. An advantage of not manually shutting down an engine in electrical lockup is that an LOX dump is performed through that engine because the engine will shut down hydraulically at MECO.

However, the shutdown priority scheme does not apply if the two stuck throttles have the same mode, i.e., two hydraulic lockups, two electrical lockups, or two command path failures. For two engines in hydraulic lockup, a matrix was developed to determine which stuck throttle to shut down. (This matrix is included in the crew cue card.) The matrix assumes that both hydraulic lockups resulted from the loss of two orbiter APU's, which causes the loss of gimballing for thrust vector control on one of the stuck engines. (Unlike SSME valve control, the SSME thrust vector control has redundant APU supplies.) From the matrix, the nongimballing engine is selected for manual shutdown at the single engine press boundary. There are other failure modes, other than the loss of an orbiter APU, that result in hydraulic lockup, such as SSME servovalve actuator failures. For these cases, even though both engines can gimbal, the matrix is used to determine which engine in hydraulic lockup to shut down at 23K. Similarly, if both stuck engines are in electrical lockup, the matrix is used to select the engine to shut down at 23K. If both stuck engines have command path failures, both engines must be manually shut down before MECO. The first engine is shut down at V_I = 23K ft/s, and the second engine is shut down at V_I = 24.5K ft/s. The hydraulic lockup matrix is used to determine which engine to shut down first.

If only two SSME's are operating and both have stuck throttles, no manual shutdown is required, unless one or both have command paths or one is nongimballing because the vehicle will not exceed 3.5g. For the case where an engine has stuck TVC loss of control is probable, but the crew should attempt to ride this condition as long as control is maintained.

B. RTLS

Consider the RTLS flight condition with three SSME's operating and two stuck throttles. Analysis shows that if both engines are stuck above 85 percent, 3.5g is violated near MECO. It is also necessary to manually throttle to minimum power at least 10 seconds before selecting RTLS or, in many cases, guidance does not converge. After the RTLS is selected, guidance automatically throttles up the engine with good throttles and stays converged. If 3.5g is violated (2 Pc's > 85 percent), one engine must be shut down at MECO - 2 minutes. This time was chosen because at MECO - 80 seconds guidance will not compensate for the loss of an engine which results in a depressed MECO condition (lower in the atmosphere) making ET separation conditions less than optimum.

When three engines are gimballing and at least one engine is stuck below 85 percent, it is unnecessary to shut down an engine unless command path failures are involved. These command path engines should be shut down at MECO. If three engines are gimballing and both are stuck above 85 percent, the shutdown priorities (1: CMD, 2: HYD, 3: ELEC) should be used to determine which engine to shut down at MECO - 2 minutes. If the second engine has a command path it should be shut down at MECO. Limits should be reenabled when the single engine RTLS boundary is achieved. If both lockups have the same cause, the no-TVC matrix should be used to select the engine to shut down.

If three engines are operating and two APU's are down, the nongimballing engine is shut down only if both stuck throttle engines have Pc's greater than or equal to 85 percent. In this instance, the nongimballing engine is shut down at MECO - 2 minutes. When an engine is determined to have stuck TVC, limits are inhibited. Limits can only be reenabled at the single engine RTLS boundary if the stuck TVC engine is shut down at MECO - 2 minutes.

For a two-engine RTLS, no action is required for the two-hydraulic-lockup case, the two-electrical-lockup case, or the one hydraulic/one electrical case. For these cases the vehicle acceleration is not excessive. If the two-hydraulic-lockup case also causes loss of TVC on a running engine, it is likely that control will be lost, but the crew should attempt to ride the two engines as long as possible.

C. TAL

During a TAL with three SSME's gimballing and two stuck throttles, at least one engine will be shut down at 22.5 to avoid exceeding 3.5g near MECO. The engine to shut down should be chosen from the shut down priorities (1: CMD, 2: HYD, 3: ELEC). If both lockups have the same cause, the no-TVC matrix should be used to select the engine to shut down. If both are stuck with command path failures, both engines are shut down at 22.5 fps. Limits should be reenabled after shutting down the first engine at 22.5 fps (this occurs after single engine). For the TAL case where three engines are running and two throttles are stuck due to APU failures, the nongimballing engine is shut down at single engine TAL. When it is determined that an engine is not gimballing, limits are inhibited and when the engine is shut down limits should be reenabled.

For the TAL cases outlined above, manual throttles should be selected if the velocity is greater than the auto-throttle down I-loads. If only two SSME's are operating and both have stuck throttles, no manual shutdown is required unless one or both have command paths or one is nongimballing because the vehicle will not exceed 3.5g. For the case where an engine has stuck TVC, loss of control is probable, but the crew should attempt to ride this condition as long as control is maintained.

More information is found in tables 2.1.5-I to 2.1.5-IV.

PROCEDURES

A. Flight Rules

5-32, MANUAL SHUTDOWN FOR COMMAND/DATA PATH FAILURES

5-34, MANUAL SHUTDOWN FOR TWO STUCK THROTTLES

8-41, SSME SHUTDOWN DUE TO HYDRAULIC SYSTEMS FAILURES

B. Crew Operations

TABLE 2.1.5-I.- CREW FAILURE RECOGNITION (PASS/BFS)

Parameter no.	Failure value/trend	Displayed on
(C) V72X0035X (L) V72X0036X (R) V72X0037X	C(L,R) amber MAIN ENGINE STATUS light	PNL F7
(C) V72P0040C (L) V72P0041C (R) V72P0042C	Pc meter indicates no throttling	PNL F7
	A fault message will indicate the particular stuck throttle condition on each engine. The three possible stuck throttle conditions are: MPS CMD C(L,R) MPS HYD C(L,R) MPS ELEC C(L,R) (Class 3 alarm)	FML

1. Crew Procedure - Cue Cards

MPS CMD/HYD/ELEC

If in bucket (PC < 104%) or 2 HYD SYS failed:
MN ENG LIMIT SHUTDN - INH

If:	When:	Shut down:
2 HYD SYS failed & 3 ENG	Nom/ATO: SE PRESS TAL: SE TAL RTLS & 2 Pc's > 85%: MECO - 2:00	MN ENG (AC/pb): ENG(HYD) | S/D C(1) & R(3) | C L(2) & C(1) | L L(2) & R(3) | R
He lk S/D req'd	Nom/ATO and: 3 ENG: V > 23K 2 ENG: V > 24.5K TAL: V > 22.5K RTLS and: 3 ENG & 2 Pc's > 85%: MECO - 2:00 He lk: $\alpha = -4$ CMD: ΔR = CO	Aff MN ENG (pb)
MPS CMD(s)		Aff MN ENG (AC/pb) If 2 CMD: repeat
2 MPS ELEC/HYD & 3 ENG		1 aff MN ENG (AC/pb) If 1 each: HYD
1 MPS ELEC/HYD & 3-ENG Nom/ATO & Perf Low or no comm	V > 23K	Aff MN ENG (AC/pb)

2. Crew Activity - Same as procedure

C. MCC Operations

TABLE 2.1.5-II.- PASS FAILURE RECOGNITION

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(ESW)
(C) E41M1003P
(L) E41M2003P
(R) E41M3003P</td><td>The ESW indicates the particular stuck throttle case affecting each of the two affected engines

Electrical lockup:<table><tr><td>Hex bits last 2 digits</td><td>OK</td><td>MCF</td><td>ELE</td></tr><tr><td></td><td>-</td><td>8E</td><td>8F</td></tr></table>Hydraulic lockup:<table><tr><td>Hex bits last 2 digits</td><td>OK</td><td>MCF</td><td>ELE</td></tr><tr><td></td><td>-</td><td>92</td><td>93</td></tr></table>Command path failure:

ESW will still indicate mainstage<table><tr><td>Hex bits last 2 digits</td><td>OK</td><td>MCF</td><td>ELE</td></tr><tr><td></td><td>85</td><td>86</td><td>87</td></tr></table>See SCP 4.1 for a description of ESW.</td><td><u>MSK</u>
1052</td></tr>
<tr><td>(Hard FID)
(C) E41M1005B
(L) E41M2005B
(R) E41M3005B</td><td>Hard FID syntax is generated by a MOC comp using the MSID's shown at left. The Hex representation of the FID is displayed on MSK's 1069 and 1070. See SCP's 3.1.2 and 4.1 for FID descriptions</td><td><u>MSK</u>
1052
1069
1070
1071</td></tr>
<tr><td>(AVG Pc)
(C) E41P1023B
(L) E41P2023B
(R) E41P3023B</td><td>The two affected engines do not throttle. AVG Pc does not change</td><td><u>MSK</u>
1052</td></tr>
</table>

TABLE 2.1.5-II.- Continued

Parameter no.	Failure value/trend	Displayed on
(GH$_2$ OUT P) (C) V41P1160A (L) V41P1260A (R) V41P1360A	GH$_2$ outlet pressure does not change	MSK 1052 2762 DDD 281 282 283
	The fault message indicates the particular stuck throttle condition on each engine. The three possible stuck throttle conditions are: MPS CMD C(L,R) MPS HYD C(L,R) MPS ELEC C(L,R) (Class 3 alarm)	FML

TABLE 2.1.5-III.- BFS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(ESW) (C) V98M2200P (L) V98M2220P (R) V98M2240P	The ESW indicates the particular stuck throttle case affecting each of the two affected engines	MSK 1052 1089 1064
(%Pc) (C) V98P2100C (L) V98P2110C (R) V98P2120C	Percent Pc does not change	MSK 1052 1089 1064
(GH$_2$ OUT P) (C) V41P1160A (L) V41P1260A (R) V41P1360A	GH$_2$ outlet pressure does not change	MSK 1052 1064 2762 1089 DDD 281 282 283
	The fault message indicates the particular stuck throttle condition. MPS CMD C(L,R) MPS HYD C(L,R) MPS ELEC C(L,R) (Class 3 alarm)	FML

1. Console Cue Card

a. Recognition of failure

2 engines stuck and/or 2 APU's failed
Pc, GH_2 outlet press unchanged
Fault messages

b. Activity

- Report stuck throttle and stuck TVC conditions
- Inhibit limits if stuck TVC
- If 2 stuck and 3 gimballing shutdown priority eng:
  1) CMD, 2) HYD, 3) ELEC

  Nominal/ATO/AOA: 23K fps
  RTLS w/2 Pc's > 85%: MECO - 2 minutes
  RTLS w/1 Pc ≤ 85%: No action
  TAL: 22.5K fps
- If 2 APU's and 3 running (1 no-TVC) shut down per no-TVC matrix

ENG HYD	PRIORITY ENG
C/1 + R/3	C
L/2 + C/1	L
L/2 + R/3	R

Nominal/ATO/AOA: single engine press
RTLS with 3 SSME's on and 2 Pc's > 85: MECO - 2 minutes
TAL with: single-engine TAL (and do not allow auto throttle)

2. MCC Activity

TABLE 2.1.5-IV.- STUCK THROTTLE CALLS

<table>
<tr><th>Step</th><th>Failure value/trend</th><th>Position</th></tr>
<tr><td>1</td><td>For each stuck engine report:
"CMD path (or HYD lockup or ELEC lockup) on C (L,R) at _____%"</td><td>ME/BSE/FD/crew</td></tr>
<tr><td>2</td><td>For Nom/ATO/AOA and 3 SSME's on, report:
"Shutdown C(L,R) at 23K"

Shutdown priority is 1) CMD, 2) HYD, 3) ELEC

If 2 HYD, shutdown designated engine:<table><tr><th>ENG HYD</th><th>DESIGN ENG</th></tr><tr><td>C&R/1&3</td><td>C</td></tr><tr><td>L&C/1&2</td><td>L</td></tr><tr><td>L&R/2&3</td><td>R</td></tr></table></td><td>ME/BSE/FD/crew</td></tr>
<tr><td></td><td>For RTLS, 3 SSME's on, 2 APU's down, 2 Pc's > 85 report:
"Shutdown C(L,R) at MECO - 2 minutes

For RTLS, 3 SSME's gimballing, 2 Pc's > 85 report:
"Shutdown C(L,R) at MECO - 2 minutes

For RTLS, 3 SSME's on, 1 Pc ≤ 85 report:
"No action required"</td><td>ME/BSE/FD/crew</td></tr>
<tr><td></td><td>For TAL 3 SSME's on, 2 APU's down, report:
"Do not allow auto-throttle. Shutdown C(L,R) at single engine TAL"

For TAL 3 SSME's gimballing report:
"Do not allow auto-throttle. Shutdown C(L,R) at 22.5K fps."</td><td>ME/BSE/FD/crew</td></tr>
</table>

3. Supporting Data

   a. Figures: None

   b. Tables: None

   c. Notes: None

REFERENCES

1. STS Operational Flight Rules, All Flights, Final, PCN-9, JSC-12820, June 20, 1991.

2. Cue Cards - Flight Data File

3. Systems Briefs

TITLE

ENGINE OUT WITH LIMITS ENABLED

CONDITION

One or more SSME's shut down prematurely during MM 102, 103, or 601.

DESCRIPTION

If an SSME's performance deteriorates during mainstage and exceeds an engine shutdown redline while limit shutdown capability is enabled, the controller will shut that engine down before uncontained engine damage can occur. An engine may also shut down prematurely from a combination of sensor failures and controller electronics failures. Lastly, an engine will shut down as a result of the loss of both engine hydraulics and Emergency Shutdown coil power. In this failure case, guidance is not moded until the affected engine's shutdown pushbutton is depressed.

The redline parameters and shutdown sensor logic are defined in Flight Rule 5-2.

A. Flight Rules

1. Failure Definitions

5-2, SSME ENGINE OUT

2. SSME Systems Management

a. 5-25, ABORT CUE REQUIREMENT

b. 5-26, AUTO/MANUAL SHUTDOWN

c. 5-27, LIMIT SHUTDOWN CONTROL

B. Crew Operations

TABLE 2.1.6-I.- FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(C) V72X0030X (L) V72X0031X (R) V72X0032X	C(L,R) red MAIN ENGINE STATUS light on	PNL F7
(C) V72P0040C (L) V72P0041C (R) V72P0042C	C(L,R) Pc meter indicates 0 percent	PNL F7
	While in MM 103 or 601, the vehicle g level will drop dramatically • The g level will drop to two-thirds of its value before SSME shutdown if three engines were running nominally and only two remain running • The g level will drop to one-half of its value before SSME shutdown if two engines were running nominally and only one remains running	PNL F8 BFS TRAJ 2

1. Crew Procedure - Cue Card (Ascent/Entry Systems Procedures L MS 9-3)

MN ENG FAIL/SHUTDN
If 'MPS Data':
  aff MN ENG SHUTDN pb
            - push
AC BUS SNSR(three) - OFF
If 1 ENG:
 When MPS PRPLT=2%:
  MAN THROT Pc→67%
  At CO:Shutdn MN(pb)

2. Crew Activity

Per MCC call, the pilot should inhibit the dump on a shutdown engine, as follows:

MPS DUMP INHIBIT
Aff MPS ENG PWR(two) -OFF
Aff MPS LO2(H2) PREVLV-CL

C. MCC Operations

TABLE 2.1.6-II.- PASS FAILURE RECOGNITION

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(ESW)
(C) E41M1003P
(L) E41M2003P
(R) E41M3003P</td><td>Last two ESW digits (in HEX) indicate engine shutdown
<table>
<tr><th>PHASE/MODE</th><th>MCF*</th><th>ELE**</th></tr>
<tr><td>SHUTDOWN HYD</td><td>A6</td><td>A7</td></tr>
<tr><td>SHUTDOWN PNEU</td><td>B2</td><td>B3</td></tr>
<tr><td>POST SHDN STANDBY</td><td>C6</td><td>C7</td></tr>
</table></td><td><u>MSK</u>
1051
1052</td></tr>
<tr><td>(Pc)
(C) E41P1023P
(L) E41P2023P
(R) E41P3023P</td><td>Pc = 0 psia</td><td>1051
1052</td></tr>
<tr><td>(GH_2 out p)
(C) V41P1160A
(L) V41P1260A
(R) V41P1360A</td><td>GH_2 outlet pressure < 1050 psia</td><td>1051
1052
2762</td></tr>
</table>

* MCF = Major component fail
** ELE = Engine limits exceeded

TABLE 2.1.6-II.- Continued

Parameter no.	Failure value/trend	Displayed on
(HARD FID) (C) M01G3000R (L) M05G3000R (R) M09G3000R	HARD FID indicates which engine limit was exceeded FID 13:"LIMIT SD-"	MSK 1051 1052 1069 1070
(ACCEL) V95U0163C	While in MM 103 or 601, the vehicle g level will drop dramatically • The g level will drop to two-thirds of its value before SSME shutdown if three engines were running nominally and only two remain running • The g level will drop to one-half of its value before SSME shutdown if two engines were running nominally and only one remains running	MSK 2762
	One of the following limits has been exceeded:	MSK
(HPOT TDT A/B) (C) E41T1012/13B (L) E41T2012/13B (R) E41T3012/13B	HPOT TURB DISCH T A and B > 1760° R or < 720° R	1051 1052
(HPOT ISP P A/B) (C) E41P1014/15B (L) E41P2014/15B (R) E41P3014/15B	HPOT ISP P A and B < 170 psia	1051 1052

TABLE 2.1.6-II.- Concluded

Parameter no.	Failure value/trend	Displayed on
(HPOT SSL P A/B) (C) E41P1051/53B (L) E41P2051/53B (R) E41P3051/53B	HPOT SEC SL CAV P A and B > 100 psia	1051 1052
(HPFT CLNT P A/B) (C) E41P1008/09B (L) E41P2008/09B (R) E41P3008/09B	HPFT CLNT LINER PA and B > LIMIT c/o PWR LVL LIMIT ~ PSIA 100 3536 104 3675 109 3849 LIMIT = 151 – 97.3 + 1.1583* (Pc avg.)	1051 1052
(HPFT TDT A/B) (C) E41T1010B/11B (L) E41T2010B/11B (R) E41T3010B/11B	HPFT TURB DISCH T A > 1850° R B > 1960° R The limit value of A or B depends on the HPFT in use	1051 1052
(Time of S/D) (C) M01G3705T (L) M02G3705T (R) M03G3705T	Time of shutdown (MET) minutes:seconds	MSK 1051 1052 2762

TABLE 2.1.6-III.- BFS FAILURE RECOGNITION

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(ESW)
(C) V98M2200P
(L) V98M2220P
(R) V98M2240P</td><td>Last two ESW digits (in HEX) indicate engine shutdown<table><tr><th>PHASE/MODE</th><th>MCF</th><th>ELE</th></tr><tr><td>SHUTDOWN HYD</td><td>A6</td><td>A7</td></tr><tr><td>SHUTDOWN PNEU</td><td>B2</td><td>B3</td></tr><tr><td>POST SHDN STANDBY</td><td>C6</td><td>C7</td></tr></table></td><td>MSK
1051
1052
1064
1089</td></tr>
<tr><td>(Pc)
(C) V98P2100C
(L) V98P2110C
(R) V98P2120C</td><td>Pc = 0 percent</td><td>1051
1052
1064
1089</td></tr>
<tr><td>(GH_2 OUT P)
(C) V41P1160A
(L) V41P1260A
(R) V41P1360A</td><td>GH_2 outlet pressure < 1050 psia</td><td>1051
1052
1064
2762</td></tr>
<tr><td>(BFS S/D)
(C) M01G4300T
(L) M02G4300T
(R) M03G4300T</td><td>Time of shutdown (MET)</td><td>MSK
1051
1052
1064
2762</td></tr>
</table>

1. Console Cue Card

Recognition of failure

- ESW indicates engine in postshutdown standby
- P_c = 0 psia
- GH_2 out press < 1050 psia
- HARD FID SYNTAX indicates cause of shutdown

- While in MM 103 or 601, the vehicle g level will drop dramatically.
  - The g level will drop to two-thirds of its value before SSME shutdown if three engines were running nominally and only two remain running.
  - The g level will drop to one-half of its value before SSME shutdown if two engines were running nominally and only one remains running.

Activity

- "C(L,R) engine out at ___" OMET

  If shutdown occurs during data path failure, determine time of shutdown from UP 2762.
- "Shutdown caused by ________"
- "Limits inhibited"
- Condition of remaining engines
- Integrity of shutdown engines (check inlet press) (LO2 INLET PRESS > 40 psia, LH2 INLET PRESS > 30 psia)

Confirm - AC BUS sensors (three) - OFF (DDD Format 293)

For one engine out and not BFS engaged:
"At single-engine-boundary: Limits enable then auto"

Reference Flight Rule 5-27 for appropriate boundary

If pneumatic shutdown, inform BSE: "LOX dump will be through two engines only."

2. MCC Activity

TABLE 2.1.6-IV.- MCC ACTIVITY

Step	Activity	Position
1	Report: "C(L,R) engine out at ____" OMET	ME/BSE/FD/crew
2	Report cause of shutdown	ME/BSE/FD
3	Report: "Limits inhibit" and condition of remaining engines and integrity of shutdown engine (LO2 INLET P > 40 psia, LH2 INLET P > 30 psia)	ME/MPS/BSE/FD/crew

TABLE 2.1.6-IV.- Concluded

Step	Activity	Position
4	Confirm AC BUS sensors OFF DDD FMT 293	ME
5	Recommend (for one engine out and not BFS engaged) at SINGLE-ENGINE-Boundary "LIM S/D - enable then auto"	ME/BSE/FD/crew
6	If pneumatic shutdown Report: "LOX dump on two engines only"	ME/BSE
7	If LO2(LH2) inlet pressures less than required, Report: "Inhibit LO2(LH2) post-MECO dump on C(L,R) engine"	MPS/BSE

3. Supporting Data

An engine sensor may violate a red line on one channel before the other channel. An MCF occurs when only one channel is voting for shutdown. The ESW's for the mainstage are listed below indicate an MCF.

Figures: None

Tables:

Mainstage	MCF
Nominal	86
Thrust Limiting	8A
Elect Lockup	8E
Hyd Lockup	92
Fixed Density	96

Notes:

a. Pogo helium precharge at shutdown:
Hydraulic S/D - 4 sec
Pneumatic S/D - 7 sec

b. The BFS does not support single engine roll control.

REFERENCES

1. STS Operational Flight Rules, All Flights, Final, PCN-6, JSC-12820, July 3, 1990

2. Flight Data File - Cue Cards

TITLE

ENGINE LIMITS EXCEEDED WITH LIMITS INHIBITED

CONDITION

An engine is operating out of limits when the limit shutdown capability is inhibited. Immediate shutdown is required if HPOP IMD SL is <170 psia.

DESCRIPTION

If an SSME's performance deteriorates during mainstage with shutdown limits inhibited, that engine may continue to run even though it has exceeded an engine redline. With limit shutdown capability inhibited, that engine will shut down safely only if commanded by guidance or the manual shutdown pushbutton.

If engine performance deteriorates to the point that physical destruction results, uncontained engine damage is likely to occur. Immediate shutdown is required for HPOP IMD SL violations. Other engine redline violations will remain inhibited until the appropriate single-engine boundary (reference Flight Rule 5-27), after which the shutdown limits will be enabled resulting in an automatic shutdown. The redline parameters and the shutdown sensor logic are defined in table 5-2E of the Flight Rules.

An engine may also shut down with limits inhibited due to the loss of both engine hydraulics and the emergency shutdown coil power. Also, guidance needs to be moded in this case so the crew needs to push the affected engine's pushbutton. Lastly, if AC BUS sensors are not OFF after the loss of controller redundancy, a single point failure could result in an engine out with limits inhibited.

A. Flight Rules

1. Failure Definitions

   5-2, SSME ENGINE OUT

2. SSME Systems Management

   a. 5-25, ABORT CUE REQUIREMENT

   b. 5-27, LIMIT SHUTDOWN CONTROL

   c. 5-28, MANUAL SHUTDOWN WITH LIMIT CONTROL INHIBITED

   d. 5-31, LIMIT SHUTDOWN CONTROL FOR PERFORMANCE LOSS CASES

B. Crew Operations

TABLE 2.1.7-I.- FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
dP/dT		
(C) V98P4997C	MPS He Tank leak - dP/dT > 20 psi/3 sec	PNL F7
(L) V98P4998C	SM ALERT	BFS GNC
(R) V98P4999C	"MPS He P C(L,R)" Fault message	SYS SUMM 1
	Limits are inhibited if any of the following conditions are met: (1) Previous Engine Out (2) Data Path Failure on any SSME and MAIN ENGINE LIMIT SHUT DN sw - AUTO (3) MAIN ENGINE LIMIT SHUT DN sw - INHIBIT	

1. Crew Procedure

   None

2. Crew Activity

TABLE 2.1.7-II.- CREW ACTIVITY

Step	Activity	Position
1	If in communication with MCC and limits are inhibited, shut down engine as required on ground call (use LIMIT SHUT DN sw - ENABLE then AUTO)	PLT
2	Per MCC call, the MPS dump inhibit may be performed as follows post-MECO: **MPS DUMP INHIBIT** **Aff MPS ENG PWR(two) - OFF** **Aff MPS LO2 (H2) PREVLV-CL**	PLT
3	For engine out due to loss of hydraulics and emergency shutdown coil power, push affected engine's shutdown pushbutton	PLT

C. MCC Operations

TABLE 2.1.7-III.- PASS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
ESW (C) E41M1003P (L) E41M2003P (R) E41M3003P Limits inhibited (C) E41X1511B (L) E41X2511B (R) E41X3511B	First 2 ESW digits = 00 HEX limits inhibited	MSK 1051 1052 DDD 281 282 283 284
HPOT ISP A/B (C) E41P1014B/15 (L) E41P2014B/15 (R) E41P3014B/15	HPOT IMD SL PA and B decreasing	MSK 1051 1052 DDD 281 282 283
Tank pressure (C) V98P2155C (L) V98P2156C (R) V98P2157C dP/dT (C) V98P4997C (L) V98P4998C (R) V98P4999C	Tank pressure decreasing dP/dT > 20 psi/3 sec	MSK 1064 1089

TABLE 2.1.7-IV.- BFS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
ESW (C) V98M2200P (L) V98M2220P (R) V98M2240P	First 2 ESW digits = 00 HEX Limits inhibited	MSK 1051 1052 1064 1089
Tank pressure (C) V98P2155C (L) V98P2156C (R) V98P2157C dP/dT (C) V98P4997C (L) V98P4998C (R) V98P4999C	Tank pressure decreasing dP/dT > 20 psi/3 sec	MSK 1064 1089

1. Console Cue Card

   a. Recognition of Failure

      Helium leak and engine limits inhibited

   b. Activity

      (1) HPOT IMD SL P decreasing

         SSME limits are inhibited

         "He tank P < 1150 psia or
         He Reg P < 715 psia"

         "LIMIT SHUT DN sw - ENABLE then AUTO"

         ✓AC BUS SENSOR (three) - OFF

      (2) Engine limit violated (other than HPOT IMD SL P)

         At appropriate single-engine boundary, with two or three SSME's on

         "LIMIT SHUT DN sw - ENABLE then AUTO"

TABLE 2.1.7-V.- LIMIT S/D INHIBITED/APPROACHING HPOP IMD SL P LIMIT

Step	Activity	Position
1	Report: "C(L,R) engine has helium leak and is approaching HPOP IMD SL P limit. Engine limits are inhibited"	ME/BSE/FD/crew
2	Recommend: "LIMIT SHUT DN sw - ENABLE, then AUTO"	ME/BSE/FD/crew
3	Report: "C(L,R) engine out at ____" OMET "Limits inhibited" condition of remaining engines	ME/BSE/FD/crew
4	Confirm AC BUS sensors off	ME
5	Check integrity of shutdown engine(s). LO2 inlet pressure > 40 psia LH2 inlet pressure > 30 psia	MPS/BSE
6	If LO2 (LH2) inlet pressures less than required, report: "Inhibit LO2 (LH2) post-MECO dump on C(L,R) engine"	MPS/BSE

TABLE 2.1.7 -VI.- LIMIT S/D INHIBITED/LIMIT EXCEEDED (NOT HPOT IMD SL P)

Step	Activity	Position
1	Report: "C(L,R) engine is running with a ____ engine limit violation. Engine limits are inhibited"	ME/BSE/FD/crew
2	Recommend (with two or three engines on) At single-engine boundary: "LIMIT SHUT DN sw - ENABLE then AUTO"	ME/BSE/FD/crew
3	Report: "C(L,R) engine out at ____ " (OMET)	ME/BSE/FD/crew
4	Report: "Limits inhibited" Condition of remaining engines	ME/BSE/FD
5	Check integrity of shutdown engine(s). LO2 inlet pressure > 40 psia LH2 inlet pressure > 30 psia	MPS/BSE
6	If LO2 (LH2) inlet pressure less than required, Report: "Inhibit LO2 (LH2) post-MECO dump on C(L,R) engine"	MPS/BSE

3. Supporting Data

   a. Figures: None

   b. Tables: None

   c. Notes:

      (1) Pneumatic shutdown is performed for an engine with no hydraulic pressure or if ac power is removed from the main engine controller.

      (2) Pogo helium precharge at shutdown:
      Hydraulic S/D 4 sec
      Pneumatic S/D 7 sec

REFERENCES

1. STS Operational Flight Rules, All Flights, Final, PCN-6, JSC-12820, July 3, 1990.

2. STS Operational Flight Rules Rational, All Flights, Final, PCN-6, JSC-12820, Feb 14, 1986.

3. Shuttle Operational Data Book

TITLE

ONE STUCK THROTTLE

CONDITION

The combination of a stuck throttle and low vehicle performance or merely a single engine with a command path failure requires manual shutdown of the affected engine before MECO.

DESCRIPTION

An SSME that cannot respond to throttle commands is referred to as having a stuck throttle. A stuck throttle can be caused by any of the following failures: an electrical lockup, a hydraulic lockup, or a command path failure.

In electrical lockup, the engine propellant valves are actively controlled at their last commanded position that existed prior to loss of both sensor channels of either the LH_2 flowmeter transducers or Pc transducer pairs (refer to SCP 2.1.1).

In hydraulic lockup, the engine propellant valve commands shall remain at the last values commanded prior to entering hydraulic lockup (refer to SCP 2.1.1), but valve drift may occur.

In a command path failure, the command capability from the GPC's to an SSME is lost. As a result, the valves remain in the last valid commanded position.

An SSME with a command path failure must be manually shut down prior to MECO due to the loss of command capability (refer to SCP 2.1.4). Sometimes, it is both necessary and possible to regain command capability by restringing and shutdown may no longer be required. One such case is when an engine is stuck in the bucket and uphill capability is not available. Two other cases occur when an SSME in hydraulic lockup shuts down pneumatically at MECO and when an SSME in electrical lockup shuts down hydraulically at MECO.

However, if the vehicle's first-stage performance is low, three SSME's are running, and an SSME in hydraulic or electrical lockup at a power level greater than 65 percent is allowed to run until MECO, the engine LO_2 NPSP and LO_2 mass requirements at MECO may be violated. This violation is due to the shutdown timers that are used with the LO_2 low-level sensors to delay the MECO command after at least two sensors are dry. Normally this delay ensures maximum allowable consumption of LO_2 during engine shutdown while still preventing LO_2 depletion. After the timer expires, a MECO command is issued and the SSME's shut down. For a nominal three-engine low-level cutoff, the timer ensures a safe shutdown from 67 percent power level, which is a total throttle of 201 percent (refer to SCP 4.2.6). However, if one SSME is stuck at a power setting greater than 67 percent, the LO_2

consumption will be greater than nominal when the timer expires. (The software presently cannot detect a stuck throttle; therefore, the same timer is used for the three-engine case regardless of what the total power level is.) If, in addition to the stuck throttle, the vehicle performance is low, the LO_2 NPSP and LO_2 mass remaining will be less than that required at MECO (fig. 2.1.8-I). To clarify this problem, low performance is defined in the next paragraph.

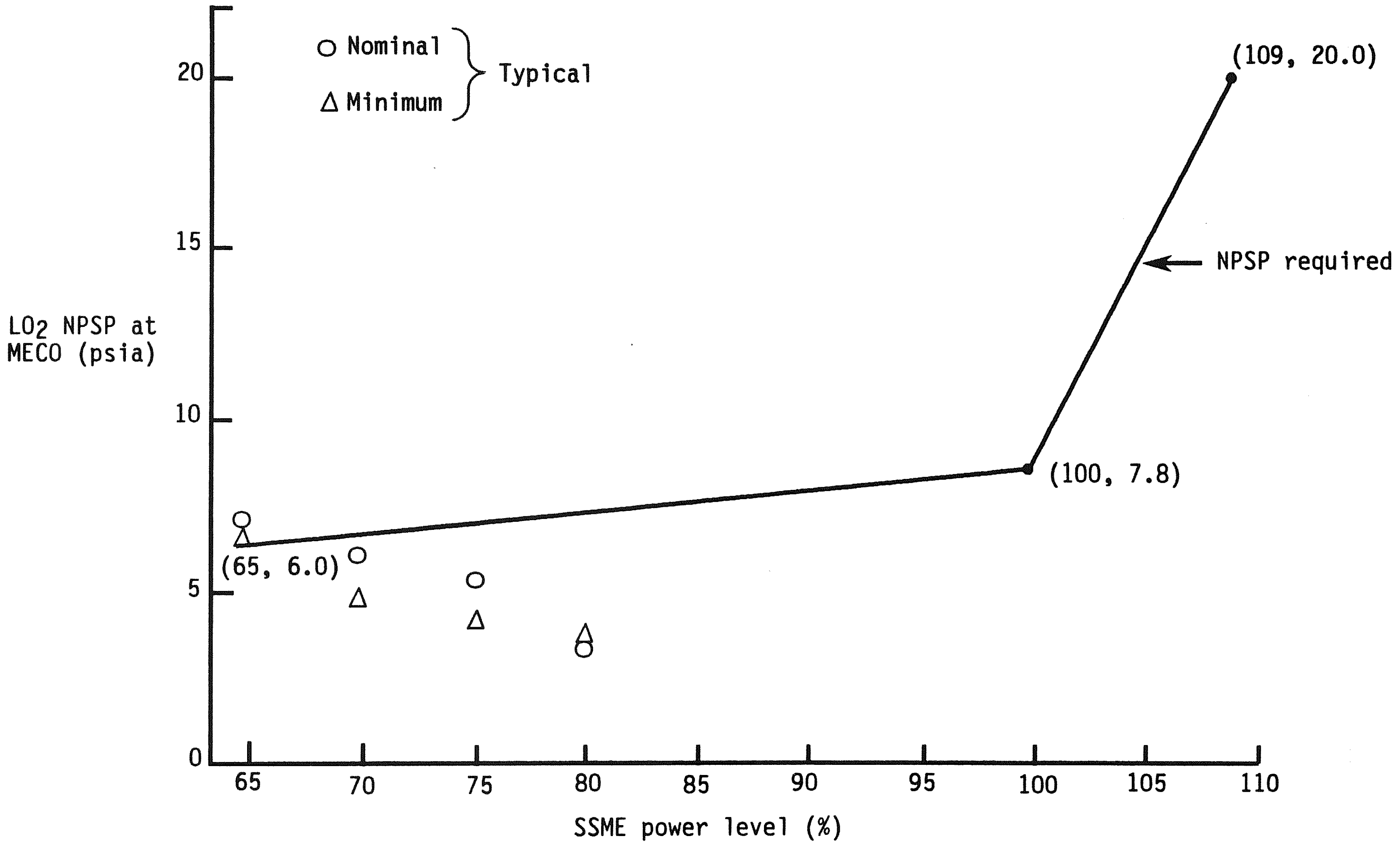
The abort region determinator (ARD) is used during ascent to evaluate the vehicle capability to reach the nominal MECO targets. This capability is expressed in terms of a velocity margin remaining at MECO. Velocity margin is defined as the difference between the delta-V available from the propellant remaining and the delta-V required to execute the mission mode in question. The velocity margin calculations are biased to protect for a 3-sigma bad performance day. If, anytime after SRB separation, the velocity margin is indicating less than zero, then a low-level cutoff is possible. The flight dynamics officer will then report on the flight loop that the first-stage performance is low. Therefore, if three engines are running, the engine in lockup at higher than 67 percent must be manually shut down before MECO. At fine count the two remaining engines will throttle to 91 percent. The low-level timer for the two-engine case is designed for two engines shutting down from 91 percent; i.e. the correct timer will be used to command a safe MECO.

If vehicle performance is low, one SSME has shutdown, and one of the two remaining SSME's is in electrical or hydraulic lockup, no action is required. Analysis has shown that the mass requirements are satisfied, but the NPSP requirements are violated. This NPSP violation was determined to be acceptable. Table 2.1.8-I and figure 2.1.8-II summarize the results of the analysis.

Figures 2.1.8-I and 2.1.8-II were derived from the ICD minimum LO_2 NPSP curve (ICD fig. 4.2.2-1). For figure 2.1.8-I, the NPSP required at shutdown for three engines running (two at 65 percent and one stuck higher than 65 percent) is the same as the ICD curve because the engine at the higher level must have its NPSP requirement met, and this requirement is higher than the two engines at MPL. Figure 2.1.8-II was derived for the nominal/ATO/AOA/TAL MECO case where only two engines are running prior to MECO. In this scenario, one of the engines is at its commanded value of 91 percent and the other is stuck between 65 and 109 percent. If the engine is stuck above the 91 percent power level, its NPSP requirement will be the driving factor, whereas, if it is stuck below 91 percent, the engine at 91 percent will drive the required NPSP.

Table 2.1.8-I was presented at the 24th psig by Rocketdyne. One change was made to the table after reviewing the low-level cutoff data from STS 51-F and is reflected in the table. After a review of the terminal drain temperatures from 51-F, it was determined that the LO_2 was supercooled and therefore had a NPSP 1.9 psi greater than previously predicted. The required NPSP for each case is driven by the engine at the highest power level and is derived from the ICD curves. The LO_2 mass data at main oxidizer valve (MOV) closure relates to the amount of LO_2 which is found

between the closed prevalve and the low pressure oxidizer pump (LPOP) inlet when the MOV closes. The ICD requirement for this mass is found in paragraph 4.3.8 and is 80 lb for each SSME which shuts down at MECO. In the total mass required row, it is assumed that the volume between the prevalve and LPOP inlet is completely filled with LO_2 (having a mass of 540 lb) for any engine which has shut down prematurely (i.e., R/L shutdown, command path manual shutdown, etc.) In the first case where one engine has shut down prematurely, one engine is stuck at 104 percent and the other is at 91 percent, the total mass required is 700 lb including the 80 lb for each running engine and the 540 lb for the engine which shut down prematurely. The minimum mass is not supplied in only two cases (the two cases of one engine shut down with two engines stuck). The negative number for the case where two engines shut down from 109 percent means that the LO_2/GO_2 interface has already gone through the LPOP inlet by the time the MOV closes.



17239:2181*009

Figure 2.1.8-I.- LO_2 NPSP required at MECO (Three SSME cases: two at 65 percent PL, one stuck at higher PL).

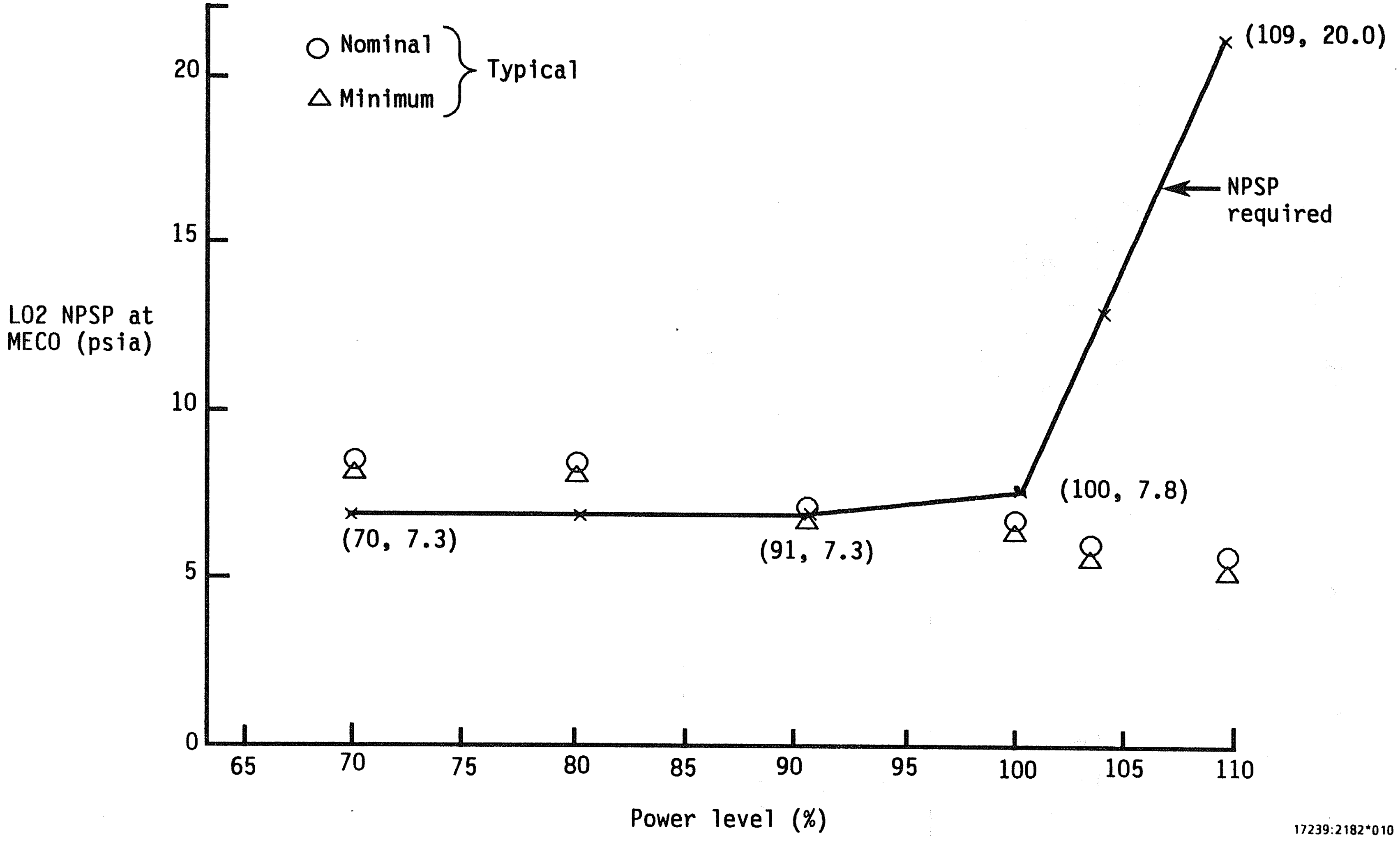


Figure 2.1.8-II.- LO_2 NPSP required at MECO (Two SSME cases: one at 91 percent, one stuck between 65 percent and 109 percent).

TABLE 2.1.8-I.- LO2 ECO SENSOR TIMERS CONDITIONS FOR STUCK THROTTLE FAILURE MODES

	One eng S/D One eng stuck		Two eng S/D	Two eng S/D One eng stuck		One eng S/D Two eng stuck	
PL (%)	91/104	91/109	91/0	104/0	109/0	104/104	109/109
NPSP required at MECO Min NPSP supplied	13.22 8.1	20.00 7.5	7.33 4.5	13.22 3.9	20.00 3.5	13.22 8.1	20.00 6.4
TOT MASS required Min TOT mass at MOV CL	700 1007	700 899	1160 2625	1160 2415	1160 2264	700 697	700 326
MASS required for each running engine Min mass supplied at MOV CL for each running engine	80 230	80 180	80 1545	80 1335	80 1184	80 79*	80 -107*
Duration of NPSP violation prior to MECO	0.82	1.23	1.28	2.19	3.17	0.82	1.25

*Propellant depletion is predicted to occur during shutdown.

A. Flight Rules - (SSME Systems Management)

1. 5-32, MANUAL SHUTDOWN FOR COMMAND/DATA PATH FAILURES
2. 5-33, MANUAL SHUTDOWN FOR HYDRAULIC OR ELECTRICAL LOCKUP
3. 5-35, ENGINE PERFORMANCE DISPERSION

B. Crew Operations

TABLE 2.1.8-II.- PASS/BFS FAILURE RECOGNITION

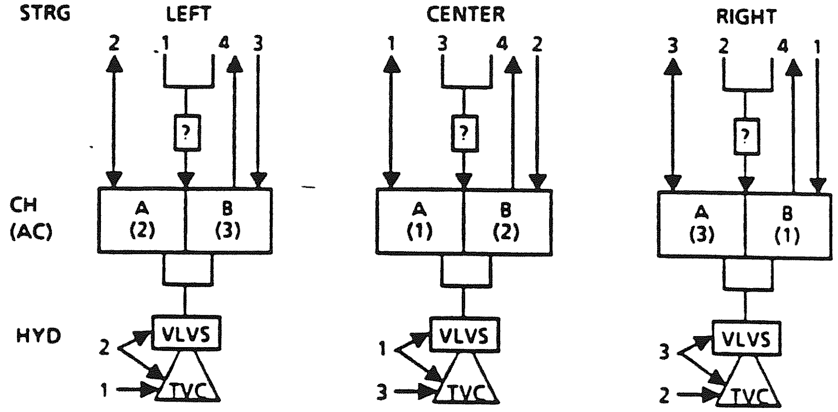
Parameter no.	Failure value/trend	Displayed on
(C) V72X0035X (L) V72X0036X (R) V72X0037X	C(L,R) amber MAIN ENGINE STATUS light	PNL F7
(C) V72P0040C (L) V72P0041C (R) V72P0042C	Pc meter indicates no throttling	PNL F7
	A fault message will indicate the particular stuck throttle condition. The three possible stuck throttle conditions are: MPS CMD C(L,R) MPS HYD C(L,R) MPS ELEC C(L,R) (class 3 alarm)	FML

1. Crew Procedure - Cue Cards

MPS CMD/HYD/ELEC

If in bucket (PC < 104%) or 2 HYD SYS failed:
MN ENG LIMIT SHUTDN - INH

If:	When:	Shut down:
2 HYD SYS failed & 3 ENG	Nom/ATO: SE PRESS TAL: SE TAL RTLS & 2 Pcs > 85%: MECO -2:00	MN ENG (AC/pb): ENG(HYD) | S/D C(1) & R(3) | C L(2) & C(1) | L L(2) & R(3) | R
He lk S/D reqd	Nom/ATO and: 3 ENG: V > 23K 2 ENG: V > 24.5K TAL: V > 22.5K RTLS and: 3 ENG & 2 Pcs>85%: MECO -2:00 He lk: α = -4 CMD: ΔR = CO	Aff MN ENG (pb)
MPS CMD(s)		Aff MN ENG (AC/pb) If 2 CMD: repeat
2 MPS ELEC/HYD & 3 ENG		1 aff MN ENG (AC/pb) If 1 each: HYD
1 MPS ELEC/HYD & 3-ENG Nom/ATO & Perf Low or no comm	V > 23K	Aff MN ENG (AC/pb)



MS 9-3 AESP/ALL/A/GEN D,15

2. Crew Activity - Same as procedure

C. MCC Operations

TABLE 2.1.8-III.- PASS FAILURE RECOGNITION

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(ESW)
(C) E41M1003P
(L) E41M2003P
(R) E41M3003P</td><td>The ESW will indicate the particular stuck throttle case affecting the SSME
Electrical lockup:
<table>
<tr><td rowspan="2">Hex bits last 2 digits</td><td>OK</td><td>MCF</td><td>ELE</td></tr>
<tr><td>--</td><td>8E</td><td>8F</td></tr>
</table>
Hydraulic lockup:
<table>
<tr><td rowspan="2">Hex bits last 2 digits</td><td>OK</td><td>MCF</td><td>ELE</td></tr>
<tr><td>--</td><td>92</td><td>93</td></tr>
</table>
Command path failure:
ESW will still indicate mainstage
<table>
<tr><td rowspan="2">Hex bits last 2 digits</td><td>OK</td><td>MCF</td><td>ELE</td></tr>
<tr><td>85</td><td>86</td><td>87</td></tr>
</table>
See SCP 4.1 for a description of ESW.</td><td>MSK
1052</td></tr>
<tr><td>(AVG Pc)
(C) E41P1023B
(L) E41P2023B
(R) E41P3023B</td><td>The affected SSME will not throttle. AVG Pc will not change</td><td>MSK
1052</td></tr>
<tr><td>(Hard FID)
(C) E41M1005B
(L) E41M2005B
(R) E41M3005B</td><td>Hard FID syntax is generated by a MOC comp which processes the Hex MSID's listed at left</td><td>MSK
1052
1069
1070
1071</td></tr>
</table>

TABLE 2.1.8-III.- Continued

Parameter no.	Failure value/trend	Displayed on
(GH2 OUT P) (C) V41P1160A (L) V41P1260A (R) V41P1360A	GH2 outlet pressure will not change	MSK 1052 2762
	The fault message will indicate the particular stuck throttle condition. The three possible stuck conditions are: MPS CMD C(L,R) MPS HYD C(L,R) MPS ELEC C(L,R) (class 3 alarm)	

TABLE 2.1.8-IV.- BFS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(ESW) (C) V98M2200P (L) V98M2220P (R) V98M2240P	The ESW will indicate the particular stuck throttle case	MSK 1052 1089 1064
(% Pc) (C) V98P2100C (L) V98M2110C (R) V98P2120C	Percent Pc will not change	MSK 1052 1089 1064
(GH2 OUT P) (C) V41P1160A (L) V41P1260A (R) V41P1360A	GH2 outlet pressure will not change	MSK 1052 2762 1089 1064
	The fault message will indicate the particular stuck throttle condition MPS CMD C(L,R) MPS HYD C(L,R) MPS ELEC C(L,R) (class 3 alarm)	FML

1. Console Cue Card

Stuck throttle

(a) Recognition of failure

- ESW
- Pc, GH2 outlet press unchanged
- Fault messages
- FID's

(b) Activity

- Report stuck throttle
- Report any performance levels or LIM S/D changes
- For MPS HYD or MPS ELEC (three-engine case)
  - If ARD ΔV margin after SRB SEP nom, "No manual shutdn required"
  - If ARD ΔV margin after SRB SEP low, "Shutdn C(L,R) at 23K"

2. MCC Activity

TABLE 2.1.8-V.- MCC ACTIVITY

Step	Activity	Position
1	Report the stuck throttle condition	ME/BSE/FD/crew
2	If engine is stuck in the bucket, report; "Main engine limits to inhibit" "Main engine limits to enable" at appropriate abort boundary	ME/BSE/FD/crew
3	Report any performance limiting levels (SCP 2.1.1)	ME/BSE/FD/crew
4	Confirm if FDO has reported after SRB separation stage whether performance is low or nominal	ME/BSE/FD/crew
5	C(L,R) command path failure - report: "Shutdown C(L,R) at 23K (at 22.5 K for TAL or MECO for RTLS)"	ME/BSE/FD/crew
6	C(L,R) hydraulic or electrical lockup ● If ARD ΔV margin after SRB SEP indicates nominal performance for three-eng case, report: "No manual shutdown required" ● If the FDO updates the performance call from nominal to low at any time following SRB SEP go to next Substep ● If ARD ΔV margin after SRB SEP indicates low performance for three-eng case, report: "Shutdown C(L,R) engine at 23K"	ME/BSE/FD/crew ME/BSE/FD/crew
7	For two stuck throttles, refer to SCP 2.1.5	

3. Supporting Data

   a. The complete malfunction procedure for command path failures is in the SCP 2.1.4.

   b. The complete malfunction procedures for hydraulic and electrical lockup are found in SCP 2.1.1.

REFERENCES

1. STS Operational Flight Rules All Flights, Final, PCN-9, JSC-12820, June 20, 1991.

2. Flight Data File - Cue Cards

3. Flight Techniques - April 29, 1988 and July 19, 1988

4. 24th PSIG - Nov. 1983

TITLE

MANUAL SSME SHUTDOWN CASES

CONDITION

An SSME has to be manually shut down.

DESCRIPTION

This SCP describes the cases requiring an SSME to be manually shut down. These shutdown cases are covered in the flight rules. The redline limits will be enabled according to Flight Rule 5-27, after the manual engine shutdown.

A matrix that summarizes the manual shutdown cases is shown in table 2.1.9-I. This matrix is used in the Console Cue Cards book for quick reference.

For each failure case, the matrix lists the shutdown decisions to be made by the MCC when in communication with the crew and by the crew when no communications exist with the MCC. Each flight phase (nominal, ATO, AOA, RTLS, and TAL) and the number of SSME's operating (three or two) are considered in the matrix.

In this SCP, each failure case in the matrix will be briefly discussed.

TABLE 2.1.9-I.- MANUAL ENGINE SHUTDOWN MATRIX

Phase			MCC decision						Onboard decision				Comments
			NOM/ATO/AOA		RTLS		TAL		NOM/ATO/AOA		RTLS	TAL	
ENGINES ON			3	2	3	2	3	2	3	2	3/2	3/2	
CMD PATH or CMD & DATA PATH			23K AC/PB	(2nd CMD) 24.5K AC/PB	MECO AC/PB	MECO AC/PB	22.5K AC/PB	22.5K AC/PB	23K AC/PB	24.5K AC/PB	MECO AC/PB	22.5K AC/PB	① 23K FPS = V_I
1 STUCK (HYD or ELEC)			If Low Perf. 23K AC/PB	--------	--------	--------	--------	--------	> 23K	-------	-------	-------	AC/PB: AC - Power switches PB - SD pusbutton
2 STUCK (CMD, HYD, ELEC) (NOT 2 CMD) (NOT 2 APU FAIL)			23K AC/PB	--------	If Both > 85% MECO-2m AC/PB	--------	22.5K AC/PB	--------	> 23K AC/PB	-------	-------	-------	② APU/HYD 1 + 3 : C 1 + 2 : L 2 + 3 : R
2 APU FAIL			SE PRESS AC/PB NonGimbal	--------	If Both > 85% MECO-2m AC/PB NonGimbal	--------	S E TAL AC/PB NonGimbal	--------					③ Only applies to 3-eng case with 2 APU's down
HELIUM LEAK	NO O-G	GOOD HYD	23K PB	24.5K PB	α - 4	α - 4	22.5K PB	22.5K PB		No comm			
		NO HYD	Min. TK P AC/PB	Min. TK P AC/PB	Min. TK P AC/PB	Min. TK P AC/PB	Min. TK P AC/PB	Min. TK P AC/PB		> 23K PB	only		④ Limits are enabled to allow controller shutdown
	NO RED LINE		Min. TK P PB	Min. TK P PB	Min. TK P PB	Min. TK P PB	Min. TK P PB	Min. TK P PB		With comm > 23K and	> 40 dpldt		
	LIMITS INHIBITED		Min. TK P ENABLE	Min. TK P ENABLE	Min. TK P ENABLE	Min. TK P ENABLE	Min. TK P ENABLE	Min. TK P ENABLE		PB only			
LIMITS EXCEEDED with LIMITS INHIBITED			STUCK IN BUCKET "1 2/3" ENA/INH	STABLE "LIMITS" ENA/INH	DATA PATH ASAP ENA/INH	S E PRESS ENA/INH	DATA PATH ASAP ENA/INH	STABLE "LIMITS" ENA/INH					⑤ √ARD = if performance is low 3-eng: ⑥ If g ≥ 3.5, SD engine per ② at a time of exceedance
			DATA PATH ASAP ENA/INH	UNSTABLE "DROOP" ENA/INH				UNSTABLE "DROOP" ENA/INH					
ENGINES ON			3	2	3	2	3	2					
			NOM/ATO/AOA		RTLS		TAL						

Note: Not all of the above cases are covered by flight rules

A. Command Path Failure

An SSME with a command path failure can no longer respond to commands, including shutdown commands, and must be shut down manually by the crew (reference SCP 2.1.4). The shutdown cue used by the crew, except for an RTLS, is indicated velocity. These velocities were chosen to ensure that the engine is shut down before reaching MECO velocity; otherwise, propellant depletion (resulting in uncontained engine failure) or vehicle overspeed could occur. For an RTLS, the engine is shutdown at MECO to ensure guidance convergence.

B. Data Path Failure

An SSME with a data path failure is unable to transmit the status of the engine parameters in the VDT. As a result of the data path failure, the crew is unaware of the SSME status. The BSE and ME console operators in the MCC can determine from OI data if the SSME is still operating. During 3g throttling, the MCC can verify the status of the command path to the SSME (refer to SCP 2.1.3). However, in a no-comm situation, the crew cannot detect a command path failure on an SSME with a data path failure. Therefore, the crew assumes a command path failure also exists on that SSME and shuts down the SSME prior to MECO. If an engine with a data and command path failure is not manually shut down, propellant depletion or prevalve closure on a running engine could occur, resulting in uncontained engine failure.

C. Command/Data Path Failure

An SSME with command path and data path failures must be manually shut down prior to MECO due to the command path failure (refer to SCP 2.1.4).

D. One Hydraulic or Electrical Lockup

An SSME in hydraulic or electrical lockup might have to be manually shut down if the ΔV margin, predicted by the ARD after SRB separation, indicates that the vehicle performance is low. A nonthrottling engine and low performance may result in the violation of the engine LO_2 NPSP and LO_2 mass requirements at shutdown (reference SCP 2.1.8).

In a no-comm situation, the crew will shut down the nonthrottling SSME prior to MECO to protect the LO_2 NPSP requirements at shutdown.

E. Two Stuck Throttles

The two stuck throttle rule has now been changed to distinguish between engines stuck because of two APU failures and engines stuck for any other combination of APU engine failures. For two engines stuck due to non-APU problems, the crew will shut down an engine at 23K for nominal, 22.5K for a TAL and MECO - 2:00 on a RTLS if both engines are above 85 percent. All of the above shutdown times were chosen to prevent the vehicle from exceeding 3.5g. If two engines are stuck for APU failures, the crew will take action at single engine press for nominal, single engine TAL for a TAL and MECO - 2:00 for a RTLS. In all cases the nongimballing engine is shut down to prevent loss of control of a gimballing engine. Currently the two-engine on, one without gimbals is considered a loss of control case.

F. Performance Limiting

If the ARD predicts early propellant depletion due to a performance limiting failure, the affected SSME will be shutdown.

G. He Leak

In this case, the engine will run with the helium leak, but the helium supply pressure will not support the zero-g shutdown requirements at MECO. For a zero-g shutdown, the LO_2 prevalves are closed, and helium is injected into the POGO accumulator system to maintain sufficient pressure at the HPOP inlet to prevent LO_2 pump overspeed during shutdown. The required helium supply pressure for a safe shutdown will depend upon the number of helium regulators operating, the helium leak rate, and the type of shutdown (i.e., hydraulic or pneumatic). A higher helium supply pressure is required when only a single regulator is operating or for higher leak rates.

The shutdown pushbutton is used for engine shutdown instead of the ac power switches in order to shut down the engine hydraulically. By shutting down the engine prior to MECO, safe engine shutdown will occur because the g-load on the vehicle will maintain adequate pressure at the HPOP inlet. The shutdown cues for nominal, ATO, AOA, and TAL are the same cues used for other manual shutdown cases. The shutdown cue for RTLS was selected to ensure RTLS capability and adequate control when the engine is shut down.

The minimum pre-MECO supply pressure represents the pressure which can close the engine valves and supply the purges for a safe hydraulic or pneumatic shutdown. If the minimum supply pressure requirement is violated, the engine may continue to operate until it reaches the controller HPOT intermediate seal purge (ISP) pressure redline. Once the redline is violated, an automatic shutdown will be commanded if the limits are enabled. Shutdown may be catastrophic because requirements for pressure and flow cannot be met during the shutdown sequence. IF hydraulic shutdown capability exists and limits are enabled, no manual shutdown is required. An automatic shutdown will occur when the HPOT intermediate seal redline is violated. The helium demand for a hydraulic engine shutdown under "g" is much less than that required to support a zero-g hydraulic or pneumatic shutdown or a pre-MECO pneumatic shutdown.

H. Engine Limits Exceeded With Limits Inhibited

This failure case applies only to the HPOT ISP pressure redline. When this redline is exceeded, the result is uncontained engine damage. Therefore, if limits are inhibited and an engine has a helium leak, the

MCC will monitor the helium tank and regulator pressures and the HPOT ISP pressure redline. When the helium tank pressure or regulator pressure drops below the crew alert value, the MCC will call for the limits to be enabled. This action will allow the controller to safely shutdown the engine when the HPOT ISP redline is exceeded (reference SCP 2.1.7).

REFERENCE

STS Operational Flight Rules, All Flights, Final, PCN-2, JSC-12820, July 5, 1989.

TITLE

SUSPECT ENGINE

CONDITION

Certain engine failures make an SSME's continued performance suspect.

DESCRIPTION

A suspect engine is an engine that has a failure that makes the continued operation of that engine suspect. A suspect engine results from any one of the following engine failure conditions:

1. Both redline sensors shift in the same direction, but only one sensor violates the redline limit
2. Both sensors exceed the limits for a particular redline after shutdown monitoring is inhibited
3. Nonisolatable MPS helium leak
4. Low LH_2 NPSP requiring manual throttle down

Each of the four failure conditions are briefly described below.

The first failure condition was identified when the turbine discharge temperature redline was developed for the high pressure fuel pump. The channel A temperature sensor nominally indicates about 110 degrees R cooler than the channel B sensor due to the flow distribution around the sensors. Therefore, the channel A and B redline values are individually set in an attempt to assure that both temperature measurements exceed their respective limits at the same time. Channel A is set at 1850 degrees R (this limit can be higher depending upon the specific pump), and channel B is set at 1960 degrees R. Because of this difference, it was decided that it was possible for the two channels not to exceed the redline limits at the same time when a pump failure occurred. This condition applies to the other redlines as well because each redline has two channels. Even though the redline limits for the two channels of the other redlines are the same, it may be possible for the two channels not to exceed their limits at the same time due to sensor or hardware problems.

The second failure condition applies to a redline limit violation occurring when the redline shutdown logic is inhibited. If both sensors have exceeded the limits, the pump may have a hardware failure and may not be able to continue to operate.

The third failure condition is a nonisolatable helium leak. Helium is required for the intermediate seal purge in the high pressure oxidizer pump. The crew will try to isolate the leak. If the leak can not be isolated and is small, there may be sufficient helium to support the purge until MECO. However, the leak may get worse, resulting in helium depletion and engine shutdown prior to MECO. For this reason, the engine will be suspect with any nonisolatable helium leak, large or small.

The fourth failure condition is low LH2 NPSP requiring manual throttle down.

A. Flight Rules

1. Failure Definitions

a. 5-5, SUSPECT ENGINE

b. 4-26H, PERFORMANCE BOUNDARIES

B. Crew Operations

The crew can detect a nonisolatable helium leak and a redline exceedance when the limits are inhibited. However, the application of the suspect-engine rules is an MCC responsibility.

C. MCC Operations

1. Recognition of failure - The BSE, ME, and MPS can identify the failures that make the affected SSME suspect.

For information on identification of redline exceedances, refer to SCP's 3.1.2 and SCP 2.1.6. For helium leak identification, refer to SCP 2.2.4. For low LH2 NPSP identification, refer to SCP 2.2.1.

2. Console Cue Card

a. Recognition of failure

Suspect engine

Condition (results from any of the following failures):

1) Both sensors shift in the same direction, but only one sensor violates redline

2) Both sensors exceed limits for a particular redline after limits inhibited

3) Helium leak (nonisolatable)

4) Low LH_2 NPSP requiring manual throttle ↓

b. Activity

FIDO call:

Abort TAL if no uphill capability available
and either of following cases are true:

(1) More than one engine suspect

(2) One engine suspect and another engine has stuck throttle

3. MCC Activity

TABLE 2.1.10-I.- MCC ACTIVITY

Step	Activity	Position
1	When applicable to an engine failure report: "C(L,R) engine is suspect"	ME/BSE/FD
2	If there is no uphill capability and if more than one engine is suspect, <u>or</u> one engine is suspect and another engine has stuck throttle, FIDO will call for TAL abort	ME/BSE

TITLE

SSME REDLINE LIMIT SWITCH USAGE

CONDITION

The SSME redline shutdown limits need to be manually enabled or inhibited.

DESCRIPTION

Prelaunch, the SSME redline shutdown limit switch is positioned in the AUTO position with the limits enabled. Therefore, if an SSME is shutdown by a redline violation or an SSME gets a data path failure, the GPC will inhibit the remaining two engines. If the engine is out, the limits will be left inhibited until the vehicle is in a region of the trajectory where intact abort capability exists which will tolerate another shutdown of an SSME. If the SSME gets a data path failure and the engine is confirmed on, the limits are enabled.

To reenable the limits, the limit switch is first placed to the ENABLE position, and then to the AUTO position so that the GPC's will automatically inhibit limits if loss of an engine or a data path failure subsequently occurs. If later the limits need to be inhibited due to, for example, an abort gap, the switch must be positioned to the INHIBIT position so that the GPC's will inhibit limits.

Proper use of the redline shutdown limit switch is very important. Tables 2.1.11-I and 2.1.11-II describe the cases for enabling or inhibiting the limits.

Flight Rules

1. 5-27, LIMIT SHUTDOWN CONTROL
2. 5-29, DATA PATH FAIL/ENGINE-ON LIMIT SHUTDOWN CONTROL
3. 5-30, DATA PATH FAIL/ENGINE-OUT ACTION
4. 5-31, LIMIT SHUTDOWN CONTROL FOR PERFORMANCE LOSS CASES

REFERENCE

STS Operational Flight Rules, All Flights, Baseline, JSC-12820, Sept. 1, 1987.

TABLE 2.1.11-I.- THREE SSME's OPERATING

Case	Limit Switch Control			Comments
	Switch Position	GPC Response	Crew Action	
<u>3 SSME's running</u> (prior to failure)				
• No failures	AUTO	- enable	- none	- Nominal
• 1 data path fail/eng on	AUTO	- inhibit	- ENABLE, then AUTO ASAP	- Can allow an SSME to shutdown - For subsequent engine out, limit sw-INH (2 Pc < 30 & Data Path = MECO)
• 1 SSME fail				
• NOM/ATO/AOA/TAL	AUTO	- inhibit	- ENABLE, then AUTO at single-engine boundary	- Have intact single-eng abort capability
• RTLS	AUTO	- inhibit	- ENABLE, then AUTO at single-engine RTLS boundary	- Single-engine RTLS close to MECO
• BFS engaged	AUTO	- inhibit	- none	- No single-engine roll control
• 1 SSME stuck in bucket	AUTO	- enable	- INHIBIT ASAP	- In abort gap
			- ENABLE, then AUTO when intact abort capability exists	- Usually at 2-eng TAL

TABLE 2.1.11-II.- TWO SSME's OPERATING

Case	Limit Switch Control			Comments
	Switch Position	GPC Response	Crew Action	
<u>2 SSME's running</u> (prior to failure)				
no other failures	AUTO	- inhibit	- ENABLE, then AUTO at single-engine boundary	- Have intact single-eng abort capability
1 data path fail/eng on	AUTO	- inhibit	- none	- If SSME without data fail shuts down, it satisfies MECO conditions in SSME OPS (2 Pc's < 30 and 1 data fail)
1 SSME fail	AUTO	- inhibit	- none	- Cannot lose remaining eng

TITLE

SSME SWITCH FAILURES MALFUNCTION PROCEDURES

PURPOSE

To discuss malfunctions and failures of SSME switches.

DISCUSSION

A. Description

There are three main groups of switches associated with the SSME. The groups are the main engine limit shutdown switch, the main engine shutdown push buttons, and the MPS engine ac power switches.

The limit shutdown switch controls the flow of shutdown enable commands to all three Space Shuttle main engine controllers (SSMEC's). This switch is on panel C3. It is a three-position switch with positions marked ENABLE, AUTO, and INHIBIT. The ENABLE position permits each SSMEC to apply its internal logic and shut down the engine when redlines are exceeded. The INHIBIT position disables the SSMEC's from applying that portion of the logic which shuts an engine down due to redline violations. The AUTO position permits the GPC to select INHIBIT commands or ENABLE commands to all three SSMEC's. This logic is explained in the SSME OPS sequence.

The left, center, and right main engine shutdown pushbuttons allow SHUTDOWN and SAFING commands to be sent from the GPC to the SSMEC. These three buttons are located on panel C3. They are two-position momentary contact switches. The shutdown commands are latched in the software (reference SSME OPS).

MPS power switches are located on panel R2. The six switches are arranged in two rows of three switches. Each switch allows AC power to be sent to a SSMEC when placed on the ON position. The OFF position prevents the selected three-phase ac power from reaching the SSMEC.

B. Redundancy

1. Main Engine Limit Shutdown Switches (fig. 2.1.12-I)
    a. Switch position is determined by a majority vote from the three contacts.
    b. Switch dilemmas will result in a default position of AUTO.
2. Main Engine Shutdown Pushbuttons (fig. 2.1.12-I)

a. Single communication faults allow the passage of guidance moding flags and engine safing commands by the GPC, but not the shutdown command.

b. A pushbutton-position disagreement on the two-contact switch annunciated by "ME SHDN SW C (L, R)" on the fault message line is the indication of a dilemma and will not permit shutdowns, safing commands, or the setting of guidance moding flags. The appropriate MDM can be commfaulted. Reference Flight Rule 5-30.

3. MPS Engine Power Switches

a. Contact failed on

1. If one or two of the ac phases are failed on, the power switch is said to be functional. The ac power to the SSMEC for that bus can be terminated since the SSMEC needs all three phases to operate.

2. If three of the ac phases are failed on, the power switch is nonfunctional. The ac power to the SSMEC for that bus would have to be removed via the ac circuit breakers on panel L4 (fig. 2.1.12-III).

b. Contact failed off

If one or more contacts for the ac power switch remain broken regardless of the switch position, then the switch is nonfunctional. Ac power to the associated SSMEC will cease and the SSMEC will report ac power failure annunciated by FID's. The SSMEC should remain on with power available via the other redundant AC power source. However, redundancy for the engine remaining on is lost. See SCP 2.1.2 for lost redundancy procedures.

C. Procedures

1. It takes two failures to cause a dilemma on a three-contact switch. Reference SCP 2.2.11. Dilemmas on the ME limit shutdown switch can be resolved by resetting the circuit breaker on the failed control bus or by commfaulting the appropriate FF MDM.

TABLE 2.1.12-I.- LIMIT SD SW/CNTL BUS/MDM MATRIX

Switch contact	Failed bus	Commfault MDM
A	BC2	FF2
B	CA3	FF3
C	BC3	FF4

2. Failure of the pushbuttons are handled by implementing the procedure of using the ac power switches to shutdown the engines. This procedure is indicated by the use of "(AC/PB)" in the checklist. The ac power is turned off first to ensure engine shutdown, and the shutdown pushbutton is pushed to mode guidance.

   Should the safing function for the pushbutton be inoperative due to power supply problems, the appropriate MDM may be commfaulted to allow the pushbutton to operate. The commfault can be achieved by power cycling the MDM, pushing the SD PB, and then performing an I/O reset on the MDM. Table 2.1.12.-II indicates the relationship between the control buses, the MDM's, and the shutdown PB's:

TABLE 2.1.12-II.- SSME SHUTDOWN PUSHBUTTON/CNTL BUS/MDM MATRIX

SD PB	Failed Control bus	Comm Fault MDM
CTR	AB1	FF1
CTR	AB2	FF2
LEFT	BC2	FF2
LEFT	CA2	FF3
RT	CA3	FF3
RT	BC3	FF4

Note: This procedure was approved by the Ascent Flight Techniques Panel meeting no. 30 on March 27, 1987 (reference Flight Rule 5-30).

If the right engine's pushbutton is "no-op'd" by the failures of GPC's 3 and 4 (which also creates a data path failure to the right engine) and the right engine fails, then the above commfault procedure will be ineffective. The only way to make the pushbutton issue the safing command is to restring either FF3 or FF4 to either GPC 1 or GPC 2.

If multiple data paths exist and guidance cannot be moded due to pushbutton failure, then the crew needs to perform the keyboard entry, "OPS 104 PRO," post-MECO. This action will set the MECO confirmed flag and allow the external tank separation sequence to start (reference flight rule 5-53, MECO CONFIRMED).

Note: The decision to commfault an MDM is made in real time. IMU's 1, 2, and 3 are on FF's 1, 2, and 3 respectively. If other Shuttle system failures exist, the decision may be to not commfault the MDM.

3. Circuit breakers can be pulled to remove power if ac power is failed on. For ac power failed-off, the SSMEC has lost redundancy and the ac bus sensors should be turned off. Reference SCP 2.1.2.

REFERENCES

1. Booster System Briefs, 1.12, JSC-19041.
2. Space Shuttle Operational, Level C, Functional Subsystem Software Requirements Document, Guidance, Navigation, and Control, Part D, Redundancy Management, January 30, 1983.
3. Space Shuttle Systems Handbook, Dwgs. 10.3, 10.4, 20.1
4. Flight Data File
5. STS Operational Flight Rules, All Flights, Baseline, JSC-12820, Sept. 1, 1987.

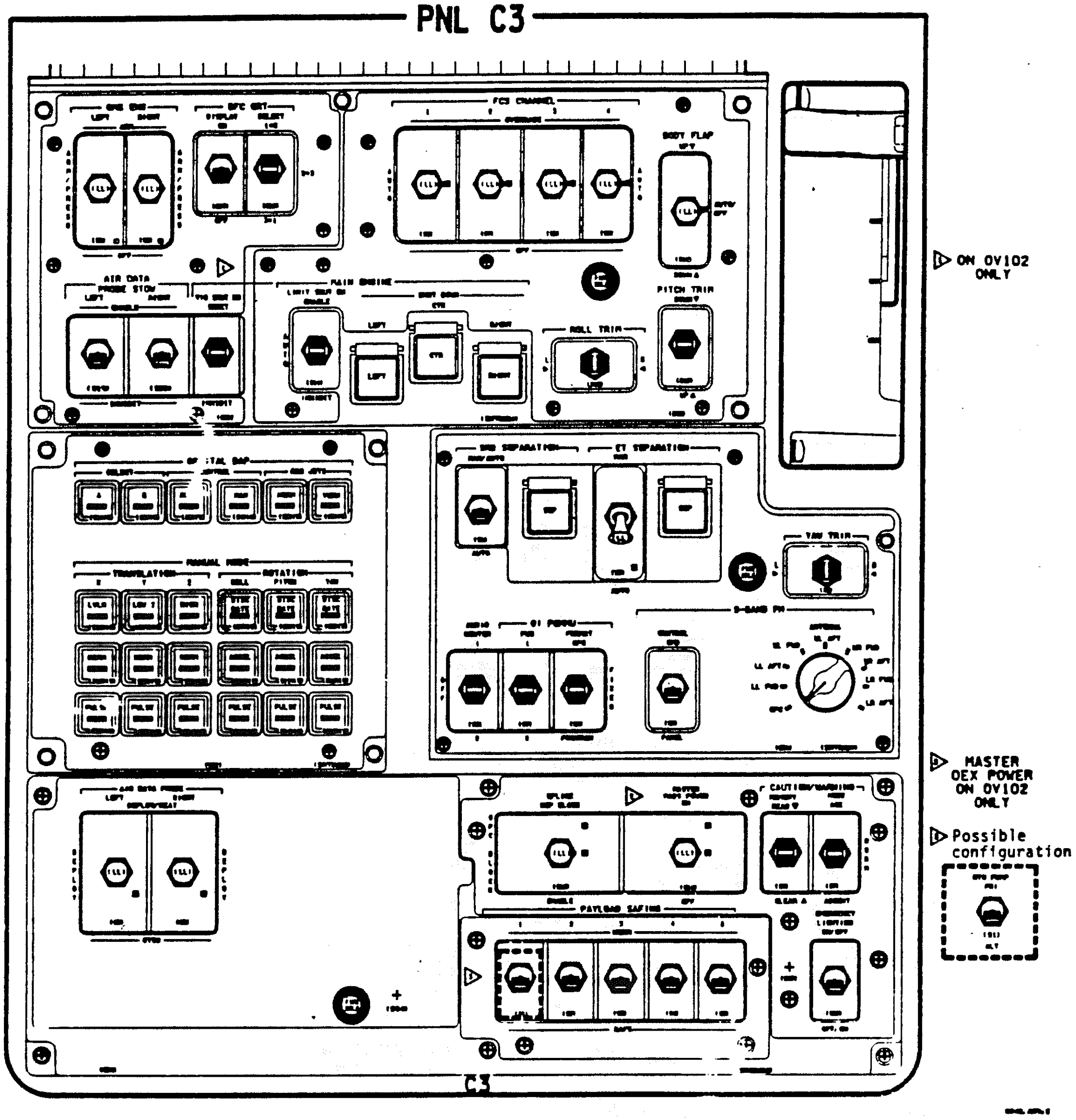


Figure 2.1.12-I.- C3 panel.

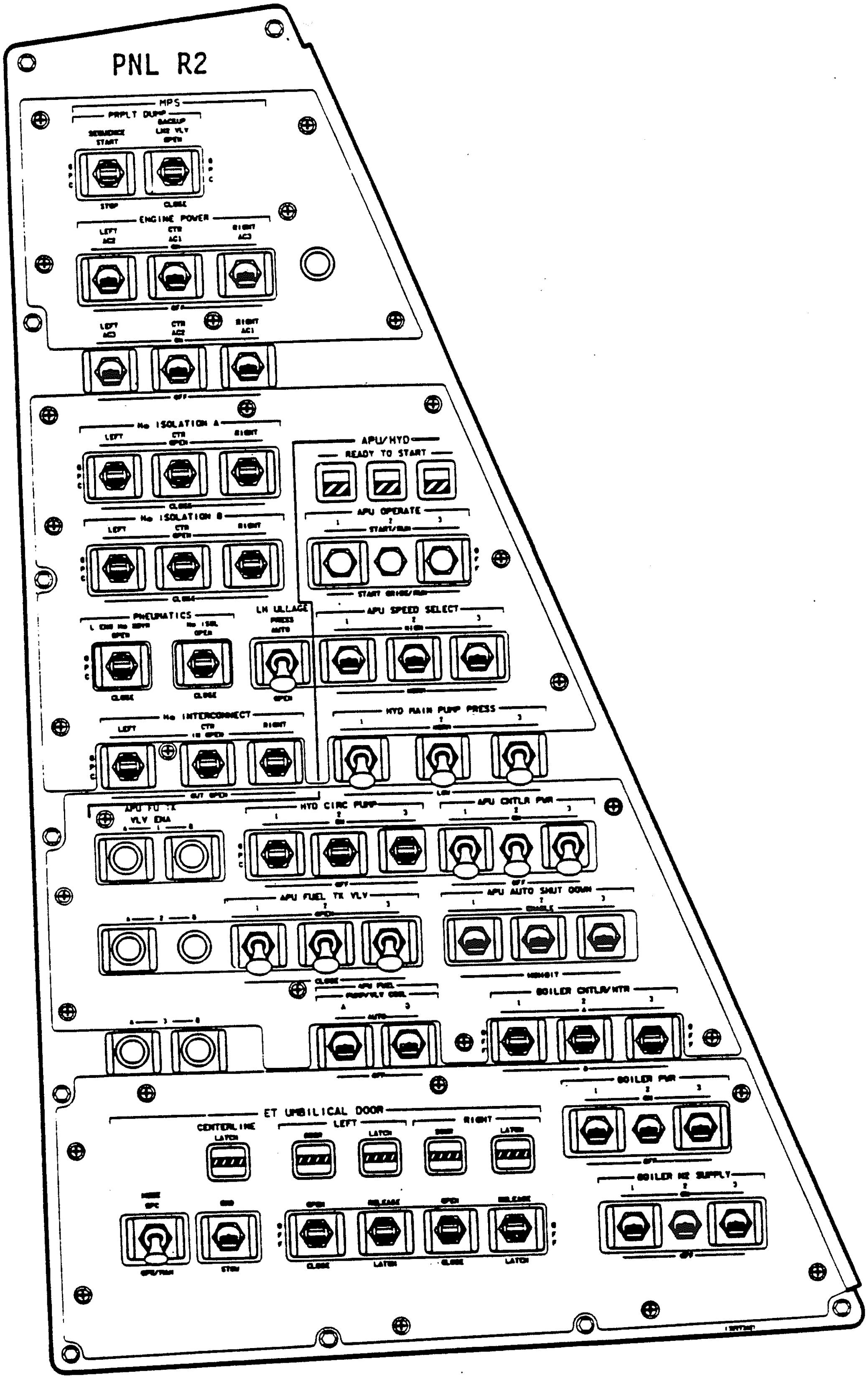


Figure 2.1.12-II.- R2 panel.

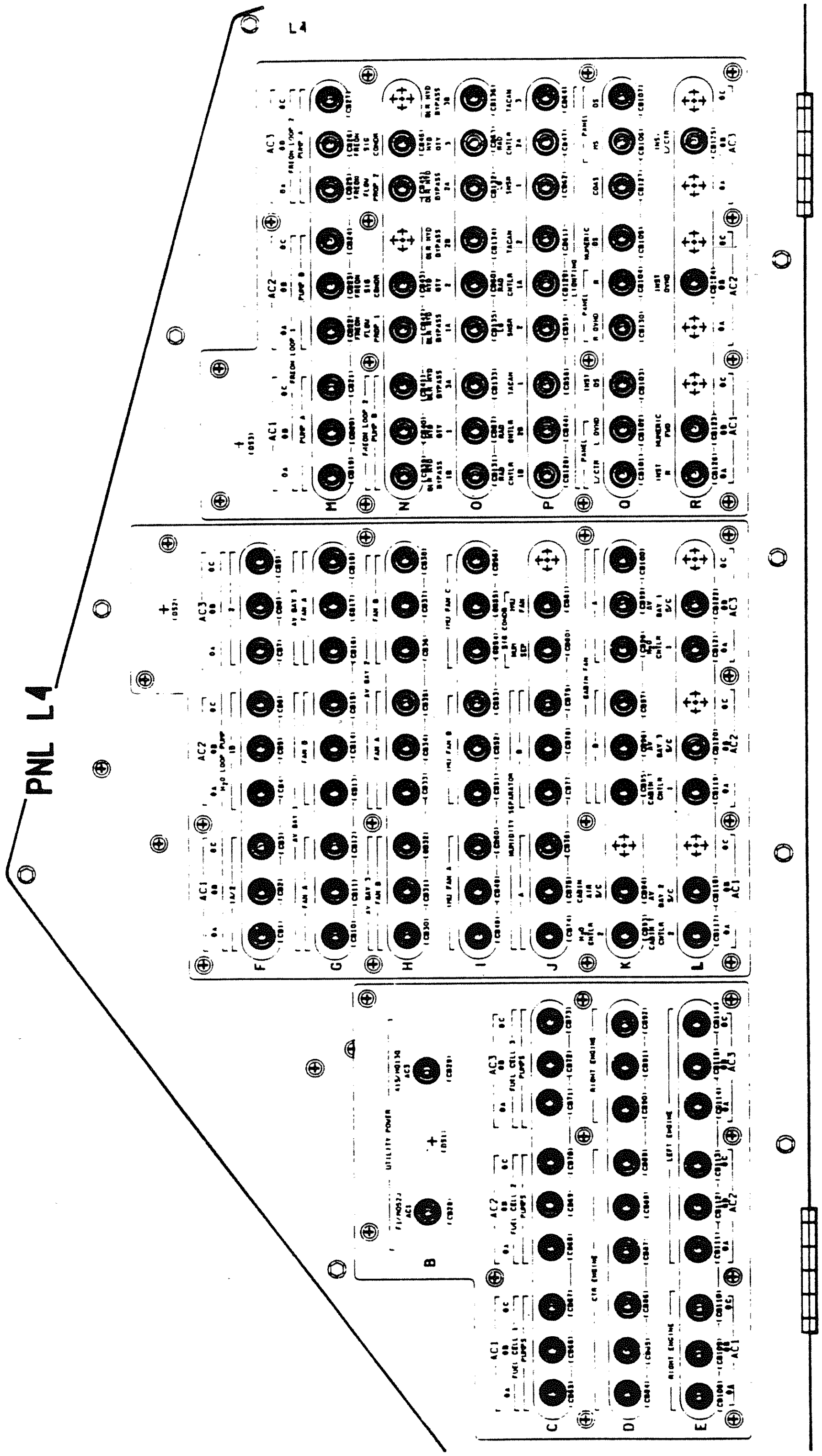


Figure 2.1.12-III.- L4 panel.

TITLE

ET LH_2 ULLAGE PRESSURIZATION FAILURES/NPSP PROBLEMS

PURPOSE

This SCP describes the ET LH_2 ullage pressurization and low LH_2 NPSP problems. It also provides what actions are taken by the crew and the MCC in response to these failures.

CONDITIONS

ET LH_2 ullage pressurization failures are:

1. LH_2 tank ullage pressure >36 psia during first stage may result in venting of the LH_2 tank, creating a potentially flammable environment. This may occur for two or three flow control valves failed open with three SSME's running or one failed open and two SSME's running. If the pressure continues to rise, the tank may burst.

2. Low LH_2 net positive suction pressure (NPSP) during powered flight might result in high pressure fuel turbopump (HPFT) turbine discharge temperature (TDT) redline shutdown of the SSME's. Manual throttling and/or a TAL abort will be performed as required per Flight Rules 5-50 and 5-51, respectively.

   Note: The ullage pressure limits represent the actual vehicle limits followed by a number in parentheses which represents the number on which flight control action will be taken. Reference Flight Rule 1-20.

DESCRIPTION

The nominal LH_2 ullage pressure is designed to be maintained between 32 and 34 psia for two reasons. First, this is the designed operating region of the tank. If the pressure rises above this control band, there is a possibility the tank will vent and may rupture if the pressure rises too high. If the ullage pressure drops below the operating band, the tank may collapse. Second, this ullage pressure band represents the pressure required to provide proper NPSP to support engine operation. The ullage pressure operational limits for structure and NPSP are shown in figure 2.2.1-I.

NPSP is defined as the total pump inlet pressure minus the liquid vapor pressure (which is an increasing function of inlet temperature). NPSP can be degraded due to an abnormally low ullage pressure or an abnormally high pump inlet temperature. Low NPSP may result in uncontained engine shutdown(s) due to pump cavitation and explosion.

The low ullage pressure may be due to a pressurization line or tank leak, an ullage gas cooling due to LH_2 slosh, an LH_2 tank vent relief valve failed open, or two or three GH_2 flow control valves failed closed. The flow control valves might be failed closed because their respective LH_2 ullage pressure sensors have failed high, a failure in the sensor electronics, or a physical valve failure. In addition, if two LH_2 ullage pressure sensors go static between 32 and 34 psia (due to transducer stiction) while their control valves are closed, the true ullage pressure may fall below the control band. (This is possible because the actual trip levels to open and close the valves are 32.4 and 33.6 psia, respectively).

A. Failed Open Flow Control Valves

If one flow control valve fails open, the remaining two control valves will be able to maintain the ullage pressure in the control band. If two flow control valves are both failed open, the actual ullage pressure will go above the control band. See figure 2.2.1-III.

If two or three GH_2 flow control valves fail open during the first two minutes of flight (first stage), the LH_2 ullage pressure may rise to the relief setting (36 ± 1 psig) and vent GH_2 into the external tank boundary layer. As a result, GH_2 burning may occur at low altitudes (below 110,000 feet) which may result in burning away of the TPS. For small fires (e.g., not causing explosion of the tank), the loss of TPS may result in higher heat transfer and a higher LH_2 bulk temperature. If the tank were to suffer this heating, the ullage pressure would remain higher longer (the flow control valves do not need to open as often) due to the expansive nature of the hydrogen under heating conditions. Yet as the tank heats, the pump inlet temperature rises which in turn causes a rise in the liquid vapor pressure; this results in a decrease in the NPSP.

B. Failed Closed Flow Control Valves

If one flow control valve fails closed, the remaining two control valves will be able to maintain the ullage pressure in the control band. If two flow control valves are both failed closed, the actual ullage pressure will drop below the control band. See figure 2.2.1-III.

If two or three flow control valves fail closed, the ullage pressure will drop below the control band. When the LH_2 ullage pressure drops below 31.6 psia, the ullage pressure switch will be manually taken to the open position. When this action is ineffective and the ullage pressure drops low enough to cause the NPSP to drop below 3.5 psi or the HPFT TDT to rise to within 75° of the redline, the engines will be manually throttled to 95 percent RPL. If one of the two cues is violated again, the engines will be throttled to 80 percent RPL and then down to 65 percent RPL if one of the two cues is violated a third time. No abort will be performed for two flow control valves failed closed. When the SSME's are first throttled down to 95 percent RPL, the main engine limits will be manually enabled to allow for safe redline shutdown, if needed.

If three flow control valves fail closed, the ullage pressure will drop below 31.6 psia. When this happens, the ullage pressure switch will be manually taken to the open position in an effort to open the valves in case a failure of the transducer or the associated electronics has not opened the valves as needed to maintain ullage pressure. The switch is not normally opened in first stage due to the venting hazard (see two or three flow control valves failed open); the risk of venting is considered less hazardous and more survivable than a potential tank collapse/ possible uncontained engine shutdown(s).

When the ullage pressure drops low enough to cause the NPSP to drop below 3.5 psi or the HPFT TDT to rise within 75° of the redline, the engines will be manually throttled to 95 percent RPL. If one of the two cues is violated again, the engines will be throttled to 80 percent RPL and then down to 65 percent RPL if one of the two cues is violated a third time. When the first throttle step is taken, the crew will perform an abort to the nearest TAL or Augmented Contingency Landing Site (ACLS). When the SSME's are first throttled down to 95 percent RPL, the main engine limits will be manually enabled to allow for safe redline shutdown.

C. Ullage Penetrations

If all of the FCV's appear to be operating and the ullage pressure is still dropping, the failure can be considered to be an ullage penetration. The low ullage pressure may be due to a pressurization line or tank leak, or an LH_2 tank vent relief valve failed open. When an ullage penetration occurs such that the ullage pressure drops below 31.6 psia, the ullage pressure switch will be manually taken to the open position. If the NPSP drops below 3.5 psi, the crew will perform an abort to the nearest TAL or ACLS and the main engine limits will be manually enabled to allow for safe redline shutdown. No manual throttling will be done because this will cause a drop in the pressurization flow (which is directly associated with the power level) resulting in lower NPSP than the no throttle case. The flow out through the penetration will be greater than the flow of pressurization GH_2 into the tank from the engines; thus, reducing the pressurization flow into the tank will only quicken the decrease in the NPSP.

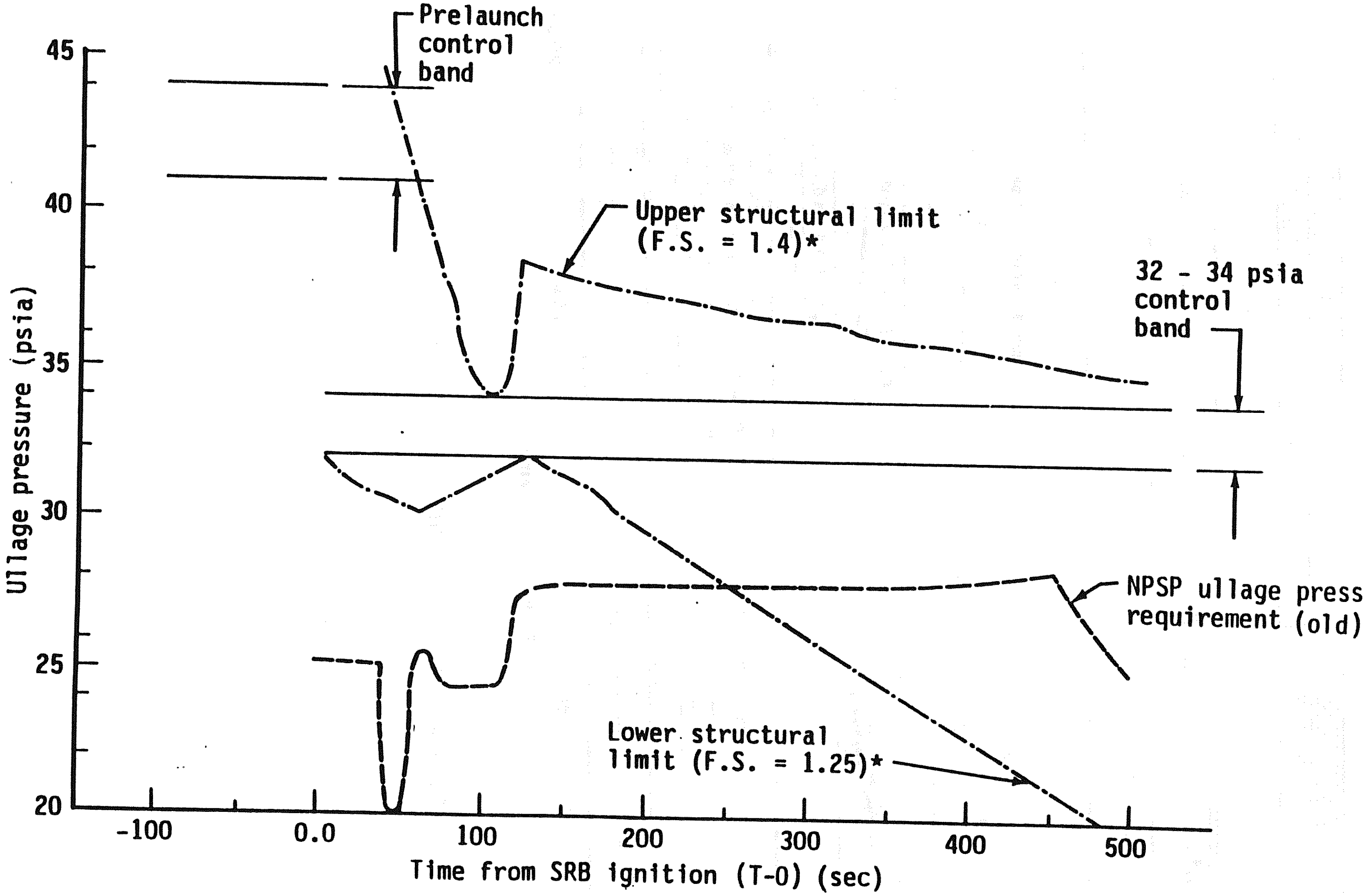
D. Effect of Low NPSP

The two main effects of low NPSP will be on the low pressure fuel turbopump turbine discharge pressure (LPFT TDP) and the HPFT TDT. The LPFT TDP will be lower than normal due to the low ullage pressure at the inlet side. The HPFT TDT will be higher than normal because the flow of hydrogen will be less than normal, causing a rise in the mixture ratio. This will cause the mixture to burn hotter than normal.

The recent deletion of the LH_2 inlet temperature transducers has reduced the accuracy of the NPSP computation for the case of propellant heating. The NPSP is computed using a constant for the inlet temperature. The computation is accurate because the temperature is fairly constant through powered flight. However, in the case where the propellant temperature begins to rise (e.g., substantial TPS loss) the computation will not be able to account for this change. The console procedure developed to cover this failure involves using the manifold temperature which is still available. For every 1° change in temperature, the NPSP changes by 3 psi. The manifold temperature is plotted on a UP to facilitate tracking. On a nominal ascent, the plot is constant.

E. How to Determine if a LH2 Flow Control Valve is Open or Closed

No position indications exist on the flow control valves. The main cues for determining if valves are opened or closed are the power indications [open (unpowered) or closed (powered)] being sent from the solenoid. The backup cue for determining if a valve is open or not is the GH_2 outlet pressure. The pressure will have a delta of approximately 300 psi between the open and closed position. This will stay generally true for all power levels, even though the actual outlet pressure is a function of the power level. At 104 percent RPL, if the GH2 outlet pressure is above 3360 psia the FCV is in the closed position. If the GH2 outlet pressure is below 3140 psia, the FCV is in the open position. The outlet pressure can be compared against these numbers to determine the actual position of the FCV if the valve is cycling.



*Represents flight loads for 109 percent

Figure 2.2.1-I.- Ullage pressure limits.

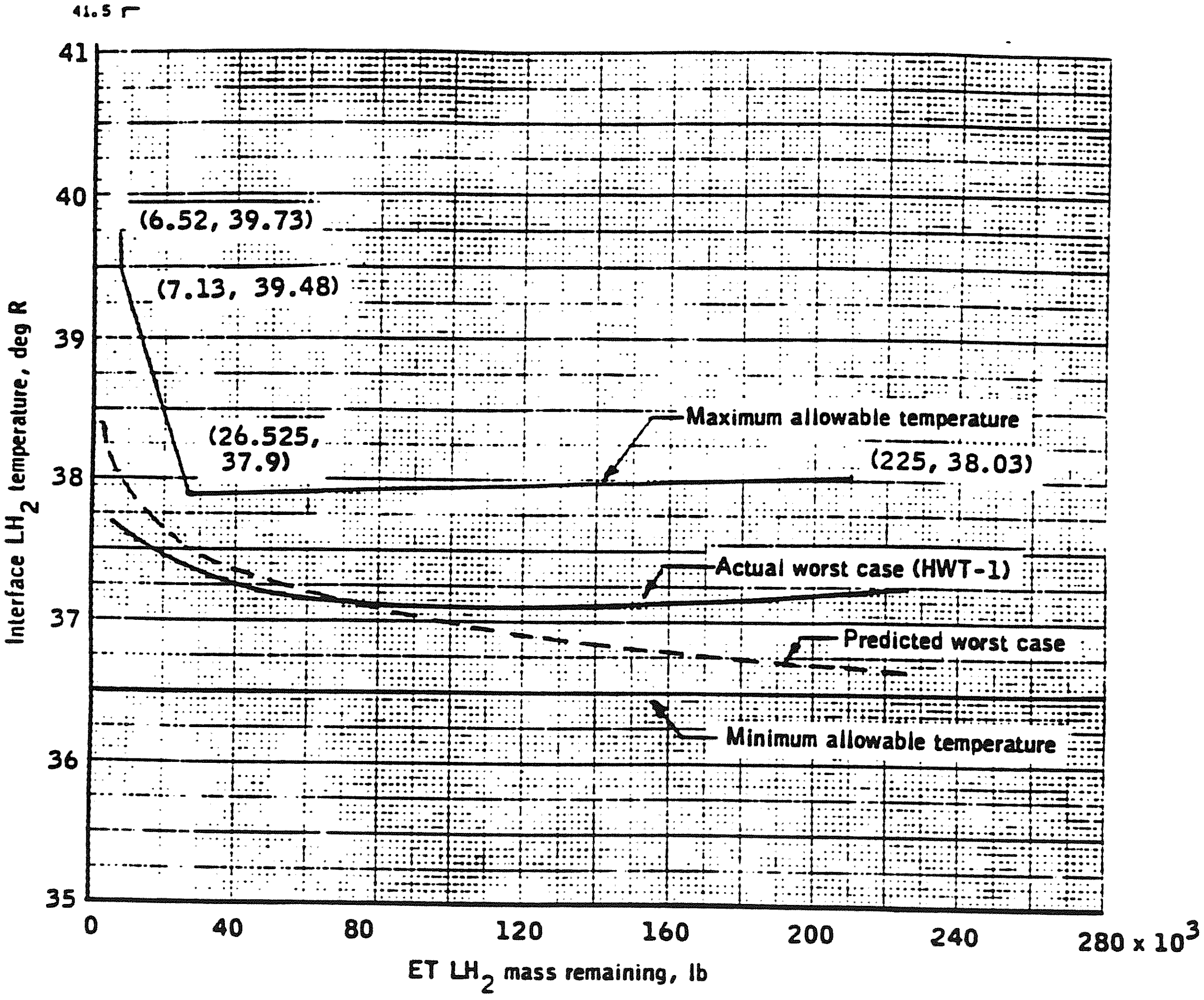


Figure 2.2.1-II.- SSME LH_2 inlet temperature.

PROCEDURES

A. Flight Rules

1. General

   1-20, VEHICLE SYSTEM LIMITS

2. Powered Flight - MPS Management

   a. 5-49, LH_2 TANK PRESSURIZATION

   b. 5-50, MANUAL THROTTLING FOR LOW LH_2 NPSP

   C. 5-51, ABORT PREFERENCE FOR LOW LH_2 NPSP

B. Crew Operations

TABLE 2.2.1-I.- FAILURE RECOGNITION (PASS/BFS)

Parameter no.	Failure value/trend	Displayed on
	"MPS LH_2 /O_2 ULL" (Class 3 alarm)	FML
(LH_2 ULL PR) (C)T41P1700C (L)T41P1701C (R)T41P1702C	LH_2 ullage pressure 2 of 3 < 32 (31.6) psia or 2 of 3 > 34 (34.5) psia	BFS, GNC SYS SUMM 1

1. Crew Procedure

   LH_2 ET ULL PRESS
   ✓MCC
   Post-SRB SEP:
   If 2,3 Ps < 31.6 or > 34.5:
     MPS LH2 ULL PRESS - OP
   When all Ps > 34.5:
     MPS LH2 ULL PRESS - AUTO

2. Crew Activity

TABLE 2.2.1-II.- CREW ACTIVITY

Step	Activity	Position
1	If in communication with ground, notify MCC of failure indications and await instructions	PLT
2	If no communications, perform preceding crew procedure	PLT

C. MCC Operations

1. Failure Recognition

TABLE 2.2.1-III.- FAILURE RECOGNITION[1]

Parameter no.	Failure value/trend	Displayed on
LH_2 ULL P (C) T41P1700C (L) T41P1701C (R) T41P1702C	• Dual pressure sensor failures (high) If two FCV's are powered closed and respective ullage pressure > 34 psia (or static between 32-34 psia) and third ullage pressure < 32 psia, assume third pressure is correct and other two are failed high	MSK's 1052 1054 1055 1064 DDD 302
GH_2 FCV CLSD PWR (C) V41X1661E (L) V41X1662E (R) V41X1663E	• Dual pressure sensor failure (low) If two FCV'S are open (unpowered) and respective ullage pressures <32 psia (or static between 32-34 psia) and third ullage pressure > 34 psia, assume the third pressure is correct and the other two are failed low	
GH2 OUTLET P (C) V41P1160A (L) V41P1260A (R) V41P1360A	• Dual flow control valve failures If three ullage pressure >34 psi and two FCV's are open[2] (unpowered), the two FCV'S are assumed failed open If three ullage pressures are <32 psia and two FCV'S are closed[2] (powered), the two FCV'S are assumed failed closed	

TABLE .2.2.1-III.- Continued

Parameter no.	Failure value/trend	Displayed on
	● Low ullage pressure due to leak or slosh: If three ullage pressures are <32 psia and three FCV's are open[2] (unpowered) and the vent valve is closed, assume low ullage pressure due to leak or slosh	
LH_2 VNT V OP T41X1727E LH_2 VNT V CL T41X1724E	● Vent valve failed open The LH_2 VNT VLV indicates not closed: monitor ullage pressure and FCV status	MSK 1054, 1064 DDD 302
LH2 MANF T V41T1428A	● High MANF Temp If the temp begins to trend up, assume inlet temp also increasing. Correct NPSP with 1° = 3 psi	MSK 2775
NPSP (C) M01G311C (L) M02G311C (R) M03G311C (AVG) M04G311C	● Low LH_2 NPSP[3] If LH_2 NPSP <3.5 psi, assume low LH_2 NPSP. (refer to SCP 3.2.6 for NPSP comp). If early engine out, add 4 psi to displayed NPSP's of two remaining engines and use lower of two values as average NPSP	MSK 1054 DDD 302

[1] Two FCV'S failed open or closed will cause the ullage pressure to go above or below the control band, respectively.

[2] See "How to Determine if a LH2 Flow Control Valve is Open or Closed" in the main body.

[3] Low NPSP can be caused by low ullage pressure or high LH_2 inlet pressure.

2. MCC Procedures

TABLE 2.2.1-IV.- MCC ACTIVITY*

Step	Activity	Position
1	Report any applicable failure: ● Any LH_2 ullage press outside control band (32 to 34 psia) ● Dual pressure sensor failure ● Dual FCV failure ● LH_2 vent valve failed open ● Static pressure sensors with FCV's closed ● Any lower than nominal NPSP	MPS/BSE
2	If LH_2 ullage press <31.6 psia and post SRB SEP (or 3 FCV's closed), request LH_2 ullage press switch on panel R2 be set to open If LH_2 ullage pressure > 34.5 psia, request LH_2 ullage press switch on panel R2 be set to AUTO	MPS/BSE/FD crew
3	Verify NPSP comp is valid per SCP 3.2.6. Report if comp is invalid	MPS/BSE
4A (2 FCV's failed closed)	If valid NPSP's <3.5 psi or HPFT TDT within 75° below redline report. "Manual throttle to 95%; limits to ENABLE (manual position)." "Stay in manual throttling. Manual MECO will be required."	MPS/BSE/FD/crew or ME/BSE/FD/crew
4B (3 FCV's failed closed)	See 4A action. Report, also, "Recommend abort TAL or ACLS"	MPS/BSE/FD/crew or ME/BSE/FD/crew
4C (Ullage gas leak)	No throttle action required. Report "Recommend abort TAL or ACLS"	N/A

TABLE 2.2.1-IV.- Concluded

Step	Activity	Position
5A (2 FCV's failed closed)	If valid NPSP <3.5 psi or HPFT TDT within 75° below redline (again), report: "Manual throttle to 80%"	MPS/BSE/FD/crew or ME/BSE/FD/crew
5B (3 FCV's failed closed)	See 5A action	MPS/BSE/FD/crew or ME/BSE/FD/crew
5C (Ullage gas leak)	Report "No action required"	MPS
6A (2 FCV's failed closed)	If valid NPSP <3.5 psi or HPFT TDT within 75° below redline (for the third time), report: "Manual throttle to 65%"	MPS/BSE/FD/crew or ME/BSE/FD/crew
6B (3 FCV's failed closed)	See 6A action	MPS/BSE/FD/crew or ME/BSE/FD/crew
6C (Ullage gas leak)	No action required	N/A
7A (2 FCV's failed closed)	If NPSP comp is invalid and LH_2 ullage pressure is less than required per figure 2.2.1-I, take throttling action per Flight Rule 5-50	MPS/BSE/FD/crew
7B (3 FCV's failed closed)	Take action per 7A and report, "Recommend abort TAL or ACLS"	MPS/BSE/FD/crew
7C (Ullage gas leak)	No throttling action required; report, "Recommend abort TAL or ACLS"	MPS/BSE/FD/crew

*Refer to "How to Determine if a LH_2 Flow Control Valve is Open or Closed" in the main body for the FCV failure cases.

TABLE 2.2.1-V.- MPS LH$_2$ PRESS PROBLEMS CONSOLE CUE CARD

DISPLAY STATUS					FAILURE DESCRIPTION	ACTION			
NPSP	FCV POSIT	ULLAGE PRESSURES	INLET TEMPS	TANK VENT		FCV SW OPEN	MAN THROT	ABORT	COMMENTS
-	-	-	-	NOT CL	RELIEF VLV FAILS OPEN	YES	NO	YES	MONITOR ULLAGE PRESSURE & FCV'S. WHEN ULL PRESS < 31.6, ULL PRESS SW TO OPEN. MONITOR NPSP FOR ABORT CUES.
-	2 OP 1 CL	2 < 32 1 > 34 *NOTE 1*	-	-	TWO ULLAGE PRESSURES FAIL LOW	-	-	-	MONITOR LH2 RELIEF VALVE FOR VENTING. IF VENTING, MONITOR LH2 INLET TEMPS FOR RISE AND POSSIBLE LOW NPSP.
-	2 OP 1 CL	3 > 34	-	-	TWO FCV'S FAIL OPEN	-	-	-	
-	3 OP	3 > 34	-	-	THREE FCV'S FAIL OPEN	-	-	-	
-	2 OP 1 CL	1 < 32 2 > 34	-	-	1 FCV FAIL OPEN & 1 ULL PRESS FAIL LOW	-	-	-	
-	2 CL 1 OP	2 > 34 1 < 32 *NOTE 1*	-	CL	TWO ULLAGE PRESSURES FAIL HIGH	YES	NO	NO	WHEN ULL PRESS < 31.6, ULL PRESS SW TO OPEN; WHEN ULL PRESS > 34.5, ULL PRESS SW TO AUTO.
-	2 CL 1 OP	3 < 32	-	CL	TWO FCV'S FAIL CLOSE	YES	YES	NO	WHEN ULL PRESS < 31.6, ULL PRESS SW TO OPEN; WHEN ULL PRESS > 34.5, ULL PRESS SW TO AUTO. MONITOR NPSP FOR MAN THROTTLE/ABORT CUES.
-	3 CL	3 < 32	-	-	3 FCV'S FAIL CLOSE	YES	YES	YES	WHEN ULL PRESS < 31.6, ULL PRESS SW TO OPEN; MONITOR NPSP FOR MAN THROTTLE /ABORT CUES.
-	3 OP	3 < 32	-	CL	LOW ULLAGE PRESS DUE TO LEAK OR SLOSH	YES	NO	YES	WHEN ULL PRESS < 31.6, ULL PRESS SW TO OPEN; MONITOR NPSP FOR ABORT CUES.
-	2 CL 1 OP	2 < 32 1 > 34	-	-	ONE FCV FAIL CLSD & ONE ULL PRESS HIGH	YES	NO	NO	WHEN ULL PRESS < 31.6, ULL PRESS SW TO OPEN; WHEN ULL PRESS > 34.5,SW-AUTO
-	-	-	3 >PRED	-	TANK HEATING >PRED'D (REF FIG 2.2.1-III)	-	-	-	MONITOR FOR LOW NPSP.
<3.5	-	-	-	-	NPSP < REQ'D*NOTE 2*	-	POSS	YES	USE CAUSE OF LOW NPSP TO TAKE ACTION
NOT VALID	-	3 < REQ'D	-	-	ULL PRESS < REQ'D (REF FIG 2.2.1-I)	YES	POSS	POSS	WHEN ULL PRESS < 31.6, ULL PRESS SW TO OPEN. POSS ABORT AND/OR MAN THROT

NOTES:
1. OR 2 STATIC BETWEEN 32 AND 34.
2. FOR 1 ENGINE OUT, ADD 4 PSI TO DISPLAYED NPSP.

FOR 104% RPL ONLY	
GH2 OUTLET PRESS	FCV POSITION
GREATER THAN 3360	CLOSED
LESS THAN 3140	OPEN

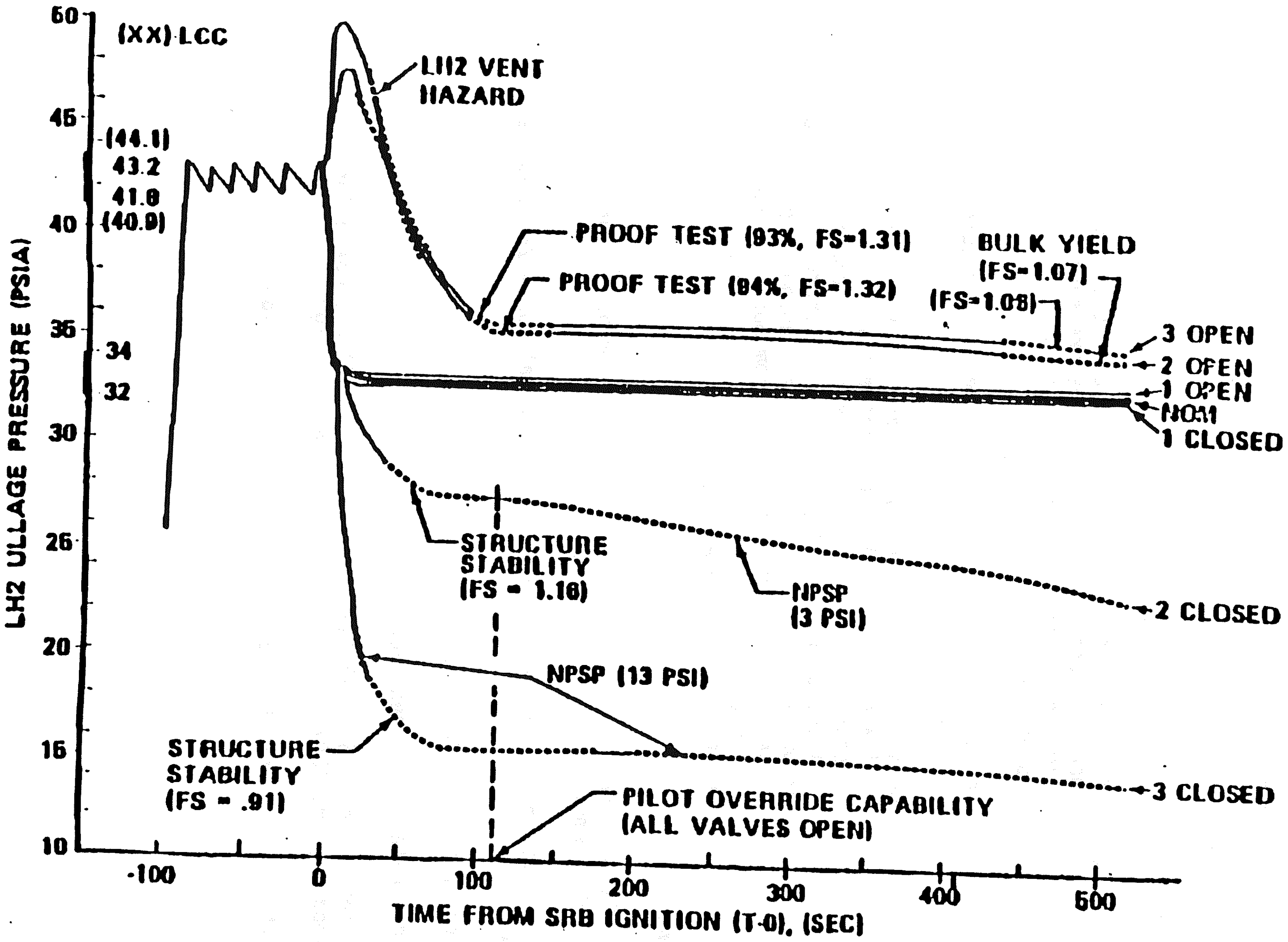


Figure 2.2.1-III.- LH_2 FCV failure cases.

3. Supporting Data

a. Figures:

Figures 2.2.1-I, 2.2.1-II, 2.2.1-III

b. Notes:

(1) It is assumed that if two LH_2 pressure control valves fail open or closed, the actual ullage pressure will go above or below the control setting (34 psia and 32 psia, respectively).

(2) Low ullage pressures or high inlet temperatures will cause low NPSP.

(3) During prelaunch, the LH_2 ullage pressure transducers may indicate off-scale low intermittently while at ambient pressure. The operation of the signal conditioner is verified by briefly switching in the spare. After tank prepress at T - 1 min 57 sec, the transducer should work properly. The cause of this phenomenon is probably excessive wear on the windings due to the extended time spent at ambient pressure.

REFERENCES

1. JSC/MOD/BOOSTER Note of Interest, SSME Throttling in Response to LH_2 NPSP Problems, R. Halyard, Feb. 22, 1980.

2. STS Operational Flight Rules, All Flights, Final, JSC-12820, May 9, 1988.

3. Flight Data File Cue Cards

4. Flight Data File Ascent Pocket Checklist

5. JSC Memo, Fuel NPSP Real-Time Computation for Flight Operations, J. G. Thibodaux, Jr. (EP) to M. R. Frank (CF), Aug. 6, 1979.

6. Shuttle Operational Data Book, JSC-08934, January 1988.

TITLE

ET SEPARATION FAILURES

INTRODUCTION

This SCP describes the external tank (ET) separation sequence and its failure conditions. Included is a discussion of the switch redundancy management (RM), 17" disconnect failures and software override capability as utilized in the sequence. The ET SEP switches are located on panel C3 as shown below (fig. 2.2.2-I).

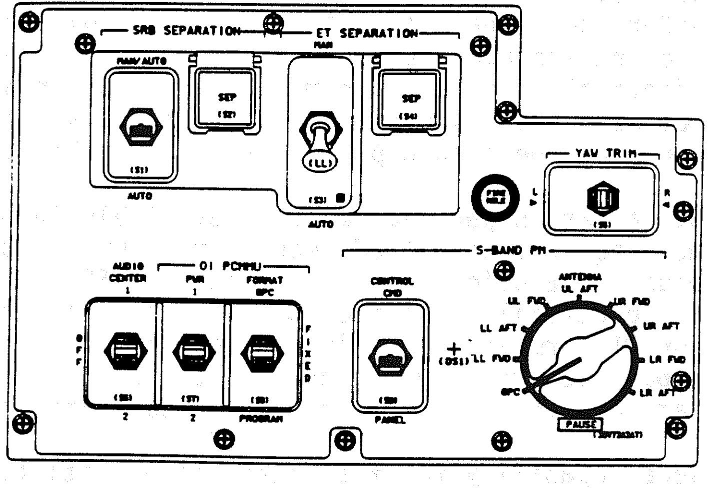


Figure 2.2.2-I.- ET SEP switches.

Switch S3 selects the auto or manual separation mode, and pushbutton S4 initiates the sequence when in the manual mode, bypassing all inhibits in the software.

DESCRIPTION OF SEQUENCE and FAILURES

The ET separation sequence is used during the ascent phase to separate the expended propellant tank from the Orbiter vehicle. Separation normally occurs automatically, but the crew has the capability to manually inhibit the separation sequence at any point (switch S3 to MAN) or to manually initiate the separation (via SEP pushbutton if S3 is in MAN) in the presence of automatic separation inhibits.

In the AUTO mode, the ET SEP sequence in the primary avionics software system (PASS) is initiated when the SSME OPS software sets the MECO CONFIRMED flag. As the sequence progresses, limit tests on certain body rates and angles, and tests for LO_2 and LH_2 feedline disconnect valve closures are performed. If any of the tests are not satisfied, the separation is inhibited and an "ET SEP INH" fault summary message is generated. The sequence can proceed only if the out-of-tolerance parameter comes back within tolerance or if the crew elects to continue the separation manually. When the inhibits are satisfied or bypassed, the structural separation PIC's are armed and fired. In the RTLS abort mode, the ET SEP sequence also performs the ET umbilical door closure function (which is normally performed manually by the crew). If any inhibits are present during the RTLS mode, the sequence is delayed up to 6 seconds, then they are automatically overridden and separation occurs. Nominal auto separation occurs in Major Mode (MM) 103 17.4 seconds after MECO CMD, while the RTLS mode (MM601) requires only 13.1 seconds (due to reduction of ET umbilical retract fire command time delay within the sequence).

If the manual mode is enabled in MM103 with PASS operating, the separation sequence is started when the SEP pushbutton is depressed (with MECO CONFIRM). If PASS initiates a manual ET SEP via the pushbutton and BFS becomes engaged before the separation, the separation will not occur unless the pushbutton is depressed again after BFS is engaged. The sequence proceeds almost identically to the auto mode except the inhibits are overridden. In both cases, manual separation time can be as short as auto and is dependent on the time the crew depresses the SEP pushbutton.

In MM102 and MM601, a fast separation mode is available in both PASS and BFS. This sequence requires only 4.82 seconds maximum to complete and is activated when manual separation is selected and the SEP pb is depressed. An RTLS abort is automatically selected and the fast separation mode bypasses delays for PIC arm and fire times, feedline disconnect close times, and ET umbilical door retract times. For this case, the SRB's remain attached to the tank and the ET doors are closed automatically.

A PASS only software capability for fast separation initiation in MM103 is also available. If two SSME's have failed and manual ET SEP is initiated in MM103, a fast separation will occur (in 3.6 maximum seconds), and the ET doors will be commanded closed automatically. Fast separation initiation capability in MM103 is not provided in BFS.

The ET SEP sequence software in the PASS and backup flight system (BFS) are as similar as possible. However, the BFS must monitor the PASS sequence to determine where to pickup in the SEP sequence if the BFS is engaged. PASS and BFS sequence execution times are the same and are as follows:

- Nominal auto separation - 17.4 seconds after MECO CMD
- RTLS auto separation - 13.1 seconds after MECO CMD
- Manual separation - crew dependent
- Fast separation MM102 and MM601 - 4.82 seconds after ET SEP MAN INIT
- MM103 - 3.6 sec seconds after ET SEP MAN INIT

The various failure modes that can cause the automatic separation of the ET to be delayed are:

1. No MECO CONFIRMED flag

2. Inhibit of the automatic ET separation sequence

3. "ET SEP MAN" message from software (OPS 1 only)

4. Switch taken to the manual position by crew.

These failure modes are described in the console cue card in table 2.2.2-I. A more indepth discussion of the failure modes will follow in later sections of this SCP.

FAILURE CASES

I. NO MECO CONFIRMED FLAG

The MECO CONFIRMED flag is set when the three SSME chamber pressures (PC) <30 percent or two SSME PC's <30 percent and the third SSME has a data path failure.

After MECO, the crew will receive two cues that the MECO CONFIRMED flag has been set. The three SSME status lights on Panel F7 will be lit with red lights. As a backup cue, the DAP lights on panel C3 will also be lit. These cues let the crew know that the guidance software is aware that the SSME's are shutdown and will start the automatic ET separation procedure.

If this condition exists that both ques do not indicate MECO CONFIRMED, the crew will push the three SSME shutdown pushbuttons (Panel C3) simultaneously or key in an OPS 104 PRO on the display electronics unit (DEU). This forces the MECO CONFIRMED flag and then should proceed with the AUTO SEP sequence.

II. INHIBITING THE AUTOMATIC SEPARATION SEQUENCE

The ET SEP INH message from the software indicates that a problem has occurred which has stopped processing of the nominal automatic ET separation sequence. This message may be caused by two problems: the vehicle rates and the verified closure of the 17-in. disconnect valves. If either of these conditions are not met, the software will issue the ET SEP INH message to the fault message line as well as other cues as discussed in section B.

If the message is displayed on the fault message line, the crew will first take the ET SEP switch (panel C3) to the manual, or MAN position. They will then check the attitude rates of the vehicle. If the rates are larger than .7 in the roll, pitch, or yaw, the ET separation will be inhibited. In this situation, the crew will attempt to null the rates with the reaction control system (RCS) thrusters. When the rates are under the required .7, the crew will push the ET SEP pushbutton (panel C3) and jettison the tank.

If the message appears on the fault message line and the rates are all within the specified ranges, the crew will assume the software did not receive the needed indications from the 17-in. disconnects. The valves are assumed failed open and the crew takes action as per Flight Rule 5-60. Should these valves fail open and ET separation is attempted, the thrust created by the escaping propellants from the ET may cause recontact of the ET and Orbiter.

The software sequence commands the latch unlocked. The software will check for 1 of 2 unlock position indications from each of the latches (both LO_2 and LH_2). If these checks are passed, the software closes the disconnects (both ET and Orbiter halves) pneumatically and retracts the umbilical. If the checks are not passed, the umbilical is retracted and the disconnect valves (both ET and Orbiter halves) will be closed by the backup mechanical closure device. After umbilical retract, the software checks for one of two closed indications for each disconnect valve (both LO_2 and LH_2). These checks are only done on the Orbiter half of each valve because no instrumentation exists on the ET half of the valve since telemetry cannot be read after umbilical retract. If the one of two check fails on either the LO_2 or LH_2 valve, it is assumed failed open for both the ET and Orbiter halves and the separation sequence is inhibited.

For a nominal/AOA/ATO mission, ET separation will be delayed for 6 minutes (reference Flight Rule 5-60). This time period will allow the ET to vent to an ullage pressure which equates to less than 1800 lb thrust out of the failed open disconnect valve. A manual (as per Flight Rule 5-64) main propulsion system (MPS) dump is performed during the 6-minute delay to reduce the APU running time. The MPS manifold repress valves (both LO_2 and LH_2) will be closed to prevent the overboard loss of helium through the failed 17-in. disconnect. This helium may be necessary later in flight for entry purges. Rationale for this 6-minute delay is taken from figures 2.2.2-II and 2.2.2-III.

The sequence will also be inhibited for loss of telemetry from the 17-in. disconnects. The following combinations of failures will cause the separation sequence to be inhibited because they cause both closed indications on either valve to fail:

Failure of the LO2 disconnect indications:

1. MDM FA2 or BCE STRING 2 D, and MDM FA3 or BCE STRING 3 D
2. Control Bus BC1 and Control Bus CA1

Failure of the LH2 disconnect indications:

1. MDM FA2 or BCE STRING 2D, and MDM FA4 or BCE STRING 4 D
2. Control Bus BC1 and Control Bus CA1

The valves themselves may be closed but these combinations of failures mask the closed position. Since no insight is available, the valve in question

TABLE 2.2.2-I.- ET SEP FAILURES

Indication	Action	Rationale
NO MECO CONFIRM	• After SSME's have shutdown (per crew/Booster console) crew should depress all three SSME shutdown pushbuttons simultaneously for 1 sec on panel C3 or perform OPS 104 PRO	• Forces MECO CONFIRM and then AUTO sequence should proceed
ET SEP INH fault summ msg (also on crew display OPS 1031 ASCENT TRAJ)	• Per ascent c/l crew checks body rates • If rates > .7,.7,.7 wait for rates to damp • If rates ≤ .7,.7,.7 assume feedline valve failure → OPS 104 PRO, ET SEP-manual perform delayed OMS-1, initiate ET SEP at MECO +6 minutes	• AUTO sequence should proceed when body rates are ≤ .7,.7,.7 • If LO2 or LH2 disconnect valve not closed, must delay SEP 6 minutes for LO_2/LH_2 to bleed overboard, otherwise ET may contact vehicle after SEP
ET SEP MAN fault summ msg (indicates sequence has defaulted to MANUAL mode, OPS 1 only)	• Per cue card, post-MECO: SPEC 51 item 38 entry (item 28 in BFS); to override INHIBITS use item 39 entry (item 29 in BFS) • Option: May initiate ET SEP in manual mode post-MECO (via pushbutton)	• Overrides switch failure back to AUTO; • Need to verify rates and LO_2/LH_2 valves closure
ET SEP AUTO fault summ msg (indicates sequence has defaulted to AUTO MODE, RTLS only)	• No action required	• For RTLS case, inhibits are automatically overriden after 6 sec
GPC's 2-on-2 redundant set split or two GPC's failed	• Pre-MECO → ET SEP to MANUAL • Post-MECO → drop at least one of the bad GPC's (per DPS), then initiate SEP (pb) • Option: May go back to AUTO after GPC dropped	• Keeps SEP sequence software in two good GPC's from completion • Dropping one bad GPC eliminates dilemma in MEC, sequence can then be initiated in MANUAL or AUTO
ET SEP does not occur after MECO +18 sec	• Check rates and feedline valves; if unsure of valve state, perform delayed OMS-1 and initiate ET SEP at MECO +6 min • If rates OK and feedline valves are closed, select MANUAL mode and initiate ET SEP (pb)	• Delays ET SEP for 6 min for LO_2/LH_2 to bleed overboard • Overrides inhibits
RCS leak (See RCS cue cards)	• Pre-MECO: go to MANUAL mode for ET SEP; post-MECO: secure RCS and return to AUTO mode for ET SEP; N/A for RTLS	• Prevents ET SEP from occurring until RCS leak is secured (RCS malfunction may not allow proper vehicle maneuver to avoid ET contact after separation)

will be assumed failed open and ET separation will be delayed for 6 minutes (as per Flight Rule 5-60) for nominal/AOA/ATO missions.

For RTLS/TAL missions, time criticality requires that the ET separate as soon as possible. The ET is automatically separated for RTLS missions (after a 6-second delay) and manually separated for TAL missions (ASAP).

A. Flight Rules

1. 5-60, ET SEPARATION INHIBIT FOR 17-INCH DISCONNECT FAILURE
2. 5-63, ET UMBILICAL DOOR CLOSURE FOR DISCONNECT VALVE FAILURE
3. 5-64, MANUAL MPS PROPELLANT DUMP

B. Crew Operations

Message	Type	Display on
SEP INH	FLASHING	BFS ASCENT TRAJ 2
SEP INH	STATIC	PASS ASCENT TRAJ
ET SEP INH	STATIC	PASS/BFS FAULT MSG LINE

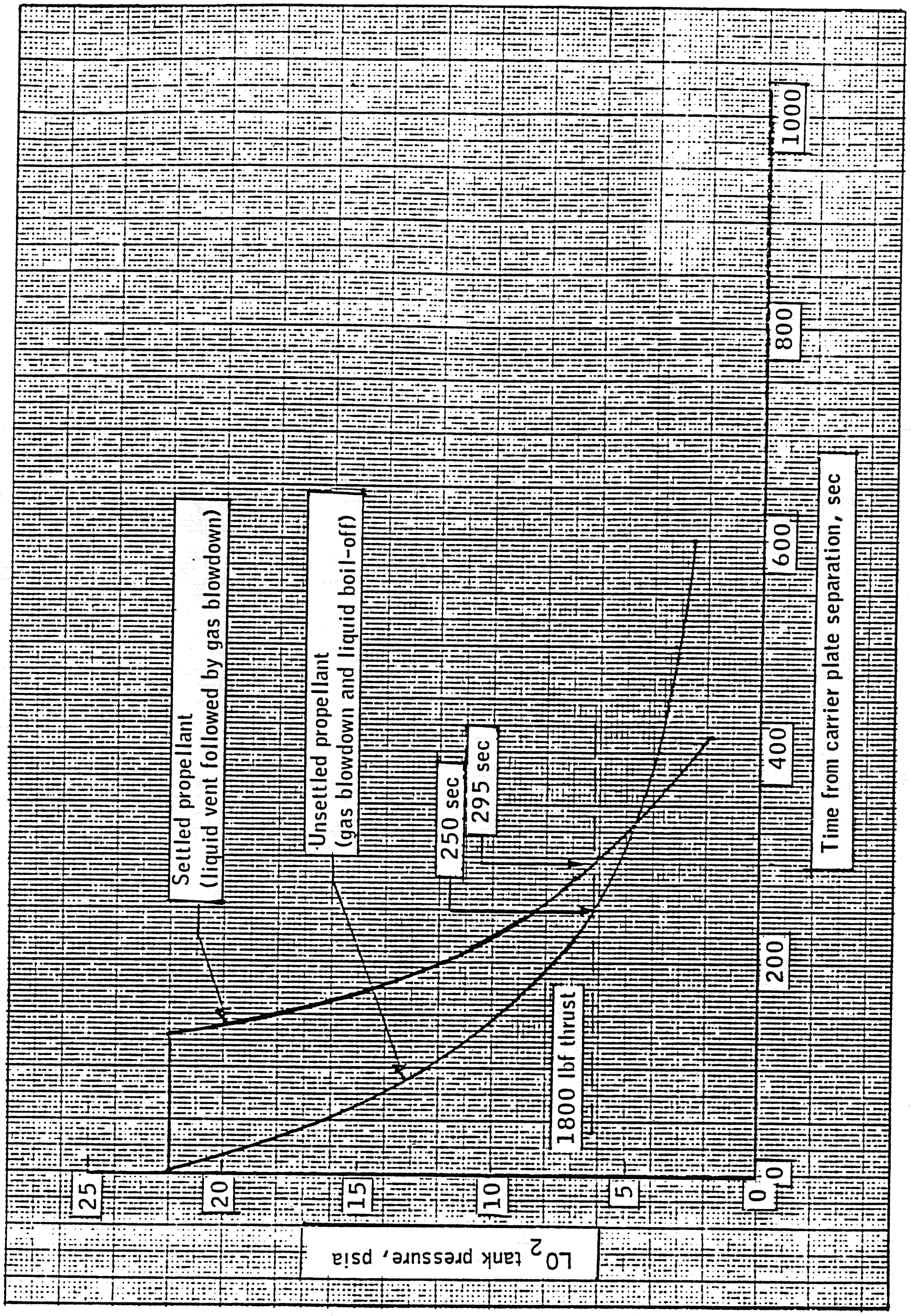


Figure 2.2.2-II.- ET LO_2 tank blowdown through failed 17-inch disc with LO2 tank tumble system open.

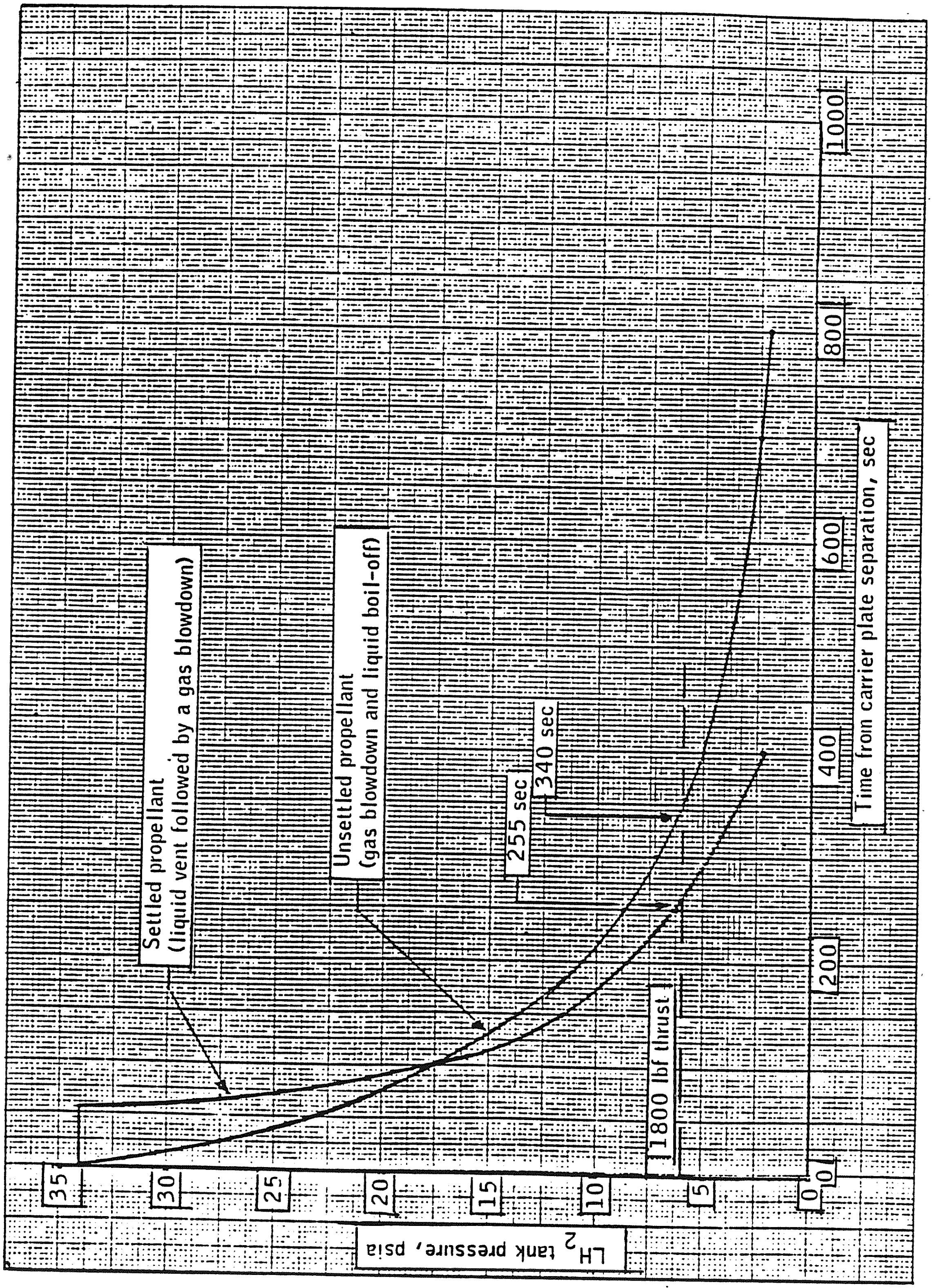


Figure 2.2.2-III.- ET LH_2 tank blowdown through failed 17-inch disc.

1. Crew Procedure

ET SEP (MECO+18)
* 'SEP INH' *
* ET SEP - MAN *
* OPS 104 - PRO (√BFS 104) *
* Rates >.7, .7, .7: *
* Null rates *
* ET SEP - SEP *
* Rates <.7, .7, .7: *
* Assume Feedline Fail *

MM104 √TGTS

* If OMS 1 reqd: *
* Go to OMS 1 BURN *

If OMS 1 not reqd:
MECO+2:00 +X xlation (5 sec)
MPS PRPLT DUMP SEQ - START
OMS ENG (two) - OFF
Go to POST OMS 1

1: GNC OMS 1 MNVR EXEC	2: GNC OMS 1 MNVR EXEC

3: BFS, GNC SYS SUMM 2

* If Feedline Fail: *
* MECO +6 (~14:30 NOM), *

* ET SEP - SEP *

POST
OMS 1

OMS 1 BURN

* DELAYED BURNS: *
* MECO +2 +X xlation, MAN MPS DUMP *
* √DUMP/STOW complete (B/F lite out)*
√MCC for APU Shutdn *
(if time permits) *
* FEEDLINE FAIL: *
* TIG -1:30 or MECO +6: *
* ET SEP - SEP *

III. "ET SEP MAN" MESSAGE FROM SOFTWARE

The ET SEP switch (Panel C3) position is polled and controlled by redundancy management (RM). In other words, the RM performs two out of three voting for the switch position. If the RM does not have at least 2 votes available, the switch will fall into a switch dilemma. If this happens, the RM will inhibit processing on the ET SEP sequence for nominal/AOA/ATO/TAL missions and issue the ET SEP MAN message to the fault message line on the crew display. For RTLS aborts, the RM logic defaults to AUTO to allow for separation of the ET in such a time critical abort phase. When the sequence moves from MANUAL to AUTO, the ET SEP AUTO message will appear on the fault message line. If the dilemma occurs before RTLS is declared (RTLS will be selected at a MET of 2:30 for engine out in first stage), the sequence will default to manual and then will move to auto when the RTLS is declared. For TAL aborts, the switch defaults to MAN, but the crew will separate from the tank immediately: this is the second worse time-critical abort phase. This message is also displayed on MSK 1054.

A triple pole switch is used for the mode switch and SEP pushbutton. As shown in figure 2.2.2-IV, the mode switch employs three contacts, each one powered from a separate 5-volt source (Dedicated Signal Conditioner (DSC) OF1, OF2, or OF3).

When in AUTO mode, each 5-volt signal is routed to its own separate flight critical MDM (FF 1, FF3 or FF4), where they are ultimately fed to the guidance and navigation computer (GNC) switch redundancy management (RM) (where two out of three voting occurs for PASS) and to the GNC switch hardware interface program (HIP) (two out of three voting for BFS).

In the MANUAL position, the mode switch supplies the 5 VDC signals to the SEP INITIATE pushbutton. This pushbutton switch also goes through the two out of three voting logic.

First, we will examine the RM logic for the mode switch in the PASS. Under normal conditions the switch is in AUTO and, with no failures, the RM sees the following:

	Mode switch contacts				RM output
	A	B	C		
AUTO	1	1	1	= 1	
MANUAL	0	0	0	= 0	AUTO

If one of the AUTO contacts failed to zero (which could be caused by DSC failure, contact failure, or an open circuit), the 2 out of 3 voting logic would be invoked, and the RM output would be the same (AUTO).

The mode switch is also commfault protected in the PASS. A commfault occurs when the GPC senses a problem with the MDM itself or the data bus that

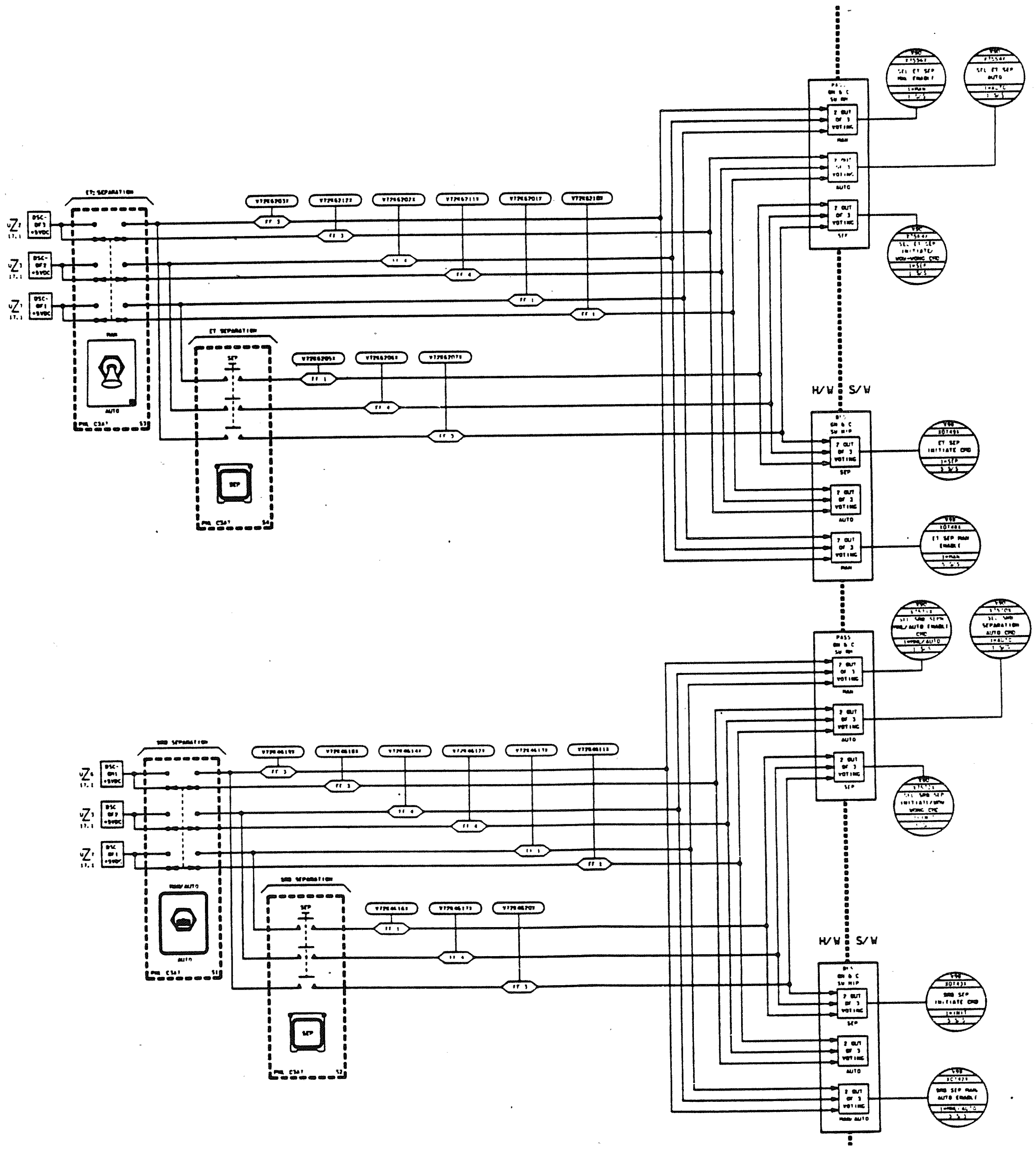


Figure 2.2.2-IV.- ET SEP flow switch hardware/software diagram.

transfers information from the MDM to the GPC. This situation results in the GPC rejecting all data from the "commfaulted" MDM. If one of the MDM's (FF1, FF3 or FF4) is commfaulted, the RM selection filter downmodes to the two remaining switch contacts.

	Mode switch contacts				RM output
	A	B	C		
AUTO	1	1	comm	= 1	
MANUAL	0	0	comm	= 0	AUTO

Note: C is commfaulted.

If you now add a failure of one of the good AUTO contacts to zero, the RM would be in dilemma. The dilemma results from the two-contact logic that contains an AND gate that requires two ON signals to pass an ON (1). Therefore both outputs will be zero.

	Mode switch contacts				RM output
	A	B	C		
AUTO	1	0	comm	= 0	Dilemma = default logic
MANUAL	0	0	comm	= 0	

Note: C is commfaulted.

When the software sees a zero (or a one) output for both positions (AUTO and MAN), it cannot determine the reason so it goes into default logic. The default position for OPS 1 is MANUAL and OPS 6 (RTLS) is AUTO. For the RTLS case, vehicle dynamics dictate a rapid ET SEP and hence, the default position is to AUTO (which bypasses all inhibits after a 6-second delay). However, if the switch is in manual and there is no dilemma, the switch will remain on manual for RTLS.

For the case of two commfaulted MDMs, the switch RM merely goes with the one remaining contact. If two contacts are failed to zero (loss of DSC, contact failure, or open circuit), the software goes to default logic.

In the PASS, the RM for the SEP pushbutton is identical to that used for the mode switch except there is no default logic. In case of a dilemma, the switch is inoperative; to initiate the manual sequence in this case an item 39 entry (item 29 in BFS) must be made to SPEC 51 (see SOFTWARE OVERRIDE).

The BFS version of RM is called the GNC switch hardware interface program. It provides no commfault protection and treats the mode switch and SEP pushbutton redundancy the same: simple 2 out of 3 majority voting. Therefore, only one failure can be accommodated without using a SPEC 51 item entry.

SOFTWARE OVERRIDE CAPABILITY

Software override capability is provided for selected switch failures via SPEC 51 in both the PASS and BFS (refer to figures 2.2.2-V and 2.2.2-VI, respectively). This display is available in OPS 1, 3 and 6. Following is a description of each item entry:

PASS

Item 38 - allows the crew to select the AUTO ET SEP mode. This item entry is routed directly to the GNC Switch RM, forcing its output to AUTO.

Item 39 - Initiates ET SEP in the MANUAL mode and could be used if the SEP pushbutton is inoperative.

BFS

Item 28 - selects the AUTO ST SEP mode. This item entry could be used if more than one of the mode switch contacts is failed.

Item 29 - selects the MANUAL mode and initiates ET SEP.

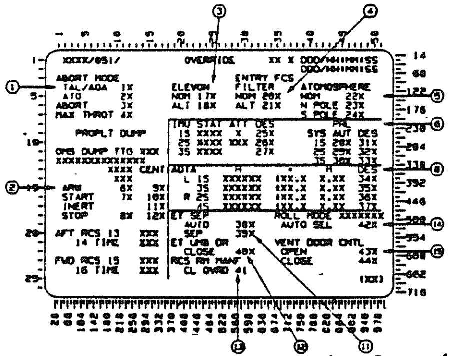


Figure 2-2.2-V.- OVERRIDE display (PASS).

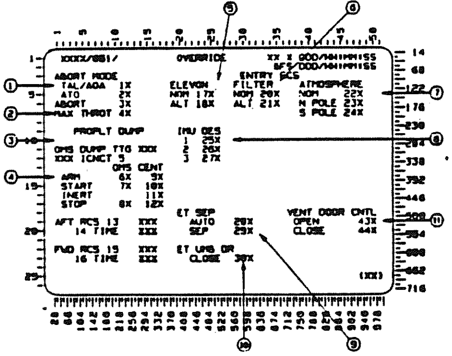


Figure 2.2.2-VI.- OVERRIDE display (BFS).

A. FAILURE RECOGNITION

*ET SEP SWITCH FAILURES

INDICATION	FAILURES								
	FF MDM			OF DSC PWR					
	1	3	4	1	2	3	1/2	1/3	2/3
ET SEP MAN (FAULT SUM MSG.)		X OR	X AND	X					
	X OR	X	AND		X				
	X	OR	X	AND		X			
							X		
								X	
									X

Note: Switch failure only occurs if FF MDM failure occurs first and power second
Switch defaults to MANUAL for nominal (AUTO for RTLS)

IV. SWITCH TAKEN TO MANUAL POSITION BY CREW

A few cases exist in which the crew will manually move the ET SEP switch (panel C3) to the MAN position. First, if a GPC 2 on 2 GPC set split or 2 GPC failures occur, the crew will take the switch to manual. At MECO, the crew will either separate from the ET with the SEP pushbutton or return the ET SEP switch to the AUTO position in order to allow the software to run the nominal separation procedure. Second, it MDM's FA2 and FA3, or FA2 and FA4 fail, the software will inhibit the ET SEP sequence because these are the MDM's that the 17-in. disconnect valve positions are read through. Post-MECO, the crew will take the switch to MAN and push the SEP pushbutton if the rates are within limits. Third, if ET SEP does not nominally occur after MECO + 18 seconds, the crew will check with MCC to ensure closure of the 17-in. disconnect and rates within limits. If both cues are good, the crew will take the SEP switch to MAN and push the ET SEP pushbutton to jettison the tank. Last, the crew will take the ET SEP switch to MAN if an RCS leak occurs pre-MECO. Post-MECO and after the RCS leak has been secured, the crew will return the switch to the AUTO position to allow the software to proceed with the ET SEP procedure. The action for the last failure case will not be done for the RTLS/TAL case due to time criticality.

REFERENCES

1. STS Operational Flight Rules, All Flights, Baseline, JSC-12820, September 1, 1987.

2. Flight Data File Cue Cards

3. Flight Data File Ascent Pocket Checklist

4. Space Shuttle Systems Handbook, JSC-11174, Revision C, DCN-5, September 13, 1985.

5. Booster Systems Software Handbook, Rev-2, JSC-190395, December 4, 1985.

TITLE

FEEDLINE MANIFOLD RELIEF VALVE/ISOLATION VALVE FAILURE

CONDITION

High engine LO_2 or LH_2 manifold pressures (post-MECO)

DESCRIPTION

LO_2 and LH_2 propellant remaining in the MPS lines after main engine cutoff (MECO) will begin to boil off as the propellant temperature rises from its cryogenic state. This boiloff will cause a pressure increase in the closed network (manifold) of MPS piping. The MPS propellant dump and the vacuum inerting are performed to remove this residual propellant and to reduce pressure in the manifolds. To relieve the pressure increase that occurs between MECO and the propellant dump and to provide a relief capability for off-nominal pressure increases, each propellant manifold (LO_2 and LH_2) is fitted with a feedline manifold relief valve. The LO_2 valve is set to crack (relieve) at 190 to 220 psig and the LH_2 valve cracks at 40 to 55 psig. By comparison, line burst pressures are 390 psig (LO_2) and 83 psig (LH_2). The maximum flow rate of the LO_2 relief isolation valve is 24 lb/sec (LO_2 at 200 psig). The maximum flow of the LH_2 relief isolation valve is 2.4 lb/sec (LH_2 at 50 psig).

Mounted in series with and upstream of each relief valve is an isolation valve that is electrically powered closed during ascent. The positions of the relief isolation valves are controlled by the FEEDLINE RLF ISOL switches on panel R4. Normally these switches are left in the GPC position, allowing the isolation valves to be opened automatically immediately after MECO. During the external tank separation (ET SEP) sequence, power is removed and the isolation valves open. The relief valve is then exposed to any pressure buildup and should relieve when the relief setting pressure limit is reached.

The isolation valves are powered closed during ascent to prevent undesired pressure venting during mainstage. During SSME operation, the manifold pressure is controlled by the demands of engine propellant consumption. Pressure buildup to a relief value is not a concern. What is of concern is the performance degradation that a failed open relief valve could cause during SSME operation. It is for this reason that the relief valves are protected by isolation valves and that those isolation valves are powered closed during ascent.

Failure of the isolation valves or the relief valves to open could result in excessive manifold pressures to be held within the propellant manifolds. Excessive pressures could rupture the feedline manifold and result in damage to the aft compartment and possible loss of vehicle. There are several failures which could lead to such a situation.

The failure of two multiplexer/demultiplexers (MDM's) can prevent the isolation valve from opening automatically at ET SEP. Crew reaction to this failure is to manually open the isolation valves per the multiple data path loss cue card. Also, the isolation valve will not open until ET SEP sequence commences. This ET SEP sequence is delayed whenever a dual SSME data path failure occurs (no MECO CONFIRM flag). The primary method for the crew to set the MECO CONFIRM flag is to push all three SSME shutdown pushbuttons simultaneously. Alternately, as a backup procedure, the crew can get the MECO CONFIRM flag by performing an item entry to transition to OPS 104. Once the MECO CONFIRM flag is set, the ET SEP sequence will commence and the isolation valves will open.

Failure of the relief valve to function can also lead to excessive manifold pressure buildup. Electrical failures or mechanical jamming could cause the relief valve to fail.

In the event that there is an unisolatable forward RCS leak during ascent, the crew will take the ET SEP switch to manual enable and leave it in that position through MECO. This will prevent the ET SEP sequence software from opening the relief isolation valves and/or B/U dump valves as well as inhibiting closure of the 17-inch disconnect valves after MECO. Overpressure in the LH_2 manifold will be prevented in this case by orbiter manifold pressure venting through the 17-inch disconnect and out through the ET tank vent valve at 36 psia. As a safety precaution the crew should open the B/U dump valve right after MECO in this case. LO_2 manifold pressure will vent out the ET tank vent valve at 31 psia.

A. Flight Rules

Post-MECO - MPS

5-61, ENGINE MANIFOLD OVERPRESSURE

B. Crew Operations

TABLE 2.2.3-I.- FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(LO$_2$ MANF P) V41P1533C	LO$_2$ MANF PRESS > 249 psia MPS and backup C/W alarm (class 2 alarm)	PNL F7
(LH$_2$ MANF P) V41P1433C	LH$_2$ MANF PRESS > 60 psia MPS and backup C/W alarm (class 2 alarm) MCC confirm "LO$_2$/LH$_2$ MANF PRESS HIGH"	PNL F7

1. Crew Procedures - Cue Card

POST MECO
MPS LH2/O2 MANF
MPS PRPLT Dump SEQ - START

2. Postdump (on orbit - OPS 2) (ref. 4)

   a. Pneu He ISOL - OP

   b. Prplt Fill/Drain LH$_2$ OUTBD - OP
      LO$_2$ OUTBD - OP

   c. CDR INST PWR - FLT/MPS
      √MPS PRESS LH$_2$ (LO$_2$) - (note reading)

   d. Go to MAL, MPS, 12.1 a (fig. 2.2.3-III) (ref. 5)

(ref. 5)

MULTIPLE DATA PATH LOSS (Non-Recov) **ASCENT**

If two FA MDMs lost during OMS burn, man shutdn of one or both OMS ENG reqd

FAILURE	TYPE	ACTIONS
GPC/FF1&2	B or I/O	Use R BODY FLAP & TRIM ENA SWs MM102, RTLS, TAL: BFS NO-GO (AAs) (Note) Post ET SEP: If no OMS-1 or DELAYED BURNS, go to 'MPS DUMMY OMS BURN'
	I/O or FF2 I/O & FF1 B	RTLS, TAL: INH ADTA to G&C FLY THETA LIMITS (ADTA 1,2,3 ↓)
GPC/FF1&3	B or I/O	MM102, RTLS, TAL: BFS NO-GO (AAs) (Note)
GPC/FF2&3	B or I/O	MM102, RTLS, TAL: BFS NO-GO (AAs) (Note)
GPC/FF3&4	B or I/O	Use L BODY FLAP & TRIM ENA SWs
	I/O or FF3 I/O & FF4 B	RTLS, TAL: INH ADTA to G&C FLY THETA LIMITS (ADTA 2,3,4 ↓)
GPC/FA1&2	D or I/O	BFS NO-GO (RGAs) (Note) SRB SEP: BFS OPS 103 PRO
	I/O	ET SEP: MPS FDLN RLF ISOL (two) - OP Preburn: L OMS ENG - OFF (TVC) Pre MPS dump: MPS PREVLVs (six) - OP
GPC/FA1&3	D or I/O	BFS NO-GO (RGAs) (Note) SRB SEP: BFS OPS 103 PRO
	I/O	ET SEP: MPS FDLN RLF ISOL (two) - OP TAL: MPS LH2 FILL/DRAIN INBOARD,OUTBOARD - OP Preburn: R OMS ENG - OFF (IGN) Pre MPS dump: MPS PREVLVs (six) - OP
GPC/FA1&4	I/O	ET SEP: MPS FDLN RLF ISOL (two) - OP Preburn: L OMS ENG - OFF (IGN) Pre MPS dump: MPS PREVLVs (six) - OP
GPC/FA2&3	D or I/O	BFS NO-GO (RGAs) (Note) Post MECO: Expect 'SEP INH' (Feedline Disc fail)
	I/O	ET SEP: MPS FDLN RLF ISOL (two) - OP Preburn: L OMS ENG - OFF (IGN) Pre MPS dump: MPS PREVLVs (six) - OP
GPC/FA2&4	D or I/O	SRB SEP: BFS OPS 103 PRO Post MECO: Expect 'SEP INH' (Feedline Disc fail)
	I/O	Preburn: R OMS ENG - OFF (IGN) Pre MPS dump: MPS PREVLVs (six) - OP
GPC/FA3&4	D or I/O	SRB SEP: BFS OPS 103 PRO
	I/O	ET SEP: MPS FDLN RLF.ISOL (two) - OP TAL: MPS LH2 FILL/DRAIN INBOARD,OUTBOARD - OP Preburn: R OMS ENG - OFF (TVC) Pre MPS dump: MPS PREVLVs (six) - OP

NOTE

If data path loss not due to MDM fail, BFS is GO and will pick up MDMs when engaged

MS 3-6A AESP/ALL/A/GEN C

*TYPE = FAULT MESSAGE
B = BCE STRG (1,2,3,4) (A,B) = FF
I/O = I/O ERROR
D = BCE STRG (1,2,3,4) (C,D) = FA

Figure 2.2.3-I.- ASC PKT C/L.

2. Crew Activity

TABLE 2.2.3-II.- PRE-MPS DUMP

Step	Activity	Position
1	Perform manual MPS dump (cue card)	PLT
2	Verify that corresponding C & W was extinguished and ENG MANF PRESS indicator on panel F7 reads 0-22 psia	PLT
3	If dual FA MDM failure, perform procedure per Ascent Pocket Checklist	PLT

TABLE 2.2.3-III.- POST-MPS DUMP

Step	Activity	Position
1	Open respective LO2 or LH2 fill/drain valves immediately	PLT
2	Close valves at approximately de-orbit minus one hour (except for AOA)	PLT
3	Verify corresponding C & W was extinguished and that ENG MANF PRESS indicator on panel F7 reads 0-22 psia	PLT

C. MCC Operations

TABLE 2.2.3-IV.- PASS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(LO_2 MANF P) V41P1533C	LO_2 MANF PRESS > 249 psia	MSK 1054, 1081 DDD 288 (Pre-MPS dump) DDD 292 (On orbit)
(LH_2 MANF P) V41P1433C	LH_2 MANF PRESS > 60 psia	MSK 1054, 1081 DDD 289 (Pre-MPS dump) DDD 292 (On orbit)

Note: There are no BFS failure recognitions.

1. Console Cue Card - None

2. Activity

TABLE 2.2.3-V.- PRE-MPS DUMP

Step	Activity	Position
1	Report LO_2 MANF PRESS > 220 psia or LH_2 MANF PRESS > 55 psia	MPS/BSE/FD/crew
2	When LO_2 MANF PRESS > 249 psia or LH_2 MANF PRESS 60 psia, request manual MPS dump ASAP	MPS/BSE/FD/crew
3	Continue to monitor MANF PRESS and report when pressure reaches acceptable value (0 psia < P < 22 psia)	MPS/BSE/FD
4	Verify manual MPS dump is terminated after 2 minutes and 21 seconds. Report completion	MPS/BSE/FD

TABLE 2.2.3-VI.- POST-MPS DUMP

Step	Activity	Position
1	Monitor manifold pressures following the MPS dump and report any increase	MPS/BSE/ FD/crew
2	When LO_2 MANF PRESS > 249 psia or LH_2 MANF PRESS>60 psia, request respective fill/drain valves be opened immediately	MPS/BSE/ FD/crew
3	Continue to monitor MANF PRESS and report when corresponding manifold pressure decreases to near 0 psia	MPS/BSE/ FD
4	Verify valve closure at approximately deorbit minus 1 hour and report when termination procedure is complete	MPS/BSE/ FD

3. Supporting Data

   a. Figures: Figure 2.2.3-I

   b. Tables: None

   c. Notes

      (1) LO_2 engine manifold pressure transducer range is 0 to 300 psia.

      (2) LH_2 engine manifold pressure transducer range is 0 to 100 psia.

      (3) LO_2 manifold proofed at 312 psig.
      LO_2 manifold design burst at 390 psig.

      (4) LH_2 manifold proofed at 66 psig.
      LH_2 manifold design burst at 83 psig.

REFERENCES

1. STS Operational Flight Rules, All Flights, Final, PCN-1, JSC-12820, February 1989
2. Flight Data File Cue Cards
3. Shuttle Operational Data Book
4. Flight Data File Orbit Pocket Check List, Section 9
5. Flight Data File Malfunction Procedures
6. Flight Data File Ascent/Entry Systems Procedures

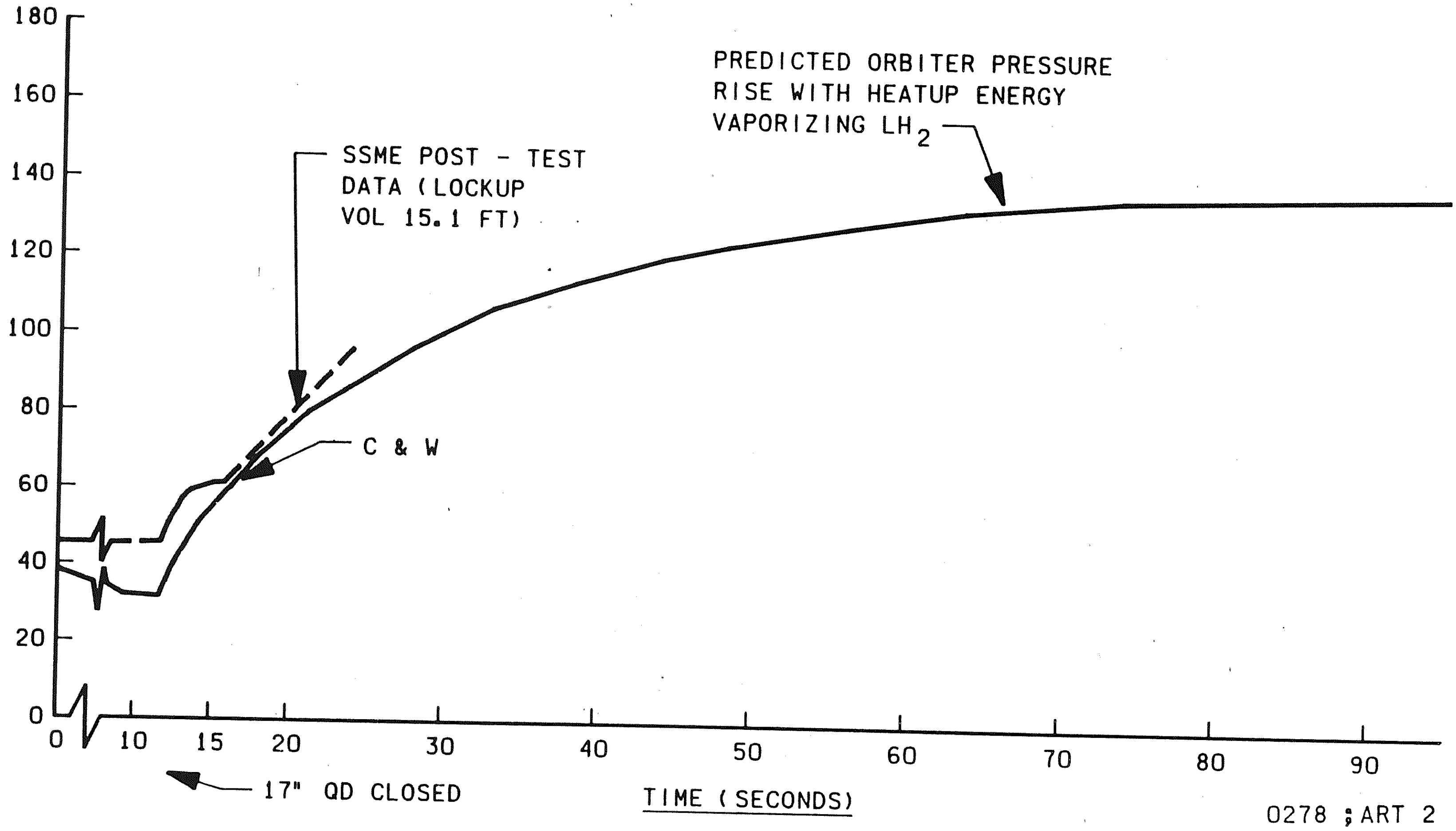


Figure 2.2.3-II.- Post-MECO LH$_2$ feedline pressure rise (RTLS dump valve closed).

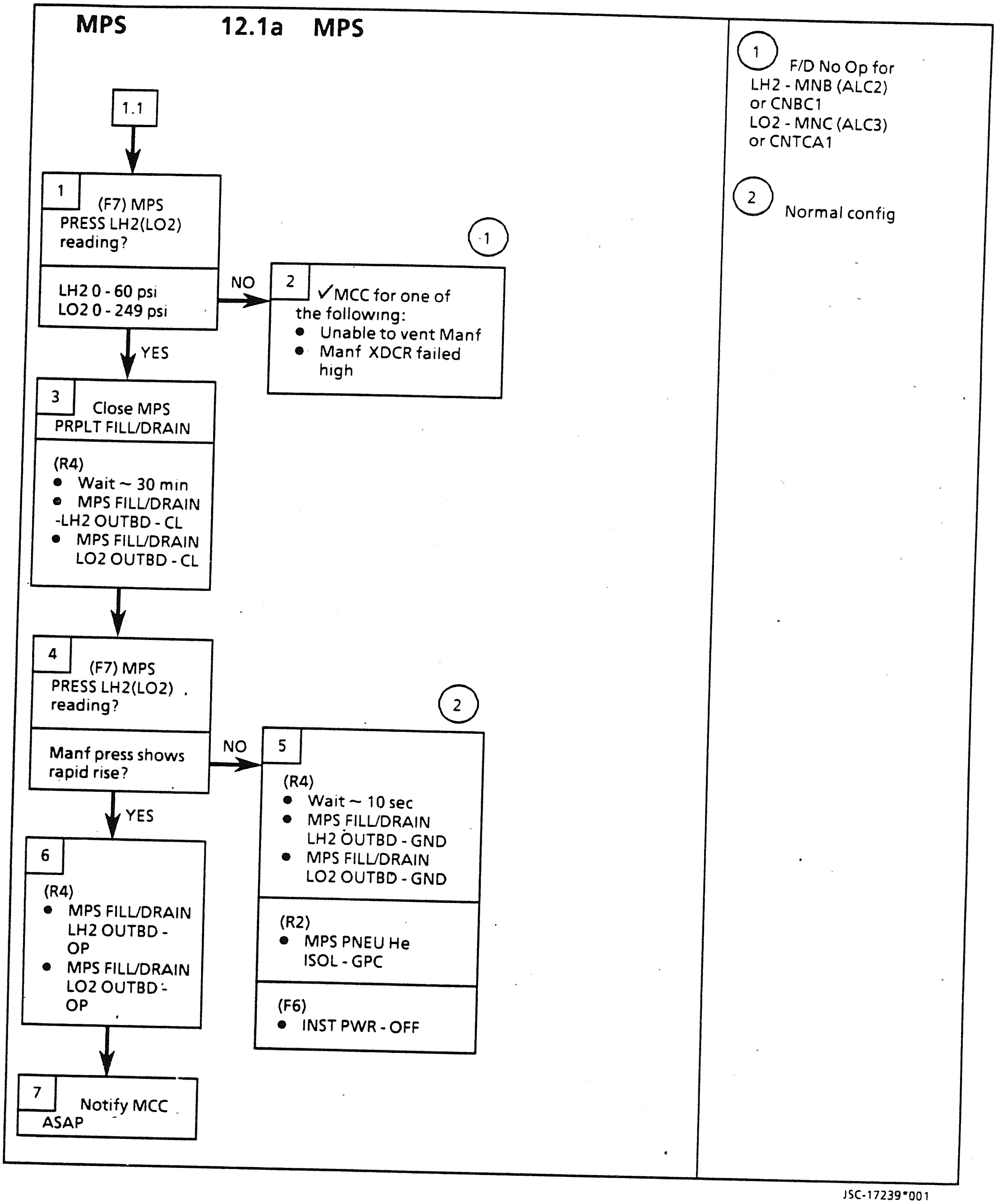


Figure 2.2.3-III.- MPS MAL procedure.

TITLE

HELIUM LEAK ISOLATION/INTERCONNECTION

CONDITION

Above normal helium usage from an engine supply tank

DESCRIPTION

The nominal helium usage per engine during mainstage is 265 scfm (0.042 lb/sec) or a helium tank decay rate (dP/dT) of 11 to 12 psi per 3 seconds. MCC monitors the tank pressures and temperatures, the downstream regulated (helium regulator) pressures, dP/dT, helium system valve positions, and calculates the helium time of depletion (TOD) for each engine to ensure normal usage. The helium TOD is calculated for each engine system, and with the pneumatic tank interconnected for both upper and lower system helium leaks. This computation, also, outputs the mass flowrate. The crew monitors the tank and regulator pressures, and the dP/dT. Caution and warning alerts are provided for the SSME tank and regulator pressures and dP/dT, reference SCP 2.3.1. Beginning with OI-8D software (STS-35), class 3 alerts will be available for the pneumatic tank pressure, regulator pressure, and accumulator pressure.

The helium system can be divided into four separate subsystems; tank system, upper system, regulator system and lower system (fig. 2.2.4-I). The tank system includes the tank set down to the check valves on the A and B legs; leaks in this region are nonisolatable. The upper system starts at the tank and ends at the inlet to the regulator. The tank system is a subsystem of the upper system and extends from the tank to the first set of redundant check valves. An upper system leak is isolatable only between the isolation valve and the regulator. The lower system starts at the regulator outlet and ends at the engine interface. The regulator system, a subsystem of the lower system, begins at the regulator and ends at the downstream set of check valves. Lower system leaks are only isolatable in the regulator subsystem.

Above normal helium usage is most readily detectable by increases in the dP/dT (above 20 psi/3 sec), and the mass flow rate (above 0.042 lb/sec). A rapid decrease in helium temperature, also, indicates a leak. Use of the tank temperature would be used in the event of a loss of the helium pressure transducer, (which would take out the dP/dT and mass flowrate readings) to monitor system health. Helium regulator pressures will first be checked if high helium usage is detected, to determine the proper isolation valve to close. A pressure reading below 679 psia would indicate a possible failed open relief valve, and greater than 806 psia indicates a possible failed open regulator. Either of these failures would result in helium being dumped into the aft compartment through the relief valve. This situation could result in engine shutdown and overpressure of the aft compartment,

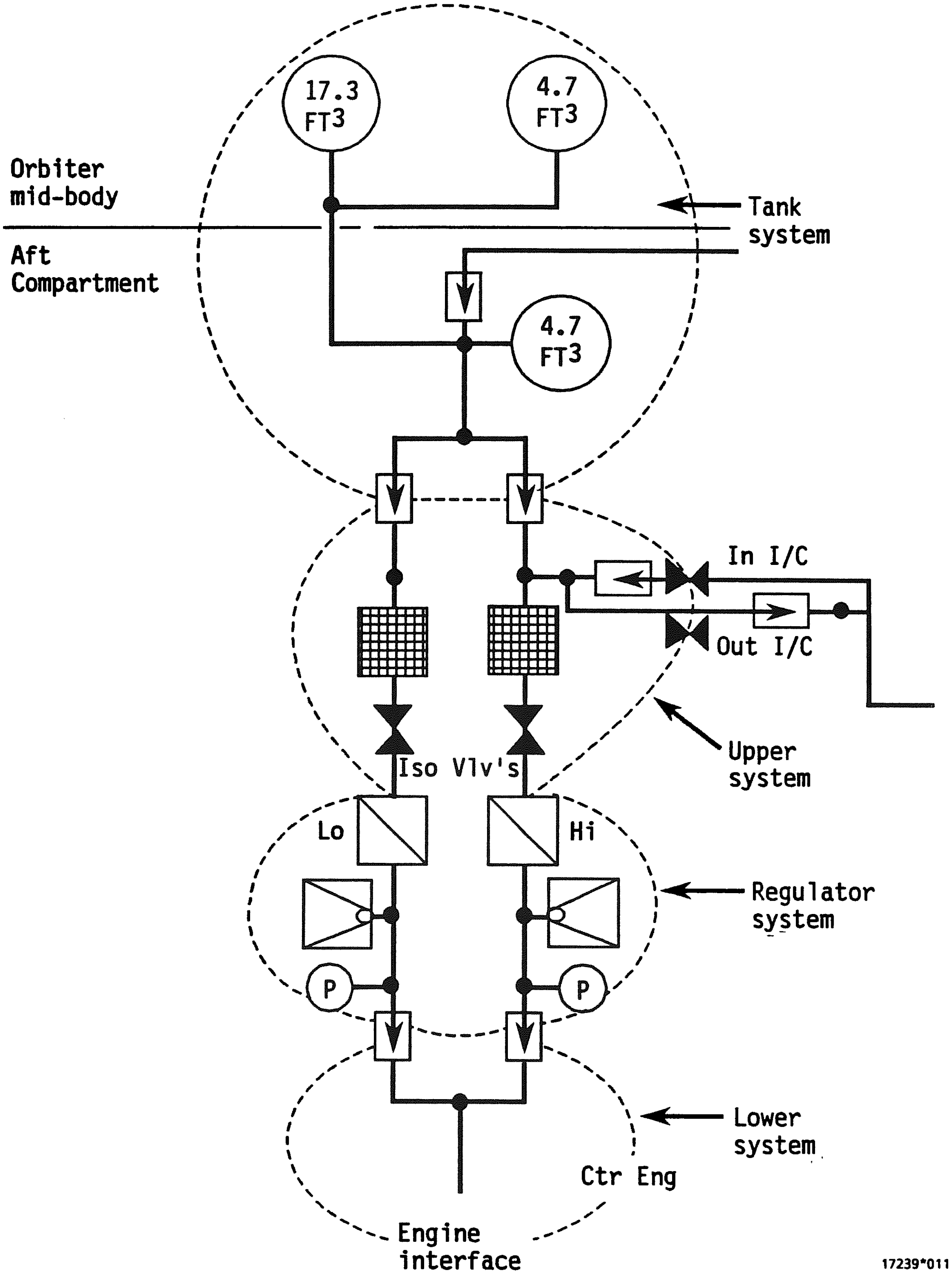


Figure 2.2.4-1.- MPS helium system breakdown.

both of which are potentially catastrophic. Based on the above, leak isolation will be performed on the off-nominal regulator; otherwise, isolation valve A will be closed first. If the helium leak isolation attempt fails, both isolation valves will be opened to ensure redundant helium paths.

Helium isolation will not be performed if the main or sub-bus powering the solenoid valve for isolation valve A fails. This situation would result in the valve closing and subsequent closure of isolation valve B would shut down the engine. The buses and sub-buses powering the A isolation valves are as follows: MN B, ALC 2, and APC 5 for the left; MN A, ALC 1, and APC 4 for the center; and MN C, ALC 3, and APC 6 for the right.

All the helium isolation B switches have dual contacts, while the isolation A switches have one contact each. Loss of switch contact power on the A isolation valve will not result in the isolation valve closing, but will result in loss of manual control of the valve. The open command applied during prelaunch prevents loss of switch power during main engine operation. This command is removed after the MPS dump.

Failure to isolate the leak will require interconnecting the pneumatic helium supply. The helium TOD for the leaking engine is used as a basis for the time to interconnect the pneumatic tank, using the interconnect valve. Actual interconnecting will be done based on a tank pressure of 1150 psia or either regulator, A or B, pressure decaying to 679 psia, provided the leak rate is small enough to support shutdown below 1150 psia. If the leak rate is high, then actual interconnecting will be based on the minimum shutdown pressures required. These values were chosen to maximize helium usage prior to interconnecting and prevent the SSME HPOT intermediate seal purge pressure from decaying below 170 psia, the SSME shutdown redline.

The helium TOD computation displays two interconnected TOD's, upper leak and lower leak. The upper leak is any leak above a regulator and is detected prior to interconnecting by a decaying mass flowrate (mass flowrate is proportional to the tank pressure). The lower leak consist of a leak below a regulator (regulated leak) and is detected by a constant mass flowrate.

The helium supply time of depletion (TOD) for each main engine system is displayed on MSK 1054 (fig. 2.2.4-II). MECO time and TOD's for both upper and lower system leaks with pneumatic interconnects are also shown on 1054. TOD's are used to determine if and when a pneumatic interconnect and/or early engine shutdown are to be performed.

Important

The TOD's shown on Display 1054 are the values used for a Pre-MECO hydraulic shutdown (under g). Therefore, for a nominal shutdown at MECO (no g) time must be taken off the computations. For example, on table 2.2.4-I with Nominal Helium usage of 0.045, 6 minutes are taken off the TOD's on Display 1054.

LEAK DETECTION AND ISOLATION PROCEDURE:

A. Use two cues to confirm leak.

  1. Rapid tank temperature decrease and one of the following:

    a. MDOT > 0.045

    b. dp/dt > 20 psi/3 seconds

    c. Rapid tank pressure decrease

B. Try isolation procedure and identify the leak as upper or lower system using the following:

  1. Lower system leak characteristics

    a. Constant MDOT and dp/dt at higher than normal values

    b. Constant TOD

    c. Constant high delta in tank temperature

  2. Upper system leak characteristics

    a. Mdot > 0.045, but decreasing

    b. The following have decreasing deltas

      (1) Tank temperature

      (2) dp/dt

      (3) TOD

  Lower and upper system leak signatures are easily recognized on console by viewing MSK 2773 (fig. 2.2.4-III).

C. Compare all TOD indications to the estimated MECO time. If MECO time is greater or within 30 seconds of the respective upper and lower system leak TOD, interconnect the pneumatics bottle and determine if conditions for zero-g, pneumatic or hydraulic shutdown, can be met. Figure 2.2.4-IV describes the interconnect procedure in greater detail.

D. Isolatable lower or upper system leaks

  1. In either case, if the leak is isolated and shutdown occurs through one regulator only, the minimum helium tank pressures required for safe engine shutdown are:

    a. Zero-g - 1963 psi

b. Pneumatic - 1457 psi

c. Hydraulic - 600 psi

The TOD's that are displayed on MSK 1054 are not the correct values. The minimum interface pressure required for safe engine shutdown is lower than was first thought, and it has been updated. However, the algorithm used by the mission operations computer (MOC) to calculate the necessary TOD's has not been updated. Two figures and two tables were created to manually correct the computation. Table 2.2.4-I and figure 2.2.4-V are used for nonisolatable lower system leaks. Table 2.2.4-II and figure 2.2.4-VI are used for nonisolatable upper system leaks.

E. Nonisolatable lower system leaks

1. Because the leak rate for lower system leaks remains constant, the MPS operator simply locates the usage rate on table 2.2.4-I and then subtracts the corresponding times from the TOD's on MSK 1054. The resulting time is compared with estimated MECO to determine if zero-g, pneumatic or hydraulic shutdown can be made. The values from figure 2.2.4-V have already been incorporated into table 2.2.4-I.

F. Nonisolatable upper system leaks

1. In this case, if the hole size remains constant, pressure-fed leaks above a regulator will decay with time. Therefore, the helium tank will maintain pressure longer than predicted by the MOC. This decay must be considered along with the engine interface pressure when making manual corrections to the TOD.

   Procedure:

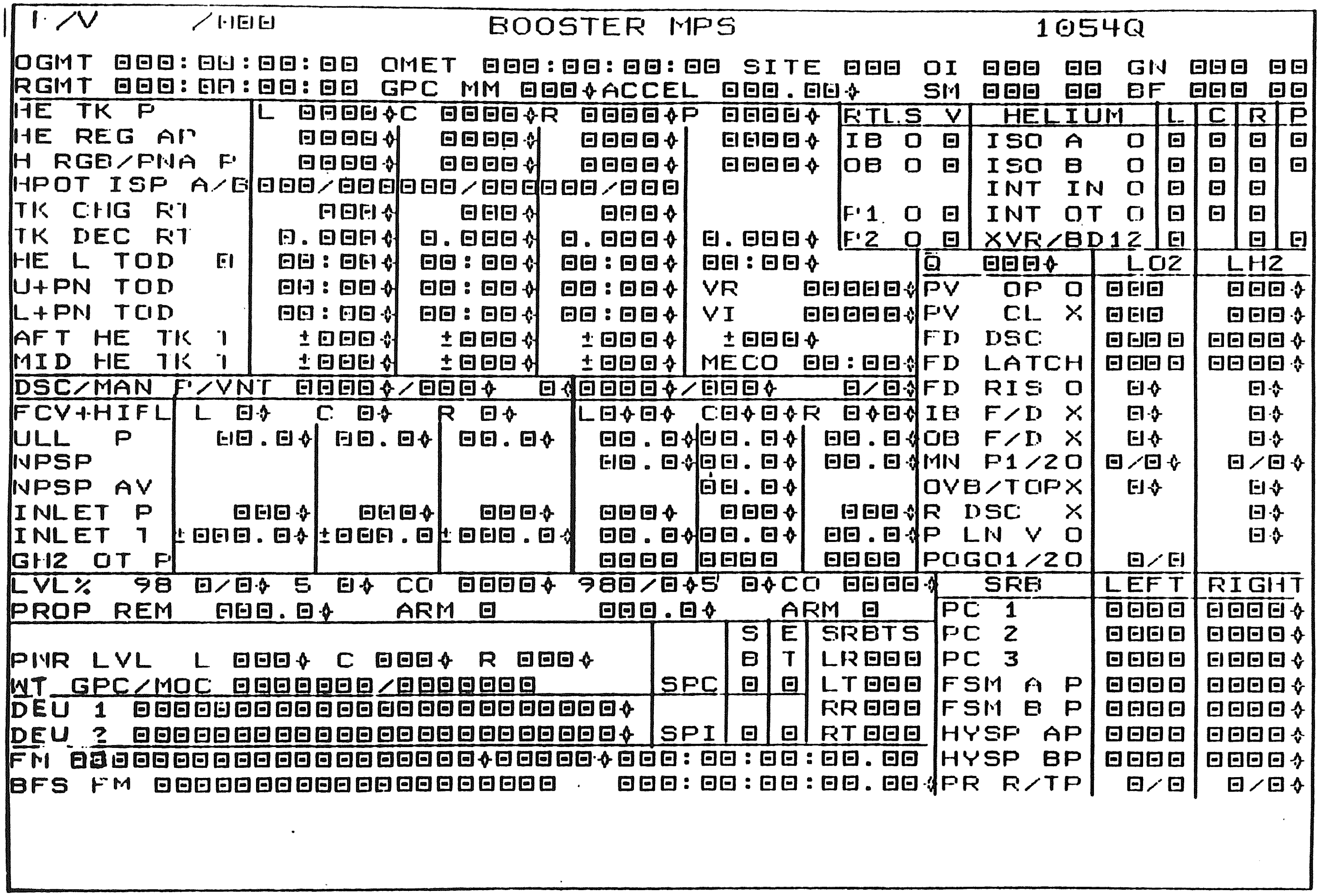
   a. Using MSK 1054, write down the leak rate and tank pressure near the time of maximum helium usage.

   b. Plot the coordinates on figure 2.2.4-VI and draw a straight line from 0.045 to the point.

   c. At the points where the straight line crosses the zero-g, pneumatic and hydraulic lines draw a vertical line to the usage axis.

   d. Using table 2.2.4-II, write down only the corresponding time delta for that case; i.e., for the zero-g case only read the number in the zero-g column.

   e. Subtract the numbers from the upper and pneumatic TOD's and compare them to the MECO time to determine if shutdown conditions for each case will be met.



```
I/V        /□□□              BOOSTER MPS                        1054Q
OGMT □□□:□□:□□:□□ OMET □□□:□□:□□:□□ SITE □□□ OI □□□ □□ GN □□□ □□
RGMT □□□:□□:□□:□□ GPC MM □□□♦ACCEL □□□.□□♦     SM □□□ □□ BF □□□ □□
HE TK P      L □□□□♦C □□□□♦R □□□□♦P □□□□♦ RTLS V  HELIUM    L C R P
HE REG AP      □□□□♦   □□□□♦   □□□□♦   □□□□♦ IB O □ ISO A  O □ □ □ □
H RGB/PNA P    □□□□♦   □□□□♦   □□□□♦   □□□□♦ OB O □ ISO B  O □ □ □ □
HPOT ISP A/B□□□/□□□□□□/□□□□□□/□□□                 INT IN O □ □ □
TK CHG RT       □□□♦     □□□♦     □□□♦          F1 O □ INT OT O □ □ □
TK DEC RT     □.□□□♦  □.□□□♦  □.□□□♦  □.□□□♦ F2 O □ XVR/BD12 □   □ □
HE L TOD  □    □□:□□♦  □□:□□♦  □□:□□♦  □□:□□♦ Q  □□□♦    LO2   LH2
U+PN TOD       □□:□□♦  □□:□□♦  □□:□□♦ VR    □□□□□♦PV  OP O  □□□   □□□♦
L+PN TOD       □□:□□♦  □□:□□♦  □□:□□♦ VI    □□□□□♦PV  CL X  □□□   □□□♦
AFT HE TK 1    ±□□□♦   ±□□□♦   ±□□□♦   ±□□□♦    FD DSC      □□□□  □□□□♦
MID HE TK 1    ±□□□♦   ±□□□♦   ±□□□♦ MECO □□:□□♦FD LATCH    □□□□  □□□□♦
DSC/MAN P/VNT □□□□♦/□□□♦   □♦□□□□♦/□□□♦    □/□♦FD RIS O      □♦    □♦
FCV+HIFL L □♦   C □♦   R □♦   L□♦□♦ C□♦□♦R □♦□♦IB F/D X      □♦    □♦
ULL P      □□.□♦ □□.□♦ □□.□♦   □□.□♦□□.□♦ □□.□♦OB F/D X      □♦    □♦
NPSP                           □□.□♦□□.□♦ □□.□♦MN P1/2O    □/□♦  □/□♦
NPSP AV                             □□.□♦      OVB/TOPX     □♦    □♦
INLET P      □□□♦   □□□♦   □□□♦    □□□♦ □□□♦  □□□♦R DSC X          □♦
INLET T ±□□□.□♦±□□□.□±□□□.□♦   □□.□♦□□.□♦ □□.□♦P LN V O          □♦
GH2 OT P                       □□□□ □□□□  □□□□ POGO1/2O     □/□
LVL% 98 □/□♦ 5 □♦ CO □□□□♦ 98□/□♦5 □♦CO □□□□♦  SRB       LEFT  RIGHT
PROP REM □□□.□♦    ARM □    □□□.□♦   ARM □   PC 1       □□□□  □□□□♦
                                     S E SRBTS PC 2       □□□□  □□□□♦
PWR LVL L □□□♦ C □□□♦ R □□□♦         B T LR□□□ PC 3       □□□□  □□□□♦
WT GPC/MOC □□□□□□□/□□□□□□□     SPC □ □ LT□□□ FSM A P    □□□□  □□□□♦
DEU 1 □□□□□□□□□□□□□□□□□□□□□□□□□□♦          RR□□□ FSM B P    □□□□  □□□□♦
DEU 2 □□□□□□□□□□□□□□□□□□□□□□□□□□♦      SPI □ □ RT□□□ HYSP AP    □□□□  □□□□♦
FM □□□□□□□□□□□□□□□□□□□□□□♦□□□□□♦□□□:□□:□□:□□.□□ HYSP BP    □□□□  □□□□♦
BFS FM □□□□□□□□□□□□□□□□□□□□       □□□:□□:□□:□□.□□♦PR R/TP     □/□   □/□♦
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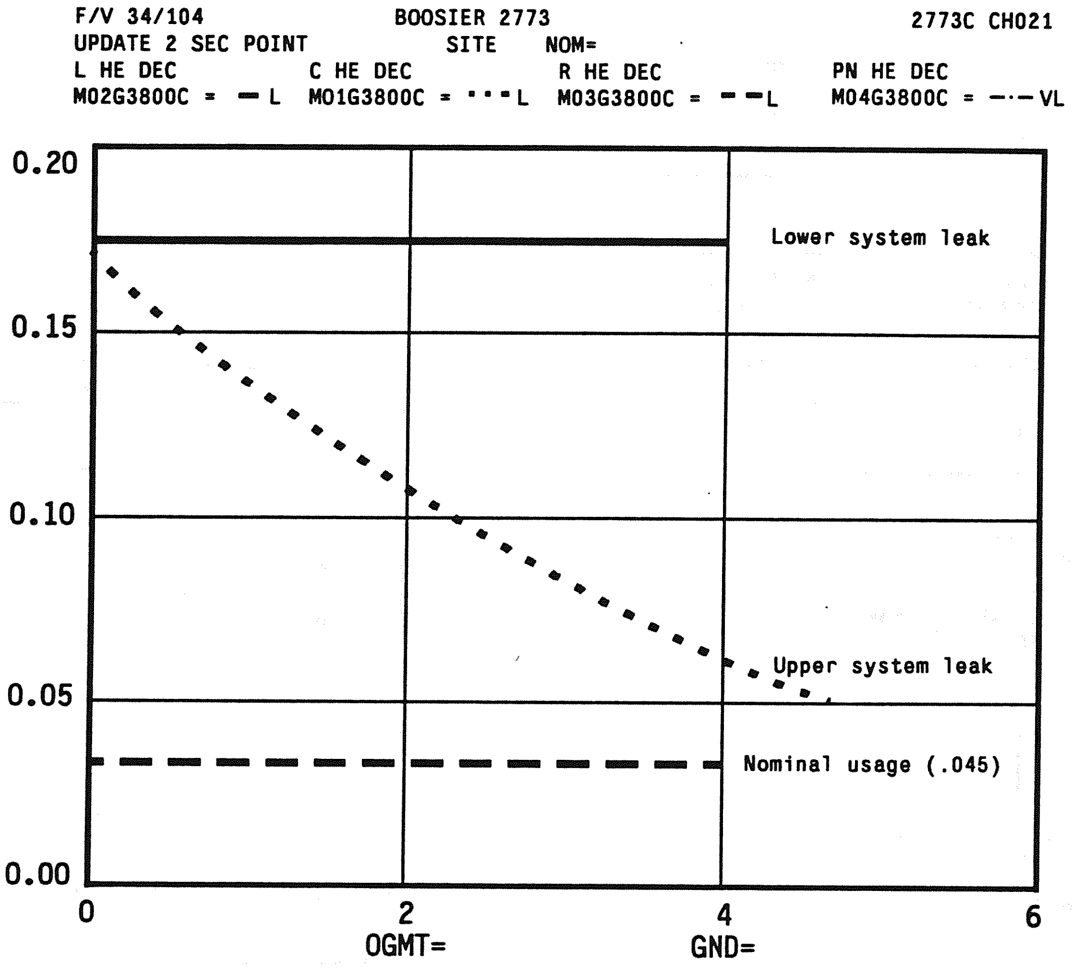
Figure 2.2.4-II.- Booster MPS, MSK 1054.



17239*024

Figure 2.2.4-III.- Booster universal plot 2773.

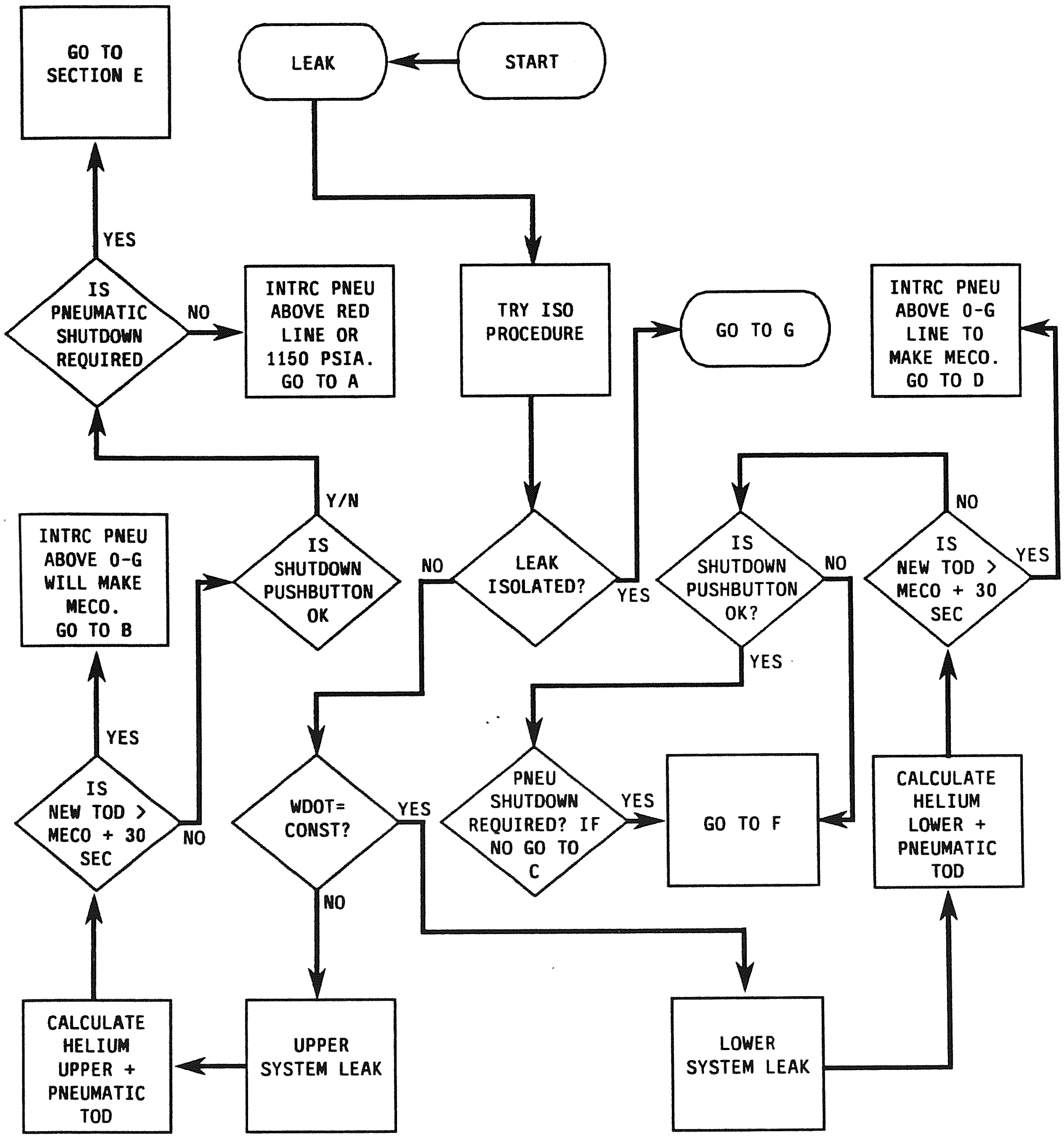


Figure 2.2.4-IV.- Helium leak procedures (one of three).

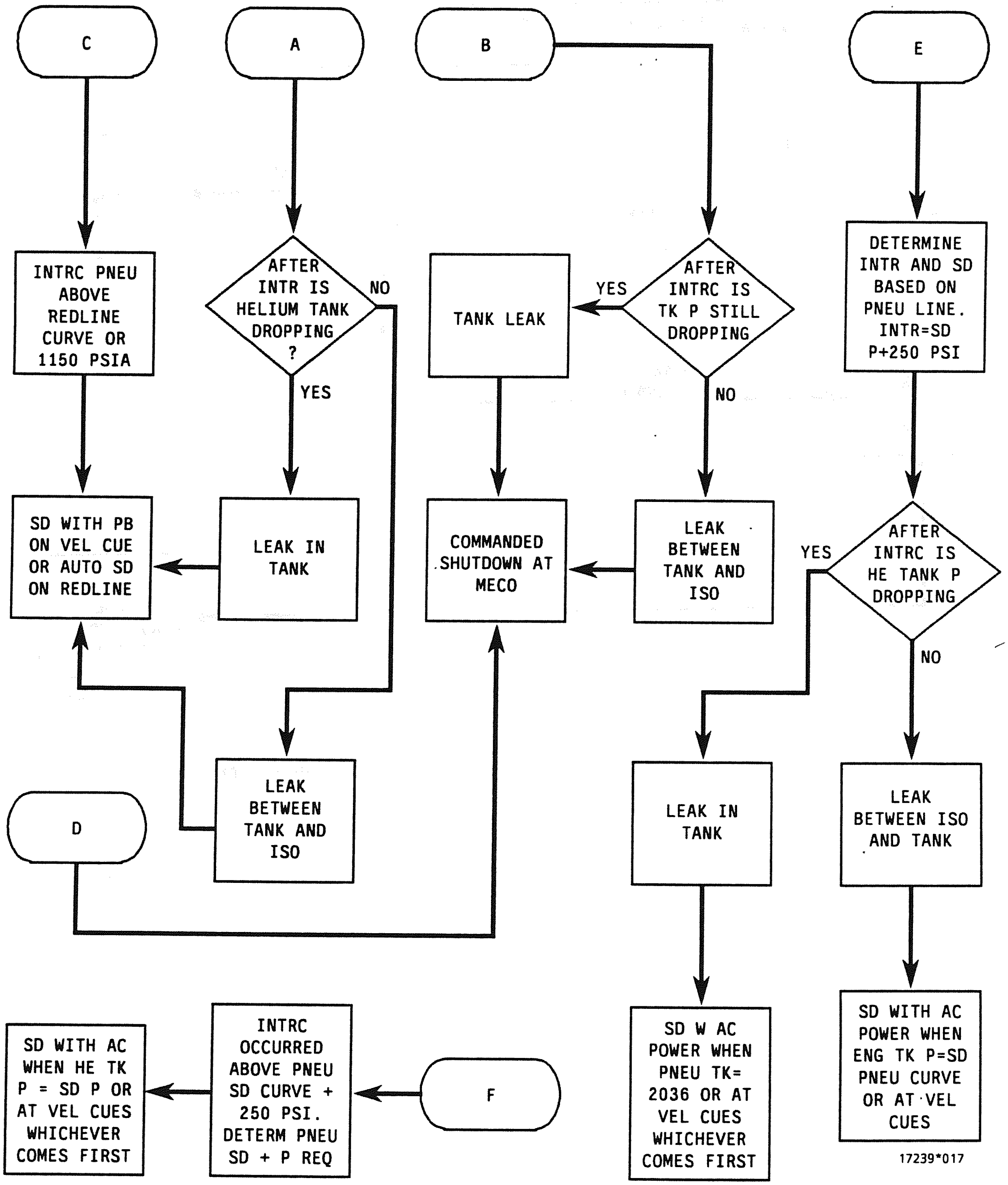


Figure 2.2.4-IV.- Helium leak procedures (two of three).

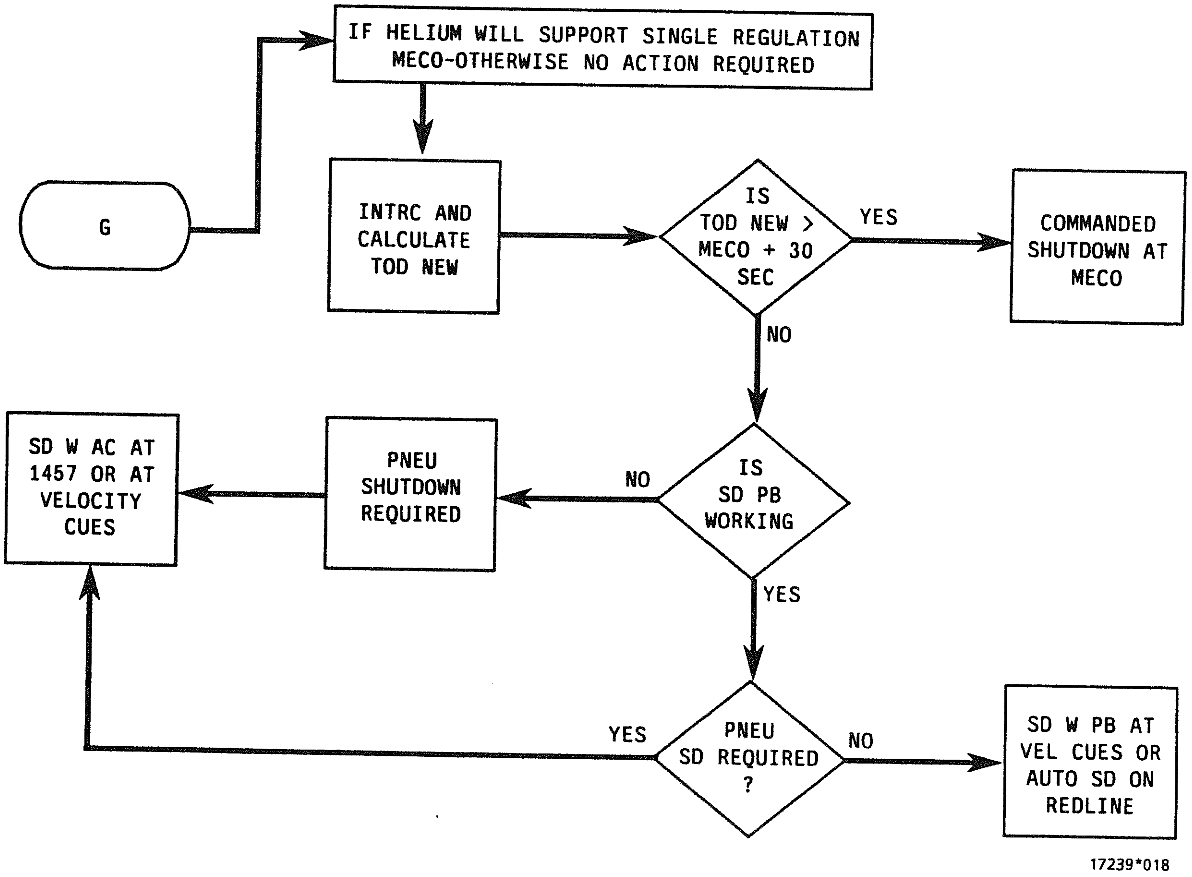


Figure 2.2.4-IV.- Helium leak procedures (three of three).

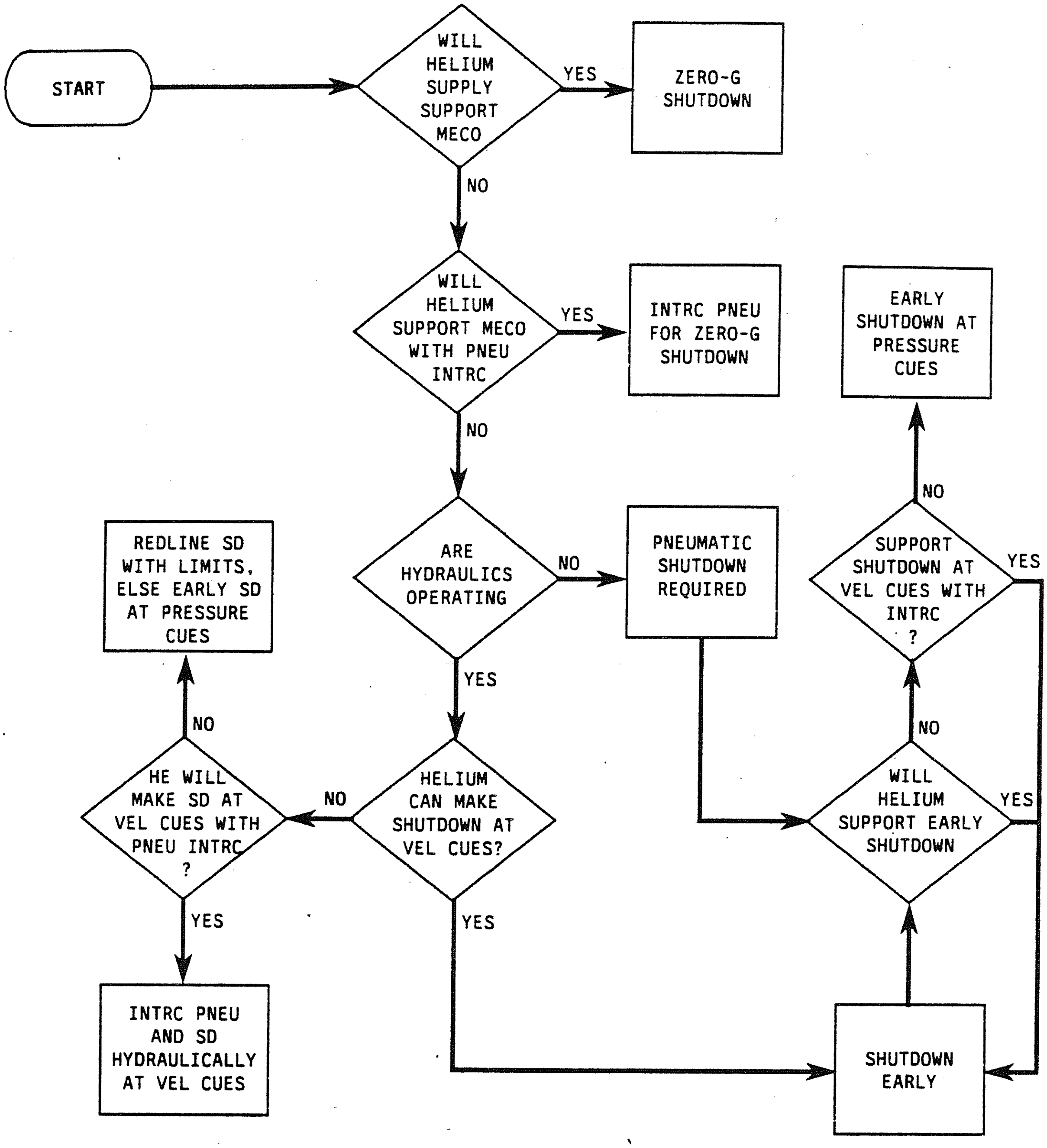
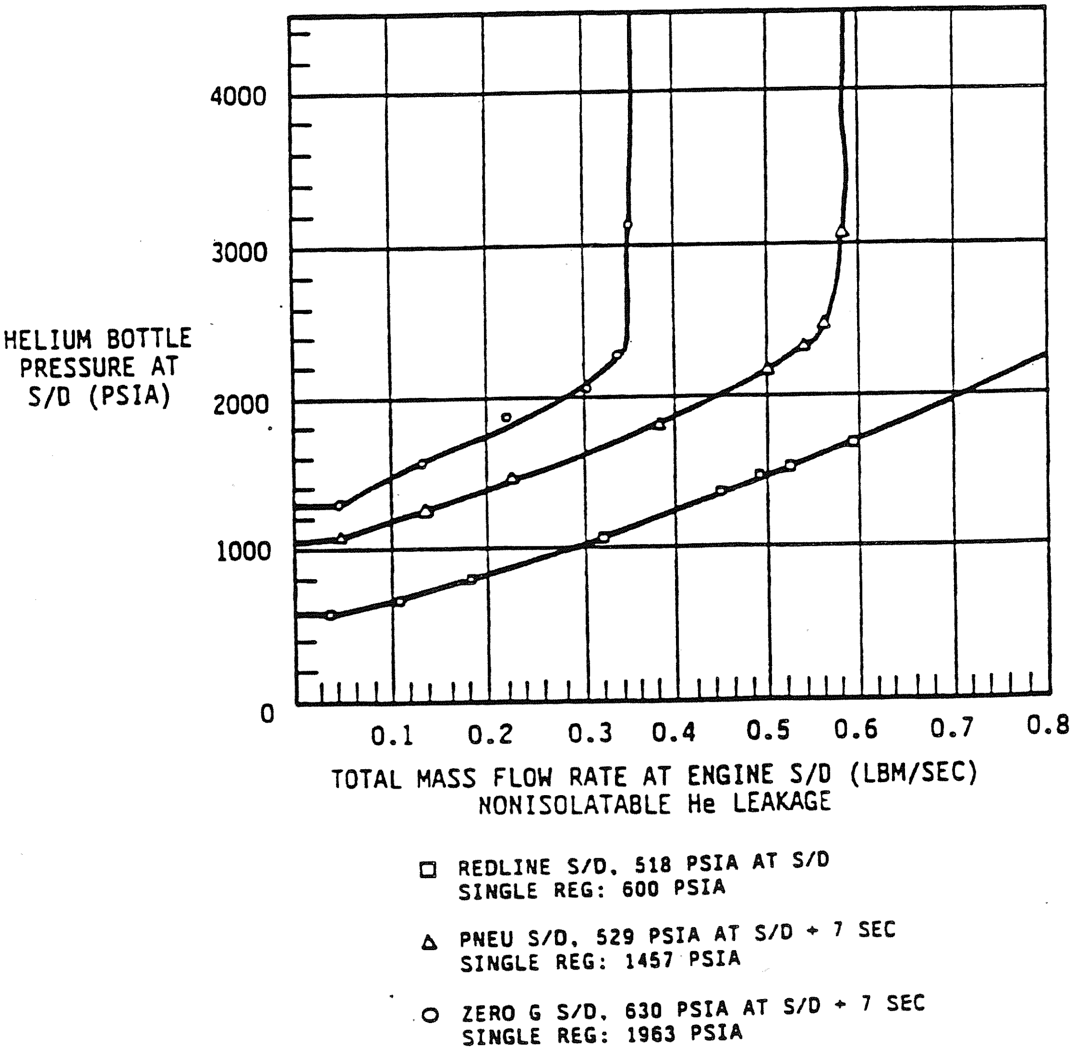


Figure 2.2.4-IV.- Helium leak procedures (summary).



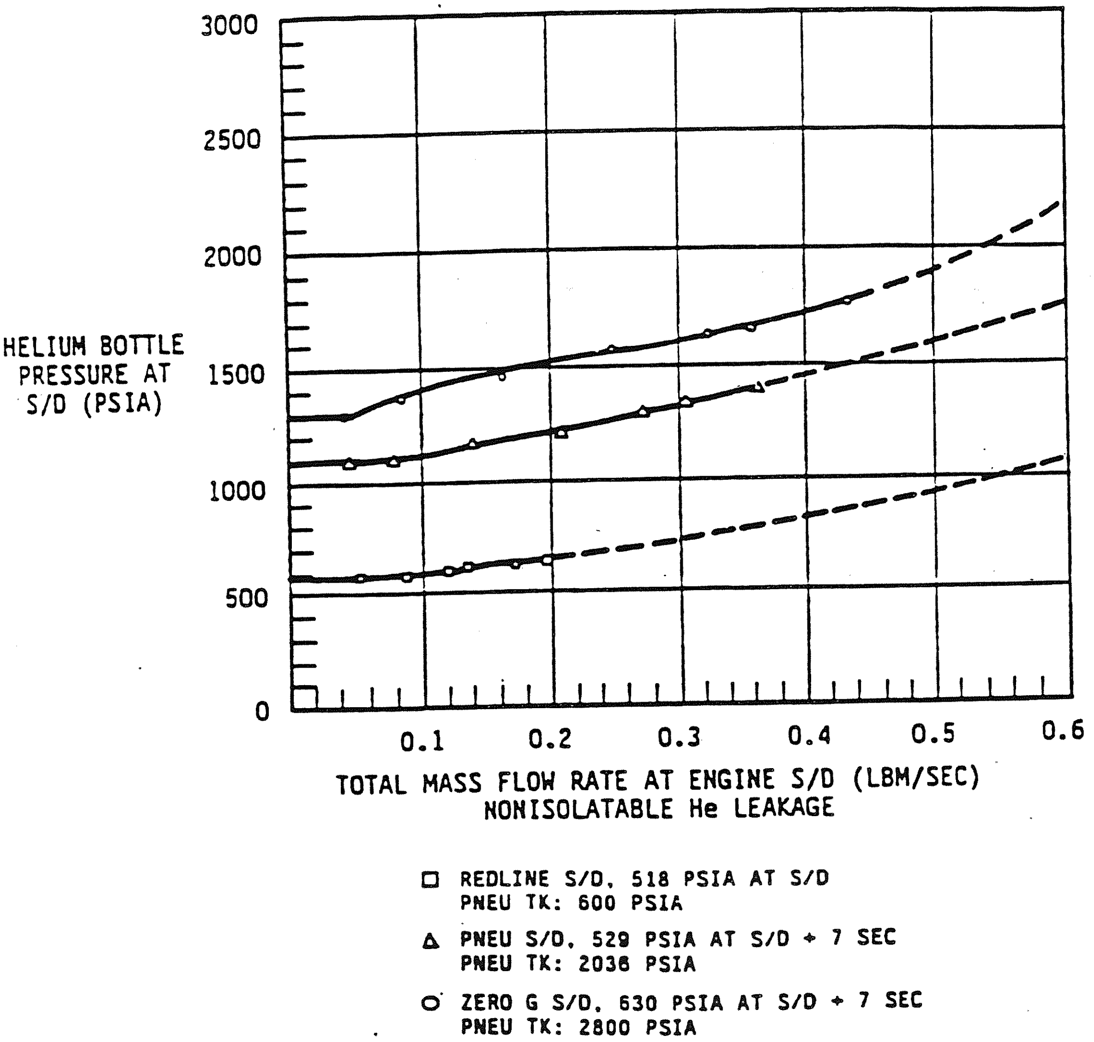
These helium leak rate (lbm/sec) versus helium tank supply pressure (psia) plots are used to determine the minimum helium supply pressure required to support a safe engine shutdown for nonisolatable leaks. They were generated assuming worst case line loss effects that occur for leaks at the Orbiter MPS helium/SSME interface.

Figure 2.2.4-V.- Minimum helium bottle pressure for SSME shutdown with lower system leak.

TABLE 2.2.4-I.- MANUAL CORRECTION TO THE MPS HELIUM TIME OF DEPLETION (TOD) MOC COMP OUTPUT FOR STS-34 (LOWER SYSTEM)

TIME CORRECTION TABLE: DASH 005 REGS

TOTAL USAGE	ZERO G SHUTDOWN	PNEUMATIC SHUTDOWN	RED LINE SHUTDOWN
0.045	-5:56 (1288)	-4:24 (1085)	-0:00 (572)
0.050	-5:28 (1308)	-4:01 (1092)	-0:04 (580)
0.075	-4:02 (1396)	-2:52 (1132)	-0:17 (621)
0.100	-3:16 (1474)	-2:17 (1175)	-0:23 (662)
0.125	-2:47 (1543)	-1:57 (1220)	-0:26 (705)
0.150	-2:27 (1607)	-1:44 (1267)	-0:29 (748)
0.175	-2:13 (1669)	-1:35 (1316)	-0:31 (792)
0.200	-2:02 (1732)	-1:28 (1368)	-0:32 (838)
0.225	-1:54 (1801)	-1:23 (1422)	-0:33 (884)
0.250	-1:48 (1876)	-1:19 (1478)	-0:34 (932)
0.275	-1:43 (1963)	-1:16 (1536)	-0:35 (980)
0.300	-1:40 (2064)	-1:13 (1597)	-0:36 (1029)
0.325	-1:39 (2182)	-1:11 (1660)	-0:36 (1080)
0.350	-1:38 (2320)	-1:09 (1726)	-0:37 (1131)
0.375		-1:08 (1794)	-0:37 (1183)
0.400		-1:07 (1864)	-0:37 (1237)
0.425		-1:06 (1936)	-0:38 (1291)
0.450		-1:05 (2011)	-0:38 (1346)
0.475		-1:04 (2088)	-0:38 (1402)
0.500		-1:04 (2167)	-0:39 (1460)
0.525		-1:03 (2249)	-0:39 (1518)
0.550		-1:03 (2333)	-0:39 (1577)
0.575		-1:02 (2419)	-0:39 (1638)
0.600			-0:40 (1699)
0.625			-0:40 (1761)
0.650			-0:40 (1824)
0.675			-0:40 (1888)
0.700			-0:40 (1954)
0.725			-0:41 (2020)
0.750			-0:41 (2087)
0.775			-0:41 (2155)
0.800			-0:41 (2224)



An upper system leak is a leak upstream of the helium regulators. The leak rate for this type of leak will decay with time. This is a nonisolatable leak and does not have corresponding single regulator values.

If this leak is a tank leak (i.e., upstream of the system leg check valves), when the pneumatic tank is interconnected these check valves will close. In this configuration, the helium in the engine supply bottle will continue leaking into the aft compartment but will also be isolated from the pneumatic supply by the closed check valves. Therefore, the only helium that is being used is from the pneumatic tank. The corresponding minimum pneumatic tank-only pressure values are 2800 psia, 2036 psia, and 600 psia for zero-g, pneumatic, and redline shutdowns, respectively.

Figure 2.2.4-VI.- Minimum helium bottle pressure for SSME shutdown with upper system leak.

TABLE 2.2.4-II.- MANUAL CORRECTION TO THE MPS HELIUM TIME OF DEPLETION (TOD) MOC COMP OUTPUT

UPPER CORRECTION TABLE
STS-34 DATE 8-24-89

CROSS FLOW RATE	ZERO G		PNEU		HYD	
0.055	-5:42	(1379)	-4:10	(1145)	-0:15	(604)
0.065	-5:07	(1397)	-3:41	(1151)	-0:14	(608)
0.075	-4:40	(1414)	-3:18	(1157)	-0:14	(613)
0.085	-4:18	(1430)	-3:05	(1163)	-0:14	(617)
0.095	-3:59	(1446)	-2:46	(1170)	-0:14	(621)
0.105	-3:43	(1461)	-2:34	(1177)	-0:13	(626)
0.115	-3:30	(1475)	-2:24	(1185)	-0:13	(631)
0.125	-3:18	(1489)	-2:15	(1193)	-0:13	(636)
0.135	-3:08	(1502)	-2:08	(1201)	-0:14	(642)
0.145	-2:59	(1514)	-2:02	(1210)	-0:14	(647)
0.155	-2:51	(1526)	-1:56	(1219)	-0:14	(653)
0.165	-2:43	(1538)	-1:52	(1228)	-0:14	(659)
0.175	-2:37	(1549)	-1:47	(1237)	-0:14	(665)
0.185	-2:31	(1560)	-1:43	(1247)	-0:14	(671)
0.195	-2:26	(1570)	-1:40	(1257)	-0:14	(677)
0.205	-2:21	(1581)	-1:37	(1268)	-0:15	(684)
0.215	-2:15	(1591)	-1:34	(1279)	-0:15	(691)
0.225	-2:11	(1601)	-1:32	(1289)	-0:15	(698)
0.235	-2:08	(1610)	-1:30	(1301)	-0:15	(705)
0.245	-2:04	(1620)	-1:28	(1312)	-0:16	(712)
0.255	-2:01	(1629)	-1:26	(1324)	-0:16	(720)
0.265	-1:57	(1639)	-1:24	(1336)	-0:16	(728)
0.275	-1:54	(1649)	-1:22	(1348)	-0:16	(736)
0.285	-1:51	(1658)	-1:21	(1360)	-0:17	(744)
0.295	-1:49	(1668)	-1:20	(1373)	-0:17	(752)
0.305	-1:47	(1678)	-1:18	(1386)	-0:17	(761)
0.315	-1:45	(1688)	-1:17	(1399)	-0:17	(769)
0.325	-1:42	(1699)	-1:16	(1412)	-0:18	(778)
0.335	-1:41	(1709)	-1:15	(1425)	-0:18	(787)
0.345	-1:39	(1721)	-1:14	(1439)	-0:18	(796)
0.355	-1:37	(1732)	-1:14	(1453)	-0:18	(806)
0.365	-1:36	(1744)	-1:13	(1466)	-0:19	(815)
0.375	-1:34	(1756)	-1:12	(1481)	-0:19	(825)
0.385	-1:33	(1769)	-1:12	(1495)	-0:19	(835)
0.395	-1:32	(1783)	-1:11	(1509)	-0:20	(845)
0.405	-1:30	(1797)	-1:10	(1523)	-0:20	(856)
0.415	-1:29	(1811)	-1:10	(1538)	-0:20	(866)
0.425	-1:29	(1827)	-1:09	(1553)	-0:20	(877)
0.435	-1:28	(1843)	-1:09	(1567)	-0:21	(888)
0.445	-1:27	(1860)	-1:08	(1582)	-0:21	(899)

Crew Operations

SUMMARY OF MPS HELIUM PROBLEMS

Problem	Reg PR	$\ddot{W}$ >> .045 &	Current HE TOD	Action
REG FAIL FULL OPEN	↑	Decaying	Increasing	Isolate
REG SHIFT UP	↑	Const	Const	Isolate*
REG LEG STRUCT LEAK	May Go ↓	Const	Const	Isolate
RLF VLV FAIL FULL OPEN	↓	Decaying	Increasing	Isolate
RLF VLV FAIL PART OPEN	↓	Const	Const	Isolate
TANK LEAK	Const.	Decaying	Increasing	Interconnect**
UPPER SYS LEAK	Const.	Decaying	Increasing	Interconnect**
LOWER SYS LEAK	May Go ↓	Const	Const	Interconnect**

*Isolation only required if regulator shifts high enough to open relief valve.
**Interconnect only if required (bottle pressure decays to 1150 psi).

FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(dP/dT) (C) V98P4997C (L) V98P4998C (R) V98P4999C	"MPS He P C(L,R)" dP/dT > 20 psia	FML BFS GNC SYS SUMM 1
(He reg press) (C) V41P1154A A (C) V41P1153A B (L) V41P1254A A (L) V41P1253A B (R) V41P1354A A (R) V41P1353A B	He regulator A or B pressure < 679 psia or > 806 psia (class 3 alarm) He regulator A pressure < 680 psia or > 810 psia * (class 2 alarm)	PNL F7 BFS GNC SYS SUMM 1
(He tank press) (C) V41P1150C (L) V41P1250C (R) V41P1350C	Tank pressure < 1150 psia (class 2 alarm) *	PNL F7 BFS GNC SYS SUMM 1

* Also on hardwired C&W

1. Crew Procedures (New)

Cue Card

MPS He P (Pre-MECO)
(✓dP/dT)
If after MECO-30:
 1.Shut down MN ENG(pb)
 ASAP (RTLS:α=-4) >>
If He REG P ↑ or ↓:
 2.Aff He ISOL - CL
Otherwise:
 3.Aff he ISOL A - CL
 If no decr in dP/dT:
 4.Aff He ISOL A - OP
 B - CL
 If no decr in dP/dT:
 5.Aff He ISOL B - OP
If any ENG failed:
 6.Failed-ENG He I'CNCT
 - OUT OP
If nonisolatable:
 7.Shut down MN ENG per
 MPS CMD/HYD/ELEC
 If/When TK P < 1150 or
 REG P < 679:
 8.Aff He I'CNCT -IN OP
If isolated:
 9.Aff He I'CNCT -IN OP
 If TK P<2100 @ S/D cue:
 10.Shutdown MN ENG per
 MPS CMD/HYD/ELEC
Post-ET Sep:
 11.He I'CNCT(s) - GPC>>

MPS PNEU TK (REG) P
1.PNEU He ISOL - CL
If PNEU ACUM P decr:
 At MECO-30:
 2.PNEU He ISOL - OP
 Wait 5 sec, then:
 3.L ENG He XOVR - OP

1. Crew Procedures (Old)

Cue Card

MPS He TK LK
Pre ET SEP
If LK begins > 23K
 and dP/dT > 40:
 1. MN ENG SHUTDN pb -
 push (pb only) >>
If He REG P ↑ of ↓:
 2. Aff He ISOL - CL
Otherwise:
 3. He ISOL A - CL
If no decr in dP/dT:
 4. He ISOL A - OP
 B - CL
No decr in dP/dT:
 5. He ISOL B - OP
If no comm and > 23K:
 6. MN ENG SHUTDN pb
 push (pb only) >>
If TK P < 1150 or
 REG P < 679:
 7. Aff He I'CNECT -
 IN OP
At ET SEP:
 8. He I'CNECT - GPC
 >>

MPS He TK LK
Post ET SEP (Not RTLS)
If TK P < 1150:
1. Affected
 He ISOL (two) - CL
If second TK P < 1150:
2. PNEU He ISOL - CL

2. Crew Activity

TABLE 2.2.4-III.- PRE-MECO

Step	Activity	Position
1	Verify CRT error message "MPS He P C(L,R)"	CDR, PLT
2	Call up BFS GNC SYS SUMM 1 a. Note the dp/dT b. If confirmed leak starts after MECO-30 seconds, shut affected engine down ASAP. c. Determine if REG P A or B is displayed with an up arrow ↑ (> 806 psia) or a down arrow ↓ (<679 psia)	CDR, PLT
3	If A(B) indicates ↑ or ↓, position He ISOLATION VALVE A(B) switch on panel R2 to CLOSE. If A(B) does not indicate ↑ or ↓, position He ISOLATION VALVE A switch on panel R2 to CLOSE, note 1.	PLT
4	On BFS GNC SYS SUMM 1 note the dP/dT observed in step 2 a. If dP/dT decreased the leak has been isolated, continue with normal monitoring of system. If isolated engine tank P less than 2100 at S/D velocity cues, with interconnect In-OP, shut engine down per MPS CMD/HYD Elec Cue Card. b. If dP/dT did not decrease, continue with step 5	PLT
5	On Panel R2, position the previously closed (step 3) He ISOLATION VALVE A(B) switch to OPEN. Position the remaining He ISOLATION VALVE B(A) switch to CLOSE, note 1.	PLT
6	On BFS GNC SYS SUMM 1 note the dP/dT observed in steps 2 and 4 a. If dP/dT decreased the leak has been isolated, continue with normal monitoring of system. If isolated engine tank P less than 2100 at 5/d velocity cues, with interconnect In-OP, shut engine down per MPS CMD/HYD Elec Cue Card. b. If dP/dT did not decrease, continue with step 7	PLT
7	On panel R2, position He ISOLATION VALVE B(A) switch to OPEN	PLT

Note 1.- The crew should monitor the dP/dT for approximately 5 seconds to allow the computation time to stabilize before continuing the procedure. The Helium interconnect valves should be taken to the out - OP position for any engine which shuts down pre-MECO.

TABLE 2.2.4-III.- Concluded

Step	Activity	Position
8	On BFS GNC SYS SUMM 1 monitor MPS He TK P and Reg P. If the TK P drops below 1150 psia or a Reg P drops below 679 psia, proceed to step 9	PLT
9	On panel R2 position affected He INTERCONNECT switch to IN OPEN/OUT CLOSE and shutdown Engler MPS CMD/HYD/Elec Cue Card	PLT
10	At ET separation, position He INTERCONNECT switch to GPC	PLT

Note 1.- The crew should monitor the dP/dT for approximately 5 seconds to allow the computation time to stabilize before continuing the procedure. The Helium interconnect valves should be taken to the out - OP position for any engine which shuts down pre-MECO.

TABLE 2.2.4-IV.- POST-ET SEP (NOT RTLS)

Step	Activity	Position
1	Verify CRT error message "MPS He P C(L,R)"	CDR, PLT
2	Call up BFS GNC SYS SUMM 1 a. Monitor MPS He TK P b. If this reading drops below 1150 psia, proceed to step 3	PLT
3	On panel R2, position He ISOLATION VALVE A and B switches to CLOSE	PLT
4	If a second MPS He TK P should drop below 1150 psia, proceed to step 5	PLT
5	On panel R2, position PNEUMATICS He ISOL switch to CLOSE	PLT

3. MCC Operations

TABLE 2.2.4-V.- PASS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(Rate of depletion) (C) M01G3800C (L) M02G3800C (R) M03G3800C	Limit sense set at > 0.05 lb/sec (Approx 12.5 psia/3 sec)	MSK 1054 1077 DDD 301
(Time of depletion) (C) M05G3800T (L) M05G3800T (R) M07G3800T	Limit sense set at 5 min	MSK 1054 1077 DDD 286
(Combined time of depletion, lower) (C) M09G3800T (L) M10G3800T (R) M11G3800T	Limit sense set at 5 min	MSK 1054 1077
(Combined time of depletion, upper) (C) M12G3800T (L) M13G3800T (R) M15G3800T	Limit sense set at 5 min	MSK 1054
(Regulator pressure) (C) V41P1154A A (C) V41P1153A B (L) V41P1254A A (L) V41P1253A B (R) V41P1354A A (R) V41P1353A B	Lower limit sense set at < 690 psia Upper limit sense set at > 800 psia	MSK 1054, 1064 1077 DDD 301
(Tank pressure) (C)V41P1150C (L)V41P1250C (R)V41P1350C	Limit sense set at < 3300 psia (Lift-off to SRB SEP) < 1500 psia (SRB SEP to ET SEP) < 1400 psia (ET SEP to on orbit)	MSK 1054 1077 DDD 301

TABLE 2.2.4-VI.- BFS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(Tank change rate) (C) V98P4997C (L) V98P4998C (R) V98P4999C	Limit sense set at >20 psia per 3 sec.	MSK 1054, 1064 1077 DDD 301
(Tank pressure) (C) V98P2155C (L) V98P2156C (R) V98P2157C	Limit sense set as: < 3300 psia (Lift-off to SRB SEP) < 1500 psia (SRB SEP to ET SEP) < 1400 psia (ET SEP to on orbit)	MSK 1089 1064

1. Console Cue Cards - The crew cue card is used at the MCC console.

2. MCC Activity

TABLE 2.2.4-VII.- PRE-MECO

Step	Activity	Position
1	Note the illuminated "Rate of Depletion" or "Tank Change Rate" lights on DDD 301 and ascertain which system (L, C, or R) the leak is in. Note if "He Reg A", "He Reg B", "Time of Depletion", or "Combined Time of Depletion" lights are illuminated. Inform BSE of system and leak	MPS/BSE/ FD/crew
2	On DDD 301 or MSK 1054 monitor the He isolation valves position for indications of crew procedure "MPS He TK LEAK." Inform BSE	MPS/BSE/ FD
3	If the control bus powering the A isolation valve switch fails, inform BSE that the A isolation valve cannot be closed.	MPS/BSE FD/crew
4	If a bus or sub-bus failure results in the A isolation valve closing, inform BSE that no helium leak isolation procedures should be performed on that engine	MPS/BSE FD/crew
5	On MSK 1054 note the "He Reg A(B)" pressures. If A(B) pressure is < 685 psia or > 800 psia and the crew has not started the "He TK Leak" procedure, recommend to BSE that the A(B) isolation valve be closed	MPS/BSE/ FD/crew

TABLE 2.2.4-VII.- Continued

Step	Activity	Position
6	On MSK 1054 note the "Time of Depletion" and "Combined Time of Depletion" times and compare with MECO time. Inform BSE if the pneumatics tank will be required and if the helium will last to MECO. Monitor for any further changes in helium decay	MPS/BSE/ FD/crew
7	On MSK 1054 monitor the "HE TK P" and engine helium regulator A & B pressures, and inform BSE as they approach 1150 psia or 679 psia, respectively.	MPS/BSE
8	On MSK 1054 or DDD 301 monitor for He INTERCONNECT to IN OPEN/OUT CLOSE. Inform BSE when this occurs. If the pneumatics tank has not been tied in by the time the pressure decays below 1150 psi, inform BSE	MPS/BSE
9	On MSK 1054 monitor pneumatics He TK P as it approaches 1500 psia. Inform BSE. Monitor HE REG P A and B. If they start to decay, inform BSE	MPS/BSE
10	At ET SEP, on MSK 1054 or DDD 301, monitor for He INTERCONNECT to CLOSE. Inform BSE when this occurs or inform BSE that it did not occur	MPS/BSE

TABLE 2.2.4-VIII.- POST-ET SEP (NOT RTLS)

Step	Activity	Position
1	On MSK 1054 note if any system (C, L, or R) is decaying faster and inform BSE	MPS/BSE
2	On MSK 1054 note when any system < 1150 psia Inform BSE	MPS/BSE
3	Verify crew closes A and B He isolation valves	MPS/BSE
4	On MSK 1054 note if a second He system < 1150 psia Inform BSE	MPS/BSE
5	Verify crew closes PNEU He isolation valves	MPS/BSE

REFERENCES

1. STS Operational Flight Rules, All Flights, Final, PCN 3, JSC-12820, Sept. 5, 1989

   Flight Rules

   Powered Flight - MPS

   5-45, ENGINE AND PNEUMATIC HELIUM INTERCONNECT

   5-46, ENGINE-TO-ENGINE HELIUM INTERCONNECT

   5-47, HELIUM LEAK ISOLATION

   5-48, PNEUMATIC HELIUM INTERCONNECT/CROSSOVER

   5-62, POST-MECO AND ENTRY HELIUM ISOLATION

2. Flight Data File Ascent Pocket Checklist
3. Flight Data File Cue Cards
4. Shuttle Operational Data Book
5. Flight Data File Ascent/Entry Systems Procedures
6. OI-8C Software

TITLE

LH_2 DUMP FAILURE

CONDITION

Failure to open the valves used for the automatic LH_2 dump.

DESCRIPTION

During standard insertion missions, the MPS propellant dump will begin with the start of the OMS 1 burn. For direct insertion missions (no OMS 1 required), the MPS propellant dump will be performed 2 minutes after MECO. Automatic LH_2 dumps occur only with standard insertions. The LH_2 dump is performed by opening the following valves: LH_2 outboard F/D valve, LH_2 inboard F/D valve for only 6 seconds, and then the LH_2 topping valve, LH_2 prevalves, and the SSME fuel bleed valves for the remainder of the dump. Should the LH_2 outboard F/D valve fail to open, the automatic dump cannot occur. A manual dump is then performed using the backup (RTLS) LH_2 valves.

Should the LH_2 inboard F/D valve fail to open, a complete dump could still be performed since propellant normally dumped from the inboard F/D valve will be evacuated through the topping valve. The probable flow time for this dump is longer due to the smaller diameter of the topping valve line. Even though a complete dump can be achieved through the topping valve, a manual dump is performed using the backup LH_2 valves. This action is taken to provide a path for the subsequent vacuum inerting.

Should the topping valve fail, only a partial dump can be completed since propellants flow only for the 6 seconds that the inboard F/D valve is open. During this abbreviated dump, approximately 50 percent of the normal dump will be completed leaving 150 lb of LH_2 residuals in the line (fig. 2.2.5-I). Later, this residual is manually dumped through the RTLS dump valves.

The crew can monitor the propellant dump sequence by observing the manifold pressure, but this does not provide a completely true status. They will see the sudden drop in manifold pressure as the dump begins, but the LH_2 feedline He repress regulator will restore and maintain the pressure at approximately 22 psig for the first 88 seconds of dump (fig. 2.2.5-I). The crew cannot tell if the dump is continuing until the pressure drops off at He pressurization termination (approximately 88 seconds into the dump sequence).

Failure of the automatic dump sequence can be caused by loss of GPC/MDM control of the valves used in the dump sequence. For these GPC/MDM failures prior to LH_2 dump, the crew will follow GPC/MDM I/O failure procedures in the cue cards to open the backup LH_2 valves. Only GPC/FA MDM 1, 2, and 3 impact the valves used for LH_2 dump (ref. SCP 4.5). To simplify the crew procedure and to make a more standardized action, the backup (RTLS) LH_2 valve switch is used for any GPC/FA MDM failure. Reference the DPS section of the Ascent Entry Systems Procedures book (fig. 2.2.5-II).

Failure of the automatic dump sequence can also be caused by the loss of main bus power to the valve driver. For these failures prior to the LH_2 dump, the crew will follow the MN bus failure procedures to open the backup LH_2 valves. Only MNA ALC1 and MNB ALC2 impact the valves used for MPS LH_2 dump. The backup LH_2 switch is used for any MNA of MNB failure. Reference the EPS section of the Ascent/Entry Systems Procedures book (fig. 2.2.5-III).

For RTLS and TAL aborts, if a good LH_2 dump did not occur, then the Booster should notify ground convoy and crew via the Flight Dynamics Officer (FIDO). It is possible that excessive LH_2 residuals in the manifold will boil off and vent which will create a hazardous postlanding condition (section 3.5 of reference 7).

Dummy OMS procedures for both the PASS and BFS are displayed in figure 2.2.5-IV. These procedures, to initiate a MPS propellant dump, are required when a dump switch failure occurs as a result of FF MDM's 1 and 2 failing or control bus AB3 or BC3 failing.

A. Flight Rules

Post-MECO - MPS

MANUAL LH_2 DUMP

Postlanding - MPS

16-17, EMERGENCY POWERDOWN

16-50, CONTAMINATION/FLAMMABILITY/TOXICITY

B. Crew Operations

1. Recognition of failure
    a. Valve Failure - None
    b. GPC/MDM Failure - FML, C&W
    c. MN Bus Failure - C&W

TABLE 2.2.5-I.- CREW OPERATIONS

Parameter no.	Failure value/trend	Displayed on
GPC V72X7011E (2E, 3E, 4E, 5E)	"GPC 1(2,3,4,5)" (class 2 alarm)	FML
MAIN BUS A(B,C) V76V0101A (201, 301)	"MAIN BUS UNDERVOLT" (class 2 alarm)	Panel F7

2. Crew Procedures

   a. Valve Failure - None: follow instruction of MCC ground call

   b. GPC/MDM Failure - Cue Cards

   c. MN Bus Failure - AESP book

C. MCC Operations

TABLE 2.2.5-II.- PASS FAILURE RECOGNITION

<table>
<tr><th>Parameter no.</th><th>Failure value/trend</th><th>Displayed on</th></tr>
<tr><td>(LH2 IB F/D V CL)
V41X1410X
(LH2 OB F/D V CL)
V41X1389X
(LH2 TOP V CL)
V41X1456X</td><td>Valve fails to open when automatic sequence begun. Closed indication remains lit</td><td>MSK 1054
DDD 288</td></tr>
<tr><td>(LH2 MANF P)
V41P1433C</td><td>Pressure remains at or above 22 psia after 88 seconds of dump. As LH_2 prevalves are also open, LH_2 inlet pressures to SSME's are a backup cure for manifold pressure.</td><td>MSK 1054
UP 2775</td></tr>
<tr><td>(ESW)
(C) E41M1003P
(L) E41M2003P
(R) E41M3003P</td><td>ESW indicates LOX dump (MOV open)*
<table>
<tr><td>HEX bits last two digits</td><td>OK
C9</td><td>MCF
CA</td><td>ELE
CB</td></tr>
</table></td><td>MSK 1052</td></tr>
</table>

* LH_2 dump occurs simultaneously with LOX dump at this time.

TABLE 2.2.5-III.- BFS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(BFS LH_2 MANF P) V98P1388C	Since the valve position TLM parameters are all PASS GPC downlist, the only indication of a LH_2 dump failure is the BFS LH_2 manifold pressure. Pressure remains at or above 22 psia after 88 sec of dump	MSK 1089 1064

1. Console Cue Card - The Ascent Pocket Checklist crew procedure is used on the MPS console (fig. 2.2.5-IV).

2. MCC Activity

TABLE 2.2.5-IV.- MCC PROCEDURE

Step	Activity	Position
1	At approximately OMS-1 ignition or at manual dump initiation, monitor status of LH_2 outboard F/D valve, inboard F/D valve, and topping valve. Indicated status should change from closed to open. LH_2 manifold pressure should begin to drop	MPS
2	If LH_2 outboard F/D valve fails to open, report failure of automatic dump and request that the crew open the backup LH_2 valves	MPS/BSE/FD/crew
3	If LH_2 inboard F/D valve fails to open, report partial dump in progress and request that the crew open the backup LH_2 valves	MPS/BSE/FD/crew
4	If LH_2 topping valve fails to open, report partial dump. Request crew to open the backup LH_2 valves	MPS/BSE/FD
5	Monitor LH_2 manifold pressure and have the crew close backup LH_2 valves after vacuum inerting termination IAW Ascent C/L. On nominal ascents, the crew will do this procedure automatically (see note 1 below).	MPS/BSE/FD/crew
6	If LH_2 residuals are projected to exist at touchdown, inform crew and ground convoy	MPS/BSE/FIDO/FD

3. Supporting Data

   A. Figures - Figures 2.2.5-I, 2.2.5-II, 2.2.5-III, 2.2.5-IV

   B. Tables - None

C. Notes:

(1) The MPS propellant dump backup LH_2 valve switch controls the backup LH_2 valves in the OPS 1 program. Therefore, if the valves have not been closed prior to transition from OPS 1, they are automatically closed by the entry dump software. Leaving the backup LH_2 valves open on orbit serves a useful purpose by providing a positive vent/relief path should the feedline relief valve fail closed. Another option to close the valves is to cycle MDM power in accordance with the following specifications.

If failed	then cycle FA MDM
MNA, MNA APC 4, or MNA APC 1	3 and 4
MNC or MNC MPC 3	4
Other power failures; or no power failures	Any one of these: 1 and 4, or 3 and 4, or 1 and 3,

(2) Rockwell refers to the backup LH_2 valves as the LH_2 RTLS dump valves.

REFERENCES

1. STS Operational Flight Rules, All Flights, Final, JSC-12820, January 20, 1989.
2. Flight Data File Ascent Entry Systems Procedures
3. Flight Data File Ascent Checklist
4. Flight Data File Cue Cards
5. Rockwell International Letter, "STS-1 On-Orbit MPS Dump Analysis," T. I. Lak to R. A. Burg, December 12, 1980.
6. Shuttle Operational Data Book
7. Booster Systems Brief, Basic, JSC-19041, Rev A, PCN-1, September 1989
8. Flight Data File Ascent Pocket Checklist

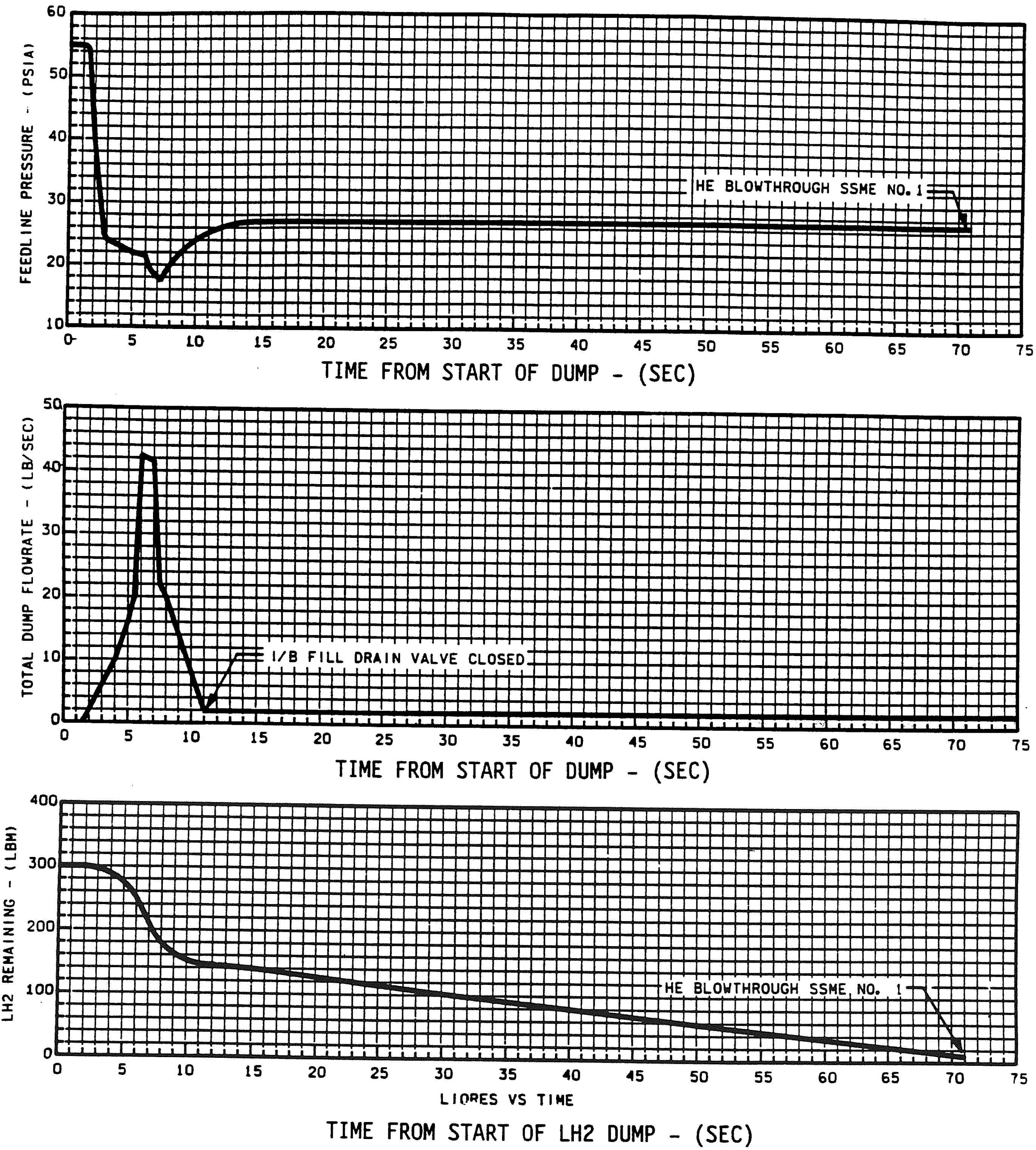


Figure 2.2.5-I.- Simulation of on-orbit MPS LH_2 dump through fill/drain and recirc/replenish system (normal mode).

DPS ASC

PASS GPC FAIL **ASCENT**
1. Aff FCS CH - OFF
2. If 2 GPC/FA/FCS CH ↓:
    Good FCS CHs - ORIDE
    ✓MPS CMD
3. If 2 on 2 split: ET SEP - MAN
4. OMS I'CNECT FAIL (SE ROLL CNTL/CONT DUMP)
5. ✓BIG 'X', then GPC/CRT as reqd
6. ✓MULT DATA PATH LOSS

Post MECO:

7. ASAP, GPC MODE - STBY,HALT
8. ✓ET SEP - AUTO
9. B/U LH2 VLV - OP
10. If GPC 1(4) ↓: L(R) OMS - sel SEC GMBL
11. If GPC 1(4) failed after ET SEP & no restrg:
    FF MDM - OFF,ON
    If GPC 1: G51 IMU 1 - desel

BFS GPC FAIL
1. Post SRB SEP: FES PRI A - ON

Post MECO:

2. GPC MODE - STBY,HALT, pause, STBY,RUN
    OUTPUT - NORM
3. If recovered: PRO to OPS 302; load TGTs (PEG7)
    GPC OUTPUT - B/U >>
4. If SM only: GPC MODE - STBY, then step 6
5. GPC MODE - HALT
6. If no comm: sel best S-BD PM ANT
7. If RTLS < 120K: H2O PUMP LOOP 1,2 (two) - ON
    NH3 CNTLR A(B) - SEC/ON

FA MDM I/O ERROR
1. I/O RESET

If recovered: Aff FCS CH - ORIDE,AUTO if reqd

2. Aff FCS CH - OFF
3. If 2 GPC/FA/FCS CH ↓: Good FCS CHs - ORIDE
4. OMS I'CNECT FAIL (SE ROLL CNTL/CONT DUMP)
5. ✓MULT DATA PATH LOSS

Post MECO:

6. B/U LH2 VLV - OP
7. If FA1(4): L(R) OMS - sel SEC GMBL

If no BFS 'BCE STRG X PASS':

8. OMS not burning:
    FA MDM - OFF,ON then step 1

MS 3-2A AESP/ALL/A/GEN D

(Reference 2)

Figure 2.2.5-II.- DPS GPC/FA MDM failures crew procedures.

MNA or AC1 Multi Φ

Do not isolate MPS He C
MSTR MADS PWR - OFF
AC BUS SNSR (three) - OFF
OMS I'CNECT FAIL (SE ROLL CNTL/CONT DUMP)
FC SHUTDN (within 9 min)
Post MECO:
BLR CNTLR/HTR 3 - B
L OMS - sel SEC
B/U LH2 VLV - OP
FAILED: SPI, L INST, TAC 1
MLS 1, RA 1, NWS, L HUD

MNB or AC2 Multi Φ

Do not isolate MPS He L
MSTR MADS PWR - OFF
AC BUS SNSR (three) - OFF
OMS I'CNECT FAIL (SE ROLL CNTL/CONT DUMP)
FC SHUTDN (within 9 min)
Post MECO:
BLR CNTLR/HTR 1 - B
SIG CONDP FREON A - AC3
B/U LH2 VLV - OP
FAILED: R INST, TAC 2
MLS 2, RA 2

MNC or AC3 Multi Φ

Do not isolate MPS He R
S-BD PM CNTL - PNL, CMD
MSTR MADS PWR - OFF
AC BUS SNSR (three) - OFF
OMS I'CNECT FAIL (SE ROLL CNTL/CONT DUMP)
FC SHUTDN (within 9 min)
Post MECO:
BLR CNTLR/HTR 2 - B
SIG CONDP FREON AB - AC2
R oms - SEL SEC
FAILED: TAC 3, MLS 3, R HUD
MLS 1, RA 1, NWS, L HUD

SUB BUS [APC 4(5,6) or ALC1(,3)]
1. DO NOT ISOLATE MPS HE C(L,R)
IF APC4(5) or ALC1(2);
2. Post MECO: B /U LH2 VLV - OP

MS 5-7 AESP/ALL/A,E/GEN D,4

(Reference 2)

Figure 2.2.5-III.- EPS AC/MN bus failures crew procedures.

POST MECO
LH2/O2 MANF PRESS HIGH
MPS PRPLT dump seq - start ASAP
✓MCC

MPS DUMMY OMS BURN (Pass)
PEG 7, ΔVX +100
✓/Load TIG, ITEM 22
✓/MNVR, VGOX = +
TIG-2:
  ✓MPS dump seq - GPC
  OMS ENG (two) - OFF
TIG-:15 EXEC
TIG-:05 +X until OMS ↓

MPS DUMMY OMS BURN (BFS)
PEG 7, ΔVX +100
✓Load TIG, ITEM 2 EXEC, ITEM 22 EXEC
✓TIMER, ITEM 23 EXEC
✓MNVR, VGOX = +
TIG-2:
  ✓MPS dump seq - GPC
  L OMS ENG - ARM/PRESS
  OMS ENG CONTROL VV L - OFF
TIG-:15 EXEC
EXPECT: OMS ↓

Figure 2.2.5-IV.- LH_2 dump crew procedure.
(Reference 2)

TITLE

MPS VACUUM INERTING FAILURE

CONDITION

High engine LO_2 or LH_2 manifold pressure (post-propellant dump)

DESCRIPTION

The MPS vacuum inert procedure is a manual procedure initiated at approximately 15 minutes mission elapsed time (MET) on AOA, ATO, and nominal missions. This procedure consists of opening the LO_2 and LH_2 feedline manifolds and LH_2 tank pressurization line to the vacuum of space to vent residuals overboard. The residuals consist of approximately 200 lb_m of LO_2 and 5 lbm of LH_2 which were not vented during the MPS dump. The LO_2 and LH_2 fill/drain valves, the LH_2 topping valve and the press line vent valves are opened to initiate the procedure. The fill/drain, and topping valves are pneumatically actuated valves with activation pressure being supplied by the MPS pneumatic helium system. The LH_2 pressurization line is inerted for 1 minute through the press line vent valve. The valve is closed to allow venting of the ET umbilical compartment prior to closure of the umbilical doors.

The MPS vacuum inert is approximately 30 minutes in duration, with initiation at approximately 15 minutes into the mission and termination 5 minutes prior to the OMS-2 burn (TIG -10 minutes for an AOA). The vacuum inert is terminated by closing the LO_2 and LH2 outboard fill/drain valves and terminating power to all the valves (inboard fill/drain valves, topping valve and pneumatic isolation valves). The outboards are closed and deenergized by placing the two outboard switches to the closed position, allowing 10 seconds for valve closure, then placing the switch to the ground position. The inboards are deenergized by placing the two switches to the ground position; this action will also close the LH_2 topping valve. Finally, the pneumatic helium isolation valves are closed to isolate the helium supply tank, and to remove power from these normally closed solenoid valves.

Should the fill/drain valves fail to open, high engine LO_2 or LH_2 manifold pressure may result. If these pressures are not relieved by the feedline relief system, rupture of the feedline manifold could occur resulting in damage to the aft compartment, and possible loss of crew and vehicle. Burst pressures of the LO_2 and LH_2 manifolds are 390 and 83 psia, respectively. The LH_2 manifold can be inerted by using the backup LH_2 dump valves for failure of the fill/drain valves, while in OPS 1. There is not an alternate dump path for the LO_2 other than the high pressure oxidizer turbopump (HPOT) intermediate seal purge (ISP) package.

If the pneumatic helium supply pressure is inadequate (less than 700 psia) to actuate the fill/drain valves, the left engine's helium will be interconnected to provide sufficient pressure. Helium will be routed by opening the left SSME helium isolation valves and the pneumatics left engine crossover valve. These valves will be closed when the vacuum inert is terminated to isolate the helium systems.

The LO_2 manifold will be inerted for pressure greater than the relief setting (190-220 psia), and less than 40 psia. This process will allow venting of residuals in a hazardous condition and when manifold pressure will not result in vehicle roll, respectively. The propulsive force of LO_2 from the fill/drain on the wing will cause the vehicle to roll out of control. For manifold pressure between 40 psia and the relief setting, the LO_2 inerting will be delayed until the manifold pressure drops below 40 psia. LO_2 will vent overboard through the HPOT ISP package. In the event the pressure does not decay to below 40 psia prior to entry, the MPS entry dump sequence will automatically open the fill/drain valves. The valves are opened at the ground relative velocity of 20K ft/s at which time there is sufficient control authority of the vehicle aerosurfaces to prevent loss of control. The LH_2 manifold will be inerted regardless of the pressure reading; vent forces will not result in loss of vehicle control.

Verification of a good vacuum inert is accomplished by crosschecking the manifold and inlet pressure readings with the nominal values. The nominal values are based on the previous flight readings of the transducers which are vehicle specific, if these are not available the preflight biases from KSC are used. If the actual pressures are above 5 psi, E&D support will be consulted to evaluate repeating the vacuum inerting.

The MPS entry software, on transition to OPS 304, will automatically inert the feedlines of any remaining residuals. Following the inerting, the manifolds are closed and pressurized with helium to prevent atmospheric contamination during entry.

A. Flight Rules

Post-MECO - MPS

1. 5-66, VACUUM INERTING FAILURE
2. 5-67, VACUUM INERTING REPEAT OPERATIONS
3. 5-68, LH_2 PRESSURIZATION VENT CONTROL

B. Crew Operations

TABLE 2.2.6-I.- HARDWIRE CAUTION AND WARNING FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(LO_2 MANF P) V41P1533C	LO_2 MANF PRESS > 249 psia (class 2 alarm)	PNL F7
(LH_2 MANF P) V41P1433C	LH_2 MANF PRESS > 60 psia (class 2 alarm)	PNL F7

TABLE 2.2.6.-II.- BFS/PASS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(LO_2 MANF P) V41P1533C	LO_2 MANF PRESS > 249 psia (class 2 alarm)	PNL F7
	"MPS LH_2/O_2 MANF" (class 2 alarm)	FML
(LH_2 MANF P) V41P1433C	LH_2 MANF PRESS > 60 psia (class 2 alarm)	PNL F7
	"MPS LH_2/O_2 MANF" (class 2 alarm)	FML

Note: In PASS SM operational during OPS 2 and 9; in BFS SM operational during launch, deorbit, and entry.

1. Crew Procedures - None

2. Crew Activity

TABLE 2.2.6-III.- CREW ACTIVITY

Step	Activity	Position
1	If the LO_2 manifold press > 249 psia after the MPS propellant dump, the MPS LO_2/LH_2 fill/drain valves will be opened. EXPECT VEHICLE ROLL.	PLT
2	If the LH_2 manifold press > 60 psia after the MPS propellant dump, the MPS LO_2/LH_2 fill/drain valves will be opened.	PLT

C. MCC Operations

TABLE 2.2.6-IV.- FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(LH_2 OB F/D C) V41X1389X	LH_2 outboard F/D valve closed during vacuum inert	MSK 1054,1055 DDD 288
(LH_2 MANF P) V41P1433C	LH_2 MANF PRESS > 55 PSIA	MSK 1054,1055 DDD 288
(LO_2 OB F/D C) V41X1514X	LO_2 outboard F/D valve closed during vacuum inert	MSK 1054,1055 DDD 288
(LO2 IB F/D C) V41X1509X	LO2 inboard F/D valve closed during vacuum inert	MSK 1054, 1055 DDD 298
(LO_2 MANF P) V41P1533C	LO_2 MANF PRESS > 220 psia	MSK 1054,1055 DDD 288
(Pneu Tk P) V41P1600A	Pneumatic tank pressure < 700 psia	MSK 1054

1. MCC Activity

TABLE 2.2.6-V.- MCC ACTIVITY

Step	Activity	Position
1	Report LO_2 inboard or outboard F/D valve, or LH_2 outboard F/D valve failed closed.	MPS/BSE/ FD/crew
2	If the LH_2 outboard F/D valve is failed closed, request backup LH_2 valves be opened when in OPS 1.	MPS/BSE/ FD/crew
3	If the backup LH_2 valves were not closed prior to entering OPS 2, a real-time 482 change may be required to cycle MDM's. See SCP 2.2.5, Supporting Data for this procedure	MPS/BSE/ FD/crew
4	If MPS pneumatic tank pressure < 700 psia, open left engine helium isolation valves and pneumatic left engine crossover valve	MPS/BSE FD/crew

2. Supporting Data - None

3. Note: Rockwell refers to the backup LH_2 valves as the LH_2 RTLS dump valves.

REFERENCES

1. STS Operational OFT Flight Rules, Baseline, JSC-12820, Sept. 1, 1987.

2. Space Shuttle Systems Handbook

3. Booster Data Pack

4. Shuttle Operational Data Book.

TITLE

SRB PC SENSOR FAILURE

CONDITION

Two of three chamber pressure (Pc) sensors on a given solid rocket booster (SRB) fail in such a way as to cause a delayed separation of the two SRB's. The delayed separation may be due to two sensors on one SRB failed high or failed low; or, one sensor failed high or low and the other sensor disabled by a failed (commfaulted) flight aft (FA) multiplexer/demultiplexer (MDM).

DESCRIPTION

The SRB separation sequence is called at "SRB SEP SEQ INITIATION TIME" (MET 1:40). This SCP describes the sequence flow for separation and the effect of individual sensor failures on that sequence. The logic flow for the SRB separation sequence is contained in figure 2.2.7-I, and a table of I-loads used in this sequence is presented in table 2.2.7-I. For a complete discussion of the SRB separation sequence, refer to the Booster Systems Software Handbook section 2.4, SRB Separation Sequence.

In the primary avionics software system (PASS), the SRB sequence is initiated at 1:40 OMET and the mid-value select of the three thrust Pc sensors for each SRB is compared for a decay below 50 psia within 5 seconds of each other. The 5-second timer starts as soon as either SRB's mid-value is less than 50 psia. The SRB separation sequence is designed to monitor the mid-value of three transducers on the left and right SRB's. If one transducer is disabled by a commfaulted FA MDM, the software will automatically monitor the average of the remaining two sensors for the Pc less than 50 psia cue. If a second sensor is disabled by another FA MDM commfault, then the remaining sensor is monitored. If a third sensor fails, the software will use the last good value. If for some reason both SRB's are not below 50 psia within the 5 seconds, then the separation sequence will not continue until a MET of 2:11.3.

Pc failures on either SRB result in an SRB SEP delay until a MET of 2:11.3 is reached. If the check on both SRB's Pc's is not less than 50 psia within 5 seconds. This situation can be caused by the following failure cases:

A. Two Pc Sensors Failed High On One SRB

The failure of two-out-of-three Pc sensors on one SRB to the high state causes the mid-valued sensor to be above 50 psia on that SRB and thus prevents the software from passing the 5-second time check.

B. One FA MDM Commfaulted And One Pc Sensor Failed High

The commfault of FA MDM 1, 2, or 3 forces the software to look at the average of the two remaining sensors on each SRB. If one Pc sensor is failed high, the average value will never drop below 50 psia and the 5-second check will not be passed.

C. Two Pc Sensors Failed Low

This failure case might or might not cause a delayed separation. If both sensors on one SRB have failed low before the sensors check starts at 1:40 OMET, then by the time the other SRB's Pc mid-value drops below 50 psia, the 5-second check may have been violated.

D. One FA MDM Commfaulted And One Pc Sensor Failed Low

If the MDM commfault and Pc sensor failure occurs and the resulting average of the two remaining sensors drops below 50 psia 5 seconds before the other SRB's average value, then a delayed separation will occur. This case is more remote than the two Pc sensor failed low case, since the averaged value will take longer to drop below 50 psia than then mid-value selected Pc.

If the Pc versus time comparison is properly met, SRB separation will occur at approximately MET 2:06. The actual separation time will vary slightly based on the temperature of the SRB propellant (cold solid propellants burn slightly longer than warm propellants) and the separation command delay I-loads chosen for a specific flight. Also the effect of a premature SSME shutdown will change this I-load to a longer time to ensure very low SRB thrust at separation so as to reduce the possibility of recontact for contingency abort scenarios. These I-loads can be found in Mission I-Load Requirements Document, JSC-19350, vol. 2.

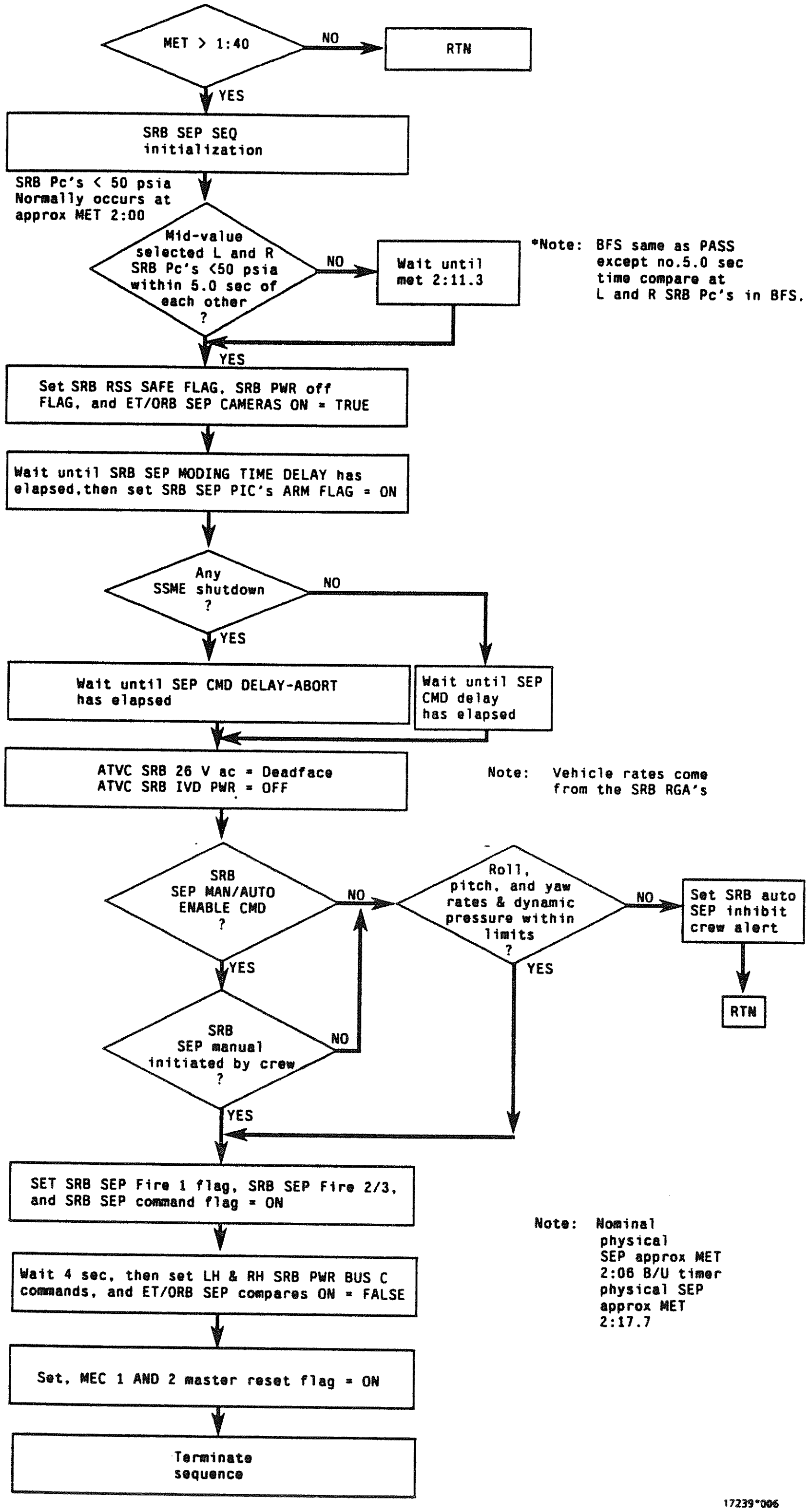
Except for the absence of the 5-second time constraint for Pc decay comparison, the backup flight system (BFS) processing is the same as the PASS. The mid-value select Pc for each SRB is monitored by the BFS and separation is commanded when the two Pc's decay below 50 psi, or at MET 2:11.3 when this comparison is not met. The absence of the time comparison creates one significant difference in the failure cases. If two Pc's on one SRB fail high, the mid-value select will be high and separation will be delayed, just as in PASS. If, however, two Pc's fail low, the mid-value select will be low and the Pc < 50 psia comparison with the other SRB will be met so normal separation will occur. This situation is not true for PASS since the 5-second time constraint would be violated.

SRB Pc's 1, 2, and 3 are displayed on MSK 1054 when in PASS; however, only the mid-value select Pc for each SRB is displayed on the BFS display, MSK 1064 or 1089.

A delayed SRB separation will probably result in a depressed trajectory and a reduced MPS flight performance reserve. Although no corrective action is possible, a dual SRB Pc failure on either SRB is passed to the flight director and crew as information which may affect later flight malfunction decisions (e.g., abort gap tolerances).

TABLE 2.2.7-I.- SRB SEPARATION TIME DELAY VALUES SUMMARY

Name	MSID	STS-35 value (sec)	Rationale
SRB SEP sequence initiation time (t_{init})	V97U9750C	100	Adequate time to allow detection of multiple P_c transducer failures to the new state less than minimum time for fastest SRB to achieve P_c = 59.4 minus Δt_{diff}. Includes 9.4 psi transducer error.
SRB SEP backup cue time ($t_{b/u}$)	V97U9751C	131.3	Protects against multiple P_c transducer failures on same SRB. Latest time that slowest SRB reaches max allowable thrust at separation for steel case SRB minus ΔT_{cmd}.
Function moding time (Δt_{fm})	V97U9752C	3.2 (Δt_{cmd} minus 1.7 seconds)	Time for SRB nozzles to reach null position from full thrust angle (5°) when driven at minimum rate (3°/sec). Also allows sufficient time for PIC's to charge (~1 second).
SRB SEP command time delay, nominal (ΔT_{cmd})	V97U9753C	4.9 c	Ensures SRB thrust < maximum allowable at separation. Ti from P_c = 59.4 psia to Fnax with all SSME's on.
SRB SEP command time delay, abort ($\Delta t_{cmd\text{-}abort}$)	V99U7589C	10	Ensures very low SRB thrust at separation. Used for 1 or 2 SSME's out; reduces probability of recontact for contingency abort scenarios.
Maximum SRB SEP cue differential time (Δt_{diff})	V97U9761C	5	Maximum expected Δt between a fast-burning SRB achieving 59.4 psia and a slow SRB achieving 40.6 psia (matched psi worst PMBT).



*Note: BFS same as PASS except no.5.0 sec time compare at L and R SRB Pc's in BFS.

Note: Vehicle rates come from the SRB RGA's

Note: Nominal physical SEP approx MET 2:06 B/U timer physical SEP approx MET 2:17.7

Figure 2.2.7-I.- SRB SEP Sequence (PASS).

A. Flight Rules - None

B. Crew Operations - None

C. MCC Operations

TABLE 2.2.7-II.- PASS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(L SRB Pc) (1) B47P1300C (2) B47P1301C (3) B47P1302C (R SRB Pc) (1) B47P2300C (2) B47P2301C (3) B47P2302C	Two SRB Pc's go off-scale high or low on either left or right SRB. SRB Pc's should normally read within ± 20 psia of one another.	MSK 1054 DDD 289

TABLE 2.2.7-III.- BFS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(L SRB Pc) V98P1740C (R SRB Pc) V98P1741C	L SRB Pc or R SRB Pc mid-value goes off-scale high.	MSK 1089 1090 1064

1. Console Cue Card - See tables 2.2.7-I, 2.2.7-IV, and 2.2.7-V.

TABLE 2.2.7-IV.- SRB SEP CUE CARD

Indications	Cause	Action
No SRB Separation	PASS moding to MM 103 with no physical SRB SEP (crew indication)	Engage BFS BFS will execute SRB SEP auto upon engagement
SRB SEP INHIB (Crew ascent traj and ground TLM)	Rates > P +2.0 R +5.0 Y +2.0 Q > 63	If rates are decreasing wait for rates to damp Rates not damping or Q violated at SEP INHIB +5 sec SRB SEP SW to man./auto initiate SEP via PB
SRB SEP MAN ENAB (Ground TLM only)	Switch default to man./auto mode	No action (auto SEP if rates and Q within limits)

Delayed separation --> 137.7 sec
With engine out --> 140.2 sec

TABLE 2.2.7-V.- DELAYED SRB SEP FAILURES CUE CARD

Indication	Failures								
	FA MDM			OF DSC PWR					
	1	2	3	1	2	3	1/2	1/3	2/3
Delayed SRB SEP (137.7)		X or	X and	X					
	X	or	X	and	X				
	X or	X			and	X			
							X		
								X	
									X

Note: Switch failure only occurs if FF MDM failure occurs first and power second.

2. MCC Activity

TABLE 2.2.7-VI.- MCC ACTIVITY

Step	Activity	Position
1	When first SRB Pc fails high or low, report: "L(R) SRB Pc 1(2,3) fail high (low): One failure away from delayed SRB Sep"	MPS/BSE
2	When second SRB Pc fails in the same direction (high or low), report: "Expect delayed SRB SEP"	MPS/BSE/ FD/crew
3	If BFS is engaged and L (R) SRB Pc fails high, report: "Expect delayed SRB SEP"	MPS/BSE/ FD/CREW

3. Supporting Data

   a. Figure: Figure 2.2.7-I

   b. Tables: Table 2.2.7-I

   c. Note: None

REFERENCES

1. Booster Systems Software Handbook, Sec. 2.4, JSC-19395

2. Booster Console Handbook, FINAL, REV-C, JSC-17239, April 10, 1987.

3. Shuttle Operational Data Book, JSC-08934, October 1984.

4. Mission I-Load Requirements Document, Volume II, JSC-19350.

5. Level C Functional Subsystem Software Requirements, STS 83-0026B, September 9, 1987.

TITLE

SRB TVC REDUNDANCY LOSS

CONDITION

Failure of hydraulic power unit (HPU) A (B) or its associated fuel supply module (FSM).

DESCRIPTION

The rock and tilt actuators, which provide thrust vector control (TVC) for the solid rocket boosters (SRB's), receive hydraulic power from two HPU's. The rock actuator receives primary power from HPU A and secondary power from HPU B. The tilt actuator receives primary power from HPU B and secondary power from HPU A. Each HPU is driven by a SRB auxiliary power unit (APU) which receives propellant from its own FSM. The TVC system is designed to withstand the loss of one HPU or APU. Such a loss creates the SRB TVC redundancy loss. If both HPU's on one SRB fail, the TVC system will attempt to lock up both rock and tilt actuators in the last commanded position. This may result in loss of the vehicle, depending on the nozzle gimbal angle at failure. The TVC system will attempt gimbal angle lockup when both hydraulic pressures are less than 700 psia. Between 700 psia and 2800 psia gimbal angle control is available, but at a greatly reduced vector angle rate.

A. Flight Rules

1. Failure Definitions

   5-1, LOSS OF SRB HYDRAULIC POWER UNIT (HPU)

2. Powered Flight

   5-20, LOSS OF SRB HYDRAULIC POWER UNIT (HPU)

B. Crew Operations

The crew has no capability for monitoring SRB performance. They have no procedures to follow and can make no response to a ground call. A ground call is passed to the crew as information because loss of the second APU or HPU on the same actuator may result in loss of vehicle control.

C. MCC Operations

TABLE 2.2.8-I.- PASS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(FSM A PRESS) (R) B46P2305C (L) B46P1305C (HYD SUP A PRESS) (R) B58P2303C (L) B58P1303C (ROCK ACTR PRI P OK)* (R) B58X2860X (L) B58X1860X	Loss of SRB TVC redundancy can be identified in the following ways: R (L) FSM A [B] PRESS < 240 psia and R (L) HYD SUP A [B] PRESS < 2800 psia and R (L) ROCK [TILT] ACTR PRI POWER light on indicates a problem in the R (L) FSM A [B] that has caused the R (L) ROCK [TILT] actuator to be switched to secondary supply pressure	MSK 1054 DDD 288
(FSM B PRESS) (R) B46P2306C (L) B46P1306C (HYD SUP B PRESS) (R) B58P2304C (L) B58P1304C (TILT ACTR PRI P OK)* (R) B58X2859X (L) B58X1859X	R (L) HYD SUPP A [B] PRESS < 2800 psia and R (L) ROCK [TILT] ACTR PRI POWER light on indicates a loss of the R (L) HPU A [B] that has caused the R (L) ROCK [TILT] actuator to be switched to secondary supply pressure	

*- ROCK(TILT) ACTR PRI P OK is presented on DDD 288 with reverse logic. That is, the absence of the indication is the nominal condition. MSK 1054 displays an "S" on the row labeled "PR R/TP" when the Left (Right) Rock (Tilt) actuator has switched to the secondary supply.

The hydraulic power will shift from the primary to secondary HPU when the primary HPU hydraulic pressure drops below 2050 psia (±150 psia), or when the primary FSM pressure drops below 80 psig.

Note: There is no BFS failure recognition.

1. Console Cue Card - Table 2.2.8-II

- Assumes transducer data valid. B/U transducers are not available with SRB HPU/TVC system except for magnetic pickup units (MPU's)

TABLE 2.2.8-II.- SRB HPU/TVC FAILURE CUE CARD

FSM pressure (PSIA)	Turbine speed (RPM)	Hydraulic pressure (PSIA)	Primary actr pri P failed	Problem
P > 240	72,000 +(-) 6000	P > 2800	----	Nominal ops
P > 240	72,000 +(-) 6000	2200-2800	----	Sick HPU, TVC, or hydraulic leak
P > 240	RPM < 66,000	2200-2800	----	Sick HPU, turbine, or low hydrazine supply rate
P > 240	80,640 +(-) 6000 (112% PWR) B/U MPU in control of rpm	P > 2800	----	Primary HPU control circuit failed, or primary control valve failed open, or primary MPU failed
P < 240	72,000 +(-) 6000	P > 2800	---	FSM leak, either hydrazine or nitrogen
P > 240	79,200 +(-) in B/U HPU (110% pwr)	P < 2200 in prime HPU	DDD light ON - pri actr failed	Failed primary HPU on B/U HPU for both rock and tilt
P < 80	79,200 +(-) 6000 in B/U hpu (110% powr)	P < 2200 in prime hpu	DDD light ON - pri actr failed	Failed primary HPU as a result of FSM leak on B/U HPU for both rock and tilt
Any value	Any value	P < 800 on both pri and B/U HPU's	DDD light ON - pri actr failed	Both primary and B/U HPU's failed. TVC will attempt lockup at last commanded position

2. MCC Activity

TABLE 2.2.8-III.- MCC ACTIVITY

Step	Activity	Position
1	Monitor FSM, HY SUP, and PRI PWR indications on MSK 1054* and DDD 288	MPS
2	For right (left): FSM A [B] PRESS < 240 psia HYD SUP A [B] PRESS < 2800 psia ROCK [TILT] PRI PWR indication lighted Report: "Loss of redundancy of right (left) SRB due to FSM A [B] failure" Also notify KSC that the FSM failure creates possible presence of hydrazine on R (L) SRB. This information is vital to the SRB recovery team	MPS/BSE/ FD/crew/ KSC
3	For right (left); HY SUP A [B] PRESS < 2800 psia ROCK [TILT] PRI PWR indication lighted Report: "Loss of redundancy of right (left) SRB due to HPU A [B] failure"	MPS/BSE/ FD/crew
4	For other combinations of the data in step 2, notify BSE of sensor fail indications. Continue to monitor for further degradation	MPS/BSE

* MSK 1054 displays an "S" on the row labeled "PR R/TP" when the Left (Right) Rock (Tilt) actuator has switched to the secondary supply.

REFERENCES

1. Shuttle Operational Data Book, JSC-08934.

2. STS Operational Flight Rules, All Flights, Final, PCN-6, JSC-12820, July, 1990

3. DF65 Data Pack.

4. Booster Systems Briefs, Basic, Rev B, JSC-19041, April, 1990.

TITLE

MPS ENTRY HELIUM PURGING MALFUNCTION

CONDITIONS

A. Insufficient helium to provide aft compartment purge, and MPS/SSME repressurization during entry

B. Critical electrical power/cooling requirements dictate that a minimum number of helium valves can be operated

DESCRIPTION

During entry, the OMS pods (2), the LH_2 external tank umbilical cavity, and the aft compartment are purged of hazardous gas concentration that might have built up in these critical areas. Failure to purge might result in fire from excessive vapor concentration, and possible loss of vehicle.

During entry, the MPS/SSME lines and manifolds are repressurized to prevent contamination by ambient air during entry. Such contamination would require disassembly and decontamination of the MPS/SSME components prior to subsequent flight.

The MPS entry purge requires one of two basic configurations. If there are no dual electrical power problems or Freon loop problems, the nominal entry purge configuration will be used. This configuration is basically the same for nominal, AOA, and TAL entries and requires a 122-SCFM average helium purge to the OMS pods, a 244-SCFM average helium purge to ET umbilical cavity, and a 4-SCFM helium purge to the LO_2 and LH_2 manifolds. The total flow rate averages about 5.25 lb/min from V_{REL} = 4500 ft/sec to touchdown. The flow is supplied through the left helium A regulator and passes through the crossover valve. Approximately 74 lb of helium are required to complete the 650-second purges. The helium system is configured pre-deorbit burn so that entry software will start the helium to flow at the V_{REL} = 4500 fps point. At this point in the descent, the software sequence will normally command the LO_2 and LH_2 manifold repress valves and helium blowdown valves to open. The LH_2 RTLS dump valves are closed at this time.

The aft compartment is purged during all entries for simplification. Members of the MPS community, however, have agreed that flight procedures can be modified real time based on the following:

a. Aft compartment entry purge is mandatory for RTLS and TAL aborts, even in the case of loss of dual Freon loops or dual fuel cells.

b. Aft compartment entry purge is mandatory for AOA unless a MPS propellant dump and a minimum of 5 minutes of MPS vacuum inerting have been accomplished.

c. Aft compartment entry purge should be considered mandatory when a leak of other hazardous fluid; e.g., N_2H_4, NH_3 or hydraulic oil, is determined to exist prior to entry.

d. Aft compartment entry purge has not been a requirement for normal entry when normal MPS dump and inerting have been accomplished.

Crew procedures also exist to cover vehicle powerdown for the loss of two fuel cells and the loss of two Freon loops. Basically these procedures are the same for EOM and AOA entries. Note that there are two separate AOA books in the Flight Data File, the Systems AOA book, and the normal AOA book for all cases other than two Freon loops or two H_2O loops failing in a standalone procedure. MPS valves that are normally closed will be positioned to save power (approximately 230 W). No LO_2 or LH_2 manifold repress will be attempted. This may result in MPS line contamination which will require more thorough cleaning procedures postlanding.

The aft compartment purge will be lost if either the main A power supply, or FA3 or FA4 is lost (ref. SCP 4.5). If main A is lost and the loss is not due to an internal bus short, main B or main C can be crosstied to regain aft compartment purge capability.

Restringing of the GPC's will be attempted to regain dump capability for GPC failures that result in a loss of LH_2 dump capability for RTLS and TAL aborts.

Figure 2.2.9-I is a logic diagram which shows how the MPS helium system is configured in the Flight Data File for EOM, AOA, and TAL cases. It covers nominal as well as powerdown situations.

The procedures mentioned above cover reconfiguration for powerdown constraints. If a failure occurs that would cause a manifold to leak helium excessively, then the manifold repress valves to the respective LO_2 or LH_2 manifold should be closed before entry. This action will require a real-time crew procedure change to the appropriate checklist. Failure modes that could cause this problem include failure to close the LO_2 feedline disconnect valve, both LO_2 inboard and outboard fill and drain valves, the LH_2 feedline disconnect valve, both LH_2 inboard and outboard fill and drain valves, or both LH_2 RTLS dump valves. Normally all of these valves will be closed at vacuum inerting terminate. Also the LO_2 prevalves will be closed at $V_{rel} < 4.5$ Kft on entry, thus allowing only a 4-SCFM leak through the HPOT intermediate seal package. If one of the LOX prevalves cannot be closed, the LO_2 manifold repress will still be performed unless the total helium mass is less than 74 lbms.

One other procedure will occur during entry that requires helium system operation. The SSME hydraulic repressurization (SSME HYD REPRESS), which is shown in fig. 2.2.9-II (Ref. 6), requires the center and right helium isolation B valves to be opened for 10 seconds while hydraulics is being applied for 10 seconds to the SSME ball valves and TVC actuators via the TVC isolation valves. Applying helium pressure to the engines will prevent the engine valves from moving when hydraulics is applied to stiffen the TVC actuators at EI - 11 minutes. Helium will be applied to the left SSME at the MM304 transition when the vent door sequence opens the pneumatic crossover valve. The only reason for not applying helium to an engine during this procedure is a serious leak below the isolation valves. In this case the appropriate helium isolation valve will remain closed during entry. This change will require a real-time crew procedure change to the SSME hyd repress procedure. If the leak is in the left SSME helium system, the entry repress configuration will need to be changed to keep the left helium isolation valves closed, the crossover valve closed (if leak is at the engine only), and to open the left helium out interconnect.

A. Flight Rules

Post-MECO - MPS

1. 5-69, ENTRY MPS HELIUM PURGING FOR CRITICAL VEHICLE POWER/COOLING

2. 5-70, SSME HYD REPRESS/POSTLANDING SSME REPOSITIONING

B. Crew Operations

1. Recognition of Failure

   a. Helium Shortage - PASS/BFS (Case A)

      The crew has no accurate indication of available He quantity. Only pressure, not mass quantities, is on display. They follow established procedures unless they receive a ground call to deviate from those procedures.

   b. Power Critical (Case B)

      Crew recognition of a fuel cell or Freon loop failure is beyond the scope of this SCP. Refer to EECOM SCPS for this case.

   c. Avionics Systems (Case C)

      Crew recognition of avionics systems failures is beyond the scope of this SCP. Refer to DPS and EPS SCPS for this case.

2. Crew Procedures - Figure 2.2.9-I is used to track nominal crew procedures.

3. Crew Activity

TABLE 2.2.9-I.- CREW ACTIVITY

Case	Activity	Position
A	No corrective action available	N/A
B	If MCC reports powerdown required for loss of two Freon loops, the crew will perform the loss of two Freon loops procedure in the Contingency Deorbit Prep or Entry Pocket Checklist (ref. 5 and 7) If MCC reports powerdown required for loss of two fuel cells, the crew will perform the loss of two fuel cells procedure in the Contingency Deorbit Prep or Entry Pocket Checklist (ref. 5 and 7)	PLT and CDR
C	If MCC reports GPC restringing is required to gain back LH2 dump capability for RTLS or TAL aborts, the crew will perform the PASS GPC (first fail or second fail) procedure in the Ascent Pocket Checklist or Entry Pocket Checklist (ref. 7 and 10) If MCC reports that Main A power supply is lost and a crosstie with Main B or Main C is needed, the crew will perform the bus tie procedure in the Ascent Pocket Checklist or Entry Pocket Checklist (ref. 7 and 10)	PLT and CDR

C. MCC Operations

1. Recognition of Failure

   a. Helium Shortage - Table 2.2.9-II

      The remaining onboard helium available for purges can be determined through the use of an algorithm on the MPSR Masscomp computer terminal (Ref. SCP 7.2.1).

   b. Power Critical - EECOM or crew reports a fuel cell or Freon loop is lost.

2. Console Cue Cards - Figure 2.2.9-I is used.

TABLE 2.2.9-II.- MCC HELIUM SHORTAGE DETERMINATION

Parameter no.	Failure value/trend	Displayed on
(He Tk Temp) (C) V41T1152A (L) V41T1252A (R) V41T1352A (P) V41T1601A	Values used by MPS operator to compute He quantity remaining	MSK 1054 1085 DDD 291
(He Tk Press) (C) V41P1150C (L) V41P1250C (R) V41P1350C (P) V41P1600A	Values used by MPS operator to compute He quantity remaining	MSK 1054 1085 DDD 290 291

3. MCC Activity

TABLE 2.2.9-III.- MCC HELIUM QUANTITY REPORTING

Step	Activity	Position
1	Report He quantity remaining post-MECO.	MPS/BSE

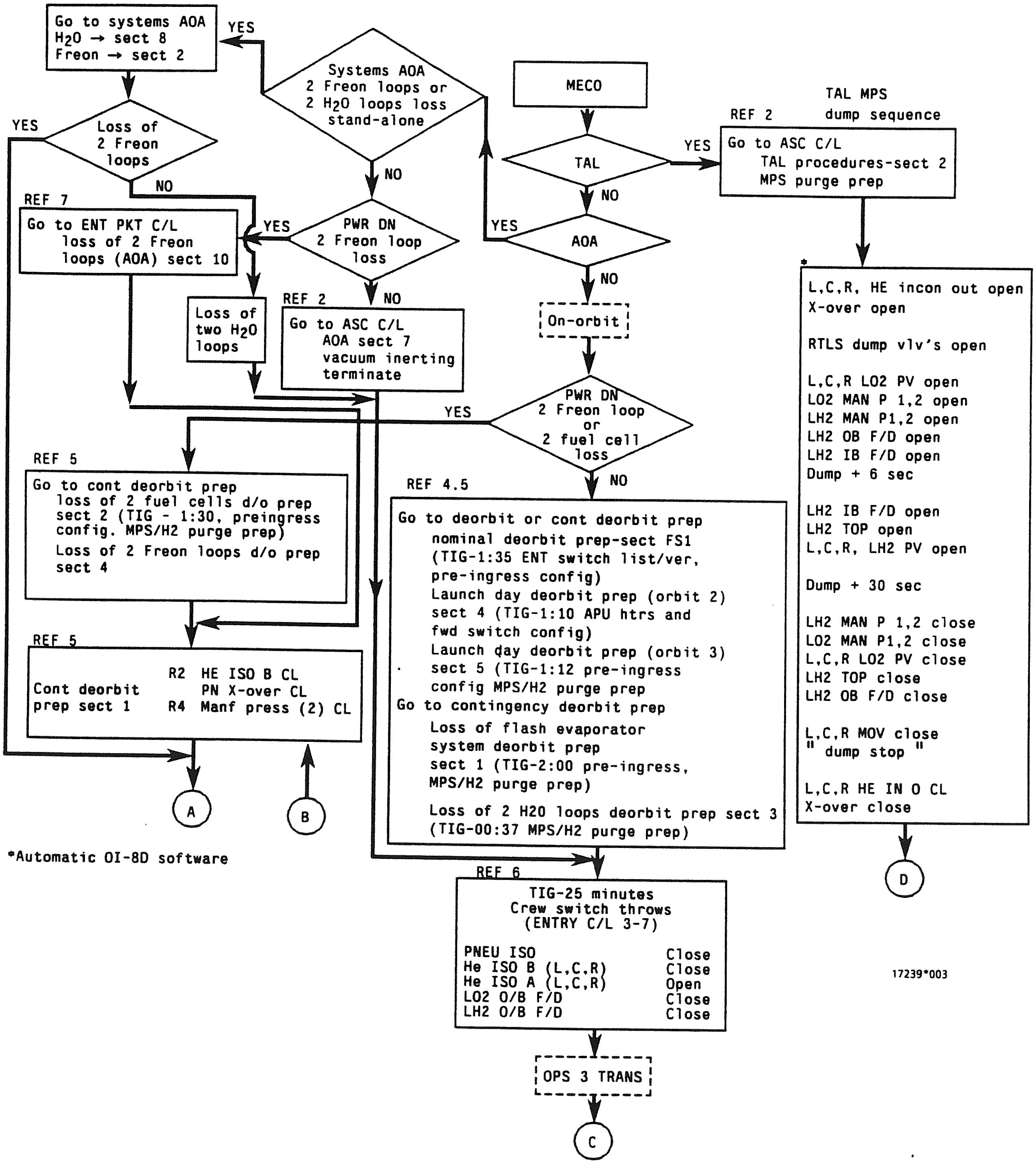
4. Supporting Data

   a. Figures - See notes

   b. Tables - None

   c. Notes:

      Helium quantity available for purges based on Rockwell International blowdown test results (ref. 8)



*Automatic OI-8D software

Figure 2.2.9-I.- Crew procedures for MPS helium purge.

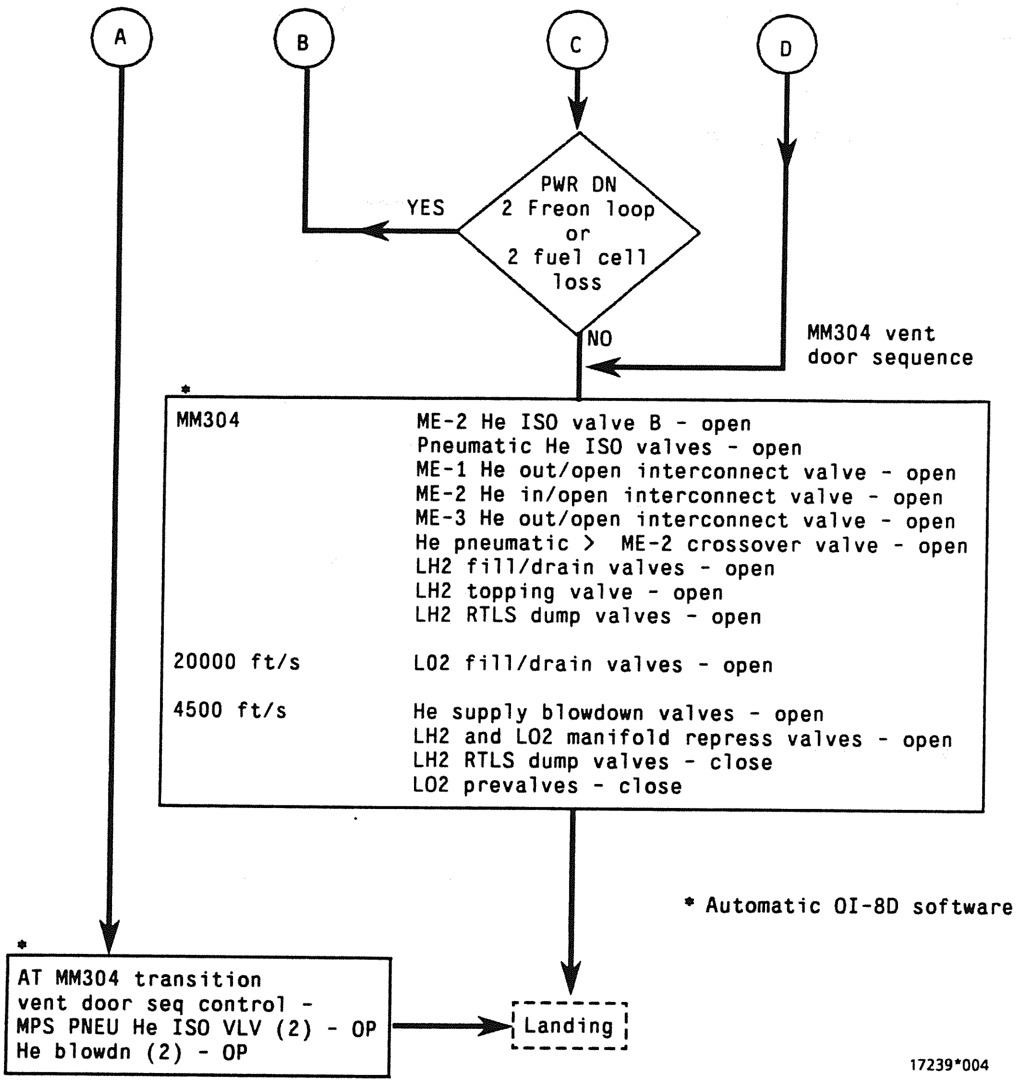


Figure 2.2.9-I.- Continued.

1: GNC DEORB MNVR COAST	2: GNC DEORB MNVR COAST
3: BFS, SM SYS SUMM 2	

* P **SSME HYD REPRESS**

R2 ✓HYD MN PUMP PRESS (three) - NORM

* If HYD SYS 2 or SYS 1 failed, *
* cycle SYS 3 *

R4 HYD MPS/TVC ISOL VLV SYS 2 - OP (MA - possible)
Hold 5 sec, ✓tb - OP
Wait 10 sec - CL
Hold 5 sec, ✓tb - CL
HYD MPS/TVC ISOL VLV SYS 1 - OP (MA - possible)
Hold 5 sec, ✓tb - OP
Wait 10 sec - CL
Hold 5 sec, ✓tb - CL

ENT/ALL/GEN A,4

*Reference 6

Figure 2.2.9-II.- Crew procedure for SSME hydraulic system repressurization.

REFERENCES

1. STS Operational Flight Rules, All Flights, Final, PCN-6, JSC-12820, July 1990.
2. Flight Data File Ascent Checklist
3. Flight Data File Post-Insertion
4. Flight Data File Deorbit Prep
5. Flight Data File Contingency Deorbit Prep
6. Flight Data File Entry Checklist
7. Flight Data File Entry Pocket Checklist
8. Shuttle Operational Data Book
9. Booster Systems Software Handbook, Basic/Rev 3 (Preliminary), JSC-19395, Dec. 1, 1987.
10. Flight Data File Ascent Pocket Checklist

TITLE

CRITICAL INSTRUMENTATION LOSS

CONDITION

Failure of onboard instrumentation (either through transducer, MDM, or GPC failure) that provide critical information to the MPS console. Transducer failure can occur as fail high, fail low, drift, or erratic shift. MDM or GPC failure will cause the displayed data to go static. Figure 2.2.10-I is used to determine the data (covered in this SCP) that will go static as a result of a specific MDM or GPC failure. This SCP focuses on the reliability of the affected instrumentation rather than the mode of failure.

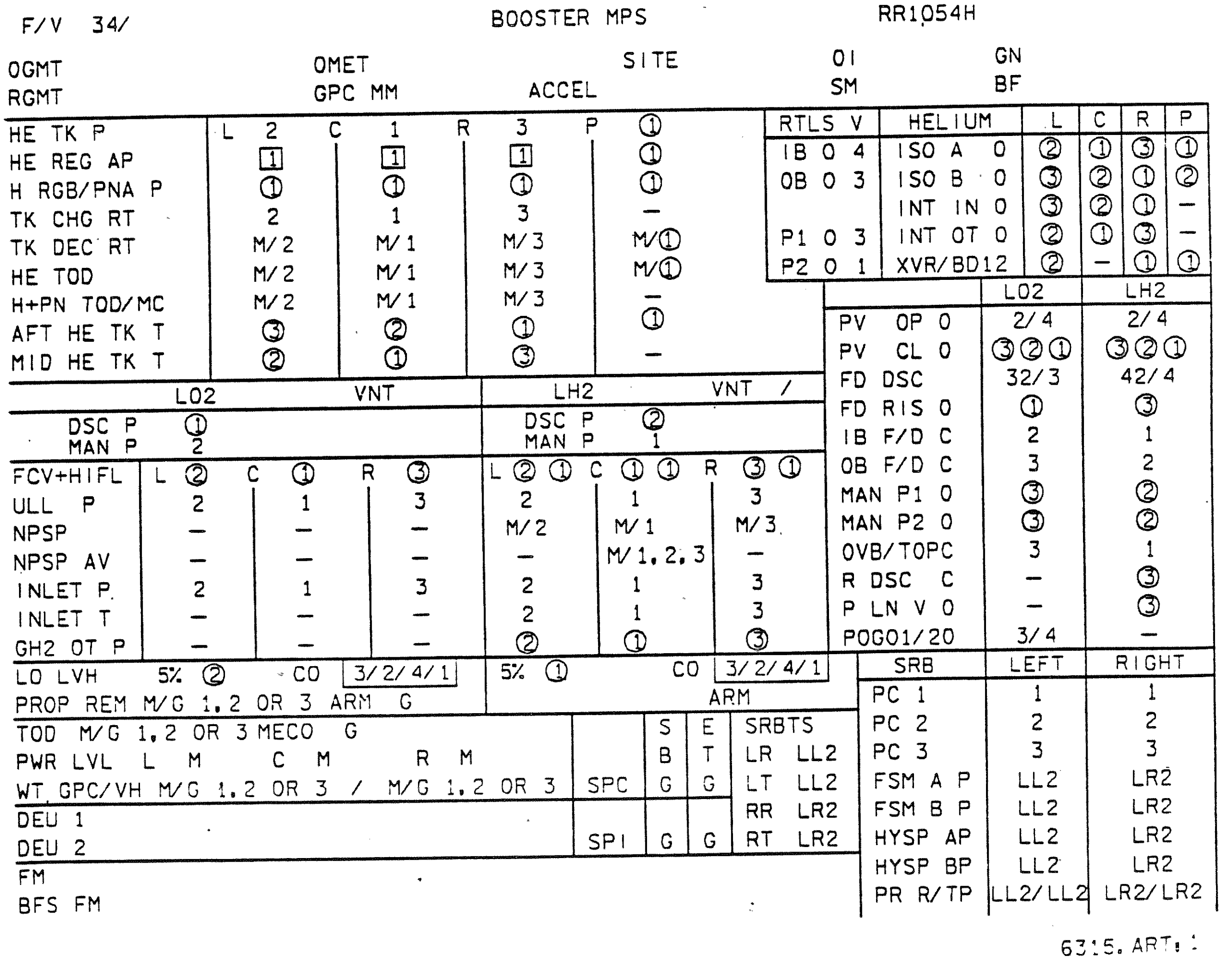
DESCRIPTION

MPS console procedures are based upon several critical parameters provided by onboard instrumentation. The following parameters are in this category.

- He tank pressure L (C, R, Pneu)
- He regulator pressure A(B)
- LO_2 (LH_2) manifold pressure
- Ullage pressure
- SRB Pc
- SRB fuel supply module A(B) pressure
- SRB hydraulic supply A(B) pressure

Loss of data is compensated by observing other related parameters. This SCP outlines the workaround procedures used for loss of each of these parameters.

N = FA MDM
$\boxed{N}$ = OF MDM
Ⓝ = OA MDM
M = COMP
G = GPC



F/V 34/ BOOSTER MPS RR1054H

OGMT OMET SITE OI GN
RGMT GPC MM ACCEL SM BF

	L	C	R	P
HE TK P	2	1	3	①
HE REG AP	$\boxed{1}$	$\boxed{1}$	$\boxed{1}$	①
H RGB/PNA P	①	①	①	①
TK CHG RT	2	1	3	—
TK DEC RT	M/2	M/1	M/3	M/①
HE TOD	M/2	M/1	M/3	M/①
H+PN TOD/MC	M/2	M/1	M/3	—
AFT HE TK T	③	②	①	①
MID HE TK T	②	①	③	—

RTLS V	
IB O	4
OB O	3
P1 O	3
P2 O	1

HELIUM	L	C	R	P
ISO A O	②	①	③	①
ISO B O	③	②	①	②
INT IN O	③	②	①	—
INT OT O	②	①	③	—
XVR/BD12	②	—	①	①

	LO2	LH2
PV OP O	2/4	2/4
PV CL O	③②①	③②①
FD DSC	32/3	42/4
FD RIS O	①	③
IB F/D C	2	1
OB F/D C	3	2
MAN P1 O	③	②
MAN P2 O	③	②
OVB/TOPC	3	1
R DSC C	—	③
P LN V O	—	③
POGO1/2O	3/4	—

LO2 VNT LH2 VNT /

LO2		LH2	
DSC P	①	DSC P	②
MAN P	2	MAN P	1

	LO2 L	LO2 C	LO2 R	LH2 L	LH2 C	LH2 R
FCV+HIFL	②	①	③	② ①	① ①	③ ①
ULL P	2	1	3	2	1	3
NPSP	—	—	—	M/2	M/1	M/3
NPSP AV	—	—	—	—	M/1, 2, 3	—
INLET P	2	1	3	2	1	3
INLET T	—	—	—	2	1	3
GH2 OT P	—	—	—	②	①	③

LO LVH 5% ② CO 3/2/4/1 5% ① CO 3/2/4/1
PROP REM M/G 1, 2 OR 3 ARM G ARM
TOD M/G 1, 2 OR 3 MECO G
PWR LVL L M C M R M
WT GPC/VH M/G 1, 2 OR 3 / M/G 1, 2 OR 3

	SB	ET
SPC	G	G
SPI	G	G

DEU 1
DEU 2
FM
BFS FM

SRBTS	
LR	LL2
LT	LL2
RR	LR2
RT	LR2

SRB	LEFT	RIGHT
PC 1	1	1
PC 2	2	2
PC 3	3	3
FSM A P	LL2	LR2
FSM B P	LL2	LR2
HYSP AP	LL2	LR2
HYSP BP	LL2	LR2
PR R/TP	LL2/LL2	LR2/LR2

6315. ART: 1

Figure 2.2.10-I.- MDM and GPC assignment.

A. Helium Tank Pressure

1. Flight Rule - None

2. Crew Operations

TABLE 2.2.10-I.- FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(He Tk P) (C) V41P1150C (L) V41P1250C (R) V41P1350C (P) V41P1600A	"MPS He P C (L,R)" Tank pressure < 1150 psia (class 2 alarm) (Pneumatic pressure on meter only, no alerts or C/W for crew)	FML PNL F7 BFS GNC SYS SUMM 1
(dp/dt) (C) V98P4997C (L) V98P4998C (R) V98P4999C	dp/dt > 20 psia/3 sec	BFS GNC SYS SUMM 1

a. Crew Procedures - Cue Card (fig. 2.2.10-II)

3. MCC Operations

TABLE 2.2.10-II.- HARDWIRED C&W FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(He Tank Pressure) (C) V41P1150C (L) V41P1250C (R) V41P1350C (P) V41P1600A	High out-of-Limits Low out-of-Limits Static	MSK 1054, 1077 DDD 286

TABLE 2.2.10-III.- BFS FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(He Tank Pressure) (C) V98P2155C (L) V98P2156C (R) V98P2157C	High out-of-limits Low out-of-limits Static	MSK 1089

a. Console Cue Cards - None

b. MCC Activity

TABLE 2.2.10-IV.- MCC ACTIVITY

Step	Activity	Position
1	If HE TK P (L, C, R, or P) is out-of-limits or static, inform BSE and monitor He TK T, MID TK T, and He REG PA and PB	MPS
2	If the other data for the affected He system in step 1 is consistent with the other He systems, inform BSE of TK P instrumentation failure and loss of class 2 C/W on the affected system	MPS/BSE FD
3	If the other data for the affected He system in step 1 is out of line with the other He systems, inform BSE of problems within that helium system. Refer to SCP 2.2.4	MPS/BSE

B. Helium Regulator Pressure A

1. Flight Rule - None

2. Crew Operations

TABLE 2.2.10-V.- FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(He REG PA) (C) V41P1154A (L) V41P1254A (R) V41P1354A (P) V41P1605A** (He REG PB) (C) V41P1153A (L) V41P1253A (R) V41P1353A	He Regulator A or B pressure < 679 psia or > 806 psia (class 3 alarm) He Regulator A pressure < 680 psia or > 810 psia* (class 2 alarm)	PNL F7 BFS GNC SYS SUMM 1

* - Hardwired C&W
** - Displayed on Panel F7 only, no alerts or warnings

a. Crew Procedures - Cue Card (fig. 2.2.10-II)

3. MCC Operations

TABLE 2.2.10-VI.- FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(He REG PA) (C) V41P1154A (L) V41P1254A (R) V41P1354A (P) V41P1605A (He REG PB) (C) V41P1153A (L) V41P1253A (R) V41P1353A	High out-of-Limits Low out-of-Limits Static	MSK 1054, 1077 DDD 286

a. Console Cue Cards - None

b. MCC Activity

TABLE 2.2.10-VII.- MCC ACTIVITY

Step	Activity	Position
1	If HE REG PA/PB (L, C, R, or P) is out-of-limits or static, inform BSE and monitor MID TK T, He TK P, and dP/dT for that system	MPS
2	If the other data for the affected He system in step 1 is consistent with the other He systems, inform BSE of He REG PA/PB instrumentation failure and loss of class 2 C/W and class 3 alert for that He REG PA/PB. (Loss of He REG PB does not cause loss of the class 2 C/W)	MPS/BSE/ FD
3	If the other data for the affected He system in step 1 is out of line with the other He systems, inform BSE of problems within that helium system. Refer to SCP 2.2.4	MPS/BSE

C. LO_2 or LH_2 Manifold Pressure

1. Flight Rule - None

2. Crew Operations

TABLE 2.2.10-VIII.- FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(LO_2 MANF P) V41P1533C	LO_2 MANF PRESS > 249 psia (class 2 alarm)	PNL F7
(LH_2 MANF P) V41P1433C	LH_2 MANF PRESS > 60 psia (class 2 alarm)	PNL F7

a. Crew Procedures - Cue Card (figure 2.2.10-II)

3. MCC Operations

TABLE 2.2.10-IX.- FAILURE RECOGNITION

Parameter no.	Failure value/trend	Displayed on
(LO$_2$ MANF P) V41P1533C	High out-of-Limits Low out-of-Limits Static	MSK 1054, 1085 DDD 288
(LH$_2$ MANF P) V41P1433C	High out-of-Limits Low out-of-Limits Static	MSK 1054, 1085 DDD 288

a. Console Cue Cards - None

b. MCC Activity

TABLE 2.2.10-X.- MCC ACTIVITY

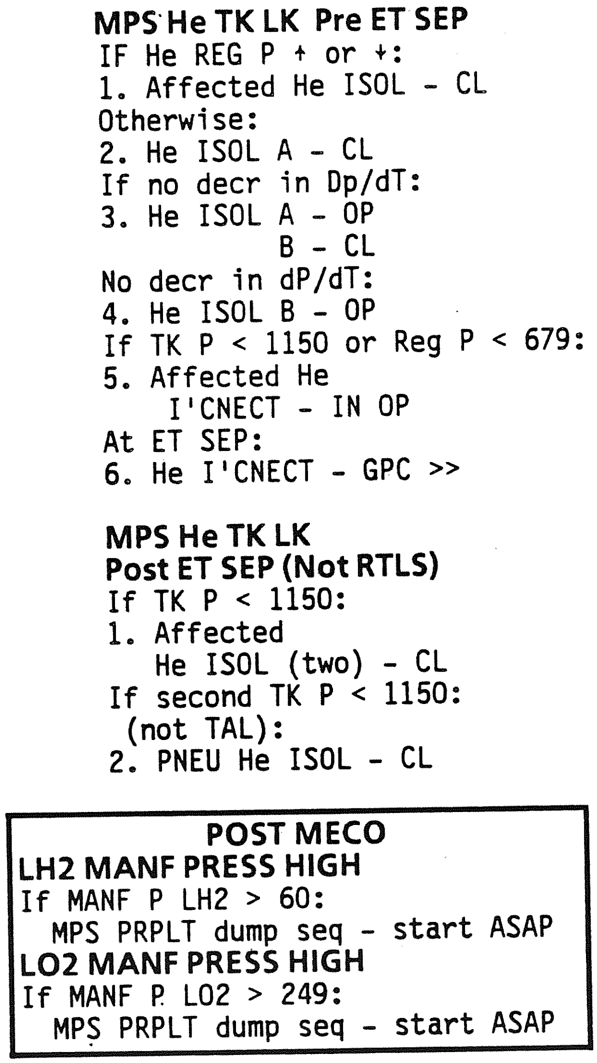
Step	Activity	Position
1	If LO$_2$/LH$_2$ MANF P is out-of-limits high, low, or static, monitor IN P.	MPS
2	With prevalves open, IN P should be approximately equal to MANF P.	MPS
3	If MANF P is out of line with IN P, inform BSE of MANF P instrumentation failure and loss of class 2 C/W.	MPS/BSE/ FD
4	If MANF P is consistent with IN P, inform BSE of manifold pressurization problems. Refer to SCP 2.2.3.	MPS/BSE

D. LO$_2$ and LH$_2$ Ullage Pressure - Refer to SCP 2.2.1

E. SRB Pc 1, 2, or 3 - Refer to SCP 2.2.7

F. SRB Fuel Supply Module A(B) Pressure - Refer to SCP 2.2.8

G. SRB Hydraulic Supply A(B) Pressure - Refer to SCP 2.2.8



MPS He TK LK Pre ET SEP

IF He REG P ↑ or ↓:
1. Affected He ISOL - CL
Otherwise:
2. He ISOL A - CL
If no decr in Dp/dT:
3. He ISOL A - OP
B - CL
No decr in dP/dT:
4. He ISOL B - OP
If TK P < 1150 or Reg P < 679:
5. Affected He
I'CNECT - IN OP
At ET SEP:
6. He I'CNECT - GPC >>

MPS He TK LK
Post ET SEP (Not RTLS)

If TK P < 1150:
1. Affected
He ISOL (two) - CL
If second TK P < 1150:
(not TAL):
2. PNEU He ISOL - CL

POST MECO

LH2 MANF PRESS HIGH

If MANF P LH2 > 60:
MPS PRPLT dump seq - start ASAP

LO2 MANF PRESS HIGH

If MANF P LO2 > 249:
MPS PRPLT dump seq - start ASAP

Figure 2.2.10-II.- Crew procedures cue card.

TITLE

SRB SEP SEQUENCE SWITCH RM AND SOFTWARE OVERRIDE

PURPOSE

This SCP describes the switch redundancy management (RM) and software override capability as utilized in the SRB separation sequence. The SRB SEP switches are located on panel C3 (fig. 2.2.11-I). Switch S1 selects the AUTO OR MAN/AUTO separation mode. Pushbutton S2 initiates the sequence when in MAN/AUTO mode bypassing all inhibits in software. Automatic separation will occur in the MAN/AUTO position with the absence of inhibits (rates and dynamic pressure).

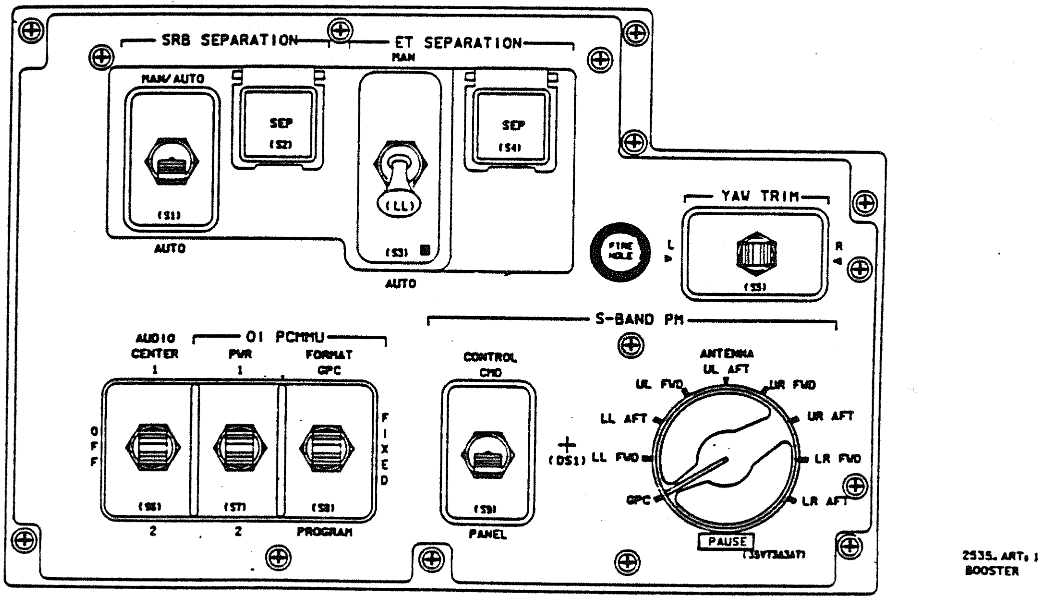


Figure 2.2.11-I.- SRB separation switches.

PROCEDURE

The SRB separation sequence is used during ascent phase to separate the SRBs from the Orbiter/ET vehicle. Separation normally occurs automatically, but the crew has the capability to manually initiate the separation (via SEP pushbutton if S1 is in MAN/AUTO) in the presence of automatic separation inhibits.

The SRB separation sequence is initiated at SRB SEP SEQ initiation time (T + 100 sec) only if MECO has not occurred. At initiation the SEP sequence monitors the mid-value selected left and right SRB chamber pressure measurements to determine when the primary separation cue has been reached (SRB Pc≤50 psia). The backup separation cue is reached when the mission elapsed time (MET) exceeds the latest possible time at which a chamber pressure of 50 psia could occur. (SRB SEQ backup cue time T + 129.8 seconds.)

In ascent in the event of multiple chamber pressure sensor failures on one SRB to the high state, SRB SEQ backup cue time serves as the separation initiation time. Protection against multiple sensor failures to the low state requires both marking the time which the mid-value selected left and right SRB Pc measurements drops below 50 psia and calculating the resultant time differential. If this differential exceeds the predicted maximum differential (Max SRB SEP Cue differential + 5.5 sec) the SRB SEQ backup cue time is used to prevent a separation attempt with excessive SRB thrust. The BFS does not calculate the delta time between SRB Pc's.

The separation process begins once either the primary or backup cue has been reached. PIC arm and GNC moding indicators are then issued at appropriate times, following delays to allow time for the solid rocket motor (SRM) nozzle actuators to null and SRB thrust to decay to an acceptable level. The vehicle's dynamic state is also compared with given criteria (roll, pitch, yaw rates, and dynamic pressure) that define the capability of the vehicle to perform a safe separation. If these dynamic state criteria are met, separation is commanded automatically. If the criteria are exceeded, automatic separation is inhibited and separation may be done manually via the SRB SEP mode switch and the SRB initiation pushbutton. Separation will occur automatically if the vehicle rates or dynamic pressure drop below the inhibit limits even though the SRB SEP mode switch is in the AUTO/MAN position.

The PASS SRB separation sequence also accounts for FA MDM commfaults. IF an FA MDM (1, 2, or 3) associated with a PC transducer is commfaulted the separation sequence will average the two remaining PC sensors on each SRB and monitor these averages for a less than 50 psi indication. If two of the three FA MDM's associated with the SRB PC's are commfaulted, the PASS sequence will monitor for a less than 50 psia indication on the remaining sensor on each SRB. Delayed separation could occur if one FA MDM is commfaulted and one PC sensor fails high. The average of the two remaining non-commfaulted pair would never drop below 50 psi. The SRB SEP cue differential of 5.5 seconds between the two SRB's reaching 50 psi would be exceeded and separation would then occur based on the backup timer.

Four seconds after SRB SEP command the SRB SEP sequencer is terminated and MEC's 1 and 2 are issued master resets.

SWITCH RM

Due to the obvious criticality of the SRB Separation sequence, triple-pole switches are used for the mode switch and SEP pushbutton. As shown in figure 2.2.11-II, the mode switch employs three contacts, each one powered from a separate 5-volt source (Dedicated Signal Conditioner OF1, 2, or 3).

When in AUTO mode, each 5-volt signal is routed to its own separate flight critical MDM (FF1,3 or 4), where they are ultimately fed to the guidance and navigation computer (GNC) switch redundancy management (RM) (where two out of three voting occurs for PASS) and to the GNC switch hardware interface program (HIP) (two out of three voting for BFS).

In the MAN/AUTO position, the mode switch supplies the 5 VDC signals to the SEP INITIATE pushbutton. This pushbutton switch also goes through the two out of three voting logic.

First, we will examine the RM logic for the mode switch in the PASS. Under normal conditions the switch is in AUTO and, with no failures, the RM sees the following:

	Mode switch contacts					RM output
	A	B	C			
AUTO	1	1	1	=	1	AUTO
MANUAL	0	0	0	=	0	

If one of the AUTO contacts failed to zero (which could be caused by DSC failure, contact failure, or an open circuit), the 2 out of 3 voting logic would be invoked, and the RM output would be the same (AUTO).

The mode switch is also commfault protected in the PASS. A commfault occurs when the GPC senses a problem with the MDM itself or the data bus that transfers information from the MDM to the GPC. This situation results in the GPC rejecting all data from the "commfaulted" MDM. If one of the MDM's (FF1, 3 or 4) is commfaulted, the RM selection filter downmodes to the two remaining switch contacts, whose inputs are "AND'ed" to make the RM output.

	Mode switch contacts					RM output
	A	B	C			
AUTO	1	1	COMM	=	1	AUTO
MANUAL	0	0	COMM	=	0	

If you now add a failure of one of the good AUTO contacts to zero, the RM would be in dilemma.

	Mode switch contacts					RM output
	A	B	C			
AUTO	1	0	COMM	=	0	Dilemma = default logic (MAN/AUTO)
MANUAL	0	0	COMM	=	0	

When the software sees a zero (or a one) output for both positions (AUTO or MAN/AUTO), it cannot determine the reason, so it goes to default logic. The default position is MAN/AUTO.

For the case of two commfaulted MDM's, the switch RM merely goes with the one remaining contact. If two contacts are failed to zero (loss of DSC, contact failure, or open circuit), the software goes to default logic.

The BFS version of RM is called the GNC switch hardware interface program (HIP). The BFS treats the mode switch as a simple 2 out of 3 majority voting. With two contacts failed to zero (loss of DSC, contact failure, or open circuit) and No pushbutton initiate, the BFS SRB SEP logic issues SRB SEP MAN/AUTO enable and continues the automatic separation sequence.

A matrix showing SRB separation switch defaults to manual/automatic for various failure modes is shown in figure 2.2.11-III.

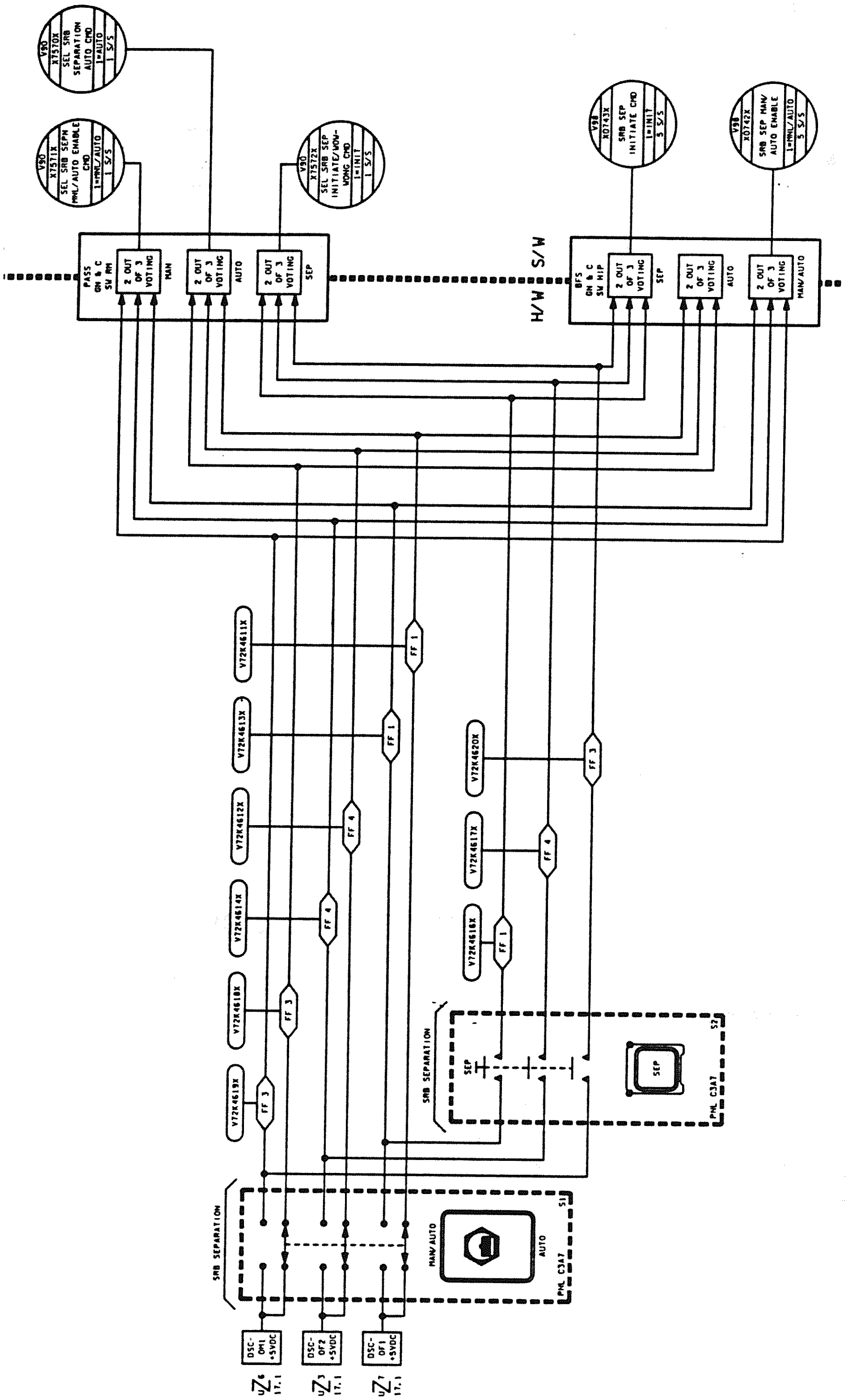


Figure 2.2.11-II.- SRB separation sequence switch wiring.

INDICATION	FAILURES								
	FF MDM			OF DSC PWR					
	1	3	4	1	2	3	1/2	1/3	2/3
SWITCH DEFAULTS TO MAN/ AUTO		X OR	X AND	X					
	X OR	X	AND		X				
	X	OR	X	AND		X			
							X		
								X	
									X

Note: Switch failure only occurs if FF MDM failure occurs first and power second.

Figure 2.2.11-III.- SRB separation switch failures cure card.

A. Flight Rules - None

B. Crew Operations - None

C. MCC Operations

TABLE 2.2.11-I.- PASS FAILURE RECOGNITION

Parameter	Failure valve	Displayed on
SRB auto enable (V90X7570X) SRB manual/auto enable (V90X7571X)	Status of SRB switch goes from auto enable to manual/auto enable	MSK 1055 and DDD 290

TABLE 2.2.11-II.- BFS FAILURE RECOGNITION

Parameter	Failure valve	Displayed on
SRB manual/auto enable (V98X0742X)	Status of SRB switch goes from auto enable to manual/auto enable	MSK 1055 and DDD 290

1. MCC Activity

TABLE 2.2.11-III.- MCC ACTIVITY

Step	Activity	Position
1	If "OF DSC" PWR 1, 2, or 3 fails or if FF MDM 1, 3, or 4 fails report: One failure away SRB SEP switch default to manual/auto (Note: Single switch contact failure is not recognizable)	MPS/BSE
2	If dual contacts fail and result in switch to manual/auto report: SRB separation switch default to manual/auto - no action required (Automatic separation will occur in manual/auto even if PB is not depressed if rates and Q within limits)	MPS/BSE FD/Crew

TITLE

TILE LOSS

PURPOSE

This SCP provides procedures for determining impacts and workarounds during entry from loss of Orbiter tile or thermal insulation.

DESCRIPTION

Critical thermal protection tiles and insulation can be damaged during ascent and on orbit and pose a risk for the Orbiter to return safely to Earth. This damage can be caused by several different failures. These failures include:

1. SRB hold down postdebris escaping their protective blast shells at liftoff.
2. SRB or ET insulation or attachments breaking off and impacting the Orbiter during ascent
3. Poor bonding of the tiles/insulation causing loss of Orbiter insulation during high aerodynamic or thermal loads during ascent
4. Uncontained damage from SSME or APU failures during ascent
5. Impact with debris in low earth orbit

Any damage that occurs must be assessed by the Booster for impacts to their system during on orbit and re-entry. Booster system impacts that need to be assessed include: (1) ability to provide re-entry purges and blowdowns, (2) helium bottle rupture, (3) pneumatic valve operation, (4) hydraulic valve operation, and (5) electrical system integrity for commands, data, and power supply. In addition, by troubleshooting their systems, Boosters can provide other system console operators with more insight into the nature of their problems as a result of common power buses, hydraulic systems, and data lines.

Orbiter tile and insulation damage is assessed by numerous sources. First, the crew reports if any material is observed to hit the Orbiter from the forward part of the ET or SRB's during ascent. In addition, KSC/JSC photo coverage of the liftoff and ascent are closely reviewed. Teams at KSC inspect the launch pad after liftoff to search for any unexpected debris.

On orbit, the crew reports any debris hits, and MCC operators monitor their systems to ensure they are functioning adequately. In addition, ground- and space-based cameras can scan the vehicle for any unusual markings or damage.

HISTORY

There have been numerous cases of insulation loss from the ET and SRB's during Shuttle ascent. Some of these have been found to cause impact damage to the Orbiter protective tiles. Fortunately, none have resulted in critical damage to Orbiter structure or systems. Improved SRB and ET bonding techniques and better inspections have been developed to minimize this hazard.

On-orbit Shuttle impact hazards also exist, primarily as a result of rocket launched space debris in low earth orbit. As of September 1988, U. S. Space Command was tracking some 7800 objects in earth orbit. This number does not include particles less than 5 to 10 centimeters in diameter which are too small to be tracked by modern surveillance systems.

In 1983, the seventh Shuttle mission was hit by a submillimeter fleck of paint in a window pane, causing enough damage to result in replacement of that pane after landing at a cost of 50,000 dollars. At least two major satellite breakups over the past seven years are suspected of being caused by collision with unknown space debris.

PROCEDURES

A. Flight Rules - None

B. Crew Operations

1. Crew Procedure

   a. Report to MCC any indication of debris hits to Orbiter during ascent or on orbit through visual observation or unusual sounds.

   b. Identify to MCC any locations on Orbiter that tile damage or insulation damage appears to have occurred through visual observation.

   c. Provide to MCC indications of any unexplained component functions or behavior or loss of cabin pressure.

2. Crew Activity

TABLE 2.2.12-I.- CREW ACTIVITY

Step	Activity	Position
1	If in communication with ground, report indications or debris hits to MCC. Identify locations of damage, if known	CDR or PLT
2	If no communication exists, take corrective action based on subsystem damage	CDR or PLT

C. MCC Operations

1. Failure Recognition

Notification of damage to flight director will come from one or more of five sources:

a. Crew visual identification or debris impact sounds. Possible loss of cabin pressure or subsystem damage

b. KSC pad reports of flight hardware in MLP area

c. KSC/JSC photo evaluation of liftoff and ascent

d. Ground or space-based cameras

e. MCC identification of system failures

2. MCC Procedures

a. Following identification of tile or insulation damage, a MER/SPAN CHIT will be written to the EECOM/MMACS.

b. EECOM determines damaged tile and insulation location areas. Coordination is made with MMACS.

c. The MMAC's/MECH team uses the Line Replaceable Unit (LRU) data base to determine affected LRU's and subsystems.

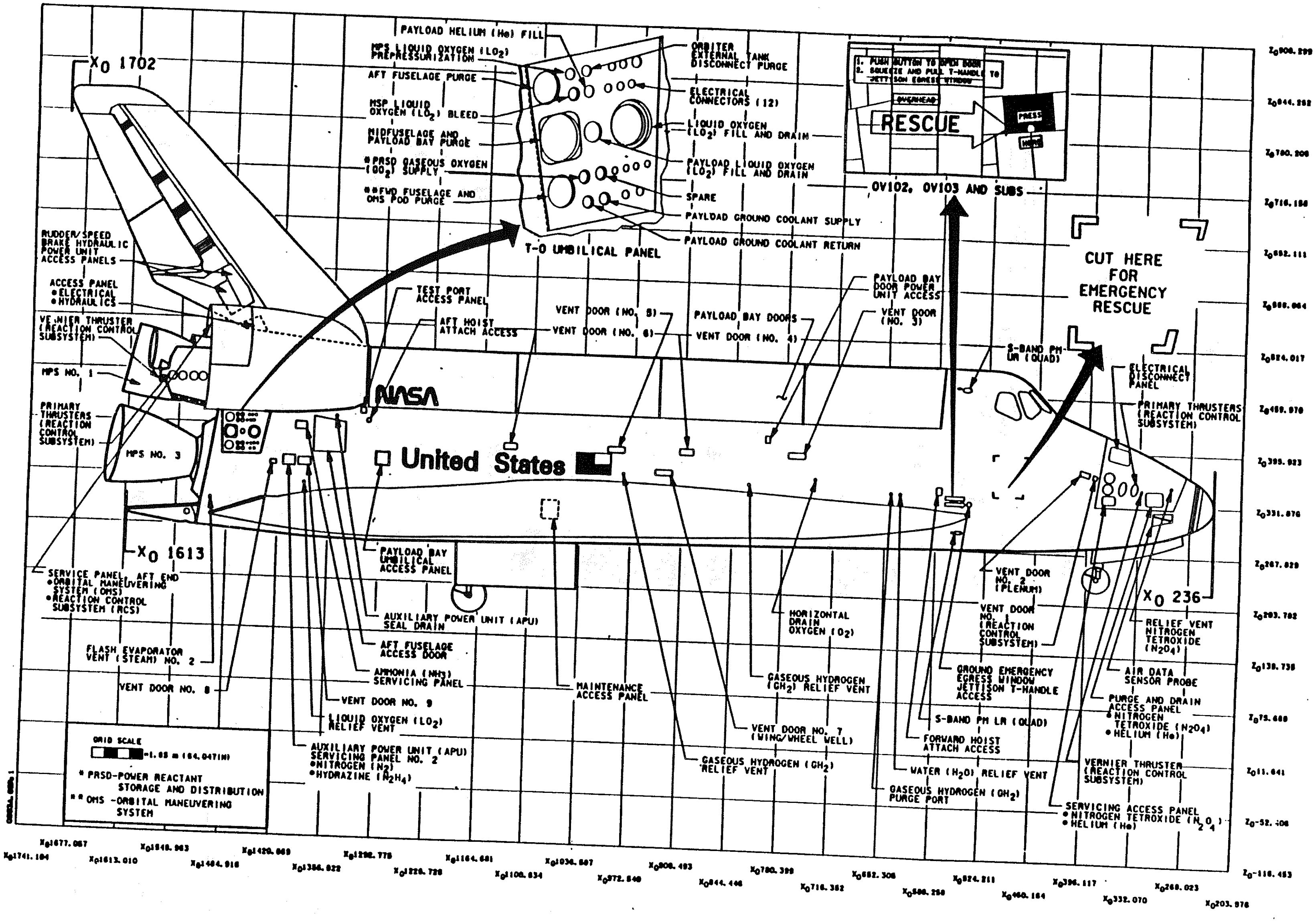
d. MMACS informs FCR operators, including Booster, of determination and gives specific data to affected operators. *

e. Booster refers to MMAC's data, reviews locations of tile and insulation damage, and locates regions affected as seen in figures 2.2.12-I, 2.2.12-II, and 2.2.12-III. *

f. Booster team identifies systems impacted and develops workaround procedures, if required, for electrical, hydraulic, pneumatic, or purge system requirements. *

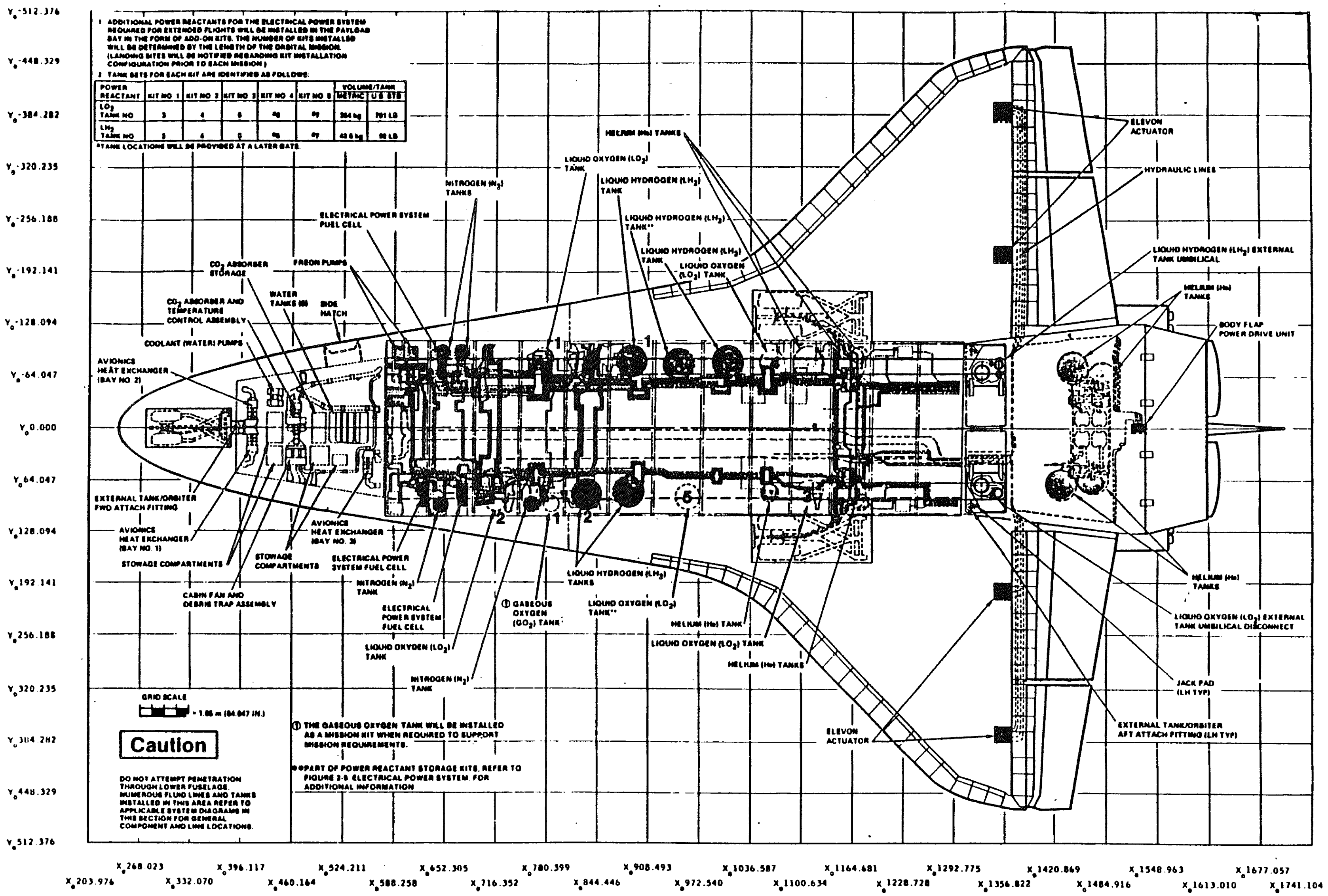
g. Booster provides inputs to MMACs who answers SPAN CHIT, as required. *

* Booster Activity



(a) Moldline penetrations/access panels/markings.

Figure 2.2.12-I.- Side exterior.



1 ADDITIONAL POWER REACTANTS FOR THE ELECTRICAL POWER SYSTEM REQUIRED FOR EXTENDED FLIGHTS WILL BE INSTALLED IN THE PAYLOAD BAY IN THE FORM OF ADD-ON KITS. THE NUMBER OF KITS INSTALLED WILL BE DETERMINED BY THE LENGTH OF THE ORBITAL MISSION. (LANDING SITES WILL BE NOTIFIED REGARDING KIT INSTALLATION CONFIGURATION PRIOR TO EACH MISSION.)

2 TANK SETS FOR EACH KIT ARE IDENTIFIED AS FOLLOWS:

POWER REACTANT	KIT NO 1	KIT NO 2	KIT NO 3	KIT NO 4	KIT NO 5	VOLUME/TANK	
						METRIC	U S STD
LO₂ TANK NO	3	4	5	6*	7*	354 kg	781 LB
LH₂ TANK NO	3	4	5	6*	7*	42.6 kg	92 LB

*TANK LOCATIONS WILL BE PROVIDED AT A LATER DATE.

Caution

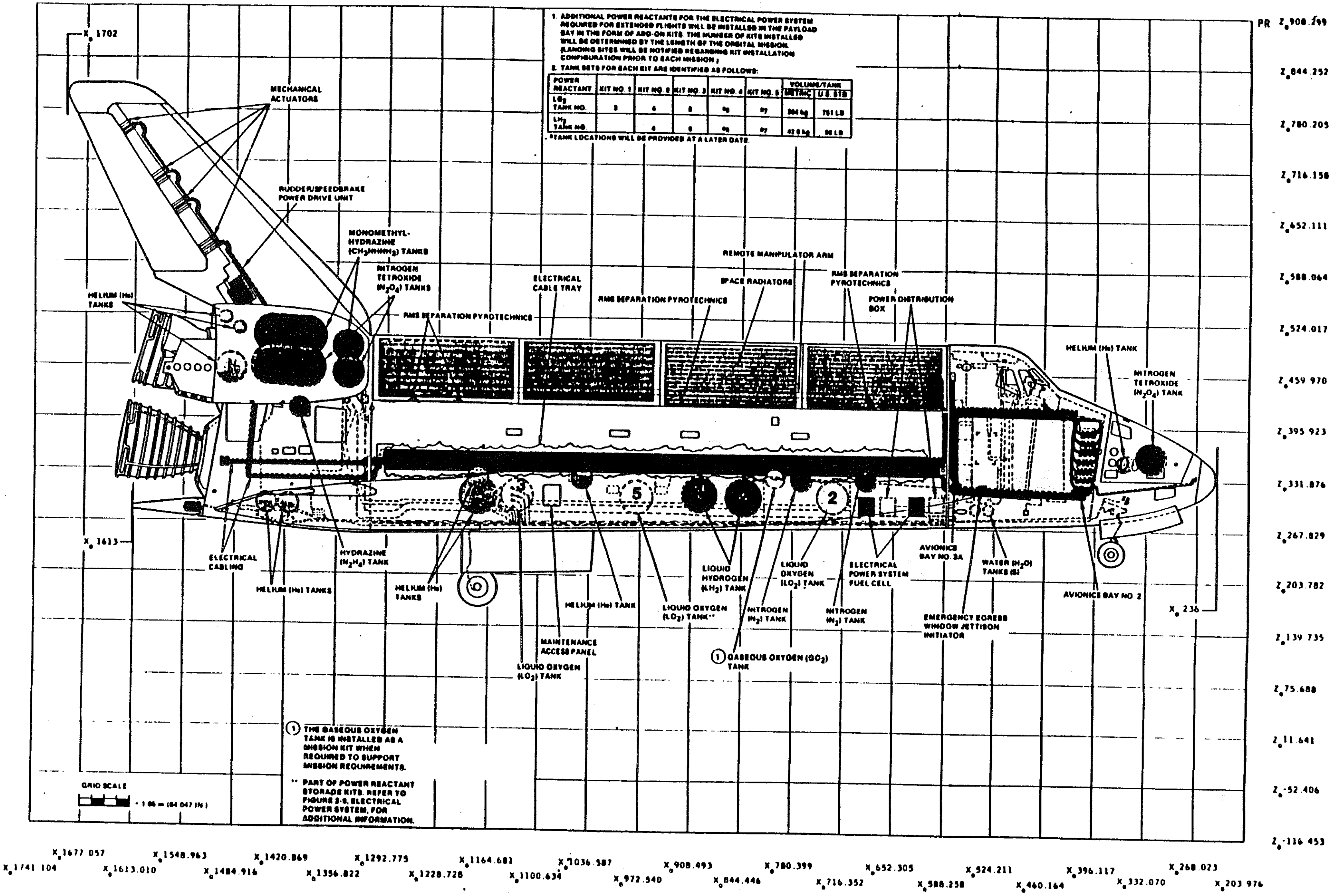
DO NOT ATTEMPT PENETRATION THROUGH LOWER FUSELAGE. NUMEROUS FLUID LINES AND TANKS INSTALLED IN THIS AREA REFER TO APPLICABLE SYSTEM DIAGRAMS IN THIS SECTION FOR GENERAL COMPONENT AND LINE LOCATIONS.

① THE GASEOUS OXYGEN TANK WILL BE INSTALLED AS A MISSION KIT WHEN REQUIRED TO SUPPORT MISSION REQUIREMENTS.

**PART OF POWER REACTANT STORAGE KITS. REFER TO FIGURE 3-8 ELECTRICAL POWER SYSTEM. FOR ADDITIONAL INFORMATION

(d) Component/system location.

Figure 2.2.12-II.- Bottom exterior.



1. ADDITIONAL POWER REACTANTS FOR THE ELECTRICAL POWER SYSTEM REQUIRED FOR EXTENDED FLIGHTS WILL BE INSTALLED IN THE PAYLOAD BAY IN THE FORM OF ADD-ON KITS. THE NUMBER OF KITS INSTALLED WILL BE DETERMINED BY THE LENGTH OF THE ORBITAL MISSION. (LANDING SITES WILL BE NOTIFIED REGARDING KIT INSTALLATION CONFIGURATION PRIOR TO EACH MISSION.)
2. TANK SETS FOR EACH KIT ARE IDENTIFIED AS FOLLOWS:

POWER REACTANT	KIT NO. 1	KIT NO. 2	KIT NO. 3	KIT NO. 4	KIT NO. 5	VOLUME/TANK	
						METRIC	U.S. STD
LO_2 TANK NO.	3	4	5	6*	7*	354 kg	781 LB
LH_2 TANK NO.		4	5	6*	7*	42.0 kg	92 LB

*TANK LOCATIONS WILL BE PROVIDED AT A LATER DATE.

① THE GASEOUS OXYGEN TANK IS INSTALLED AS A MISSION KIT WHEN REQUIRED TO SUPPORT MISSION REQUIREMENTS.

** PART OF POWER REACTANT STORAGE KITS. REFER TO FIGURE 2-8, ELECTRICAL POWER SYSTEM, FOR ADDITIONAL INFORMATION.

(e) Component/system location

Figure 2.2.12-III.- Side interior.

3. Supporting Data

   a. Figures

   Figures 2.2.12-I, 2.2.12-II, and 2.2.12-III

   b. Notes

   Any loss of thermal protection in the aft or midbody of the Orbiter may require bleeding down some high pressure pneumatic and helium supply systems to prevent re-entry heating and aerodynamic loads from rupturing high pressure lines or bottles with even greater catastrophic damage.

   Flight controllers should be able to trace wiring, cables, and cable bundles using Rockwell drawings. These drawings are in the RSOC library. Rockwell-Downey has an on-line CAD system that can produce assembly drawings of any view of the Orbiter. In addition, the MMACs have a large library of photographic files of most regions of the Orbiter.

REFERENCES

1. Systems Division Tile Loss Paper Simulation, August 8, 1988, Paul F. Dye.

2. MMACS Shuttle Console Procedures Handbook (SCP) on Tile Loss Procedures.

3. Space Technology International, Reginald Turnhill, Editor; Cornhill Publications Limited, London, England, 1989.

TITLE

CAUTION AND WARNING/SM ALERT SYSTEMS/SSME FAULTS

PURPOSE

This SCP describes the operation of the two limit sensing systems used to alert the flight crew to limit violations.

MPS C&W DESCRIPTION

The MPS caution and warning (C&W) system drives class 2 alerts that inform the crew of out-of-limits conditions or improperly configured systems. It consists of two subsystems: primary and backup. The primary MPS C&W is a hardware system that is wired from the transducer to the MPS light on the annunciator light matrix. It sounds the C&W tone, lights the four master alarm lights, and lights the MPS light on the matrix.

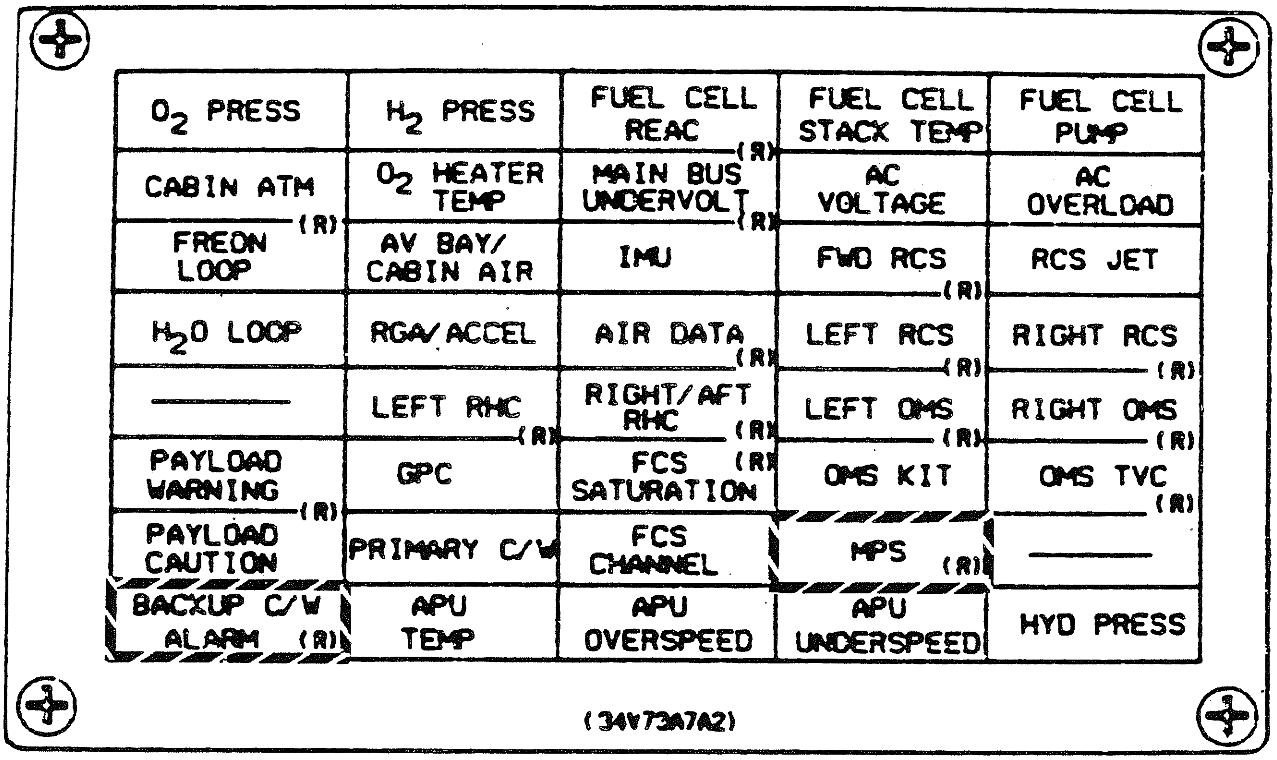


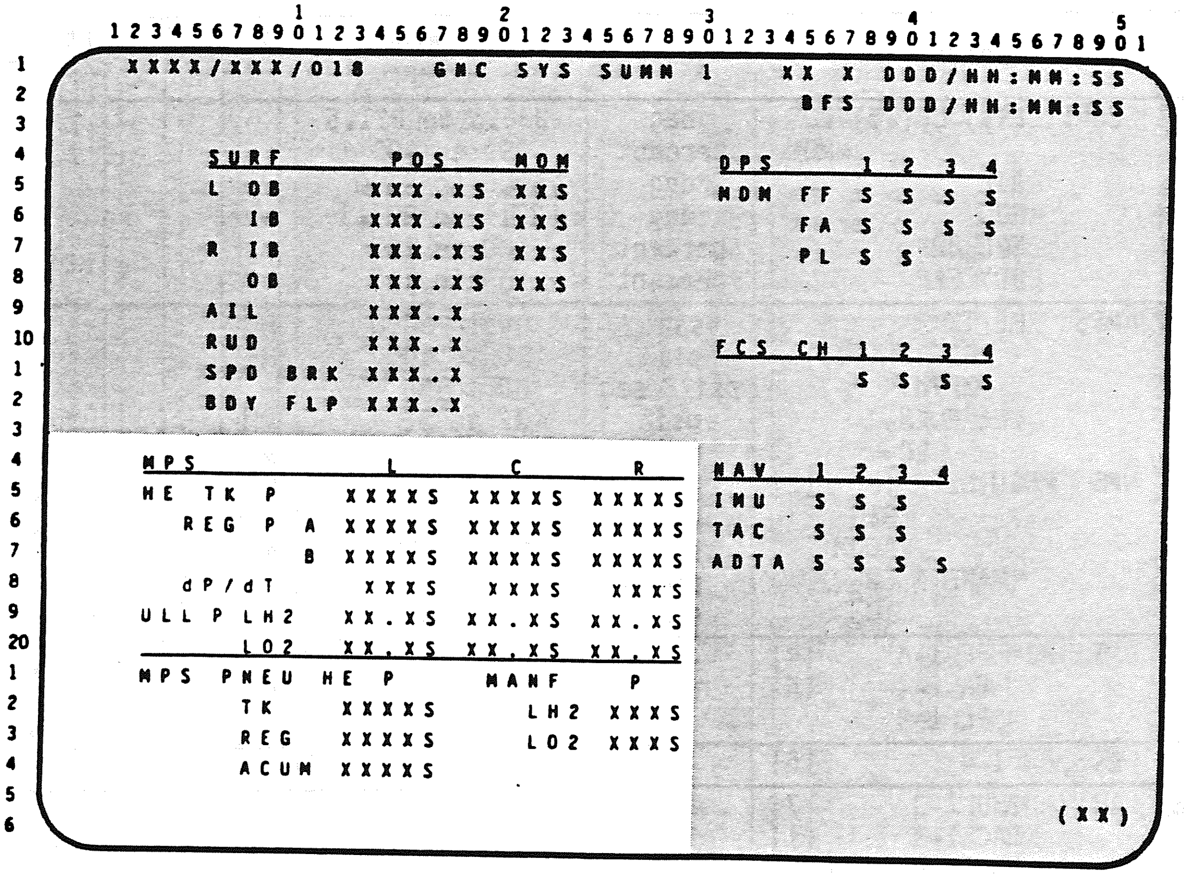
Figure 2.3.2-I.- Annunciator light matrix - panel F7.

The backup C&W is a flight software system that feeds MPS pressure measurement into the BFS GN&C annunciation interface (GAX) for limit sensing. The backup C&W sets the same alarms as the primary system for He TK pressures and LO_2 and LH_2 manifold pressures, lights the BACKUP C/W ALARM light, and generates a fault message on a CRT. The MPS parameters which are presently being limit sensed by the primary and backup C&W system are listed in table 2.3.2-I.

TABLE 2.3.2-I.- MPS C&W PARAMETERS

C&W CH	Parameter name	MML	Low C&W	High C&W	Fault message
49	MPS HE REG A P L	V41P1254A	680	810	MPS He P L
39	C	V41P1154A	680	810	MPS He P C
59	R	V41P1354A	680	810	MPS He P R
19	MPS HE TK P L	V41P1250C	1150		MPS HE P L
9	C	V41P1150C	1150		MPS HE P C
29	R	V41P1350C	1150		MPS HE P R
79	MPS MANF P LH_2 H1	V41P1433C		60.0	MPS LH_2/LO_2 MANF
69	MPS MANF P LO_2 H1	V41P1533C		249.0	MPS LH_2/LO_2 MANF

After one of these alarms is set, the crew can call up BFS "GNC SYS SUMM 1" (DISP 18) via the SYS SUMM key to check digital readouts (fig.2.3.2-II). A down arrow (↓) by a number indicates a low limit has been violated. An up arrow (↑) indicates a high limit has been violated.



```
XXXX/XXX/018    GNC SYS SUMM 1       XX X DDD/HH:MM:SS
                                          BFS DDD/HH:MM:SS

      SURF        POS     MOM            DPS       1 2 3 4
      L OB      XXX.XS    XXS            MOM  FF   S S S S
        IB      XXX.XS    XXS                 FA   S S S S
      R IB      XXX.XS    XXS                 PL   S S
        OB      XXX.XS    XXS
      AIL       XXX.X
      RUD       XXX.X                    FCS CH  1 2 3 4
      SPD BRK   XXX.X                            S S S S
      BDY FLP   XXX.X

  MPS              L       C       R     NAV   1 2 3 4
  HE TK P        XXXXS   XXXXS   XXXXS   IMU   S S S
     REG P A     XXXXS   XXXXS   XXXXS   TAC   S S S
           B     XXXXS   XXXXS   XXXXS   ADTA  S S S S
     dP/dT        XXXS    XXXS    XXXS
  ULL P LH2      XX.XS   XX.XS   XX.XS
        LO2      XX.XS   XX.XS   XX.XS
  MPS PNEU HE P          MANF     P
        TK       XXXXS     LH2  XXXS
        REG      XXXXS     LO2  XXXS
        ACUM     XXXXS
                                                     (XX)
```

GNC SYS SUMM 1 is a BFS GNC display (DISP 18) available in OPS 1, 3, and 6 via the SYS SUMM key. Digital data and/or status information which supports aerosurfaces, main propulsion system (MPS), digital propulsion system (DPS), flight control subsystem channels (FCS CH), and navigation sensor subsystems are displayed.

Figure 2.3.2-II.- GNC SYS SUMM 1 display.

Parameter characteristics

CRT name	Units	Displayed range	Status indicators				
			M	H	L	↑	↓
[1] SURF: L(R) OB(IB) POS	deg	U36.5 to D21.5				↑	↓
MOM	percent	-99 to +99				↑	
AIL	deg	L5.0 to R5.0					
RUD	deg	L27.1 to R27.1					
SPD BRK	percent	0 to 100					
BDY FLP	percent	0 to 100					
[2] MPS: HE TK P	psia	0 to 5000	M				↓
REG P (A,B)	psia	0 to 1000	M			↑	↓
dP/dT	psi/3 sec	0 to 50				↑	
ULL P LH_2	psia	12 to 52	M			↑	↓
LO_2	psig	0 to 30	M			↑	↓
MPS PNEU HE P TK [3]	psia	0 to 5000	M				↓
REG	psia	0 to 1000	M			↑	↓
ACUM	psia	0 to 1000	M				↓
MANF P LH_2	psia	0 to 100	M			↑	
LO_2	psia	0 to 300	M			↑	
DPS MDM FF 1-4 [4]			M				↓
FA 1-4 [4]			M				↓
PL 1-2							↓
FCS CH 1-4 [5]			M				↓
[6] NAV: IMU 1-3 [7]							↓
TAC 1-3 [1]							↓
ADTA 1-4 [1]							↓

Remarks

1. OPS 3, MM602, and MM603 only.

2. OPS 1 and 6.

3. Limit sensing and fault annunciation is terminated at MECO command.

4. 'M' status indicates pre-engage failure of BFS to track PFS.

5. Only the first actuator failure on a give channel will be annunciated. Subsequent failures of different actuators on the same channel will not be annunciated unless the first failure has been reset (UB08324).

6. '↓' represents failure, missing data, or IMU deselection by item entry on BFS OVERRIDE display.

7. OPS 1 and MM601.

Figure 2.3.2-II.- Concluded.

The parameters can also be checked on the MPS meters (fig. 2.3.2-III) in front of the pilot. On the helium meter, either the tank or regulator pressure can be shown by changing the switch below the meter. The regulator pressure meter shows only the REG A values.

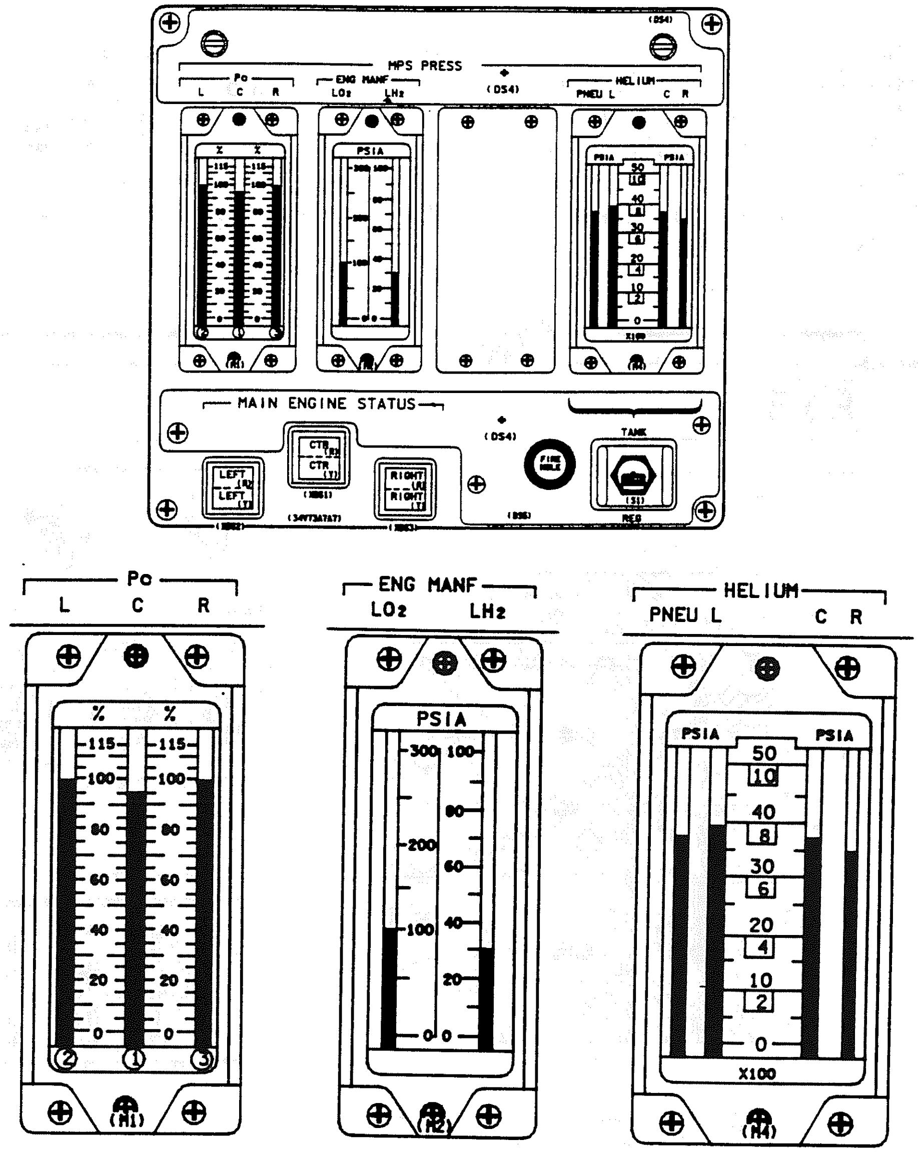


Figure 2.3.2-III.- MPS meters - panel F7.

MPS C&W RATIONALE

In the primary C&W, limit sensing is only done on the A regulators. The helium regulator high value warns of a failed open regulator. The low value warns of a relief valve failed open, a regulator shifted low, or a line break. The helium tank pressure low limit warns when the helium pressure is too low to ensure a proper interface pressure at the main engine intermediate seal package. The LH_2 and LO_2 manifold high limit alerts the crew that the relief valve or the relief isolation valve has failed closed, and the feedlines could rupture due to excessive pressure buildup. When one of these conditions is detected, the C&W system alerts the crew with both the audio and visual alarms. Additional rationale on the C&W may be found in the Flight Procedures Handbook.

The backup C&W for the MPS is active only in OPS 1 and 6 (ascent and RTLS). The primary C&W for the MPS remains active throughout flight and must be inhibited on orbit using the C&W status light matrix on panel R13 (fig. 2.3.2-IV). On orbit, the crew inhibits channels 9, 19, 29, 39, 49, and 59 which inhibit the helium regulator and tank pressure limits. During the rest of the mission, the primary C&W senses only the LH2 and LO2 manifold high pressures.

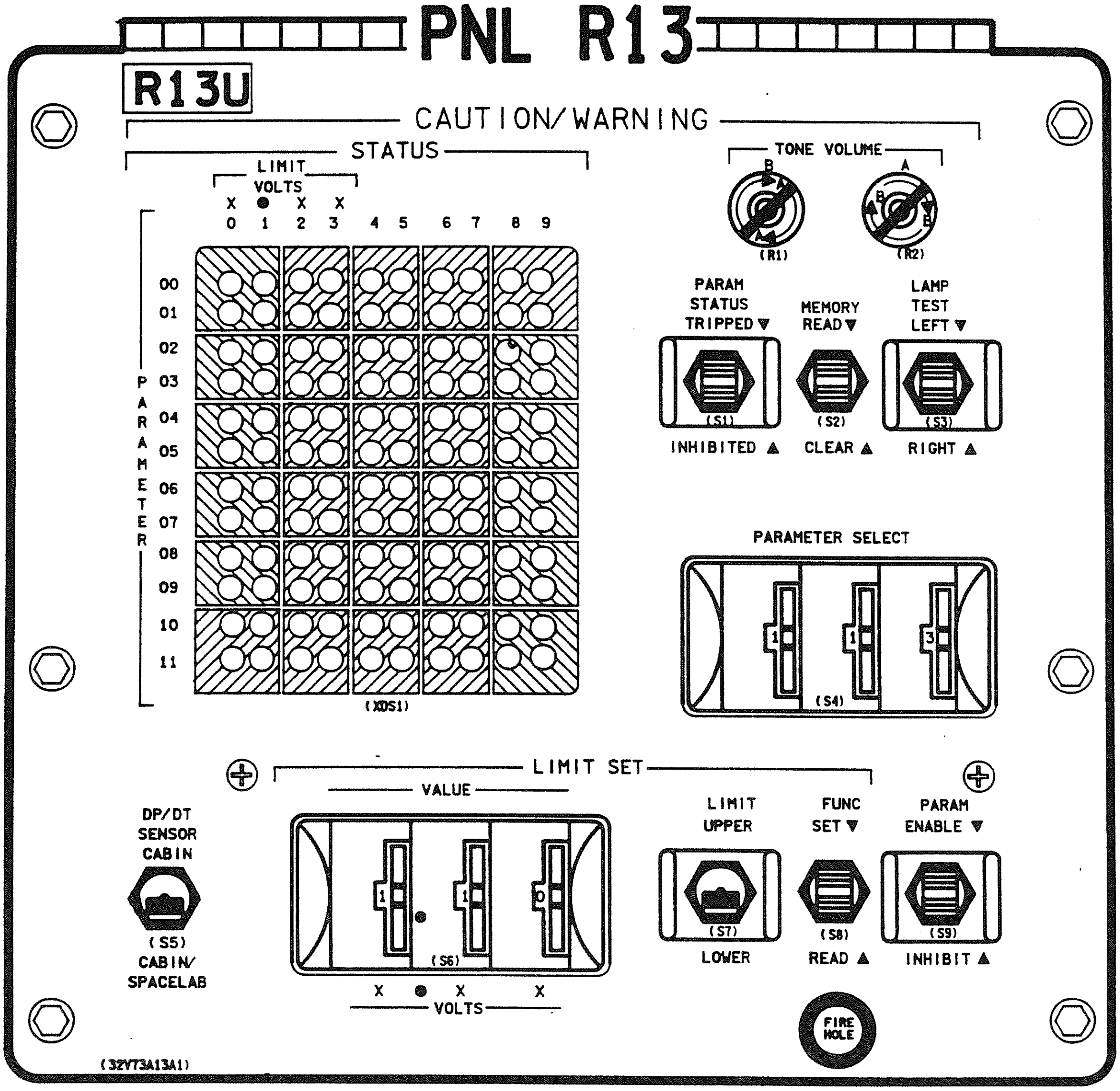


Figure 2.3.2-IV.- C&W status light matrix.

SM ALERT DESCRIPTION

The systems management (SM) alert is a class 3 alert activated when BFS software has determined that a parameter has exceeded the limits as sensed by the BFS GAX program. When one of these conditions is detected, the SM system sounds the SM alert tone, lights the blue SM alert light, and sends a fault message. Then the digital readout can be checked on the BFS GNC SYS SUMM 1 display as in the C&W system. These SM alerts for the MPS data are active only in OPS 1 and 6. The MPS parameters that are being limit sensed by the SM alert system are listed in table 2.3.2-II.

TABLE 2.3.2-II.- SM ALERT PARAMETERS

Parameter name	MML	Low SM	High SM	Fault message
MPS MANF P LH_2	V41P14336	-	60.0	MPS LH_2/LO_2 MANF
MPS MANF P LO_2	V41P1533C	-	249	MPS LH_2/LO_2 MANF
MPS ET ULL P LH_2 C	T41P1700C	31.6	46.0	MPS LH_2/LO_2 ULL
L	T41P1701C	31.6	46.0	MPS LH_2/LO_2 ULL
R	T41P1702C	31.6	46.0	MPS LH_2/LO_2 ULL
MPS ET ULL P LO_2 C	T41P1750C	0.0	29.0	MPS LH_2/LO_2 ULL
L	T41P1751C	0.0	29.0	MPS LH_2/LO_2 ULL
R	T41P1752C	0.0	29.0	MPS LH_2/LO_2 ULL
MPS He dP/dT			20.0	MPS He P C (L,R)
MPS He REG P L A	V41P1254A	679	806	MPS He P L
C A	V41P1154A	679	806	C
R A	V41P1354A	679	806	R
L B	V41P1253A	679	806	L
C B	V41P1153A	679	806	C
R B	V41P1353A	679	806	R
MPS He TANK P L	V41P1250C	1150	-	L
C	V41P1150C	1150	-	C
R	V41P1350C	1150	-	R
*MPS PNEU He TK P	V41P1600A	3800	N/A	MPS He PPN
REG P	V41P1605A	700	806	MPS He PPN
ACC P	V41P1650A	700	N/A	MPS He PPN

* C&W available in OI-8D

SM ALERT RATIONALE

The LH_2 and LO_2 high ullage pressure values warn if the ET vent/relief valve did not open. The LH_2 low valve warns the crew when they have reached the minimum pressure needed to maintain a NPSP of 5.3 psi for the main engine. Each of the LH_2 and LO_2 ullage pressure transducers is individually limit sensed. The MPS helium tank pressure dP/dT detects excessive helium decay rates and warns of a helium leak. The alert is sounded when a pressure decay of 20 psi measured over 3 seconds occurs. Two consecutive cycles of greater than 20 are required to set this alarm. The helium regulator valves warn of the same thing as in the C&W system, but both A and B regulators are used in the SM system.

SSME FAULTS DESCRIPTION

The SSME fault messages (table 2.3.2-III) and status lights (fig. 2.3.2-V) are used to alert the crew of major problems with the main engines. The messages and lights are driven by the PASS when active and by the BFS when engaged.

TABLE 2.3.2-III.- SSME FAULT MESSAGES

Fault message	Cause
ME SHDN SW C (L, R)	Switch contacts disagree
MPS CMD C (L, R)	Command path fail
MPS DATA C (L, R)	Data path fail
MPS ELEC C (L, R)	Electrical lockup
MPS HYD C (L, R)	Hydraulic lockup
SSME FAIL C (L, R)	Premature main engine shutdown

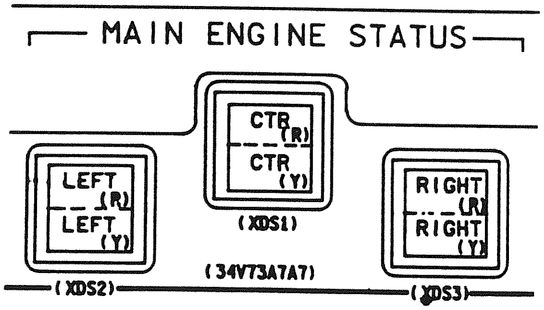


Figure 2.3.2-V.- Main engine status lights.

The top of each status light is red and the bottom is amber. The red light indicates that an engine has shut down or that an engine limit has been exceeded as determined by the controller. If one engine shuts down, the limits in the other engines are automatically inhibited to keep the remaining engines from shutting down with a limit violation. The amber light indicates electrical lockup, hydraulic lockup, command path failure, or data path failure in the corresponding engine. Along with the amber light, a fault message is generated, the blue SM alert light is turned on, and the SM alert tone is sounded. The failures that light the amber light are detected from the engine status word generated by the main engine controller.

SSME FAULTS RATIONALE

Electrical lockup occurs when the phase bits in the engine status word indicate both Pc transducers or both fuel flowmeter transducers have been lost. The LOX flow rate and mixture ratio cannot be calculated without the Pc transducers or fuel flow sensors. Thus, the engine maintains the last commanded position. The engine cannot be throttled, but it can still be shutdown.

The main engines have five propellant valves (MFV, MOV, CCV, OPOV, FPOV), and each uses a hydraulic actuator for movement. Each engine has an APU assigned to it for use in the hydraulic system in that engine. The engine propellant valves are hydraulically isolated at their last position if the actuator's A channel shows an error of 6 percent and the B channel shows an error of 10 percent. After hydraulic lockup occurs, the engines cannot be throttled and at MECO the helium in the pneumatics system closes the valves. These valves cannot be throttled later in the flight with hydraulics.

For hydraulic lockup or electrical lockup in the thrust bucket, the crew is warned by the amber light of an impending abort gap. For dual failures at RPL (100 percent), the crew is warned that the 3g limit will be violated, and an engine may have to be shut down before MECO.

A command path failure is the loss of command capability from the GPC's to the main engines. The failure can result from the failure of the GPC's assigned to EIU MIA's 1 and 2, the failure of EIU MIA's 1 and 2, or the failure of any two of three EIU or controller CIA's. The main engine controller must get two of three commands sent, and they must be the same to be accepted. The controller then sends out an acceptance message to the GPC's. If the GPC's do not get the acceptance message, a command path failure is declared. For this failure, the amber light indicates that a manual shutdown using the main engine power switches will be required on that engine prior to MECO.

A data path failure is the loss of data from the SSME's to the GPC's. It is caused by the failure of the GPC's assigned to EIU MIA's 1 and 4, the failure of EIU MIA's 1 and 4, the failure of EIU CIA's 1 and 2, or the complete loss of power to a main engine controller. The main engine controller sends out a T_{ref} signal and ID words 1 and 2 to the GPC's. The SSME SOP in the GPC's must see T_{ref} updating and ID words 1 and 2 in agreement, or a data path failure on that particular engine is announced. Besides the regular warnings, the Pc meter also drops to zero for the data path failure. If the MCC determines that the engine with the data path failure has shut down, the crew will be told to mode guidance for an engine out with the shutdown pushbutton. If the MCC determines that the engine is running but cannot be throttled, the crew will have to protect against a command path failure at MECO by shutting down the engine with the power switches.

REFERENCES

1. Flight Data File Reference Data
2. Flight Data File Data Processing System Dictionary
3. System Handbook Drawings
4. Flight Procedures Handbook
5. Shuttle Operational Data Book

TITLE

FLIGHT RULES RATIONALE

PURPOSE

The purpose of this standard console procedure (SCP) is to document and expand the Flight Rules Rationale. Recently there has been an effort to limit the length of the flight rationale in the Flight Rules document. This effort could eliminate important historical information. This SCP is intended to maintain all relevent historical data pertaining to the Flight Rules.

FLIGHT RULES DESCRIPTION

The Flight Rules outline preplanned decisions to minimize the amount of real-time decision making required when off-nominal situations occur from the start of the terminal countdown through crew egress or ground support equipment (GSE) cooling activation, whichever occurs later.

FLIGHT RULES RATIONALE

Failure Definitions

Flight Rule 5-1 - LOSS OF SRB HYDRAULIC POWER UNIT (HPU)

The SRB TVC system has a lock-out style valve which activates according to specifications when the hydraulic supply pressure drops below 600 psia. Two hydraulic power units are installed for each SRB, and both can supply hydraulic power to the TVC actuators. Control is switched from the primary HPU to the secondary HPU when the hydraulic supply pressure reaches 2050 ± 150 psia. This switchover effectively loses one HPU, although TVC is not lost until pressure drops below 600 psia. Note that primary rock control is on HPU A and primary tilt control is on HPU B. When the hydraulic pressure to the lock-out valve reaches 700 to 800 psia, the TVC will likely be lost. Above 1000 psia, the lock-out valve opens and TVC is still available.

Flight Rule 5-2 - SSME ENGINE OUT

A. Onboard (with Valid SSME Data)

Two cues are required for calls that may result in an abort. The MPS dedicated display driver sequence in the flight software illuminates the red status light if the SSME is in shutdown or post-shutdown phase. The SSME operations sequence in the flight software uses power level < 30 percent as the indication that the SSME has shut down. The engine cannot operate under 30-percent power.

B. MCC (with Valid SSME Data)

Two cues are required for calls that require an abort. Shutdown and post-shutdown phases are set in the engine status word when the SSME controller commands shut down. Pc of 900 psia corresponds to a 30-percent power level.

C. Onboard (with SSME Data Path Failure)

During second stage, when one, two, or three engines are shut down, the g-level decreases by 1/3, 1/2, and 100 percent, respectively. During first stage, the SRB thrust far exceeds the SSME thrust making it difficult to detect an engine shutdown based upon the changes in vehicle acceleration. If the engine did not previously have a helium leak, the crew can monitor the helium tank pressure to compare the tank pressure with that of any running engine. If the tank pressure remains constant, no helium is being used and, therefore, the engine has shut down.

D. MCC (with SSME Data Path Failure)

The GH_2 outlet pressure and the GO_2 outlet temperature are orbiter parameters that can be used to determine whether or not the engine is running. For an engine shutdown during first stage, the second-stage performance, as determined by the ARD, would reflect the loss in performance from the engine shutdown. If an engine fails in second stage, an abrupt drop in acceleration results. The helium system parameters (i.e., tank pressures and temperatures) can be used as an engine-out cue if there is no helium leak in that system. If no helium is being used by that engine, then that engine has shut down. It is important to note that for a short time the engine will use an increased amount of helium during shutdown to perform shutdown purges to various engine components.

E. Engine Limit Exceeded and Shutdown Sensor Failure Definitions

(1) Parameters - Variables which the SSME controller qualifies, monitors, and uses to shut down the engine.

(2) Controller shutdown processing - If two redline sensors are qualified, both must vote for shutdown for action to proceed. If only one sensor is qualified, the controller must rely only on that vote.

(3) Reasonableness testing - Reasonableness testing is required to qualify the sensors for application to shutdown logic. The values chosen screen out sensors with identified sensor problems.

(4) Shutdown limits - Redline parameters are monitored to ensure that the engine is performing within safe operating conditions. Limits are set to guard against uncontained SSME damage. The limits are based upon test stand data, flight experience, and/or engineering

analysis. The engine redline design criteria was defined by MSFC and approved by Level II.

(5) HPFT coolant liner pressure - The redline limit was selected to prevent buckling of the coolant liner and subsequent stalling of the HPFT. This limit was derived from an uncontained failure of SSME 0108 during a ground test. The exhaust turnaround duct buckled, the HPFT stalled, and the low-pressure fuel duct ruptured. Based upon this incident and upon further analysis, the buckling pressure has been determined to be 595 psid with the delta pressure being measured between the coolant liner cavity and the turnaround duct. The redline was set to protect for a delta pressure of 400 psi and has been verified through experimental testing. The reasonableness limits of 4500 and 1800 psi were established because they bracket the sensor range. The redline upper limit is calculated in real time by the controller software and is a function of engine power level. Therefore, the limits at 100, 104, and 109-percent power levels are approximately 3536, 3675, and 3850, respectively.

(6) HPFT turbine discharge temperature - The limit was derived from analysis and protects against stress rupture of the HPFT blades due to high-temperature operation. This redline was developed following uncontained failures on engines 0204 and 2013 during ground testing. These failures were attributed to turbine blade failure which resulted in HPFT seizure and low-pressure fuel duct rupture. Subsequent analysis determined a 2160° R maximum turbine blade root temperature capability for 109-percent power level. This temperature equates to a 2060° R turbine exhaust temperature. The 1960° R limit provides a 100° R margin for the channel B location. The channel A location runs approximately 100° R cooler resulting in a limit of 1850° R for channel A. The upper reasonableness limit of 2900° R guards against open circuits when the connector wire breaks. The lower reasonableness limit of 0° R protects against a degraded sensor. The reasonableness limit for each transducer is calculated real time by the controller software and is a function of engine power level. The lower limit is based upon the average startup temperature between 5 to 5.64 seconds after SSME ignition. This is done on a flight-by-flight basis to ensure comparable margin on channel A and channel B between the predicted nominal value and the redline. Some flight SSME HPFT's may operate at a higher temperature. Engines with these turbopumps may have their redline adjusted upward to provide the same 100° R difference between the main stage operating temperature and the redline as present on other HPFT's.

(7) HPOT turbine discharge temperature - The upper redline was derived from analysis to protect the heat exchanger from overheating and rupturing, which would lead to catrostrophic failure. The limit of 1760° R provides a 100° margin (1860° R is based on meeting one mission life capability; i.e., until nominal predicted MECO). The lower redline limit of 720° R provides protection against inadver-

tent deep throttling of the engine which causes ice formation on the HPOT turbine, subsequent turbine imbalance, and HPOT failure. The reasonableness limit of 2900° R was established to guard against sensors which fail open due to broken wires. Also note that these measurements are temporarily disqualified for shutdown monitoring when in the range between 725° and 795° R.

(8) HPOT secondary seal pressure - The redline limit was derived from analysis to prevent the LO_2 from the HPOT pump from combining with the hot fuel-rich turbine gas in the seal purge cavity. The redline protects against failures of the HPOT primary or secondary turbine seals. The limit is set to ensure that the HPOT intermediate seal cavity pressure is greater than the HPOT secondary seal cavity pressure by 9 psi during main stage, with a minimum seal purge flow rate and a maximum seal gap. Both reasonableness tests provide protection against avionics failures of the pressure sensor system.

(9) HPOT intermediate seal pressure - The redline limit was derived from analysis to prevent the LO_2 from the HPOT pump from combining with the hot fuel-rich turbine gas in the purge cavity. This redline guards against excessive seal wear or loss of the helium purge by ensuring that the HPOT intermediate seal cavity pressure is greater than the HPOT secondary seal cavity pressure by 9 psi during main stage, under the worst seal gap condition. Both reasonableness tests provide protection against avionics failures of the pressure sensor system.

(10) MCC Pc sensor average - This redline was added to protect the engine against the type of failure seen on engine 2106, in which a burnthrough of the bellows section of the HPOT turbine section occurred. This failure was caused by an oxidizer preburner failure and resulted in a bypass of hot gas flow from the turbine directly into the hot gas manifold causing a massive drop in MCC Pc. The redline of 400 psi below the commanded Pc was chosen based upon the amount of damage sustained by engine 2106 HPOT at the time the engine was shut down by a facility redline. The intrachannel reasonableness limit (/Bridge 1 - Bridge 2/ < or = 125 psi) protects against single-bridge failures.

Due to hardware and software limitations in the controller for sampling sensor inputs, the delta value must be set large enough to account for differences in the actual MCC Pc, if the actual MCC Pc is decreasing rapidly due to a real engine combustion problem. If the value is set too tight, the actual MCC Pc could drop greater than the reasonableness limit between sampling the bridge 1 and bridge 2 sensor measurements. A smaller value could allow one or both MCC Pc channels to be erroneously disqualified. If both channels are disqualified, the MCC Pc redline is disabled at a time when it is most needed. The redline qualification limit was increased from 75 psi to 125 psi in response to the catastrophic failure of development SSME 0212 (test 904-44), during which the actual decay rate of the MCC Pc was 105 psi between input samples of the A1/A2 and the B1/B2 Pc pairs. The channel average upper reasonableness limit protects against an off-scale high sensor pair or input electronics failure. The lower limit protects against a failed low sensor pair or input electronics failure. The lower limit protects against a failed low sensor pair or input electronics failure. Note that the intrachannel check and the channel average must be within the specified limits in order to be processed by the controller's shutdown limit logic. These reasonableness checks are in addition to the normal sensor monitoring performed for ignition confirmed and control loop processing qualification. The intrachannel check and the channel average must be within the specified limits in order to be processed by the controller's shutdown limit logic. These reasonableness checks are in addition to the normal monitoring performed for ignition confirmed and control loop processing qualification. The MCC Pc channels are disqualified for control purposes for an intrachannel difference of greater than 75 psi. The MCC Pc redline logic incorporates two reasonableness criteria to ensure that only valid pressures are used.

Notes:

(a) A parameter must be over its redline or reasonableness limit for three consecutive 20-msec controller cycles before action is taken by the controller. This requirement prevents action from being taken on a data hit.

(b) Shutdown for an out-of-limit condition is initiated by the main engine controller if its engines limits are enabled. Limit inhibit/enable operations are dependent on the position of the main engine limit shutdown switch.

(c) If both sensors fail reasonableness, that redline is deleted and redline monitoring is no longer performed on that parameter.

F. SSME Instrumentation/Electronics Failure Matrix

This matrix identifies failures which result in the loss of controller redundancy and in premature engine shutdown. Shutdown caused by dual controller failures cannot be prevented even if the limit shutdown monitoring is inhibited. In these cases, when the second failure occurs, the engine immediately shuts down via the controller's fail-safe pneumatic shutdown sequence. If power is removed from the emergency shutdown solenoid, which is redundantly powered by the main engine's controller, the engine subsequently shuts down pneumatically. Shutdowns caused by redline violations can be manually inhibited by the limit monitoring switch or automatically, via GPC software, after an engine out or a data path failure. If an engine shuts down during ascent or a data path occurs, the limits on the other two engines are inhibited to avoid gaps in abort selection.

TABLE 2.3.2-I.- SSME INSTRUMENTATION/ELECTRONICS FAILURE MATRIX

	CHANNEL B ①									
CHANNEL A ①	DCU/ CIE B ③	IE B ③	OE B ③	PS B ③	HPOT TURB DISCH T B ②	HPOT ISP B ②	HPOT SEC SEAL P B ②	HPFT COOL LINER P B ②	HPFT TURB DISCH T B ②	MCC Pc B AVG ②
DCU/CIE A ③	X			X						
IE A ③		X		X	△X	△X	△X	△X	△X	△X
OE A ③			X	X						
PS A ③	X	X	X	X	△X	△X	△X	△X	△X	△X
HPOT TURB DISCH T A ②		△X		△X	△X					
HPOT ISP P A ②		△X		△X		△X				
HPOT SEC SEAL P A ②		△X		△X			△X			
HPFT COOLANT LINER P A ②		△X		△X				△X		
HPFT TURB DISCH T A ②		△X		△X					△X	
MCC Pc A AVE ②		△X		△X						△X

NOTES:

① CHANNEL A FAILURES WHEN ALIGNED WITH SPECIFIC CHANNEL B FAILURES THAT CAUSE SHUTDOWN ARE DENOTED BY X or △X.

② SENSORS FAIL LIMIT BUT PASS REASONABLENESS CHECKS.

③ LOSS OF CONTROLLER REDUNDANCY.

LEGEND:

X SHUTDOWNS THAT CANNOT BE INHIBITED. PNEUMATIC SHUTDOWN WILL OCCUR.

△X SHUTDOWNS THAT CAN BE INHIBITED USING MAIN ENGINE LIMIT SHUTDOWN SWITCH.

Flight Rule 5-3 - STUCK THROTTLE

Failure of a main engine to throttle can be caused by any of the following failures/conditions:

A. Electrical Lockup

The SSME valves are controlled to their last commanded values to minimize mixture ratio excursions. Mixture ratio is a function of measured Pc and LH_2 flowrate. The mass flow rate is calculated from measured volumetric flowrate and calculated fluid density (as calculated from the LPFT discharge pressure and temperature). Should the LPFT discharge pressure or temperature be disqualified, a "fixed" LH_2 density value is used. Should either the measured Pc or the volumetric flow rate be disqualified, the engine enters into the "electrical lockup" mode and all of the engine valves are maintained at their last commanded position until shutdown is commanded.

B. Hydraulic Lockup

All five engine propellant valves are hydraulically isolated at their last position when one of the hydraulically actuated engine valves violates the surviving actuator channel limits of 6 percent for channel A and 10 percent for channel B. Hydraulic isolation of the valves minimizes, but does not prevent, valve drift which could result in further deviations from the nominal valve positions causing loss of performance and/or possible engine shutdown. One hydraulic system supplies hydraulic actuation to the five valves (a different hydraulic system for each engine). Each valve has a redundant servocontrol system. Channel A is normally controlling unless an error in excess of 6 percent is detected between the commanded and measured positions (expressed in terms of percent of full range valve travel). If channel A fails, channel B control is automatically activated. Channel B uses a 10 percent error comparison instead of 6 percent to take into account the switchover transient from channel A to channel B. Should channel B also fail its 10-percent comparison check, the SSME enters "hydraulic lockup". This would be the case should the orbiter auxiliary power unit (APU) fail to supply hydraulics to its respective engine. If this occurs and a redline limit is exceeded, then the engine is shut down pneumatically. If a redline is not exceeded, then engine shutdown is performed by engine pneumatics when the manual or guidance shutdown command is issued.

C. Command Path Failure

A command path failure is defined as the loss of command capability from the GPC's to an SSME. Without GPC commanding, the SSME is not able to perform the following functions: change throttle settings, inhibit/enable shutdown limits, respond to shutdown commands, or perform an LO_2 dump. Shutdown commands could result from guidance software, from a low-level cutoff, or from a manual pushbutton shutdown. Each controller requires two of three valid command paths from the GPC's to control the SSME. Shutdown of the SSME without GPC control is accomplished by the removal of ac power to the controller. This action activates the fail-safe engine pneumatic system, shutting the SSME down safely. A data path failure results from this action, requiring the crew to push the affected engine's shutdown pushbutton to inform guidance of an engine-out and to safe the engine by closing the LO_2 and LH_2 prevalves.

Flight Rule 5-4 - DATA PATH FAILURE

Since time reference (Tref), engine status word, and average Pc values are present in both the primary and secondary data, the loss of both data types from the controller is required for the GPC's to acknowledge a data path failure. This failure is identified by the GPC SSME SOP software. The loss of both data paths prevents onboard and ground monitoring of all SSME data. If a data path occurs during ascent, the GPC's cannot determine if the engine is out or not. Therefore, for limits purposes, the GPC's take a conservative approach and command the limits on the remaining two engines to inhibited. If the engine is on, the limit control switch can be taken to the "auto" position and then to the "enable" position to re-enable the limits on the good engines. If the engine failed behind a data path, then the limits remain inhibited until crew action is taken at the appropriate abort boundary.

Flight Rule 5-5 - SUSPECT ENGINE

A suspect engine is a result of any of the following failure conditions:

A. If both redline sensors pass their reasonableness limits and only one redline sensor exceeds its shutdown limit, the SSME can continue to operate but will shut down if the second sensor exceeds its shutdown limit. The fact that both sensors have moved toward their redlines indicates that something is wrong with the engine and shutdown could occur at any moment.

B. If both redline sensors exceed limits with the shutdown monitoring inhibited, the SSME is approaching the failure situation which the limits were designed to prevent. The redline will only remain inhibited as long as the vehicle is in a nonintact abort region. While the limits are inhibited the engine may fail at any moment with uncontained engine damage and loss of crew and vehicle. This scenario would result because the shutdown limit protection is not available for this case. The flight director should also be notified and kept informed of the situation so that limits can be enabled immediately, upon reaching the appropriate abort boundary.

C. Using the MPS helium leak isolation procedure, the crew can determine if isolating a given leg will stop the leak. If the procedure is not successful in stopping the leak, it is nonisolatable and may result in SSME shutdown due to the degradation of the HPOT intermediate seal pressure beyond its redline value. The SSME with a nonisolatable helium leak is considered suspect because it may shut down at any moment. If the redline pressure is being violated, the limits are taken to the hard "enable" position immediately so that the engine can shut down safely, even when the vehicle is not in an intact abort region. This is the only redline for which this action is taken, because this is the only redline that has not been tested on an engine test stand. The reason this redline limit has not been tested is because of the fear of a catastrophic/uncontained engine failure.

D. If LH_2 NPSP is low enough to require manual throttling (i.e., below the ICD requirement), at least one SSME may be approaching a redline shutdown due to high HPFT turbine discharge temperature. This Flight Rule is discussed in further detail in Flight Rule 5-50.

Flight Rule 5-6 - Reserved

Flight Rule 5-7 - ENGINE HELIUM SYSTEM LEAK

A tank pressure decay rate (DP/DT) > 20 psia/3 seconds is twice the nominal usage value of approximately 10 psia/3 seconds. This value takes into account normal data noise and the 10 psia data granularity and represents the minimum value usable to detect helium leaks. Note that the decay rate refers to the onboard BFS decay rate computation.

Flight Rule 5-8 - LOSS OF PNEUMATIC HELIUM SUPPLY

The loss of the pneumatic helium supply results in the inability to maintain a regulator outlet pressure greater than or equal to 700 psia for pneumatic valve closures/openings or He flow for propellant dump or entry repressurization. 700 psia is the minimum activation pressure that ensures the proper prevalve response. Pressures of 400 to 500 psia position the valves; however, the prevalves may not meet response timing requirements. The pogo valves require 600 psia for proper operation.

Flight Rule 5-10 - MPS PROPELLANT DUMPS AND INERTING DEFINITIONS

The dumping and inerting of propellants are done to ensure that there are no propellants remaining in the manifolds prior to entry. The orbiter center of gravity is improved by dumping the residual LO_2. The hazard of venting LH_2 during entry and ingesting it into the aft compartment is removed by dumping the residual LH_2. If the LH_2 were ingested into the aft compartment, there are enough ignition sources to ignite the LH_2 which could result in an explosive scenario with the possible loss of crew and vehicle.

POWERED FLIGHT

Flight Rule 5-20 - LOSS OF SRB HYDRAULIC POWER UNITS (HPU's)

The loss of two HPU's on one SRB results in no TVC control on that SRB. This may result in loss of control depending on the nozzle position required for the specific trajectory being flown. Since there is no manual control available, the crew option is to hope that control is maintained through SRB separation.

SSME SYSTEMS MANAGEMENT

Flight Rule 5-25 - ABORT CUE REQUIREMENT

Any engine condition that results in an abort decision is confirmed using two unrelated cues. Two cues are required so that a single instrumentation failure does not cause an erroneous abort decision.

Flight Rule 5-26 - AUTO/MANUAL SHUTDOWN

Manual shutdown of an engine is not attempted if automatic limit shutdown capability is enabled and the engine is approaching a shutdown limit. An exception to this rule is when excessive helium leakage requires manual engine shutdown as discussed in Flight Rule 5-28, ENGINE SHUTDOWN FOR HELIUM LEAKS. The automatic limit shutdown system was designed to prevent a catastrophic failure of an engine. Due to response times and the complexity of the SSME's, the ground and crew will not try to interfere with this system. The automatic limit shutdown system provides the greatest amount of run time while preventing the catastrophic failure of the engine. This procedure also eliminates the risk of the ground or crew of performing an unnecessary or untimely action.

Flight Rule 5-28 - LIMIT SHUTDOWN CONTROL

A. Premature Engine Shutdown

The main engine limit shutdown switch is a three-position switch: ENABLE, AUTO, and INHIBIT. At lift-off, the switch is in the AUTO position, and the limit shutdown control logic is enabled on all three engines.

After one engine-out occurs, the engine shutdown control capability on the two remaining engines is automatically inhibited. This prohibits the engine controller from commanding a shutdown of a second engine for violation of a redline whether the violation is real or is an instrumentation problem. If one of the remaining engines were to shut down, a manual contingency abort would have to be performed unless Single Engine Press-to-MECO, Single Engine TAL, or Droop capability exists. The risk of an engine failing catastrophically while the limits are inhibited is considered to be less than the risk associated with the manual contingency abort.

The re-enabling of the main engine shutdown limits software is accomplished by taking the limit control switch to ENABLE and then to AUTO. This allows one of the running engines to shut down due to limit violation while automatically inhibiting the engine limit shutdown control capability on the one remaining engine. Single-engine flight control capability would then take the vehicle to MECO. The BFS limit control software does not allow the limits to be re-enabled on two remaining engine if the BFS is engaged. The BFS does not have single-engine flight control software and therefore cannot control the vehicle with two engines shut down.

The philosophy of when to re-enable the shutdown limits balances the risk of a second engine shutdown due to sensor failures against the capability of achieving a runway or, if no runway can be reached, against achieving a safe bailout attitude. The September 15, 1987 and November 18, 1987, Ascent Flight Techniques panels reviewed the failure history of the redline sensors and came to the conclusion that the engine redline sensors are reliable and should be trusted not to cause an inadvertent shutdown.

If the MCC determines that all of the redline sensors on all three engines are good, part 2A of paragraph A is applied to re-enable the shutdown limits. The limits are re-enabled on an RTLS when an abort boundary (as defined in Flight Rule 4-26, PERFORMANCE BOUNDARIES) is reached such that a single-engine abort can be accomplished. On a TAL, AOA, or ATO, the limits will be are re-enabled when a suitable bailout condition can be achieved. A safe bailout can only be accomplished if the vehicle is flyable. The vehicle would not be flyable if the engine limits remained inhibited such that the engine redlines could not protect against a catastrophic failure which might destroy critical flight control hardware in the aft compartment. On a TAL, AOA, or ATO, the safe bailout condition occurs when the Droop boundary is crossed.

The limits are re-enabled if one of the redline sensors is failed on the remaining engine and the appropriate boundary exists (RTLS - Single Engine RTLS; TAL, AOA, or ATO - Single Engine Limits if weather or landing aids permits, otherwise Single Engine Press). This rule allows the shutdown limits to be enabled at an appropriate boundary with one sensor failure on one of the three engines, because one sensor failure does not indicate a trend for a generic failure of the sensors. The limits are not re-enabled on an RTLS when an abort boundary (as defined in Flight Rule 4-26, PERFORMANCE BOUNDARIES) is reached such that a single-engine abort can be accomplished. On a TAL, AOA, or ATO, the limits are re-enabled at an appropriate boundary if a suitable runway can be reached. A suitable runway is defined by the weather conditions or landing aids at the runway (ref. Flight Rule 4-64, LANDING SITE WEATHER CRITERIA). If a suitable runway cannot be reached and a sensor has failed, the limits remain until single-engine press-to-MECO even though the bailout capability is available. With one sensor failure, the risk of an engine shutdown due to a second sensor failure is higher than that due to an actual engine failure if the limits were re-enabled. Because of the increased risk of an engine shutdown caused by sensor failures, the exposure bailout is not acceptable. For these reasons the limits are inhibited until the single-engine limits boundary to minimize the need for a contingency abort and crew bailout.

The limit shutdown software is not re-enabled if the MCC determines that two similar redline sensors (temperature or pressure) on one or more engines have exhibited a failure mode such that a subsequent generic sensor failure could cause a shutdown of another engine. This rule defines how the limit control would be managed if two or more sensors failed on the same type of redline. The shutdown sensors on the same redline are suspected of having a generic problem if more than one sensor fails during ascent. The limit control remains inhibited through MECO in order to prevent future sensor failures from shutting down a good engine. The two failures could occur on one or more engines including the failed engine. The MCC is responsible for evaluating sensor failures since the flight crew has no visiblity into the sensor health. Software flags issued by the onboard main engine controller sensor reasonableness software or previously observed failure modes would be used by the MCC as criteria to say that a sensor had failed. If previous to the first engine shutdown, a sensor failure was detected and then the engine shut down based on the remaining redline sensor, that second failure would not be counted as a sensor failure unless the flight controllers could positively identify the sensor failure mode. A subsequent sensor failure on another running engine would have to occur before two sensor failures could be counted. This type of situation occurred on STS 51-F when all sensor failures were detected by the onboard main engine sensor reasonableness software. This software also informed the flight controllers of the failures via the downlisted failure identifier data words.

If an engine exceeds redline limits with limits inhibited and the stability of the exceedance exists, re-enabling of the limits is delayed until the single engine limits boundary. Otherwise, the limits are enabled at Droop. This rule attempts to avoid causing loss of the orbiter and requiring the crew to bail out when the engine has exhibited stable performance with a limit exceedance.

B. Stuck Throttle in the Thrust Bucket

When an engine experiences a stuck throttle in the thrust bucket, performance may be reduced sufficiently such that an abort gap will occur between RTLS capability and any downrange abort capability. Uphill capability may also be lost. The loss of a good engine in this gap will result in the loss of vehicle. Therefore, the main engine shutdown limits are manually inhibited to prevent an inadvertent shutdown due to sensor failures.

If the stuck throttle condition cannot be recovered, shutdown limits will be re-enabled upon reaching the abort capability. This represents the earliest time after which an attempt can be made to reach a landing site with a good engine out. This also can represent the earliest time a safe bailout condition is met.

C. Helium Limits Management

If the vehicle is in an abort gap and pneumatic helium or good engine helium is available to sustain safe engine operation, limits will be inhibited. The shutdown limits will be re-enabled when the appropriate boundary is reached (first abort capability (ACLS, TAL) is reached). Note that limits will be re-enabled to allow the engine with a helium leak to shut down safely.

D. Ullage Limits Management

If flow control valve failures or an ullage gas leak produces low LH_2 NPSP conditions, the limits will be manually enabled by placing the limit shutdown switch to "ENABLE", and manually throttling for low LH_2 NPSP in the flow control valve failure scenario.

E. Data Path Fail/Engine-on Limit Shutdown Control

If a data path occurs on a confirmed running engine, the limits are re-enabled unless there is already a good engine out and the remaining engine does not have a data path. Note that two engines with Pc's less than 30-percent power level and the remaining engine with a data path failure is by software definition (SSME OPS Sequence) MECO.

F. GPC Set Split Limits Management

If a GPC set split occurs and the shutdown limits on two engines are automatically inhibited, the main engine limits are manually enabled.

In a set split condition, two GPC's do not see data from one of the engines and automatically inhibit the limits on the other two engines. If limits are re-enabled by taking the switch to "ENABLE" and then to the "AUTO" position, the limits would be automatically inhibited on the next cycle. Therefore, the limit switch is only taken to the "ENABLE" position.

G. Limit Control for Two Stuck Throttles

For three engines running with one stuck TVC, the loss of a gimballing engine requires the nongimballing engine to be shut down immediately in an attempt to prevent loss of control. This results in the effective loss of two SSME's and a contingency abort if prior to single engine capability, so SSME limits are inhibited to prevent a gimballing SSME from shutting down. Flight Rule 8-41 calls for shutdown of the nongimballing engine at single-engine press on uphill or TAL cases. For some RTLS cases, all engines run to MECO and thus the limit shutdown remains inhibited to MECO.

Flight Rule 5-28 - ENGINE SHUTDOWN FOR HELIUM LEAKS

Safe Shutdown Pressures

Crew intervention may be required to shut down engines early in the event of an excessive helium leak during mainstage to ensure a safe SSME shutdown. Critical helium usage at SSME shutdown is required for (1) LO2 prevalve closure (2) SSME engine shutdown purges, and (3) POGO charge for MECO. The amount of helium usage varies and depends on the three different types of shutdowns. These are (A) pre-MECO hydraulic shutdowns, also known as redline S/D's, (B) pre-MECO pneumatic shutdowns, and (C) zero G shutdowns, either pneumatic or hydraulic. The helium pressures for safe shutdowns do not vary for different abort modes (i.e., nominal, TAL, AOA, ATO, RTLS, contingency). The velocity cues for pre-MECO shutdowns vary, however. These are nominally tagged for MECO - 30-second velocities, except for the RTLS abort.

The helium requirements for these three cases are as follows:

CASE SSME/orbiter interface helium pressure for a safe shutdown

* Single regulator assumes crew-isolated helium leak

Pre-MECO hydraulic S/D - (also known as redline S/D)	518 psia at S/D (dual regulators) 600 psia at S/D (single regulator)
Pre-MECO pneumatic S/D -	529 psia at S/D + 7 sec. (dual regulators) 1457 psia at S/D + 7 sec. (single regulators)
Zero G S/D -	630 psia at S/D + 7 sec. (dual regulators) 1963 psia at S/D + 7 sec. (single regulators)

The helium pressures for safe shut down also can vary depending on whether or not a pneumatic helium interconnect is performed, how many SSME's are running at MECO, whether the helium leak is a pressure-fed leak (i.e., upstream of the 750 psi regulators), or a constant pressure leak (i.e., downstream of the 750 psi regulators), and finally, what the leak rate is. The safe S/D conditions and characteristics of the items covered in the last paragraph include:

CASE SSME/orbiter interface helium pressure for a safe shutdown

Pre-MECO hydraulic S/D (pneumatic tank only)	600 psia at shutdown
Pre-MECO pneumatic S/D (pneumatic tank only)	2036 psia at shutdown + 7 sec.
Zero G S/D (pneumatic tank only)	2800 psia at shutdown + 7 sec. (3 SSME x-con in/open)
Note: Number of x-con's in/op 2220 psia at shutdown + 7 sec. (1 SSME x-con in/open)	Dependent on number of SSME tank pressures less than 2000 psia at MECO.

Leak characteristics

Case	Characteristics
Pressure-fed leak	DP/DT decreasing over time • Helium mass flow is any value above 0.045 lb/sec. • Helium reg, pressures nominal • Helium temps dropping rapidly
Constant pressure leak	DP/DT constant over time • Helium mass flow is always less than 0.8 lb/sec • Helium reg pressures probably off-nominal reg p high - reg fail high reg p low - reg fail low or relief fail open or line break • Helium temps dropping rapidly

Two independent cues are always used to confirm leaks. In the event that helium tank pressure transducers fail, the temperature transducers can be used to approximate tank pressue drops. For every 20 to 30 psia drop in tank pressure, helium tank temperatures (either aft or midbody) drop 1° F. To be conservative, a 30 psi/degree drop can be used. For example, if tank temperatures drop 10° F, a corresponding pressure drop of 200 to 300 psia can be expected. This relationship has been verified through both actual postflight data and SODB, vol. 1, predictions.

For nonisolatable helium leaks, the safe shutdown helium pressures versus total helium flow rates are shown as figure 2.3.2-1 for lower system leaks, and 2.3.2-2 for upper system leaks.

The procedures that MCC operators use to detect and evaluate leaks are discussed in greater detail in SCP 2.2.4.

Zero G S/D

The first thing to evaluate when a leak occurs is if the SSME can support a safe Zero G or MECO S/D. If not, the SSME must be shut down at either (1) a minimum safe tank pressure or regulator pressure or (2) a velocity cue prior to MECO velocity.

For a Zero G S/D, the LO_2 prevalves are closed and helium is injected into the POGO accumulators to maintain sufficient head at the HPOP inlet to

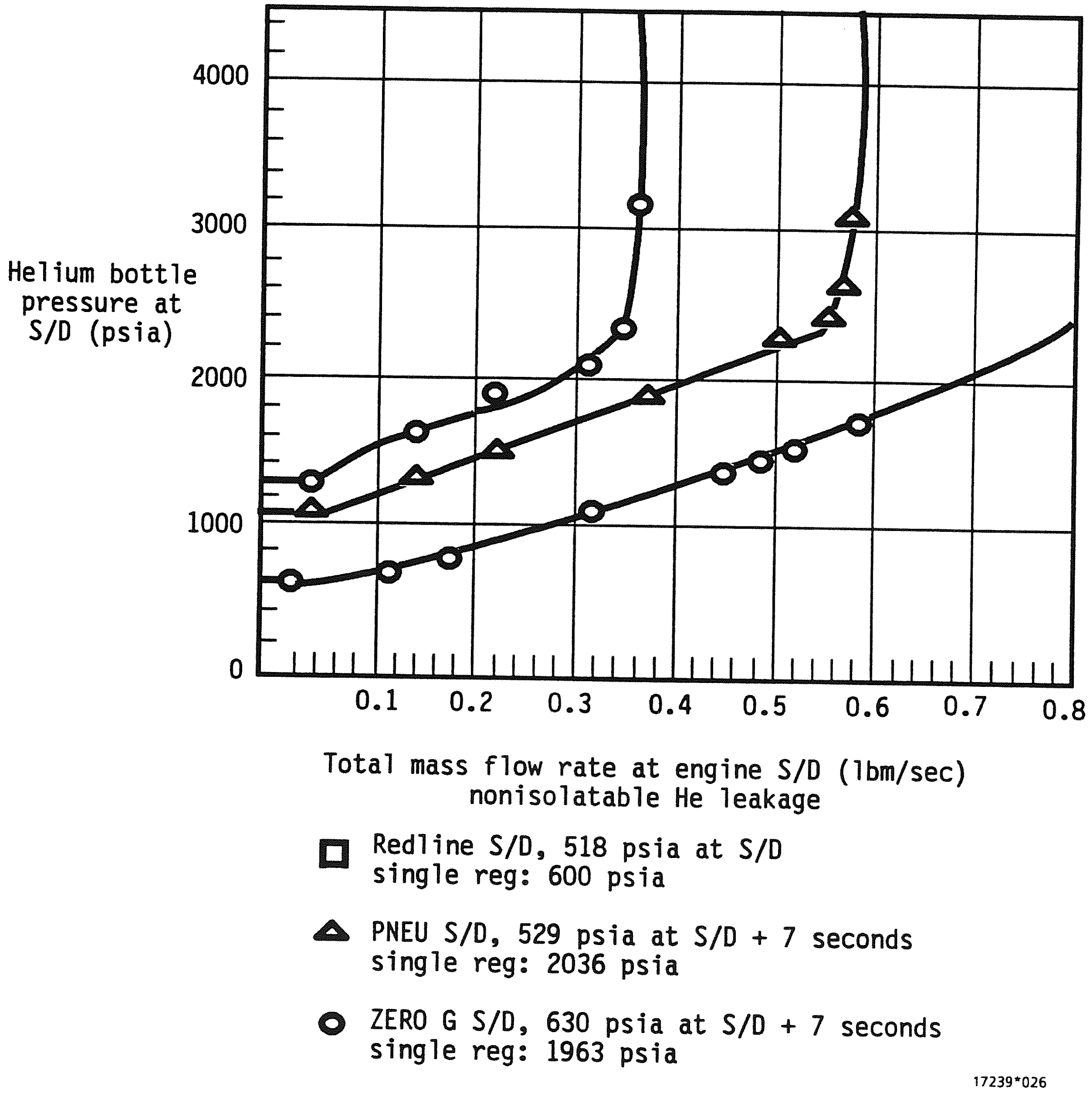


Figure 2.3.2-1.- Minimum helium bottle pressure for SSME shutdown with lower system leak.

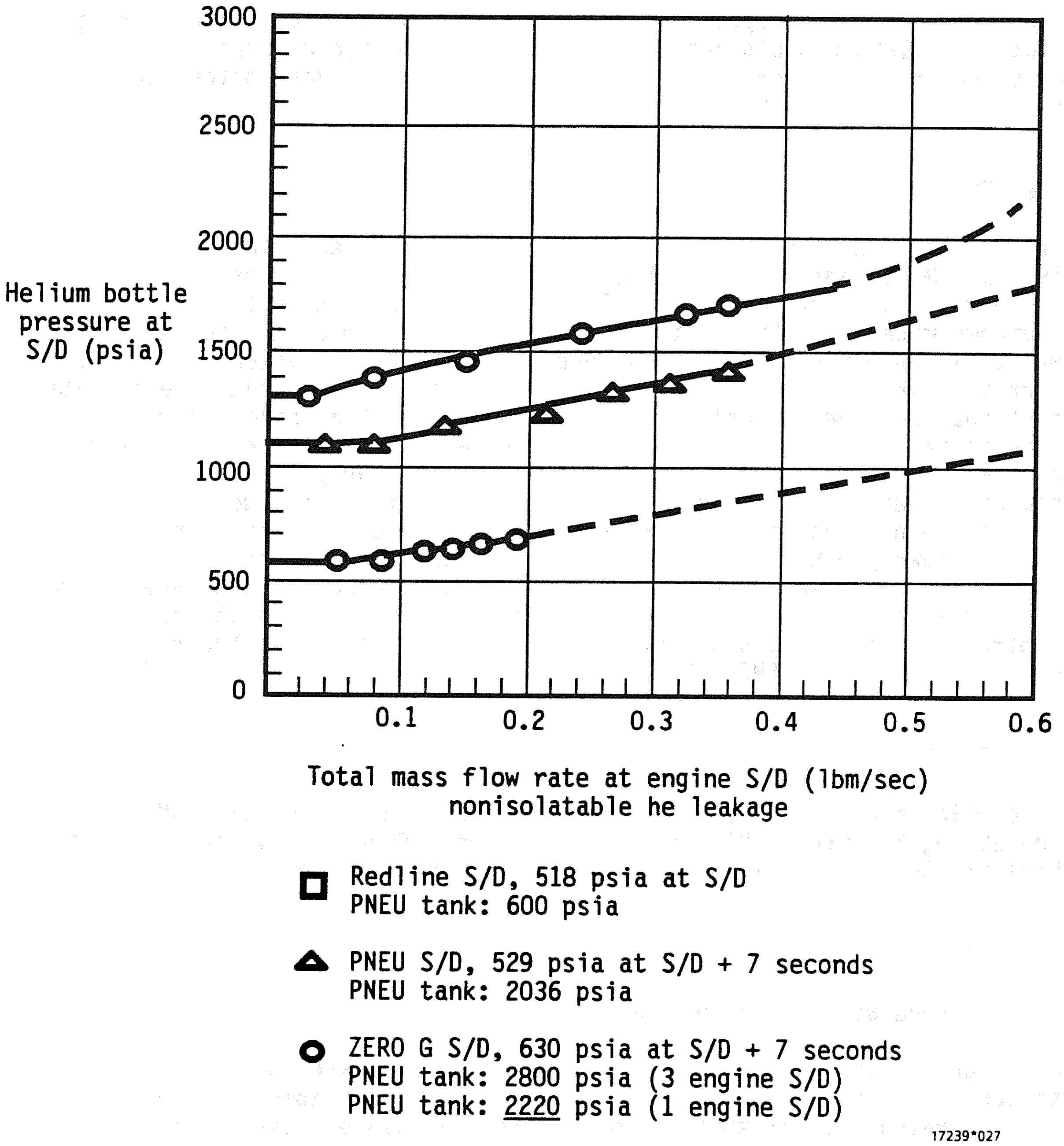


Figure 2.3.2-2.- Minimum helium bottle pressure for SSME shutdown with uppper system leak.

prevent LO_2 pump overspeed and uncontained turbine blade damage during shutdown. Zero G S/D's require the highest helium pressures. The helium pressures required for a safe Zero G S/D's are the same whether that shutdown is done pneumatically or hydraulically.

Pre-MECO Pneumatic S/D

If the SSME cannot support a safe Zero G S/D, the next step is to determine if a pre-MECO redline or pre-MECO hydraulic shutdown can be done. This is the nominal shutdown mode of a SSME at MECO. It is also the nominal shutdown mode of a SSME anytime one shuts down from a redline violation pre-MECO. If an orbiter APU or its respective hydraulic system is failed, the corresponding SSME cannot shut down hydraulically. In this case the SSME must shutdown pneumatically. By shutting down a SSME prior to MECO, the g-load on the vehicle keeps adequate pressure at the HPOP inlet. pre-MECO pneumatic SSME S/D helium pressures are higher than pre-MECO hydraulic shutdown pressures. In addition, if a SSME must be shut down pre-MECO and the shutdown pushbuttons for hydraulic shutdown do not work, the SSME must be shut down pre-MECO with the ac power switches. This shuts down the SSME pneumaticlly. However, even if the SSME shutdown pushbuttons are failed, if the hydraulic system is operational and SSME limits are enabled, the SSME controller can safely shut down the SSME hydraulically at the redline condition based on SSME HPOT intermediate seal pressure (i.e., 170 psia).

Pre-MECO Hydraulic S/D

As mentioned above, this is the nominal shutdown mode of the SSME's at MECO and during pre-MECO SSME redline violations. Pre-MECO hydraulic shutdown's have the lowest helium requirements of any shutdown case.

Special cases

- Low regulator outlet pressure

With large leak rates, even if the tank pressures are adequate for a safe shutdown, the regulator outlet pressures may not be adequate. If regulator outlet pressures, irrespective of the tank pressures, ever drop below 679 psia (C&W and SM alert limit), an interconnect to the pneumatic tank should be done.

- Nonintact abort gap boundarys

If an excessive helium leak exists so that even with pneumatic helium available an intact abort is not available, see rationale for Flight Rule 5-46, ENGINE TO ENGINE HELIUM INTERCONNECT.

- Checkvalve backflow

If two SSME's have simultaneous helium leaks, a single system helium leak coupled with one checkvalve backflowing is a likely cause of the problem (except for cases of uncontained damage in the aft end). See SCP 2.2.4.

- Worse case scenario

What would happen if an SSME, with all available helium, could not make it to the Droop boundary before running low on helium for a safe shutdown? This is a very unlikely case involving multiple failures in time-critical windows, but it has occured during MCC simulations before. There are no effective solutions here. If the SSME is shut down at the safe helium pressure, the crew cannot make safe bailout prior to Droop velocity. If the SSME's run long enough for safe bailout after Droop, the SSME may shut down catastrophically. The MPS operator must recommend the option that allows the minimum level of violations of velocity or helium pressure.

Flight Rule 5-29 - DATA PATH FAIL/ENGINE-ON LIMIT SHUTDOWN CONTROL

The GPC's no longer recieve data from an engine that has a data path failure. Because that engine may have shut down, the GPC's automatically inhibit the limits on the other two SSME's to prevent shut downs due to redline violations. The GPC's do not automatically inhibit the limits on the engine with the data path failure. When the MCC confirms that the engine with the data path is running, the crew manually places the limit shutdown switch to "ENABLE", then to "AUTO" to remove the inhibits. Any further decisions made by the MCC on inhibiting and re-enabling the limits after a subsequent engine shutdown will depend upon which engine has shut down.

If the engine that has shut down is the engine with the data path failure, the limits are not automatically inhibited. The crew must manually place the limit shutdown switch to "INHIBIT" if the appropriate boundary has not been reached for single-engine capability. If the engine that had shut down did not have the data path failure, the limit shutdown control capability of the two remaining engines will be automatically inhibited by the GPC's. In this case, however, the limits are not reenabled at any time. The reason is that if the limits were re-enabled and the remaining engine with the good data path exceeds a redline and shuts down, MECO conditions would be satisfied by having two engines with main combustion Pc's of less than 30-percent power level and one engine with a data path failure. The MECO command would be sent, resulting in the shutdown of the engine with the data path failure. This early MECO could result in an unacceptable underspeed.

Flight Rule 5-30 - DATA PATH FAIL/ENGINE-OUT ACTION

The GPC guidance software does not know an engine has shut down prematurely if the data path to that engine has also failed. Pushing the corresponding shutdown pushbutton sets the safing command for that engine in the GPC's. When the safing command is set, the SSME OPS sequence closes the prevalves and sets the engine fail flag for that engine. Closing the prevalves is essential to isolating the failed engine if the engine failure caused damage to the engine propellant supply lines. There is a potential for a fire or propellant loss with the prevalves open. The engine fail flag is used by the ascent guidance software to adjust the guidance and targeting functions to correspond to the number of SSME's that are operating. This adjustment is required for proper vehicle control.

If the two contacts on the shutdown pushbutton disagree, the safing command is not set. A contact disagreement can be caused by the failure of a contact, the loss of a fuse to a contact, or the loss of a control bus providing power to a contact. Commfaulting the MDM associated with that contact will allow the safing command to be set when the pushbutton is pushed. The MDM can be recovered after the appropriate shutdown pushbutton is pushed and guidance has been moded. Since the loss of a control bus is the only detectable failure, commfaulting will only be attempted for this failure mode. Note that commfaulting the FF MDM's will cage the IMU's - FF1 corresponds to IMU1, FF2 correponds to IMU2, etc.

Flight Rule 5-31 - Reserved

Flight Rule 5-32 - MANUAL SHUTDOWN FOR COMMAND/DATA PATH FAILURES

A. Command Path Failure

In the case of a command path failure, the only way to shut down an engine is with the engine ac power switches. Shutting down with the ac power switches also creates a data path failure. Therefore, the shutdown pushbutton is pushed to tell guidance that an engine is out. The engine is shut down approximately 30 seconds before MECO to prevent depleting LO_2 through an engine which could cause uncontained engine damage. A velocity which equates to MECO minus 30 seconds is also chosen to allow guidance enough time to adjust to the engine out so that guidance can converge to the proper MECO targets. The only exception is an RTLS where the engine is shut down at MECO. On a two-or-three-engine RTLS, if an engine is shut down at a TGO of less than or equal to 60 seconds, guidance will not mode to the target corresponding to the remaining number of engines. To prevent this situation from occurring, the engine is shut down at MECO. On a three-engine press-to-MECO case, MECO minus 30 seconds occurs at a V_i=23 kpfs. On a two-engine press-to-MECO case, MECO minus 30 seconds occurs at a Vi=24.5 kfps. On a TAL abort, MECO minus 30 seconds occurs at a V_i=22.5 kfps.

B. Data Path Failure

For a data path failure, the engine accepts throttling and MECO commands so that no action is required. The crew cannot tell the difference between a data path failure and a command/data path failure. The two failures that caused the data path failure may also have caused a command path failure (i.e., two controller interface adapters (CIA's), or a CIA and a multiplexer interface adapter (MIA) in the EIU). Unless the command capability is verified by the MCC, the crew assumes a command and data path failure and takes the same action as a command path failure. The MCC can verify the command path status by observing that the GH_2 outlet pressure changes with throttle commands.

C. Command and Data Path Failure

The loss of an EIU, the loss of a MIA and a CIA, or the loss of two CIA's will cause a data path failure and a command path failure on the same engine.

This is a very serious failure mode because this failure will close the LO_2 prevalves on an operating engine if preventative action is not taken. A water-hammer effect could occur which would rupture the LO_2 feedline and result in uncontained engine damage and the loss of vehicle. At MECO, the GPC logic assumes an engine with a data path failure does not have a command path loss (i.e., the GPC assumes the engine accepted and complied with the shutdown command); therefore, the prevalves are commanded closed. To prevent this engine catastrophe at MECO, the engine ac switches must be used to shut down the engine before MECO is commanded. The pushbutton must then be used to mode guidance.

Flight Rule 5-33 - MANUAL SHUTDOWN FOR HYDRAULIC OR ELECTRICAL LOCKUP

In the MCC the FDO evaluates the vehicle's capability to reach the nominal MECO targets by evaluating the ARD-predicted delta-V margin. Delta-V margin is defined as the difference between delta-V available from the external tank propellant remaining and the delta-V required to execute a guided MECO. The delta-V margin threshold used to make the "performance nominal" call ensures at least a 3-sigma confidence of making a guided MECO. If after SRB separation the velocity margin is indicating less than the 3-sigma propellant margin, a low-level cutoff may occur and the FDO reports that the vehicle performance is low.

When vehicle performance is low, manual shutdown of an engine in hydraulic or electrical lockup is only required for a three-engine nominal, ATO, or AOA mission. The three-engine LO_2 low-level timer is designed for three engines shutting down from 65-percent power level. If one engine is stuck above 65 percent, the LO_2 net positive suction pressure (NPSP) and post-shutdown LO_2 mass requirements may be violated. Therefore, an LO_2 depletion cutoff at power levels greater than that accounted for by the low-level timers could cause high pressure oxidizer pump overspeed resulting in uncontained engine damage. By shutting down the stuck engine prior to MECO, the two remaining engines throttle to 91-percent power level for fine count. The low-level timer for the two-engine case is designed for two engines shutting down from 91 percent.

For the two-engine-on case with stuck throttles at any power level, the technical community determined that the NPSP would not be severely violated and the minimum post-shutdown LO_2 mass requirements would be satisfied.

Therefore, no action would be required. For an RTLS or a TAL abort, the LO_2 residuals should be sufficient enough to prevent an LO_2 low-level shutdown.

If an engine is locked up and there is no communication with the crew, the crew assumes low first-stage performance.

Flight Rule 5-34 - MANUAL SHUTDOWN FOR TWO STUCK THROTTLES (NOT DUAL APU FAILURES)

A. Three Engines Running

Shutdown priority: (1) command path fail, (2) hydraulic lockup, (3) electrical lockup

B. Two Engines Running - No action required

For dual command path failures ref. Flight Rule 5-32 MANUAL SHUTDOWN FOR COMMAND/DATA PATH FAILURES. For dual hydraulic failures, ref. Flight Rule 8-41, SSME SHUTDOWN DUE TO HYDRAULIC SYSTEM FAILURES.

If two of three operating engines have stuck throttles, manual shutdown of an engine will be required to prevent violation of LO_2 NPSP limits and 3.5g acceleration limits. These limits cannot be violated with only two engines operating. Also, these limits cannot be violated on a three engine RTLS if at least one of the stuck throttles is less than or equal to 85 percent. Above 85 percent, shutting down an engine 2 minutes prior to MECO ensures that these limits will not be violated.

For all RTLS cases with two stuck throttles, minimum throttles are selected prior to abort selection. This allows guidance to converge on the correct average thrust level and reduces the probability of an early powered pitcharound. Manual powered pitcharound may be performed, based on ARD predictions, in order to ensure that the desired MECO targets are achieved.

Shutdown priorities are established to protect against the maximum risk. Command path failure means the engine will not automatically shut down at MECO, which is catastrophic. Hydraulic lockup means shutdown requires the nonredundant pneumatic system. Electric lockup results in a nominal shutdown.

For TAL, it is undesirable to throttle down the good engine due to the guidance transients which may occur and the fact that little time would be gained to perform the abort dump. Therefore, manual throttles are selected, if necessary, to prevent an automatic throttle down when TAL is declared. This action is not required if TAL is declared early enough that automatic throttling does not occur at abort selection. AUTO throttles are reselected after TAL is declared.

Flight Rule 5-35 - ENGINE PERFORMANCE DISPERSION

The engine performance dispersion rule defines the failures and criteria necessary before a performance update is made to the ARD. The method of detecting these performance problems is defined in the main engine cue cards. Updates to the ARD consist of Pc, ISP, and mixture ratio numbers. The ARD uses these SSME performance parameters to predict abort mode capabilities real time. A change in any of these parameters could affect the abort boundaries significantly. The Pc, HPOT turbine discharge temperature, and HPOT discharge pressure are the primary cues for determining performance cases. Mixture ratio and Pc shifts are caused by anomalies in the respective control loops such as pump problems, or sensor shifts. For the Pc sensor shift cases, the rule is clarifying that the properly functioning sensor is the one used in the Booster and FDO performance tables. That is, for a Pc sensor shift high case, the lower Pc is the accurate value and the one used to determine the ARD adjustment. A shift of 25 psia is the minimum detectable shift.

A shifted Pc sensor can so adversely impact engine performance that an ATO cannot be achieved. For such cases, the FDO may call for the malfunctioning sensor to be turned off, so the Booster Officer must be prepared to identify the channel and switch to be deactivated by the crew. Powering down the channel which has a shifted Pc sensor will restore engine operation to nominal thrust and mixture ratio conditions. This action should not be taken if it will cause engine shutdown or not correct the performance dispersion. Cases that would cause engine shutdown consist of another shutdown sensor shift on the remaining channel or loss of the other channel's DCU, IE, or OE. If the engine is electrical or hydraulic lockup, shutting off the sensor (channel) will not correct the dispersion since the engine valves cannot be repositioned. If turning the bad channel causes the engine to be locked up (either hydraulically or electrically), the sensor is not turned off for the same reasons.

A performance adjustment to the ARD, for the LPFT discharge temperature sensor shift case, is only made for the temperature shift low case so that the LPFT discharge temperature cannot become colder in reality. The LPFT discharge temperature at liftoff if 43° R. The minimum detectable error is 2° R to cover instrumentation accuracy and to ensure sufficient change in the engine parameters for failure identification.

If electrical lockup was caused by Pc sensor failures, the actual Pc is calculated from the HPOT discharge pressure. The mixture and specific impulse is then calculated real time for the ARD update. If lockup was caused by LH_2 flowmeter sensor failures, the engine parameters are evaluated to quantify the sensor error. The minimum detectable flowmeter error is 300 GPM.

The SSME controller software uses a closed loop calculation to control mixture ratio and power level. The mixture ratio calculation is based on the measured volumetric flowrate from the LH2 flowmeter. A shift in the flowmeter will cause the controller to calculate incorrect values for LH_2 mass flowrate and mixture ratio. The controller then attempts to return the calculated mixture ratio to the nominal value by adjusting the SSME valves. This will cause the real mixture ratio to be off-nominal. A flowmeter shift low will cause the controller to increase LH_2 flow, creating an actual low mixture ratio condition. A flowmeter shift high causes the controller to decrease LH_2 flow, creating an actual high mixture ratio condition.

For an engine in hydraulic lockup, the mixture ratio and specific impulse is calculated real time. If the performance is changing with time due to valve drift, the average engine performance during operation in lockup will be predicted real time using a computer program. The drift rate is assumed to be linear. Ground testing of hydraulic lockup has shown that significant valve drift can occur on an engine in hydraulic lockup.

Anytime an engine is in hydraulic or electric lockup, the OPOV and FPOV valves can no longer adjust the engine performance in response to vehicle acceleration effects. The overall average performance of an engine in lockup is dependent upon what the acceleration was at the time engine entered lockup. Therefore, the vehicle acceleration effect on performance will be approximated. This approximation is based upon data (SODB TBD) where the LO_2 inlet conditions were varied to simulate acceleration effects.

An ARD update is made for a nozzle leak or HPOT efficiency loss only when the engine has the thrust limiting mode. This mode limits the maximum opening of the OPOV which is used in the thrust control loop. Nozzle leaks and HPOT efficiency loss failures that are not bad enough to cause the engine to go into the thrust limiting mode cannot be distinguished from each other. In these cases, the OPOV is open to maintain Pc; however, the HPOT efficiency loss failure does not result in engine operation with off-nominal performance. The nozzle leak failure results in off-nominal performance because, unlike the HPOT efficiency loss failure, fuel will be lost overboard. Any fuel leak below the fuel flowmeter is referred to as a nozzle leak because leakage from the nozzle tubes is the most likely source based upon SSME experience). If the nozzle leaks and HPOT efficiency losses are bad enough to result in thrust limiting, the nozzle leak or HPOT efficiency loss failures can be identified, the resulting performance quantified, and the ARD updated.

Flight Rule 5-36 - AC BUS SENSOR ELECTRONICS CONTROL

There are single point failures in the ac bus sensor electronics that can cause loss of a single phase of an ac bus which powers the SSME controllers. After an engine failure or electrical/avionics failures that leave an engine one failure away from shutdown, the bus overvoltage protection is less important than keeping an engine running. Therefore, the sensor monitoring electronics power is terminated by moving three switches (AC BUS SNSR) on panel R1 to OFF.

Flight Rule 5-37 - ENGINE OPERATION IN HPFP CRITICAL SPEED RANGE

The HPFP impeller has a life limit of 160 seconds of engine operation in the 32,000 to 32,600 rpm speed range (which corresponds to 82 to 95-percent power level). This limit was established following a failure during ground testing. Normally, prolonged operation in this critical speed range is avoided by the mission trajectory design. However, certain failures during a flight could result in engine operation in that critical speed range. For these cases, engine operation can be continued to MECO with sufficient safety margin. Documentation of this safety margin can be found in RID T-023C closeout (dated 8-14-87) for the fuel turbopump FMEA/CIL. In this RID, the safety margin available in the worst case was evaluated. That worst case was an engine (with an impeller that had accumulated 140 seconds of operation in the critical speed range from previous use) going into lockup at a power level in the critical speed range (i.e., during throttling for maximum dynamic pressure) and then completing an RTLS mission. An RTLS represents the longest runtime required for an engine to reach MECO. The RID closeout indicated that for an RTLS mission, the overall margin of safety is greater than 3.

Another case where the engines may be required to operate in the critical speed range is manual throttling to prevent the LH_2 NPSP from dropping below the required minimum NPSP.

Flight Rule 5-38 - MANUAL THROTTLEDOWN FOR LO_2 NPSP PROTECTION AT SHUTDOWN

If the FDO is predicting a low-level cutoff prior to the guidance software issue of the fine count command (ref. rationale of Rule 4-29G, MANUAL THROTTLE SELECTION), the engines will shut down at an unsafe power level. This will cause the LO_2 NPSP to be well below the required value, possibly causing uncontained engine damage at shutdown. Manual throttling will be performed to 67-percent power level, thereby reducing the NPSP requirements prior to reaching a low-level cutoff condition. The 67-percent throttle level was selected because it provides the best LO_2 NPSP shutdown conditions. The throttledown cue of 2 percent propellant remaining was selected to allow sufficient time to perform manual throttling while minimizing any performance impact. The throttledown times for an invalid onboard propellant remaining computation are based on underspeeds predicted by the FDO (ref. the rationale of Flight Rule 4-29G, MANUAL THROTTLING SELECTION). The onboard computation could be in error if an engine has a stuck throttle in the thrust bucket, or if an engine is operating at an off-nominal mixture ratio. Throttledown for the two-engine on case is an FDO call.

Postthrottledown, the crew will be prepared to perform a manual MECO at the desired MECO velocity should it be reached prior to the low-level cutoff.

MPS MANAGEMENT

Flight Rule 5-45 - ENGINE AND PNEUMATIC HELIUM INTERCONNECT

If an engine experiences a helium leak, the crew will perform an isolation procedure. If the leak is successfully isolated, the MCC will evaluate helium supply to determine if an interconnect with the pneumatic helium is required prior to MECO for single regulator engine helium supply requirements. If the leak is nonisolatable, the MCC will instruct the crew to keep both isolation valves open and evaluate the leak to determine if an interconnect is required to the pneumatic tank.

All of an engine's helium will be used to maintain engine operation as long as possible. With limits enabled, the SSME controller monitors the HPOT intermediate seal pressure and shut down the SSME to protect the safe hydraulic shutdown pressure when HPOT ISP drops below 170 psia. This will occur at a tank pressure of about 600 - 900 psia.

If the pneumatic tank needs to be interconnected to a depleted SSME tank, the interconnect will be done as soon as possible for lower system or isolated leaks. This is done to prevent the crew from having to throw switches during the high g environment of the latter part of the second-stage burn and to avoid the risk of multiple tasks to perform just prior to MECO. If there is an upper system leak, the interconnect is delayed as long as possible. This is to prevent excessive helium from being wasted due to closed tank check valves which isolate the engine system from the leaking tank when the pneumatic helium is interconnected. The tank will continue to leak and any extra helium will be unavailable for future use. The MPS operator cannot distinguish a tank leak from other upper system leaks until after the interconnect is done.

If interconnects are done, they are always done at a minimum pressure of 1150 psia or higher, depending on the situation. See rationale for Flight Rule 5-28.

Flight Rule 5-46 - ENGINE-TO-ENGINE HELIUM INTERCONNECT

If an engine helium system is depleting due to a leak, interconnecting another engine helium system will be allowed for two cases. In both cases, the pneumatic helium supply is interconnected first in an attempt to sustain that engine's operation. Reference Flight Rules 5-28, 5-45, and 5-48.

In the first case, if abort capability is available with a subsequent engine shutdown and the leaking engine is predicted to shut down prior to MECO, the only engine that will be allowed to be interconnected to the leaking engine's helium system is a previously shut down engine. A running engine is not interconnected because there is no assurance that the leak would not increase and jeopardize the good engine helium supply causing a two-engine out situation.

In the second case, if the leaking engine is predicted to shut down prior to achieving abort capability, a previously failed engine (first choice), or a running engine (second choice) will be interconnected in an attempt to avoid certain nonintact abort situations. These situations could result from one engine with a stuck throttle at a low power level on a performance-critical flight or one engine failed. If no previous engine shutdown has occured, a running engine will be interconnected. An engine that has performance or operational degradation will be selected before interconnecting to the good engine. It is safer to jeopardize another engine in trouble before risking a good engine. Using helium from another running engine to support an engine with a helium leak puts the continued operation of that interconnected engine at risk.

However, this risk is less than that associated with a contingency abort that might result if the helium system was not interconnected and the leaking engine shuts down. The running systems are interconnected one at a time, as required. Interconnecting is based on the minimum required pressure of the last supply tank interconnected or the regulator pressure reading of the leaking engine. This will minimize the exposure of a good helium system to the leak. When an abort is achievable, the continued exposure of the nonleaking engine systems to an early shutdown is not warranted and the interconnect from the operating engines are terminated. See Flight Rules 5-27, 5-28, and 5-51.

Flight Rule 5-47 - PRE-MECO HELIUM LEAK ISOLATION

Helium leak isolation pre-MECO is attempted for any detectable helium leak rate from either the SSME helium tanks or the pneumatic helium tanks. Two independent cues must be used to verify a leak actually exists. For certain power bus failures, (MNA, APC4, or ALC1; MNB, APC5, or AL2; or MNC, AP6, or ALC3; for the center, left, and right helium leg A isolation valves, respectively) no helium isolation will be attempted. The A isolation valves would fail closed in these cases and an attempt to close the B isolation valves would shut the respective engine down. It takes two power buses to fail the B isolation valves closed.

The pneumatic helium supply pressure is also critical. It is not used during nominal mainstage operations but is needed to support MECO valve closings and post-MECO purges and post-MECO pneumatic valve operation. The most critical operation is to close the LO_2 prevalves at MECO + 1.1 seconds (700-psia minimum required). Failure to do so could cause HPOT overspeed and uncontained engine damage at shutdown. Two 500-in^3 accumulators downstream of the pneumatic tank, and protected by a check valve, ensure helium for LO_2 prevalve closure in the event of loss of pneumatic tank pressure or pneumatic regulator failure.

If a pneumatic tank leak is detected and the crew isolation procedure is not sucessful, no further crew action is required prior to MECO if accumulator pressure is 700 psia or greater. However, for inadequate accumulator pressure (sometimes called surge Pc), the pneumatic and left engine helium pressures will be manually configured to attempt to supply pressure for valve activation at MECO - 30 seconds.

If the crew isolates a pneumatic tank leak pre-MECO and a subsequent SSME shuts down prior to MECO, the nonreplenished helium accumulator pressure will fall about 40 to 50 psia as a result of the failed SSME's pneumatic LO2 prevalve, LH_2 prevalve, and recirc disconnect going closed. If the resultant accumulator pressure drops below 700 psia, the MECO - 30 second procedure should be performed. Also, if a subsequent FA_2 or MNC fails and helium pressure is above or below 700 psia (helium x-over lost), the crew should initiate the MECO - 30 second accumulator replenish procedure. The helium x-over nominally opens right at MECO command.

Flight Rule 5-48 - PNEUMATIC HELIUM INTERCONNECT

The crew will perform a pneumatic interconnect to a SSME helium tank if needed to extend the SSME's run time to MECO with adequate helium pressure. The pneumatic helium will be used as long as possible to sustain that engine's run time, even if it means depleting the entire pneumatic tank. The C&W value of 1150 psia was based upon the minimum regulator inlet pressure of 900 psia and the helium tank pressure transducer accuracy. The engine tank helium pressure should never drop to 1150 psia unless a leak has occured. Typically, helium tank pressure will fall from about 4300 psia at liftoff to about 2300 psia at a nominal MECO time.

Both the A and B regulators are limit sensed by the backup flight software at the low limit of 679 psia. This value was obtained by subtracting a 36-psia transducer error from the minimum specified regulator outlet pressure of 715 psia. A leak downstream of the regulator could result in the regulator pressure indicating below 679 psia limit while the tank pressure is above 1150 psia. See Flight Rule 5-28 and 5-46.

For the unlikely failure scenario whereby the left SSME helium system is depleted and the left engine interconnect in/open is failed, additional pneumatic helium may be fed into the left SSME through the helium cross-over valve. This situation is unique to left SSME helium leaks, not the right or center SSME systems. Run time with this engine x-over feed is unpredictable and should only be used with engine limits enabled and hydraulic shutdown available. The cross-over valve can only supply enough flow to sustain the HPOT intermediate seal cavity purge, and does not allow enough flow to supply the post-MECO engine purges. Therefore, if the left engine is being fed through the cross-over, this engine should be shut down prior to MECO.

Flight Rule 5-49 - LH2 TANK PRESSURIZATION

The ET pressurization flow control system consists of three tank ullage pressure sensors, signal conditioners in the orbiter, flow control electronics, and three gaseous hydrogen flow control valves. Each control system is single string. The flow control valves are used to maintain the

LH2 tank ullage pressure in a control band of 32 to 34 psia. This band satisfies the ICD NPSP requirements of the main engines.

The failures associated with the system are as follows:

- Two flow control valve sensors failed high - Two sensors failing high would keep the flow control valves closed. One system cannot maintain the pressure within the control band; therefore, the crew would take manual control of the valves to maintain adequate ullage pressure.
- Two flow control valves failed closed, tank leak, or relief valve failure - For these failures, the pressure would decay below the control band and eventually violate the minimum ICD NPSP requirements. If the valves are failed closed the switch will not open them and, for the other two cases, the flow control valves are all open but the leak prevents the system from maintaining proper pressure.

Flight Rule 5-50 - MANUAL THROTTLING FOR LOW H2 NPSP

If the steps of 5-49 were ineffective, this rule is applicable. The engines will violate the HPFT TDT redlines and cavitate if the LH_2 NPSP falls below requirements.

If the failure is identified as two or three flow control valves failed closed, the main engines would be manually throttled to maintain NPSP greater than 3.5. This value was selected to avoid NPSP regions where the HPFT starts to severely cavitate and the rate of temperature rise increases exponentially. HPFT Turbine Discharge Temperature is the back-up cue in case the HPFT starts to cavitate at a higher NPSP than expected.

Throttling in three steps minimizes crew/MCC impact and approximately divides the actions into thirds. The throttle steps are 95-80-65 percent.

If the failure is an ullage leak or a relief valve failed open, the main engines are not throttled since this would deliver less impulse then allowing the engines to shut down because of low NPSP. In this failure scenario, a transoceanic abort landing (TAL) would be selected to allow for early engine out capability. Before selecting TAL, the crew should select manual throttles and enable the main engine limit. Selecting manual throttles will prevent automatic throttledown for fuel dissipation upon TAL selection, and enabling the main engine limits will allow for the engines to shut down early should NPSP requirements be violated. After TAL is selected, the crew may reselect automatic throttles without the threat of throttledown. Throttledown is undesirable in the ullage leak scenario, because less ullage is being supplied to the external tank.

Flight Rule 5-51 - ABORT PREFERENCE FOR SYSTEM FAILURES

For the cases of three flow control valves failed closed, an ullage gas leak, or engine-to-engine helium interconnect due to a leak, a TAL abort is preferred.

A. Ullage leak or three flow control valves failed closed - A TAL abort is preferred over RTLS because TAL MECO conditions are satisfied sooner then RTLS MECO conditions. Once an ullage leak occurs, it may become worse, causing NPSP to deteriorate faster than the three failed flow control valves case. Since the engine shutdown time cannot be predicted, it is important to reach multiple engine out capability and MECO conditions as soon as possible, and these occur during a TAL abort.

B. Engine-to-engine interconnect - An engine-to-engine helium interconnect would only be implemented for severe helium leaks, and adequate helium may not be available to support three-engine operations to nominal MECO in this case. The leaking as well as the nonleaking engine could shut down due to insufficient helium. Therefore, the earliest multiple engine out capability and MECO conditions are required. These occur for a TAL abort.

Flight Rule 5-52 - ET LOW-LEVEL CUTOFF SENSOR FAILED DRY

Three or more low-level sensors failed dry will require a TAL abort. Propellant low-level shutdown software is provided to protect the vehicle from an uncontrolled engine failure caused by LO_2 or LH_2 depletion. Software requires two qualified sensors to indicate dry after the arming mass is reached in order to start the low-level timer and issue the MECO command. On the first pass the software will disable one dry sensor. Low-level sensors will not be acknowledged if its associated FA MDM is commfaulted. On the next pass, the software will command MECO if two other sensors on the same tank are failed dry. Therefore, three sensors dry when the arming mass is reached will result in an early MECO which may require a TAL abort if a 2-sigma confidence of achieving AOA with an early MECO does not exist.

Flight Rule 5-53 - MECO CONFIRMED

The depression of three pushbuttons simultaneously are required to set the MECO confirmed flag. The SSME OPS sequence checks for a data path on one engine and Pc's less than 30 psia on the other two for MECO confirmed. If two engines have data paths, the software will not pass this check and MECO confirmed will not be issued. For this case the crew will push all three pushbuttons simultaneously after MECO to set the MECO confirm logic. This is required to start the ET SEP sequence. In the event of a pushbutton failure, the crew can PRO to Operational Sequence 104.

Post-MECO - MPS

Flight Rule 5-60 - ET SEP INHIBIT FOR 17-INCH DISCONNECT FAILURE

The ET SEP sequence will automatically inhibit separation if at least one of two close position indications are not recieved by the GPC's. Separation is inhibited, in the open disconnect scenario, because of the threat of ET recontact due to large venting forces. Although there is a mechanical backup for closing the valves, if insight into their position is lost, then separation is inhibited. The crew would perform a manual separation after 6 minutes. The delay allows the tank and orbiter manifold pressures to dissipate such that the venting force through the open disconnect is considered safe for separation.

If an OMS-1 burn is required, separation is performed at TIG - 1 minute 30 seconds. This gives the crew sufficient time to prepare for the burn.

Flight Rule 5-61 - ENGINE MANIFOLD OVERPRESSURE

A. An engine manifold overpressure condition exists when the pressure is greater than 249 psia in the LO_2 manifold or 60 psia on the LH_2 manifold.

The conditon may occur if the LH_2 of LO_2 relief isolation valves fail to open or if the LH_2 or LO_2 relief valves fail to relieve with residuals in the manifold. Heat soaks back into the cold fluids and causes the pressurization. The condition can be relieved by performing the MPS propellant dump, if it has not been performed. This vents the manifold and residuals. If the condition occurs after the dump, the manual vacuum inerting can be performed with the same results. For the LH_2 system, overpressurization can be relieved by opening the LH_2 RTLS Backup Dump Valves. However, these can only be opened manually during OPS 1 and OPS 6.

B. If the LH_2 manifold pressure C&W alert capability is lost prelaunch or pre-MECO, the crew is required to open the LH_2 RTLS backup dump valves post-MECO. This is to protect the system against an undetectable overpressurization condition. This is sufficient to relieve the system until a complete dump and vacuum inerting is performed. This concern is only on the LH_2 system because hydrogen expands at a much faster rate then LO_2.

C. If the LH_2 relief isolation valve fails closed post-MECO, the LH_2 RTLS backup dump valves are opened to relieve the manifold. With the relief isolation valve failed closed, the LH_2 manifold cannot be relieved and the nominal pressure build up post-MECO results in manifold rupture.

Flight Rule 5-62 - POST-MECO AND ENTRY HELIUM ISOLATION

If a leak occurs on an engine or pneumatic helium system, the affected system will be isolated. Helium is required for manifold pressurization during the MPS dump and entry, valve actuation, and the entry aft compartment purge. If more than one system appears to be depleting simultaneously while the helium systems are manifolded together, the leak is probably located in the common manifold. In this case, isolation is attempted by closing the pneumatic isolation valves to prevent a total loss of helium.

For nominal missions, if a leak occurs prior to the MPS dump, the leak may be isolated and the helium system subsequently reconfigured to support the MPS dump. Helium leak isolation is performed on any MPS helium system during entry. If time permits, after the leak is isolated, the helium system may be manually reconfigured to support the entry purge. The entry purge is highly desirable for nominal end-of-mission but is considered mandatory during aborts. If a hazardous gas leak is evident in the aft compartment or the OMS pods, the entry purge is required. Contamination may also be injested into the evacuated MPS manifolds if the helium pressurization is not performed. The contamination in the lines would require cleaning before the next flight, increasing the vehicle's turnaround time.

During an RTLS abort, post-MECO isolation may not be performed. Because of the limited flight duration and the crew workload, there may not be adequate time to reconfigure the MPS helium system to support the entry purge.

Flight Rule 5-63 - ET UMBILICAL DOOR CLOSURE DELAY FOR DISCONNECT VALVE FAILURE

Manual closure of the ET umbilical doors is delayed for the failure of the LO_2 and/or LH_2 17-inch disconnect valve to close. Door closure is delayed to allow for residuals to sublimate and vent. A minimum of 40 minutes of bottom Sun exposure immediately prior to ET door closure will satisfy these requirements. This allows proper door closure/sealing and prevent pressurization of the ET umbilical compartment. This also reduces the chance of residuals entering the aft compartment.

Flight Rule 5-64 - MANUAL MPS PROPELLANT DUMP

A. On a standard insertion, the dump starts automatically when the OMS burn flag is set. If the burn is to be delayed beyond MECO plus 6 minutes, the MPS dump will be manually initiated. On a direct insertion, OMS-1 is normally not performed; therefore, the dump must be manually initiated. In both cases, the manual dump is performed at MECO plus 2 minutes to conserve APU propellant and to allow the FDO to acquire a state vector without the effect of the dump. The APU's are required to supply hydraulic pressure to open the main oxidizer valve on each SSME for the LO_2 dump. The MPS dump imparts approximately 13 ft/sec delta-v on the vehicle which would impact the FDO's acquisition of the orbiter state vector post-MECO.

B. On an RTLS, the MPS dump is initiated at the MM 602 transition and terminated at a ground relative velocity of 3800 fps. However, following the transition to MM 602 on certain contingency aborts declared after RTLS has been selected, the orbiter relative velocity is less than the 3800 fps at the MM 602 transition. In this case, the MPS dump is initiated and terminated at the same computer software cycle. Therefore, a special procedure is required to allow hazardous LH_2 residuals to be vented overboard away from the orbiter. The crew performs this manual LH_2 dump by taking the MPS dump switch to start prior to the MM

602 transition. This action activates the software to open the LH_2 prevalves and the LH_2 fill/drain valves.

Flight Rule 5-65 - NOMINAL AOA AND ATO MPS PROPELLANT DUMP FAILURES

A. The MPS dump switch can no longer be used to manually start the dump if the switch fails redundancy management. As a workaround, the OMS burn targets would be loaded but the OMS engines would be not be configured for the burn. At the TIG time, the burn flag would be set which would initiate the MPS dump sequence.

B. The LH_2 propellant dump is pressurized via helium through the topping valve and overboard through the fill and drain valves. If a valve fails to open for the dump, the RTLS dump valves will be opened to ensure LH_2 residuals are vented and to provide redundancy against the additional failure of the manifold relief valve.

C. LO_2 residuals are expelled through the SSME main oxidizer valves. The only alternate dump path available is through the fill and drain valves. The expulsion momentum of these residuals would result in the generation of roll rates on the vehicle. Therefore, it is desirable to allow the residuals to vent through the high-pressure oxidizer pump seals, provided the LO_2 prevalves are open and the relief system will protect the manifold from overpressurization. LO_2 residuals should be allowed to vent such that roll rates can be counterbalanced through RCS firings. It has been determined through analysis that roll rates can be maintained if fill and drain initiation is postponed until the manifold pressure decreases below 40 psia. Approximately 70 minutes of venting is required for the pressures to dissipate below 40 psia.

Flight Rule 5-66 - MANUAL VACUUM INERTING REQUIREMENTS (NOMINAL, ATO, AOA)

LO_2 manifold pressure will be less than 40 psia if a propellant dump is performed successfully. However, if two or three main engine oxidizer valves were not able to open for the dump, the residual oxidizer could result in a manifold pressure greater than 40 psia. As a result, opening the LO_2 fill and drain valves when the manifold pressure is greater than 40 psia will cause the vehicle to roll significantly, as was experienced during a dump detailed test objective on STS 51-D. The roll was due to the oxidizer flow force at the LO_2 outboard fill and drain valve and the flow impingement on the wing. Opening the fill and drain valves will not be delayed if the manifold pressure is high enough to trigger the crew alert of 249 psia (refer to Flight Rule 5-61, ENGINE MANIFOLD OVERPRESSURE).

The reason the LO_2 vacuum inerting will be delayed is that the LO_2 prevalves remain open after the dump which allows the pressure to vent through the engine high pressure oxidizer pump seals. After the pressure decays below 40 psia, the crew can then perform vacuum inerting without any control problems. For a nominal or ATO mission, there should be sufficient time to allow the pressure to decay, and then the vacuum inert can be performed.

However, for an AOA, there may not be sufficient time to vent below 40 psia. For this case, the LO_2 manifold will be inerted automatically at Mach 20 by the MPS entry sequence. At this time, there should be sufficient control authority from the vehicle aerosurfaces to provide vehicle control.

Flight Rule 5-67 - VACUUM INERT REPEAT OPERATIONS

Vacuum inerting will be repeated if propellants are believed to remain in the manifolds. Propellant remaining could be the result of an incomplete MPS dump or vacuum inert, or of frozen propellants becoming trapped in screens and/or crevices in the MPS manifolds.

Thermal drift of the transducers under noncryogenic conditions may cause false indications of a pressure rise which does not exist. The transducers are vehicle unique; therefore, previous flight data should be used to determine thermal drift rates. In addition, preflight ambient transducer readings are used to determine actual manifold pressures.

Flight Rule 5-68 - LH_2 PRESSURIZATION VENT CONTROL

The LH_2 pressurization line vent must be closed for at least 30 seconds prior to ET/orbiter umbilical door closure in order to prevent damage to the doors or to the cavity. The 30 seconds ensures low pressure in the cavity (ref. SODB, vol. I, section 3.4.3.1-6).

Flight Rule 5-69 - ENTRY MPS HELIUM PURGING FOR CRITICAL VEHICLE POWER/COOLING

The loss of two Freon coolant loops or the loss of two fuel cells will require that critical power and cooling be conserved. For these failure cases, power reductions in all systems are required to accomplish a safe entry. MPS valves that are normally closed valves will be positioned to the CLOSE position.

This reconfiguration saves approximately 234 watts. The lack of repressurization during entry may result in contamination of the MPS propellant lines requiring cleaning during vehicle turnaround. This could cause a long turnaround and possibly impact the flight manifest.

The MPS entry purge for RTLS and TAL abort cases is required to purge the system of hazardous residual MPS propellants.

Flight Rule 5-70 - SSME HYDRAULIC REPRESSURIZATION/POSTLANDING SSME REPOSITIONING

Hydraulic pressure is applied to the TVC actuators to prevent SSME movement during on-orbit, entry, and postlanding operations. Maintaining helium pressure on the closed side of the engine valves keeps the valves from opening when hydraulic pressure is applied to the TVC actuators. Keeping the valves closed prevents engine contamination during entry and postlanding. On-orbit SSME contamination is unlikely; therefore, the application of helium for on-orbit TVC drift is not required. This will also reduce MPS helium regulator cycles.

Flight Rule 5-71 - ENTRY MPS PROPELLANT DUMP FAILURES

A complete LH_2 dump can be performed if either the RTLS dump valves or the LH2 fill and drain valves can be opened. A complete LO_2 dump can be performed if two or three main oxidizer valves or if the LO_2 fill and drain valves can be opened (ref. Rockwell Internal Letter no. 287-104-87-004, January 8, 1987).

In the LH_2 system, there are single-avionics failures which result in the loss of GPC control of the LH_2 fill and drain valves and the LH_2 topping valve. In these cases, the fill and drain valves are opened manually on a TAL or an RTLS only if the RTLS dump valves are not open. There are also combinations of avionics failures which result in the loss of both LH_2 dump paths. For these cases, GPC control of the RTLS dump valves, the LH_2 inboard fill and drain valve, and the LH_2 topping valve is lost. On a TAL abort, the crew will manually open the LH_2 fill and drain valves, which will also open the topping valve. The RTLS dump valves cannot be opened manually in these cases because the switch is only read by software, and only in OPS 1. The MM 304 transition cue used to manually open the fill and drain valves is the same as that used by the GPC software. On an RTLS, the crew will restring for any two GPC's/FA's down to regain jets needed for ET separation; therefore, the dump paths may be automatically regained without further crew action.

In the LO_2 system, there are single avionics failures which result in the loss of GPC control of the LO_2 fill and drain valves. In these cases, the fill and drain valves are opened manually on a TAL or RTLS if less than two main oxidizer valves are open. The manual opening of the fill and drain valves cannot be performed until the vehicle aerosurfaces can provide sufficient control authority. The Mach and Q-bar cues used to manually open the valves are the same as those used by the GPC software.

The MPS propellant dump and vacuum inerting should provide a sufficient dump of the LO_2 and LH_2 residuals on nominal, ATO, and AOA missions prior to entry. However, if residuals remain due to GPC/MDM failures, the crew will manually open the affected fill and drain valves.

An attempt will be made to close the LO_2 and LH_2 outboard fill and drain valves in order to preserve helium for the aft compartment purge and to minimize contamination of the manifolds. The velocity cues used to close the valves represent an altitude at which possible ignition of residual MPS propellants can occur.

Flight Rule 5-72- DUMP INHIBIT FOR A FAILED SSME

For nominal, RTLS, TAL, ATO, and AOA missions, the dump is inhibited by manually closing the associated prevalve and powering down that engine's controller. Closing the prevalve isolates the engine systems. Powering down the controller ensures closure of the bleed valves. This will prevent excessive leakage of propellant into the aft compartment during the MPS propellant dump, thereby minimizing potentially hazardous conditions in the aft compartment.

The inlet pressures should be evaluated soon after the engine fails since heat soak back could increase the pressure(s) above the dump inhibit criteria.

Reference the PSIG Flight Rule review of 2/25/88.

Flight Rule 8-41 - SSME SHUTDOWN DUE TO HYDRAULIC SYSTEM FAILURES

SES testing has verified that vehicle control is acceptable with three engines running and one nongimballing (two-engine control laws are utilized). To minimize the time to single-engine press, the nongimballing engine will be allowed to continue to run. The risk incurred in this period is that a good engine will shut down and the required immediate action (shutting down the nongimballing engine, ref. part A above) may or may not recover control. This will result in a contingency abort due to two SSME's out. For this reason, main engine limit shutdown is inhibited during this period (ref. Flight Rule 5-27F, LIMIT SHUTDOWN CONTROL).

After single engine capability is achieved, the performance risk incurred due to a good engine failing following shutdown of the nongimballing engine is minimized. At the same time, the loss of control risk associated with allowing the nongimballing engine to continue to run remains. Therefore, the nongimballing engine should be shut down at single-engine press to minimize the next failure impact.

If two engine throttles are stuck at a high power level, 3.5g may be exceeded near MECO. Shutting an engine down at an operationally convenient point such as single-engine press will eliminate this problem.

The risk of incurring an engine failure with shutdown limits inhibited between Droop and single engine press is considered to be less than the risk of shutting down the nongimballing engine with the inherent performance loss at Droop.

For a three-engine TAL the same rationale as part 1 above applies or engine shutdown. There are several reasons why it is undesirable to throttle down the good engine: it may result in guidance transients, flight control would not be as good during the roll to heads up (although it would still be acceptable), little time would be gained to perform the abort dump, and the time to single-engine press would be increased. Therefore, manual throttles will be selected, if necessary, to prevent an automatic throttle down when TAL is declared. This action is not required if TAL is declared early enough that automatic throttledown will not occur at abort selection. AUTO throttles are reselected after TAL is declared.

During an RTLS, as with the NOM/ATO/TAL cases, it is preferable to leave the nongimballing engine running through single-engine press to MECO and accept the risk of the loss of a gimballing engine to this point. Doing so can reduce the time to MECO by as much as 2 minutes. However, single-engine press to MECO occurs at 45 seconds to go on RTLS, and RTLS guidance retargeting is inhibited 60 seconds prior to powered pitchdown (approximately 80 seconds before MECO). Shutting down an engine at single-engine press results in higher dynamic pressure during mated coast and ET separation, which causes sluggish flight control response and can lead to ET recontact.

For cases in which at least one throttle is stuck at or below 85 percent, there is no threat of exceeding 3.5g. Therefore, the risk of losing a gimballing engine during the last 45 seconds of powered flight is accepted and the nongimballing engine is left running to MECO in order to avoid the problems associated with shutting down an engine at single-engine press. For cases in which both stuck throttles are above 85 percent, an engine must be shutdown in order to avoid the possibility of exceeding 3.5g. Since single-engine press is not an acceptable cue, the nongimballing engine will be shut down 2 minutes prior to MECO to ensure stabilization of the shutdown transients prior to the time at which guidance retargeting is inhibited. For all RTLS cases with two stuck throttles, minimum throttles are selected prior to abort selection. This allows guidance to converge on the correct average thrust level and reduces the probability of an early powered pitcharound. Manual powered pitcharound may be performed, based on ARD predictions, in order to ensure that the desired MECO targets are achieved.

Shutdown Matrix

Failed hyd system	Nongimballing engine	Engines with stuck throttles
1 and 3	Center	Center and right
1 and 2	Left	Center and left
2 and 3	Right	Left and right

The failure of two hydraulic systems causes two engines to lock up hydraulically and eliminates TVC capability on one of these two engines. The engine shutdown matrix identifies which engines have lost TVC and/or throttle capability.

(This rule references Flight Rule 5-34, MANUAL SHUTDOWN FOR TWO STUCK THROTTLES, and Flight Rule 5-27, LIMIT SHUTDOWN CONTROL. It is referenced by Flight Rule 5-34, Flight Rule 5-27, and Flight Rule 2-200, CONTINGENCY ACTION SUMMARY).

COMPUTATIONS 3

COMPUTATIONS

TITLE

SSME SHUTDOWN TIME TAGS

PURPOSE

This SCP describes the special computation (with PASS data) required to compute the time that each main engine enters the shutdown phase. The current operating phase of each main engine is determined in the engine status word (ESW) processing computation. The engine phase is determined by monitoring bits 9, 10, and 11 of the ESW from each engine. When a 101-bit pattern is observed indicating C (L,R) SHTDN, mission elapsed time (MET) is used to time tag the event. A similar computation is done on the BFS ESW by the flight dynamics section.

PROCEDURES

A. Inputs

TABLE 3.1.1-I.- SSME SHUTDOWN TIMETAG COMP INPUTS

TM inputs	Comp no.	Nomenclature	Units
(ESW) E41M1003P	M25G3708E	C SHTDN	EVENT
E41M2003P	M26G3708E	L SHTDN	EVENT
E41M3003P	M27G3708E	R SHTDN	EVENT
	M01G1900T	GPC MET	min:sec

B. Outputs

Whenever one of the inputs changes to 101, the current MET is loaded into the corresponding output time tag. If the same input changes from 101, the output is frozen, but will update with a new MET if the input changes back to 101.

The PASS C (L,R) times of shutdown are displayed on the Booster MSK's 1052, 1071, 1072, 1073, 1074, 1075, 1076, 1079, and 1080. The BFS times of shutdown are displayed on MSK 1052 and the BFS MSK's 1064, 1065, 1089, and 1090.

TABLE 3.1.1-II.- PASS SSME SHUTDOWN TIME TAGS (BOOSTER COMP)

Comp no.	Nomenclature	Units
M01G3705T	CTMOF SHDN	min:sec
M02G3705T	LTMOF SHDN	min:sec
M03G3705T	RTMOF SHDN	min:sec

TABLE 3.1.1-III.- BFS SSME SHUTDOWN TIME TAGS (FDO COMP)

Comp no.	Nomenclature	Units
M01G4300T	BFS S/D CTR	min:sec
M02G4300T	BFS S/D LEFT	min:sec
M03G4300T	BFS S/D RIGHT	min:sec

REFERENCE

MCC Level B and C Requirements For Shuttle (JSC-11028) Vol I, Book 5, Errata for June 12, 1989.

TITLE

SSME HARD FAILURE IDENTIFICATION (ID) PROCESSING

PURPOSE

This SCP describes the initialization and control of the special SSME hard failure ID display and the interpretation of associated displays.

DESCRIPTION

The latest failure identification (FID) is currently reported in vehicle data table (VDT) word number 5. This word represents the last confirmed failure at VDT transmission initiation. If multiple failures occur within 40 milliseconds, only the last failure is reported in the VDT. The last failure remains on the downlink until replaced by subsequent failures.

The three 16-bit words containing main engine FID data (one per SSME) are received and processed at a 25 Hz sample rate. These data are displayed for each of three main engines in columns on the SSME HARD FAILURE ID displays, MSK's 1069 and 1070. The FID for each engine is also included in hexadecimal on that engine's history tabs, MSK 1071 through MSK 1076. MSK 1069 is the preferred display for monitoring the FID's. The latest FID syntax for each engine is also available on MSK's 1051 and 1052.

Bits 1 through 7 define, in octal, the FID number which indicates the type of failure or function affected; i.e., DCU A, DCU B, IE A, IE B, OE A, OE B, Bits 8 through 16 define, in octal the delimiter number which will indicate what element of the function failed.

The FID and the delimiter syntaxes are combined into one character stream (14 characters on the first line, 14 characters on the second line). Time of failure is displayed opposite the first line of each failure message. Time is derived from timing reference (TREF) (E41W1004B, E41W2004B, E41W3004B) and starts incrementing at SSME start. Failure messages are listed sequentially with the latest data appearing at the bottom of the list. If a left engine, center engine, and/or right engine column becomes full, that column becomes frozen and the other columns continue to update. There is no recall capability to display failures that occur during the time a column is full and frozen. Failure messages are entered into MSK's 1069 and 1070 whether or not it is called up.

MSK 1069 is identical to MSK 1070 except for the addition of three columns (one for each engine) to display the octal representations of the failure ID's and the delimiter ID's. The octal failure ID and delimiter ID combination should span two lines with the failure ID appearing on the first line (next to the time reference) and the delimiter ID appearing immediately below it on the second line.

Each column can accommodate up to 19 hard failures that require both first and second lines of 14 characters.

FID and/or delimiter numbers that are undefined in ground processing are displayed in octal with the applicable time reference.

No syntax will be output if the FID word (both FID and delimiter) is all zeros because that is the normal downlink state when no failures are being transmitted.

Figure 3.1.2-I shows how the following failures from flight 51-F appear in the MCC time tagged with time reference.

1. SEN FAIL - HPFT TURB DISCH TB (FID 11, delimiter 002) was reported on the center engine at TREF = 3:37.4. This time corresponds to MET = 3:30.8.

2. LIMIT SD-001 (FID 13, delimiter 001) was reported on the center engine at TREF = 5:49.4 (MET = 5:42.8). This FID indicates the center engine shutdown when the HPFT turbine discharge temperature A exceeded its redline.

3. EXCD LIM 002 (FID 113, delimiter 002) was reported on the right engine at TREF = 8:18.7 (MET = 8:12.1). This FID indicates that the HPFT turbine discharge temperature B had exceeded its shutdown limit while limits were inhibited.

4. SEN FAIL - HPFT TURB DISCH TB (FID 11, delimiter 002) was reported on the right engine at TREF = 8:21.7 (MET = 8:15.1). This FID indicates the sensor failed its reasonableness test.

Figure 3.1.2-II shows an example of FID outputs on MSK 1069. The data are from a simulation run and are shown as an example. The FID and DLM numbers and associated syntax shown are based on the current version of controller flight software.

Table 3.1.2-I lists the telemetry inputs and processing logic for the SSME hard failure ID processing.

Note: As the SSME controller software is updated (i.e., new FID table), the MOC tables also need to be updated via a STSOC support requirement (SR).

Table 3.1.2-II lists the manual inputs from the summary message keyboard (SMEK). Two pushbutton indicator (PBI) inputs are required for each input to the computation. This table lists the MSID's of the PBI's and of the inputs to the computation. These inputs are used to clear the columns on MSK's 1069 and 1070.

Table 3.1.2-III lists the hard failure reporting identification numbers, delimiter numbers, and current MOD syntax (incorrect syntax is identified by an asterisk).

SCP 4.1 gives a description of the first 32 words of SSME telemetry. Controller software brief 1.4 gives a description of each failure, including responses. Brief 3.1 gives a complete description of the entire 128 words in the VDT.

Failure ID's for which the MOD syntax is incorrect are summarized in table 3.1.2-IV, SSME FID cue card.

Block II FID's 22, 23, 34, 35, 36, 43, 44, 45, 46, 47, 51, 52, 71, 72, 135, and 136 do not have defined syntax since they are applicable to time frames too early in the prelaunch flow for the ME or Booster operators to monitor. FID 40 is only used for flight readiness firings (FRF's) and is in a special version of the flight software.

PROCEDURES

A. To select the SSME hard FID display on the console, call up MSK 1069 or 1070. The latest failure can also be found on MSK 1051 or 1052.

B. To preclude losing the data, the SSME hard FID display must be hard copied prior to clearing any of the three columns.

C. To clear a full column on MSK 1069 or 1070 (left engine, center engine, or right engine), press the following PBI's on the SMEK panel (fig. 3.1.2-III).

1. LEFT (CNTR, RIGHT)
2. ME HARD FAIL
3. EXECUTE
4. CLEAR

D. Prior to ignition, either of the SSME hard failure ID displays must be called up, and the availability of adequate space for the ascent phase must be verified.

E. Nominally, the ME console position monitors the SSME hard failure ID display during the ascent phase.

F. The ME console position is responsible for the operation of the SMEK and the acquisition of hard copies of the SSME hard failure ID display.

G. On MSK's 1071-1076, CENTER (LEFT, RIGHT) MAIN ENGINE history tabs, the FID's are displayed in hexadecimal (based on the entire 16-bit VDT word number 5).

H. To relate controller TREF to MET, approximately 6.6 seconds must be subtracted from TREF since MET is zero at SRB ignition.

I. No FID's are available on BFS.

J. There are two tables for FID syntax: BLK1 and BLK2. These stand for the Block I (BLK1) FID's and those from the Block II (BLK2) controller. Two tables are needed to accommodate use of either type of controller until the fleet is completely transitioned over to Block II controllers.

The default configuration is the BLK2 set. The megadata or workstations are used to change the configuration to the BLK1 set. BLK2 appears adjacent to the word FAILURE in each engine's column. The default syntax set may be changed by means of a Megadata WEX input using the text input menu V23. Enter MSID M11G3000M in the PARAMETER NUMBER column, and enter the letters BLK1CLR, followed by two blanks in the RTXT VALUE column. This menu may be transmitted independently of mission phase and is included with other special comp menus on the ME MED disk.

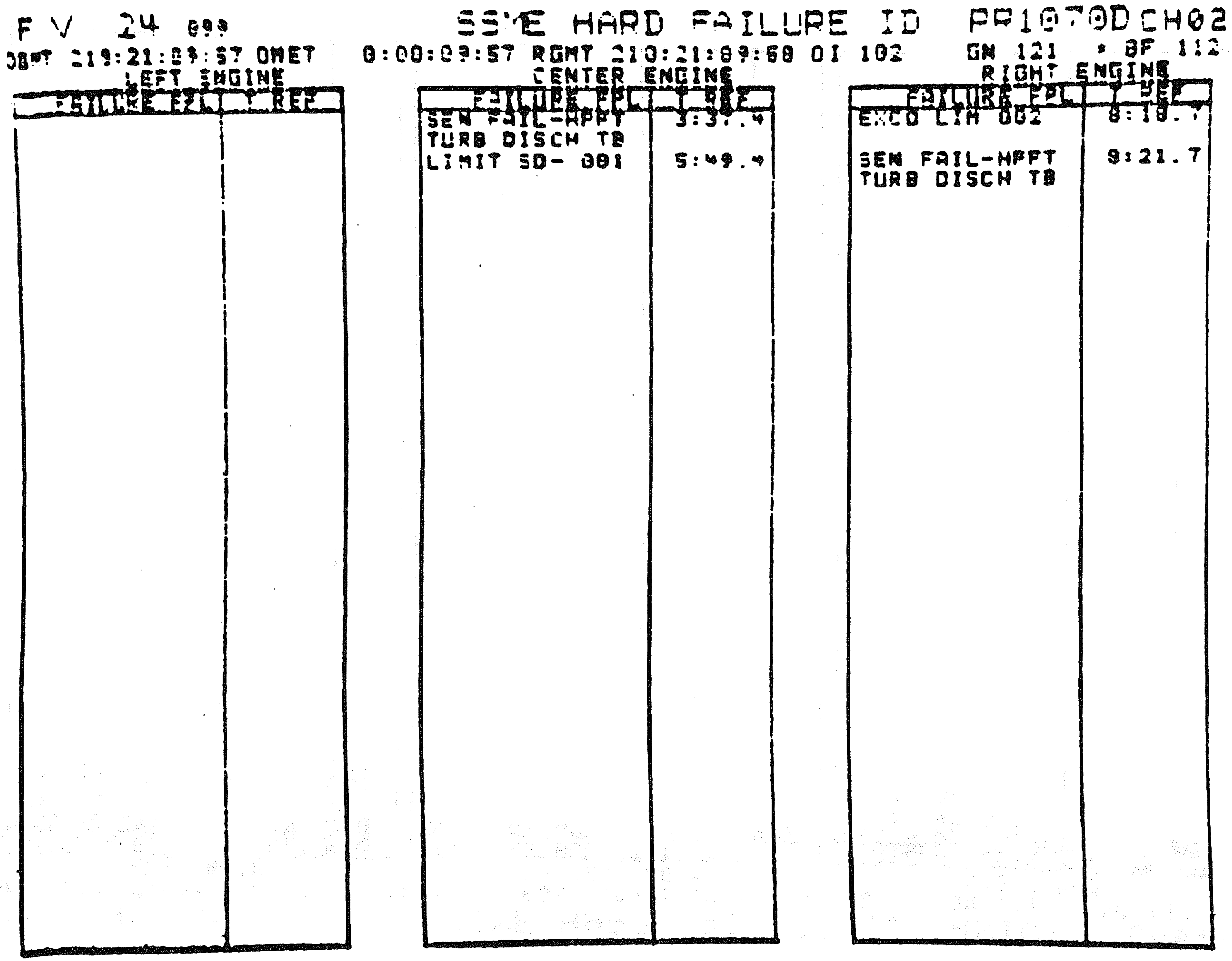
Figure 3.1.2-IV shows the MED menu which selects the BLK1 set of FID syntax for the center, left, and right engines. If the BLK2 configuration is desired on all of the engines, then substitute BLK2 for RPL in the above procedure. Variations of this procedure allow individual engines to have different tables. The CLR portion of the RTXT VALUE designates the selected configuration (BLK2 or BLK1) for the center, left, and right SSME's. If only selected engines are desired, then substitute the appropriate initial(s) after the desired syntax set (e.g., BLK1R).

Note: The community has an agreement not to mix controller types on a given vehicle.

K. Clearing the latest FID syntax from MSK's 1051 and 1052 requires a special procedure which must be coordinated with the ground controller (GC) and the flight director on a real flight day (no coordination is needed during simulations).

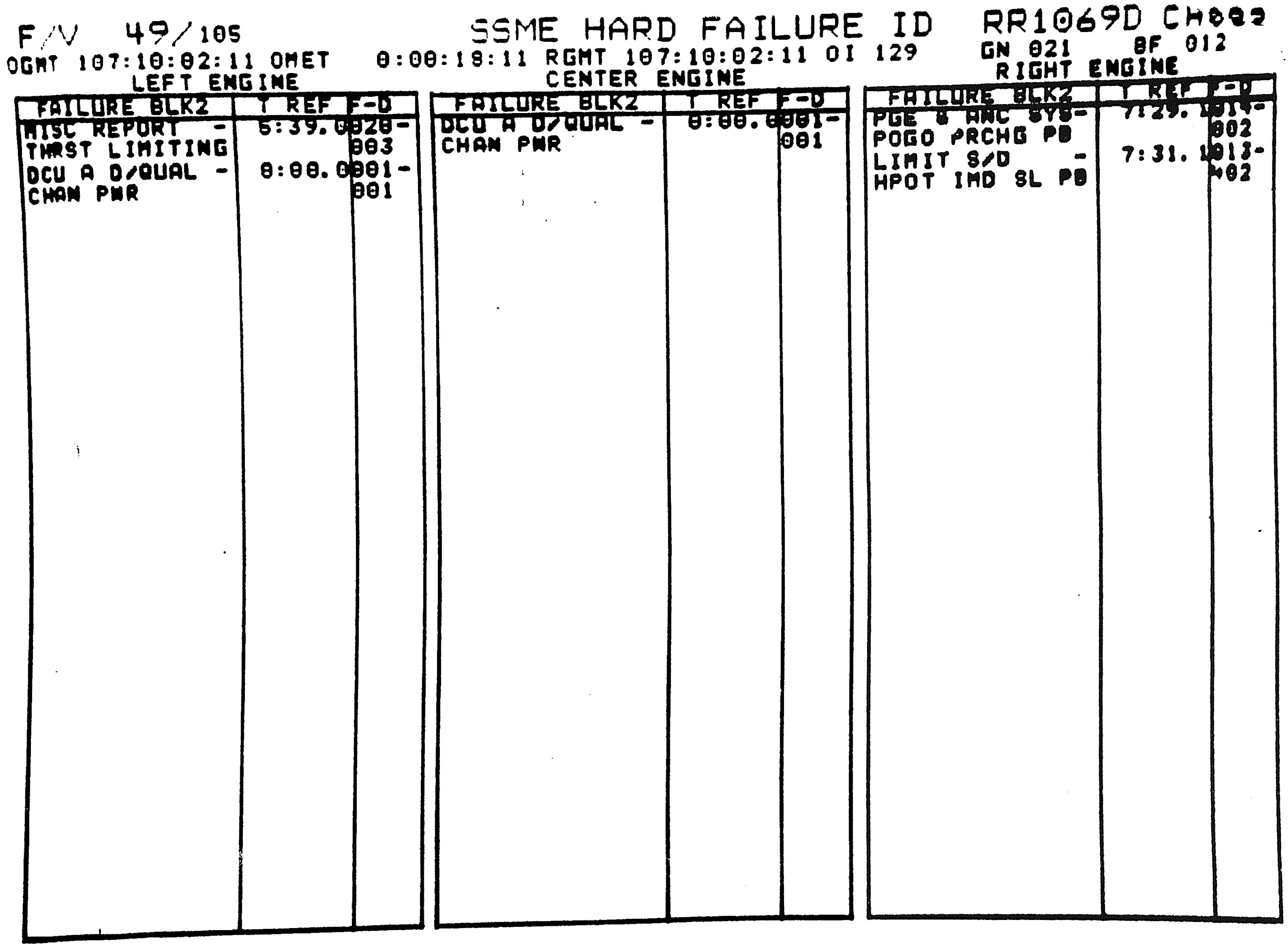
1. Call GC and request "test bit mode," versus the normal "actual bit mode." GC will have the flight director approve this request.
2. Call up one of the three megadata V23 displays ('FID CLR1', 'FID CLR2', or 'FID CLR3') and transmit it once the MOC is in "test bit mode." Each of the three V23 displays will clear any syntax from its respective engine's column on MSK's 1051 and 11052. See figures 3.1.2-V, 3.1.2-VI, and 3.1.2-VII.
3. Let GC know when you are ready to return to "actual bit mode."

On flight day, this procedure is normally used to clear garbage syntax leftover from controller powerup operations or noisy data. The actual process is normally performed around T - 1 hour, when FDO also needs to be in "test bit mode."



```
F V  24  099                    SSME HARD FAILURE ID  PR1070D CH027
GMT 210:21:09:57 OMET   0:00:09:57 RGMT 210:21:09:58 OI 102    GN 121  * BF 112
         LEFT ENGINE                  CENTER ENGINE                  RIGHT ENGINE
  FAILURE FPL     T REF       FAILURE FPL        T REF      FAILURE FPL         T REF
                             SEN FAIL-HPFT       3:37.4    EXCD LIM 002         8:18.7
                             TURB DISCH TB
                             LIMIT SD- 001       5:49.4    SEN FAIL-HPFT        9:21.7
                                                           TURB DISCH TB
```

Figure 3.1.2-I.- Example of MSK 1070 from 51-F flight data.



F/V 49/105 SSME HARD FAILURE ID RR1069D CH002
OGMT 107:10:02:11 OMET 0:00:18:11 RGMT 107:10:02:11 OI 129 GN 021 BF 012

LEFT ENGINE

FAILURE BLK2	T REF	F-D
MISC REPORT - THRST LIMITING	5:39.0	020- 003
DCU A D/QUAL - CHAN PWR	0:00.0	001- 001

CENTER ENGINE

FAILURE BLK2	T REF	F-D
DCU A D/QUAL - CHAN PWR	0:00.0	001- 001

RIGHT ENGINE

FAILURE BLK2	T REF	F-D
PGE & ANC SYS- POGO PRCHG PB	7:29.1	014- 002
LIMIT S/D - HPOT IMD SL PB	7:31.1	013- 402

Figure 3.1.2-II.- Example of MSK 1069 from simulated data.

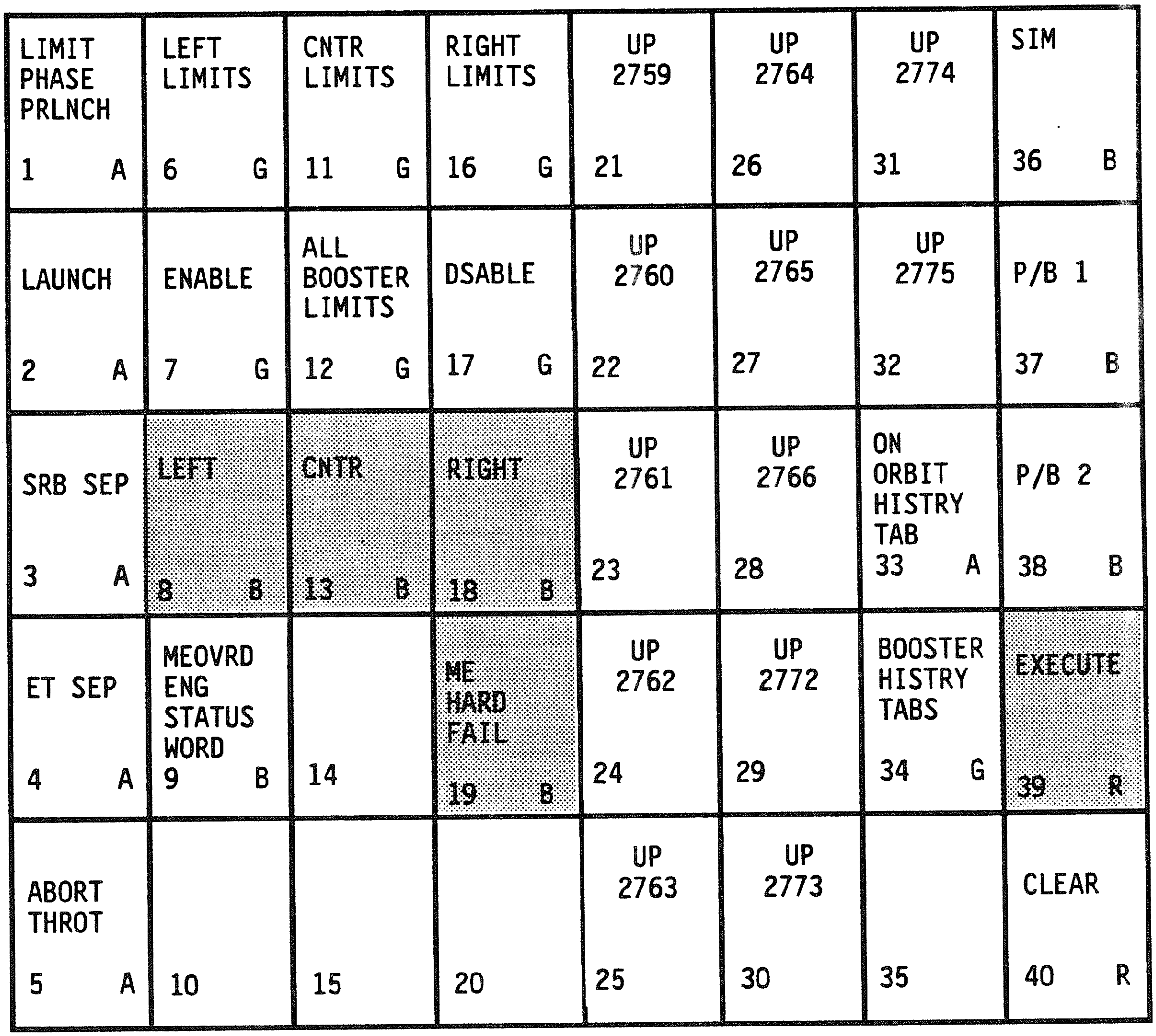
TABLE 3.1.2-I.- TELEMETRY INPUTS AND PROCESSING LOGIC

MML no.	Logic	Output/computation numbers	Display column
E41M1005P	B1-7-Convert to octal and determine FID B8-16-Convert to octal and determine delimiter for center engine failures	First line of 14 characters M01G3000R (8 Chars) M02G3000R (8 Chars) Second line of 14 characters M03G3000R (8 Chars) M04G3000R (8 Chars)	CENTER ENGINE FAILURE
E41M2005P	Same as above, except it's for left engine	First line of 14 characters M05G3000R (8 Chars) M06G3000R (8 Chars) Second line of 14 characters M07G3000R (8 Chars) M08G3000R (8 Chars)	LEFT ENGINE FAILURE
E41M3005P	Same as above, except it's for right engine	First line of 14 characters M09G3000R (8 Chars) M10G3000R (8 Chars) Second line of 14 characters M11G3000R (8 Chars) M12G3000R (8 Chars)	RIGHT ENGINE FAILURE
E41W1004B	Convert to min:sec.tenths (MM:SS.T)	M13G3000T	CENTER ENGINE TREF
E41W2004B	CONVERT TO min:sec.tenthS (MM:SS.T)	M14G3000T	LEFT ENGINE TREF
E41W3004B	Convert to min:sec.tenths (MM:SS.T)	M115G3000T	RIGHT ENGINE TREF

TABLE 3.1.2-II.- SMEK INPUTS

PBI LABEL	PBI MSID	INPUT MSID*
ME HARD FAIL	M32G3000P	
LEFT	M31G0000P	M32G3000E
CENTER	M32G0000P	M31G3000E
RIGHT	M33G0000P	M33G3000E

* INPUT = ME HARD FAIL (AND) LEFT (OR CENTER OR RIGHT)



LIMIT PHASE PRLNCH 1 A	LEFT LIMITS 6 G	CNTR LIMITS 11 G	RIGHT LIMITS 16 G	UP 2759 21	UP 2764 26	UP 2774 31	SIM 36 B
LAUNCH 2 A	ENABLE 7 G	ALL BOOSTER LIMITS 12 G	DSABLE 17 G	UP 2760 22	UP 2765 27	UP 2775 32	P/B 1 37 B
SRB SEP 3 A	LEFT 8 B	CNTR 13 B	RIGHT 18 B	UP 2761 23	UP 2766 28	ON ORBIT HISTRY TAB 33 A	P/B 2 38 B
ET SEP 4 A	MEOVRD ENG STATUS WORD 9 B	14	ME HARD FAIL 19 B	UP 2762 24	UP 2772 29	BOOSTER HISTRY TABS 34 G	EXECUTE 39 R
ABORT THROT 5 A	10	15	20	UP 2763 25	UP 2773 30	35	CLEAR 40 R

Figure 3.1.2-III.- ME SMEK panel.

V23#

①013/RR

PARAMETER NUMBER	RTXT VALUE	PARAMETER NUMBER	RTXT VALUE
M11G3000M ,	'BLK1CLR '	____________,	'____________',
____________,	'____________',	____________,	'____________',
____________,	'____________',	____________,	'____________',
____________,	'____________',	____________,	'____________',
____________,	'____________',	____________,	'____________',
____________,	'____________',	____________,	'____________',
____________,	'____________',	____________,	'____________',
____________,	'____________',	____________,	'____________',
____________,	'____________',	____________,	'____________',
____________,	'____________',	____________,	____________,

①Use current flight number.

Figure 3.1.2-IV.- TLM special comp RTXT input menu.

```
V23,/M01G3000R,'          ',M02G3000R,'          ',M03G3000R,'          ',M04G3000R,'
      '/$

 ①029/RR

CLEAR CENTER ENG FID SYSTAX

                         WELCOME TO THE COMMAND AND CONTROL SYSTEM

                         ***************** CAUTION ****************
                         DURING INITIALIZATION AND RESTART/SELECTOVER
                         FUNCTIONS-HOLD ALL INPUTS UNTIL CLEARED BY
                         THE COMPUTER SUPERVISOR OR THE
                         GROUND CONTROLLER
                         ******************************************

                         MENUS ARE REQUESTED FOR DISPLAY
                         BY ENTERING IN THE UPPER LEFT HAND CORNER
                         THE THREE CHARACTER MENU ID FOLLOWED BY A ?


FID CLR1
```

① Use current flight number.

Figure 3.1.2-V.- Center engine FID clear input menu (FID CLR1).

```
V23,/M05G3000R,           ',M06G3000R,'          ',M07G3000R,'          ',M08G3000R,'
      '/$

①029/RR

CLEAR LEFT   ENG FID SYSTAX

                         WELCOME TO THE COMMAND AND CONTROL SYSTEM

                         **************** CAUTION *****************
                         DURING INITIALIZATION AND RESTART/SELECTOVER
                         FUNCTIONS-HOLD ALL INPUTS UNTIL CLEARED BY
                         THE COMPUTER SUPERVISOR OR THE
                         GROUND CONTROLLER
                         ******************************************

                         MENUS ARE REQUESTED FOR DISPLAY
                         BY ENTERING IN THE UPPER LEFT HAND CORNER
                         THE THREE CHARACTER MENU ID FOLLOWED BY A ?


FID CLR2
```

① Use current flight number.

Figure 3.1.2-VI.- Left engine FID clear input menu (FID CLR2).

```
V23,/M09G3000R,'             ',M10G3000R,'            ',M11G3000R,'            ',M12G3000R,'
       '/$

①029/RR

CLEAR RIGHT   ENG FID SYSTAX

                         WELCOME TO THE COMMAND AND CONTROL SYSTEM

                         ****************** CAUTION ****************
                         DURING INITIALIZATION AND RESTART/SELECTOVER
                         FUNCTIONS-HOLD ALL INPUTS UNTIL CLEARED BY
                         THE COMPUTER SUPERVISOR OR THE
                         GROUND CONTROLLER
                         *******************************************

                         MENUS ARE REQUESTED FOR DISPLAY
                         BY ENTERING IN THE UPPER LEFT HAND CORNER
                         THE THREE CHARACTER MENU ID FOLLOWED BY A ?

FID CLR3
```

① Use current flight number.

Figure 3.1.2-VII.- Right engine FID clear input menu (FID CLR3).

TABLE 3.1.2-III.- FAILURE IDENTIFICATION (STS-46, 47, 49 AND SUBS)

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
001	000	DCU A D/QUAL - SELF D/QUAL	DCU A D/QUAL - & OE & ACTRS
	001	DCU A D/QUAL - CHAN PWR	DCU A D/QUAL - CHAN PWR
	002	DCU A D/QUAL - SELF REPORT	DCU A D/QUAL - CHAN PWR
002	000	DCU B D/QUAL - SELF D/QUAL	DCU B D/QUAL - DCU/CIE ONLY
	001	DCU B D/QUAL - CHAN PWR	DCU B D/QUAL - CHAN PWR
	002	DCU B D/QUAL - SELF REPORT	DCU B D/QUAL - CHAN PWR
003	000	IE A D/QUAL - SENSORS DQL	IE A D/QUAL - (undefined)
	001	003-001	IE A D/QUAL - & OE & ACTRS
	002	003-002	IE A D/QUAL - & OE & ACTRS
	012	003-012	IE A D/QUAL - & OE & ACTRS
	013	003-013	IE A D/QUAL - & OE & ACTRS
	201	003-201	IE A D/QUAL - & OE & ACTRS
	202	003-202	IE A D/QUAL - & OE & ACTRS
	203	003-203	IE A D/QUAL - & OE & ACTRS
	204	003-204	IE A D/QUAL - & OE & ACTRS

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
003 (CONT'D)	205	003-205	IE A D/QUAL - & OE & ACTRS
	206	003-206	IE A D/QUAL - & OE & ACTRS
	207	003-207	IE A D/QUAL - & OE & ACTRS
	210	003-210	IE A D/QUAL - & OE & ACTRS
	211	003-211	IE A D/QUAL - & OE & ACTRS
	501	003-501	IE A D/QUAL - & OE & ACTRS
004	000	IE B D/QUAL - SENSORS DQL	IE B D/QUAL - (undefined)
	001	004-001	IE B D/QUAL - & OE & ACTRS
	002	004-002	IE B D/QUAL - & OE & ACTRS
	012	004-012	IE B D/QUAL - & OE & ACTRS
	013	004-013	IE B D/QUAL - & OE & ACTRS
	201	004-201	IE B D/QUAL - & OE & ACTRS
	202	004-202	IE B D/QUAL - & OE & ACTRS
	203	004-203	IE B D/QUAL - & OE & ACTRS
	204	004-204	IE B D/QUAL - & OE & ACTRS

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
004 (CONT'D)	205	004-205	IE B D/QUAL - & OE & ACTRS
	206	004-206	IE B D/QUAL - & OE & ACTRS
	207	004-207	IE B D/QUAL - & OE & ACTRS
	210	004-210	IE B D/QUAL - & OE & ACTRS
	211	004-211	IE B D/QUAL - & OE & ACTRS
	501	004-501	IE B D/QUAL - & OE & ACTRS
005	000	OE A D/QUAL - MAJ BITE FAIL	OE A D/QUAL - & ACTUATORS
	100	005-100	OE A D/QUAL - & ACTUATORS
	101	OE A D/QUAL - REG 1 FAIL ON	OE A D/QUAL - EMER S/D ON
	102	OE A D/QUAL - REG 2 FAIL	OE A D/QUAL - IGN FAIL ON
	300	005-300	OE A D/QUAL - & ACTUATORS
	400	005-400	OE A D/QUAL - & ACTUATORS
	401	005-401	OE A D/QUAL - & ACTUATORS
	404	005-404	OE A D/QUAL - & ACTUATORS
	405	005-405	OE A D/QUAL - & ACTUATORS

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
005 (CONT'D)	406	005-406	OE A D/QUAL - & ACTUATORS
	407	005-407	OE A D/QUAL - & ACTUATORS
	500	005-500	OE A D/QUAL - * & ACTUATORS
006	000	OE B D/QUAL - MAJ BITE FAIL	OE B D/QUAL - & ACTUATORS
	100	006-100	OE B D/QUAL - & ACTUATORS
	101	OE B D/QUAL - REG 1 FAIL ON	OE B D/QUAL - EMER S/D ON
	102	OE B D/QUAL - REG 2 FAIL	OE B D/QUAL - IGN FAIL ON
	200	006-200	OE B D/QUAL - & ACTUATORS
	300	006-300	OE B D/QUAL - & ACTUATORS
	400	006-400	OE B D/QUAL - & ACTUATORS
	401	006-401	OE B D/QUAL - & ACTUATORS
	402	006-402	OE B D/QUAL - & ACTUATORS
	403	006-403	OE B D/QUAL - & ACTUATORS
	404	006-404	OE B D/QUAL - & ACTUATORS

* - Not defined in OI-5.

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
006 (CONT'D)	405	006-405	OE B D/QUAL - & ACTUATORS
	406	006-406	OE B D/QUAL - & ACTUATORS
	407	006-407	OE B D/QUAL - & ACTUATORS
007	000	IE/OE A N/DQL- BITE FAIL	007-000
	100	007-100	OE A, NOT DQL- REGISTER 1
	101	IE/OE A N/DQL- REG 1 FAIL	007-101
	102	IE/OE A N/DQL- REG 2 FAIL	007-102
	200	007-200	OE A, NOT DQL- REGISTER 2
	300	007-300	OE A, NOT DQL- REGISTER 3
010	000	IE/OE B N/DQL- BITE FAIL	010-000
	100	010-100	OE B, NOT DQL- REGISTER 1
	101	IE/OE B N/DQL- REG 1 FAIL	010-101
	102	IE/OE B N/DQL- REG 2 FAIL	010-102
	200	010-200	OE B, NOT DQL- REGISTER 2
	300	010-300	OE B, NOT DQL- REGISTER 3

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
011	000	RDNT SEN FAIL- FU FLW RTE A&B	011-000
	001	RDNT SEN FAIL- FU FLW RTE A	011-001
	002	RDNT SEN FAIL- FU FLW RTE B	011-002
	003	RDNT SEN FAIL- FU FLW RTE A1	011-003
	004	RDNT SEN FAIL- FU FLW RTE B1	011-004
	005	RDNT SEN FAIL- FU FLW RTE A2	011-005
	006	RDNT SEN FAIL- FU FLW RTE B2	011-006
	007	RDNT SEN FAIL- LPFP DISCH PA	011-007
	010	RDNT SEN FAIL- LPFP DISCH PB	011-010
	011	RDNT SEN FAIL- LPFP DISCH TA	011-011
	012	RDNT SEN FAIL- LPFP DISCH TB	011-012
	013	RDNT SEN FAIL- PcA CTL-INTRA	011-013
	014	RDNT SEN FAIL- PcB CTL-INTRA	011-014
	015	RDNT SEN FAIL- PcA CTL-REF	011-015
	016	RDNT SEN FAIL- PcB CTL-REF	011-016

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
011 (CONT'D)	017	RDNT SEN FAIL- FPB SD PGE P	011-017
	020	RDNT SEN FAIL- OPB SD PGE P	011-020
	021	RDNT SEN FAIL- HPOP IMD SL PA	011-021
	022	RDNT SEN FAIL- HPOP IMD SL PB	011-022
	023	RDNT SEN FAIL- HPOP SEC SL PA	011-023
	024	RDNT SEN FAIL- HPOP SEC SL PB	011-024
	025	RDNT SEN FAIL- HPOT TD TA	011-025
	026	RDNT SEN FAIL- HPOT TD TB	011-026
	027	RDNT SEN FAIL- HPFP TD TA	011-027
	030	RDNT SEN FAIL- HPFP TD TB	011-030
	031	RDNT SEN FAIL- HPFP CL LN PA	011-031
	032	RDNT SEN FAIL- HPFP CL LN PB	011-032
	035	RDNT SEN FAIL- MCC Pc A-R/L	011-035
	036	RDNT SEN FAIL- MCC Pc B-R/L	011-036
	040	RDNT SEN FAIL- PBP DISCH T	011-040

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
011 (CONT'D)	041	RDNT SEN FAIL-POGO PRCHG PA	011-041
	042	RDNT SEN FAIL-POGO PRCHG PB	011-042
	053	RDNT SEN FAIL-PcA CTL-SP	011-053
	054	RDNT SEN FAIL-PcB CTL-SP	011-054
	100	011-100	RDNT SEN FAIL-FFM |A - B|
	101	011-101	RDNT SEN FAIL-FFM INTRA A
	102	011-102	RDNT SEN FAIL-FFM INTRA B
	103	011-103	RDNT SEN FAIL-FFM SNSR A1
	104	011-104	RDNT SEN FAIL-FFM SNSR B1
	105	011-105	RDNT SEN FAIL-FFM SNSR A2
	106	011-106	RDNT SEN FAIL-FFM SNSR B2
	107	011-107	RDNT SEN FAIL-FFM PRC - A1
	110	011-110	RDNT SEN FAIL-FFM PRC - B1
	111	011-111	RDNT SEN FAIL-FFM PRC - A2
	112	011-112	RDNT SEN FAIL-FFM PRC - B2

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
011 (CONT'D)	201	011-201	RDNT SEN FAIL-PcA CTL-INTRA
	202	011-202	RDNT SEN FAIL-PcB CTL-INTRA
	203	011-203	RDNT SEN FAIL-PcA CTL-REF/SP
	204	011-204	RDNT SEN FAIL-PcB CTL-REF/SP
	301	011-301	RDNT SEN FAIL-LPFT DISCH PA
	302	011-302	RDNT SEN FAIL-LPFT DISCH PB
	303	011-303	RDNT SEN FAIL-LPFT DISCH TA
	304	011-304	RDNT SEN FAIL-LPFT DISCH TB
	401	011-401	RDNT SEN FAIL-HPOT IMD SL PA
	402	011-402	RDNT SEN FAIL-HPOT IMD SL PB
	403	011-403	RDNT SEN FAIL-HPOT SEC SL PA
	404	011-404	RDNT SEN FAIL-HPOT SEC SL PB
	405	011-405	RDNT SEN FAIL-HPOT TD TA
	406	011-406	RDNT SEN FAIL-HPOT TD TB
	407	011-407	RDNT SEN FAIL-HPFT TD TA

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
011 (CONT'D)	410	011-410	RDNT SEN FAIL- HPFT TD TB
	411	011-411	RDNT SEN FAIL- HPFT CL LN PA
	412	011-412	RDNT SEN FAIL- HPFT CL LN PB
	413	011-413	RDNT SEN FAIL- FPB S/D PGE P
	414	011-414	RDNT SEN FAIL- OPB S/D PGE P
	415	011-415	RDNT SEN FAIL- PcA RL-RSNBLNS
	416	011-416	RDNT SEN FAIL- PcB RL-RSNBLNS
	417	011-417	RDNT SEN FAIL- PcA RL-INTRA
	420	011-420	RDNT SEN FAIL- PcB RL-INTRA
	505	011-505	RDNT SEN FAIL- AFV POS A
	506	011-506	RDNT SEN FAIL- AFV POS B
	507	011-507	RDNT SEN FAIL- HPFT SHFT SPDA
	510	011-510	RDNT SEN FAIL- HPFT SHFT SPDB
	511	011-511	RDNT SEN FAIL- HPFT SHFT SPDA
	512	011-512	RDNT SEN FAIL- HPFT SHFT SPDB

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
011 (CONT'D)	601	011-601	RDNT SEN FAIL-POGO PRCHG PA
	602	011-602	RDNT SEN FAIL-POGO PRCHG PB
	620	011-620	RDNT SEN FAIL-PBP DISCH T
	701	011-701	RDNT SEN FAIL-POGO PRCHG PA
	702	011-702	RDNT SEN FAIL-POGO PRCHG PB
012	001	ENGINE READY - LPFP DISCH P	ENGINE READY - LPFT DISCH PA
	002	ENGINE READY - LPFP DISCH T	ENGINE READY - LPFT DISCH PB
	003	ENGINE READY - PBP DISCH T	ENGINE READY - LPFT DISCH TA
	004	ENGINE READY - LPOP DISCH P	ENGINE READY - LPFT DISCH TB
	005	ENGINE READY - EM SHDN P	ENGINE READY - PBP DISCH TA
	006	ENGINE READY - PBP SD PGE P	ENGINE READY - PBP DISCH TB
	007	ENGINE READY - MOV HYD T	ENGINE READY - LPOT DISCH PA
	010	ENGINE READY - MFV HYD T	ENGINE READY - LPOT DISCH PB
	011	012-011	ENGINE READY - EMER SHDN PA
	012	012-012	ENGINE READY - EMER SHDN PB

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
012 (CONT'D)	013	012-013	ENGINE READY - FBP SD PGE PA
	014	012-014	ENGINE READY - OBP SD PGE PB
	015	012-015	ENGINE READY - MOV HYD TA
	016	012-016	ENGINE READY - MOV HYD TB
	017	012-017	ENGINE READY - MFV HYD TA
	020	012-020	ENGINE READY - MFV HYD TB
013	001	LIMIT S/D - IGNC Pc-2.3s	LIMIT S/D - IGNC HPFT SPDA
	002	LIMIT S/D - IGNC AFV	LIMIT S/D - IGNC HPFT SPDB
	003	LIMIT S/D - IGNC HPFP SPD	LIMIT S/D - IGNC Pc A-1.7s
	004	LIMIT S/D - IGNC Pc-1.7s	LIMIT S/D - IGNC Pc B-1.7s
	005	013-005	LIMIT S/D - IGNC Pc A-2.3s
	006	013-006	LIMIT S/D - IGNC Pc B-2.3s
	007	013-007	LIMIT S/D - IGNC AFV POS A
	010	013-010	LIMIT S/D - IGNC AFV POS B
	017	LIMIT S/D - FPB SD PGE P	013-017

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
013 (CONT'D)	020	LIMIT S/D - OPB SD PGE P	013-020
	021	LIMIT S/D - HPOP IMD SL PA	013-021
	022	LIMIT S/D - HPOP IMD SL PB	013-022
	023	LIMIT S/D - HPOP SEC SL PA	013-023
	024	LIMIT S/D - HPOP SEC SL PB	013-024
	025	LIMIT S/D - HPOT TD TA	013-025
	026	LIMIT S/D - HPOT TD TB	013-026
	027	LIMIT S/D - HPFT TD TA	013-027
	030	LIMIT S/D - HPFT TD TB	013-030
	031	LIMIT S/D - HPFP CL LN PA	013-031
	032	LIMIT S/D - HPFP CL LN PB	013-032
	035	LIMIT S/D - MCC Pc A	013-035
	036	LIMIT S/D - MCC Pc B	013-036
	401	013-401	LIMIT S/D - HPOT IMD SL PA
	402	013-402	LIMIT S/D - HPOT IMD SL PB

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
013 (CONT'D)	403	013-403	LIMIT S/D - HPOT SEC SL PA
	404	013-404	LIMIT S/D - HPOT SEC SL PB
	405	013-405	LIMIT S/D - HPOT TD TA
	406	013-406	LIMIT S/D - HPOT TD TB
	407	013-407	LIMIT S/D - HPFT TD TA
	410	013-410	LIMIT S/D - HPFT TD TB
	411	013-411	LIMIT S/D - HPFT CL LN PA
	412	013-412	LIMIT S/D - HPFT CL LN PB
	413	013-413	LIMIT S/D - FPB SD PGE P
	414	013-414	LIMIT S/D - OPB SD PGE P
	415	013-415	LIMIT S/D - MCC Pc A
	416	013-416	LIMIT S/D - MCC Pc B
014	001	PGE & ANC SYS-POGO PRCHG PA	PGE & ANC SYS-POGO PRCHG PA
	002	PGE & ANC SYS-POGO PRCHG PB	PGE & ANC SYS-POGO PRCHG PB
	003	PGE & ANC SYS-FU SYS PGE PA	014-003

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
014 (CONT'D)	004	PGE & ANC SYS- FU SYS PGE PB	014-004
	005	PGE & ANC SYS- MOV HYD TA	PGE & ANC SYS- FU SYS PGE PA
	006	PGE & ANC SYS- MOV HYD TB	PGE & ANC SYS- FU SYS PGE PB
	007	PGE & ANC SYS- MFV HYD TA	PGE & ANC SYS- MOV HYD TA
	010	PGE & ANC SYS- MFV HYD TB	PGE & ANC SYS- MOV HYD TB
	011	PGE & ANC SYS- HPOP IMD SL PA	PGE & ANC SYS- MFV HYD TA
	012	PGE & ANC SYS- HPOP IMD SL PB	PGE & ANC SYS- MFV HYD TB
	013	PGE & ANC SYS- AFV POS A	PGE & ANC SYS- HPOT IMD SL PA
	014	PGE & ANC SYS- AFV POS B	PGE & ANC SYS- HPOT IMD SL PB
	015	PGE & ANC SYS- FBV POS	PGE & ANC SYS- AFV POS A
	016	PGE & ANC SYS- OBV POS	PGE & ANC SYS- AFV POS B
	017	PGE & ANC SYS- POGO RIV POS	PGE & ANC SYS- FBV POS
	020	PGE & ANC SYS- POGO PRCHG P	PGE & ANC SYS- OBV POS
	021	PGE & ANC SYS- PB SD PGE P	PGE & ANC SYS- POGO RIV POS
	022	PGE & ANC SYS- HPOP IMD SL P	014-022

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
014 (CONT'D)	023	014-023	PGE & ANC SYS-EMER S/D PA
	024	014-024	PGE & ANC SYS-EMER S/D PB
	025	014-025	PGE & ANC SYS-POGO PRCHG PA
	026	014-026	PGE & ANC SYS-POGO PRCHG PB
	030	014-030	PGE & ANC SYS-BD PG/POGO P
	031	PGE & ANC SYS-EM SHDN PA	PGE & ANC SYS-BD PG/PB SDP
	032	PGE & ANC SYS-EM SHDN PB	014-032
	033	PGE & ANC SYS-HPOP IMD SL PA	PGE & ANC SYS-BD PG/IMD SL P
	034	PGE & ANC SYS-HPOP IMD SL PB	014-034
	036	PGE & ANC SYS-MCC LOX DOME T	014-036
	041	014-041	PGE & ANC SYS-HPOT IMD SL PA
	042	014-042	PGE & ANC SYS-HPOT IMD SL PB
	052	014-052	PGE & ANC SYS-MCC LOX DOME T
015	001	SRVO ACT FAIL-MFV CH A	015-001
	002	SRVO ACT FAIL-MFV CH B	015-002

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
015 (CONT'D)	0003	SRVO ACT FAIL-MOV CH A	015-003
	004	SRVO ACT FAIL-MOV CH B	015-004
	005	SRVO ACT FAIL-CCV CH A	015-005
	006	SRVO ACT FAIL-CCV CH B	015-006
	007	SRVO ACT FAIL-FPOV CH A	015-007
	010	SRVO ACT FAIL-FPOV CH B	015-010
	011	SRVO ACT FAIL-OPOV CH A	SRVO ACT FAIL-SEII-MFV CH A
	012	SRVO ACT FAIL-OPOV CH B	SRVO ACT FAIL-SEII-MFV CH B
	013	SRVO ACT FAIL-RVDT CMP MON	015-013
	015	SRVO ACT FAIL-RVDT BLUELINE	015-015
	017	SRVO ACT FAIL-MFVA-PWR T MON	015-017
	020	SRVO ACT FAIL-MFVB-PWR T MON	015-020
	021	015-021	SRVO ACT FAIL-SEII-MOV CH A
	022	SRVO ACT FAIL-PSN4 ACTR CHK	SRVO ACT FAIL-SEII-MOV CH B
	031	015-031	SRVO ACT FAIL-SEII-CCV CH A

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
015 (CONT'D)	032	015-032	SRVO ACT FAIL-SEII-CCV CH B
	041	015-041	SRVO ACT FAIL-SEII-FPOV CH A
	042	015-042	SRVO ACT FAIL-SEII-FPOV CH B
	051	015-051	SRVO ACT FAIL-SEII-OPOV CH A
	052	015-052	SRVO ACT FAIL-SEII-OPOV CH B
	110	015-110	SRVO ACT FAIL-RVDT MC-MFV
	120	015-120	SRVO ACT FAIL-RVDT MC-MOV
	130	015-130	SRVO ACT FAIL-RVDT MC-CCV
	140	015-140	SRVO ACT FAIL-RVDT MC-FPOV
	150	015-150	SRVO ACT FAIL-RVDT MC-OPOV
	401	015-401	SRVO ACT FAIL-HPOT TDT B/L
	471	015-471	SRVO ACT FAIL-HPFT TDT B/L
	512	015-512	SRVO ACT FAIL-SP -3%: MFVB
	522	015-522	SRVO ACT FAIL-SP -3%: MOVB
	532	015-532	SRVO ACT FAIL-SP -3%: CCVB

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
015 (CONT'D)	542	015-542	SRVO ACT FAIL- SP -3%: FPOVB
	552	015-552	SRVO ACT FAIL- SP -3%: OPOVB
	611	015-611	SRVO ACT FAIL- D/A-MFV CH A
	612	015-612	SRVO ACT FAIL- D/A-MFV CH B
	621	015-621	SRVO ACT FAIL- D/A-MOV CH A
	622	015-622	SRVO ACT FAIL- D/A-MOV CH B
	631	015-631	SRVO ACT FAIL- D/A-CCV CH A
	632	015-632	SRVO ACT FAIL- D/A-CCV CH B
	641	015-641	SRVO ACT FAIL- D/A-FPOV CH A
	642	015-642	SRVO ACT FAIL- D/A-FPOV CH B
	651	015-651	SRVO ACT FAIL- D/A-OPOV CH A
	652	015-652	SRVO ACT FAIL- D/A-OPOV CH B
	701	015-701	SRVO ACT FAIL- SVACTR MDL-CHA
	702	015-702	SRVO ACT FAIL- SVACTR MDL-CHB
	710	015-710	SRVO ACT FAIL- PSN4 ACTR CHK

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
016	101	016-101	FASCOS D/QUAL-HPFT CH A
	102	016-102	FASCOS D/QUAL-HPFT CH B
	103	016-103	FASCOS D/QUAL-HPFT CH C
	201	016-201	FASCOS D/QUAL-HPOT CH A
	202	016-202	FASCOS D/QUAL-HPOT CH B
	203	016-203	FASCOS D/QUAL-HPOT CH C
	211	FASCOS BITE - A1&A2 D/QUAL	016-211
	222	FASCOS BITE - B1&B2 D/QUAL	016-222
	233	FASCOS BITE - FASCOS D/QUAL	016-233
	244	FASCOS BITE - C1&C2 D/QUAL	016-244
	255	FASCOS BITE - FASCOS D/QUAL	016-255
	266	FASCOS BITE - FASCOS D/QUAL	016-266
	277	FASCOS BITE - FASCOS D/QUAL	016-277
	301	016-301	FASCOS D/QUAL-CH C +15V PWR
	4XX (XX=00-77)	FASCOS BITE - FASCOS D/QUAL	Undefined, except for 401
	401	FASCOS BITE - FASCOS D/QUAL	FASCOS D/QUAL-CH C -15V PWR

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
017	0X7 (X=0-6)	FASCOS LIM SD-HPFP	017-0X7
	07X	FASCOS LIM SD-HPOP	017-07X
	077	FASCOS LIM SD-HPFP&HPOP	017-077
	101	017-101	FASCOS S/D - HPFT CH A
	102	017-102	FASCOS S/D - HPFT CH B
	103	017-103	FASCOS S/D - HPFT CH C
	201	017-201	FASCOS S/D - HPOT CH A
	202	017-202	FASCOS S/D - HPOT CH B
	203	017-203	FASCOS S/D - HPOT CH C
020	001	020-001	MISC REPORT - HPOT TDTA <810
	002	020-002	MISC REPORT - HPOT TDTB <810
	003	020-003	MISC REPORT - THRST LIMITING
	004	020-004	MISC REPORT - PcREF IN VDT
	100	020-100	MISC REPORT - SWITCH VDT CMD
	200	020-200	MISC REPORT - PSE B VOLTS

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
021	001	021-001	PROP DROP - LPFT DISCH TA
	002	021-002	PROP DROP - LPFT DISCH TB
	003	021-003	PROP DROP - PBP DISCH TA
	004	021-004	PROP DROP - PBP DISCH TB
	005	021-005	PROP DROP - FFM SNSR A1
	006	021-006	PROP DROP - FFM SNSR B1
	007	021-007	PROP DROP - FFM SNSR A2
	010	021-010	PROP DROP - FFM SNSR B2
037	001	037-001	PWR TRANSIENT-IN CHG CHANNEL
	002	037-002	PWR TRANSIENT-CROSS CHANNEL
040	000	FRF B/U S/D - TMR EXPIRED	FRF B/U S/D - TMR EXPIRED
042	000	CMD CHAN FAIL-CMD M/COMPARE	042-000
	001	CMD CHAN FAIL-CH 1 M/COMPARE	042-001
	002	CMD CHAN FAIL-CH 2 M/COMPARE	042-002
	003	042-003	042-003

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
042 (CONT'D)	004	CMD CHAN FAIL-CH 3 M/COMPARE	042-004
	101	042-101	CMD CHAN FAIL-CH1 M/COMPARE
	102	042-102	CMD CHAN FAIL-CH2 M/COMPARE
	103	042-103	CMD CHAN FAIL-CH3 M/COMPARE
043	001	PWR TRANSIENT-CH A	043-001
	002	PWR TRANSIENT-CH B	043-002
044	000	THRUST LIMITING	044-000
045	000	Pc REF IN VDT WORD 6	045-000
075	001	075-001	DCU A PNEU SD-LOSS OF RDNCY
	010	075-010	DCU A PNEU SD-LOSS OF RDNCY
	011	075-011	DCU A PNEU SD-LOSS OF RDNCY
	020	075-020	DCU A PNEU SD-LOSS OF RDNCY
	021	075-021	DCU A PNEU SD-LOSS OF RDNCY
	030	075-030	DCU A PNEU SD-LOSS OF RDNCY
	031	075-031	DCU A PNEU SD-LOSS OF RDNCY

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
075 (CONT'D)	032	075-032	DCU A PNEU SD-LOSS OF RDNCY
	033	075-033	DCU A PNEU SD-LOSS OF RDNCY
	034	075-034	DCU A PNEU SD-LOSS OF RDNCY
	040	075-040	DCU A PNEU SD-LOSS OF RDNCY
	041	075-041	DCU A PNEU SD-LOSS OF RDNCY
	050	075-050	DCU A PNEU SD-LOSS OF RDNCY
	051	075-051	DCU A PNEU SD-LOSS OF RDNCY
	060	075-060	DCU A PNEU SD-LOSS OF RDNCY
	061	075-061	DCU A PNEU SD-LOSS OF RDNCY
	100	075-100	DCU A PNEU SD-LOSS OF RDNCY
	101	075-101	DCU A PNEU SD-LOSS OF RDNCY
	110	075-110	DCU A PNEU SD-LOSS OF RDNCY
	111	075-111	DCU A PNEU SD-LOSS OF RDNCY
	114	075-114	DCU A PNEU SD-LOSS OF RDNCY
	115	075-115	DCU A PNEU SD-LOSS OF RDNCY

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
075 (CONT'D)	116	075-116	DCU A PNEU SD- LOSS OF RDNCY
	117	075-117	DCU A PNEU SD- LOSS OF RDNCY
	120	075-120	DCU A PNEU SD- LOSS OF RDNCY
	121	075-121	DCU A PNEU SD- LOSS OF RDNCY
	122	075-122	DCU A PNEU SD- LOSS OF RDNCY
	123	075-123	DCU A PNEU SD- LOSS OF RDNCY
	130	075-130	DCU A PNEU SD- LOSS OF RDNCY
	131	075-131	DCU A PNEU SD- LOSS OF RDNCY
	140	075-140	DCU A PNEU SD- LOSS OF RDNCY
	300	075-300	DCU A PNEU SD- LOSS OF RDNCY
	500	075-500	DCU A PNEU SD- LOSS OF RDNCY
	503	075-503	DCU A PNEU SD- LOSS OF RDNCY
	504	075-504	DCU A PNEU SD- LOSS OF RDNCY
	505	075-505	DCU A PNEU SD- LOSS OF RDNCY
	510	075-510	DCU A PNEU SD- LOSS OF RDNCY

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
075 (CONT'D)	601	075-601	DCU A PNEU SD-LOSS OF RDNCY
	602	075-602	DCU A PNEU SD-LOSS OF RDNCY
	603	075-603	DCU A PNEU SD-LOSS OF RDNCY
	604	075-604	DCU A PNEU SD-LOSS OF RDNCY
	605	075-605	DCU A PNEU SD-LOSS OF RDNCY
	606	075-606	DCU A PNEU SD-LOSS OF RDNCY
	607	075-607	DCU A PNEU SD-LOSS OF RDNCY
	610	075-610	DCU A PNEU SD-LOSS OF RDNCY
	611	075-611	DCU A PNEU SD-LOSS OF RDNCY
	612	075-612	DCU A PNEU SD-LOSS OF RDNCY
	613	075-613	DCU A PNEU SD-LOSS OF RDNCY
	614	075-614	DCU A PNEU SD-LOSS OF RDNCY
	630	075-630	DCU A PNEU SD-LOSS OF RDNCY
	631	075-631	DCU A PNEU SD-LOSS OF RDNCY
	632	075-632	DCU A PNEU SD-LOSS OF RDNCY

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
075 (CONT'D)	633	075-633	DCU A PNEU SD-LOSS OF RDNCY
	640	075-640	DCU A PNEU SD-LOSS OF RDNCY
	650	075-650	DCU A PNEU SD-LOSS OF RDNCY
	651	075-651	DCU A PNEU SD-LOSS OF RDNCY
	660	075-660	DCU A PNEU SD-LOSS OF RDNCY
	661	075-661	DCU A PNEU SD-LOSS OF RDNCY
	700	075-700	DCU A PNEU SD-LOSS OF RDNCY
076	001	076-001	DCU B PNEU SD-LOSS OF RDNCY
	002	076-002	DCU B PNEU SD-LOSS OF RDNCY
	010	076-010	DCU B PNEU SD-LOSS OF RDNCY
	011	076-011	DCU B PNEU SD-LOSS OF RDNCY
	020	076-020	DCU B PNEU SD-LOSS OF RDNCY
	021	076-021	DCU B PNEU SD-LOSS OF RDNCY
	030	076-030	DCU B PNEU SD-LOSS OF RDNCY
	031	076-031	DCU B PNEU SD-LOSS OF RDNCY

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
076 (CONT'D)	032	076-032	DCU B PNEU SD-LOSS OF RDNCY
	033	076-033	DCU B PNEU SD-LOSS OF RDNCY
	034	076-034	DCU B PNEU SD-LOSS OF RDNCY
	040	076-040	DCU B PNEU SD-LOSS OF RDNCY
	041	076-041	DCU B PNEU SD-LOSS OF RDNCY
	050	076-050	DCU B PNEU SD-LOSS OF RDNCY
	051	076-051	DCU B PNEU SD-LOSS OF RDNCY
	060	076-060	DCU B PNEU SD-LOSS OF RDNCY
	061	076-061	DCU B PNEU SD-LOSS OF RDNCY
	100	076-100	DCU B PNEU SD-LOSS OF RDNCY
	101	076-101	DCU B PNEU SD-LOSS OF RDNCY
	110	076-110	DCU B PNEU SD-LOSS OF RDNCY
	111	076-111	DCU B PNEU SD-LOSS OF RDNCY
	114	076-114	DCU B PNEU SD-LOSS OF RDNCY
	115	076-115	DCU B PNEU SD-LOSS OF RDNCY

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
076 (CONT'D)	116	076-116	DCU B PNEU SD-LOSS OF RDNCY
	117	076-117	DCU B PNEU SD-LOSS OF RDNCY
	120	076-120	DCU B PNEU SD-LOSS OF RDNCY
	121	076-121	DCU B PNEU SD-LOSS OF RDNCY
	122	076-122	DCU B PNEU SD-LOSS OF RDNCY
	123	076-123	DCU B PNEU SD-LOSS OF RDNCY
	130	076-130	DCU B PNEU SD-LOSS OF RDNCY
	140	076-140	DCU B PNEU SD-LOSS OF RDNCY
	300	076-300	DCU B PNEU SD-LOSS OF RDNCY
	500	076-500	DCU B PNEU SD-LOSS OF RDNCY
	503	076-503	DCU B PNEU SD-LOSS OF RDNCY
	504	076-504	DCU B PNEU SD-LOSS OF RDNCY
	505	076-505	DCU B PNEU SD-LOSS OF RDNCY
	510	076-510	DCU B PNEU SD-LOSS OF RDNCY
	520	075-520	DCU B PNEU SD-LOSS OF RDNCY

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
076 (CONT'D)	521	076-521	DCU B PNEU SD- LOSS OF RDNCY
	522	076-522	DCU B PNEU SD- LOSS OF RDNCY
	523	076-523	DCU B PNEU SD- LOSS OF RDNCY
	601	076-601	DCU B PNEU SD- LOSS OF RDNCY
	602	076-602	DCU B PNEU SD- LOSS OF RDNCY
	603	076-603	DCU B PNEU SD- LOSS OF RDNCY
	604	076-604	DCU B PNEU SD- LOSS OF RDNCY
	605	076-605	DCU B PNEU SD- LOSS OF RDNCY
	606	076-606	DCU B PNEU SD- LOSS OF RDNCY
	607	076-607	DCU B PNEU SD- LOSS OF RDNCY
	610	076-610	DCU B PNEU SD- LOSS OF RDNCY
	611	076-611	DCU B PNEU SD- LOSS OF RDNCY
	612	076-612	DCU B PNEU SD- LOSS OF RDNCY
	613	076-613	DCU B PNEU SD- LOSS OF RDNCY
	614	076-614	DCU B PNEU SD- LOSS OF RDNCY

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
076 (CONT'D)	630	076-630	DCU B PNEU SD-LOSS OF RDNCY
	631	076-631	DCU B PNEU SD-LOSS OF RDNCY
	632	076-632	DCU B PNEU SD-LOSS OF RDNCY
	633	076-633	DCU B PNEU SD-LOSS OF RDNCY
	640	076-640	DCU B PNEU SD-LOSS OF RDNCY
	650	076-650	DCU B PNEU SD-LOSS OF RDNCY
	651	076-651	DCU B PNEU SD-LOSS OF RDNCY
	660	076-660	DCU B PNEU SD-LOSS OF RDNCY
	661	076-661	DCU B PNEU SD-LOSS OF RDNCY
	700	076-700	DCU B PNEU SD-LOSS OF RDNCY
111	001	1ST SEN FAIL - FU FLW RTE A	111-001
	002	1ST SEN FAIL - FU FLW RTE B	111-002
	003	1ST SEN FAIL - FU FLW RTE A1	111-003
	004	1ST SEN FAIL - FU FLW RTE B1	111-004
	005	1ST SEN FAIL - FU FLW RTE A2	111-005

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
111 (CONT'D)	006	1ST SEN FAIL - FU FLW RTE B2	111-006
	007	1ST SEN FAIL - LPFP DISCH PA	111-007
	010	1ST SEN FAIL - LPFP DISCH PB	111-010
	011	1ST SEN FAIL - LPFP DISCH TA	111-011
	012	1ST SEN FAIL - LPFP DISCH TB	111-012
	013	1ST SEN FAIL - PcA CTL-INTRA	111-013
	014	1ST SEN FAIL - PcB CTL-INTRA	111-014
	015	1ST SEN FAIL - PcA CTL-REF	111-015
	016	1ST SEN FAIL - PcB CTL-REF	111-016
	017	1ST SEN FAIL - FPB SD PGE P	111-017
	020	1ST SEN FAIL - OPB SD PGE P	111-020
	021	1ST SEN FAIL - HPOP IMD SL PA	111-021
	022	1ST SEN FAIL - HPOP IMD SL PB	111-022
	023	1ST SEN FAIL - HPOP SEC SL PA	111-023
	024	1ST SEN FAIL - HPOP SEC SL PB	111-024

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
111 (CONT'D)	025	1ST SEN FAIL - HPOT TD TA	111-025
	026	1ST SEN FAIL - HPOT TD TB	111-026
	027	1ST SEN FAIL - HPFT TD TA	111-027
	030	1ST SEN FAIL - HPFT TD TB	111-030
	031	1ST SEN FAIL - HPFP CL LN PA	111-031
	032	1ST SEN FAIL - HPFP CL LN PB	111-032
	035	1ST SEN FAIL - MCC Pc A-R/L	111-035
	036	1ST SEN FAIL - MCC Pc B-R/L	111-036
	041	1ST SEN FAIL - POGO PRCHG PA	111-041
	042	1ST SEN FAIL - POGO PRCHG PB	111-042
	053	1ST SEN FAIL - PcA CTL-SP	111-053
	054	1ST SEN FAIL - PcB CTL-SP	111-054
	101	111-101	1ST SEN FAIL - FFM INTRA A
	102	111-102	1ST SEN FAIL - FFM INTRA B
	103	111-103	1ST SEN FAIL - FFM SNSR A1

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
111 (CONT'D)	104	111-104	1ST SEN FAIL - FFM SNSR B1
	105	111-105	1ST SEN FAIL - FFM SNSR A2
	106	111-106	1ST SEN FAIL - FFM SNSR B2
	107	111-107	1ST SEN FAIL - FFM PRC - A1
	110	111-110	1ST SEN FAIL - FFM PRC - B1
	111	111-111	1ST SEN FAIL - FFM PRC - A2
	112	111-112	1ST SEN FAIL - FFM PRC - B2
	201	111-201	1ST SEN FAIL - PcA CTL-INTRA
	202	111-202	1ST SEN FAIL - PcB CTL-INTRA
	203	111-203	1ST SEN FAIL - PcA CTL-REF/SP
	204	111-204	1ST SEN FAIL - PcB CTL-REF/SP
	301	111-301	1ST SEN FAIL - LPFT DISCH PA
	302	111-302	1ST SEN FAIL - LPFT DISCH PB
	303	111-303	1ST SEN FAIL - LPFT DISCH TA
	304	111-304	1ST SEN FAIL - LPFT DISCH TB

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
111 (CONT'D)	401	111-401	1ST SEN FAIL - HPOT IMD SL PA
	402	111-402	1ST SEN FAIL - HPOT IMD SL PB
	403	111-403	1ST SEN FAIL - HPOT SEC SL PA
	404	111-404	1ST SEN FAIL - HPOT SEC SL PB
	405	111-405	1ST SEN FAIL - HPOT TD TA
	406	111-406	1ST SEN FAIL - HPOT TD TB
	407	111-407	1ST SEN FAIL - HPFT TD TA
	410	111-410	1ST SEN FAIL - HPFT TD TB
	411	111-411	1ST SEN FAIL - HPFT CL LN PA
	412	111-412	1ST SEN FAIL - HPFT CL LN PB
	413	111-413	1ST SEN FAIL - FPB S/D PGE P
	414	111-414	1ST SEN FAIL - OPB S/D PGE P
	415	111-415	1ST SEN FAIL - PcA RL-RSNBLNS
	416	111-416	1ST SEN FAIL - PcB RL-RSNBLNS
	417	111-417	1ST SEN FAIL - PcA RL-INTRA

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
111 (CONT'D)	420	111-420	1ST SEN FAIL - PcB RL-INTRA
	505	111-505	1ST SEN FAIL - AFV POS A
	506	111-506	1ST SEN FAIL - AFV POS B
	507	111-507	1ST SEN FAIL - HPFT SHFT SPDA
	510	111-510	1ST SEN FAIL - HPFT SHFT SPDB
	511	111-511	1ST SEN FAIL - HPFT SHFT SPDA
	512	111-512	1ST SEN FAIL - HPFT SHFT SPDB
	601	111-601	1ST SEN FAIL - POGO PRCHG PA
	602	111-602	1ST SEN FAIL - POGO PRCHG PB
	701	111-701	1ST SEN FAIL - POGO PRCHG PA
	702	111-702	1ST SEN FAIL - POGO PRCHG PB
113	017	EXCD LIM - FPB SD PGE P	113-017
	020	EXCD LIM - OPB SD PGE P	113-020
	021	EXCD LIM - HPOP IMD SL PA	113-021
	022	EXCD LIM - HPOP IMD SL PB	113-022

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
113 (CONT'D)	023	EXCD LIM - HPOP SEC SL PA	113-023
	024	EXCD LIM - HPOP SEC SL PB	113-024
	025	EXCD LIM - HPOT TD TA	113-025
	026	EXCD LIM - HPOT TD TB	113-026
	027	EXCD LIM - HPFT TD TA	113-027
	030	EXCD LIM - HPFT TD TB	113-030
	031	EXCD LIM - HPFP CL LN PA	113-031
	032	EXCD LIM - HPFP CL LN PB	113-032
	035	EXCD LIM - MCC Pc A	113-035
	036	EXCD LIM - MCC Pc B	113-036
	401	113-401	EXCDING LIMIT- HPOT IMD SL PA
	402	113-402	EXCDING LIMIT- HPOT IMD SL PB
	403	113-403	EXCDING LIMIT- HPOT SEC SL PA
	404	113-404	EXCDING LIMIT- HPOT SEC SL PB
	405	113-405	EXCDING LIMIT- HPOT TD TA

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
113 (CONT'D)	406	113-406	EXCDING LIMIT- HPOT TD TB
	407	113-407	EXCDING LIMIT- HPFT TD TA
	410	113-410	EXCDING LIMIT- HPFT TD TB
	411	113-411	EXCDING LIMIT- HPFT CL LN PA
	412	113-412	EXCDING LIMIT- HPFT CL LN PB
	413	113-413	EXCDING LIMIT- FPB SD PGE P
	414	113-414	EXCDING LIMIT- OPB SD PGE P
	415	113-415	EXCDING LIMIT- MCC Pc A
	416	113-416	EXCDING LIMIT- MCC Pc B
116	101	116-101	1ST VIB DQL - HPFT CH A
	102	116-102	1ST VIB DQL - HPFT CH B
	103	116-103	1ST VIB DQL - HPFT CH C
	104	116-104	1ST VIB DQL - HPFT SNSR CA
	105	116-105	1ST VIB DQL - HPFT SNSR CB
	201	116-201	1ST VIB DQL - HPOT CH A

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
116 (CONT'D)	202	116-202	1ST VIB DQL - HPOT CH B
	203	116-203	1ST VIB DQL - HPOT CH C
	204	116-204	1ST VIB DQL - HPOT SNSR CA
	205	116-205	1ST VIB DQL - HPOT SNSR CB
	301	116-301	1ST VIB DQL - CH C +15V PWR
	302	116-302	1ST VIB DQL - CH C +15, CH A
	303	116-303	1ST VIB DQL - CH C +15, CH B
	401	116-401	1ST VIB DQL - CH C -15V PWR
	402	116-402	1ST VIB DQL - CH C -15, CH A
	403	116-403	1ST VIB DQL - CH C -15, CH B
117	001	VIB EXCD LIM - HPFT-1	117-001
	002	VIB EXCD LIM - HPFP-1	117-002
	003	VIB EXCD LIM - HPFT-2	117-003
	004	VIB EXCD LIM - HPFP-1	117-004
	005	VIB EXCD LIM - HPFP-2	117-005

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
117 (CONT'D)	006	VIB EXCD LIM - HPFP-2	117-006
	007	VIB EXCD LIM - HPFP-3	117-007
	010	VIB EXCD LIM - HPOP-1	117-010
	011	VIB EXCD LIM - HPFP-1, HPOP-1	117-011
	012	VIB EXCD LIM - HPFP-1, HPOP-1	117-012
	013	VIB EXCD LIM - HPFP-2, HPOP-1	117-013
	014	VIB EXCD LIM - HPFP-1, HPOP-1	117-014
	015	VIB EXCD LIM - HPFP-2, HPOP-1	117-015
	016	VIB EXCD LIM - HPFP-2, HPOP-1	117-016
	017	VIB EXCD LIM - HPFP-3, HPOP-1	117-017
	020	VIB EXCD LIM - HPOP-1	117-020
	021	VIB EXCD LIM - HPFP-1, HPOP-1	117-021
	022	VIB EXCD LIM - HPFP-1, HPOP-1	117-022
	023	VIB EXCD LIM - HPFP-2, HPOP-1	117-023
	024	VIB EXCD LIM - HPFP-1, HPOP-1	117-024

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
117 (CONT'D)	025	VIB EXCD LIM - HPFP-2, HPOP-1	117-025
	026	VIB EXCD LIM - HPFP-2, HPOP-1	117-026
	027	VIB EXCD LIM - HPFP-3, HPOP-1	117-027
	030	VIB EXCD LIM - HPOP-2	117-030
	031	VIB EXCD LIM - HPFP-1, HPOP-2	117-031
	032	VIB EXCD LIM - HPFP-1, HPOP-2	117-032
	033	VIB EXCD LIM - HPFP-2, HPOP-2	117-033
	034	VIB EXCD LIM - HPFP-1, HPOP-2	117-034
	035	VIB EXCD LIM - HPFP-2, HPOP-2	117-035
	036	VIB EXCD LIM - HPFP-2, HPOP-2	117-036
	037	VIB EXCD LIM - HPFP-3, HPOP-2	117-037
	040	VIB EXCD LIM - HPOP-1	117-040
	041	VIB EXCD LIM - HPFP-1, HPOP-1	117-041
	042	VIB EXCD LIM - HPFP-1, HPOP-1	117-042
	043	VIB EXCD LIM - HPFP-2, HPOP-1	117-043

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
117 (CONT'D)	044	VIB EXCD LIM - HPFP-1, HPOP-1	117-044
	045	VIB EXCD LIM - HPFP-2, HPOP-1	117-045
	046	VIB EXCD LIM - HPFP-2, HPOP-1	117-046
	047	VIB EXCD LIM - HPFP-3, HPOP-1	117-047
	050	VIB EXCD LIM - HPOP-2	117-050
	051	VIB EXCD LIM - HPFP-1, HPOP-2	117-051
	052	VIB EXCD LIM - HPFP-1, HPOP-2	117-052
	053	VIB EXCD LIM - HPFP-2, HPOP-2	117-053
	054	VIB EXCD LIM - HPFP-1, HPOP-2	117-054
	055	VIB EXCD LIM - HPFP-2, HPOP-2	117-055
	056	VIB EXCD LIM - HPFP-2, HPOP-2	117-056
	057	VIB EXCD LIM - HPFP-3, HPOP-2	117-057
	060	VIB EXCD LIM - HPOP-2	117-060
	061	VIB EXCD LIM - HPFP-1, HPOP-2	117-061
	062	VIB EXCD LIM - HPFP-1, HPOP-2	117-062

TABLE 3.1.2-III.- Continued

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
117 (CONT'D)	063	VIB EXCD LIM - HPFP-2, HPOP-2	117-063
	064	VIB EXCD LIM - HPFP-1, HPOP-2	117-064
	065	VIB EXCD LIM - HPFP-2, HPOP-2	117-065
	066	VIB EXCD LIM - HPFP-2, HPOP-2	117-066
	067	VIB EXCD LIM - HPFP-3, HPOP-2	117-067
	070	VIB EXCD LIM - HPOP-3	117-070
	071	VIB EXCD LIM - HPFP-1, HPOP-3	117-071
	072	VIB EXCD LIM - HPFP-1, HPOP-3	117-072
	073	VIB EXCD LIM - HPFP-2, HPOP-3	117-073
	074	VIB EXCD LIM - HPFP-1, HPOP-3	117-074
	075	VIB EXCD LIM - HPFP-2, HPOP-3	117-075
	076	VIB EXCD LIM - HPFP-2, HPOP-3	117-076
	077	VIB EXCD LIM - HPFP-3, HPOP-3	117-077
	101	117-101	VIB EXCD LIM - HPFT CH A
	102	117-102	VIB EXCD LIM - HPFT CH B

TABLE 3.1.2-III.- Concluded

Failure Identifier (1)		Syntax (2)	
FID	DLM	BLK1 syntax	BLK2 syntax
117 (CONT'D)	103	117-103	VIB EXCD LIM - HPFT CH C
	201	117-201	VIB EXCD LIM - HPOT CH A
	202	117-202	VIB EXCD LIM - HPOT CH B
	203	117-203	VIB EXCD LIM - HPOT CH C

Notes:

Abbreviations:		
	LSB	Least significant bit
	MSB	Most significant bit
	MCF	Major component failure
	WDT	Watch dog timer
	VDT	Vehicle data table
	DCU	Digital computer unit
	CIE	Computer interface electronics
	PSE	Power supply electronics
	IE	Input electronics
	OE	Output electronics
	FID	Failure Identification
	DLM	Delimiter
	FRF	Flight readiness firing

1. Failure identification is reported in VDT data word no. 5. It consists of two parts: the FID number is encoded in the seven MSB's. The DLM is encoded in the nine LSB's.

2. Erroneous syntax is marked with an asterisk (*).

REFERENCES

1. STSOC CR 2314, ME Hard Failure Identification Processing and Special Displays, August 6, 1987.

2. MCC Level B & C Requirements, Section 5.5.2.19.

3. Block I Sensor Monitoring Package, AR02, January 18, 1991.

4. CP406R0001, Part I, Revision H, Computer Program Contract End Item, Flight 4C Configuration, Space Shuttle Main Engine Controller Operational Program, December 11, 1990.

5. STSOC CR 2314 A, MCC Level B & C Requirements - ME Hard Failure Identification Syntax Table Update, February 19, 1988.

6. STSOC SR 5310, MCC Level B & C Requirements - ME Hard FID Syntax Table Update for SSME Controller S/W Vers. AR01, November 9, 1989.

7. STSOC SR 5669, MCC Level B & C Requirements - ME Hard FID Syntax Table Update for SSMEC S/W Vers. AR01 Changes, February 22, 1990.

8. STSOC SR 6825A, MCC Level B & C Requirements - ME Hard Failure Identification Syntax Table Update for SSME Block II Controller Software, September 4, 1991.

9. CP406R0002F (V.2.5), Part I, Computer Program Contract End Item, Block II SSME Controller Operational Program, January 10, 1992.

TITLE

SSME TOTAL THRUST, POWER LEVEL CALCULATIONS, AND P_C COMPARISONS

PURPOSE

This SCP describes the special computation required to compute SSME total thrust, C(L,R) power level, average power level, and C(L,R) P_C comparison.

PROCEDURES

A. Total thrust F_T, is the summation of calculated vacuum thrust from the main engines using average P_C from each engine. To calculate thrust for each engine requires the TM downlinked P_C's in table 3.1.3-I, and the MED inputs in table 3.1.3-II and computations in table 3.1.3-III. The MED inputs are calculated by the Main Engine Table program, reference SCP 7.1.2. The thrust is calculated as a function of the average Pc; however, if an off-nominal SSME condition is detected the calculation is based on ISP and flowrates. The thrust equations are shown in table 3.1.3-IV. Total thrust is not displayed but is required in calculating power level.

B. The power level is computed for each main engine and displayed as PWR LVL under the appropriate engine column on MSK's 1051, 1052, and 1054. The center main engine MSK's 1071, 1072, left main engine MSK's 1073, 1074 and right main engine MSK's 1075, 1076 contain POWER LEVEL for the C(L,R) engines respectively. To calculate the power level for each engine requires the individual engine thrusts calculated in table 3.1.3-IV and the constant C1. The constant C1, MED M01G3108M, is the vacuum thrust rating of each main engine (which is the Tag value adjusted to 100 percent) and is displayed on MSK 2064. The power level equations are shown in table 3.1.3-V.

C. For a mixture ratio dispersion failure, the power level will be incorrect; refer to performance evaluation SCP 2.1.1.

D. Average power level is simply the average of the individual power levels, table 3.1.3-V. It is displayed as AVE PWR LEVEL on the MPS Consumables MSK's 1079 and 1080 and as AV PL on MSK 1051.

E. The P_C comparison is computed for each main engine and is displayed as PWR LVL-CMD. An out-of-limits condition will light the C(L,R) PWLV-CM SSME LIMIT SENSE light. This is the delta in percent between the actual and GPC commanded engine thrust. The individual power levels in table 3.1.3-V and commanded P_C (CMD-V90U1948C) are used in the computation. The equations are shown in table 3.1.3-VI.

REFERENCES

1. MCC Level B and C Requirements for Shuttle Book 5, Errata for June 12, 1989, JSC-11028.

TABLE 3.1.3-I.- THRUST TM INPUTS

Parameter no.	Parameter name	Acronym	Units
E41P1023B	C AVG P_C	P_{CC}	psia
E41P2023B	L AVG P_C	P_{CL}	psia
E41P3023B	R AVG P_C	P_{CR}	psia

TABLE 3.1.3-II.- THRUST MED CONTANTS

SDPC MED no.	Constant name	SMS value	Flight value*	Units
M01G3108M	C_1	470139	469809	lb
M02G3108M	A_1	158.309	158.309	lb/psia
M03G3108M	B_1	-6311.2	-6311.2	lb
M04G3108M	A_2	158.309	158.309	lb/psia
M05G3108M	B_2	-6311.2	-6311.2	lb
M06G3108M	A_3	158.309	158.309	lb/psia
M07G3108M	B_3	-6311.2	-6311.2	lb

Available on MSK 2064.

* Typical values. Actual values are flight dependent.

TABLE 3.1.3-III.- CALCULATED PARAMETER INPUTS

Para. no.	Symbol	Name	Units	Source
M02G3112C	N_C	C SSME T. L. case number	-	SCP 3.1.6
M04G3112C	N_L	L SSME T. L. case number	-	SCP 3.1.6
M06G3112C	N_R	R SSME T. L. case number	-	SCP 3.1.6
M01G3112C	ISP_C	C SSME specific impulse	sec	SCP 3.1.6
M03G3112C	ISP_L	L SSME specific impulse	sec	SCP 3.1.6
M05G3112C	ISP_R	R SSME specific impulse	sec	SCP 3.1.6
M01G3103C	$\dot{W}_{FC}$	C SSME fuel flow rate	lb/sec	SCP 3.1.4
M02G3103C	$\dot{W}_{FL}$	L SSME fuel flow rate	lb/sec	SCP 3.1.4
M03G3103C	$\dot{W}_{FR}$	R SSME fuel flow rate	lb/sec	SCP 3.1.4
M01G3101C	$\dot{W}_{OC}$	C SSME oxidizer flow rate	lb/sec	SCP 3.1.4
M02G3101C	$\dot{W}_{OL}$	L SSME oxidizer flow rate	lb/sec	SCP 3.1.4
M03G3101C	$\dot{W}_{OR}$	R SSME oxidizer flow rate	lb/sec	SCP 3.1.4

TABLE 3.1.3-IV.- THRUST EQUATIONS

Comp parameter	Acronym	Equation	Units
Center engine thrust	F_C	$F_C = P_{CC}\ (A_1) + B_1$; IF $N_C > 0$, $F_C = ISP_C(\dot{W}_{OC} + \dot{W}_{FC})$	lb
Left engine thrust	F_L	$F_L = P_{CL}(A_2) + B_2$; IF $N_L > 0$, $F_L = ISP_L(\dot{W}_{OL} + \dot{W}_{FL})$	lb
Right engine thrust	F_R	$F_R = P_R(A_3) + B_3$; IF $N_R > 0$, $F_R = ISP_R(\dot{W}_{OR} + \dot{W}_{FR})$	lb
Total thrust	F_T	$F_T = F_C + F_L + F_R$	lb

TABLE 3.1.3-V.- POWER LEVEL EQUATIONS

Comp no.	Comp parameter	Acronym	Equation	Units
M01G3108C	C power level	P_{LC}	$P_{LC} = (F_C/C_1)100$	%
M02G3108C	L power level	P_{LL}	$P_{LL} = (F_L/C_1)100$	%
M03G3108C	R power level	P_{LR}	$P_{LR} = (F_R/C_1)100$	%
M04G3108C	AVG power level	P_{LA}	$P_{LA} = (P_{LC} + P_{LL} + P_{LR})/3$	%

TABLE 3.1.3-VI.- P_C COMPARISON

Comp no.	Comp parameter	Equation	Units
M01G3701C	C PWR LVL-CMD	C PWR LVL-CMD = $P_{LC} - P_C$ CMD	%
M02G3701C	L PWR LVL-CMD	L PWR LVL-CMD = $P_{LL} - P_C$ CMD	%
M03G3701C	R PWR LVL-CMD	R PWR LVL-CMD = $P_{LR} - P_C$ CMD	%

TITLE

ENGINE FUEL AND OXIDIZER FLOWRATES

PURPOSE

This SCP describes the initialization and control of the formulation to compute center, left, and right main engine fuel and oxidizer flow rates.

Fuel flowrate is calculated by converting downlisted flowmeter data from GPM to lb/sec. The fuel flowrate is dependent on fuel density which is calculated from downlisted LPFT Discharge Temperature and LPFT Discharge Pressure. Since there is no oxidizer flowmeter, the oxidizer flowrate is calculated from the computed fuel flowrate and downlisted chamber pressure.

PROCEDURES

A. To calculate center, left, right fuel, and oxidizer flow rates, two groups of data are needed. One group of data is the TM downlink parameters listed in table 3.1.4-I. The other group of data is the MED input constants and initial values shown in tables 3.1.4-II and 3.1.4-III. These inputs are engine constants used in the flow rate equations (table 3.1.4-IV). These constants are used to convert the flow rate from GPM to lb/sec. The initial values are determined by Rocketdyne. (They "curve fit" a block of temperature and pressure test data points for various power levels.)

B. The flowrates $\dot{W}_{FC}$, $\dot{W}_{OC}$, $\dot{W}_{FL}$, $\dot{W}_{OL}$, $\dot{W}_{FR}$, and $\dot{W}_{OR}$ are displayed on MSK's 1071, 1072, 1073, 1074, 1075, 1076, 1079, 1080, 1051, and 1052. These computations are incorrect unless all MED constants and TM inputs are present and the engine is running.

C. T-1 DAYS: A hardcopy of the engine constants (MSK's 2063 and 2064) should be obtained and checked against constants listed in tables 3.14-II and 3.14-III.

D. This computation provides valid outputs for nominal case only in SSME operation. Early engine-out, stuck throttle, HPOT efficiency loss, and hydraulic lockup cases are covered in SCP 3.1.6. The equation used for calculating the oxidizer flow rate will be employed using the actual chamber pressure and the flow constants, shown in tables 3.1.4-II and 3.1.4-III.

E. The corrections to the oxidizer flow rate equations for calculating flowrates from actual chamber pressures (i.e., the second bracketed terms for $\dot{W}_{OC}$, $\dot{W}_{OL}$, and $\dot{W}_{OR}$ in table 3.1.4-IV) were made available by the changes of STSOC CR 2013. The fuel density constants are the same as in the main engine controller software.

F. The Main Engine Table program will calculate a different value of fuel density (JF) for use during simulations; otherwise, the value is 0.0022175.

REFERENCES

1. MCC Level B and C Requirements for Shuttle OFT Vol. I: Shuttle Data Processing Complex (SDPC) Software Rev 7.

2. Computer Program Component #8: "Sensor Data Processing" Number RR00001-08, Rev C, May 2, 1985.

3. STSOC CR #2013, SSME Performance Special Computations, April 17. 1987.

TABLE 3.1.4-I.- TM INPUTS

Parameter no.	Parameter name	Acronym	Units
E41R1021B*	Main eng C, avg flow rate, LH_2	Q_{FDC}	gpm
E41R2021B*	Main eng L, avg flow rate, LH_2	Q_{FDL}	gpm
E41R3021B*	Main eng R, avg flow rate, LH_2	Q_{FDR}	gpm
E41P1018B*	Main eng C, LPFT disch P	P_{FDC}	psia
E41P2018B*	Main eng L, LPFT disch P	P_{FDL}	psia
E41P3018B*	Main eng R, LPFT disch P	P_{FDR}	psia
E41T1019B*	Main eng C, LPFT disch T	T_{FDC}	°R
E41T2019B*	Main eng L, LPFT disch T	T_{FDL}	°R
E41T3019B*	Main eng R, LPFT disch T	T_{FDR}	°R
E41P1023B**	Main eng C, avg P_c	P_{CC}	psia
E41P2023B**	Main eng L, avg P_c	P_{CL}	psia
E41P3023B**	Main eng R, avg P_c	P_{CR}	psia

*Used in calculating LH_2 flowrates

**Used in calculating LO_2 flowrates

TABLE 3.1.4-II.- LH_2 MED CONSTANTS

MED no.	Constant	Center	Left	Right	Units
M01G3103M	E_1	3.0926×10^{-6}			lb/ft^3-psia-°R^2
M02G3103M	E_2	-2.1467×10^{-4}			lb/ft^3-psia-°R
M03G3103M	E_3	4.2739×10^{-3}			lb/ft^3-psia
M07G3103M	E_4		3.0926×10^{-6}		lb/ft^3-psia-°R^2
M08G3103M	E_5		-2.1467×10^{-4}		lb/ft^3-psia-°R
M09G3103M	E_6		4.2739×10^{-3}		lb/ft^3-psia
M13G3103M	E_7			3.0926×10^{-6}	lb/ft^3-psia-°R^2
M14G3103M	E_8			-2.1467×10^{-4}	lb/ft^3-psia-°R
M15G3103M	E_9			4.2739×10^{-3}	lb/ft^3-psia
M04G3103M	D_1	-1.4013×10^{-3}			lb/ft^3-°R^2
M05G3103M	D_2	6.522×10^{-2}			lb/ft^3-°R
M06G3103M	D_3	3.8956			lb/ft^3
M10G3103M	D_4		-1.4013×10^{-3}		lb/ft^3-°R^2
M11G3103M	D_5		6.522×10^{-2}		lb/ft^3-°R
M12G3103M	D_6		3.8956		lb/ft^3
M16G3103M	D_7			-1.4013×10^{-3}	lb/ft^3-°R^2
M17G3103M	D_8			6.522×10^{-2}	lb/ft^3-°R
M18G3103M	D_9			3.8956	lb/ft^3
M19G3101M	J	0.0022175	0.0022175	0.0022175	ft^3-min/sec-gal

TABLE 3.1.4-III.- LO2 MED CONSTANTS

MED no.	Constant	Center	Left	Right	Units
M01G3101M	W_{BC}	14.516			psia
M02G3101M	W_{CC}	0.000005507			sec/lb
M03G3101M	W_{DC}	2.92062			psia-sec/lb
M04G3101M	W_{BL}		14.516		psia
M05G3101M	W_{CL}		0.000005507		sec/lb
M06G3101M	W_{DL}		2.92062		psia-sec/lb
M07G3101M	W_{BR}			14.516	psia
M08G3101M	W_C	-0.0000000034			psi-sec/lb
M09G3101M	W_L		-0.0000000034		psi-sec/lb
M10G3101M	W_R			-0.0000000034	psi-sec/lb
M11G3101M	W_{CR}			0.000005507	sec/lb
M12G3101M	W_{DR}			2.92062	psia-sec/lb
M13G3101M	W_A	1.0	1.0	1.0	-------------

$W_{DC,L,R}$ varies from flight to flight as given from the MED output page of the met program:

$$WD = \frac{P_{CREF} + 14.5}{W_{TAG}} + 0.00001224\ P_{CREF}$$ where W_{TAG}

is the average tag value of the SSME total overboard flow rates.

TABLE 3.1.4-IV.- FLOW-RATE EQUATIONS*

Output MSID	Flow rate	Equation	Units
M01G3103C	$\dot{W}_{FC}$	$JQ_{FDC}\left\{T_{FDC}^2\left[P_{FDC}(E_1)+D_1\right]+T_{FDC}\left[P_{FDC}(E_2)+D_2\right]+P_{FDC}(E_3)+D_3\right\}$	lb/sec
M02G3103C	$\dot{W}_{FL}$	$JQ_{FDL}\left\{T_{FDL}^2\left[P_{FDL}(E_4)+D_4\right]+T_{FDL}\left[P_{FDL}(E_5)+D_5\right]+P_{FDL}(E_6)+D_6\right\}$	lb/sec
M03G3103C	$\dot{W}_{FR}$	$JQ_{FDR}\left\{T_{FDR}^2\left[P_{FDR}(E_7)+D_7\right]+T_{FDR}\left[P_{FDR}(E_8)+D_8\right]+P_{FDR}(E_9)+D_9\right\}$	lb/sec
M01G3101C	$\dot{W}_{OC}$	$\left[\dfrac{P_{CC}+W_{BC}}{W_C(P_{CC})^2+W_{CC}(P_{CC})+W_{DC}}-\dot{W}_{FC}\right]W_A$	lb/sec
M02G3101C	$\dot{W}_{OL}$	$\left[\dfrac{P_{CL}+W_{BL}}{W_L(P_{CL})^2+W_{CL}(P_{CL})+W_{DL}}-\dot{W}_{FL}\right]W_A$	lb/sec
M03G3101C	$\dot{W}_{OR}$	$\left[\dfrac{P_{CR}+W_{BR}}{W_R(P_{CR})^2+W_{CR}(P_{CR})+W_{DR}}-\dot{W}_{FR}\right]W_A$	lb/sec

*J = 2.228×10^{-3} ft^3-min/sec-gal for all engines

M19G3103M = J = 2.2175×10^{-3} ft^3-min/sec-gal (LH_2)

M14G3101M = J = 2.228×10^{-3} ft^3-min/sec-gal (LO_2)

M13G3101M = W_A = 1.000 for all three engines.

TITLE

SSME SHUTDOWN PARAMETER DELTAS

PURPOSE

This SCP describes the main engine shutdown parameter delta special computations that drive event lights on the main engine event panels 282 (left), 281 (center), and 283 (right). The event ON logic compares these deltas with the limits described in SCP 5.1.4 and generates a light if a delta is outside of its allowable limits.

DESCRIPTION

Table 3.1.5-I describes the TM inputs required by the computations in table 3.1.5-II, which drive the C(L,R) SSME LIMIT SENSE event lights on the panels listed above.

REFERENCES

1. MCC Level B and C Requirements for Shuttle Vol. I, Book 5 (JSC-11028), Errata for June 12, 1989.
2. Master Measurement Listing, Product Ref #A1361, FLT 34, REV FOO. *(MML uses ME-1, ME-2, ME-3 nomenclature for the C, L, R SSME's respectively)

TABLE 3.1.5-I.- TM INPUTS

Parameter no.	Parameter name	Acronym	Units
E41T1010B	C HPFT TURB disch T A	T_{FTCA}	°R
E41T1011B	C HPFT TURB disch T B	T_{FTCB}	°R
E41T2010B	L HPFT TURB disch T A	T_{FTLA}	°R
E41T2011B	L HPFT TURB disch T B	T_{FTLB}	°R
E41T3010B	R HPFT TURB disch T A	T_{FTRA}	°R
E41T3011B	R HPFT TURB disch T B	T_{FTRB}	°R
E41T1012B	C HPOT TURB disch T A	T_{OTCA}	°R
E41T1013B	C HPOT TURB disch T B	T_{OTCB}	°R
E41T2012B	L HPOT TURB disch T A	T_{OTLA}	°R
E41T2013B	L HPOT TURB disch T B	T_{OTLB}	°R
E41T3012B	R HPOT TURB disch T A	T_{OTRA}	°R
E41T3013B	R HPOT TURB disch T B	T_{OTRB}	°R
E41P1014B	C HPOT IMD SL PGE P A	P_{ISCA}	psia
E41P1015B	C HPOT IMD SL PGE P B	P_{ISCB}	psia
E41P2014B	L HPOT IMD SL PGE P A	P_{ISLA}	psia
E41P2015B	L HPOT IMD SL PGE P B	P_{ISLB}	psia
E41P3014B	R HPOT IMD SL PGE P A	P_{ISRA}	psia
E41P3015B	R HPOT IMD SL PGE P B	P_{ISRB}	psia
E41P1051B	C HPOT SEC SL P A	P_{SSCA}	psia
E41P1053B	C HPOT SEC SL P B	P_{SSCB}	psia
E41P2051B	L HPOT SEC SL P A	P_{SSLA}	psia
E41P2053B	L HPOT SEC SL P B	P_{SSLB}	psia
E41P3051B	R HPOT SEC SL P A	P_{SSRA}	psia

TABLE 3.1.5-I.- Concluded

Parameter no.	Parameter name	Acronym	Units
E41P3053B	R HPOT SEC SL P B	P_{SSRB}	psia
E41P1016B	C PC A	P_{CCA}	psia
E41P1017B	C PC B	P_{CCB}	psia
E41P2016B	L PC A	P_{CLA}	psia
E41P2017B	L PC B	P_{CLB}	psia
E41P3016B	R PC A	P_{CRA}	psia
E41P3017B	R PC B	P_{CRB}	psia
E41P1008B	C HPFT C LN P A	P_{CLCA}	psia
E41P1009B	C HPFT C LN P B	P_{CLCB}	psia
E41P2008B	L HPFT C LN P A	P_{CLLA}	psia
E41P2009B	L HPFT C LN P B	P_{CLLB}	psia
E41P3008B	R HPFT C LN P A	P_{CLRA}	psia
E41P3009B	R HPFT C LN P B	P_{CLRB}	psia

TABLE 3.1.5-II.- COMPUTATIONS

Spec no.	Parameter name	Equation	Units
M01G3702C	C HPFT TURB disch T delta	$D_{FTC} = \lvert T_{FTCA} - T_{FTCB} \rvert$	°R
M02G3702C	L HPFT TURB disch T delta	$D_{FTL} = \lvert T_{FTLA} - T_{FTLB} \rvert$	°R
M03G3702C	R HPFT TURB disch T delta	$D_{FTR} = \lvert T_{FTRA} - T_{FTRB} \rvert$	°R
M04G3702C	C HPOT TURB disch T delta	$D_{OTC} = \lvert T_{OTCA} - T_{OTCB} \rvert$	°R
M05G3702C	L HPOT TURB disch T delta	$D_{OTL} = \lvert T_{OTLA} - T_{OTLB} \rvert$	°R
M06G3702C	R HPOT TURB disch T delta	$D_{OTR} = \lvert T_{OTRA} - T_{OTRB} \rvert$	°R
M07G3702C	C HPOT IMD PGE P delta	$D_{ISC} = \lvert P_{ISCA} - P_{ISCB} \rvert$	psia
M08G3702C	L HPOT IMD PGE P delta	$D_{ISL} = \lvert P_{ISLA} - P_{ISLB} \rvert$	psia
M09G3702C	R HPOT IMD PGE P delta	$D_{ISR} = \lvert P_{ISRA} - P_{ISRB} \rvert$	psia
M10G3702C	C HPOT SEC SL P delta	$D_{SCC} = \lvert P_{SSCA} - P_{SSCB} \rvert$	psia
M11G3702C	L HPOT SEC SL P delta	$D_{SSL} = \lvert P_{SSLA} - P_{SSLB} \rvert$	psia
M12G3702C	R HPOT SEC SL P delta	$D_{SSR} = \lvert P_{SSRA} - P_{SSRB} \rvert$	psia
M13G3702C	C PC delta	$D_{CC} = \lvert P_{CCA} - P_{CCB} \rvert$	psia
M14G3702C	L PC delta	$D_{CL} = \lvert P_{CLA} - P_{CLA} \rvert$	psia
M15G3702C	R PC delta	$D_{CR} = \lvert P_{CRA} - P_{CRB} \rvert$	psia
M16G3702C	C HPFT C LN P delta	$D_{CLC} = \lvert P_{CLCA} - P_{CLCB} \rvert$	psia
M17G3702C	L HPFT C LN P delta	$D_{CLL} = \lvert P_{CLLA} - P_{CLLB} \rvert$	psia
M18G3702C	R HPFT C LN P delta	$D_{CLR} = \lvert P_{CLRA} - P_{CLRB} \rvert$	psia

TITLE

AUTOMATED PERFORMANCE LIMITING LOGIC AND CORRECTIONS FOR FLOW RATES, MIXTURE RATIOS, POWER LEVELS, ISP, AND VEHICLE WEIGHT

PURPOSE

This SCP describes the MOC computations that provide automated monitoring of the various performance limiting conditions and SSME soft failures, in addition to correcting SSME mixture ratio, oxidizer and fuel flow rates, specific impulse (ISP), and power level for these failures. The problems covered include chamber pressure and fuel pump discharge temperature sensor shifts, HPOT efficiency loss, nozzle leaks, and hydraulic lockup.

PROCEDURES

A. To calculate performance limiting logic and corrections, various MED inputs, TM downlink parameters and previously calculated parameters are required (refer to tables 3.1.6-I, 3.1.6-II, and 3.1.6-III). The MED inputs associated with SSME performance (i.e., MED constants unique to a given engine) will be determined from individual SSME engine data and tag values and will be documented by JSC internal notes. The inputs are used in determining performance limiting case numbers (which denote the problem condition) and corrected values for mixture ratio, flow rates, and ISP's (refer to SCP's 3.1.4 and 3.2.4 for uncorrected flow rate and mixture ratio calculations and SCP 3.1.3 for uncorrected and corrected power level calculations). Equations for generating corrected values are listed in this SCP.

B. If a performance limiting case is detected, the flight average performance is calculated. The flight average performance consists of average mixture ration and power level, and the mixture ratio shift with respect to the predicted value. The average values are calculated using at least-squares curve fit of the instantaneous mixture ration and power level from the time that the performance case was detected until the predicted MECO time. The least-squares curve fit method is used since test data shows that SSME performance is affected linearly when an SSME is locked up.

C. The corrected mixture ratios, flow rates, ISP's, power levels and performance limiting case numbers are displayed on MSK 1052. If a performance case is detected, the performance case number (fig. 3.6.I), the average mixture ration and power level, and mixture ratio shift are displayed to MSK 1052. The calculated values are dependent on the TM and MED inputs.

D. The performance limiting logic and SSME case number (figure 3.1.6-I) are designed for operation at any commanded thrust level. However, when the SSME's are throttled during the "thrust bucket," the parameter values generated during this period (approx 20 seconds) should not be used in updating the ARD. The SSME flow rates are used in calculating vehicle weight, oxidizer and fuel remaining, overall mixture ratio, and fuel NPSP. The calculation of W_{VT}, Vehicle Weight from Thrust and Acceleration, is displayed on MSK 1087, MSK 1054 and on the ARD MSK. ARD support personnel will be responsible for monitoring W_{VT} and updating the ARD vehicle weight as needed.

The values for flow rates, vehicle weight, oxidizer and fuel remaining, and overall mixture ratio will be invalid if the automatic performance limiting corrections are invalid. The fuel NPSP values will be affected in a minor way but can still be considered valid.

E. Performance values are not accurate if primary SSME data are lost.

REFERENCES

1. Determination of SSME Performance using C Star Equation, JSC Internal Note.

2. Computer results of MSFC SSME model runs for nozzle leaks and HPOT efficiency losses with thrust limiting in affect.

3. STSOC Change Request 002013 - SSME Performance Special Computations, 12-1-87.

4. GSR 168 - Rev 5 B and Rev 5 C

TABLE 3.1.6-I.- TM INPUTS

E41T1012B	Main eng C HPOTT disch temp CH A	°R	T_{OTAC}
E41T1013B	Main eng C HPOTT disch temp CH B	°R	T_{OTBC}
E41T2012B	Main eng L HPOTT disch temp CH A	°R	T_{OTAL}
E41T2013B	Main eng L HPOTT disch temp CH B	°R	T_{OTBL}
E41T3012B	Main eng R HPOTT disch temp CH A	°R	T_{OTAR}
E41T3013B	Main eng R HPOTT disch temp CH B	°R	T_{OTBR}
E41P1016B	Main eng C MCC pressure CH A	PSIA	Pc_{AC}
E41P1017B	Main eng C MCC pressure CH B	PSIA	Pc_{BC}
E41P1023B	Main eng C MCC pressure AVE	PSIA	Pc_{C}
E41P2016B	Main eng L MCC pressure CH A	PSIA	Pc_{AL}
E41P2017B	Main eng L MCC pressure CH B	PSIA	Pc_{BL}
E41P2023B	Main eng L MCC pressure AVE	PSIA	Pc_{L}
E41P3016B	Main eng R MCC pressure CH A	PSIA	Pc_{AR}
E41P3017B	Main eng R MCC pressure CH B	PSIA	Pc_{BR}
E41P3023B	Main eng R MCC pressure AVE	PSIA	Pc_{R}
E41T1019B	Main eng C LPFT disch temp (AVE)	°R	T_{fdC}
E41T2019B	Main eng L LPFT disch temp (AVE)	°R	T_{fdL}
E41T3019B	Main eng R LPFT disch temp (AVE)	°R	T_{fdR}
V41P1130C	Main eng C LOX inlet press	PSIA	P_{IC}
V41P1230C	Main eng L LOX inlet press	PSIA	P_{IL}
V41P1330C	Main eng R LOX inlet press	PSIA	P_{IR}
V90U1948C	Main eng commanded power level	%	PLC
V95U0163C	Vehicle accel	G's	A_G

TABLE 3.1.6-II.- CALCULATED PARAMETER INPUTS

Parameter	Name	Units	Acronym	Source
M49G3708E	Main eng C status WD, bits 12-14; Code 010, thrust limiting flag		TLC	SCP 4.1
M50G3708E	Main eng L status WD, bits 12-14; Code 010, thrust limiting flag		TLL	SCP 4.1
M51G3708E	Main eng R status WD, bits 12-14; Code 010, thrust limiting flag		TLR	SCP 4.1
M16G3708E	Main eng C status WD, bits 9-11, Code 100, mainstage flag		MSC	SCP 4.1
M17G3708E	Main eng L status WD, bits 9-11, Code 100, mainstage flag		MSL	SCP 4.1
M18G3708E	Main eng R status WD, bits 9-11, Code 100, mainstage flag		MSR	SCP 4.1
M22G3708E	Main eng C status WD, bits 12-14, Code 100, HYD lockup flag		HLC	SCP 4.1
M22G3708E	Main eng L status WD, bits 12-14, Code 100, HYD lockup flag		HLL	SCP 4.1
M24G3708E	Main eng R status WD, bits 12-14, Code 100, HYD lockup flag		HLR	SCP 4.1
M01G3103C	Center eng fuel flow rate	lb/sec	W_{FC}	SCP 3.1.4
M02G3013C	Left eng fuel flow rate	lb/sec	W_{FL}	SCP 3.1.4
M03G3103C	Right eng fuel flow rate	lb/sec	W_{FR}	SCP 3.1.4
M01G1900T	GPC MET	sec		MOC

TABLE 3.1.6-III.- MED INPUTS AND INITIAL VALUES

Parameter	Name	Units	Acronym	Value (SIM/FLT)
M02G3112M	Center engine nominal ISP	SEC	ISP_{NC}	452.34/452.66
M03G3112M	Left engine nominal ISP	SEC	ISP_{NL}	452.34/452.66
M04G3112M	Right engine nominal ISP	SEC	ISP_{NR}	452.34/452.66
*M05G3112M	Center engine HPOTT disch temp A	°R	T_{LIMAC}	1566/1434
*M06G3112M	Center engine HPOTT disch temp B	°R	T_{LIMBC}	1566/1533
*M07G3112M	Left engine HPOTT disch temp A	°R	T_{LIMAL}	1566/1572
*M08G3112M	Left engine HPOTT disch temp B	°R	T_{LIMBL}	1566/1449
*M09G3112M	Right engine HPOTT disch temp A	°R	T_{LIMAR}	1566/1467
*M10G3112M	Right engine HPOTT disch temp B	°R	T_{LIMBR}	1566/1585
M11G3112M	Center eng MCC press efficiency loss	PSIA	P_{LIMEC}	2986/2986
M12G3112M	Left eng MCC press efficiency loss	PSIA	P_{LIMEL}	2986/2986
M13G3112M	Right eng MCC press efficiency loss	PSIA	P_{LIMER}	2986/2986
M14G3112M	Center eng MCC press P_c shift limit	PSIA	P_{LIMPC}	3026/3026
M15G3112M	Left eng MCC press P_c shift limit	PSIA	P_{LIMPL}	3026/3026
M16G3112M	Right eng MCC press P_c shift limit	PSIA	P_{LIMPR}	3026/3026
M18G3112M	ISP constant - C_{10}			280.62/280.62
M19G3112M	ISP constant - C_{11}			167.24/167.24
M22G3112M	LH_2 leak constant - C_{L0}			2.984/2.984
M23G3112M	LH_2 leak constant - C_{L1}			3.189/3.189
M26G3112M	Center engine nominal P_c	PSIA	P_{CNC}	3006/3006
M27G3112M	Left engine nominal P_c	PSIA	P_{CNL}	3006/3006
M28G3112M	Right engine nominal P_c	PSIA	P_{CNR}	3006/3006
M29G3112M	Center engine MR constant - C_{MR0C}			.028174/0.028141
M45G3112M	Center engine MR constant - C_{MR1C}			2.89845/2.89119
M46G3112M	Center engine MR constant - C_{MR2C}			1.15815/1.15815
M47G3112M	Center engine MR constant - C_{MR3C}			0.000000379
M30G3112M	Left engine MR constant - C_{MR0L}			0.028174/0.028141
M31G3112M	Left engine MR constant - C_{MR1L}			2.89845/2.89119
M32G3112M	Left engine MR constant - C_{MR2L}			1.15815/4.15815
M33G3112M	Left engine MR constant - C_{MR3L}			0.00000379
M34G3112M	Right engine MR constant - C_{MR0R}			.028174/0.028141
M35G3112M	Right engine MR constant - C_{MR1R}			2.89845/2.89119
M36G3112M	Right engine MR constant - C_{MR2R}			1.15815/1.15815
M37G3112M	Right engine MR constant - C_{MR3R}			0.00000379
M39G3112M	LPFT disch temp limit	°R	T_{LIMF}	60/60
M40G3112M	LPFT disch temp default limit	°R	T_{LIMD}	60/60
M41G3112M	LPFT disch temp default limit	°R	T_{LIML}	29/29
M42G3112M	LPFT disch temp default limit	°R	T_{LIMU}	42/42
M64G3112M	Nominal LOX pump inlet press	PSIA	P_{IN}	65/65
M44G3112M	Vehicle weight scaling factor		C_V	1.0/1.0
M38G3112M	Temp shift for P_c shift low	°R	K_7	-143/-113
M43G3112M	Temp shift for P_c shift high	°R	K_8	-193/-168
M17G3112M	HPOT temp influence coefficient		C_T	.0067/0.00653

*Updated each flight per main engine table (MET) program and SSME tag values. (See SCP 7.1.2.)

TABLE 3.1.6-III.- Concluded

Parameter	Name	Units	Acronym	Value (SIM/FLT)
M48G3112M	Center eng nominal HPOT pressure	PSIA	POTC	3872/3896
M49G3112M	Left eng nom. HPOT pressure	PSIA	POTL	3872/3873
M50G3112M	Right eng nom. HPOT pressure	PSIA	POTR	3872/3855
M51G3112M	ISP constant - H1		H1	-2.3567/-2.3567
M52G3112M	ISP constant - H2		H2	24.8046/24.8046
M53G3112M	ISP constant - H3		H3	-63.87/63.842
M54G3112M	ISP constant - H4		H4	.00114/0.00114
M55G3112M	ISP constant - H5		H5	3126/3126
M56G3112M	HPOT PR constant - K1		K1	30/30
M57G3112M	HPOT PR constant - K2		K2	.01151/0.01151
M58G3112M	Thrust bucket time constant - K3	sec	K3	10.0/10.0
M59G3112M	Thrust bucket time constant - K4	sec	K4	76.0/76.0
M60G3112M	Electrical lockup constant - K5		K5	2611/2611
M61G3112M	Electrical lockup constant - K6		K6	395.0/395
M62G3112M	Hydraulic lockup constant - H6	PSIA	H6	1000/1000
M63G3112M	LO_2 pump inlet constant		Cp	0.0/-.00043

*Updated each flight per main engine table (MET) program and SSME tag valves (see SCP 7.1.2).

E. Calculations logic and calculations

1. LPFT discharge temperature mid-value select

   T_{MID} = Mid-value select (T_{fdc} * MSC, T_{fdl} * MSL, T_{fdR} * MSR) ;

   Mid-value select of the LPFT DT readings of the SSME's in mainstage. The mainstage flag is set to zero for SSME failure.

   Perform the step 2 through 11 for each SSME. i = C, L and R.

2. Initialize ISP, thrust limiting case number, reference Pc ration, and HPOT discharge temperature and pressure limits:

   $ISP_i = ISP_{Ni}$, ISP (seconds)

   Ni = 0, thrust limiting case number

   $R_i = (100 \times Pc_i) / (PL_i \times P_{CNi})$, reference Pc ratio

   P_{LIMHi} = (POTi + K1) (1 + K2 (PLC - 100)), high pressure limit (psia)

   P_{LIMLi} = (POTi - K1) (1 + K2 (PLC - 100)), low pressure limit (psia)

   $T_{LIMA} = T_{LIMAi}$ (1 + C_T(PLC - 100) (1 + $C_P(P_{Ii} - P_{IN})$, temperature A limit (°R)

   $T_{LIMB} = T_{LIMBi}$ (1 + C_T(PLC - 100) (1 + $C_P(P_{Ii} - P_{IN})$, temperature B limit (°R)

3. Nozzle leak. If TLi = 1:

   $ISP_i = C_{IO} + C_{IO} (R_i)$, ISP (seconds)

   $MR_i = C_{LO} + C_{L1} (R_i)$, mixture ratio

   $W_{Oi} = MR_i \times W_{Fi}$, SSME oxidizer flowrate (lb/sec)

   Ni = 1, thrust limiting case number

4. HPOT efficiency loss. If TLi = 1 and (T_{OTAi} =< T_{LIMA} or

   T_{OTBi} =< T_{LIMB}) and $Pc_i < P_{LIMEi}$ (PLC/100) :

   Ni = 2, thrust limiting case number

5. Pc Sensor shift high actual low *. If

   (T_{OTAi} => $T_{LIMA} + K_7$ and T_{OTBi} => $T_{LIMB} + K_7$)
   <u>and</u> $Pc_i < P_{LIMEi}$ (PLC/100) :

   Pc_i = Higher of Pc_{Ai} or Pc_{Bi} , Pc average for calculations

   Ni = 3 , thrust limiting case number

6. Pc sensor shift low actual high *. If

   (T_{OTAi} =< $T_{LIMA} + K_8$ or T_{OTBi} =< $T_{LIMB} + K_8$)
   <u>or</u> $Pc_i > P_{LIMEi}$ (PLC/100):

   Pc_i = Lower of Pc_{Ai} or Pc_{Bi} , Pc average for calculations

   Ni = 4 , thrust limiting case number

7. Fuel Pump Discharge Temp shift. If

   (($T_{LIMD} > T_{fdi} > T_{LIMF}$ or $T_{LIMU} > T_{fdi} > T_{LIML}$)
   <u>and</u> $| T_{fdi} - T_{MID} | > 2$) :

   $W_{Fi} = W_{Fi} \times (1 + 0.01 (T_{fdi} - T_{MID}))$, SSME fuel flowrate

   NI = 5 , thrust limiting case number

8. Electrical lockup. If ELi = 1:

   $Pc_i = K5 * (PHPOTi / POTi) + K6$; Pc average for calculations

   Ni = 6 , thrust limiting case number

9. Hydraulic lockup. If (HLi = 1 or PHYDi < H6):

   $Pc_i = (Pc_{Ai} + Pc_{Ai}) / 2$, Pc average for calculations

   Ni = 7 , thrust limiting case number

10. Mixture ratio

    $MR_i = (-B - (B^2 - 4AC)^{1/2})) / (2A)$; Mixture Ratio

    where: $A = C_{MR0i}$,

    $B = C_{MR0i} (C_{MR2i} + C_{MR3i} \times Pc_i)$

    $C = (Pc_i / (C_{MR1i} W_{Fi})) - (C_{MR2i} + C_{MR3i} Pc_i)$

    $W_{Oi} = MR_i \times W_{Fi}$, SSME oxidizer flowrate (lb/sec)

11. Specific impulse. If NC > 1:

$$ISP_i = ISP_{Ni} + H1\,(MR_i)^2 + H2(MR_i) + H3 + H4(Pc_i - H5)$$

* Do not perform this step when K3 < MET < K4.

12. If the SSME performance case number is set to a nonzero value, latch the MET for display to MSK 1052.

13. Vehicle Weight as Calculated From Thrust and Acceleration.

$$W_{VT} = \frac{ISP_c(W_{OC}+W_{FC})MSC + ISP_L(W_{OL}+W_{FL})MSL + ISP_R(W_{OR}+W_{FR})MSR}{C_v \times A_v}$$

N	Performance case
0	Nominal
1	Nozzle Leak
2	HPOT Efficiency Loss
3	Pc Shift Low, Actual High
4	Pc Shift High, Actual Low
5	LPFT Discharge Temp Shift Low
6	Electrical Lockup
7	Hydraulic Lockup

Figure 3.1.6-I.- SSME performance case number for performance limiting conditions and SSME soft failures

TABLE 3.1.6-IV.- CALCULATED PARAMETER OUTPUTS

Para. No.	Symbol	Name	Units	Source
M02G3112C	NC	C SSME T.L. case number	-	SCP 3.1.8
M04G3112C	NL	L SSME T.L. case number	-	SCP 3.1.8
M06G3112C	NR	R SSME T.L. case number	-	SCP 3.1.8
M01G3112C	ISPC	C SSME specific impulse	secs	SCP 3.1.8
M03G3112C	ISPL	L SSME specific impulse	secs	SCP 3.1.8
M05G3112C	ISPR	R SSME specific impulse	secs	SCP 3.1.8
M01G3103C	WFC	C SSME fuel flow rate	lb/sec	SCP 3.1.8
M02G3103C	WFL	L SSME fuel flow rate	lb/sec	SCP 3.1.8
M03G3103C	WFR	R SSME fuel flow rate	lb/sec	SCP 3.1.8
M01G3101C	WOC	C SSME oxidizer flow rate	lb/sec	SCP 3.1.8
M02G3101C	WOL	L SSME oxidizer flow rate	lb/sec	SCP 3.1.8
M03G3101C	WOR	R SSME oxidizer flow rate	lb/sec	SCP 3.1.8
M02G3107C	MRiC	C SSME mixture ratio	-	SCP 3.1.8
M03G3107C	MRiL	L SSME mixture ratio	-	SCP 3.1.8
M04G3107C	MRiR	R SSME mixture ratio	-	SCP 3.1.8
M07G3112C	W_{VT}	vehicle weight from thrust	lbs	SCP 3.1.8
ARD75C	C TH LIM	C SOFT FAILURE	min:sec	SCP 3.1.8
ARD75L	L TH LIM	L SOFT FAILURE	min:sec	SCP 3.1.8
ARD75R	R TH LIM	R SOFT FAILURE	min:sec	SCP 3.1.8

TITLE

SSME POWER LEVEL VERSUS HPOT DISCHARGE PRESSURE

PURPOSE

This SCP describes a backup procedure to compute main engine power level from HPOT discharge pressure.

DESCRIPTION

Prior to STS-26, the SSME controller computed synthesized main combustion chamber (MCC) pressure (Pc) for cases when the measured value was not available (i.e., failed MCC Pc transducer pairs). For STS-26 and subsequent flights, synthetic Pc is no longer needed by the controller. The equation used for synthesized Pc is used for the HPOT discharge pressure versus Pc flight day console cue card. A flight day console cue card is presented in table 3.1.7-I.

The Pc equation defined in the MOC is as follows:

$$Pc(psia) = K_5\left(=2611\right)\left(\frac{HPOT\,DP \qquad (psia)}{HPOT\,DP_{@100\%}\,(psia)}\right) + K_6(=395)$$

The SSME controller uses main combustion chamber pressure to control power level. The power level may be calculated using the HPOT discharge pressure which is a backup measurement to Pc. The equation used to compute power level is as follows:

Power level (%) = .0221057 * HPOT DP + 14.471679

Data verified from document CP406R001, 3G, Rev. C, Part 1, page 81, May 1, 1985.

A console cue card for the SMS only is presented in table 3.1.7-II. For the SMS, an HPOT discharge pressure of 4050 psia corresponds to 104 percent.

REFERENCES

1. STS 61-C Flight Data
2. Engine 2028 Acceptance Test Data

TABLE 3.1.7-I.- BOOSTER ME CUE CARD - STS 26+
POWER LEVEL VERSUS HPOT DISCHARGE PRESSURE

PWR LVL	Pc	HPOT DP		PWR LVL	Pc	HPOT DP
109	3277	4301		86	2585	3247
108	3246	4254		85	2555	3201
107	3216	4208		84	2525	3156
106	3186	4162		83	2495	3110
105	3156	4117		82	2465	3064
104	3126	4071		81	2435	3018
103	3096	4025		80	2405	2973
102	3066	3980		79	2375	2927
101	3036	3934		78	2345	2881
100	3006	3888		77	2315	2836
99	2976	3842		76	2285	2790
98	2946	3797		75	2255	2744
97	2916	3751		74	2224	2697
96	2886	3705		73	2194	2651
95	2856	3660		72	2164	2606
94	2826	3614		71	2134	2560
93	2796	3568		70	2104	2514
92	2766	3523		69	2074	2469
91	2735	3475		68	2044	2423
90	2705	3430		67	2014	2377
89	2675	3384		66	1984	2331
88	2645	3338		65	1954	2286
87	2615	3293				

Pc = 0.6645*HPOT DP + 435.02
Revised 2/3/88. Supersedes all previous revisions.
*Actual HPOT discharge pressure will vary from engine to engine. This data is included in the main engine tables program.

TABLE 3.1.7-II.- SIMULATION CUE CARD
POWER LEVEL VERSUS HPOT DISCHARGE PRESSURE

PWR LVL	Pc	HPOT DP
109	3277	4276
108	3246	4230
107	3216	4185
106	3186	4140
105	3156	4095
104	3126	4050
103	3096	4004
102	3066	3959
101	3036	3914
100	3006	3869
99	2976	3824
98	2946	3779
97	2916	3734
96	2886	3688
95	2856	3643
94	2826	3598
93	2796	3553
92	2766	3508
91	2735	3461
90	2705	3416
89	2675	3371
88	2645	3326
87	2615	3281
86	2585	3235
85	2555	3190
84	2525	3145
83	2495	3100
82	2465	3055
81	2435	3010
80	2405	2965
79	2375	2919
78	2345	2874
77	2315	2829
76	2285	2784
75	2255	2739
74	2224	2692
73	2194	2647
72	2164	2602
71	2134	2557
70	2104	2512
69	2074	2466
68	2044	2421
67	2014	2376
66	1984	2331
65	1954	2286

TITLE

ABSOLUTE/GAUGE PRESSURE CONVERSION

PURPOSE

This SCP describes the computation of the gauge pressures for the ET LH_2 ullage. These gauge pressures will be used to monitor the possible operation of the LH_2 vent and relief valve, whose operating range is relief 36 ± 1 psig; reseat ≥34 psig for the lightweight tank (LWT).

PROCEDURES

A. This computation requires four telemetry inputs and no manual inputs.

B. The three telemetry inputs for LH_2 ullage pressure:

T41P1700C - LH_2 ULL PC,
T41P1701C - LH_2 ULL PL, and
T41P1702C - LH_2 ULL PR,

are in psia. These measurements are converted to psig using the fourth telemetry input, V95H0175C - ALTITUDE in feet and the formula

$$PSIG = PSIA - 14.7e^{\left(\frac{-ALTITUDE}{25000}\right)}$$

The computation outputs are listed in table 3.2.1-I.

C. This formula was checked against the "U.S. Standard Atmosphere Supplements, 1966" and the results are shown in table 3.2.1-II.

D. The computation outputs are displayed on the booster MPS tab MSK 1051 or 1054 and history tab MSK 1081. The outputs are also limit sensed and displayed on event lights, event format numbers 287 and 302.

REFERENCE

MCC Level B/C Requirements for Shuttle, Vol. 1, Rev. 9, CH. 0, par. 5.3.3.37.06.

TABLE 3.2.1-I.- COMPUTATION OUTPUTS

Comp. no.	Parameter name	Units
M01G3706C	Gauge LH2 ULL PC	psig
M02G3706C	Gauge LH2 ULL PL	psig
M03G3706C	Gauge LH2 ULL PR	psig

TABLE 3.2.1-II.- STANDARD AND COMPUTATION COMPARISON

Altitude, ft x 1000	Computation, psia	U.S. standard atmosphere			
		30° N lat July		30°-60° N lat spring/ fall	
		Tables psia	Δ	Tables psia	Δ
0	14.7	14.7	0	14.7	0
5	12.03	12.34	-.31	12.23	-.20
10	9.85	10.30	-.45	10.11	-.26
20	6.60	7.05	-.45	6.75	-.15
30	4.43	4.68	-.25	4.36	-.07
40	2.97	3.00	-.03	2.72	-.25
50	1.99	1.84	.15	1.68	.31
60	1.33	1.10	.23	1.04	.29
70	.89	.68	.21	.64	.25
80	.60	.42	.18	.40	.20
90	.40	.26	.14	.25	.15
100	.27	.17	.10	.16	.11

TITLE

SSME HELIUM SUPPLY COMPUTATIONS

PURPOSE

This SCP describes the method used to formulate the SSME helium supply computations. These computations predict the time-of-depletion of the helium supply tanks for the SSME's and are utilized to determine if the helium in the tank is sufficient to support the planned SSME firing to the abort boundary call. The combined time-of-depletion (TOD) provides the information to determine if the pneumatics tank can supply sufficient additional helium to the center, left, or right SSME's to complete the desired engine burn time. If the time-of-depletion computation indicates that an engine's helium supply depletes prior to press-to-MECO, the crew is instructed to interconnect the pneumatics tank to supplement the helium flow to that engine.

PROCEDURES

These computations use changes in tank pressure and temperature to determine the mass flow rate of helium from each tank. A value for the minimum usable mass of helium is established for each tank. Using the mass flow rate and minimum usable mass, a prediction of the time-to-depletion is performed. Utilizing mission elapsed time (MET) and time-to-depletion (TTD), a mission time-of-depletion is calculated. Due to the experienced inaccuracies of temperature measurements of helium during a blowdown, the actual tank temperature is used only for initialization. The temperature during blowdown is calculated using time-to-depletion. The relationship between time-to-depletion and the temperature was determined from E&D blowdown analysis. Using the same technique, a value for time-of-depletion with the pneumatic tank interconnected (TODPN) is also calculated. TOD and TODPN assume that the leak is below the regulator and therefore constant. A time-of-depletion for a leak above the regulator (TODU) is calculated assuming a polytropic blowdown and a leakage rate that is proportional to tank pressure.

A. Manual Inputs for Helium Computations (table 3.2.2-I)

Manual inputs are determined and entered into the program either by voice to the computer operator or from the Megadata (MED) terminal located in the MPSR.

1. M01G3800M: PMIN, is the assumed helium tank pressure at SSME shutdown.
2. M02G3800M: GMT_I, GMT of initialization. When the GMT of initialization is less than or equal to the actual GMT, the computation starts when the STOP HELIUM COMP PBI is executed. Start the computation at T_0 -5 seconds.

3. M03G3800M: K_C; M04G3800M: K_L; M05G3800M: K_R; M06G3800M: K_P. These values are the helium masses for the center, left, right, and pneumatics tanks. This is the nominal weight of helium in each tank considered to be unusable. The unusable gas in a tank is the gas remaining in the tank when the tank pressure reaches 572 psia. This value for the 26.7 ft^3 tanks is 17.66 pounds and for the 4.73 ft^3 tanks is 3.12 pounds. This value varies as the volume of the tanks varies.

4. M07G3800M: V_C; M08G3800M: V_L; M09G3800M: V_R; M010G3800M: V_P. These values are volume of the center, left, right, and pneumatics tanks. This is the actual volume of each helium supply system.

5. M31G3800M: STOP HELIUM COMP PBI. This PBI is located on the SMEK panel and is utilized to start and stop the computation. The computation should be stopped following normal MECO.

6. M11G3800M: TD; M12G3800M: TDP. These values are taken from blowdown analysis curves and represent the expected temperature drop of the helium in the tanks during blowdown. With added information obtained during actual operations, these values are adjusted.

7. M13G3800M N; M14G300M NP, blowdown constants. These are the polytropic blowdown constants assumed for leaks above the regulator. The value of 1.36 for the constants was derived from the polytropic blowdown equation $T/T_0 = (P/P_0)$ EXPONENT((N-1)/N), where $T_0 = 530°R$ and $P_0 = 4200$ psia (from STS-1 and STS-2 flight data at ESC), T = 312.67°R (i.e., 217.33°R below 530°R), and P = 800 psia (the assumed value for PMIN).

8. M15G3800M RISP, nominal ISP usage. The nominal SSME intermediate seal purge (ISP) usage rate is 0.042 lb/sec.

9. M16G300M CISP, ISP adjustment constant. This adjustment constant was empirically derived and is used to optimize TODU for the effect of ISP usage.

B. During initialization, GMTI through GMTI+19 seconds, the temperature T and pressure P of each tank are sampled each second. The value for T at 3 seconds and the average value for P for the first 5 seconds are set to TI and PI, respectively. These TI and PI values are used to calculate the compressibility factor (Z) and the weight of helium (MI) in each tank. The change rate for temperature with respect to mass (S) is calculated by dividing the usable helium mass (MI-K) by the assumed temperature drop (TD) for each tank. Set the estimates for temperature at 3 and 17 seconds (T1 and T2, respectively) to TI.

1. Start output calculations at GMTI+19 seconds. Set P1 to the average of the first five values of P, and set P2 to the average of the last five values of P for each tank.

   Calculate values for Z1 and Z2 and M1 and M2 from the above.

2. Calculate the helium mass decay rate (R) by dividing the difference between M1 and M2 by the difference between their corresponding sample times for each tank.

3. Calculate the lower system time-of-depletion (TOD) by dividing the usable helium mass for each tank by its decay rate, and adding current OMET.

4. Calculate the lower system time-of-depletion for each SSME with pneumatic tank interconnected (TODPN) by dividing the sum of the engine tank and pneumatic tank usable helium masses by the sum of their decay rates, and adding current OMET.

5. Calculate the upper system time-of-depletion for each SSME with pneumatic tank interconnected (TODU) from current engine tank and pneumatic tank masses, pressures and decay rates using equations 2g and 2h. Equation 2g calculates a time-of-depletion assuming a polytropic blowdown of the engine and pneumatic tanks, and equation 2h averages this with a time-of-depletion assuming ISP usage only. (See ref. 1 for derivation of TODU).

6. Estimate the next values for T1 and T2 by subtracting the product of S and the drop in mass (i.e., MI-M1 and MI-M2) from TI for each tank.

7. Reset the values in the tank pressure buffer for each tank (P,n-1 through P,n-19) to the values one cycle earlier (e.g., P,n-19 = P,n-18), in order to prepare for the next cycle.

8. Repeat steps 2a through 2j until the Start/Stop PBI is pressed. If data is static for greater than 2 seconds, or if PBI is reenabled, reinitialize COMP starting with first nonstatic data (but use initial values for S).

   Display the last valid output values during the reinitialization period. If the current value for P is greater than the previous P+200 psi, or less than the previous P-200 psi, use the previous value for updating. Reference tables 3.2.2-I, -II and -III for Manual Input, Telemetry Inputs, Formulations, and MOC Outputs, respectively.

REFERENCES

1. Revised Main Propulsion System Helium Time of Depletion Real-Time Computations for Flight Operations, MEMO DF6-86-77, 11/13/86.

2. SSME Helium TOD Computation, STSOC CR No. 1188A, 2/8/88

TABLE 3.2.2-I.- MANUAL INPUTS FOR HELIUM COMPUTATIONS

MED no.	Acronym	Parameter name	Units	Initial value
M01G3800M	PMIN	Helium tank pressure at SSME shutdown	psia	572
M02G3800M	GMT	GMT of initialization	day:hr: min:sec	00:00:00:00
M03G3800M	K_C	Helium mass (center engine)	lb	17.66
M04G3800M	K_L	Helium mass (left engine)	lb	17.66
M05G3800M	K_R	Helium mass (right engine)	lb	17.66
M06G3800M	K_P	Helium mass (pneumatics)	lb	3.12
M07G3800M	V_C	Volume of helium (cntr eng)	ft^3	26.7
M08G3800M	V_L	Volume of helium (left eng)	ft^3	26.7
M09G3800M	V_R	Volume of helium (right eng)	ft^3	26.7
M10G3800M	V_P	Volume of helium (pneumatics)	ft_3	4.73
M31G3800M	N/A	Computation start/stop PBI	NA	NA
M11G3800M	TDC,L,R	Blowdown Δ temp (C,L and R eng)	R°	217.33
M12G3800M	TDP	Blowdown Δ temp (pneumatics)	R°	217.33
M13G3800M	NC,L,R	Blowdown const (C,L and R eng)	NA	1.36
M14G3800M	NP	Blowdown const (pneumatics)	NA	1.36
M15G3800M	RISP	Nominal ISP usage	lb/sec	0.042
M16G3800M	CISP	ISP adjustment const	NA	0.91

TABLE 3.2.2-II.- HELIUM COMPUTATIONS TELEMETRY INPUTS

TM no.	Acronym	Parameter name	Units
V41P1150C	P_C	Pressure for tanks C	psia
V41T1152A	T_C	Temperature for tanks C	°F
V41P1250C	P_L	Pressure for tanks L	psia
V41T1252A	T_L	Temperature for tanks L	°F
V41P1350C	P_R	Pressure for tanks R	psia
V41T1352A	T_R	Temperature for tanks R	°F
V41P1600A	P_P	Pressure for pneumatic tank	psia
V41T1601A	T_P	Temperature for pneumatic tank	°F
V91M1999PX	GMT	GPC GMT	day:hr:min:sec*
M01G1900T	MET	GPC MET	day:hr:min:sec*

*Converted to decimal hours for use in computation

The following is a list of MPS helium computations.

FORMULATIONS (perform for i = P,C,L,R).

1. Initialization

   When Start/Stop PBI is enabled, set GMTI = GMT and start initialization for i = P,C,L,R which takes 20 seconds. If the Start/Stop PBI is pressed a second time, the computation will stop. If the PBI is then reenabled, the same initialization logic will apply.
   Note: If static data occurs (i.e., GMT, current > GMT, last + 1 second) during initialization, restart the computation.

   a. Set Pi,n-19 through Pi,n equal to Pi values at GMT,n-19 through GMT,n, where GMT,n is the most current time. If current value for Pi < previous Pi - 200 psi or > previous Pi + 200 psi, use previous value for updating.

   b. Set TIi = Ti,n-17 +459.7,
      PIi = (Pi,n-19 + Pi,n-18 + Pi,n-17 + Pi,n-16 + Pi,n-15)/5,
      (= average Pi for first 5 seconds).

   c. The helium compressibility subroutine, Z(P,T), is defined as follows:

   $$Z = (-B + \surd R^{2} - 4AC)/(2A),$$

   where A = 61.849 T - 9567.6
   B = 21345.1 - 78.803 T
   C = 16.995 T -P -11761.6

   d. Set T = TIi, P = PIi,
      Call Z(P,T), and set ZIi = Z,
      Set MIi = 144 (PIi) Vi/(TIi (386) ZIi),
      Si = TDi/MIi - Ki).

2. Start output calculations at GMTI+19 seconds.

   Note: If static data > 2 seconds duration occurs (i.e., GMT,current > GMT,last + 3 seconds), reinitialize the computation starting with the first nonstatic data (but continue to use initial values for Si). Display the last valid output values during the reinitialization period. If current value for Pi < previous Pi - 200 psi or > previous Pi + 200 psi, use previous value for updating.

```
a. Set Pi,n = Pi ,
       P2i = (Pi,n + Pi,n-1 + Pi,n-2 + Pi,n-3 + Pi,n-4)/5,
       where P2i = average for most recent 1 through 5 values,
       GMT2 = GMT,n-2 ,
       P1i - (Pi,n-15 + Pi,n-16 + Pi,n-17 + Pi,n-18 + Pi,n-19)/5,
       where P1i = average for most recent 15 through 20 values,
       GMT1 = GMT,n-17.

b. Set T = T2i, P + P2i,
   Call Z(P,T), and set Z2i = Z,
   Set M2i = 144 (P2i) Vi/(T2i (386) Z2i).

c. Set T = T1i, P = P1i,
   Call Z(P,T), and set Z1i = Z,
   Set M1i = 144 (P1i) Vi/(T1i (386) Z1i).

d. Set Ri = (M1i - M2i)/((GMT2 - GMT1) * 3600),
      where Ri is helium decay rate, lbs/sec.

e. Set TODi = (M2i - Ki)/((R2i) * 3600) + OMET,
      where TODi = TOD for helium sphere i, hours, for lower system
      leak without pneumatic sphere interconnected.

f. Set TODPNi = (M2i + M2P - Ki - KP)/((R2i + RP) * 3600) + OMET,
      where TODPNi = TOD for helium sphere i, hours, for lower
      system leak with pneumatic sphere interconnected.

      Note:  TODPNP has no meaning.

g. Set TODUIi = (M2i / ((R2i - RISP) * 3600)) * (2/(Ni-1))
                * ((P2i/PMIN)$^{(Ni-1)/2Ni}$ - 1)
                + (M2P/((R2i - RISP) * 3600))
                * (P2i/P2P)$^{(NP+1)/2NP}$ * (2/(NP-1))
                * ((P2P / PMIN)$^{(NP-1)/2NP}$ - 1) ,
   where TODUIi = intermediate value for TODUi.

h. Set TODUi = CISP * ((M2i + M2P - Ki - KP)/
                ((RISP) * 3600)) * TODUIi/
                ((M2i + M2P - Ki - KP)/
                ((RISP) * 3600) + TODUIi) + OMET,
   where TODUi = TOD for helium sphere i, hours, for upper system
   leak with pneumatic sphere interconnected.

   Note:  TODUP has no meaning.

i. Set T1i = TIi - Si (MIi - M1i),
       T2i = TIi - Si (MIi - M2i).
```

j. Reset: (PERFORM IN REVERSE ORDER)
Pi,n-1 = Pi,n, Pi,n-2 = Pi,n-1, Pi,n-3 = Pi,n-2, Pi,n-4 = Pi,n-3, Pi,n-5 = Pi,n-4, Pi,n-6 = Pi,n-5, Pi,n-7 = Pi,n-6, Pi,n-8 = Pi,n-7, Pi,n-9 = Pi,n-8, Pi,n-10 = Pi,n-9, Pi,n-11 = Pi,n-10, Pi,n-12 = Pi,n-11, Pi,n-13 = Pi,n-12, Pi,n-14 = Pi,n-13, Pi,n-15 = Pi,n-14, Pi,n-16 = Pi,n-15, Pi,n-17 = Pi,n-16, Pi,n-18 = Pi,n-17, Pi,n-19 = Pi,n-18.

k. Repeat steps 2a through 2j each time GMT updates 1 second.

TABLE 3.2.2-IV.- COMPUTATION OUTPUTS

Comp no.	Acronym	Parameter name	Units
M01G3800C	R_C	Rate-of-depletion tank C	lb/sec
M02G3800C	R_L	Rate-of-depletion tank L	lb/sec
M03G3800C	R_R	Rate-of-depletion tank R	lb/sec
M04G3800C	R_P	Rate-of-depletion tank P	lb/sec
M05G3800C	TODC	Time-of-depletion tank C	min:sec
M06G3800C	TODL	Time-of-depletion tank L	min:sec
M07G3800C	TODR	Time-of-depletion tank R	min:sec
M08G3800C	TODP	Time-of-depletion tank P	min:sec
M09G3800C	TODPNC	Time-of-depletion tanks PN + C	min:sec
M10G3800C	TODPNL	Time-of-depletion tanks PN + L	min:sec
M11G3800C	TODPNR	Time-of-depletion tanks PN + R	min:sec
M12G3800C	TODUC	Upper system TOD tanks PN + C	min:sec
M13G3800C	TODUL	Upper system TOD tanks PN + L	min:sec
M14G3800C	TODUR	Upper system TOD tanks PN + R	min:sec

TITLE

MPS FUEL AND OXIDIZER CONSUMED

PURPOSE

This SCP describes the initialization and control of the formulation to compute the total oxidizer and fuel consumed.

PROCEDURES

A. TM downlink parameters required for the computation are listed in table 3.2.3-I. SCP 3.1.4 engine fuel and oxidizer flow rates outputs are described in table 3.2.3-II.

B. Several SMEK inputs are required. The SMEK panel is shown in figure 3.2.3-I. For loss of data at lift-off, PBI 14 must be depressed followed by the appropriate engine(s); PBI 8 for left, PBI 13 for center, and PBI 18 for right. This action will cause the first good flow rate data to be used to calculate approximate consumption from mainstage to acquisition of data for the appropriate engine(s). Therefore care must be exercised that the first data are not acquired during the loads throttle-back early in flight (i.e., execute PBI should not be actuated until satisfactory data are present, and the throttle is at nominal mission power level).

If the NO ME LIFT-OFF DATA (SMEK 14) function is utilized after the throttle back early in flight, the fuel and oxidizer monitored values need to be corrected by adding the propellant which was not used during the throttle-back (i.e., delta flow rate between throttle settings times delta time from start of throttle down to start of throttle up). The propellant corrections should be determined preflight as a function of mission profile.

C. Prior to lift-off, subsequent to test or calibration exercises, or after a scrubbed sim, PBI 15-ME REINIT ACCUM must be depressed to reinitialize the computation.

D. Operation of the SMEK keyboard for these functions will be the responsibility of the SSR MPS console operator. This computation is activated by mainstage bits of the engine status word or the actuation of the appropriate above described SMEK's.

E. The equations used for the computation are shown in table 3.2.3-IV. Total fuel and oxidizer consumed are displayed on MSK 1079 history tab entitled MPS consumables. Intermediate calculations are not displayed.

F. This computation, using LO_2 and LH_2 flow rates (SCP 3.1.4), will provide valid outputs for nominal runs, early engine-out, stuck throttle, HPOT efficiency loss, nozzle leak, Pc shift, LPFT discharge temperature shift, electrical lockup, and hydraulic lockup.

TABLE 3.2.3-I.- TM INPUTS

Parameter no.	Parameter name	Acronym	Units	DSREF
M10H0040J	Greenwich Mean Time	GMT	sec	
E41W1003B	Center engine status word	ESW	hex	ESW
E41J1512B	C-ESW bits 9, 10, 11			
E41W2003B	Left engine status word	ESW	hex	ESW
E41J2512B	L-ESW bits 9, 10, 11			
E41W3003B	Right engine status word	ESW	hex	ESW
E41J3512B	R-ESW bits 9, 10, 11			

TABLE 3.2.3-II.- ENGINE FLOW RATES (FROM SCP 3.1.4)

Comp number	Parameter name	Acronym	Units
M01G3101C	Center engine LOX flow rate	$\dot{W}_{OC}$	lb/sec
M02G3101C	Left engine LOX flow rate	$\dot{W}_{OL}$	lb/sec
M03G3101C	Right engine LOX flow rate	$\dot{W}_{OR}$	lb/sec
M01G3103C	Center engine fuel flow rate	$\dot{W}_{FC}$	lb/sec
M02G3103C	Left engine fuel flow rate	$\dot{W}_{FL}$	lb/sec
M03G3103C	Right engine fuel flow rate	$\dot{W}_{FR}$	lb/sec

TABLE 3.2.3-III.- MED INPUTS

MED no.	Acronym	Name	Initial value	Units
M01G3102M	T_B **	Engine time bias	000/00/00/05	sec

**Source is HI DS 25648-01 Spec-time from engine start command until main stage issued, table XI.

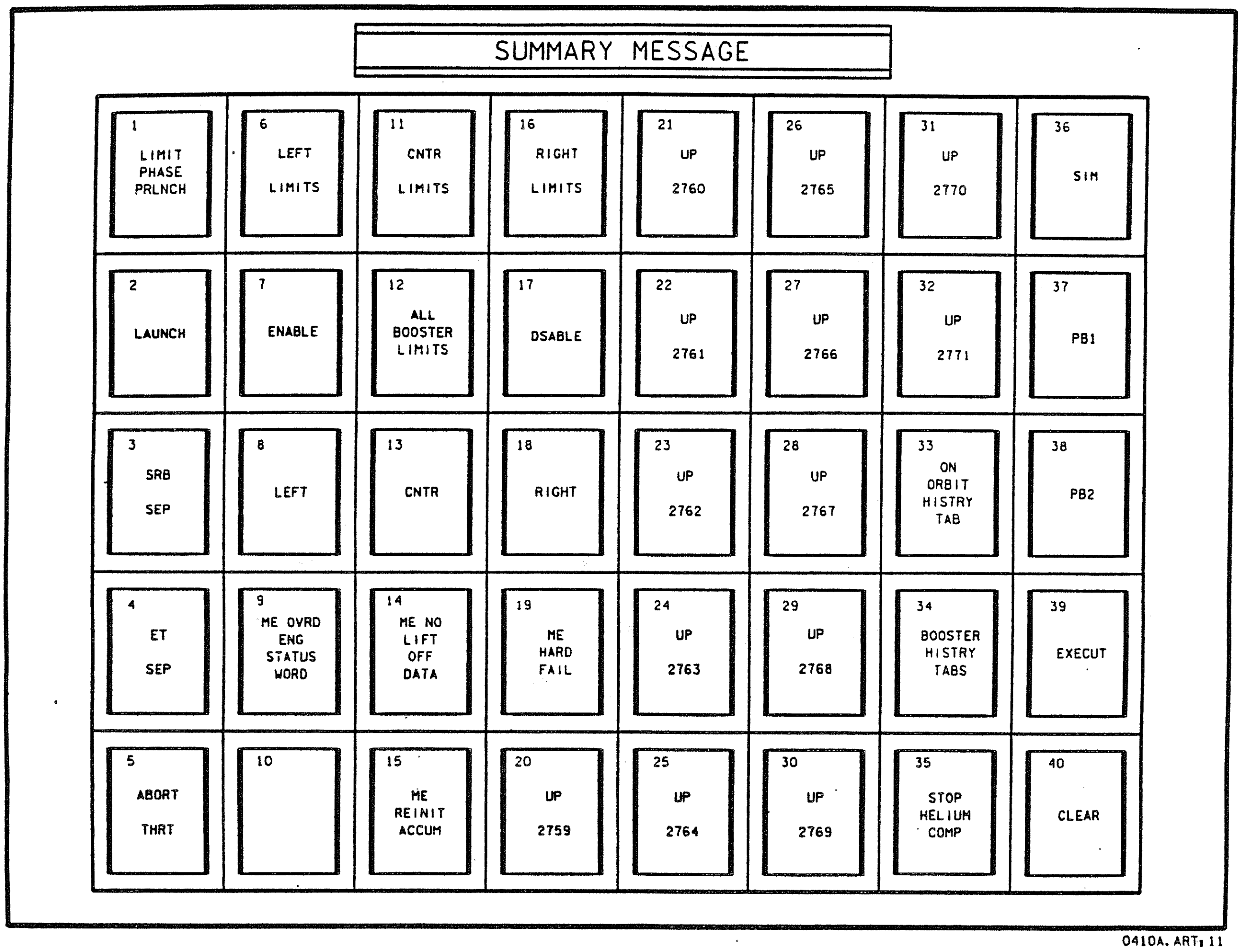


Figure 3.2.3-I.- BSE SMEK panel.

TABLE 3.2.3-IV.- EQUATIONS

Comp no.	Acronym	Equation	Units
-	O_{CCi}**	$\frac{W_{OC}\ \text{NOW} + W_{OC}\ \text{last sample}}{2}$ (GMT now - GMT last sample)	lb
-	O_{CLi}**	$\frac{W_{OL}\ \text{NOW} + W_{OL}\ \text{last sample}}{2}$ (GMT now - GMT last sample)	lb
-	O_{CRi}**	$\frac{W_{OR}\ \text{NOW} + W_{OR}\ \text{last sample}}{2}$ (GMT now - GMT last sample)	lb
-	O_{CCT}*	$\sum_i O_{CCi}$	lb
-	O_{CLT}*	$\sum_i O_{CLi}$	lb
-	O_{CRT}*	$\sum_i O_{CRi}$	lb
M01G3102C	O_{MCT}	$O_{CCT} + O_{CLT} + O_{CRT}$	lb
-	F_{CCi}**	$\frac{W_{FC}\ \text{NOW} + W_{FC}\ \text{last sample}}{2}$ (GMT now - GMT last sample)	lb
-	F_{CLi}**	$\frac{W_{FL}\ \text{NOW} + W_{FL}\ \text{last sample}}{2}$ (GMT now - GMT last sample)	lb
-	F_{CRi}**	$\frac{W_{FR}\ \text{NOW} + W_{FR}\ \text{last sample}}{2}$ (GMT now - GMT last sample)	lb
-	F_{CCT}*	$\sum_i F_{CCi}$	lb
-	F_{CLT}*	$\sum_i F_{CLi}$	lb
-	F_{CRT}*	$\sum_i F_{CRi}$	lb
M01G3104C	F_{MCT}	$F_{CCT} + F_{CLT} + F_{CRT}$	lb
-	O_{CCT}	W_{OC} NOW (GMT - GMT_{ST})	lb
-	O_{CLT}	W_{OC} NOW (GMT - GMT_{ST})	lb
-	O_{CRT}	W_{OC} NOW (GMT - GMT_{ST})	lb
-	F_{CCT}	W_{OC} NOW (GMT - GMT_{ST})	lb
-	F_{CLT}	W_{OC} NOW (GMT - GMT_{ST})	lb
-	F_{CRT}	W_{OC} NOW (GMT - GMT_{ST})	lb

*Set to zero by SMEK PBI 15 ME reinit accum.

**SMEK PBI 14 ME no lift-off data uses the following equations to reinitialize on receipt of good data.

REFERENCE

SSME Performance Comp, CR: 2013B, NASA/JSC
February 6, 1989

TITLE

MPS OXIDIZER/FUEL REMAINING, INSTANTANEOUS, AND OVERALL MIXTURE RATIO

PURPOSE

This SCP describes the initialization and control of percent LO_2 (O_{MRP}) and LH_2 (F_{MRP}), instantaneous (MR_i), and overall (MR_o) mixture ratio. Data valid during second stage computation are used to advise TRAJ of vehicle weight and if performance problems occur. The vehicle weight input tables in this SCP are for example only and must be updated for each flight.

PROCEDURES

A. Percent Oxidizer and Fuel Remaining

The oxidizer and fuel remaining are calculated and displayed as O_{MRP} and F_{MRP} respectively, as shown by the formulation in table 3.2.4-I and displayed on MSK 1079.

B. Instantaneous Mixture Ratio

The instantaneous mixture ratios, MR_i, for each engine are calculated from the calculated instantaneous flow rates as shown by equations in table 3.2.4-I. These mixture ratios are displayed on MSK 1051.

C. Overall Mixture Ratio

The overall mixture ratio, MR_o, is calculated from the ratio of oxidizer to fuel consumed O_{MCT} and F_{MLT} as described by the formulation in table 3.2.4-I. MR_o is displayed on MSK 1079.

D. Verification

After completion of this SCP, the MED inputs listed in table 3.2.4-II should be verified as entered in the SDPC by calling up MSK 2063 and 2064.

TABLE 3.2.4-I.- FORMULATIONS

MED no.	Symbol	Equations	Description	Units
M01G3105C	O_{MRP}	$1 - \frac{O_{MCT}}{O_{ML}} \times 100$	Oxidizer weight remaining	%
M01G3106C	F_{MRP}	$1 - \frac{F_{MCT}}{F_{ML}} \times 100$	Fuel weight remaining	%
M02G3017C	MR_{iC}	$W_{oC} \div W_{fC}$	Center engine instantaneous mixture ratio	-
M03G3107C	MR_{iL}	$W_{oL} \div W_{fL}$	Left engine instantaneous mixture ratio	-
M04G3107C	MR_{iR}	$W_{oR} \div W_{fR}$	Right engine instantaneous mixture ratio	-
M01G3107C	MR_{O}	$O_{MCT} \div F_{MCT}$	Overall mixture ratio	

TABLE 3.2.4-II.- MED INPUTS IN THIS SCP (TYPICAL)

MED no.	Symbol	Description	Initial value	Units	Source
M01G3105M	O_{ML}	LO_2 loaded above c/off sensors	1,354,679	lb	Nominal Flight Predictions (SODB)
M01G3106M	F_{ML}	LH_2 loaded above c/off sensors	227,594	lb	

TABLE 3.2.4-III.- COMPUTATIONS FROM OTHER SCP's

MED no.	Symbol	SCP no.	Description	Units
M01G3102C	OMCT	3.2.3	Total oxidizer weight consumed	lb
M01G3104C	FMCT	3.2.3	Total fuel weight consumed	lb
M01G3101C	W_{oC}	3.1.4	Current center engine oxidizer flow rate	lb/sec
M01G3103C	W_{fC}	3.1.4	Current center engine fuel flow rate	lb/sec
M02G3101C	W_{oL}	3.1.4	Current left engine oxidizer flow rate	lb/sec
M02G3103C	W_{fL}	3.1.4	Current left engine fuel flow rate	lb/sec
M03G3101C	W_{oR}	3.1.4	Current right engine oxidizer flow rate	lb/sec
M03G3103C	W_{fR}	3.1.4	Current right engine fuel flow rate	lb/sec

REFERENCES

1. Shuttle Operational Data Book, JSC-08934, October 1984.
2. Booster Console Handbook, Final, Rev-C, JSC-17239, April 10, 1987.
3. DF65 Data Pack.

TITLE

MPS DEPLETION TIME, 3G THROTTLING TIME, AND LOADED MIXTURE RATIO

PURPOSE

This SCP describes the initialization and control of the time-of-depletion (TOD) of MPS propellant, time of main engine throttling (TOT), and loaded mixture ratio (MRL).

Note: This computation is no longer valid due to the deletion from the T/M downlist of certain OMS/RCS parameters used as comp inputs. This SCP is being retained only for historical purposes.

PROCEDURES

A. The TOD is calculated to provide the console operator with advance knowledge of expected main engine shutdown via signals from the LO_2 and LH_2 depletion sensors.

The TOD must have TBD* seconds added for use of NO ME DATA, SMEK 14.

The TOT is calculated for information only to give insight of when to expect 3g throttling.

The flight director will be advised if TOD is 5 seconds or greater than TMECO.

B. The MED's in SCP 3.2.4 must be properly calculated and documented in order for the calculations in this SCP to be correct. All inputs from other SCP's required for the accomplishment of this SCP are listed in table 3.2.5-I.

C. Verify that the action in table 3.2.5-II has been completed to reflect the current effective exhaust velocity.

D. The equations utilized and logic choices required to calculate the expected time of propellant depletion and/or time of expected main engine throttling are listed in table 3.2.5-III. These times are displayed on MSK's 1051 and 1079.

*i.e. the difference between the MPS propellant flow (integral of flowrate over time) during the thrust bucket and the corresponding flow at the nominal flowrate divided by the nominal flowrate, for a given flight.

TABLE 3.2.5-I.- COMPUTATIONS AND MED's FROM OTHER SCP's

COMP/MED no.	Symbol	SCP no.	Description	Units
M01G3109C	W_V	*	Vehicle weight at any time	lb
M01G3017C	MR_O	3.2.4	Overall mixture ratio	--
M01G3105M	O_{ML}	3.2.4	Oxidizer weight loaded above c/off sensors	lb
M01G3106M	F_{ML}	3.2.4	Fuel weight loaded above c/off sensors	lb
M04G3108C	F_T	3.1.3	Total thrust from operating engines	lb
M01G1900T	MET	N/A	Mission elapsed time ground	min sec
M01G3101C	W_{OC}	3.1.4	Center engine oxidizer flow rate	lb/sec
M02G3101C	W_{OL}	3.1.4	Left engine oxidizer flow rate	lb/sec
M03G3101C	W_{OR}	3.1.4	Right engine oxidizer flow rate	lb/sec
M01G3103C	W_{FC}	3.1.4	Center engine fuel flow rate	lb/sec
M02G3103C	W_{FL}	3.1.4	Left engine fuel flow rate	lb/sec
M03G3103C	W_{FR}	3.1.4	Right engine fuel flow rate	lb/sec
M08G3109M	W_{LO}	3.2.4	Vehicle weight at lift-off	lb
Not Displayed	W_{AB}	*	Weight of abort OMS/RCS prop used	lb

*No longer calculated.

TABLE 3.2.5-II.- MED INPUTS AND INITIAL VALUES

MED no.	Symbol	Description	Initial value	Units	Source
M01G3110M	V_{EX}	Effective exhaust velocity	14,541[a]	ft/s	GPC I-load

[a] Based on T/C ISP = 451.95 seconds (assessed TAG value)

TABLE 3.2.5-III.- TM INPUTS

Parameter No.	Parameter name	Symbol	Units
E41J1512B	C - ESW BITS 9, 10, 11 (CODE 100 = MAINSTAGE)	MSC	-
E41J2512B	L - ESW BITS 9, 10, 11 (CODE 100 = MAINSTAGE)	MSL	-
E41J3512B	R - ESW BITS 9, 10, 11 (CODE 100 = MAINSTAGE)	MSR	-

TABLE 3.2.5-IV.- FORMULATIONS

ID no.	Symbol	Equations	Description	Units
M04G3101C	$\dot{W}_{OT}$	$\dot{W}_{OC}$ MSC + $\dot{W}_{OL}$ MSL + $\dot{W}_{OR}$ MSR	Total oxidizer flowrate	lb/sec
M04G3103C	$\dot{W}_{FT}$	$\dot{W}_{FC}$ MSC + $\dot{W}_{FL}$ MSL + $\dot{W}_{FR}$ MSR	Total fuel flowrate	lb/sec
Not displayed	W_{3G}	FT ÷ 3	Vehicle weight at 3G acceleration	lb
Not displayed	MR_L	$O_{ML} \div F_{ML}$ If $MR_O \leq S/B_2\ MR_L$, then	Loaded mixture ratio	--
Not displayed	W_{PA}	$O_{ML} - F_{ML}\ (MR_O)$, otherwise $W_{PA} = F_{ML} - \frac{O_{ML}}{MR_O}$	Weight of propellant adjusted for off nominal mixture ratio engine operation	lb
Not displayed	W_{BO}	$W_{LO} - W_{AB} + W_{PA}$ If W3G $\leq W_{BO}$, then	Burnout weight	lb
M02G3110T	TOD	$\frac{\dot{W}_V - \dot{W}_{BO}}{W_{OT} + \dot{W}_{FT}}$ + M01G1900T If $W_{3G} > W_B$ & $W_V > W_{3G}$, then	Time of propellant depletion, throttling will not occur	min-sec
M02G3110T	TOD	$\frac{W_V - W_{3G}}{W_{OT} + \dot{W}_{FT}} + \frac{V_E}{96.6} \ln \frac{W_{3G}}{W_{GO}}$ + M01G1900T and	Time of propellant depletion, throttling will occur	min-sec
M03G3110T	TOT	$\frac{W_V - W_{3G}}{\dot{W}_{OT} + \dot{W}_{FT}}$ + M01G1900T If $W_{3G} > W_{BO}$ & $W_V\ \ W_{3G}$, then	Time of expected throttling to maintain 3G acceleration limit	min-sec
M02G3110T	TOD	$\frac{V_{EX}}{96.6} \ln \frac{W_V}{W_{BO}}$ + M01G1900T	Time of propellant depletion, throttling in progress	min-sec

TITLE

LH2 ENGINE INLET NPSP COMPUTATION

PURPOSE

This SCP describes the SSME fuel net positive suction pressure (NPSP) computation and provides instructions on its use.

BACKGROUND

The definition of NPSP is total pump inlet pressure minus propellant vapor pressure, where vapor pressure is a function of pump inlet temperature (ref. 2). Because of instrumentation accuracy considerations, the fuel tank ullage pressure is used to calculate total pump inlet pressure. The calculated total pump inlet pressure equals the ullage pressure plus the propellant head at the pump (a function of propellant in the tank and the vehicle acceleration) minus the friction drop in the propellant ducting (a function of flow rate per ref. 3). As there are three ullage pressures and three engines, three fuel NPSP's are calculated (each from a different ullage pressure, inlet temperature, and flow rate), and the results are averaged. The required fuel NPSP is 4.8, 5.3, and 5.9 psi at 65-percent, 100-percent, and 109-percent power level, respectively, with linear variation between points (ref. 1). NPSP computation telemetry inputs, computation inputs from other SCP's, MED inputs, MED inputs from other SCP's, and NPSP formulations are provided in tables 3.2.6-I, 3.2.6-II, 3.2.6-III, 3.2.6-IV, and 3.2.6-V, respectively. Baseline and best estimate friction drops used in the computation are provided in tables 3.2.6-VI and 3.2.6-VII. The accuracies of the individual NPSP values and the average NPSP values are ±1.5 psi and ±0.9 psi, respectively.

Note: The pressure loss in the manifold varies for the three main engines.

PROCEDURES

A. Verify that the fuel flow rate comp (SCP 3.1.4) and the fuel remaining comp (SCP 3.2.4) are operating properly (fuel remaining should be between 0 percent and 100 percent, and the fuel flow rates should be between 90 lb/sec and 160 lb/sec).

B. Monitor left, center, right, and average values for fuel NPSP on MSK 1087 or 1054.

C. If the left, center, and right values for fuel NPSP agree with the average value within their accuracy limits (i.e., ±1.5 psi), the average NPSP will be used for comparisons with the required NPSP.

D. If the high <u>or</u> low value for NPSP deviates from the average by more than the accuracy limit, ignore the average NPSP and the deviating NPSP and use the lower of the two remaining NPSP values for comparisons. An exception would be a command path failure during throttle back; in this case flow rate can actually deviate, and the average NPSP will provide a correct value for the two nominal engines.

E. Because of vibration problems, the LH2 inlet transducers have been removed from the orbiters, but their MSID's have been retained in the T/M downlist so that T/M override values (assumed to be 37.2° R, which corresponds to 3g throttleback) can be used in the LH2 NPSP MOC COMP. The accuracy of the assumed values are approximately ±0.3° R, and results in an NPSP error of approximately ±0.9 psi. The use of an assumed temperature is not a problem unless loss of ET insulation or boundary layer combustion of vented GH2 results in elevated LH2 temperature and vapor pressure.

F. If the high <u>and</u> low values for NPSP deviate from the average by more than the accuracy limit, monitor left, center, and right values for fuel ullage pressure on MSK 1087 or 1054. If ullage pressures used in calculating two of the NPSP values fail, use the remaining NPSP value for comparisons. If the three pressure values deviate from one another in excess of their accuracy limits (±1.2 psi) and the correct parameter set is not obvious, the NPSP computation should be considered invalid.

G. If one or two of the three engines have been cut off, the NPSP of the remaining engines plus the value provided in table 3.2.6-VIII will provide correct values. Use the lower of the two values for comparisons with the required NPSP for the two-engine on case. See tables 3.2.6-VI and 3.2.6-VII for baseline and best estimate feedline friction drops.

TABLE 3.2.6-VIII.- ENGINE VALUES

No. of engines on	Power level	Add to NPSP
2	<95	2
2	95	3
2	>95	4
1	<95	3
1	95	5
1	>95	6

TABLE 3.2.6-I.- TELEMETRY INPUTS

TLM no.	Symbol	Definition	Units
T4101700C	P_{UFC}	ET LH_2 ullage pressure no. 1 (C)	psia
T4101701C	P_{UFL}	ET LH_2 ullage pressure no. 2 (L)	psia
T4101702C	P_{UFR}	ET LH_2 ullage pressure no. 3 (R)	psia
V41G1101C*	T_{FIC}	Main engine C, LPFTP inlet temp	°R
V41T1201C*	T_{FIL}	Main engine L, LPFTP inlet temp	°R
V41T1301C*	T_{FIR}	Main engine R, LPFTP inlet temp	°R
V95U0163C	A_V	Vehicle acceleration	g

TABLE 3.2.6-II.- COMPUTATIONS FROM OTHER SCP's

COMP no.	Symbol	Definition	Units	SCP no.
M01G3104C	F_{MCT}	Fuel consumed	lb	3.2.3
M01G3103C	W_{FC}	Center engine fuel flow rate	lb/sec	3.1.4
M02G3103C	W_{FL}	Left engine fuel flow rate	lb/sec	3.1.4
M03G3103C	W_{FR}	Right engine fuel flow rate	lb/sec	3.1.4

* Because of vibration problems, the LH2 inlet transducers have been removed from the orbiters, but their MSID's have been left in the downlist so that T/M override values (37.2° R) can be used in the LH2 NPSP MOC COMP.

TABLE 3.2.6-III.- MED INPUTS FOR THIS SCP

COMP no.	Symbol	Definition	Units	Initial value
M01G3111M	F_{mu}	Unusable fuel in ET	lb	413
M02G3111M	P_{17}	Friction drop in fuel ducting	psi	8.02[a]
M03G3111M	H_{10}	Constant	lb/ft^3	4.42
M04G3111M	H_{11}	Constant	ft	3.48
M05G3111M	H_{12}	Constant	ft^2	592.86
M06G3111M	H_{13}	Constant	ft^3	4069
M07G3111M	H_{14}	Constant	ft	10.34
M08G3111M	H_{15}	Constant	-	0.59
M08G3111M	H_{16}	Constant	ft	5.67
M10G3111M	H_{17}	Constant	ft^2 - in/lb - sec^2	32.6
M11G3111M	P_1	Constant	psi	16
M12G3111M	P_2	Constant	-	5.7
M13G3111M	W_1	Constant	lb/sec	148
M14G3111M	T_1	Constant	°R	37

[a] Best estimate friction drop

TABLE 3.2.6-IV.- MED INPUT FROM OTHER SCP's

COMP no.	Symbol	Definition	Units	SCP no.
M03G3106M	F_{ML}	Fuel above C/O sensors	lb	3.2.4

TABLE 3.2.6-V.- FORMULATIONS

Comp no.	Symbol	Equation	Parameter
N/A	V_F	$$\frac{F_{mu} + F_{ML} - F_{MCT}}{H_{10}}$$	Fuel volume in ET, ft^3
N/A	H_{FT}	If $V_F \geq H_{13}$, $H_{FT} = H_{11} + \frac{V_F}{H_{12}}$ If $V_F < H_{13}$, $H_{FT} = H_{14}\left(\frac{V_F}{H_{13}}\right)^{H_{15}}$	Fuel height in ET, ft
M01G3111C	$NPSP_{FC}$	$$P_{UFC} + \frac{A_V}{H_{17}}(H_{FT} + H_{16}) - P_1\left(\frac{T_{FIC}}{T_1}\right)^{P_2} - P_{17}\left(\frac{W_{FC}}{W_1}\right)^2$$	Fuel NPSP for left engine, psi
M02G3111C	$NPSP_{FL}$	$$P_{UFL} + \frac{A_V}{H_{17}}(H_{FT} + H_{16}) - P_1\left(\frac{T_{FIL}}{T_1}\right)^{P_2} - P_{17}\left(\frac{W_{FL}}{W_1}\right)^2$$	Fuel NPSP for left engine, psi
M03G3111G	$NPSP_{FR}$	$$P_{UFR} + \frac{A_V}{H_{17}}(H_{FT} + H_{16}) - P_1\left(\frac{T_{FIR}}{T_1}\right)^{P_2} - P_{17}\left(\frac{W_{FR}}{W_1}\right)^2$$	Fuel NPSP for right engine, psi
M04G3111C	$NPSP_{FA}$	$$\frac{NPSP_{FC} + NPSP_{FL} + NPSP_{FR}}{3}$$	Average fuel NPSP

TABLE 3.2.6-VI.- LH$_2$ FEED SYSTEM PRESSURE LOSS (BASELINE)

	At RPL (148 lb/sec/eng) $\bar{q}$ 12 = 0.85 psi $\bar{q}$ 17-2 = 0.89 psi $\bar{q}$ 17-3 = 2.00 psi	Feed system pressure loss (psi)								
		Three SSME's operating			Two SSME's operating					
					No. 1 out		No. 2 out		No. 3 out	
		No. 1	No. 2	No. 3	No. 2	No. 3	No. 1	No. 3	No. 1	No. 2
ORB	12-in duct Prevalve Screen	0.56 0.21 0.90			0.56 0.21 0.90					
	12-in total	(1.67)			1.67					
	Manifold	0.44	2.0	0.44	0.70	0.10	0.30	0.50	0.10	0.70
ET	17-in duct Disconnect Bellows Syphon Screen	1.52 2.00 0.62 0.54 0.50			0.68 0.88 0.28 0.24 0.22					
	17-in total	5.62	7.18	5.62	3.00	2.40	2.60	2.80	2.40	3.00
SYSTEM GRAND TOTAL		7.29	8.85[a]	7.29	4.67[a]	4.07	4.27	4.47	4.07	4.67[a]

[a] Because of higher friction drop and low LH$_2$ NPSP, SSME 2 will be the first to shut down. Following early-engine-out, friction drop to remaining two engines will be approximately 4 psi less than the 8.85 psi assumed for SSME 2 and for the NPSP comp friction drop. These values correspond to 100 percent level and vary with power level squared.

TABLE 3.2.6-VII.- LH_2 FEED SYSTEM PRESSURE LOSS (BEST ESTIMATE)

	At RPL (148 lb/sec/eng) $\bar{q}$ 12 = 0.85 psi $\bar{q}$ 17-2 = 0.89 psi $\bar{q}$ 17-3 = 2.00 psi	Feed system pressure loss drop @ RPL (psi)								
		Three SSME's operating			Two SSME's operating					
					No. 1 out		No. 2 out		No. 3 out	
		No. 1	No. 2	No. 3	No. 2	No. 3	No. 1	No. 3	No. 1	No. 2
ORB	12-in duct Prevalve Screen	0.54 0.09 0.90	0.53 0.09 0.90	0.53 0.09 0.90	0.53 0.09 0.90	0.53 0.09 0.90	0.54 0.09 0.90	0.53 0.09 0.90	0.54 0.09 0.90	0.53 0.09 0.90
	12-in total	1.53	1.52	1.52	1.52	1.52	1.53	1.52	1.53	1.52
	Manifold	0.40	1.80	0.40	0.62	0.09	0.27	0.45	0.09	0.62
ET	17-in duct Disconnect Bellows Syphon Screen	1.20 2.00 0.62 0.46 0.42			0.53 0.88 0.28 0.20 0.19					
	17-in total	5.10	6.50	5.10	2.70	2.17	2.35	2.53	2.16	2.70
SYSTEM GRAND TOTAL		6.63	8.02[a]	6.62	4.22[a]	3.69	3.88	4.05	3.70	4.22[a]

[a] Because of higher friction drop and low LH_2 NPSP, SSME 2 will be the first to shut down. Following early-engine-out, friction drop to remaining two engines will be approximately 4 psi less than the 8.02 psi assumed for SSME 2 and for the NPSP comp friction drop. These values correspond to 100 percent level and vary with power level squared.

REFERENCES

1. ICD 13M15000, SSME/Orbiter Vehicle Interface Control Document (rev U).

2. NBS Technical Note 617, Thermophysical Properties of Parahydrogen from the Freezing Liquid Line to 5000° R for Pressures to 10,000 psia.

3. MPTA Feed System Performance Analysis and NPSP Definition for SF-5 through SF-8, Rockwell International Letter, 789-200-78-046, December 20, 1978.

4. JSC Memo, "Fuel NPSP Real-Time Computation for Flight Operations," J. G. Thibodaux, Jr., (CP) to M. R. Frank (CF), August 6, 1979.

INSTRUMENTATION/ POWER ANALYSIS

4

INSTRUMENTATION/ POWER ANALYSIS

TITLE

SSME VEHICLE DATA TABLE DESCRIPTION

SCOPE

The intent of this SCP is to provide information on each of the data words in the vehicle data table (VDT) seen in real time by the flight controllers in the MCC. This SCP also provides cue cards for decoding the engine status word (ESW) and identification (ID) word 2. Information on the entire VDT is available in SSMEC software brief 3.1 (ref. 7). Detailed information on data word 5, which contains the most recent failure identification word (FID), has been moved to SSME controller software brief 1.4. Information on the MOC computation which provides syntax for the FID words is available in SCP 3.1.2. Information on non-VDT SSME parameters used for engineering assessment of hardware performance and turnaround processing are available in Booster Systems Brief TBD.

DESCRIPTION

A. Table 4.1-I contains a listing of the first 32 of the 128 words output in the standard VDT used for flight, which is provided by each SSME controller (SSMEC). The VDT is transmitted every 40 ms (every other controller cycle) over two controller data buses, called the primary and secondary data paths, to a dedicated engine interface unit (EIU) which provides the data to the GPC's and to the 60-kbit downlink. Both controller data buses contain data from the same digital computer unit (DCU).

Usually the data source is DCU A, since it is nominally the in-charge DCU. If a DCU switchover occurs due to a failure in DCU A, the data source switches to DCU B since it is now the in-charge DCU. A SWITCH VDT command issued by the GPC's can also change the source of the VDT without affecting which DCU is in charge (currently the GPC's only have the capability to command a switch from DCU A to DCU B: the Block II software has the capability to go back to DCU A data which is not utilized). The SWITCH VDT command is issued if both the primary and secondary data paths have been disqualified. This is an attempt by the GPC's to regain data if the cause of the data loss was a single-point failure in the vehicle interface electronics (VIE) that both channels of DCU A data must pass through. For this special case, the SWITCH VDT command, if successfully received by DCU A, will cause the data source to use a different hardware path which will bypass the failed circuit which caused loss of the data. Only in this case will a SWITCH VDT command be successful. However, since the data source is not the in-charge DCU, the VDT will not provide all of the same data as it normally does (e.g., sensor monitoring is not performed by the standby DCU). See references 1 and 7 for more details on the standby DCU processing.

The VDT contains 128 16-bit words. Only the first 32 words are available in the GPC downlist via the primary data path. Due to GPC I/O limitations, only the first 6 words of the VDT are requested from the secondary data path by the GPC's, even though all 32 are available. The BFS only requests the first six words from both the primary and secondary data paths, but only five are available in the downlist (word 5, the FID word, is not downlisted). Until OI-22 software is available, the secondary data path's information, except for main combustion chamber pressure (MCC Pc), is also unavailable in the downlist. All 128 words, plus 4 EIU bite words, are available in the 60-kbit data stream. The EIU's operational instrumentation (OI) section adds the 4 EIU bite words to the 128 SSME words and ships it out to three sources: the FM downlink, the LPS T-0 umbilical, and to the orbiter OPS Recorders. The MCC currently only has access to the GPC-downlisted, first 32 words. Plans are in work to access the 60-kbit FM downlink data for real-time operations in the MCC.

The MML MSID's for the engine are the same for the three engines, with the exception being the fifth digit: a "1" is for the center engine, a "2" is for the left engine, and a "3" is for the right engine. For specific information on the vehicle interface and the formatting of the VDT, see reference 6.

B. Figure 4.1-II contains a listing of all the VDT parameters used in GPC software sequences and the specific sequence using each of those parameters.

REFERENCES

1. CP406R0002 (V2.5), Part I, Computer Program Contract End Item, Block II SSME Operational Program, Jan. 10, 1992.
2. RCN 5193, "DCU Switchover Following Channel A Actuator Disqualification," Feb. 5, 1992.
3. "Orbiter/SSME Software Interface" briefing, D. Townsend (JSC), Sept. 3, 1987.
4. "SSME Interface Processing" briefing, R. Dobson (IBM), Sept. 3, 1987.
5. Space Shuttle Technical Manual, Controller and Software Reference Handbook, RKD RSS-8628, date unknown.
6. Space Shuttle Orbiter Vehicle/Main Engine Interface Control Document, ICD 13M15000, Rev. Y.
7. Booster Systems Software Handbook, vols. I & II, JSC-19395.
8. Booster Systems Briefs, JSC-19041, basic, Rev. B, April 1, 1990.
9. NSTS Launch Commit Criteria, NSTS 16007.

TABLE 4.1-I. - SSME STANDARD VEHICLE DATA TABLE

VDT WORD NO. (1)	MML NO. (2)	PARAMETER NAME	FULL SCALE RANGE (4)	ENGINE OPERATING RANGE (5)	LCC SSID (6)	ENGINE READY PARAM. (7)	PERFORMANCE CONTROL (8)	SHUTDOWN REDLINE PARAM. (9)	REMARKS
1	E41M1001P	ID Word 1			RSLS-01 (16)				(10)
2	E41M1002P	ID Word 2			RSLS-01 (16)				(10)
3	E41M1003P (3) (13)	Engine Status Word (ESW)			SSME-07 RSLS-01				(11)
4	E41W1004P (3)	Time Reference (TRef)	0-65535 mcc (20 msec)		RSLS-01 (16)				(12)
5	E41M1005P	Failure ID (FID)			(14)				
6	E41P1023B (3)	MCC Pc Avg	0-3500 psia (± 2% FS)	1,954-3,274 (65-109%)	RSLS-01 (15)				(18)
7	E41R1021B	LH2 Flowrate Avg	0-24000 gpm (± 1% FS)	10,141-15,639					(8)
8	E41R1022B	LO2 Flowrate	0-7000 gpm	3,683-5,726					
9	E41P1018B	LPFT Discharge Pressure Avg	0-300 psia (± 2% FS)	193-200		YES			(8)
10	E41T1019B	LPFT Discharge Temperature Avg	30-55 degR (± 2%)	41.5-42.2		YES			(8)

TABLE 4.1-I. - SSME STANDARD VEHICLE DATA TABLE (continued)

VDT WORD NO. (1)	MML NO. (2)	PARAMETER NAME	FULL SCALE RANGE (4)	ENGINE OPERATING RANGE (5)	LCC SSID (6)	ENGINE READY PARAM. (7)	PERFORMANCE CONTROL (8)	SHUTDOWN REDLINE PARAM. (9)	REMARKS
11	E41T1020B	PBP Discharge Temperature Ch A	160-230 degR (± 2%)	180-210	SSME-20 SSME-38 (17)	YES			
12	E41P1051B	HPOT Sec Cavity Seal Press Ch A	0-300 psia (± 2% FS)	0-38	SSME-27			YES	
13	E41P1053B	HPOT Sec Cavity Seal Press Ch B	0-300 psia (± 2% FS)	0-38	SSME-27			YES	
14	E41P1008B	HPFT Coolant Liner Press Ch A	0-4500 psia (± 2% FS)	2,317-3,675	SSME-28			YES	
15	E41P1009B	HPFT Coolant Liner Press Ch B	0-4500 psia (± 2% FS)	2,317-3,675	SSME-28			YES	
16	E41T1010B	HPFT Turbine Disch Temp Ch A	150-2450 degR (± 2%)	1,463-1,742	SSME-24			YES	
17	E41T1011B	HPFT Turbine Disch Temp Ch B	150-2450 degR (± 2%)	1,463-1,742	SSME-24			YES	
18	E41T1012B	HPOT Turbine Disch Temp Ch A	150-2450 degR (± 2%)	917-1,422	SSME-25			YES	
19	E41T1013B	HPOT Turbine Disch Temp Ch B	150-2450 degR (± 2%)	917-1,422	SSME-25			YES	
20	E41P1014B	HPOT Intermediate Seal Press Ch A	0-600 psia (± 2%)	211-425	SSME-3,10, & 26			YES	

TABLE 4.1-I. - SSME STANDARD VEHICLE DATA TABLE (concluded)

VDT WORD NO. (1)	MML NO. (2)	PARAMETER NAME	FULL SCALE RANGE (4)	ENGINE OPERATING RANGE (5)	LCC SSID (6)	ENGINE READY PARAM. (7)	PERFORMANCE CONTROL (8)	SHUTDOWN REDLINE PARAM. (9)	REMARKS
21	E41P1015B	HPOT Intermediate Seal Press Ch B	0-600 psia (± 2%)	211-425	SSME-3,10, & 26			YES	
22	E41P1016B	MCC Pc Ch A Avg	0-3500 psia (± 2%)	1,954-3,274 (65-109%)	SSME-31		YES	YES	(19)
23	E41P1017B	MCC Pc Ch B Avg	0-3500 psia (± 2%)	1,954-3,274 (65-109%)	SSME-31		YES	YES	(19)
24	E41H1024B	MFV Actuator Psn	0-100 % (± 1% FS)	0-100	SSME-8,34				
25	E41H1025B	MOV Actuator Psn	0-100 % (± 1% FS)	0-100	SSME-8,34				
26	E41H1026B	CCV Actuator Psn	0-100 % (± 1% FS)	0-100	SSME-34				
27	E41H1027B	FPOV Actuator Psn	0-100 % (± 1% FS)	69.5-84.0	SSME-8,34				
28	E41H1028B	OPOV Actuator Psn	0-100 % (± 1% FS)	52.9-72.5	SSME-8,34				
29	E41P1029B	HPFT Discharge Pressure	0-9500 psia (± 2% FS)	4,030-6,210					
30	E41P1030B	HPOT Discharge Pressure	0-7000 psia (± 2% FS)	2,318-4,115					
31	E41P1031B	Fuel Preburner Chamber Pressure	0-7000 psia (± 2% FS)	3,040-5,180					
32	E41P1054B	Hydraulic Supply Pressure	0-4000 psia (± 2% FS)	3,029-3,284					

NOTES

(1) VDT Word Format:

15 14 13 12 11 10 09 08 07 06 05 04 03 02 01 00
MSB LSB

MSB = most significant bit
LSB = least significant bit

Note: Block I SSMEC VDT word format was numbered 1 through 16 with bit 1 being the MSB and bit 16 being the LSB. In both controllers, the MSB is the left-most bit in the word.

(2) The MML number represents the center SSME only (engine 1). For the left SSME (engine 2), the fifth character changes to a 2 (E41_2_____). For the right SSME (engine 3), the fifth character changes to a 3 (E41_3_____).

(3) The BFS only downlists the ESW, TRef and PcAvg even though all 6 of the first 32 words are fetched from the primary data path. If the primary data path fails, only PcAvg data are available in the downlist. In OI-22, the ESW and TRef also becomes available in the downlist via the secondary data path. PcAvg is only downlisted at 1 sample/sec as opposed to the 25 sample/sec available from the PASS.

(4) Precision of data is in parenthesis.

(5) Engine operating range values are based on maximum and minimum STS-51L mainstage operating values.

(6) See reference 9, sections 20, 21, and 36 for complete information on LCC parameters.

(7) Engine Ready mode is entered automatically from PSN4 by satisfying the following criteria and having no INHIBIT response in effect:

PARAMETER	ENGINE READY LIMITS		QUALIFICATION LIMITS	
	LOWER	UPPER	LOWER	UPPER
LPFT Disch T Ch A LPFT Disch T Ch B	37 °R 37 °R	42 °R 42 °R	35 °R 35 °R	45 °R 45 °R
LPFT Disch P Ch A LPFT Disch P Ch B	47 psia 47 psia	61 psia 61 psia	0 psia 0 psia	61 psia 61 psia
PBP Disch T Ch A PBP Disch T Ch B (aka, HPOT Boost Stage Disch T)	------- -------	186.5 °R 186.5 °R	------- -------	220 psia 220 psia
LPOT Disch P Ch A LPOT Disch P Ch B	95 psia 95 psia	------ ------		
Emergency S/D P Ch A Emergency S/D P Ch B	------- -------	50 psia 50 psia	------- ------- (monitor starts at PSN4 + 2 sec)	50 psia 50 psia
FBP S/D Pge P OPB S/D Pge P	------- -------	50 psia 50 psia	0 psia 0 psia (monitor starts at PSN3 + 1 sec)	160 psia 535 psia
MOV Hydraulic T Ch A MOV Hydraulic T Ch B	490 °R 490 °R	------- -------	450 °R 450 °R	-------- --------
MFV Hydraulic T Ch A MFV Hydraulic T Ch B	490 °R 490 °R	------- -------	460 °R 460 °R	-------- --------

These parameters are monitored from PSN4 + 10 sec until Engine Ready is achieved and up until the START ENABLE command is received. The failure responses for this monitoring is the corresponding FID 12, and MCF, an INHIBIT. These responses can be expected if the STEN command is issued and the engine is not in Engine Ready or if any of the above parameters fails once Engine Ready has been achieved. If failure occurs after Engine Ready mode had been entered, the controller would roll the engine back into PSN4 mode.

(8) Performance control parameters, which are available in the first 32 words of the VDT, are MCC Pc Avg, MCC Pc Ch A Avg, MCC Pc Ch B Avg, LPFT Discharge Pressure Avg, LPFT Discharge Temperature Avg, and Fuel Flowmeter Average. The LPFT discharge pressure and temperature are used to derive a fuel density value which is used to determine volumetric flowrate in conjunction with the fuel flowmeter readings (see SCP 2.1.1 and references 1, 7, and 8). The LO2 flowrate output in word 8 is a derived parameter and is a relic from the time when a hardware LO2 flowmeter was installed on the engine. Shown below are the reasonableness tests pertaining to control loop monitoring performed on the MCC Pc, LH2 fuel flowrate, and LPFT discharge temperature and pressure:

PARAMETERS	REASONABLENESS TESTING
MAIN COMBUSTION CHAMBER PRESSURE SENSORS A1, A2, B1 & B2 (psia)	|A1-A2| < 75 PSI |B1-B2| < 75 |CH Average - PcRef| ≤ Delta Delta = 200 (i) During throttling & 50 major cycles thereafter (ii) During steady state if commanded power level ≤ 75 % RPL (iii) For 50 major cycles after a Major Cycle Restart DELTA = 75 If none of the above conditions exist
LH$_2$ FUEL FLOWMETER SENSORS A1, A2, B1 & B2 (gpm)	|A1-A2| < 1800 |B1-B2| < 1800 Pulse Rate Convertor Self Test 5,000 < A1,A2,B1,B2 < 20,000 |CH A Avg - CH B Avg| < 1800
LPFT DISCHARGE PRESSURE CH A & CH B (psia)	140 < CH A < 300 140 < CH B < 300
LPFT DISCHARGE TEMPERATURE CH A & CH B (° R)	40 < CH A < 45 40 < CH B < 45

(9) A cue card with the SSME mainstage redlines and their qualification limits is shown in figure 4.1-I. For information regarding ignition confirmed and other start redlines, see references 1 and 7.

REDLINE SHUTDOWN PARAMETERS - BLK II GENERIC

PARAMETER	QUAL. LIMITS		GENERIC REDLINE LIMITS	
	Lower	Upper	Lower	Upper
HPOT TD TA, TB	150°R	2650°R	720°R	1760°R
HPOP IMSL PGE PA, PB	0 psia	650 psia	170 psia	-------
HPOP SEC SL PGE PA, PB	4 psia	300 psia	--------	100 psia
HPFT TD TA	"calc" see note 1 (≈810°R)	2650°R	--------	1850°R
TB			--------	1960°R
HPFP CL LNR PA, PB	1800 psia	4500 psia	--------	see note 2 2317 psia @ 65% 3536 psia @ 100% 3675 psia @ 104% 3849 psia @ 109%
MCC Pc Ch A Avg	1000 psia & |A1 - A2| ≤125 psia	3500 psia	(PcRef - PcAvg) > 400 psid	----------
Ch B Avg	1000 psia & |B1 - B2| ≤125 psia	3500 psia	(PcRef - PcAvg) > 400 psid	----------

NOTES:

(1) Qual limit "calc" = ((slope)(PcRef) + offset) or 810 (use highest value)
offset = (channel average) - (slope)(PcRef) - 100
(calculated at 5.64 sec using 32 samples from 5.00 to 5.62 sec)
slope = 0.1421 (A), 0.1809 (B)
Default = 810 if PcRef ≤ 65%

(2) Redline limit = 53.7 + 1.1583 (MCC Pc) psia (provides 300 psia delta-P on coolant liner)

(3) RVDT Blueline Limits: HPOT TDT B/L = 770 (min) 1710 (max) HPFT TDT B/L = 1800 (max-Ch A)
1910 (max-Ch B)

(4) HPOT TDT "MCF Limit" Test (FID 20-001,002) issues MCF if TDT < 810, but does not disqualify channel.

Figure 4.1-I.- SSMEC block II redline shutdown matrix.

(10) ID Word 1 Decoding (bit 15 = MSB):

Bits 15-5 are only alterable by memory load.
Bit 4 is loaded as 0 in both DCU's at memory load. DCU A remains zero and DCU B is set to 1.
Bits 3-0 are updated by software.

Bits 15-10: Nominal value (6 MSB's) = 101010

Bits 9-7 : Vehicle Number

VEHICLE	CODE	
Spare	000	
OV-102	001	
OV-099	010	
OV-103	011	
OV-104	100	
OV-105	101	
Single Engine	110	(default)
Spare	111	

Bits 6-5 : Engine Position

POSITION	CODE	
Not Used	00	
Center	01	(default)
Left	10	
Right	11	

Bit 4 : DCU Identifier (In-charge DCU or DCU outputting VDT)

DCU A = 0
DCU B = 1

Bits 3-0 : Memory Configuration

CONFIGURATION	CODE
Spare	0000
FRT-1	0001
Ground Checkout	0011
FRT-2	0111
Flight Operation	1111
Spares	All Others

ID Word 2 is a bit by bit one's complement of ID Word 1 and is based on the same requirements as ID Word 1.

The two tables listed below are the cue cards used to decode both ID Word 1 (table 4.1-II) and ID Word 2 (table 4.1-III). Only the ID Word 2 cue card is used on console since ID Word 1 is not on a display.

TABLE 4.1-II.- ID WORD 1 NOMINAL HEX VALUES FOR FLIGHT

ENGINE VEHICLE	LEFT		CENTER		RIGHT	
	DCU A	DCU B*	DCU A	DCU B*	DCU A	DCU B*
OV-102	A8CF	A8DF	A8AF	A8BF	A8EF	A8FF
OV-103	A9CF	A9DF	A9AF	A9BF	A9EF	A9FF
OV-104	AA4F	AA5F	AA2F	AA3F	AA6F	AA7F
OV-105	AACF	AADF	AAAF	AABF	AAEF	AAFF

* - Switch VDT has occurred; or, DCU B is in control.

TABLE 4.1-III.- ID WORD 2 NOMINAL HEX VALUES FOR FLIGHT

ENGINE VEHICLE	LEFT		CENTER		RIGHT	
	DCU A	DCU B*	DCU A	DCU B*	DCU A	DCU B*
OV-102	5730	5720	5750	5740	5710	5700
OV-103	5630	5620	5650	5640	5610	5600
OV-104	55B0	55A0	55D0	55C0	5590	5580
OV-105	5530	5520	5550	5540	5510	5500

* - Switch VDT has occurred; or, DCU B is in control.

(11) ESW Decoding:

Bit 15 : Load Mode

Not in Load Mode = 0
Load Mode = 1 (only used by PROM)

Bits 14-13: Command status of last command received since last VDT transmission (per table 4.1-IV)

No command received since last VDT, or voted command is the last voted command = 00
Command failed voting = 01
Command voted but rejected, incompatible with phase/mode, or invalid code = 10
Command accepted = 11

Bit 12 : Command Channel 3 Status (per table 4.1-IV)

Channel OK = 0
Channel Failed = 1

Bit 11 : Command Channel 2 Status (per table 4.1-IV)

Channel OK = 0
Channel Failed = 1

Bit 10 : Command Channel 1 Status (per table 4.1-IV)

Channel OK = 0
Channel Failed = 1

Bit 9 : FRT Status

Normal Operation = 0
FRT Mode = 1

Bit 8 : Limit Control Status

Limits Inhibited = 0
Limits Enabled = 1

Bits 7-5 : Engine Phase

PHASE	CODE
Spare	000
Checkout	001
Start Prep (PSN1 - PSN4)	010
Start	011
Mainstage	100
Shutdown	101
Post-Shutdown	110
Reserved for PROM	111

Bits 4-2 : Engine Operating Mode (depends on phase)

PHASE	MODE	CODE
Checkout	Hydraulic Conditioning	000
	Standby	001
	Actuator Checkout	010
	Engine Leak Detection	011
	Igniter Checkout	100
	Pneumatic Checkout	101
	Sensor Checkout	110
	Controller Checkout	111
Start Prep	Not Used	000
	Purge Sequence 1 (PSN1)	001
	Purge Sequence 2 (PSN2)	010
	Purge Sequence 3 (PSN3)	011
	Purge Sequence 4 (PSN4)	100
	Not Used	101
	Engine Ready	110
	Not Used	111
Start	Not Used	000
	Start Initiation	001
	Thrust Buildup	010
	Not Used	011
	Not Used	100
	Fixed Density	101
	Not Used	110
	Not Used	111
Mainstage	Not Used	000
	Normal Control	001
	Thrust Limiting	010
	Electrical Lockup	011
	Hydraulic Lockup	100
	Fixed Density	101
	Not Used	110
	Not Used	111
Shutdown	Not Used	000
	Not Used	001
	Throttling to Zero	010
	Propellant Vlvs Clsd	011
	Fail-Safe Pneumatic	100
	Not Used	101
	Not Used	110
	Not Used	111
Post-Shutdown	Not Used	000
	Standby	001
	Oxidizer Dump	010
	Not Used	011
	Not Used	100
	Not Used	101
	Not Used	110
	Terminate Sequence	111

Bits 1-0 : Self-Test Status

Spare = 00
Engine OK = 01
Major Component Failed (MCF) = 10
Engine Limit Exceeded (ELE) = 11

TABLE 4.1-IV.- COMMAND VOTING REQUIREMENTS

INPUT COMMAND WORD COMBINATIONS (1)	ESW COMMAND STATUS: ESW bits 14-13 (2)	ESW CMD CH STATUS: ESW bits 12-10 (2,3)	VEH CMD ENTRY (VDT words 98-99)	OPERATIONAL RESPONSE (4)
No Change	00	000	No Entry	None
3 All Zero Cmds	01	111	No Entry	FID 042-101 & FID 042-102 & FID 042-103
2 All Zero, 1 Non-Zero Cmd	01	011 or 101 or 110	No Entry	FID 042-101 & FID 042-102 & FID 042-103
1 Zero Cmd & 2 Non-Zero Cmds: Vote Fails	01 (6)	001 or 010 or 100	No Entry	FID 042-101 & FID 042-102 & FID 042-103
1 Zero Cmd & 2 Non-Zero Cmds: Vote OK	10 or 11 (6,7)	001 or 010 or 100	Voted Command (6)	Execute cmd & FID 042-101 or FID 042-102 or FID 042-103
3 Non-Zero Commands: Vote Fails (0 agree)	01	000	No Entry	FID 042-101 & FID 042-102 & FID 042-103
3 Non-Zero Commands: Vote Fails (2 agree) (5)	01 (6)	001 or 010 or 100	No Entry	FID 042-101 or FID 042-102 or FID 042-103
3 Non-Zero Commands: Vote OK (2 agree)	10 or 11 (6,7)	001 or 010 or 100	Voted Command (6)	Execute cmd & FID 042-101 or FID 042-102 or FID 042-103
3 Non-Zero Commands: Vote OK (3 agree)	10 or 11 (6,7)	000	Voted Command (6)	Execute cmd &

NOTES:

(1) The success of voting depends on the command indicated (see reference 1, 3.2.2:1.2).

(2) Subsequent to VDT transmission, the command status field of the ESW will be initialized to indicate no command received since the last VDT transmission, and the channel status field of the ESW will be initialized to indicate all channels are OK.

(3) Channel status bits are set to a logical 1 on the zero channels or the one whose command does not agree with the other two.

(4) Execute = If command passes acceptance checks, then the commanded function will be performed.
FID 042-10# (# = 1,2,3 for channels 1,2,3) = VDT words 5 & 100-102 will indicate which command channels are miscomparing or indicating zero(es)

(5) All three command channels must agree to accept either the START or START ENABLE command to successfully pass command voting.

(6) Indicated entry is updated only if:
(a) the voted command is different than the last voted command, or
(b) for a failed vote, 2 non-zero channels agree and are different than the last voted command.

(7) Command status code depends on outcome of command acceptance check (see reference 1, 3.2.2:1.3)

TABLE 4.1-V.- ENGINE STATUS WORD CUE CARD

ENGINE STATUS WORD: Bits 15-08 4/17/92, Rev. Y

CH STATUS	LIMITS INHIBITED				LIMITS ENABLED			
	NO NEW CMD	VOTE FAIL	CMD REJ	CMD ACC	NO NEW CMD	VOTE FAIL	CMD REJ	CMD ACC
CHAN OK	00	20	40	60	01	21	41	61
CH(S) 1	04	24	44	64	05	25	45	65
WITH 2	08	28	48	68	09	29	49	69
M/CMPR 3	10	30	50	70	11	31	51	71
1 & 2	0C	2C	4C	6C	0D	2D	4D	6D
1 & 3	14	34	54	74	15	35	55	75
2 & 3	18	38	58	78	19	39	59	79
1, 2 & 3	1C	3C	5C	7C	1D	3D	5D	7D

ENGINE STATUS WORD: Bits 7-0 4/17/92, REV. Y

PHASE / MODE	OK	MCF	ELE
CHECKOUT			
HYDRAULIC CONDITIONG	21	22	note 1
STANDBY	25	26	note 1
ACTUATOR CHECKOUT	29	2A	note 1
ENGINE LEAK DETECTION	2D	2E	note 1
IGNITER CHECKOUT	31	32	note 1
PNEUMATIC CHECKOUT	35	36	note 1
SENSOR CHECKOUT	39	3A	note 1
CONTROLLER CHECKOUT	3D	3E	note 1
START PREP			
PURGE SEQUENCE 1	45	46	--
PURGE SEQUENCE 2	49	4A	--
PURGE SEQUENCE 3	4D	4E	--
PURGE SEQUENCE 4	51	52	--
ENGINE READY	59	--	--
START			
START INITIATION	65	66	67
THRUST BUILDUP	69	6A	6B
FIXED DENSITY	--	76	77
MAINSTAGE			
NORMAL	85	86	87
THRUST LIMITING	--	8A	8B
ELECTRICAL LOCKUP	--	8E	8F
HYDRAULIC LOCKUP	--	92	93
FIXED DENSITY	--	96	97
SHUTDOWN			
THROTTLING TO ZERO THRUST	A9	AA	AB
PROPELLANT VALVES CLOSED	AD	AE	AF
F/S PNEUMATIC S/D	--	B2	B3
POST SHUTDOWN			
STANDBY	C5	C6	C7
OXIDIZER DUMP	C9	CA	CB
TERMINATE SEQUENCE	DD	DE	DF

(12) TRef is based on the number of major cycle counts (mcc) since the last major cycle reset. The counts are 16-bit unsigned integers and each count is equivalent to 20 msec. Therefore, the range of 0 - 65535 mcc corresponds to 0 - 1310.7 seconds. TRef is reset at PSN1, Start, Shutdown/Pneumatic Shutdown, and at LO2 dump sequence initiation.

(13) The ESW has several parameters derived from its contents which are used in the LCC. These parameters and their MSID's are listed below:

MSID	PARAMETER DESCRIPTION	LCC SSID
E41J#512B (# = 1,2,3 for C,L,R)	PHASE IN EFFECT	SSME-07
E41J#513B (# = 1,2,3 for C,L,R)	OPERATING MODE	SSME-07
V95X119#X (# = 4,5,6 for C,L,R)	ELECTRICAL LOCKUP MODE	RSLS-01
V95X1###X (# = 198,199,200 for C,L,R)	HYDRAULIC LOCKUP MODE	RSLS-01
V95X123#X (# = 0,1,2 for C,L,R)	MAJOR COMPONENT FAIL	RSLS-01
V95X119#X (# = 0,1,2 for C,L,R)	ENGINE LIMIT EXCEEDED	RSLS-01
V95X118#X (# = 2,3,4 for C,L,R)	ENGINE READY INDICATOR	RSLS-01
V95X115#X (# = 5,6,7 for C,L,R)	SHUTDOWN PHASE	RSLS-01
V95X116#X (# = 0,1,2 for C,L,R)	POST SHUTDOWN PHASE	RSLS-01
V95X123#X (# = 6,7,8 for C,L,R)	CHANNEL FAIL	RSLS-01

(14) The FID annunciated in word 5 is used as a backup monitor or as a confirming clue by the LCC (e.g., DPS-18, SSME-05, and RSLS-01).

(15) The GPC's convert the MCC Pc from psia to percent throttle level. The following MSID's are the MCC Pc's calculated by the GPC's which are used by the RSLS for verification that all three engines have achieved enough thrust for liftoff (SRB ignition) to be commanded.

MSID	PARAMETER NAME
V95X1160X	MPS Engine 1 Percent Ch Press
V95X1161X	MPS Engine 2 Percent Ch Press
V95X1162X	MPS Engine 3 Percent Ch Press

(16) ID words 1 and 2 and TRef are used in the validation of the data paths performed by the SSME SOP. If either the primary or secondary data paths are failed prelaunch, the SSME SOP running in the PASS will annunciate a pad data path failed flag. The RSLS will then cause either a launch scrub or a pad abort, depending on whether the engines have started or not. This is an LCC documented in SSID RSLS-01.

(17) LCC SSID SSME-20 is the Engine Ready monitoring of the PBP discharge temperature. Both channels are required for Engine Ready. SSME-38 is the LCC SSID for hardware integrity monitor and both channels must be failed to annunciate this failure.

(18) If both channels of MCC Pc are disqualified for control loop control, the SSMEC software will run a VDT qualification test on all four Pc sensors. If any of the four are between 1000 and 3500 psia, then they are used to derive a PcAvg for VDT output. If all four of the sensors have been disqualified for VDT reporting of words 6 and 39, then PcRef is used instead.

(19) Regardless of qualification status, the value output into VDT words 22 and 23 for the current values of MCC Pc Ch A and Ch B will be the actual values being read by the IE's.

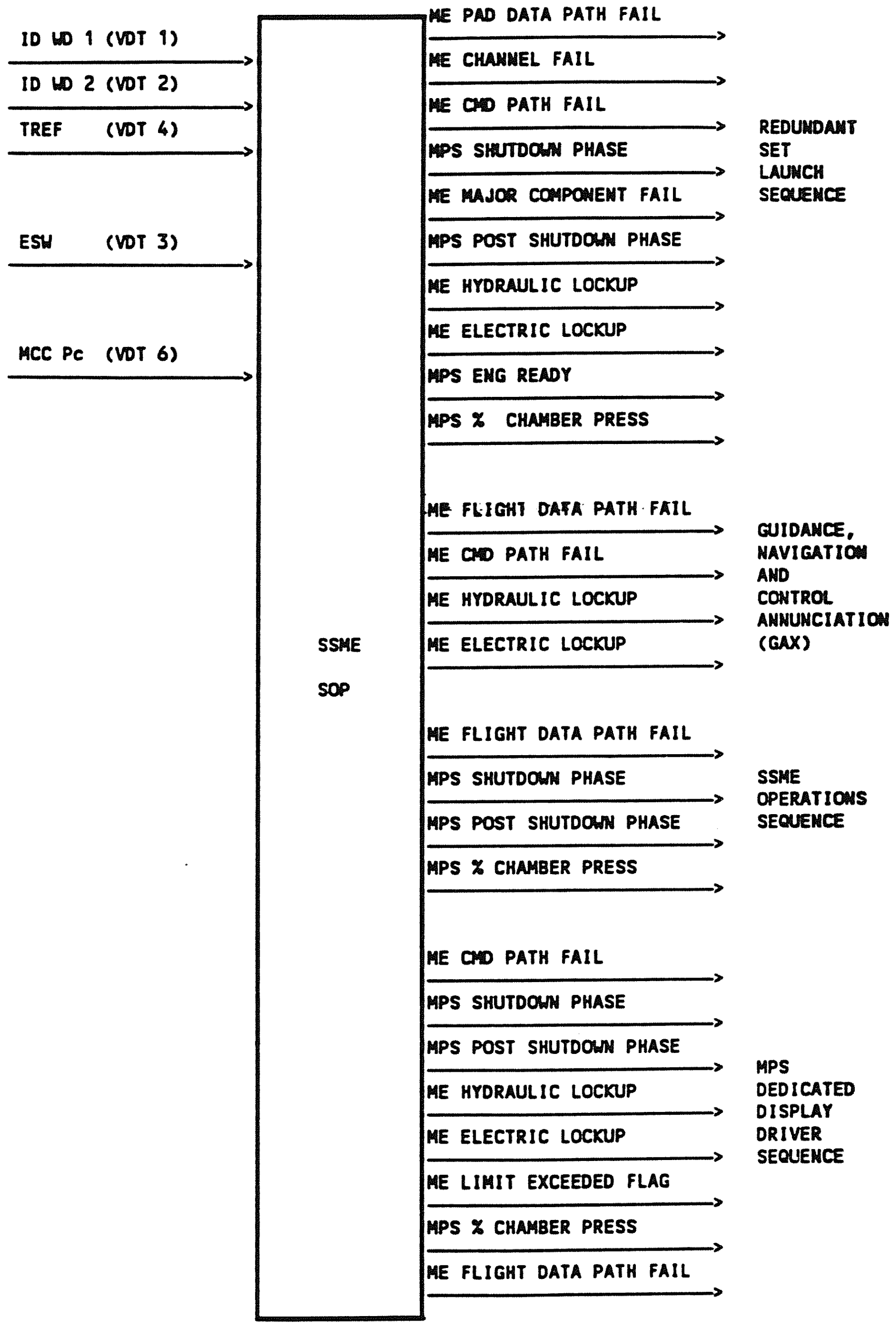


Figure 4.1-II.- PASS GPC uses of the VDT.

TITLE

BOOSTER TELEMETRY

PURPOSE

This SCP describes all of the downlinked telemetry (TM) associated with the booster systems. Not all of the data are considered operational.

DESCRIPTION

Tables 4.2-I through 4.2-VIII contain data describing the downlinked TM associated with the booster systems. The following is a description of the table contents:

- Measurement stimulation identification (MSID) - The TM parameter numbers are listed in numerical order, with the first characters listed in alphabetical order. The first letter of a parameter indicates the location from which the measurement was taken (i.e., B - SRB, E - engine, T - external tank, and V - vehicle). The second letter within the parameter indicates the type of measurement (i.e., P - pressure, R - angular velocity (rpm), T - temperature, X - valve position, V - voltage, Q - quantity, S - switch position). The last letter of the parameter indicates bilevel parameters (E or X) or parameters measuring values within a data range (all other letters).
- Operational TM - Operational name of the measurement.
- Display MSK number. All booster display numbers are four-digit numbers beginning with 10.
- Event light (DDD format no.) - Overlay format number.
- SCR MSK - Strip chart recorder format number.
- Phase/TM format rate (samples per second) - Downlink and shuttle data processor (SDP) high and low bit rates (samples per second) for the mission phases: prelaunch, ascent, on orbit, entry checkout, and entry. For a specific flight, the format numbers assigned to each format and phase can be found in the measurement requirements list (MRL).
- Data range - High and low values of transducer range.
- Units - Engineering units of parameter (e.g., psia, rpm, event, etc.).
- Uncertainty (percent) - Quoted Master Measurement List (MML) accuracy of transducer.

- TM format type - Format types are identified as OI - operational instrumentation, GN - primary flight system, BF - backup flight system.
- MDM/card - The MDM and/or card number through which the MSID is passed.

REFERENCES

1. Booster Data Pack, as of Sept 1, 1989
2. Master Measurements List
3. Space Shuttle Systems Handbook
4. Reconfiguration Data Collection System (RDCS)
5. Shuttle Configuration Analysis Programs (SCAP)

SUBSYSTEM: SRB

TABLE 4.2-I.- SRB DOWNLINKED TM (one of four)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)																				Data range		Units	Uncertainty (Percent)	TM format type	ADM/card
					Prelaunch				Ascent				On-orbit				Entry checkout				Entry									
					Downlink		SDPC (MOC)		Downlink		SDPC (MOC)		Downlink		SDPC (MOC)		Downlink		SDPC (MOC)		Downlink		SDPC (MOC)							
					High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	Low	High				
B46P1305C	L FSM A P	1054, 1083, 1084, 1051	288 298		044(1)		(1)		021(1)		(1)														0	600	PSIA	4	GN	LL02
B46P1306C	L FSM B P	1054, 1083, 1084, 1051	288 298		044(1)		(1)		021(1)		(1)														0	600	PSIA	4	GN	LL02
B46R1406C	L HPU A TURB SPD 1	1054, 1051			044(1)		(1)		021(1)		(1)														0	120	KRPM	2	GN	LL02
B46R1407C	L HPU B TURB SPD 1	1054, 1051			044(1)		(1)		021(1)		(1)														0	120	KRPM	2	GN	LL02
B46R1408C	L HPU A TURB SPD 2	1054, 1051	288 298		044(1)		(1)		021(12.5)		(12.5)														0	120	KRPM	2	GN	LL02
B46R1409C	L HPU B TURB SPD 2	1054, 1051	288 298		044(1)		(1)		021(12.5)		(12.5)														0	120	KRPM	2	GN	LL02
B46T1501C	L FSM A T	1056			044(1)		(1)		021(1)		(1)														32	140	DEG F	5	GN	LL02
B46T1502C	L FSM B T	1056			044(1)		(1)		021(1)		(1)														32	140	DEG F	5	GN	LL02
B46T1503C	L GG BED A T				044(1)		(1)		021(1)		(1)														0	250	DEG F	3	GN	LL02
B46T1504C	L GG BED B T				044(1)		(1)		021(1)		(1)														0	250	DEG F	3	GN	LL02
B46X1851X	L HPU A ISOV OP	1053. 1055			044(1)		(1)		021(1)		(1)														CL	OP	EVENT		GN	LL02
B46X1852X	L HPU B ISOV OP	1053. 1055			044(1)		(1)		021(1)		(1)														CL	OP	EVENT		GN	LL02
B46X1853X	L HPU A ISOV CL	1053. 1055			044(1)		(1)		021(1)		(1)														OP	CL	EVENT		GN	LL02
B46X1854X	L HPU B ISOV CL	1053. 1055			044(1)		(1)		021(1)		(1)														OP	CL	EVENT		GN	LL02
B46X1861X	L GG A SOV CL	1053. 1055			044(1)		(1)		021(1)		(1)														OP	CL	EVENT		GN	LL02
B46X1862X	L GG A CONTR V OP	1053. 1055			044(1)		(1)		021(1)		(1)														CL	OP	EVENT		GN	LL02
B46X1863X	L GG B SOV CL	1053. 1055			044(1)		(1)		021(1)		(1)														OP	CL	EVENT		GN	LL02
B46X1864X	L GG B CONTR V OP	1053. 1055			044(1)		(1)		021(1)		(1)														CL	OP	EVENT		GN	LL02
B46X1908X	L HPU A GG HTR 1 ON	1053			044(1)		(1)		021(1)		(1)														OFF	ON	EVENT		GN	LL02
B46X1909X	L HPU A GG HTR 2 ON	1053			044(1)		(1)		021(1)		(1)														OFF	ON	EVENT		GN	LL02
B46X1910X	L HPU B GG HTR 1 ON	1053			044(1)		(1)		021(1)		(1)														OFF	ON	EVENT		GN	LL02
B46X1911X	L HPU B GG HTR 2 ON	1053			044(1)		(1)		021(1)		(1)														OFF	ON	EVENT		GN	LL02

SUBSYSTEM: SRB

TABLE 4.2-I.- SRB DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Low	High				
B46P2305C	R FSM A P	1054, 1083, 1084, 1051	288 298		044(1)	(1)	021(1)	(1)							0	600	PSIA	4	GN	LR02
B46P2306C	R FSM B P	1054, 1083, 1084, 1051	288 298		044(1)	(1)	021(1)	(1)							0	600	PSIA	4	GN	LR02
B46R2406C	R HPU A TURB SPD 1	1054, 1051			044(1)	(1)	021(1)	(1)							0	120	KRPM	2	GN	LR02
B46R2407C	R HPU B TURB SPD 1	1054, 1051			044(1)	(1)	021(1)	(1)							0	120	KRPM	2	GN	LR02
B46R2408C	R HPU A TURB SPD 2	1054, 1051	288 298		044(1)	(1)	021(12.5)	(12.5)							0	120	KRPM	2	GN	LR02
B46R2409C	R HPU B TURB SPD 2	1054, 1051	288 298		044(1)	(1)	021(12.5)	(12.5)							0	120	KRPM	2	GN	LR02
B46T2501C	R FSM A T	1056			044(1)	(1)	021(1)	(1)							32	140	DEG F	5	GN	LR02
B46T2502C	R FSM B T	1056			044(1)	(1)	021(1)	(1)							32	140	DEG F	5	GN	LR02
B46T2503C	R GG BED A T				044(1)	(1)	021(1)	(1)							0	250	DEG F	3	GN	LR02
B46T2504C	R GG BED B T				044(1)	(1)	021(1)	(1)							0	250	DEG F	3	GN	LR02
B46X2851X	R HPU A ISOV OP	1053, 1055			044(1)	(1)	021(1)	(1)							CL	OP	EVENT		GN	LR02
B46X2852X	R HPU B ISOV OP	1053, 1055			044(1)	(1)	021(1)	(1)							CL	OP	EVENT		GN	LR02
B46X2853X	R HPU A ISOV CL	1053, 1055			044(1)	(1)	021(1)	(1)							OP	CL	EVENT		GN	LR02
B46X2854X	R HPU B ISOV CL	1053, 1055			044(1)	(1)	021(1)	(1)							OP	CL	EVENT		GN	LR02
B46X2861X	R GG A SOV CL	1053, 1055			044(1)	(1)	021(1)	(1)							OP	CL	EVENT		GN	LR02
B46X2862X	R GG A CONTR V OP	1053, 1055			044(1)	(1)	021(1)	(1)							CL	OP	EVENT		GN	LR02
B46X2863X	R GG B SOV CL	1053, 1055			044(1)	(1)	021(1)	(1)							OP	CL	EVENT		GN	LR02
B46X2864X	R GG B CONTR V OP	1053, 1055			044(1)	(1)	021(1)	(1)							CL	OP	EVENT		GN	LR02
B46X2908X	R HPU A GG HTR 1 ON	1053, 1055			044(1)	(1)	021(1)	(1)							OFF	ON	EVENT		GN	LR02
B46X2909X	R HPU A GG HTR 2 ON	1053, 1055			044(1)	(1)	021(1)	(1)							OFF	ON	EVENT		GN	LR02
B46X2910X	R HPU B GG HTR 1 ON	1053, 1055			044(1)	(1)	021(1)	(1)							OFF	ON	EVENT		GN	LR02
B46X2911X	R HPU B GG HTR 2 ON	1053, 1055			044(1)	(1)	021(1)	(1)							OFF	ON	EVENT		GN	LR02

SUBSYSTEM: SRB

TABLE 4.2-I.- SRB DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer- tainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
B47P1300C	L SRB PC 1	1054, 1083, 1084, 1051	289 299		044(5)	(5)	021(5)	(5)							0	1000	PSIA	2	GN	FA01
B47P1301C	L SRB PC 2	1054, 1083, 1084, 1051	289 299		044(1)	(1)	021(1)	(1)							0	1000	PSIA	2	GN	FA02
B47P1302C	L SRB PC 3	1054, 1083, 1084, 1051	289 299		044(1)	(1)	021(12.5)	(12.5)							0	1000	PSIA	2	GN	FA03
B47X1901X	L SRB PC 1 SIM CMD				044(1)	(1)	021(5)	(5)							OFF	ON	EVENT		GN	LL01
B47X1902X	L SRB PC 2 SIM CMD				044(1)	(1)	021(1)	(1)							OFF	ON	EVENT		GN	LL01
B47X1903X	L SRB PC 3 SIM CMD				044(1)	(1)	021(5)	(5)							OFF	ON	EVENT		GN	LL01
B47P2300C	R SRB PC 1	1054, 1083, 1084, 1051	289 299		044(1)	(1)	021(5)	(5)							0	1000	PSIA	2	GN	FA01
B47P2301C	R SRB PC 2	1054, 1083, 1084, 1051	289 299		044(5)	(5)	021(1)	(1)							0	1000	PSIA	2	GN	FA02
B47P2302C	R SRB PC 3	1054, 1083, 1084, 1051	289 299		044(1)	(1)	021(12.5)	(12.5)							0	1000	PSIA	2	GN	FA03
B47P2901C	R SRB PC 1 SIM CMD				044(1)	(1)	021(5)	(5)							OFF	ON	EVENT		GN	LR01
B47P2902C	R SRB PC 2 SIM CMD				044(1)	(1)	021(1)	(1)							OFF	ON	EVENT		GN	LR01
B47P2903C	R SRB PC 3 SIM CMD				044(1)	(1)	021(5)	(5)							OFF	ON	EVENT		GN	LR01
B55V1803C	L IGN PIC A CAP VDC	1091, 1092			044(1)	(1)	021(1)	(1)							0	40	VDC	10	GN	FA01
B55V1804C	L IGN PIC B CAP VDC	1091, 1092			044(1)	(1)	021(1)	(1)							0	40	VDC	10	GN	FA02
B55V1813C	L F SEP MTR PIC A VDC	1091, 1092			044(1)	(1)	021(5)	(5)							0	40	VDC	10	GN	LL01
B55V1814C	L F SEP MTR PIC B VDC	1091, 1092			044(1)	(1)	021(1)	(1)							0	40	VDC	10	GN	LL01
B55V1815C	L A SEP MTR PIC A VDC	1091, 1092			044(1)	(1)	021(5)	(5)							0	40	VDC	10	GN	LL02
B55V1816C	L A SEP MTR PIC B VDC	1091, 1092			044(1)	(1)	021(1)	(1)							0	40	VDC	10	GN	LL02
B55X1842X	L IGN S&A ARMED	1053, 1055			044(1)	(1)	021(5)	(5)							SAFE	ARM	EVENT		GN	LL01
B55X1843X	L IGN S&A SAFED	1053, 1055			044(1)	(1)	021(5)	(5)							ARM	SAFE	EVENT		GN	LL01
B55V2603C	R IGN PIC A CAP VDC	1091, 1092			044(1)	(1)	021(1)	(1)							0	40	VDC	10	GN	FA01
B55V2604C	R IGN PIC B CAP VDC	1091, 1092			044(1)	(1)	021(1)	(1)							0	40	VDC	10	GN	FA02

SUBSYSTEM: SRB

TABLE 4.2 I.- SRB DOWNLINKED TM (Concluded)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncertainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
B55V2613C	R F SEP MTR PIC A VDC	1091, 1092			044(1)	(1)	021(5)	(5)							0	40	VDC	10	GN	LR01
B55V2814C	R F SEP MTR PIC B VDC	1091, 1092			044(1)	(1)	021(1)	(1)							0	40	VDC	10	GN	LR01
B55V2815C	R A SEP MTR PIC A VDC	1091, 1092			044(1)	(1)	021(5)	(5)							0	40	VDC	10	GN	LR02
B55V2816C	R A SEP MTR PIC B VDC	1091, 1092			044(1)	(1)	021(1)	(1)							0	40	VDC	10	GN	LR02
B55X2842X	R IGN S&A ARMED	1053, 1055			044(1)	(1)	021(5)	(5)							SAFE	ARM	EVENT		GN	LR01
B55X2843X	R IGN S&A SAFED	1053, 1055			044(1)	(1)	021(5)	(5)							ARM	SAFE	EVENT		GN	LR01
B58P1303C	L HYD SUP A P	1054, 1083, 1084, 1051	288 298		044(5)	(5)	021(5)	(5)							0	3500	PSIA	5	GN	LL02
B58P1304C	L HYD SUP B P	1054, 1083, 1084, 1051	288 298		044(5)	(5)	021(5)	(5)							0	3500	PSIA	5	GN	LL02
B58Q1350C	L HYD RES A QTY				044(1)	(1)	021(1)	(1)							0	100	PCT	6	GN	LL02
B58Q1351C	L HYD RES B QTY				044(1)	(1)	021(1)	(1)							0	100	PCT	6	GN	LL02
B58X1859X	L H EV TILT SERVO ACTR PRI PRESS OK	1054, 1083, 1084, 1051	288 298		044(1)	(1)	021(1)	(1)							OK		EVENT		GN	LL02
B58X1860X	L H EV ROCK SERVO ACTR PRI PRESS OK	1054, 1083, 1084, 1051	288 298		044(1)	(1)	021(1)	(1)							OK		EVENT		GN	LL02
B58P2303C	R HYD SUP A P	1054, 1083, 1084, 1051	288 298		044(5)	(5)	021(5)	(5)							0	3500	PSIA	5	GN	LR02
B58P2304C	R HYD SUP B P	1054, 1083, 1084, 1051	288 298		044(5)	(5)	021(5)	(5)							0	3500	PSIA	5	GN	LR02
B58Q2350C	R HYD RES A QTY				044(1)	(1)	021(1)	(1)							0	100	PCT	6	GN	LR02
B58Q2351C	R HYD RES B QTY				044(1)	(1)	021(1)	(1)							0	100	PCT	6	GN	LR02
B58X2859X	R H EV TILT SERVO ACTR PRI PRESS OK	1054, 1083, 1084, 1051	288 298		044(1)	(1)	021(1)	(1)							OK		EVENT		GN	LR02
B58X2860X	R H EV ROCK SERVO ACTR PRI PRESS OK	1054, 1083, 1084, 1051	288 298		044(1)	(1)	021(1)	(1)							OK		EVENT		GN	LR02

SUBSYSTEM: MAIN ENGINE

TABLE 4.2-II.- MAIN ENGINE DOWNLINKED TM (one of eight)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncertainty (Percent)	TM format type	MDM/card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Low	High				
E41S0192E	C AC PWR 1 ON		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT	1	OI	OF01
E41S0193E	C AC PWR 2 ON		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT	1	OI	OF02
E41S0195E	C HTR PWR ON				PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT	1	OI	OA01
E41S0292E	L AC PWR 1 ON		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT	1	OI	OF03
E41S0293E	L AC PWR 2 ON		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT	1	OI	OF01
E41S0295E	L HTR PWR ON				PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT	1	OI	OA02
E41S0392E	R AC PWR 1 ON		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT	1	OI	OF02
E41S0393E	R AC PWR 2 ON		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT	1	OI	OF03
E41S0395E	R HTR PWR ON				PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT	1	OI	OA03

PH - 171, 172, 180   AH - 129, 166, 201   AL = 102, 118, 119   OH = 129, 161, 183, 192, 204, 211   EH = 129, 164, 166, 201

SUBSYSTEM: MAIN ENGINE

TABLE 4.2-II.- MAIN ENGINE DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncertainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
E41M1002P	C ID WD TWO	1052, 1071, 1072					021(5)	(5)										1	GN	EIU1
E41M1003P	C ENG STAT WD	1052, 1071, 1072			044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU1
E41W1004B	C TIME REF	1052, 1071, 1072			044(1)	(1)	021(1) 021(1)	(1) (1)							0	1311	S	1	GN	EIU1
E41M1005P	C HARD FAIL	1071, 1072,			044(12.5)	(12.5)	021(25) 021(25)	(26) (25)											GN	EIU1
E41P1008B	C HPFT CL LN P A	1052, 1071, 1072	281				021(5) 021(5)	(5) (5)							0	300	PSIA	2	GN	EIU1
E41P1009B	C HPFT CL LN P B	1052, 1071, 1072	281				021(1) 021(1)	(1) (1)							0	300	PSIA	2	GN	EIU1
E41T1010B	C HPFT TURB DISCH T A	1052, 1071, 1072	281				021(1) 021(1)	(1) (1)							200	2760	DEG R	2	GN	EIU1
E41T1011B	C HPFT TURB DISCH T B	1052, 1071, 1072	281				021(5) 021(5)	(5) (5)							200	2760	DEG R	2	GN	EIU1
E41T1012B	C HPOT TURB DISCH T A	1052, 1071, 1072, 1087, 1088	281				021(1) 021(1)	(1) (1)							200	2760	DEG R	2	GN	EIU1
E41T1013B	C HPOT TURB DISCH T B	1052, 1071, 1072	281				021(5) 021(5)	(5) (5)							200	2760	DEG R	2	GN	EIU1
E41P1014B	C HPOT IMD SL PGE P A	1052, 1071, 1072	281		044(1)	(1)	021(1) 021(1)	(1) (1)							0	600	PSIA	2	GN	EIU1
E41P1015B	C HPOT IMD SL PGE P B	1052, 1071, 1072	281				021(1) 021(1)	(1) (1)							0	600	PSIA	2	GN	EIU1
E41P1016B	C PC A	1052, 1071, 1072, 1087, 1088	281				021(1) 021(1)	(1) (1)							0	3500	PSIA	2	GN	EIU1
E41P1017B	C PC B	1052, 1071, 1072, 1087, 1088	281				021(1) 021(1)	(1) (1)							0	3500	PSIA	2	GN	EIU1
E41P1018B	C LPFT DISCH P	1052, 1071, 1072	281		044(1)	(1)	021(1) 021(1)	(1) (1)							0	300	PSIA	2	GN	EIU1
E41T1019B	C LPFT DISCH T	1052, 1071, 1072, 1087, 1088	281		044(1)	(1)	021(1) 021(1)	(1) (1)							30	55	DEG R	2	GN	EIU1
E41T1020B	C POP DISCH T	1071, 1072,			044(1)	(1)	021(1) 021(1)	(1) (1)							160	210	DEG R	2	GN	EIU1
E41R1021B	C FU FLOWRT	1052, 1071, 1072	281				021(1) 021(1)	(1) (1)							1080	18,000	GPM	1	GN	EIU1
E41R1022B	C OX FLOWRT	1071, 1072,	281				021(1) 021(1)	(1) (1)							420	7000	GPM	1	GN	EIU1
E41P1023B	C PC	1052, 1071, 1072					021(5) 021(6)	(5) (5)							0	3600	PSIA	2	GN	EIU1
E41H1024B	C MFV POS	1052, 1071, 1072					021(1) 021(1)	(1) (1)							400	100	PCT	1	GN	EIU1

SUBSYSTEM: MAIN ENGINE

TABLE 4.2 II. MAIN ENGINE DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
E41H1025B	C MOV POS	1052, 1071, 1072					021(1) 021(1)	(1) (1)							0	100	PCT	1	GN	EIU1
E41H1026B	C CCV POS	1052, 1071, 1072					021(1) 021(1)	(1) (1)							0	100	PCT	1	GN	EIU1
E41H1027B	C FPOV POS	1052, 1071, 1072					021(1) 021(1)	(1) (1)							0	100	PCT	1	GN	EIU1
E41H1028B	C OPOV POS	1052, 1071, 1072					021(1) 021(1)	(1) (1)							0	100	PCT	1	GN	EIU1
E41P1029B	C HPFT DISCH P						021(1)	(1)							0	9500	PSIA	2	GN	EIU1
E41P1030B	C HPOT DISCH P	1052, 1071, 1072	284		044(1)	(1)	021(5) 021(5)	(5) (5)							0	7000	PSIA	2	GN	EIU1
E41P1031B	C FPB PC						021(1)	(1)							0	7000	PSIA	2	GN	EIU1
E41P1051B	C HPOT SEC SL CAV	1052, 1071, 1072	281				021(5) 021(5)	(5) (5)							0	300	PSIA	2	GN	EIU1
E41P1053B	C HPOT SEC SI CAV	1052, 1071, 1072	281				021(1) 021(1)	(1) (1)							0	300	PSIA	2	GN	EIU1
E41P1054B	C HYD SYS P	1052, 1071, 1072	285				021(1)	(1)							0	4000	PSIA	2	GN	EIU1
E41T1150A	C CONT TEMP				PH(1)	(1)	AH(1)	(1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)	-75	300	DEG F	5	OI	OA01
E41T1151A	C OPOV LO2 SUP T 1				PH(1)	(1)	AH(1)	(1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)	-325	300	DEG F	5	OI	OA01
E41T1152A	C OPOV LO2 SUP T 2				PH(1)	(1)	AH(1)	(1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)	325	500	DEG F	5	OI	OA01
E41T1153A	C MFV DWNST T 1				PH(1)	(1)	AH(1)	(1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)	-430	200	DEG F	5	OI	OA03
E41T1154A	C MFV DWNST T 2				PH(1)	(1)	AH(1)	(1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)	375	600	DEG F	5	OI	OA01
E41T1155A	AFV T1 C	1056			PH(1)	(1)	AH(1) AL(1)	(1) (1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)			DEG F		OI	OF03
E41T1156A	AFV T2 C	1056			PH(1)	(1)	AH(1) AL(1)	(1) (1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)			DEG F		OI	OF04
E41J1504B	C ID WD TWO B1-11						021(5)	(5)										1	GN	EIU1
E41X1505B	VDT A DATA		285				021(5)	(5)							OFF	ON	EVENT	1	GN	EIU1
E41J1506B	C OVERLAY CONFIG						021(5)	(5)										1	GN	EIU1
E41X1507B	C MEMORY LOAD MODE				044(1)	(1)	021(1) 021(1)	(1) (1)							OFF	ON	EVENT	1	GN	EIU1

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 EH = 129, 164, 166, 201

SUBSYSTEM: MAIN ENGINE

TABLE 4.2-II.- MAIN ENGINE DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)																				Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/ card
					Prelaunch				Ascent				On-orbit				Entry checkout				Entry									
					Downlink		SDPC (MOC)		Downlink		SDPC (MOC)		Downlink		SDPC (MOC)		Downlink		SDPC (MOC)		Downlink		SDPC (MOC)							
					High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	Low	High				
E41J1508B	C COMMAND STATUS				044(1)		(1)		021(1)	021(1)	(1)	(1)																1	GN	EIU1
E41J1509B	C CHANNEL STATUS				044(1)		(1)		021(1)	021(1)	(1)	(1)																1	GN	EIU1
E41X1510B	C FRT MODE				044(1)		(1)		021(1)	021(1)	(1)	(1)													OFF	ON	EVENT	1	GN	EIU1
E41X1511B	LIMIT CONTROL ENABLED		281 284		044(1)		(1)		021(1)	021(1)	(1)	(1)													OFF	ON	EVENT	1	GN	EIU1
E41J1512B	C PHASE IN EFFECT				044(1)		(1)		021(1)	021(1)	(1)	(1)																1	GN	EIU1
E41J1513B	C MODE IN EFFECT				044(1)		(1)		021(1)	021(1)	(1)	(1)																1	GN	EIU1
E41J1514B	C SELF TEST STATUS				044(1)		(1)		021(1)	021(1)	(1)	(1)																1	GN	EIU1
E41J1515B	C HARD FID CODE				044(12.5)		(12.5)		021(26)	021(26)	(26)	(25)																25	GN	EIU1
E41J1516B	C DELIMITER CODE				044(12.5)		(12.5)		021(25)	021(25)	(25)	(25)																25	GN	EIU1
E41M2002P	L ID WD TWO	1052, 1073, 1074							021(5)		(5)																	1	GN	EIU2
E41M2003P	L ENG STAT WD	1052, 1073, 1074			044(1)		(1)		021(1)	021(1)	(1)	(1)																1	GN	EIU2
E41W2004B	L T REF	1052, 1073, 1074			044(1)		(1)		021(1)	021(1)	(1)	(1)													0	1311	S	1	GN	EIU2
E41M2005P	L HARD FAIL	1073, 1074			044(12.5)		(12.5)		021(25)	021(25)	(25)	(26)																25	GN	EIU2
E41P2008B	L HPFT CL LN P A	1052, 1073, 1074	282						021(6)	021(5)	(5)	(5)													0	300	PSIA	2	GN	EIU2
E41P2009B	L HPFT CL LN P B	1052, 1073, 1074	282						021(1)	021(1)	(1)	(1)													0	300	PSIA	2	GN	EIU2
E41T2010B	L HPFT TURB DISCH T A	1052, 1073, 1074	282						021(1)	021(1)	(1)	(1)													200	2760	DEG R	2	GN	EIU2
E41T2011B	L HPFT TURB DISCH T B	1052, 1073, 1074	282						021(5)	021(6)	(6)	(6)													200	2760	DEG R	2	GN	EIU2
E41T2012B	L HPOT TURB DISCH T A	1052, 1073, 1074, 1087, 1088	282						021(1)	021(1)	(1)	(1)													200	2760	DEG R	2	GN	EIU2
E41T2013B	L HPOT TURB DISCH T B	1052, 1073, 1074	282						021(6)	021(5)	(5)	(5)													200	2760	DEG R	2	GN	EIU2
E41P2014B	L HPOT IMD SL PGE P A	1052, 1073, 1074	282		044(1)		(1)		021(1)	021(1)	(1)	(1)													0	600	PSIA	2	GN	EIU2
E41P2015B	L HPOT IMD SL PGE P B	1052, 1073, 1074	282						021(1)	021(1)	(1)	(1)													0	600	PSIA	2	GN	EIU2
E41P2016B	L PC A	1052, 1073, 1074, 1087, 1088	282						021(1)	021(1)	(1)	(1)													0	3500	PSIA	2	GN	EIU2
E41P2017B	L PC B	1052, 1073, 1074, 1087, 1088	282						021(1)	021(1)	(1)	(1)													0	3500	PSIA	2	GN	EIU2

SUBSYSTEM: MAIN ENGINE

TABLE 4.2 II. MAIN ENGINE DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DOD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer- tainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
E41P2018B	L LPFT DISCH P	1052, 1073, 1074	282		044(1)	(1)	021(1) 021(1)	(1) (1)							0	300	PSIA	2	GN	EIU2
E41T2019B	L LPFT DISCH T	1052, 1073, 1074, 1087, 1088	282		044(1)	(1)	021(1) 021(1)	(1) (1)							35	65	DEG R	2	GN	EIU2
E41T2020B	L POP DISCH T	1073, 1074			044(1)	(1)	021(1) 021(1)	(1) (1)							180	210	DEG R	2	GN	EIU2
E41R2021B	L FU FLOWRT	1052, 1073, 1074	282				021(1) 021(1)	(1) (1)							1080	18,000	GPM	1	GN	EIO2
E41R2022B	L OX FLOWRT	1073, 1074	282				021(1) 021(1)	(1) (1)							420	7000	GPM	1	GN	EIO2
E41P2023B	L PC	1052, 1073, 1074					021(5) 021(5)	(5) (5)							0	3500	PSIA	2	GN	EIU2
E41H2024B	L MFV POS	1052, 1073, 1074					021(1) 021(1)	(1) (1)							0	100	PCT	1	GN	EIU2
E41H2025B	L MFV POS	1052, 1073, 1074					021(1) 021(1)	(1) (1)							0	100	PCT	1	GN	EIU2
E41H2026B	L CCV POS	1052, 1073, 1074					021(1) 021(1)	(1) (1)							0	100	PCT	1	GN	EIU2
E41H2027B	L FPOV POS	1052, 1073, 1074					021(1) 021(1)	(1) (1)							0	100	PCT	1	GN	EIU2
E41H2028B	L OPOV POS	1052, 1073, 1074					021(1) 021(1)	(1) (1)							0	100	PCT	1	GN	EIU2
E41P2029B	L HPFT DISCH P						021(1)	(1)							0	9500	PSIA	2	GN	EIU2
E41P2030B	L HPOT DISCH P	1052, 1073, 1074	284		044(1)	(1)	021(5) 021(5)	(5) (5)							0	7000	PSIA	2	GN	EIU2
E41P2031B	L FPB PC						021(1)	(1)							0	7000	PSIA	2	GN	EIU2
E41P2051B	L HPOT SEC SL CAV P A	1052, 1073, 1074	282				021(5) 021(5)	(5) (5)							0	300	PSIA	2	GN	EIU2
E41P2053B	L HPOT SEC SL CAV P B	1052, 1073, 1074	282				021(1) 021(1)	(1) (1)							0	300	PSIA	2	GN	EIU2
E41P2054B	L HYD SYS P	1052, 1073, 1074	285				021(1)	(1)							0	1000	PSIA	2	GN	EIU2
E41T2150A	L CONT TEMP				PH(1)	(1)	AH(1)	(1)	129,161(1)	(1)	129,161(1)	(1)	EH(1)	(1)	-75	300	DEG F	5	OI	OA02
E41T2151A	L OPOV LO2 SUP T 1				PH(1)	(1)	AH(1)	(1)	129,161(1)	(1)	129,161(1)	(1)	EH(1)	(1)	325	300	DEG F	5	OI	OA02
E41T2152A	L OPOV LO2 SUP T 2				PH(1)	(1)	AH(1)	(1)	129,161(1)	(1)	129,161(1)	(1)	EH(1)	(1)	325	500	DEG F	5	OI	OA02
E41T2153A	L MFV DWNST T 1				PH(1)	(1)	AH(1)	(1)	129,161(1)	(1)	129,161(1)	(1)	EH(1)	(1)	430	200	DEG F	5	OI	OA03
E41T2154A	L MFV DWNST T 2				PH(1)	(1)	AH(1)	(1)	129,161(1)	(1)	129,161(1)	(1)	EH(1)	(1)	325	500	DEG F	5	OI	OA02
E41T2155A	AIV II L	1056			PH(1)	(1)	AH(1) AL(1)	(1) (1)	129,161(1)	(1)	129,161(1)	(1)	•(1)	(1)			DEG F		OI	OA02

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 EH = 129, 164, 201 • = 129, 166, 201

SUBSYSTEM: MAIN ENGINE

TABLE 4.2 11.- MAIN ENGINE DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncertainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
E41T2156A	AFV T2 L	1056			PH(1)	(1)	AH(1) AL(1)	(1) (1)	120(1)	(1)	129(1)	(1)	*(1)	(1)			DEG F		OI	OA03
E41J2504B	L ID WD 2 B1-11						021(5)	(5)										1	GN	EIU2
E41X2505B	VDT A DATA		285				021(5)	(5)							OFF	ON	EVENT	1	GN	EIU2
E41J2506B	L OVERLAY CONFIG						021(5)	(5)										1	GN	EIU2
E41X2507B	L MEMORY LOAD MODE				044(1)	(1)	021(1) 021(1)	(1) (1)							OFF	ON	EVENT	1	GN	EIU2
E41J2508B	L COMMAND STATUS				044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU2
E41J2509B	L CHANNEL STATUS				044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU2
E41X2510B	L FRT MODE				044(1)	(1)	021(1) 021(1)	(1) (1)							OFF	ON	EVENT	1	GN	EIU2
E41X2511B	LIMIT CONTROL ENABLED		282 284		044(1)	(1)	021(1) 021(1)	(1) (1)							OFF	ON	EVENT	1	GN	EIU2
E41J2512B	L PHASE IN EFFECT				044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU2
E41J2513B	L MODE IN EFFECT				044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU2
E41J2514B	L SELF TEST STATUS				044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU2
E41J2515B	L HARD FID CODE				044(12.5)	(12.5)	021(25) 021(25)	(25) (25)										25	GN	EIU2
E41J2516B	L DELIMITER CODE				044(12.5)	(12.5)	021(25) 021(25)	(25) (25)										25	GN	EIU2
E41M3002P	R ID WD TWO	1052, 1075, 1076					021(5)	(5)										1	GN	EIU3
E41M3003P	R ENG STAT WD	1052, 1075, 1076			044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU3
E41W3004B	R T R & F	1052, 1075, 1076			044(1)	(1)	021(1) 021(1)	(1) (1)							0	1311	S	1	GN	EIU3
E41M3005P	R HARD FAIL	1076, 1076			044(12.5)	(12.5)	021(25) 021(25)	(25) (25)										25	GN	EIU3
E41P3008B	R HPFT CL LN P A	1052, 1075, 1076	283				021(5) 021(6)	(5) (5)							0	300	PSIA	2	GN	EIU3
E41P3009B	R HPFT CL LN P B	1052, 1075, 1076	283				021(1) 021(1)	(1) (1)							0	300	PSIA	2	GN	EIU3
E41T3010B	R HPFT TURB DISCH T A	1052, 1075, 1076	283				021(1) 021(1)	(1) (1)							200	2760	DEG R	2	GN	EIU3
E41T3011B	R HPFT TURB DISCH T B	1052, 1075, 1076	283				021(5) 021(5)	(5) (5)							200	2760	DEG R	2	GN	EIU3
E41T3012B	R HPOT TURB DISCH T A	1052, 1075, 1076, 1087, 1088	283				021(1) 021(1)	(1) (1)							200	2760	DEG R	2	GN	EIU3

PH - 171, 172, 180 AL - 102, 118, 119 AH - 129, 166, 201 * - 129, 166, 201

SUBSYSTEM: MAIN ENGINE

TABLE 4.2 II.- MAIN ENGINE DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
E41T3013B	R HPOT TURB DISCH T B	1052, 1075, 1076	283				021(5)	(5)							200	2760	DEG R	2	GN	EIU3
							021(5)	(5)												
E41P3014B	R HPOT IMD SL PGE P A	1052, 1075, 1076	283		044(1)	(1)	021(1)	(1)							0	600	PSIA	2	GN	EIU3
							021(1)	(1)												
E41P3015B	R HPOT IMD SL PGE P B	1052, 1075, 1076	283				021(1)	(1)							0	600	PSIA	2	GN	EIU3
							021(1)	(1)												
E41P3016B	R PC A	1052, 1075, 1076, 1087, 1088	283				021(1)	(1)							0	3500	PSIA	2	GN	EIU3
							021(1)	(1)												
E41P3017B	R PC B	1052, 1075, 1076, 1087, 1088	283				021(1)	(1)							0	3500	PSIA	2	GN	EIU3
							021(1)	(1)												
E41P3018B	R LPFT DISCH P	1052, 1075, 1076	283		044(1)	(1)	021(1)	(1)							0	300	PSIA	2	GN	EIU3
							021(1)	(1)												
E41T3019B	R LPFT DISCH T	1052, 1075, 1076, 1087, 1088	283		044(1)	(1)	021(1)	(1)							30	55	DEG R	2	GN	EIU3
							021(1)	(1)												
E41T3020B	R LPOT DISCH T	1075, 1076			044(1)	(1)	021(1)	(1)							160	210	DEG R	2	GN	EIU3
							021(1)	(1)												
E41R3021B	R FU FLOWRT	1052, 1075, 1076	283				021(1)	(1)							1080	18,000	GPM	1	GN	EIU3
							021(1)	(1)												
E41R3022B	R OX FLOWRT	1075, 1076	283				021(1)	(1)							420	7000	GPM	1	GN	EIU3
							021(1)	(1)												
E41P3023B	R PC	1052, 1075, 1076					021(5)	(5)							0	3500	PSIA	2	GN	EIU3
							021(5)	(5)												
E41H3024B	R MFV POS	1052, 1075, 1076					021(1)	(1)							0	100	PCT	1	GN	EIU3
							021(1)	(1)												
E41H3025B	R MOV POS	1052, 1075, 1076					021(1)	(1)							0	100	PCT	1	GN	EIU3
							021(1)	(1)												
E41H3026B	R CCV POS	1052, 1075, 1076					021(1)	(1)							0	100	PCT	1	GN	EIU3
							021(1)	(1)												
E41H3027B	R FPOV POS	1052, 1075, 1076					021(1)	(1)							0	100	PCT	1	GN	EIU3
							021(1)	(1)												
E41H3028B	R OPOV POS	1052, 1075, 1076					021(1)	(1)							0	100	PCT	1	GN	EIU3
							021(1)	(1)												
E41P3029B	R HPFT DISCH P						021(1)	(1)							0	9500	PSIA	2	GN	EIU3
E41P3030B	R HPOT DISCH P	1052, 1075, 1076	284		044(1)	(1)	021(5)	(5)							0	7000	PSIA	2	GN	EIU3
							021(5)	(5)												
E41P3031B	R FPB PC						021(1)	(1)							0	7000	PSIA	2	GN	EIU3
E41P3051B	R HPOT SEC SL CAVITY P A	1052, 1075, 1076	283				021(5)	(5)							0	300	PSIA	2	GN	EIU3
							021(5)	(5)												
E41P3053B	R HPOT SEC SL CAVITY P B	1052, 1075, 1076	283				021(1)	(1)							0	300	PSIA	2	GN	EIU3
							021(1)	(1)												
E41P3054B	R HYD SYS P	1052, 1075, 1076	285				021(1)	(1)							0	4000	PSIA	2	GN	EIU3

SUBSYSTEM: MAIN ENGINE

TABLE 4.2 II. MAIN ENGINE DOWNLINKED TM (Concluded)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
E41T3150A	R CONT TEMP				PH(1)	(1)	AH(1)	(1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)	-75	300	DEG F	5	OI	0A03
E41T3151A	R OPOV LO2 SUP T 1				172, 180(1)	(1)	AH(1)	(1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)	-325	300	DEG F	5	OI	0A03
E41T3152A	R OPOV LO2 SUP T 2				PH(1)	(1)	AH(1)	(1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)	-325	500	DEG F	5	OI	0A03
E41T3153A	R MFV DWNST T 1				172, 180(1)	(1)	AH(1)	(1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)	-430	200	DEG F	5	OI	0A03
E41T3154A	R MFV DWNST T 2				172, 180(1)	(1)	AH(1)	(1)	129, 161(1)	(1)	129, 161(1)	(1)	EH(1)	(1)	-325	500	DEG F	5	OI	0A03
E41T3155A	AFV T1 R	1056			PH(1)	(1)	AH(1) AL(1)	(1) (1)	129(1)	(1)	129(1)	(1)	•(1)	(1)			DEG F		OI	0F04
E41T3156A	AFV T2 R	1056			PH(1)	(1)	AH(1) AL(1)	(1) (1)	129(1)	(1)	129(1)	(1)	•(1)	(1)			DEG F		OI	0F03
E41J3504B	R ID WD 2 B1 11						021(5)	(5)										1	GN	EIU3
E41X3505B	VDT A DATA		285				021(5)	(5)							OFF	ON	EVENT	1	GN	EIU3
E41J3506B	R OVERLAY CONFIG						021(5)	(5)										1	GN	EIU3
E41X3507B	R MEMORY LOAD MODE				044(1)	(1)	021(1) 021(1)	(1) (1)							OFF	ON	EVENT	1	GN	EIU3
E41J3508B	R COMMAND STATUS				044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU3
E41J3509B	R CHANNEL STATUS				044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU3
E41X3510B	R FRT MODE				044(1)	(1)	021(1) 021(1)	(1) (1)							OFF	ON	EVENT	1	GN	EIU3
E41X3511B	LIMIT CONTROL ENABLED		283 284		044(1)	(1)	021(1) 021(1)	(1) (1)							OFF	ON	EVENT	1	GN	EIU3
E41J3512B	R PHASE IN EFFECT				044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU3
E41J3513B	R MODE IN EFFECT				044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU3
E41J3514B	R SELF TEST STATUS				044(1)	(1)	021(1) 021(1)	(1) (1)										1	GN	EIU3
E41J3515B	R HARD FID CODE				044(12.5)	(12.5)	021(25) 021(25)	(25) (25)										25	GN	EIU3
E41J3516B	R DELIMITER CODE				044(12.5)	(12.5)	021(25) 021(25)	(25) (25)										25	GN	EIU3

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 EH = 129, 164, 166, 201 • = 129, 166, 201

SUBSYSTEM: EXTERNAL TANK

TABLE 4.2-III.- EXTERNAL TANK DOWNLINKED TM (one of two)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncertainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entrycheckout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
T41P1700C	LH2 ULL PC	1054, 1081, 1082, 1087, 1088, 1051	302		044(5)	(5)	021(5) 021(5)	(5) (5)							12	52	PSIA	5	GN	FA01
T41P1701C	LH2 ULL PL	1054, 1081, 1082, 1087, 1088, 1051	302		044(5)	(5)	021(5) 021(5)	(5) (5)							12	52	PSIA	5	GN	FA02
T41P1702C	LH2 ULL PR	1054, 1081, 1082, 1087, 1088, 1051	302		044(5)	(5)	021(5) 021(5)	(5) (5)							12	52	PSIA	5	GN	FA03
T41T1705A	LH2 ULL T				171(1)	(1)	AH(1)	(1)	129(1)	(1)	129(1)	(1)	129(1)	(1)	-430	200	DEG F	5	OI	OA03
T41X1712E	LH2 5% LIQ LVL	1054, 1079, 1080, 1051, 1056	287 302		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		OI	OA01
T41X1715E	LH2 98% LIQ LVL 1	1053, 1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		OI	OA02
T41X1716E	LH2 98% LIQ LVL 2	1053, 1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		OI	OA01
T41X1724E	LH2 VNT V CL	1054, 1081, 1084, 1051	287 302		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OPEN	CLOSE	EVENT		OI	OA01
T41X1727E	LH2 VNT V OP	1054, 1051	287		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(1)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	CLOSE	OPEN	EVENT		OI	OA01
T41X1730X	LH2 CO SEN 1	1054, 1051	287 302		044(5)	(5)	021(1) 021(1)	(1) (1)							WET	DRY	EVENT		GN	FA03
T41X1731X	LH2 CO SEN 2	1054, 1051	287 302		044(5)	(5)	021(1) 021(1)	(1) (1)							WET	DRY	EVENT		GN	FA02
T41X1732X	LH2 CO SEN 3	1054, 1051	287 302		044(5)	(5)	021(1) 021(1)	(1) (1)							WET	DRY	EVENT		GN	FA04
T41X1733X	LH2 CO SEN 4	1054, 1051	287 302		044(5)	(5)	021(1) 021(1)	(1) (1)							WET	DRY	EVENT		GN	FA01
T41P1750C	LO2 ULL P C	1054, 1081, 1082, 1051, 1056	287 302		044(5)	(5)	021(5) 021(5)	(5) (5)							0	30	PSIG	5	GN	FA01
T41P1751C	LO2 ULL P L	1054, 1081, 1082, 1051, 1056	287 302		044(5)	(5)	021(5) 021(5)	(5) (5)							0	30	PSIG	5	GN	FA02
T41P1752C	LO2 ULL P R	1054, 1081, 1082, 1051, 1056	287 302		044(5)	(5)	021(5) 021(5)	(5) (5)							0	30	PSIG	5	GN	FA03
T41T1755A	LO2 ULL T				171(1)	(1)	AH(1)	(1)	129(1)	(1)	129(1)	(1)	*(1)	(1)	325	500	DEG F	5	OI	OA02
T41X1717E	LH2 100% SEC 1	1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(1) (1)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		OI	OA02

PH = 171, 172, 180   AL = 102, 118, 119   AH = 129, 166, 201   OH = 129, 161, 183, 192, 204, 211   EH = 129, 164, 166, 201   * 129, 166, 201

SUBSYSTEM: EXTERNAL TANK

TABLE 4.2 III. EXTERNAL TANK DOWNLINKED TM (Concluded)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
T41X1718E	LH2 100% PRI 1	1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA01
T41X1719E	LH2 100% PRI 2	1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA02
T41X1720E	LH2 100% SEC 2	1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA01
T41X1721E	LH2 OVERFILL	1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA02
T41X1762E	LO2 5% LIQ LVL	1054, 1079, 1080, 1051, 1056	287 302		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA02
T41X1765E	LO2 98% LIQ LVL 1	1053, 1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA01
T41X1766E	LO2 98% LIQ LVL 2	1053, 1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA02
T41X1767E	LO2 99.85% LIQ LVL	1053, 1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA01
T41X1768E	LO2 100% LIQ LVL 1	1053, 1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA02
T41X1769E	LO2 100% LIQ LVL 2	1053, 1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA01
T41X1770E	LO2 100.15% LIQ LVL	1053, 1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA02
T41X1771E	LO2 102% LIQ LVL	1053, 1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA01
T41X1774E	LO2 VNT V CL	1054, 1081, 1082, 1051, 1056	287 302		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	WET	DRY	EVENT		01	OA03
T56X0002E	ET TUMBLE ARMED		302		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	SAFE	ARM	EVENT		01	OA02

PH = 171, 172, 180   AL = 102, 118, 19   AH = 129, 166, 201   OH = 129, 161, 183, 192, 204, 211   EH = 129, 164, 166, 201

SUBSYSTEM: MPS

TABLE 4.2 IV.- MPS DOWNLINKED TM (one of fourteen)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer- tainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V41P1100C	C LH2 IN P	1054, 1081, 1082, 1085, 1086, 1051, 1056	289 292 299		044(1)	(1)	021(12.5)	(12.5)	022(1)	(1)	022(1)	(1)	023(1)	(1)	0	200	PSIA	5	GN	FA01
V41T1101C	C LH2 IN T	1054, 1087, 1088, 1051, 1056	289 299		044(1)	(1)	021(5) 021(5)	(5) (5)							-430	-406	DEG F	3	GN	FA01
V41X1102E	C LH2 PV CL PWR ON	1063, 1066			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1103E	C LH2 PV OP PWR ON	1063, 1066			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1104X	C LH2 PV OP A	1064, 1062 1061, 1066	288 299 292		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	OFF	ON	EVENT		GN	FA01
V41X1105E	C LH2 PV CL	1054, 1052 1061, 1055	288 299		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1106X	C LH2 PV OP B	1053, 1055			044(5)	(5)	021(1) 021(1)	(1) (1)					023(1) 023(1)	(1) (1)	OFF	ON	EVENT		GN	FA03
V41X1109E	C RECIRC V OP	1063			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1110E	C RECIRC V CL	1053			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1112E	RECIRC V OP PWR ON	1053			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41R1115A	C RECIRC PMP SPD	1056					AH(10)	(10)	129(1)	(1)	129(1)	(1)	129(1)	(1)	0	20000	RPM		OI	OA03
V41S1119E	C LH2 PV OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA01
V41S1122E	C LH2 PV CL	1063, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OFF	ON	EVENT		OI	OA01
V41P1130C	C LO2 IN P	1054, 1081, 1082, 1085, 1086, 1051, 1056	292		044(1)	(1)	021(12.5)	(12.5)	022(1)	(1)	022(1)	(1)	023(1)	(1)	0	300	PSIA	5	GN	FA01
V41T1131C	C LO2 IN T	1056	298		044(1)	(1)	021(1)	(1)							-306	-255	DEG F	3	GN	FA01
V41X1132E	C LO2 PV CL PWR ON	1063, 1065			PH(1)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1133E	C LO2 PV OP PWR ON	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1134X	C LO2 PV OP	1064, 1052, 1051, 1055	288 298 292		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1) 022(1)	(1) (1)	022(1) 022(1)	(1) (1)	023(1) 023(1)	(1) (1)	ON	OFF	EVENT		GN	FA01
V41X1135E	C LO2 PV CL	1054, 1052, 1061, 1065	288 298		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41S1136E	C LO2 PV OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA01
V41S1139I	C LO2 PV CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA01

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 OH = 129, 161, 183, 192, 204, 211 EH = 129, 164, 166, 201

SUBSYSTEM: MPS

TABLE 4.2-IV.- MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second) Prelaunch Downlink High Low	Prelaunch SDPC (MOC) High Low	Ascent Downlink High Low	Ascent SDPC (MOC) High Low	On-orbit Downlink High Low	On-orbit SDPC (MOC) High Low	Entry checkout Downlink High Low	Entry checkout SDPC (MOC) High Low	Entry Downlink High Low	Entry SDPC (MOC) High Low	Data range Low	Data range High	Units	Uncertainty (Percent)	TM format type	MDM/card
V41X1144E	C LO2 PV CL PWR ON 2	1053, 1055			PH(10)	(5)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41P1150C	C HE TK P	1054, 1052, 1077, 1078, 1085, 1086, 1051, 1056	286 291 301		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1)	(1)	0	5000	PSIA	3.4	GN	FA01
V41T1151A	C HE TK T	1054, 1077, 1078, 1085, 1086, 1051, 1056	291		172,180(1)	(5)	AH(1) AL(1)	(1) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	-325	300	DEG F	3	OI	OA02
V41T1152A	C HE MID TK T	1054, 1077, 1078, 1085, 1086, 1051, 1056	291 301		172,180(1)	(1)	AH(1) AL(1)	(1) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	-325	300	DEG F	3	OI	OA01
V41P1153A	C HE REG P B	1054, 1077, 1078, 1085, 1086, 1051, 1056	286 291 301		PH(10)	(10)	AH(10) AL(10)	(10) (10)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	0	1000	PSIA	3.6	OI	OA01
V41P1154A	C HE REG P A	1054, 1077, 1078, 1085, 1086, 1051, 1056	286 291 301		PH(5)	(5)	AH(5) AL(1)	(5) (1)	•(5)	(1)	•(5)	(5)	EH(5) 105(1)	(5) (1)	0	1000	PSIA	3.6	OI	OF01
V41S1155E	C HE ISOL A OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	CL	OP	EVENT		OI	OA01
V41S1156E	C HE ISOL B OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41X1158E	C HE ISOL A OP PWR	1054, 1051, 1055	286 291 301		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(1) (10)	OFF	ON	EVENT		OI	OA01
V41X1159E	C HE ISOL B OP PWR	1054, 1051, 1055	286 291 301		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41P1160A	C GH2 OUT P	1054, 1052, 1083, 1084, 1051, 1064	281				AH(10) AL(1)	(10) (1)	129(1)	(1)	129(1)	(1)	129(1)	(1)	0	6000	PSIA	6	OI	OA01
V41T1161A	C GH2 OUT T	1052, 1083, 1084					AH(1) AL(1)	(1) (1)	129(1)	(1)	129(1)	(1)	129(1)	(1)	-325	500	DEG F	3	OI	OA01
V41S1162E	C HE INTCN IN OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41X1164E	C HE INTCN IN PWR	1054, 1051, 1055	291 301		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41S1165E	C HE ISOL A CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OP	CL	EVENT		OI	OA01
V41S1166E	C HE ISOL B CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41S1168E	C HE INTCN OUT OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA01
V41X1170E	C HE INTCN OUT PWR	1054, 1051, 1055	291		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA01
V41T1171A	C GO2 OUT T	1052, 1083, 1084					AH(1) AL(1)	(1) (1)	129(1)	(1)	129(1)	(1)	129(1)	(1)	150	650	DEG F	3	OI	OA01

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 OH = 129, 181, 183, 192, 204, 211 EH = 129, 164, 166, 201 • = 129, 161, 192, 211

SUBSYSTEM: MPS

TABLE 4.2-IV. MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DOD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V41P1200C	L LH2 IN P	1054, 1081, 1082, 1085, 1086, 1051, 1056	288 292 299		044(1)	(1)	021(12.5)	(12.5)	022(1)	(1)	022(1)	(1)	023(1)	(1)	0	200	PSIA	5	GN	FA02
V41T1201C	L LH2 IN T	1054, 1087, 1088, 1051, 1056	288 299		044(1)	(1)	021(1) 021(1)	(1) (1)							-430	-405	DEG F	3	GN	FA02
V41X1202E	L LH2 PV CL PWR ON	1053, 1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1203E	L LH2 PV OP PWR ON	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1204X	L LH2 PV OP A	1054, 1052, 1061, 1055	288 299 292		044(6)	(6)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	023(1) 023(1)	OFF	ON	EVENT		GN	FA02
V41X1205E	L LH2 PV CL	1054, 1052, 1051, 1055	288 299		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA03
V41X1206X	L LH2 PV OP B	1053, 1055			044(5)	(5)	021(1) 021(1)	(1) (1)					023(1) 023(1)	(1) (1)	OFF	ON	EVENT		GN	FA04
V41X1209E	L RECIRC V OP	1053			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1210E	L RECIRC V CL	1053			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41R1215A	L RECIRC PMP SPD	1056					AH(10)	(10)	129(1)	(1)	129(1)	(1)	129(1)	(1)	0	20,000	RPM		OI	OA03
V41S1219E	L LH2 PV OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41S1222E	L LH2 PV CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41P1230C	L LO2 IN P	1054, 1081, 1082, 1085, 1086, 1051, 1056	292		044(1)	(1)	021(12.5)	(12.5)	022(1)	(1)	022(1)	(1)	023(1)	(1)	0	300	PSIA	5	GN	FA02
V41T1231C	L LO2 IN T	1056	298		044(1)	(1)	021(1)	(1)							-305	-255	DEG F	3	GN	FA02
V41X1232E	L LO2 PV CL PWR ON	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1233E	L LO2 PV OP PWR ON	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1234X	L LO2 PV OP	1054, 1052, 1051, 1055	288 298 292		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	ON	OFF	EVENT		GN	FA02
V41X1235E	L LO2 PV CL	1054, 1052, 1051, 1055	288 298		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	OA03
V41S1238E	L LO2 PV OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41S1239E	L LO2 PV CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41X1244E	L LO2 PV CL PWR ON 2	1053, 1055			PH(10)	(10)	AH(10) AL(1)	(10) (1)	OH(10) 103(1)	(10) (1)	OH(10) 103(1)	(10) (1)	EH(10) 105(1)	(10) (1)	OFF	ON	EVENT		OI	OA03

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 OH = 129, 161, 183, 192, 204, 211 EH = 129, 164, 166, 201

SUBSYSTEM: MPS

TABLE 4.2-IV.- MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V41P1250C	L HE TK P	1054, 1052, 1077, 1078, 1085, 1086, 1051, 1056	286 291 301		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1)	(1)	0	5000	PSIA	3.4	GN	FA02
V41T1251A	L HE TK T	1054, 1077, 1078, 1085, 1086, 1051, 1056	291		172,180(1)	(1)	AH(1) AL(1)	(1) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	-325	300	DEG F	3	OI	OA03
V41T1252A	L HE MID TK T	1054, 1077, 1078, 1085, 1086, 1051, 1056	291 301		172,180(1)	(1)	AH(1) AL(1)	(1) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	-325	300	DEG F	3	OI	OA02
V41P1253A	L HE REG P B	1054, 1077, 1078, 1085, 1086, 1051, 1056	286 291 301		PH(10)	(10)	AH(1) AL(1)	(1) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	0	1000	PSIA	3.6	OI	OA01
V41P1254A	L HE REG P A	1054, 1077, 1078, 1085, 1086, 1051, 1056	286 291 301		PH(5)	(5)	AH(1) AL(1)	(1) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	0	1000	PSIA	3.8	OI	OF01
V41S1255E	L HE ISOL A OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	CL	OP	EVENT		OI	OA02
V41S1256E	L HE ISOL B OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA03
V41X1258E	L HE ISOL B OP PWR	1054, 1051, 1055	286 291 301		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1259E	L HE ISOL B OP PWR	1054, 1051, 1055	286 291 301		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA03
V41P1260A	L GH2 OUT P	1054, 1052, 1083, 1084, 1051, 1064	282				AH(1) AL(1)	(1) (1)	129(1)	(1)	129(1)	(1)	129(1)	(1)	0	5000	PSIA	5	OI	OA02
V41T1261A	L GH2 OUT T	1052, 1083, 1084					AH(1) AL(1)	(1) (1)							-325	500	DEG F	3	OI	OA02
V41S1262E	L HE INTCN IN OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA03
V41X1264E	L HE INTCN IN PWR	1054, 1051, 1055	291 301		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA03
V41S1265E	L HE ISOL A CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OP	CL	EVENT		OI	OA02
V41S1266E	L HE ISOL B CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA03
V41S1268E	L HE INTCN OUT OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41X1270E	L HE INTCN OUT PWR	1054, 1051, 1055	291		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41T1271A	L GO2 OUT T	1052, 1083, 1084					AH(1)	(1)	129(1)	(1)	129(1)	(1)	129(1)	(1)	-160	650	DEG F	3	OI	OA02
V41P1300C	R LH2 IN P	1054, 1081, 1082, 1085, 1086, 1051, 1056	289 292 299		044(1)	(1)	021(12.5)	(12.5)	022(1)	(1)	022(1)	(1)	023(1)	(1)	0	200	PSIA	5	GN	FA03

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 OH = 129, 161, 183, 192, 204, 211 EH = 129, 164, 166, 201 • = 129, 161, 192, 211

SUBSYSTEM: MPS

TABLE 4.2-IV.- MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V41T1301C	R LH2 IN T	1054, 1087, 1088, 1051, 1056	289 299		044(1)	(1)	021(5)	(5)							-430	-405	DEG F	3	GN	FA03
V41X1302E	R LH2 PV CL PWR ON	1053, 1055			PH(10)	(10)	AH(10)	(10)	OH(10)	(10)	OH(10)	(10)	EH(10)	(10)	OFF	ON	EVENT		OI	OA03
							AL(10)	(10)	103(10)	(10)	103(10)	(10)	105(10)	(10)						
V41X1303E	R LH2 PV OP PWR ON	1053, 1055			PH(10)	(10)	AH(10)	(10)	OH(10)	(10)	OH(10)	(10)	EH(10)	(10)	OFF	ON	EVENT		OI	OA03
							AL(10)	(10)	103(10)	(10)	103(10)	(10)	105(10)	(10)						
V41X1304X	R LH2 PV OP A	1054, 1052, 1051, 1055	288 292 299		044(5)	(5)	021(12.5)	(12.5)	022(12.5)	(12.5)	022(12.5)	(12.5)	023(12.6)	(12.5)	OFF	ON	EVENT		GN	FA04
							021(12.5)	(12.5)	022(12.5)	(12.5)	022(12.5)	(12.5)	023(12.6)	(12.5)						
V41X1305E	R LH2 PV CL	1054, 1052, 1051, 1055	288 299		PH(10)	(10)	AH(10)	(10)	OH(10)	(10)	OH(10)	(10)	EH(10)	(10)	OFF	ON	EVENT		OI	OA01
							AL(10)	(10)	103(10)	(10)	103(10)	(10)	106(10)	(10)						
V41X1306X	R LH2 PV OP B	1053, 1055			044(5)	(5)	021(12.5)	(12.5)					023(12.6)	(12.6)	OFF	ON	EVENT		GN	FA03
							021(12.5)	(12.5)					023(12.5)	(12.5)						
V41X1309E	R RECIRC V OP	1053			PH(10)	(10)	AH(10)	(10)	OH(10)	(10)	OH(10)	(10)	EH(10)	(10)	OFF	ON	EVENT		OI	OA03
							AL(10)	(10)	103(10)	(10)	103(10)	(10)	105(10)	(10)						
V41X1310E	R RECIRC V CL	1053			PH(10)	(10)	AH(10)	(10)	OH(10)	(10)	OH(10)	(10)	EH(10)	(10)	OFF	ON	EVENT		OI	OA03
							AL(10)	(10)	103(10)	(10)	103(10)	(10)	106(10)	(10)						
V41R1315A	R RECIRC PMP SPD	1056					AH(10)	(10)							0	20,000	RPM		OI	OA03
V41S1319E	R LH2 PV OP	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	OA03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V41S1322E	R LH2 PV CL	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	OA03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	106(1)	(1)						
V41P1330C	R LO2 IN P	1054, 1081, 1082, 1085, 1086, 1051, 1056	292		044(1)	(1)	021(12.6)	(12.6)	022(1)	(1)	022(1)	(1)	023(1)	(1)	0	300	PSIA	6	GN	FA03
V41T1331C	R LO2 IN T	1056	298		044(1)	(1)	021(1)	(1)							-306	-265	DEG F	3	GN	FA03
V41X1332E	R LO2 PV CL PWR ON	1053, 1055			PH(10)	(10)	AH(10)	(10)	OH(10)	(10)	OH(10)	(10)	EH(10)	(10)	OFF	ON	EVENT		OI	OA03
							AL(10)	(10)	103(10)	(10)	103(10)	(10)	106(10)	(10)						
V41X1333E	R LO2 PV OP PWR ON	1053, 1055			PH(10)	(10)	AH(10)	(10)	OH(10)	(10)	OH(10)	(10)	EH(10)	(10)	OFF	ON	EVENT		OI	OA03
							AL(10)	(10)	103(10)	(10)	103(10)	(10)	106(10)	(10)						
V41X1334X	R LO2 PV OP	1054, 1052, 1051, 1055	288 298 292		044(6)	(6)	021(1)	(1)	022(1)	(1)	022(1)	(1)	023(1)	(1)	ON	OFF	EVENT		GN	FA04
							021(1)	(1)					023(1)	(1)						
V41X1335E	R LO2 PV CL	1054, 1052, 1051, 1055	288 298		PH(10)	(10)	AH(10)	(10)	OH(10)	(10)	OH(10)	(10)	EH(10)	(10)	OFF	ON	EVENT		OI	OA01
							AL(10)	(10)	103(10)	(10)	103(10)	(10)	105(10)	(10)						
V41S1336E	R LO2 PV OP	1053, 1055			PH(10)	(10)	AH(10)	(10)	OH(10)	(10)	OH(10)	(10)	EH(10)	(10)	OFF	ON	EVENT		OI	OA03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	106(1)	(1)						
V41S1339E	R LO2 PV CL	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	OA03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V41X1344E	R LO2 PV CL PWR ON 2	1053, 1055			PH(10)	(10)	AH(10)	(10)	OH(10)	(10)	OH(10)	(10)	EH(10)	(10)	OFF	ON	EVENT		OI	OA01
							AL(10)	(10)	103(10)	(10)	103(10)	(10)	105(10)	(10)						
V41P1350C	R HE TK P	1054, 1052, 1077, 1078, 1085, 1086, 1051, 1056	286 291 301		044(5)	(5)	021(1)	(1)	022(1)	(1)	022(1)	(1)	023(1)	(1)	0	5000	PSIA	3.4	GN	FA03
							021(1)	(1)	022(1)	(1)	022(1)	(1)								

PH = 171, 172, 180   AL = 102, 118, 119   AH = 129, 166, 201   OH = 129, 161, 183, 192, 204, 211   EH = 129, 164, 166, 201

SUBSYSTEM: MPS

TABLE 4.2-IV.- MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Prelaunch Downlink High Low	Prelaunch SDPC (MOC) High Low	Ascent Downlink High Low	Ascent SDPC (MOC) High Low	On-orbit Downlink High Low	On-orbit SDPC (MOC) High Low	Entry checkout Downlink High Low	Entry checkout SDPC (MOC) High Low	Entry Downlink High Low	Entry SDPC (MOC) High Low	Data range Low	Data range High	Units	Uncertainty (Percent)	TM format type	MDM/ card
V41T1351A	R HE TK T	1054, 1077, 1078, 1085, 1086, 1051, 1056	291		172,180(1)	(1)	AH(1) AL(1)	(1) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	-325	300	DEG F	3	OI	0A01
V41T1352A	R HE MID TK T	1054, 1077, 1078, 1085, 1086, 1051, 1056	291 301		172,180(1)	(1)	AH(1) AL(1)	(1) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	-325	300	DEG F	3	OI	0A03
V41P1353A	R HE REG P B	1054, 1077, 1078, 1085, 1086, 1051, 1056	286 291 301		PH(10)	(10)	AH(10) AL(1)	(10) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	0	1000	PSIA	3.6	OI	0A01
V41P1354A	R HE REG P B	1054, 1077, 1078, 1085, 1086, 1051, 1056	286 291 301		PH(5)	(5)	AH(5) AL(1)	(5) (1)	•(1)	(1)	•(1)	(1)	EH(5) 105(1)	(5) (1)	0	1000	PSIA	3.6	OI	0F01
V41S1355E	R HE ISOL A OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	CL	OP	EVENT		OI	0A03
V41S1356E	R HE ISOL B OP	1053, 1055, 1051			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V41X1358E	R HE ISOL A OP PWR	1054, 1055, 1051	286 291 301		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A03
V41X1359E	R HE ISOL B OP PWR	1054, 1055, 1051	286 291 301		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A01
V41P1360A	R GH2 OUT P	1054, 1052, 1083, 1084, 1051, 1084	283				AH(10) AL(1)	(10) (1)	129(1)	(1)	129(1)	(1)	129(1)	(1)	0	5000	PSIA	6	OI	0A03
V41T1361A	R GH2 OUT T	1052, 1083, 1084					AH(1) AL(1)	(1) (1)	129(1)	(1)	129(1)	(1)	129(1)	(1)	-325	600	DEG F	3	OI	0A03
V41S1362E	R HE INTCN IN OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V41X1364E	R HE INTCN IN PWR	1054, 1051, 1055	291 301		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V41S1365E	R HE ISOL A CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V41S1366E	R HE ISOL B CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V41S1368E	R HE INTCN OUT OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V41X1370E	R HE INTCN OUT PWR	1054, 1055, 1051	291		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V41T1371A	R GO2 OUT T	1052, 1083, 1084					AH(1) AL(1)	(1) (1)	129(1)	(1)	129(1)	(1)	129(1)	(1)	-150	650	DEG F	3	OI	0A03
V41X1381E	LH2 FD DISC V CL PWR	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A02
V41X1382E	LH2 FD DISC V OP PWR	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A02
V41X1385E	LH2 OB F/D V CL PWR	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A02

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 OH = 129, 161, 183, 192, 204, 211 EH = 129, 164, 166, 201 • = 129, 161, 192, 211

SUBSYSTEM: MPS

TABLE 4.2 IV.- MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncertainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V41X1386E	LH2 OB F/D V OP PWR	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1388E	LH2 OB F/D V OP	1053, 1055	299		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1389X	LH2 OB F/D V CL	1054, 1055	289 292		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	OFF	ON	EVENT		GN	FA02
V41S1391E	LH2 OB F/D OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41S1393E	LH2 OB F/D CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41S1401E	LH2 IB F/D OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	CL	OP	EVENT		OI	OA01
V41X1405E	LH2 IB F/D V CL PWR	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1406E	LH2 IB F/D V OP PWR	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1409E	LH2 IB F/D V OP	1053, 1055	299		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1410X	LH2 IB F/D V CL	1054, 1051, 1055	289 292		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	OFF	ON	EVENT		GN	FA01
V41S1412E	LH2 IB F/D CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA01
V41X1418E	LH2 RECRC DISC V O	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	ON	OFF	EVENT		OI	OA03
V41X1420E	LH2 RECRC DISC V CL	1054, 1051	289 299		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	ON	OFF	EVENT		OI	OA03
V41T1428A	LH2 FD DISC T	1054, 1087, 1051, 1056			172, 180(1)	(1)	AH(1)	(1)	129(1)	(1)	129(1)	(1)	*(1)	(1)	430	405	DEG F	3	OI	OA01
V41X1429X	LH2 FD DISC V OP	1054, 1051	289 299		044(5)	(5)	021(1) 021(1)	(1) (1)							OFF	ON	EVENT		GN	FA01
V41X1430X	LH2 FD DISC V CL A	1054, 1055, 1051	289 299		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	ON	OFF	EVENT		GN	FA02
V41S1431E	LH2 MANF PRESS CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OP	CL	EVENT		OI	OA02
V41P1433C	LH2 ENG MANF P	1054, 1081, 1082, 1085, 1086, 1051, 1056	289 299 292 287		044(1)	(1)	021(1) 021(1)	(1) (1)	022(1) 022(1)	(1) (1)	022(1) 022(1)	(1) (1)	023(1) 023(1)	(1) (1)	0	100	PSIA	5	GN	FA01
V41X1434X	LH2 FD DISC V CL B	1054, 1051	289 299		044(5)	(5)	021(1) 021(1)	(1) (1)					023(1) 023(1)	(1) (1)			EVENT		GN	FA04
V41S1435E	LH2 MANF PRESS OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41X1436E	LH2 MANF PRESS 1 OP	1054, 1055, 1051	289 298 292		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02

PH = 171, 172, 180   AL - 102, 118, 119   AH = 129, 166, 201   OH = 129, 161, 183, 192, 204, 211   EH = 129, 164, 166, 201   * = 129, 166, 201

SUBSYSTEM: MPS

TABLE 4.2-IV.- MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V41X1438E	LH2 MANF PRESS 2 OP	1054, 1051, 1055	289 299 292		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A02
V41X1439E	LH2 RECR DISC V CL P	1053			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A03
V41X1440E	LH2 RECRC DISC V OP P	1053			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A03
V41X1441E	LH2 FDLN RLF ISOL OP	1054, 1051	289 299 292		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A03
V41X1442E	LH2 FDLN RLF ISOL CL	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	0A03
V41S1443E	LH2 FDLN RLF ISOL CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V41S1447E	LH2 FDLN RLF ISOL CL	1053, 1065			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OP	CL	EVENT		OI	0A03
V41X1449E	LH2 FDLN RLF ISOL CL	1063, 1065			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	0A01
V41X1453E	LH2 TOP V OP	1053, 1055	299		PH(10)	(10)	AH(10) AH(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	ON	OFF	EVENT		OI	0A01
V41X1456X	LH2 TOP V CL	1054, 1051, 1055	289 292		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	ON	OFF	EVENT		GN	FA01
V41X1458E	LH2 TOP V OP P	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A01
V41P1464A	LO2 TK ΔP	1058					AH(1)	(1)							40	70	PSID	6	OI	0A03
V41X1467E	LH2 HI PNT BLD OP PWR	1053			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	0A01
V41X1468E	LH2 HI PNT BLD OP	1053			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A01
V41X1469E	LH2 HI PNT BLD CL	1053			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (1)	OFF	ON	EVENT		OI	0A01
V41S1477E	LH2 TK P HI FLOW ON	1054, 1051	287 302		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V41P1490A	GH2 DISC P	1054, 1081, 1082, 1083, 1084, 1085, 1086, 1051	292		PH(1)	(1)	AH(10) AL(1)	(10) (1)	•(1)	(1)	•(1)	(1)	EH(1) 106(1)	(1) (1)	0	1000	PSIA	5	OI	0A02
V41X1492E	H2 PRESS LN VNT OP P	1054, 1051	289 292		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	0A03
V41S1493E	H2 PRESS LN VNT OP	1053			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OP	CL	EVENT		OI	0A03
V41X1505E	LO2 IB F/D V CL P	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A02
V41X1506E	LO2 IB F/D V OP P	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	0A02

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 OH = 129, 161, 183, 192, 204, 211 EH = 129, 164, 166, 201 • = 129, 161, 192, 211

SUBSYSTEM: MPS

TABLE 4.2 IV.- MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (ODD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V41X1507E	LO2 OB F/D V CL P	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA03
V41X1508E	LO2 OB F/D V OP P	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA03
V41X1509X	LO2 IB F/D V CL	1054, 1055, 1051	289 292		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	OFF	ON	EVENT		GN	FA02
V41X1510E	LO2 IB F/D V OP	1053, 1055	298		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41S1511E	LO2 IB F/D OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41S1512E	LO2 IB F/D CL	1053, 1056			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA02
V41X1513E	LO2 OB F/D V OP	1053, 1055	298		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA03
V41X1514X	LO2 OB F/D V CL	1054, 1055	289 292		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	OFF	ON	EVENT		GN	FA03
V41S1515E	LO2 OB F/D CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA03
V41S1518E	LO2 OB F/D OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA03
V41T1528A	LO2 FD MANF DISC T	1056			172,180(1)	(1)	AH(1)	(1)	129(1)	(1)	129(1)	(1)	129(1)	(1)	-305	-255	DEG F	3	OI	OA03
V41X1529X	LO2 FD DISC V OP	1054, 1051	289 298		044(5)	(5)	021(1) 021(1)	(1) (1)							OFF	ON	EVENT		GN	FA04
V41X1530X	LO2 FD DISC V CL A	1054, 1051	289 298		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	ON	OFF	EVENT		GN	FA02
V41S1531E	LO2 MANF PRESS CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OP	CL	EVENT		OI	OA03
V41P1533C	LO2 ENG MANF P	1054, 1081, 1082, 1085, 1086, 1051, 1056	287 288 292 299		044(1)	(1)	021(1) 021(1)	(1) (1)	022(1) 022(1)	(1) (1)	022(1) 022(1)	(1) (1)	023(1) 023(1)	(1) (1)	0	300	PSIA	5	GN	FA02
V41X1534X	LO2 FD DISC V CL B	1054, 1051	289 298		044(5)	(5)	021(1) 021(1)	(1) (1)					023(1) 023(1)	(1) (1)			EVENT		GN	FA03
V41S1535E	LO2 MANF PRESS OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	CL	OP	EVENT		OI	OA03
V41X1538E	LO2 MANF PRESS 1 OP	1054, 1051	289 292 298		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA03
V41X1539E	LO2 MANF PRESS 2 OP	1054, 1051	292 289 298		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA03
V41X1541E	LO2 FDLN RLF ISOV OP	1054, 1051	289 292 298		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1542E	LO2 FDLN RLF ISOV CL	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41S1543E	LO2 FDLN RLF ISOV OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	CL	OP	EVENT		OI	OA03

PH = 171, 172, 180   AL = 102, 118, 119   AH = 129, 166, 201   OH = 129, 161, 183, 192, 204, 211   EH = 129, 164, 186, 201

SUBSYSTEM: MPS

TABLE 4.2 IV. MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent	TM format type	MDM/card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Low	High				
V41S1547E	LO2 FDLN RLF ISOV CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	CL	OP	EVENT		OI	0A01
V41X1549E	LO2 FDLN RLF ISOV CL P	1053, 1056			PH(10)	(10)	AH(10) AL(1)	(10) (1)	OH(10) 103(1)	(10) (1)	OH(10) 103(1)	(10) (1)	EH(10) 105(1)	(10) (1)			EVENT		OI	0A03
V41P1564A	LH2 TK ΔP	1056					AH(1)	(1)							0	3	PSID	6	OI	0A03
V41X1580X	LO2 OVBD BLV CL A	1064, 1051, 1055	289		044(5)	(5)	021(1) 021(1)	(1) (1)					023(1) 023(1)	(1) (1)	OP	CL	EVENT		GN	FA03
V41X1581X	LO2 OVBD BLV CL B	1063, 1065			044(5)	(5)	021(1) 021(1)	(1) (1)					023(1) 023(1)	(1) (1)			EVENT		GN	FA02
V41X1582E	LO2 OVBD BLV CL P	1063, 1056			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A03
V41X1587E	LO2 OVBD BLV OP	1063, 1055	298		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A02
V41P1590A	LO2 DISC P	1054, 1081, 1082, 1083, 1084, 1085, 1086, 1051	292		172,180(1)	(1)	AH(10) AL(1)	(10) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	0	1000	PSIA	5	OI	0A01
V41X1596E	GO2 P SOV C CLP	1054, 1051	287 302		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A01
V41X1555X	LO2 LEFT NO. 1 ECO SENSOR	1054, 1051	287 302		044(5)	(5)	021(1) 021(1)	(1) (1)							WET	DRY	EVENT		GN	FA03
V41X1556X	LO2 LEFT NO. 2 ECO SENSOR	1054, 1051	287 302		044(5)	(5)	021(1) 021(1)	(1) (1)							WET	DRY	EVENT		GN	FA02
V41X1557X	LO2 RIGHT NO. 2 ECO SENSOR	1054, 1051	287 302		044(5)	(5)	021(1) 021(1)	(1) (1)							WET	DRY	EVENT		GN	FA04
V41X1558X	LO2 RIGHT NO. 1 ECO SENSOR	1054, 1051	287 302		044(5)	(5)	021(1) 021(1)	(1) (1)							WET	DRY	EVENT		GN	FA01
V41X1598E	GO2 P SOV L CL P	1054, 1051	287 302		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A02
V41P1600A	PNEU HE TK P	1054, 1077, 1078, 1085, 1086, 1051, 1056	291 286 301		172,180(1)	(1)	AH(10) AL(1)	(10) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	0	5000	PSIA	5	OI	0A01
V41T1601A	PNEU HE TK T	1054, 1077, 1078, 1085, 1086, 1051, 1056	291 301		172,180(1)	(1)	AH(1) AL(1)	(1) (1)	•(1)	(1)	•(1)	(1)	EH(1) 105(1)	(1) (1)	-325	300	DEG F	3	OI	0A01
V41X1603E	GO2 P SOV R CL P	1054, 1051	287 302		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	0A03
V41P1605A	PNEU HE REG P	1054, 1077, 1078, 1085, 1086, 1051, 1056	286 291 301		172,180(1)	(1)	AH(10) AL(1)	(10) (1)	OH(10) 103(1)	(10) (1)	OH(1) 103(1)	(1) (1)	EH(10) 105(1)	(10) (1)	0	1000	PSIA	3.8	OI	0A01
V41S1607E	PNEU HE ISOL OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	CL	OP	EVENT		OI	0A01
V41S1609E	PNEU HE ISOL CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OP	CL	EVENT		OI	0A02

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 OH = 129, 161, 183, 192, 204, 211 EH = 129, 164, 166, 201 • = 129, 161, 192, 211

SUBSYSTEM: MPS

TABLE 4.2-IV.- MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncertainty (Percent)	TM format type	MDM/card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC(MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V41S1613E	L HE XOVR OP	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OA03
V41X1614E	L HE XOVR OP PWR	1054, 1055, 1051	286 291 301		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(1)	(10) (1)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA03
V41S1619E	L HE XOVR CL	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OP	CL	EVENT		OI	OA03
V41X1632E	HE BLDN 1 OP P	1054, 1051	291 301		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1634E	HE BLDN 2 OP P	1054, 1051	291 301		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1645E	PNEU HE ISOL 1 OP PWR	1054, 1051	286 291 301		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1646E	PNEU HE ISOL 2 OP PWR	1054, 1051	286 291		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1661E	GH2 P SOV C CL P	1054, 1051	287 302		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA01
V41X1662E	GH2 P SOV L CL P	1054, 1051	287 302		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1663E	GH2 P SOV R CL P	1054, 1051	287 302		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	OA03
V41X1806E	LO2 FD DISC V CL P	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1807E	LO2 FD DISC V OP P	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1811X	POGO RECRC V1 OP	1054, 1051, 1055	288		044(5)	(5)	021(12.5) 021(12.5)	(12.5) (12.5)					023(12.5) 023(12.5)	(12.5) (12.5)	OFF	ON	EVENT		GN	FA03
V41X1813E	POGO RECRC V1 CL P	1053, 1055			PH(10)	(10)	AH(10) AL(1)	(10) (1)	OH(10) 103(1)	(10) (1)	OH(10) 103(1)	(10) (1)	EH(10) 105(1)	(10) (1)	OFF	ON	EVENT		OI	OA01
V41X1818E	POGO RECRC V1 CL	1053, 1055	298		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OP	CL	EVENT		OI	OA01
V41X1821X	POGO RECRC V2 OP	1054, 1051, 1055	288		044(5)	(5)	021(12.5) 021(12.5)	(12.5) (12.5)					023(12.5) 023(12.5)	(12.5) (12.5)	OFF	ON	EVENT		GN	FA04
V41X1823E	POGO RECRC V2 CL P	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 106(10)	(10) (10)	OFF	ON	EVENT		OI	OA02
V41X1828E	POGO RECRC V2 CL	1053, 1055	298		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OP	CL	EVENT		OI	OA02
V41X1901E	RTLS MANF REPR 1 PWR	1054, 1051	288 299		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OFF	ON	EVENT		OI	OA03
V41X1902E	RTLS MANF REPR 2 PWR	1054, 1051	288 299		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OFF	ON	EVENT		OI	OA01
V41X1911E	RTLS OB DMP V OP P	1053, 1055	.		PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	OFF	ON	EVENT		OI	OA03
V41X1917E	RTLS OB DMP V OP	1053, 1055	299		PH(10)	(10)	AH(10) AL(1)	(10) (1)	OH(10) 103(1)	(10) (1)	OH(10) 103(1)	(10) (1)	EH(10) 105(1)	(10) (1)	CL	OP	EVENT		OI	OA01

PH - 171, 172, 180   AL = 102, 118, 119   AH = 129, 166, 201   OH = 129, 161, 183, 192, 204, 211   EH = 129, 164, 166, 201

SUBSYSTEM: MPS

TABLE 4.2-IV.- MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second): Prelaunch Downlink High Low	Prelaunch SDPC (MOC) High Low	Ascent Downlink High Low	Ascent SDPC (MOC) High Low	On-orbit Downlink High Low	On-orbit SDPC (MOC) High Low	Entry checkout Downlink High Low	Entry checkout SDPC (MOC) High Low	Entry Downlink High Low	Entry SDPC (MOC) High Low	Data range Low	Data range High	Units	Uncer-tainty (Percent)	TM format type	MDM/card
V41X1919X	RTLS OB DMP V CL	1054, 1051	289		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	OFF	ON	EVENT		GN	FA03
V41X1921E	RTLS IB DMP V OFF	1053, 1055			PH(10)	(10)	AH(10) AL(10)	(10) (10)	OH(10) 103(10)	(10) (10)	OH(10) 103(10)	(10) (10)	EH(10) 105(10)	(10) (10)	CL	OP	EVENT		OI	0A03
V41X1927E	RTLS IB DMP V OP	1053, 1055	299		PH(10)	(10)	AH(10) AL(1)	(10) (1)	OH(10) 103(1)	(10) (1)	OH(10) 103(1)	(10) (1)	EH(10) 105(1)	(10) (1)	CL	OP	EVENT		OI	0A01
V41X1929X	RTLS IB DMP V CL	1054, 1051	289		044(5)	(5)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	OFF	ON	EVENT		GN	FA04
V41P1650A	PN ACC P	1054	301		172(10)	(10)	AH(10) 102(5)	(10) (5)	129(10)	(10)	129(10)	(10)	129(10) 105(5)	(10) (5)					OI	0A02
V76X0501E	LH2 RLF SOL RPC A	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V76X0503E	LH2 RLF SOV RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X0551E	LO2 RLF SOV RPC A	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V76X0553E	LO2 RLF SOV RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X3050E	PT SEN ELEC RPC B	1053			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V76X3055E	PT SEN ELEC RPC C	1053			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X4110E	C LH2 PV OP RPC A	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V76X4111E	C LH2 PV OP RPC B	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V76X4113E	C LH2 PV CL RPC A	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V76X4114E	C LH2 PV CL RPC B	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V76X4116E	L LH2 PV OP RPC B	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V76X4117E	L LH2 PV OP RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X4119E	L LH2 PV CL RPC B	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 106(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V76X4120E	L LH2 PV CL RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X4122E	R LH2 PV OP RPC C	1053, 1055			PH(10)	(10)	AH(10) AL(1)	(10) (1)	OH(10) 103(1)	(10) (1)	OH(10) 103(1)	(10) (1)	EH(10) 105(1)	(10) (1)	OFF	ON	EVENT		OI	0A03
V76X4123E	R LH2 PV OP RPC A	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V76X4125E	R LH2 PV CL RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X4126E	R LH2 PV CL RPC A	1053, 1055			PH(10)	(10)	AH(10) AL(1)	(10) (1)	OH(10) 103(1)	(10) (1)	OH(10) 103(1)	(10) (1)	EH(10) 105(1)	(10) (1)	OFF	ON	EVENT		OI	0A01

PH = 171, 172, 180   AL = 102, 118, 119   AH = 129, 166, 201   OH = 129, 181, 183, 192, 204, 211   EH = 129, 184, 186, 201

SUBSYSTEM: MPS

TABLE 4.2-IV.- MPS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncertainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Downlink High Low	SDPC (MOC) High Low	Low	High				
V76X4130E	C LO2 PV OP RPC A	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A01
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	106(1)	(1)						
V76X4131E	C LO2 PV OP RPC B	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A02
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4133E	C LO2 PV CL RPC A	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A01
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	106(1)	(1)						
V76X4134E	C LO2 PV CL RPC B	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A02
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4136E	L LO2 PV OP RPC B	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A02
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	106(1)	(1)						
V76X4137E	L LO2 PV OP RPC C	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4139E	L LO2 PV CL RPC B	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A02
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4140E	L LO2 PV CL RPC C	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4142E	R LO2 PV OP RPC C	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	106(1)	(1)						
V76X4143E	R LO2 PV OP RPC A	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A01
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	106(1)	(1)						
V76X4145E	R LO2 PV CL RPC C	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	106(1)	(1)						
V76X4146E	R LO2 PV CL RPC A	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A01
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	106(1)	(1)						
V76X4151E	C HE INT IN/OP RPC A	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A01
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	106(1)	(1)						
V76X4152E	C HE INT IN/OP RPC B	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A02
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4155E	L HE INT IN/OP RPC B	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A02
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4156E	L HE INT IN/OP RPC C	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	106(1)	(1)						
V76X4158E	R HE INT IN/OP RPC C	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4159E	R HE INT IN/OP RPC A	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A01
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4161E	RTLS IB DMP RPC A	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A01
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4162E	RTLS OB DMP RPC A	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A01
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4163E	RTLS IB DMP RPC C	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						
V76X4164E	RTLS OB DMP RPC C	1053, 1055			PH(1)	(1)	AH(1)	(1)	OH(1)	(1)	OH(1)	(1)	EH(1)	(1)	OFF	ON	EVENT		OI	0A03
							AL(1)	(1)	103(1)	(1)	103(1)	(1)	105(1)	(1)						

PH = 171, 172, 180   AL = 102, 118, 119   AH = 129, 166, 201   OH = 129, 161, 183, 192, 204, 211   EH = 129, 164, 166, 201

SUBSYSTEM: MPS

TABLE 4.2-IV.- MPS DOWNLINKED TM (Concluded)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer- tainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V76X4165E	RTLS P1 RPC A	1053			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V76X4166E	RTLS P1 RPC C	1053			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X4167E	RTLS P2 RPC A	1053			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V76X4168E	RTLS P2 RPC C	1053			PH(10)	(10)	AH(10) AL(1)	(10) (1)	OH(10) 103(1)	(10) (1)	EH(10) 103(1)	(10) (1)	EH(10) 105(1)	(10) (1)	OFF	ON	EVENT		OI	0A03
V76X4171E	C HE ISOL 2 RPC B	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V76X4172E	C HE ISOL 2 RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X4173E	L HE ISOL 2 RPC A	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V76X4174E	L HE ISOL 2 RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X4175E	R HE ISOL 2 RPC A	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V76X4176E	R HE ISOL 2 RPC B	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V76X4178E	LO2 OVBD BLV RPC B	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V76X4179E	LO2 OVBD BLV RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X4186E	LH2 DISC OP RPC B	1053, 1055			PH(10)	(10)	AH(10) AL(1)	(10) (1)	OH(10) 103(1)	(10) (1)	EH(10) 103(1)	(10) (1)	EH(10) 105(1)	(10) (1)	OFF	ON	EVENT		OI	0A02
V76X4187E	LH2 DISC OP RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X4189E	LH2 DISC CL RPC B	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V76X4190E	LH2 DISC CL RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X4196E	LO2 DISC OP RPC B	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V76X4197E	LO2 DISC OP RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V76X4199E	LO2 DISC CL RPC B	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V76X4200E	LO2 DISC CL RPC C	1053, 1055			PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03

PH - 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 OH = 129, 161, 183, 192, 204, 211 EH = 129, 164, 166, 201

SUBSYSTEM: ORBITER

TABLE 4.2-V.- ORBITER DOWNLINKED TM

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V58P0116C	VEH HYD 1 P C	1052			044(1)	(1)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	0	4000	PSIA	2.5	GN	FA04
V58P0216C	VEH HYD 2 P C	1052			044(1)	(1)	021(1) 021(1)	(1) (1)	022(1)	(1) (1)	022(1)	(1)	023(1) 023(1)	(1) (1)	0	4000	PSIA	2.5	GN	FA03
V58P0316C	VEH HYD 3 P C	1052			044(1)	(1)	021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1) 023(1)	(1) (1)	0	4000	PSIA	2.5	GN	FA02
V72S0097E	EIU RPC A		285		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V72S0099E	EIU RPC B		285		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V72S0102E	EIU RPC C		285		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A03
V72K0051X	ENG LIMIT ENABLE A		293		044(1)	(1)									OFF	ON	EVENT		GN	FF02
V72K0052X	ENG LIMIT ENABLE B		293		044(1)	(1)									OFF	ON	EVENT		GN	FF03
V72K0053X	ENG LIMIT ENABLE C		293		044(1)	(1)									OFF	ON	EVENT		GN	FF04
V72K0071X	ENG LIMIT AUTO A		293		044(1)	(1)									OFF	ON	EVENT		GN	FF02
V72K0072X	ENG LIMIT AUTO B		293		044(1)	(1)									OFF	ON	EVENT		GN	FF03
V72K0073X	ENG LIMIT AUTO C		293		044(1)	(1)									OFF	ON	EVENT		GN	FF04
V72K0061X	ENG LIMIT INHIBIT A		293		044(1)	(1)									OFF	ON	EVENT		GN	FF02
V72K0062X	ENG LIMIT INHIBIT B		293		044(1)	(1)									OFF	ON	EVENT		GN	FF03
V72K0063X	ENG LIMIT INHIBIT C		293		044(1)	(1)									OFF	ON	EVENT		GN	FF04
V76S4601E	MEC PWR 1	1055	290 300		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A01
V76S4605E	MEC PWR 2	1055	290 300		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	0A02
V90X7554X	ET SEP AUTO ENAB		290 300				021(1) 021(1)	(1) (1)							OFF	ON	EVENT		GN	XXXX
V90X7556X	ET SEP MAN ENAB		290 300				021(1) 021(1)	(1) (1)							OFF	ON	EVENT		GN	XXXX
V90X7564X	ET SEP INIT		290 300				021(1) 021(1)	(1) (1)							OFF	ON	EVENT		GN	XXXX

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 168, 201 OH = 129, 161, 183, 192, 204, 211 EH = 129, 164, 168, 201

SUBSYSTEM: GUIDANCE

TABLE 4.2 VI.- GUIDANCE DOWNLINKED TM (one of three)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncertainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V72X4528X	SYS MGMT ALERT		285				021(1)	(1)	022(1) 022(1)	(1) (1)	022(1) 022(1)	(1) (1)	023(1)	(1)	OFF	ON	EVENT		GN	FF01
V72X4533X	GNC BU C & W		285				021(1)	(1)	022(1) 022(1)	(1) (1)	022(1) 022(1)	(1) (1)	023(1)	(1)	OFF	ON	EVENT		GN	FF04
V72X5135X	MAN THROTTLE		285				021(1) 021(1)	(1) (1)					023(1)	(1)	OFF	ON	EVENT		GN	FF04
V72X7011E	GPC 1 FAIL		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OF01
V72X7012E	GPC 2 FAIL		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OF01
V72X7013E	GPC 3 FAIL		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OF01
V72X7014E	GPC 4 FAIL		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OF01
V72X7015E	GPC 5 FAIL		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)	OFF	ON	EVENT		OI	OF01
V73X1567E	C & W MASTER		285		PH(50)	(50)	AH(50) AL(1)	(50) (1)	OH(50) 103(1)	(50) (1)	OH(50) 103(1)	(50) (1)	EH(50) 105(1)	(50) (1)	OFF	ON	EVENT		OI	OF03
V75W3504D	VOTED GMT				PH(5)	(5)	AH(5) AL(5)	(5) (5)	OH(5) 103(5)	(5) (5)	OH(5) 103(5)	(5) (5)	EH(5) 105(5)	(5) (5)			D/H/M/S		OI	OF01
V75W3514D	VOTED MET				PH(5)	(5)	AH(5) AL(5)	(5) (5)	OH(5) 103(5)	(5) (5)	OH(5) 103(5)	(5) (5)	EH(5) 105(5)	(5) (5)			D/H/M/S		OI	OF01
V90W1941C	T GO - VEL CO	1054, 1052 1079, 1080, 1051					021(1) 021(1)	(1) (1)	022(1)	(1)	022(1)	(1)	023(1)	(1)	0	1000	S		GN	XXXX
V90X1942X	ET LEVEL SENSOR ARM CMD	1054, 1051	287 302				021(1) 021(1)	(1) (1)							OFF	ON	EVENT		GN	XXXX
V90U1948C	ME THRUST LEVEL CMD	1052, 1071 1072, 1073 1074, 1075 1076					021(1) 021(1)	(1) (1)							50	90	PCT		GN	XXXX
V90U1961C	CURR VEH MASS	1054, 1051 1087, 1088					021(1)	(1)							0	75000	SLUG		GN	XXXX
V90W1970C	DESIRED MECO	1054, 1057 1079, 1080 1087, 1088, 1051					021(1)	(1)							0	1000	S		GN	XXXX
V90P2535C	L SRB PC SELECTED														0	1000	PSIA		GN	XXXX
V90P2536C	R SRB PC SELECTED														0	1000	PSIA		GN	XXXX
V90X7570X	SRB SEP AUTO ENAB		290 300				021(1) 021(1)	(1) (1)							OFF	ON	EVENT		GN	XXXX
V90X7571X	SRB SEP MAN ENAB		290 300				021(1) 021(1)	(1) (1)							OFF	ON	EVENT		GN	XXXX
V90X7572X	SRB SEP INIT CMD		290 300				021(1) 021(1)	(1) (1)							OFF	ON	EVENT		GN	XXXX

PH = 171, 172, 180 AL -- 102, 118, 119 AH = 129, 166, 201 OH = 129, 161, 183, 192, 204, 211 EH = 129, 164, 168, 201.

SUBSYSTEM: GUIDANCE

TABLE 4.2 VI.- GUIDANCE DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format (samples per second)																				Data range		Units	Uncer- tainty (Percent)	TM format type	MDM/ card
					Prelaunch				Ascent				On-orbit				Entry checkout				Entry									
					Downlink		SDPC (MOC)		Downlink		SDPC (MOC)		Downlink		SDPC (MOC)		Downlink		SDPC (MOC)		Downlink		SDPC (MOC)							
					High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	Low	High				
V90Q8001C	MAJOR MODE	1054, 1052, 1051, 1064							021(1)		(1)		022(1)	022(1)	(1)	(1)	022(1)	022(1)	(1)	(1)	023(1)		(1)		101	801	CNT		GN	XXXX
V90X8250X	ET SEP CMD FLG	1054, 1051	290 300						021(1)	021(1)	(1)	(1)													ENHIB	ENB	EVENT		GN	XXXX
V90X8259X	ET AUTO SEP INHIBIT CREW ALERT	1054, 1051	290 300						021(1)		(1)														ENBL	INHIB	EVENT		GN	XXXX
V90X8315X	8 NULL JETS ON FLAG								021(1)	021(1)	(1)	(1)													OFF	ON	EVENT		GN	XXXX
V90X8316X	14 NULL JETS ON FLAG								021(1)	021(1)	(1)	(1)													OFF	ON	EVENT		GN	XXXX
V90X8317X	20 NULL JETS ON FLAG								021(1)	021(1)	(1)	(1)													OFF	ON	EVENT		GN	XXXX
V90W8325C	OMS T ΔCOMPUTED								021(1)		(1)														0	400	S		GN	XXXX
V90X8331X	SRB SEP CMD FLG	1054, 1051	289 290						021(1)	021(1)	(1)	(1)													OFF	ON	EVENT		GN	XXXX
V90X8333X	SRB SEP INIT		290 300						021(1)	021(1)	(1)	(1)													OFF	ON	EVENT		GN	XXXX
V90X8340X	SRB AUTO SEP INHIBIT CREW ALERT	1054, 1051	289 290						021(1)	021(1)	(1)	(1)													OFF	ON	EVENT		GN	XXXX
V90X8383X	L SRB P/C A		300						021(1)		(1)																EVENT		GN	XXXX
V90X8384X	L SRB P/C B		300						021(1)		(1)																EVENT		GN	XXXX
V90X8385X	R SRB P/C A		300						021(1)		(1)																EVENT		GN	XXXX
V90X8386X	R SRB P/C B		300						021(1)		(1)																EVENT		GN	XXXX
V90X8561X	MECO CONFIRMED		290						021(1)	021(1)	(1)	(1)													OFF	ON	EVENT		GN	XXXX
V90X8667X	R S HOLD		287 293 302						021(1)		(1)														OFF	ON	EVENT		GN	XXXX
V91M1999PX	GMT				044(1)		(1)		021(1)	021(1)	(1)	(1)	022(1)	022(1)	(1)	(1)	022(1)	022(1)	(1)	(1)	023(1)	023(1)	(1)	(1)					GN	XXXX
V91X2813XX	EIU1/P4		285		044(1)		(1)		021(1)	021(1)	(1)	(1)	022(1)	022(1)	(1)	(1)	022(1)	022(1)	(1)	(1)	023(1)	023(1)	(1)	(1)		ERROR	EVENT		GN	XXXX
V91X2817XX	EIU2/P4		285		044(1)		(1)		021(1)	021(1)	(1)	(1)	022(1)	022(1)	(1)	(1)	022(1)	022(1)	(1)	(1)	023(1)	023(1)	(1)	(1)		ERROR	EVENT		GN	XXXX
V91X2821XX	EIU3/P4		285		044(1)		(1)		021(1)	021(1)	(1)	(1)	022(1)	022(1)	(1)	(1)	022(1)	022(1)	(1)	(1)	023(1)	023(1)	(1)	(1)		ERROR	EVENT		GN	XXXX

SUBSYSTEM: GUIDANCE

TABLE 4.2-VI.- GUIDANCE DOWNLINKED TM (Concluded)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V91X2821XX	EIU3/P4		285		044(1)	(1)	021(1) 021(1)	(1) (1)	022(1) 022(1)	(1) (1)	022(1) 022(1)	(1) (1)	023(1) 023(1)	(1) (1)		ERROR	EVENT		GN	XXXX
V91X2927XX	EIU1/P1		285		044(1)	(1)	021(1) 021(1)	(1) (1)	022(1) 022(1)	(1) (1)	022(1) 022(1)	(1) (1)	023(1) 023(1)	(1) (1)		ERROR	EVENT		GN	XXXX
V91X2930XX	EIU2/P1		285		044(1)	(1)	021(1) 021(1)	(1) (1)	022(1) 022(1)	(1) (1)	022(1) 022(1)	(1) (1)	023(1) 023(1)	(1) (1)		ERROR	EVENT		GN	XXXX
V91X2933XX	EIU3/P1		285		044(1)	(1)	021(1) 021(1)	(1) (1)	022(1) 022(1)	(1) (1)	022(1) 022(1)	(1) (1)	023(1) 023(1)	(1) (1)		ERROR	EVENT		GN	XXXX
V91M7475PX	GNC MET				044(1)	(1)			022(1) 022(1)	(1) (1)	022(1) 022(1)	(1) (1)	023(1) 023(1)	(1) (1)			D/H/M/S		GN	XXXX
V93Q0022CX	GPC (FORMAT)	1054, 1052 1087, 1088, 1051			044(25)	(25)	021(25) 021(25)	(25) (25)	022(25) 022(25)	(25) (25)	022(25) 022(25)	(25) (25)	023(25) 023(25)	(25) (25)			INTEGER		GN	XXXX
V93Q0022CY	SM (FORMAT)	1054, 1052 1087, 1088, 1051															INTEGER		GN	XXXX
V93Q0022CZ	OI (FORMAT)	1054, 1052 1087, 1088, 1051															INTEGER		GN	XXXX
V95U0163C	TOTAL LOAD (G's)	1054, 1052 1087, 1088, 1051					021(5) 021(5)	(5) (5)					023(1)	(1)	-100	100	EVENT		GN	XXXX
V95H0175C	ALTITUDE						021(1) 021(1)	(1) (1)					023(1) 023(1)	(1) (1)	-10	1000	FT		GN	XXXX

SUBSYSTEM: BFS

TABLE 4.2-VII. - BFS DOWNLINKED TM (one of three)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V98Q0009C	BF (FORMAT)	1054, 1052 1087, 1088, 1051					012(26) 012(26)	(25) (25)					013(25) 013(26)	(25) (26)	0	255	INTEGER		BF	XXXX
V98X0742X	SRB SEP M/A ENAB	1089, 1064 1090	290 300				012(5) 012(5)	(5) (5)							OFF	ON	EVENT		BF	XXXX
V98X0743X	SRB SEP INIT	1089 1090	290 300				012(5) 012(5)	(5) (5)							OFF	ON	EVENT		BF	XXXX
V98X0744X	SRB SEP ARM	1089 1090	290 300				012(5) 012(5)	(6) (5)							OFF	ON	EVENT		BF	XXXX
V98X0748X	ET SEP MAN ENAB	1089 1090	290 300				012(5) 012(5)	(5) (5)							OFF	ON	EVENT		BF	XXXX
V98X0749X	ET SEP INIT	1089 1090	290 300				012(5) 012(5)	(5) (5)							OFF	ON	EVENT		BF	XXXX
V98X0752X	ET SEP ARM		290 300				012(5) 012(6)	(5) (5)							OFF	ON	EVENT		BF	XXXX
V98X0821X	BFS EIU1 PRI		285				012(1) 012(1)	(1) (1)					013(1) 013(1)	(1) (1)	OFF	ON	EVENT		BF	XXXX
V98X0824X	BFS EIU1 SEC		285				012(1) 012(1)	(1) (1)					013(1) 013(1)	(1) (1)	OFF	ON	EVENT		BF	XXXX
V98X0826X	BFS EIU2 PRI		285				012(1) 012(1)	(1) (1)					013(1) 013(1)	(1) (1)	OFF	ON	EVENT		BF	XXXX
V98X0828X	BFS EIU2 SEC		285				012(1) 012(1)	(1) (1)					013(1) 013(1)	(1) (1)	OFF	ON	EVENT		BF	XXXX
V98X0831X	BFS EIU3 PRI		285				012(1) 012(1)	(1) (1)					013(1) 013(1)	(1) (1)	OFF	ON	EVENT		BF	XXXX
V98X0832X	BFS EIU3 SEC		285				012(1) 012(1)	(1) (1)					013(1) 013(1)	(1) (1)	OFF	ON	EVENT		BF	XXXX
V98X1268X	BFS BACK UP C & W		286 299				012(1) 012(1)	(1) (1)					013(1) 013(1)	(1) (1)	OFF	ON	EVENT		BF	XXXX
V98X1269X	BFS ALERT		285 299				012(1) 012(1)	(1) (1)					013(1) 013(1)	(1) (1)	OFF	ON	EVENT		BF	XXXX
V98W1330C	TIME	1054, 1052					012(1) 012(1)	(1) (1)					013(1) 013(1)	(1) (1)			M/S		BF	XXXX
V98P1388C	LH2 MAN P	1089, 1064 1090					012(1)	(1)					013(1)	(1)			PSIA		BF	XXXX
V98P1389C	LO2 MAN P	1089, 1064 1090					012(1)	(1)					013(1)	(1)			PSIA		BF	XXXX
V98W1390C	ME1 TIME REF	1089, 1064 1090					012(1)	(1)									M/S		BF	XXXX
V98W1391C	ME2 TIME REF	1089, 1064 1090					012(1)	(1)									M/S		BF	XXXX
V98W1392C	ME3 TIME REF	1089, 1064 1090					012(1)	(1)									M/S		BF	XXXX
V98P1740C	L SRB PC	1089, 1090, 1064					012(1)	(1)							0	1000	PSI		BF	XXXX

SUBSYSTEM: BFS

TABLE 4.2 VII. - BFS DOWNLINKED TM (Continued)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncertainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V98P1741C	R SRB PC	1089, 1090, 1064					012(1)	(1)							0	1000	PSI		BF	XXXX
V98W1815C	TIME TO GO VECO	1089, 1090, 1064					012(1) 012(1)	(1) (1)					013(1) 013(1)	(1) (1)	0	200	S		BF	XXXX
V98U2001C	THROTTLE CMD	1089, 1090, 1064					012(1) 012(1)	(1) (1)							0	100	PCT		BF	XXXX
V98P2100C	C PC	1052, 1089, 1090, 1064	281				012(1) 012(1)	(1) (1)							0	115	PCT		BF	XXXX
V98P2110C	L PC	1052, 1089, 1090, 1064	282				012(1) 012(1)	(1) (1)							0	116	PCT		BF	XXXX
V98P2120C	R PC	1052, 1089, 1090, 1064	283				012(1) 012(1)	(1) (1)							0	115	PCT		BF	XXXX
V98P2140C	LH2 ULL PC	1089, 1090, 1064					012(1)	(1)							12	52	PSIA		BF	XXXX
V98P2155C	C HE TK P	1089, 1090, 1064					012(1) 012(1)	(1) (1)					013(1)	(1)	0	5000	PSIA		BF	XXXX
V98P2156C	L HE TK P	1089, 1090, 1064					012(1) 012(1)	(1) (1)					013(1)	(1)	0	5000	PSIA		BF	XXXX
V98P2157C	R HE TK P	1089, 1090, 1064					012(1) 012(1)	(1) (1)					013(1)	(1)	0	5000	PSIA		BF	XXXX
V98M2200P	C ESW	1052, 1089, 1090, 1064					012(1) 012(1)	(1) (1)					013(1)	(1)					BF	XXXX
V98M2220P	L ESW	1052, 1089, 1090, 1064					012(1) 012(1)	(1) (1)					013(1)	(1)					BF	XXXX
V98M2240P	R ESW	1052, 1089, 1090, 1064					012(1) 012(1)	(1) (1)					013(1)	(1)					BF	XXXX
V98X3532X	SRB SEP INIT	1089 1090	290 300				012(1) 012(1)	(1) (1)							OFF	ON			BF	XXXX
V98X3534X	SRB SEP CMD.	1089, 1064 1090	290 300				012(1) 012(1)	(1) (1)							OFF	ON			BF	XXXX
V98X3546X	MECO CONFIRM	1089 1090	290 300				012(1) 012(1)	(1) (1)							OFF	ON			BF	XXXX
V98X3550X	ET SEP CMD	1089, 1064 1090	290 300				012(1) 012(1)	(1) (1)							OFF	ON			BF	XXXX
V98P4997C	SSME HE TK PRESS 1 CHANGE RATE	1054, 1077, 1078, 1064	286 301				012(1) 012(1)	(1) (1)							0	50	PSIA/S	1	BF	XXXX
V98F4998C	SSME HE TK PRESS 2 CHANGE RATE	1054, 1077, 1078, 1064	286 301				012(1) 012(1)	(1) (1)							0	50	PSIA/S	1	BF	XXXX
V98P4999C	SSME HE TK PRESS 3 CHANGE RATE	1054, 1077, 1078, 1064	286 301				012(1) 012(1)	(1) (1)							0	50	PSIA/S	1	BF	XXXX
V76V0120A	CTL AB1 VOLTS		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			VOLTS		OI	OF01

PH - 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 OH = 129, 161, 183, 192, 204, 211 EH = 129, 164, 166, 201

SUBSYSTEM: BFS

TABLE 4.2-VII - BFS DOWNLINKED TM (Concluded)

MSID	Operational TM	Display (MSK no.)	Event light (DDD format no.)	SCR MSK	Phase/TM format, rate (samples per second)										Data range		Units	Uncer-tainty (Percent)	TM format type	MDM/ card
					Prelaunch		Ascent		On-orbit		Entry checkout		Entry							
					Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)	Downlink	SDPC (MOC)						
					High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	High Low	Low	High				
V78V0121A	CTL AB2 VOLTS		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			VOLTS		0I	0F01
V76V0122A	CTL AB3 VOLTS		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			VOLTS		0I	0F01
V76V0220A	CTL BC1 VOLTS		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			VOLTS		0I	0F02
V78V0221A	CTL BC2 VOLTS		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			VOLTS		0I	0F02
V78V0222A	CTL BC3 VOLTS		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			VOLTS		0I	0F02
V76V0320A	CTL CA1 VOLTS		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			VOLTS		0I	0F03
V76V0321A	CTL CA2 VOLTS		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			VOLTS		0I	0F03
V78V0322A	CTL CA3 VOLTS		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			VOLTS		0I	0F03
V76S1504E	AC1 BUS SENS OFF		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			EVENT		0I	0F01
V76S1604E	AC2 BUS SENS OFF		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			EVENT		0I	0F02
V76S1704E	AC3 BUS SENS OFF		293		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			EVENT		0I	0F03
V76V3091A	MN A APC4 VOLTS		293		PH(5)	(5)	AH(5) AL(5)	(5) (5)	OH(5) 103(5)	(5) (5)	OH(5) 103(5)	(5) (5)	EH(5) 105(5)	(5) (5)			VOLTS		0I	0A01
V76V3092A	MN B APC5 VOLTS		293		PH(5)	(5)	AH(5) AL(5)	(5) (5)	OH(5) 103(5)	(5) (5)	OH(5) 103(5)	(5) (5)	EH(5) 105(6)	(5) (5)			VOLTS		0I	0A01
V76V3093A	MN C APC6 VOLTS		293		PH(5)	(5)	AH(5) AL(5)	(5) (6)	OH(5) 103(5)	(5) (6)	OH(5) 103(5)	(5) (5)	EH(5) 106(6)	(6) (6)			VOLTS		0I	0A01
V74X4754	LOW BIT RATE, 64K		302		PH(1)	(1)	AH(1) AL(1)	(1) (1)	OH(1) 103(1)	(1) (1)	OH(1) 103(1)	(1) (1)	EH(1) 105(1)	(1) (1)			EVENT		0I	0F03

PH = 171, 172, 180 AL = 102, 118, 119 AH = 129, 166, 201 OH = 129, 161, 183, 192, 204, 211 EH = 129, 164, 166, 201

TITLE

FLIGHT PERFORMANCE RESERVE AND PROPELLANT MANAGEMENT

PURPOSE

This SCP describes the various performance parameter quantities that constitute the Shuttle flight performance reserve (FPR) and the MPS propellant inventory.

BACKGROUND

An FPR requirement for a nominal baseline planning mission type 1 (i.e., nonabort) flight of 5547 pounds of main engine propellant has been set aside. For mission types 3A and 4, the nominal FPR is 4764 pounds. Individual subsystem groupings such as SSME performance, SRB performance, and aerodynamics were combined in an additive manner to protect against off-nominal performance in multiple subsystems (ref. 1 and 2). The fuel bias (902 or 971 lb per ref. 6) is separate from the FPR. The FPR components of LO_2 and LH_2 follow the overboard SSME mixture ratio of 6.02 for ET numbers less than 40 and 6.03 for numbers 40 and greater for all dispersion sources with the exception of the SSME mixture ratio and loading dispersion values, which were derived by statistical analysis. The FPR values quoted in this SCP are subject to change; they are for a 6.03 mixture ratio and are for reference only.

From a mission control standpoint, the AOA FPR has a greater significance than the nominal flight FPR. The individual items and their effect on FPR are controlled in the S.S. System Specification (ref. 2) as shown in table 4.3-I. From these values, the parameters utilized by the abort region determinator (ARD) are selected and utilized for the AOA FPR prediction. Table 4.3-II shows a typical ARD FPR loading of 2695 pounds. The STS 61-A propellant inventory is provided in table 4.3-III. From this table, it can be seen that the AOA fuel bias is 801 lb and the total FPR is 3580 lb (1857 lb in the Orbiter lines and 1723 lb in the ET). All of these numbers change flight-to-flight, and the numbers provided in this SCP are for reference only. The ARD receives a state vector update at SRB separation, which eliminates the requirement for a SRB performance allowance in the ARD FPR loading.

The main tool in controlling the actual fuel bias and FPR for a given mission is the duration of LO2 drainback (at approximately 21.3 lb/sec), which determines the LO_2 load and loaded mixture ratio at lift-off. Increasing the drainback time increases the fuel bias and decreases the total FPR. If the desired fuel bias and FPR are reevaluated prior to launch, the actual values can be modified by changing the planned drainback time.

DESCRIPTION OF FPR DISPERSION SOURCES

The various sources of design or operation dispersions are described in this section.

A. Aerodynamics - Dispersions from the nominal aerodynamic coefficients (e.g.; lift, drag, surface moments) used for flight performance predictions.

B. Atmosphere - Dispersions from the nominal wind vector and atmospheric density as a function of altitude. The wind vector and air density affect the vehicle aerodynamic forces and moments.

C. SSME Performance

1. Mixture Ratio and Loading - The specified three sigma dispersion for mixture ratio is ±1 percent per engine (ref. 2) and the specified loading accuracy (ref. 2) is ±0.43 percent and ±0.35 percent for LO_2 and LH_2, respectively. The FPR components for LO_2 and LH_2 and the fuel bias were determined statistically using the Monte Carlo technique, and they do not follow the 6.03 SSME mixture ratio. Due to the analysis method used, a simple formula does not exist for determining the LO_2 and LH_2 components for the mixture ratio and loading FPR allotments. The duration of launch hold allowance (following LO_2 drainback) built into the FPR is a function of mission requirements.

2. Initial Specific Impulse - The SSME specific impulse (ISP) is the engine thrust (lb) divided by the flow rate (lb/sec) and is nominally 452.5 seconds. The specified dispersion for ISP is ±2.3 seconds (ref 3) and affects the total impulse (i.e., the integral of thrust and time) available during powered flight.

3. Thrust - The specified SSME thrust dispersion is ±6000 lb per engine (ref. 3) and affects the velocity losses due to gravity.

4. Startup - The specified SSME startup duration dispersion is negligible.

D. SRB Performance

1. Web Action Time - Web Action Time (WAT) is the time from the beginning of steady state operation (i.e., vacuum thrust per SRB is 1.9 million lb or greater) to the beginning of tailoff (defined as the bisector of the intercept of lines tangent to the steady state and tailoff portions of the chamber pressure vs. time curve as projected onto the curve). The specified WAT dispersion is ±3.8 percent (ref. 2) and affects velocity losses due to gravity during first stage. WAT dispersions are the result of variations in grain burn area and in propellant temperature (i.e., warmer propellant burns faster).

2. ISP - The specified dispersion for SRB is ±0.5 percent (ref. 2) and affects the total impulse available during first stage.

3. Loading - The specified propellant load dispersion is ±0.21 percent (ref. 2) and affects the SRB propellant available during first stage.

4. WAT Mismatch - WAT differences between the two SRB's result in thrust vectoring losses during first stage.

5. SRB Jettison Timing - Increased time between SRB tailoff and jettison results in a velocity loss due to the acceleration of the SRB dead weight during the additional time period.

E. Mass Properties Uncertainties - Dispersions due to deviations from the nominal values for center of gravity and for Orbiter inert weight, ET inert weight, SRB inert weight, payload weight, RCS and OMS loading, and nonpropulsive consumables used for flight performance predictions.

F. GN&C Performance - Dispersions that result in thrust vectoring losses due to IMU and rate gyro biases and alignment errors, MECO nav state error, and digital auto pilot (DAP) control errors.

G. Thrust Misalignments - Dispersions that result in thrust vectoring losses due to SRB installation and static thrust vector errors due to SSME installation and static and dynamic thrust vector errors. Static thrust vector errors result from nozzle asymmetries and dynamic thrust vector errors result from structural deformation during gimbaling.

REFERENCES

1. Operational Flight Profile, Appendix A to Flight Requirement Document, JSC-17462-(FH).

2. Space Shuttle Flight and Ground System Specification, Space Shuttle System Weight and Performance Control, JSC-07700 Volume X, Appendix 10.12.

3. ICD 13M15000, SSME/Orbiter Vehicle Interface Control Document (current issue).

4. MMC-ET-CM02a-A (CPT01M26A) Basic, ET Contract End Item Specification (CEI) - Part I.

5. STS 61-A ARD Loading AOA FPR (SODS J-771 Add 1).

6. Shuttle Operational Data Submittal

TABLE 4.3-I.- FLIGHT PERFORMANCE RESERVES - MISSIONS 1, 3A, AND 4
(lb of FPR)

Dispersion	Magnitude	Mission 1 (Nominal)	Mission 3A and 4 (Nominal)	AOA
Aerodynamics				
C_{AF}	Aero 3 dispersion	780	510	319
C_{AB}	Values contained	832	739	581
C_{NF}	in IVBC-3 ref	2	0	0
C_{Y}	Aero data book	4	3	2
C_{MF}		36	38	17
C_{MY}		5	4	3
Weights				
Inert Orb	±0.1%	13	17	11
Inert ET	±0.25%	112	74	19
Inert SRB	±0.85%	21	7	8
X_{CG}	Function of	0	-3	0
Y_{CG}	Vehicle ref	0	0	0
Z_{CG}	data bk-charts 1 FSDP/MAI 83-236	0	1	0
OMS load	±0.5% load	1	2	1
ET TPS	194 lbs.	7	8	5
ACC Y	acc 0.018 align 0422°	28	26	19
ACC Z	acc 0.034 align 0.228°	260	322	178
IMVU(P)	0.5	53	61	27
IMVU(Y)	0.5	2	1	1
Rate Gyro (P)	0.157°/sec	1	7	2
Rate Gyro (Y)	0.157°/sec	1	0	0
MECO NS	Covariance matrix	20	23	20
SSME TV (P)	1.066°	9	10	7
SSME TV (Y)	0.618	3	2	12
SRB TV (P)	0.743°	151	480	247
SRB TV (Y)	0.743°	16	8	4
SRB TMM	84,000 lb	75	49	49
SRM IMM	1%	1	1	1
SRB WAT	±3.8%	1105	415	250
SRB ISP	±0.5%	272	215	109

TABLE 4.3-I.- Concluded

Dispersion	Magnitude	Mission 1 (Nominal)	Mission 3A and 4 (Nominal)	AOA
ORB ISP	2.3 sec/SSME	525	538	319
ORB thrust	6000/SSME	79	65	158
SRB propellant	0.21%	17	14	6
MR	±1%	1115	1129	893
LOX load	±0.43%			
LH load	±0.35%			
fb		902	979	923
FPR		5547	4764	3329

TABLE 4.3-II.- STS 61-A ARD AOA FPR LOADING (TYPICAL)

1.	2.	3.	4.	5.	6.
FPR item	Premission FPR value	To get ARD 2σ multiply by	ARD 2σ MPS FPR	ARD FPR contribution	% contribution to ARD FPR
ET load and MR	19 ± 1372	1	19 ± 1372	19 ± 707	26.6
LOX LH$_2$ MR	(±.36%=4898 lb) (±.46%=1047 lb) (1% per SSME)				
SSME ISP (2.3 sec per SSME)	0 ± 1491	1	0 ± 1491	0 ± 834	31.3
SSME thrust (6000 lb per SSME)	6 ± 1690	1	6 ± 1690	6 ± 1072	40.3
SSME startup	0 ± 0	1	0 ± 0	0 ± 0	0.0
MASS PROP UNC.	0 ± 242	1	0 ± 242	0 ± 22	0.8
Orbiter inert ET inert (TPS) OMS load XCG YCG ZCG	0 ± 197 0 ± 126 0 ± 55 0 ± 13 0 ± 4 0 ± 25				
Thrust MIS	6 ± 124	1	6 ± 124	6 ± 6	0.2
ARD NAV ST (TM)	0 ± 241	1	0 ± 241	0. ± 22	0.8
Results (MN FPR + 2σ FPR)			32 ± 2663**		100.0
			Total=269.5		

*-Sum of column

**-RSS of column

Note: In column 4, the FPR values are summed, and their deviations are RSS'd. The percentage relations of the deviations squared to the total deviation squared are shown in column 6, and the deviations shown in column 5 are these percentages multiplied by the total deviation.

TABLE 4.3-III.- MPS PROPELLANT INVENTORY, STS 61-A (For reference)

AOA T = T1 + 0
ULLAGE H2 = 1.54% ULLAGE O2 = 1.58% SIGMA = 2.
FPR = 3580. FUEL BIAS = 801. OMBR = 6.0395

	LH2	LO2	TOTAL - lbs.
Loaded (100% sensor)	231,742	1,387,858	1,619,599
ORB lines	249	3304	3553
SSME X 3	58	1325	1383
ET	231,435	1,383,229	1,614,663
Loss prior to ENG START CMD	104	5,640	5,744
Boiloff, bleed, seal leak, POGO flush	104	5,640	5,744
Loaded at ENG START CMD	231,638	1,382,218	1,613,855
ORB lines	249	3304	3553
SSME X 3	58	1325	1383
ET	231,331	1,377,587	1,608,919
Transferred from ET	58	172	230
Used for thrust buildup & SRB ign delay	1733	9,434	11,167
Loaded at SRB IGNITION CMD	229,905	1,372,784	1,608,688
ORB lines	249	3304	3553
SSME X 3	116	1497	1613
ET	229,540	1,367,983	1,597,522
Unusable	2197	5647	7844
ORB lines (LOX ECO T = 0, NPSP = 7.7)	249	1447	1696
SSME X 3	58	1325	1383
ET wet walls, bellows	0	175	175
ET lines	810	0	810
FLT pressurant	1080	2700	3780
Usable reserves	1310	3071	4381
ORB lines (FPR)	0	1857	1857
SSME X 3	0	0	0
ET (FPR)	509	1214	1723
Bias	801	0	801
Usable impulse	226,398	1,364,055	1,590,462
Used at OBMR	225,483	1,361,810	1,587,292
Shutdown consumption	857	2083	2940
SSME from nom. %	309	771	1080
SSME from 91%	548	1312	1860
Vented after SSME valve closure	58	172	230

Note:

Item		LOW 2	LH2
Vented ullage pressure, psig	=	0.76	0.30
Unpress density, lb./ft^3	=	71.13	4.411
Press density, lb/ft^3	=	71.14	4.420
Sensor station, X_T	=	412.60	1044.60
Percent ullage vol at ESC	=	1.581	1.535
Bubble vol, ft^3	=	40.00	58.25
Total tank vol pressurized, ft^3	=	19675.52	53153.32
Tank vol below sensor (vented), ft^3	=	19486.50	52525.86

TITLE

ET LOW LEVEL ARM/CUTOFF

PURPOSE

This SCP describes the operation of the ET LOW LEVEL SENSOR ARM CMD and subsequent shutdown of the SSME's through actuation of low-level cutoff sensors.

DESCRIPTION

The low-level cutoff sensors are used to shut down the SSME's before the propellant supply to the engines is depleted. Depletion of either propellant to a running engine will cause uncontained damage to engine components. To prevent a premature SSME shutdown caused by failed dry sensors, the low-level sensors are not armed until an arm command is received from guidance.

The ET LOW LEVEL SENSOR ARM CMD is initiated by the ascent second-stage guidance function or the powered RTLS guidance function. From either source, the ARM command is sent to the SSME's under one of the following conditions:

- A second SSME has failed
- The current calculated vehicle mass (M) becomes less than an I-loaded value (MASS LOW LEVEL)

The current calculated vehicle M is operating at all times. The low-level sensors will be armed even when manual throttle is selected.

This I-loaded value is selected to provide the orbiter with a TAL underspeed capability in case MECO should occur when the ARM command is received. This situation would happen if three LO_2 (or LH_2) level sensors had failed dry after lift-off.

There are four LO_2 low-level sensors located in the orbiter LO_2 feedline and four LH_2 low-level sensors located in the ET LH_2 tank. These sensors are located to ensure sufficient propellant between the sensors and the SSME pump inlets to prevent propellant depletion during engine shutdown. During flight, when the ET LOW LEVEL SENSOR ARM CMD is received, the SSME operations sequence (on the first pass only) monitors the eight low-level sensors for dry indications. The logic will cause the first dry LO_2 sensor and the first dry LH_2 sensors disable flag to be set. This will protect against using a sensor that fails dry after launch and before the arm command. On subsequent passes through the logic, the eight sensors are monitored for dry indications, commfault indications, or a disable flag. Sensors that have been disabled or commfaulted are disregarded.

If two or more of the LH_2 sensors (not previously disabled or commfaulted) indicate dry, the sequence issues a MECO command and the SSME's are shut down. If two or more LO_2 sensors (not previously disabled or commfaulted) indicate dry, one of the shutdown timers is started.

Timers are used with the LO_2 low-level sensors to delay the MECO command after two sensors are dry. This delay ensures maximum allowable consumption of LO_2 during engine shutdown while still preventing LO_2 depletion. The time between two sensors dry and LO_2 depletion at the SSME's is dependent upon LO_2 flow rate which is proportional to throttle setting. The time delay (timer) used for each mission leg is shown in table 4.4-I. Rationale for the timer selection follows.

TABLE 4.4.-I.- TIMER SELECTION RATIONALE

MSID	Mission leg	Shutdown power level (%)	Timer* (sec)
V97U9864C	RTLS	65/104	0.0
V97U9863C	Nominal	65	0.478
V97U9865C	PTM	91	0.0

* Timer values may vary from flight to flight. Refer to PASS I-loads for specific flight values.

For a two-engine RTLS with one stuck at 104 percent and one throttled to 65 percent before MECO, total throttle is 169 percent. Although the total throttle is less than a nominal MECO, the time delay will be shorter because the shutdown of an engine from 104 percent requires a higher NPSP. The shorter 0.0-second timer will provide a larger head of LO_2 and therefore a higher NPSP for the engine shutdown from 104 percent. All two-engine RTLS shutdowns will use the 0.0-second timer.

For the nominal case, when all three engines shut down from 65 percent, the 0.478-second timer is used. Although the total throttle for the nominal MECO (195 percent) is greater than the RTLS case (169 percent), the shutdown of all engines from 65 percent requires a lower NPSP and therefore a lower head of LO_2.

The two-engine PTM case (where the engines are throttled to 104 percent and both are shut down from 91 for a total of 182 percent) will use a timer setting of 0.0 seconds. The total throttle percentage is similar in all three situations, and the determining factor for the timer value is the NPSP required at shutdown.

After the shutdown timer expires, a MECO command is issued and the SSME's are shut down. Such a shutdown is known as an LO_2 low-level cutoff. MECO initiated by low-level sensors is a flight anomaly that generally produces a flight performance penalty. To reduce that penalty, the SSME's must be allowed to run as long as possible without depleting either propellant. The low-level sensor shutdown logic, as covered in this SCP, provides the boundary between propellant depletion and excessively early engine shutdown.

As with all systems, there are failures that can occur which can render a system ineffective, including the LLCO sensors. In the event that two (or more) avionic failures occur that result in the loss of LLCO protection with FDO predicting a LLCO, appropriate action must be taken to prevent a catastrophic, propellant depletion shutdown.

Table 4.4-II identifies 12 two-failure combinations that can result in the loss of LLCO protection.

TABLE 4.4-II.- TWO-FAILURE COMBINATIONS WHICH RESULT IN LLCO PROTECTION LOSS

Case number	Avionics failures
1	MDM FA 1 power fail and LLCO sensor 2 (or 3) failing dry prior to the arming mass (on the propellant side that will deplete before MECO)
2	MDM FA 1 power fail and MDM FA 2 power fail
3	MDM FA 1 power fail and MDM FA 2 commfaulted
4	MDM FA 1 power fail and MDM FA 4 power fail
5	MDM FA 1 power fail and MDM FA 4 commfaulted
6	MDM FA 2 power fail and MDM FA 4 power fail
7	Dual bus loss Main A (or ALC1) and Main B (or ALC2)
8	Dual bus loss Main B (or ALC2) and Main C (or ALC3)
9	Bus loss Main B (or ALC2) and MDM FA 1 power fail
10	Bus loss Main B (or ALC2) and MDM FA 4 power fail
11	Bus loss Main C (or ALC3) and MDM FA 1 power fail
12	Bus loss Main C (or ALC3) and MDM FA 2 power fail

In each of these cases, three of the four LLCO sensors on the LO2 and/or LH2 systems are affected. The failures in each of these cases is equivalent to having three LLCO sensors failed wet. Only one sensor in each system is operating properly to indicate when a propellant has been depleted to the emergency cutoff level. It should be noted that the 12 cases identified here are not the only cases that can result in the loss of LLCO protection, but they are the only two-failure combinations. There are many combinations of three or more avionic failures that can result in the loss of LLCO protection. For the purposes of this SCP, the 12 cases identified in table 4.4-II are used as examples; however, other three or more failure combinations, which are too numerous to specify here, could use the procedures outlined later in this SCP.

The flowchart in figure 4.4-I shows the decision process that could be implemented in the event this scenario arises. Five options have been identified as possible manual procedures to compensate for the loss of LLCO protection and are as follows:

1. Port Mode/Power Cycle/Restring/BFS engage
2. Bus Tie
3. Manual MECO based on time or velocity cue from FIDO
4. Abort TAL
5. Abort RTLS

Depending on the type of failures involved, only certain options may be available. Table 4.4-III identifies which of the 5 options are available for the 12 cases identified in table 4.4-II.

TABLE 4.4-III.- AVAILABLE OPTIONS FOR LLCO PROTECTION LOSS

	Cases											
Options	1	2	3	4	5	6	7	8	9	10	11	12
1. PM/PC/R/BFS	X	X	X	X	X	X			X	X	X	X
2. Bus tie							X	X	X	X	X	X
3. Manual MECO	X	X	X	X	X	X	X	X	X	X	X	X
4. TAL	X	X	X	X	X	X	X	X	X	X	X	X
5. RTLS							X	X				

Depending on the avionics failures involved, the options identified in table 4.4-III may be available for the particular case. The following paragraphs discuss which options are available for various avionics failures.

1. MDM down at the GPC - A port mode could possibly recover an MDM that is down at the GPC. However, if a port mode is unsuccessful or could not be attempted for some reason, and if LLCO protection is defined as a critical capability for this scenario, then Flight Rule 2-23(E) calls for a restring. If a restring is not possible due to high g-levels or the crew being instructed not to restring, for example, a BFS engage will recover the commfaulted MDM's. If this is the appropriate action to take, then two good sensors will be operating after completion of the port mode, restring, or BFS engaged. The port mode/restring/BFS engage option is only available for case numbers 3 and 5.

   MDM down at the MDM - If an MDM is down at the MDM, the following actions can be attempted to regain the MDM: (1) I/O reset, (2) port moding, and/or (3) power cycling. If this is the appropriate action to take, then at least three good sensors will be operating after actions are taken against the affected MDM's. All cases, except for numbers 7 and 8, have this option.

2. Bus tie - Since it takes two buses to lose LLCO protection, a bus tie of just one of the down buses to the remaining good bus regains LLCO protection, assuming at least one of the faulty buses is an unshorted main bus. If subbuses are the cause of the loss of LLCO protection, then a main bus tie would not be effective. It is not necessary to tie all three buses together to regain LLCO protection. If this is the appropriate action to take, then three good sensors will be operating after completion of the bus tie. Bus ties can be used for cases 7 through 12 only if the faulty buses are not shorted.

3. Manual MECO - If a time or velocity cue can be identified as to when the LLCO will occur, then this value can be passed onto the crew. This method is desirable because the crew has an onboard cue they could use to initiate a safe shutdown of the running engines. Inaccuracies associated with the ARD predictions can lead to a MECO earlier than actually required, or worse, a MECO time/velocity cue that would not be reached until after propellant depletion. A velocity cue is normally preferred over a time cue since the MECO time can change (due to throttling, for example), but the velocity at which propellant depletion occurs does not change. All cases have this as an option.

4. Abort TAL - The TAL option provides the earliest MECO time/velocity which a safe shutdown of all running engines, and good probability of intact capability, can occur. In most cases, the TAL cutoff time/velocity will be reached prior to a cutoff initiated by the LLCO sensors going dry. This option is only used if uphill/orbital capability is lost. Flight Rule 2-11(A) identifies the TAL abort as the next option since it provides the earliest contingency avoidance capability. All cases have this as an option.

5. Abort RTLS - The abort RTLS options is only valid if two main buses fail prior to MET 3:40, in which case an RTLS is initiated for systems requirements, and not for the loss of LLCO protection. The RTLS abort for two main buses is specified in Flight Rule 2-13 (A6), and is also specified in the Ascent Checklist Flight Data File. If the loss of LLCO protection is due to main bus problems, then cases 7 and 8 are valid for this option.

REFERENCES

1. Space Shuttle Operational Flight Rules, All Flights, final, Jan. 20, 1989.

2. Data Processing System Principles and Interfaces, DPS PRINC 2102, MOD, Training Division, Nov. 1987.

3. Electrical Power System, EPS 2102, MOD, Training Division, Aug. 1990.

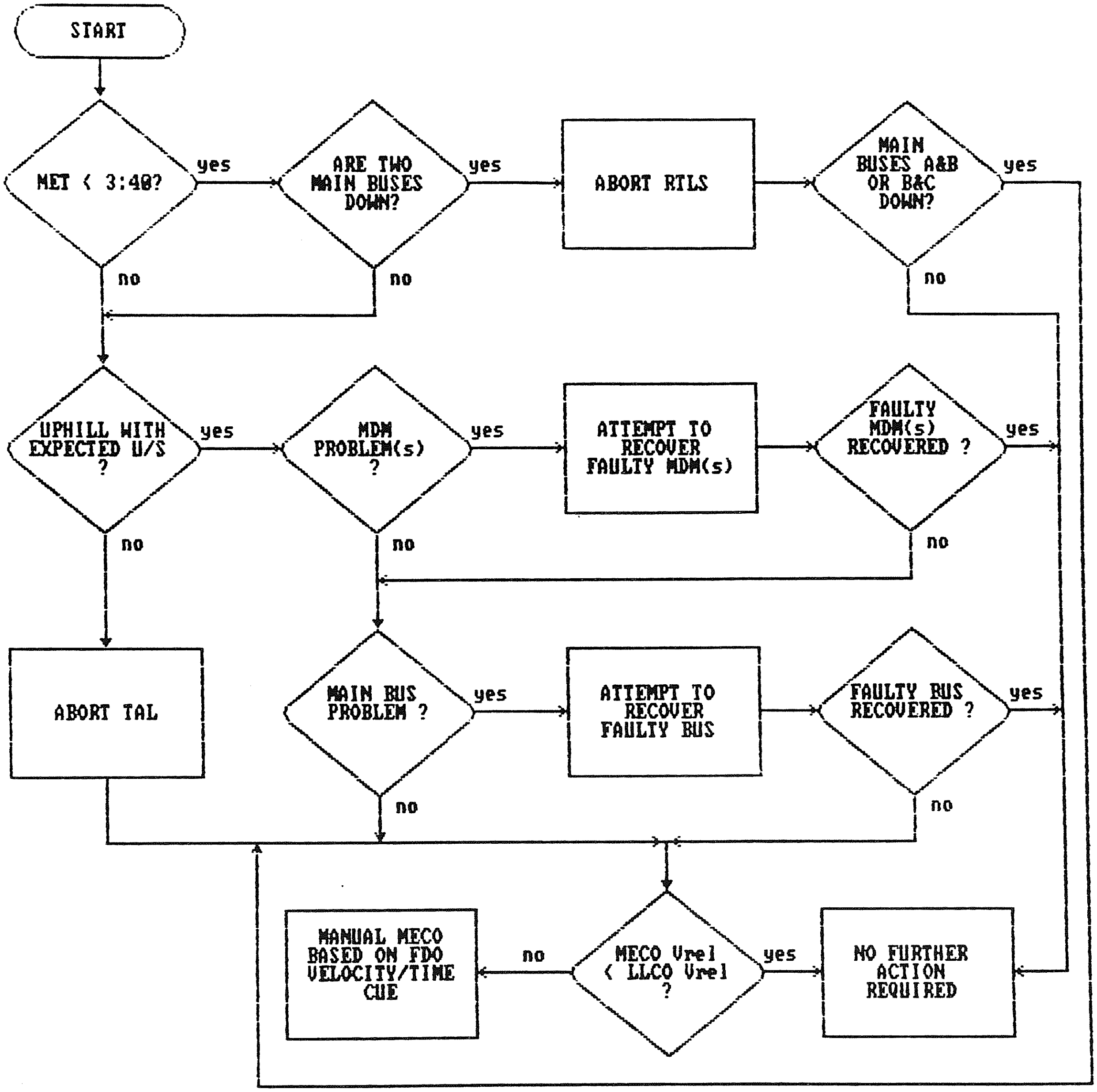


Figure 4.4-I.- Regaining LLCO protection flowchart.

TITLE

MDM/POWER LOSS MATRIX

PURPOSE

This SCP uses a matrix format to track equipment function and instrumentation losses resulting from single and dual MDM or bus failures.

PROCEDURES

Six failure modes are covered by this SCP. General purpose computer (GPC) and string failures are covered in table 4.5-I. Single MDM failures which cause equipment losses are listed in table 4.5-II. Equipment losses resulting from single power bus failures are listed in table 4.5-III. Dual bus failure effects and single bus failure effects are covered in table 4.5-IV. Equipment losses resulting from an MDM failure, a bus failure, and dual MDM failures, are also covered by table 4.5-IV. Parameter vs. signal conditioner (SC) card loss are listed in table 4.5-V. GPC and bus failures which affect the main engines are covered in figures 4.5-IV and 4.5-V. A discussion of how to use each of the five tables and figures 4.5-IV and 4.5-V follows.

A. Single GPC or String Loss Matrix (table 4.5-I)

This matrix indicates those flight critical MDM's and engine interface unit (EIU) multiplexer interface assembly (MIA) ports which become inoperative due to a single GPC or flight critical data/command bus failure. Since port moding on MDM's is not approved for OPS 1, 3, and 6, only those flight critical bus failures which affect the primary MDM ports are presented in this table. An X placed in the appropriate row and column will indicate those MDM's and EIU MIA's which are lost due to a corresponding GPC, string, or data/command bus failure. A GPC or string failure will result in a loss of all data/command buses, MDM's, and EIU ports associated with that GPC or string. It should be noted that string reassignment will recover those MDM's and MIA's lost due to a GPC failure, but the decision to restring is a real-time decision and will not be discussed by this SCP. Table 4.5-I should be used in conjunction with tables 4.5-II and 4.5-IV to determine the equipment lost due to an MDM failure. Certain FC data and command buses send commands to and receive data from the EIU MIA's. The commands that pass through MIA's 3 and 4 pass through a first in/first out buffer. Only one of these commands will get to the main engine controller. An "X" in the EIU column of the cue card shows which MIA will be affected for each GPC/FC bus failure. The arrows show whether both commands and data are lost from that MIA, or whether only commands, or only data, are lost to that MIA. Command path failures and data path failures occur only after dual GPC/FC bus failures. These dual failures are covered in figures 4.5-IV and 4.5-V.

Note: If a flight critical (FC) MDM fails at the GPC, then the associated FC bus is also lost. If a FC MDM fails at the MDM, then only the MDM is lost.

B. Losses Due to a Single MDM Failure (table 4.5-II)

Listed in table 4.5-II are those functions and telemetry lost due to a single flight critical MDM or operational MDM failure. This table provides a quick reference and can be used instead of table 4.5-IV. figure 2.2.10-I is used as the console cue card for telemetry lost due to a single MDM.

C. Equipment Lost Due to a Single Bus Failure (table 4.5-III)

Listed in this table are those sub-buses, functions, and telemetry lost due to a single power bus failure. This table provides a quick reference and can be used instead of table 4.5-IV for single bus failures. The buses in this table are listed to indicate the hierarchy of each family of buses. For example, the loss of VMNA APC4 will mean that all functions and telemetry listed under the sub-buses VMNA ALC1 and VMNA APC1 will also be lost. This hierarchy is indicated by an arrow in the sub-bus lost column. Figure 4.5-I is used as the console cue card for functions and telemetry lost due to a single main bus loss.

D. Single and Dual MDM and Bus Loss Matrix (table 4.5-IV)

Single and dual power bus failure effects are covered by this matrix. Single MDM failures and combinations of single MDM and single bus failures are also presented in this matrix. The procedure for each failure mode is described below. A list of the notes used for this matrix is provided at the end of this procedure. The power buses in this matrix are listed in order of their hierarchy. Each sub-bus is indented below its parent bus. The failure of a parent bus will cause the loss of its sub-buses and their related equipment functions. For example, a failure of VMNA APC4 will result in the loss of ALC1, APC1, and APC1's sub-buses VMNA/C R SRB and L SRB. The functions powered by these buses will be lost. The fuel cells (FC's) that supply power to the main buses are also listed in this matrix. the loss of FC 1, FC 2, or FC 3 will result in the loss of VMNA, VMNB, or VMNC respectively and their associated sub-buses and functions.

1. Single Bus Failure

Those functions that are lost due to a single bus failure are indicated by an X in the appropriate row and column.

2. Dual Bus Failures

In many cases two bus failures are required to cause the loss of a function. To cover two failure cases an alphabetic code has been devised. The code only applies to the vertical column under the function being considered. If a letter such as "A" appears by a failed bus it will indicate to the operator that the function under which it appears is now only single-fault tolerant. If a subsequent bus is lost with the same letter "A" by it and under the same function as the previous bus failure, then that function will be lost. The same letter might appear more than twice in a given column, but this only means that there is more than one combination of failures that will cause the loss of that particular function. For example, under the GPC CL column for the LO_2 OVB BLV valve an "A" appears by VMNB APC2 and VMNC APC3. A failure of one of these buses will not affect the valve operation, but the failure of both buses will cause the valve to fail open during ascent as indicated by note 3.

3. Single MDM Failure

Those functions that are lost due to a single flight critical or operational MDM are indicated by an X in the appropriate row and column.

4. Single MDM and Single Bus Failure Combinations

The FA MDM's are the only MDM's identified that can fail and leave some functions vulnerable to a subsequent power failure. All other MDM failures covered by table 4.5.-IV are single-point failures. The FA MDM's and power bus failure combinations are identified by a numerical code. The numbers 1,2,3,4 are assigned to FA 1, FA 2, FA 3, and FA 4 respectively. If a number appears next to a bus, this indicates that a failure combination of that bus and the corresponding FA MDM is required to lose the function under which that number appears. The same number may appear more than twice in a given column but this only means that there is more than one FA MDM and bus failure combination which will lose the function under which that number appears. For example, under the GPC CL column for the LO_2 FD RLF ISO valve, the number 1 can be found in the rows marked FA 1 and VMNA MPC1. This situation implies that both FA 1 and VMNA MPC1 must fail to cause the valve to fail open as indicated by note 3.

5. Console Cue Card

Figure 4.5-II is used as the console cue card. This figure has many of the same failures in a format that is easier to use in real-time.

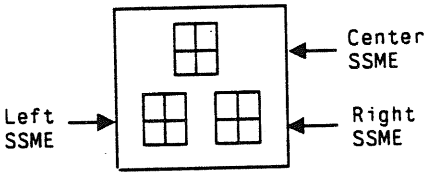
E. Parameter vs. Signal Conditioner Card Loss (table 4.5-V)

Listed in table 4.5-V are those functions and telemetry lost due to failure of a single dedicated signal conditioner (DSC) or card channel. The MDM through which the lost telemetry flows is also listed.

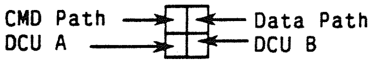
F. SSME Single and Dual GPC and Bus Loss Matrix (figure 4.5-V)

To help in determining those SSME functions and interfaces that are lost because of GPC and bus failures, the attached cue card has been generated (figure 4.5-V). Figure 4.5-III is used as the Main Engine control/function loss console cue card. Figure 4.5-IV shows the command and data paths for each SSME and is the prime SSME cue card.

Each large square depicts the three SSME's



Each small square depicts a single SSME and is divided into four areas. The four areas represent command path, data path, DCU A, and DCU B.




- Indicates one of the three CMD paths is lost. CMD capability to SSME is still possible.


- Indicates two or more CMD paths are lost. CMD capability to SSME is lost (command path failure).


- Indicates command capability may be lost. The deciding factor is which command gets to FIFO buffer first.


- Indicates data from the SSME has been lost.


- Indicates secondary data path from the SSME has been lost.


- Indicates data from the SSME has been lost (data path failure).


- Indicates DCU A has been lost and the SSME is operating on DCU B.


- Indicates DCU B has been lost, and the SSME is operating on DCU A.


- Indicates DCU A and B are lost and the SSME will shut down.

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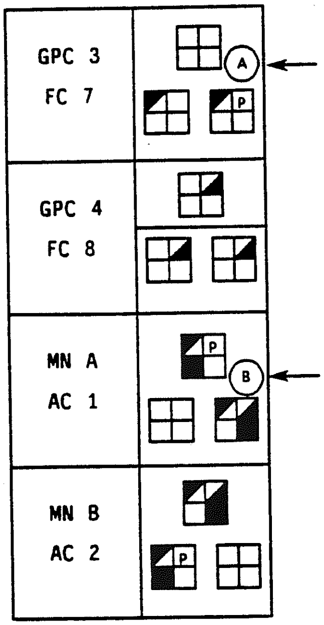
The second column of the cue card shows those functions lost for the single failures shown in column one.

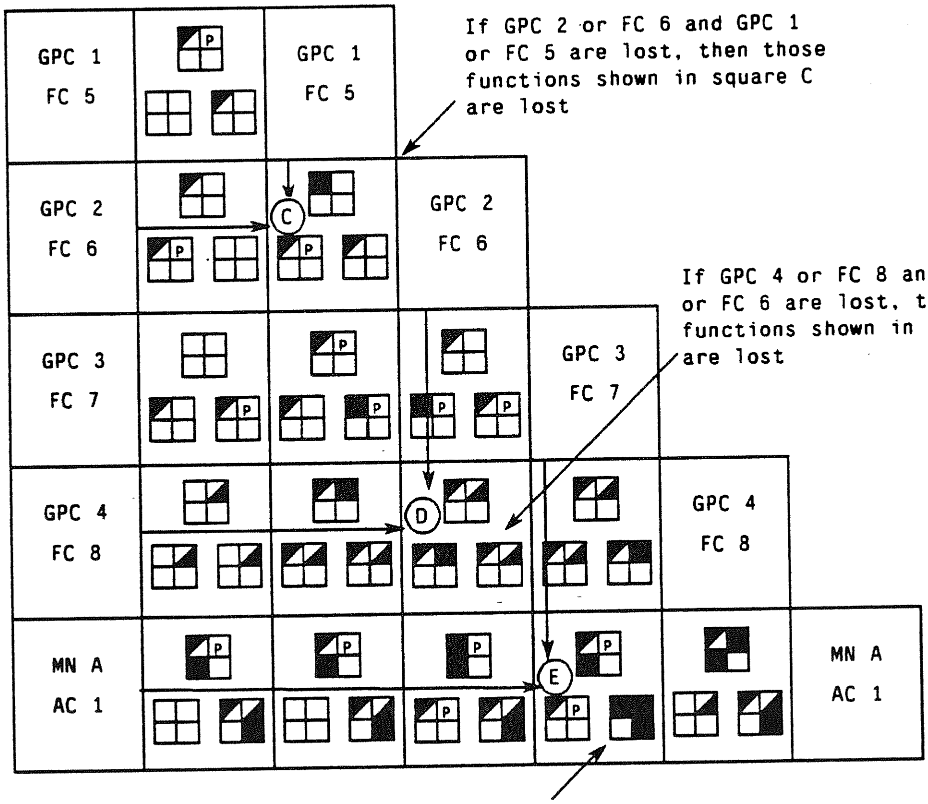


If GPC 3 or FC 7 is lost, then those functions shown in square A are lost

If MNA or AC 1 is lost, then those functions shown in square B are lost

17239*014

If dual failures occur, the functions lost will be shown at the intersection of a failure listed in column 1 with the second failure listed at the top of columns 3, 4, 5, 6, 7 or 8.



If GPC 2 or FC 6 and GPC 1 or FC 5 are lost, then those functions shown in square C are lost

If GPC 4 or FC 8 and GPC 2 or FC 6 are lost, then those functions shown in square D are lost

If MN A or AC 1 and GPC 3 or FC 7 are lost, then those functions shown in square E are lost

17239*015

TABLE 4.5-1.- SINGLE GPC OR STRING LOSS MATRIX

GPC	STRING (ASCENT ONLY)	FC DATA AND CMD BUS	MDM								EIU												
												LEFT				CENTER				RIGHT			
			FA1	FA2	FA3	FA4	FF1	FF2	FF3	FF4	MIA	1	2	3	4	1	2	3	4	1	2	3	4
											CMD	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
											DATA	↓			↓	↓			↓	↓			↓
1	1	1					☒																
		5	☒											☒		☒					☒		
2	2	2						☒															
		6		☒								☒					☒					☒	
3	3	3							☒														
		7			☒								☒					☒		☒			
4	4	4								☒													
		8				☒									☒				☒				☒

FOR USE DURING OPS 1,3,6

01511.ART,12

The following list tabulates those notes used in tables 4.5-II through 4.5-V.

Notes:

① Fails to last position.

② Fails closed.

③ Fails open.

④ Fails wet.

⑤ Two of four sensors required.

⑥ If ullage pressure sensor fails high and control bus fails, the ullage pressure valve will remain closed.

⑦ Loss of power to talkback will result in the talkback indicating closed.

⑧ If DCU A and DCU B are lost the SSME will shut down pneumatically.

⑨ Loss of DCU will result in loss of its data and an automatic switchover to the remaining DCU.

⑩ PASS switch RM logic (3 CMD switch):

No. CMD's lost	No. CMD's req'd.
0	2
1	2
2	1

BFS logic requires two of the two commands for the switch to operate, regardless of MDM status.

⑪ PASS switch RM logic (2 CMD switch):

No. CMD's lost	No. CMD's req'd.
0	2
1	1

BFS logic requires two of the two commands for the switch to operate, regardless of MDM status.

⑫ Refer to SCP 2.2.10 for activity to be taken in response to loss.

⑬ Control buses are only used in manual mode.

⑭ MDM failure will cause loss of TM in the GPC mode but not in the manual mode.

⑮ For MDM failures, if one of the three SRB Pc signals is lost, the average of the remaining two is used in the SRB SEP sequence. If two signals are lost, the remaining PC is used in the SEP sequence.

⑯ STS-1: If one of the two pushbutton contacts fails to the energized state (pushbutton not depressed), and the complementary MDM fails, the engine will be shut down.

STS-2 and subsequent: If one of the two pushbutton contacts fails to the energized state, and the complementary MDM fails, RM switch processing logic disqualifies the switch. The engine will not be shut down and cannot be shut down via the pushbutton; the power switches must be used.

⑰ Loss of power to the switching valve microswitch will cause a false indication that the switching valve has moved to the backup HPU position. Hydraulic pressure may be used as a possible secondary indication that switching has occurred.

⑱ Main engine status light power can be recovered by selecting the backup power on panel O6.

- Loss of MNA O14 and A8 (left engine status lights) - crew should select annunciator bus select ACA 1 - MNB
- Loss of MNB O15 and A8 (center and right engine status lights) - crew should select annunciator bus select ACA 2/3 - MNC

TABLE 4.5-II.- MDM/PWR LOSS

MDM Lost	Function Lost		Telemetry Lost	
	Description	MSID	Description	MSID
FA 01	C GH_2 press SOV; sensor power (auto CL CMD); 3			
	C GO_2 press SOV; sensor power (auto CL CMD); 3	V41K0075X		
	LO_2 left no. 1 ECO sensor PWR; 4			
	LO_2 right no. 1 ECO sensor (lost input to GPC)		LO_2 RIGHT NO. 1 ECO SENSOR	V41X1558X
	POGO RECRC valve 1; CLOSE CMD A; 3	V41K1815X		
	Replace LO_2 ULL press no. 1 XDCR;	V41K1750X	C LO_2 ULL P C LO_2 IN P	T41P1750C V41P1130C
	LH_2 IB F/D VLV; close CMD; 1	V41K1412X	C LO_2 IN T C LO_2 PV OP	V41T1131C V41X1134X
	LO_2 IB F/D VLV; open CMD A; 1		C LH_2 PV OP LH_2 IB F/D V CL	V41X1104X V41X1410X
	LH_2 top VLV; open command; 2	V41K1411X	LH_2 TOP VLV CL	V41X1456X
	LH_2 MANF repress VLV 1; open CMD; 2	V41K1435X		
	LH_2 cutoff sensor 1; power; 4			
	LH_2 cutoff sensor 4 (lost input to GPC);		LH_2 ECO SEN 4	T41X1733X
	Caution and warning		C LH_2 IN P; LH_2 ENG MANF P; 12 LH_2 ULL P C; 12	V41P1100C V41P1433C T41P1700C
	Replace LH_2 ULL press no. 1, XDCR;	V41K1700K		
	C,AVG SSME LH_2 NPSP COMP		C NPSP COMP AVG NPSP COMP	M01G3111C M04G3111C

TABLE 4.5-II.- Continued

MDM Lost	Function Lost		Telemetry Lost	
	Description	MSID	Description	MSID
FA 01 (cont)	C He TK decay rate COMP;		C He TK decay rate COMP;	M01G3800C
	C He TOD COMP;		C He TOD COMP;	M05G3800T
	C He L + PN TOD COMP;		C He L + PN TOD COMP;	M09G3800T
	C He U + PN TOD COMP;		C He U + PN TOD COMP;	M12G3800T
	C He ISO VLV A; GPC open CMD; 2	V41K1155X		
	PNEU He ISO VLV 1; open CMD; 2	V41K1607X		
	C He interconnect out VLV; GPC open CMD; 2	V41K1168X		
	C He TK change rate		C He TK P ⑫ C He TK CHG RT	V41P1150C V98P4997C
	L SRB PC 1		L SRB PC 1 ⑫	B47P1300C
	R SRB PC 1		R SRB PC 1 ⑫	B47P2300C
FA 02	LO_2 IB F/D CL CMD; 1	V41K1523X	L LO_2 PV OP LO_2 IB F/D V CL	V41X1234X V41X1509X
	SIG CON PWR NO. 2 ON CMD; fails off;	V41K0076X	LO_2 feed DISC V CL A	V41X1530X
	L GO_2 press FCV; auto close CMD; sensor POWER: 3	V41K0076X	LO_2 OB bleed V CL B	V41X1581X
	LO_2 left NO. 2 ECO sensor; PWR; 4	V41K0076X	LO_2 L C/O no. 2 SENSOR	V41X1556X
	Left GH_2 press FCV; auto close CMD; sensor PWR; 3	V41K0076X		
	LH_2 ECO sensor 2; PWR; 4	V41K0076X	LH_2 C/O SEN 2	T41X1731X
	POGO RCRC VLV 2; GPC CL CMD A; 3	V41K1825X	LO_2 ENG MANF P ⑫ L LO_2 ULL P	V41P1533C T41P1751C

TABLE 4.5-II.- Continued

MDM Lost	Function Lost		Telemetry Lost	
	Description	MSID	Description	MSID
FA 02 (cont)	LH_2 OB F/D OP CMD; 1	V41K1391X	L LO_2 IN P	V41P1230C
	LH_2 OB F/D CL CMD;1	V41K1393X	L LO_2 IN T	V41T1231C
	LH_2 IB F/D open CMD;1	V41K1401X	L LH_2 PV OP A	V41X1204X
	LH_2 MANF repress No. 2; open CMD; 2	V41K1437X	L LH_2 ULL P; 12	T41P1701C
	L SSME LH_2 NPSP COMP;		L NPSP COMP	M02G3111C
	AVG SSME LH_2 NPSP COMP;		AVG NPSP COMP	M04G3111C
	L He TK decay rate COMP;		L He TK P 12 L He DECAY RATE	V41P1250C M02G3800C
	L He TK change rate COMP;		L He TK CHG RT;	V98P4998C
	L He TOD COMP;		L He TOD COMP	M06G3800T
	L He L + PN TOD COMP;		L He L + PN TOD COMP	M10G3800T
	L He U + PN TOD COMP;		L He U + PN TOD COMP	M13G3800T
	L He ISO VLV A; open CMD; 2	V41K1255X	L LH_2 IN P	V41P1200C
	L He X-OVER VLV; open CMD; 2	V41K1613X	L LH_2 IN T	V41T1201C
	L He INTCON OUT/OP; open CMD; 2		L LH_2 OB F/D V CL	V41X1389X
	L SRB PC 2;		L SRB PC2; 12	B47P1301C
	R SRB PC 2;		R SRB PC2; 12	B47P2301C

TABLE 4.5-II.- Continued

MDM Lost	Function Lost		Telemetry Lost	
	Description	MSID	Description	MSID
FA 03	LO_2 MANF repress no. 1 open CMD; 2	V41K1535X	LO_2 OB F/D VLV CL;	V41X1514X
	POGO RCRC VLV 1 CL CMD B; 3	V41K1816X	LO_2 OVB bleed VLV CL A;	V41X1580X
			POGO RECRC VLV 1 OPEN;	V41X1811X
			LO_2 feedline DISC VLV CL B;	V41X1534X
			LO_2 left #1 ENG C/O sensor;	V41X1555X
			R LO_2 ULL P	T41P1752C
			R LO_2 INLET P;	V41P1330C
			R LO_2 INLET T;	V41T1331C
	LH_2 IB F/D V; open CMD B; 1	V41K1402X	LH_2 ENG L/O SENSOR NO. 1	T41X1730X
			RTLS OUTBD D/V closed;	V41X1919X
			C LH_2 PRE VLV OPEN B;	V41X1106X
			R LH_2 PRE VLV OPEN B;	V41X1306X
			R LH_2 IN P	V41P1300C
			R LH_2 IN T	V41T1301C
			R LH_2 ULL P	T41P1702C
	R LH_2 NPSP COMP;		R LH_2 NPSP COMP;	M03G3111C
	AVG LH_2 NPSP COMP;		AVG LH_2 NPSP COMP	M04G3111C
			R He TK P; ⑫	V41P1350C
	R He TK CHG COMP;		R He TK CHG RT;	V98P4999C

TABLE 4.5-II.- Continued

MDM Lost	Function Lost		Telemetry Lost	
	Description	MSID	Description	MSID
FA 03 (cont)	R He TK decay rate COMP;		R He TK decay rate;	M03G3800C
	R He TOD COMP;		R He TOD COMP;	M07G3800T
	R U + PN He TOD COMP;		R U + PN He TOD COMP;	M14G3800T
	R L + PN He TOD COMP;		R L + PN He TOD COMP;	M11G3800T
	R He ISO VLV A open CMD; 2	V41K1355X		
	He blowdown #1 open CMD; 2	V41K1631X		
	L SRB PC 3		L SRB PC 3 ⑫	B47P1302C
	R SRB PC 3		R SRB PC 3 ⑫	B47P2302C
FA 04	LO_2 MANF repress no. 2 open CMD; 2	V41K1537X	R LO_2 PV OP	V41X1334X
	R GO_2 press FCV; auto close CMD; sensor PWR;	V41K0077X		
	R LO_2 ULL P; SENSOR PWR;			
	LO_2 ENG C/O RIGHT no. 2 sensor power; 4	V41K0077X	LO_2 ENG C/O right no. 2 sensor;	V41X1557X
	POGO RECRC VLV 2; GPC close CMD B; 3	V41K1826X	POGO RECRC VLV no. 2 open;	V41X1821X
	LO_2 IB F/D VLV open COMP B; 1	V41K1502X		
	LO_2 OB F/D VLV open COMP; 1	V41K1518X		
	LO_2 OB F/D VLV close CMD; 1	V41K1515X		
	R GH_2 PRESS FCV; auto close CMD; sensor PWR; 3	V41K0077X	RTLS IB dump VLV CL; LO_2 FD DISC V OP A; LH_2 FD DISC V CL B; R LH_2 PV OP A	V41X1929X V41X1529X V41X1434X V41X1304X
	LH_2 RECRC DISC close CMD; 1	V41K1422X		
	LH_2 RECRC DISC open CMD; 1	V41K1421X		

TABLE 4.5-II.- Continued

MDM Lost	Function Lost		Telemetry Lost	
	Description	MSID	Description	MSID
FA 04 (cont)	LH_2 ENG L/O SENS no. 3; sensor PWR; 4		LH_2 ENG C/O SENS #3;	T41X1732X
	R LH_2 ULL P; sensor PWR;			
	PNEUM He ISO VLV no. 2 open CMD; 2	V41K1608X		
	R He interconnect out/open; open CMD; 2	V41K1368X		
	He blowdown VLV no. 2 open CMD; 2	V41K1633X		
FF 01	C SSME shutdown CMD A;	V72K0091X	C SSME status/amber light;	V72X0035X
	MPS PRPLT dump SEQ start A;	V72K0081X	C SSME status/red light;	X72X0030X
	MPS PRPLT dump SEQ stop A;	V72K0083X	C press PC meter; panel F7;	V72P0040C
FF 02	C SSME shutdown CMD B;	V72K0092X	L SSME status/amber light;	V72X0036X
	L SSME shutdown CMD A;	V72K0093X	L SSME status/red light;	V72X0031X
	SSME limit control enable CMD A	V72K0051X	L PRESS PC meter; panel F7;	V72P0041C
	SSME limit control inhibit CMD A	V72K0061X		
	SSME limit control auto CMD A	V72K0071X		
	MPS PRPLT dump SEQ start B;	V72K0082X		
	MPS PRPLT dump SEQ stop B;	V72K0084X		

TABLE 4.5-II.- Continued

MDM Lost	Function Lost		Telemetry Lost	
	Description	MSID	Description	MSID
FF 03	R SSME shutdown CMD A;	V72K0095X	R SSME status/amber light;	V72X0037X
	L SSME shutdown CMD B;	V72K0094X	R SSME status/red light;	V72X0032X
	SSME limit control enable CMD B	V72K0052X	R press PC meter; panel F7;	V72P0042C
	SSME limit control inhibit CMD B	V72K0062X		
	SSME limit control auto CMD B	V72K0072X		
	BKUP LH$_2$ dump VLV open A	V72K0085X		
	BKUP LH$_2$ dump VLV CL A	V72K0087X		
FF 04	R SSME shutdown CMD B;	V72K0096		
	SSME limit control enable CMD C	V72K0053X		
	SSME limit control inhibit CMD C	V72K0063X		
	SSME limit control auto CMD C	V72K0073X		
	BKUP LH$_2$ dump VLV open B;	V72K0086X		
	BKUP LH$_2$ dump VLV close B;	V72K0088X		
LL 02			L FSM A P ⑫	B46P1305C
			L FSM B P ⑫	B46P1306C
			L HYD SUP A P ⑫	B58P1303C
			L HYD SUP B P ⑫	B48P1304C

TABLE 4.5-II.- Continued

MDM Lost	Function Lost		Telemetry Lost	
	Description	MSID	Description	MSID
LR 02			R FSM A P ⑫	B46P2305C
			R FSM B P ⑫	B46P2306C
			R HYD SUP A P ⑫	B58P2303C
			R HYD SUP B P ⑫	B48P2304C

TABLE 4.5-II.- Continued

MDM lost	Function lost	Telemetry lost	Parameter no.
OA 01		R LO2 PV CL	V41X1335E
		LO2 FDLN RLF ISOV OP	V41X1541E
		LO2 FDLN RLF ISOV CL	V41X1542E
		POGO RECRC V 1 CL	V41X1818E
		GO2 P SOV C CL P	V41X1596E
	Backup C SSME OUT determ	C GO2 OUT T	V41T1171A
		GO2 DISC P	V41P1590A
		R LH2 PV CL	V41X1305E
		LH2 IB F/D V OP	V41X1409E
		LH2 HI PNT BLD OP	V41X1468E
		LH2 HI PNT BLD CL	V41X1469E
		RTLS IB DMP V OP	V41X1927E
		RTLS OB DMP V OP	V41X1917E
		LH2 RTLS MANF REPR 2 OP	V41X1902E
		GH2 P SOV C CL P	V41X1661E
		LH2 TK P HI FLOW ON	V41S1477E
		LH2 5 PCT LIQ LVL	T41X1712E
		LH2 VNT V OP	T41X1727E
		LH2 VNT V CL	T41X1724E
	Backup C SSME OUT determ	C GH2 OUT P	V41P1160A
	Backup C SSME OUT determ	C GH2 OUT T	V41T1161A
		C HE ISOL A OP PWR	V41X1158E
		R HE ISOL B OP PWR	V41X1359E
		PNEU HE ISOL 1 OP PWR	V41X1645E
		R HE INTCN IN PWR	V41X1364E
		C HE INTCN OUT PWR	V41X1170E
		HE BLDN 1 PWR	V41X1632E
		HE BLDN 2 PWR	V41X1634E
	PNEU HE MASS calculation	PNEU HE TK P ⑫	V41P1600A
		PNEU HE REG P ⑫	V41P1605A
	C HE Mass calculation	C HE MID TK T	V41T1152A
	R HE Mass calculation	R HE AFT TK T	V41T1351A
	PNEU HE Mass calculation	PNEU HE TK T	V41T1601A
		C CNTLR INT AUTO HTR	E41S0195E
	Class 3 Alert	C HE REG P B ⑫	V41P1153A
	Class 3 Alert	L HE REG P B ⑫	V41P1253A
	Class 3 Alert	R HE REG P B ⑫	V41P1353A

TABLE 4.5-II.- Continued

MDM lost	Function lost	Telemetry lost	Parameter no.
OA 02		C LO2 PV CL	V41X1135E
		LO2 IB F/D V OP	V41X1510E
		LO2 OVBD BLV OP	V41X1587E
		POGO RECRC V 2 CL	V41X1828E
		GO2 P SOV L CL P	V41X1598E
		ET TUMBLE ARMED	T56X0002E
		LO2 5 PCT LIQ LVL	T41X1762E
	Backup L SSME OUT determ	L GO2 OUT T	V41T1271A
		C LH2 PV CL	V41X1105E
		LH2 OB F/D V OP	V41X1388E
		LH2 MANIF PRESS 1 OP ⑫	V41X1436E
		LH2 MANIF PRESS 2 OP ⑫	V41X1438E
		GH2 P SOV L CL P	V41X1662E
		GH2 DISC P	V41P1490A
	Backup L SSME OUT determ	L GH2 OUT P	V41P1260A
	Backup L SSME OUT determ	L GH2 OUT T	V41T1261A
		PNEU ACC P	V41P1650A
		L HE ISOL A OP PWR	V41X1258E
		C HE ISOL B OP PWR	V41X1159E
		PNEU HE ISOL 2 OP	V41X1646E
		C HE INTCN IN PWR	V41X1164E
		L HE INTCN OUT PWR	V41X1270E
	C HE Mass calculation	C HE AFT TK T	V41T1151A
	L HE Mass calculation	L HE MID TK T	V41T1252A
		L CNTLR INT AUTO HTR	E41S0295E
OA 03		L LO2 PV CL	V41X1235E
		LO2 OB F/D V OP	V41X1513E
		LO2 MANF PRESS 1 OP ⑫	V41X1538E
		LO2 MANF PRESS 2 OP ⑫	V41X1539E
		GO2 P SOV R CL P	V41X1603E
		LO2 VNT V CL	T41X1774E
	Backup R SSME OUT determ	R GO2 OUT T	V41T1371A
		L LH2 PV CL	V41X1205E
		H2 PRESS LN VNT OP	V41S1493E
		LH2 FDLN RLF ISOL OP	V41X1441E
		LH2 FDLN RLF ISOL CL	V41X1442E

TABLE 4.5-II.- Concluded

MDM lost	Function lost	Telemetry lost	Parameter no.
OA 03 (cont)		LH2 RECIRC DISC V OP	V41X1419E
		LH2 RECIRC DISC V CL	V41X1420E
		RTLS MANF REPR 1 PWR	V41X1901E
		GH2 P SOV R CL P	V41X1663E
	Backup R SSME OUT determ	R GH2 OUT P	V41P1360A
	Backup R SSME OUT determ	R GH2 OUT T	V41T1361A
		L HE ISOL B OP PWR	V41X1259E
		R HE ISOL A OP PWR	V41X1358E
		L HE XOVR OP PWR	V41X1614E
		L HE INTCN IN PWR	V41X1264E
		R HE INTCN OUT PWR	V41X1370E
	L HE Mass calculation	L HE AFT TK T	V41T1251A
	R HE Mass calculation	R HE MID TK T	V41T1352A
		R CNTLR INT AUTO HTR	E41S0395E
OF 1		C HE REG PRESS A	V41P1154A
		L HE REG PRESS A	V41P1254A
		R HE REG PRESS A	V41P1354A
		C ENG PWR AC1	E41S0192E
		L ENG PWR AC3	E41S0293E
OF 2		C ENG PWR AC2	E41S0193E
		R ENG PWR AC3	E41S0392E
OF 3		L ENG PWR AC2	E41S0292E
		R ENG PWR AC1	E41S0393E

TABLE 4.5-III.- EQUIPMENT LOST DUE TO A SINGLE BUS FAILURE

Fuel Cell lost	Bus lost	Sub-bus lost	Function lost	Telemetry lost	Parameter no.
FC 1	VMNA APC4		MAIN PROPULSION SYSTEM ENGINE CNTLR HTR CTR fails off		
		VMNA ALC1	GO2 P SOV C fails open	LO2 FDLN RLF ISOV OP	V41X1541E
			LO2 ULL P C fails low	C LO2 PV OP	V41X1134X
			LO2 CO SEN 1 fails wet	R LO2 PV CL	V41X1335E
			LO2 POGO RECRC V1 fails open	LO2 ULL P C	T41P1750C
				LO2 POGO RECRC V1 OP	V41X1811X
			LH2 IB F/D V man and GPC open cap	C LH2 PV OP A	V41X1104X
			LH2 IB F/D V man and GPC close cap	R LH2 PV CL	V41X1305X
				LH2 IB F/D V OP	V41X1409X
			LH TOP V man and GPC open cap	LH2 IB F/D V CL	V41X1410X
			C GH2 P SOV fails open	LH2 TOP V CL	V41X1456X
			LH2 C/O SEN 1 fails wet	LH2 ULL P C ⑫	T41P1700C
				LH2 VNT V OP	T41X1727E
				LH2 VNT V CL	T41X1724E
			C HE ISOL VLV A fails closed (no GPC or man open cap)		
			C HE INTN OUT VLV fails closed (no GPC or man open cap)		
			PNEU HE ISOL VLV 1 fails closed (no GPC or man open cap)		
			HE BLDN VLV 1 and 2 fail closed		
		VMNA ALC1			

TABLE 4.5-III.- Continued

Fuel Cell lost	Bus lost	Sub-bus lost	Function lost	Telemetry lost	Parameter no.
FC 1	VMNA FPC1	VMNA AC1ϕA AC1ϕB AC1ϕC	CTR ENGINE CNTLR CHAN A PWR SUPPLY R ENGINE CNTLR CHAN B PWR SUPPLY	CTR ENGINE CHAN A DATA R ENGINE CHAN B DATA	
↓	↓	↓			
	VMNA 014 and A8		MPS PRESS LO2 and LH2 ENG MANF MTR M2 MPS PRESS HELIUM PNEU, L, C, R TANK/ REG MTR M4 MPS PRESS PC L, C, R MTR M1		
			L MAIN ENGINE STATUS LIGHTS-RED and AMBER		
			Note: CREW SHOULD SELECT BACK-UP POWER PNL 06 ANNUNCIATOR BUS SELECT ACA1-MNB		
↓	↓	↓			

TABLE 4.5-III.- Continued

Fuel Cell lost	Bus lost	Sub-bus lost	Function lost	Telemetry lost	Parameter no.
FC 2	VMNB APC5		MAIN PROPULSION SYSTEM ENGINE CNTLR HTR LEFT fails off		
		VMNB ALC2	LO2 IB F/D V man and GPC open cap LO2 IB F/D V man and GPC close cap	L LO2 PV OP C LO2 PV CL LO2 IB F/D V OP LO2 IB F/D V CL	V41X1234X V41X1135E V41X1510E V41X1509X
			GO2 P SOV L fails open LO2 ULL P L fails low LO2 C/O SEN 2 fails wet		
				LO2 ULL P L	T41P1751C
			LO2 POGO RECRC V2 fails open	LO2 POGO RECRC V2 OP	V41X1821X
			ET TUMBLE SYS ARM CMD ET TUMBLE SYS FIRE CMD		
			LH2 OB F/D V man and GPC open cap LH2 OB F/D V man and GPC close cap	L LH2 PV OP C LH2 PV CL LH2 OB F/D V CL	V41X1204X V41X1105E V41X1389X
			LH2 MANIF REPRESS VLV NO 1 (auto and man open cap) LH2 MANIF REPRESS VLV NO 2 (auto and man open cap) L GH2 P SOV fails open		
				LH2 ULL P L ⑫	T41P1701C
			LH2 ULL P L fails low LH2 C/O SEN 2 fails wet		

TABLE 4.5-III.- Continued

Fuel Cell lost	Bus lost	Sub-bus lost	Function lost	Telemetry lost	Parameter no.
FC 2			L HE ISOL VLV A fails closed (no GPC or man open cap) L HE INTN OUT VLV fails closed (no GPC or man open cap) PNEU HE ISOL VLV 2 fails closed (no GPC or man open cap)		
		APC2			
	VMNB FPC2				
		VMNB AC2φA AC2φB AC2φC	LEFT ENGINE CNTLR CHAN A PWR SUPPLY CTR ENGINE CNTLR CHAN B PWR SUPPLY	LEFT ENGINE CHAN A DATA CTR ENGINE CHAN B DATA	
	VMNB 015&A8		C MAIN ENGINE STATUS LIGHTS RED and AMBER Note: CREW SHOULD SELECT BACK-UP POWER PNL 06 ANNUNCIATOR BUS SELECT ACA2/3-MNC		
			R MAIN ENGINE STATUS LIGHTS RED and AMBER Note: CREW SHOULD SELECT BACK-UP POWER PNL 06 ANNUNCIATOR BUS SELECT ACA2/3-MNC		
			L MAIN ENGINE STATUS LIGHT RED and AMBER		

TABLE 4.5-III.- Continued

Fuel Cell lost	Bus lost	Sub-bus lost	Function lost	Telemetry lost	Parameter no.
FC 3	VMNC APC6		MAIN PROPULSION SYSTEM ENGINE CNTLR HTR RIGHT fails off		
		VMNC ALC3	LO2 OB F/D V man and GPC open cap	L LO2 PV CL R LO2 PV OP	V41X1235E V41X1334X
			LO2 OB F/D V man and GPC close cap	LO2 OB F/D V OP LO2 OB F/D V CL	V41X1513E V41X1514X
			LO2 MANF PRESS 1 fails closed	LO2 OVBD BV CL A	V41X1580X
			LO2 MANF PRESS 2 fails closed	LO2 ULL P R	T41P1752C
				LO2 VNT V CL	T41X1724E
			GO2 P SOV R fails open	L LH2 PV CL	V41X1205E
			LO2 ULL P R fails low	R LH2 PV OP	V41X1304X
			LO2 C/O SEN 3 fails wet		
				LH2 FDLN RLF ISOL OP	V41X1441E
			H2 PRESS LINE VENT man open cap		
			LH2 RECRC DISC V auto open cap	LH2 RECRC DISC V CL	V41X1420E
				RTLS IB DMP V CL	V41X1929X
			LH2 RECRC DISC V auto close cap	RTLS OB DMP V CL	V41X1919X
			R GH2 P SOV fails open	LH2 ULL P R (SENSOR and TM) 12	T41P1702C
			LH2 C/O SEN 3 fails wet		
			R HE ISOL VLV A fails closed (no GPC or man open cap)		
			L HE XOVR VLV fails closed (no GPC or man open cap)		
			R HE INTN OUT VLV fails closed (no GPC or man open cap)		

TABLE 4.5-III.- Continued

Fuel Cell lost	Bus lost	Sub-bus lost	Function lost	Telemetry lost	Parameter no.
FC 3	VMNC APC3				
↓	↓				
	VMNC FPC3	VMNC AC3ϕA AC3ϕB AC3ϕC	LEFT ENGINE CNTLR CHAN B PWR SUPPLY RIGHT ENGINE CNTLR CHAN A PWR SUPPLY	LEFT ENGINE CHAN B DATA RIGHT ENGINE CHAN A DATA	
	↓				
	VMNC MPC3				
	↓				
	VMNC 016				
↓	↓				

TABLE 4.5-III.- Continued

Bus lost	Sub-bus lost	Function lost	Telemetry lost	Parameter no.
VCNTL AB1		C HE ISOL VLV A man open cap C MAIN ENGINE SHUTDOWN man cap (A) C MPS ENGINE CNTLR HTR auto control LH2 IB F/D V man open cap LH2 HI PNT BLD man open cap		
VCNTL AB2		C HE INTN OUT VLV man open cap C MAIN ENGINE SHUTDOWN man cap (B) LH2 IB F/D V man open cap LH2 IB F/D V man close cap LH2 HI PNT BLD man open cap BACKUP LH2 DUMP VALVE OPEN CAPABILITY		
		C EIU APC4		
		L HE ISOL VLV B man close cap		

TABLE 4.5-III.- Continued

Bus lost	Sub-bus lost	Function lost	Telemetry lost	Parameter no.
VCNTL AB3		PRPLT DUMP sequence man start cap (A)		
		PRPLT DUMP sequence man stop cap (A)		
		LH2 TOP V man open cap		
		R HE ISOL VLV man close cap		
		PNEU HE ISOL VLV 1 man open and close cap		
		L EIU APC6		
VCNTL BC1		LO2 IB F/D V man open cap		
		L MPS ENGINE CNTLR HTR auto control		
		LH2 OB F/D man open and close cap		
		L EIU APC5		
		R EIU APC4		
VCNTL BC2		R HE ISOL VLV B man close cap		
		LO2 IB F/D V man open cap		
		LO2 IB F/D V man close cap		
		LH2 MANIF REPRESS VLV No. 1 man open cap		
		BACKUP LH2 DUMP VALVE OPEN CAPABILITY		
		L HE INTN OUT VLV man open cap		
		L MAIN ENGINE SHUTDOWN man cap (A)		
		MAIN ENGINE LIMIT SHUTDOWN ENABLE CMD A AUTO CMD A INHIBIT CMD A		
		C HE ISOL VLV B manual close cap		

TABLE 4.5-III.- Continued

Bus lost	Sub-bus lost	Function lost	Telemetry lost	Parameter no.
VCNTL BC3 ↓		LO2 PRPLT DUMP man start cap (B) LO2 PRPLT DUMP man stop cap (B) LH2 MANIF REPRESS VLV no. 2 man open cap L HE ISOL VLV A man open and close cap PNEU HE ISOL VLV 2 man open and close cap R MAIN ENGINE SHUTDOWN man cap (B) MAIN ENGINE LIMIT SHUTDOWN ENABLE CMD AUTO CMD C INHIBIT CMD C		

TABLE 4.5-III.- Concluded

Bus lost	Sub-bus lost	Function lost	Telemetry lost	Parameter no.
VCNTL CA1		LO2 OB F/D V man open cap LO2 OB F/D V man close cap LO2 MANF PRESS 1 VLV man open cap (VLV fails closed) H2 PRESS LINE VENT man open cap L HE ISOL VLV B man close capability R HE INTN OUT VLV man open cap R MPS ENGINE CNTLR HTR auto control		
VCNTL CA2		LO2 MANF PRESS 2 VLV man open cap (VLV fails closed) R HE ISOL VLV A man open and close cap L HE XOVR VLV man open cap (VLV fails closed)		
		L MAIN ENGINE SHUTDOWN man cap (B) R EIU APC6 C EIU APC5		
VCNTL CA3		R MAIN ENGINE SHUTDOWN man cap (A)		
		MAIN ENGINE LIMIT SHUT-DOWN ENABLE CMD B AUTO CMD B INHIBIT CMD B C HE ISOL VLV B man close capability		

TABLE 4.5-IV.- SINGLE AND DUAL BUS LOSS MATRIX

	FUNCTION	LO$_2$ PREVALVES ①																							LO$_2$ F/D ①												MPS MANF PRESS LO$_2$ ②												LO$_2$ FD RLF ③ ISOL						③ LO$_2$ OVB BLV					POGO ③ RECR V1				POGO ③ RECR V2				① LO$_2$ FD DIS V					LO2 FD DIS LATCH						CO$_2$ PRESS SOV ③																	
		LEFT								CENTER								RIGHT								INBD						OUTBD						REPRESS 1						REPRESS 2																												LOCK			UNLOCK			LEFT						CENTER						RIGHT					
		OP			CL1		CL2			OP			CL1		CL2			OP			CL1		CL2			OP			CL			OP			CL			OP ⑭			CL			OP ⑭			CL			OP			CL			OP		CL			OP		CL		OP		CL		OP		CL									OP			CL			OP			CL			OP			CL		
	BUS/MDM LOST	GPC	MAN	TM	GPC	MAN	GPC	MAN	TM	GPC	MAN	TM	GPC	MAN	GPC	MAN	TM	GPC	MAN	TM	GPC	MAN	GPC	MAN	TM	GND	MAN	TM	GND	MAN	TM	GND	MAN	TM	GND	MAN	TM	GPC	MAN	TM	GPC	MAN	TM	GPC	MAN	TM	GPC	MAN	TM	GPC	MAN	TM	GPC	MAN	TM	GPC	TM	GPC	TMA	TMB	GPC	TM	GPC	TM	GPC	TM	GPC	TM	GPC	TM	GPC	TMA	TMB	GPC	TMA	TMB	GPC	TMA	TMB	GPC	SEN	TM	GPC	SEN	TM	GPC	SEN	TM	GPC	SEN	TM	GPC	SEN	TM	GPC	SEN	TM
FC1	MMA APC4									A1 24	A8		4C	C	3C	C		A1B 24	B		2 C	C	1 C	C																																																									T	T		T	T																		
	ALC1											☒													☒																											☒			☒							☒	☒	☒											B	B		B	B										☒	☒							
	APC1																																																																											D	D		D	D																		
	MMA/C RSRB																																																																																																
	MMA/C LSRB																																																																																															
	FPC1																																																																																																
	AC10A																																																																																																	
	AC10B																																																																																																	
	AC10C																																																																																																	
	MPC1																																																			13 B	B D																																												
	014																																																																																																		
	014AA8																																																																																																		
FC2	MMB APC5	A2 34	A8		4 C	C	1 C	C		A1B 23	B		3 C	C	2 C	C																																																											A2 4			A3																				
	ALC2			☒													☒									☒	☒	☒	☒	☒	☒																										☒			☒						☒	☒	☒				☒											☒	☒													
	APC2																																																									A 3											A3		A3																											
	MMB/C RSRB																																																																																																
	MMB/C LSRB																																																																																																
	FPC2																																																																																																	
	AC20A																																																																																																	
	AC20B																																																																																																	
	AC20C																																																																																																	
	MPC 2																																																																																																	
	015AA8																																																																																																	
FC3	MMC APC6	A1B 23	B		1 C	C	3 C	C										A1 34	A8		3 C	C	2 C	C																																																					A3			A2 4																				
	ALC3								☒											☒												☒	☒	☒	☒	☒	☒	☒	☒					☒	☒														☒											☒			☒																						☒	☒	
	APC3																																																									A8 24											A8 24		A8 24																											
	FPC3																																																																																																		
	AC30A																																																																																																		
	AC30B																																																																																																		
	AC30C																																																																																																		
	MPC3																																																			2 B	C D																																												
	016																																																																																																			
	ESS1BC																																																																																																		
	APC4																																																																																																		
	ALC1									B 24			2																																																																																				
	ESS2CA																																																																											T			T																				
	APC5																																																																										B			B																				
	ALC2	B 34			3																																																																					D			D																				
	ESS3AB																																																																																																		
	APC6																																																																																																		
	ALC3																	B 13			3																																					B 23											B2 3		B2 3																											
	CNTLAB1 ⑬										AB			B		A			A			B		B																																																																									
	CNTLAB2										AB			A		B																																																																																		
	CNTLAB3										AB			A		A																																																																																		
	CNTLBC1		AB			B		A			A			B		B											☒																																																																					
	CNTLBC2		AB			A		B																			☒			☒																																																																			
	CNTLBC3		AB			A		A																																																																																											
	CNTLCA1		A			B		B											AB			B		A									☒			☒			☒															AC																																															
	CNTLCA2																		AB			A		B																					☒									AB																																															
	CNTLCA3																		AB			A		A																														AB																																																
MDM	FA 01	1C			B1		B1			1C			A1		B1			1C			A1		A1			☒																											1A										☒												☒														☒	☒							
	FA 02	2C			A2		B2			2C			A2		A2			2C			B2		B2						☒		☒																						2A					2C		☒							☒		2C		2C	☒		2C			2C	☒					☒	☒													
	FA 03	3C			A3		A3			3C			B3		B3			3C			A3		A3														☒	☒															3A					3C	☒			☒	☒						3C	☒	3C		☒	3C		☒	3C																				
	FA 04	4C			B4		A4			4C			B4		A4			4C			A4		B4			☒						☒			☒										☒														4C								☒	☒		4C		4C			4C			4C		☒																☒	☒	
	OA 01																								☒																											☒			☒									☒																											☒						
	OA 02																☒											☒																														☒											☒																	☒												
	OA 03								☒																									☒						☒						☒																																																				☒
	OA 04																																																																																																			

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TABLE 4.5-IV.- SINGLE AND DUAL BUS LOSS MATRIX (CONTINUED)

FUNCTION		LO_2 LL SENSORS															LO_2 VENT TM	TUMBLE SYS			LO_2 SENSORS											MANF P MTR	LO_2 ULLAGE PRESS TM			PRPLT DUMP SEQUENCE ⑪			
		CUTOFF ④ ⑤												SK ④				ARM		FIRE	LO_2 IN P			LO_2 IN T			GO_2 OUT T			MANF P TM	DISC P					START		STOP	
		NO. 1			NO. 2			NO. 3			NO. 4																												
BUS/MDM LOST		WET	DRY	TM	WET	DRY	TM	WET	DRY	TM	WET	DRY	TM	WET	DRY	TM	GL	GPC	TM		L	C	R	L	C	R	L	C	R				L	C	R	A	B	A	B
FC 1	MNA APC4																																						
	ALC1	X																																X					
	APC1																																						
	MNA/C RSRB																																						
	MNA/C LSRB																																						
	FPC1																																						
	AC10A																																						
	AC10B																																						
	AC10C																																						
	MPC1																																						
	014																														X							
	014AAB																																						
FC 2	MNB APC5																																						
	ALC2				X						AB 4			AB 4				X		X													X						
	APC2										CD 4			CD 4																									
	MNB/C RSRB																																						
	MNB/C LSRB																																						
	FPC2																																						
	AC20A																																						
	AC20B																																						
	AC20C																																						
	MPC 2																																						
	015AAB																																						
FC 3	MNC APC6																																						
	ALC3							X			AC 2			AC 2			X																		X				
	APC3										BD 2			BD 2																									
	FPC3																																						
	AC30A																																						
	AC30B																																						
	AC30C																																						
	MPC3																																						
	016																																						
	ESS1BC																																						
	APC4																																						
	ALC1																																						
	ESS2CA																																						
	APC5																																						
	ALC2																																						
	ESS3AB																																						
	APC6																																						
	ALC3																																						
	CNTLAB1 ⑬																																						
	CNTLAB2																																						
	CNTLAB3																																			X		X	
	CNTLBC1																																						
	CNTLBC2																																						
	CNTLBC3																																				X		X
	CNTLCA1																																						
	CNTLCA2																																						
	CNTLCA3																																						
	FA 01	X											X									X			X									X					
	FA 02				X		X				2 E			2 E							X			X						X			X						
	FA 03			X																			X			X													
	FA 04							X		X	4 E			4 E																					X				
MDM	FF 01																																			X		X	
	FF 02																																				X		X
	FF 03																																						
	FF 04																																						
	OA 01																										X			X									
	OA 02														X			X								X													
	OA 03															X												X												
	OA 04																																						

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TABLE 4.5-IV.- SINGLE AND DUAL BUS LOSS MATRIX (CONTINUED)

	FUNCTION	LH_2 PREVALVES ①																				
		LEFT							CENTER							RIGHT						
		OP				CL			OP				CL			OP				CL		
	BUS/MDM LOST	CPC	MAN	TMA	TMB	CPC	MAN	TM	CPC	MAN	TMA	TMB	CPC	MAN	TM	CPC	MAN	TMA	TMB	CPC	MAN	TM
FC1	MNA APC4								A8 12	CD			A8 12	CD		A2	BD			A2	BD	
	ALC1										X								X			X
	APC1																					
	MNA/C RSA8																					
	MNA/C LSA8																					
	FPC1																					
	AC10A																					
	AC10B																					
	AC10C																					
	MPC1																					
	O14																					
	O14AA8																					
FC2	MNB APC5	A8 21	CD			A8 21	CD		A3	BD			A3	BD								
	ALC7			X								X			X							
	APC2																					
	MNB/C RSA8																					
	MNB/C LSA8																					
	FPC2																					
	AC20A																					
	AC20B																					
	AC20C																					
	MPC 2																					
	O15AA8																					
FC3	MNC APC6	A1	BD			A1	BD									A8 14	CD			A8 14	CD	
	ALC3				X			X										X				
	APC3																					
	FPC3																					
	AC30A																					
	AC30B																					
	AC30C																					
	MPC3																					
	O16																					
	ESS1BC																					
	APC4																					
	ALC1								B2 3	CE			B2 3	CE								
	ESS2CA																					
	APC5																					
	ALC2	B1 4	CE			B1 4	CE															
	ESS3AB																					
	APC6																					
	ALC3															B 12	CE			B 12	CE	
	CNTLAB1 ⑬									A8 E				A8 E								
	CNTLAB2									A8				A8								
	CNTLAB3									AC				AC								
	CNTLBC1		A8 E				A8 E															
	CNTLBC2		A8				A8															
	CNTLBC3		AC				AC															
	CNTLCA1																A8 E				A8 E	
	CNTLCA2																A8				A8	
	CNTLCA3																AC				AC	
MDM	FA 01	1C				1C			1C		X		1C			1C				1C		
	FA 02	2C		X		2C			2C				2C			2C				2C		
	FA 03								3C			X	3C						X			
	FA 04	4C			X	4C										4C		X		4C		
	DA 01																					X
	DA 02														X							
	DA 03							X														
	DA 04																					

	FUNCTION	LH_2 F/D ①												LH_2 HI PNT BLD ②					
		INBD						OUTBD											
		OP			CL			OP			CL			OP			CL		
	BUS/MDM LOST	CMD	MAN	TM	CMD	MAN	TM	CMD	MAN	TM	CMD	MAN	TM	CMD	MAN	TM	CMD	MAN	TM
FC1	MNA APC4																		
	ALC1	X	X	X	X	X	X							X	X	X			X
	APC1																		
	MNA/C RSA8																		
	MNA/C LSA8																		
	FPC1																		
	AC10A																		
	AC10B																		
	AC10C																		
	MPC1																		
	O14																		
	O14AA8																		
FC2	MNB APC5																		
	ALC7							X	X	X	X	X	X						
	APC2																		
	MNB/C RSA8																		
	MNB/C LSA8																		
	FPC2																		
	AC20A																		
	AC20B																		
	AC20C																		
	MPC 2																		
	O15AA8																		
FC3	MNC APC6																		
	ALC3																		
	APC3																		
	FPC3																		
	AC30A																		
	AC30B																		
	AC30C																		
	MPC3																		
	O16																		
	ESS1BC																		
	APC4																		
	ALC1																		
	ESS2CA																		
	APC5																		
	ALC2																		
	ESS3AB																		
	APC6																		
	ALC3																		
	CNTLAB1 ⑬		X												X				
	CNTLAB2		X			X									X				
	CNTLAB3																		
	CNTLBC1								X			X							
	CNTLBC2																		
	CNTLBC3																		
	CNTLCA1																		
	CNTLCA2																		
	CNTLCA3																		
MDM	FA 01				X		X							LA1					
	FA 02	X						X			X		X						
	FA 03	X																	
	FA 04																		
	DA 01			X												X			X
	DA 02									X									
	DA 03																		
	DA 04																		

	FUNCTION	H_2 PRESS LINE VENT ②						LH_2 TOPPING VALVE ②						MPS MANF PRESS LH_2 ②											
														REPRESS 1						REPRESS 2					
		OP			CL			OP			CL			OP ⑭			CL			OP ⑭			CL		
	BUS/MDM LOST	CMD	MAN	TM	CMD	MAN	TM	CMD	MAN	TM	CMD	MAN	TM	CPC	MAN	TM	CPC	MAN	TM	CPC	MAN	TM	CPC	MAN	TM
FC1	MNA APC4																								
	ALC1							X	X				X												
	APC1																								
	MNA/C RSA8																								
	MNA/C LSA8																								
	FPC1																								
	AC10A																								
	AC10B																								
	AC10C																								
	MPC1																								
	O14																								
	O14AA8																								
FC2	MNB APC5																								
	ALC7													X	X					X	X				
	APC2																								
	MNB/C RSA8																								
	MNB/C LSA8																								
	FPC2																								
	AC20A																								
	AC20B																								
	AC20C																								
	MPC 2																								
	O15AA8																								
FC3	MNC APC6																								
	ALC3	X	X																						
	APC3																								
	FPC3																								
	AC30A																								
	AC30B																								
	AC30C																								
	MPC3																								
	O16																								
	ESS1BC																								
	APC4																								
	ALC1																								
	ESS2CA																								
	APC5																								
	ALC2																								
	ESS3AB																								
	APC6																								
	ALC3																								
	CNTLAB1 ⑬																								
	CNTLAB2																								
	CNTLAB3								X																
	CNTLBC1																								
	CNTLBC2														X										
	CNTLBC3																				X				
	CNTLCA1		X																						
	CNTLCA2																								
	CNTLCA3																								
MDM	FA 01	LA1						X					X	X											
	FA 02																			X					
	FA 03																								
	FA 04																								
	DA 01									X															
	DA 02															X						X			
	DA 03			X																					
	DA 04																								

	FUNCTION	LH_2 FD RLF ISO						LH_2 FD DIS V ①					LH_2 FD DISC LATCH						LH_2 RLC DIS V ①				LH_2 RTLS DUMP V							
													LOCK			UNLOCK							INBD				OUTBD			
		OP			CL			OP		CL									OP		CL		OP		CL		OP		CL	
	BUS/MDM LOST	CPC	MAN	TM	CPC	MAN	TM	CPC	TM	CPC	TMA	TMB	CPC	TMA	TMB	CPC	TMA	TMB	CPC	TM	CPC	TM	CPC	TM	CPC	TM	CPC	TM	CPC	TM
FC1	MNA APC4													T	T		T	T												
	ALC1													B	B		B	B						X				X		
	APC1													D	D		D	D					A3				A3			
	MNA/C RSA8																													
	MNA/C LSA8																													
	FPC1																													
	AC10A																													
	AC10B																													
	AC10C																													
	MPC1				A 14	BD																								
	O14																													
	O14AA8																													
FC2	MNB APC5												A2 4			A3														
	ALC7										X																			
	APC2							A3		A3																				
	MNB/C RSA8																													
	MNB/C LSA8																													
	FPC2																													
	AC20A																													
	AC20B																													
	AC20C																													
	MPC 2																													
	O15AA8																													
FC3	MNC APC6												A3			A 24														
	ALC3								X			X							X	X	X	X				X				X
	APC3			X			X	A8 24		A8 24																				
	FPC3																													
	AC30A																													
	AC30B																													
	AC30C																													
	MPC3				A3	CD																	A8 14				A8 14			
	O16																													
	ESS1BC																													
	APC4																													
	ALC1																													
	ESS2CA												T			T														
	APC5												B			B														
	ALC2												D			D														
	ESS3AB																													
	APC6																													
	ALC3							B2 3		B2 3													B1 3				B1 3			
	CNTLAB1 ⑬																													
	CNTLAB2																													
	CNTLAB3																													
	CNTLBC1																													
	CNTLBC2																													
	CNTLBC3																													
	CNTLCA1					AC																								
	CNTLCA2					A8																								
	CNTLCA3					A8																								
MDM	FA 01				1C									X									1C				1C			
	FA 02							2C		2C	X		2C			2C	X													
	FA 03				3C			3C		3C			3C		X	3C							3C				3C			X
	FA 04				4C			4C	X	4C		X	4C			4C		X	X		X		4C			X	4C			
	DA 01																							X				X		
	DA 02																													
	DA 03			X			X													X		X								
	DA 04																													

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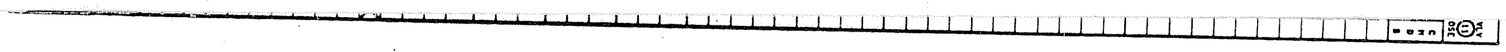

	FUNCTION	LEFT									T ②				RIGHT											
		ISOL VLV A						ISOL			OUT				IN						OUT ⑭					
		OP ⑭			CL			OP				CL			OP			CL			OP			CL		
BUS/MDM LOST		GPC	MAN	TM	GPC	MAN	TM	GPC	MAN	TM	TM	GPC	MAN	TM	GPC	MAN	TM	GPC	MAN	TM	GPC	MAN	TM	GPC	MAN	TM
FC1	MNA APC4							4 AB	AB																	
	ALC1							4 CD																		
	APC1																									
	MNA/C RSRB																									
	MNA/C LSRB																									
	FPC1																									
	AC10A																									
	AC10B																									
	AC10C																									
	MPC1														A3	A8										
	014																									
	014AA8																									
FC2	MNB APC5																									
	ALC2	☒	☒																							
	APC2																									
	MNB/C RSRB																									
	MNB/C LSRB																									
	FPC2																									
	AC20A																									
	AC20B																									
	AC20C																									
	MPC 2																									
	015AA8																									
FC3	MNC APC6							1 AC	AC																	
	ALC3							1 BD													☒	☒				
	APC3																									
	FPC3																									
	AC30A																									
	AC30B																									
	AC30C																									
	MPC3														A1	AC										
	016																									
	CNTLAB1 ⑬																									
	CNTLAB2								CD																	
	CNTLAB3															CD										
	CNTLBC1																									
	CNTLBC2																									
	CNTLBC3		☒																							
	CNTLCA1								BD							BD						☒				
	CNTLCA2																									
	CNTLCA3																									
MDM	FA 01							1E							1B											
	FA 02	☒																								
	FA 03														3B											
	FA 04							4E													☒					
	OA 01																☒									
	OA 02			☒																						
	OA 03									☒													☒			
	OA 04																									

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TABLE 4.5-IV.- SINGLE AND DUAL BUS LOSS MATRIX (CONTINUED)

	FUNCTION	ENGINE CONTROLLER ⑧ ⑨						EIU						MAIN ENGINE LIMIT SHUTDOWN ⑩									MAIN ENGINE MAN. SHUTDN ⑯ ⑪						MAIN ENGINE STATUS LITE ⑱						MPS PRESS PC MTR			MPS ENGINE CNTLR HTR					
		L		C		R		L		C		R		ENA			AUTO			INH			LEFT		CNTR		RIGHT		LEFT		CNTR		RIGHT					LEFT		CNTR		RIGHT	
	BUS/MDM LOST	DCU A	DCU B	DCU A	DCU B	DCU A	DCU B	CMD	DATA	CMD	DATA	CMD	DATA	CMD A	CMD B	CMD C	CMD A	CMD B	CMD C	CMD A	CMD B	CMD C	CMD A	CMD B	CMD A	CMD B	CMD A	CMD B	RED	AMBER	RED	AMBER	RED	AMBER	LEFT	CNTR	RIGHT	AUTO	OFF	AUTO	OFF	AUTO	OFF
FC1	MNA APC4									AC	AC	AC	AC																											X			
	ALC1																																										
	APC1																																										
	MNA/C RSRB																																										
	MNA/C LSRB																																										
	FPC1																																										
	AC10A			X			X																																				
	AC10B			X			X																																				
	AC10C			X			X																																				
	MPC1																																										
	014																																		X	X	X						
	014&A8																												A	A													
FC2	MNB APC5							AD	AD	AD	AD																											X					
	ALC2																																										
	APC2																																										
	MNB/C RSRB																																										
	MNB/C LSRB																																										
	FPC2																																										
	AC20A	X			X																																						
	AC20B	X			X																																						
	AC20C	X			X																																						
	MPC 2																																										
	015&A8																												A	A	A	A	A	A									
FC3	MNC APC6							AC	AC			AD	AD																													X	
	ALC3																																										
	APC3																																										
	FPC3																																										
	AC30A		X			X																																					
	AC30B		X			X																																					
	AC30C		X			X																																					
	MPC3																																										
	016																														A	A	A	A									
	CNTLAB1 ⑬																								X															X			
	CNTLAB2									BD	BD															X																	
	CNTLAB3							BD	BD																																		
	CNTLBC1							BC	BC			BD	BD																									X					
	CNTLBC2													X			X			X			X																				
	CNTLBC3															X			X			X						X															
	CNTLCA1																																									X	
	CNTLCA2									BC	BC	BC	BC											X																			
	CNTLCA3														X			X			X						X																
MDM	FA 01																																										
	FA 02																																										
	FA 03																																										
	FA 04																																										
	FF 01																								X						X	X				X							
	FF 02													X			X			X			X			X			X	X					X								
	FF 03														X			X			X			X			X						X	X			X						
	FF 04															X			X			X						X															
	OA 01																																							X			
	OA 02																																					X					
	OA 03																																									X	
	OA 04																																										

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TABLE 4.5-IV.- SINGLE AND DUAL BUS LOSS MATRIX (CONTINUED)

	FUNCTION / BUS/MDM LOST	HELIUM BLOWDOWN ②								MPS HE PRESS TM													MPS HE TEMP SENSOR/TM						
		NO. 1				NO. 2				L			C			R			PNEU		MTR		AFT TK T				MID TK T		
		OP		CL		OP		CL																					
		GPC	TM	GPC	TM	GPC	TM	GPC	TM	TK	REG A	REG B	TK	REG A	REG B	TK	REG A	REG B	TK	REG	TK	REG	L	C	R	PN	L	C	R
FC1	MNA APC4																						AB		AB	AB		AB	AB
	ALC1	X				X																							
	APC1																												
	MNA/C RSRB																												
	MNA/C LSRB																												
	FPC1																												
	AC10A																												
	AC10B																												
	AC10C																												
	MPC1																												
	014																												
	014&AB																				X	X							
FC2	MNB APC5																												
	ALC2																												
	APC2																												
	MNB/C RSRB																												
	MNB/C LSRB																												
	FPC2																												
	AC20A																												
	AC20B																												
	AC20C																												
	MPC 2																												
	015&AB																												
FC3	MNC APC6																												
	ALC3																												
	APC3																												
	FPC3																												
	AC30A																												
	AC30B																												
	AC30C																												
	MPC3																												
	016																												
	CNTLAB1 ⑬																												
	CNTLAB2																												
	CNTLAB3																												
	CNTLBC1																												
	CNTLBC2																												
	CNTLBC3																												
	CNTLCA1																												
	CNTLCA2																												
	CNTLCA3																												
MDM	FA 01												X																
	FA 02									X																			
	FA 03	X														X													
	FA 04					X																							
	OA 01		X				X				OF1	X		OF1	X		OF1	X	X	X					X	X		X	
	OA 02																							X			X		
	OA 03																						X						X
	OA 04																												

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TABLE 4.5-IV.- SINGLE AND DUAL BUS LOSS MATRIX (CONTINUED)

	FUNCTION	SRB PC ⑮						FSM PRESS				HYDRAULIC PRESS				FUEL ISOLATION VALVE ②								PRIMARY CONTROL VALVE ③								SECONDARY CONTROL VALVE ②								SWITCH POS. ①			
		LEFT			RIGHT			LEFT		RIGHT		LEFT		RIGHT		LEFT				RIGHT				LEFT				RIGHT				LEFT				RIGHT				LEFT		RIGHT	
		PC 1	PC 2	PC 3	PC 1	PC 2	PC 3	FSM A	FSM B	FSM A	FSM B	HYD A	HYD B	HYD A	HYD B	A		B		A		B		A		B		A		B		A		B		A		B		ROCK	TILT	ROCK	TILT
	BUS/MDM LOST															OP	CL	OP	CL	OP	CL	OP	CL	OP	CL	OP	CL	OP	CL	OP	CL	OP	CL	OP	CL	OP	CL	OP	CL				
FC1	MNA APC4																																										
	ALC1																																										
	APC1																																										
	MNA/C RSRB				A		A			A				A						A									A							A							A
	MNA/C LSRB	A		A				A				A				A									A							A									A		
	FPC1																																										
	AC1ΦA																																										
	AC1ΦB																																										
	AC1ΦC																																										
	MPC1																																										
	014																																										
	014&A8																																										
FC2	MNB APC5																																										
	ALC2																																										
	APC2																																										
	MNB/C RSRB					A					A				A							A									A							A				A	
	MNB/C LSRB		A						A				A					A									A							A						A			
	FPC2																																										
	AC2ΦA																																										
	AC2ΦB																																										
	AC2ΦC																																										
	MPC 2																																										
	015&A8																																										
FC3	MNC APC6																																										
	ALC3																																										
	APC3																																										
	MNA/C RSRB				A		A			A				A						A									A							A							A
	MNA/C LSRB	A		A				A				A				A									A							A									A		
	MNB/C RSRB					A					A				A							A									A							A				A	
	MNB/C LSRB		A						A				A					A									A							A						A			
	FPC3																																										
	AC3ΦA																																										
	AC3ΦB																																										
	AC3ΦC																																										
	MPC3																																										
	016																																										
MDM	FA 01	☒			☒																																						
	FA 02		☒			☒																																					
	FA 03			☒			☒																																				
	FA 04																																										
	LL 01																																										
	LL 02							☒	☒			☒	☒			☒		☒							☒		☒					☒		☒						☒	☒		
	LR 03																																										
	LR 04									☒	☒			☒	☒					☒		☒							☒		☒					☒		☒				☒	☒

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TABLE 4.5-IV.- SINGLE AND DUAL BUS LOSS MATRIX (CONCLUDED)

FUNCTION / BUS LOST		DSC					MDM											
							OI				FC							
		OF1	OM2	OA1	OA2	OA3	OA1	OA2	OA3	OF1	FF1	FF2	FF3	FF4	FA1	FA2	FA3	FA4
FC1	MNA APC4			AB		AB	AB		AB						AB		AB	AB
	FPC1										AB		AB					
	MPC1																	
	014																	
	014 & A8	A	A							A								
FC2	MNB APC5			BC	AB		BC	AB							AC	AB		
	FPC2										BC	AB		AB				
	MPC2																	
	015 & A8	A	A							A								
FC3	MNC APC6				BC	BC		BC	BC							AC	AC	AC
	FPC3											AC	AC	AC				
	MPC3																	
	016																	
	CNTL AB1						CD		CD						CD			
	CNTL AB2			CD		CD					CD				BD			
	CNTL AB3										AD							
	CNTL BC1						AD	CD						CD		CD		
	CNTL BC2			AD	CD							CD				BD		
	CNTL BC3											BD		BD				
	CNTL CA1				AD	AD											CD	CD
	CNTL CA2							AD	AD				CD				BD	
	CNTL CA3												BD					BD

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Example : OA1 Down = CNTL Bus AB1 & BC1

BC1 FD = V76V0220A1
BC2 FD = V76V0221A1

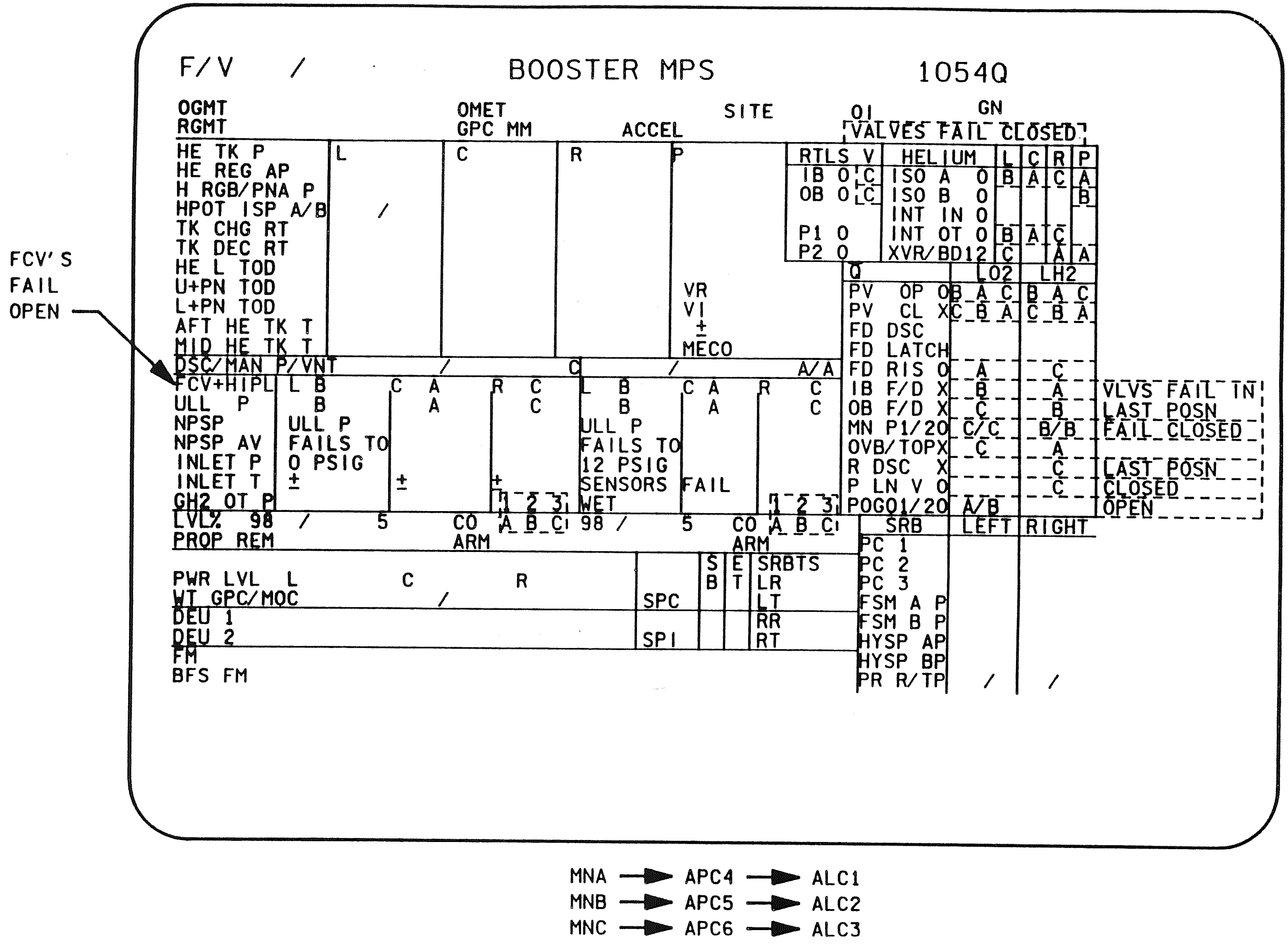

Figure 4.5-I.- Main power bus loss.

FUNCTIONS LOST: G = GPC
M = MANUAL
● = TOTAL
C = CLOSE
O = OPEN
L = LOCK
U = UNLOCK
T = SENSOR FAILURE - RESULTS IN ET SEP INH
* = CAUSES DELAYED SRB SEP

				FA MDMS										BUS			DUAL BUS			MNA & FA				MNB & FA				MNC & FA				CNTL AB			CNTL BC			CTLCA	
				1	2	3	4	12	13	14	23	24	34	A	B	C	AB	AC	BC	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	1	2	3	1	2
	SRB PC(LT & RT)			1	2	3		12*	13*	1	23*	2	3				1	13*	23*	1	2	3		1	2	3		1	2	3									
PANEL R4	!! PRE-VALVES	LO2	C					Go	Go	Go	Go	Go	Go				●	Go	Go	Go	Go		Go	Go	Go	Go													
			L					Go	Go	Go	Go	Go	Go					Go	●						Go	Go	Go	Go	Go	Go									
			R					Go	Go	Go	Go	Go	Go				Go	●		Go	Go		Go					Go		Go	Go								
		LH2	C					G●	G●		G●						●			G●	G●					G●													
			L					G●		G●		G●							●						G●		G●	G●											
			R					G●		G●		G●						●			G●							G●			G●								
	FEEDLINE DISC'S *		LO2								●I	●	●					●I	●I							●			●		●								
			LH2								●	●I	●					●I	●I							●			●		●								
	FEEDLINE LATCH *		LO2								●	●	●					●	●								●		●		●								
			LH2								●	●	●					●	●								●		●		●								
PANEL R4	!! FILL & DRAIN	INB	LO2	Go	Gc		Go	G●	Go	Go	Gc	G●	Go		●		●	Go	●	Go	Gc		Go	●	●	●	●	Go	Gc		Go				Mo	M●			
			LH2	Gc	Go	Go		G●	G●	Gc	Go	Go	Go	●			●	●	Go	●	●	●	●	Gc	Go	Go		Gc	Go	Go		Mo	M●						
		OUT	LO2				G●			G●		G●	G●			●		●	●				G●				G●	●	●	●	●							M●	
			LH2		G●			G●			G●	G●			●		●		●		G●			●	●	●	●		G●						M●				
PANEL R4	!! FDLN RELIEF ISO (NO)		LO2					G	G		G							●	G	G		G							G										
			LH2						G	G			G				G	●		G			G							G									
PANEL R4	LH2	!!PR LN VT NC		LA				LA	LA	LA						●	LA	●	●	LA				LA				●	●	●	●							M	
		!!TOPPING NC		G				G	G	G				●			●	●		●	●	●	●	G				G						M					
		RECIRC DISC					●			●		●	●			●		●	●				●				●	●	●	●	●								
	LO2	POGO (NO)	*1	●		●		●	●	●	●		●	●			●	●		●	●	●	●	●		●		●		●									
			*2		●		●	●		●	●	●	●		●		●	●	●		●		●	●	●	●	●		●		●								
		OVB BLD (NO)									●	●	●					●	●							●			●		●								
PANEL R4	!! MANIFOLD	LO2	*1			G			G		G		G			●		●	●			G				G		●	●	●	●							M	
			*2				G			G		G	G			●		●	●				G				G	●	●	●	●								M
	REPRESS (NC)	LH2	*1	G				G	G	G					●		●		●	G				●	●	●	●	G								M			
			*2		G			G			G	G			●		●		●		G			●	●	●	●		G								M		
RTLS	DUMP (NC)		IN						●	●			●					●				●						●			●								
			OUT						●	●			●					●				●						●			●								
	REPRS (NC)		*1						●	●			●					●				●						●			●								
			*2					●		●		●						●					●					●	●										
	ET ULLAGE FCV's (NO)		GO2	C	L		R	LC	C	CR	L	LR	R	C	L	R	LC	CR	LR	C	LC	C	CR	LC	L	L	LR	CR	LR	R	R								
			GH2	C	L		R	LC	C	CR	L	LR	R	C	L	R	LC	CR	LR	C	LC	C	CR	LC	L	L	LR	CR	LR	R	R								
PNL R2	!!H2 ULL PRS SW																																	C		L		R	
	!! DUMP SEQ MAN		NOM					FF																										●			●		
			B/U											FF																			●			●			

FA MDMs LOST →	1	34	2
FF MDMs LOST →	1	3	24

REV: 10/23/89

LA = LOSS OF GPC CONTROL THROUGH GROUND MDM

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Figure 4.5-II.- Console cue card for multibus and MDM failures.

				FA MDMS										BUS			DUAL BUS			MNA & FA				MNB & FA				MNC & FA				CNTL AB			CNTL BC			CTLCA		
				1	2	3	4	12	13	14	23	24	34	A	B	C	AB	AC	BC	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	1	2	3	1	2	3
PANEL R2	II HELIUM TANK ISO VALVES (NC)	C	A	G				G	G	G				●			●	●		●	●	●	●	G				G				M								
			B								G								●							G			G							Mc				Mc
		L	A		G			G			G	G			●		●		●		G			●	●	●	●		G								M			
			B							G								●					G					G					Mc					Mc		
		R	A			G			G		G		G			●		●	●			G				G		●	●	●	●								M	
			B					G									●				G			G										Mc	Mc					
		P	1	G				G	G	G				●			●	●		●	●	●	●	G				G						M						
			2				G			G		G	G		●		●	G	●				G	●	●	●	●				G						M			
PANEL R2	II HELIUM TANK INTER-CONNECT VALVES (NC)	IN OP	C					G									●				G			G																
			L								G								●							G			G											
			R						G									●				G						G												
		OUT OP	C	G				G	G	G				●			●	●		●	●	●	●	G				G					M							
			L		G			G			G	G			●		●		●		G			●	●	●	●		G							M				
			R				G			G		G	G			●		●	●				G				G	●	●	●	●							M		
		X	L		G			G			G	G				●		●	●		G				G			●	●	●	●								M	
HELIUM BLOWDOWN VALVES (NC)			*1			●			●		●		●	●			●	●		●	●	●	●			●				●										
			*2				●			●		●	●	●			●	●		●	●	●	●				●				●									
ENG LOW LVL C/O SENSORS (FAIL WET)			LO2	1	2		3	12	1	13	2	234	3	1	2	3	12	13	234	1	12	1	13	12	2	2	24	13	23	3	3									
			LH2	1	2		3	12	1	13	2	234	3	1	2	3	12	13	234	1	12	1	13	12	2	2	24	13	23	3	3									
ET TUMBLE VALVE			ARM												●		●		●					●	●	●	●													
			FIRE												●		●		●					●	●	●	●													
5% SNSR			O2/H2									●							●								●		●											
98% SNSR1			O2/H2				●			●		●	●			●		●	●				●				●	●	●	●	●									
98% SNSR2			O2/H2		●			●			●	●			●		●		●		●			●	●	●	●		●											
99.XX SNSR			O2/H2	●				●	●	●				●			●	●		●	●	●	●	●				●												
100% SNSR1			O2/H2									●							●								●		●											
100% SNSR2			O2/H2				●			●		●	●			●		●	●				●				●	●	●	●	●									
100.X%			O2/H2		●			●			●	●			●		●		●		●			●	●	●	●		●											
102% SNSR			O2/H2	●				●	●	●				●			●	●		●	●	●	●	●				●												

FOOD FOR THOUGHT:

MNA → APC4 → ALC1
MNB → APC5 → ALC2
MNC → APC6 → ALC3

GPC1 → STRING 1 → FC5 → FA1
GPC2 → STRING 2 → FC6 → FA2
GPC3 → STRING 3 → FC7 → FA3
GPC4 → STRING 4 → FC8 → FA4

LOX LOW LEVEL SENSORS:
L1(*1) L2(*2) R2(*3) R1(*4)

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USE FOR SOLENOID VALVES OR SPRING LOADED PNEUMATIC VALVES:

G, M → USE ONLY IF BOTH GPC AND MAN CAPABILITY EXISTS.
● → TOTAL LOSS OF GPC AND MANUAL CONTROL

FOR BISTABLE VALVES, USE:

Go
Gc
G● → BOTH O & C
Mo
Mc
M● → BOTH O & C
● → BOTH G & M

LEGEND

II = SWITCH
• = CAUSES DELAYED SRB SEP
I = ET SEP INH DUE TO TELEMETRY FAILURE
● = TOTAL
C = CLOSE
O = OPEN
G = GPC
M = MANUAL
* = BACKUP SEP WHEN •

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Figure 4.5-II.- Concluded.

MN A AC1	MN B AC2	MN C AC3
C DCU A	C DCU B L DCU A	L DCU B R DCU A
R DCU B		

SSMEC FAILURE	IMPACT
PS A (B)	DCU/CIE A (B)
IE A (B)	SENSORS A (B)
OE A (B)	VALVE ACT. A (B)
DCU/CIE A (B)	REDUNDANCY A (B)

CH. A SENSORS ONLY: HPOT DISCHARGE PR
HYD SYSTEM PR

LOSS OF CONTROLLER REDUNDANCY

VAC < 95 V FOR 30 MSEC
95 V < VAC < 110 V FOR 1 SEC
120 V < VAC < 130 V FOR 20 MSEC
130 V < VAC -- IMMEDIATE LOSS
110 V < NORMAL RANGE < 120 V

MNA 014	MNB 015
C,L,R Pc METER L STATUS LIGHT	C,R STATUS LIGHT

DSC/MDM	OA1	OA2	OA3
GH2 OUT P	C	L	R
GH2 OUT T	C	L	R
GH2 OUT T	C	L	R

GPC 1 STRING 1 MDM FF1	GPC 2 STRING 2 MDM FF2	GPC 3 STRING 3 MDM FF3	GPC 4 STRING 4 MDM FF4
C S/D Pb C Pc METER C STATUS LIGHT	C S/D Pb L S/D Pb L Pc METER L STATUS LIGHT	L S/D Pb R S/D Pb R Pc METER R STATUS LIGHT	R S/D Pb
C S/D Pb(A) O2 DMP ST/SP(A)	LIM INH/ENA(A) C S/D Pb(B) L S/D Pb(A) O2 DMP ST/SP(B)	LIM INI/ENA(B) L S/D Pb(B) R S/D Pb(A)	LIM INH/ENA(C) R S/D Pb(B)

CONTROL AB1	CONTROL AB2	CONTROL AB3	CONTROL BC1
C S/D Pb(A) C SAFING CMD(A)	C S/D Pb(B) C SAFING CMD(B) C EIU PWR, APC4	L EIU PWR, APC6 O2 DMP ST/SP(A)	L EIU PWR, APC5 R EIU PWR, APC4
C S/D Pb NO-OP NO C GUID MODE	C S/D Pb NO-OP NO C GUID MODE	NO MAN O2 DUMP	

CONTROL BC2	CONTROL BC3	CONTROL CA2	CONTROL CA3
L S/D Pb(A) L SAFING CMD(A) LIM INH/ENA(A)	R S/D Pb(B) R SAFING CMD(B) LIM INH/ENA(C) O2 DMP ST/SP(B)	L S/D Pb(B) L SAFING CMD(B) C EIU PWR, APC5 R EIU PWR, APC6	R S/D Pb(A) R SAFING CMD(A) LIM INH/ENA(B)
L S/D Pb NO-OP NO L GUID MODE	R S/D Pb NO-OP NO R GUID MODE NO MAN O2 DUMP	L S/D Pb NO-OP NO L GUID MODE	R S/D Pb NO-OP NO R GUID MODE

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Figure 4.5-III.- SSME control/function loss cue card.

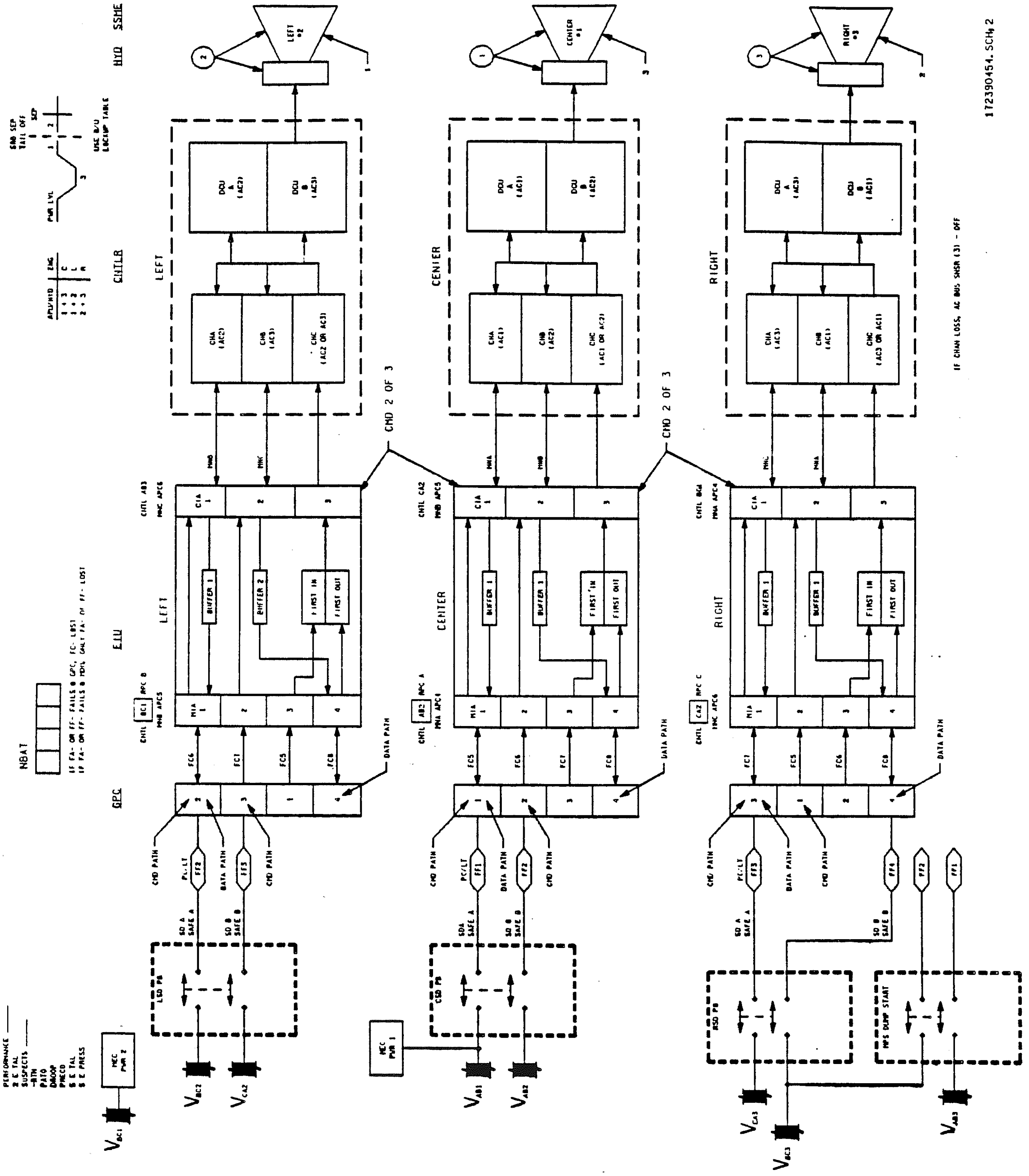

Figure 4.5-IV.- SSME data/command path cue card.

TABLE 4.5-V.- PARAMETER VS. S/C CARD LOSS
(a) DSC OA1

CARD CHAN	MSID	TELEMETRY LOST	FUNCTION LOST	MDM
5/B	V41P1590A	GOX DISCONNECT PRESS		OA1
5/D	V41P1605A	PNEU VLV HE REG PRESS		OA1
14/C	V41P1160A	C GH2 OUTLET PRESS	BACKUP C SSME OUT DETERM.	OA1
17/A	V41T1171A	C GOX OUTLET TEMP	BACKUP C SSME OUT DETERM.	OA1
21/B	V41T1161A	C GH2 OUTLET TEMP	BACKUP C SSME OUT DETERM.	OA1
22/B	V41P1600A	PNEU HE TANK PRESS ⑫	PNEU HE MASS CALC.	OA1
24/A	V41T1351A	R AFT HE TK TEMP	R HE MASS CALC.	OA1
24/B	V41T1601A	PNEU HE TK TEMP	PNEU HE MASS CALC.	OA1
24/C	V41T1152A	C MID HE TK TEMP	C HE MASS CALC.	OA1
26/A	V41T1131C	C LOX INLET TEMP		FA1
27/A	V41P1150C	C HE TK PRESS ⑫	C&W, HE dP/dT, C HE MASS CALC.	FA1
27/B	V41P1100C	C LH2 INLET PRESS		FA1
27/C	V41P1130C	C LOX INLET PRESS		FA1
28/A	V41P1433C	LH2 ENG MANF PRESS ⑫	C&W	FA1
28/B			C HE REG PRESS A METER	
29/A	V41T1101C	C LH2 INLET TEMP	C, AVG. SSME LH2 NPSP COMP.	FA1

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TABLE 4.5-V.- PARAMETER VS. S/C CARD LOSS
(b) DSC OA2

CARD CHAN	MSID	TELEMETRY LOST	FUNCTION LOST	MDM
13/A	V41P1490A	GH2 DISCONNECT PRESS		OA2
14/C	V41P1260A	L GH2 OUTLET PRESS	BACKUP L SSME OUT DETERM.	OA2
17/A	V41T1271A	L GOX OUTLET TEMP	BACKUP L SSME OUT DETERM.	OA2
21/B	V41T1261A	L GH2 OUTLET TEMP	BACKUP L SSME OUT DETERM.	OA2
24/B	V41T1151A	C AFT HE TK TEMP	C HE MASS CALC.	OA2
24/C	V41T1252A	L MID HE TK TEMP	L HE MASS CALC.	OA2
26/A	V41T1231C	L LOX INLET TEMP		FA2
27/A	V41P1250C	L HE AFT TK PRESS ⑫	C&W, HE dP/dT, L HE MASS CALC.	FA2
27/B	V41P1200C	L LH2 INLET PRESS		FA2
27/C	V41P1230C	L LOX INLET PRESS		FA2
28/A	V41P1533C	LOX ENG MANF PRESS	C&W	FA2
28/B			L HE REG PRESS A METER	
29/A	V41T1201C	L LH2 INLET TEMP	L, AVG SSME LH2 NPSP COMP.	FA2

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TABLE 4.5-V.- PARAMETER VS. S/C CARD LOSS
(c) DSC OA3

CARD CHAN	MSID	TELEMETRY LOST	FUNCTION LOST	MDM
14/C	V41P1360A	R GH2 OUTLET PRESS	BACKUP R SSME OUT DETERM.	OA3
17/A	V41T1371A	R GOX OUTLET TEMP	BACKUP R SSME OUT DETERM.	OA3
21/B	V41T1361A	R GH2 OUTLET TEMP	BACKUP R SSME OUT DETERM.	OA3
24/A	V41T1251A	L AFT HE TK TEMP	L HE MASS CALC.	OA3
24/C	V41T1352A	R MID HE TK TEMP	R HE MASS CALC.	OA3
26/A	V41T1331C	R LOX INLET TEMP		FA3
27/A	V41P1350C	R HE TK PRESS ⑫	C&W, HE dP/dT, R HE MASS CALC.	FA3
27/B	V41P1300C	R LH2 INLET PRESS		FA3
27/C	V41P1330C	R LOX INLET PRESS		FA3
28/B			R HE REG PRESS A METER	
29/A	V41T1301C	R LH2 INLET TEMP	R, AVG SSME LH2 NPSP COMP.	FA3

0151J.ART, 5

TABLE 4.5-V.- PARAMETER VS. S/C CARD LOSS
(d) DSC OF1

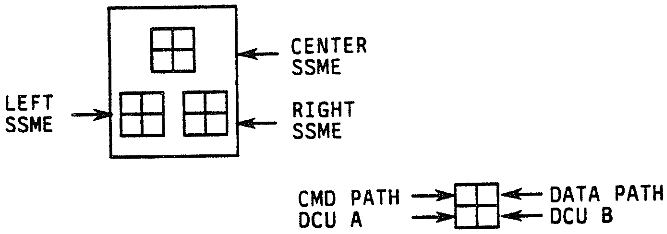
CARD CHAN	MSID	TELEMETRY LOST	FUNCTION LOST	MDM
19/A	V41P1154A	C HE REG PRESS A ⑫	C&W, CLASS 3 ALERT, METER	OF1
18/B	V41P1254A	L HE REG PRESS A ⑫	C&W, CLASS 3 ALERT, METER	OF1
11/C	V41P1354A	R HE REG PRESS A ⑫	C&W, CLASS 3 ALERT, METER	OF1

01510.ART, 11

TABLE 4.5-V.- PARAMETER VS. S/C CARD LOSS
(e) DSC OM2

CARD CHAN	MSID	TELEMETRY LOST	FUNCTION LOST	MDM
16/A	V41P1153A	C HE REG PRESS B ⑫	CLASS 3 ALERT	OA1
16/B	V41P1253A	L HE REG PRESS B ⑫	CLASS 3 ALERT	OA1
16/C	V41P1353A	R HE REG PRESS B ⑫	CLASS 3 ALERT	OA1

0151P. ART. 12



ONE OF THREE CMD PATHS LOST. CMD CAPABILITY STILL POSSIBLE

CMD CAPABILITY COULD BE LOST - BASED ON WHICH CMD PASSES FIFO BUFFER FIRST

TWO OF THREE CMD PATHS LOST. CMD CAPABILITY LOST

PRIMARY DATA LOST

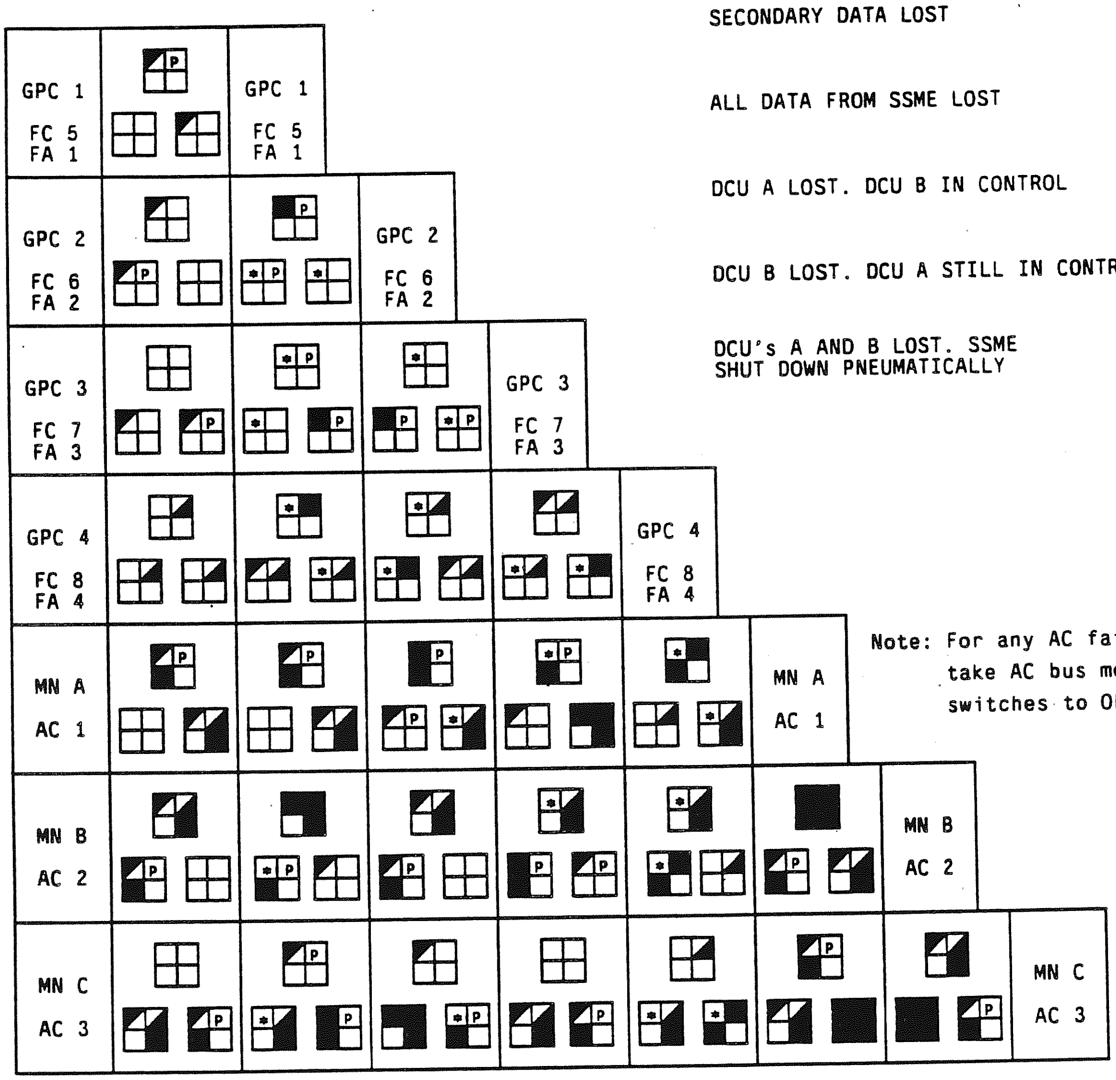
SECONDARY DATA LOST

ALL DATA FROM SSME LOST

DCU A LOST. DCU B IN CONTROL

DCU B LOST. DCU A STILL IN CONTROL

DCU's A AND B LOST. SSME SHUT DOWN PNEUMATICALLY



Note: For any AC failure take AC bus monitor switches to OFF.

Figure 4.5-V.- SSME single and dual GPC/bus loss matrix.

CONSOLE
DESCRIPTION

5

CONSOLE
DESCRIPTION

TITLE

ME CONSOLE LOCATIONS AND CONFIGURATION

PURPOSE

This SCP provides the Main Engine (ME) console location and configuration.

DESCRIPTION

ME consoles are located in room numbers 310 and 233 of building 30. Console number 466 is in room number 310 (the room used for secure operations). Normal operations use console number 348 in room number 233. Figure 5.1.1-I shows the console configuration. Each event light module has an assigned format number printed on the overlay. Table 5.1.1-I also lists the format numbers corresponding to the panel location. Formats can be verified using MSK 0075 for console 348 formats and MSK 0087 for console 466 formats, the digital display driver (DDD) guide display, and table 5.1.1-I.

REFERENCES

1. Booster Data Pack, as of Sep. 1, 1989.
2. Current layout of Mission Operations Wing

TABLE 5.1.1-I.- PANEL LOCATION AND DDD FORMAT NUMBER

Panel number	DDD Format Number
1	282
2	281
3	283
4	290
5	293
18	284
19	285

Panel location	Description	Panel location	Description
01	EVENT INDICATOR	28	VOICE COMM POSITION-2123
02	EVENT INDICATOR	32	SUMMARY MSG ENABLE KBRD-ME
03	EVENT INDICATOR	33	SUMMARY MSG ENABLE KBRD-MMACS
04	EVENT INDICATOR	57	VOICE COMM SPEAKER
05	EVENT INDICATOR	61	BLANK PANEL
18,19	EVENT INDICATOR	62	BLANK PANEL
20	TV MONITOR	63	BLANK PANEL
21	TV MONITOR	64	BLANK PANEL
22	TV MONITOR	900	LAST SOURCE
25	MANUAL SELECT KEYBOARD	A	WEX 2.1 TERMINAL
27	VOICE COMM POSITION-2122	B	RTDS TERMINAL
		C	WEX 2.3 TERMINAL

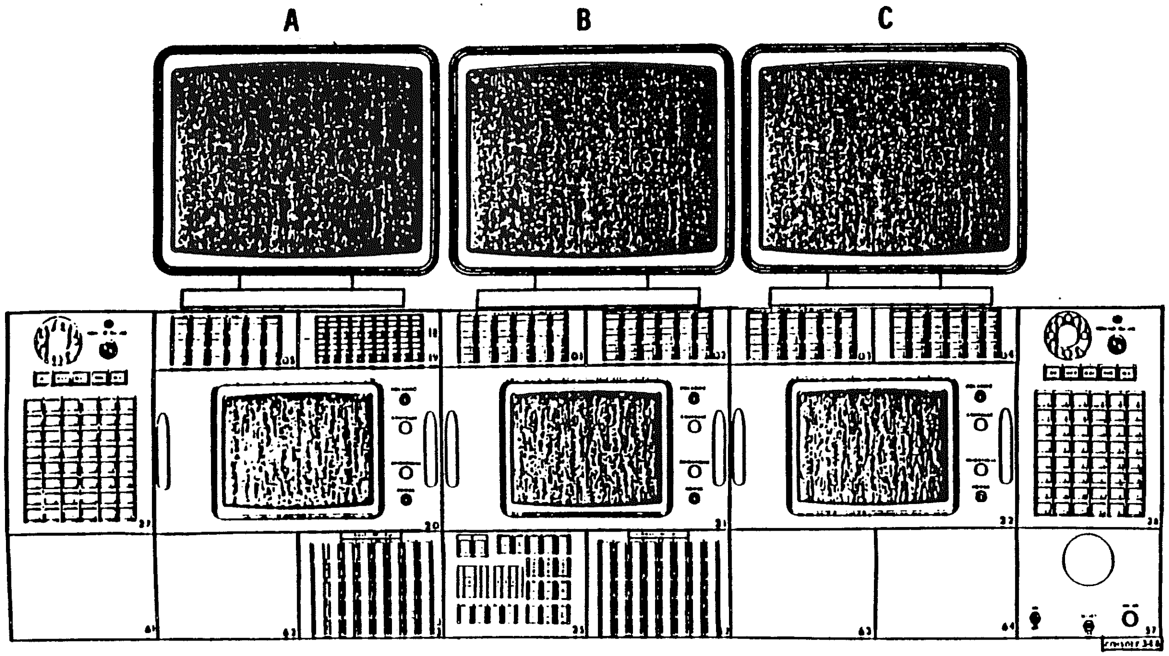


Figure 5.1.1-1.- ME console (number 348) configuration.

TITLE

ME CONSOLE CRT DISPLAYS

PURPOSE

This SCP shows the CRT displays available at ME consoles which monitor the performance of the SSME's.

DESCRIPTION

A. The primary display used to monitor the SSME performance is Booster MSK 1051. This display is shown in figure 5.1.2-I. The master measurement list (MML) number (or MSID number) for each parameter is included in the figure or listed in table 5.1.2-I below.

TABLE 5.1.2-I.- MSK 1051 ADDITIONAL MSID's

No.	MSID	Notes
A1	M10H0015J	Site
A2	V75X4070D M40H0134J M40H0135J	Format Static Suspect
A3	V93Q0022CX M40H0234J M40H0235J	Format Static Suspect
A4	V93Q0022CY M40H0334J M40H0335J	Format Static Suspect
A5	V98Q0009C M40H0434J M40H0435J	Format Static Suspect

F/V / M10H0009J BOOSTER ME 1051B CH ---

OGMT M40H0121J OMET M40H0107J SITE A1 OI A2 GN A3
RGMT M40H0108J GPC MM V90Q8001C ACCEL V95U0163C SM A4 BF A5

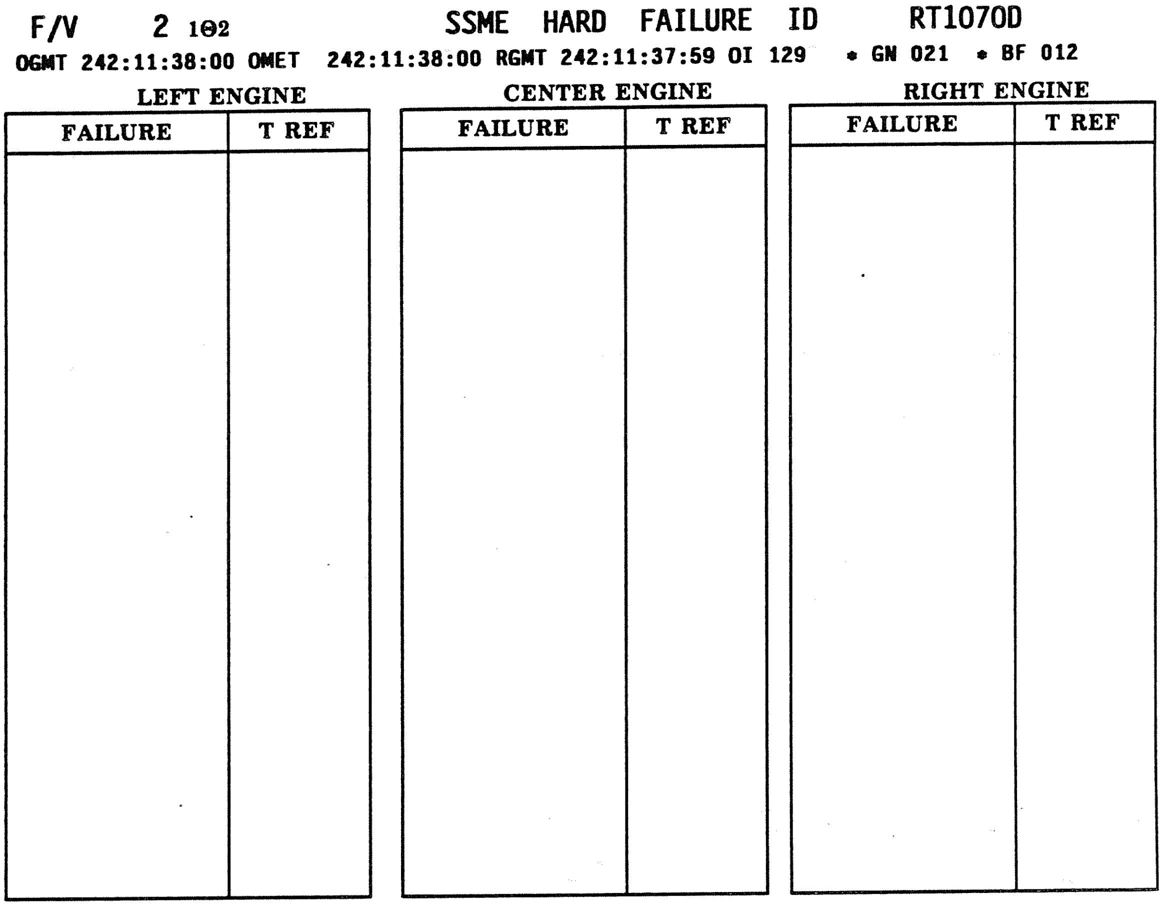
VI SCOMP21	TF V90U1979C TGO V90W1941C	MECO V90W1970C	SD M02G3705T M01G3705T M03G3705T
GH2 OUT P/T'F PC AVG/GO2 OUT T MCC PC A / B PWR LVL / CMD	V41P1260A / V41T1261A E41P2023B / V41T1271A E41P2016B / E41P2017B M02G3108C / V90U1948C	V41P1160A / V41T1161A E41P1023B / V41T1171A E41P1016B / E41P1017B M01G3108C / V90U1948C	V41P1360A / V41T1361A E41P3023B / V41T1371A E41P3016B / E41P2017B M03G3108C / V90U1948C
ESW / T REF ID WD 2 / T FAIL HARD FID	E41M2003P E41W2004B E41M2002P M14G3000T M05G3000R M06G3000R M07G3000R M08G3000R	E41M1003P E41W1004B E41M1002P M13G3000T M01G3000R M02G3000R M03G3000R M04G3000R	E41M3003P E41W3004B E41M3002P M15G3000T M09G3000R M10G3000R M11G3000R M12G3000R
HPOT D P / N FU FLOW GPM/LBS LPFT DISCH T/P	E41P2030B / M04G3112C E41R2021B / M02G3103C E41T2019B / E41P2018B	E41P1030B / M02G3112C E41R1021B / M01G3103C E41T1019B / E41P1018B	E41P3030B / M05G3112C E41R3021B / M03G3103C E41T3019B / E41P3018B
HE TK P /HE MDOT HPOT ISP P A/B HPOT SEC P A/B	V41P1250C / V98P4998C E41P2014B / E41P2015B E41P2051B / E41P2053B	V41P1150C / V98P4997C E41P1014B / E41P1015B E41P1051B / E41P1053B	V41P1350C / V98P4999C E41P3014B / E41P3015B E41P3051B / E41P3053B
HPFT CL LN PA/B	E41P2008B / E41P2009B	E41P1008B / E41P1009B	E41P3008B / E41P3009B
HPOT/HPFT TD TA HPOT/HPFT TD TB OPOV / FPOV	E41T2012B / E41T2010B E41T2013B / E41T2011B E41H2028B / E41H2027B	E41T1012B / E41T1010B E41T1013B / E41T1011B E41H1028B / E41H1027B	E41T3012B / E41T3010B E41T3013B / E41T3011B E41H3028B / E41H3027B
MOV / MFV / CCV HYD P VEH/ ME	E41H2025B/E41H2024B/E41H2026B V58P0216C / E41P2054B	E41H1025B/E41H1024B/E41H1026B V58P0116C / E41P1054B	E41H3025B/E41H3024B/E41H3026 V58P0316C / E41P3054B
MR / ISP AV PWR LVL/AV MR MR LVL / TN / N	M03G3107C / M03G3112C M05G3113C / M02G3113C M08G3113C/ARD75L/M04G3112C	M02G3107C / M01G3112C M04G3113C / M01G3113C M07G3113C/ARD75C/M02G3112C	M04G3107C / M05G3112C M06G3113C / M03G3113C M09G3113C/ARD75R/M06G3112C
BFS ESW/ PC%	V98M2220P / V98P2110C	V98M2200P / V98P2100C	V98M2240P / V98P2120C

FML M01G0800R M02G0800R M03G0800R M22G0800T
FML M04G0800R M05G0800R M06G0800R M22G0800T
BFS FML M01G0801R M02G0801R M03G0801R V98W1330C

BFS S/D M01G4300T
M02G4300T M03G4300T
VR V95L0151C

Figure 5.1.2-I.-Booster ME.

B. The SSME hard failure identification display, MSK 1070, is shown in figure 5.1.2-II. Each SSME has a dedicated column. SCP 3.1.2 describes SSME hard failure ID processing. As new failures occur, the column fills up automatically. After the column is full, no more updates on that column are possible until the display is cleared using SMEK PBI's (ref. SCP 6.2). The new SSME hard FID display, MSK 1069, which includes octal values, is shown in figure 5.1.2-III.



F/V 2 102 SSME HARD FAILURE ID RT1070D

OGMT 242:11:38:00 OMET 242:11:38:00 RGMT 242:11:37:59 OI 129 * GN 021 * BF 012

LEFT ENGINE		CENTER ENGINE		RIGHT ENGINE	
FAILURE	T REF	FAILURE	T REF	FAILURE	T REF

Figure 5.1.2-II.- SSME HARD FAILURE ID, MSK 1070 display.

C. Universal Plots - The universal plots (UP's) plot parameters in real time or playbacks. The parameters and scales of each plot are input through the Megadata (MED) terminal and stored in menus on a floppy diskette. Prior to a mission or simulation, these menus are loaded into the MOC through the MED terminal. (Refer to SCP 6.3 on MED terminal operations.) To start each plot, the SMEK panel is used (see SCP 6.2).

The ME console uses UP 2759 through 2766 to monitor the SSME's. A display of each UP is shown in figures 5.1.2-IV through 5.1.2-XI. On each plot, time (the abscissa) is labeled in minutes. At the top left of each of the plots is "UDRATE", the plot update rate - all of which are in seconds. UP 2762 is perhaps the most useful plot. This is used as an additional quick cue regarding engine performance.

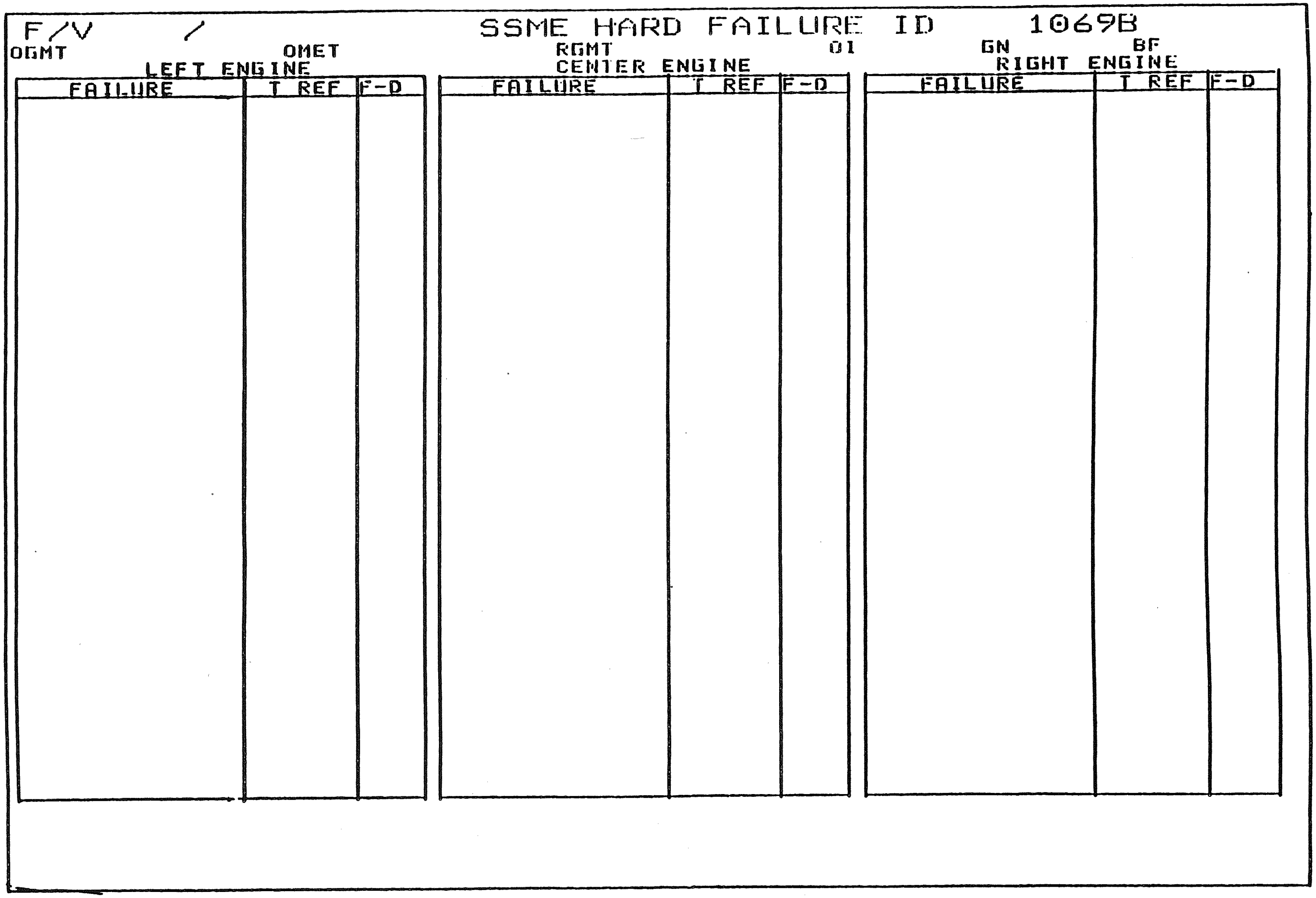
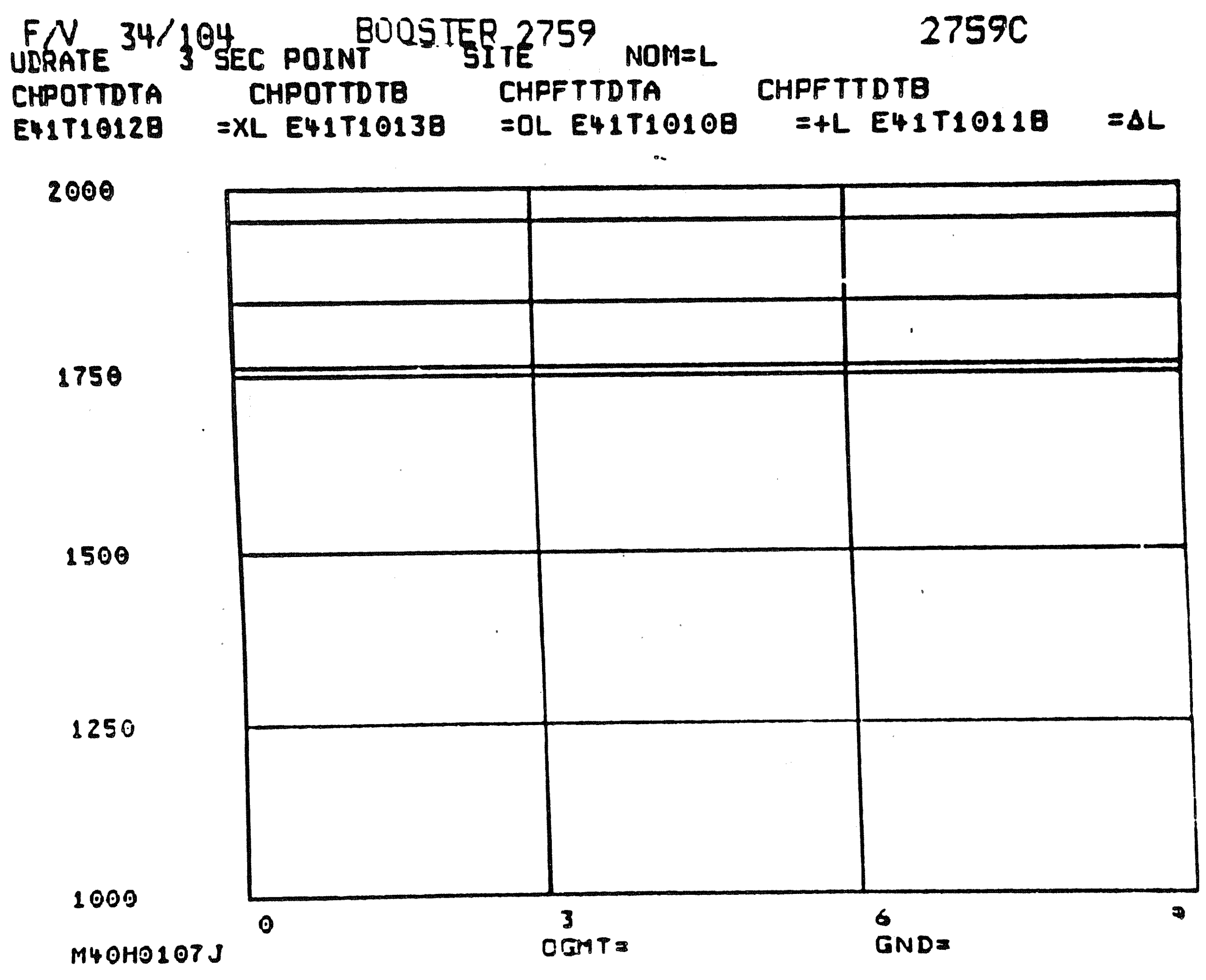


Figure 5.1.2-III.- SSME HARD FAILURE ID, MSK 1069B display.



```
F/V  34/104        BOOSTER 2759                      2759C
UDRATE    3 SEC POINT       SITE      NOM=L
CHPOTTDTA      CHPOTTDTB      CHPFTTDTA      CHPFTTDTB
E41T1012B   =XL E41T1013B   =OL E41T1010B   =+L E41T1011B   =ΔL
```

Figure 5.1.2-IV.- UP 2759.

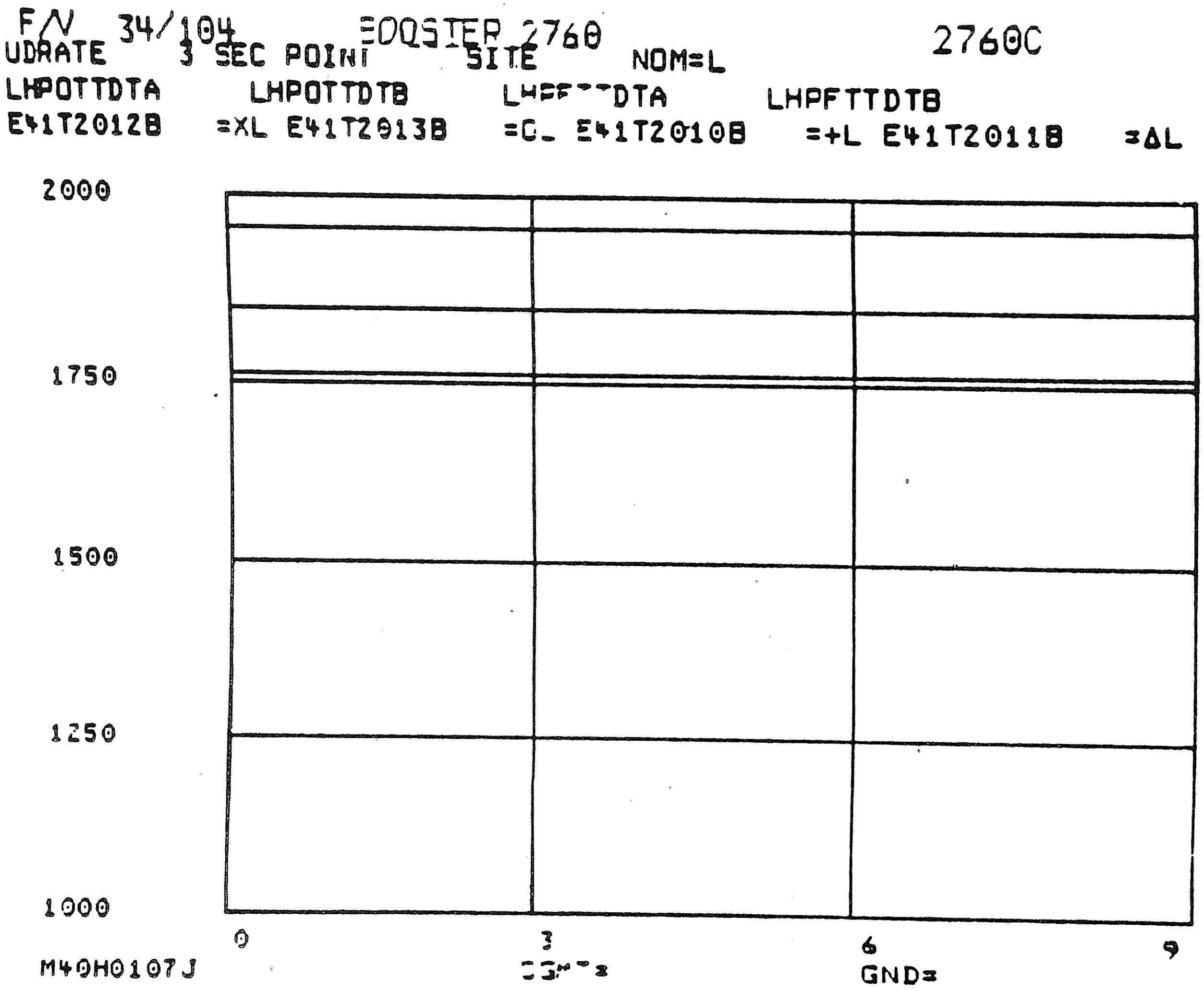
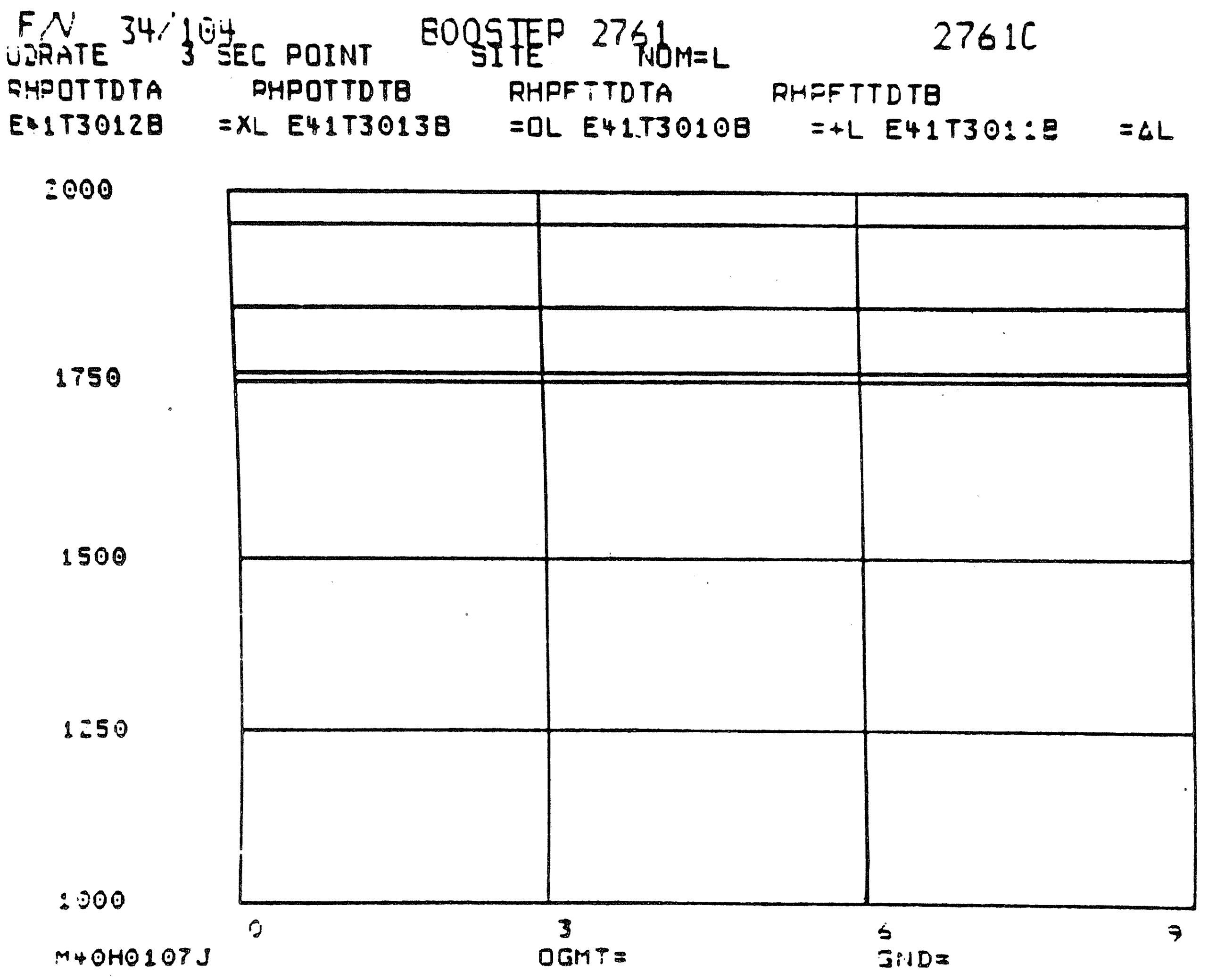


Figure 5.1.2-V.- UP 2760.



```
F/V  34/104          BOOSTEP 2761              2761C
UDRATE    3 SEC POINT     SITE    NOM=L
RHPOTTDTA      RHPOTTDTB      RHPFTTDTA      RHPFTTDTB
E41T3012B   =XL E41T3013B   =OL E41T3010B   =+L E41T3011B   =ΔL
```

Figure 5.1.2-VI.- UP 2761.

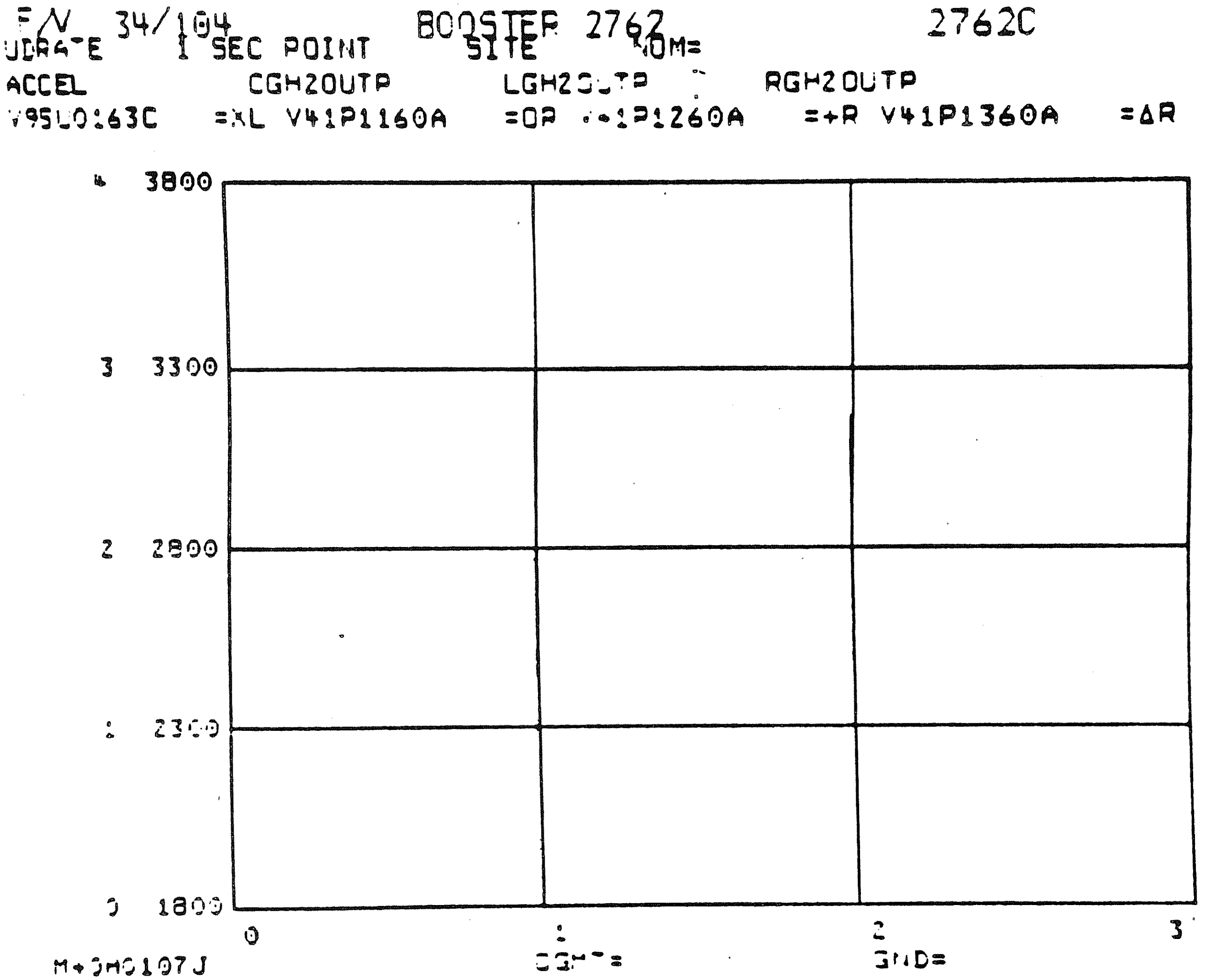


Figure 5.1.2-VII.- UP 2762.

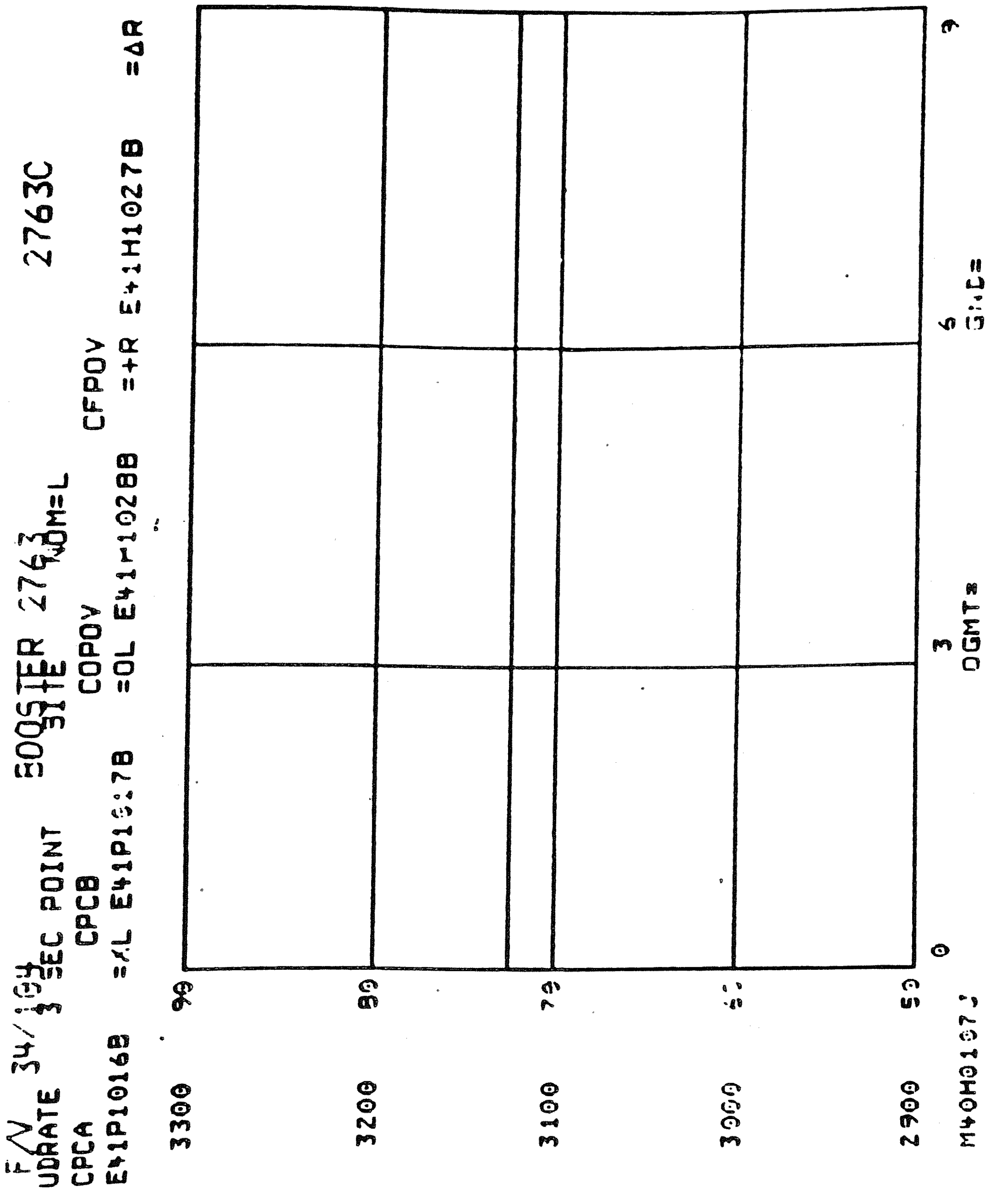


Figure 5.1.2-VIII.- UP 2763.

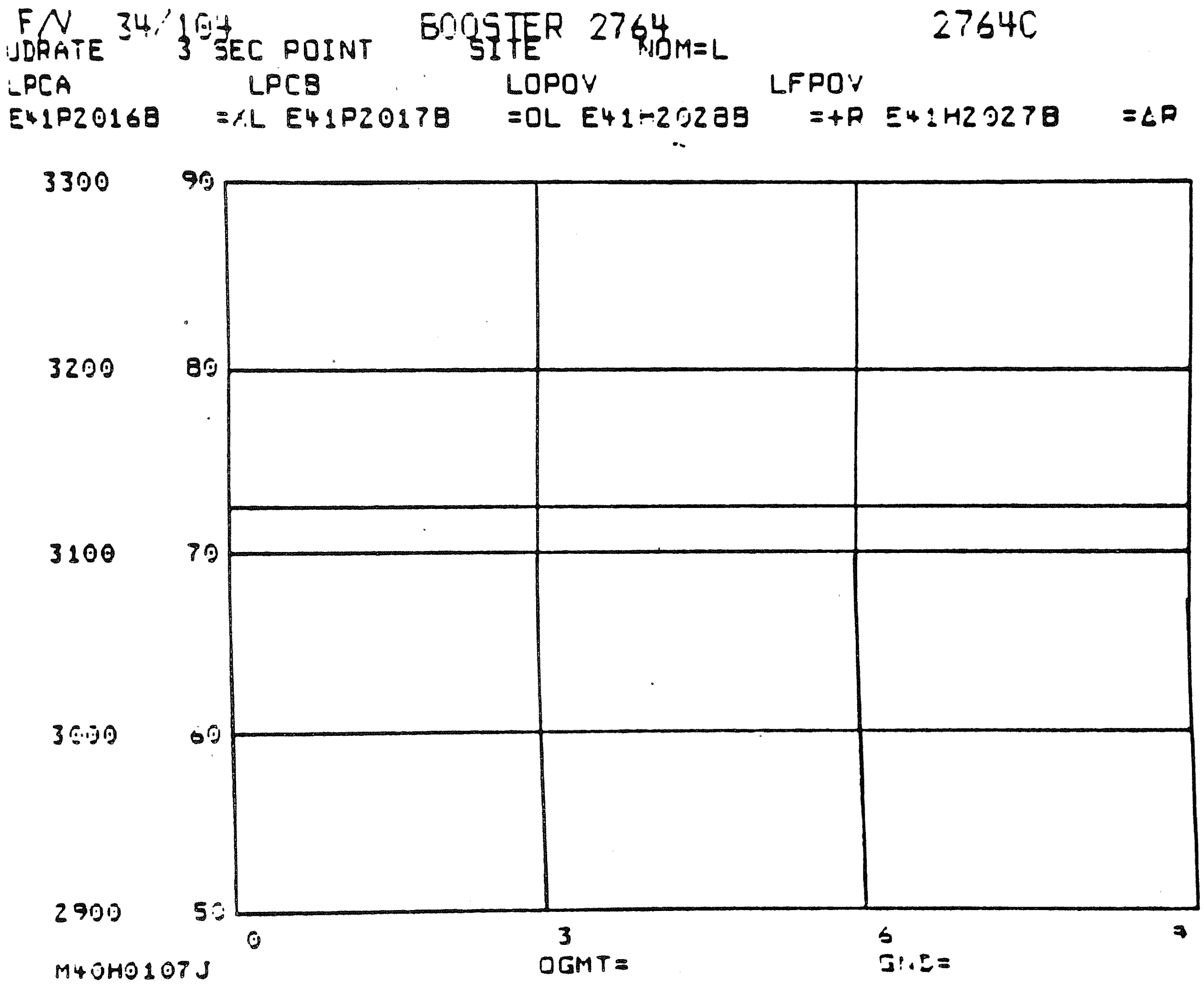


Figure 5.1.2-IX.- UP 2764.

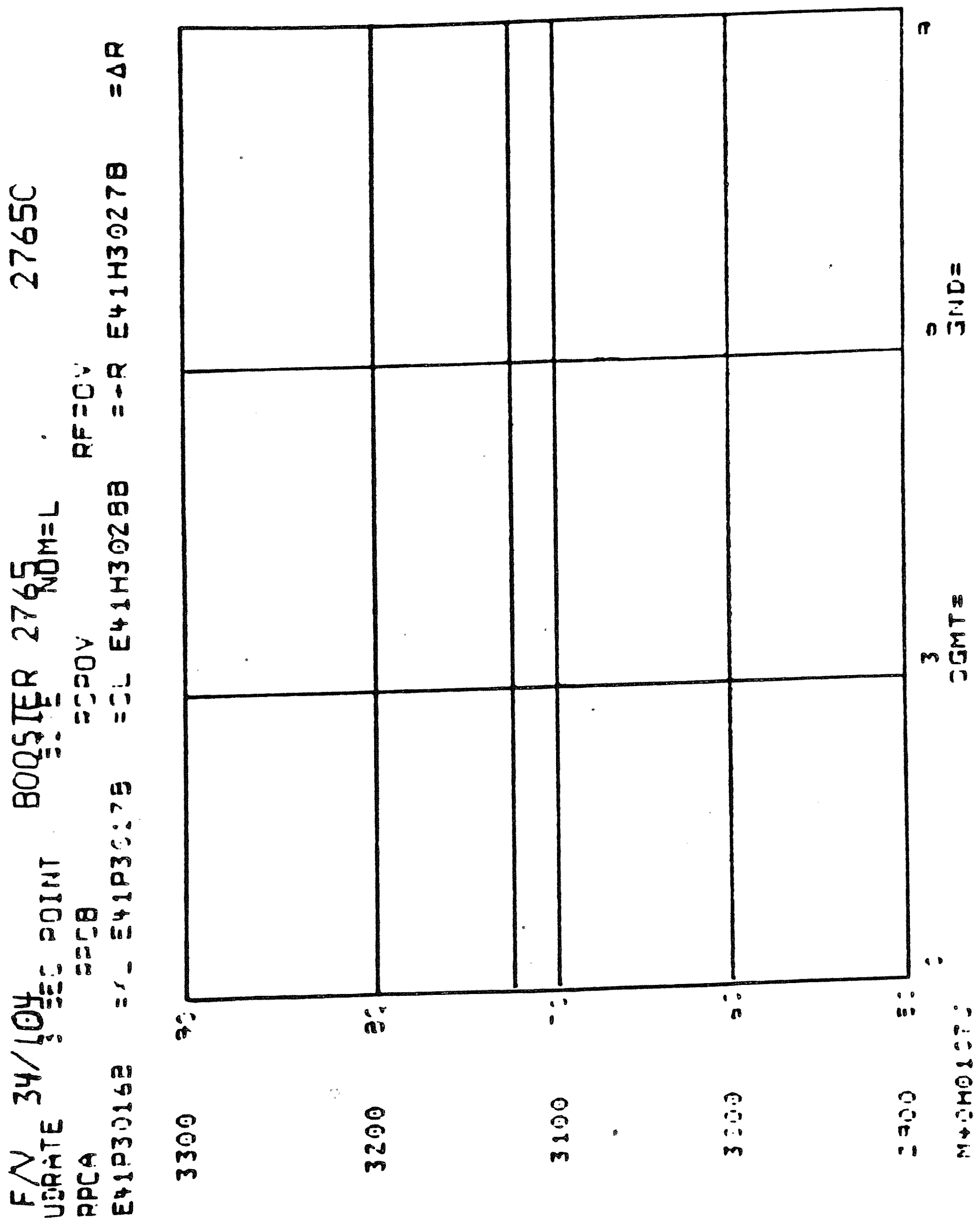


Figure 5.1.2-X.- UP 2765.

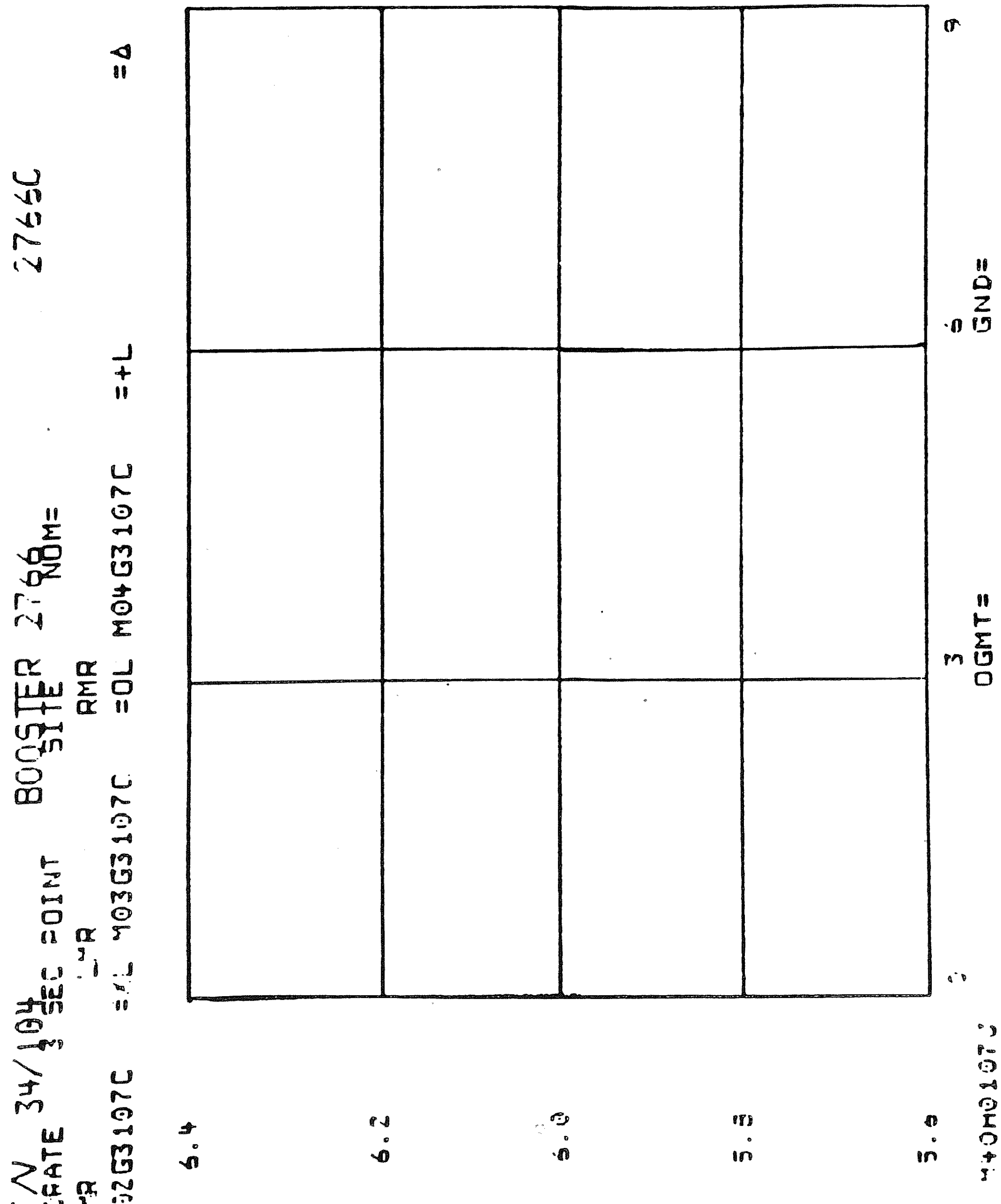
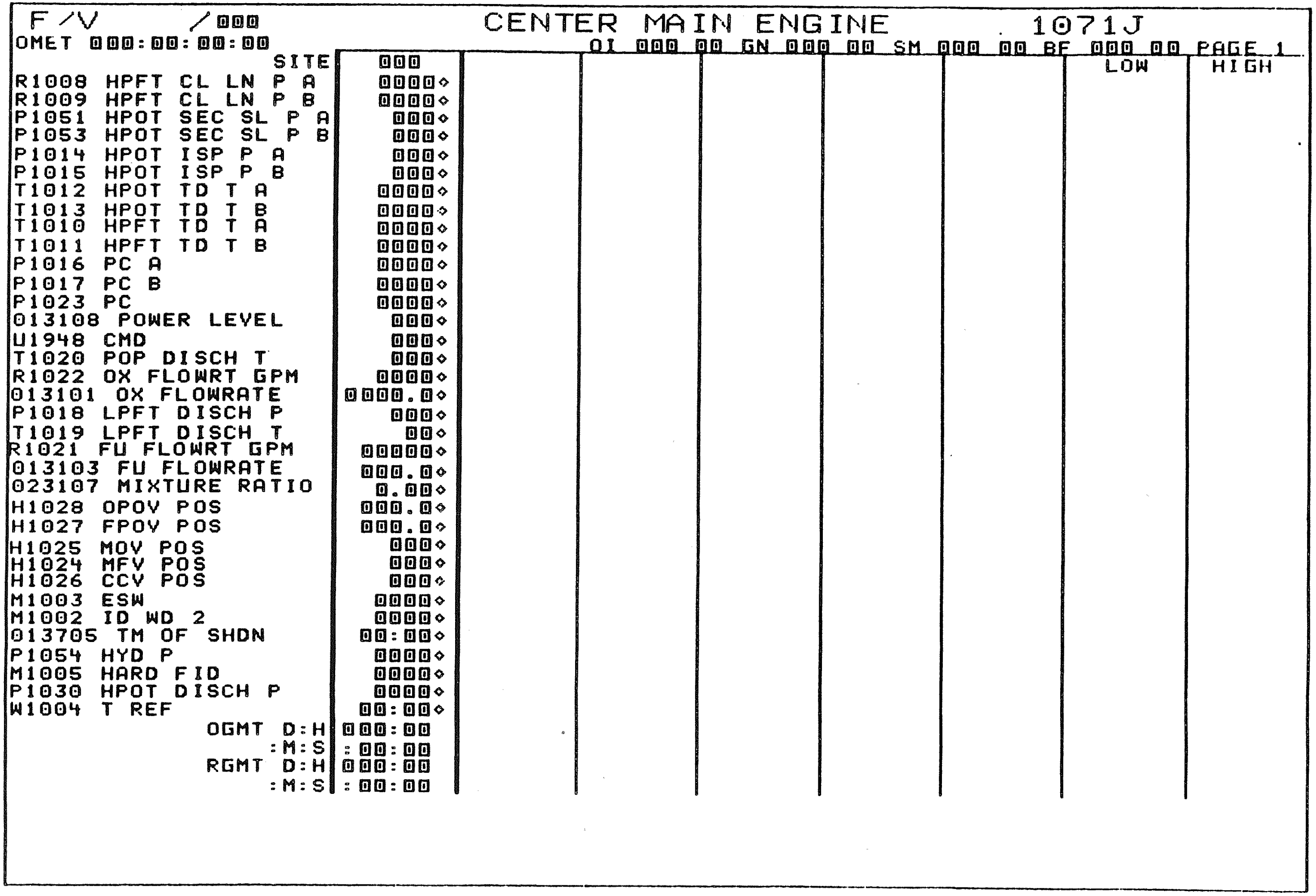


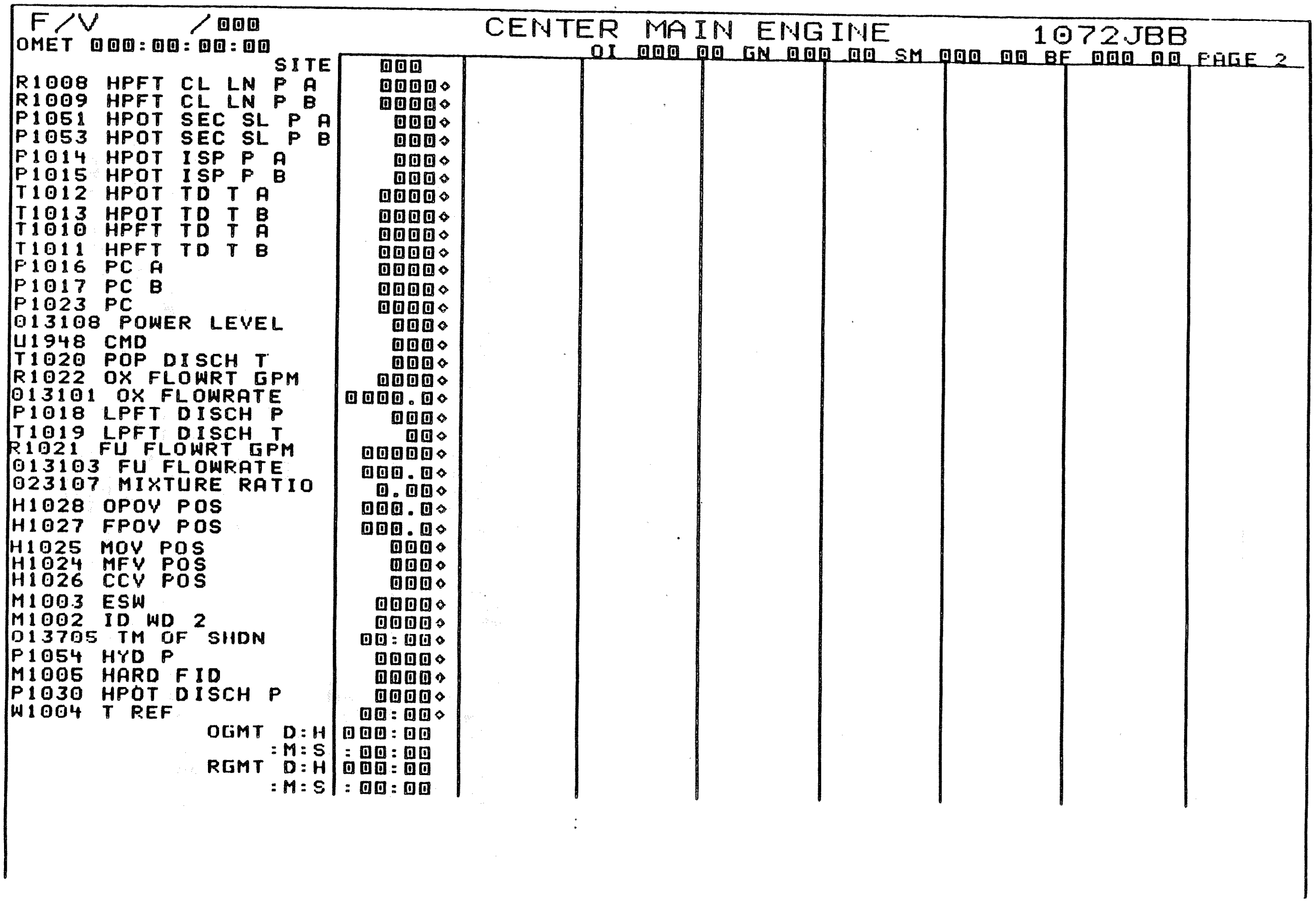
Figure 5.1.2-XI.- UP 2766.

D. History Tabulation Displays - The history tabulation (HT) displays are used to store predefined telemetry. The SSME HT displays include MSK 1071 through MSK 1076 and MSK's 1089 and 1090. A display of each HT is shown in figure 5.1.2-XII through figure 5.1.2-XIX. There is an HT display for each engine and for the BFS telemetry. Each HT display has two pages. Five columns of history data are stored on the first page, and eight columns of history data are stored on the second page. A page of the HT display is selected by using the MSK panel (refer to SCP 6.1.1). A column of data is stored on the HT displays by depressing the HT PBI on the SMEK (refer to SCP 6.1.2).



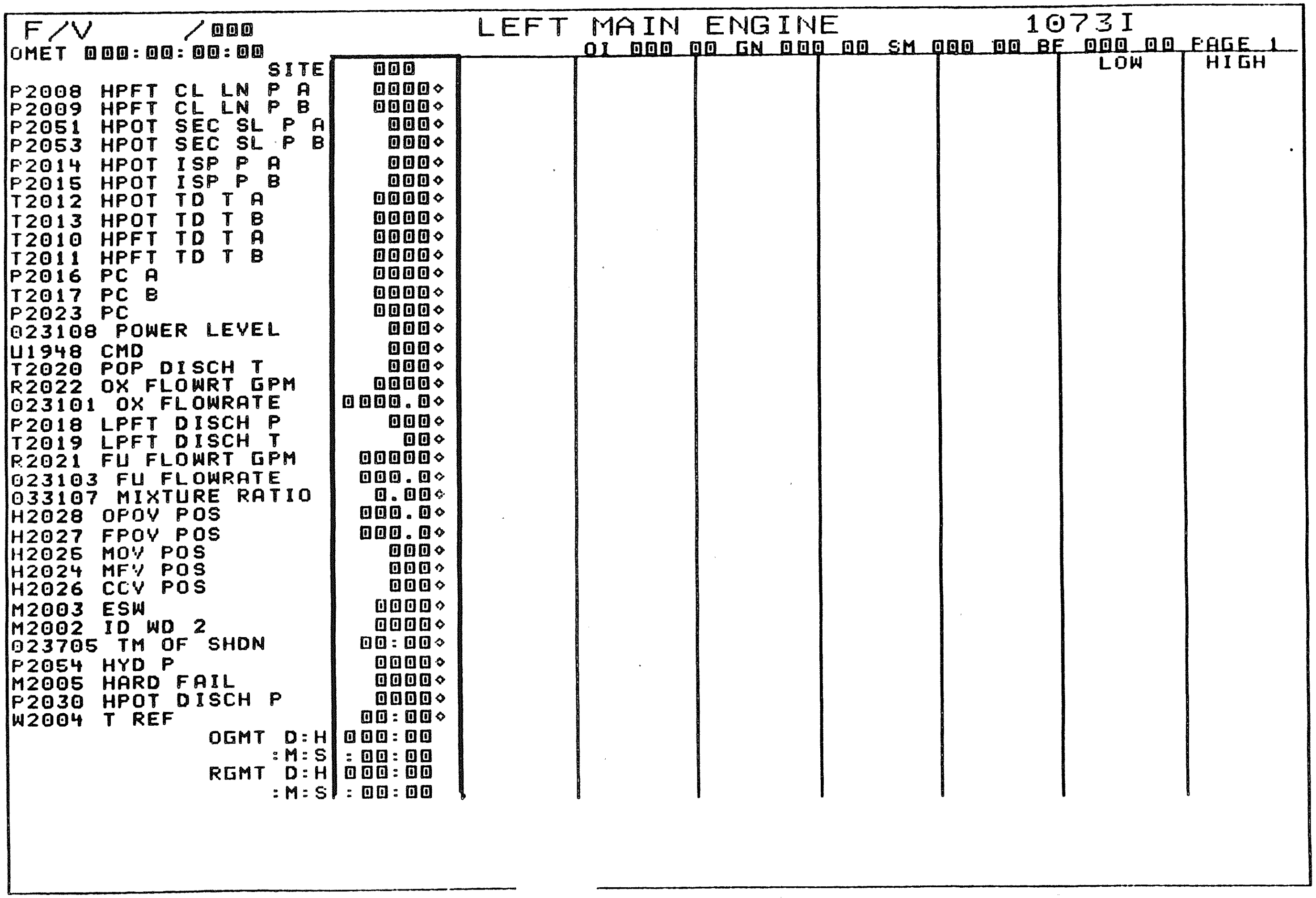
```
 F/V        /□□□                CENTER MAIN ENGINE         1071J
OMET □□□:□□:□□:□□                 OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 1
                    SITE    □□□                                        LOW   HIGH
R1008 HPFT CL LN P A       □□□□◇
R1009 HPFT CL LN P B       □□□□◇
P1051 HPOT SEC SL P A       □□□◇
P1053 HPOT SEC SL P B       □□□◇
P1014 HPOT ISP P A          □□□◇
P1015 HPOT ISP P B          □□□◇
T1012 HPOT TD T A          □□□□◇
T1013 HPOT TD T B          □□□□◇
T1010 HPFT TD T A          □□□□◇
T1011 HPFT TD T B          □□□□◇
P1016 PC A                 □□□□◇
P1017 PC B                 □□□□◇
P1023 PC                   □□□□◇
013108 POWER LEVEL          □□□◇
U1948 CMD                   □□□◇
T1020 POP DISCH T           □□□◇
R1022 OX FLOWRT GPM        □□□□◇
013101 OX FLOWRATE       □□□□.□◇
P1018 LPFT DISCH P          □□□◇
T1019 LPFT DISCH T           □□◇
R1021 FU FLOWRT GPM       □□□□□◇
013103 FU FLOWRATE        □□□.□◇
023107 MIXTURE RATIO       □.□□◇
H1028 OPOV POS            □□□.□◇
H1027 FPOV POS            □□□.□◇
H1025 MOV POS               □□□◇
H1024 MFV POS               □□□◇
H1026 CCV POS               □□□◇
M1003 ESW                  □□□□◇
M1002 ID WD 2              □□□□◇
013705 TM OF SHDN         □□:□□◇
P1054 HYD P                □□□□◇
M1005 HARD FID             □□□□◇
P1030 HPOT DISCH P         □□□□◇
W1004 T REF               □□:□□◇
             OGMT D:H   □□□:□□
                  :M:S  :□□:□□
             RGMT D:H   □□□:□□
                  :M:S  :□□:□□
```

Figure 5.1.2-XII.- SSME HT display, MSK 1071.



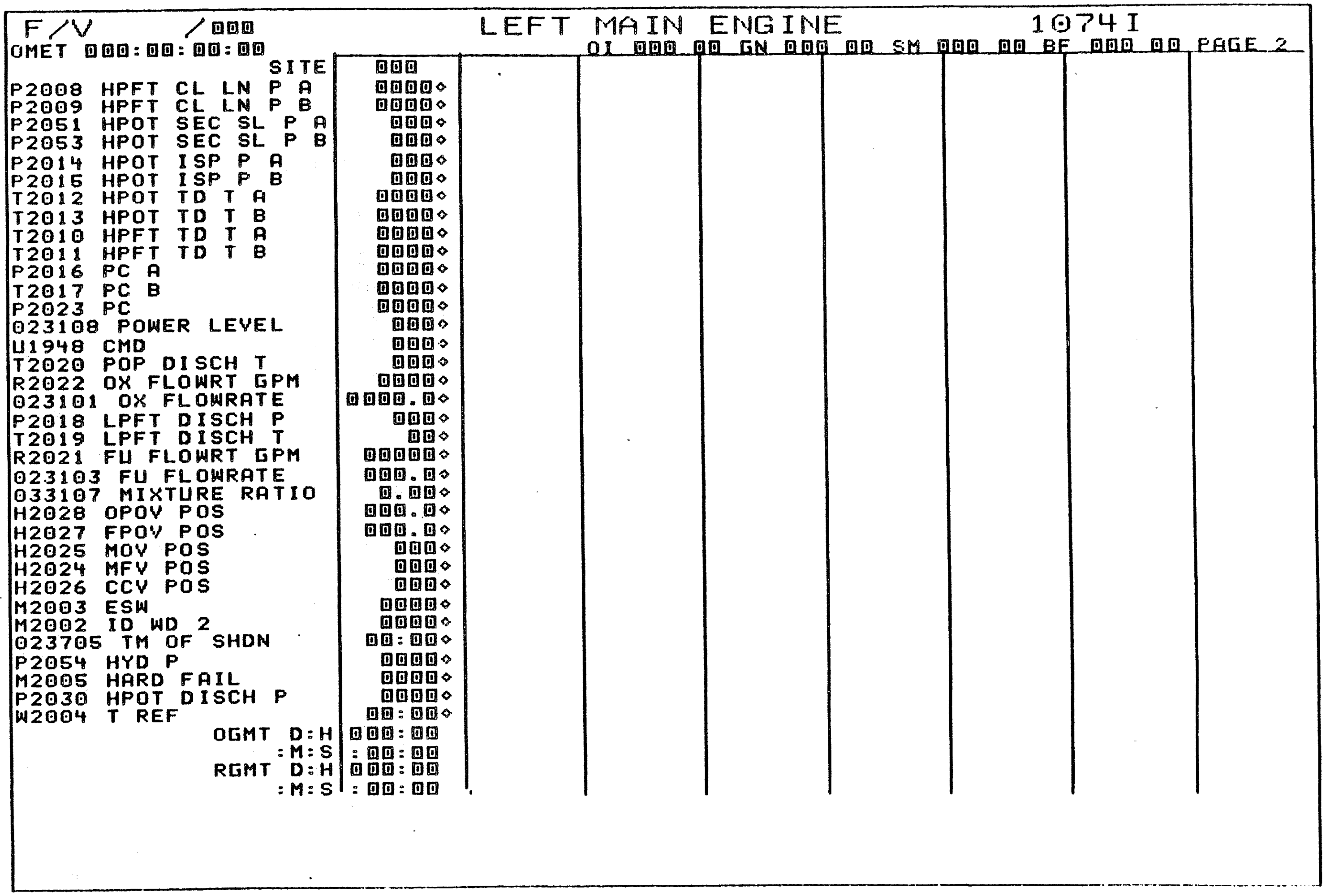
```
F/V      /□□□                       CENTER MAIN ENGINE          1072JBB
OMET □□□:□□:□□:□□                      OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 2
                             SITE     □□□
R1008 HPFT CL LN P A         □□□□◇
R1009 HPFT CL LN P B         □□□□◇
P1051 HPOT SEC SL P A         □□□◇
P1053 HPOT SEC SL P B         □□□◇
P1014 HPOT ISP P A            □□□◇
P1015 HPOT ISP P B            □□□◇
T1012 HPOT TD T A            □□□□◇
T1013 HPOT TD T B            □□□□◇
T1010 HPFT TD T A            □□□□◇
T1011 HPFT TD T B            □□□□◇
P1016 PC A                   □□□□◇
P1017 PC B                   □□□□◇
P1023 PC                     □□□□◇
013108 POWER LEVEL            □□□◇
U1948 CMD                     □□□◇
T1020 POP DISCH T             □□□◇
R1022 OX FLOWRT GPM          □□□□◇
013101 OX FLOWRATE         □□□□.□◇
P1018 LPFT DISCH P            □□□◇
T1019 LPFT DISCH T             □□◇
R1021 FU FLOWRT GPM         □□□□□◇
013103 FU FLOWRATE          □□□.□◇
023107 MIXTURE RATIO         □.□□◇
H1028 OPOV POS              □□□.□◇
H1027 FPOV POS              □□□.□◇
H1025 MOV POS                 □□□◇
H1024 MFV POS                 □□□◇
H1026 CCV POS                 □□□◇
M1003 ESW                    □□□□◇
M1002 ID WD 2                □□□□◇
013705 TM OF SHDN           □□:□□◇
P1054 HYD P                  □□□□◇
M1005 HARD FID               □□□□◇
P1030 HPOT DISCH P           □□□□◇
W1004 T REF                 □□:□□◇
                 OGMT D:H  □□□:□□
                      :M:S  :□□:□□
                 RGMT D:H  □□□:□□
                      :M:S  :□□:□□
```

Figure 5.1.2-XIII.- SSME HT display, MSK 1072.



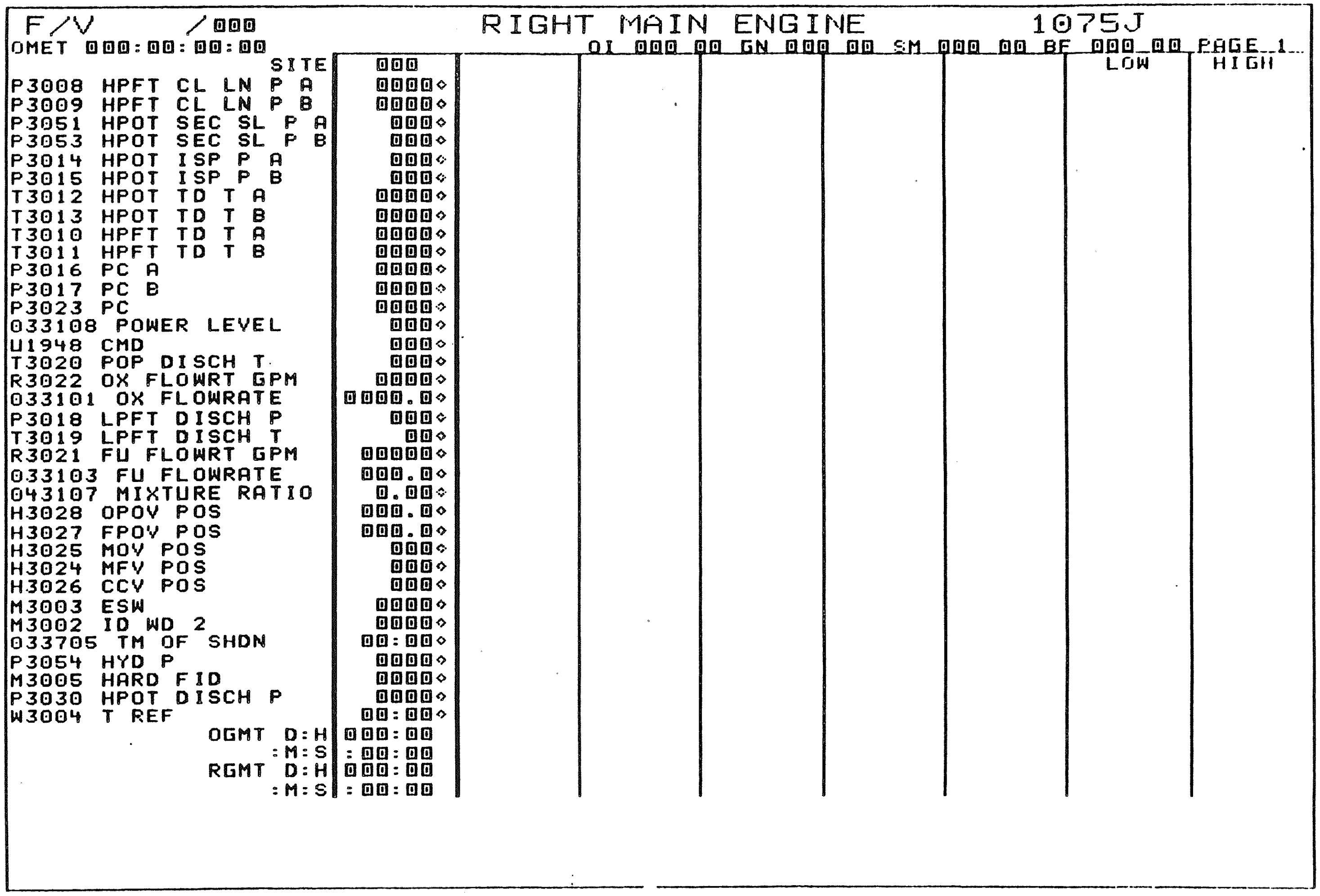
```
 F/V         /000                LEFT MAIN ENGINE                 1073I
OMET 000:00:00:00                      01 000 00 GN 000 00 SM 000 00 BF 000 00 PAGE 1
                             SITE     000                                      LOW   HIGH
P2008 HPFT CL LN P A         0000◇
P2009 HPFT CL LN P B         0000◇
P2051 HPOT SEC SL P A         000◇
P2053 HPOT SEC SL P B         000◇
P2014 HPOT ISP P A            000◇
P2015 HPOT ISP P B            000◇
T2012 HPOT TD T A            0000◇
T2013 HPOT TD T B            0000◇
T2010 HPFT TD T A            0000◇
T2011 HPFT TD T B            0000◇
P2016 PC A                   0000◇
T2017 PC B                   0000◇
P2023 PC                     0000◇
023108 POWER LEVEL            000◇
U1948 CMD                     000◇
T2020 POP DISCH T             000◇
R2022 OX FLOWRT GPM          0000◇
023101 OX FLOWRATE         0000.0◇
P2018 LPFT DISCH P            000◇
T2019 LPFT DISCH T             00◇
R2021 FU FLOWRT GPM         00000◇
023103 FU FLOWRATE          000.0◇
033107 MIXTURE RATIO         0.00◇
H2028 OPOV POS              000.0◇
H2027 FPOV POS              000.0◇
H2025 MOV POS                 000◇
H2024 MFV POS                 000◇
H2026 CCV POS                 000◇
M2003 ESW                    0000◇
M2002 ID WD 2                0000◇
023705 TM OF SHDN           00:00◇
P2054 HYD P                  0000◇
M2005 HARD FAIL              0000◇
P2030 HPOT DISCH P           0000◇
W2004 T REF                 00:00◇
                 OGMT D:H  000:00
                      :M:S :00:00
                 RGMT D:H  000:00
                      :M:S :00:00
```

Figure 5.1.2-XIV.- SSME HT display, MSK 1073.



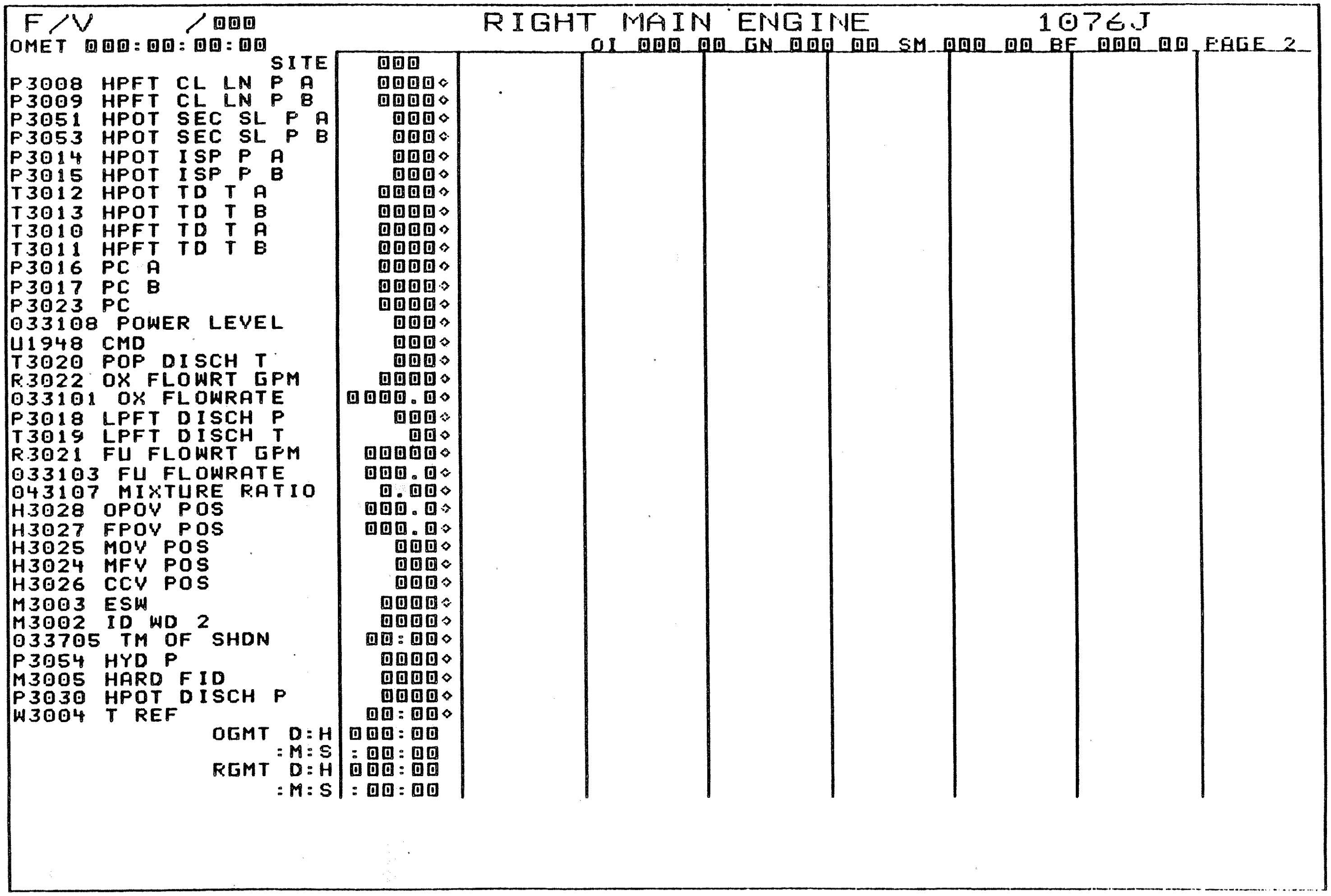
```
F/V      /□□□                     LEFT MAIN ENGINE          1074I
OMET □□□:□□:□□:□□                   OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 2
                     SITE      □□□
P2008 HPFT CL LN P A          □□□□◇
P2009 HPFT CL LN P B          □□□□◇
P2051 HPOT SEC SL P A          □□□◇
P2053 HPOT SEC SL P B          □□□◇
P2014 HPOT ISP P A             □□□◇
P2015 HPOT ISP P B             □□□◇
T2012 HPOT TD T A             □□□□◇
T2013 HPOT TD T B             □□□□◇
T2010 HPFT TD T A             □□□□◇
T2011 HPFT TD T B             □□□□◇
P2016 PC A                    □□□□◇
T2017 PC B                    □□□□◇
P2023 PC                      □□□□◇
023108 POWER LEVEL             □□□◇
U1948 CMD                      □□□◇
T2020 POP DISCH T              □□□◇
R2022 OX FLOWRT GPM           □□□□◇
023101 OX FLOWRATE          □□□□.□◇
P2018 LPFT DISCH P             □□□◇
T2019 LPFT DISCH T              □□◇
R2021 FU FLOWRT GPM          □□□□□◇
023103 FU FLOWRATE           □□□.□◇
033107 MIXTURE RATIO          □.□□◇
H2028 OPOV POS               □□□.□◇
H2027 FPOV POS               □□□.□◇
H2025 MOV POS                  □□□◇
H2024 MFV POS                  □□□◇
H2026 CCV POS                  □□□◇
M2003 ESW                     □□□□◇
M2002 ID WD 2                 □□□□◇
023705 TM OF SHDN            □□:□□◇
P2054 HYD P                   □□□□◇
M2005 HARD FAIL               □□□□◇
P2030 HPOT DISCH P            □□□□◇
W2004 T REF                  □□:□□◇
              OGMT D:H    □□□:□□
                   :M:S   :□□:□□
              RGMT D:H    □□□:□□
                   :M:S   :□□:□□
```

Figure 5.1.2-XV.- SSME HT display, MSK 1074.



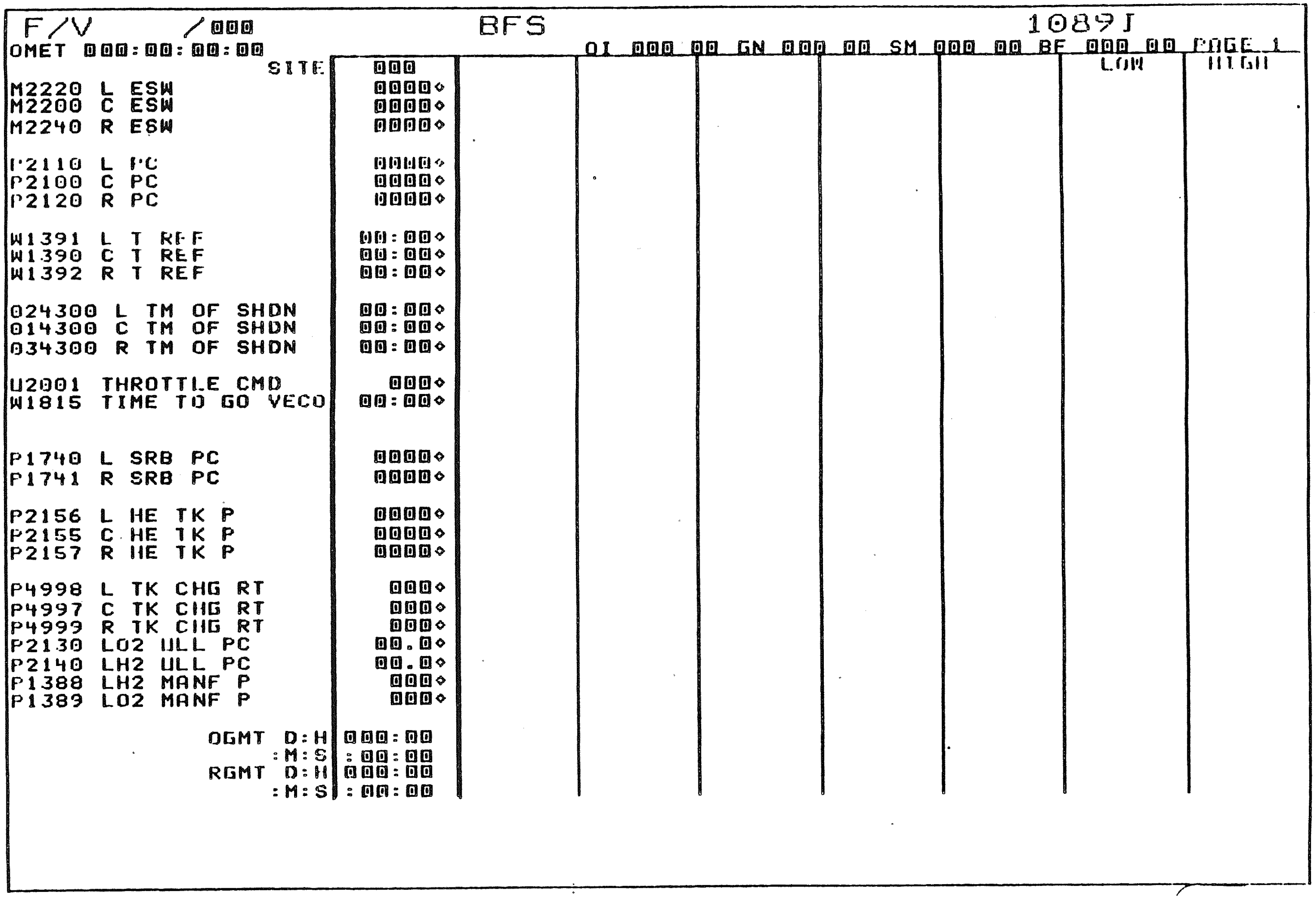
```
 F/V        /000             RIGHT MAIN ENGINE          1075J
OMET 000:00:00:00               OI 000 00 GN 000 00 SM 000 00 BF 000 00 PAGE 1
                    SITE    000                                    LOW   HIGH
P3008 HPFT CL LN P A       0000◇
P3009 HPFT CL LN P B       0000◇
P3051 HPOT SEC SL P A       000◇
P3053 HPOT SEC SL P B       000◇
P3014 HPOT ISP P A          000◇
P3015 HPOT ISP P B          000◇
T3012 HPOT TD T A          0000◇
T3013 HPOT TD T B          0000◇
T3010 HPFT TD T A          0000◇
T3011 HPFT TD T B          0000◇
P3016 PC A                 0000◇
P3017 PC B                 0000◇
P3023 PC                   0000◇
033108 POWER LEVEL          000◇
U1948 CMD                   000◇
T3020 POP DISCH T           000◇
R3022 OX FLOWRT GPM        0000◇
033101 OX FLOWRATE       0000.0◇
P3018 LPFT DISCH P          000◇
T3019 LPFT DISCH T           00◇
R3021 FU FLOWRT GPM       00000◇
033103 FU FLOWRATE        000.0◇
043107 MIXTURE RATIO       0.00◇
H3028 OPOV POS            000.0◇
H3027 FPOV POS            000.0◇
H3025 MOV POS               000◇
H3024 MFV POS               000◇
H3026 CCV POS               000◇
M3003 ESW                  0000◇
M3002 ID WD 2              0000◇
033705 TM OF SHDN         00:00◇
P3054 HYD P                0000◇
M3005 HARD FID             0000◇
P3030 HPOT DISCH P         0000◇
W3004 T REF               00:00◇
               OGMT D:H  000:00
                    :M:S :00:00
               RGMT D:H  000:00
                    :M:S :00:00
```

Figure 5.1.2-XVI.- SSME HT display, MSK 1075.



```
 F/V      /□□□                     RIGHT MAIN ENGINE          1076J
OMET □□□:□□:□□:□□                    OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 2
                    SITE    □□□
P3008  HPFT CL LN P A      □□□□◇
P3009  HPFT CL LN P B      □□□□◇
P3051  HPOT SEC SL P A      □□□◇
P3053  HPOT SEC SL P B      □□□◇
P3014  HPOT ISP P A         □□□◇
P3015  HPOT ISP P B         □□□◇
T3012  HPOT TD T A         □□□□◇
T3013  HPOT TD T B         □□□□◇
T3010  HPFT TD T A         □□□□◇
T3011  HPFT TD T B         □□□□◇
P3016  PC A                □□□□◇
P3017  PC B                □□□□◇
P3023  PC                  □□□□◇
033108 POWER LEVEL          □□□◇
U1948  CMD                  □□□◇
T3020  POP DISCH T          □□□◇
R3022  OX FLOWRT GPM       □□□□◇
033101 OX FLOWRATE       □□□□.□◇
P3018  LPFT DISCH P         □□□◇
T3019  LPFT DISCH T          □□◇
R3021  FU FLOWRT GPM      □□□□□◇
033103 FU FLOWRATE        □□□.□◇
043107 MIXTURE RATIO       □.□□◇
H3028  OPOV POS           □□□.□◇
H3027  FPOV POS           □□□.□◇
H3025  MOV POS              □□□◇
H3024  MFV POS              □□□◇
H3026  CCV POS              □□□◇
M3003  ESW                 □□□□◇
M3002  ID WD 2             □□□□◇
033705 TM OF SHDN         □□:□□◇
P3054  HYD P               □□□□◇
M3005  HARD FID            □□□□◇
P3030  HPOT DISCH P        □□□□◇
W3004  T REF              □□:□□◇
              OGMT D:H  □□□:□□
                   :M:S  :□□:□□
              RGMT D:H  □□□:□□
                   :M:S  :□□:□□
```

Figure 5.1.2-XVII.- SSME HT display, MSK 1076.



```
F/V      /000                      BFS                             1089J
OMET 000:00:00:00                      OI 000 00 GN 000 00 SM 000 00 BF 000 00 PAGE 1
                         SITE    000                                         LOW    HIGH
M2220  L  ESW                   0000◇
M2200  C  ESW                   0000◇
M2240  R  ESW                   0000◇

P2110  L  PC                    0000◇
P2100  C  PC                    0000◇
P2120  R  PC                    0000◇

W1391  L  T  REF               00:00◇
W1390  C  T  REF               00:00◇
W1392  R  T  REF               00:00◇

024300  L  TM  OF  SHDN        00:00◇
014300  C  TM  OF  SHDN        00:00◇
034300  R  TM  OF  SHDN        00:00◇

U2001  THROTTLE  CMD             000◇
W1815  TIME  TO  GO  VECO      00:00◇

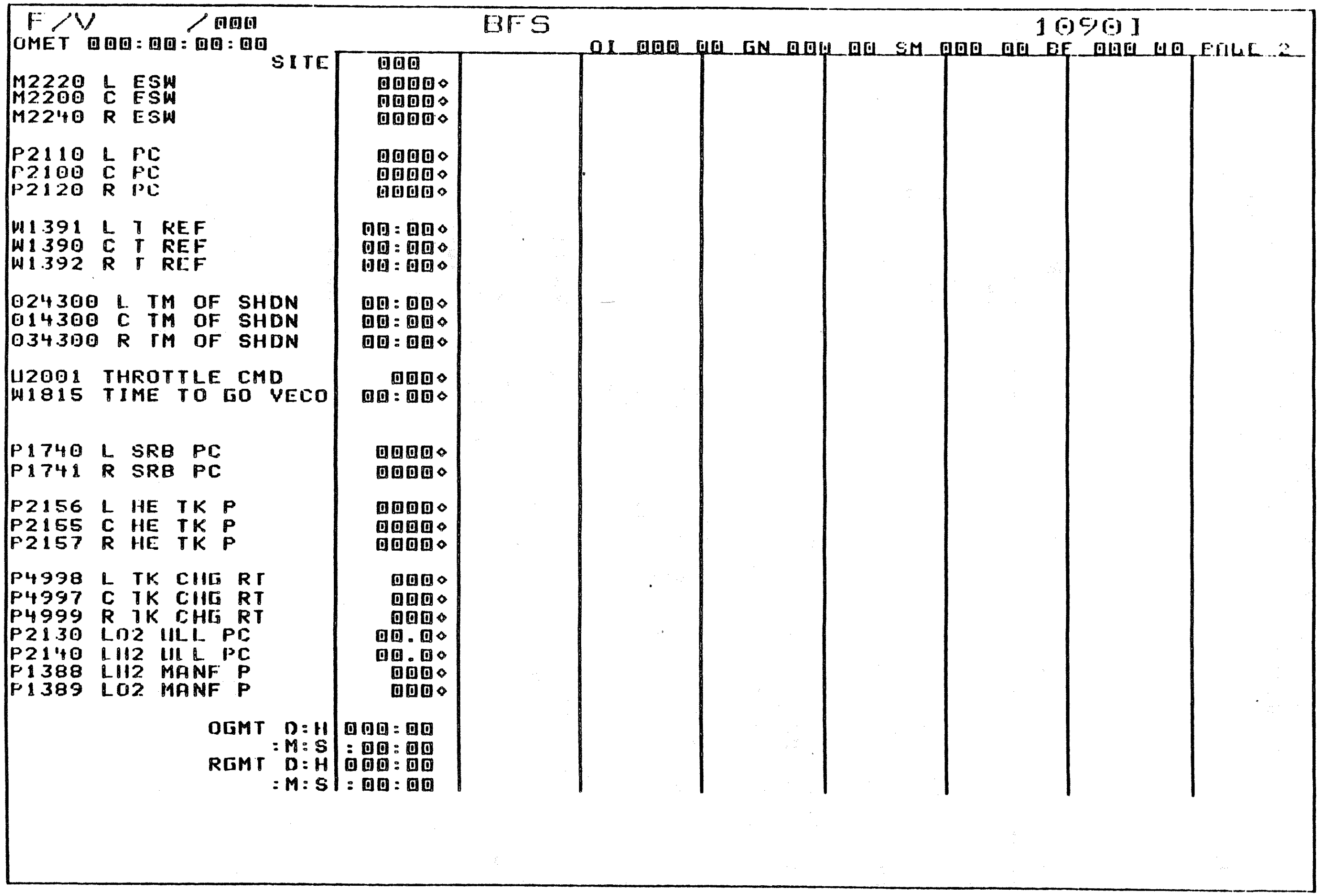

P1740  L  SRB  PC               0000◇
P1741  R  SRB  PC               0000◇

P2156  L  HE  TK  P             0000◇
P2155  C  HE  TK  P             0000◇
P2157  R  HE  TK  P             0000◇

P4998  L  TK  CHG  RT            000◇
P4997  C  TK  CHG  RT            000◇
P4999  R  TK  CHG  RT            000◇
P2130  LO2  ULL  PC             00.0◇
P2140  LH2  ULL  PC             00.0◇
P1388  LH2  MANF  P              000◇
P1389  LO2  MANF  P              000◇

              OGMT  D:H   000:00
                    :M:S  :00:00
              RGMT  D:H   000:00
                    :M:S  :00:00
```

Figure 5.1.2-XVIII.- SSME HT display, MSK 1089.



```
F/V        /□□□                BFS                           1090]
OMET □□□:□□:□□:□□               OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 2
                     SITE   □□□
M2220  L  ESW              □□□□◇
M2200  C  ESW              □□□□◇
M2240  R  ESW              □□□□◇

P2110  L  PC               □□□□◇
P2100  C  PC               □□□□◇
P2120  R  PC               □□□□◇

W1391  L  T REF           □□:□□◇
W1390  C  T REF           □□:□□◇
W1392  R  T REF           □□:□□◇

024300  L  TM  OF  SHDN   □□:□□◇
014300  C  TM  OF  SHDN   □□:□□◇
034300  R  TM  OF  SHDN   □□:□□◇

U2001  THROTTLE CMD         □□□◇
W1815  TIME TO GO VECO    □□:□□◇


P1740  L  SRB  PC          □□□□◇
P1741  R  SRB  PC          □□□□◇

P2156  L  HE  TK  P        □□□□◇
P2155  C  HE  TK  P        □□□□◇
P2157  R  HE  TK  P        □□□□◇

P4998  L  TK  CHG  RT       □□□◇
P4997  C  TK  CHG  RT       □□□◇
P4999  R  TK  CHG  RT       □□□◇
P2130  LO2  ULL  PC        □□.□◇
P2140  LH2  ULL  PC        □□.□◇
P1388  LH2  MANF  P         □□□◇
P1389  LO2  MANF  P         □□□◇

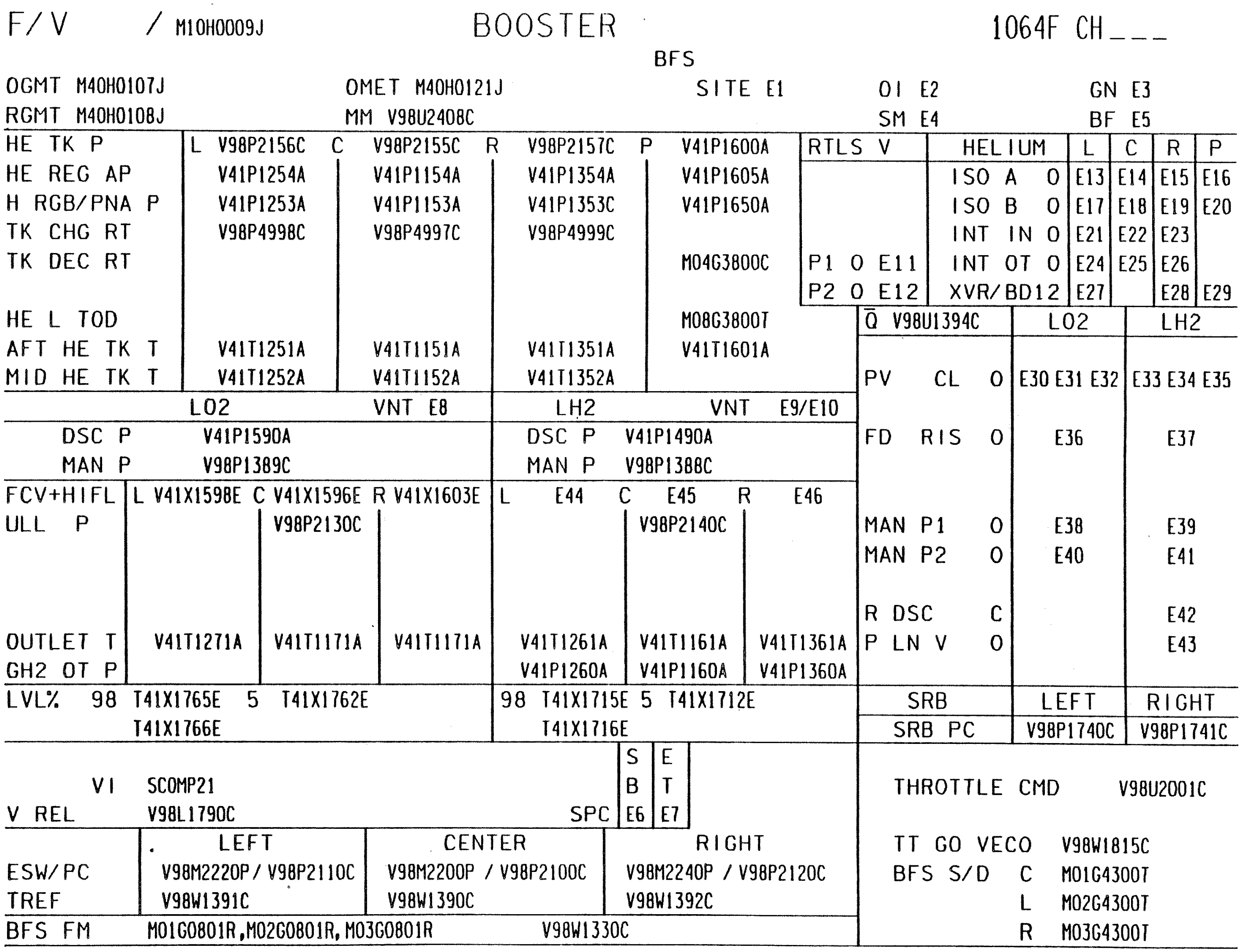
                OGMT  D:H  □□□:□□
                      :M:S  :□□:□□
                RGMT  D:H  □□□:□□
                      :M:S  :□□:□□
```

Figure 5.1.2-XIX.- SSME HT display, MSK 1090.

E. BFS Displays - When the BFS is engaged, most of our displays do not update properly. This situation is because the BFS does not handle or downlist the same amount of data as does the PASS. One way to monitor data is to use MSK 1064 or MSK 1065. Engine data of interest include: GO2 outlet temperatures, GH2 outlet pressures, engine status words, chamber pressures, engine reference times, engine shutdown times, and throttle commands. For MSK 1064, see table 5.1.2-II and figure 5.1.2-XX; for MSK 1065, see table 5.1.2-III and figure 5.1.2-XXI.

TABLE 5.1.2-II.- MSK 1064 ADDITIONAL MSID's

No.	MSID	Notes	No.	MSID	Notes
E1	M10H0015J	Site	E21	V41X1264E	
E2	V75X4070D	Format	E22	V41X1164E	
	M40H0134J	Static	E23	V41X1364E	
	M40H0135J	Suspect	E24	V41X1270E	
E3	V93Q0022CX	Format	E25	V41X1170E	
	M40H0234J	Static	E26	V41X1370E	
	M40H0235J	Suspect	E27	V41X1614E	
E4	V93Q0022CY	Format	E28	V41X1632E	
	M40H0334J	Static	E29	V41X1634E	
	M40H0335J	Suspect	E30	V41X1235E	
E5	V98Q0009C	Format	E31	V41X1135E	
	M40H0434J	Static	E32	V41X1335E	
	M40H0435J	Suspect	E33	V41X1205E	
E6	V98X3534X		E34	V41X1105E	
E7	V98X3550X		E35	V41X1305E	
E8	T41X1774E		E36	V41X1541E	
E9	T41X1727E		E37	V41X1441E	
E10	T41X1724E		E38	V41X1538E	
E11	V41X1901E		E39	V41X1436E	
E12	V41X1902E		E40	V41X1539E	
E13	V41X1258E		E41	V41X1438E	
E14	V41X1158E		E42	V41X1420E	
E15	V41X1358E		E43	V41X1492E	
E16	V41X1645E		E44	V41X1662E	
E17	V41X1259E			V41S1477E	
E18	V41X1159E		E45	V41X1661E	
E19	V41X1359E			V41S1477E	
E20	V41X1646E		E46	V41X1663E	
				V41S1477E	



```
F/V     / M10H0009J               BOOSTER                         1064F CH___
                                           BFS
OGMT  M40H0107J           OMET  M40H0121J       SITE E1       OI  E2           GN  E3
RGMT  M40H0108J           MM  V98U2408C                       SM  E4           BF  E5
HE TK P       L V98P2156C  C  V98P2155C  R  V98P2157C  P  V41P1600A  RTLS V   HELIUM     L   C   R   P
HE REG AP       V41P1254A     V41P1154A     V41P1354A     V41P1605A           ISO A   O E13 E14 E15 E16
H RGB/PNA P     V41P1253A     V41P1153A     V41P1353C     V41P1650A           ISO B   O E17 E18 E19 E20
TK CHG RT       V98P4998C     V98P4997C     V98P4999C                         INT IN  O E21 E22 E23
TK DEC RT                                                 M04G3800C  P1 O E11 INT OT  O E24 E25 E26
                                                                     P2 O E12 XVR/BD12  E27     E28 E29
HE L TOD                                                  M08G3800T    Q̄ V98U1394C    LO2        LH2
AFT HE TK T     V41T1251A     V41T1151A     V41T1351A     V41T1601A
MID HE TK T     V41T1252A     V41T1152A     V41T1352A                  PV   CL   O E30 E31 E32 E33 E34 E35
              LO2                VNT  E8    LH2              VNT  E9/E10
     DSC P      V41P1590A                   DSC P  V41P1490A           FD   RIS  O     E36         E37
     MAN P      V98P1389C                   MAN P  V98P1388C
FCV+HIFL   L V41X1598E C V41X1596E R V41X1603E  L   E44    C   E45    R   E46
ULL   P                  V98P2130C                         V98P2140C        MAN P1  O     E38         E39
                                                                            MAN P2  O     E40         E41

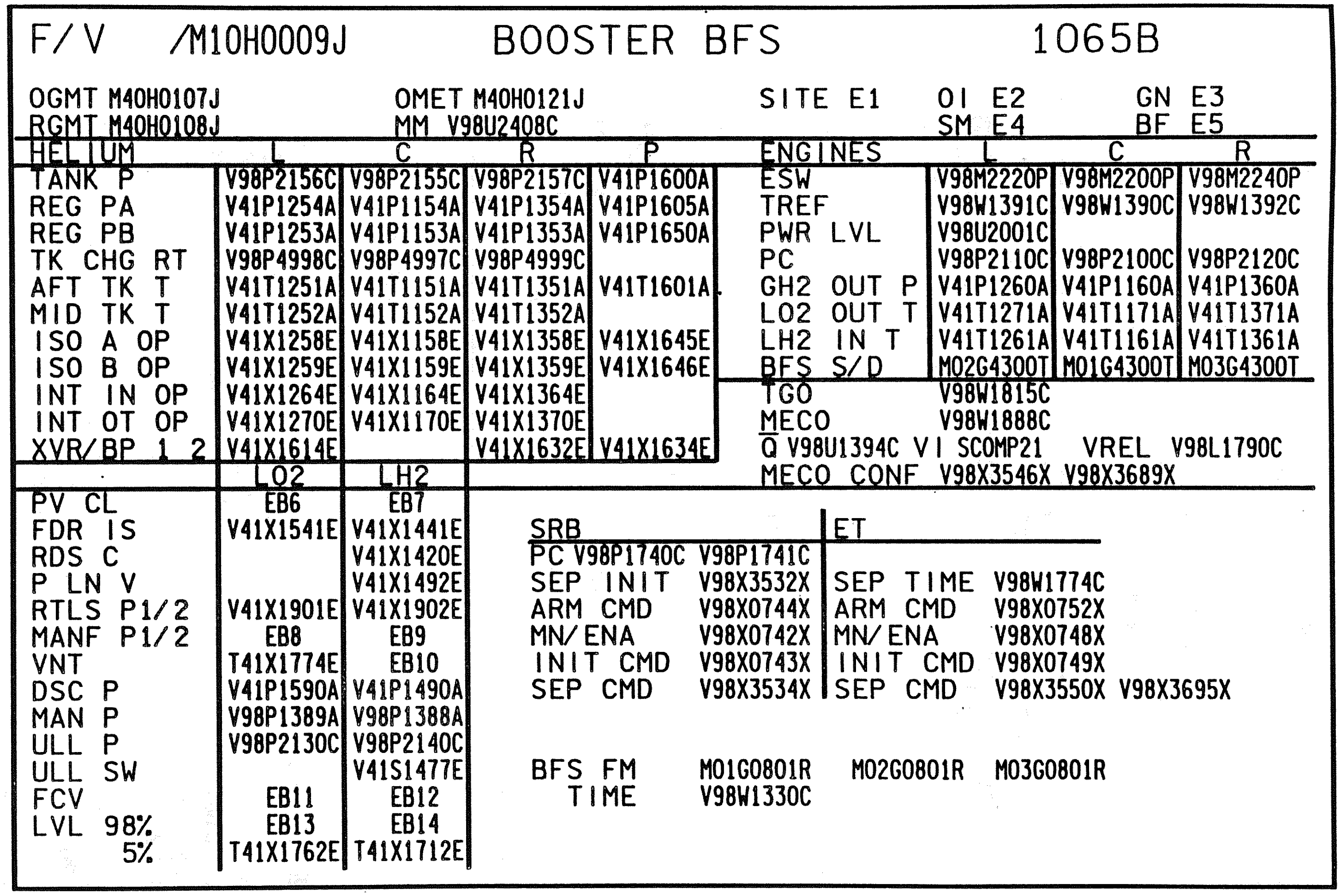
                                                                            R DSC   C                 E42
OUTLET T     V41T1271A   V41T1171A   V41T1171A  V41T1261A  V41T1161A  V41T1361A  P LN V  O         E43
GH2 OT P                                        V41P1260A  V41P1160A  V41P1360A
LVL%    98  T41X1765E   5   T41X1762E       98  T41X1715E 5 T41X1712E       SRB       LEFT       RIGHT
            T41X1766E                           T41X1716E                   SRB PC    V98P1740C  V98P1741C
                                                           S  E
         VI   SCOMP21                                      B  T             THROTTLE CMD    V98U2001C
V REL         V98L1790C                                SPC E6 E7
                .   LEFT                CENTER                  RIGHT       TT GO VECO    V98W1815C
ESW/PC       V98M2220P/ V98P2110C  V98M2200P / V98P2100C  V98M2240P / V98P2120C   BFS S/D  C  M01G4300T
TREF         V98W1391C             V98W1390C              V98W1392C                        L  M02G4300T
BFS FM       M01G0801R,M02G0801R, M03G0801R          V98W1330C                             R  M03G4300T
```

172395210. CRT, 2

Figure 5.1.2-XX.- Booster BFS, MSK 1064.

TABLE 5.1.2-III.- MSK 1065 ADDITIONAL MSID's

No.	MSID	Notes
E1	M10H0015J	Site
E2	V75X4070D	Format
	M40H0134J	Static
	M40H0135J	Suspect
E3	M93Q0022CX	Format
	M40H0234J	Static
	M40H0235J	Suspect
E4	V93Q0022CY	Format
	M40H0334J	Static
	M40H0335J	Suspect
E5	V98Q0009C	Format
	M40H0434J	Static
	M40H0435J	Suspect
EB6	V41X1235E	L
	V41X1135E	C
	V41X1335E	R
EB7	V41X1205E	L
	V41X1105E	C
	V41X1305E	R
EB8	V41X1438E	
	V41X1539E	
EB9	V41X1436E	
	V41X1438E	
EB10	V41X1727E	
	V41X1724E	
EB11	V41X1598E	L
	V41X1596E	C
	V41X1603E	R
EB12	V41X1662E	L
	V41X1661E	C
	V41X1663E	R
EB13	T41X1765E	
	T41X1766E	
EB14	T41X1715E	
	T41X1716E	



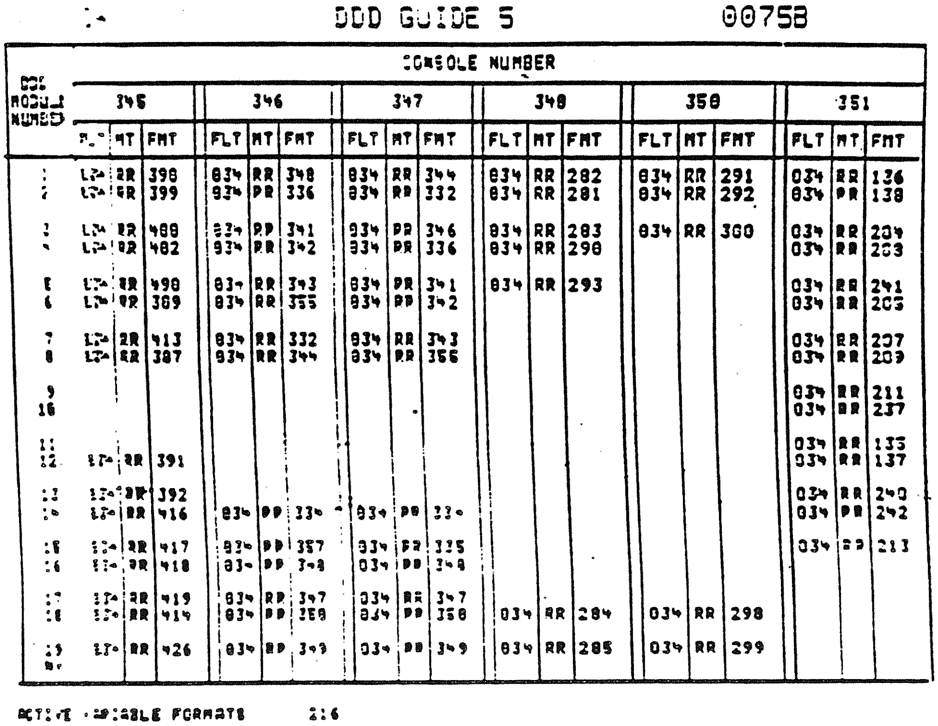
```
F/V   /M10H0009J          BOOSTER BFS              1065B

OGMT M40H0107J            OMET M40H0121J          SITE E1    OI  E2       GN  E3
RGMT M40H0108J            MM  V98U2408C                      SM  E4       BF  E5
HELIUM            L          C          R          P        ENGINES          L          C          R
TANK P         V98P2156C  V98P2155C  V98P2157C  V41P1600A   ESW          V98M2220P  V98M2200P  V98M2240P
REG PA         V41P1254A  V41P1154A  V41P1354A  V41P1605A   TREF         V98W1391C  V98W1390C  V98W1392C
REG PB         V41P1253A  V41P1153A  V41P1353A  V41P1650A   PWR LVL      V98U2001C
TK CHG RT      V98P4998C  V98P4997C  V98P4999C              PC           V98P2110C  V98P2100C  V98P2120C
AFT TK T       V41T1251A  V41T1151A  V41T1351A  V41T1601A   GH2 OUT P    V41P1260A  V41P1160A  V41P1360A
MID TK T       V41T1252A  V41T1152A  V41T1352A              LO2 OUT T    V41T1271A  V41T1171A  V41T1371A
ISO A OP       V41X1258E  V41X1158E  V41X1358E  V41X1645E   LH2 IN T     V41T1261A  V41T1161A  V41T1361A
ISO B OP       V41X1259E  V41X1159E  V41X1359E  V41X1646E   BFS S/D      M02G4300T  M01G4300T  M03G4300T
INT IN OP      V41X1264E  V41X1164E  V41X1364E              TGO          V98W1815C
INT OT OP      V41X1270E  V41X1170E  V41X1370E              MECO         V98W1888C
XVR/BP 1 2     V41X1614E             V41X1632E  V41X1634E   Q V98U1394C VI SCOMP21    VREL  V98L1790C
                  LO2        LH2                            MECO CONF    V98X3546X  V98X3689X
PV CL             EB6        EB7
FDR IS         V41X1541E  V41X1441E      SRB                          ET
RDS C                     V41X1420E      PC V98P1740C  V98P1741C
P LN V                    V41X1492E      SEP INIT      V98X3532X   SEP TIME   V98W1774C
RTLS P1/2      V41X1901E  V41X1902E      ARM CMD       V98X0744X   ARM CMD    V98X0752X
MANF P1/2         EB8        EB9         MN/ENA        V98X0742X   MN/ENA     V98X0748X
VNT            T41X1774E     EB10        INIT CMD      V98X0743X   INIT CMD   V98X0749X
DSC P          V41P1590A  V41P1490A      SEP CMD       V98X3534X   SEP CMD    V98X3550X  V98X3695X
MAN P          V98P1389A  V98P1388A
ULL P          V98P2130C  V98P2140C
ULL SW                    V41S1477E      BFS FM        M01G0801R   M02G0801R  M03G0801R
FCV               EB11       EB12          TIME        V98W1330C
LVL 98%           EB13       EB14
     5%        T41X1762E  T41X1712E
```

172395111.CRT, 1

Figure 5.1.2-XXI.- Booster BFS, MSK 1065.

F. Event Light Display - This display is the dedicated display driver (DDD) guide and is used to verify that each event light format number is assigned to the correct module on a console. Also included is the flight number and data type. A sample DDD guide is shown in figure 5.1.2-XXII. MSK 0075 or 0076 should be used to check the console configuration. Current operations, on the second floor, are from console number 348. Prior to flight, this display should be checked to ensure that the event light panels are correctly configured. Refer to SCP 5.1.3 concerning the main engine event light indicators.



DDD GUIDE 5 0075B

DDD MODULE NUMBER	CONSOLE NUMBER 345			346			347			348			350			351		
	FLT	MT	FMT	FLT	MT	FMT	FLT	MT	FMT	FLT	MT	FMT	FLT	MT	FMT	FLT	MT	FMT
1	LTA	RR	398	034	RR	348	034	RR	344	034	RR	282	034	RR	291	034	RR	136
2	LTA	RR	399	034	RR	336	034	RR	332	034	RR	281	034	RR	292	034	RR	138
3	LTA	RR	400	034	RR	341	034	RR	346	034	RR	283	034	RR	300	034	RR	234
4	LTA	RR	402	034	RR	342	034	RR	336	034	RR	290				034	RR	233
5	LTA	RR	490	034	RR	343	034	RR	341	034	RR	293				034	RR	241
6	LTA	RR	309	034	RR	355	034	RR	342							034	RR	203
7	LTA	RR	413	034	RR	332	034	RR	343							034	RR	207
8	LTA	RR	387	034	RR	344	034	RR	356							034	RR	209
9																034	RR	211
10																034	RR	237
11																034	RR	135
12	LTA	RR	391													034	RR	137
13	LTA	RR	392													034	RR	240
14	LTA	RR	416	034	RR	330	034	RR	330							034	RR	242
15	LTA	RR	417	034	RR	357	034	RR	335							034	RR	213
16	LTA	RR	418	034	RR	348	034	RR	348									
17	LTA	RR	419	034	RR	347	034	RR	347									
18	LTA	RR	414	034	RR	350	034	RR	350	034	RR	284	034	RR	298			
19	LTA	RR	426	034	RR	349	034	RR	349	034	RR	285	034	RR	299			
20																		

ACTIVE VARIABLE FORMATS 216

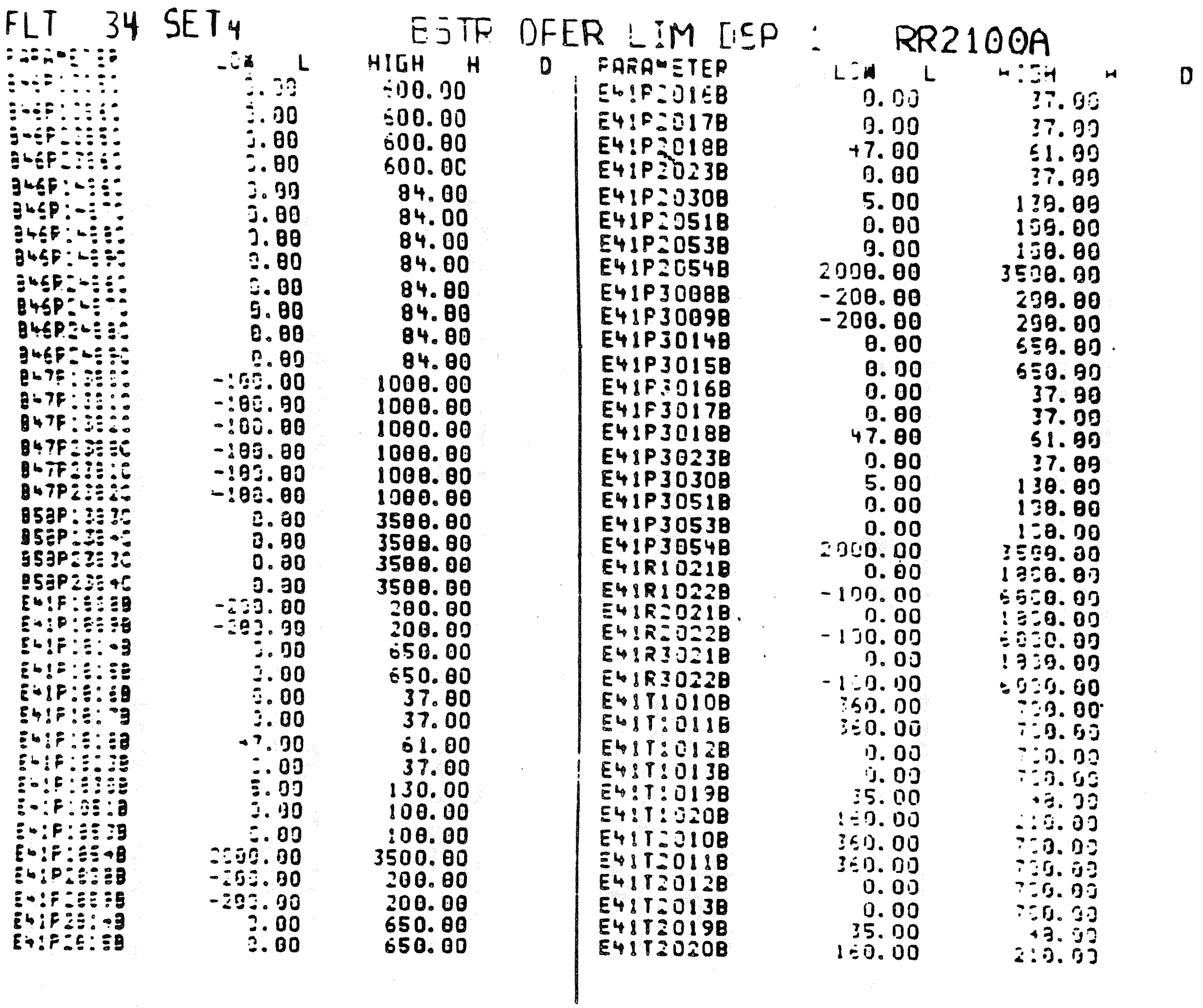
Figure 5.1.2-XXII.- DDD GUIDE 6 display.

G. Booster Operating Limits Display - This display (fig. 5.1.2-XXIII) has three pages (MSK's 2100, 2101, and 2102) and lists the high and low limits for each parameter monitored by the ME, MPS, and Booster consoles. Limits are established by the main engine operator and reviewed by the booster operator prior to each flight. Rational for the limits is maintained by the main engine operator.

H. GPC MED Display - This display (fig. 5.1.2-XXIV) has two pages (MSK'S 2063 AND 2064). The display shows the constants stored in the MOC that are used in computations for the SSME fuel and oxidizer flow rates and SSME power level.

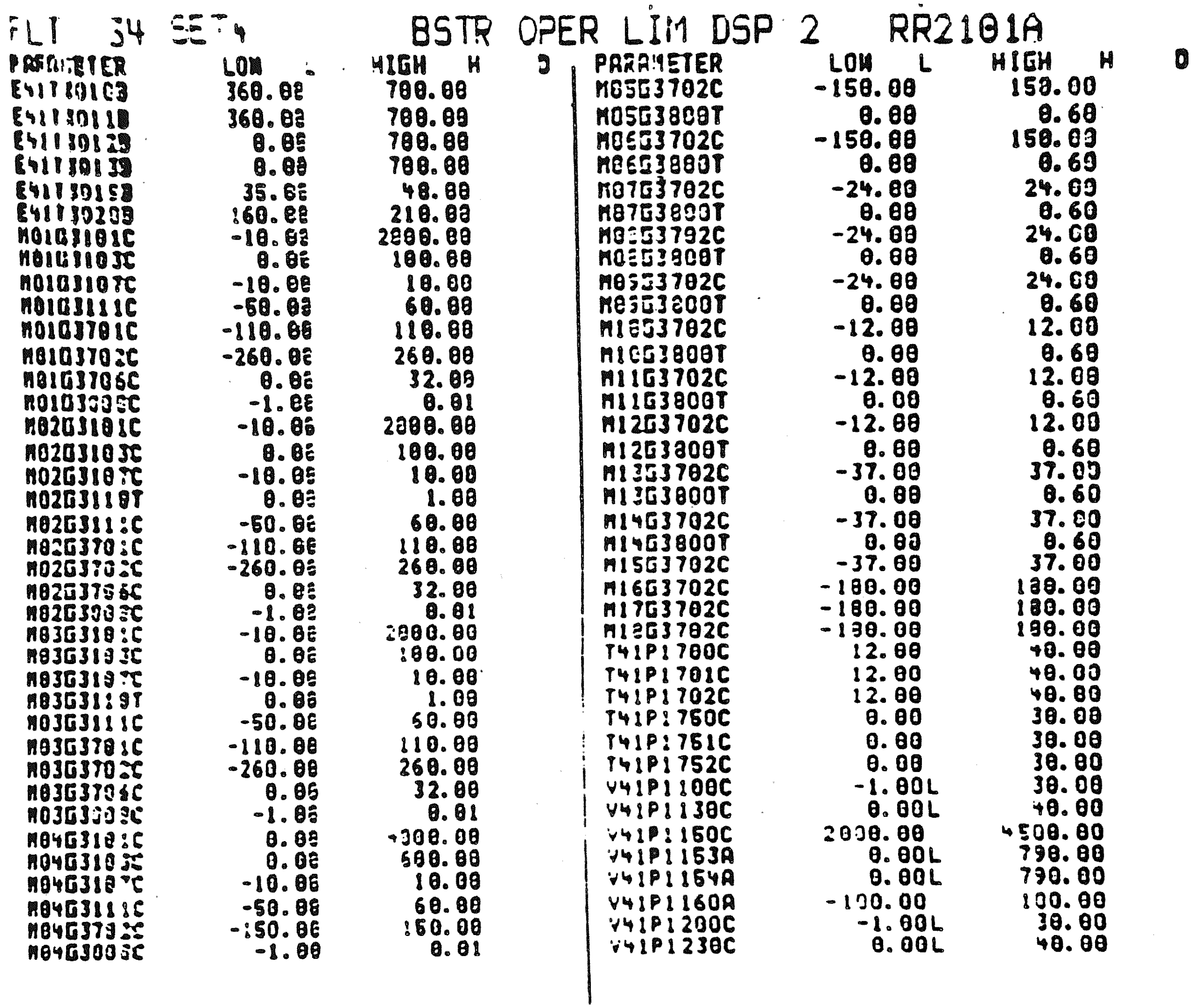
REFERENCES

1. Booster Data Pack, as of Sept. 1, 1989.



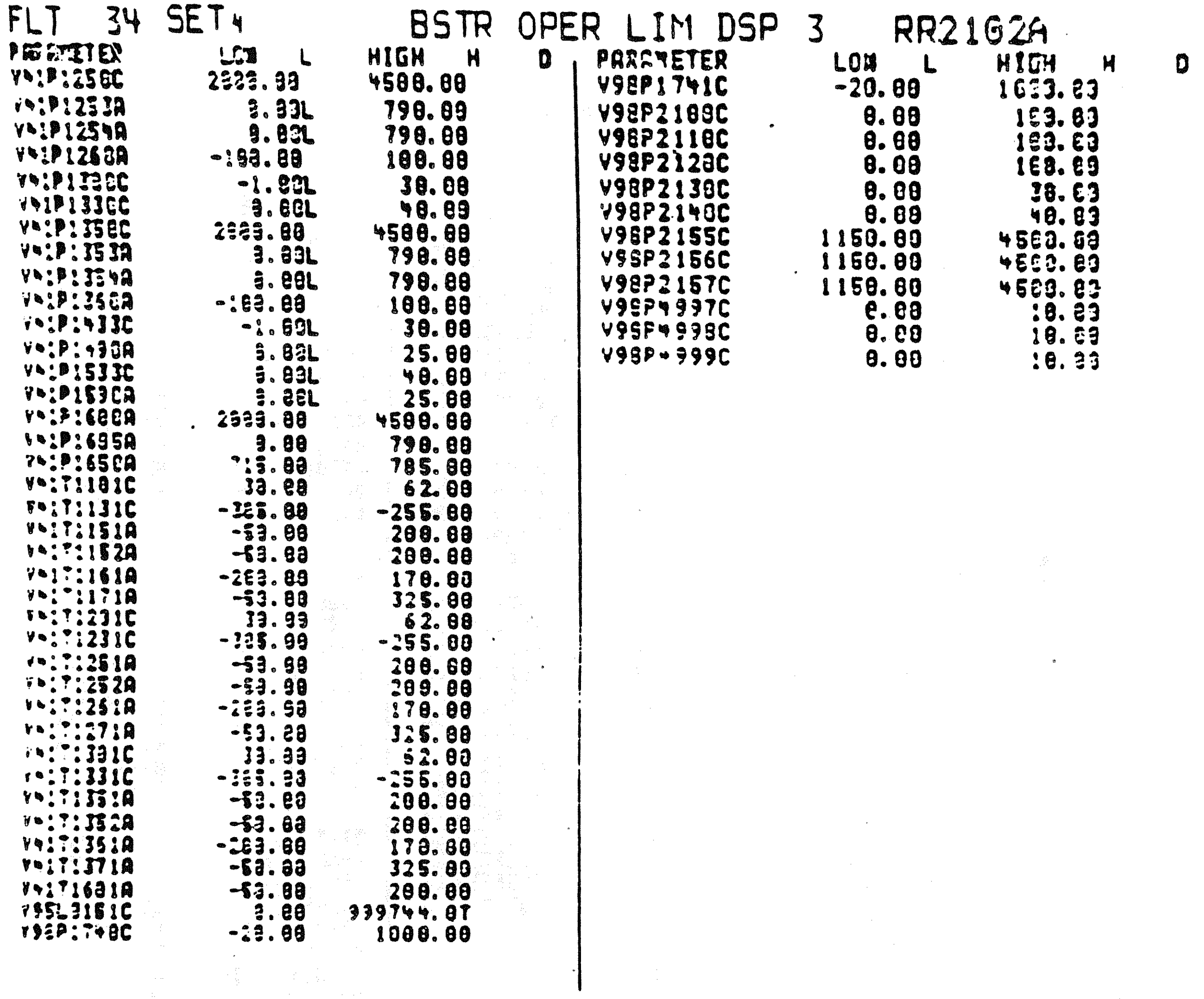
```
FLT  34 SET4         BSTR OPER LIM DSP 1    RR2100A
PARAMETER       LOW   L   HIGH    H   D | PARAMETER       LOW   L     HIGH   H   D
B46P[illegible]     0.00     600.00       | E41P2016B       0.00       37.00
B46P[illegible]     0.00     600.00       | E41P2017B       0.00       37.00
B46P[illegible]     0.00     600.00       | E41P2018B      47.00       61.00
B46P[illegible]     0.00     600.00       | E41P2023B       0.00       37.00
B46P[illegible]     0.00      84.00       | E41P2030B       5.00      130.00
B46P[illegible]     0.00      84.00       | E41P2051B       0.00      150.00
B46P[illegible]     0.00      84.00       | E41P2053B       0.00      130.00
B46P[illegible]     0.00      84.00       | E41P2054B    2000.00     3500.00
B46P[illegible]     0.00      84.00       | E41P3008B    -200.00      200.00
B46P[illegible]     0.00      84.00       | E41P3009B    -200.00      200.00
B46P[illegible]     0.00      84.00       | E41P3014B       0.00      650.00
B46P[illegible]     0.00      84.00       | E41P3015B       0.00      650.00
B47P[illegible]  -100.00    1000.00       | E41P3016B       0.00       37.00
B47P[illegible]  -100.00    1000.00       | E41P3017B       0.00       37.00
B47P[illegible]  -100.00    1000.00       | E41P3018B      47.00       61.00
B47P[illegible]  -100.00    1000.00       | E41P3023B       0.00       37.00
B47P[illegible]  -100.00    1000.00       | E41P3030B       5.00      130.00
B47P[illegible]  -100.00    1000.00       | E41P3051B       0.00      130.00
B58P[illegible]     0.00    3500.00       | E41P3053B       0.00      130.00
B58P[illegible]     0.00    3500.00       | E41P3054B    2000.00     3500.00
B58P[illegible]     0.00    3500.00       | E41R1021B       0.00     1800.00
B58P[illegible]     0.00    3500.00       | E41R1022B    -100.00     6500.00
E41P[illegible]  -200.00     200.00       | E41R2021B       0.00     1800.00
E41P[illegible]  -200.00     200.00       | E41R2022B    -100.00     6000.00
E41P[illegible]     0.00     650.00       | E41R3021B       0.00     1800.00
E41P[illegible]     0.00     650.00       | E41R3022B    -100.00     6000.00
E41P[illegible]     0.00      37.00       | E41T1010B     360.00      720.00
E41P[illegible]     0.00      37.00       | E41T1011B     360.00      720.00
E41P[illegible]    47.00      61.00       | E41T1012B       0.00      720.00
E41P[illegible]     0.00      37.00       | E41T1013B       0.00      720.00
E41P[illegible]     5.00     130.00       | E41T1019B      35.00       43.00
E41P[illegible]     0.00     100.00       | E41T1020B     160.00      210.00
E41P[illegible]     0.00     100.00       | E41T2010B     360.00      720.00
E41P[illegible]  2000.00    3500.00       | E41T2011B     360.00      720.00
E41P[illegible]  -200.00     200.00       | E41T2012B       0.00      720.00
E41P[illegible]  -200.00     200.00       | E41T2013B       0.00      720.00
E41P[illegible]     0.00     650.00       | E41T2019B      35.00       43.00
E41P[illegible]     0.00     650.00       | E41T2020B     160.00      210.00
```

Figure 5.1.2-XXIII.-BSTR OPER LIM DSP (sheet 1 of 3).



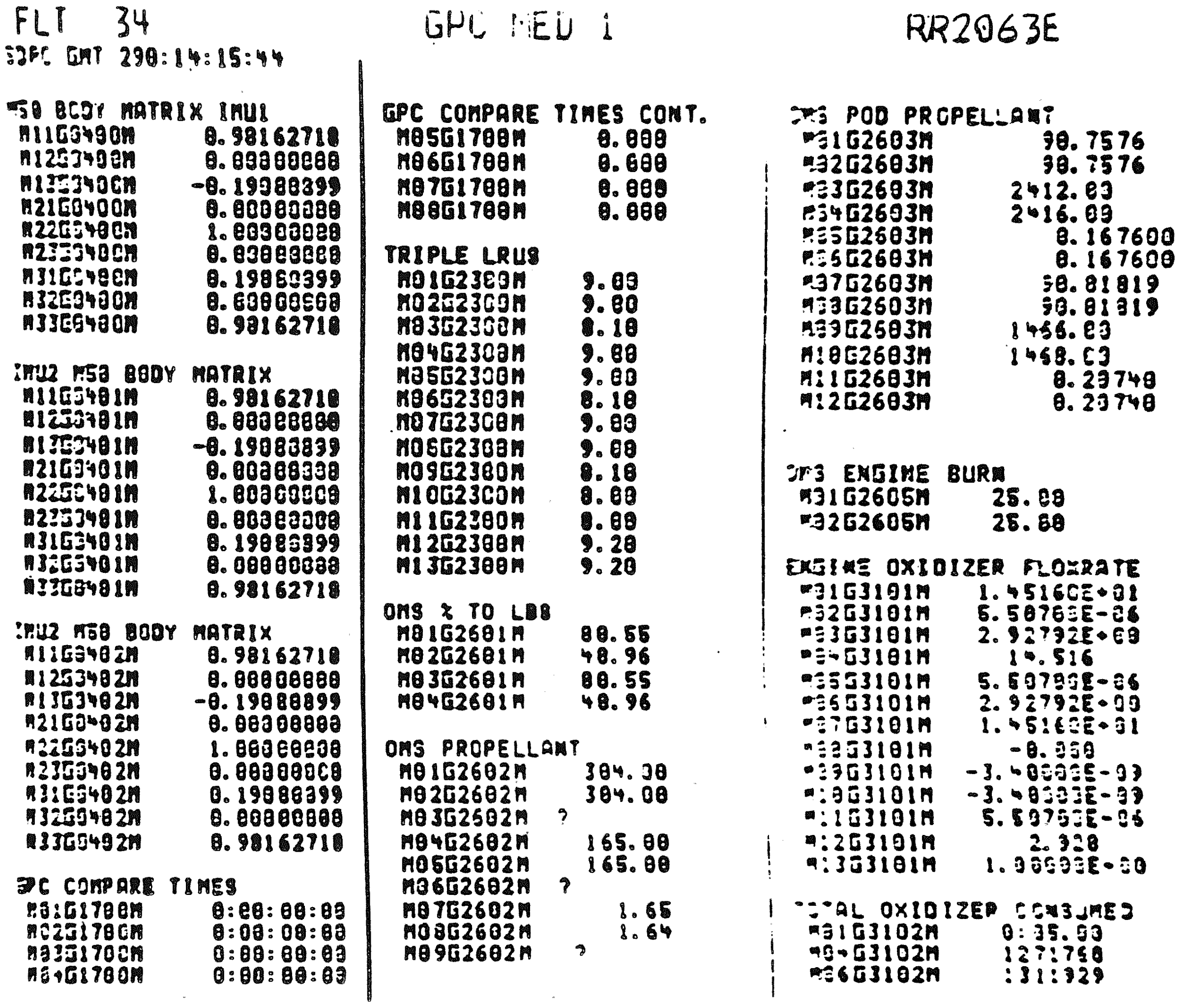
```
FLT   34 SET4          BSTR OPER LIM DSP 2    RR2101A
PARAMETER      LOW   L   HIGH   H   D | PARAMETER      LOW   L    HIGH   H   D
E41T1010C    360.00      700.00       | M05G3702C   -150.00       150.00
E41T1011D    360.00      700.00       | M05G3800T      0.00         0.60
E41T1012D      0.00      700.00       | M06G3702C   -150.00       150.00
E41T1013D      0.00      700.00       | M06G3800T      0.00         0.60
E41T1015D     35.60       48.00       | M07G3702C    -24.00        24.00
E41T1020D    160.00      210.00       | M07G3800T      0.00         0.60
M01G3101C    -10.00     2000.00       | M08G3702C    -24.00        24.00
M01G3103C      0.00      100.00       | M08G3800T      0.00         0.60
M01G3107C    -10.00       10.00       | M09G3702C    -24.00        24.00
M01G3111C    -60.00       60.00       | M09G3800T      0.00         0.60
M01G3701C   -110.00      110.00       | M10G3702C    -12.00        12.00
M01G3702C   -260.00      260.00       | M10G3800T      0.00         0.60
M01G3706C      0.00       32.00       | M11G3702C    -12.00        12.00
M01G3005C     -1.00        0.01       | M11G3800T      0.00         0.60
M02G3101C    -10.00     2000.00       | M12G3702C    -12.00        12.00
M02G3103C      0.00      100.00       | M12G3800T      0.00         0.60
M02G3107C    -10.00       10.00       | M13G3702C    -37.00        37.00
M02G3110T      0.00        1.00       | M13G3800T      0.00         0.60
M02G3111C    -50.00       60.00       | M14G3702C    -37.00        37.00
M02G3701C   -110.00      110.00       | M14G3800T      0.00         0.60
M02G3702C   -260.00      260.00       | M15G3702C    -37.00        37.00
M02G3706C      0.00       32.00       | M16G3702C   -180.00       180.00
M02G3003C     -1.00        0.01       | M17G3702C   -180.00       180.00
M03G3101C    -10.00     2000.00       | M18G3702C   -180.00       180.00
M03G3103C      0.00      100.00       | T41P1700C     12.00        40.00
M03G3107C    -10.00       10.00       | T41P1701C     12.00        40.00
M03G3119T      0.00        1.00       | T41P1702C     12.00        40.00
M03G3111C    -50.00       60.00       | T41P1750C      0.00        30.00
M03G3701C   -110.00      110.00       | T41P1751C      0.00        30.00
M03G3702C   -260.00      260.00       | T41P1752C      0.00        30.00
M03G3706C      0.05       32.00       | V41P1100C     -1.00L       30.00
M03G3003C     -1.00        0.01       | V41P1130C      0.00L       40.00
M04G3101C      0.00     4300.00       | V41P1150C   2000.00      4500.00
M04G3103C      0.00      600.00       | V41P1153A      0.00L      790.00
M04G3107C    -10.00       10.00       | V41P1154A      0.00L      790.00
M04G3111C    -50.00       60.00       | V41P1160A   -100.00       100.00
M04G3702C   -150.00      160.00       | V41P1200C     -1.00L       30.00
M04G3005C     -1.00        0.01       | V41P1230C      0.00L       40.00
```

Figure 5.1.2-XXIII.- BSTR OPER LIM DSP (sheet 2 of 3).



```
FLT  34 SET4        BSTR OPER LIM DSP 3   RR21G2A
PARAMETER     LOW   L    HIGH   H    D | PARAMETER    LOW   L    HIGH   H    D
V98P1250C   2000.00     4500.00        | V98P1741C   -20.00     1000.00
V98P1253A      0.00L     790.00        | V98P2100C     0.00      100.00
V98P1254A      0.00L     790.00        | V98P2110C     0.00      100.00
V98P1260A   -100.00      100.00        | V98P2120C     0.00      100.00
V98P1320C     -1.00L      30.00        | V98P2130C     0.00       30.00
V98P1330C      0.00L      40.00        | V98P2140C     0.00       40.00
V98P1350C   2000.00     4500.00        | V98P2155C  1150.00     4500.00
V98P1353A      0.00L     790.00        | V98P2156C  1150.00     4500.00
V98P1354A      0.00L     790.00        | V98P2157C  1150.00     4500.00
V98P1360A   -100.00      100.00        | V98P4997C     0.00       10.00
V98P1433C     -1.00L      30.00        | V98P4998C     0.00       10.00
V98P1490A      0.00L      25.00        | V98P4999C     0.00       10.00
V98P1533C      0.00L      40.00        |
V98P1590A      0.00L      25.00        |
V98P1600A   2000.00     4500.00        |
V98P1695A      0.00      790.00        |
V98P1650A     15.00      785.00        |
V98T1101C     33.00       62.00        |
V98T1131C   -325.00     -255.00        |
V98T1151A    -53.00      200.00        |
V98T1152A    -53.00      200.00        |
V98T1161A   -263.00      170.00        |
V98T1171A    -53.00      325.00        |
V98T1231C     33.00       62.00        |
V98T1231C   -325.00     -255.00        |
V98T1251A    -53.00      200.00        |
V98T1252A    -53.00      200.00        |
V98T1261A   -263.00      170.00        |
V98T1271A    -53.00      325.00        |
V98T1331C     33.00       62.00        |
V98T1331C   -325.00     -255.00        |
V98T1351A    -53.00      200.00        |
V98T1352A    -53.00      200.00        |
V98T1351A   -263.00      170.00        |
V98T1371A    -53.00      325.00        |
V98T1681A    -53.00      200.00        |
V95L3161C      0.00   339744.0T        |
V98P1748C    -20.00     1000.00        |
```

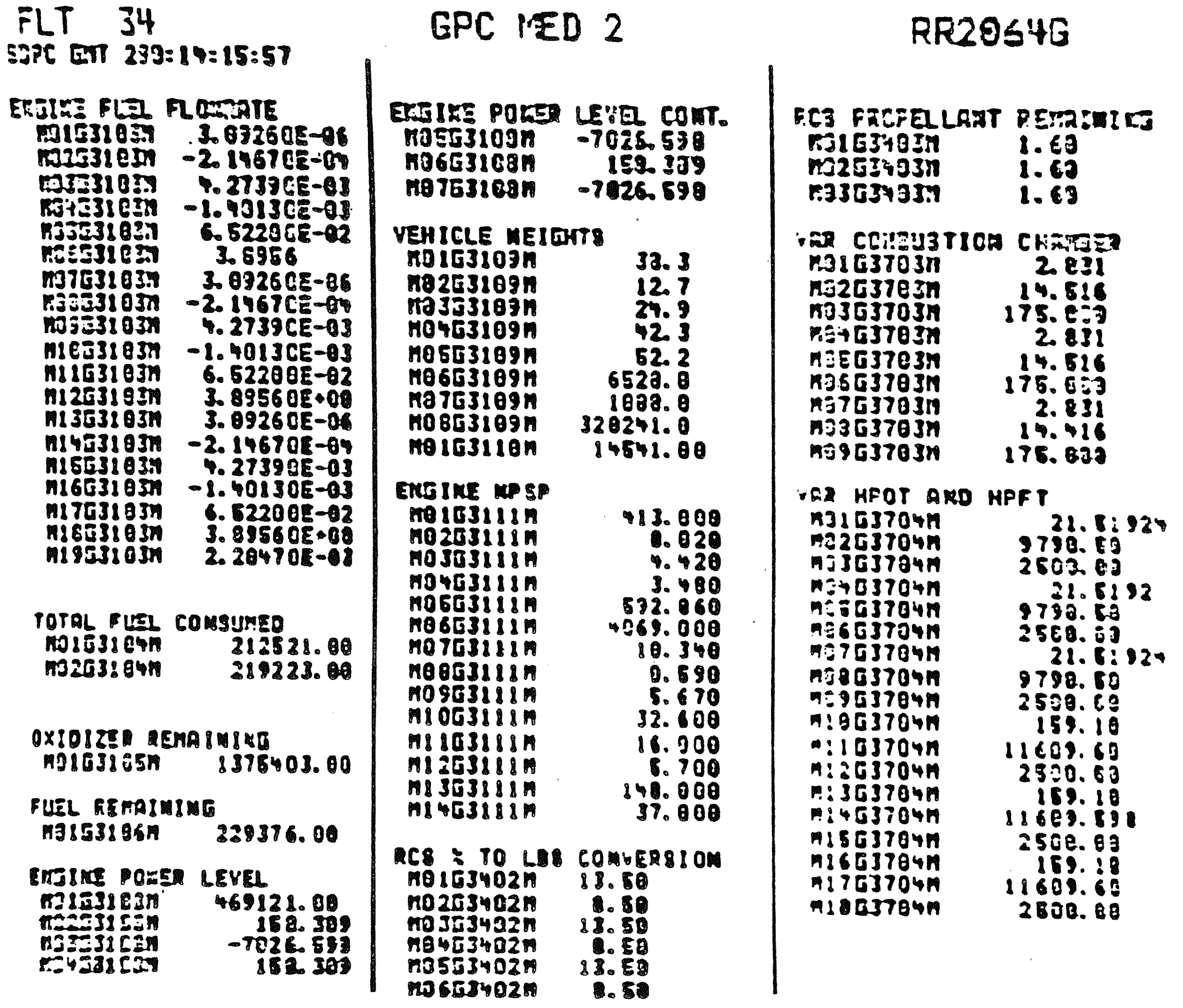
Figure 5.1.2-XXIII.-BSTR OPER LIM DSP (sheet 3 of 3).



```
FLT 34                             GPC MED 1                          RR2063E
GPC GMT 290:14:15:44

M50 BODY MATRIX IMU1           GPC COMPARE TIMES CONT.        OMS POD PROPELLANT
 M11G3400M    0.98162710        M05G1700M     0.000            M31G2603M        90.7576
 M12G3400M    0.00000000        M06G1700M     0.000            M32G2603M        90.7576
 M13G3400M   -0.19080399        M07G1700M     0.000            M33G2603M     2412.03
 M21G3400M    0.00000000        M08G1700M     0.000            M34G2603M     2416.09
 M22G3400M    1.00000000                                       M35G2603M         0.167600
 M23G3400M    0.00000000       TRIPLE LRUS                     M36G2603M         0.167600
 M31G3400M    0.19080399        M01G2300M    9.00              M37G2603M        90.81819
 M32G3400M    0.00000000        M02G2300M    9.00              M38G2603M        90.81819
 M33G3400M    0.98162710        M03G2300M    0.10              M39G2603M     1456.03
                                M04G2300M    9.00              M40G2603M     1468.03
IMU2 M50 BODY MATRIX            M05G2300M    9.00              M41G2603M         0.29740
 M11G3401M    0.98162710        M06G2300M    0.10              M42G2603M         0.29740
 M12G3401M    0.00000000        M07G2300M    9.00
 M13G3401M   -0.19080839        M08G2300M    9.00
 M21G3401M    0.00000000        M09G2300M    0.10             OMS ENGINE BURN
 M22G3401M    1.00000000        M10G2300M    0.00              M31G2605M    25.00
 M23G3401M    0.00000000        M11G2300M    0.00              M32G2605M    25.00
 M31G3401M    0.19080899        M12G2300M    9.20
 M32G3401M    0.00000000        M13G2300M    9.20             ENGINE OXIDIZER FLOWRATE
 M33G3401M    0.98162710                                       M31G3101M    1.45160E+01
                               OMS % TO LBS                    M32G3101M    5.50760E-06
IMU2 M50 BODY MATRIX            M01G2601M    80.55             M33G3101M    2.92792E+00
 M11G3402M    0.98162710        M02G2601M    40.96             M34G3101M     14.516
 M12G3402M    0.00000000        M03G2601M    80.55             M35G3101M    5.50790E-06
 M13G3402M   -0.19080899        M04G2601M    40.96             M36G3101M    2.92792E+00
 M21G3402M    0.00000000                                       M37G3101M    1.45160E+01
 M22G3402M    1.00000000       OMS PROPELLANT                  M38G3101M     -0.000
 M23G3402M    0.00000000        M01G2602M    304.00            M39G3101M   -3.40000E-09
 M31G3402M    0.19080399        M02G2602M    304.00            M40G3101M   -3.40000E-09
 M32G3402M    0.00000000        M03G2602M  ?                   M41G3101M    5.50750E-06
 M33G3402M    0.98162710        M04G2602M    165.00            M42G3101M      2.920
                                M05G2602M    165.00            M43G3101M    1.00000E+00
GPC COMPARE TIMES               M06G2602M  ?
 M01G1700M    0:00:00:00        M07G2602M      1.65           TOTAL OXIDIZER CONSUMED
 M02G1700M    0:00:00:00        M08G2602M      1.64            M31G3102M     0:35.00
 M03G1700M    0:00:00:00        M09G2602M   ?                  M34G3102M     1271750
 M04G1700M    0:00:00:00                                       M36G3102M     :31:929
```

Figure 5.1.2-XXIV.- GPC MED display (sheet 1 of 2).



```
FLT  34                    GPC MED 2                        RR2064G
SRPC GMT 239:14:15:57

ENGINE FUEL FLOWRATE         ENGINE POWER LEVEL CONT.         RCS PROPELLANT REMAINING
  M01G3103M  3.09260E-06       M05G3109M  -7026.598            M01G3403M     1.60
  M02G3103M -2.14670E-04       M06G3108M    159.309            M02G3403M     1.60
  M03G3103M  4.27390E-03       M07G3108M  -7026.598            M03G3403M     1.60
  M04G3103M -1.40130E-03
  M05G3103M  6.52200E-02     VEHICLE WEIGHTS                  VAR COMBUSTION CHAMBER
  M06G3103M   3.6956           M01G3109M        33.3           M01G3703M       2.831
  M07G3103M  3.09260E-06       M02G3109M        12.7           M02G3703M      14.516
  M08G3103M -2.14670E-04       M03G3109M        24.9           M03G3703M     175.609
  M09G3103M  4.27390E-03       M04G3109M        42.3           M04G3703M       2.831
  M10G3103M -1.40130E-03       M05G3109M        52.2           M05G3703M      14.516
  M11G3103M  6.52200E-02       M06G3109M      6520.0           M06G3703M     176.609
  M12G3103M  3.89560E+00       M07G3109M      1000.0           M07G3703M       2.831
  M13G3103M  3.09260E-06       M08G3109M    320241.0           M08G3703M      14.416
  M14G3103M -2.14670E-04       M01G3110M     14641.00          M09G3703M     176.600
  M15G3103M  4.27390E-03
  M16G3103M -1.40130E-03     ENGINE NPSP                      VAR HPOT AND HPFT
  M17G3103M  6.52200E-02       M01G3111M      413.000          M01G3704M        21.61924
  M18G3103M  3.89560E+00       M02G3111M        0.020          M02G3704M     9790.60
  M19G3103M  2.20470E-03       M03G3111M        4.420          M03G3704M     2600.00
                               M04G3111M        3.480          M04G3704M        21.6192
 TOTAL FUEL CONSUMED           M05G3111M      592.060          M05G3704M     9790.60
  M01G3104M      212521.00     M06G3111M     4069.000          M06G3704M     2560.00
  M02G3104M      219223.00     M07G3111M       10.340          M07G3704M        21.61924
                               M08G3111M        0.590          M08G3704M     9790.60
                               M09G3111M        5.670          M09G3704M     2500.60
 OXIDIZER REMAINING            M10G3111M       32.600          M10G3704M      159.10
  M01G3105M     1376403.00     M11G3111M       16.900          M11G3704M    11609.60
                               M12G3111M        6.700          M12G3704M     2500.60
 FUEL REMAINING                M13G3111M      140.000          M13G3704M      159.10
  M01G3106M      229376.00     M14G3111M       37.000          M14G3704M    11609.598
                                                               M15G3704M     2500.00
 ENGINE POWER LEVEL          RCS % TO LBS CONVERSION           M16G3704M      159.10
  M01G3103M      469121.00     M01G3402M   13.50               M17G3704M    11609.60
  M02G3103M         158.309    M02G3402M    8.50               M18G3704M     2800.00
  M03G3103M       -7026.598    M03G3402M   13.50
  M04G3103M         158.309    M04G3402M    8.50
                               M05G3402M   13.50
                               M06G3402M    8.50
```

Figure 5.1.2-XXIV.- GPC MED display (sheet 2 of 2).

TITLE

ME CONSOLE EVENT LIGHT INDICATORS

PURPOSE

This SCP describes the light formats for the event panels on the Main Engine (ME) console. Also provided is a table that lists the limit-sensed parameters for each event light panel. SCP 5.1.4 describes the process by which the limits that trigger the lights are set. SCP's 6.1 and 6.14 describe the processes by which the limits that trigger the lights are loaded.

DESCRIPTION

The Main Engine console is configured with seven panels of event lights. The purpose of each event light is to warn the console operator of a change in the operating state of each SSME. These changes in state might be the result of normal sequence changes such as the change from mainstage to shutdown phase at MECO or the change from post-shutdown phase to LOX dump. Other changes in state may be the result of an off-nominal engine condition such as an off-nominal temperature or pressure or an engine performance problem. If a light is illuminated, the console operator should check one of the main engine displays to determine the value and direction (high or low) of the out-of-limit condition.

Each panel on the Main Engine console has its own event panel format. A brief description of each format is provided below. These light formats are also active on the Booster console.

Formats 281, 282, and 283 are the SSME limit light panel formats for the center, left, and right engines, respectively. All three panels are configured identically with 36 lights. These panels limit sense the main engine shutdown parameters and some engine performance parameters. The limits are set so that the event light will illuminate before an engine shutdown limit is exceeded.

Format 284 decodes the engine status word from the left, center, and right engines. These 16-bit words are decoded to indicate the following: limit control inhibited or enabled; the engine phase in effect (start, mainstage, shutdown, post shutdown, or LO_2 dump); engine mode of operation (electrical lockup or hydraulic lockup); and engine self-test status (engine limit exceeded or major component failure).

Format 285 is a 36-light panel which is used to indicate the status of the engine interface unit through which engine data and commands are transmitted. Also included on this panel are lights which indicate out-of-limit conditions for the hydraulic pressures, fuel NPSP, fuel flow rates, and mixture ratios.

The Main Engine console operator uses format 290 to check which of the five operating limits (prelaunch, launch, SRB separation, ET separation, or abort-throttle) are in effect and which of the engine limits have been disabled by the SMEK panel. This format also indicates whether a high or low data downlist rate is being transmitted. The separation command and inhibit lights indicate the status of SRB separation and ET separation.

Format 293 was developed to provide a status of main engine limit switch positions, AC bus sensor status, engine power switches, and status of main buses, control buses, and GPC's.

The event light panel for each format is shown in figures 5.1.3-II through 5.1.3-VII. These figures show the overlay name and master measurement list (MML) number for each parameter. The indicator locations, color, logic, overlay name, measurement number, and measurement description for each format are listed in tables 5.1.3-I through 5.1.3-VII. The indicator location number specifies the position of the overlay name on the event light matrix. Two types of overlay matrices are used and are illustrated in figure 5.1.3.-I (the numbers identify the indicator location numbers).

TYPE A

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31	32	33	34	35	36

TYPE B

1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25	26	27
28	29	30	31	32	33	34	35	36

Figure 5.1.3-I.- DDD panel types.

Formats 281, 282, 283, 290, and 293 use the type A matrix; formats 284 and 285 use the type B matrix.

Each overlay name on the matrix is color coded to alert the operator to the different types of events which might occur. Five colors are used: red, amber, white, green, and blue. A red light is used for those events which indicate a hazardous condition, or events which should be brought to the operator's immediate attention. An amber light signifies the approach of a hazardous condition (the amber light is also used for the five operating limit phase indicators). A white light is used to indicate the position of a valve. A green light is also used for valve positions and nonhazardous events. The one blue light indicates a low data rate. The color of each event light is indicated in the color column of tables 5.1.3-1 through 5.1.3-VI and in the upper left corner of each event light position in figures 5.1.3-II through 5.1.3-VII.

The logic which illuminates each light is indicated in the logic column on the tables. A blank space in the logic column indicates that "normal" logic is being used to illuminate the event light (i.e., a "1" discrete output resulting from an event such as a valve closure is being used to control the indicator logic). If the letter "R" appears in the logic column, the indicator logic has been reversed (i.e., a "0" discrete output from an event such as a change in a switch position is being used to control the indicator logic).

REFERENCES

Booster Data Pack, as of Sept. 1, 1989.

R HPOTISPPA E41P1014B	R HPOTSSLPA E41P1051B	R HPFTCLNPA E41P1008B	R HPOTTD TA E41T1012B	R HPFTTD TA E41T1010B	A PC A E41P1016B
R HPOTISPPB E41P1015B	R HPOTSSLPB E41P1053B	R HPFTCLNPB E41P1009B	R HPOTTD TB E41T1013B	R HPFTTD TB E41T1011B	A PC B E41P1017B
A HPOTISPPΔ M07G3702C	A HPOTSSLPΔ M10G3702C	A HPFTCLNPΔ M16G3702C	A HPOTTD TΔ M04G3702C	A HPFTTD TΔ M01G3702C	A PC Δ M13G3702C
A COMPNT FL M34G3708E	R LIM EXCED M31G3708E	R SHUTDOWN M25G3708E	A LPFTDSCHT E41T1019B	A OXFLO GPM E41R1022B	A PWLV-CMD M01G3701C
A ELEC HOLD M19G3708E	W	R POST SHTD M28G3708E	A LPFTDSCHP E41P1018B	A FUFLO GPM E41R1021B	A BFS PC V98P2100C
A HYD LOCK M22G3708E	A TH LIM M49G3708E	A LIM S INH E41X1511B	A FU FLOWRT M01G3103C	A MIX RATIO M02G3107C	A GH2 OUT P V41P1160A

Figure 5.1.3-II.- Center SSME event lights
(format number: 281, type: A).

TABLE 5.1.3-I.- CENTER SSME EVENT LIGHTS (FORMAT NUMBER: 281, TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	R		HPOTISPPA ● E41P1014B	E41P1014B	C HPOT intermediate seal purge pressure A
02	R		HPOTSSLPA ● E41P1051B	E41P1051B	C HPOT secondary seal pressure A
03	R		HPFTCLNPA ● E41P1008B	E41P1008B	C HPFT coolant liner pressure A
04	R		HPOTTD TA ● E41T1012B	E41T1012B	C HPOT turbine discharge temperature A
05	R		HPFTTD TA ● E41T1010B	E41T1010B	C HPFT turbine discharge temperature A
06	A		PC A ● E41P1016B	E41P1016B	C Main combustion chamber pressure A
07	R		HPOTISPPB ● E41P1015B	E41P1015B	C HPOT intermediate seal purge pressure B
08	R		HPOTSSLPB ● E41P1053B	E41P1053B	C HPOT secondary seal pressure B
09	R		HPFTCLNPB ● E41P1009B	E41P1009B	C HPFT coolant liner pressure B
10	R		HPOTTD TB ● E41T1013B	E41T1013B	C HPOT turbine discharge temperature B
11	R		HPFTTD TB ● E41T1011B	E41T1011B	C HPFT turbine discharge temperature B
12	A		PC B ● E41P1017B	E41P1017B	C MAIN combustion chamber pressure B
13	A		HPOTISPPΔ ● M07G3702C	M07G3702C	C HPOT intermediate seal purge pressure delta (|PA-PB|)
14	A		HPOTSSLPΔ ● M10G3702C	M10G3702C	C HPOT secondary seal pressure delta (|PA-PB|)
15	A		HPFTCLNPΔ ● M16G3702C	M16G3702C	C HPFT coolant liner pressure delta (|PA-PB|)
16	A		HPOTTD TΔ ● M04G3702C	M04G3702C	C HPOT turbine discharge temperature delta (|TA-TB|)
17	A		HPFTTD TΔ ● M01G3702C	M01G3702C	C HPFT turbine discharge temperature delta (|TA-TB|)
18	A		PC Δ ● M13G3702C	M13G3702C	C Main comb chamber pressure delta (|PA-PB|)
19	A		COMPNT FL ● M34G3708E	M34G3708E	C SSME component failure
20	R		LIM EXCED ● M31G3708E	M31G3708E	C SSME shutdown limit exceeded
21	R		SHUTDOWN ● M25G3708E	M25G3708E	C SSME in shutdown phase
22	A		LPFTDSCHT ● E41T1019B	E41T1019B	C LPFT discharge temperature
23	A		OXFLO GPM ● E41R1022B	E41R1022B	C LOX flow rate - gallons per minute
24	A		PWLV-CMD ● M01G3701C	M01G3701C	C delta between actual and commanded power LVL
25	A		ELEC HOLD ● M19G3708E	M19G3708E	C SSME in electronic hold
26	W				
27	R		POST SHTD ● M28G3708E	M28G3708E	C SSME in post shutdown phase
28	A		LPFTDSCHP ● E41P1018B	E41P1018B	C LPFT discharge pressure
29	A		FUFLO GPM ● E41R1021B	E41R1021B	C LH_2 flow rate - gallons per minute
30	A		BFS PC ● V98P2100C	V98P2100C	C backup flight system downlisted PC
31	A		HYD LOCK ● M22G3708E	M22G3708E	C SSME in hydraulic lockup
32	A		TH LIM ● M49G3708E	M49G3708E	C SSME operating in thrust limiting
33	A	R	LIM S INH ● E41X1511B	E41X1511B	C SSME shutdown limits inhibited
34	A		FU FLOWRT ● M01G3103C	M01G3103C	C LH_2 flow rate - lb per sec
35	A		MIX RATIO ● M02G3107C	M02G3107C	C SSME mixture ratio
36	A		GH2 OUT P ● V41P1160A	V41P1160A	C gaseous H_2 outlet pressure

R HPOTISPPA E41P2014B	R HPOTSSLPA E41P2051B	R HPFTCLNPA E41P2008B	R HPOTTD TA E41T2012B	R HPFTTD TA E41T2010B	A PC A E41P2016B
R HPOTISPPB E41P2015B	R HPOTSSLPB E41P2053B	R HPFTCLNPB E41P2009B	R HPOTTD TB E41T2013B	R HPFTTD TB E41T2011B	A PC B E41P2017B
A HPOTISPPΔ M08G3702C	A HPOTSSLPΔ M11G3702C	A HPFTCLNPΔ M17G3702C	A HPOTTD TΔ M05G3702C	A HPFTTD TΔ M02G3702C	A PC Δ M14G3702C
A COMPNT FL M35G3708E	R LIM EXCED M32G3708E	R SHUTDOWN M26G3708E	A LPFTDSCHT E41T2019B	A OXFLO GPM E41R2022B	A PWLV-CMD M02G3701C
A ELEC HOLD M20G3708E	W	R POST SHTD M29G3708E	A LPFTDSCHP E41P2018B	A FUFLO GPM E41R2021B	A BFS PC V98P2110C
A HYD LOCK M23G3708E	A TH LIM M50G3708E	A LIM S INH E41X2511B	A FU FLOWRT M02G3103C	A MIX RATIO M03G3107C	A GH2 OUT P V41P1260A

Figure 5.1.3-III.- Left SSME event lights
(format number: 282, type: A).

TABLE 5.1.3-II.- LEFT SSME EVENT LIGHTS (FORMAT NUMBER: 282, TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	R		HPOTISPPA ● E41P2014B	E41P2014B	L HPOT intermediate seal purge pressure A
02	R		HPOTSSLPA ● E41P2051B	E41P2051B	L HPOT secondary seal pressure A
03	R		HPFTCLNPA ● E41P2008B	E41P2008B	L HPFT coolant liner pressure A
04	R		HPOTTD TA ● E41T2012B	E41T2012B	L HPOT turbine discharge temperature A
05	R		HPFTTD TA ● E41T2010B	E41T2010B	L HPFT turbine discharge temperature A
06	A		PC A ● E41P2016B	E41P2016B	L Main combustion chamber pressure A
07	R		HPOTISPPB ● E41P2015B	E41P2015B	L HPOT intermediate seal purge pressure B
08	R		HPOTSSLPB ● E41P2053B	E41P2053B	L HPOT secondary seal pressure B
09	R		HPFTCLNPB ● E41P2009B	E41P2009B	L HPFT coolant liner pressure B
10	R		HPOTTD TB ● E41T2013B	E41T2013B	L HPOT turbine discharge temperature B
11	R		HPFTTD TB ● E41T2011B	E41T2011B	L HPFT turbine discharge temperature B
12	A		PC B ● E41P2017B	E41P2017B	L MAIN combustion chamber pressure B
13	A		HPOTISPPΔ ● M08G3702C	M08G3702C	L HPOT intermediate seal purge pressure delta (|PA-PB|)
14	A		HPOTSSLPΔ ● M11G3702C	M11G3702C	L HPOT secondary seal pressure delta (|PA-PB|)
15	A		HPFTCLNPΔ ● M17G3702C	M17G3702C	L HPFT coolant liner pressure delta (|PA-PB|)
16	A		HPOTTD TΔ ● M05G3702C	M05G3702C	L HPOT turbine discharge temperature delta (|TA-TB|)
17	A		HPFTTD TΔ ● M02G3702C	M02G3702C	L HPFT turbine discharge temperature delta (|TA-TB|)
18	A		PC Δ ● M14G3702C	M14G3702C	L Main comb chamber pressure delta (|PA-PB|)
19	A		COMPNT FL ● M35G3708E	M35G3708E	L SSME component failure
20	R		LIM EXCED ● M32G3708E	M32G3708E	L SSME shutdown limit exceeded
21	R		SHUTDOWN ● M26G3708E	M26G3708E	L SSME in shutdown phase
22	A		LPFTDSCHT ● E41T2019B	E41T2019B	L LPFT discharge temperature
23	A		OXFLO GPM ● E41R2022B	E41R2022B	L LOX flow rate - gallons per minute
24	A		PWLV-CMD ● M02G3701C	M02G3701C	L delta between actual and commanded power LVL
25	A		ELEC HOLD ● M20G3708E	M20G3708E	L SSME in electronic hold
26	W				
27	R		POST SHTD ● M29G3708E	M29G3708E	L SSME in post shutdown phase
28	A		LPFTDSCHP ● E41P2018B	E41P2018B	L LPFT discharge pressure
29	A		FUFLO GPM ● E41R2021B	E41R2021B	L LH_2 flow rate - gallons per minute
30	A		BFS PC ● V98P2110C	V98P2110C	L backup flight system downlisted PC
31	A		HYD LOCK ● M23G3708E	M23G3708E	L SSME in hydraulic lockup
32	A		TH LIM ● M50G3708E	M50G3708E	L SSME operating in thrust limiting
33	A	R	LIM S INH ● E41X2511B	E41X2511B	L SSME shutdown limits inhibited
34	A		FU FLOWRT ● M02G3103C	M02G3103C	L LH_2 flow rate - lb per sec
35	A		MIX RATIO ● M03G3107C	M03G3107C	L SSME mixture ratio
36	A		GH2 OUT P ● V41P1260A	V41P1260A	L gaseous H_2 outlet pressure

R HPOTISPPA E41P3014B	R HPOTSSLPA E41P3051B	R HPFTCLNPA E41P3008B	R HPOTTD TA E41T3012B	R HPFTTD TA E41T3010B	A PC A E41P3016B
R HPOTISPPB E41P3015B	R HPOTSSLPB E41P3053B	R HPFTCLNPB E41P3009B	R HPOTTD TB E41T3013B	R HPFTTD TB E41T3011B	A PC B E41P3017B
A HPOTISPPΔ M09G3702C	A HPOTSSLPΔ M12G3702C	A HPFTCLNPΔ M18G3702C	A HPOTTD TΔ M06G3702C	A HPFTTD TΔ M03G3702C	A PC Δ M15G3702C
A COMPNT FL M36G3708E	R LIM EXCED M33G3708E	R SHUTDOWN M27G3708E	A LPFTDSCHT E41T3019B	A OXFLO GPM E41R3022B	A PWLV-CMD M03G3701C
A ELEC HOLD M21G3708E	W	R POST SHTD M30G3708E	A LPFTDSCHP E41P3018B	A FUFLO GPM E41R3021B	A BFS PC V98P2120C
A HYD LOCK M24G3708E	A TH LIM M51G3708E	A LIM S INH E41X3511B	A FU FLOWRT M03G3103C	A MIX RATIO M04G3107C	A GH2 OUT P V41P1360A

Figure 5.1.3-IV.- Right SSME event lights
(format number: 283, type: A).

TABLE 5.1.3-III.- RIGHT SSME EVENT LIGHTS (FORMAT NUMBER: 283, TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	R		HPOTISPPA ● E41P3014B	E41P3014B	R HPOT intermediate seal purge pressure A
02	R		HPOTSSLPA ● E41P3051B	E41P3051B	R HPOT secondary seal pressure A
03	R		HPFTCLNPA ● E41P3008B	E41P3008B	R HPFT coolant liner pressure A
04	R		HPOTTD TA ● E41T3012B	E41T3012B	R HPOT turbine discharge temperature A
05	R		HPFTTD TA ● E41T3010B	E41T3010B	R HPFT turbine discharge temperature A
06	A		PC A ● E41P3016B	E41P3016B	R Main combustion chamber pressure A
07	R		HPOTISPPB ● E41P3015B	E41P3015B	R HPOT intermediate seal purge pressure B
08	R		HPOTSSLPB ● E41P3053B	E41P3053B	R HPOT secondary seal pressure B
09	R		HPFTCLNPB ● E41P3009B	E41P3009B	R HPFT coolant liner pressure B
10	R		HPOTTD TB ● E41T3013B	E41T3013B	R HPOT turbine discharge temperature B
11	R		HPFTTD TB ● E41T3011B	E41T3011B	R HPFT turbine discharge temperature B
12	A		PC B ● E41P3017B	E41P3017B	R MAIN combustion chamber pressure B
13	A		HPOTISPPΔ ● M09G3702C	M09G3702C	R HPOT intermediate seal purge pressure delta (|PA-PB|)
14	A		HPOTSSLPΔ ● M12G3702C	M12G3702C	R HPOT secondary seal pressure delta (|PA-PB|)
15	A		HPFTCLNPΔ ● M18G3702C	M18G3702C	R HPFT coolant liner pressure delta (|PA-PB|)
16	A		HPOTTD TΔ ● M06G3702C	M06G3702C	R HPOT turbine discharge temperature delta (|TA-TB|)
17	A A		HPFTTD TΔ ● M03G3702C	M03G3702C	R HPFT turbine discharge temperature delta (|TA-TB|)
18			PC Δ ● M15G3702C	M15G3702C	R Main comb chamber pressure delta (|PA-PB|)
19	A		COMPNT FL ● M36G3708E	M36G3708E	R SSME component failure
20	R		LIM EXCED ● M33G3708E	M33G3708E	R SSME shutdown limit exceeded
21	R		SHUTDOWN ● M27G3708E	M27G3708E	R SSME in shutdown phase
22	A		LPFTDSCHT ● E41T3019B	E41T3019B	R LPFT discharge temperature
23	A		OXFLO GPM ● E41R3022B	E41R3022B	R LOX flow rate - gallons per minute
24	A		PWLV-CMD ● M03G3701C	M03G3701C	R delta between actual and commanded power LVL
25	A		ELEC HOLD ● M21G3708E	M21G3708E	R SSME in electronic hold
26	W				
27	R		POST SHTD ● M30G3708E	M30G3708E	R SSME in post shutdown phase
28	A		LPFTDSCHP ● E41P3018B	E41P3018B	R LPFT discharge pressure
29	A		FUFLO GPM ● E41R3021B	E41R3021B	R LH_2 flow rate - gallons per minute
30	A		BFS PC ● V98P2120C	V98P2120C	R backup flight system downlisted PC
31	A		HYD LOCK ● M24G3708E	M24G3708E	R SSME in hydraulic lockup
32	A		TH LIM ● M51G3708E	M51G3708E	R SSME operating in thrust limiting
33	A	R	LIM S INH ● E41X3511B	E41X3511B	R SSME shutdown limits inhibited
34	A		FU FLOWRT ● M03G3103C	M03G3103C	R LH_2 flow rate - lb per sec
35	A		MIX RATIO ● M04G3107C	M04G3107C	R SSME mixture ratio
36	A		GH2 OUT P ● V41P1360A	V41P1360A	R gaseous H_2 outlet pressure

G START M14G3708E	R SHUTDOWN M26G3708E	G LO2 DUMP M38G3708E	G START M13G3708E	R SHUTDOWN M25G3708E	G LO2 DUMP M37G3708E	G START M15G3708E	R SHUTDOWN M27G3708E	G LO2 DUMP M39G3708E
G MAINSTAGE M17G3708E	R POST SHTD M29G3708E	A HPOT D P E41P2030B	G MAINSTAGE M16G3708E	R POST SHTD M28G3708E	A HPOT D P E41P1030B	G MAINSTAGE M18G3708E	R POST SHTD M30G3708E	A HPOT D P E41P3030B
A ELEC HOLD M20G3708E	R LIM EXCED M32G3708E	A LIM S INH E41X2511B	A ELEC HOLD M19G3708E	R LIM EXCED M31G3708E	A LIM S INH E41X1511B	A ELEC HOLD M21G3708E	R LIM EXCED M33G3708E	A LIM S INH E41X3511B
A HYD LOCK M23G3708E	W	R COMPNT FL M35G3708E	A HYD LOCK M22G3708E	W	A COMPNT FL M34G3708E	A HYD LOCK M24G3708E	W	A COMPNT FL M36G3708E

Figure 5.1.3-V.- SSME status L,C,R (format number: 284, type: B).

TABLE 5.1.3-IV.- SSME STATUS L,C,R (FORMAT NUMBER: 284, TYPE: B)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	G		START ● M14G3708E	M14G3708E	L SSME in start phase
02	R		SHUTDOWN ● M26G3708E	M26G3708E	L SSME in shutdown phase
03	G		LO2 DUMP ● M38G3708E	M38G3708E	L SSME in LO$_2$ dump
04	G		START ● M13G3708E	M13G3708E	C SSME in start phase
05	R		SHUTDOWN ● M25G3708E	M25G3708E	C SSME in shutdown phase
06	G		LO2 DUMP ● M37G3708E	M37G3708E	C SSME in LO$_2$ dump
07	G		START ● M15G3708E	M15G3708E	R SSME in start phase
08	R		SHUTDOWN ● M27G3708E	M27G3708E	R SSME in shutdown phase
09	G		LO2 DUMP ● M39G3708E	M39G3708E	R SSME in Lo$_2$ dump
10	G		MAINSTAGE ● M17G3708E	M17G3708E	L SSME in mainstage operation
11	R		POST SHTD ● M29G3708E	M29G3708E	L SSME in post shutdown standby
12	A		HPOT D P ● E41P2030B	E41P2030B	L SSME HPOT discharge press limit exceeded
13	G		MAINSTAGE ● M16G3708E	M16G3708E	C SSME in mainstage operation
14	R		POST SHTD ● M28G3708E	M28G3708E	C SSME in post shutdown standby
15	A		HPOT D P ● E41P1030B	E41P1030B	C SSME HPOT discharge press limit exceeded
16	G		MAINSTAGE ● M18G3708E	M18G3708E	R SSME in mainstage operation
17	R		POST SHTD ● M30G3708E	M30G3708E	R SSME in post shutdown standby
18	A		HPOT D P ● E41P3030B	E41P3030B	R SSME HPOT discharge press limit exceeded
19	A		ELEC HOLD ● M20G3708E	M20G3708E	L SSME in electronic hold
20	R		LIM EXCED ● M32G3708E	M32G3708E	L SSME shutdown limit has been exceeded
21	A	R	LIM S INH ● E41X2511B	E41X2511B	L SSME shutdown limits are inhibited
22	A		ELEC HOLD ● M19G3708E	M19G3708E	C SSME in electronic hold
23	R		LIM EXCED ● M31G3708E	M31G3708E	C SSME shutdown limit has been exceeded
24	A	R	LIM S INH ● E41X1511B	E41X1511B	C SSME shutdown limits inhibited
25	A		ELEC HOLD ● M21G3708E	M21G3708E	R SSME in electronic hold
26	R		LIM EXCED ● M33G3708E	M33G3708E	R SSME shutdown limit has been exceeded
27	A	R	LIM S INH ● E41X3511B	E41X3511B	R SSME shutdown limits inhibited
28	A		HYD LOCK ● M23G3708E	M23G3708E	L SSME in hydraulic lockup
29	W				
30	A		COMPNT FL ● M35G3708E	M35G3708E	L SSME component failure
31	A		HYD LOCK ● M22G3708E	M22G3708E	C SSME in hydraulic lockup
32	W				
33	A		COMPNT FL ● M34G3708E	M34G3708E	C SSME component failure
34	A		HYD LOCK ● M24G3708E	M24G3708E	R SSME in hydraulic lockup
35	W				
36	A		COMPNT FL ● M36G3708E	M36G3708E	R SSME component failure

A EIU P1 91X2930XX	A DCUB DATA E41X2505B	A EIU BFSP1 V98X0826X	A EIU P1 91X2927XX	A DCUB DATA E41X1505B	A EIU BFSP1 V98X0821X	A EIU P1 91X2933XX	A DCUB DATA E41X3505B	A EIU BFSP1 V98X0831X
A EIU P4 91X2817XX	A HYD SYS P E41P2054B	A EIU BFSP4 V98X0828X	A EIU P4 91X2813XX	A HYD SYS P E41P1054B	A EIU BFSP4 V98X0824X	A EIU P4 91X2821XX	A HYD SYS P E41P3054B	A EIU BFSP4 V98X0832X
R NPSP L M02G3111C	R NPSP C M01G3111C	R NPSP R M03G3111C	W MAN THRTL V72X5135X	A TOTFUFLRT M04G3103C	A TMIXRATIO M01G3107C	R BFS BU CW V98X1268X	R BFS ALERT V98X1269X	R GNC ALERT V72X4526X
A EIU RPC B V72S0099E	R NPSP A M04G3111C	B LBR 64K	A EIU RPC A V72S0097E			A EIU RPC C V72S0102E	R GNC BU CW V72X4533X	R C AND W V73X1567E

Figure 5.1.3-VI.- SSME data L,C,R (format number: 285, type: B).

TABLE 5.1.3-V.- SSME DATA L,C,R (FORMAT NUMBER: 285, TYPE: B)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		EIU P1 ● 91X2930XX	V91X2930XX	L EIU port 1 bypassed
02	A	R	DCUB DATA ● E41X2505B	E41X2505B	L SSME DCU B data is being downlisted
03	A		EIU BFSP1 ● V98X0826X	V98X0826X	L EIU port 1 bypassed while in BFS control
04	A		EIU P1 ● 91X2927XX	V91X2927XX	C EIU port 1 bypassed
05	A	R	DCUB DATA ● E41X1505B	E41X1505B	C SSME DCU B data is being downlisted
06	A		EIU BFSP1 ● V98X0821X	V98X0821X	C EIU port 1 bypassed while in BFS control
07	A		EIU P1 ● 91X2933XX	V91X2933XX	R EIU port 1 bypassed
08	A	R	DCUB DATA ● E41X3505B	E41X3505B	R SSME DCU B data is being downlisted
09	A		EIU BFSP1 ● V98X0831X	V98X0831X	R EIU port 1 bypassed while in BFS control
10	A		EIU P4 ● 91X2817XX	V91X2817XX	L EIU port 4 bypassed
11	A		HYD SYS P ● E41P2054B	E41P2054B	L SSME hydraulic press limit exceeded
12	A		EIU BFSP4 ● V98X0828X	V98X0828X	L EIU port 4 bypassed while in BFS control
13	A		EIU P4 ● 91X2813XX	V91X2813XX	C EIU port 4 bypassed
14	A		HYD SYS P ● E41P1054B	E41P1054B	C SSME hydraulic press limit exceeded
15	A		EIU BFSP4 ● V98X0824X	V98X0824X	C EIU port 4 bypassed while in BFS control
16	A		EIU P4 ● 91X2821XX	V91X2821XX	R EIU port 4 bypassed
17	A		HYD SYS P ● E41P3054B	E41P3054B	R SSME hydraulic press limit exceeded
18	A		EIU BFSP4 ● V98X0832X	V98X0832X	R EIU port 4 bypassed while in BFS control
19	R		NPSP L ● M0203111C	M02G3111C	L SSME LPFP net positive suction press limit violated
20	R		NPSP C ● M01G3111C	M01G3111C	C SSME LPFP net positive suction press limit violated
21	R		NPSP R ● M03G3111C	M03G3111C	R SSME LPFP net positive suction press limit violated
22	W		MAN THRTL ● V72X5135X	V72X5135X	Pilot has engaged manual throttle
23	A		TOTFUFLRT ● M04G3103C	M04G3103C	Total LH_2 flow rate from ET limit violated
24	A		TMIXRATIO ● M01G3107C	M01G3107C	Total ET mixture ratio limit violated
25	R		BFS BU CW ● V98X1268X	V98X1268X	Backup caution and warning alarm
26	R		BFS ALERT ● V98X1269X	V98X1269X	BFS class 3 alert
27	R		GNC ALERT ● V72X4526X	V72X4526X	Pass class 3 alert
28	A	R	EIU RPC B ● V72S0099E	V72S0099E	L EIU RPC B off
29	R		NPSP A ● M04G3111C	M04G3111C	Average LH_2 net positive suction press
30	B		LBR ● 64K	V74X4754E	64 KB/s low bit rate
31	A	R	EIU RPC A ● V72S0097E	V72S0097E	C EIU RPC A off
32					
33					
34	A	R	EIU RPC C ● V72S0102E	V72S0102E	R EIU RPC C off
35	R		GNC BU CW ● V72X4533X	V72X4533X	Pass backup caution and warning alarm
36	R		C AND W ● V73X1567E	V73X1567E	Primary caution and warning alarm (system A only)

A PRELAUNCH LIMITS	A LAUNCH LIMITS	A SRB SEP LIMITS	A ET SEP LIMITS	R SITE STATIC	R GN STATIC
G L LIMITS DISABLE	G C LIMITS DISABLE	G R LIMITS DISABLE	A ABORT THRT LIMITS	R BFCS STATIC	R OI STATIC
G MEC PWR 1 V76S4601E	G SRB SEP INIT	G SRB SEP ARM CMD	W SRB SEP MN/AU ENA	W SRB SEP INIT CMD	G SRB SEP CMD
G MEC PWR 2 V76S4605E	G MECO CONFIRMED	G ET ORB SEP ARM	W ET SEP MAN ENAB	W ET SEP INIT CMD	G ET SEP CMD
G SRB SEP AUTO ENAB	G SRB SEP INIT	R SRB SEP INHIB	W SRB SEP MN/AU ENA	W SRB SEP INIT CMD	G SRB SEP CMD
G ET SEP AUTO ENAB	G MECO CONFIRMED	R ET SEP INHIB	W ET SEP MAN ENAB	W ET SEP INIT CMD	G ET SEP CMD

Figure 5.1.3-VII.- Limits status (format number: 290, type: A).

TABLE 5.1.3-VI.- Limits status; (FORMAT NUMBER: 290, TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		PRELAUNCH ● LIMITS	M60K0011I	Limit sense set at prelaunch limits
02	A		LAUNCH ● LIMITS	M60K0012I	Limit sense set at launch limits
03	A		SRB SEP ● LIMITS	M60K0013I	Limit sense set at SRB separation limits
04	A		ET SEP ● LIMITS	M60K0014I	Limit sense set at external tank separation limits
05	R		SITE ● STATIC	M20K0012D	All site data static
06	R		GN ● STATIC	M40H0234D	Downlink data static
07	G		L LIMITS ● DISABLE	M13K0034I	Left SSME limit sense disabled
08	G		C LIMITS ● DISABLE	M13K0035I	Center SSME limit sense disabled
09	G		R LIMITS ● DISABLE	M13K0036I	Right SSME limit sense disabled
10	A		ABRT THRT ● LIMITS	M60K0015I	Limit sense set at abort SSME throttling limits
11	R		BFCS ● STATIC	M40H0434D	Backup flight control system data static
12	R		OI ● STATIC	M40H0134D	Operational instrumentation data static
13	G		MEC PWR 1 ● V76S4601E	V76S4601E	Master events controller power 1 on
14	G		SRB SEP ● INIT	V98X3532X	SRB separation initiation (BFS)
15	G		SRB SEP ● ARM CMD	V98X0744X	SRB separation arm command (BFS)
16	W		SRB SEP ● MN/AU ENA	V98X0742X	SRB separation manual/auto enable (BFS)
17	W		SRB SEP ● INIT CMD	V98X0743X	SRB separation initiation command (BFS)
18	G		SRB SEP ● CMD	V98X3534X	SRB separation command (BFS)
19	G		MEC PWR 2 ● V76S4605E	V76S4605E	Master events controller power 2 on (BFS)
20	G		MECO ● CONFIRMED	V98X3546X	Main engine cut off confirmed (BFS)
21	G		ET ORB ● SEP ARM	V98X0752X	ET/Orbiter separation arm (BFS)
22	W		ET SEP ● MAN ENA	V98X0748X	ET separation manual enable (BFS)
23	W		ET SEP ● INIT CMD	V98X0749X	ET separation initiation command (BFS)
24	G		ET SEP ● CMD	V98X3550X	ET separation command (BFS)
25	G		SRB SEP ● AUTO ENA	V90X7570X	SRB separation auto enable
26	G		SRB SEP ● INIT	V90X8333X	SRB separation initiation
27	R		SRB SEP ● INHIB	V90X8340X	SRB separation inhibit
28	W		SRB SEP ● MN/AU ENA	V90X7571X	SRB separation manual enable
29	W		SRB SEP ● INIT CMD	V90X7572X	SRB separation initiation command
30	G		SRB SEP ● CMD	V90X8331X	SRB separation command
31	G		ET SEP ● AUTO ENA	V90X7554X	ET separation auto enable
32	G		MECO ● CONFIRMED	V90X8561X	Main engine cut off confirmed
33	R		ET SEP ● INHIB	V90X8259X	ET separation inhibit
34	W		ET SEP ● MAN ENA	V90X7556X	ET separation manual enable
35	W		ET SEP ● INIT CMD	V90X7564X	ET separation initiation command
36	G		ET SEP ● CMD	V90X8250X	ET separation command

A ENG LIMIT ENABLE A	A ENG LIMIT ENABLE B	A ENG LIMIT ENABLE C	A MN A APC4 VOLTS	A MN A APC5 VOLTS	A MN A APC6 VOLTS
G AUTO A	G AUTO B	G AUTO C	A CTL AB1 VOLTS	A CTL AB2 VOLTS	A CTL AB3 VOLTS
R INHIBIT A	R INHIBIT B	R INHIBIT C	A CTL BC1 VOLTS	A CTL BC2 VOLTS	A CTL BC3 VOLTS
G AC 1 BUS SENSR OFF	G AC 2 BUS SENSR OFF	G AC 3 BUS SENSR OFF	A CTL CA1 VOLTS	A CTL CA2 VOLTS	A CTL CA3 VOLTS
R ENG PWR L AC 2	R ENG PWR C AC 1	R ENG PWR R AC 3	R GPC 1 FAIL	R GPC 2 FAIL	R GPC 3 FAIL
R L AC 3	R C AC 2	R R AC 1	R GPC 4 FAIL	R GPC 5 FAIL	R RS HOLD

Figure 5.1.3-VIII.- ME AUX DATA (format number: 293; type A).

TABLE 5.1.3-VII.- ME AUX DATA (FORMAT NUMBER: 293, TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		ENG LIMIT ● ENABLE A	V72K0051X	Contact A of limit switch is enabled
02	A		ENG LIMIT ● ENABLE B	V72K0052X	Contact B of limit switch is enabled
03	A		ENG LIMIT ● ENABLE C	V72K0053X	Contact C of limit switch is enabled
04	A		MN A APC4 ● VOLTS	V76V3091A	Main A volts are out of limits
05	A		MN B APC5 ● VOLTS	V76V3092A	Main B volts are out of limits
06	A		MN C APC6 ● VOLTS	V76V3093A	Main C volts are out of limits
07	G		● AUTO A	V72K0071X	Contact A of limit switch is in Auto
08	G		● AUTO B	V72K0072X	Contact B of limit switch is in Auto
09	G		● AUTO C	V72K0073X	Contact C of limit switch is in Auto
10	A		CTL AB1 ● VOLTS	V76V0120A	Control bus AB1 voltage is out of limits
11	A		CTL AB2 ● VOLTS	V76V0121A	Control bus AB2 voltage is out of limits
12	A		CTL AB3 ● VOLTS	V76V0122A	Control bus AB3 voltage is out of limits
13	R		● INHIBIT A	V72K0061X	Contact A of limit switch is inhibited
14	R		● INHIBIT B	V72K0062X	Contact B of limit switch is inhibited
15	R		● INHIBIT C	V72K0063X	Contact C of limit switch is inhibited
16	A		CTL BC1 ● VOLTS	V76V0220A	Control bus BC1 voltage is out of limits
17	A		CTL BC2 ● VOLTS	V76V0221A	Control bus BC2 voltage is out of limits
18	A		CTL BC3 ● VOLTS	V76V0222A	Control bus BC3 voltage is out of limits
19	G	R	AC 1 BUS ● SENSR OFF	V76S1504E	AC bus monitor switch for AC1 is off
20	G	R	AC 2 BUS ● SENSR OFF	V76S1604E	AC bus monitor switch for AC2 is off
21	G	R	AC 3 BUS ● SENSR OFF	V76S1704E	AC bus monitor switch for AC3 is off
22	A		CTL CA1 ● VOLTS	V76V0320A	Control Bus CA1 voltage is out of limits
23	A		CTL CA2 ● VOLTS	V76V0321A	Control Bus CA2 voltage is out of limits
24	A		CTL CA3 ● VOLTS	V76V0322A	Control Bus CA3 voltage is out of limits
25	R	R	ENG PWR ● L AC 2	E41S0292E	Engine power switch L AC 2 is off
26	R	R	ENG PWR ● C AC 1	E41S0192E	Engine power switch C AC 1 is off
27	R	R	ENG PWR ● R AC 3	E41S0392E	Engine power switch R AC 3 is off
28	R		GPC 1 ● FAIL	V72X7011E	GPC 1 has self announced fail
29	R		GPC 2 ● FAIL	V72X7012E	GPC 2 has self announced fail
30	R		GPC 3 ● FAIL	V72X7013E	GPC 3 has self announced fail
31	R	R	● L AC 3	E41S0293E	Engine power switch L AC 3 is off
32	R	R	● C AC 2	E41S0193E	Engine power switch C AC 2 is off
33	R	R	● R AC 1	E41S0393E	Engine power switch R AC 1 is off
34	R		GPC 4 ● FAIL	V72X7014E	GPC 4 has self announced fail
35	R		GPC 5 ● FAIL	V72X7015E	GPC 5 has self announced fail
36	R		RS ● HOLD	V90X8667X	Redundant set hold flag is set

TITLE

ME CONSOLE LIMIT SENSING/INITIALIZATION

PURPOSE

This SCP presents the five operational limit sets which are used for parameter limit sensing on the main engine console.

DESCRIPTION

The mission operations computer (MOC) has the capability to store five limit sets. Each limit set is used to limit sense a parameter for a high or low limit exceedance, which will cause an up or down arrow to appear adjacent to the parameter on MSK 1052, and will light an event light for a parameter on an event panel. Each limit set corresponds to the specific mission phase: prelaunch, launch, SRB sep, ET sep, and abort throttles.

The first four sets of limits are individually selected at the appropriate time in the mission by the MPS console operator via the SMEK pushbutton panel. (The SMEK inputs are described in SCP 6.1.2.) The abort throttle set of limits is selected by the ME console operator when max throttles are selected by the crew.

Limit sets currently active are displayed on MSK 1071 through 1076. All Booster limits are displayed on MSK 2105-2107.

PROCEDURES

Premission, a predefined value for each limit is initially loaded into the MOC. These values are described in the console data pack. Changes to these limit values can be made prelaunch or post ET separation by using the megadata terminal, if required.

Set 1 is the prelaunch limits which are active from propellant loading until SRB ignition. Since the SSME's are being prepared for firing during this phase, most of the limits are designed to indicate off-nominal conditions during engine purges and to indicate when engine ready parameters are within limits for engine ignition. Set 2 is the launch limits which are selected at SRB ignition. The limits in this phase are configured to detect engine problems before an engine redline is exceeded. Set 3 is the SRB separation limits which are selected at SRB separation. Set 4 is the ET separation and post-MECO limits which are selected at ET separation. These limits are designed to keep all main engine event lights extinguished post-MECO since main engine operation is now complete. Set 5 is labeled ABORT THROTTLE and is a set of limits for SSME operation at the abort throttle level for a specific mission. If a situation occurs during ascent where abort throttle level is required, this set of limits will be activated.

Each set of limits must be loaded while the appropriate limit phase is activated on the SMEK panel. This should be accomplished prelaunch since the megadata terminal is locked out during ascent. The SMEK panel can also be used to disable limits for an individual engine if that engine shuts down before MECO. Limits can also be reenabled, if required. This disabling and reenabling feature is accomplished by assigning each parameter a category. Category 34 includes those parameters associated with the left SSME, category 35 includes those parameters associated with the center SSME, category 36 is associated with the right SSME parameters, and category 37 includes all booster parameters.

The measurement number and name for each limit sensed main engine parameter as well as the low and high limit value sets for each mission phase are listed in table 5.1.4-I. The rationale for the various values are provided in the table notes.

These values may be different than the permanent values described in the data pack and may change from time to time since engine operating characteristics change as hardware and software changes are made. For this reason all new limits should be entered in the Mission Operations Computer before each simulation or flight. Since the engine model in the simulator is different in some ways than the real flight engines, only the floppy diskette labeled SIM should be used for simulations. The limits on this diskette are listed in table 5.1.4-II (STS 34 SIM-load limits are shown as an example). The actual flight limits are recorded on the diskette labeled FLIGHT. The limits on this diskette are listed in table 5.1.4-I. Care should be taken to ensure that the correct flight number is in the upper left hand corner of each menu on the SIM and FLIGHT diskettes.

REFERENCE

1. Computer Program Contract End Item, Flight 4 Configuration, SSME Controller Operational Program, Part I, Rev E, CPC 406R001.

2. LCC Requirements for STS-28 and subs.

TABLE 5.1.4-I.- FLIGHT LIMITS FOR CENTER (LEFT, RIGHT) SSME @ 104% RPL

PAGE 1 OF 4

MSID C: # = 1 L: # = 2 R: # = 3	PARAMETER	1 PRELAUNCH		2 LAUNCH		3 SRB SEP		4 ET SEP		5 ABORT		UNITS	SENSOR RANGE ㉑	
		L	H	L	H	L	H	L	H	L	H		L	H
E41P#008B	C(L,R) HPFP CL LNR PA	① -30	① 50	㉗ 1900	⑦ 3575	㉗ 1900	⑦ 3575	⑯ -200	⑯ 200	㉗ 1900	⑦ 3750	PSIA	0	4500
E41P#009B	C(L,R) HPFP CL LNR PB	① -30	① 50	㉗ 1900	⑦ 3575	㉗ 1900	⑦ 3575	⑯ -200	⑯ 200	㉗ 1900	⑦ 3750	PSIA	0	4500
M16G3702C (M17G3702C) (M18G3702C)	C(L,R) HPFP CL LNR P DELTA	㉓ -40	㉓ 40	㉙ -50	㉙ 50	㉙ -50	㉙ 50	⑬ -40	⑬ 40	㉙ -50	㉙ 50	PSIA	----	----
E41P#051B	C(L,R) HPOP SEC SL PA	① 4	① 20	② 4	⑨ 88	② 4	⑨ 88	⑬ 4	⑬ 20	② 4	⑨ 88	PSIA	0	300
E41P#053B	C(L,R) HPOP SEC SL PB	① 4	① 20	② 4	⑨ 88	② 4	⑨ 88	⑬ 4	⑬ 20	② 4	⑨ 88	PSIA	0	300
M10G3702C (M11G3702C) (M12G3702C)	C(L,R) HPOP SEC SL P DELTA	㉓ -8	㉓ 8	㉘ -8	㉘ 8	㉘ -8	㉘ 8	⑬ -8	⑬ 8	㉘ -8	㉘ 8	PSIA	----	----
E41P#014B	C(L,R) HPOP IMSL PA	① 175	① 650	⑩ 194	② 650	⑩ 194	② 650	② 0	② 650	⑩ 194	② 650	PSIA	0	600
E41P#015B	C(L,R) HPOP IMSL PB	① 175	① 650	⑩ 194	② 650	⑩ 194	② 650	② 0	② 650	⑩ 194	② 650	PSIA	0	600
M07G3702C (M08G3702C) (M09G3702C)	C(L,R) HPOP IMSL P DELTA	⑧ -24	⑧ 24	㉙ -5	㉙ 5	㉙ -5	㉙ 5	⑧ -24	⑧ 24	㉙ -5	㉙ 5	PSIA	----	----

TABLE 5.1.4-I.- Continued

MSID C: # = 1 L: # = 2 R: # = 3	PARAMETER	1 PRELAUNCH		2 LAUNCH		3 SRB SEP		4 ET SEP		5 ABORT		UNITS	SENSOR RANGE ㉑	
		L	H	L	H	L	H	L	H	L	H		L	H
E41T#012B	C(L,R) HPOT TD TA	① 420	① 600	㉚ 1000	③ 1560	㉚ 1000	③ 1560	⑬ 420	⑬ 650	㉚ 1000	③ 1660	°R	460	2760
E41T#013B	C(L,R) HPOT TD TB	① 420	① 600	㉚ 1000	③ 1560	㉚ 1000	③ 1560	⑬ 420	⑬ 650	㉚ 1000	③ 1660	°R	460	2760
M04G3702C (M05G3702C) (M06G3702C)	C(L,R) HPOT TD T DELTA	㉓ -90	㉓ 90	⑪ -100	⑪ 100	⑪ -100	⑪ 100	㉓ -90	㉓ 90	⑪ -100	⑪ 100	°R	----	----
E41T#010B	C(L,R) HPFT TD TB	① 420	① 600	⑳ 1400	⑫ 1775	⑳ 1400	⑫ 1775	⑬ 420	⑬ 650	⑳ 1400	⑫ 1775	°R	460	2760
E41T#011B	C(L,R) HPFT TD TB	① 420	① 600	⑳ 1400	⑫ 1885	⑳ 1400	⑫ 1885	⑬ 420	⑬ 650	⑳ 1400	⑫ 1885	°R	460	2760
M01G3702C (M02G3702C) (M03G3702C)	C(L,R) HPFT TD T DELTA	㉓ -90	㉓ 90	⑭ -160	⑭ 160	⑭ -160	⑭ 160	㉓ -90	㉓ 90	⑭ -160	⑭ 160	°R	----	----
E41P#016B	C(L,R) Pc A AVG	① 0	① 37	㉛ 1924	⑮ 3151	㉛ 1924	⑮ 3151	⑬ 0	⑬ 37	㉛ 1924	⑮ 3301	PSIA	0	3500
E41P#017B	C(L,R) Pc B AVG	① 0	① 37	㉛ 1924	⑮ 3151	㉛ 1924	⑮ 3151	⑬ 0	⑬ 37	㉛ 1924	⑮ 3301	PSIA	0	3500
M13G3702C (M14G3702C) (M15G3702C)	C(L,R) Pc DELTA	㉓ -18	㉓ 18	⑮ -25	⑮ 25	⑮ -25	⑮ 25	⑬ -18	⑬ 18	⑮ -25	⑮ 25	PSIA	----	----
E41P#023B	C(L,R) Pc AVG	㉔ 0	㉔ 37	㉛ 1924	⑮ 3151	㉛ 1924	⑮ 3151	⑬ 0	⑬ 37	㉛ 1924	⑮ 3301	PSIA	----	----
M1G3701C (M02G3701C) (M03G3701C)	C(L,R) PWR LVL-CMD	㉒ -110	㉒ 110	⑤ -2	⑤ 2	⑤ -2	⑤ 2	⑯ -110	⑯ 110	⑤ -2	⑤ 2	%	----	----

TABLE 5.1.4-I.- Continued

PAGE 3 OF 4

MSID C: # = 1 L: # = 2 R: # = 3	PARAMETER	1 PRELAUNCH		2 LAUNCH		3 SRB SEP		4 ET SEP		5 ABORT		UNITS	SENSOR RANGE ㉑	
		L	H	L	H	L	H	L	H	L	H		L	H
E41T#020B	C(L,R) PBP DISCH TA	⑱ 160	㉕ 186.5	⑱ 160	⑱ 210	⑱ 160	⑱ 210	⑱ 160	⑱ 210	⑱ 160	⑱ 210	°R	160	210
E41T#022B	C(L,R) OXIDIZER FLOWRATE	⑯ -100	⑯ 6000	④ 3700	④ 6000	④ 3700	④ 6000	⑬ -100	⑬ 6000	④ 3700	④ 6288	GPM	0	7000
M01G3101C (M02G3101C) (M03G3101C)	C(L,R)OXIDIZER FLOWRATE (COMP)	⑯ -10	⑯ 2000	④ 500	④ 940	④ 500	④ 940	㉝ -10	㉝ 2000	④ 500	④ 985	LB/SEC	----	----
E41P#018B	C(L,R) LPFP DISCH P	① 47	① 61	② 140	② 300	② 140	② 300	⑬ 47	⑬ 61	② 140	② 300	PSIA	0	300
E41T#019B	C(L,R) LPFP DISCH T	① 37	① 42	㉜ 42	② 45	㉜ 42	② 45	㉝ 35	② 45	㉜ 42	② 45	°R	30	55
E41T#021B	C(L,R) FUEL FLOWRATE	㉖ 0	㉖ 1800	④ 9000	④ 16400	④ 9000	④ 16400	⑬ 0	⑬ 180	④ 9000	④ 17188	GPM	0	18000
M01G3103C (M02G3103C) (M03G3103C)	C(L,R) FUEL FLOWRATE (COMP)	㉞ 0	㉞ 17	㉞ 84	㉞ 155	㉞ 84	㉞ 155	㉞ 0	㉞ 17	㉞ 84	㉞ 163	LB/SEC	----	----

TABLE 5.1.4-I.- Concluded

PAGE 4 OF 4

MSID C: # = 1 L: # = 2 R: # = 3	PARAMETER	1 PRELAUNCH		2 LAUNCH		3 SRB SEP		4 ET SEP		5 ABORT		UNITS	SENSOR RANGE ㉑	
		L	H	L	H	L	H	L	H	L	H		L	H
M02G3107C (M03G3107C) (M04G3107C)	C(L,R) OVRBD MIXTURE RATIO	16 -10	16 10	6 5.9	4 6.2	6 5.9	4 6.2	13 -10	13 10	6 5.9	4 6.2	MRU	----	----
E41P#054B	C(L,R) SSME HYDRAULIC P	1 2850	1 3400	4 2850	4 3400	4 2850	4 3400	4 2850	4 3400	4 2850	4 3400	PSIA	0	4000
V98P2100C (V98P2110C) (V98P2120C)	C(L,R)BFS Pc AVG	16 0	16 100	17 64	17 105	17 64	17 105	13 0	13 100	17 64	17 110	%	----	----
E41P#030B	C(L,R) HPOT DISCH P	16 5	16 130	31 2243	19 4150	31 2243	19 4150	13 5	13 130	31 2243	19 4375	PSIA	0	7000

Table Notes for Limit Sets
(Flight at 104%)

#	Remarks
1.	Per launch commit criteria
2.	Per SSME controller reasonableness test for transducer.
3.	Limit set to indicate possible turbine temperature problems. If engine was to be throttled to 109%, LOX turbine temps should increase about 100°R when throttled from 104% to 109%. Therefore, limit at 109% is set 100° below redline and the limit at 104% is set 200° below redline.
4.	These limits bracket the engine operating range.
5.	Limit set to detect a 2% dispersion of Pc real from Pc Ref.
6.	Limit set to detect a low mixture ratio case prior to reaching point which is classified as severe performance impact.
7.	Redline minus 100 PSIA -- for advance indication of failure.
8.	Delta represents 4% of sensor full scale output range.
9.	Redline minus 4% of sensor full scale output range.
10.	Redline plus 4% of sensor full scale output range.
11.	Allows for a maximum shift of 100°R for a hot gas sensor.
12.	Limit set to indicate possible low LH_2 NPSP problems. Therefore, limits are set at the redlines minus 75°R (1775°R, 1885°R).
13.	Same as prelaunch value.
14.	Allows for 50°R sensor drift plus 110°R delta between channel A and B owing to the differing positions of the transducers on the hot gas manifold.
15.	Set for a level 1 Pc shift equating to a difference of 30 PSIA from commanded level.
16.	Keeps event light off for mission phase when no call required. Parameter value doesn't apply.
17.	Reflects power level computational accuracy of 1%.
18.	Reflects sensor full scale output range.

19. Limit is based on predicted value at that power level (104/109) plus 100 psia.

20. Limit set to catch a drifting sensor. Actual controller limit is set to 100°R below the start/mainstage 32 point average.

21. Reference CP406R001, table V.

22. Set to keep lights off.

23. Delta represents ± 1/2 of range set on individual channels.

24. Average set to same value as individual channels.

25. Engine ready value.

26. Average set to same value as individual channels, which are not displayed/available. Limits based on LCC.

27. Lower qualification limit + 100 psia for advance indication of failure.

28. Delta represents ± 1/2 of range set by qualification limits of individual channels.

29. Delta represents reasonable range of dispersion between channels.

30. Redline plus 280° -- for advance indication of failure.

31. Limit represents 64% power level -- below stable engine operating range.

32. Limit set to detect a sensor shift low.

33. Limit based on engine off lower qualification limit prelaunch.

34. Fuel flow rate in lb/sec is derived by converting the gpm value into lb/sec using the following equation:

$$\frac{(X\ gal/min)(4.33\ lb/ft^3)}{(60\ sec/min)(7.48\ gal/ft^3)} = X_{lb/sec}$$

Where 4.33 lb/ft^3 is the fuel density used when the controller puts the engine in fixed density.

TABLE 5.1.4-II.- SIM LIMITS FOR CENTER (LEFT, RIGHT) SSME @ 104% RPL

PAGE 1 OF 3

MSID C: # = 1 L: # = 2 R: # = 3	PARAMETER	1 PRELAUNCH		2 LAUNCH		3 SRB SEP		4 ET SEP		5 ABORT		UNITS
		L	H	L	H	L	H	L	H	L	H	
E41P#008B	C(L,R) HPFP CL LNR PA	-30	50	1900	3575	1900	3575	-200	200	1900	3750	PSIA
E41P#009B	C(L,R) HPFP CL LNR PB	-30	50	1900	3575	1900	3575	-200	200	1900	3750	PSIA
M16G3702C (M17G3702C) (M18G3702C)	C(L,R) HPFP CL LNR P DELTA	-40	40	-50	50	-50	50	-40	40	-50	50	PSIA
E41P#051B	C(L,R) HPOP SEC SL PA	4	20	4	88	4	88	4	20	4	88	PSIA
E41P#053B	C(L,R) HPOP SEC SL PB	4	20	4	88	4	88	4	20	4	88	PSIA
M10G3702C (M11G3702C) (M12G3702C)	C(L,R) HPOP SEC SL P DELTA	-8	8	-8	8	-8	8	-8	8	-8	8	PSIA
E41P#015B	C(L,R) HPOP IMSL PA	175	650	194	650	194	650	0	650	194	650	PSIA
E41P#014B	C(L,R) HPOP IMSL PB	175	650	194	650	194	650	0	650	194	650	PSIA
M07G3702C (M08G3702C) (M09G3702C)	C(L,R) HPOP IMSL P DELTA	-24	24	-5	5	-5	5	-24	24	-5	5	PSIA

TABLE 5.1.4-II.- Continued

PAGE 2 OF 3

MSID C: # = 1 L: # = 2 R: # = 3	PARAMETER	1 PRELAUNCH		2 LAUNCH		3 SRB SEP		4 ET SEP		5 ABORT		UNITS
		L	H	L	H	L	H	L	H	L	H	
E41T#012B	C(L,R) HPOT TD TA	420	600	1000	1560	1000	1560	420	650	1000	1660	°R
E41T#013B	C(L,R) HPOT TD TB	420	600	1000	1560	1000	1560	420	650	1000	1660	°R
M04G3702C (M05G3702C) (M06G3702C)	C(L,R) HPOT TD T DELTA	-90	90	-100	100	-100	100	-90	90	-100	100	°R
E41T#010B	C(L,R) HPFT TD TB	420	600	1400	1775	1400	1775	420	650	1400	1775	°R
E41T#011B	C(L,R) HPFT TD TB	420	600	1400	1885	1400	1885	420	650	1400	1885	°R
M01G3702C (M02G3702C) (M03G3702C)	C(L,R) HPFT TD T DELTA	-90	90	-160	160	-160	160	-90	90	-160	160	°R
E41P#016B	C(L,R) Pc A AVG	0	37	1924	3151	1924	3151	0	37	1924	3301	PSIA
E41P#017B	C(L,R) Pc B AVG	0	37	1924	3151	1924	3151	0	37	1924	3301	PSIA
M13G3702C (M14G3702C) (M15G3702C)	C(L,R) Pc DELTA	-18	18	-25	25	-25	25	-18	18	-25	25	PSIA
E41P#023B	C(L,R) Pc AVG	0	37	1924	3151	1924	3151	0	37	1924	3301	PSIA
M1G3701C (M02G3701C) (M03G3701C)	C(L,R) PWR LVL-CMD	-110	110	-2	2	-2	2	-110	110	-2	2	%

TABLE 5.1.4-II. - SIM LIMITS FOR CENTER (LEFT, RIGHT) SSME @ 104% RPL

PAGE 1 OF 4

MSID C: # = 1 L: # = 2 R: # = 3	PARAMETER	1 PRELAUNCH		2 LAUNCH		3 SRB SEP		4 ET SEP		5 ABORT		UNITS
		L	H	L	H	L	H	L	H	L	H	
E41P#008B	C(L,R) HPFP CL LNR PA	-30	50	1900	3575	1900	3575	-200	200	1900	3575	PSIA
E41P#009B	C(L,R) HPFP CL LNR PB	-30	50	1900	3575	1900	3575	-200	200	1900	3575	PSIA
M16G3702C (M17G3702C) (M18G3702C)	C(L,R) HPFP CL LNR P DELTA	-40	40	-50	50	-50	50	-40	40	-50	50	PSIA
E41P#051B	C(L,R) HPOP SEC SL PA	4	20	4	88	4	88	4	20	4	88	PSIA
E41P#053B	C(L,R) HPOP SEC SL PB	4	20	4	88	4	88	4	20	4	88	PSIA
M10G3702C (M11G3702C) (M12G3702C)	C(L,R) HPOP SEC SL P DELTA	-8	8	-8	8	-8	8	-8	8	-8	8	PSIA
E41P#014B	C(L,R) HPOP IMSL PA	175	650	194	650	194	650	0	650	194	650	PSIA
E41P#015B	C(L,R) HPOP IMSL PB	175	650	194	650	194	650	0	650	194	650	PSIA
M07G3702C (M08G3702C) (M09G3702C)	C(L,R) HPOP IMSL P DELTA	-24	24	-5	5	-5	5	-24	24	-5	5	PSIA

TABLE 5.1.4-II. - SIM LIMITS FOR CENTER (LEFT, RIGHT) SSME @ 104% RPL

PAGE 2 OF 4

MSID C: # = 1 L: # = 2 R: # = 3	PARAMETER	1 PRELAUNCH		2 LAUNCH		3 SRB SEP		4 ET SEP		5 ABORT		UNITS
		L	H	L	H	L	H	L	H	L	H	
E41T#012B	C(L,R) HPOT TD TA	420	600	1000	1560	1000	1560	420	600	1000	1660	°R
E41T#013B	C(L,R) HPOT TD TB	420	600	1000	1560	1000	1560	420	600	1000	1660	°R
M04G3702C (M05G3702C) (M06G3702C)	C(L,R) HPOT TD T DELTA	-90	90	-100	100	-100	100	-90	90	-100	100	°R
E41T#0100	C(L,R) HPFT TD TA	420	600	1400	1775	1400	1775	420	600	1400	1775	°R
E41T#011B	C(L,R) HPFT TD TB	420	600	1400	1885	1400	1885	420	600	1400	1885	°R
M01G3702C (M02G3702C) (M03G3702C)	C(L,R) HPFT TD T DELTA	-90	90	-160	160	-160	160	-90	90	-160	160	°R
E41P#016B	C(L,R) Pc A AVG	0	37	1924	3151	1924	3151	0	37	1924	3301	PSIA
E41P#017B	C(L,R) Pc B AVG	0	37	1924	3151	1924	3151	0	37	1924	3301	PSIA
M13G3702C (M14G3702C) (M15G3702C)	C(L,R) Pc DELTA	-18	18	-50	50	-50	50	-18	18	-50	50	PSIA
E41P#023B	C(L,R) Pc AVG	0	37	1924	3151	1924	3151	0	37	1924	3301	PSIA
M01G3701C (M02G3701C) (M03G3701C)	C(L,R) PWR LVL-CMD	-110	110	-2	2	-2	2	-110	110	-2	2	%

TABLE 5.1.4-II. - SIM LIMITS FOR CENTER (LEFT, RIGHT) SSME @ 104% RPL

PAGE 3 OF 4

MSID C: # = 1 L: # = 2 R: # = 3	PARAMETER	1 PRELAUNCH		2 LAUNCH		3 SRB SEP		4 ET SEP		5 ABORT		UNITS
		L	H	L	H	L	H	L	H	L	H	
E41T#020B	C(L,R) PBP DISCH TA	160	186.5	160	210	160	210	160	210	160	210	°R
E41R#022B	C(L,R) OXIDIZER FLOWRATE	-100	6000	3700	6000	3700	6000	-100	6000	3700	6288	GPM
M01G3101C	C(L,R) OXIDIZER FLOWRATE (COMP)	-10	2000	500	940	500	940	-10	2000	500	985	LB/SEC
E41P#018B	C(L,R) LPFP DISCH P	47	61	140	300	140	300	47	61	140	300	PSIA
E41T#019B	C(L,R) LPFP DISCH T	37	42	42	45	42	45	35	45	42	45	°R
E41R#021B	C(L,R) FUEL FLOWRATE	0	1800	9000	16500	9000	16500	0	1800	9000	17300	GPM
M01G3103C (M02G3103C) (M03G3103C)	C(L,R) FUEL FLOWRATE (COMP)	0	17	84	159	84	159	0	17	84	167	LB/SEC
M02G3107C (M03G3107C) (M04G3107C)	C(L,R) OVRBD MIXTURE RATIO	-10	10	5.9	6.2	5.9	6.2	-10	10	5.9	6.2	MRU
E41P#054B	C(L,R) SSME HYDRAULIC P	2850	3400	2850	3400	2850	3400	2850	3400	2850	3400	PSIA
V98P2100C (V98P2110C) (V98P2120C)	C(L,R) BFS Pc AVG	0	100	64	105	64	105	0	100	64	110	%

TABLE 5.1.4-II. - SIM LIMITS FOR CENTER (LEFT, RIGHT) SSME @ 104% RPL

PAGE 4 OF 4

MSID C: # = 1 L: # = 2 R: # = 3	PARAMETER	1 PRELAUNCH		2 LAUNCH		3 SRB SEP		4 ET SEP		5 ABORT		UNITS
		L	H	L	H	L	H	L	H	L	H	
E41P1030B	C HPOT DISCH P	5	130	2326	4125	2326	4125	5	130	2326	4348	PSIA
E41P2030B	L HPOT DISCH P	5	130	2368	4167	2368	4167	5	130	2368	4390	PSIA
E41P3030B	R HPOT DISCH P	5	130	2260	4059	2260	4059	5	130	2260	4282	PSIA
E41H1027B	C FPOV PSN	0	100	0	100	0	100	0	100	0	100	%
E41H1028B	C OPOV PSN	0	100	0	100	0	100	0	100	0	100	%
E41H2027B	L FPOV PSN	0	100	0	100	0	100	0	100	0	100	%
E41H2028B	L OPOV PSN	0	100	0	100	0	100	0	100	0	100	%
E41H3027B	R FPOV PSN	0	100	0	100	0	100	0	100	0	100	%
E41H3028B	R OPOV PSN	0	100	0	100	0	100	0	100	0	100	%

TITLE

MAIN ENGINE NRT FORMATS

PURPOSE

This SCP provides a table for locating the format numbers of all main engine (ME) parameters included in near real-time (NRT) data recording.

DESCRIPTION

A listing of ME NRT formats including the NRT format title, microfiche number, and format number is provided in table 5.1.5-I.

A listing of all ME NRT parameters (including MML/COMP number, parameter name, format number(s), and microfiche number) are provided in table 5.1.5-II. Parameters are listed with the MML/COMP number in alphanumeric order. Several format numbers, including plots, are located on more than one microfiche.

NRT log on procedures, including initialization, are found in SCP 6.11.

PROCEDURES

To determine the NRT format number and/or microfiche number for any ME parameter on NRT, locate the parameter in table 5.1.5-II by using the MML/COMP number.

NRT data on fiche at a sample rate of one sample per minute is automatically sent to the console and therefore does not have to be requested. NRT at sample rates up to once per second must be requested using an MDRF.

Nominally, the ME/Booster Flight Controller requests NRT at once per second for the ascent phase. NRT may be requested by using the procedure in SOP 4.8 and the MDRF provided in 10.1 of the Flight Control Operations Handbook (FCOH).

In contingency situations, where fast turnaround is required, the flight controller may contact DI on the DATA loop and voice request a NRT product. Immediate MDRF followup is then required. The MDRF must then specify why the request is critical. Under time criticality, use the phrase "Systems Priority" to identify a request for data when a known or suspected system failure condition exists. The DI will process "Systems Priority" MDRF's before "ASAP" and routine requests. MDRF's identified as "Systems Priority" or "ASAP" can delay other NRT processing - use these options only when necessary.

Super THRIFT is described in SCP 5.1.6, and is required for sample rates higher than once per second.

REFERENCES

1. Statements of Requirements No. GSR 346, "THRIFT Format Requirements for the Main Propulsion System (MPS) Parameters," Revision 5, March 10, 1980.

2. Flight Control Operations Handbook, JSC-12805, Vol. I, Final, Rev-B, January 16, 1987.

3. JSC Memo CF83-21

4. Booster Data Pack, as of Sept. 1, 1989.

TABLE 5.1.5-I.- ME NRT FORMATS

Title	Format no.
LEFT MAIN ENGINE LIMIT MONITORING	1051
LEFT MAIN ENGINE PERFORMANCE CONTROL	1052
LEFT MAIN ENGINE CCV, ESW, TREF, IDWD, T OF SD	1053
L HPFP CL LN/SEC SL PRESSURES VS. TIME	1054*
L HPOT/HPFT TURBINE DISCHARGE TEMP VS. TIME	1055*
L HPOT ISP PRESSURE VS. TIME	1056*
L Pc PSIA VS. TIME	1057*
L POWER LEVEL PERCENT VS. TIME	1058*
L OXIDIZER/FUEL FLOW RATE LBS/SEC VS. TIME	1059*
L ACTUATOR RVDT POSITION PERCENT VS. TIME	1060*
L ACTUATOR RVDT POSITION PERCENT (CCV) VS. TIME	1061*
CENTER MAIN ENGINE LIMIT MONITORING	1062
CENTER MAIN ENGINE PERFORMANCE CONTROL	1063
CENTER MAIN ENGINE CCV, ESW, TREF, IDWD, T OF SD	1064
C HPFP CL LN/SEC SL PRESSURE VS. TIME	1065*
C HPOT/HPFT TURBINE DISCHARGE TEMP VS. TIME	1066*
C HPOT ISP PRESSURE VS. TIME	1067*
C Pc PSIA VS. TIME	1068*
C POWER LEVEL PERCENT VS. TIME	1069*
C OXIDIZER/FUEL FLOW RATE LBS/SEC VS. TIME	1070*
C ACTUATOR RVDT POSITION PERCENT VS. TIME	1071*
C ACTUATOR RVDT POSITION PERCENT (CCV) VS. TIME	1072*
BFS - ESW, Pc, HELIUM TANK PRESSURES	1073
RIGHT MAIN ENGINE LIMIT MONITORING	1074
RIGHT MAIN ENGINE PERFORMANCE	1075
RIGHT MAIN ENGINE CCV, ESW, TREF, IDWD, T OF SD	1076
R HPFP CL LN/SEC SL PRESSURE VS. TIME	1077*
R HPOT/HPFT TURBINE DISCHARGE TEMP VS. TIME	1078*
R HPOT ISP PRESSURE VS. TIME	1079*
R Pc PSIA VS. TIME	1080*
R POWER LEVEL PERCENT VS. TIME	1081*
R OXIDIZER/FUEL FLOW RATE LBS/SEC VS. TIME	1082*
R ACTUATOR RVDT POSITION PERCENT VS. TIME	1083*
R ACTUATOR RVDT POSITION PERCENT (CCV) VS. TIME	1084*
MPS HELIUM (IMD SL PGE P)	1086
ET PRESSURANT	1091
GH2 OUT P	1096*
MPS CONSUMABLES (OX, FU FLOW RT)	1099
MPS CONSUMABLES (ALTITUDE)	1101
MPS PRESSURES AND TEMPERATURES	1110
MPS EVENTS	1111

*-Plots.

TABLE 5.1.5-I.- Concluded

Title	Format no.
DUMMY PLOTS	1114*
C HPOT SEAL PRESSURES	1120*
L HPOT SEAL PRESSURES	1121*
R HPOT SEAL PRESSURES	1122*
ORBITER HYDRAULIC PRESSURES	1123*
BFS T OF SD, GH2 OUT P	1124
C, L, R MAIN ENGINE P_C, PSIA VS. TIME	1125*
C, L, R LPFT DISCH TEMP, DEG R VS. TIME	1126*
C/L FUEL, OXID FLOW RATES, GPM VS. TIME	1127*
R FUEL, OXID FLOW RATES, GPM VS. TIME	1128*

*-Plots.

Note: All formats are found on NRT microfiche labeled no. 1, except format no. 1128 which is found on NRT microfiche no. 2.

TABLE 5.1.5-II.- ME NRT PARAMETERS

MML/COMP no.	NRT parameter name	NRT format nos.
E41H1024B	C MFV POS	1063, 1071*
E41H1025B	C MOV POS	1063, 1071*
E41H1026B	C CCV POS	1064, 1072*
E41H1027B	C FPOV POS	1063, 1071*
E41H1028B	C OPOV POS	1063, 1071*
E41H2024B	L MFV POS	1052, 1060*
E41H2025B	L MOV POS	1052, 1060*
E41H2026B	L CCV POS	1053, 1061*
E41H2027B	L FPOV POS	1052, 1060*
E41H2028B	L OPOV POS	1052, 1060*
E41H3024B	R MFV POS	1075, 1083*
E41H3025B	R MOV POS	1075, 1083*
E41H3026B	R CCV POS	1076, 1084*, 1114*
E41H3027B	R FPOV POS	1075, 1083*
E41H3028B	R OPOV POS	1075, 1083*
E41M1002P	C ID WD2	1064
E41M1003P	C ESW	1064
E41M2002P	L ID WD2	1053
E41M2003P	L ESW	1053
E41M3002P	R ID WD2	1076
E41M3003P	R ESW	1076
E41P1008B	C HPFP CL LN PA	1062, 1065*, 1120*
E41P1009B	C HPFP CL LN PB	1062, 1065*, 1120*
E41P1014B	C HPOT IMD SL PGE PA	1062, 1067*, 1086
E41P1015B	C HPOT IMD SL PGE PB	1062, 1067*, 1086
E41P1016B	C PC A	1062, 1068*
E41P1017B	C PC B	1062, 1068*
E41P1018B	C LPFT DISCH P	1063
E41P1023B	C PC	1063, 1068*, 1125*
E41P1051B	C HPOT SEC SL PA	1062, 1065*, 1067*, 1120*
E41P1053B	C HPOT SEC SL PB	1062, 1065*, 1067*, 1120*
E41P2008B	L HPFP CL LN PA	1051, 1054*, 1121*
E41P2009B	L HPFP CL LN PB	1051, 1054*, 1121*
E41P2014B	L HPOT IMD SL PGE PA	1051, 1056*, 1086
E41P2015B	L HPOT IMD SL PGE PB	1051, 1056*, 1086
E41P2016B	L PC A	1051, 1057*
E41P2017B	L PC B	1051, 1057*
E41P2018B	L LPFT DISCH P	1052
E41P2023B	L PC	1052, 1057*, 1125*
E41P2051B	L HPOT SEC SL PA	1051, 1054*, 1056*, 1121*
E41P2053B	L HPOT SEC SL PB	1051, 1054*, 1056*, 1121*

*-Plot.

TABLE 5.1.5-II.- Continued

MML/COMP no.	NRT parameter name	NRT format nos.
E41P3008B	R HPFP CL LN PA	1074, 1077*, 1122*
E41P3009B	R HPFP CL LN PB	1074, 1077*, 1122*
E41P3014B	R HPOT IMD SL PGE PA	1074, 1079*, 1086
E41P3015B	R HPOT IMD SL PGE PB	1074, 1079*, 1086
E41P3016B	R PC A	1074, 1080*
E41P3017B	R PC B	1074, 1080*
E41P3018B	R LPFT DISCH P	1075
E41P3023B	R PC	1075, 1080*, 1125*
E41P3051B	R HPOT SEC SL PA	1074, 1077*, 1079*, 1122*
E41P3053B	R HPOT SEC SL PB	1074, 1077*, 1079*, 1122*
E41R1021B	C FU FLOWRT	1063, 1127*
E41R1022B	C OX FLOWRT	1063, 1127*
E41R2021B	L FU FLOWRT	1052, 1127*
E41R2022B	L OX FLOWRT	1052, 1127*
E41R3021B	R FU FLOWRT	1075, 1128*
E41R3022B	R OX FLOWRT	1075, 1128*
E41T1010B	C HPC HPFT TURB	1062, 1066*
E41T1011B	C HPFT TURB DISCH TB	1062, 1066*
E41T1012B	C HPOT TURB DISCH TA	1062, 1066*
E41T1013B	C HPOT TURB DISCH TB	1062, 1066*
E41T1019B	C LPFT DISCH T	1063, 1126*
E41T1020B	C POP DISCH T	1063
E41T1150A	C CONTROLLER T	1072*
E41T2010B	L HPFT TURB DISCH TA	1051, 1055*
E41T2011B	L HPFT TURB DISCH TB	1051, 1055*
E41T2012B	L HPOT TURB DISCH TA	1051, 1055*
E41T2013B	L HPOT TURB DISCH TB	1051, 1055*
E41T2019B	L LPFT DISCH T	1052, 1126*
E41T2020B	L POP DISCH T	1052
E41T2150A	L CONTROLLER T	1061*
E41T3010B	R HPFT TURB DISCH TA	1074, 1078*
E41T3011B	R HPFT TURB DISCH TB	1074, 1078*
E41T3012B	R HPOT TURB DISCH TA	1074, 1078*
E41T3013B	R HPOT TURB DISCH TB	1074, 1078*
E41T3019B	R LPFT DISCH T	1075, 1126*
E41T3020B	R POP DISCH T	1075
E41T3150A	R CONTROLLER T	1084*

*-Plot.

TABLE 5.1.5-II.- Continued

MML/COMP no.	NRT parameter name	NRT format nos.
E41W1004B	T REF	1064
E41W2004B	T REF	1053
E41W3004B	T REF	1076
E41X1505B	(C) VDT A DATA	1111
E41X1511B	LIMIT CONTROL ENABLE	1111
E41X2505B	(L) VDT A DATA	1111
E41X3505B	(R) VDT A DATA	1111
M01G3101C	C OX FLOW RATE	1063, 1070*, 1099
M01G3102C	TOTAL OXIDIZER CONSUMED	1099
M01G3103C	C FUEL FLOW RATE	1063, 1070*, 1099
M01G3104C	TOTAL FUEL CONSUMED	1099
M01G3105C	OXIDIZER REMAINING	1099
M01G3106C	FUEL REMAINING	1099
M01G3107C	OVERALL MIXTURE RATIO	1099
M01G3108C	C POWER LEVEL (%)	1063, 1069*
M01G3112C	C ISP	1062
M01G3705T	C TIME OF SHUTDOWN	1064
M01G4300T	C BFS TIME OF SHDN	1124
M02G3101C	L OX FLOW RATE	1052, 1059*, 1099
M02G3103C	L FUEL FLOW RATE	1052, 1059*, 1099
M02G3107C	C MIXTURE RATIO	1063
M02G3108C	L POWER LEVEL (%)	1052, 1058*
M02G3112C	C N	1062
M02G3705T	L TIME OF SHUTDOWN	1053
M02G4300T	L BFS TIME OF SHDN	1124
M03G3101C	R OX FLOW RATE	1075, 1082*, 1099
M03G3103C	R FUEL FLOW RATE	1075, 1082*, 1099
M03G3107C	L MIXTURE RATIO	1052
M03G3108C	R POWER LEVEL	1075, 1081*
M03G3112C	L ISP	1051
M03G3705T	R TIME OF SHUTDOWN	1076
M03G4300T	R BFS TIME OF SHDN	1124
M04G3101C	TOTAL OXIDIZER FLOW RATE	1099
M04G3103C	TOTAL FUEL FLOW RATE	1099
M04G3107C	R MIXTURE RATIO	1075
M04G3112C	L N	1051
M05G3112C	R ISP	1074
M06G3112C	R N	1074

*-Plot.

TABLE 5.1.5-II.- Concluded

MML/COMP no.	NRT parameter name	NRT format nos.
M08G3112T	C TL TAG	1064
M10G3112T	L TL TAG	1053
M12G3112T	R TL TAG	1076
M40H0107J	OGMT	1053, 1064, 1076 ‡
V41P1160A	C GH2 OUT P	1091, 1096*, 1124*, 1063
V41P1260A	L GH2 OUT P	1091, 1096*, 1124*, 1052
V41P1360A	R GH2 OUT P	1091, 1096*, 1124*, 1075
V58P0116B	C HYD P	1123*
V58P0216B	L HYD P	1123*
V58P0316B	R HYD P	1123*
V75W3514D	MTU-MET	1053, 1064, 1073, 1076
V90U1948C	ME THRUST LEVEL CMD	1052, 1063, 1075
V90X8250X	ET SEP CMD FLAG	1110
V90X8259X	ET AUTO SEP-INHIBIT ALERT	1110
V90X8331X	SRB SEP CMD FLAG	1110
V90X8340X	SRB SEP INHIBIT	1110
V95H0175C	ALTITUDE	1101
V98M2200P	C ESW	1073
V98M2220P	L ESW	1073
V98M2240P	R ESW	1073
V98P1740C	L SRB PC	1073
V98P1741C	R SRB PC	1073
V98P2100C	C PC	1073
V98P2110C	L PC	1073
V98P2120C	R PC	1073
V98P2140C	L H2 ULL P1	1073
V98P2155C	C HE TK P	1073
V98P2156C	L HE TK P	1073
V98P2157C	R HE TK P	1073
V98X1268X	BFS BU C&W	1111

‡-On all formats, but on these three this parameter is repeated.
*-Plot.

TITLE

ME SUPER THRIFT

PURPOSE

This SCP describes the formats of ME super THRIFT.

DESCRIPTION

A listing of these formats including the title and format number is provided in table 5.1.6-I. A listing of the ME parameters included on super THRIFT is provided in table 5.1.6-II, with the MML numbers in alphanumeric order.

PROCEDURES

The format numbers and parameters included in tables 5.1.6-I and 5.1.6-II were provided by Engineering and Development (E&D). The formats and their contents should be verified prior to flight by checking with the Flight Data Office or E&D.

To request parameters grouped by SSME, identify the format number in table 5.1.6-I. To determine the format number for a specific SSME parameter, locate the parameter in table 5.1.6-II.

Nominally, the ME console operator requests super THRIFT at 25 samples per second during ascent phase from the Orbiter Data Reduction Complex (ODRC). The procedure is described in section 4.8.2 of the FCOH and requires the MDRF and the ODRC Data Processing Request forms to be filled out in triplicate. A same day turnaround is usual.

Parameters for which a super THRIFT format has not been defined may be required using the above forms and an ODRC extension form, if required. An additional day's turnaround will result.

All super THRIFT requests should be limited to 10 minutes and two formats.

REFERENCES

1. Flight Control Operations Handbook, January 16, 1987, JSC-12805.
2. JSC Memo CF83-21

TABLE 5.1.6-I.- ME SUPER THRIFT FORMATS

Title (a)		Format no. (b)
C,L,R	Pc*	SA016F
C	Pc and MR Parameter	TY001F
C	Redlines	TY002F
C	Fuel Density + Misc.	TY003F
L	Pc + MR Parameter	TY004F
L	Redlines	TY005F
L	Fuel Density + Misc.	TY006F
R	Pc + MR Parameter	TY007F
R	Redlines	TY008F
R	Fuel Density + Misc.	TY009F
C,L,R	AC + Htr PWR Commands	TY010F
C,L,R	TREF	TB019F
C	Parent Parameter*	TB026F
L	Parent Parameter*	TB027F
R	Parent Parameter*	TB028F
C,L,R	ESW Decode	TA017F

[a] Titles are descriptive and assigned by the ME for reference only. (*) Designates plots. SA016F is a continuous form plot.

[b] Subject to change.

TABLE 5.1.6-II.- ME SUPER THRIFT PARAMETERS

MML/COMP number	Parameter name	Super THRIFT format number (a)
E41H1024B	C MFV POS	TY003F
E41H1025B	C MOV POS	TY003F
E41H1026B	C CCV POS	TY003F
E41G1027B	C FPOV POS	TY001F
E41H1028B	C OPOV POS	TY001F
E41H2024B	L MFV POS	TY006F
E41H2025B	L MOV POS	TY006F
E41H2026B	L CCB POS	TY006F
E41H0027B	L FPOV POS	TY004F
E41H2028B	L OPOV POS	TY004F
E41H3024B	R MFV POS	TY009F
E41H3025B	R MOV POS	TY009F
E41H3026B	R CCV POS	TY009F
E41H3027B	R FPOV POS	TY007F
E41H3028B	R OPOV POS	TY007F
E41J1504B	C ESW B1-11	TB026F
E41J1505B	C ESW B13-16	TB026F
E41J1508B	C CMD STATUS	TB026F
E41J1509B	C CHAN STATUS	TB026F
E41J1512B	C ENG PHASE	TB026F
E41J1513B	C ENG MODE	TB026F
E41J1514B	C ENG SELF TEST STATUS	TB026F
E41J1515B	C HARD FAIL ID	TB026F
E41J1516B	C HARD FAIL DELIM	TB026F
E41J2504B	L ESW B1-11	TB027F
E41J2505B	L ESW B13-16	TB027F
E41J2508B	L CMD STATUS	TB027F
E41J2509B	L CHAN STATUS	TB027F
E41J2512B	L ENG PHASE	TB027F
E41J2513B	L ENG MODE	TB027F
E41J2514B	L ENG SELF TEST STATUS	TB027F
E41J2515B	L HARD FAIL ID	TB027F
E41J2516B	L HARD FAIL DELIM	TB027F
E41J3504B	R ESWB1-11	TB028F
E41J3505B	R ESW B13-16	TB028F
E41J3508B	R CMD STATUS	TB028F
E41J3509B	R CHAN STATUS	TB028F
E41J3512B	R ENG PHASE	TB028F
E41J3513B	R ENG MODE	TB028F
E41J3514B	R ENG SELF TEST STATUS	TB028F

[a] Subject to change.

TABLE 5.1.6-II.- Continued

MML/COMP number	Parameter name	Super THRIFT format number (a)
E41J3515B	R HARD FAIL ID	TB028F
E41J3516B	R HARD FAIL DELIM	TB028F
E41M1002P	C ID WD 2	TB026F
E41M1003P	C ESW	TB026F, TA017F
E41M1005P	C H FAIL ID	TB026F
E41M2002P	L ID WD 2	TB027F
E41M2003P	L ESW	TB027F, TA017F
E41M2005P	L H FAIL ID	TB027F
E41M3002P	R ID WD 2	TB028F
E41M3003P	R ESW	TB028F, TA017F
E41M3005P	R H FAIL ID	TB028F
E41P1008P	C HPOT PR DR P A	TY001F
E41P1009P	C HPOT PR DR P B	TY002F
E41P1014B	C HPOT IMD SL PGE PA	TY002F
E41P1015B	C HPOT IMD SL PGE PB	TY002F
E41P1016B	C PC A	TY002F
E41P1017B	C PC B	TY002F
E41P1018B	C LPFT DISCH P	TY0017F
E41P1023B	C PC	TY001F, SA016F
E41P1029B	C HPFT DISCH P	TY0017F
EH1P1030B	C HPOT DISCH P	TY0017F
E41P1031B	C FPB CHAMBER P	TY001F
E41P1051B	C HPOT SEC SL P A	TY001F
E41P1053B	C HPOT SEC SL P B	TY001F
E41P1054B	C ME HYD P	TY001F
E41P2008P	L HPOT PR DR P A	TY004F
E41P2009P	L HPOT PR DR P B	TY005F
E41P2014B	L HPOT IMD SL PGE PA	TY005F
E41P2015B	L HPOT IMD SL PGE PB	TY005F
E41P2016B	L PC A	TY005F
E41P2017B	L PC B	TY005F
E41P2018B	L LPFT DISCH P	TY005F
E41P2023B	L PC	TY004F, SA016F
E41P2029B	L HPFT DISCH P	TY006F
E41P2030B	L HPOT DISCH P	TY006F
E41P2031B	L FPB CHAMBER P	TY004F
E41P2051B	L HPOT SEC SL P A	TY004F
E41P2053B	L HPOT SEC SL P B	TY004F
E41P2054B	L ME HYD P	TY004F
E41P3008B	R HPOT PR DR P A	TY007F

[a] Subject to change.

TABLE 5.1.6-II.- Continued

MML/COMP number	Parameter name	Super THRIFT format number (a)
E41P3009B	R HPOT PR DR P B	TY008F
E41P3014B	R HPOT IMD SL PGE PA	TY008F
E41P3015B	R HPOT IMD SL PGE PB	TY008F
E41P3016B	R PC A	TY008F
E41P3017B	R PC B	TY008F
E41P3018B	R LPFT DISCH P	TY009F
E41P3023B	R PC	TY007F, SA016F
E41P3029B	R HPFT DISCH P	TY009F
E41P3030B	R HPOT DISCH P	TY009F
E41P3031B	R FPB CHAMBER P	TY007F
E41P3051B	R HPOT SEC SL P A	TY007F
E41P3053B	R HPOT SEC SL P B	TY007F
E41P3054B	R ME HYD P	TY007F
E41R1021B	C FU FLOWRT	TY001F
E41R1022B	C OX FLOWRT	TY001F
E41R2021B	L FU FLOWRT	TY004F
E41R2022B	L OX FLOWRT	TY004F
E41R3021B	R FU FLOWRT	TY007F
E41R3022B	R OX FLOWRT	TY007F
E41S0192E	C AC1 ON CMD	TY010F
E41S0193E	C AC2 ON CMD	TY010F
E41S0195E	C HTR ON CMD	TY010F
E41S0292E	L AC1 ON CMD	TY010F
E41S0293E	L AC2 ON CMD	TY010F
E41S0295E	L HTR ON CMD	TY010F
E41S0392E	R AC1 ON CMD	TY010F
E41S0393E	R AC2 ON CMD	TY010F
E41S0395E	R HTR ON CMD	TY010F
E41T1010B	C HPFT TURB DISCH TA	TY002F
E41T1011B	C HPFT TURB DISCH TB	TY002F
E41T1012B	C HPOT TURB DISCH TA	TY002F
E41T1013B	C HPOT TURB DISCH TB	TY002F
E41T1019B	C LPFT DISCH T	TY003F
E41T1020B	C POP DISCH T	TY003F
E41T1150A	C CONTROLLER T	TY003F
E41T2010B	L HPFT TURB DISCH TA	TY005F
E41T2011B	L HPFT TURB DISCH TB	TY005F
E41T2012B	L HPOT TURB DISCH TA	TY005F

[a] Subject to change.

TABLE 5.1.6-II.-Concluded

MML/COMP number	Parameter name	Super THRIFT format number (a)
E41T2013B	L HPOT TURB DISCH TB	TY005F
E41T2019B	L LPFT DISCH T	TY006F
E41T2020B	L POP DISCH T	TY006F
E41T2150A	L CNTLR T	TY006F
E41T3010B	R HPFT TURB DISCH TA	TY008F
E41T3011B	R HPFT TURB DISCH TB	TY008F
E41T3012B	R HPOT TURB DISCH TA	TY008F
E41T3013B	R HPOT TURB DISCH TB	TY008F
E41T3019B	R LPFT DISCH T	TY009F
E41T3020B	R POP DISCH T	TY009F
E41T3150A	R CNTLR T	TY009F
E41W1004B	C TREF	TB019F
E41W2004B	L TREF	TB019F
E41W3004B	R TREF	TB019F
E41X1505B	C VDT A DATA	TB026F
E41X1507B	C MEMORY LOAD MODE	TB026F
E41X1510B	C FRT MODE	TB026F
E41X1511B	C LIMIT CONTROLS ENABLED	TB026F
E41X2505B	L VDT A DATA	TB027F
E41X2507B	L MEMORY LOAD MODE	TB027F
E41X2510B	L FRT MODE	TB027F
E41X2511B	L LIMIT CONTROLS ENABLED	TB027F
E41X3505B	R VDT A DATA	TB028F
E41X3507B	R MEMORY LOAD MODE	TB028F
E41X3510B	R FRT MODE	TB028F
E41X3511B	R LIMIT CONTROLS ENABLED	TB028F

[a] Subject to change.

TITLE

MPS CONSOLE LOCATION/CONFIGURATION

PURPOSE

The purpose of this SCP is to give the Main Propulsion System (MPS) console location and show the console configuration.

DESCRIPTION

MPS consoles are located in room numbers 310 and 233 of building 30. Console number 467 is in room 310; the room used for secure operations. Normal operations use console number 350 in room number 233. Figure 5.2.1-I shows the console configuration and identifies each module on the console. Each event light module has an assigned format number. The event light format number corresponding to each panel location for each flight phase is listed in table 5.2.1-I also. The ascent formats should be verified prior to flight by comparing the ascent column in table 5.2.1-I to MSK 0075 for console 350 formats or MSK 0087 for console 467 formats, the digital display driver (DDD) guide display. The on-orbit/ entry configuration is manually configured by the MPS operator after the first vacuum inerting.

REFERENCES

1. Data Pack: DF65/Booster

Panel location	Description	Panel location	Description
01	EVENT INDICATOR	28	VOICE COMM POSITION-2125
02	EVENT INDICATOR	33	SUMMARY MSG ENABLE KBRD
03	EVENT INDICATOR	38	STOP CLOCK
18	EVENT INDICATOR	60	BLANK PANEL
19	EVENT INDICATOR	61	BLANK PANEL
20	TV MONITOR	62	BLANK PANEL
21	TV MONITOR		
25	MANUAL SELECT KEYBOARD		
27	VOICE COMM POSITION-2124		

Figure 5.2.1-I.- MPS console configuration.

TABLE 5.2.1-I.- EVENT LIGHT FORMATS vs. PANEL LOCATION

Panel number	Flight phase	
	Ascent	On-orbit/entry
1	301	292
2	302	291
3	300	300
18	298	-
19	299	-

TITLE

MPS CONSOLE CRT DISPLAYS

PURPOSE

The purpose of this SCP is to show the CRT displays used at the MPS console and to show the displays used to monitor the performance of the SRB's and the main propulsion system.

DESCRIPTION

A. The primary displays used to monitor SRB and main propulsion system performance are Booster MSK 1054 and 1055. These displays are shown in figures 5.2.2-I and 5.2.2-II. The backup displays used are Booster MSK's 1051 and 1053 (figures 5.2.2-III and 5.2.2-IV). The Booster prelaunch display MSK 1056 is shown in figure 5.2.2-V. The Shuttle pyrotechnics display MSK 0606, figure 5.2.2-XXIV, is used to monitor the SRB pyro-initiator capacitors voltage. The master measurement list (MML) number for each parameter is included in these figures.

B. BFS displays are shown in figure 5.2.2-VI and table 5.2.2-I. When the BFS is engaged, most of our displays do not update properly, because the BFS does not handle or downlist the same amount of data as the PASS. MSK 1054 and 1051 will have some non-updated data. The yet-to-be-validated MSK 1064 removes the data so that only valid data are displayed.

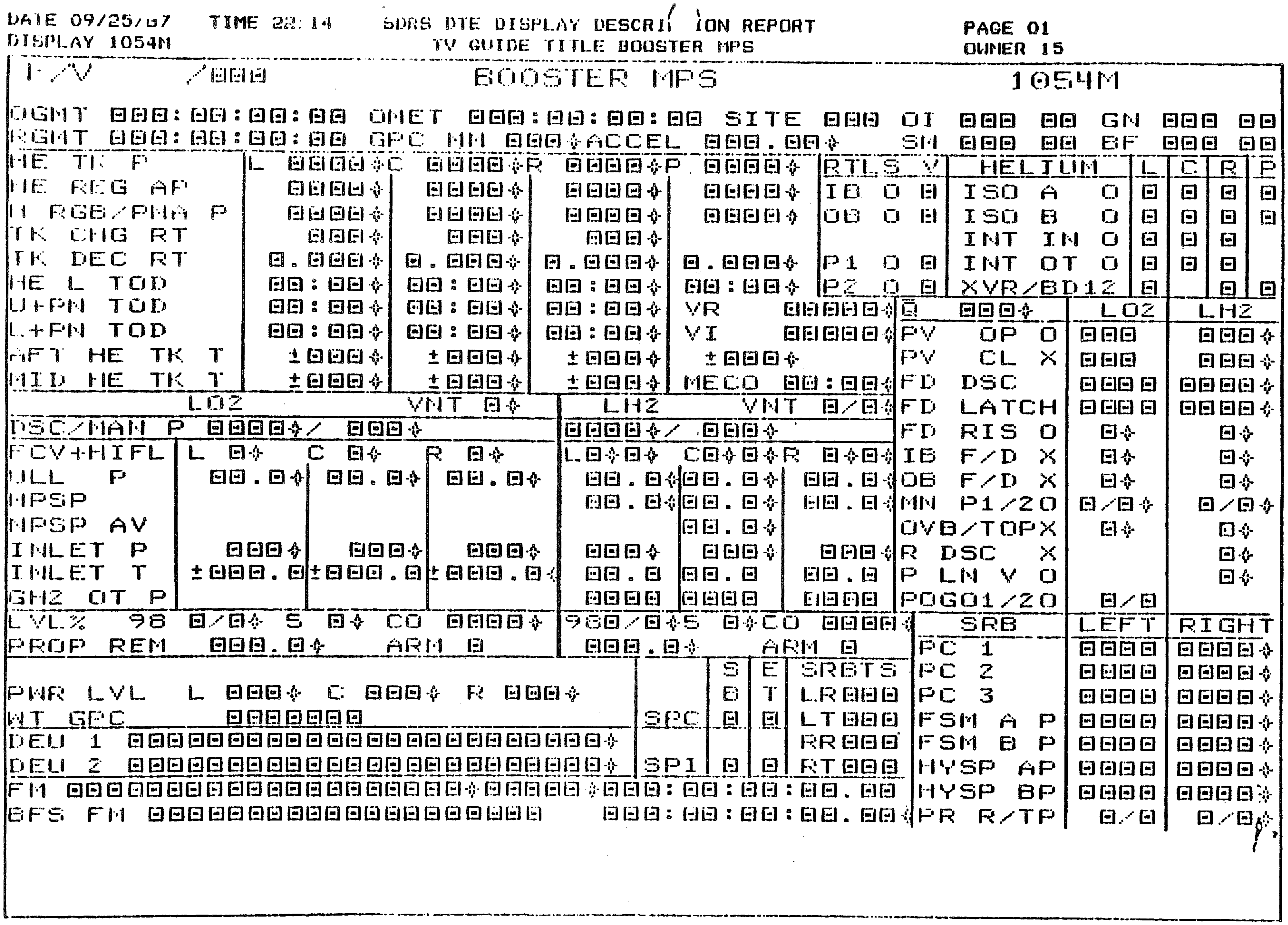
C. The MPS console operator also uses 14 history tab displays (MSK 1077-1092) shown in figures 5.2.2-VII through 5.2.2-XIV. Each odd-numbered display is page one of a two-page set with the next even-numbered display being page two (e.g., MSK 1077 and 1078). Page one displays contain the low and high limits for each parameter in the last two columns of the display, while page two displays contain only history tab data. The limits displayed on page one displays are input by the MPS console operator from the Megadata (MED) Terminal during prelaunch and on-orbit preparations.

D. Universal plot (UP) displays (MSK 2767-2775), shown in figures 5.2.2-XV through 5.2.2-XXIII, are displayed at the MPS console. These plots are used to monitor the LH_2 and LO_2 ullage, manifold and inlet pressures, SRB chamber pressures, and the MPS helium tank and regulator pressures, and temperatures. These displays are entered from the MED and then started/reinitialized from the SMEK panel.

E. During entry, the MPS operator uses MSK 1057 to monitor tank pressures, regulator pressures, temperatures and valve configuration. The MPS entry display is shown in figure 5.2.2-XXV.

REFERENCES

Data Pack: DF6/Booster



```
DATE 09/25/87   TIME 22:14   SDRS DTE DISPLAY DESCRI  ION REPORT        PAGE 01
DISPLAY 1054M                  TV GUIDE TITLE BOOSTER MPS                OWNER 15
 F/V       /⊟⊟⊟                BOOSTER MPS                          1054M
OGMT ⊟⊟⊟:⊟⊟:⊟⊟:⊟⊟ OMET ⊟⊟⊟:⊟⊟:⊟⊟:⊟⊟ SITE ⊟⊟⊟ OI ⊟⊟⊟ ⊟⊟ GN ⊟⊟⊟ ⊟⊟
RGMT ⊟⊟⊟:⊟⊟:⊟⊟:⊟⊟ GPC MM ⊟⊟⊟♦ACCEL ⊟⊟⊟.⊟⊟♦     SM ⊟⊟⊟ ⊟⊟ BF ⊟⊟⊟ ⊟⊟
HE TK P       |L ⊟⊟⊟⊟♦C ⊟⊟⊟⊟♦R ⊟⊟⊟⊟♦P ⊟⊟⊟⊟♦|RTLS V|  HELIUM  |L|C|R|P
HE REG AP     |   ⊟⊟⊟⊟♦|   ⊟⊟⊟⊟♦|   ⊟⊟⊟⊟♦|   ⊟⊟⊟⊟♦|IB O ⊟|ISO A    O|⊟|⊟|⊟|⊟
H RGB/PHA P   |   ⊟⊟⊟⊟♦|   ⊟⊟⊟⊟♦|   ⊟⊟⊟⊟♦|   ⊟⊟⊟⊟♦|OB O ⊟|ISO B    O|⊟|⊟|⊟|⊟
TK CHG RT     |    ⊟⊟⊟♦|    ⊟⊟⊟♦|    ⊟⊟⊟♦|        |      |INT IN   O|⊟|⊟|⊟|
TK DEC RT     | ⊟.⊟⊟⊟♦| ⊟.⊟⊟⊟♦| ⊟.⊟⊟⊟♦| ⊟.⊟⊟⊟♦|P1 O ⊟|INT OT   O|⊟|⊟|⊟|
HE L TOD      | ⊟⊟:⊟⊟♦| ⊟⊟:⊟⊟♦| ⊟⊟:⊟⊟♦| ⊟⊟:⊟⊟♦|P2 O ⊟|XVR/BD12  |⊟| |⊟|⊟
U+PN TOD      | ⊟⊟:⊟⊟♦| ⊟⊟:⊟⊟♦| ⊟⊟:⊟⊟♦|VR    ⊟⊟⊟⊟⊟♦|Q̄    ⊟⊟⊟♦|  LO2  |  LH2
L+PN TOD      | ⊟⊟:⊟⊟♦| ⊟⊟:⊟⊟♦| ⊟⊟:⊟⊟♦|VI    ⊟⊟⊟⊟⊟♦|PV   OP O|⊟⊟⊟   |  ⊟⊟⊟♦
AFT HE TK T   |  ±⊟⊟⊟♦|  ±⊟⊟⊟♦|  ±⊟⊟⊟♦|  ±⊟⊟⊟♦     |PV   CL X|⊟⊟⊟   |  ⊟⊟⊟♦
MID HE TK T   |  ±⊟⊟⊟♦|  ±⊟⊟⊟♦|  ±⊟⊟⊟♦|MECO ⊟⊟:⊟⊟♦|FD DSC   |⊟⊟⊟⊟  |⊟⊟⊟⊟♦
          LO2             VNT ⊟♦  |    LH2       VNT ⊟/⊟♦|FD LATCH |⊟⊟⊟⊟  |⊟⊟⊟⊟♦
DSC/MAN P ⊟⊟⊟⊟♦/ ⊟⊟⊟♦              |⊟⊟⊟⊟♦/ ⊟⊟⊟♦            |FD RIS  O|  ⊟♦   |  ⊟♦
FCV+HIFL|L ⊟♦     C ⊟♦     R ⊟♦    |L⊟♦⊟♦  C⊟♦⊟♦R  ⊟♦⊟♦    |IB F/D  X|  ⊟♦   |  ⊟♦
ULL P   |  ⊟⊟.⊟♦|  ⊟⊟.⊟♦|  ⊟⊟.⊟♦   | ⊟⊟.⊟♦|⊟⊟.⊟♦|  ⊟⊟.⊟♦|OB F/D  X|  ⊟♦   |  ⊟♦
NPSP    |        |        |          | ⊟⊟.⊟♦|⊟⊟.⊟♦|  ⊟⊟.⊟♦|MN P1/2O|⊟/⊟♦   |⊟/⊟♦
NPSP AV |        |        |          |       |⊟⊟.⊟♦|        |OVB/TOPX|  ⊟♦   |  ⊟♦
INLET P |   ⊟⊟⊟♦|   ⊟⊟⊟♦|   ⊟⊟⊟♦   | ⊟⊟⊟♦ | ⊟⊟⊟♦ |   ⊟⊟⊟♦|R DSC   X|       |  ⊟♦
INLET T |±⊟⊟⊟.⊟|±⊟⊟⊟.⊟|±⊟⊟⊟.⊟♦     | ⊟⊟.⊟  |⊟⊟.⊟  |   ⊟⊟.⊟ |P LN V  O|       |  ⊟♦
GH2 OT P|        |        |          | ⊟⊟⊟⊟  |⊟⊟⊟⊟  |   ⊟⊟⊟⊟ |POGO1/2O|  ⊟/⊟  |
LVL%    98 ⊟/⊟♦ S ⊟♦ CO ⊟⊟⊟⊟♦       |98⊟/⊟♦S ⊟♦CO ⊟⊟⊟⊟♦     |   SRB    |LEFT   |RIGHT
PROP REM   ⊟⊟⊟.⊟♦     ARM ⊟         | ⊟⊟⊟.⊟♦     ARM ⊟     |PC 1     |⊟⊟⊟⊟   |⊟⊟⊟⊟♦
                                     |   |S|E|SRBTS           |PC 2     |⊟⊟⊟⊟   |⊟⊟⊟⊟♦
PWR LVL   L ⊟⊟⊟♦  C ⊟⊟⊟♦  R ⊟⊟⊟♦    |   |B|T|LR⊟⊟⊟          |PC 3     |⊟⊟⊟⊟   |⊟⊟⊟⊟♦
WT GPC          ⊟⊟⊟⊟⊟⊟⊟⊟             |SPC|⊟|⊟|LT⊟⊟⊟          |FSM A P  |⊟⊟⊟⊟   |⊟⊟⊟⊟♦
DEU 1 ⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟♦     |   | | |RR⊟⊟⊟          |FSM B P  |⊟⊟⊟⊟   |⊟⊟⊟⊟♦
DEU 2 ⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟♦     |SPI|⊟|⊟|RT⊟⊟⊟          |HYSP AP  |⊟⊟⊟⊟   |⊟⊟⊟⊟♦
FM ⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟♦⊟⊟⊟⊟⊟♦⊟⊟⊟:⊟⊟:⊟⊟:⊟⊟.⊟⊟        |HYSP BP  |⊟⊟⊟⊟   |⊟⊟⊟⊟♦
BFS FM ⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟⊟    ⊟⊟⊟:⊟⊟:⊟⊟:⊟⊟.⊟⊟♦     |PR R/TP  |  ⊟/⊟  |  ⊟/⊟
```

Figure 5.2.2-I.- MPS display, MSK 1054 (sheet 1 of 3).

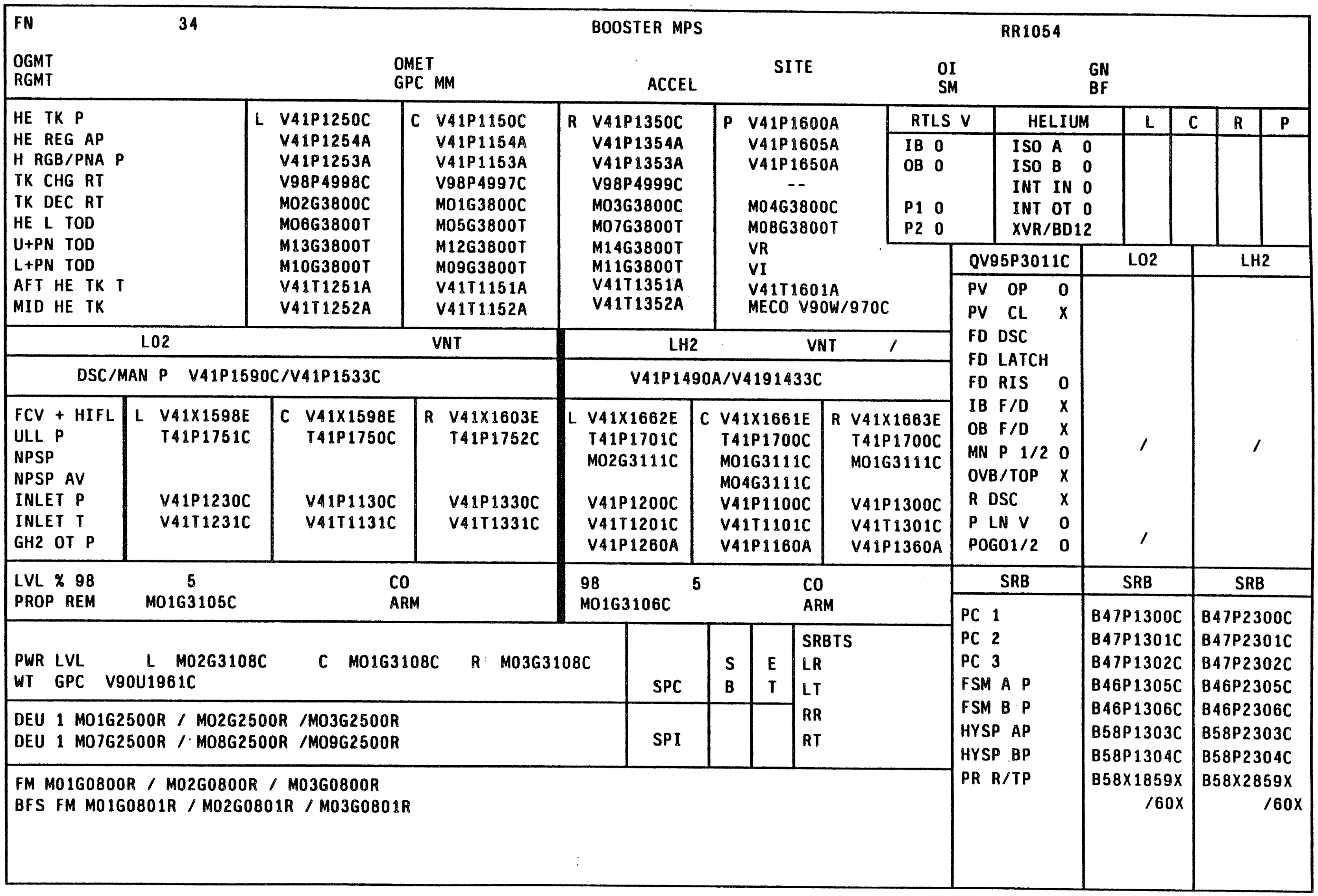
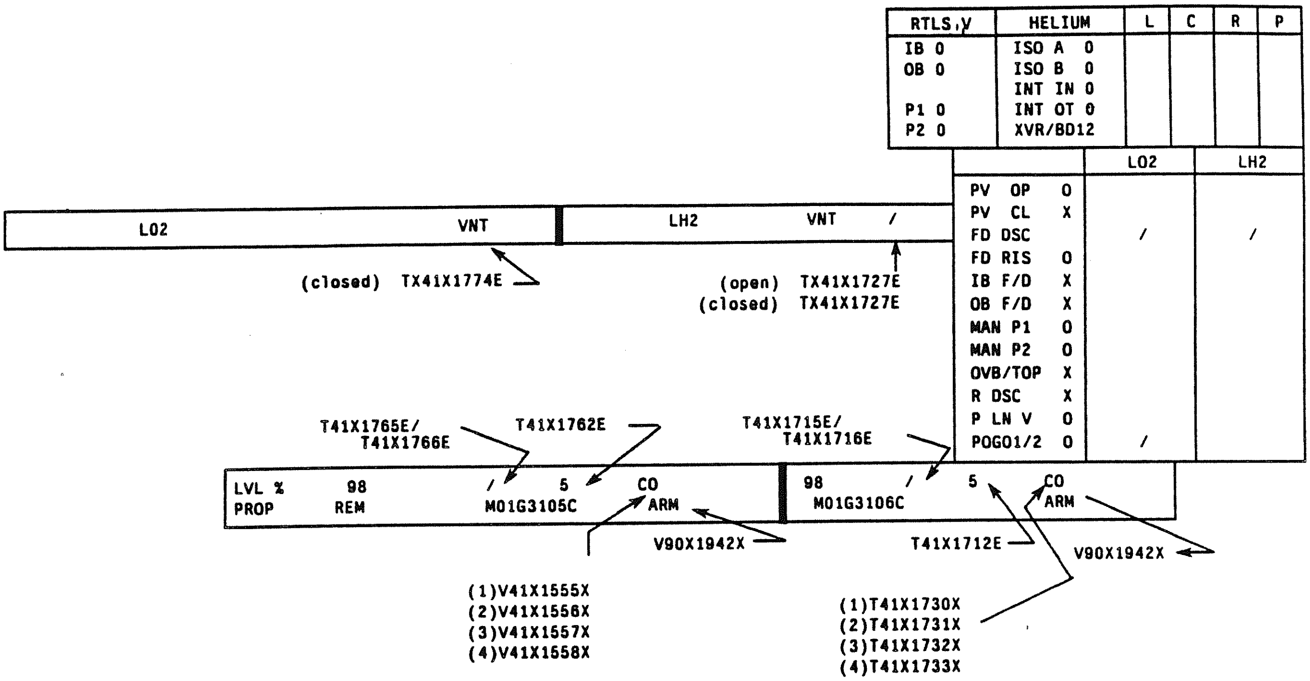


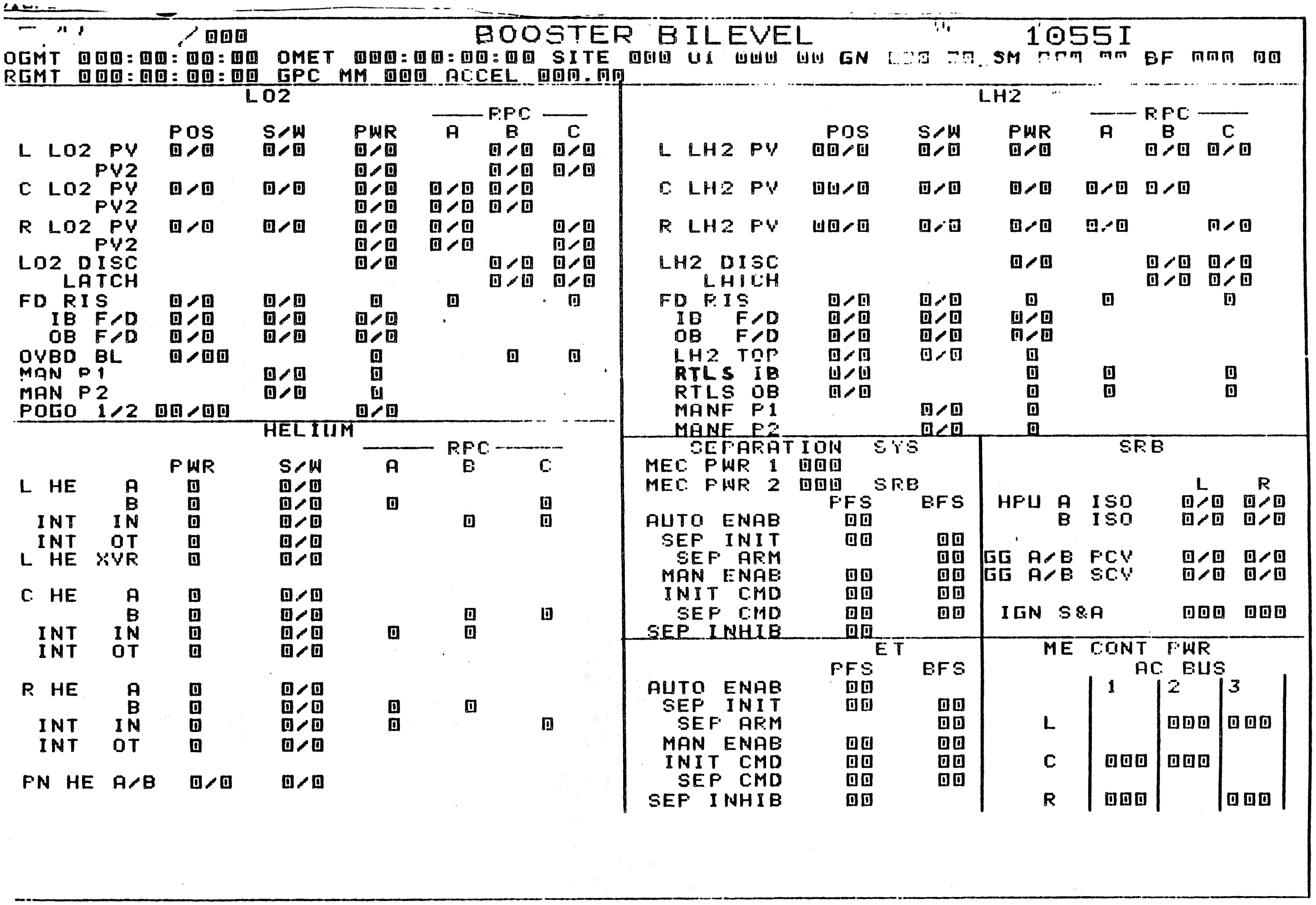
Figure 5.2.2-I.- MPS display, MSK 1054 (sheet 2 of 3).



RTLS V		HELIUM	L	C	R	P
IB 0	V41X1929X	ISO A 0	V41X1258E	V41X1158E	V41X1358E	V41X1645E
OB 0	V41X1919X	ISO B 0	V41X1259E	V41X1159E	V41X1359E	V41X1646E
	------	INT IN 0	V41X1264E	V41X1164E	V41X1364E	-------
P1 0	V41X1901E	INT OT 0	V41X1270E	V41X1170E	V41X1370E	-------
P2 0	V41X1902E	XVR/BD12	V41X1614E	-------	(1)V41X1632E	(2)V41X1634E

	LO2			LH2		
PV OP 0	V41X1234X	V41X1134X	V41X1334X	V41X1204X	V41X1104X	V41X1304X
PV CL X	V41X1235E	V41X1135E	V41X1335E	V41X1205E	V41X1105E	V41X1305E
FD DSC	0-V41X1529X	C-V41X1530X	C-V41X1534X	0-V41X1429X	C-V41X1430X	C-V41X1434X
FD LATCH	---------	V41X1541E	---------	---------	V41X1441E	---------
FD RIS 0	---------	V41X1509X	---------	---------	V41X1410X	---------
IB F/D X	---------	V41X1514X	---------	---------	V41X1389X	---------
CB F/D X	---------	V41X1538E	---------	---------		---------
MAN P1/2 0	(1)V41X1538E	(2)V41X1539E	---------	(1)V41X1436E	(2)V41X1438E	---------
OVB/TOP X	---------	V41X1580X	---------	---------	V41X1456X	---------
R DSC X	---------	--------	---------	---------	V41X1420E	---------
P LN V 0	---------	--------	---------	---------	V41X1492E	---------
POGO1/2 0	V41X1811X	V41X1821X	---------	---------	--------	---------

Figure 5.2.2-I.- MPS display, MSK 1054 (sheet 3 of 3).



```
        /□□□                BOOSTER BILEVEL                          1055I
OGMT □□□:□□:□□:□□  OMET □□□:□□:□□:□□  SITE □□□ UI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□
RGMT □□□:□□:□□:□□  GPC  MM □□□  ACCEL □□□.□□

                      LO2
                                        ---- RPC ----
               POS     S/W     PWR     A     B     C
L LO2 PV       □/□     □/□     □/□           □/□   □/□
      PV2                      □/□           □/□   □/□
C LO2 PV       □/□     □/□     □/□     □/□   □/□
      PV2                      □/□     □/□   □/□
R LO2 PV       □/□     □/□     □/□     □/□         □/□
      PV2                      □/□     □/□         □/□
LO2 DISC                       □/□           □/□   □/□
    LATCH                                    □/□   □/□
FD RIS         □/□     □/□     □       □           □
   IB F/D      □/□     □/□     □/□
   OB F/D      □/□     □/□     □/□
OVBD BL        □/□□            □             □     □
MAN P1                 □/□     □
MAN P2                 □/□     □
POGO 1/2      □□/□□            □/□

                      LH2
                                        ---- RPC ----
               POS     S/W     PWR     A     B     C
L LH2 PV       □□/□    □/□     □/□           □/□   □/□
C LH2 PV       □□/□    □/□     □/□     □/□   □/□
R LH2 PV       □□/□    □/□     □/□     □/□         □/□
LH2 DISC                       □/□           □/□   □/□
    LATCH                                    □/□   □/□
FD RIS         □/□     □/□     □       □           □
  IB  F/D      □/□     □/□     □/□
  OB  F/D      □/□     □/□     □/□
  LH2 TOP      □/□     □/□     □
  RTLS IB      □/□             □       □           □
  RTLS OB      □/□             □       □           □
  MANF P1              □/□     □
  MANF P2              □/□     □

                     HELIUM
                                 ------ RPC ------
               PWR     S/W       A       B       C
L HE     A     □       □/□
         B     □       □/□       □               □
  INT    IN    □       □/□               □       □
  INT    OT    □       □/□
L HE     XVR   □       □/□

C HE     A     □       □/□
         B     □       □/□               □       □
  INT    IN    □       □/□       □       □
  INT    OT    □       □/□

R HE     A     □       □/□
         B     □       □/□       □       □
  INT    IN    □       □/□       □               □
  INT    OT    □       □/□

PN HE A/B      □/□     □/□

     SEPARATION SYS
MEC PWR 1  □□□
MEC PWR 2  □□□   SRB
               PFS    BFS
AUTO ENAB      □□
 SEP INIT      □□     □□
  SEP ARM             □□
 MAN ENAB      □□     □□
 INIT CMD      □□     □□
  SEP CMD      □□     □□
SEP INHIB      □□
                 ET
               PFS    BFS
AUTO ENAB      □□
 SEP INIT      □□     □□
  SEP ARM             □□
 MAN ENAB      □□     □□
 INIT CMD      □□     □□
  SEP CMD      □□     □□
SEP INHIB      □□     

                SRB
                      L     R
HPU A ISO            □/□   □/□
    B ISO            □/□   □/□
GG A/B PCV           □/□   □/□
GG A/B SCV           □/□   □/□

IGN S&A              □□□   □□□

     ME CONT PWR
        AC BUS
       | 1   | 2   | 3
  L    |     | □□□ | □□□
  C    | □□□ | □□□ |
  R    | □□□ |     | □□□
```

Figure 5.2.2-II.- Booster bilevel display MSK 1055 (sheet 1 of 3).

LO2

Item	POS O/X	SW O/X	PWR O/X	RPC A O/X	RPC B O/X	RPC C O/X
L LO2 PV	V41X1234X/35E	V41S1236E/39E	V41X1233E/32E		V76X4136E/39E	V76X4137E/40E
PV2			V41X1245E/44E		V76X4043E/13E	V76X4044E/14E
C LO2 PV	V41X1134X/35E	V41S1136E/39E	V41X1133E/32E	V76X4130E/33E	V76X4131E/34E	
PV2			V41X1145E/44E	V76X4040E/10E	V76X4041E/11E	
R LO2 PV	V41X1334X/35E	V41S1336E/39E	V41X1333E/32E	V76X4143E/46E		V76X4142E/45E
PV2			V41X1345E/44E	V76X4046E/16E		V76X4047E/17E
LO2 DISC	V41X1529X/30X,34X		V41X1807E/06E			
LATCH					V76X4120E/22E	V76X4421E/23E
FD RIS	V41X1541E/42X	V41S1543E/47E	V41X1549E	V76X0551E		V76X0553E
IB F/D	V41X1510E/09X	V41S1511E/12E	V41X1506E/05E			
OB F/D	V41X1513E/14X	V41S1511E/12E	V41X1508E/07E			
OVBD BL	V41X1587E/80X,81X		V41X1582E		V76X4178E	V76X4179E
MAN P1		V41S1535E/31E	V41X1538E			
MAN P2		V41S1535E/31E	V41X1539E			
POGO 1/2	V41X1811X,18E/21X, 28E		V41X813E/23E			

Helium

Power on = 0 off = X		O/X PWR	S/W	RPC		
				A	B	C
L HE	A	V41X1258E	V41S1255E/65E			
	B	V41X1259E	V41S1256E/66E	V76X4173E		V76X4174E
INT	IN	V41X1264E	V41S1262E/68E		V76X4155E	V76X4156E
INT	OT	V41X1270E	V41S1268E/62E			
L HE	XVR	V41X1614E	V41S1613E/19E			
C HE	A	V41X1158E	V41S1155E/65E			
	B	V41X1159E	V41S1156E/66E		V76X4171E	V76X4172E
INT	IN	V41X1164E	V41S1162E/68E	V76X4151E	V76X4152E	
INT	OT	V41X1170E	V41S1168E/62E			
R HE	A	V41X1358E	V41S1355E/65E			
	B	V41X1359E	V41S1356E/66E	V76X4175E	V67X4176E	
INT	IN	V41X1364E	V41S1362E/68E	V76X4159E		V76X4158E
	OT	V41X1370E	V41S1368E/62E			
Pn HE	A/B	V41X1645/46E	V41S1607E/09E			

Figure 5.2.2-II.- Booster bi-level display, MSK 1055 (sheet 2 of 3).

LH2

Item	POS O/C	SW O/X	PWR O/X	RPC A O/X	RPC B O/X	RPC C O/X
L LH2 PV	V41X1204X,06X/05E	V41S1219E/22E	V41X1203E/02E		V76X4116E/19E	V76X4117E/20E
C LH2 PV	V41X1104X,06X/05E	V41S1119E/22E	V41X1103E/02E	V76X4110E/13E	V76X4111E/14E	
R LH2 PV	V41X1304X,06X/05E	V41S1319E/22E	V41X1303E/02E	V76X4123E/26E		V76X4122E/25E
LH2 DISC	V41X1429X/30X,34X		V41X1382E/81E		V76X4186E/89E	V76X4187E/90E
LATCH					V76X4430E/32E	V76X4431E/33E
FD RIS	V41X1441E/42E	V41S1443E/47E	V41X1449E	V76X0501E		V76X0503E
IB F/D	V41X1409E/10E	V41S1401E/12E	V41X1406E/05E			
OB F/D	V41X1388E/89X	V41S1391E/93E	V41X1386E/85E			
LH2 TOP	V41X1453E/56X	V41S1401E/12E	V41X1458E			
RTLS IB	V41X1927E		V41X1921E	V76X4161E	V76X4163E	
RTLS OB	V41X1917E		V41X1911E	V76X4162E		V76X4164E
Manf P1		V41S1435E/31E	V41X1436E			
Manf P2		V41S1435E/31E	V41X1438E			

Separation Sys

MEC PWR 1	V76S4601E
MEC PWR 2	V76S4605E

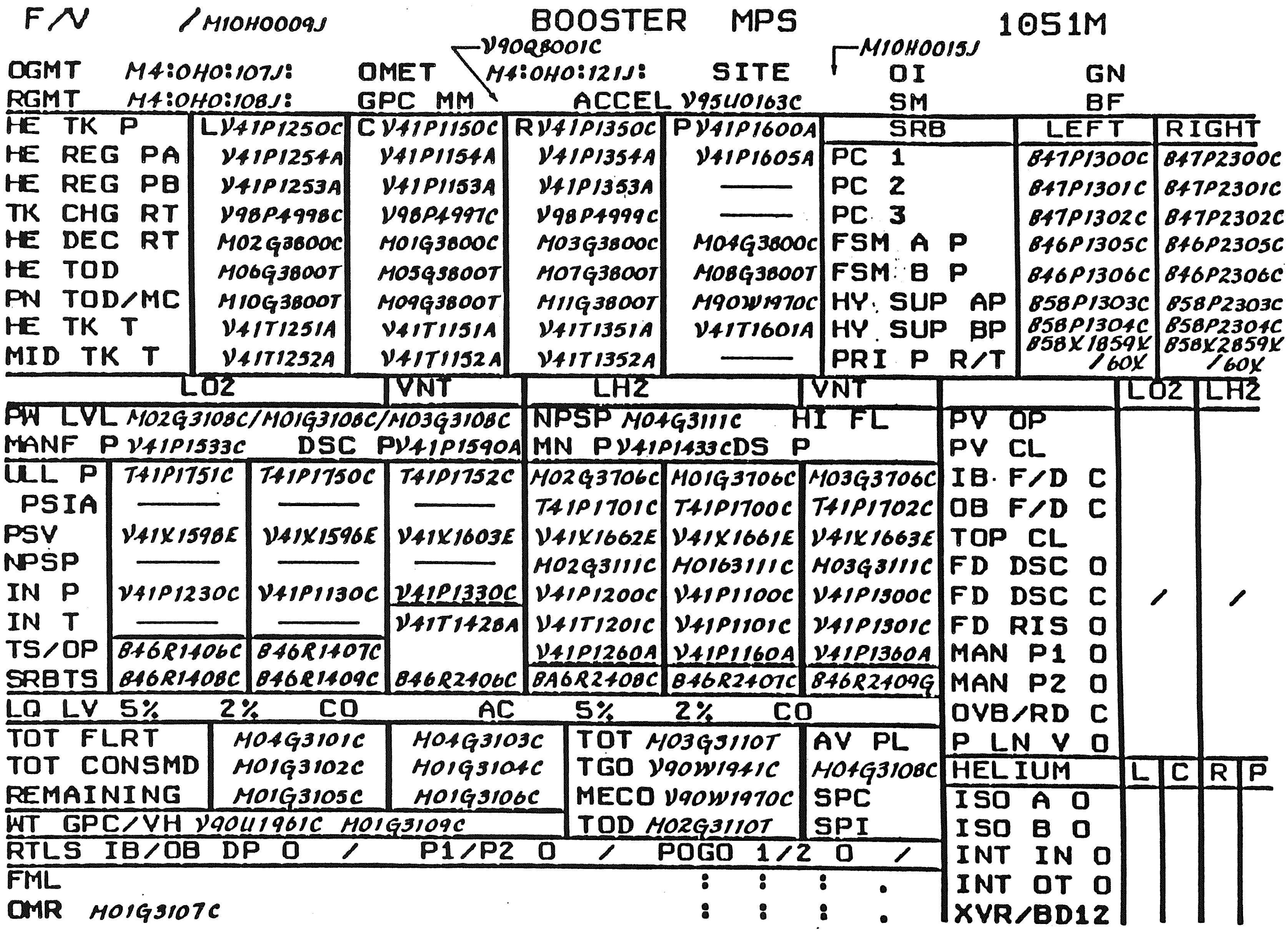
	SRB PFS	SRB BFS
Auto ENAB	V90X7570X	
SEP INIT	V90X8333X	V98X3532X
SEP ARM		V98X0744X
MAN ENAB	V90X7571X	V98X0742X
INIT CMD	V90X7572X	V98X0743X
SEP CMD	V90X8331X	V98X3534X
SEP INHIB	V90X8340X	

	SRB L	SRB R
HPU A ISO	B46X1851X/53X	B46X2851X/53X
B ISO	B46X1852X/54X	B46X2852X/54X
GG A/B PCV O	B46X1862X/64X	B46X2862X/64X
GG A/B SCV X	B46X1861X/63X	B46X2861X/63X
IGN S&A	B55X1842X	B55X2842X

	ET PFS	ET BFS
Auto ENAB	V90X7554X	
SEP INIT	V90X7564X	V98X0749X
SEP ARM		V98X0752X
MAN ENAB	V90X7556X	V98X0748X
INIT CMD	V90X7564X	V98X0749X
SEP CMD	V90X8250X	V98X3550X
SEP INHIB	V90X8259X	

ME CONT PWR AC BUS	1	2	3
L		E41S0292E	E41S0293E
C	E41S0192E	E41S0193E	
R	E41S0392E		E41S0393E

Figure 5.2.2-II.- Booster Bi-level display, MSK 1055 (sheet 3 of 3).



```
F/V        /M10H0009J                      BOOSTER  MPS                      1051M
                                    -V90Q8001C                 -M10H0015J
OGMT  M4:0H0:107J:      OMET   \ M4:0H0:121J:      SITE        OI               GN
RGMT  M4:0H0:108J:      GPC MM          ACCEL V95U0163C        SM               BF
HE TK P     |LV41P1250C|CV41P1150C|RV41P1350C|PV41P1600A|       SRB      |   LEFT    |  RIGHT
HE REG PA   | V41P1254A| V41P1154A| V41P1354A| V41P1605A|PC 1            |B47P1300C  |B47P2300C
HE REG PB   | V41P1253A| V41P1153A| V41P1353A|  ——————  |PC 2            |B47P1301C  |B47P2301C
TK CHG RT   | V98P4998C| V98P4997C| V98P4999C|  ——————  |PC 3            |B47P1302C  |B47P2302C
HE DEC RT   | M02G3800C| M01G3800C| M03G3800C| M04G3800C|FSM A P         |B46P1305C  |B46P2305C
HE TOD      | M06G3800T| M05G3800T| M07G3800T| M08G3800T|FSM B P         |B46P1306C  |B46P2306C
PN TOD/MC   | M10G3800T| M09G3800T| M11G3800T| M90W1970C|HY SUP AP       |B58P1303C  |B58P2303C
HE TK T     | V41T1251A| V41T1151A| V41T1351A| V41T1601A|HY SUP BP       |B58P1304C  |B58P2304C
MID TK T    | V41T1252A| V41T1152A| V41T1352A|  ——————  |PRI P R/T       |B58X1859X  |B58X2859X
                                                                         |  /60X     |  /60X
              LO2          |VNT      |        LH2           |VNT     |              |LO2 |LH2
PW LVL M02G3108C/M01G3108C/M03G3108C|NPSP M04G3111C      HI FL       |PV OP         |    |
MANF P V41P1533C    DSC PV41P1590A  |MN PV41P1433CDS P               |PV CL         |    |
ULL P |T41P1751C |T41P1750C |T41P1752C |M02G3706C|M01G3706C|M03G3706C|IB F/D C      |    |
 PSIA |  ——————  |  ——————  |  ——————  |T41P1701C|T41P1700C|T41P1702C|OB F/D C      |    |
PSV   |V41X1598E |V41X1596E |V41X1603E |V41X1662E|V41X1661E|V41X1663E|TOP CL        |    |
NPSP  |  ——————  |  ——————  |  ——————  |M02G3111C|M0163111C|M03G3111C|FD DSC O      |    |
IN P  |V41P1230C |V41P1130C |V41P1330C |V41P1200C|V41P1100C|V41P1300C|FD DSC C      | /  |  /
IN T  |  ——————  |  ——————  |V41T1428A |V41T1201C|V41P1101C|V41P1301C|FD RIS O      |    |
TS/OP |B46R1406C |B46R1407C |          |V41P1260A|V41P1160A|V41P1360A|MAN P1 O      |    |
SRBTS |B46R1408C |B46R1409C |B46R2406C |BA6R2408C|B46R2407C|B46R2409G|MAN P2 O      |    |
LQ LV 5%    2%     CO              AC     5%     2%     CO            |OVB/RD C      |    |
TOT FLRT     |  M04G3101C |  M04G3103C |TOT M03G3110T  |AV PL        |P LN V O      |    |
TOT CONSMD   |  M01G3102C |  M01G3104C |TGO V90W1941C   |M04G3108C    |HELIUM        |L|C|R|P
REMAINING    |  M01G3105C |  M01G3106C |MECO V90W1970C  |SPC          |ISO A O       | | | |
WT GPC/VH V90U1961C  M01G3109C         |TOD M02G3110T   |SPI          |ISO B O       | | | |
RTLS IB/OB DP O  /     P1/P2 O  /     POGO 1/2 O  /                   |INT IN O      | | | |
FML                                          :    :    :    .         |INT OT O      | | | |
OMR  M01G3107C                               :    :    :    .         |XVR/BD12      | | | |
```

Figure 5.2.2-III.- Booster MPS display MSK 1051 (sheet 1 of 2).

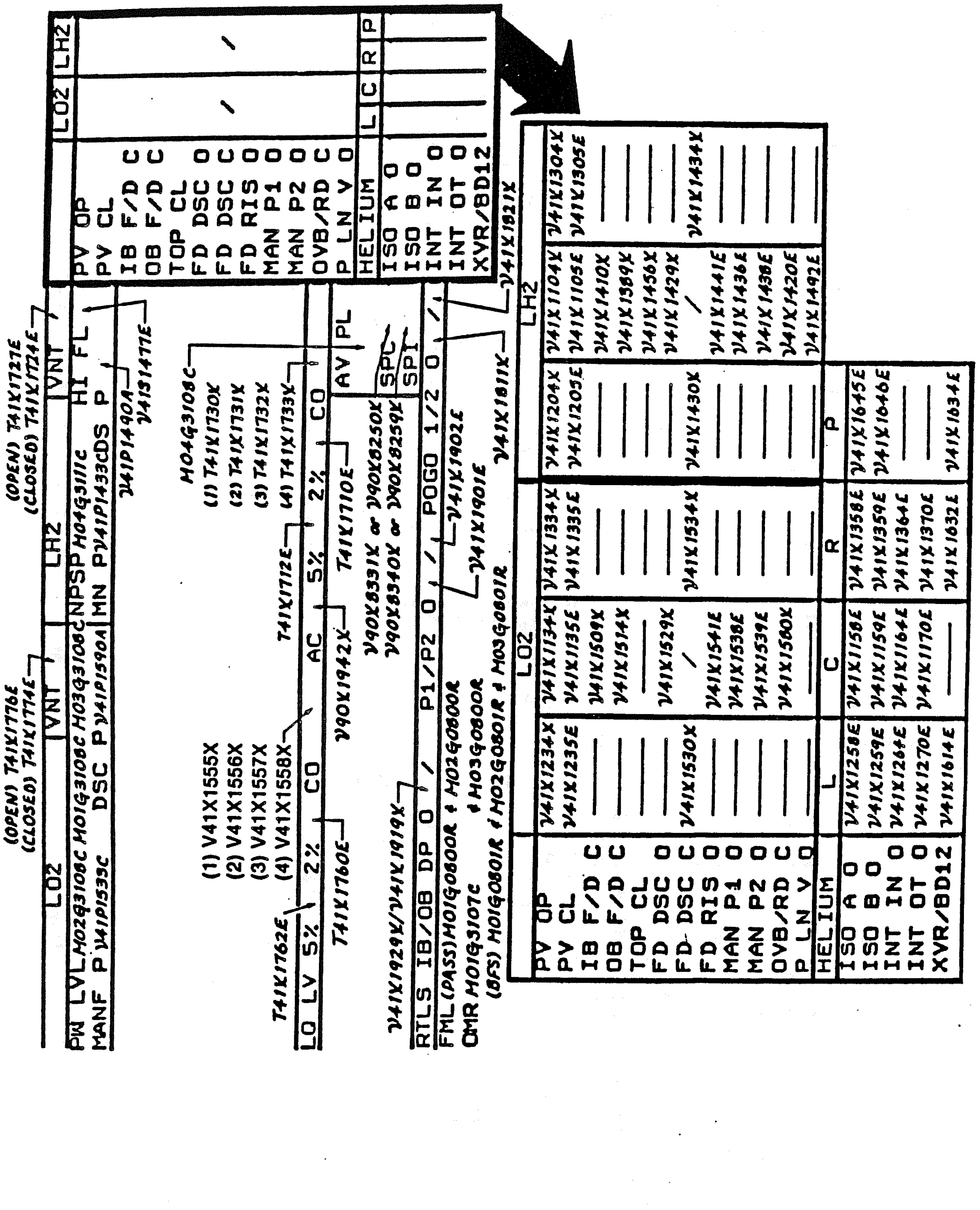
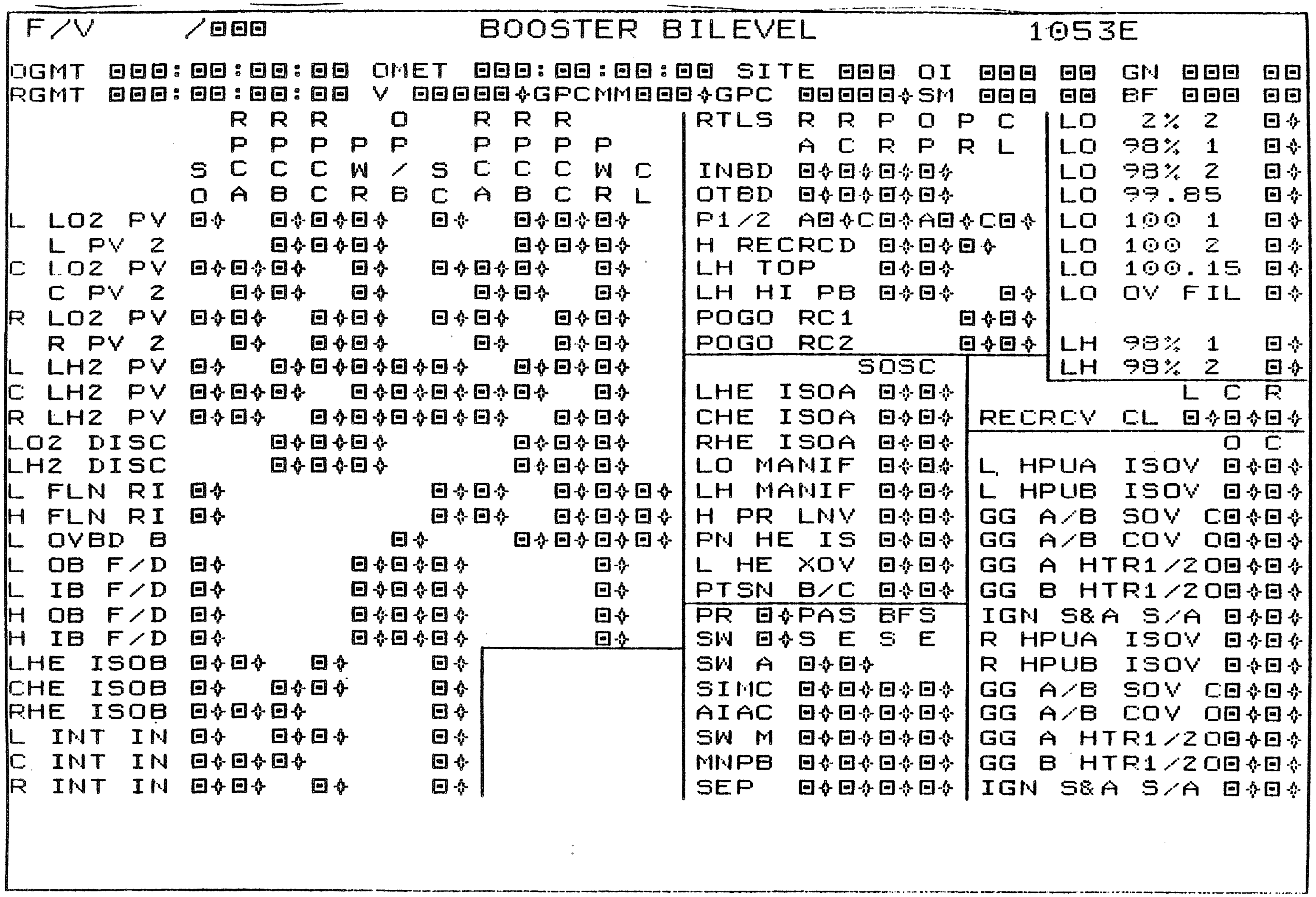


Figure 5.2.2-III.- Booster MPS display MSK 1051 (sheet 2 of 2).



```
 F/V     /▣▣▣          BOOSTER BILEVEL          1053E
OGMT ▣▣▣:▣▣:▣▣:▣▣ OMET ▣▣▣:▣▣:▣▣:▣▣ SITE ▣▣▣ OI ▣▣▣ ▣▣ GN ▣▣▣ ▣▣
RGMT ▣▣▣:▣▣:▣▣:▣▣ V ▣▣▣▣▣◆GPCMM▣▣▣◆GPC ▣▣▣▣▣◆SM ▣▣▣ ▣▣ BF ▣▣▣ ▣▣
           R R R   O   R R R      RTLS R R P O P C  LO  2% 2   ▣◆
           P P P P P   P P P P         A C R P R L  LO 98% 1   ▣◆
         S C C C W / S C C C W C  INBD ▣◆▣◆▣◆▣◆     LO 98% 2   ▣◆
         O A B C R B C A B C R L  OTBD ▣◆▣◆▣◆▣◆     LO 99.85   ▣◆
L LO2 PV ▣◆  ▣◆▣◆▣◆  ▣◆  ▣◆▣◆▣◆   P1/2 A▣◆C▣◆A▣◆C▣◆ LO 100 1   ▣◆
  L PV 2     ▣◆▣◆▣◆      ▣◆▣◆▣◆   H RECRCD ▣◆▣◆▣◆   LO 100 2   ▣◆
C LO2 PV ▣◆▣◆▣◆  ▣◆  ▣◆▣◆▣◆  ▣◆   LH TOP   ▣◆▣◆     LO 100.15  ▣◆
  C PV 2   ▣◆▣◆  ▣◆    ▣◆▣◆  ▣◆   LH HI PB ▣◆▣◆  ▣◆ LO OV FIL  ▣◆
R LO2 PV ▣◆▣◆  ▣◆▣◆  ▣◆▣◆  ▣◆▣◆   POGO RC1     ▣◆▣◆
  R PV 2   ▣◆  ▣◆▣◆    ▣◆  ▣◆▣◆   POGO RC2     ▣◆▣◆ LH 98% 1   ▣◆
L LH2 PV ▣◆  ▣◆▣◆▣◆▣◆▣◆  ▣◆▣◆▣◆           SOSC      LH 98% 2   ▣◆
C LH2 PV ▣◆▣◆▣◆  ▣◆▣◆▣◆▣◆▣◆  ▣◆   LHE ISOA ▣◆▣◆          L C R
R LH2 PV ▣◆▣◆  ▣◆▣◆▣◆▣◆▣◆  ▣◆▣◆   CHE ISOA ▣◆▣◆ RECRCV CL ▣◆▣◆▣◆
LO2 DISC     ▣◆▣◆▣◆      ▣◆▣◆▣◆   RHE ISOA ▣◆▣◆             O C
LH2 DISC     ▣◆▣◆▣◆      ▣◆▣◆▣◆   LO MANIF ▣◆▣◆ L HPUA ISOV ▣◆▣◆
L FLN RI ▣◆          ▣◆▣◆  ▣◆▣◆▣◆ LH MANIF ▣◆▣◆ L HPUB ISOV ▣◆▣◆
H FLN RI ▣◆          ▣◆▣◆  ▣◆▣◆▣◆ H PR LNV ▣◆▣◆ GG A/B SOV C▣◆▣◆
L OVBD B           ▣◆    ▣◆▣◆▣◆▣◆ PN HE IS ▣◆▣◆ GG A/B COV O▣◆▣◆
L OB F/D ▣◆      ▣◆▣◆▣◆      ▣◆   L HE XOV ▣◆▣◆ GG A HTR1/2O▣◆▣◆
L IB F/D ▣◆      ▣◆▣◆▣◆      ▣◆   PTSN B/C ▣◆▣◆ GG B HTR1/2O▣◆▣◆
H OB F/D ▣◆      ▣◆▣◆▣◆      ▣◆   PR ▣◆PAS BFS  IGN S&A S/A ▣◆▣◆
H IB F/D ▣◆      ▣◆▣◆▣◆      ▣◆   SW ▣◆S E S E  R HPUA ISOV ▣◆▣◆
LHE ISOB ▣◆▣◆  ▣◆    ▣◆           SW A ▣◆▣◆     R HPUB ISOV ▣◆▣◆
CHE ISOB ▣◆  ▣◆▣◆    ▣◆           SIMC ▣◆▣◆▣◆▣◆ GG A/B SOV C▣◆▣◆
RHE ISOB ▣◆▣◆▣◆      ▣◆           AIAC ▣◆▣◆▣◆▣◆ GG A/B COV O▣◆▣◆
L INT IN ▣◆  ▣◆▣◆    ▣◆           SW M ▣◆▣◆▣◆▣◆ GG A HTR1/2O▣◆▣◆
C INT IN ▣◆▣◆▣◆      ▣◆           MNPB ▣◆▣◆▣◆▣◆ GG B HTR1/2O▣◆▣◆
R INT IN ▣◆▣◆  ▣◆    ▣◆           SEP  ▣◆▣◆▣◆▣◆ IGN S&A S/A ▣◆▣◆
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Figure 5.2.2-IV.- Booster MPS display, MSK 1053 (sheet 1 of 3).

	SWITCH OPEN	RPC A	RPC B	RPC C	POWER	OPEN B	SWITCH CLOSE	RPC A	RPC B	RPC C	POWER	POWER 2 CLOSE
L LO2 PV	V41S1236E		V76X4136E	V76X4137E	V41X1233E		V41S1239E		V76X4139E	V76X4140E	V41X1232E	V41X1244E
C LO2 PV	V41S1136E	V76X4130E	V76X4131E		V41X1133E		V41S1139E	V76X4133E	V76X4134E		V41X1132E	V41X1144E
R LO2 PV	V41S1336E	V76X4143E		V76X4142E	V41X1333E		V41S1339E	V76X4146E		V76X4145E	V41X1332E	V41X1344E
L LH2 PV	V41S1219E		V76X4116E	V76X4117E	V41X1203E	V41X1206X	V41S1222E		V76X4119E	V76X4120E	V41X1202E	
C LH2 PV	V41S1119E	V76X4110E	V76X4111E		V41X1103E	V41X1106X	V41S1122E	V76X4113E	V76X4114E		V41X1102E	
R LH2 PV	V41S1319E	V76X4123E		V76X4122E	V41X1303E	V41X1306X	V41S1322E	V76X4126E		V76X4125E	V41X1302E	
LO2 DISC			V76X4196E	V76X4197E	V41X1807E				V76X4199E	V76X4200E	V41X1806E	
LH2 DISC			V76X4186E	V76X4187E	V41X1382E				V76X4189E	V76X4190E	V41X1381E	
L FLN RI	V41S1543E						V41S1547E	V76X0551E		V76X0553E	V41X1549E	V41X1542E
H FLN RI	V41S1443E						V41S1447E	V76X0501E		V76X0503E	V41X1449E	V41X1442E
L OVBD B						V41X1587E			V76X4178E	V76X4179E	V41X1582E	V41X1581X
L OB F/D	V41S1518E				V41X1508E	V41X1513E	V41S1515E				V41X1507E	
L IB F/D	V41S1511E				V41X1506E	V41X1510E	V41S1512E				V41X1505E	
H OB F/D	V41S1391E				V41X1386E	V41X1388E	V41S1393E				V41X1385E	
H IB F/D	V41S1401E				V41X1406E	V41X1409E	V41S1412E				V41X1405E	
L HE ISO B	V41S1256E	V76X4173E		V76X4174E			V41S1266E					
C HE ISO B	V41S1156E		V76X4171E	V76X4172E			V41S1166E					
R HE ISO B	V41S1356E	V76X4175E	V76X4176E				V41S1366E					
L INT IN	V41S1262E		V76X4155E	V76X4156E			V41S1268E					
C INT IN	V41S1162E	V76X4151E	V76X4152E				V41S1168E					
R INT IN	V41S1362E	V76X4159E		V76X4158E			V41S1368E					
RTLS IBD		V76X4161E		V76X4163E	V41X1921E	V41X1927E						
RTLS OBD		V76X4162E		V76X4164E	V41X1911E	V41X1917E						
RTLS P 1/2		A V76X4165E		C V76X4166E	A V76X4167E		C V76X4168E					

Figure 5.2.2-IV.- Booster MPS display, MSK 1053 (sheet 2 of 3).

RTLS	R A	R C	P R	O P	P R	C L
INBD	V76X4161E	V76X4163E	V41X1921E	V41X1927E		
OTBD	V76X4162E	V76X4164E	V41X1911E	V41X1917E		
P1/2	A V76X4165E	C V76X4166E	A V76X4167E			CV76X4168E
H RECRC D			V41X1440E	V41X1419E	V41X1439E	
LH TOP			V41X1458E	V41X1453E		
LH HI PB			V41X1467E	V41X1468E		V41X1469E
POGO RC1					V41X1813E	V41X1818E
POGO RC2					V41X1823E	V41X1828E

LO 2% 2	T41X1761E
LO 98% 1	T41X1765E
LO 98% 2	T41X1766E
LO 99.85	T41X1767E
LO 100 1	T41X1768E
LO 100 2	T41X1769E
LO 100.15	T41X1770E
LO OV FIL	T41X1771E
LH 98% 1	T41X1715E
LH 98% 2	T41X1716E
LH OV FIL	T41X1743E

	L	C	R
RECRCV CL	V41X1210E	V41X1110E	V41X1310E

	SWITCH OPEN	SWITCH CLOSED
LHE ISO A	V41S1255E	V41S1265E
CHE ISO A	V41S1155E	V41S1165E
RHE ISO A	V41S1355E	V41S1365E
LO MANIF	V41S1535E	V41S1531E
LH MANIF	V41S1435E	V41S1431E
H PR LNV	V41S1493E	V41S1494E
PN HE IS	V41S1607E	V41S1609E
LHE XOV	V41S1613E	V41S1619E
PTSN B/C	V76X3050E	V76X3055E

	OPEN	CLOSE
L HPU A ISOV	B46X1851X	B46X1853X
L HPU B ISOV	B46X1852X	B46X1854X
GG A/B SOV C	B46X1861X	B46X1863X
GG A/B COV O	B46X1862X	B46X1864X
GG A HTR 1/2 O	B46X1908X	B46X1909X
GG B HTR 1/2 O	B46X1910X	B46X1911X
IGN S&A S/A	B55X1843X	B55X1842X
R HPU A ISOV	B46X2851X	B46X2853X
R HPU B ISOV	B46X2852X	B46X2854X
GG A/B SOV C	B46X2861X	B46X2863X
GG A/B COV O	B46X2862X	V46X2864X
GG A HTR 1/2 O	B46X2908X	V46X2909X
GG B HTR 1/2 O	B46X2910X	B46X2911X
IGN S&A S/A	B55X2843X	B55X2842X

PR V76S4601E SW V76S4605E	PASS		BFS	
	S	E	S	E
SW A	V90X7570X	V90X7554		
SIMC	B90X8333X	V90X8561X	V98X3532X	V98X3546X
AIAC	V90X8340X	V90X8259X	V98X0744X	V98X0752X
SW M	V90X7571X	V90X7556X	V98X0742X	V98X0748X
MN P B	V90X7572X	V90X7564X	V98X0743X	V98X0749X
SEP	V90X8331X	V90X8250X	V98X3534X	V98X3550X

Figure 5.2.2-IV.- BOOSTER MPS display, MSK 1053 (sheet 3 of 3).

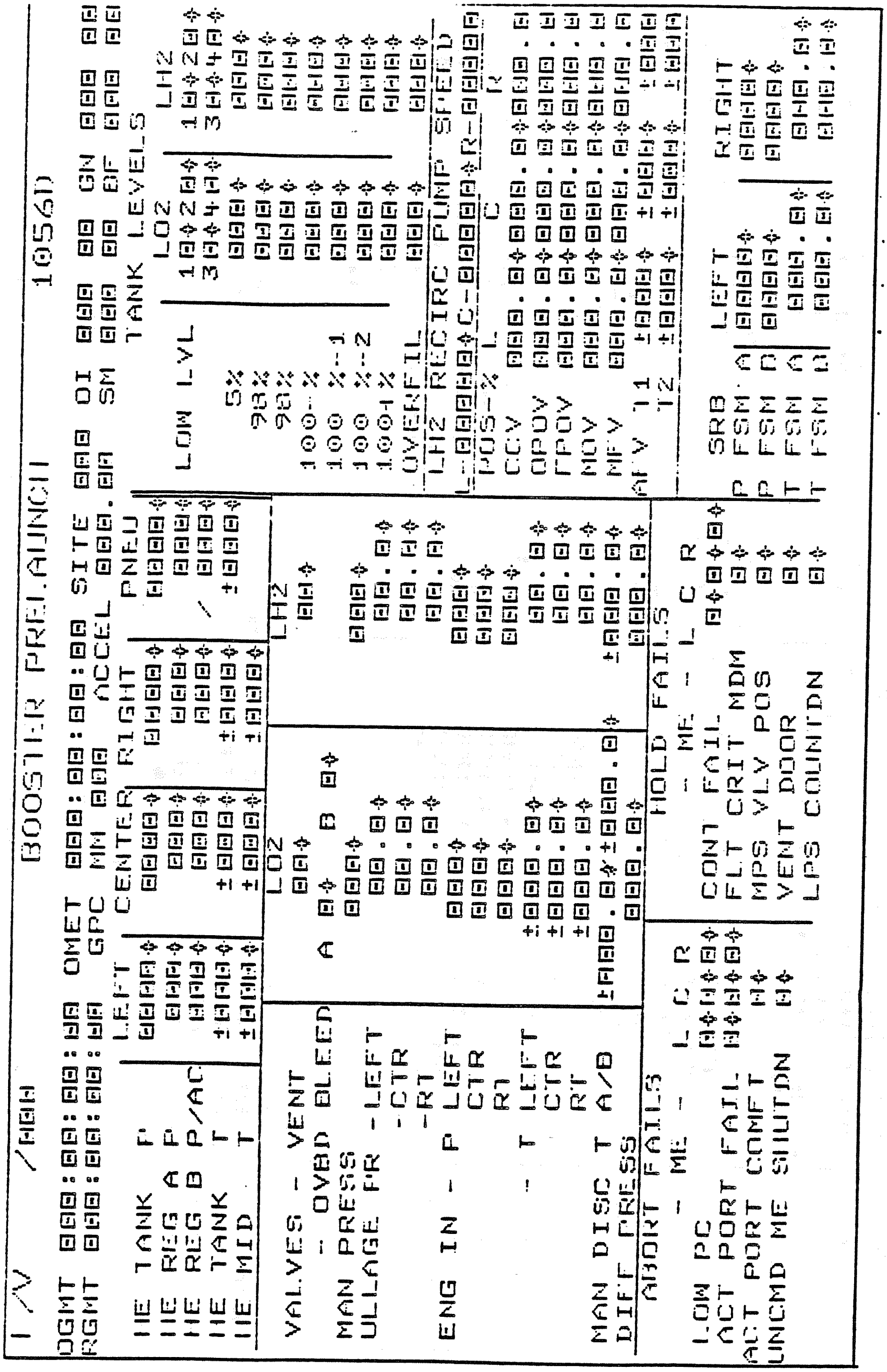


Figure 5.2.2-V.- Booster prelaunch display, MSK 1056 (sheet 1 of 2).

Item	Left	Center	Right	PNEU
HE TANK P	V41P1250C	V41P1150C	V41P1350C	V41P1600A
HE REG A P	V41P1254A	V41P1154C	V41P1354C	V41P1605A
HE REG B P/AC	V41P1253A	V41P1153A	V41P1353A	V41P1650A
HE TANK T	V41T1251A	V41T1151A	V41T1351A	V41T1011A
HE MID T	V41T1252A	V41T1152A	V41T1352A	

		LO2		LH2
Valves - VENT		T41X1774E	O/X	T41X17273/24E
OVBD BLEED	A/B	V41X1580X/81X		
MAN PRESS		V41P1533C		V41P1433C
Ullage PR-LEFT		T41P1751C		T41P1701C
-CTR		T41P1750C		T41P1700C
-RT		T41P1752C		T41P1702C
ENG IN-P-LEFT		V41P1230C		T41P1200C
CTR		V41P1130C		V41P1100C
RT		V41P1330C		V41P1300C
-T LEFT		V41T1231C		V41T1201C
CTR		V41T1131C		V41T1101C
RT		V41T1331C		V41T1301C
MAN DISCT A/B		V41T1528A/27A		V41T1428A
DIFF PRESS		V41P1464A		V41P1564A

Tank levels	LO2	LH2
LOW LVL 1/2	V41X1555X/56X	T41X1730X/31X
3/4	V41X1557X/58X	T41X1732X/33X
5%	T41X1762E	T41X1712E
98%	T41X1765E	T41X1715E
98%	T41X1766E	T41X1716E
100 - %	T41X1767E	T41X1717E
100 % - 1	T41X1768E	T41X1718E
100 % - 2	T41X1769E	T41X1719E
100 + %	T41X1770E	T41X1720E
OVERFILL	T41X1771E	T41X1721E

LH2 RECIRC PUMP SPEED

L - V41R1215A C - V41R1115A R - V41R1315A

POS - %	L	C	R
CCV	E41H2026B	E41H1026B	E41H3026B
OPOV	E41H2028B	E41H1028B	E41H3028B
FPOV	E41H2027B	E41H1027B	E41H3027B
MOV	E41H2025B	E41H1025B	E41H3025B
MFV	E41H2024B	E41H1024B	E41H3024B
AFV T1	E41T2155A	E41T1155A	E41T3155A
T2	E41T2156A	E41T1156A	E41T3156A

ABORT FAILS

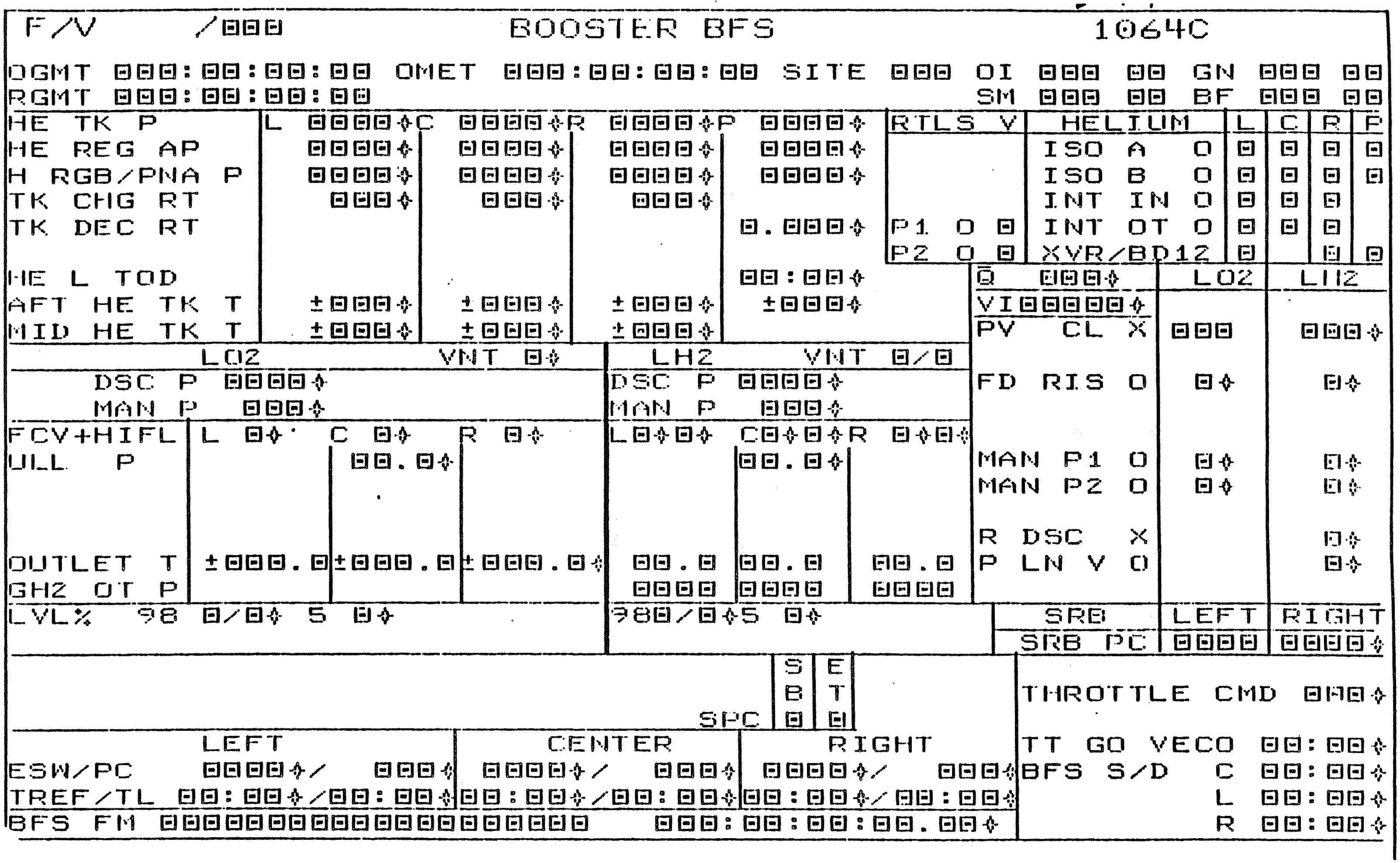
ME	L	C	R
LOW PC	V90X8774X	73X	75X
ACT PORT FAIL	V90X8777X	76X	78X
ACT PORT COMFT		V90X8772X	
VACMD MESD		V90X8771X	

HOLD FAILS

ME	L	C	R
CONT FAIL	V90X8680X	79X	81X
FLT CRIT MDM		V90X8767X	78X
MPS VLV POS		V90X8769X	
VENT DOOR		V90X8770X	
LPS COUNTDN		V90X8768X	

SRB	LEFT	RIGHT
P FSM A	B46P1305C	B46P2305C
P FSM B	B46P1306C	B46P2306C
T FSM A	B46T1501C	B46T2501C
T FSM B	B46T1502C	B46T2502C

Figure 5.2.2-V.- Booster prelaunch display, MSK 1056 (sheet 2 of 2).



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F/V      /□□□                  BOOSTER BFS                          1064C
OGMT □□□:□□:□□:□□ OMET □□□:□□:□□:□□ SITE □□□ OI □□□ □□ GN □□□ □□
RGMT □□□:□□:□□:□□                                SM □□□ □□ BF □□□ □□
HE TK P      |L □□□□◊C □□□□◊R □□□□◊P □□□□◊|RTLS V|  HELIUM   |L|C|R|P
HE REG AP    |  □□□□◊   □□□□◊  □□□□◊  □□□□◊|      | ISO A   O|□|□|□|□
H RGB/PNA P  |  □□□□◊   □□□□◊  □□□□◊  □□□□◊|      | ISO B   O|□|□|□|□
TK CHG RT    |   □□□◊    □□□◊   □□□◊       |      | INT IN  O|□|□|□|
TK DEC RT    |                       □.□□□◊|P1 O □| INT OT  O|□|□|□|
             |                             |P2 O □| XVR/BD12 |□| |□|□
HE L TOD     |                       □□:□□◊|Q̄  □□□◊   |  LO2  |  LH2
AFT HE TK T  | ±□□□◊   ±□□□◊  ±□□□◊  ±□□□◊ |VI□□□□□◊  |       |
MID HE TK T  | ±□□□◊   ±□□□◊  ±□□□◊        |PV    CL X| □□□   | □□□◊
       LO2              VNT □◊|  LH2        VNT □/□|
    DSC P □□□□◊                |DSC P □□□□◊         |FD  RIS O |  □◊   |  □◊
    MAN P  □□□◊                |MAN P  □□□◊         |
FCV+HIFL|L □◊  C □◊   R □◊     |L□◊□◊ C□◊□◊R □◊□◊   |
ULL  P  |       |□□.□◊|        |      |□□.□◊|       |MAN P1  O |  □◊   |  □◊
        |       |     |        |      |     |       |MAN P2  O |  □◊   |  □◊
        |       |     |        |      |     |       |
        |       |     |        |      |     |       |R DSC   X |       |  □◊
OUTLET T|±□□□.□|±□□□.□|±□□□.□◊| □□.□ |□□.□ | □□.□  |P LN V  O |       |  □◊
GH2 OT P|       |     |        | □□□□ |□□□□ | □□□□  |
LVL%  98 □/□◊ 5 □◊             |98□/□◊5 □◊              |  SRB   | LEFT | RIGHT
                               |                        | SRB PC | □□□□ | □□□□◊
                                          |S|E|
                                          |B|T|    THROTTLE CMD □□□◊
                                       SPC|□|□|
        LEFT          |     CENTER     |     RIGHT      |TT GO VECO  □□:□□◊
ESW/PC  □□□□◊/  □□□◊  |□□□□◊/  □□□◊    |□□□□◊/  □□□◊    |BFS S/D   C □□:□□◊
TREF/TL □□:□□◊/□□:□□◊ |□□:□□◊/□□:□□◊   |□□:□□◊/□□:□□◊   |          L □□:□□◊
BFS FM □□□□□□□□□□□□□□□□□□□□□□     □□□:□□:□□:□□.□□◊  |          R □□:□□◊
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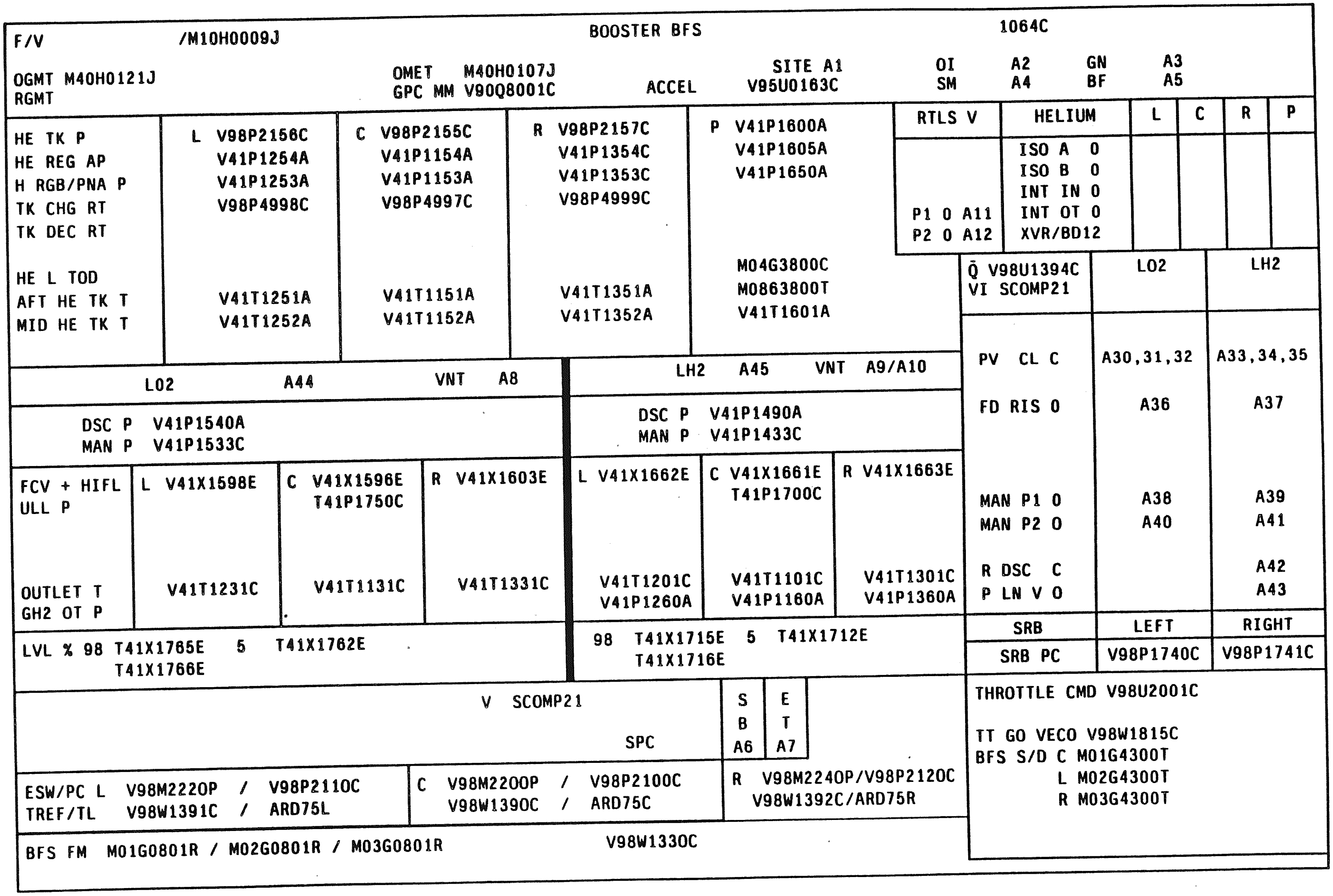
Figure 5.2.2-VI.- BFS display, MSK 1064 (sheet 1 of 2).



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F/V          /M10H0009J                 BOOSTER BFS                    1064C
OGMT M40H0121J        OMET   M40H0107J              SITE A1    OI    A2    GN    A3
RGMT                  GPC MM V90Q8001C      ACCEL   V95U0163C  SM    A4    BF    A5

HE TK P        L V98P2156C   C V98P2155C   R V98P2157C   P V41P1600A   RTLS V     HELIUM     L  C  R  P
HE REG AP        V41P1254A     V41P1154A     V41P1354C     V41P1605A              ISO A  0
H RGB/PNA P      V41P1253A     V41P1153A     V41P1353C     V41P1650A              ISO B  0
TK CHG RT        V98P4998C     V98P4997C     V98P4999C                            INT IN 0
TK DEC RT                                                              P1 0 A11   INT OT 0
                                                                       P2 0 A12   XVR/BD12
HE L TOD                                                   M04G3800C
AFT HE TK T      V41T1251A     V41T1151A     V41T1351A     M0863800T     Q̄ V98U1394C    LO2          LH2
MID HE TK T      V41T1252A     V41T1152A     V41T1352A     V41T1601A     VI SCOMP21

       LO2          A44          VNT   A8     LH2   A45   VNT   A9/A10     PV  CL C     A30,31,32    A33,34,35

   DSC P  V41P1540A                          DSC P  V41P1490A              FD RIS 0       A36          A37
   MAN P  V41P1533C                          MAN P  V41P1433C

FCV + HIFL  L V41X1598E  C V41X1596E  R V41X1603E  L V41X1662E  C V41X1661E  R V41X1663E
ULL P                      T41P1750C                              T41P1700C
                                                                                       MAN P1 0     A38          A39
                                                                                       MAN P2 0     A40          A41

OUTLET T      V41T1231C    V41T1131C    V41T1331C    V41T1201C    V41T1101C    V41T1301C    R DSC  C                  A42
GH2 OT P                                             V41P1260A    V41P1160A    V41P1360A    P LN V 0                  A43

LVL % 98 T41X1765E   5   T41X1762E    98  T41X1715E  5  T41X1712E     SRB          LEFT         RIGHT
         T41X1766E                        T41X1716E                   SRB PC       V98P1740C    V98P1741C

                            V  SCOMP21             S   E             THROTTLE CMD V98U2001C
                                                   B   T
                                       SPC         A6  A7            TT GO VECO V98W1815C
                                                                     BFS S/D C M01G4300T
ESW/PC L  V98M2220P / V98P2110C   C V98M2200P / V98P2100C   R V98M2240P/V98P2120C     L M02G4300T
TREF/TL   V98W1391C / ARD75L        V98W1390C / ARD75C        V98W1392C/ARD75R         R M03G4300T

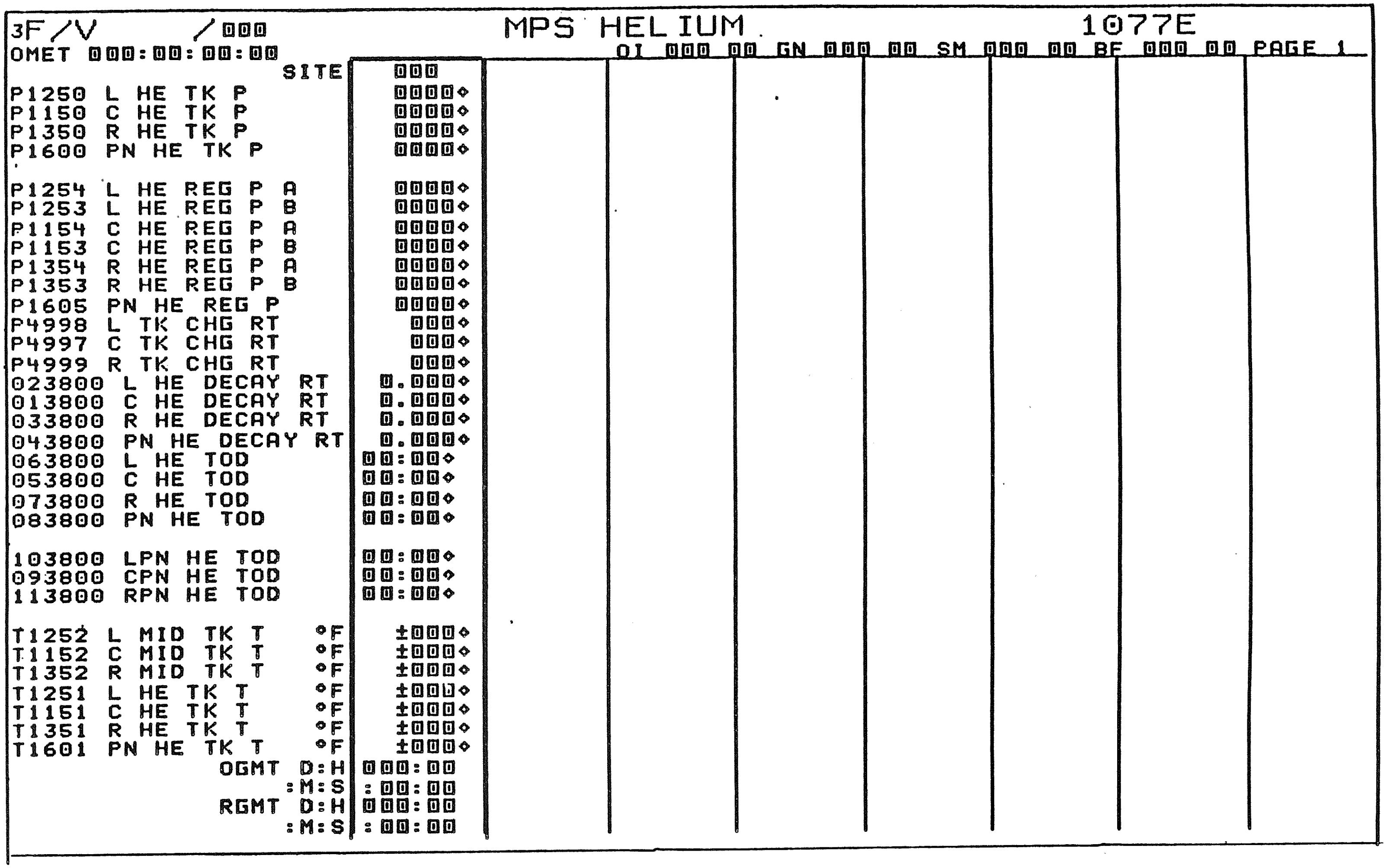
BFS FM  M01G0801R / M02G0801R / M03G0801R           V98W1330C
```

Note: For MSID's identified with an "A", see table 5.2.2-I.

Figure 5.2.2-VI.- BFS display, MSK 1064 (sheet 2 of 2).

TABLE 5.2.2-I.- BFS DISPLAYS

No.	MSID	Notes
A1	M10H0015J	
A2	V75X4070D	
	M40H0134J	(Static)
	M70H0135J	(Suspect)
A3	V93Q0022CY	
	M40H0234J	(Static)
	M40H0235J	(Suspect)
A4	V93Q0022CY	
	M40H0334J	(Static)
	M40H0335J	(Suspect)
A5	V98Q0009C	
	M40H0434J	(Static)
	M40H0435J	(Suspect)
A6	V98X3534X	
A7	V98X3550X	
A8	T41X1774E	
A9	T41X1727E	
A10	T41X1724E	
A11	V41X1901E	
A12	V41X1902E	
A13	V41X1258E	
A14	V41X11583	
A15	V41X1358E	
A16	V41X1645E	
A17	V41X1259E	
A18	V41X1159E	
A19	V41X1359E	
A20	V41X1646E	
A21	V41X1264E	
A22	V41X1164E	
A23	V41X1364E	
A24	V41X1270E	
A25	V41X1170E	
A26	V41X1370E	
A27	V41X614E	
A28	V41X1632E	
A29	V41X1634E	
A30	V41X1235E	
A31	V41X1135E	
A32	V41X1335E	
A33	V41X1205E	
A34	V41X1105E	
A35	V41X1305E	
A36	V41X1541E	
A37	V41X1441E	
A38	V41X1538E	
A39	V41X1436E	
A40	V41X1539E	
A41	V41X1438E	
A42	V41X1420E	
A43	V41X1492E	
A44	V41X1598E, V41X1596E, V41X1603E	
A45	V41X1662E, V41X1661E, V41X1663E	



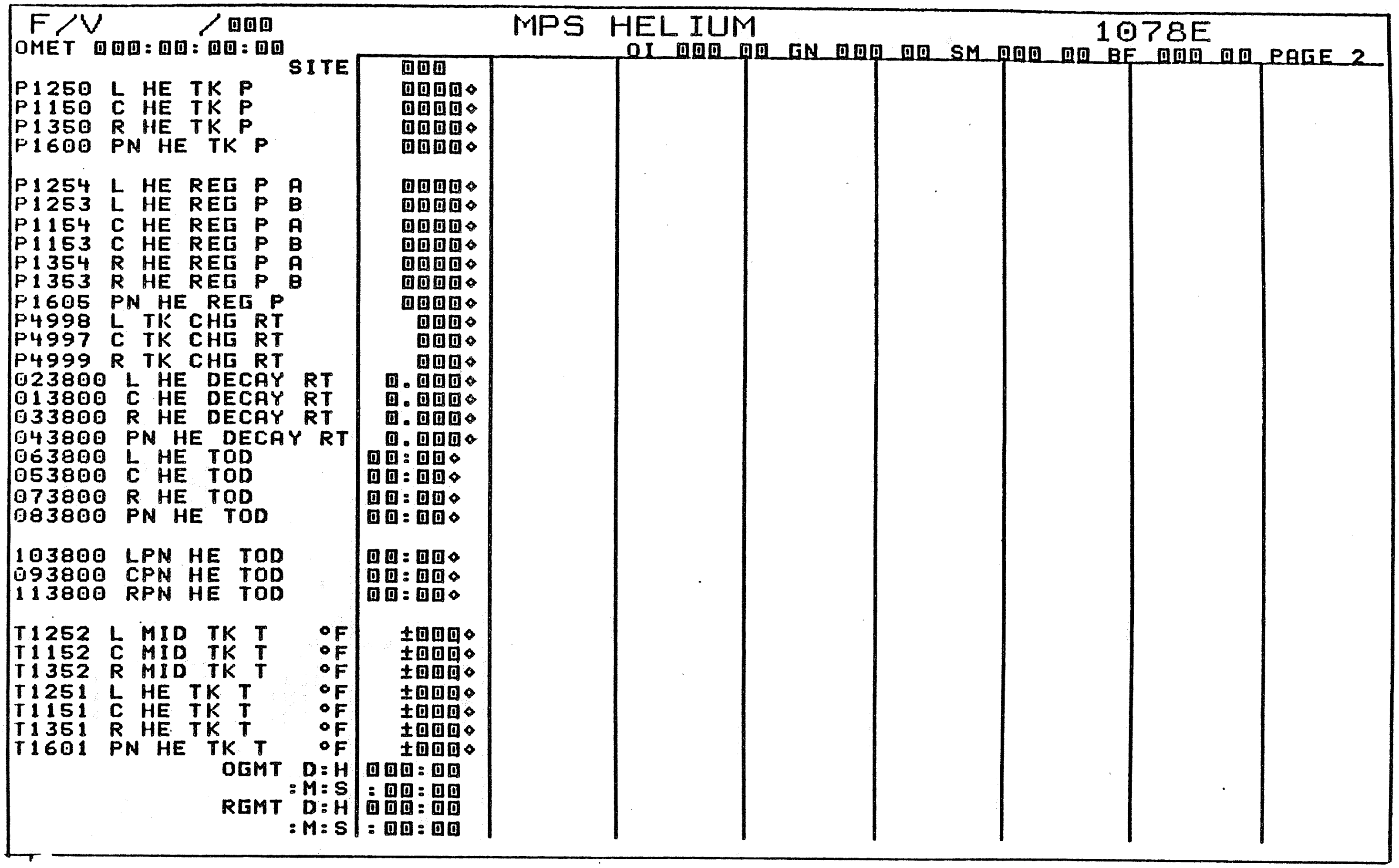
```
3F/V      /□□□               MPS HELIUM                    1077E
OMET □□□:□□:□□:□□              OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 1
                      SITE    □□□
P1250 L HE TK P              □□□□◇
P1150 C HE TK P              □□□□◇
P1350 R HE TK P              □□□□◇
P1600 PN HE TK P             □□□□◇

P1254 L HE REG P A           □□□□◇
P1253 L HE REG P B           □□□□◇
P1154 C HE REG P A           □□□□◇
P1153 C HE REG P B           □□□□◇
P1354 R HE REG P A           □□□□◇
P1353 R HE REG P B           □□□□◇
P1605 PN HE REG P            □□□□◇
P4998 L TK CHG RT             □□□◇
P4997 C TK CHG RT             □□□◇
P4999 R TK CHG RT             □□□◇
023800 L HE DECAY RT       □.□□□◇
013800 C HE DECAY RT       □.□□□◇
033800 R HE DECAY RT       □.□□□◇
043800 PN HE DECAY RT      □.□□□◇
063800 L HE TOD           □□:□□◇
053800 C HE TOD           □□:□□◇
073800 R HE TOD           □□:□□◇
083800 PN HE TOD          □□:□□◇

103800 LPN HE TOD         □□:□□◇
093800 CPN HE TOD         □□:□□◇
113800 RPN HE TOD         □□:□□◇

T1252 L MID TK T      °F     ±□□□◇
T1152 C MID TK T      °F     ±□□□◇
T1352 R MID TK T      °F     ±□□□◇
T1251 L HE TK T       °F     ±□□□◇
T1151 C HE TK T       °F     ±□□□◇
T1351 R HE TK T       °F     ±□□□◇
T1601 PN HE TK T      °F     ±□□□◇
              OGMT D:H  □□□:□□
                   :M:S  :□□:□□
              RGMT D:H  □□□:□□
                   :M:S  :□□:□□
```

Figure 5.2.2-VII.- History tab display, MSK 1077, 1078 (sheet 1 of 2).



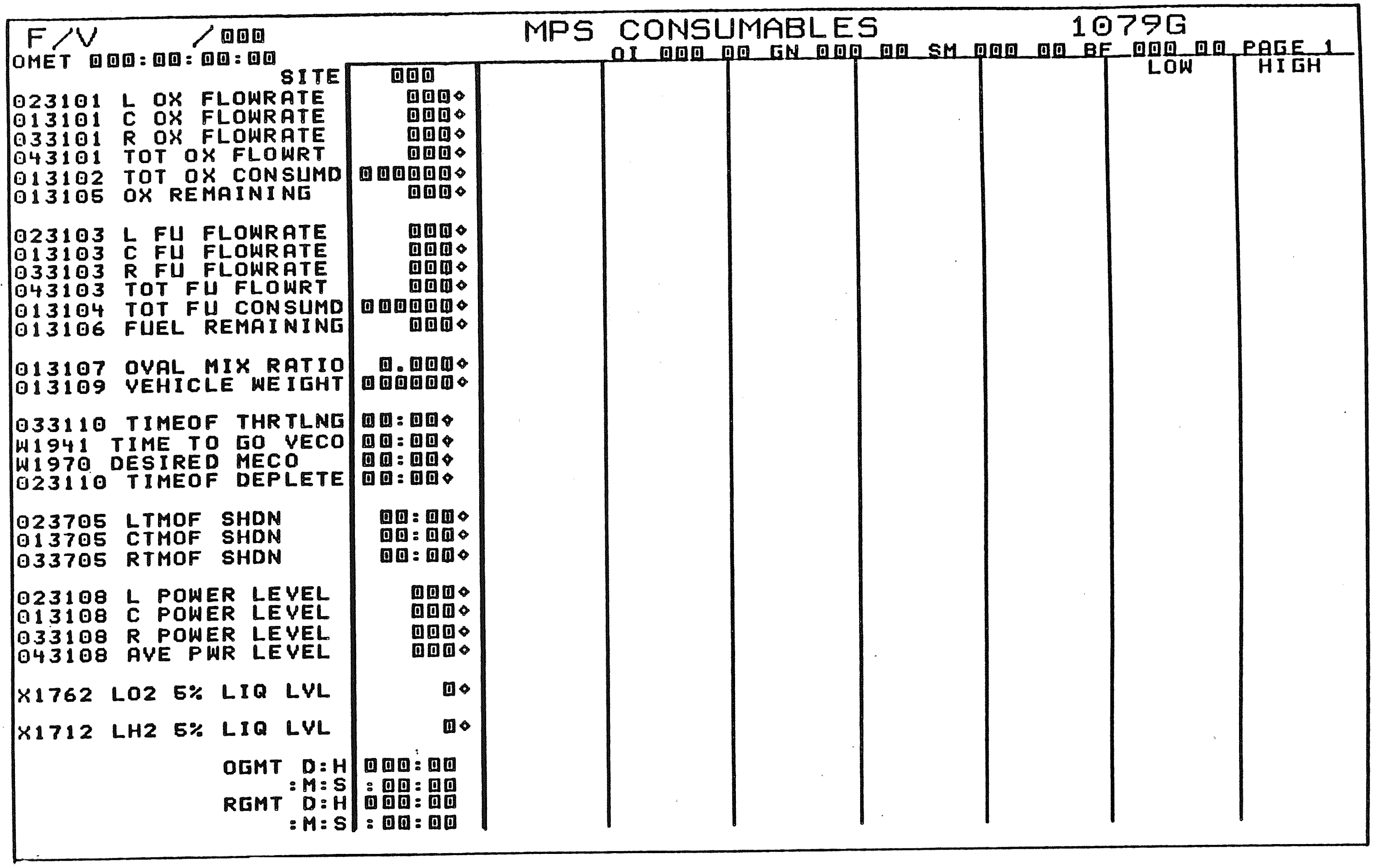
```
F/V       /□□□                  MPS HELIUM                    1078E
OMET □□□:□□:□□:□□                    OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 2
                  SITE   □□□
P1250 L HE TK P          □□□□◇
P1150 C HE TK P          □□□□◇
P1350 R HE TK P          □□□□◇
P1600 PN HE TK P         □□□□◇

P1254 L HE REG P A       □□□□◇
P1253 L HE REG P B       □□□□◇
P1154 C HE REG P A       □□□□◇
P1153 C HE REG P B       □□□□◇
P1354 R HE REG P A       □□□□◇
P1353 R HE REG P B       □□□□◇
P1605 PN HE REG P        □□□□◇
P4998 L TK CHG RT         □□□◇
P4997 C TK CHG RT         □□□◇
P4999 R TK CHG RT         □□□◇
023800 L HE DECAY RT   □.□□□◇
013800 C HE DECAY RT   □.□□□◇
033800 R HE DECAY RT   □.□□□◇
043800 PN HE DECAY RT  □.□□□◇
063800 L HE TOD       □□:□□◇
053800 C HE TOD       □□:□□◇
073800 R HE TOD       □□:□□◇
083800 PN HE TOD      □□:□□◇

103800 LPN HE TOD     □□:□□◇
093800 CPN HE TOD     □□:□□◇
113800 RPN HE TOD     □□:□□◇

T1252 L MID TK T    °F   ±□□□◇
T1152 C MID TK T    °F   ±□□□◇
T1352 R MID TK T    °F   ±□□□◇
T1251 L HE TK T     °F   ±□□□◇
T1151 C HE TK T     °F   ±□□□◇
T1351 R HE TK T     °F   ±□□□◇
T1601 PN HE TK T    °F   ±□□□◇
            OGMT D:H  □□□:□□
                 :M:S :□□:□□
            RGMT D:H  □□□:□□
                 :M:S :□□:□□
```

Figure 5.2.2-VII.- History tab display, MSK 1077, 1078 (sheet 2 of 2).



```
F/V        /☐☐☐                     MPS CONSUMABLES              1079G
OMET ☐☐☐:☐☐:☐☐:☐☐                OI ☐☐☐ ☐☐ GN ☐☐☐ ☐☐ SM ☐☐☐ ☐☐ BF ☐☐☐ ☐☐ PAGE 1
                        SITE    ☐☐☐                                   LOW     HIGH
023101 L OX FLOWRATE            ☐☐☐◇
013101 C OX FLOWRATE            ☐☐☐◇
033101 R OX FLOWRATE            ☐☐☐◇
043101 TOT OX FLOWRT            ☐☐☐◇
013102 TOT OX CONSUMD        ☐☐☐☐☐☐◇
013105 OX REMAINING             ☐☐☐◇

023103 L FU FLOWRATE            ☐☐☐◇
013103 C FU FLOWRATE            ☐☐☐◇
033103 R FU FLOWRATE            ☐☐☐◇
043103 TOT FU FLOWRT            ☐☐☐◇
013104 TOT FU CONSUMD        ☐☐☐☐☐☐◇
013106 FUEL REMAINING           ☐☐☐◇

013107 OVAL MIX RATIO         ☐.☐☐☐◇
013109 VEHICLE WEIGHT        ☐☐☐☐☐☐◇

033110 TIMEOF THRTLNG        ☐☐:☐☐◇
W1941 TIME TO GO VECO        ☐☐:☐☐◇
W1970 DESIRED MECO           ☐☐:☐☐◇
023110 TIMEOF DEPLETE        ☐☐:☐☐◇

023705 LTMOF SHDN              ☐☐:☐☐◇
013705 CTMOF SHDN              ☐☐:☐☐◇
033705 RTMOF SHDN              ☐☐:☐☐◇

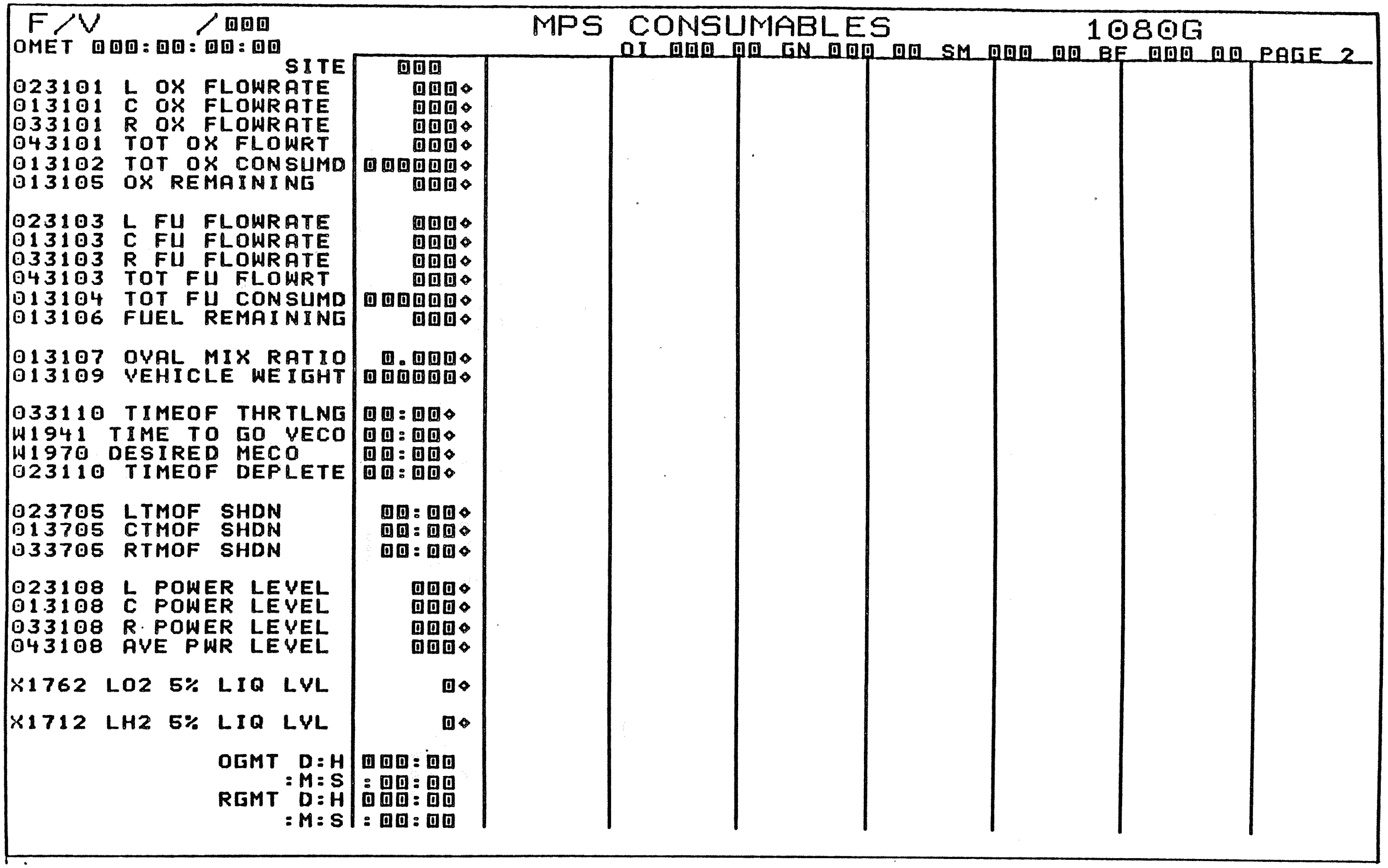
023108 L POWER LEVEL            ☐☐☐◇
013108 C POWER LEVEL            ☐☐☐◇
033108 R POWER LEVEL            ☐☐☐◇
043108 AVE PWR LEVEL            ☐☐☐◇

X1762 LO2 5% LIQ LVL              ☐◇

X1712 LH2 5% LIQ LVL              ☐◇

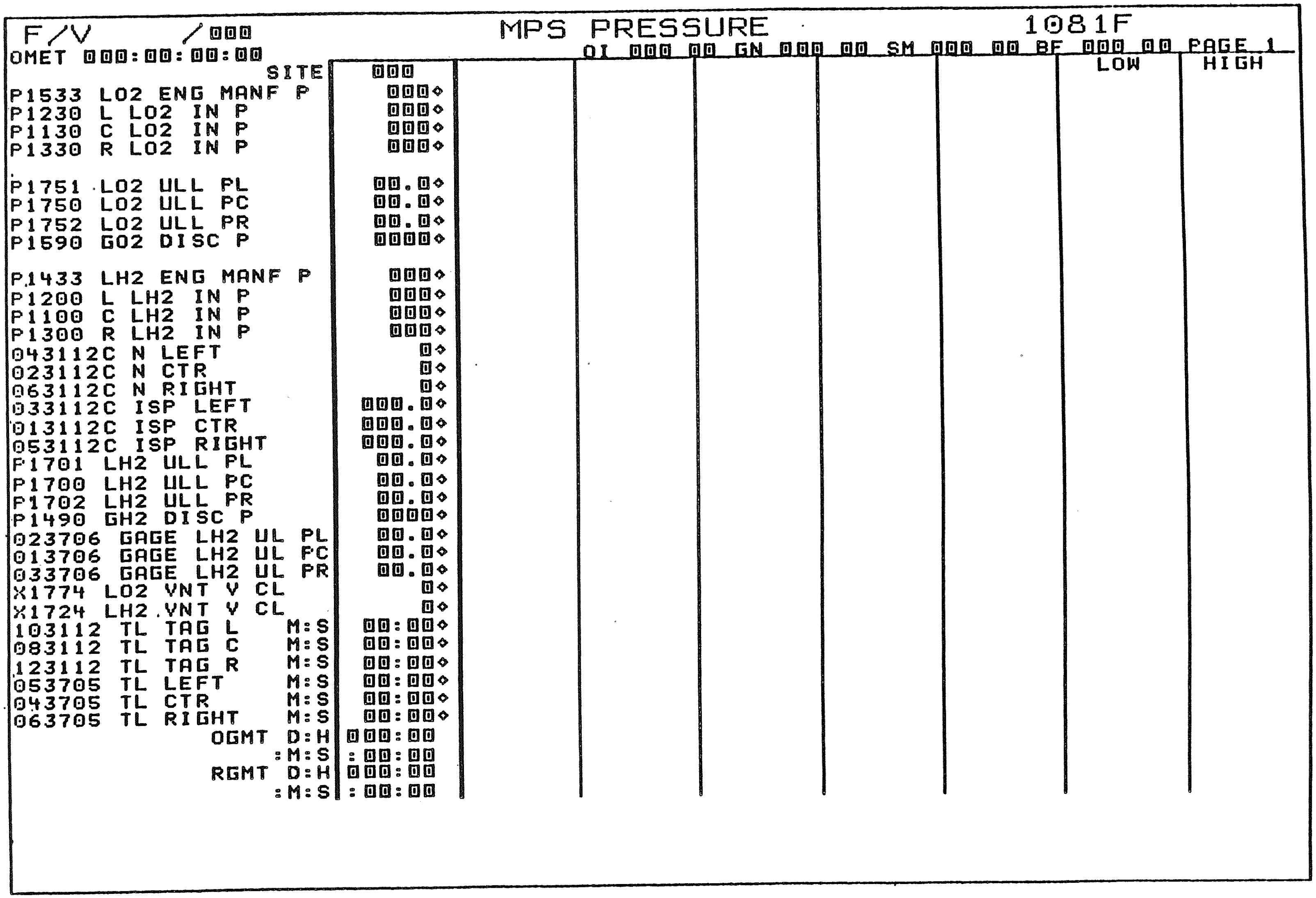
                OGMT D:H     ☐☐☐:☐☐
                     :M:S    :☐☐:☐☐
                RGMT D:H     ☐☐☐:☐☐
                     :M:S    :☐☐:☐☐
```

Figure 5.2.2-VIII.- History tab display MSK 1079 and 1080 (sheet 1 of 2).



```
F/V       /□□□                     MPS CONSUMABLES                 1080G
OMET □□□:□□:□□:□□                      OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 2
                   SITE|  □□□
023101 L OX FLOWRATE   |   □□□◇
013101 C OX FLOWRATE   |   □□□◇
033101 R OX FLOWRATE   |   □□□◇
043101 TOT OX FLOWRT   |   □□□◇
013102 TOT OX CONSUMD  |□□□□□□◇
013105 OX REMAINING    |   □□□◇
                       |
023103 L FU FLOWRATE   |   □□□◇
013103 C FU FLOWRATE   |   □□□◇
033103 R FU FLOWRATE   |   □□□◇
043103 TOT FU FLOWRT   |   □□□◇
013104 TOT FU CONSUMD  |□□□□□□◇
013106 FUEL REMAINING  |   □□□◇
                       |
013107 OVAL MIX RATIO  | □.□□□◇
013109 VEHICLE WEIGHT  |□□□□□□◇
                       |
033110 TIMEOF THRTLNG  |□□:□□◇
W1941 TIME TO GO VECO  |□□:□□◇
W1970 DESIRED MECO     |□□:□□◇
023110 TIMEOF DEPLETE  |□□:□□◇
                       |
023705 LTMOF SHDN      | □□:□□◇
013705 CTMOF SHDN      | □□:□□◇
033705 RTMOF SHDN      | □□:□□◇
                       |
023108 L POWER LEVEL   |   □□□◇
013108 C POWER LEVEL   |   □□□◇
033108 R POWER LEVEL   |   □□□◇
043108 AVE PWR LEVEL   |   □□□◇
                       |
X1762 LO2 5% LIQ LVL   |     □◇
                       |
X1712 LH2 5% LIQ LVL   |     □◇
                       |
            OGMT D:H   |□□□:□□
                 :M:S  |:□□:□□
            RGMT D:H   |□□□:□□
                 :M:S  |:□□:□□
```

Figure 5.2.2-VIII.- History tab display MSK 1079 and 1080 (sheet 2 of 2).

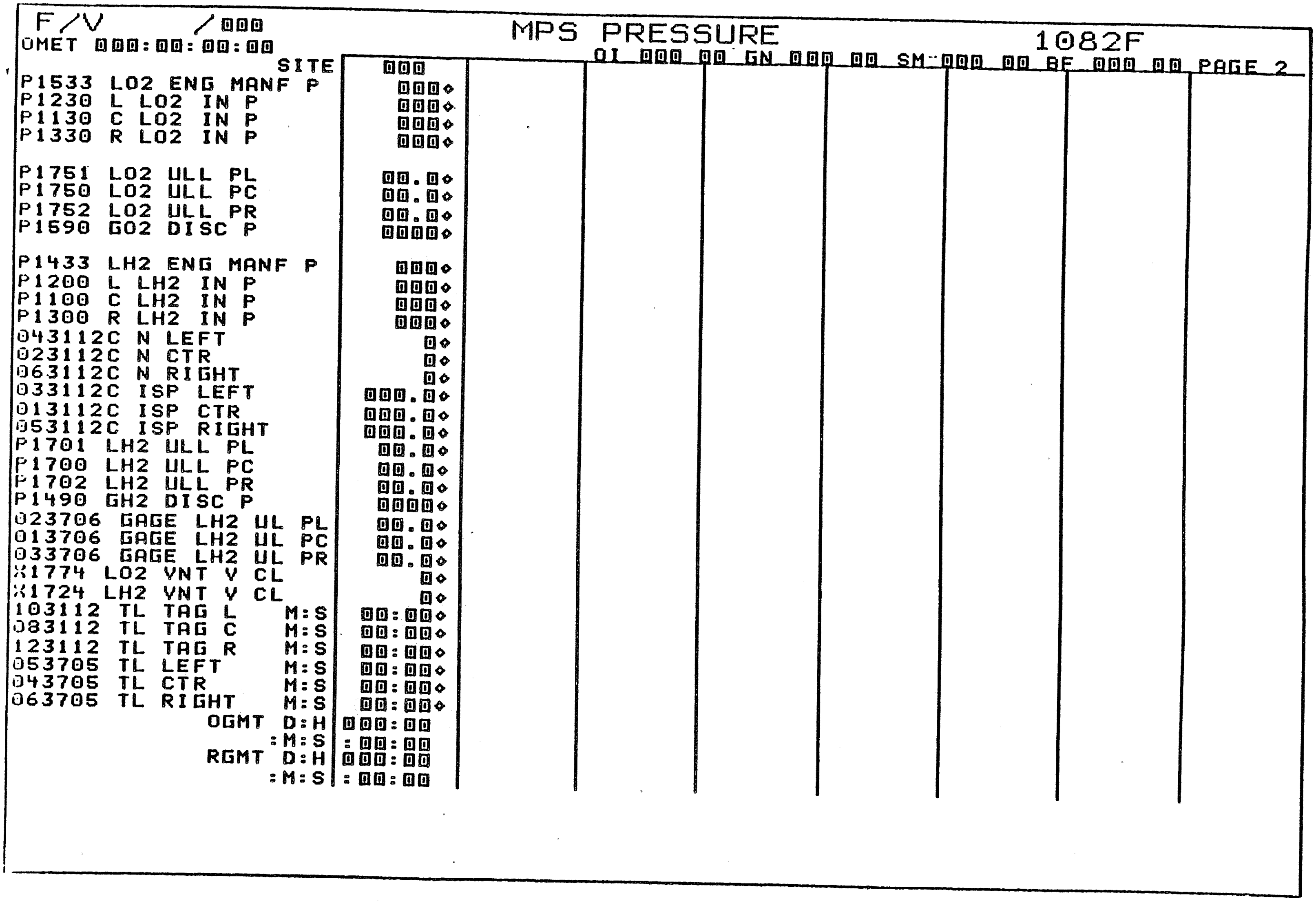


```
F/V       /□□□                  MPS PRESSURE                 1081F
OMET □□□:□□:□□:□□           OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 1
                    SITE   □□□                                      LOW    HIGH
P1533 LO2 ENG MANF P       □□□◇
P1230 L LO2 IN P           □□□◇
P1130 C LO2 IN P           □□□◇
P1330 R LO2 IN P           □□□◇

P1751 LO2 ULL PL          □□.□◇
P1750 LO2 ULL PC          □□.□◇
P1752 LO2 ULL PR          □□.□◇
P1590 GO2 DISC P          □□□□◇

P1433 LH2 ENG MANF P       □□□◇
P1200 L LH2 IN P           □□□◇
P1100 C LH2 IN P           □□□◇
P1300 R LH2 IN P           □□□◇
043112C N LEFT               □◇
023112C N CTR                □◇
063112C N RIGHT              □◇
033112C ISP LEFT         □□□.□◇
013112C ISP CTR          □□□.□◇
053112C ISP RIGHT        □□□.□◇
P1701 LH2 ULL PL          □□.□◇
P1700 LH2 ULL PC          □□.□◇
P1702 LH2 ULL PR          □□.□◇
P1490 GH2 DISC P          □□□□◇
023706 GAGE LH2 UL PL     □□.□◇
013706 GAGE LH2 UL PC     □□.□◇
033706 GAGE LH2 UL PR     □□.□◇
X1774 LO2 VNT V CL           □◇
X1724 LH2 VNT V CL           □◇
103112 TL TAG L     M:S  □□:□□◇
083112 TL TAG C     M:S  □□:□□◇
123112 TL TAG R     M:S  □□:□□◇
053705 TL LEFT      M:S  □□:□□◇
043705 TL CTR       M:S  □□:□□◇
063705 TL RIGHT     M:S  □□:□□◇
              OGMT  D:H □□□:□□
                    :M:S :□□:□□
              RGMT  D:H □□□:□□
                    :M:S :□□:□□
```

Figure 5.2.2-IX.- History tab display, MSK 1081 and 1082 (sheet 1 of 2).

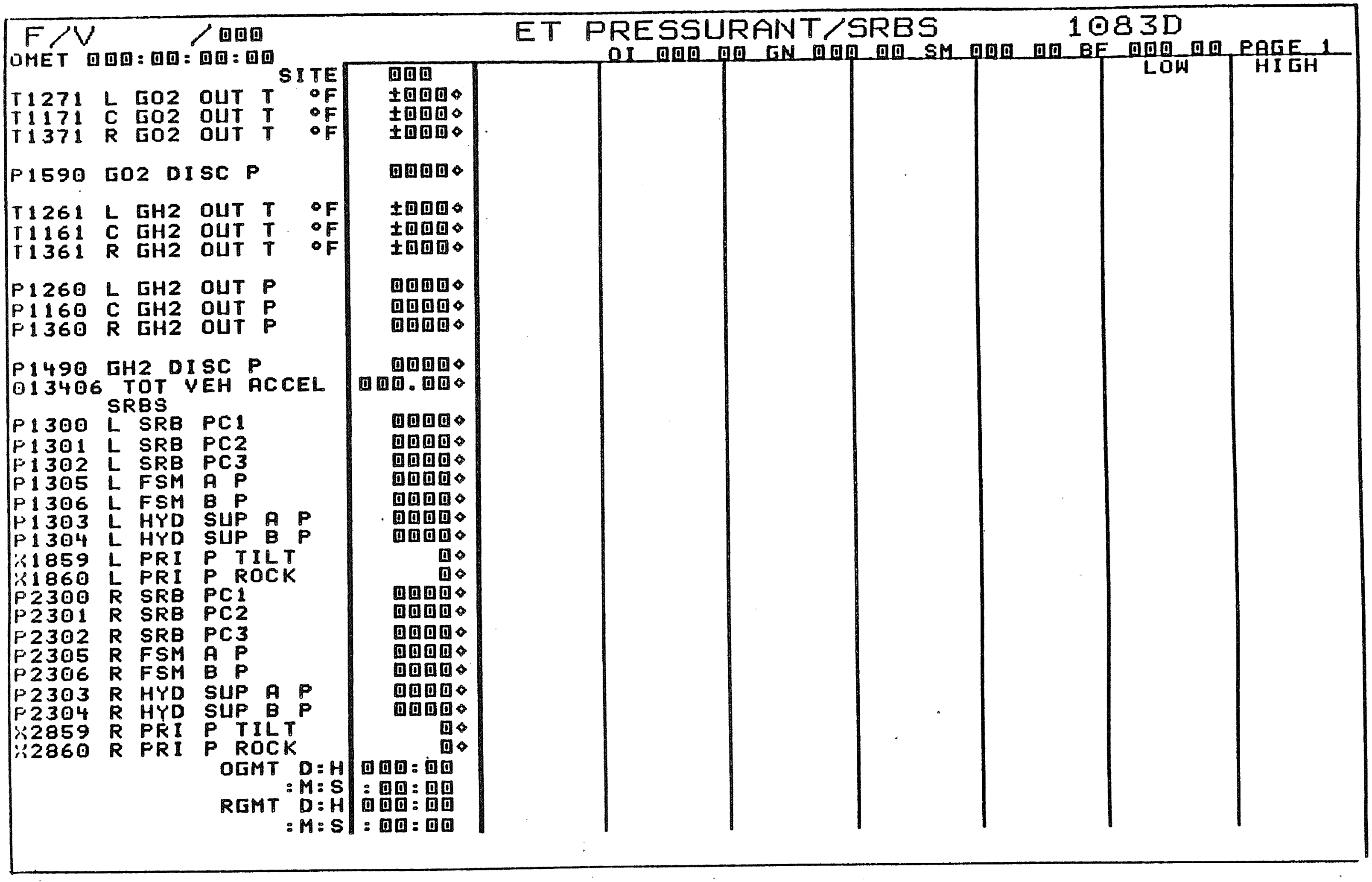


```
F/V        /□□□
OMET □□□:□□:□□:□□              MPS PRESSURE                1082F
                   SITE          OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 2
                           □□□
P1533 LO2 ENG MANF P      □□□◇
P1230 L LO2 IN P          □□□◇
P1130 C LO2 IN P          □□□◇
P1330 R LO2 IN P          □□□◇

P1751 LO2 ULL PL         □□.□◇
P1750 LO2 ULL PC         □□.□◇
P1752 LO2 ULL PR         □□.□◇
P1590 GO2 DISC P         □□□□◇

P1433 LH2 ENG MANF P      □□□◇
P1200 L LH2 IN P          □□□◇
P1100 C LH2 IN P          □□□◇
P1300 R LH2 IN P          □□□◇
043112C N LEFT              □◇
023112C N CTR               □◇
063112C N RIGHT             □◇
033112C ISP LEFT        □□□.□◇
013112C ISP CTR         □□□.□◇
053112C ISP RIGHT       □□□.□◇
P1701 LH2 ULL PL         □□.□◇
P1700 LH2 ULL PC         □□.□◇
P1702 LH2 ULL PR         □□.□◇
P1490 GH2 DISC P         □□□□◇
023706 GAGE LH2 UL PL    □□.□◇
013706 GAGE LH2 UL PC    □□.□◇
033706 GAGE LH2 UL PR    □□.□◇
X1774 LO2 VNT V CL          □◇
X1724 LH2 VNT V CL          □◇
103112 TL TAG L     M:S □□:□□◇
083112 TL TAG C     M:S □□:□□◇
123112 TL TAG R     M:S □□:□□◇
053705 TL LEFT      M:S □□:□□◇
043705 TL CTR       M:S □□:□□◇
063705 TL RIGHT     M:S □□:□□◇
            OGMT D:H □□□:□□
                :M:S :□□:□□
            RGMT D:H □□□:□□
                :M:S :□□:□□
```

Figure 5.2.2-IX.- History tab display, MSK 1081 and 1082 (sheet 2 of 2).



```
F/V      /□□□                        ET PRESSURANT/SRBS        1083D
OMET □□□:□□:□□:□□                 OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 1
                         SITE   □□□                                          LOW     HIGH
T1271  L  GO2  OUT  T    °F   ±□□□◇
T1171  C  GO2  OUT  T    °F   ±□□□◇
T1371  R  GO2  OUT  T    °F   ±□□□◇

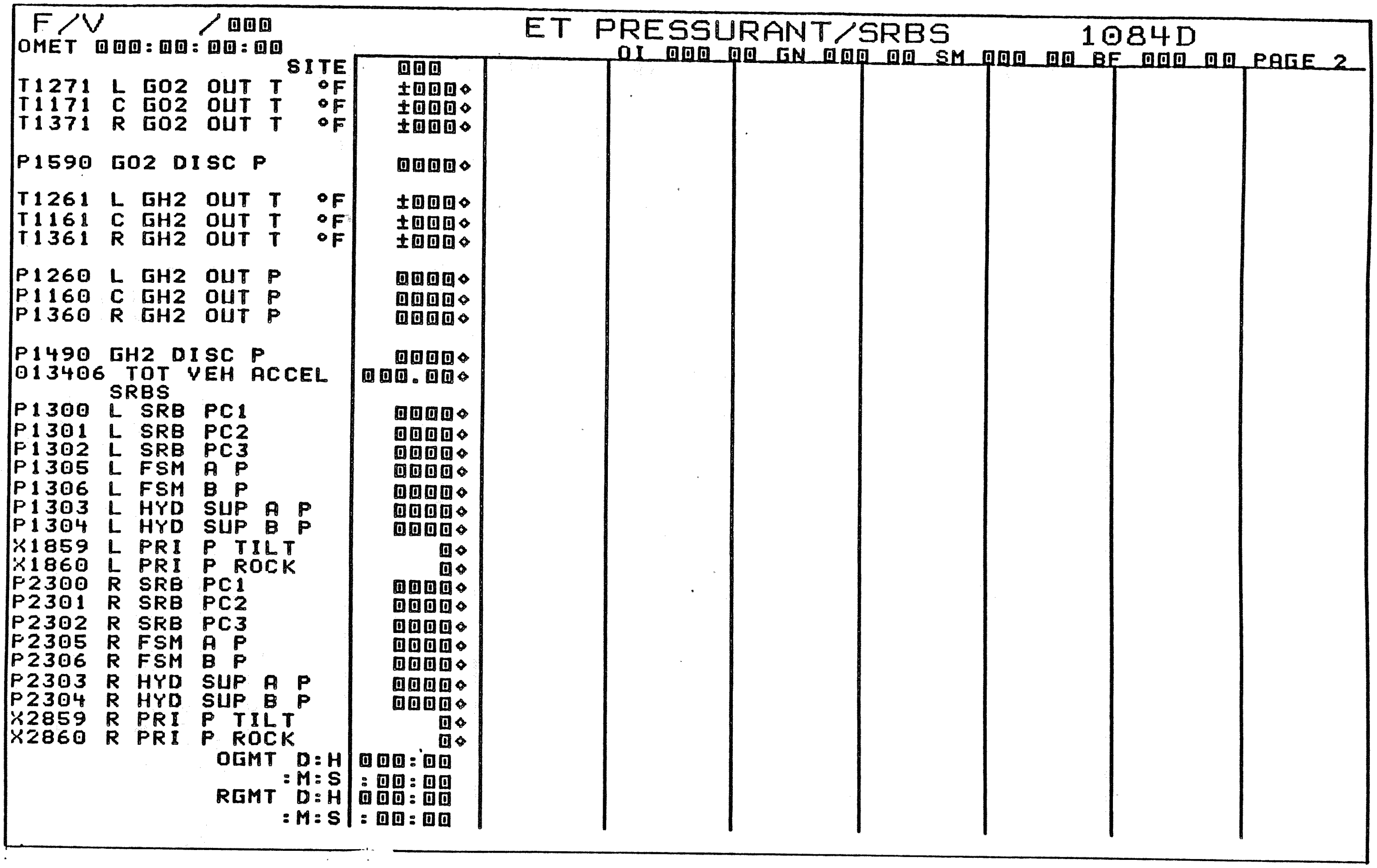
P1590  GO2  DISC  P           □□□□◇

T1261  L  GH2  OUT  T    °F   ±□□□◇
T1161  C  GH2  OUT  T    °F   ±□□□◇
T1361  R  GH2  OUT  T    °F   ±□□□◇

P1260  L  GH2  OUT  P         □□□□◇
P1160  C  GH2  OUT  P         □□□□◇
P1360  R  GH2  OUT  P         □□□□◇

P1490  GH2  DISC  P           □□□□◇
013406  TOT  VEH  ACCEL     □□□.□□◇
        SRBS
P1300  L  SRB  PC1            □□□□◇
P1301  L  SRB  PC2            □□□□◇
P1302  L  SRB  PC3            □□□□◇
P1305  L  FSM  A  P           □□□□◇
P1306  L  FSM  B  P           □□□□◇
P1303  L  HYD  SUP  A  P      □□□□◇
P1304  L  HYD  SUP  B  P      □□□□◇
X1859  L  PRI  P  TILT           □◇
X1860  L  PRI  P  ROCK           □◇
P2300  R  SRB  PC1            □□□□◇
P2301  R  SRB  PC2            □□□□◇
P2302  R  SRB  PC3            □□□□◇
P2305  R  FSM  A  P           □□□□◇
P2306  R  FSM  B  P           □□□□◇
P2303  R  HYD  SUP  A  P      □□□□◇
P2304  R  HYD  SUP  B  P      □□□□◇
X2859  R  PRI  P  TILT           □◇
X2860  R  PRI  P  ROCK           □◇
                 OGMT  D:H   □□□:□□
                       :M:S  :□□:□□
                 RGMT  D:H   □□□:□□
                       :M:S  :□□:□□
```

Figure 5.2.2-X.- History tab display, MSK 1083 and 1084 (sheet 1 of 2).



```
 F/V       /□□□                   ET PRESSURANT/SRBS        1084D
OMET □□□:□□:□□:□□                     OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 2
                    SITE   □□□
T1271 L GO2 OUT T   °F    ±□□□◇
T1171 C GO2 OUT T   °F    ±□□□◇
T1371 R GO2 OUT T   °F    ±□□□◇

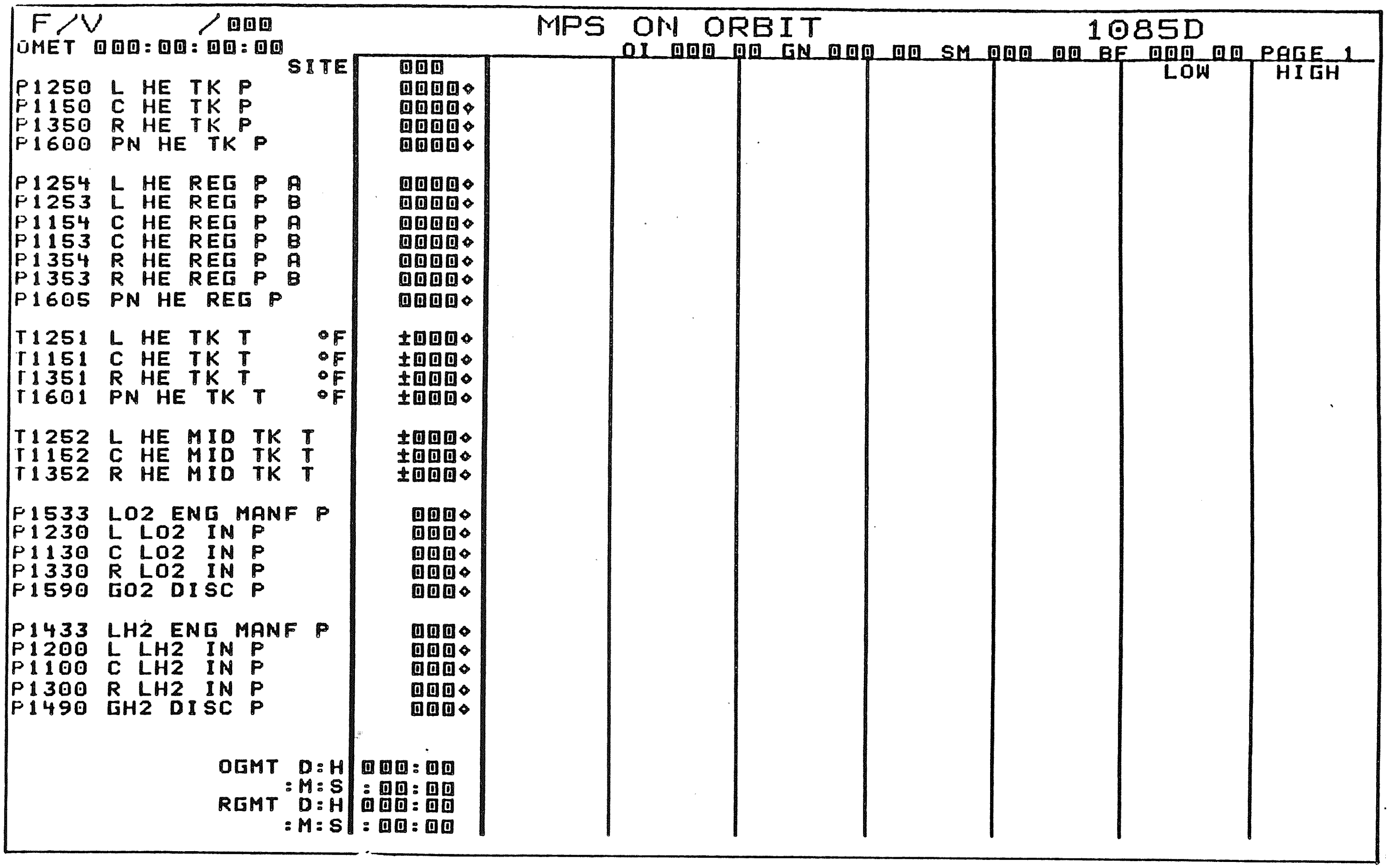
P1590 GO2 DISC P          □□□□◇

T1261 L GH2 OUT T   °F    ±□□□◇
T1161 C GH2 OUT T   °F    ±□□□◇
T1361 R GH2 OUT T   °F    ±□□□◇

P1260 L GH2 OUT P         □□□□◇
P1160 C GH2 OUT P         □□□□◇
P1360 R GH2 OUT P         □□□□◇

P1490 GH2 DISC P          □□□□◇
013406 TOT VEH ACCEL    □□□.□□◇
       SRBS
P1300 L SRB PC1           □□□□◇
P1301 L SRB PC2           □□□□◇
P1302 L SRB PC3           □□□□◇
P1305 L FSM A P           □□□□◇
P1306 L FSM B P           □□□□◇
P1303 L HYD SUP A P       □□□□◇
P1304 L HYD SUP B P       □□□□◇
X1859 L PRI P TILT           □◇
X1860 L PRI P ROCK           □◇
P2300 R SRB PC1           □□□□◇
P2301 R SRB PC2           □□□□◇
P2302 R SRB PC3           □□□□◇
P2305 R FSM A P           □□□□◇
P2306 R FSM B P           □□□□◇
P2303 R HYD SUP A P       □□□□◇
P2304 R HYD SUP B P       □□□□◇
X2859 R PRI P TILT           □◇
X2860 R PRI P ROCK           □◇
             OGMT D:H   □□□:□□
                  :M:S  :□□:□□
             RGMT D:H   □□□:□□
                  :M:S  :□□:□□
```

Figure 5.2.2-X.- History tab display, MSK 1083 and 1084 (sheet 2 of 2).



```
F/V       /□□□                        MPS ON ORBIT                     1085D
OMET □□□:□□:□□:□□              OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 1
                      SITE   □□□                                          LOW     HIGH
P1250 L HE TK P              □□□□◇
P1150 C HE TK P              □□□□◇
P1350 R HE TK P              □□□□◇
P1600 PN HE TK P             □□□□◇

P1254 L HE REG P A           □□□□◇
P1253 L HE REG P B           □□□□◇
P1154 C HE REG P A           □□□□◇
P1153 C HE REG P B           □□□□◇
P1354 R HE REG P A           □□□□◇
P1353 R HE REG P B           □□□□◇
P1605 PN HE REG P            □□□□◇

T1251 L HE TK T        °F    ±□□□◇
T1151 C HE TK T        °F    ±□□□◇
T1351 R HE TK T        °F    ±□□□◇
T1601 PN HE TK T       °F    ±□□□◇

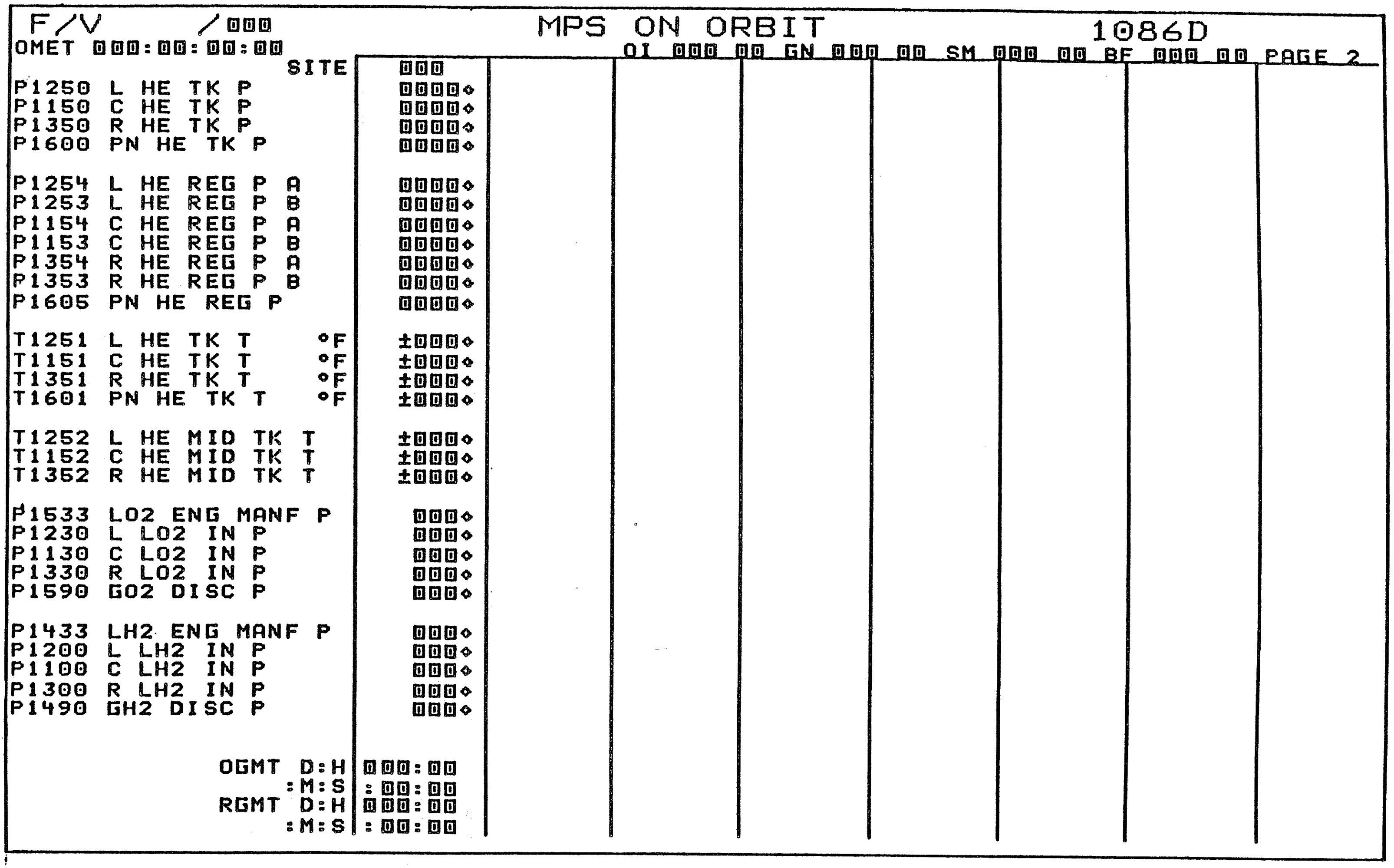
T1252 L HE MID TK T          ±□□□◇
T1152 C HE MID TK T          ±□□□◇
T1352 R HE MID TK T          ±□□□◇

P1533 LO2 ENG MANF P          □□□◇
P1230 L LO2 IN P              □□□◇
P1130 C LO2 IN P              □□□◇
P1330 R LO2 IN P              □□□◇
P1590 GO2 DISC P              □□□◇

P1433 LH2 ENG MANF P          □□□◇
P1200 L LH2 IN P              □□□◇
P1100 C LH2 IN P              □□□◇
P1300 R LH2 IN P              □□□◇
P1490 GH2 DISC P              □□□◇

                 OGMT  D:H  □□□:□□
                       :M:S  :□□:□□
                 RGMT  D:H  □□□:□□
                       :M:S  :□□:□□
```

Figure 5.2.2-XI.- History tab display, MSK 1085 and 1086 (sheet 1 of 2).



```
F/V       /□□□                       MPS ON ORBIT                    1086D
OMET □□□:□□:□□:□□                  OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 2
                        SITE  □□□
P1250 L HE TK P               □□□□◇
P1150 C HE TK P               □□□□◇
P1350 R HE TK P               □□□□◇
P1600 PN HE TK P              □□□□◇

P1254 L HE REG P A            □□□□◇
P1253 L HE REG P B            □□□□◇
P1154 C HE REG P A            □□□□◇
P1153 C HE REG P B            □□□□◇
P1354 R HE REG P A            □□□□◇
P1353 R HE REG P B            □□□□◇
P1605 PN HE REG P             □□□□◇

T1251 L HE TK T       °F      ±□□□◇
T1151 C HE TK T       °F      ±□□□◇
T1351 R HE TK T       °F      ±□□□◇
T1601 PN HE TK T      °F      ±□□□◇

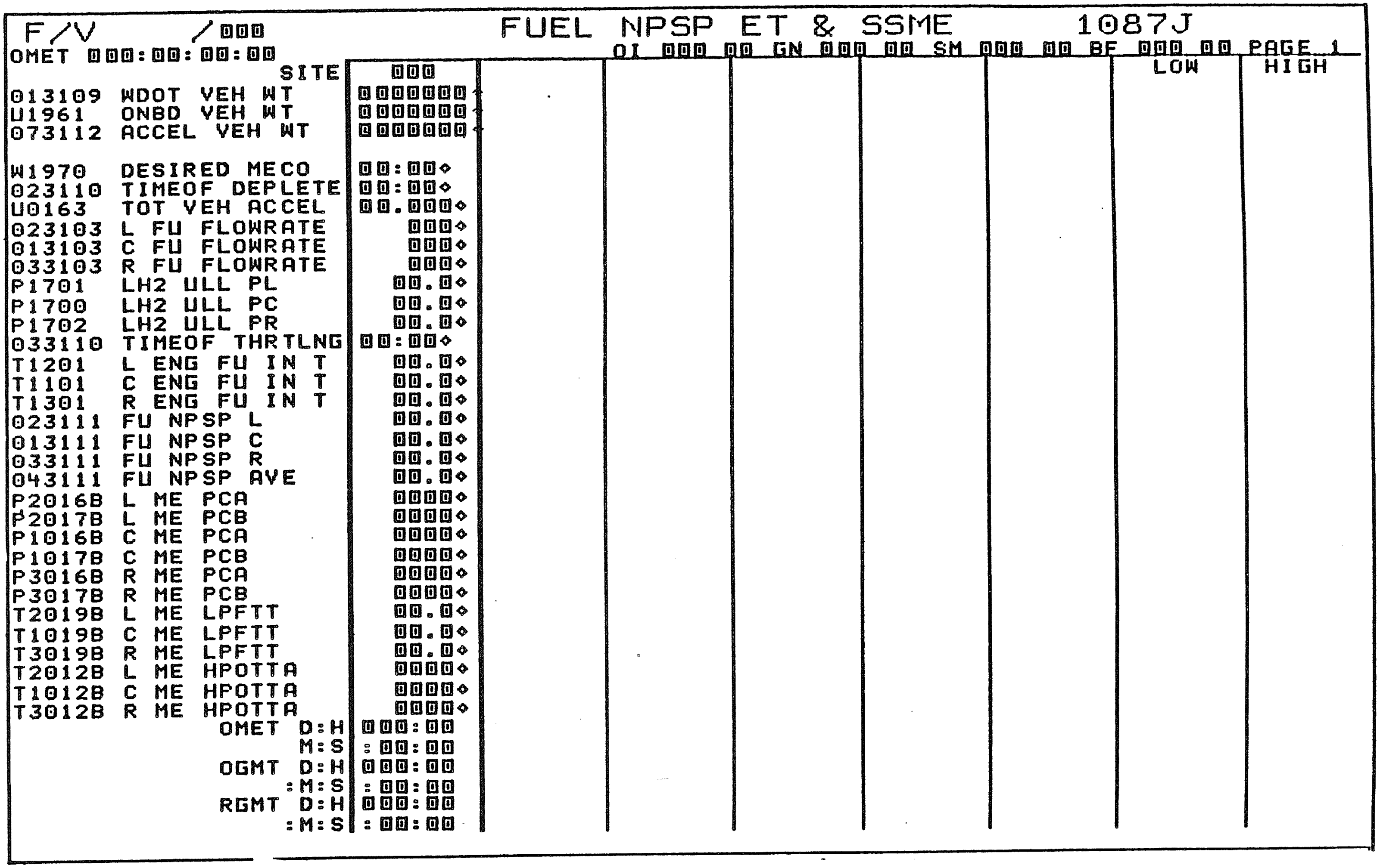
T1252 L HE MID TK T           ±□□□◇
T1152 C HE MID TK T           ±□□□◇
T1352 R HE MID TK T           ±□□□◇

P1533 LO2 ENG MANF P           □□□◇
P1230 L LO2 IN P               □□□◇
P1130 C LO2 IN P               □□□◇
P1330 R LO2 IN P               □□□◇
P1590 GO2 DISC P               □□□◇

P1433 LH2 ENG MANF P           □□□◇
P1200 L LH2 IN P               □□□◇
P1100 C LH2 IN P               □□□◇
P1300 R LH2 IN P               □□□◇
P1490 GH2 DISC P               □□□◇

                  OGMT D:H  □□□:□□
                       :M:S  :□□:□□
                  RGMT D:H  □□□:□□
                       :M:S  :□□:□□
```

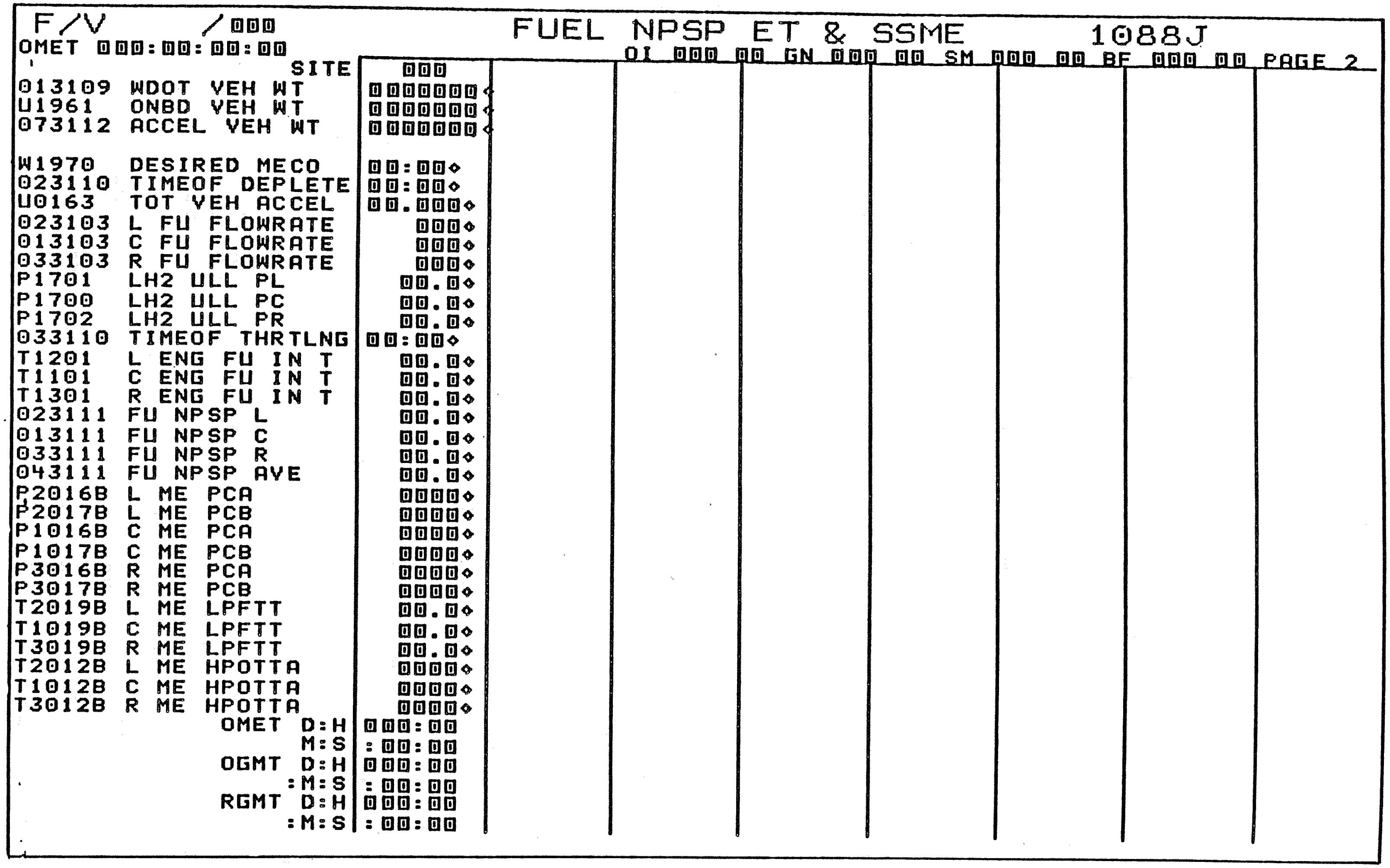
Figure 5.2.2-XI.- History tab display, MSK 1085 and 1086 (sheet 2 of 2).



```
 F/V       /□□□                 FUEL NPSP ET & SSME      1087J
OMET □□□:□□:□□:□□                      OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 1
                     SITE   □□□                                           LOW   HIGH
013109 WDOT  VEH  WT     □□□□□□□◇
U1961  ONBD  VEH  WT     □□□□□□□◇
073112 ACCEL  VEH  WT    □□□□□□□◇

W1970  DESIRED MECO      □□:□□◇
023110 TIMEOF DEPLETE    □□:□□◇
U0163  TOT VEH ACCEL     □□.□□□◇
023103 L FU FLOWRATE       □□□◇
013103 C FU FLOWRATE       □□□◇
033103 R FU FLOWRATE       □□□◇
P1701  LH2 ULL PL         □□.□◇
P1700  LH2 ULL PC         □□.□◇
P1702  LH2 ULL PR         □□.□◇
033110 TIMEOF THRTLNG    □□:□□◇
T1201  L ENG FU IN T      □□.□◇
T1101  C ENG FU IN T      □□.□◇
T1301  R ENG FU IN T      □□.□◇
023111 FU NPSP L          □□.□◇
013111 FU NPSP C          □□.□◇
033111 FU NPSP R          □□.□◇
043111 FU NPSP AVE        □□.□◇
P2016B L ME PCA           □□□□◇
P2017B L ME PCB           □□□□◇
P1016B C ME PCA           □□□□◇
P1017B C ME PCB           □□□□◇
P3016B R ME PCA           □□□□◇
P3017B R ME PCB           □□□□◇
T2019B L ME LPFTT         □□.□◇
T1019B C ME LPFTT         □□.□◇
T3019B R ME LPFTT         □□.□◇
T2012B L ME HPOTTA        □□□□◇
T1012B C ME HPOTTA        □□□□◇
T3012B R ME HPOTTA        □□□□◇
              OMET  D:H  □□□:□□
                     M:S :□□:□□
              OGMT  D:H  □□□:□□
                    :M:S :□□:□□
              RGMT  D:H  □□□:□□
                    :M:S :□□:□□
```

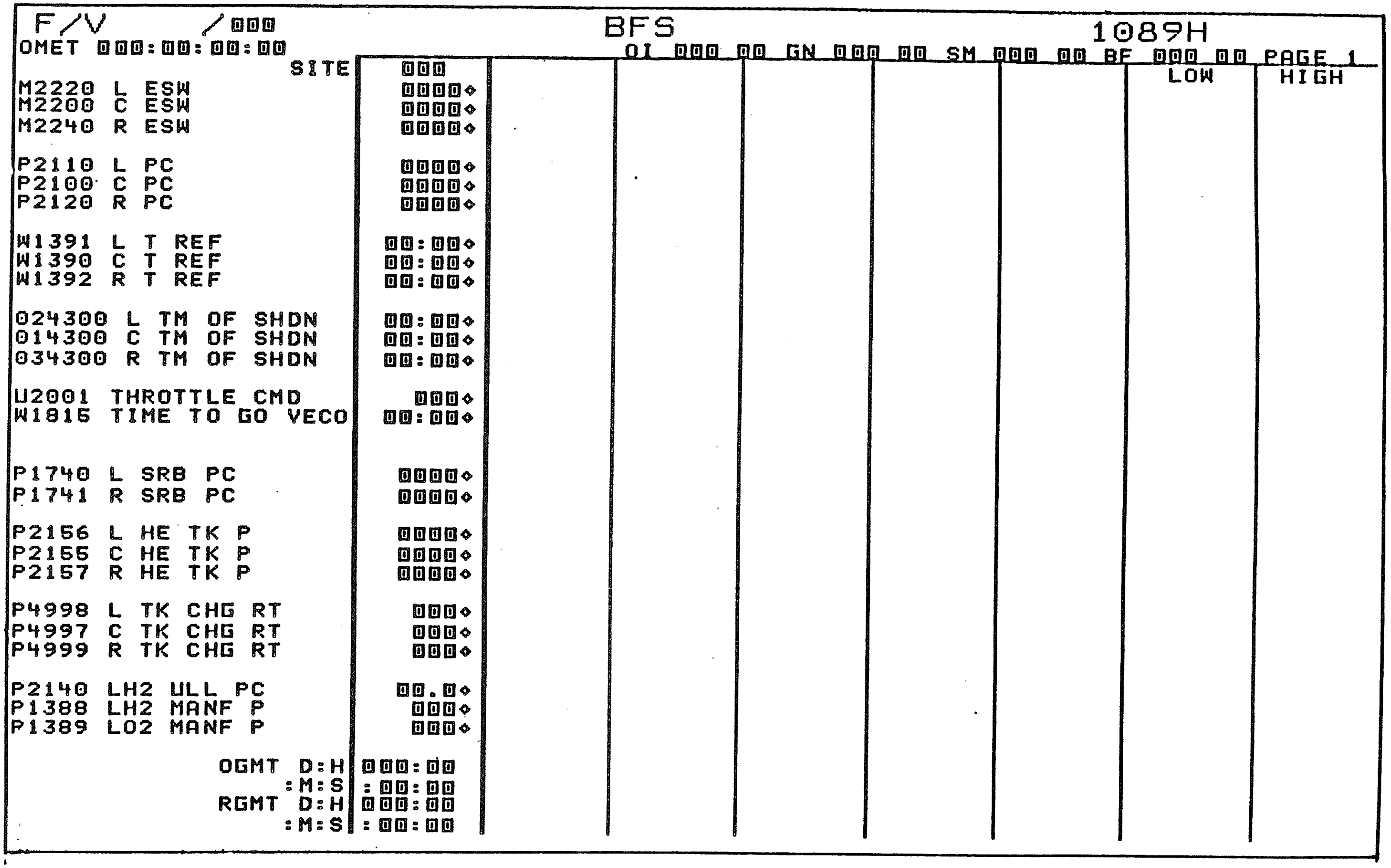
Figure 5.2.2-XII.- History tab display, MSK 1087 and 1088 (sheet 1 of 2).



```
F/V        /□□□                FUEL NPSP ET & SSME        1088J
OMET □□□:□□:□□:□□                 OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 2
                         SITE  □□□
013109  WDOT  VEH  WT          □□□□□□□◇
U1961   ONBD  VEH  WT          □□□□□□□◇
073112  ACCEL  VEH  WT         □□□□□□□◇

W1970   DESIRED MECO           □□:□□◇
023110  TIMEOF DEPLETE         □□:□□◇
U0163   TOT VEH ACCEL          □□.□□□◇
023103  L FU FLOWRATE             □□□◇
013103  C FU FLOWRATE             □□□◇
033103  R FU FLOWRATE             □□□◇
P1701   LH2 ULL PL              □□.□◇
P1700   LH2 ULL PC              □□.□◇
P1702   LH2 ULL PR              □□.□◇
033110  TIMEOF THRTLNG         □□:□□◇
T1201   L ENG FU IN T           □□.□◇
T1101   C ENG FU IN T           □□.□◇
T1301   R ENG FU IN T           □□.□◇
023111  FU NPSP L               □□.□◇
013111  FU NPSP C               □□.□◇
033111  FU NPSP R               □□.□◇
043111  FU NPSP AVE             □□.□◇
P2016B  L ME PCA                □□□□◇
P2017B  L ME PCB                □□□□◇
P1016B  C ME PCA                □□□□◇
P1017B  C ME PCB                □□□□◇
P3016B  R ME PCA                □□□□◇
P3017B  R ME PCB                □□□□◇
T2019B  L ME LPFTT              □□.□◇
T1019B  C ME LPFTT              □□.□◇
T3019B  R ME LPFTT              □□.□◇
T2012B  L ME HPOTTA             □□□□◇
T1012B  C ME HPOTTA             □□□□◇
T3012B  R ME HPOTTA             □□□□◇
                 OMET  D:H     □□□:□□
                         M:S   :□□:□□
                 OGMT  D:H     □□□:□□
                        :M:S   :□□:□□
                 RGMT  D:H     □□□:□□
                        :M:S   :□□:□□
```

Figure 5.2.2-XII.- History tab display, MSK 1087 and 1088 (sheet 2 of 2).



```
F/V      /□□□                       BFS                      1089H
OMET □□□:□□:□□:□□       OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 1
                   SITE   □□□                                 LOW     HIGH
M2220 L ESW             □□□□◇
M2200 C ESW             □□□□◇
M2240 R ESW             □□□□◇

P2110 L PC              □□□□◇
P2100 C PC              □□□□◇
P2120 R PC              □□□□◇

W1391 L T REF          □□:□□◇
W1390 C T REF          □□:□□◇
W1392 R T REF          □□:□□◇

024300 L TM OF SHDN    □□:□□◇
014300 C TM OF SHDN    □□:□□◇
034300 R TM OF SHDN    □□:□□◇

U2001 THROTTLE CMD        □□□◇
W1815 TIME TO GO VECO  □□:□□◇

P1740 L SRB PC          □□□□◇
P1741 R SRB PC          □□□□◇

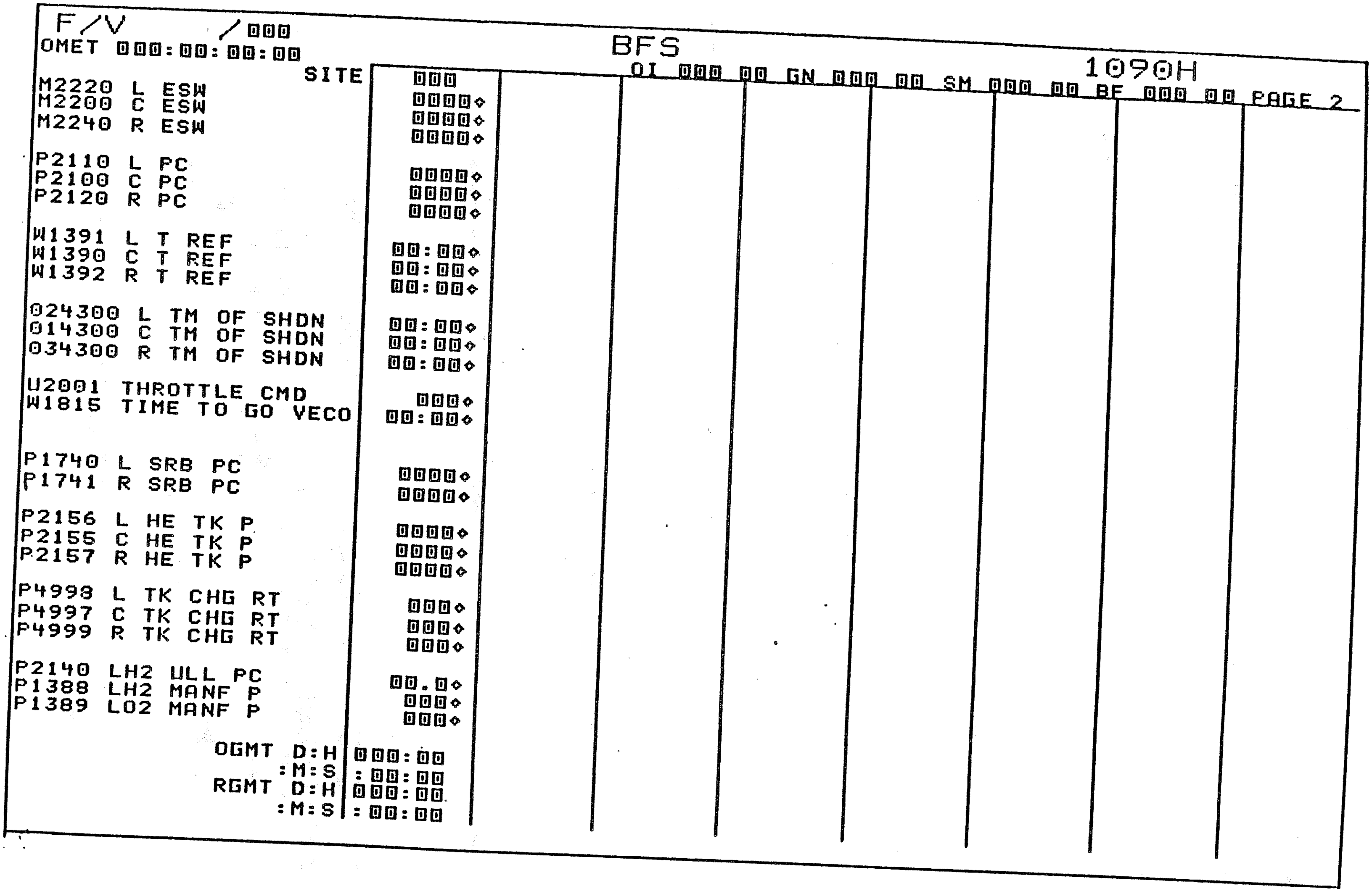
P2156 L HE TK P         □□□□◇
P2155 C HE TK P         □□□□◇
P2157 R HE TK P         □□□□◇

P4998 L TK CHG RT        □□□◇
P4997 C TK CHG RT        □□□◇
P4999 R TK CHG RT        □□□◇

P2140 LH2 ULL PC        □□.□◇
P1388 LH2 MANF P         □□□◇
P1389 LO2 MANF P         □□□◇

          OGMT D:H  □□□:□□
                :M:S  :□□:□□
          RGMT D:H  □□□:□□
                :M:S  :□□:□□
```

Figure 5.2.2-XIII.- History tab display, MSK 1089 and 1090 (sheet 1 of 2).



```
F/V          /□□□
OMET □□□:□□:□□:□□               BFS                         1090H
                          SITE │      OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□ PAGE 2
M2220  L  ESW            □□□   │
M2200  C  ESW           □□□□◇  │
M2240  R  ESW           □□□□◇  │
                        □□□□◇  │
P2110  L  PC                   │
P2100  C  PC            □□□□◇  │
P2120  R  PC            □□□□◇  │
                        □□□□◇  │
W1391  L  T  REF               │
W1390  C  T  REF       □□:□□◇  │
W1392  R  T  REF       □□:□□◇  │
                       □□:□□◇  │
024300 L  TM OF SHDN   □□:□□◇  │
014300 C  TM OF SHDN   □□:□□◇  │
034300 R  TM OF SHDN   □□:□□◇  │
U2001  THROTTLE CMD      □□□◇  │
W1815  TIME TO GO VECO □□:□□◇  │

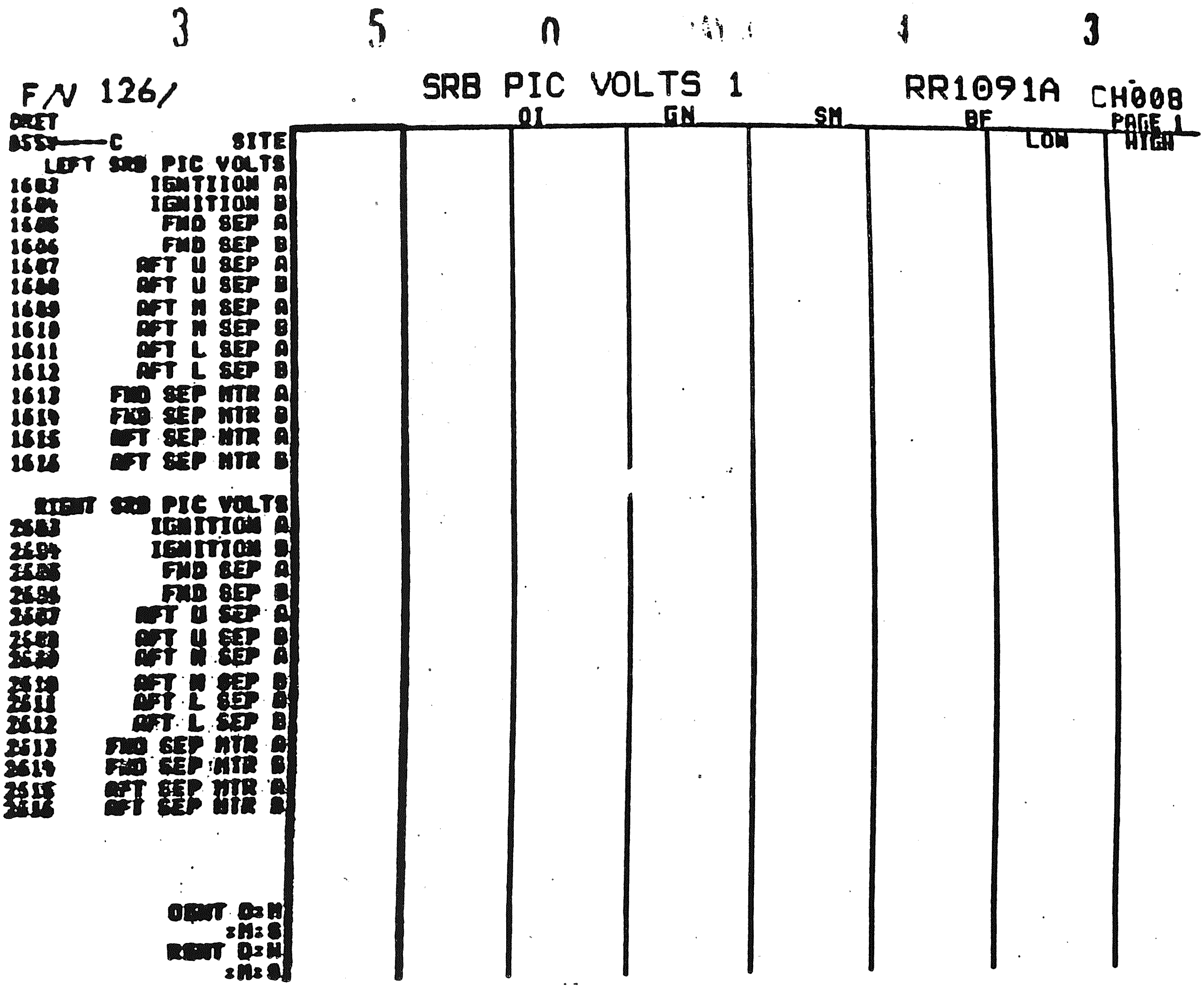
P1740  L  SRB  PC       □□□□◇  │
P1741  R  SRB  PC       □□□□◇  │

P2156  L  HE  TK  P     □□□□◇  │
P2155  C  HE  TK  P     □□□□◇  │
P2157  R  HE  TK  P     □□□□◇  │

P4998  L  TK  CHG  RT    □□□◇  │
P4997  C  TK  CHG  RT    □□□◇  │
P4999  R  TK  CHG  RT    □□□◇  │

P2140  LH2  ULL  PC     □□.□◇  │
P1388  LH2  MANF  P      □□□◇  │
P1389  LO2  MANF  P      □□□◇  │
             OGMT D:H │□□□:□□  │
                 :M:S │:□□:□□  │
             RGMT D:H │□□□:□□  │
                 :M:S │:□□:□□  │
```

Figure 5.2.2-XIII.- History tab display, MSK 1089 and 1090 (sheet 2 of 2).

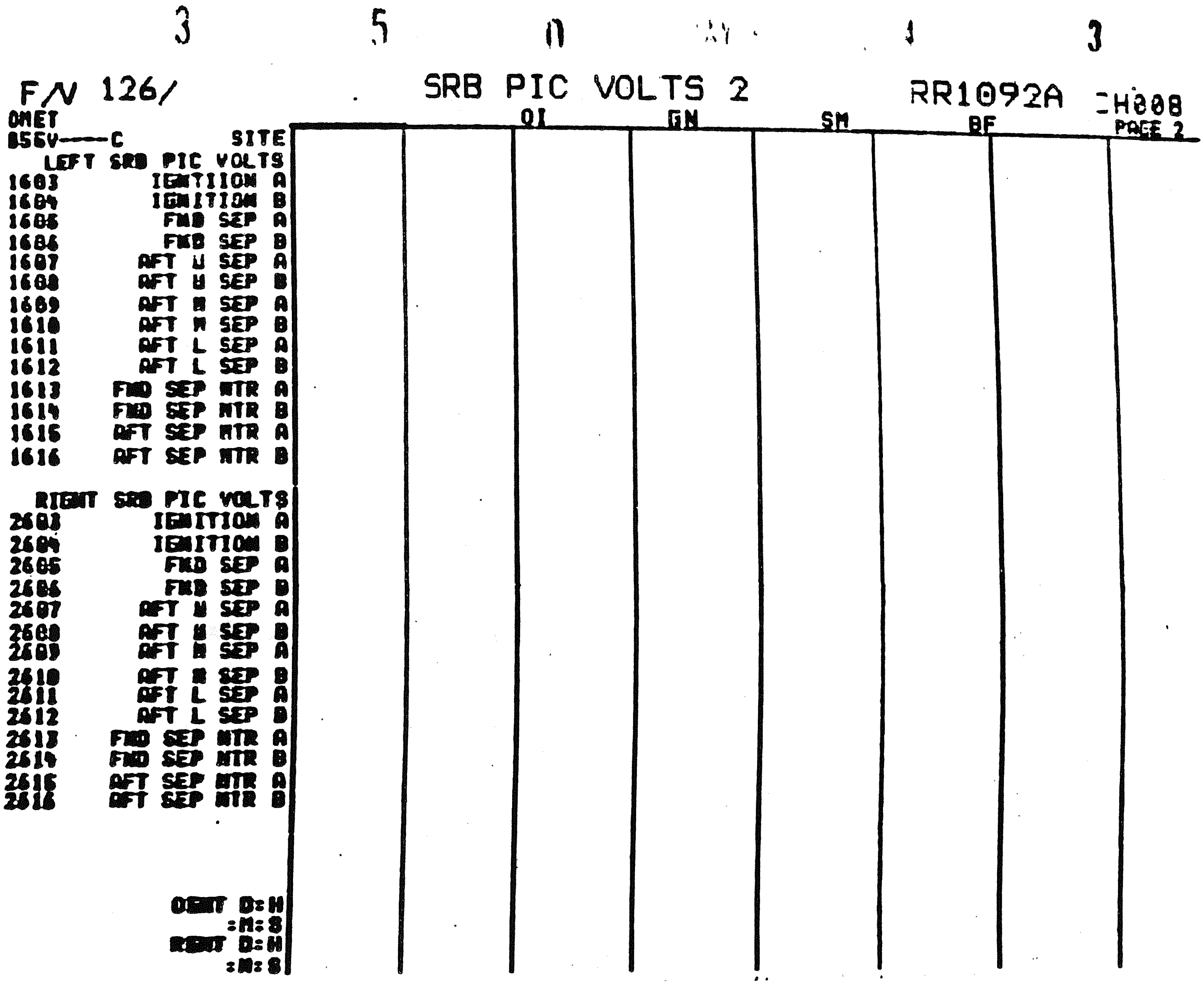


```
3          5          0                  4          3
F/V 126/               SRB PIC VOLTS 1       RR1091A  CH008
DRET                          OI       GN       SM       BF       PAGE 1
ASSY----C             SITE                                   LOW  HIGH
   LEFT SRB PIC VOLTS
1603        IGNITION A
1604        IGNITION B
1605         FWD SEP A
1606         FWD SEP B
1607       AFT U SEP A
1608       AFT U SEP B
1609       AFT M SEP A
1610       AFT M SEP B
1611       AFT L SEP A
1612       AFT L SEP B
1613     FWD SEP MTR A
1614     FWD SEP MTR B
1615     AFT SEP MTR A
1616     AFT SEP MTR B

  RIGHT SRB PIC VOLTS
2603        IGNITION A
2604        IGNITION B
2605         FWD SEP A
2606         FWD SEP B
2607       AFT U SEP A
2608       AFT U SEP B
2609       AFT M SEP A
2610       AFT M SEP B
2611       AFT L SEP A
2612       AFT L SEP B
2613     FWD SEP MTR A
2614     FWD SEP MTR B
2615     AFT SEP MTR A
2616     AFT SEP MTR B

         ORBT D:H
             :M:S
         RCNT D:H
             :M:S
```

Figure 5.2.2-XIV.- History tab display 1091 and 1092 (sheet 1 of 2).



```
F/V 126/                 SRB PIC VOLTS 2          RR1092A  -H008
OMET                            OI      GN      SM      BF      PAGE 2
B55V----C              SITE
   LEFT SRB PIC VOLTS
1603          IGNITION A
1604          IGNITION B
1605           FWD SEP A
1606           FWD SEP B
1607         AFT U SEP A
1608         AFT U SEP B
1609         AFT M SEP A
1610         AFT M SEP B
1611         AFT L SEP A
1612         AFT L SEP B
1613     FWD SEP MTR A
1614     FWD SEP MTR B
1615     AFT SEP MTR A
1616     AFT SEP MTR B

  RIGHT SRB PIC VOLTS
2603          IGNITION A
2604          IGNITION B
2605           FWD SEP A
2606           FWD SEP B
2607         AFT U SEP A
2608         AFT U SEP B
2609         AFT M SEP A
2610         AFT M SEP B
2611         AFT L SEP A
2612         AFT L SEP B
2613     FWD SEP MTR A
2614     FWD SEP MTR B
2615     AFT SEP MTR A
2616     AFT SEP MTR B



              OMET D:H
                  :M:S
              RMET D:H
                  :M:S
```

Figure 5.2.2-XIV.- History tab display, 1091 and 1092 (sheet 2 of 2).

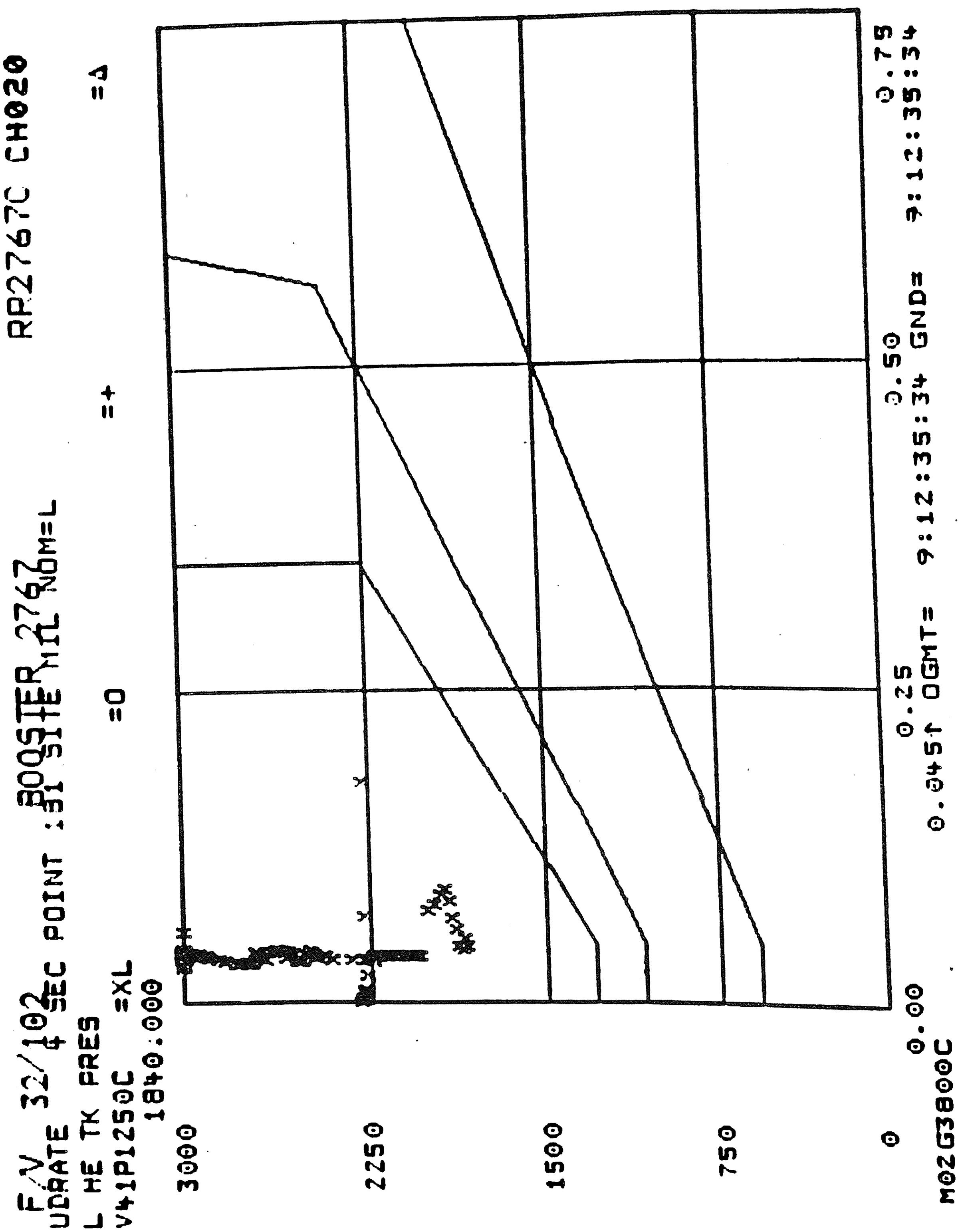


Figure 5.2.2-XV.- Booster plot 2767.

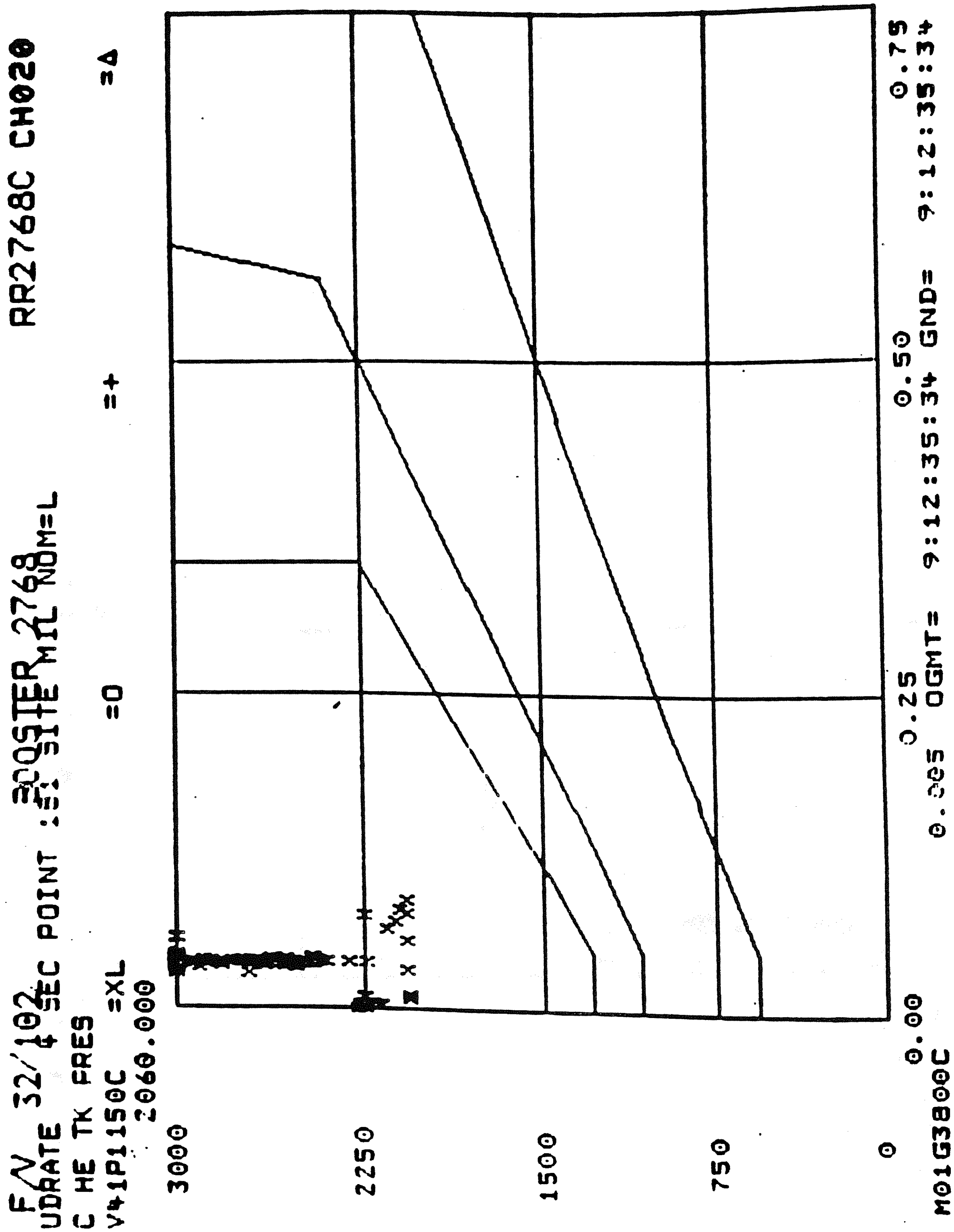


Figure 5.2.2-XVI.- Booster plot 2768.

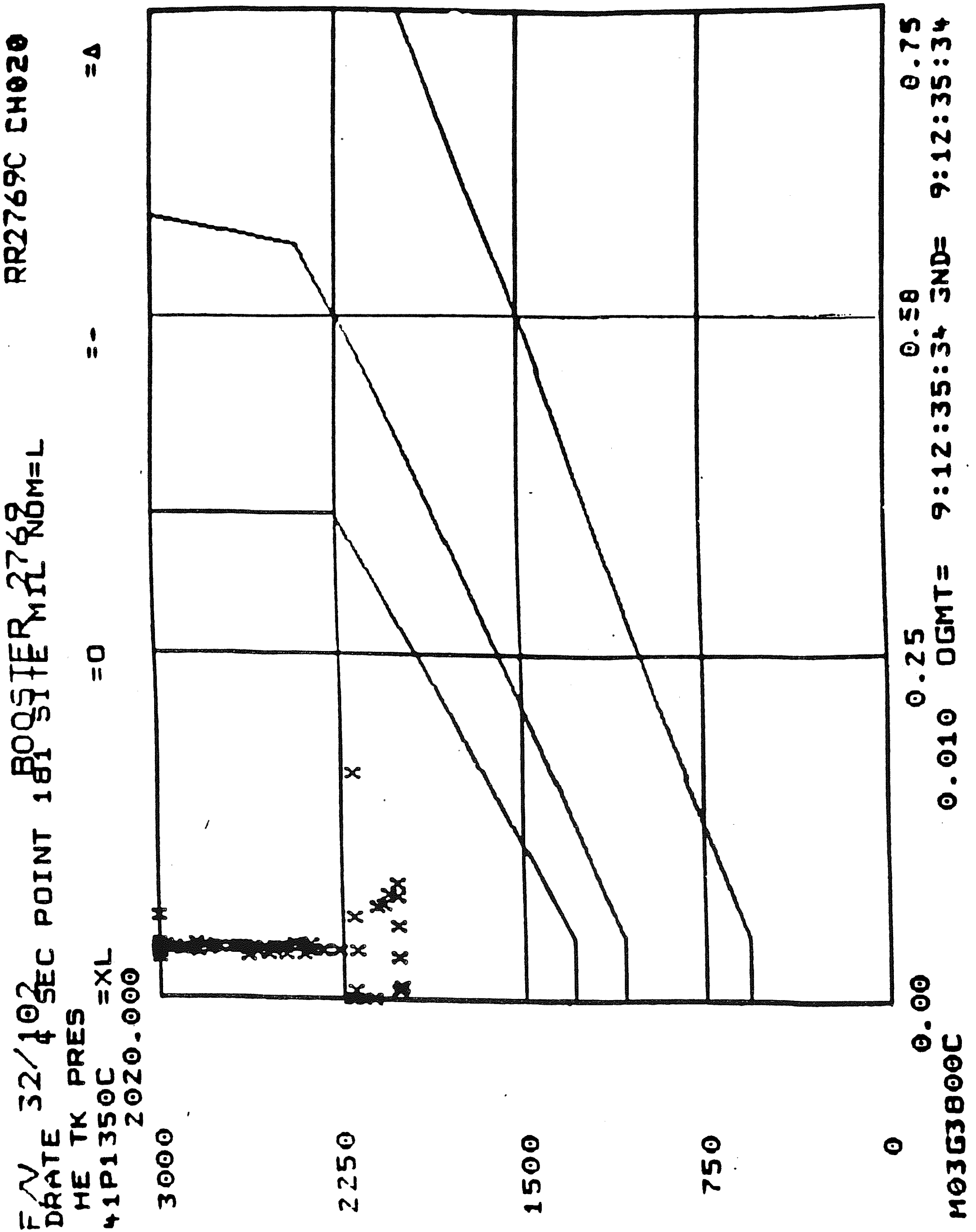


Figure 5.2.2-XVII.- Booster plot 2769.

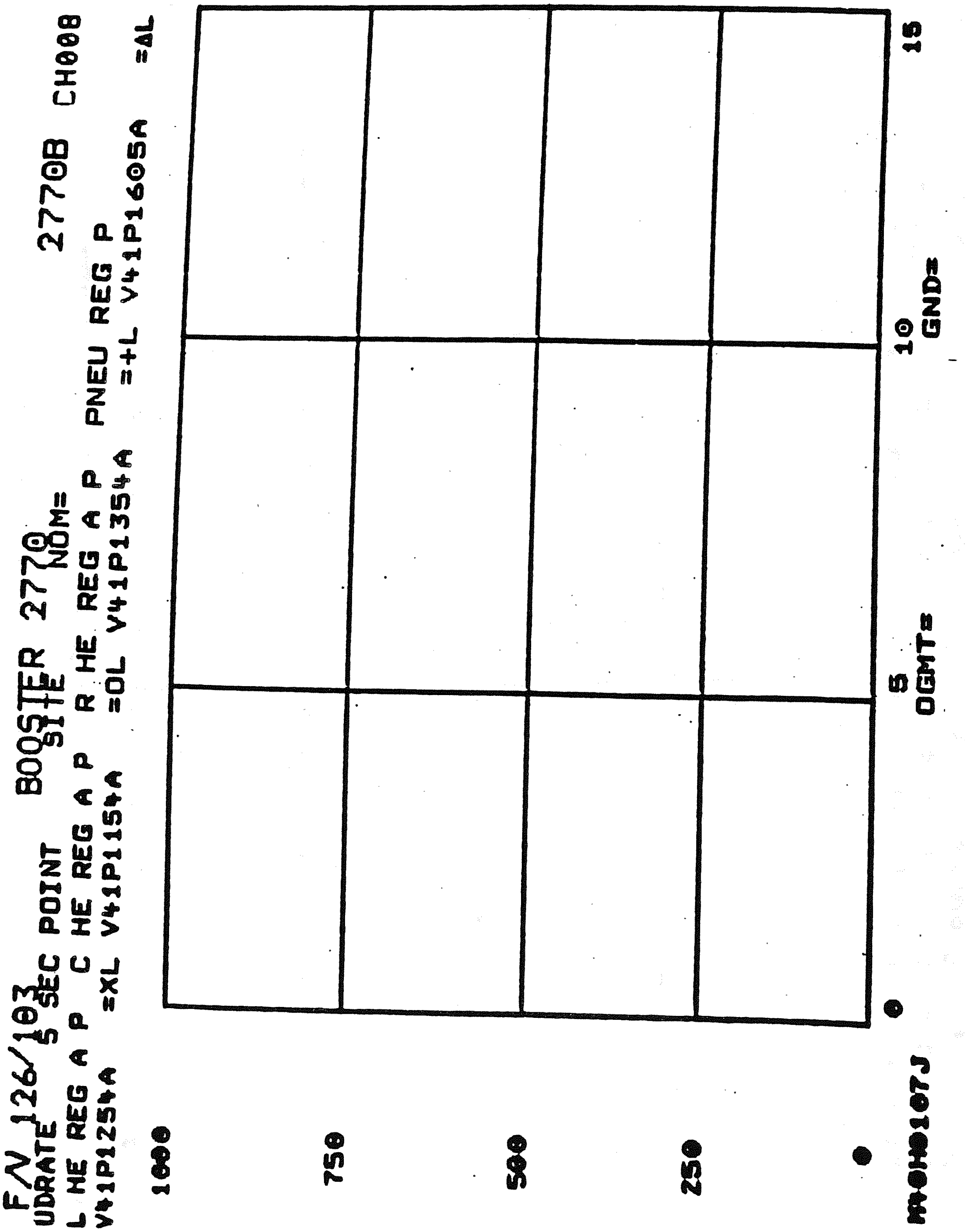


Figure 5.2.2-XVIII.- Booster universal plot 2770.

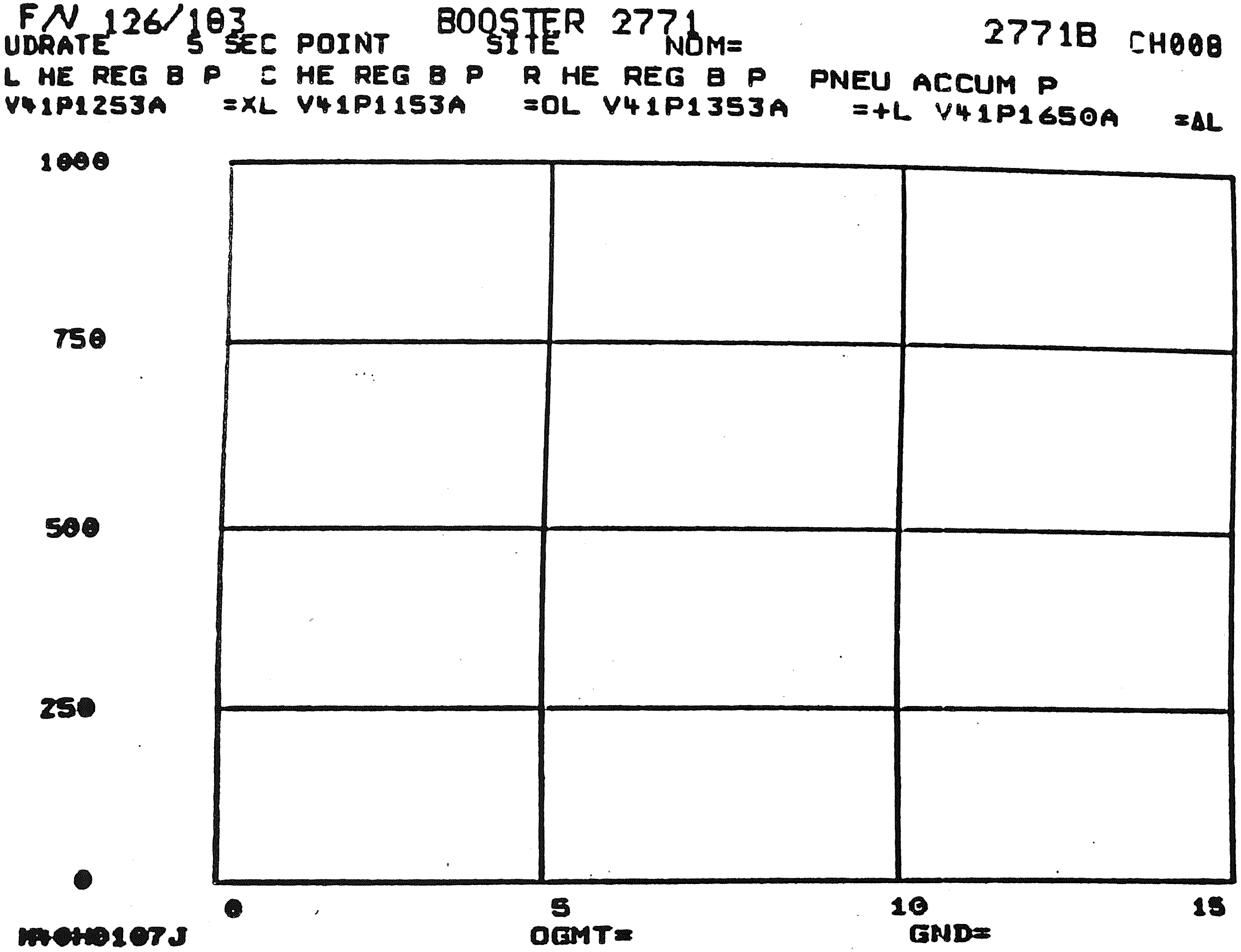


Figure 5.2.2-XIX.- Booster universal plot 2771.

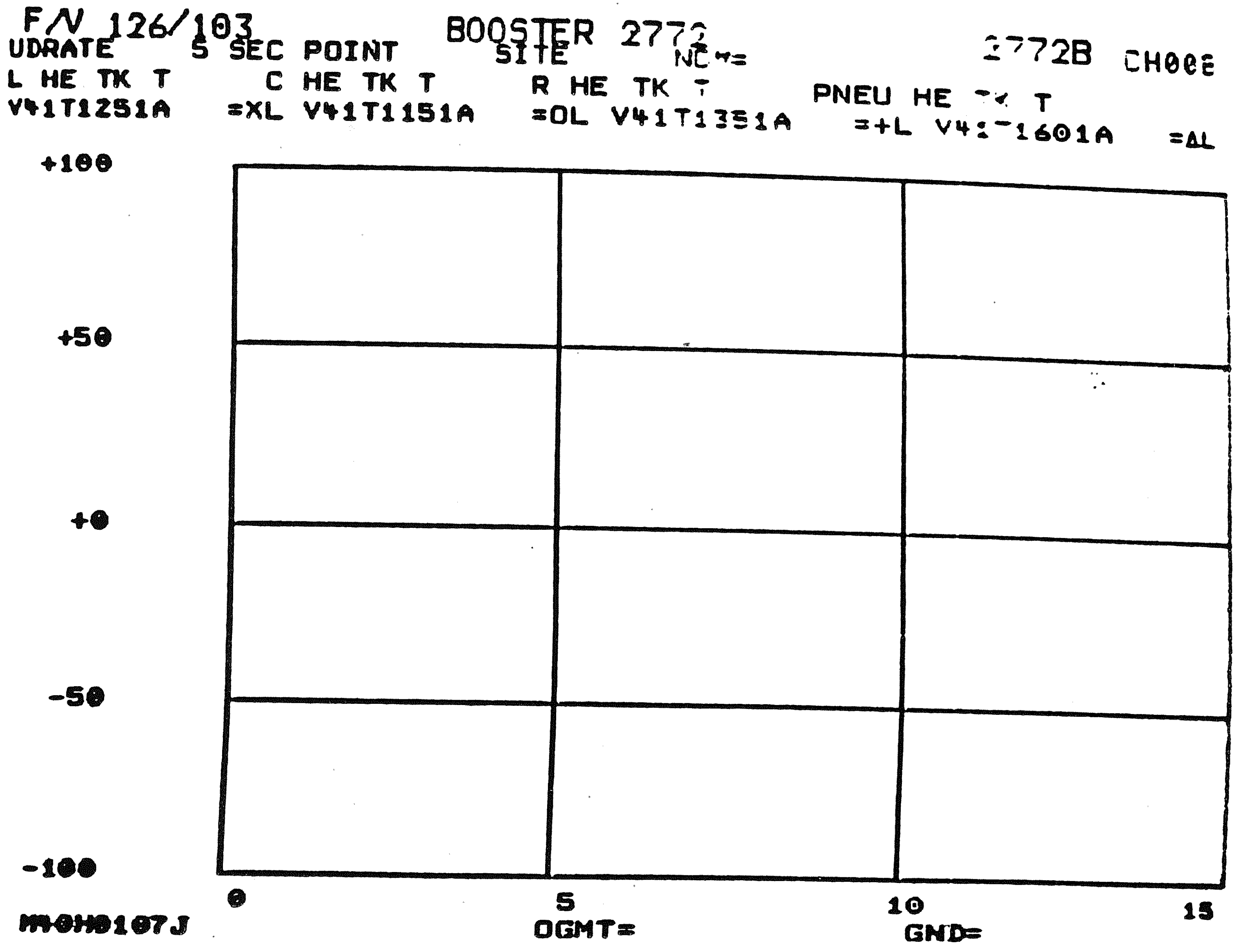


Figure 5.2.2-XX.- Booster universal plot 2772.

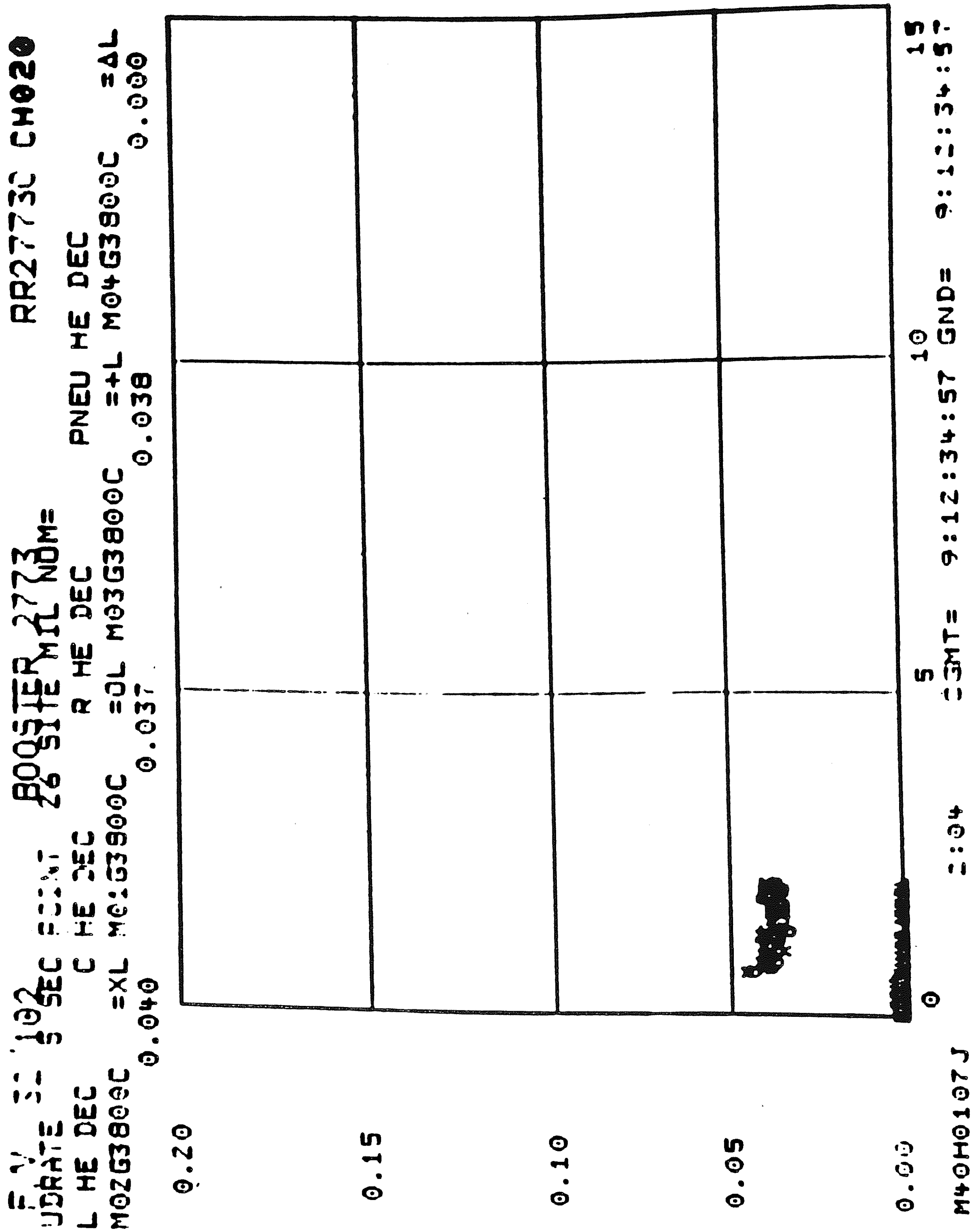


Figure 5.2.2-XXI.- Booster plot 2773.

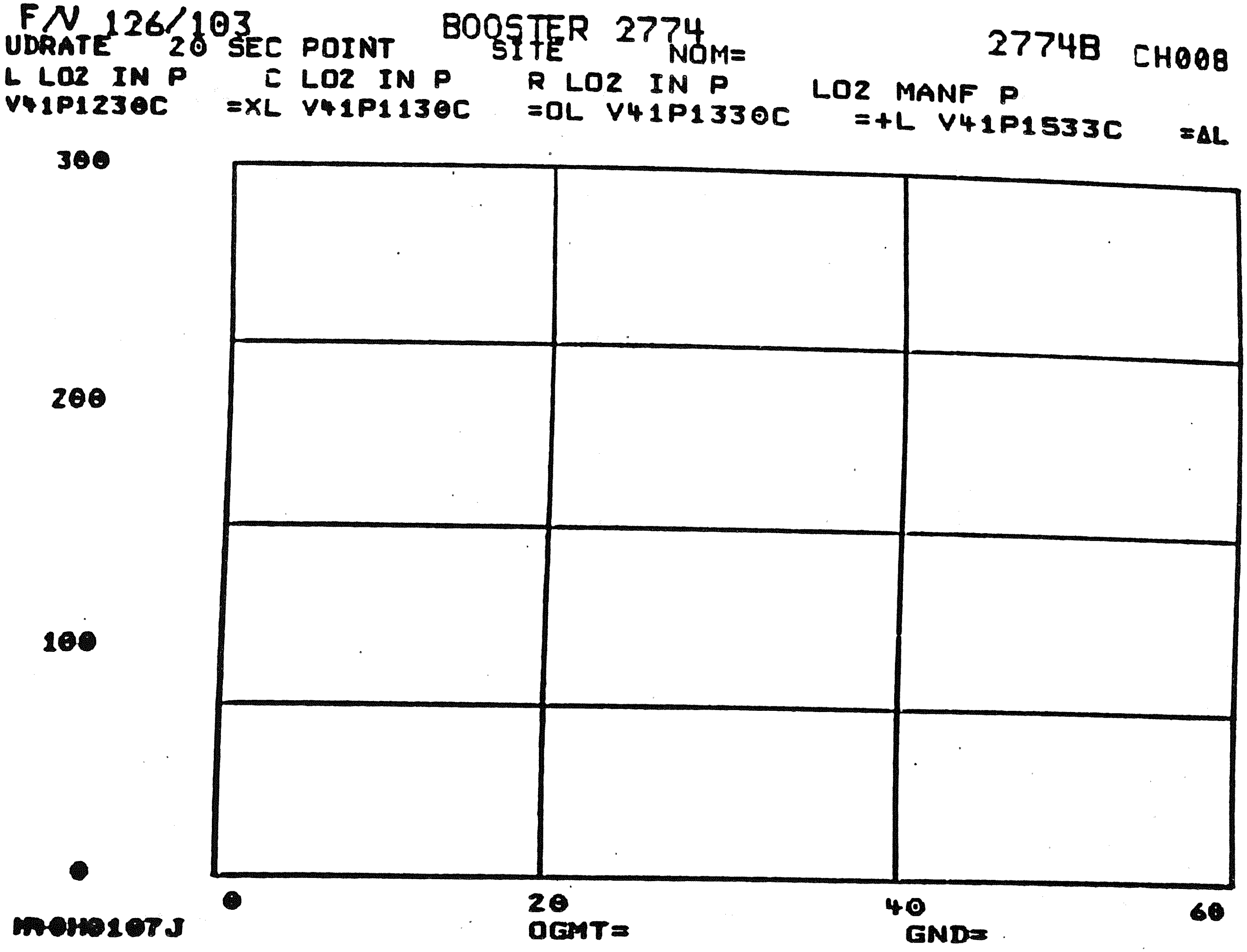


Figure 5.2.2-XXII.- Booster universal plot 2774.

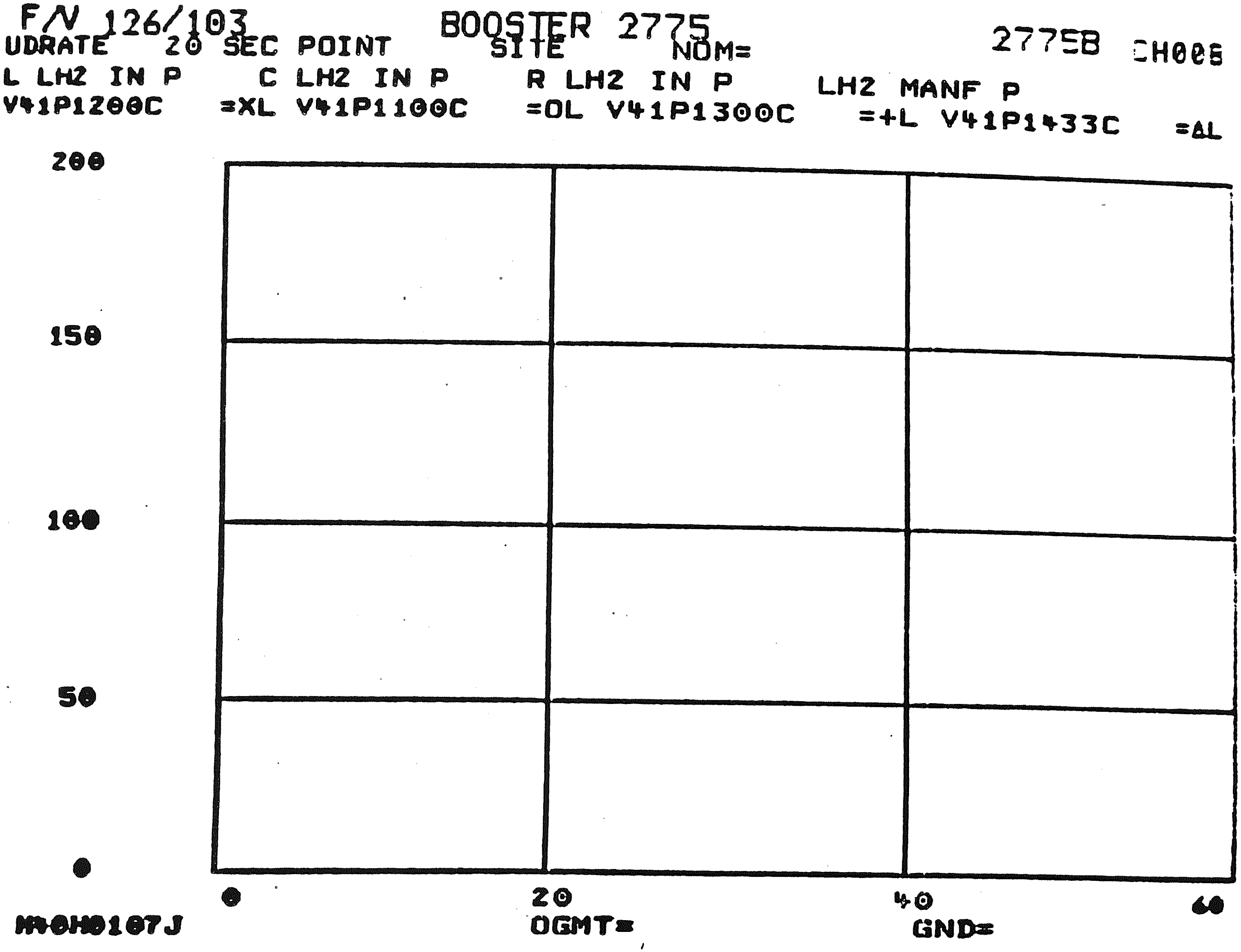
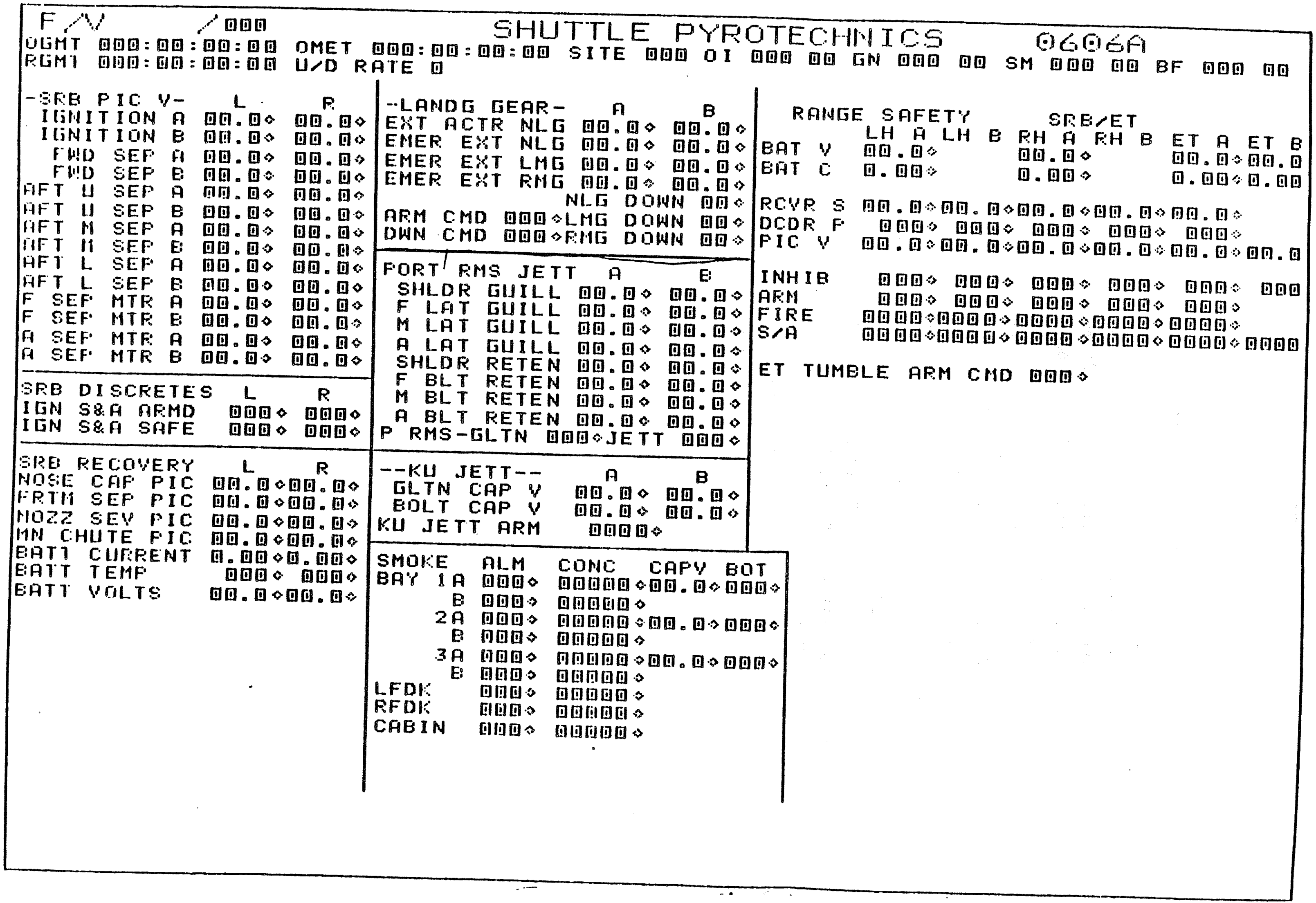


Figure 5.2.2-XXIII.- Booster universal plot 2775.



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F/V       /□□□              SHUTTLE PYROTECHNICS         0606A
UGMT □□□:□□:□□:□□ OMET □□□:□□:□□:□□ SITE □□□ OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□
RGMT □□□:□□:□□:□□ U/D RATE □

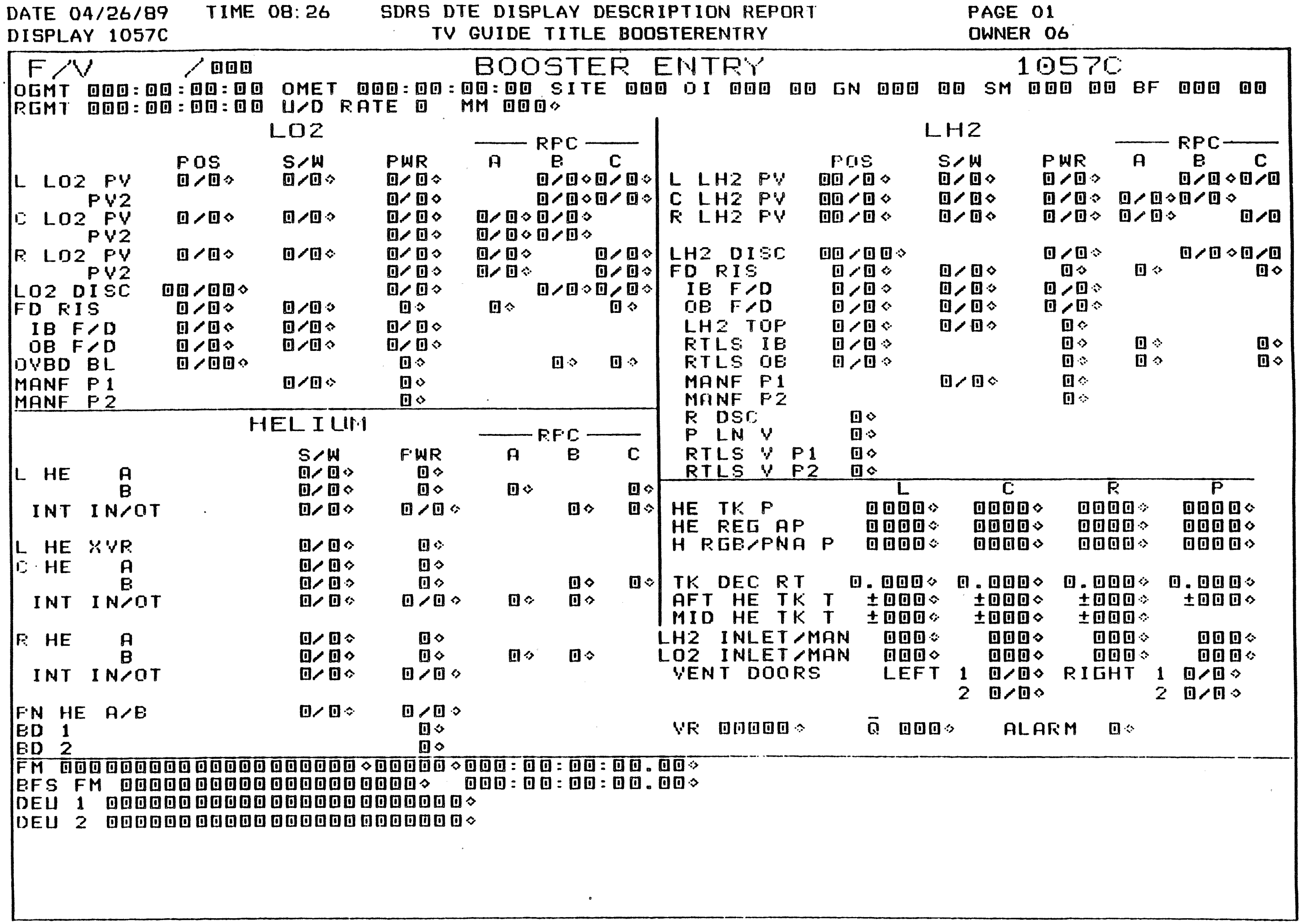
-SRB PIC V-      L        R     | -LANDG GEAR-     A        B     |  RANGE SAFETY        SRB/ET
 IGNITION A  □□.□◇  □□.□◇       | EXT ACTR NLG □□.□◇  □□.□◇       |         LH A  LH B  RH A  RH B  ET A  ET B
 IGNITION B  □□.□◇  □□.□◇       | EMER EXT NLG □□.□◇  □□.□◇       | BAT V   □□.□◇       □□.□◇       □□.□◇□□.□
   FWD SEP A □□.□◇  □□.□◇       | EMER EXT LMG □□.□◇  □□.□◇       | BAT C   □.□□◇       □.□□◇       □.□□◇□.□□
   FWD SEP B □□.□◇  □□.□◇       | EMER EXT RMG □□.□◇  □□.□◇       |
AFT U SEP A  □□.□◇  □□.□◇       |              NLG DOWN □□◇       | RCVR S □□.□◇□□.□◇□□.□◇□□.□◇□□.□◇
AFT U SEP B  □□.□◇  □□.□◇       | ARM CMD □□□◇LMG DOWN □□◇        | DCDR P  □□□◇ □□□◇ □□□◇ □□□◇ □□□◇
AFT M SEP A  □□.□◇  □□.□◇       | DWN CMD □□□◇RMG DOWN □□◇        | PIC V  □□.□◇□□.□◇□□.□◇□□.□◇□□.□◇□□.□
AFT M SEP B  □□.□◇  □□.□◇       |---------------------------------|
AFT L SEP A  □□.□◇  □□.□◇       | PORT RMS JETT  A        B       | INHIB   □□□◇ □□□◇ □□□◇ □□□◇ □□□◇ □□□
AFT L SEP B  □□.□◇  □□.□◇       |  SHLDR GUILL □□.□◇  □□.□◇       | ARM     □□□◇ □□□◇ □□□◇ □□□◇ □□□◇
F SEP MTR A  □□.□◇  □□.□◇       |  F LAT GUILL □□.□◇  □□.□◇       | FIRE   □□□□◇□□□□◇□□□□◇□□□□◇□□□□◇
F SEP MTR B  □□.□◇  □□.□◇       |  M LAT GUILL □□.□◇  □□.□◇       | S/A    □□□□◇□□□□◇□□□□◇□□□□◇□□□□◇□□□□
A SEP MTR A  □□.□◇  □□.□◇       |  A LAT GUILL □□.□◇  □□.□◇       |
A SEP MTR B  □□.□◇  □□.□◇       |  SHLDR RETEN □□.□◇  □□.□◇       | ET TUMBLE ARM CMD □□□◇
--------------------------------|  F BLT RETEN □□.□◇  □□.□◇       |
SRB DISCRETES     L     R       |  M BLT RETEN □□.□◇  □□.□◇       |
IGN S&A ARMD   □□□◇  □□□◇       |  A BLT RETEN □□.□◇  □□.□◇       |
IGN S&A SAFE   □□□◇  □□□◇       | P RMS-GLTN □□□◇JETT □□□◇        |
--------------------------------|---------------------------------|
SRB RECOVERY      L      R      | --KU JETT--      A        B     |
NOSE CAP PIC  □□.□◇□□.□◇        |  GLTN CAP V  □□.□◇  □□.□◇       |
FRTM SEP PIC  □□.□◇□□.□◇        |  BOLT CAP V  □□.□◇  □□.□◇       |
NOZZ SEV PIC  □□.□◇□□.□◇        | KU JETT ARM    □□□□◇            |
MN CHUTE PIC  □□.□◇□□.□◇        |------------------------------------
BATT CURRENT  □.□□◇□.□□◇        | SMOKE   ALM    CONC   CAPY BOT  |
BATT TEMP      □□□◇ □□□◇        | BAY 1A  □□□◇  □□□□□◇□□.□◇□□□◇   |
BATT VOLTS    □□.□◇□□.□◇        |      B  □□□◇  □□□□□◇            |
                                |     2A  □□□◇  □□□□□◇□□.□◇□□□◇   |
                                |      B  □□□◇  □□□□□◇            |
                                |     3A  □□□◇  □□□□□◇□□.□◇□□□◇   |
                                |      B  □□□◇  □□□□□◇            |
                                | LFDK    □□□◇  □□□□□◇            |
                                | RFDK    □□□◇  □□□□□◇            |
                                | CABIN   □□□◇  □□□□□◇            |
```

Figure 5.2.2-XXIV.- MSK 0606 (sheet 1 of 2).

F/V
OGMT
RGMT

- SRB PIC V -	L	
IGNITION A	B55V1603C	B55V2603C
IGNITION B	B55V1604C	B55V2604C
FWD SEP A	B55V1605C	B55V2605C
FWD SEP B	B55V1606C	B55V2606C
AFT U SEP A	B55V1607C	B55V2607C
AFT U SEP B	B55V1608C	B55V2608C
AFT M SEP A	B55V1609C	B55V2609C
AFT M SEP B	B55V1610C	B55V2610C
AFT L SEP A	B55V1611C	B55V2611C
AFT L SEP B	B55V1612C	B55V2612C
F SEP MTR A	B55V1613C	B55V2613C
F SEP MTR B	B55V1614C	B55V2614C
A SEP MTR A	B55V1615C	B55V2615C
A SEP MTR B	B55V1616C	B55V2616C

Figure 5.2.2-XXIV MSK 0606 (sheet 2 of 2)



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DATE 04/26/89   TIME 08:26    SDRS DTE DISPLAY DESCRIPTION REPORT            PAGE 01
DISPLAY 1057C                   TV GUIDE TITLE BOOSTERENTRY                    OWNER 06

F/V       /□□□               BOOSTER ENTRY                          1057C
OGMT □□□:□□:□□:□□  OMET □□□:□□:□□:□□  SITE □□□ OI □□□ □□ GN □□□ □□ SM □□□ □□ BF □□□ □□
RGMT □□□:□□:□□:□□  U/D RATE □   MM □□□◇
                  LO2                            |                    LH2
                                  ---RPC---      |                                         ---RPC---
             POS    S/W    PWR     A    B    C   |                POS    S/W    PWR     A    B    C
L LO2 PV     □/□◇   □/□◇   □/□◇        □/□◇□/□◇  | L LH2 PV      □□/□◇  □/□◇   □/□◇        □/□◇□/□
      PV2                  □/□◇        □/□◇□/□◇  | C LH2 PV      □□/□◇  □/□◇   □/□◇  □/□◇□/□◇
C LO2 PV     □/□◇   □/□◇   □/□◇  □/□◇□/□◇        | R LH2 PV      □□/□◇  □/□◇   □/□◇  □/□◇       □/□
      PV2                  □/□◇  □/□◇□/□◇        |
R LO2 PV     □/□◇   □/□◇   □/□◇  □/□◇      □/□◇  | LH2 DISC      □□/□□◇        □/□◇        □/□◇□/□
      PV2                  □/□◇  □/□◇      □/□◇  | FD RIS         □/□◇  □/□◇    □◇    □◇        □◇
LO2 DISC    □□/□□◇         □/□◇        □/□◇□/□◇  |   IB F/D       □/□◇  □/□◇   □/□◇
FD RIS       □/□◇   □/□◇    □◇    □◇         □◇  |   OB F/D       □/□◇  □/□◇   □/□◇
  IB F/D     □/□◇   □/□◇   □/□◇                  |   LH2 TOP      □/□◇  □/□◇    □◇
 OB F/D      □/□◇   □/□◇   □/□◇                  |   RTLS IB      □/□◇          □◇    □◇        □◇
DVBD BL      □/□□◇          □◇         □◇    □◇  |   RTLS OB      □/□◇          □◇    □◇        □◇
MANF P1             □/□◇    □◇                   |   MANF P1            □/□◇    □◇
MANF P2                     □◇                   |   MANF P2                    □◇
-------------------------------------------------|   R DSC        □◇
                HELIUM                           |   P LN V       □◇
                                  ---RFC---      |   RTLS V P1    □◇
                    S/W    FWR     A    B    C   |   RTLS V P2    □◇
L HE     A          □/□◇    □◇                   |-------------------------------------------------
         B          □/□◇    □◇     □◇        □◇  |                    L        C        R        P
 INT IN/OT          □/□◇   □/□◇         □◇   □◇  | HE TK P         □□□□◇    □□□□◇    □□□□◇    □□□□◇
                                                 | HE REG AP       □□□□◇    □□□□◇    □□□□◇    □□□□◇
L HE XVR            □/□◇    □◇                   | H RGB/PNA P     □□□□◇    □□□□◇    □□□□◇    □□□□◇
C HE     A          □/□◇    □◇                   |
         B          □/□◇    □◇          □◇   □◇  | TK DEC RT     □.□□□◇   □.□□□◇   □.□□□◇   □.□□□◇
 INT IN/OT          □/□◇   □/□◇    □◇   □◇       | AFT HE TK T     ±□□□◇    ±□□□◇    ±□□□◇    ±□□□◇
                                                 | MID HE TK T     ±□□□◇    ±□□□◇    ±□□□◇
R HE     A          □/□◇    □◇                   LH2 INLET/MAN      □□□◇     □□□◇     □□□◇     □□□◇
         B          □/□◇    □◇     □◇   □◇       LO2 INLET/MAN      □□□◇     □□□◇     □□□◇     □□□◇
 INT IN/OT          □/□◇   □/□◇                   VENT DOORS       LEFT  1  □/□◇  RIGHT  1  □/□◇
                                                                         2  □/□◇         2  □/□◇
FN HE A/B           □/□◇   □/□◇
BD 1                        □◇                    VR □□□□□◇     Q̄ □□□◇     ALARM  □◇
BD 2                        □◇
-----------------------------------------------------------------------------------------------------
FM □□□□□□□□□□□□□□□□□□□□□□□□□□◇□□□□□◇□□□:□□:□□:□□.□□◇
BFS FM □□□□□□□□□□□□□□□□□□□□□□□□□□□□◇  □□□:□□:□□:□□.□□◇
DEU 1 □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□◇
DEU 2 □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□◇
```

Figure 5.2.2-XXV.-Booster entry display 1057.

TITLE

MPS CONSOLE EVENT LIGHT INDICATORS

PURPOSE

This SCP provides a description of the MPS event light formats and a table listing the parameters on each MPS format.

DESCRIPTION

The format layouts provide the actual arrangement of the event lights with each light label and color. The tables present the parameter name and measurement number along with each light label, color, and logic that drives the light.

Five colors are used: red, amber, white, green, and blue. The red is used for those events that indicate a hazardous condition or an event which should be brought to the operator's immediate attention. Amber signifies the approach of a hazardous condition and is used for the five sets of limit sense. White is used to indicate the position of a valve. Green is also used for valve positions and nonhazardous events. There is one blue light indicating a high data rate.

The letter R in the logic column indicates reverse logic. The light will be illuminated with the zero state of the measurement. The indicator locations for each type of module are numbered as shown in figure 5.2.3-I.

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31	32	33	34	35	36

Type A

1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25	26	27
28	29	30	31	32	33	34	35	36

Type B

Figure 5.2.3-I.- DDD format types.

A HE REG PA V41P1254A	A HE REG PA V41P1154A	A HE REG PA V41P1354A	A HE REG PA V41P1605A	W LHEISOAOP V41X1258E	W LHEISOBOP V41X1259E
A HE REG PB V41P1253A	A HE REG PB V41P1153A	A HE REG PB V41P1353A	W HEISOAOP V41X1645E	W CHEISOAOP V41X1158E	W CHEISOBOP V41X1159E
A TK CHG RT V98P4998C	A TK CHG RT V98P4997C	A TK CHG RT V98P4999C	W HEISOBOP V41X1646E	W RHEISOAOP V41X1358E	W RHEISOBOP V41X1359E
A HE DEC RT M02G3800C	A HE DEC RT M01G3800C	A HE DEC RT M03G3800C	A HE DEC RT M04G3800C	A L HE TK P V41P1250C	A C HE TK P V41P1150C
A HE TOD M06G3800T	A HE TOD M05G3800T	A HE TOD M07G3800T	A HE TOD M08G3800T	A R HE TK P V41P1350C	A HE TK P V41P1600A
A LPN TOD M10G3800T	A CPN TOD M09G3800T	A RPN TOD M11G3800T	W HEXOVROP V41X1614E	A LBR 64K	B HBR 128K

Figure 5.2.3-II.- Helium (format number: 286, type: A).

TABLE 5.2.3-I.- HELIUM (FORMAT NUMBER: 286; TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		HE REG PA ● V41P1254A	V41P1254A	Left helium regulator A pressure
02	A		HE REG PA ● V41P1154A	V41P1354A	Center helium regulator A pressure
03	A		HE REG PA ● V41P1354A	V41P1354A	Right helium regulator A pressure
04	A		HE REG P ● V41P1605A	V41P1605A	Pneumatics helium regulator pressure
05	W		LHEISOAOP ● V41X1258E	V41X1258E	Left helium isolation valve A open power
06	W		LHEISOBOP ● V41X1259E	V41X1259E	Left helium isolation valve B open power
07	A		HE REG PB ● V41P1253A	V41P1253A	Left helium regulator B pressure
08	A		HE REG PB ● V41P1153A	V41P1153A	Center helium regulator B pressure
09	A		HE REG PB ● V41P1353A	V41P1353A	Right helium regulator B pressure
10	W		HEISOAOP ● V41X1645E	V41X1645E	Pneumatics helium isolation valve A open power
11	W		CHEISOAOP ● V41X1158E	V41X1158E	Center helium isolation valve A open power
12	W		CHEISOBOP ● V41X1159E	V41X1159E	Center helium isolation valve B open power
13	A		TK CHG RT ● V98P4998C	V98P4998C	Left helium tank pressure change rate
14	A		TK CHG RT ● V98P4997C	V98P4997C	Center helium tank pressure change rate
15	A		TL CHG RT ● V98P4999C	V98P4999C	Right helium tank pressure change rate
16	W		HEISOBOP ● V41X1646E	V41X1646E	Pneumatics isolation valve B open power
17	W		RHEISOAOP ● V41X1358E	V41X1358E	Right helium isolation valve A open power
18	W		RHEISOBOP ● V41X1359E	V41X1359E	Right helium isolation valve B open power
19	A		HE DEC RT ● M02G3800C	M02G3800C	Left helium tank pressure decay rate
20	A		HE DEC RT ● M01G3800C	M01G3800C	Center helium tank pressure decay rate
21	A		HE DEC RT ● M03G3800C	M03G3800C	Right helium tank pressure decay rate
22	A		HE DEC RT ● M04G3800C	M04G3800C	Pneumatics helium tank pressure decay rate
23	A		L HE TK P ● V41P1250C	V41P1250C	Left helium tank pressure
24	A		C HE TK P ● V41P1150C	V41P1150C	Center helium tank pressure
25	A		HE TOD ● M06G3800T	M06G3800T	Left helium tank pressure time of decay
26	A		HE TOD ● M05G3800T	M05G3800T	Center helium tank pressure time of decay
27	A		HE TOD ● M07G3800T	M07G3800T	Right helium tank pressure time of decay
28	A		HE TOD ● M08G3800T	M08G3800T	Pneumatic helium tank pressure time of decay
29	A		R HE TK P ● V41P1350C	V41P1350C	Right helium tank pressure
30	A		HE TK P ● V41P1600A	V41P1600A	Helium tank pressure
31	A		LPN TOD ● M10G3800T	M10G3800T	Combined left and pneumatics helium tanks time of decay
32	A		CPN TOD ● M09G3800T	M09G3800T	Combined centered and pneumatics helium tanks time of decay
33	A		RPN TOD ● M11G3800T	M11G3800T	Combined right and pneumatics helium tanks time of decay
34	W		HEXOVROP ● V41X1614E	V41X1614E	Left helium crossover valve open power
35	A		LBR ● 64K	V74X4754E	Low bit rate 64000
36	B		HBR ● 128K	V74X4753E	High bit rate 128000

A L O2ULL PL T41P1751C	W 02PSVLOPP V41X1598E	R LO2 MAN P V41P1533C	A LH UL GPL M02G3706C	W H2PSVLOPP V41X1662E	R LH2 MAN P V41P1433C
A LO2ULL PC T41P1750C	W 02PSVCOPP V41X1596E	A LO5% LQLV T41X1762E	A LH UL GPC M01G3706C	W H2PSVCOPP V41X1661E	A LH5% LQLV T41X1712E
A LO2ULL PR T41P1752C	W 02PSVROPP V41X1603E	R LOCO SEN1 V41X1555X	A LH UL GPR M03G3706C	W H2PSVROPP V41X1663E	R LHCO SEN1 T41X1730X
A TOTOXFLRT M04G3101C	R RS HOLD	R LOCO SEN2 V41X1556X	R FU NPSP L M02G3111C	R LH2VNTVOP T41X1727C	R LHCO SEN2 T41X1731X
A TOTFUFLRT M04G3103C	G LO2VNTVCL T41X1774E	R LOCO SEN3 V41X1557X	R FU NPSP C M01G3111C	G LH2VNTVCL T41X1724E	R LHCO SEN3 T41X1732X
R LOW LV AC V90X1942X	A LHTKPHIFL V41S1477E	R LOCO SEN4 V41X1558X	R FU NPSP R M03G3111C	R FU NPSP A M04G3111C	R LHCO SEN4 T41X1733X

Figure 5.2.3-III.- ET PRESS/PRPLNT (format number: 287, type: A).

TABLE 5.2.3-II.- ET PRES/PRPLNT (FORMAT NUMBER: 287; TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		LO2ULL PL ● T41P1751C	T41P1751C	External tank left LO2 ullage pressure
02	W	R	O2PSVLOPP ● V41X1598E	V41X1598E	Left GO2 pressure flow control valve close power
03	R		LO2 MANP ● V41P1533C	V41P1533C	LO2 manifold pressure
04	A		LH UL GPL ● M02G3706C	M02G3706C	External tank left LH2 ullage gage pressure
05	W	R	H2PSVLOPP ● V41X1662E	V41X1662E	Left GH2 pressure flow control valve close power
06	R		LH2 MANP ● V41P1433C	V41P1433C	LH2 manifold pressure
07	A		LO2ULL PC ● T41X1750C	T41X1750C	External tank center LO2 ullage pressure
08	W	R	O2PSVCOPP ● V41X1596E	V41X1596E	Center GO2 pressure flow control valve close power
09	A		LO5% LQLV ● T41X1762E	T41X1762E	External tank LO2 5% liquid level
10	A		LH UL GPC ● M01G3706C	M01G3706C	External tank center LH2 ullage gage pressure
11	W	R	H2PSVCOPP ● V41X1661E	V41X1661E	Center GH2 pressure flow control valve close power
12	A		LH5% LQLV ● T41X1712E	T41X1712E	External tank LH2 5% liquid level
13	A		LO2ULL PR ● T41P1752C	T41P1752C	External tank right LO2 ullage pressure
14	W	R	O2PSVROPP ● T41X1603E	T41X1603E	Right GO2 pressure flow control valve close power
15	R		LOCO SEN1 ● V41X1555X	V41X1555X	Orbiter LO2 low level cutoff sensor no. 1 dry
16	A		LH UL GPR ● M03G3706C	M03G3706C	External tank right LH2 ullage gage pressure
17	W	R	H2PSVROPP ● V41X1663E	V41X1663E	Right GH2 pressure flow control valve close power
18	R		LHCO SEN1 ● T41X1730X	T41X1730X	External tank LH2 low level cutoff sensor no. 1 dry
19	A		TOTOXFLRT ● M04G3101C	M04G3101C	Total LO2 flow rate
20	R		RS ● HOLD	V90X8667X	Redundant set hold
21	R		LOCO SEN2 ● V41X1556X	V41X1556X	Orbiter LO2 low level cutoff sensor no. 2 dry
22	R		FU NPSP L ● M02G3111C	M02G3111C	Left SSME fuel net positive suction pressure
23	R		LH2VNTVOP ● T41X1727E	T41X1727E	External tank LH2 vent valve open
24	R		LHCO SEN2 ● T41X1731X	T41X1731X	External tank LH2 low level cutoff sensor no. 2 dry
25	A		TOTFUFLRT ● M04G3103C	M04G3103C	Total fuel flow rate
26	G		LO2VNTVCL ● T41X1774E	T41X1774E	External tank LO2 vent valve closed
27	R		LOCO SEN3 ● V41X1557X	V41X1557X	Orbiter LO2 low level cutoff sensor no. 3 dry
28	R		FU NPSP C ● M01G3111C	M01G3111C	Center SSME fuel net positive suction pressure
29	G		LH2VNTVCL ● T41X1724E	T41X1724E	External tank LH2 vent valve closed
30	R		LHCO SEN3 ● T41X1732X	T41X1732X	External tank LH2 low level cutoff sensor no. 3 dry
31	R		LOW LV AC ● V90X1942X	V90X1942X	Low level cut off sensors arm command
32	A		LHTKPHIFL ● V41S1477E	V41S1477E	External tank GH2 ullage high flow on
33	R		LOCO SEN4 ● V41X1558X	V41X1558X	Orbiter LO2 low level cutoff sensor no. 4 dry
34	R		FU NPSP R ● M03G3111C	M03G3111C	Right SSME fuel net positive suction pressure
35	R		FU NPSP A ● M04G3111C	M04G3111C	Average SSME fuel net positive suction pressure
36	R		LHCO SEN4 ● T41X1733X	T41X1733X	External tank LH2 low level cutoff sensor no. 4 dry

A L FSM AP B46P1305C	A L FSM BP B46P1306C	A R FSM AP B46P2305C	A R FSM BP B46P2306C	W POGORC1OP V41X1811X	G LO2 PV OP V41X1234E	W LO2 PV CL V41X1235E	G LH2 PV OP V41X1204X	W LH2 PV CL V41X1205E
A L TRB SA2 B46R1408C	A L TRB SB2 B46R1409C	A R TRB SA2 B46R2408C	A R TRB SB2 B46R2409C	W POGORC2OP V41X1821X	G LO2 PV OP V41X1134X	W LO2 PV CL V41T1135E	G LH2 PV OP V41X1104X	W LH2 PV CL V41X1105E
A LHYDSUPAP B58P1303C	A LHYDSUPBP B58P1304C	A RIHYDSUPAP B58P2303C	A RIHYDSUPBP B58P2304C	R RS HOLD	G LO2 PV OP V41X1334X	W LO2 PV CL V41X1335E	G LH2 PV OP V41X1304X	W LH2 PV CL V41X1305E
A LROCKPRIP B58X1860X	A LTILTPRIP B58X1859X	A RROCKPRIP B58X2860X	A RTILTPRIP B58X2859X	A LO MANF P V41P1533C	W RTLSP1 OPP V41X1901E	W RTLSP2 OPP V41X1902E	A LH2 IN T V41T1201C	A LH2 IN P V41P1200C

Figure 5.2.3-IV.- MPS PRESS (format number: 288; type: B).

TABLE 5.2.3-III.- MPS event (FORMAT NUMBER: 288; TYPE: B)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		L FSM A P ● B46P1305C	B46P1305C	Left SRB A fuel supply module pressure
02	A		L FSM B P ● B46P1306C	B46P1306C	Left SRB B fuel supply module pressure
03	A		R FSM A P ● B46P2305C	B46P2305C	Right SRB A fuel supply module pressure
04	A		R FSM B P ● B46P2306C	B46P2306C	Right SRB B fuel supply module pressure
05	W		POGORC1OP ● V41X1811X	V41X1811X	POGO recirculation valve 1 open
06	G		LO2 PV OP ● V41X1234X	V41X1234X	Left LO2 prevalve open
07	W		LO2 PV CL ● V41X1235E	V41X1235E	Left LO2 prevalve closed
08	G		LH2 PV OP ● V41X1204X	V41X1204X	Left LH2 prevalve open
09	W		LH2 PV CL ● V41X1205E	V41X1205E	Left LH2 prevalve closed
10	A		L TRB SA2 ● B46R1408C	B46R1408C	Left SRB A turbine speed 2
11	A		L TRB SB2 ● B46R1409C	B46R1409C	Left SRB B turbine speed 2
12	A		R TRB SA2 ● B46R2408C	B46R2408C	Right SRB A turbine speed 2
13	A		R TRB SB2 ● B46R2409C	B46R2409C	Right SRB B turbine speed 2
14	W		POGORC2OP ● V41X1821E	V41X1821X	POGO recirculation valve 2 open
15	G		LO2 PV OP ● V41X1134X	V41X1134X	Center LO2 prevalve open
16	W		LO2 PV CL ● V41X1135E	V41X1135E	Center LO2 prevalve closed
17	G		LH2 PV OP ● V41X1104X	V41X1104X	Center LH2 prevalve open
18	W		LH2 PV CL ● V41X1105E	V41X1105E	Center LH2 prevalve closed
19	A		LHYDSUPAP ● B58P1303C	B58P1303C	Left SRB A hydraulic supply pressure
20	A		LHYDSUPBP ● B58P1304C	B58P1304C	Left SRB B hydraulic supply pressure
21	A		RHYDSUPAP ● B58P2303C	B58P2303C	Right SRB A hydraulic supply pressure
22	A		RHYDSUPBP ● B58P2304C	B58P2304C	Right SRB B hydraulic supply pressure
23	R		RS ● Hold	V90X8667X	Redundant set hold
24	G		LO2 PV OP ● V41X1334X	V41X1334X	Right LO2 prevalve open
25	W		LO2 PV CL ● V41X1335E	V41X1335E	Right LO2 prevalve closed
26	G		LH2 PV OP ● V41X1304X	V41X1304X	Right LH2 prevalve open
27	W		LH2 PV CL ● V41X1305E	V41X1305E	Right LH2 prevalve closed
28	A	R	LROCKPRIP ● B58X1860X	B58X1860X	Left SRB rock actuator primary pressure OK
29	A	R	LTILTPRIP ● B58X1859X	B58X1859X	Left SRB tilt actuator primary pressure OK
30	A	R	RROCKPRIP ● B58X2860X	B58X2860X	Right SRB rock actuator primary pressure OK
31	A	R	RTILTPRIP ● B58X2859X	B58X2859X	Right SRB tilt actuator primary pressure OK
32	A		LO MANF P ● V41P1533C	V41P1533C	LO2 manifold pressure
33	W		RTLSP1 OPP	V41X1901E	RTLS pressurization valve no. 1 open power
34	W		RTLSP2 OPP	V41X1902E	RTLS pressurization valve no. 2 open power
35	A		LH2 IN T ● V41T1201C	V41T1201C	Left SSME LH2 inlet temperature
36	A		LH2 IN P ● V41P1200C	V41P1200C	Left SSME LH2 inlet pressure

A L SRB PC1 B47P1300C	A L SRB PC3 B47P1302C	A R SRB PC1 B47P2300C	A R SRB PC3 B47P2302C	A LH MANF P V41P1433C	W RTLSIBDPO V41X1929X	W RTLSOBDPO V41X1919X	A LH2 IN T V41T1101C	A LH2 IN P V41P1100C
A L SRB PC2 B47P1301C	G SRBSEPCMD V90X8331X	A R SRB PC2 B47P2301C	R SRBSEPINH V90X8340X	W H2PLNVOP V41X1492E	W LHRCDSCCL V41X1420E	G BSTR LIM DISABLE	A LH2 IN T V41T1301C	A LH2 IN P V41P1300C
G LOFDDSCOP V41x1529X	W LOFDDSCCL V41X1530X	W LOFDDSBCL V41X1534X	G LOFDRISOP V41X1541E	W LOMNP10PP V41X1538E	W LOMNP20PP V41X1539E	G LOIBF/DCL V41X1509X	G LOOBF/DCL V41X1514X	G LOOVBBVCL V41X1580X
G LHFDDSCOP V41X1429X	W LHFDDSCCL V41X1430X	W LHFDDSBCL V41X1434X	G LHFDRISOP V41X1441E	W LHMNP10PP V41X1436E	W LHMNP20PP V41X1438E	G LHIBF/DCL V41X1410X	G LHOBF/DCL V41X1389X	G LH TOP CL V41X1456X

Figure 5.2.3-V.- MPS event (format number: 289; type: B).

TABLE 5.2.3-IV.- MPS EVENT (FORMAT NUMBER: 289; TYPE: B)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		L SRB PC1 ● B47P1300C	B47P1300C	Left SRB chamber pressure no. 1
02	A		L SRB PC3 ● B47P1302C	B47P1302C	Left SRB chamber pressure no. 3
03	A		R SRB PC1 ● B47P2300C	B47P2300C	Right SRB chamber pressure no. 1
04	A		R SRB PC3 ● B47P2302C	B47P2302C	Right SRB chamber pressure no. 3
05	A		LH MANF P ● V41P1433C	V41P1433C	LH2 manifold pressure
06	W	R	RTLSIBDPO ● V41X1929X	V41X1929X	RTLS inboard dump valve open
07	W	R	RTLSOBDPO ● V41X1919X	V41X1919X	RTLS outboard dump valve open
08	A		LH2 IN T ● V41T1101C	V41T1101C	Center SSME LH2 inlet temperature
09	A		LH2 IN P ● V41P1100C	V41P1100C	Center SSME LH2 inlet pressure
10	A		L SRB PC2 ● B47P1301C	B47P1301C	Left SRB chamber pressure no. 2
11	G		SRB SEP CMD ● V90X8331X	V90X8331X	SRB separation command
12	A		R SRB PC2 ● B47P2301C	B47P2301C	Right SRB chamber pressure no. 2
13	R		SRB SEP INH ● V90X8340X	V90X8340X	SRB separation inhibit
14	W		H2PLNVOP ● V41X1492E	V41X1492E	GH2 pressurization line vent valve open power
15	W		LHRCDSCCL ● V41X1420E	V41X1420E	LH2 recirculation disconnect valve closed
16	G		BSTR LIM ● DISABLE	M13K0037I	Booster limits disable
17	A		LH2 IN T ● V41T1301C	V41T1301C	Right SSME LH2 inlet temperature
18	A		LH2 IN P ● V41P1300C	V41P1300C	Right SSME LH2 inlet pressure
19	G		LOFDDSCOP ● V41X1529X	V41X1529X	LO2 ET/ORB feedline disconnect valve open
20	W		LOFDDSCCL ● V41X1530X	V41X1530X	LO2 ET/ORB feedline disconnect valve closed A
21	W		LOFDDSBCL ● V41X1534X	V41X1534X	LO2 ET/ORB feedline disconnect valve closed B
22	G		LOFDRISOP ● V41X1541E	V41X1541E	LO2 feedline relief isolation valve open
23	W		LOMNPIOPP ● V41X1538E	V41X1538E	LO2 manifold repressurization valve no. 1 open power
24	W		LOMNP2OPP ● V41X1539E	V41X1539E	LO2 manifold repressurization valve no. 2 open power
25	G		LOIBF/DCL ● V41X1509X	V41X1509X	LO2 inboard fill and drain valve closed
26	G		LOOBF/DCL ● V41X1514X	V41X1514X	LO2 outboard fill and drain valve closed
27	G		LOOVBBVCL ● V41X1580X	V41X1580X	LO2 overboard bleed valve closed
28	C		LHFDDSCOP ● V41X1429X	V41X1429X	LH2 ET/ORB feedline disconnect valve open
29	W		LHFDDSCCL ● V41X1430X	V41X1430X	LH2 ET/ORB feedline disconnect valve closed A
30	W		LHFDDSBCL ● V41X1434X	V41X1434X	LH2 ET/ORB feedline disconnect valve closed B
31	G		LHFDRISOP ● V41X1441E	V41X1441E	LH2 feedline relief isolation valve open
32	W		LHMNP1OPP ● V41X1436E	V41X1436E	LH2 manifold repressurization valve no. 1 open power
33	W		LHMNP2OPP ● V41X1438E	V41X1438E	LH2 manifold repressurization valve no. 2 open power
34	G		LHIBF/DCL ● V41X1410X	V41X1410X	LH2 inboard fill and drain valve closed
35	G		LHOBF/DCL ● V41X1389X	V41X1389X	LH2 outboard fill and drain valve closed
36	G		LH TOP CL ● V41X1456X	V41X1456X	LH2 topping valve closed

A PRELAUNCH LIMITS	A LAUNCH LIMITS	A SRB SEP LIMITS	A ET SEP LIMITS	R SITE STATIC	R GN STATIC
G L LIMITS DISABLE	G C LIMITS DISABLE	G R LIMITS DISABLE	A ABRT THRT LIMITS	R BFCS STATIC	R OI STATIC
G MEC PWR 1 V76S4601F	G SRB SEP INIT	G SRB SEP ARM CMD	W SRB SEP MN/AU ENA	W SRB SEP INIT CMD	G SRB SEP CMD
G MEC PWR 2 V76S4605E	G MECO CONFIRMED	G ET ORB SEP ARM	W ET SEP MAN ENA	W ET SEP INIT CMD	G ET SEP CMD
G SRB SEP AUTO ENA	G SRB SEP INIT	R SRB SEP INHIB	W SRB SEP MN/AU ENA	W SRB SEP INIT CMD	G SRB SEP CMD
G ET SEP AUTO ENA	G MECO CONFIRMED	R ET SEP INHIB	W ET SEP MAN ENA	W ET SEP INIT CMD	G ET SEP CMD

Figure 5.2.3-VI.- Limits status (format number: 290, type: A).

TABLE 5.2.3-V.- LIMITS STATUS (FORMAT NUMBER: 290; TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		PRELAUNCH ● LIMITS	M60K0011I	Limit sense set at prelaunch limits
02	A		LAUNCH ● LIMITS	M60K0012I	Limit sense set at launch limits
03	A		SRB SEP ● LIMITS	M60K0013I	Limit sense set at SRB separation limits
04	A		ET SEP ● LIMITS	M60K0014I	Limit sense set at external tank separation limits
05	R		SITE ● STATIC	M20K0012D	All site data static
06	R		GN ● STATIC	M40H0234D	Downlink data static
07	G		L LIMITS ● DISABLE	M13K0034I	Left SSME limit sense disabled
08	G		C LIMITS ● DISABLE	M13K0035I	Center SSME limit sense disabled
09	G		R LIMITS ● DISABLE	M13K0036I	Right SSME limit sense disabled
10	A		ABRT THRT ● LIMITS	M60K0015I	Limit sense set at abort SSME throttling limits
11	R		BFCS ● STATIC	M40H0434D	Backup flight control system data static
12	R		OI ● STATIC	M40H0134D	Operational instrumentation data static
13	G		MEC PWR 1 ● V76S4601E	V76S4601E	Master events controller power 1 on
14	G		SRB SEP ● INIT	V98X3532X	SRB separation initiation (BFS)
15	G		SRB SEP ● ARM CMD	V98X0744X	SRB separation arm command (BFS)
16	W		SRB SEP ● MN/AU ENA	V98X0742X	SRB separation manual/auto enable (BFS)
17	W		SRB SEP ● INIT CMD	V98X0743X	SRB separation initiation command (BFS)
18	G		SRB SEP ● CMD	V98X3534X	SRB separation command (BFS)
19	G		MEC PWR 2 ● V76S4605E	V76S4605E	Master events controller power 2 on (BFS)
20	G		MECO ● CONFIRMED	V98X3546X	Main engine cut off confirmed (BFS)
21	G		ET ORB ● SEP ARM	V98X0752X	ET/orbiter separation arm (BFS)
22	W		ET SEP ● MN/AU ENA	V98X0748X	ET separation manual enable (BFS)
23	W		ET SEP ● INIT CMD	V98X0749X	ET separation initiation command (BFS)
24	G		ET SEP ● CMD	V98X3550X	ET separation command (BFS)
25	G		SRB SEP ● AUTO ENA	V90X7570X	SRB separation auto enable
26	G		SRB SEP ● INIT	V90X8333X	SRB separation initiation
27	R		SRB SEP ● INHIB	V90X8340X	SRB separation inhibit
28	W		SRB SEP ● MN/AU ENA	V90X7571X	SRB separation manual enable
29	W		SRB SEP ● INIT CMD	V90X7572X	SRB separation initiation command
30	G		SRB SEP ● CMD	V90X8331X	SRB separation command
31	G		ET SEP ● AUTO ENA	V90X7554X	ET separation auto enable
32	G		MECO ● CONFIRMED	V90X8561X	Main engine cut off confirmed
33	R		ET SEP ● INHIB	V90X8259X	ET separation inhibit
34	W		ET SEP ● MAN ENA	V90X7556X	ET separation manual enable
35	W		ET SEP ● INIT CMD	V90X7564X	ET separation initiation command
36	G		ET SEP ● CMD	V90X8250X	ET separation command

A HE TK P V41P1250C	A HE TK P V41P1150C	A HE TK P V41P1350C	A HE TK P V41P1600A	W HEBD1 OPP V41X1632E	W HEBD2 OPP V41X1634E
A HE TK T V41T1251A	A HE TK T V41T1151A	A HE TK T V41T1351A	A HE TK T V41T1601A	A HE MD TKT V41T1252A	A HE MD TKT V41T1152A
A HE REG PA V41P1254A	A HE REG PA V41P1154A	A HE REG PA V41P1354A	A HE REG P V41P1605A	W HEXOVROPP V41X1614E	A HE MD TKT V41T1352A
A HE REG PB V41P1253A	A HE REG PB V41P1153A	A HE REG PB V41P1353A		W HEINTINOP V41X1264E	W HEINTOTOP V41X1270E
W HEISOAOPP V41X1258E	W HEISOAOPP V41X1158X	W HEISOAOPP V41X1358E	W HEISOAOPP V41X1645E	W HEINTINOP V41X1164E	W HEINTOTOP V41X1170E
W HEISOBOPP V41X1259E	W HEISOBOPP V41X1159E	W HEISOBOPP V41X1359E	W HEISOBOPP V41X1646E	W HEINTINOP V41X1364E	W HEINTOTOP V41X1370E

Figure 5.2.3-VII.- MPS on orbit (format number: 291, type A).

TABLE 5.2.3-VI.- MPS ON ORBIT (FORMAT NUMBER: 291; TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		HE TK P ● V41P1250C	V41P1250C	Left helium tank pressure
02	A		HE TK P ● V41P1150C	V41P1150C	Center helium tank pressure
03	A		HE TK P ● V41P1350C	V41P1350C	Right helium tank pressure
04	A		HE TK P ● V41P1600A	V41P1600A	Pneumatics helium tank pressure
05	W		HEBD1 OPP ● V41X1632E	V41X1632E	Helium blowdown valve no. 1 open power
06	W		HEBD2 OPP ● V41X1634E	V41X1634E	Helium blowdown valve no. 2 open power
07	A		HE TK T ● V41T1251A	V41T1251A	Left helium tank temperature
08	A		HE TK T ● V41T1151A	V41T1151A	Center helium tank temperature
09	A		HE TK T ● V41T1351A	V41T1351A	Right helium tank temperature
10	A		HE TK T ● V41T1601A	V41T1601A	Pneumatics helium tank temperature
11	A		HE MDTK T ● V41T1252A	V41T1252A	Left helium mid tank temperature
12	A		HE MDTK T ● V41T1152A	V41T1152A	Center helium mid tank temperature
13	A		HE REG PA ● V41P1254A	V41P1254A	Left helium regulator A pressure
14	A		HE REG PA ● V41P1154A	V41P1154A	Center helium regulator A pressure
15	A		HE REG PA ● V41P1354A	V41P1354A	Right helium regulator A pressure
16	A		HE REG P ● V41P1605A	V41P1605A	Pneumatics helium regulator pressure
17	W		HEXOVROPP ● V41X1614E	V41X1614E	Left helium crossover valve open power
18	A		HEMDTK T ● V41T1352A	V41T1352A	Right helium mid tank temperature
19	A		HE REG PB ● V41P1253A	V41P1253A	Left helium regulator B pressure
20	A		HE REG PB ● V41P1153A	V41P1153A	Center helium regulator B pressure
21	A		HE REG PB ● V41P1353A	V41P1353A	Right helium regulator B pressure
22			(BLANK)		Blank
23	W		HEINTINOP ● V41X1264E	V41X1264E	Left helium interconnect in valve open power
24	W		HEINTOTOP ● V41X1270E	V41X1270E	Left helium interconnect out valve open power
25	W		HEISOAOPP ● V41X1258E	V41X1258E	Left helium isolation valve A open power
26	W		HEISOAOPP ● V41X1158E	V41X1158E	Center helium isolation valve A open power
27	W		HEISOAOPP ● V41X1358E	V41X1358E	Right helium isolation valve A open power
28	W		HEISOAOPP ● V41X1645E	V41X1654E	Pneumatics helium isolation valve A open power
29	W		HEINTINOP ● V41X1164E	V41X1164E	Center helium interconnect in valve open power
30	W		HEINTOTOP ● V41X1170E	V41X1170E	Center helium interconnect out valve open power
31	W		HEISOBOPP ● V41X1259E	V41X1259E	Left helium isolation valve B open power
32	W		HEISOBOPP ● V41X1159E	V41X1159E	Center helium isolation valve B open power
33	W		HEISOBOPP ● V41X1359E	V41X1359E	Right helium isolation valve B open power
34	W		HEISOBOPP ● V41X1646E	V41X1646E	Pneumatics helium isolation valve B open power
35	W		HEINTINOP ● V41X1364E	V41X1364E	Right helium interconnect in valve open power
36	W		HEINTOTOP ● V41X1370E	V41X1370E	Right helium interconnect out valve open power

A LO2 IN P V41P1230C	A LO2 IN P V41P1130C	A LO2 IN P V41P1330C	W LO2PV OP V41X1234X	W LO2PV OP V41X1134X	W LO2PV OP V41X1334X
A LO MANF P V41P1533C	A O2 DISC P V41P1590A	W LOIBF/DCL V41X1509X	W LOOBF/DNC V41X1514X	W LOMANP1OP V41X1538E	W LOMANP2OP V41X1539E
					W LOFDRISNO V41X1541E
A LH2 IN P V41P1200C	A LH2 IN P V41P1100C	A LH2 IN P V41P1300C	W LH2PVNOP V41X1204X	W LH2PVNOP V41X1104X	W LH2PVNOP V41X1304X
A LH MANF P V41P1433C	A H2 DISC P V41P1490A	W LHIBF/DCL V41X1410X	W LHOBF/DNC V41X1389X	W LHMANP1OP V41X1436E	W LHMANP2OP V41X1438E
W LH TOP NC V41X1456X	W H2PLNVOPP V41X1492E				W LHFDRISNO V41X1441E

Figure 5.2.3-VIII.- MPS on orbit (format number: 292, type: A).

TABLE 5.2.3-VII.- MPS ON ORBIT (FORMAT NUMBER: 292; TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		LO2 IN P ● V41P1230C	V41P1230C	Left SSME LO2 in pressure
02	A		LO2 IN P ● V41P1130C	V41P1130C	Center SSME LO2 in pressure
03	A		LO2 IN P ● V41P1330C	V41P1330C	Right SSME LO2 in pressure
04	W		LO2 PVOP ● V41X1234X	V41X1234X	Left LO2 prevalve open
05	W		LO2 PVOP ● V41X1134X	V41X1134X	Center LO2 prevalve open
06	W		LO2 PVOP ● V41X1334X	V41X1334X	Right LO2 prevalve open
07	A		LO MANF P ● V41P1533C	V41P1533C	LO2 manifold pressure
08	A		O2 DISC P ● V41P1590A	V41P1590A	GO2 disconnect pressure
09	W		LOIBF/DCL ● V41X1509X	V41X1509X	LO2 inboard fill and drain valve closed
10	W	R	LOOBF/DNC ● V41X1514X	V41X1514X	LO2 outboard fill and drain valve not closed
11	W		LOMANP1OP ● V41X1538E	V41X1538E	LO2 manifold repressurization valve no. 1 open pwr
12	W		LOMANP2OP ● V41X1539E	V41X1539E	LO2 manifold repressurization valve no. 2 open pwr
13			(BLANK)	-	Blank
14			(BLANK)	-	Blank
15			(BLANK)	-	Blank
16			(BLANK)	-	Blank
17			(BLANK)	-	Blank
18	W	R	LOFDRISNO ● V41X1541E	V41X1541E	LO2 feedline relief isolation valve not open
19	A		LH2 IN P ● V41P1200C	V41P1200C	Left SSME LH2 in pressure
20	A		LH2 IN P ● V41P1100C	V41P1100C	Center SSME LH2 in pressure
21	A		LH2 IN P ● V41P1300C	V41P1300C	Right SSME LH2 in pressure
22	W	R	LH2 PVNOP ● V41X1204X	V41X1204X	Left LH2 prevalve not open
23	W	R	LH2 PVNOP ● V41X1104X	V41X1104X	Center LH2 prevalve not open
24	W	R	LH2 PVNOP ● V41X1304X	V41X1304X	Right LH2 prevalve not open
25	A		LH MANF P ● V41P1433C	V41P1433C	LH2 manifold pressure
26	A		H2 DISC P ● V41P1490A	V41P1490A	GH2 disconnect pressure
27	W	R	LHIBF/DCL ● V41X1410X	V41X1410X	LH2 inboard fill and drain valve closed
28	W		LHOBF/DNC ● V41X1389X	V41X1389X	LH2 outboard fill and drain valve not closed
29	W		LHMANP1OP ● V41X1436E	V41X1436E	LH2 manifold repressurization valve no. 1 open pwr
30	W		LHMANP2OP ● V41X1438E	V41X1438E	LH2 manifold repressurization valve no. 2 open pwr
31	W		LH TOP NC ● V41X1456X	V41X1456X	LH2 topping valve not closed
32	W	R	H2PLNVOPP ● V41X1492E	V41X1492E	GH2 pressurization line vent valve open power
33			(BLANK)	-	Blank
34			(BLANK)	-	Blank
35			(BLANK)	-	Blank
36	W	R	LHFDRISNO ● V41X1441E	V41X1441E	LH2 feedline relief isolation valve not open

(SRB)

(LO$_2$)					(left)		(right)	
G LO2 PV OP V41X1234X	W LO2 PV CL V41X1235E	G FD RIS OP V41X1541E	G MAN P1 OP V41X1538E	W O2 OVB OP V41X1587E	A L FSM A B46P1305C	A L FSM B B46P1306C	A R FSM A B46P2305C	A R FSM B B46P2306C
G LO2 PV OP V41X1134X	W LO2 PV CL V41X1135E	G IB FD OP V41X1510X	G MAN P2 OP V41X1539E	R L INLET T V41T1231C	A L HYSP AP B58P1303C	A L HYSP BP B58P1304C	A R HYSP AP B58P2303C	A R HYSP BP B58P2304C
G LO2 PV OP V41X1334X	W LO2 PV CL V41X1335E	G OB FD OP V41X1513X	W POGO 1 CL V41X1818E	R C INLET T V41T1131C	A* L RCK PRI B58X1860X	A* L TLT PRI B58X1859X	A* R RCK PRI B58X2860X	A* R TLT PRI B58X2859X
G FD DSC OP V41X1529X	W FD DSC CL V41X1530X	W FD DSC CL V41X1534X	W POGO 2 CL V41X1828E	R R INLET T V41T1331C	A L TRB SA B46R1408C	A L TRB SB B46R1409C	A R TRB SA B46R2408C	A R TRB SB B46R2409C

Figure 5.2.3-IX.- MPS PRESS (format number: 298; type: B).

TABLE 5.2.3-VIII.- MPS event (FORMAT NUMBER: 298; TYPE: B)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	G		LO2 PV OP ● V41X1234X	V41X1234X	Left LO2 prevalve open
02	W		LO2 PV CL ● V41X1235E	V41X1235E	Left LO2 prevalve closed
03	G		FD RIS OP ● V41X1541E	V41X1541E	LO2 Feedline Relief Isolation valve open
04	G		MAN P1 OP ● V41X1538E	V41X1538E	LO2 Manifold Pressurization 1 valve open power
05	W		02 OVB OP ● V41X1587E	V41X1587E	Overboard bleed valve open
06	A		L FSM A ● B46P1305C	B46P1305C	Left SRB A fuel supply module pressure
07	A		L FSM B ● B46P1306C	B46P1306C	Left SRB B fuel supply module pressure
08	A		R FSM A ● B46P2305C	B46P2305C	Right SRB A fuel supply module pressure
09	A		R FSM B ● B46P2306C	B46P2306C	Right SRB B fuel supply module pressure
10	G		LO2 PV OP ● V41X1134X	V41X1134X	Center LO2 prevalve open
11	W		LO2 PV OP ● V41X1135E	V41X1135E	Center LH2 prevalve closed
12	G		IB FD OP ● V41X1510X	V41X1510X	LO2 inboard filldrain valve closed
13	G		MAN P2 OP ● V41X1539E	V41X1539E	LO2 Manifold Pressurization 2 valve open power
14	R		L INLET T ● V41T1231C	V41T1231C	Left SSME LO2 inlet temperature
15	A		L HYDSP AP ● B58P1303C	B58P1303C	Left SRB A hydraulic supply pressure
16	A		L HYDSP BP ● B58P1304C	B58P1304C	Left SRB B hydraulic supply pressure
17	A		R HYDSP AP ● B58P2303C	B58P2303C	Right SRB A hydraulic supply pressure
18	A		R HYDSP BP ● B58P2304C	B58P2304C	Right SRB B hydraulic supply pressure
19	G		LO2 PV OP ● V41X1334X	V41X1334X	Right LO2 prevalve open
20	W		LO2 PV CL ● V41X1335E	V41X1335E	Right LO2 prevalve closed
21	G		OB FD OP ● V41X1513X	V41X1513X	LO2 outboard filldrain valve closed
22	W		POGO 1 CL ● V41X1818E	V41X1818E	POGO recirculation valve 1 close
23	R		C INLET T ● V41T1131C	V41T1131C	Center SSME LO2 inlet temperature
24	A	R	L RCK PRI ● B58X1860X	B58X1860X	Left SRB rock actuator primary pressure OK
25	A	R	L TLT PRI ● B58X1859X	B58X1859X	Left SRB tilt actuator primary pressure OK
26	A	R	R RCK PRI ● B58X2860X	B58X2860X	Right SRB rock actuator primary pressure OK
27	A	R	R TLT PRI ● B58X2859X	B58X2859X	Right SRB tilt actuator primary pressure OK
28	G		FD OSC OP ● V41X1529X	V41X1529X	LO2 Feedline Disconnect valve open
29	W		FD DSC CL ● V41X1530X	V41X1530X	LO2 Feedline Disconnect valve closed
30	W		FD DSC CL ● V41X1534X	V41X1534X	LO2 Feedline Disconnect valve closed
31	W		POGO 2 CL ● V41X1828E	V41X1828E	POGO recirculation valve 2 close
32	R		R INLET T ● V41T1331C	V41T1331C	Right SSME LO2 inlet temperature
33	A		L TRB SA ● B46R1408C	B46R1408C	Left SRB A turbine speed 2
34	A		L TRB SA ● B46R1409C	B46R1409C	Left SRB B turbine speed 2
35	A		R TRB SA ● B46R2408C	B46R2408C	Right SRB A turbine speed 2
36	A		R TRB SA ● B46R2409C	B46R2409C	Right SRB B turbine speed 2

G LH2 PV OP V41X1204X	W LH2 PV CL V41X1205E	G FD RIS OP V41X1441E	G MAN P1 OP V41X1436E	G RTLS P1 O V41X1901E	A LH2 MAN P V41P1433C	A LO2 MAN P V41P1533C	A L SRB PC1 B47P1300C	A R SRB PC1 B47P2300C
G LH2 PV OP V41X1104X	W LH2 PV CL V41X1105E	G IB FD OP V41X1409E	G MAN P2 OP V41X1438E	G RTLS P2 O V41X1902E	A L INLET T V41P1201C	A L INLET P V41P1200C	A L SRB PC2 B47P1301C	A R SRB PC2 B47P2301C
G LH2 PV OP V41X1304X	W LH2 PV CL V41X1305E	G OB FD OP V41X1388E	G H2 TOP OP V41X1453E	G RTLS IB O V41X1927E	A C INLET T V4151101C	A C INLET P V41P1100C	A L SRB PC3 B47P1302C	A R SRB PC3 B47P2302C
G FD DSC OP V41X1429X	W FD DSC CL V41X1430X	W FD DSC CL V41X1434X	W R DSC CL V41X1420E	G RTLS OB O V41X1917E	A R INLET T V41T1301C	A R INLET P V41P1300C	R BFS BU CW V98X1268X	R BFS ALERT V98X1269X

Figure 5.2.3-X.- MPS event (format number: 299; type: B).

TABLE 5.2.3-IX.- MPS EVENT (FORMAT NUMBER: 299; TYPE: B)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	G		LH2 PV OP ● V41X1204X	V41X1204X	Left LH2 prevalve open
02	W		LH2 PV CL ● V41X1205E	V41X1205E	Left LH2 prevalve closed
03	G		FD RIS OP ● V41X1441E	V41X1441E	LH2 feedline relief isolation valve open
04	G		MAN P1 OP ● V41X1436E	V41X1436E	LH2 manifold repressurization valve no. 1 open power
05	G		RTLS P1 O ● V41X1901E	V41X1901E	LH2 RTLS manifold repressurization 1 valve open
06	A		LH2 MAN P ● V41P1433C	V41P1433C	LH2 manifold pressure
07	A		LO2 MAN P ● V41P1533C	V41P1533C	LO2 manifold pressure
08	A		L SRB PC1 ● B47P1300C	B47P1300C	Left SRB chamber pressure no. 1
09	A		R SRB PC1 ● B47P2300C	B47P2300C	Right SRB chamber pressure no. 1
10	G		LH2 PV OP ● V41X1104X	V41X1104X	Center LH2 prevalve open
11	W		LH2 PV CL ● V41X1105E	V41X1105E	Center LH2 prevalve closed
12	G		IB FD OP ● V41X1409E	V41X1409E	LH2 inboard fill and drain valve closed
13	G		MAN P2 OP ● V41X1438E	V41X1438E	LH2 manifold repressurization valve no. 2 open power
14	G		RTLS P2 O ● V41X1902E	V41X1902E	LH2 RTLS manifold repressurization 2 valve open
15	A		L INLET T ● V41T1201C	V41T1201C	Left SSME inlet temperature
16	A		L INLET P ● V41P1200C	V41P1200C	Left SSME inlet pressure
17	A		L SRB PC2 ● B47P1301C	B47P1301C	Left SRB chamber pressure no. 2
18	A		R SRB PC2 ● B47P2301C	B47P2301C	Right SRB chamber pressure no. 2
19	G		LH2 PV OP ● V41X1304X	V41X1304X	Right LH2 prevalve open
20	W		LH2 PV CL ● V41X1305E	V41X1305E	Right LH2 prevalve closed
21	G		OB FD OP ● V41X1388E	V41X1388E	LH2 outboard fill and drain valve closed
22	G		H2 TOP OP ● V41X1453E	V41X1453E	LH2 topping valve closed
23	G		RTLS IB O ● V41X1927E	V41X1927E	RTLS inboard dump valve open
24	A		C INLET T ● V41T1101C	V41T1101C	Center SSME LH2 inlet temperature
25	A		C INLET P ● V41T1100C	V41T1100C	Center SSME LH2 inlet pressure
26	A		L SRB PC3 ● B47P1302C	B47P1302C	Left SRB chamber pressure no. 3
27	A		R SRB PC3 ● B47P2302C	B47P2302C	Right SRB chamber pressure no. 3
28	G		FD DSC OP ● V41X1429X	V41X1429X	LH2 ET/ORB feedline disconnect valve open
29	W		FD DSC CL ● V41X1430X	V41X1430X	LH2 ET/ORB feedline disconnect valve closed A
30	W		FD DSC CL ● V41X1434X	V41X1434X	LH2 ET/ORB feedline disconnect valve closed B
31	W		R DSC CL ● V41X1420E	V41X1420E	LH2 recirculation disconnect valve closed
32	G		RTLS OB O ● V41X1917E	V41X1917X	RTLS outboard dump valve open
33	A		R INLET T ● V41T1301C	V41T1301C	Right SSME LH2 inlet temperature
34	A		R INLET P ● V41P1300C	V41P1300C	Right SSME LH2 inlet pressure
35	R		BFS BU CW ● V98X1268X	V98X1268X	BFS backup caution and warning
36	R		BFS ALERT ● V98X1269X	V98X1268X	BFS alert

	A PRELAUNCH LIMITS	A LAUNCH LIMITS	A SRB SEP LIMITS	A ET SEP LIMITS	A ABRT THRT LIMITS	R GN STATIC
	W L SRB PIC A	W L SRB PIC B	W R SRB PIC A	W R SRB PIC B	R BFCS STATIC	R OI STATIC
(BFS)	G MEC PWR 1 V76S4601E	G SRB SEP INIT	G SRB SEP ARM CMD	W SRB SEP MN/AU ENA	W SRB SEP INIT CMD	G SRB SEP CMD
	G MEC PWR 2 V76S4605E	G MECO CONFIRMED	G ET ORB SEP ARM	A ET SEP MAN ENA	W ET SEP INIT CMD	G ET SEP CMD
(PASS)	G SRB SEP AUTO ENA	G SRB SEP INIT	R SRB SEP INHIB	A SRB SEP MN/AU ENA	W SRB SEP INIT CMD	G SRB SEP CMD
	G ET SEP AUTO ENA	G MECO CONFIRMED	R ET SEP INHIB	A ET SEP MAN ENA	W ET SEP INIT CMD	G ET SEP CMD

Figure 5.2.3-XI.- Limits status (format number: 300, type: A).

TABLE 5.2.3-X.- LIMITS STATUS (FORMAT NUMBER: 300; TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		PRELAUNCH ● LIMITS	M60K0011I	Limit sense set at prelaunch limits
02	A		LAUNCH ● LIMITS	M60K0012I	Limit sense set at launch limits
03	A		SRB SEP ● LIMITS	M60K0013I	Limit sense set at SRB separation limits
04	A		ET SEP ● LIMITS	M60K0014I	Limit sense set at external tank separation limits
05	A		ABRT THRT ● LIMITS	M60K0015I	Limit sense set at abort SSME throttling limits
06	R		GN ● STATIC	M40H0234D	Downlink data static
07	W		L SRB ● PIC A	V90X8383X	
08	W		L SRB ● PIC B	V90X8384X	
09	W		R SRB ● PIC A	V90X8385X	
10	W		R SRB ● PIC B	V90X8386X	
11	R		BFCS ● STATIC	M40H0434D	Backup flight control system data static
12	R		OI ● STATIC	M40H0134D	Operational instrumentation data static
13	G		MEC PWR 1 ● V76S4601E	V76S4601E	Master events controller power 1 on
14	G		SRB SEP ● INIT	V98X3532X	SRB separation initiation (BFS)
15	G		SRB SEP ● ARM CMD	V98X0744X	SRB separation arm command (BFS)
16	A		SRB SEP ● MN/AU ENA	V98X0742X	SRB separation manual/auto enable (BFS)
17	W		SRB SEP ● INIT CMD	V98X0743X	SRB separation initiation command (BFS)
18	G		SRB SEP ● CMD	V98X3534X	SRB separation command (BFS)
19	G		MEC PWR 2 ● V76S4605E	V76S4605E	Master events controller power 2 on (BFS)
20	G		MECO ● CONFIRMED	V98X3546X	Main engine cut off confirmed (BFS)
21	G		ET ORB ● SEP ARM	V98X0752X	ET/orbiter separation arm (BFS)
22	A		ET SEP ● MAN ENA	V98X0748X	ET separation manual enable (BFS)
23	W		ET SEP ● INIT CMD	V98X0749X	ET separation initiation command (BFS)
24	G		ET SEP ● CMD	V98X3550X	ET separation command (BFS)
25	G		SRB SEP ● AUTO ENA	V90X7570X	SRB separation auto enable
26	G		SRB SEP ● INIT	V90X8333X	SRB separation initiation
27	R		SRB SEP ● INHIB	V90X8340X	SRB separation inhibit
28	A		SRB SEP ● MN/AU ENA	V90X7571X	SRB separation manual enable
29	W		SRB SEP ● INIT CMD	V90X7572X	SRB separation initiation command
30	G		SRB SEP ● CMD	V90X8331X	SRB separation command
31	G		ET SEP ● AUTO ENA	V90X7554X	ET separation auto enable
32	G		MECO ● CONFIRMED	V90X8561X	Main engine cut off confirmed
33	R		ET SEP ● INHIB	V90X8259X	ET separation inhibit
34	A		ET SEP ● MAN ENA	V90X7556X	ET separation manual enable
35	W		ET SEP ● INIT CMD	V90X7564X	ET separation initiation command
36	G		ET SEP ● CMD	V90X8250X	ET separation command

A L HE TK P V41P1250C	A C HE TK P V41P1150C	A R HE TK P V41P1350C	A PNEU TK P V41P1600A	W* L ISOA CL V41X1258E	W* L ISOB CL V41X1259E
A L REG AP V41P1254A	A C REG AP V41P1154A	A R REG AP V41P1354A	A PN REG P V41P1605A	W* C ISOA CL V41X1158E	W* C ISOB CL V41X1159E
A L REG BP V41P1253A	A C REG BP V41P1153A	A R REG BP V41P1353A	A PN ACC P V41P1650A	W* R ISOA CL V41X1358E	W* R ISOB CL V41X1359E
A TK CHG RT V98P4998C	A TK CHG RT V98P4997C	A TK CHG RT V98P4999C	W PN ISO CL V41X1645E	G PN BLDN 1 V41X1632E	G L IN IN/O V41X1264E
A TK DEC RT M02G3800C	A TK DEC RT M01G3800C	A TK DEC RT M03G3800C	A TK DEC RT M04G3800C	G PN BLDN 2 V41X1634E	G C IN IN/O V41X1164E
A L HE TK T V41T1252A	A C HE TK T V41T1152A	A R HE TK T V41T1352A	A PNEU TK T V41T1601A	G HE XVR OP V41X1614X	G R IN IN/O V41X1364X

Figure 5.2.3-XII.- Helium (format number: 301, type: A).

TABLE 5.2.3-XI.- HELIUM (FORMAT NUMBER: 301; TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		L HE TK P ● V41P1250C	V41P1250C	Left helium tank pressure
02	A		C HE TK P ● V41P1150C	V41P1150C	Center helium tank pressure
03	A		R HE TK P ● V41P1350C	V41P1350C	Right helium tank pressure
04	A		PNUE TK P ● V41P1600A	V41P1600A	Pneumatic helium tank pressure
05	W	R	LHEISOACL ● V41X1258E	V41X1258E	Left helium isolation valve A open power
06	W	R	LHEISOBCL ● V41X1259E	V41X1259E	Left helium isolation valve B open power
07	A		L REG AP ● V41P1254A	V41P1254A	Left helium regulator A pressure
08	A		C REG AP ● V41P1154A	V41P1354A	Center helium regulator A pressure
09	A		R REG AP ● V41P1354A	V41P1354A	Right helium regulator A pressure
10	A		PN REG P ● V41P1605A	V41P1605A	Pneumatics helium regulator pressure
11	W	R	CISOACL ● V41X1158E	V41X1158E	Center helium isolation valve A open power
12	W	R	CISOBCL ● V41X1159E	V41X1159E	Center helium isolation valve B open power
13	A		L REG BP ● V41P1253A	V41P1253A	Left helium regulator B pressure
14	A		C REG BP ● V41P1153A	V41P1153A	Center helium regulator B pressure
15	A		R REG BP ● V41P1353A	V41P1353A	Right helium regulator B pressure
16	A		PN ACC P ● V41P1650A	V41P1650A	Pneumatic helium accumulater pressure
17	W	R	RISOACL ● V41X1358E	V41X1358E	Right helium isolation valve A open power
18	W	R	RISOBCL ● V41X1359E	V41X1359E	Right helium isolation valve B open power
19	A		TK CHG RT ● V98P4998C	V98P4998C	Left helium tank pressure change rate
20	A		TK CHG RT ● V98P4997C	V98P4997C	Center helium tank pressure change rate
21	A		TL CHG RT ● V98P4999C	V98P4999C	Right helium tank pressure change rate
22	W	R	PNISOACL ● V41X1645E	V41X1645E	Pneumatics helium isolation valve A open power
23	G		PN BLDN 1 ● V41X1632E	V41X1632E	Pneumatic helium blowdown valve 1 open power
24	G		L IN IN/O ● V41X1264E	V41X1264E	Left helium interconnect in/open open power
25	A		TK DEC RT ● M02G3800C	M02G3800C	Left helium tank pressure decay rate
26	A		TK DEC RT ● M01G3800C	M01G3800C	Center helium tank pressure decay rate
27	A		TK DEC RT ● M03G3800C	M03G3800C	Right helium tank pressure decay rate
28	A		TK DEC RT ● M04G3800C	M04G3800C	Pneumatics helium tank pressure decay rate
29	G		PN BLDN 2 ● V41X1634E	V41X1634E	Pneumatic helium blowdown valve 2 open power
30	G		C IN IN/O ● V41X1164E	V41X1164E	Center helium interconnect in/open open power
31	A		L HE TK T ● V41T1252A	V41T1252A	Left helium midbody temperature
32	A		C HE TK T ● V41T1152A	V41T1352A	Center helium midbody temperature
33	A		R HE TK T ● V41T1352A	V41T1352A	Right helium midbody temperature
34	A		PNEU TK T ● V41T1601A	V41T1601A	Pneu helium aft temperature
35	G		HE XVR OP ● V41X1614E	V41X1614E	Left helium crossover valve open power
36	G		R IN IN/O ● V41X1364E	V41X1364E	Right helium interconnect in/open open power

A L H2 GA P M02G3706C	A C H2 GA P M01G3706C	A R H2 GA P M03G3706C	A LBR 64K	R LOW LV AC V90X1942X	R RS HOLD
A L H2 ULLP T41P1701C	A C H2 ULLP T41P1700C	A R H2 ULLP T41P1702C	R* LH2 VT OP T41X1724E	A LO2 5% LV T41X1762E	A LH2 5% LV T41X1712E
G* L FCV OP V41X1662E	G* C FCV OP V41X1661E	G* R FCV OP V41X1663E	A LH2 HI FL V41S1477E	R LO2 CO 1 V41X1555X	R LH2 CO 1 T41X1730X
R L NPSP M02G3111C	R C NPSP M01G3111C	R R NPSP M03G3111C	R NPSP AVG M04G3111C	R LO2 CO 2 V41X1556X	R LH2 CO 2 T41X1731X
A L O2 ULLP T41P1751C	A C O2 ULLP T41P1750C	A R O2 ULLP T41P1752C	R* LO2 VT OP T41X1774E	R LO2 CO 3 V41X1557X	R LH2 CO 3 T41X1732X
G* L FCV OP V41X1598E	G* C FCV OP V41X1596E	G* R FCV OP V41X1603E	G ET TUMBLE ARMED	R LO2 CO 4 V41X1558X	R LH2 CO 4 T41X1733X

Figure 5.2.3-XIII.- ET PRESS/PRPLNT (format number: 302, type: A).

TABLE 5.2.3-XII.- ET PRES/PRPLNT (FORMAT NUMBER: 302; TYPE: A)

Indicator location	Color	Logic	Overlay label	Measurement number	Measurement description
01	A		L H2 GAP ● M02G3706C	M02G3706C	External tank left LH2 ullage gage pressure
02	A		C H2 GAP ● M01G3706C	M01G3706C	External tank center LH2 ullage gage pressure
03	A		R H2 GAP ● M03G3706C	M03G3706C	External tank right LH2 ullage gage pressure
04	A		LBR ● 64K	V74X4754E	Low bit rate 64000
05	R		LOW LV AC ● V90X1942X	V90X1942X	Low level cut off sensors arm command
06	R		RS ● HOLD	V90X8667X	Redundant set hold
07	A		L H2 ULLP ● T41P1701C	T41P1701C	External tank left LH2 ullage absolute pressure
08	A		C H2 ULLP ● T41P1700C	T41P1700C	External tank center LH2 ullage absolute pressure
09	A		R H2 ULLP ● T41P1702C	T41P1702C	External tank right LH2 ullage absolute pressure
10	R	R	LH2 VT OP ● T41X1724E	T41X1724E	External tank LH2 vent valve closed
11	A		LO2 5% LV ● T41X1762E	T41X1762E	External tank LO2 5% liquid level
12	A		LH2 5% LV ● T41X1712E	T41X1712E	External tank LH2 5% liquid level
13	G	R	L FCV OP ● V41X1662E	V41X1662E	Left GH2 pressure flow control valve close power
14	G	R	C FCV OP ● V41X1661E	V41X1661E	Center GH2 pressure flow control valve close power
15	G	R	R FCV OP ● V41X1663E	V41X1663E	Right GH2 pressure flow control valve close power
16	A		LH2 HI FL ● V41S1477E	V41S1477E	External tank GH2 ullage high flow on
17	R		LO2 CO 1 ● V41X1555X	V41X1555X	Orbiter LO2 low level cutoff sensor no. 1 dry
18	R		LH2 CO 1 ● T41X1730X	T41X1730X	External tank LH2 low level cutoff sensor no. 1 dry
19	R		L NPSP ● M02G3111C	M02G3111C	Left SSME fuel net positive suction pressure
20	R		C NPSP ● M01G3111C	M01G3111C	Center SSME fuel net positive suction pressure
21	R		R NPSP ● M03G3111C	M03G3111C	Right SSME fuel net positive suction pressure
22	R		NPSP AVG ● M04G3111C	M04G3111C	Average SSME fuel net positive suction pressure
23	R		LO2 CO 2 ● V41X1556X	V41X1556X	Orbiter LO2 low level cutoff sensor no. 2 dry
24	R		LH2 CO 2 ● T41X1731X	T41X1731X	External tank LH2 low level cutoff sensor no. 2 dry
25	A		L O2 ULLP ● T41P1751C	T41P1751C	External tank left LO2 ullage pressure
26	A		C O2 ULLP ● T41X1750C	T41X1750C	External tank center LO2 ullage pressure
27	A		R O2 ULLP ● T41P1752C	T41P1752C	External tank right LO2 ullage pressure
28	R	R	LO2 VT OP ● T41X1774E	T41X1774E	External tank LO2 vent valve closed
29	R		LO2 CO 3 ● V41X1557X	V41X1557X	Orbiter LO2 low level cutoff sensor no. 3 dry
30	R		LH2 CO 3 ● T41X1732X	T41X1732X	External tank LH2 low level cutoff sensor no. 3 dry
31	G	R	L FCV OP ● V41X1598E	V41X1598E	Left GO2 pressure flow control valve close power
32	G	R	C FCV OP ● V41X1596E	V41X1596E	Center GO2 pressure flow control valve close power
33	G	R	R FCV OP ● T41X1603E	T41X1603E	Right GO2 pressure flow control valve close power
34	G		ET TUMBLE ● ARMED	T56X0002E	External tank tumble valve armed indication
35	R		LO2 CO 4 ● V41X1558X	V41X1558X	Orbiter LO2 low level cutoff sensor no. 4 dry
36	R		LH2 CO 4 ● T41X1733X	T41X1733X	External tank LH2 low level cutoff sensor no. 4 dry

TITLE

MPS CONSOLE LIMIT SENSING CONTROL

PURPOSE

This SCP provides a description of the MPS console limit sensing operation and control. A table listing the limits for each parameter in each phase of the mission is provided.

DESCRIPTION

The Mission Operations Computer, MOC, has the capability to store five sets of high and low limits for each parameter. The MOC is initialized with permanent limits in these five sets. Either limit for any parameter may be temporarily changed using the MED terminal. These changes are temporary and the permanent limits will be selected each time the MOC is initialized. These five sets of limits are individually selected using the SMEK panel. The limit sets can be selected by either the Booster, Main Engine or Main Propulsion System console operator; however, selection of limit sets is the responsibility of the MPS operator. The sets are divided by mission phase, set 1 is used prelaunch, set 2 is selected at launch, set 3 is selected at SRB SEP, set 4 is selected at ET SEP, and set 5, ABRT THRT, will be used if the SSME's are throttled above nominal power levels (e.g., 109%). The permanent limits used are shown in table 5.2.4-I. The limits for each actual mission are adjusted by means of the MED terminal to allow for differences between individual SSME's. Therefore, the limits shown may not represent the current flight configuration. Refer to SCP 1.2.5 for on-orbit limit sense operations.

If a high or a low limit is exceeded for a parameter displayed on a console event light indicator, that light will be illuminated. The parameters displayed on a CRT will have an up arrow "↑" following the parameter value if a high limit was exceeded or a down arrow "↓" if a low limit was exceeded.

Each parameter is also assigned one or more of four categories. The categories provide a means to disable and reenable the limits for four combinations of parameters. Category 34 includes those parameters associated with the left SSME, category 35 the center SSME, category 36 the right SSME, and category 37 all booster parameters.

REFERENCES

1. DF65 Data Pack

2. Booster Console Handbook, Final, REV-C, JSC-17239, April 10, 1987.

TABLE 5.2.4-I. MISSION LIMITS

MSID	Parameter	1 PRELCH		2 Launch		3 and 5 SRB SEP		Abort		4 ET SEP		Unit	Category	Rationale for limits
		L	H	L	H	L	H	L	H	L	H			
V41P1250C	He tank press.,L	4100	4500	3500	4500	1500	4500	1500	1500	1400	4500	psia	37	1. (A) 2. (E) - 4300 to 3500 Low limit 200 psi below min nominal value 3. (E) 3500 to 2400 3,5 - Covers 700s RTLS at 4 psi/sec. 4. SRB SEP limit (-) 100 for dump
V41P1150C	" ,C	4100	4500	3500	4500	1500	4500	1500	1500	1400	4500	psia	37	
V41P1350C	" ,R	4100	4500	3500	4500	1500	4500	1500	1500	1400	4500	psia	37	
V41P1600A	" ,Pn	4100	4500	3500	4500	3500	4500	3500	4500	1400	4500	psia	37	
V41P1254A	He reg A pr ,L	730	785	680	790	680	790	680	790	0	790	psia	37	1. (B) 2-5.10 psi inside C&W limit. Provides indication before C&W reached
V41P1154A	" ,C	730	785	680	790	680	790	680	790	0	790	psia	37	
V41P1354A	" ,R	730	785	680	790	680	790	680	790	0	790	psia	37	
V41P1605A	" ,Pn	700	790	700	790	700	790	700	790	0	790	psia	37	
M02G3800C	He depletion rate ,L	0	.001	0	.05	0	.05	0	.05	-1	.01	lbs/s	37	1. (C) ; 4. Limits N/A-No comp. 2,3,4.-Normal usage is .045; limits give tolerance of ±.01 about nominal. Pneumatic bottle limits set to detect low leak rate
M01G3800C	" ,C	0	.001	0	.05	0	.05	0	.05	-1	.01	lbs/s	37	
M03G3800C	" ,R	0	.001	0	.05	0	.05	0	.05	-1	.01	lbs/s	37	
M04G3800C	" ,Pn	0	.001	-1	.01	-1	.01	-1	.01	-1	.01	lbs/s	37	
M06G3800T	He TOD ,L	0	.0028	.0956	.6	.0956	→	.0956	.6	0	.6	hr	37	1. (C) 2,3,5.-Low limit set for TOD at PTM (-5) Upper-(D)
M05G3800T	" ,C	0	.0028	.0956	.6	.0956	→	.0956	.6	0	.6	hr	37	
M07G3800T	" ,R	0	.0028	.0956	.6	.0956	→	.0956	.6	0	.6	hr	37	
M08G3800T	" ,Pn	0	.0028	-1	20000	-1	20000	-1	20000	0	.6	hr	37	
M10G3800T	TOD with PNE ,L	0	.0028	.0956	.6	.0956	.6	.0956	.6	0	.6	hr	37	1. (C) 2,3,5.-Low limit set for TOD at PTM (-5) Upper-(D)
M09G3800T	" ,C	0	.0028	.0956	.6	.0956	.6	.0956	.6	0	.6	hr	37	
M11G3800T	" ,R	0	.0028	.0956	.6	.0956	.6	.0956	.6	0	.6	hr	37	
V41T1251A	He tank temp (AFT) ,L	-5	65	10	65	-50	65	-50	65	-50	65	deg F	37	1. (A) -Ascent (E) 60 → (-) 20 2. Δ = (-) 30 from prelaunch min 3,4,5.Δ = (-) 100° from prelaunch min for 700s RTLS Max set for prelaunch LCC
V41T1151A	" ,C	-5	65	10	65	-50	65	-50	65	-50	65	deg F	37	
V41T1351A	" ,R	-5	65	10	65	-50	65	-50	65	-50	65	deg F	37	

TABLE 5.2.4-I.- Continued

MSID	Parameter	1 PRELCH		2 Launch		3 and 5 SRB SEP		3 and 5 Abort		4 ET SEP		Unit	Category	Rationale for limits
		L	H	L	H	L	H	L	H	L	H			
V41T1601A	" ,Pn	30	70	30	70	30	70	30	70	-50	70	deg F	37	
V41T1152A	Mid-tank temp ,C	45	135	45	135	0	135	0	135	-50	135	deg F	37	1. (A) - Ascent (E) 120 → 40 (SRB SEP nom =100)
V41T1252A	" ,L	45	135	45	135	0	135	0	135	-50	135	deg F	37	2. Δ = (-) 30 from prelaunch min 3,4,5.Δ = (-) 100° from prelaunch min Max set for prelaunch LCC
V41T1352A	" ,R	45	135	45	135	0	135	0	135	-50	135	deg F	37	
V98P4997C	Tank change rt ,C	0	20	0	20	0	20	0	20	0	10	psi/ 3 sec	37	1,2,3,5. Normal rate approx 12 psi/3 sec Limits adequate to indicate off nom operation 4. Limits N/A
V98P4998C	" ,L	0	20	0	20	0	20	0	20	0	10	psi/ 3 sec	37	
V98P4999C	" ,R	0	20	0	20	0	20	0	20	0	10	psi/ 3 sec	37	
V41P1153A	HE reg B pr ,C	730	785	680	790	680	790	680	790	0	790	psia	37	1. (B) 2-5. 10 psi inside C&W limit. Provides indication before C&W reached.
V41P1253A	" ,L	730	785	680	790	680	790	680	790	0	790	psia	37	
V41P1353A	" ,R	730	785	680	790	680	790	680	790	0	790	psia	37	
M04G3101C	Total ox flow rt	0	4000	0	4000	→	→	→	→	→	→	lbs/ sec	34,35, 36,37	1. (C) - Others: Reasonableness check on comp
M04G3103C	Total fu flow rt	0	600	0	600	→	→	→	→	→	→	lbs/ sec	34,35, 36,37	1. (C) - Others: Reasonableness check on comp
M01G3107C	Overall MR	0	7	5	7	→	→	5	7	0	1	-	-	1. (C) - Others: Reasonableness check on comp
M03G3110T	Time 3g throttle	0	1	0	1	→	→	→	→	→	→	hr	-	1. (C) - Others: Reasonableness check on comp
M02G3110T	Prop TOD	0	1	0	1	→	→	→	→	→	→	hr	-	1. (C) - Others: Reasonableness check on comp
V41P1533C	LO_2 man. press.	95	108	60	170	50	170	50	170	0	40	psia	37	1. Nom 102 after prepress, before start; 2,3,5. nom 55 to 150; 4. Above relief
V41P1230C	LO_2 inlet press. ,L	101	113	40	170	40	170	40	170	0	40	psia	34,37	1. Nom 107 after prepress, before start (ICD 103 to 111)
V41P1130C	" ,C	101	113	40	170	40	170	40	170	0	40	psia	35,37	2,3,5. Nom 55 to 160. Spike at SRB SEP to 45. High limit covers 3.4g

TABLE 5.2.4-I.- Continued

MSID	Parameter	1 PRELCH		2 Launch		3 and 5 SRB SEP		Abort		4 ET SEP		Unit	Category	Rationale for limits
		L	H	L	H	L	H	L	H	L	H			
V41P1330C	" ,R	101	113	40	170	40	170	40	170	0	40	psia	36,37	4. High set above relief (200) and below C&W
T41P1751C	LO_2 Ull press. ,L	17.3	20.5	16	22	20	22	20	22	0	30	psig	37	1. (A) 2. Set for press dip and overshoot in first stage 3,5 - Control band (ICD) 4.-(D)
T41P1750C	,C	17.3	20.5	16	22	20	22	20	22	0	30	psig	37	
T41P1752C	,R	17.3	20.5	16	22	20	22	20	22	0	30	psig	37	
V41P1590A	GO_2 disc press.	0	1000	200	500	→	→	200	500	0	100	psia	37	1. (D);2,3,5.-(E) 250 to 460, spike to 150; 4.(D)-Limits cover 65% P/L
V41P1433C	LH_2 man. press.	43	54	27	40	26	35	26	35	0	40	psia	37	1. Nom 44; 2,3,5.-(E) 30-32 4. Set above 50 psi relief
V41P1200C	LH_2 Inlet press.L	43	54	23	40	23	35	23	35	0	40	psia	34,37	1. Nom 53 with recirc pump on, A6 with pump off (ICD43-47) 2,3,5-(E) 26 to 34 4. Set above 50 psi relief pressure
V41P1100C	" ,C	43	54	23	40	23	35	23	35	0	40	psia	35,37	
V41P1300C	" ,R	43	54	23	40	23	35	23	35	0	40	psia	36,37	
V41P1490A	GH_2 disc. press.	0	1000	50	550	50	550	50	550	0	150	psia	37	1. (D);2,3,5-(E) 100 to 500 (65-104% P/L) 4. Data base 0 to 112
M02G3706C	LH2 Ull. Press.,L	40.9	44.1	32	34	32	34	32	34.4	0	32	psig	37	1. (D); 4.(D) 2. (E) 18-33.5 3,5-(E) 32.5 to 33.5, lower limit is lower control band limit, upper is 0.6 above upper but below relief band of 35-37 Crew alert - 31.6 psia
M01G3706C	" ,C	40.9	44.1	32	34	32	34	32	34.4	0	32	psig	37	
M03G3706C	" ,R	40.9	44.1	32	34	32	34	32	34.4	0	32	psig	37	
V41T1271A	GO2 out temp. ,L	-20	100	140	500	300	500	300	500	-50	325	deg F	34,37	1. Lower-(A), Upper-(D),4.(D) 2. (E) 140+480-Limits on lower limit range. Upper-20 above limit 3,5.(E) 380 to 480 @ 104% P/L 350 to 460 @ 100% P/L Note: Flight rule to detect eng out uses 300° min
V41T1171A	" ,C	-20	100	140	500	300	500	300	500	-50	325	deg F	35,37	
V41T1371A	" ,R	-20	100	140	500	300	500	300	500	-50	325	DEG F	36,37	
V41T1261A	GH_2 out temp ,L	-20	100	-50	30	-30	30	-30	30	-200	170	deg F	36,37	1. (D). 4. (D) 2. 10 deg beyond (E) of (-)40 to (+)20 3,5. 10 deg beyond (E) of 0 to 20° at 104% P/L and (-)20 to (+)5 @ 100% PL

TABLE 5.2.4-I.- Continued

MSID	Parameter	1 PRELCH		2 Launch		3 and 5 SRB SEP		Abort		4 ET SEP		Unit	Category	Rationale for limits
		L	H	L	H	L	H	L	H	L	H			
V41T1161A	GH_2 out temp. ,C	-20	100	-50	30	-30	30	-30	30	-200	170	deg F	35,37	
V41T1361A	" ,R	-20	100	-50	30	-30	30	-30	30	-200	170	deg F	36,37	
V41P1260A	GH_2 out press.,L	-100	1000	1800	3700	1800	3700	1800	3800	-100	100	psia	34,37	1. (D); 4.(D) 2. (E) 2000 to 3350 3,5.(E) 2900 to 3400 at 104% Lower limit based on 65% P/L
V41P1160A	" ,C	-100	1000	1800	3700	1800	3700	1800	3800	-100	100	psia	35,37	
V41P1360A	" ,R	-100	1000	1800	3700	1800	3700	1800	3800	-100	100	psia	36,37	
T41P1701C	LH_2 ull press.,L	40.9	44.1	32	34	32	34	32	34	0	40	psia		1. (A); 4.(D) 2,3,5.(E) 32.5 to 33.5 Lower limit is lower control band limit Upper limit (-)0.6 below relief Crew alert 31.6 psia
T41P1700C	" ,C	40.9	44.1	32	34	32	34	32	34	0	40	psia		
T41P1702C	" ,R	40.9	44.1	32	34	32	34	32	34	0	40	psia		
V41T1201C	LH_2 in temp. ,L	38	40	35	39	35	39	35	39	30	62	deg R	34,37	1. ICD 37-40°R, Limits 2° outside ICD 2,3,5.-(E) 36.5 to 38. Upper limit 1° above range 4.-(D)
V41T1101C	" ,C	38	40	35	39	35	39	35	39	30	62	deg R	35,37	
V41T1301C	" ,R	38	40	35	39	35	39	35	39	30	62	deg R	36,37	
M01G3111C	NPSP ,C	0	60	5	24	5	24	5	15	-50	60	psia	37	1. (C); 4.(C) 2. (E) 12 to 20 3,5.(E) 12 to 14; Lower Limits set to detect low NPSP before ICD requirement violation
M02G3111C	" ,L	0	60	5	24	5	24	5	15	-50	60	psia	37	
M03G3111C	" ,R	0	60	5	24	5	24	5	15	-50	60	psia	37	
M04G3111C	" ,AVG	0	60	5	24	5	24	5	15	-50	60	psia	37	
B46R1406C	L HPU A turb sp 1	66	78	67	78	0	84	0	84	0	84	krpm	37	1. (A) at 100% 2. (E) = 72 to 78 KRPM 100% = 72 ± 5.76 110% = 79.2 ± 6.76 112% = 80.64 ± 5.78 3,4,5.-(D)
B46R1407C	" B " 1	66	78	67	78	0	84	0	84	0	84	krpm	37	
B46R1408C	" A " 2	66	78	67	78	0	84	0	84	0	84	krpm	37	
B46R1409C	" B " 2	66	78	67	78	0	84	0	84	0	84	krpm	37	
B46R2406C	R HPU A turb sp 1	66	78	67	78	0	84	0	84	0	84	krpm	37	
B46R2407C	" B " 1	66	78	67	78	0	84	0	84	0	84	krpm	37	

TABLE 5.2.4-I.- Continued

MSID	Parameter	1 PRELCH		2 Launch		3 and 5 SRB SEP		Abort		4 ET SEP		Unit	Category	Rationale for limits
		L	H	L	H	L	H	L	H	L	H			
B46R2408C	R HPU A turb sp 2	66	78	67	78	0	84	0	84	0	84	krpm	37	
B46R2409C	" B " 2	66	78	67	78	0	84	0	84	0	84	krpm	37	
B47P1301C	L SRB Pc 2	5	37	50	975	-100	1000	-100	1000	-100	1000	psia	37	1. (A)-Min ensures meas operable. Max is max unbiased output
B47P1302C	L SRB Pc 3	3.8	45.5	50	975	-100	1000	-100	1000	-100	1000	psia	37	2. Max operating press. = 920 3,4,5-(D) Lower indicates Pc < 50
B46P1305C	L fuel sup mod pr, A	350	415	280	400	0	600	0	600	0	600	psia	37	1. (A); 2 - range in handbook 280 to 400 3,4,5.-(D)
B46P1306C	L fuel sup mod pr, B	350	415	280	400	0	600	0	600	0	600	psia	37	
B58P1303C	L hyd sup press., A	2800	3363	2800	3500	0	3500	0	3500	0	3500	psia	37	1. (A); 2.-(E) 3000 to 3300, Switch over to backup supply between 2100 and 2500. Limit senses switchover
B58P1304C	L hyd sup press., B	2800	3363	2800	3500	0	3500	0	3500	0	3500	psia	37	3,4,5-(D)
B47P2300C	R SRB Pc 1	5	37	50	975	-100	1000	-100	1000	-100	1000	psia	37	1. (A) (See above)
B47P2302C	" 3	5	37	50	975	-100	1000	-100	1000	-100	1000	psia	37	
B46P2305C	R fuel sup mod pr, A	350	415	280	400	0	600	0	600	0	600	psia	37	1. (A) (See above)
B46P2306C	R fuel sup mod pr, B	350	415	280	400	0	600	0	600	0	600	psia	37	
B58P2303C	R hyd sup press., A	2800	3363	2800	3500	0	3500	0	3500	0	3500	psia	37	1. (A) (See above)
B58P2304C	R hyd sup press., B	2800	3363	2800	3500	0	3500	0	3500	0	3500	psia	37	
B47P1300C	L SRB Pc 1	5	37	50	975	-100	1000	-100	1000	-100	1000	psia	37	1. (A) (See above)
B47P2301C	R SRB Pc 2	5	37	50	975	-100	1000	-100	1000	-100	1000	psia	37	
V98P2156C	BFS - He Tk press, L	4100	3500	3300	4500	1500	4500	1500	4500	1150	4500	psia	37	1. (A);2.(E) 4300 to 3500, Low limit 200 psi below min nominal value 3. (E) 3500 to 2400 3,5 - covers 700s RTLS at 4 psi/sec

TABLE 5.2.4 I.- Continued

MSID	Parameter	Unit	Category	1 PRELCH		2 Launch		3 and 5 SRB SEP		3 and 5 Abort		4 ET SEP		Rationale for limits
				L	H	L	H	L	H	L	H	L	H	
V98P2155C	BFS - He Tk press. ,C	psia	37	4100	4500	3500	4500	1500	4500	1500	4500	1150	4500	
V98P2157C	BFS - He Tk press. ,R	psia	37	4100	4500	3500	4500	1500	4500	1500	4500	1150	4500	4. SRB SEP limit (-)100 for dump
V98P2140C	BFS-LH2 V11 press	psia	37	40.9	44.1	32	34	32	34	32	34	0	40	1. (A); 2,3,5 - E 32.5 to 33.5, lower limit is lower control band limit 4. (D) - Crew alert = 31.6 psia
V98P1740C	BFS-L SRB Pc	psia	37	5	37	50	975	-20	1000	-20	1000	-20	1000	1. (A) - 2. Max oper press. 920 lower indicates for Pc < 50
V98P1741C	BFS-R SRB Pc	psia	37	5	37	50	975	-20	1000	-20	1000	-20	1000	3, 4, 5.-(D)

TABLE 5.2.4-I.- Continued

On orbit limits

MSID	Parameter	MIN	MAX	Units	Category	Rationale for limits
V41P1250C	He tank press., L	2000	4500	psia	37	Min set to detect low purge Helium - Nom > 2200
V41P1150C	He tank press., C	2000	4500	psia	37	Min set to detect low purge Helium - Nom > 2200
V41P1350C	He tank press., R	2000	4500	psia	37	Min set to detect low purge Helium - Nom > 2200
V41P1600A	He tank press., Pn	2000	4500	psia	37	Min set to detect low purge Helium - Nom > 2200
V41P1254A	He reg A press., L	0	800	psia	37	Max just below relief press.
V41P1154A	He reg A press., C	0	800	psia	37	Max just below relief press.
V41P1354A	He reg A press., R	0	800	psia	37	Max just below relief press.
V41P1605A	He reg A press., Pn	0	800	psia	37	Max just below relief press.
V41T1251A	Aft He tank temp, L	-50	200	deg. F	37, 34	
V41T1151A	Aft He tank temp, C	-50	200	deg. F	37, 35	
V41T1351A	Aft He tank temp, R	-50	200	deg. F	37, 36	
V41T1601A	Aft He tank temp, Pn	-50	200	deg. F	37	
V41P1153A	He Reg B press., C	0	800	psia	37	Max just below relief press.
V41P1253A	He Reg B press., L	0	800	psia	37	Max just below relief press.
V41P1353A	He Reg B press., R	0	800	psia	37	Max just below relief press.

TABLE 5.2.4-I.- Concluded

On orbit limits

MSID	Parameter	MIN	MAX	Units	Category	Rationale for limits
V41P1533C	LO_2 manif press	-1	*40	psia	37	Set to detect excess press - allows for thermal drift.
V41P1230C	LO_2 inlet press., L	-1	*20	psia	34, 37	Set to detect excess press - allows for thermal drift.
V41P1130C	LO_2 inlet press., C	-1	*20	psia	35, 37	Set to detect excess press - allows for thermal drift.
V41P1330C	LO_2 inlet press., R	-1	*20	psia	36, 37	Set to detect excess press - allows for thermal drift.
V41P1590A	GO_2 disc press.	0	25	psia	37	
V41P1433C	LH_2 manif press.	-1	*45	psia	37	Set to detect excess press - allows for thermal drift.
V41P1200C	LH2 inlet press., L	-1	*30	psia	34, 37	Set to detect excess press - allows for thermal drift.
V41P1100C	LH2 inlet press., C	-1	*30	psia	35, 37	Set to detect excess press - allows for thermal drift.
V41P1300C	LH2 inlet press., R	-1	*30	psia	36, 37	Set to detect excess press - allows for thermal drift.
V41P1490A	GH_2 disc press	0	25	psia	37	
V41T1252A	Mid He tank temp., L	-50	200	deg. F	34, 37	
V41T1152A	Mid He tank temp., C	-50	200	deg. F	35, 37	
V41T1352A	Mid He tank temp., R	-50	200	deg. F	36, 37	

Notes:

A. LCC values

B. Values 15 psi inside LCC (715-800) to indicate a potential problem.

C. Default value: comp doesn't start unti liftoff

D. Limits chosen to prevent limit exceeded indications. Value N/A.

E. Normal operation band of parameter

TITLE

MPS NEAR REAL TIME FORMATS

PURPOSE

This SCP provides a table for locating the format numbers for all MPS near real-time (NRT) parameters.

DESCRIPTION

A listing of NRT formats including the NRT format title, microfiche number and format number is provided in table 5.2.5-I.

A listing of all main propulsion system (MPS) NRT parameters, which includes the MML/COMP number, the parameter name, the format number(s), and the microfiche number, is provided in table 5.2.5-II. The parameters are listed with the MML/COMP number in alphanumeric order. Several format numbers, including plots, are located on more than one microfiche. NRT replaces Thrift on STS-7 and subs.

PROCEDURES

To determine the NRT format number and/or the microfiche number for any MPS parameter or NRT, locate the parameter in table 5.2.5-II by using the MML/COMP number.

Nominally, the MPS/Booster flight controller requests special NRT at one sample per second during the ascent and on-orbit phases. NRT formats can be requested by using the procedure in the Mission Data Request Form (MDRF) provided in 10.1 of the Flight Control Operations Handbook. Reference Booster SCP 6.11 "Near Real Time (NRT) Processing Initialization" for procedures for loading MED constants and limits into the NRT computer. Loading the appropriate MED constants is required to generate correct comp outputs.

REFERENCES

1. Statement of Requirements No. GSR 346 THRIFT Format Requirements for the Main Propulsion System (MPS) Parameters, Revision 5, March 10, 1980.

2. Flight Control Operations Handbook, JSC-12805, January 16, 1987.

TABLE 5.2.5-I - MPS NRT FORMATS

Fiche no.	Title	Format no.
1	L SSME PERFORMANCE CONTROL	1052
1	L POWER LEVEL VS TIME	1058*
1	L OXIDIZER/FUEL FLOWRATE (LB/SEC) VS TIME	1059*
1	C SSME PERFORMANCE CONTROL	1063
1	C POWER LEVEL VS TIME	1069*
1	C OXIDIZER/FUEL FLOWRATE (LB/SEC) VS TIME	1070*
1	BFS-SRB PC (AVG), HE TK PR, LH2 ULLAGE PR	1073
2	R SSME PERFORMANCE CONTROL	1075
2	R POWER LEVEL VS TIME	1081*
2	R OXIDIZER/FUEL FLOWRATE (LB/SEC) VS TIME	1082*
2	HE DEPLETION TIMES, TANKS AND REG. A PR	1085
2	HE DEPLETION TIMES	1086
2	HE REG B PR AND TANK TEMPS	1087
2	HE TANK PRESSURE VS TIME	1088*
2	HE REG. A PRESSURE VS TIME	1089*
2	HE MASS-FLOWRATE VS TIME	1090*
3	GH2 OUTLET PR, GH2/GO2 DISCONNECT PR	1091
3	SRB. PC, HYDRAULIC AND FSM PRESSURES	1092
3	SRB HYDRAULIC SUPPLY PR VS TIME	1093*
3	SRB FSM PRESSURE VS TIME	1094*
3	SRB PC VS TIME	1095*
3	GH2 OUTLET PRESSURE VS TIME	1096*
3	GH2 OUTLET TEMP VS TIME	1097*
3	GO2 OUTLET TEMP VS TIME	1098*
3	OXIDIZER, FUEL AND VEHICLE WEIGHT	1099
3	SSME POWER LEVEL	1100
3	ME THRUST LEVEL, OMS/RCS TIMES	1101
3	OXIDIZER/FUEL PCT. VS TIME	1102
3	GO2 DISC AND LH2/LO2 ULLAGE AND INLET PR.s	1103
3	LH2 ULLAGE PR(GAUGE), LH2 VENT CL	1104
3	LH2 ULLAGE PR(GAUGE) VS TIME	1105
3	LH2 INLET PRESSURE VS TIME	1106*
3	LO2 INLET PRESSURE VS TIME	1107*
3	LO2 ULLAGE PRESSURE VS TIME	1108*
3	LO2/LH2 MANIFOLD PRESSURE VS TIME	1109*
4	ET OXIDIZER/FUEL MONITORING, LH2 C/O SENSORS	1110
4	HELIUM POWER SWITCHES	1111

*-PLOT

TABLE 5.2.5-I.- Concluded

Fiche no.	Title	Format no.
4	HE XOVER AND ISO. B SW., LO2 C/O SENSORS, SRB ACTUATORS	1112
	HE 1 AND 2 TANK PRESSURES	1113
	HE ISO. A AND LO2/LH2 MPS SWITCHES	1115
	SRB - L PC 1, R PC 2	1116
	FUEL NPSP AND AVG., FUEL INLET TEMP	1117
	BFS - HELIUM PRESSURE DECAY RATE (LB/3 sec)	1118
	HELIUM MIDTANK TEMPS	1119
	ORBITER HYDRAULIC PRESSURES	1123
	BFS - TIME OF SHUTDOWN, GH2 ONLET PRESSURE	1124

*-PLOT

TABLE 5.2.5-II.- MPS NRT PARAMETERS

MML/COMP no.	NRT parameter name	NRT format nos.	NRT microfiche nos.
B46P1305C	L FSM A P	1092, 1094*	3, 3
B46P1306C	L FSM B P	1092, 1094*	3, 3
B46P2305C	R FSM A P	1092, 1094*	3, 3
B46P2306C	R FSM B P	1092, 1094*	3, 3
B47P1301C	L SRB PC 2	1092, 1095*	3, 3
B47P1302C	L SRB PC 3	1092, 1095*	3, 3
B47P2300C	R SRB PC 1	1092, 1095*	3, 3
B47P2302C	R SRB PC 3	1092, 1095*	3, 3
B47P1300C	L SRB PC 1	1116	4
B47P2301C	R SRB PC 2	1116	4
B58P1303C	L HYD SUP A P	1092, 1093*	3, 3
B58P1304C	L HYD SUP B P	1092, 1093*	3, 3
B58X1859X	LH EV TILT SERVO ACTR PRI PRESS OK	1112	4
B58X1860X	LH EV ROCK SERVO ACTR PRI PRESS OK	1112	4
B58P2303C	R HYD SUP A P	1092, 1093*	3, 3
B58P2304C	R HYD SUP B P	1092, 1093*	3, 3
B58X2859X	RH EV TILT SERVO ACTR PRI PRESS OK	1112	4
B58X2860X	RH EV ROCK SERVO ACTR PRI PRESS OK	1112	4

*-PLOT

TABLE 5.2.5-II.- Continued

MML/COMP no.	NRT parameter name	NRT format nos.	NRT microfiche nos.
M01G3101C	C OX FLOW RATE	1063, 1070*, 1099	1, 1, 3
M01G3102C	TOTAL OX CONSUMED	1099	3
M01G3103C	C FUEL FLOW RATE	1063, 1070*, 1099	1, 1, 3
M01G3104C	TOTAL FUEL CONSUMED	1099	3,
M01G3105C	OX REMAINING (%)	1099, 1102*	3, 3
M01G3106C	FUEL REMAINING (%)	1099, 1102*	3, 3
M01G3107C	OVERALL MIXTURE RATIO	1099	3
M01G3108C	C POWER LEVEL (%)	1063, 1069*, 1100	1, 1, 3
M01G3109C	VEHICLE WEIGHT	1099	3
M01G3701C	C POWER LVL COMP-CMD	1063, 1069*	1, 1
M01G3705T	C TIME OF SHUTDOWN	1100, 1076	3
M01G3706C	C GAUGE LH2 ULL PC	1104, 1105*	3, 3
M01G3800C	C HE TANK DECAY RATE	1085, 1090*	2
M02G3101C	L OX FLOW RATE	1052, 1059*, 1099	1, 1, 3,
M02G3103C	L FUEL FLOW RATE	1052, 1059*, 1099	1, 1, 3
M02G3107C	C MIXTURE RATIO	1063	1
M02G3108C	L POWER LEVEL (%)	1052, 1058*, 1100	1, 1, 3
M02G3110T	TIME OF DEPLETION	1100	3
M02G3701C	L POWER LVL COMP CMD	1052, 1058*	1, 1
M02G3705T	TIME OF L SHUTDOWN	1100	3
M02G3706C	L GAUGE LH2 ULL PC	1104, 1105*	3, 3
M02G3800C	L HE TANK DECAY RATE	1085, 1090*	2, 2
M03G3101C	R OX FLOW RATE	1075, 1082*, 1099	2, 2, 3,
M03G3103C	R FUEL FLOW RATE	1075, 1082*, 1099	2, 2, 3
M02G4300T	C TIME OF SD	1124	4
M01G4300T	L TIME OF SD	1124	4
M03G4300T	R TIME OF SD	1124	4

*-PLOT

TABLE 5.2.5-II.- Continued

MML/COMP no.	NRT parameter name	NRT format nos.	NRT microfiche nos.
M03G3107C	L MIXTURE RATIO	1052	1
M03G3108C	R POWER LEVEL	1075, 1081*, 1100	2, 2, 3
M03G3110T	TIME OF DEPLETION	1099	3
M03G3701C	R POWER LVL COMP-CMD	1075, 1081*	2, 2
M03G3705T	TIME OF R SHUTDOWN	1100	3
M03G3706C	R GAUGE LH2 ULL PR	1104, 1105*	3, 3
M03G3800C	R HE TANK DECAY RATE	1085, 1090*	2, 2
M04G3101C	TOTAL OX FLOW RATE	1099	3
M04G3103C	TOTAL FUEL FLOW RATE	1099	3
M04G3107C	R MIXTURE RATIO	1075	2
M04G3108C	AVE POWER LEVEL	1100	3
M04G3800C	PN HE TANK DECAY RATE	1085, 1090*	2, 2
M05G3800T	C HE DEPLETION TIME	1085	2
M06G3800T	L HE DEPLETION TIME	1085	2
M07G3800T	R HE DEPLETION TIME	1086	2
M08G3800T	PN HE DEPLETION TIME	1086	2
M09G3800T	C + PN L HE DEPLETION TIME	1086	2
M10G3800T	L + PN L HE DEPLETION TIME	1086	2
M11G3800T	R + PN L HE DEPLETION TIME	1086	2
M12G3800T	C + PN U HE DEPLETION TIME	1086	2
M13G3800T	L + PN U HE DEPLETION TIME	1086	2
M14G3800T	R + PN U HE DEPLETION TIME	1086	2
M02G3111C	FU NPSP C	1117	4
M01G3111C	FU NPSP L	1117	4
M03G3111C	FU NPSP R	1117	4
M04G3111C	FU NPSP AVE	1117	4
V41P1590A	GO2 DISC	1103	3
T41P1700C	LH2 ULL PC	1103	3
T41P1701C	LH2 ULL PL	1103	3
T41P1702C	LH2 ULL PR	1103	3
T41P1750C	LO2 ULL PC	1103, 1108*	3, 3
T41P1751C	LO2 ULL PL	1103, 1108*	3, 3
T41P1752C	LO2 ULL PR	1103, 1108*	3, 3
T41X1712E	LH2 5 PERCENT LIQ LVL	1110	4
T41X1724E	LH2 VNT V CL	1104, 1110	3, 4
T41X1727E	LH2 VNT V OP	1110	4

*-PLOT

TABLE 5.2.5-II.- Continued

MML/COMP no.	NRT parameter name	NRT format nos.	NRT microfiche nos.
T41X1730X	LH2 CO SEN 1	1110	4
T41X1731X	LH2 CO SEN 2	1110	4
T41X1732X	LH2 CO SEN 3	1110	4
T41X1733X	LH2 CO SEN 4	1110	4
T41X1760E	LO2 2 PERCENT LIQ LVL	1110	4
T41X1762E	LO2 5 PERCENT LIQ LVL	1110	4
T41X1774E	LO2 VNT V CL	1104, 1110	3, 4
T41X1776E	LO2 VNT V OP	1110	4
V41X1555X	LO2 CO SEN 1	1112	4
V41X1556X	LO2 CO SEN 2	1112	4
V41X1557X	LO2 CO SEN 3	1112	4
V41X1558X	LO2 CO SEN 4	1112	4
V41P1100C	C LH2 IN P	1103, 1106*	3, 3
V41P1130C	C LO2 IN P	1103, 1107*	3, 3
V41P1150C	C HE TK P	1085, 1088*, 1113	2, 2, 4
V41P1154A	C HE REGA P	1085, 1089*	2, 2
V41P1160A	C GH2 OUT P	1091, 1096*, 1124	3, 3, 4
V41P1200C	L LH2 IN P	1103, 1106*	3, 3
V41P1230C	L LO2 IN P	1103, 1107*	3, 3
V41P1250C	L HE TK P	1085, 1088*, 1113	2, 2, 4
V41P1254A	L HE REGA P	1085, 1089*	2, 2
V41P1260A	L GH2 OUT P	1091, 1096*, 1124	3, 3, 4
V41P1300C	R LH2 IN P	1103, 1106*	3, 3
V41P1330C	R LO2 IN P	1103, 1107*	3, 3
V41P1350C	R HE TK P	1085, 1088*	2, 2
V41P1354A	R HE REGA P	1085, 1089*	2, 2
V41P1360A	R GH2 OUT P	1091, 1096*, 1124	3, 3, 4
V41P1433C	LH2 ENG MANF P	1103, 1109*	3, 3
V41P1490A	GH2 DISC P	1091, 1104	3, 3
V41P1533C	LO2 ENG MANF P	1103, 1109*	3, 3
V41P1590A	GO2 DISC P	1091	3
V41P1600A	PNEU HE TK P	1085, 1088*	2, 2
V41P1605A	PNEU HE REG P	1085, 1089*	2, 2
V41P1153A	C HE REGB P	1087	2
V41P1253A	L HE REGB P	1087	2
V41P1353A	R HE REGB P	1087	2
V41S1236E	L LO2 PV SO	1115	4
V41S1239E	L LO2 PV SC	1115	4

*-PLOT

TABLE 5.2.5-II.- Continued

MML/COMP no.	NRT parameter name	NRT format nos.	NRT microfiche nos.
V41S1136E	C LO2 PV SO	1115	4
V41S1139E	C LO2 PV SC	1115	4
V41S1336E	R LO2 PV SO	1115	4
V41S1339E	R LO2 PV SC	1115	4
V41S1219E	L LH2 PV SO	1115	4
V41S1222E	L LH2 PV SC	1115	4
V41S1119E	C LH2 PV SO	1115	4
V41S1122E	C LH2 PV SC	1115	4
V41S1319E	R LH2 PV SO	1115	4
V41S1322E	R LH2 PV SC	1115	4
V41S1255E	L HE ISO A SO	1115	4
V41S1265E	L HE ISO A SC	1115	4
V41S1155E	C HE ISO A SO	1115	4
V41S1165E	C HE ISO A SC	1115	4
V41S1355E	R HE ISO A SO	1115	4
V41S1365E	R HE ISO A SC	1115	4
V41S1535E	LO MANF PR SO	1115	4
V41S1531E	LO MANF PR SC	1115	4
V41S1518E	L OB FD SO	1115	4
V41S1515E	L OB FD SC	1115	4
V41S1435E	LH MANF PR SO	1115	4
V41S1431E	LH MANF PR SC	1115	4
V41S1511E	L IB FD SO	1115	4
V41S1512E	L IB FD SC	1115	4
V41S1391E	H OB FD SO	1115	4
V41S1393E	H OB FD SC	1115	4
V41S1607E	PN HE ISO SO	1115	4
V41S1609E	PN HE ISO SC	1115	4
V41S1401E	H IB FD SO	1115	4
V41S1412E	H IB FD SC	1115	4
V41S1543E	L FLN RI SO	1115	4
V41S1547E	L FLN RI SC	1115	4
V41S1443E	H FLN RI SO	1115	4
V41S1447E	H FLN RI SC	1115	4
V41S1493E	H PRLN VLV SO	1115	4
V41S1494E	H PR LN VLV SC	1115	4
V41S1513E	L HE XOV SO	1112	4
V41S1519E	L HE XOV SC	1112	4
V41S1256E	L HE ISO B SO	1112	4
V41S1266E	L HE ISO B SC	1112	4
V41S1156E	C HE ISO B SO	1112	4

*-PLOT

TABLE 5.2.5-II.- Continued

MML/COMP no.	NRT parameter name	NRT format nos.	NRT microfiche nos.
V41S1166E	C HE ISO B SC	1112	4
V41S1356E	R HE ISO B SO	1112	4
V41S1366E	R HE ISO B SC	1113	4
V41S1262E	L INTCNT IN SO	1113	4
V41S1268E	L INTCNT IN SC	1113	4
V41S1162E	C INTCNT IN SO	1113	4
V41S1168E	C INTCNT IN SC	1113	4
V41S1362E	R INTCNT IN SO	1113	4
V41S1368E	R INTCNT IN SC	1113	4
V41T1151A	C HE TK T	1087	2
V41T1152A	C HE MID TK T	1089, 1119*	2, 4
V41X1158E	C HE ISOL A OP PWR	1110	4
V41T1161A	C GH2 OUT T	1091, 1097*	3, 3
V41T1171A	C GO2 OUT T	1091, 1098*	3, 3
V41T1251A	L HE TK T	1086,	2
V41T1252A	L HE MID TK T	1087, 1119*	2, 4
V41T1261A	L GH2 OUT T	1091, 1097*	3, 3
V41T1271A	L GO2 OUT T	1091, 1098*	3, 3
V41T1351A	R HE TK	1087	2
V41T1352A	R HE MID TK T	1087 1119*	2, 4
V41T1361A	R GH2 OUT T	1091, 1097*	3, 3
V41T1371A	R GO2 OUT T	1091, 1098*	3, 3
V41T1601A	PNEU HE TR T	1087	2
V41T9233A	L GMBL BRG SURF T	1104	3
V41T1101C	C FU INT	1117	4
V41T1201C	L FU INT	1117	4
V41T1301C	R FU INT	1117	4
V41T1428A	FD FU T	1117	4
V41X1104X	C LH2 PV OP A	1110	4
V41X1105E	C LH2 PV CL	1110	4
V41X1134X	C LO2 PV OP	1110	4
V41X1135E	C LO2 PV CL	1110	4
V41X1158E	C HE ISOL A OP PWR	1111	4
V41X1159E	C HE ISO B OP PWR	1112	4
V41X1164E	C HE INTCN IN PWR	1111	4
V41X1170E	C HE INTCN OUT PWR	1111	4
V41X1204X	L LH2 PV OP A	1110	4
V41X1205E	L LH2 PV CL	1110	4
V41X1234X	L LO2 PV OP	1110	4
V41X1235E	L LO2 PV CL	1110	4
V41X1258E	L HE ISOL A OP PWR	1111	4

*-PLOT

TABLE 5.2.5-II.- Continued

MML/COMP no.	NRT parameter name	NRT format nos.	NRT microfiche nos.
V41X1259E	L HE ISOL B OP PWR	1111	4
V41X1264E	L HE INTCN IN PWR	1111	4
V41X1270E	L HE INTCN OUT PWR	1111	4
V41X1304X	R LH2 PV OP A	1110	4
V41X1305E	R LH2 PV CL	1110	4
V41X1334X	R LO2 PV OP	1110	4
V41X1335X	R LO2 PV CL	1110	4
V41X1358E	R HE ISOL A OP PWR	1111	4
V41X1359E	R HE ISOL B OP PWR	1111	4
V41X1364E	R HE INTCN IN PWR	1111	4
V41X1370E	R HE INTCN OUT PWR	1111	4
V41X1389X	LH2 OB F/D V CL	1110	4
V41X1410X	LH2 IB F/D V CL	1110	4
V41X1420E	LH2 RECRC DISC V CL	1110	4
V41X1429X	LH2 FD DISC V OP	1110	4
V41X1430X	LH2 FD DISC V CL A	1110	4
V41X1431X	LH2 MANF P	1110	4
V41X1434X	LH2 FD V CL B	1112	4
V41X1436E	LH2 MANF P1 OP	1112	4
V41X1438E	LH2 MANF P2 OP	1112	4
V41X1441E	LH2 FDLN RLF ISOL OP	1112	4
V41X1456X	LH2 TOP V CL	1112	4
V41X1492E	H2 PRESS LN VNT OP	1112	4
V41X1509X	LO2 IB F/D V CL	1110	4
V41X1514X	LO2 OB F/D V CL	1111	4
V41X1529X	LO2 FD DISC V OP	1111	4
V41X1530X	LO2 FD DISC V CLA	1111	4
V41X1531X	LO2 MANF P C	1112	4
V41X1534E	LO2 FD DISC V CL B	1112	4
V41X1538E	LO2 MANF PRESS 1 OP	1111	4
V41X1539E	LO2 MANF PRESS 2 OP	1111	4
V41X1541E	LO2 FDLN RLF ISOV OP	1111	4
V41X1580X	LO2 OVBD BLV CL A	1111	4
V41X1596E	GO2 P SOV C CL P	1112	4
V41X1598E	GO2 P SOV L CL P	1112	4
V41X1603E	GO2 P SOV R CL P	1112	4
V41X1614E	L HE XOVR OP PWR	1111	4
V41X1645E	PNEU HE ISOL 1 OP PWR	1111	4
V41X1646E	PNEU HE ISOL 2 OP PWR	1111	4
V41X1661E	GH2 P SOV C CL P	1112	4
V41X1662E	GH2 P SOV R CL P	1112	4
V41X1663E	GH2 P SOV R CL P	1112	4
V41X1811X	POGO RECRC V1 OP	1111	4

*-PLOT

TABLE 5.2.5-II.- Continued

MML/COMP no.	NRT parameter name	NRT format nos.	NRT microfiche nos.
V41X1821X	POGO RECRC V2 OP	1111	4
V41X1901E	RTLS MANF REPR 1 PWR	1112	4
V41X1902E	RTLS MANF REPR 2 PWR	1112	4
V41X1919X	RTLS OB DMP V CL	1111	4
V41X1929X	RTLS TBD CL	1111	4
V58P0116B	C HYD P	1123	4
V58P0216B	L HYD P	1123	4
V58P0316B	R HYD P	1123	4
V72X4526X	GNC ALERT	1111	4
V72X4533X	GNC BU C&W	1112	4
V73X1567E	C&W	1110	4
V75W3514D	MET	1053, 1064, 1073 1076, 1087 1092, 1101, 1104	1, 1, 1 2, 2 3, 3, 3
V90U1948C	ME THRUST LEVEL CMD	1101, 1058*, 1063	3
V90U1961C	VEHICLE WT	1091	3
V90W1941C	T GO VECO	1100	3
V90W1970C	DESIRED MECO	1100	3
V90W8325C	OMS ΔT COMPUTED	1101	3
V90W8326C	OMS PROP + ΔT COMP	1101	3
V90W8327C	OMS PROP NULL ΔT COMP	1101	3
V90W8328C	P MECO RCS + ΔT	1101	3
V90W8329C	P MECO RCS NULL ΔT COMP	1101	3
V90X1942X	LL ARM CMD	1112	4
V90X8250X	ET SEP CMD FLAG	1110	4
V90X8259X	ET AUTO SEP-INHIBIT ALERT	1110	4
V90X8315X	8 NULL JETS ON FLAG	1111	4
V90X8316X	12 NULL JETS ON FLAG	1111	4
V90X8317X	20 NULL JETS ON FLAG	1111	4
V90X8331X	SRB SEP CMD FLAG	1110	4
V90X8340X	SRB SEP INHIBIT	1110	4
V95H0175C	ALTITUDE	1101	3
V95U0163C	VEH ACCEL	1117	4
V98M2200P	C ESW	1073	1
V98M2220P	L ESW	1073	1
V98M2240P	R ESW	1073	1
V98P2100C	C PC	1073	1
V98P2110C	L PC	1073	1
V98P2120C	R PC	1073	1

*-PLOT

TABLE 5.2.5-II.- Concluded

MML/COMP no.	NRT parameter name	NRT format nos.	NRT microfiche nos.
V98P2140C	LH2 ULL PC	1073	1
V98P2155C	C HE TK P	1073	1
V98P2156C	L HE TK P	1073	1
V98P2157C	R HE TK P	1073	1
V98P1740C	L SRB PC	1073	1
V98P1741C	R SRB PC	1073	1
V98P4997C	HE TANK 1 PDOT	1118	4
V98P4998C	HE TANK 2 PDOT	1118	4
V98P4999C	HE TANK 3 PDOT	1118	4
V98X1268X	BFS BU C&W	1111	4
V99X8829X	LPS HOLD	1110	4

*-PLOT

TITLE

MPS SUPER THRIFT

PURPOSE

This SCP provides a table for locating the format (product) numbers for all MPS SUPER THRIFT parameters.

DESCRIPTION

A listing of all main propulsion system (MPS) SUPER THRIFT parameters, which includes the MML number, the parameter name, and the format number(s), are provided in table 5.2.6-I. The parameters are listed with the format number in alphanumeric order.

PROCEDURES

To determine the SUPER THRIFT format number for any MPS parameter, locate the parameter in table 5.2.6-I by using the MML/COMP number.

Nominally, the MPS/Booster flight controller requests SUPER THRIFT at the downlink rate during the ascent and on-orbit phases. THRIFT formats can be requested by using the procedure in the Mission Data Request Form (MDRF) provided in 10.1 of the Flight Control Operations Handbook.

REFERENCES

1. STS-26 Cross Referenced MSID/Product Report, Sept. 6, 1988.

2. Flight Control Operations Handbook, JSC-12805, January 16, 1987.

TABLE 5.2.6-I.- MPS SUPER THRIFT PARAMETERS

MML	Parameter name	Format no.
V90U1948C	COMMANDED SSME THROTTLE SETTING	TB047F
V90W1941C	TIME TO GO TO VELOCITY CUTOFF	TB047F
V90X1942X	ET LEVEL SENSOR ARM CMD	TB048F
V90X8250X	ET SEPARATION CMD FLAG	TB047F
V90X8331X	SRB SEPARATION CMD FLAG	TB036F
V90X8561X	MECO CONFIRMED FLAG	TB047F
V90X8569X	MECO COMMAND FLAG	TB047F
V95X1202X	ME-1 COMMAND PATH FAIL FLAG	TB047F
V95X1203X	ME-2 COMMAND PATH FAIL FLAG	TB047F
V95X1204X	ME-3 COMMAND PATH FAIL FLAG	TB047F
V98X3537X	AS30 MPS LOW MONITOR BFS	TB039F
V41X1555X	ET-LO2 ECO SENSOR LEFT 1	TB085F
V41X1556X	ET-LO2 ECO SENSOR LEFT 2	TB085F
V41X1557X	ET-LO2 ECO SENSOR RIGHT 1	TB085F
V41X1558X	ET-LO2 ECO SENSOR RIGHT 2	TB085F
T41X1730X	ET-LH2 LOW LEVEL LIQ SENSOR NO 1	TB048F
T41X1731X	ET-LH2 LOW LEVEL LIQ SENSOR NO 2	TB048F
T41X1732X	ET-LH2 LOW LEVEL LIQ SENSOR NO 3	TB048F
T41X1733X	ET-LH2 LOW LEVEL LIQ SENSOR NO 4	TB048F
V41X1813E	MPS LO2 ACC RECIRC VLV 1 CL PWR ON	TY088F
V41X1811X	MPS LO2 ACCUM RECIRC VLV 1 OPEN	TY088F
V41X1818E	MPS LO2 ACC RECIRC VLV 1 CLOSED	TY088F
V41X1823E	MPS LO2 ACC RECIRC VLV 2 CL PWR ON	TY088F
V41X1821X	MPS LO2 ACC RECIRC VLV 2 OPEN	TY088F
V41X1828E	MPS LO2 ACC RECIRC VLV 2 CLOSED	TY088F
V41X1596E	MPS-GO2 PRESS SOV 1 CLOSE PWR ON	TY086F
V41X1599E	MPS-GO2 PRESS SOV 2 CLOSE PWR ON	TY086F
V41X1603E	MPS-GO2 PRESS SOV 3 CLOSE PWR ON	TY086F
V41X1661E	MPS-GH2 PRESS SOV 1 CLOSE PWR ON	TY086F
V41X1662E	MPS-GH2 PRESS SOV 2 CLOSE PWR ON	TY086F
V41X1663E	MPS-GH2 PRESS SOV 3 CLOSE PWR ON	TY086F
V41X1112E	MPS LH2 RECIRC VLV OPEN PWR ON	TB051F
V41X1109E	MPS-ENG NO 1 LH2 RECIRC VLV OPEN	TB051F
V41X1110E	MPS-ENG NO 1 LH2 RECIRC VLV CLOSED	TB051F
V41X1209E	MPS-ENG NO 2 LH2 RECIRC VLV OPEN	TB051F
V41X1210E	MPS-ENG NO 2 LH2 RECIRC VLV CLOSED	TB051F
V41X1309E	MPS-ENG NO 3 LH2 RECIRC VLV OPEN	TB051F
V41X1310E	MPS-ENG NO 3 LH2 RECIRC VLV CLOSED	TB051F
V90X7548X	SEL MPS ENG LIMIT CONTROL AUTO	TB052F
V90X7551X	SEL MPS ME-1 SHUTDOWN CMD	TB052F
V90X7552X	SEL MPS ME-2 SHUTDOWN CMD	TB052F

TABLE 5.2.6-I.- Continued

MML	Parameter name		Format no.
V90X7553X	SEL MPS ME-3 SHUTDOWN CMD		TB052F
V90X7554X	SEL ET SEP INITIATE/WOW-WONG CMD		TB036F
V41R1115A	MPS-ENG NO 1 LH2 RECIRC PMP SPEED		TB036F
V41R1215A	MPS-ENG NO 2 LH2 RECIRC PMP SPEED		TB036F
V41R1315A	MPS-ENG NO 3 LH2 RECIRC PMP SPEED		TB036F
V41P1160A	MPS-ENG NO 1 GH2 OUTLET PRESS		TY016F
V41P1260A	MPS-ENG NO 2 GH2 OUTLET PRESS		TY016F
V41P1360A	MPS-ENG NO 3 GH2 OUTLET PRESS		TY016F
V41T1161A	MPS-ENG NO 1 GH2 PRESS OUTLET TEMP		TY016F
V41T1261A	MPS-ENG NO 2 GH2 PRESS OUTLET TEMP		TY016F
V41T1361A	MPS-ENG NO 3 GH2 PRESS OUTLET TEMP		TY016F
V41T1171A	MPS-ENG NO 1 GOX PRESS OUTLET TEMP		TY016F
V41T1271A	MPS-ENG NO 2 GOX PRESS OUTLET TEMP		TY016F
V41T1371A	MPS-ENG NO 3 GOX PRESS OUTLET TEMP		TY016F
T41X1724E	ET-LH2 VENT VLV NO 1 CLOSED IND		TB040F
T41X1727E	ET-LH2 VENT VLV NO 1 OPEN IND		TB040F
T41X1774E	ET-LO2 VENT VLV NO 1 CLOSED IND		TY014F
V98P4997C	SSME HE TK 1 CHG RATE	BFS	TF154F
V98P4998C	SSME HE TK 2 CHG RATE	BFS	TF154F
V98P4999C	SSME HE TK 3 CHG RATE	BFS	TF154F
V98X3688X	AB35 MECO CMD	BFS	TB045F
V98X3689X	AB36 MECO CONFIRMED	BFS	TB045F
V98X3693X	AB36C ME PREVALVES CLOSED	BFS	TB045F
V98X3695X	AB37 ET SEP CMD	BFS	TB045F
V98X3733X	AB40C MPS DUMP START	BFS	TF054F
V95X3735X	AB40E MPS DUMP STOP	BFS	TF054F
V95X1207X	MPS E1 FAIL FLAG		TB036F
V95X1208X	MPS E2 FAIL FLAG		TB036F
V95X1209X	MPS E3 FAIL FLAG		TB036F
V41P1464A	MPS-LOX SYSTEM DIFFERENTIAL PRESS		TY018F
V41P1564A	MPS-LH2 SYSTEM DIFFERENTIAL PRESS		TY018F
V41X1102E	MPS-E1 LH2 PREVALVE CLOSE PWR ON		TB040F
V41X1103E	MPS-E1 LH2 PREVALVE OPEN PWR ON		TB040F
V41X1104X	MPS-E1 LH2 PREVALVE OPEN A		TB040F
V41X1106X	MPS-E1 LH2 PREVALVE OPEN B		TB038F
V41X1105E	MPS-ENG NO 1 LH2 PREVALVE CLOSED		TB040F
V41X1132E	MPS-E1 LOX PREVALVE CLOSE PWR ON 1		TB040F
V41X1133E	MPS-E1 LOX PREVALVE OPEN PWR ON		TB040F
V41X1134X	MPS-ENG NO 1 LOX PREVALVE OPEN		TB037F
V41X1135E	MPS-ENG NO 1 LOX PREVALVE CLOSED		TB040F

TABLE 5.2.6-I.- Continued

MML	Parameter name	Format no.
V41X1202E	MPS-E2 LH2 PREVALVE CLOSE PWR ON	TB040F
V41X1203E	MPS-E2 LH2 PREVALVE OPEN PWR ON	TB040F
V41X1204X	MPS-E2 LH2 PREVALVE OPEN A	TB037F
V41X1206X	MPS-E2 LH2 PREVALVE OPEN B	TB038F
V41X1205E	MPS-ENG NO 2 LH2 PREVALVE CLOSED	TB040F
V41X1232E	MPS-E2 LOX PREVALVE CLOSE PWR ON 1	TB040F
V41X1233E	MPS-E2 LOX PREVALVE OPEN PWR ON	TB040F
V41X1234X	MPS-ENG NO 2 LOX PREVALVE OPEN	TB038F
V41X1235E	MPS-ENG NO 2 LOX PREVALVE CLOSED	TB040F
V41X1302E	MPS-E3 LH2 PREVALVE CLOSE PWR ON	TY0211
V41X1303E	MPS-E3 LH2 PREVALVE OPEN PWR ON	TY0211
V41X1304X	MPS-E3 LH2 PREVALVE OPEN A	TY0211
V41X1306X	MPS-E3 LH2 PREVALVE OPEN B	TY0211
V41X1305E	MPS-ENG NO 3 LH2 PREVALVE CLOSED	TY0211
V41X1332E	MPS-E3 LOX PREVALVE CLOSE PWR ON 1	TY0211
V41X1333E	MPS-E3 LOX PREVALVE OPEN PWR ON	TY0211
V41X1334X	MPS-ENG NO 3 LOX PREVALVE OPEN	TY0211
V41X1335E	MPS-ENG NO 3 LOX PREVALVE CLOSED	TY0211
V41X1505E	MPS-LOX INBD FILL VLV CLOSE PWR ON	TY022F
V41X1506E	MPS-LOX INBD FILL VLV OPEN PWR ON	TY022F
V41X1509X	MPS-LOX INBD FILL VLV CLOSED	TY022F
V41X1510E	MPS-LOX INBOARD FILL VLV OPEN	TY022F
V41X1507E	MPS-LOX OTBD FILL VLV CLOSE PWR ON	TY022F
V41X1508E	MPS-LOX OTBD FILL VLV OPEN PWR ON	TY022F
V41X1513E	MPS-LOX OUTBD FILL VLV OPEN	TY022F
V41X1514X	MPS-LOX OUTBD FILL VLV CLOSED	TY022F
V41X1405E	MPS-LH2 INBD FILL VLV CLOSE PWR ON	TY023F
V41X1406E	MPS-LH2 INBD FILL VLV OPEN PWR ON	TY023F
V41X1409E	MPS-LH2 INBD FILL VLV OPEN	TY023F
V41X1410X	MPS-LH2 INBOARD FILL VLV CLOSED	TY023F
V41X1385E	MPS-LH2 OTBD FILL VLV CLOSE PWR ON	TY023F
V41X1386E	MPS-LH2 OTBD FILL VLV OPEN PWR ON	TY023F
V41X1388E	MPS-LH2 OUTBD FILL VLV OPEN	TY023F
V41X1389X	MPS-LH2 OUTBD FILL VLV CLOSED	TY023F
V41X1453E	MPS-LH2 TOPPING VLV OPEN	TY024F
V41X1456X	MPS-LH2 TOPPING VLV CLOSED	TY024F
V41X1458E	MPS-LH2 TOPPING VLV OPEN PWR ON	TY024F
V41X1911E	MPS LH2 RTLS OTBD D/V OPEN PWR ON	TY024F
V41X1917E	MPS LH2 RTLS OTBD D/V OPEN	TY024F
V41X1919X	MPS LH2 RTLS OTBD D/V CLOSE	TY024F
V41X1921E	MPS LH2 RTLS INBD D/V OPEN PWR ON	TY024F
V41X1927E	MPS LH2 RTLS INBD D/V OPEN	TY024F
V41X1929X	MPS LH2 RTLS INBD D/V CLOSED	TY024F

TABLE 5.2.6-I.- Continued

MML	Parameter name	Format no.
V41X1164E	MPS-E1 HE INTCON IN/OPEN PWR ON	TY025F
V41X1170E	MPS-E1 HE INTCON OUT/OPEN PWR ON	TY025F
V41X1264E	MPS-E2 HE INTCON IN/OPEN PWR ON	TY025F
V41X1270E	MPS-E2 HE INTCON OUT/OPEN PWR ON	TY025F
V41X1364E	MPS-E3 HE INTCON IN/OPEN PWR ON	TY025F
V41X1370E	MPS-E3 HE INTCON OUT/OPEN PWR ON	TY025F
V41X1614E	MPS-PNEU CROSSOVER 2 OPEN PWR ON	TY025F
V41X1632E	MPS-HE SPLY BLWDN 1 OPEN PWR ON	TY025F
V41X1634E	MPS-HE SPLY BLWDN 2 OPEN PWR ON	TY025F
V41X1538E	MPS-LOX MANF REPRESS 1 OPEN PWR ON	TY026F
V41X1539E	MPS-LOX MANF REPRESS 2 OPEN PWR ON	TY026F
V41X1436E	MPS-LH2 MANF REPRESS 1 OPEN PWR ON	TY026F
V41X1438E	MPS-LH2 MANF REPRESS 2 OPEN PWR ON	TY026F
V41X1901E	MPS-LH2 RTLS MANF REPRESS 1 PWR ON	TY026F
V41X1902E	MPS-LH2 RTLS MANF REPRESS 2 PWR ON	TY026F
V41X1441E	MPS-LH2 FEEDLINE RELIEF SOV OPEN	TY027F
V41X1442E	MPS-LH2 FEEDLINE RELIEF SOV CLOSED	TY027F
V41X1449E	MPS-LH2 FDLN RLF SOV CLOSE PWR ON	TY027F
V41X1541E	MPS-LOX FEEDLINE RELIEF SOV OPEN	TY027F
V41X1542E	MPS-LOX FEEDLINE RELIEF SOV CLOSED	TY027F
V41X1549E	MPS-LOX FDLN RLF SOV CLOSE PWR ON	TY027F
V41X1381E	MPS-LH2 FEED DISC VLV CLOSE PWR ON	TY028F
V41X1382E	MPS-LH2 FEED DISC VLV OPEN PWR ON	TY028F
V41X1429X	MPS-LH2 FEED DISC VLV OPEN	TY028F
V41X1430X	MPS-LH2 FEED DISC VLV CLOSED A	TY028F
V41X1434X	MPS-LH2 FEED DISC VLV CLOSED B	TY028F
V41X1806E	MPS-LOX FEED DISC VLV CLOSE PWR ON	TY028F
V41X1807E	MPS-LOX FEED DISC VLV OPEN PWR ON	TY028F
V41X1529X	MPS-LOX FEED DISC VLV OPEN	TY028F
V41X1530X	MPS-LO2 FEED DISC VLV CLOSED A	TY028F
V41X1534X	MPS-LO2 FEED DISC VLV CLOSED B	TY028F
V41X1582E	MPS-LO2 OVBD B/V CLOSE PWR ON	TY029F
V41X1580X	MPS-LO2 OVERBOARD B/V CLOSED A	TY029F
V41X1581X	MPS-LO2 OVERBOARD B/V CLOSED B	TY029F
V41X1587E	MPS-LO2 OVERBOARD BLEED VALVE OPEN	TY029F
V41X1467E	LH2-HI POINT BLEED OPEN PWR ON IND	TY029F
V41X1468E	LH2-HI POINT BLEED OPEN IND	TY029F
V41X1469E	LH2-HI POINT BLEED CLOSE IND	TY029F
V98X3545X	AS32 MECO CMD BFS	TB039F
V98X3546X	AS33 MECO CONFIRMED BFS	TB039F
V98X3549X	AS33D ME PREVALVES CLOSED BFS	TB039F
V98X3550X	AS34 ET SEP CMD BFS	TB039F
V98X3566X	AS42C LO2 DUMP START BFS	TF050F
V98X3569X	AS43A TERM MPS DUMP, STOW SSMES BFS	TF050F

TABLE 5.2.6-I.- Continued

MML	Parameter name	Format no.
V41X1158E	MPS-E1 HE ISLN VLV A OPEN PWR ON	TB040F
V41X1159E	MPS-E1 HE ISLN VLV B OPEN PWR ON	TB040F
V41X1258E	MPS-E2 HE ISLN VLV A OPEN PWR ON	TB040F
V41X1259E	MPS-E2 HE ISLN VLV B OPEN PWR ON	TB044F
V41X1358E	MPS-E3 HE ISLN VLV A OPEN PWR ON	TY030F
V41X1359E	MPS-E3 HE ISLN VLV B OPEN PWR ON	TY030F
V41X1645E	MPS-PNEU HE ISLN VLV 1 OPEN PWR ON	TY030F
V41X1646E	MPS-PNEU HE ISLN VLV 2 OPEN PWR ON	TY030F
V41X1439E	MPS-LH2 RECIRC DISC VLV CL PWR ON	TY031F
V41X1440E	MPS-LH2 RECIRC DISC VLV OP PWR ON	TY031F
V41X1419E	MPS-LH2 RECIRC DISC VLV OPEN	TY031F
V41X1420E	MPS-LH2 RECIRC DISC VLV CLOSED	TY031F
V41X1492E	MPS-GH2 PRESS LINE VENT OP PWR ON	TY031F
V41S1391E	MPS-LH2 OUTBD FILL VALVE OPEN CMD	TY032F
V41S1393E	MPS-LH2 OUTBD FILL VALVE CLOSE CMD	TY032F
V41S1401E	MPS-LH2 INBD FILL VLV OPEN CMD A	TY032F
V41S1412E	MPS-LH2 INBD FILL VALVE CLOSE CMD	TY032F
V41S1511E	MPS-LO2 INBOARD FILL VLV OPEN CMD	TY032F
V41S1512E	MPS-LO2 INBOARD FILL VLV CLOSE CMD	TY032F
V41S1515E	MPS-LO2 OUTBD FILL VLV CLOSE CMD	TY032F
V41S1518E	MPS-LO2 OUTBD FILL VLV OPEN CMD	TY032F
V41X1162E	MPS-E1 HE INTCN IN/OPEN-OUT/CLOSED	TY033F
V41X1168E	MPS-E1 HE INTCN OUT/OPEN-IN/CLOSED	TY033F
V41S1262E	MPS-E2 HE INTCN IN/OPEN-OUT/CLOSED	TY033F
V41S1268E	MPS-E2 HE INTCN OUT/OPEN-IN/CLOSED	TY033F
V41S1362E	MPS-E3 HE INTCN IN/OPEN-OUT/CLOSED	TY033F
V41S1368E	MPS-E3 HE INTCN OUT/OPEN-IN/CLOSED	TY033F
V41S1619E	MPS-PNEU CROSSOVER NO 2 CLOSE CMD	TY033F
V41S1613E	MPS-PNEU CROSSOVER NO 2 OPEN CMD	TY033F
V41S1543E	MPS-LO2 FDLN RLF S/O VLV OPEN CMD	TY034F
V41S1547E	MPS-LO2 FDLN RLF S/O VLV CLOSE CMD	TY034F
V41S1443E	MPS-LH2 FDLN RLF S/O VLV OP CMD	TY034F
V41S1447E	MPS-LH2 FDLN RLF S/O VLV CLOSE CMD	TY034F
V41S1493E	MPS-GH2 PRESS LINE VENT-OPEN CMD	TY034F
V41S1494E	MPS-GH2 PRESS LINE VENT CLOSE CMD	TY034F
V41S1155E	MPS E1 HELIUM SUPPLY A OPEN	TY035F
V41S1165E	MPS E1 HELIUM SUPPLY A CLOSE	TY035F
V41S1156E	MPS E1 HELIUM SUPPLY B OPEN	TY035F
V41S1166E	MPS E1 HELIUM SUPPLY B CLOSE	TY035F
V41S1255E	MPS E2 HELIUM SUPPLY A OPEN	TY035F
V41S1265E	MPS E2 HELIUM SUPPLY A CLOSE	TY035F
V41S1256E	MPS E2 HELIUM SUPPLY B OPEN	TY035F

TABLE 5.2.6-I.- Continued

MML	Parameter name	Format no.
V41S1266E	MPS E2 HELIUM SUPPLY B CLOSE	TY035F
V41S1355E	MPS E3 HELIUM SUPPLY A OPEN	TY036F
V41S1365E	MPS E3 HELIUM SUPPLY A CLOSE	TY036F
V41S1356E	MPS E3 HELIUM SUPPLY B OPEN	TY036F
V41S1366E	MPS E3 HELIUM SUPPLY B CLOSE	TY036F
V41S1607E	MPS PNEU VLV HE ISLN VALVES OP CMD	TY036F
V41X1609E	MPS PNEU VLV HE ISLN VALVES CL CMD	TY036F
V41S1431E	MPS-LH2 MANIF REPRESS CLOSE CMD	TY037F
V41S1435E	MPS-LH2 MANF REPRESS NO 1 OPEN CMD	TY037F
V41S1531E	MPS-LO2 MANF REPRESS VALVES CL CMD	TY037F
V41S1535E	MPS-LO2 MANF REPRESS NO 1 OPEN CMD	TY037F
V41S1477E	MPS-LH2 TK PRESS HI FLOW ON	TY037F
V41S1136E	MPS E1 LO2 PREVALVE OPEN CMDS	TY038F
V41S1139E	MPS E1 LO2 PREVALVE CLOSE CMDS	TY038F
V41S1236E	MPS E2 LO2 PREVALVE OPEN CMDS	TY038F
V41S1239E	MPS E2 LO2 PREVALVE CLOSE CMDS	TY038F
V41S1336E	MPS E3 LO2 PREVALVE OPEN CMDS	TY038F
V41S1339E	MPS E3 LO2 PREVALVE CLOSE CMDS	TY038F
V41S1119E	MPS E1 LH2 PREVALVE OPEN CMD A	TY039F
V41S1122E	MPS E1 LH2 PREVALVE CLOSE CMD A	TY039F
V41S1219E	MPS E2 LH2 PREVALVE OPEN CMD A	TY039F
V41S1222E	MPS E2 LH2 PREVALVE CLOSE CMD A	TY039F
V41S1319E	MPS E3 LH2 PREVALVE OPEN CMD A	TY039F
V41S1322E	MPS E3 LH2 PREVALVE CLOSE CMD A	TY039F
V41P1153A	MPS E1 HELIUM REG B OUTLET PRESS	TY040F
V41P1154A	MPS E1 HELIUM REG A OUTLET PRESS	TY040F
V41P1253A	MPS E2 HELIUM REG B OUTLET PRESS	TY040F
V41P1254A	MPS E2 HELIUM REG A OUTLET PRESS	TY040F
V41P1353A	MPS E3 HELIUM REG B OUTLET PRESS	TY040F
V41P1354A	MPS E3 HELIUM REG A OUTLET PRESS	TY040F
V41P1605A	MPS-PNEU VLV HE RGLTR OUTLET PRESS	TY040F
V41T1151A	MPS E1 AFT FUSLG HE SUPPLY TEMP	TY041F
V41T1152A	MPS E1 MID FUSLG HE SUPPLY TEMP	TY041F
V41T1251A	MPS E2 AFT FUSLG HE SUPPLY TEMP	TY041F
V41T1252A	MPS E2 MID FUSLG HE SUPPLY TEMP	TY041F
V41T1351A	MPS E3 AFT FUSLG HE SUPPLY TEMP	TY041F
V41T1352A	MPS E3 MID FUSLG HE SUPPLY TEMP	TY041F
V41T1601A	MPS-PNEUMATIC VLV HE BOTTLE TEMP	TY041F
V41P1150C	MPS-ENG NO 1 HELIUM SUPPLY PRESS	TY042F
V41P1250C	MPS-ENG NO 2 HELIUM SUPPLY PRESS	TY042F
V41P1350C	MPS-ENG NO 3 HELIUM SUPPLY PRESS	TY042F

TABLE 5.2.6-I.- Concluded

MML	Parameter name	Format no.
V41P1600A	MPS-PNEUMATIC VLV HE SUPPLY PRESS	TY042F
V41P1490A	MPS-GH2 DISCONNECT PRESSURE	TY043F
V41P1590A	MPS-GOX DISCONNECT PRESSURE	TY043F
V41P1130C	MPS-ENG NO 1 LOX INLET PRESS	TY044F
V41T1131C	MPS-ENG NO 1 LOX INLET TEMP	TY044F
V41P1230C	MPS-ENG NO 2 LOX INLET PRESS	TY044F
V41T1231C	MPS-ENG NO 2 LOX INLET TEMP	TY044F
V41P1330C	MPS-ENG NO 3 LOX INLET PRESS	TY044F
V41T1331C	MPS-ENG NO 3 LOX INLET TEMP	TY044F
V41P1533C	MPS-LOX ENGINE MANIFOLD PRESSURE	TY044F
V41T1528A	MPS-LOX FEED MANIFOLD DISC TEMP	TY044F
V41P1100C	MPS-ENG NO 1 LH2 INLET PRESS	TY045F
V41T1101C	MPS-ENG NO 1 LH2 INLET TEMP	TY045F
V41P1200C	MPS-ENG NO 2 LH2 INLET PRESS	TY045F
V41T1201C	MPS-ENG NO 2 LH2 INLET TEMP	TY045F
V41P1300C	MPS-ENG NO 3 LH2 INLET PRESS	TY045F
V41T1301C	MPS-ENG NO 3 LH2 INLET TEMP	TY045F
V41P1433C	MPS-LH2 ENGINE MANIFOLD PRESSURE	TY045F
V41T1428A	MPS-LH2 FEED MANIFOLD DISC TEMP	TY045F
V41K1413X	MPS-LH2 FEED DISC VALVE OP CMD A	TY055F
V41K1414X	MPS-LH2 FEED DISC VALVE OP CMD B	TY055F
V41K1415X	MPS-LH2 FEED DISC VALVE OP CMD C	TY055F
V41K1421X	MPS-LH2 RECIRC DISC VLV OPEN CMD	TY055F
V41K1435X	MPS-LH2 MANF REPRESS NO 1 OPEN CMD	TY055F
V41K1437X	MPS-LH2 MANF REPRESS NO 2 OPEN CMD	TY055F
V41K1521X	MPS-LO2 FEED DISC VALVE OP CMD A	TD026F
V41K1522X	MPS-LO2 FEED DISC VALVE OP CMD B	TD026F
V41K1523X	MPS-LO2 FEED DISC VALVE OP CMD C	TD026F
V41K1535X	MPS-LO2 MANF REPRESS NO 1 OPEN CMD	TD026F
V41K1537X	MPS-LO2 MANF REPRESS NO 2 OPEN CMD	TD026F
V41K1908X	LH2-RTLS MANF REPRESS 2 OPEN CMD B	TD026F
T41P1700C	ET LH2 ULLAGE PRESS NO 1	TY011F
T41P1701C	ET LH2 ULLAGE PRESS NO 2	TY011F
T41P1702C	ET LH2 ULLAGE PRESS NO 3	TY011F
T41P1750C	ET LO2 ULLAGE PRESS NO 1	TY011F
T41P1751C	ET LO2 ULLAGE PRESS NO 2	TY011F
T41P1752C	ET LO2 ULLAGE PRESS NO 3	TY011F

TITLE

BOOSTER CONSOLE CUE CARDS

PURPOSE

This SCP contains the more frequently used cue cards at the Booster, MPS, and ME consoles.

DESCRIPTION

The cue cards listed in table 5.2.7-I are those that can be found in the referenced document. The cue cards enclosed within this SCP have been created by individuals and are not found in a separate document.

TABLE 5.2.7-I.- BOOSTER CONSOLE CUE CARDS

Cue card title/subject	Location
TV Channels	General OPS, Sect 2
Main engine	
Nozzle Leaks	SCP 2.1.1
HPOT Efficiency Loss	SCP 2.1.1
Pc Shift Low	SCP 2.1.1
Pc Shift High	SCP 2.1.1
LPFT DISCH T Shift Low	SCP 2.1.1
Flight AVG Performance LVL	SCP 2.1.1
LH_2 F/M GPM1 Sensor Shift High	SCP 2.1.1
LH_2 F/M GPM1 Sensor Shift Low	SCP 2.1.1
ELEC Lockup-Pc Sensor Failures	SCP 2.1.1
Backup ELEC Lockup	SCP 2.1.1
Lockup Table	SCP 2.1.1
Hydraulic Lockup	SCP 2.1.1
Controller Redundancy Management Scheme	SCP 2.1.2
SSME Shutdown/Lockup Failure Matrix	SCP 2.1.2
MAN SSME SHUTDN Cases	SCP 2.1.9
SSME Pc vs. HPOT DP Table (Left, center, right)	SCP 3.1.7
Engine Status Word (ESW)	SCP 4.1
MPS	
MPS MDM/PWR Loss Matrix	SCP 4.5
He LK ISOL/Interconnection	SCP 2.2.4
MPS LH2 Pressure Problems	SCP 2.2.1
MPS He Purge	SCP 2.2.9
SRB SEP Failures	SCP 2.2.7
Delayed SRB SEP Failures	SCP 2.2.7
SRB SEP Time Delay Values	SCP 2.2.7
ET SEP Failures	SCP 2.2.2
SSME Hydraulic Repress	SCP 2.2.9
MPS Vacuum Inert	SCP 1.2.5
C/W Parameter Inhibit/Enable	SCP 1.2.5
LH_2 Dump Failure	SCP 2.2.5
PASS GPC Fail	FDF-A/E SYS PROC: DPS ASC
FA MDM I/O Error	FDF-A/E SYS PROC: DPS ASC
MULT Data Path Loss	FDF-A/E SYS PROC: DPS ASC
MPS Ascent Cue Cards	FDF-A/E SYS PROC: MPS ASC
Contingency Abort	FDF-ASC C/L: ASC Cue Cards
MPS Entry	FDF-A/E SYS PROC: MPS ENT

	MSK	DESCRIPTION
GENERAL	0001	TV GUIDE
	0071	DDD FORMATS - FCR 1
	0075	DDD FORMATS - MPSR 1
	0083	DDD FORMATS - FCR 2
	0087	DDD FORMATS - MPSR 2
OPERATIONS	1051	ME DATA
	1052	ME DATA (OLD)
	1053	MPS BILEVEL (OLD)
	1054	MPS DATA
	1055	MPS BILEVEL
	1056	BOOSTER PRELAUNCH
	1057	BOOSTER ENTRY
	1064	BOOSTER BFS (MPS format)
	1065	BOOSTER BFS (ME format)
	0606	PIC VOLTS
MISC	1300	GPC/BFS FAULT SUM PAGE
	1305,6	GPC FAULT SUM PAGE 1,2,...
	1315,6	BFS FAULT SUM PAGE 1,2,...
	0516	ENTRY PAGE] DO NOT DISPLAY
	0521	ENTRY PAGE] REQUEST
	2020	SNAPSHOT PAGE
	2030	TIMERS
	2023-6	UNIVERSAL DIGITALS (UDD)
	0006	SYSTEM STATUS (for DRs)
	0008	CONSOLE CONFIG GUIDE
	0918	MRTC's] L&R mon enter
	0919	RTC's] PBI's = Scroll
LIMITS	2100	BOOSTER LIMITS (Sets 1-5)
	2101	BOOSTER LIMITS (Sets 1-5)
	2102	BOOSTER LIMITS (Sets 1-5)
	2063-5	GPC MED CONSTANTS
	2023-6	UNIVERSAL DIGITALS (UDD)

DDD FMT#	DESCRIPTION
281	C SSME LIMITS
282	L SSME LIMITS
283	R SSME LIMITS
284	SSME STATUS
285	SSME DATA
286	HELIUM
287	ET PRESS/PROP
288	MPS PRESSURES
289	MPS EVENTS
290	ME LIMIT SET/STATUS
291	MPS ON ORBIT
292	MPS ON ORBIT
293	ME AUXILIARY DATA
298	MPS EVENTS
299	MPS EVENTS
300	MPS LIMIT SET/STATUS
301	HELIUM
302	ET PRESS/PROP (NEW)
303	ET PRESS/PROP (NEWER)
304	C SSME LIMITS (NEW)
305	L SSME LIMITS (NEW)
306	R SSME LIMITS (NEW)

	MSK	DESCRIPTION
TABLES	1069	ME HARD FID
	1070	ME HARD FID (OLD)
	1071,2	CENTER MAIN ENGINE
	1073,4	LEFT MAIN ENGINE
	1075,6	RIGHT MAIN ENGINE
	1077,8	MPS HELIUM
	1079	MPS CONSUMABLES
	1080	MPS CONSUMABLES
	1081,2	MPS PRESSURES
	1083,4	ET PRESSURANT/SRBS
	1085,6	MPS ON ORBIT
	1087,8	FUEL NPSP ET & SSME
	1089	BFS TAB
	1090	BFS TAB
	1091,2	SRB PIC VOLTS
PLOTS	2759	HPOT TD A&B, HPFT TD A&B C
	2760	HPOT TD A&B, HPFT TD A&B L
	2761	HPOT TD A&B, HPFT TD A&B R
	2762 *	ACCEL & GH2 OUT PRESS
	2763	Pc A&B, OPOV, FPOV C
	2764	Pc A&B, OPOV, FPOV L
	2765	Pc A&B, OPOV, FPOV R
	2766	MIXTURE RATIO C,L,R
	2767	HELIUM TANK PRESSURE L
	2768	HELIUM TANK PRESSURE C
	2769	HELIUM TANK PRESSURE R
	2770	HE REG A P L,C,R,PNEU
	2771	HE REG B P L,C,R,PNEU ACCUM
	2772 *	HE TANK T L,C,R,PNEU
	2773	HE DEC RT L,C,R,PNEU
	2774	LO2 INLET P & MANIFOLD P
	2775	LH2 INLET P & MANIFOLD P

TYPE		STATUS INDICATOR
		Telemetry:
T	1	EXCEEDED DISPLAY CAPABILITY
D	2	PARAMETER DEAD (No Downlink)
H	3	OFF-SCALE HIGH (PCM high)
L	3	OFF-SCALE LOW (PCM low)
*	4	STATIC FORMAT (Out of sync)
S	4	STATIC PARAM. (Out of Sync)
↑	5	OUT OF LIMITS - HIGH
↓	5	OUT OF LIMITS - LOW
		MOC Comps:
M	1	PRM. MISSING (input=D,H,L,/0)
S	2	PARAMETER STATIC (input=*,S)
B	3	SUSPECT DATA IN OI DOWNLINK
G	3	SUSPECT DATA IN GN, SM, BFS

MPSR 1 SCR FORMATS-CHECK ON MSK 0070			
POSITION	SCR#	LAUNCH	SRB SEP
LEFT	623	114	114
CENTER	606	113	113
RIGHT	622	115	115
PRP MPSR	624	112	111

TV CHAN	DESCRIPTION
0001	TV GUIDE
0002	MSK 6 - (For DRs)
0171	TIME OVERHEAD - FCR 1
0065	TIME OVERHEAD - FCR 2
0066	WEATHER MAP
0078	FRONT ROOM CAMERA

Figure 5.2.7-I.- MSK no., DDD formats, and SCR formats.

TABLE 5.2.7-II.- REFERENCE DESIGNATION AND NOMENCLATURE

Ref Desig	Nomenclature
CV22	E2 GH_2 Press Isolation Check Valve
CV23	E3 GH_2 Press Isolation Check Valve
CV24	GH_2 Press Manif Repress Check Valve
CV25	E1 He Supply Check Valve
CV26	E1 He Supply Check Valve
CV27	E1 He Interconnect Check Valve-Panel In
CV28	E1 He Interconnect Check Valve-Panel Out
CV29	E1 He Reg Outlet Check Valve-Panel No. 1B
CV30	LH_2 Feed Manif RTLS Repress Check Valve
CV31	E1 LO_2 Bleed Check Valve
CV33	E2 LO_2 Bleed Check Valve
CV35	C3 LO_2 Bleed Check Valve
CV36	E2 He Supply Check Valve
CV37	E2 He Supply Check Valve
CV38	E2 He Interconnect Check Valve-Panel In
CV39	E2 He Interconnect Check Valve-Panel Out
CV40	E2 He Reg Outlet Check Valve-Panel No. 2B
CV41	E3 He Supply Check Valve
CV42	E3 He Supply Check Valve
CV43	E3 He Interconnect Check Valve-Panel In
CV44	E3 He Interconnect Check Valve-Panel Out
CV45	E3 He Reg Outlet Check Valve-Panel No. 3B
PV1	E1 LO_2 Prevalve
PV2	E2 LO_2 Prevalve
PV3	E3 LO_2 Prevalve
PV4	E1 LH_2 Prevalve
PV5	E2 LH_2 Prevalve
PV6	E3 LH_2 Prevalve
PV7	LO_2 Feedline Relief Shutoff Valve
PV8	LH_2 Feedline Relief Shutoff Valve
PV9	LO_2 Outboard Fill Valve
PV10	LO_2 Inboard Fill Valve
PV11	LH_2 Outboard Fill Valve
PV12	LH_2 Inboard Fill Valve
PV13	LH_2 Replenish Valve
PV14	E1 LH_2 Recirc Pump Valve
PV15	E2 LH_2 Recirc Pump Valve
PV16	E3 LH_2 Recirc Pump Valve
PV17	LH_2 Feed RTLS Inboard Valve
PV18	LH_2 Feed RTLS Outboard Valve
PV19	LO_2 Bleed Shutoff Valve
PV20	LO_2 Pogo Accum Recirc Valve

Ref Desig	Nomenclature
PV21	LO_2 Pogo Accum Recirc Valve
PV22	LH_2 Hi Point Bleed Valve
PD1	LO_2 Feed (ORB/ET) Disconnect Valve (ORB Half)
PD2	LO_2 Feed (ORB/ET) Disconnect Valve (ORB Half)
PD3	LH_2 Recirc (ORB/ET) Disconnect Valve (ORB Half)
PD4	GO_2 Pressurization (ORB/ET)Disconnect Valve (ORB Half)
PD5	GH_2 Pressurization (ORB/ET)Disconnect Valve (ORB Half)
PD8	He Supply (ORB/GND) Disconnect (ORB Half)
PD9	LO_2 Tank Ground Pre-Press (ORB/GND) Disc (ORB Half)
PD10	LH_2 Tank Ground Pre-Press (ORB/GND) Disc (ORB Half)
PD11	LH_2 Ground Fill & Drain (ORB/GND) Disc (ORB Half)
PD12	LO_2 Ground Fill & Drain (ORB/GND) Disc (ORB Half)
PD13	LO_2 Overboard Bleed (ORB/GND) Disc (ORB Half)
PD14	Main Engine GN_2 Purge (ORB/GND) Disc (ORB Half)
PD15	GO_2 Press Manif Test Point Coupling (ORB Half)
PD16	GH_2 Press Manif Test Point Coupling (ORB Half)
PD17	LH_2 Hi Point Bleed (ORB/GND) Disc (ORB Half)
TBD	LO_2 Feed (ORB/ET) Disconnect Valve (ET Half)
TBD	LH_2 Feed (ORB/ET) Disconnect Valve (ET Half)
TBD	LH_2 Recirc (ORB/ET) Disconnect Valve (ET Half)
TBD	GO_2 Pressurization (ORB/ET) Disconnect (ET Half)
TBD	GH_2 Pressurization (ORB/ET) Disconnect (ET Half)
TBD	He Supply (ORB/GND) Disconnect Valve (GND Half)
TBD	LO_2 Tank Ground Pre-Press (ORB/GND) Disc (GND Half)
TBD	LH_2 Tank Ground Pre-Press (ORB/GND) Disc (GND Half)
TBD	LH_2 Ground Fill & Grain (ORB/GND) Disc (ORB Half)
TBD	LO_2 Ground Fill & Drain (ORB/GND) Disc (ORB Half)
TBD	LO_2 Overboard Bleed (ORB/GND) Disc (GND Half)
TBD	Main Engine GN_2 Purge (ORB/GND) Disc (GND Half)
LV1	E1 He Supply Isolation Valve
LV2	E1 He Supply Isolation Valve
LV3	E2 He Supply Isolation Valve
LV4	E2 He Supply Isolation Valve
LV5	E3 He Supply Isolation Valve
LV6	E3 He Supply Isolation Valve
LV7	Pneu Valve He Supply Isolation Valve
LV8	Pneu Valve He Supply Isolation Valve
LV10	E2 Pneu He Crossover Solenoid
LV12	E1 LO_2 Prevalve Opening Solenoid
LV13	E1 LO_2 Prevalve Closing Solenoid
LV14	E2 LO_2 Prevalve Opening Solenoid
LV15	E2 LO_2 Prevalve Closing Solenoid

TABLE 5.2.7-II.- Continued

Ref Desig	Nomenclature
LV16	E3 LO_2 Prevalve Opening Solenoid
LV17	E3 LO_2 Prevalve Closing Solenoid
LV18	E1 LH_2 Prevalve Opening Solenoid
LV19	E1 LH_2 Prevalve Closing Solenoid
LV20	E2 LH_2 Prevalve Opening Solenoid
LV21	E2 LH_2 Prevalve Closing Solenoid
LV22	E3 LH_2 Prevalve Opening Solenoid
LV23	E3 LH_2 Prevalve Closing Solenoid
LV24	LO_2 Feedline Relief Shutoff Valve Closing Solenoid
LV25	LH_2 Feedline Relief Shutoff Valve Closing Solenoid
LV26	He Supply Blowdown Valve
LV27	He Supply Blowdown Valve
LV28	LO_2 Outboard Fill Valve Opening Solenoid
LV29	LO_2 Outboard Fill Valve Closing Solenoid
LV30	LO_2 Inboard Fill Valve Opening Solenoid
LV31	LO_2 Inboard Fill Valve Closing Solenoid
LV32	LH_2 Outboard Fill Valve Opening Solenoid
LV33	LH_2 Outboard Fill Valve Closing Solenoid
LV34	LH_2 Inboard Fill Valve Opening Solenoid
LV35	LH_2 Inboard Fill Valve Closing Solenoid
LV36	LH_2 Recirc Pump Valve Opening Solenoid
LV39	LH_2 Replenish Valve Opening Solenoid
LV40	LO_2 Manif Repress Valve
LV41	LO_2 Manif Repress Valve
LV42	LH_2 Manif Repress Valve
LV43	LH_2 Manif Repress Valve
LV46	LO_2 Feed Disconnect Valve Opening Solenoid
LV47	LO_2 Feed Disconnect Valve Closing Solenoid
LV48	LH_2 Feed Disconnect Valve Opening Solenoid
LV49	LH_2 Feed Disconnect Valve Closing Solenoid
LV50	LH_2 Recirc Disconnect Valve Opening Solenoid
LV51	LH_2 Recirc Disconnect Valve Closing Solenoid
LV52	LH_2 Press Line Vent Valve
LV53	E1 GO_2 Press Flow Control Valve
LV54	E2 GO_2 Press Flow Control Valve
LV55	E3 GO_2 Press Flow Control Valve
LV56	E1 GH_2 Press Flow Control Valve
LV57	E2 GH_2 Press Flow Control Valve
LV58	E3 GH_2 Press Flow Control Valve
LV59	E1 He Supply Interconnect Panel In Valve
LV60	E1 He Supply Interconnect Panel Out Valve
LV61	E2 He Supply Interconnect Panel In Valve

Ref Desig	Nomenclature
LV62	E2 He Supply Interconnect Panel Out Valve
LV63	E3 He Supply Interconnect Panel In Valve
LV64	E3 He Supply Interconnect Panel Out Valve
LV72	LH_2 Feed RTLS Inboard Dump Valve Opening Solenoid
LV73	LH_2 Feed RTLS Outboard Dump Valve Opening Solenoid
LV74	LH_2 Feed Manif RTLS Press Valve
LV75	LH_2 Feed Manif RTLS Press Valve
LV76	LH_2 Overboard Bleed Valve Closing Solenoid
LV77	LO_2 Pogo Accum Recirc Valve Closing Solenoid
LV78	LO_2 Pogo Accum Recirc Valve Closing Solenoid
LV79	LH_2 Hi Point Bleed Valve Opening Solenoid
PR1	E1 He Regulator-Panel No. 1A
PR2	E2 He Regulator-Panel No. 2A
PR3	E3 He Regulator-Panel No. 3A
PR4	Pneu Valve He Supply Regulator-Panel No. 4
PR5	LO_2 Manif Repress Regulator
PR6	LH_2 Manif Repress Regulator
PR7	E1 He Regulator-Panel No. 1B
PR8	E2 He Regulator-Panel No. 2B
PR9	E3 He Regulator-Panel No. 3B
RV1	E1 He Relief Valve-Panel No. 1A
RV2	E2 He Relief Valve-Panel No. 2A
RV3	E3 He Relief Valve-Panel No. 3A
RV4	Pneu Valve He Supply Relief Valve
RV5	LO_2 Feed Manif Relief Valve
RV6	LH_2 Feed Manif Relief Valve
RV7	LH_2 Recirc Manif Relief Valve
RV8	E1 He Relief Valve-Panel No. 1B
RV9	E2 He Relief Valve-Panel No. 2B
RV10	E3 He Relief Valve-Panel No. 3B
PP1	E1 LH_2 Recirc Pump
PP2	E2 LH_2 Recirc Pump
PP3	E3 LH_2 Recirc Pump
TK1	E1 He Supply Tank
TK2	E2 He Supply Tank
TK3	E3 He Supply Tank
TK4	Pneumatic Valve He Supply Tank
TK6	E1 He Supply Tank (Mid-Body)
TK7	E1 He Supply Tank (Mid-Body)
TK8	E2 He Supply Tank (Mid-Tank)
TK9	E2 He Supply Tank (Mid-Tank)
TK10	E3 He Supply Tank (Mid-Body)

TABLE 5.2.7-II.- Concluded

Ref Desig	Nomenclature
TK11	E3 He Supply Tank (Mid-Body)
AU5	LO_2 Prevalve Pneumatic Accumulator
AU6	LH_2 Prevalve Pneumatic Accumulator
RP1	GO_2 Press Manif Repress Orifice
RP9	LH_2 Feed Manif RTLS Repress Orifice
RP10	LH_2 Dump Pressurization Orifice
FL1	LH_2 Feedline Relief Flame Arrester
FL2	E1 He Supply Filter Panel No. 1A
FL3	E2 He Supply Filter Panel No. 2A
FL4	E3 He Supply Filter Panel No. 3A
FL5	Pneumatic He Supply Filter Panel No. 4
FL6	E1 He Supply Filter Panel No. 1B
FL7	E2 He Supply Filter Panel No. 2B
FL8	E3 He Supply Filter Panel No. 3B
MT1	LO_2 Low Level Liquid Sensors No. 1 & No. 2
MT2	LO_2 Low Level Liquid Sensors No. 3 & No. 4
MT44	LH_2 System ΔP Transducer
MT50	LO_2 System ΔP Transducer
TBD	GO_2 Press Manif Test Point Coupling (GND Half)
TBD	GH_2 Press Manif Test Point Coupling (GND Half)
TBD	LH_2 Hi Point Bleed (ORB/GND) Disc (GND Half)
CV1	E1 He Supply Check Valve
CV2	E2 He Supply Check Valve
CV3	E3 He Supply Check Valve
CV4	Pneu Valve He Supply Check Valve
CV5	E1 He Reg Outlet Check Valve-Panel No. 1A
CV6	E2 He Reg Outlet Check Valve-Panel No. 2A
CV7	E3 He Reg Outlet Check Valve-Panel No. 3A
CV8	Pneu Valve He Reg Outlet Check Valve-Panel No. 4
CV9	Pneu Valve He Isolation Check Valve-Panel No. 4
CV10	GO_2 Press Manif Repress Check Valve
CV12	LO_2 Feed Manif Repress Check Valve
CV13	GH_2 Press Manif Repress Check Valve
CV14	LH_2 Recirc Manif Repress Check Valve
CV15	LH_2 Feed Manif Nom Repress Check Valve
CV16	LO_2 Tank Pre-Press Check Valve
CV17	LH_2 Tank Pre-Press Check Valve
CV18	E1 GO_2 Press Isolation Check Valve
CV19	E2 GO_2 Press Isolation Check Valve
CV20	E3 GO_2 Press Isolation Check Valve
CV21	E1 GH_2 Press Isolation Check Valve

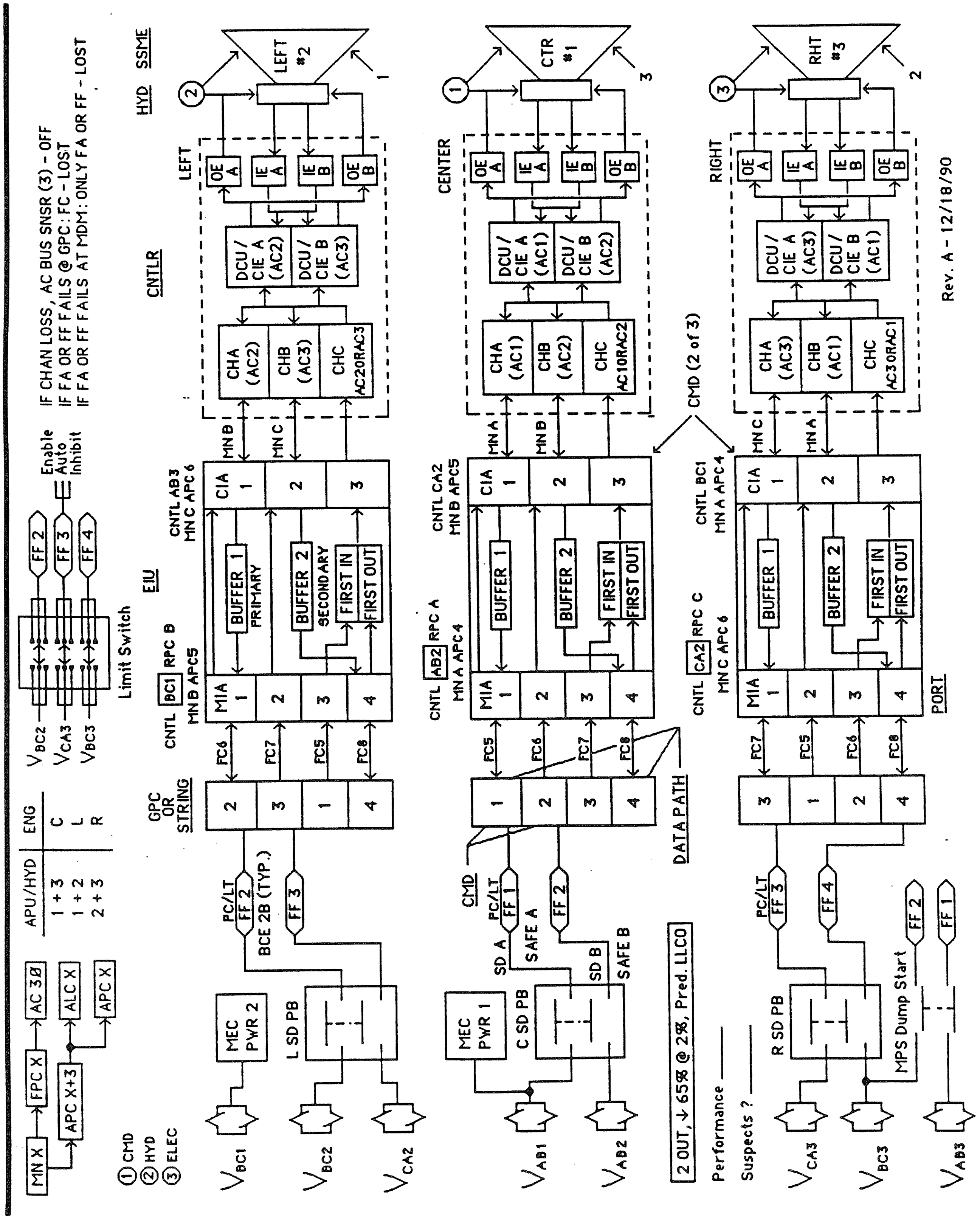

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Figure 5.2.7-II.- SSME data.

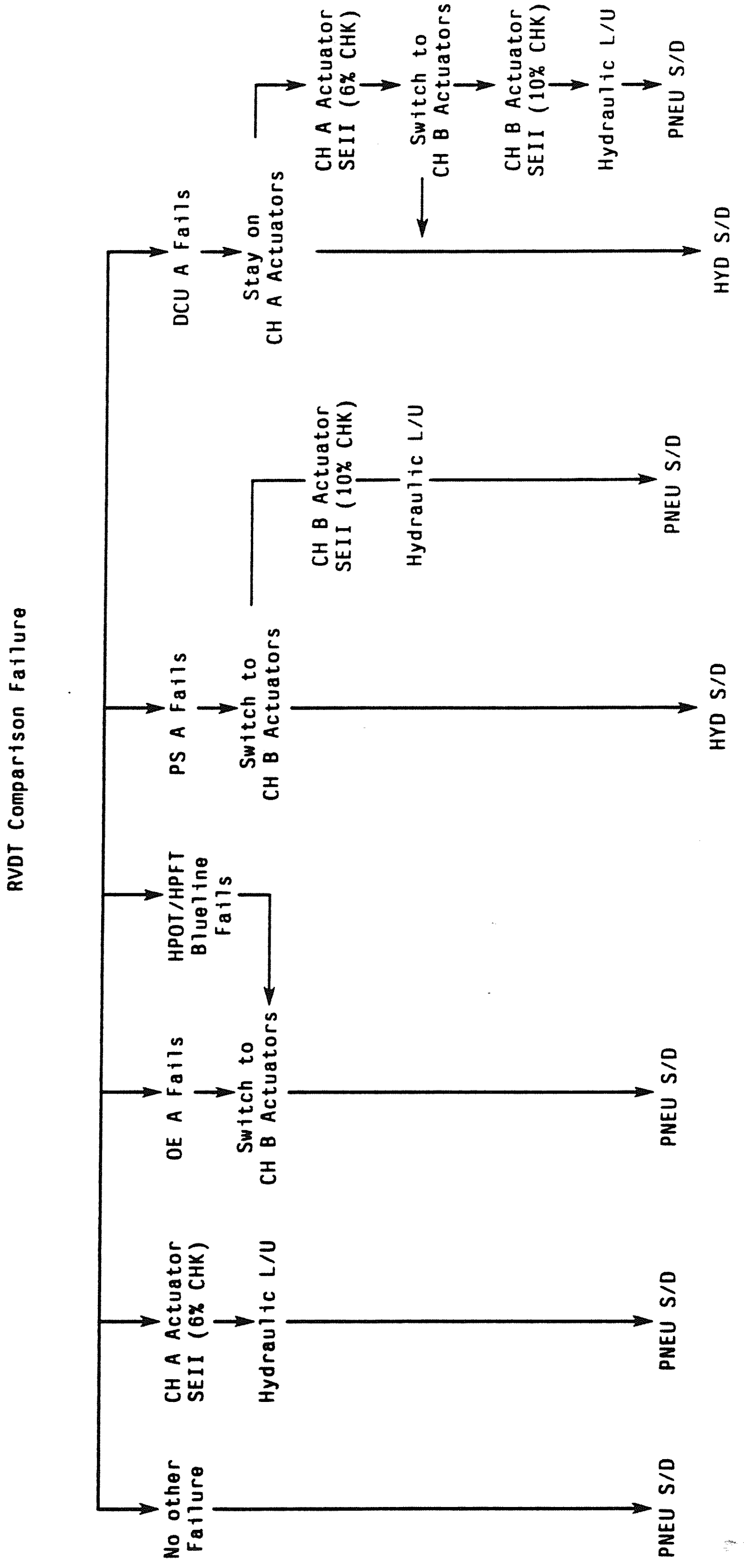


Figure 5.2.7-III.- RVDT comparison monitor failure response diagram.

TABLE 5.2.7-III.- ORBITER VEHICLE ON-ORBIT PRESSURES POSTVACUUM INERT

Orbiter vehicle	LO_2 Pressures				LH_2 Pressures			
	Manifold	L Inlet	C Inlet	R Inlet	Manifold	L Inlet	C Inlet	R Inlet
OV-102 Columbia	L	L	L	L	L	3	2	5
OV-103 Discovery	L	L	L	L	3	L	L	L
OV-104 Atlantis	L	2	L	L	2	L	L	1

Summary of engine data for vehicle SIM

TABLE 5.2.7-IV.- ENGINE DATA SUMMARY FOR SIM NO. S34

Engine parameters	Left 2	Center 1	Right 3	Averages
Thrust	487886	487886	487886	487886
ISP	452.34	452.34	452.34	452.34
OB H_2 Flow	153.340	153.340	153.340	153.340
OB OX Flow	925.252	925.252	925.252	925.252
OB MR	6.034	6.034	6.034	6.034
IN H_2 Flow	154.067	154.067	154.067	154.067
IN OX Flow	926.892	926.892	926.892	926.892
IN MR	6.016	6.016	6.016	6.016
Pc Ref	3126	3126	3126	3126
HPOT TD A	1436	1436	1436	1436
HPOT TD B	1436	1436	1436	1436
HPFT TD A	1704	1704	1704	1704
HPFT TD B	1704	1704	1704	1704
HPOT DP	4050	4050	4050	4050
OPOV POS	67.0	67.0	67.0	
FPOV POS	77.0	77.0	77.0	

Note: Overboard (OB) values are calculated from inlet values for flowrates minus average pressurant flowrates.

References:

1. MSFC FLT S34 Tags, dated 7-5-89
2. MSFC Memo, 'ARD Data for 104 pct Class Engines' dated 1/26/84
3. Booster Console Handbook, SCP 3.1.4, Engine Fuel and Oxidizer Flowrates
4. Booster Console Handbook, SCP 3.1.6, Automated Thrust Limiting Logic

TABLE 5.2.7-V.- SIM NO. S38

SSME Turbine Discharge Temps and Valve Position
Nominal Values for 104 pct

Event Light			L 1g-3g	C 1g-3g	R 1g-3g
1660	HPOT TD	TA	1368-1368	1350-1350	1380-1380
		TB	1378-1378	1360-1360	1420-1420
1800	HPFT TD	TA	1665-1665	1680-1680	1705-1705
		TB	1715-1715	1700-1700	1735-1735
	OPOV		66.7-66.7	66.4-66.4	67.7-67.7
	FPOV		80.6-80.6	81.2-81.2	81.4-81.4
	HPOT DISCH	PR	4117	4075	4009

Turbine Temp Redlines

HPOT	>	1760	R
	<	720	R
HPOT SEC P	>	100	
HPOT ISP	<	170	

		L	C	R
HPFT TA	>	1850 R	1850 R	1850
TB	>	1960 R	1960 R	1960

HPFT CLNT LNR Press.	>	2317	@	65 pct
	>	3536	@	100 pct
	>	3675	@	104 pct
	>	3849	@	109 pct

Nominal Values for 109 pct

		L	C	R
HPOT TD	TA	1418-1418	1400-1400	1430-1430
	TB	1428-1428	1410-1410	1470-1470
HPFT TD	TA	1715-1715	1730-1730	1755-1755
	TB	1765-1765	1750-1750	1785-1785
OPOV		70.3-70.3	70.9-70.9	72.5-72.5
FPOV		83.0-83.0	84.0-84.0	83.1-83.1
HPOT DISCH PR		4342	4300	4234

Note: The 1-g and 3-g values are for LO2 inlet pressure values of 55 and 160 psia, respectively, and based on those values provided at an inlet pressure of 63 psia.

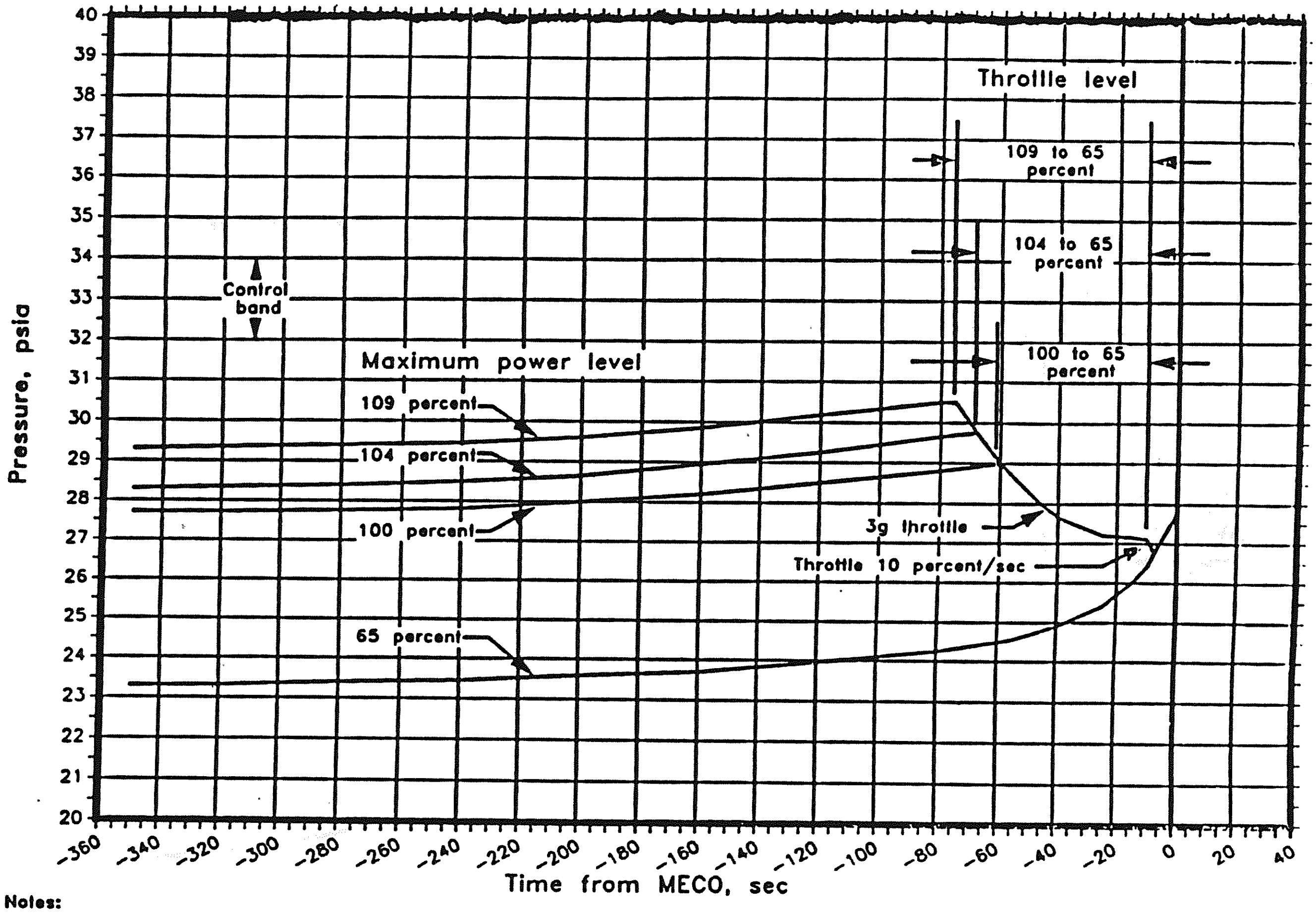
TABLE 5.2.7-VI.- TURBINE DISCHARGE TEMPERATURES CUE CARD

SMS 104 Percent Turbine Discharge Temperatures

HPOT DP	4117	4075	4009
HPOT/HPFT A	1368 / 1665	1350 / 1680	1380 / 1705
HPOT/HPFT B	1378 / 1715	1360 / 1700	1420 / 1735
OPOV / FPOV	66.7 / 80.6	66.4 / 81.2	67.7 / 81.4

SMS 109 Percent Turbine Discharge Temperatures

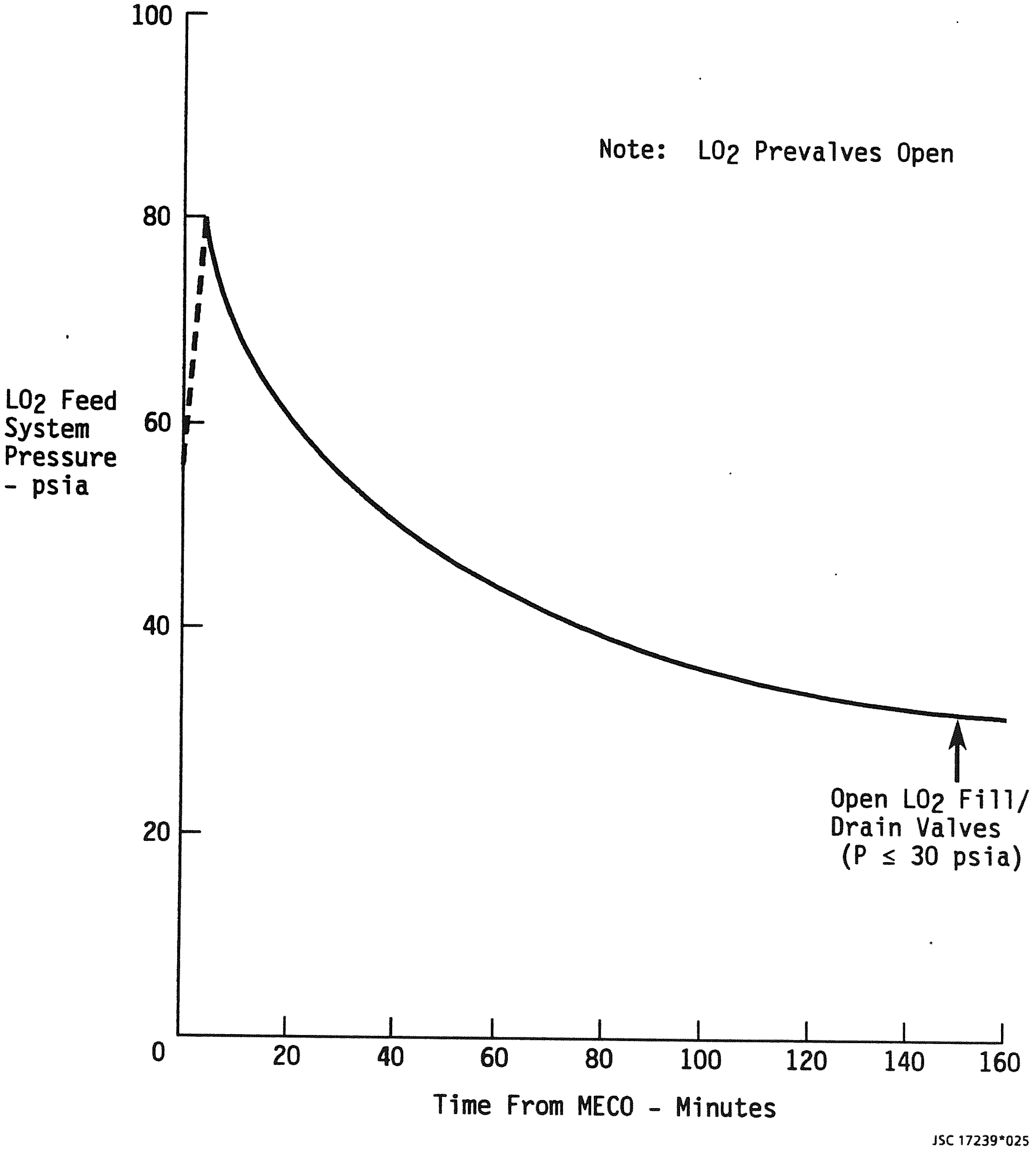
HPOT DP	4342	4300	4234
HPOT/HPFT A	1418 / 1715	1400 / 1730	1430 / 1755
HPOT/HPFT B	1428 / 1765	1410 / 1750	1470 / 1785
OPOV / FPOV	70.3 / 83.0	70.9 / 84.0	72.5 / 83.1



Notes:

1. Baseline LH_2 ullage pressure control band = 32 to 34 psia
2. Curve maintains minimum LH_2 net positive suction pressure of 4.8 at 65 percent
   5.3 at 100 percent
   5.43 at 104 percent
   5.6 at 109 percent
3. Best estimate heat load

Figure 5.2.7-IV.- Minimum allowable liquid hydrogen ullage pressure, 1, 2, and 3.

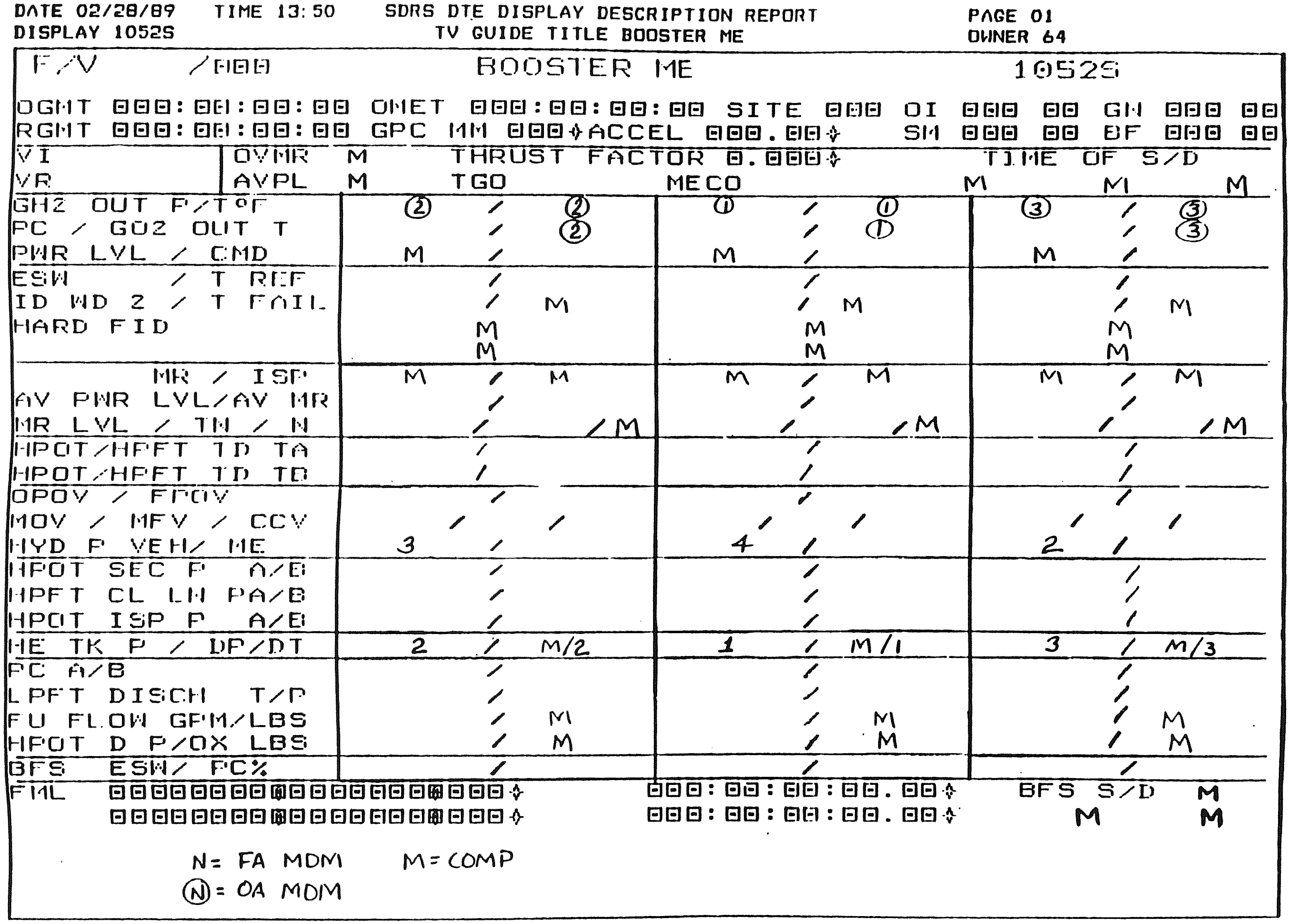


Predicted LO$_2$ Manifold Pressure Decay Through HPOT seal
(NO LO$_2$ Dump)

TABLE 5.2.7-VII.- LO_2 MANIFOLD PRESSURE AND RESIDUAL AS A FUNCTION OF OPERATING SSMEs

	Manifold pressure (psia) at F/D open end dump (1)		LO_2 mass (lbm) (2) at F/D open end dump	
Dump in MM 104 (normal, ATO, AOA) (3)				
3 SSME operating	NA	~0	NA	~200
2 SSME operating	NA	~0	NA	~900
1 SSME operating	NA	~25	NA	~1210
0 SSME operating	NA	~75	NA	~3500
Dump in MM 304 (TAL abort)				
3 SSME operating	~0	~0	<1	<1
2 SSME operating	~0	~0	<1	<1
1 SSME operating	~10	~0	<200	<1
0 SSME operating	70-75	~0	<3600	<1
Dump in MM 602 (RTLS abort)				
3 SSME operating	20	~0	<2700	<1
2 SSME operating	30	~0	<2800	<1
1 SSME operating	40	~0	<3100	<1
0 SSME operating	80	~0	<3750	<1

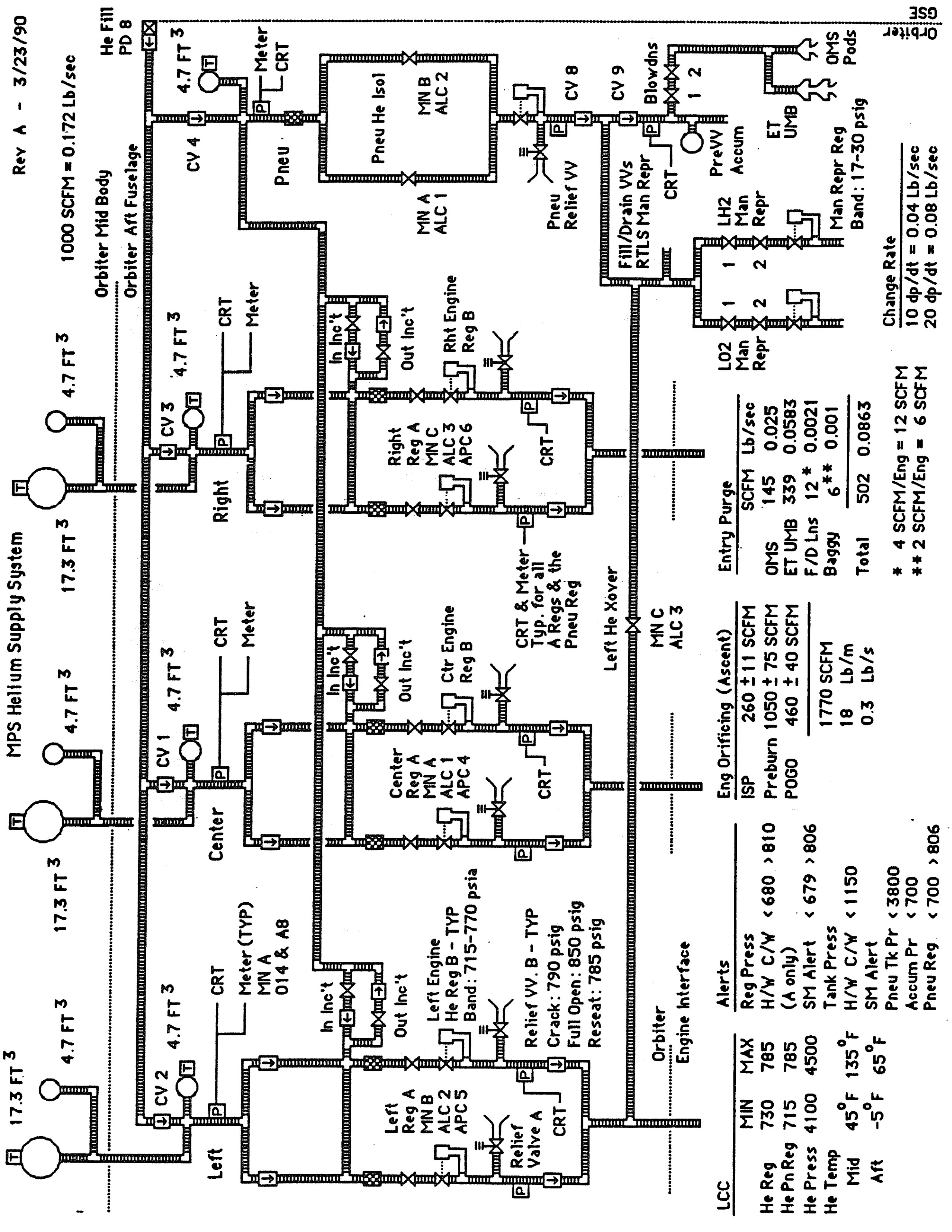
(1) Assumes F/D valves operate
(2) LO_2 residual based on full Orbiter line at MECO. Residual for LLCO is less
(3) Fill/drain valve is not opened during MPS dump sequence in MM 104



```
DATE 02/28/89   TIME 13:50    SDRS DTE DISPLAY DESCRIPTION REPORT           PAGE 01
DISPLAY 1052S                   TV GUIDE TITLE BOOSTER ME                    OWNER 64
 F/V        /□□□                     BOOSTER ME                          1052S
OGMT □□□:□□:□□:□□ OMET □□□:□□:□□:□□ SITE □□□ OI □□□ □□ GN □□□ □□
RGMT □□□:□□:□□:□□ GPC MM □□□⇕ACCEL □□□.□□⇕  SM □□□ □□ BF □□□ □□
VI          | OVMR  M     THRUST FACTOR □.□□□⇕          TIME OF S/D
VR          | AVPL  M     TGO            MECO          M        M        M
GH2 OUT P/T°F    |  ②    /    ②   |  ①    /    ①   |  ③    /    ③
PC / GO2 OUT T   |       /    ②   |       /    ①   |       /    ③
PWR LVL / CMD    |  M    /        |  M    /        |  M    /
ESW      / T REF |       /        |       /        |       /
ID WD 2  / T FAIL|       /    M   |       /    M   |       /    M
HARD FID         |       M        |       M        |       M
                 |       M        |       M        |       M
      MR / ISP   |  M    /    M   |  M    /    M   |  M    /    M
AV PWR LVL/AV MR |       /        |       /        |       /
MR LVL / TN / N  |      /      /M |      /      /M |      /      /M
HPOT/HPFT TD TA  |      /         |       /        |       /
HPOT/HPFT TD TB  |      /         |       /        |       /
OPOV / FPOV      |       /        |       /        |       /
MOV / MFV / CCV  |     /      /   |     /      /   |     /      /
HYD P VEH/ ME    |  3    /        |  4    /        |  2    /
HPOT SEC P  A/B  |       /        |       /        |       /
HPFT CL LN PA/B  |       /        |       /        |       /
HPOT ISP P  A/B  |       /        |       /        |       /
HE TK P / DP/DT  |  2    /   M/2  |  1    /   M/1  |  3    /   M/3
PC A/B           |       /        |       /        |       /
LPFT DISCH  T/P  |       /        |       /        |       /
FU FLOW GPM/LBS  |       /    M   |       /    M   |       /    M
HPOT D P/OX LBS  |       /    M   |       /    M   |       /    M
BFS  ESW/ PC%    |       /        |       /        |       /
FML  □□□□□□□□□□□□□□□□□□□□□□□□□⇕  □□□:□□:□□:□□.□□⇕  BFS S/D   M
     □□□□□□□□□□□□□□□□□□□□□□□□□⇕  □□□:□□:□□:□□.□□⇕    M       M

        N= FA MDM      M= COMP
        Ⓝ= OA MDM
```

Figure 5.2.7-VI.- Main engine telemetry loss cue card.



LCC

	MIN	MAX
He Reg	730	785
He PnReg	715	785
He Press	4100	4500
He Temp		
Mid	45°F	135°F
Aft	-5°F	65°F

Alerts

Reg Press		
H/W C/W	< 680	> 810
(A only)		
SM Alert	< 679	> 806
Tank Press		
H/W C/W	< 1150	
SM Alert		
Pneu Tk Pr	< 3800	
Accum Pr	< 700	
Pneu Reg	< 700	> 806

Eng Orificing (Ascent)

ISP	260 ± 11 SCFM
Preburn	1050 ± 75 SCFM
POGO	460 ± 40 SCFM
	1770 SCFM
	18 Lb/m
	0.3 Lb/s

Entry Purge

	SCFM	Lb/sec
OMS	145	0.025
ET UMB	339	0.0583
F/D Lns	12 *	0.0021
Baggy	6 **	0.001
Total	502	0.0863

* 4 SCFM/Eng = 12 SCFM
** 2 SCFM/Eng = 6 SCFM

Change Rate

10 dp/dt = 0.04 Lb/sec
20 dp/dt = 0.08 Lb/sec

Figure 5.2.7-VII.- MPS helium supply system.

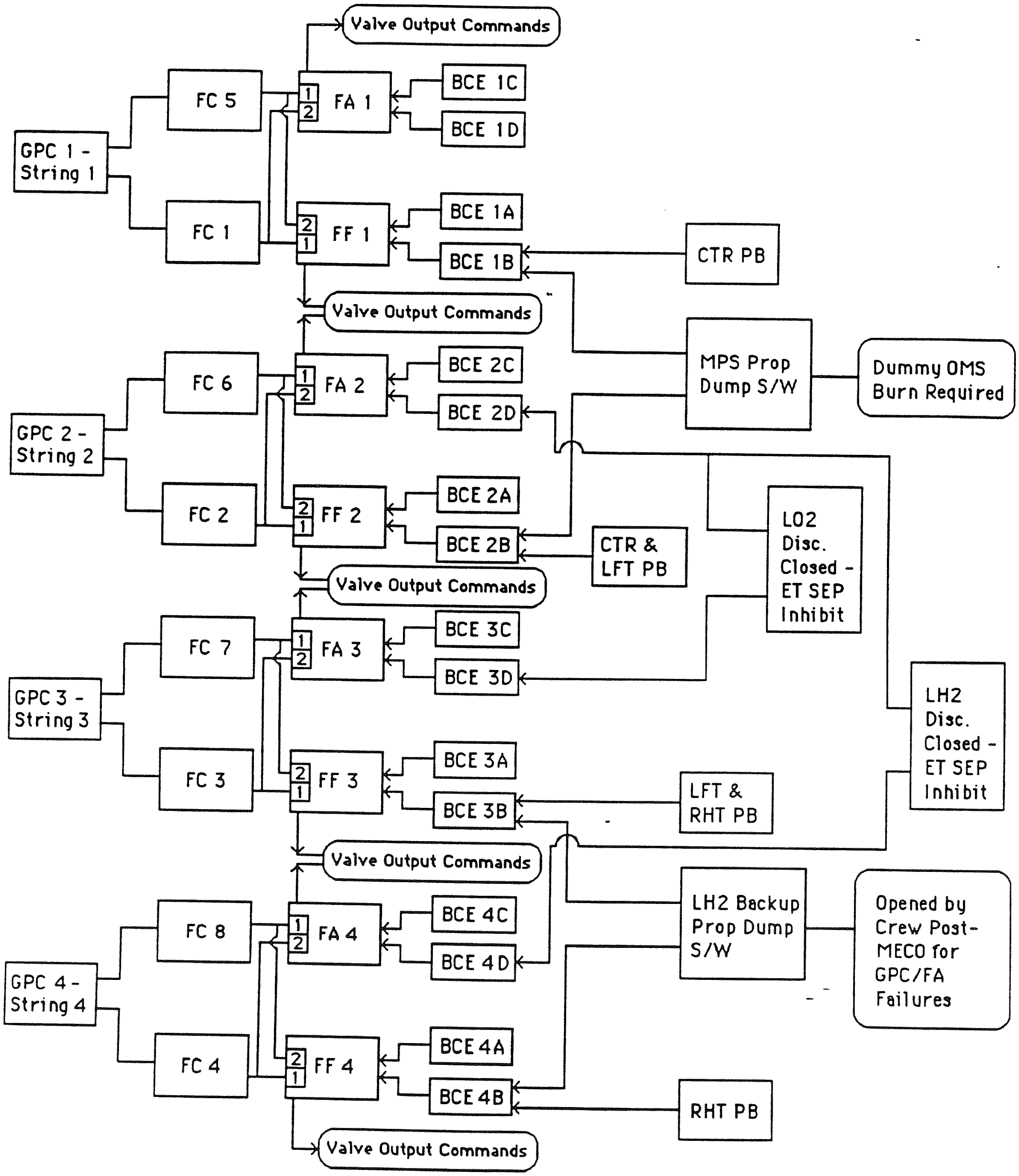


Figure 5.2.7-VIII.- MPS channelization cue card.

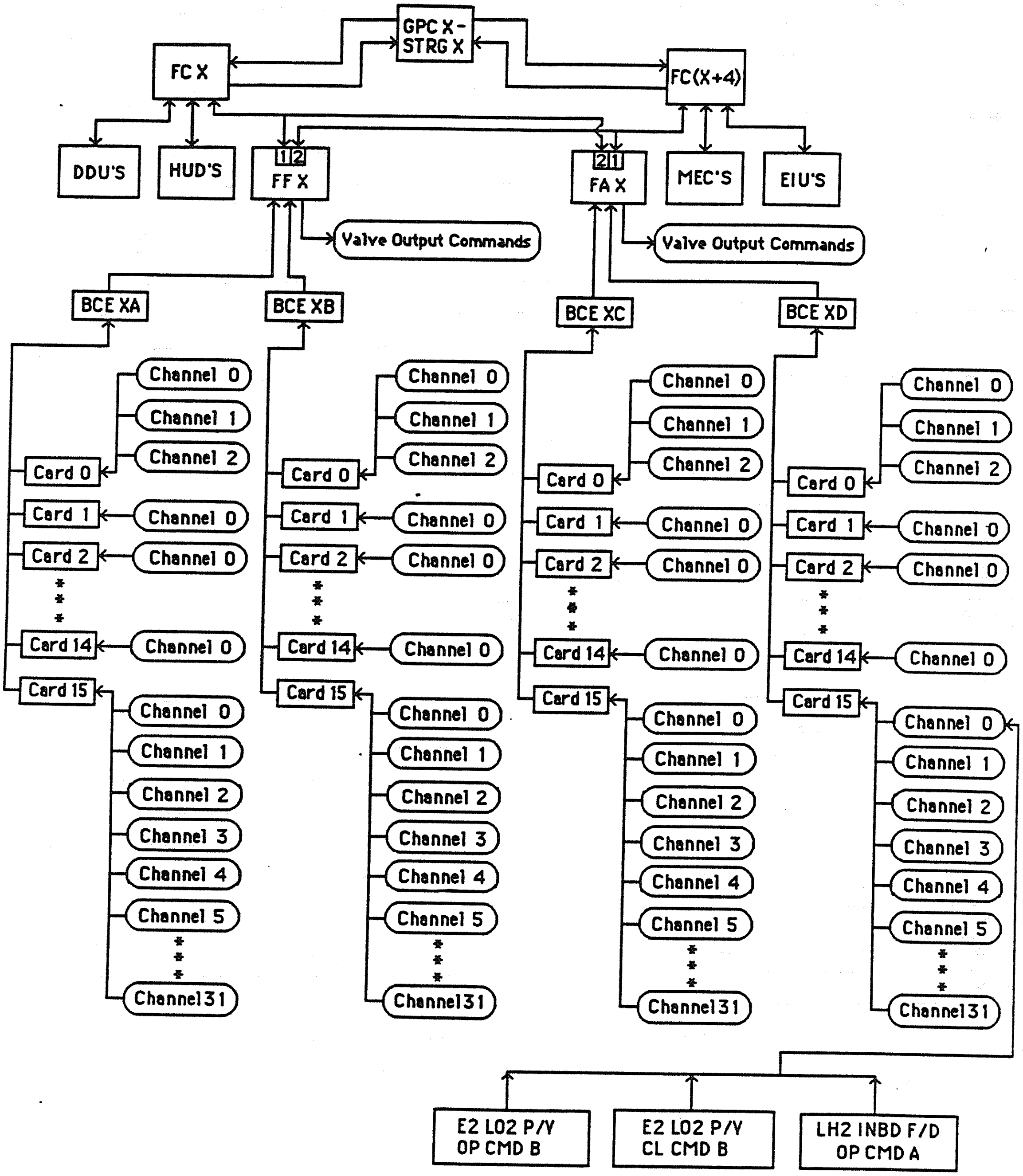


Figure 5.2.7-IX.- Channelization cue card.

				FA MDMs										BUS			DUAL BUS			MN A & FA				MN B & FA				MN C & FA				CNTL AB			CNTL BC			CNTL AC		
				1	2	3	4	12	13	14	23	24	34	A	B	C	AB	AC	BC	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	1	2	3	1	2	3
PANEL R2	!! HELIUM TANK ISO VALVES (NC)	C	A	G				G	G	G				*			*	*		*	*	*	*	G				G				M								
			B								G								*							G			G							Mc				Mc
		L	A		G			G			G	G			*		*		*		G			*	*	*	*		G								M			
			B							G								*					G					G					Mc					Mc		
		R	A			G			G		G		G			*		*	*			G				G		*	*	*	*								M	
			B					G									*				G			G										Mc	Mc					
		P	1	G				G	G	G				*			*	*		*	*	*	*	G				G						M						
			2				G			G		G	G		*		*	G	*				G	*	*	*	*				G						M			
PANEL R4	!! HELIUM TANK INTER-CONNECT VALVES (NC)	IN. OP	C					G									*				G			G																
			L								G								*							G			G											
			R						G									*				G						G												
		OUT OP	C	G				G	G	G				*			*	*		*	*	*	*	G				G					M							
			L		G			G			G	G			*		*		*		G			*	*	*	*		G							M				
			R				G			G		G	G			*		*	*				G				G	*	*	*	*							M		
		X	L		G			G			G	G				*		*	*		G				G			*	*	*	*								M	
	HELIUM BLOWDOWN VALVES (NC)		#1			*			*		*		*	*			*	*		*	*	*	*			*				*										
			#2				*			*		*	*	*			*	*		*	*	*	*				*				*									
	LO2(H2) ECO SENSORS 12 34	MDM	PWR FAIL	w c	c	c	c	WC C	c c	W CC	cc	C CW	c c	w	w	w	WW C	c c	C WW	w c	wc	c	w c	WW C	c	cw	W CW	W WC	C WW	c w	c									
		FAIL	PWR/ COMM					WC C	c c	W CC	cc	c c	c c																											
			COMM FALT	c	c	c	c	c c	c c	cc	cc	c c	c c							w c	wc	c	w c	w c	c	cw	w c	wc	c w	c w	c									
	ET TUMBLE		A&F												*		*		*					*	*	*	*													
LIQUID SENSORS	5%		O2/H2									*							*								*		*											
	98% #1		O2/H2				*			*		*	*			*		*	*				*				*	*	*	*	*									
	98% #2		O2/H2		*			*			*	*			*		*		*		*			*	*	*	*		*											
	99.X%		O2/H2	*				*	*	*				*			*	*		*	*	*	*	*				*												
	100% #1		O2/H2									*							*								*		*											
	100% #2		O2/H2				*			*		*	*			*		*	*				*				*	*	*	*	*									
	100.X%		O2/H2		*			*			*	*			*		*		*		*			*	*	*	*		*											
	102%		O2/H2	*				*	*	*				*			*	*		*	*	*	*	*				*												

FOOD FOR THOUGHT:

MN A --> ALC1 --> APC4
MN B --> ALC2 --> APC5
MN C --> ALC3 --> APC6

GPC1 --> STRING 1 --> FC5 --> FA1
GPC2 --> STRING 2 --> FC6 --> FA2
GPC3 --> STRING 3 --> FC7 --> FA3
GPC4 --> STRING 4 --> FC8 --> FA4

LEGEND

!! = SWITCH
# = CAUSES DELAYED SRB SEP
I = ET SEP INH DUE TO TELEMETRY FAILURE
* = TOTAL
C = CLOSE
O = OPEN
G = GPC
M = MANUAL

10/4/91

USE FOR SOLENOID VALVES OR SPRING LOADED PNEUMATIC VALVES:

G, M --> USE ONLY IF BOTH GPC AND MAN CAPABILITY EXISTS
* -----> TOTAL LOSS OF EITHER GPC OR MANUAL CONTROL

FOR BISTABLE VALVES, USE:

Go
Gc
G* --> BOTH O & C
Mo
Mc
M* --> BOTH O & C
* --> BOTH G & M

For ECO Sensors

w,W = failed wet
c,C = commfault

if all letters are capitals:
No LLCO protection

Figure 5.2.7-X.- Multibus and MDM failures cue card (11/29/88).

				FA MDMS										BUS			DUAL BUS			MNA & FA				MNB & FA				MNC & FA				CNTL AB			CNTL BC			CTLCA	
				1	2	3	4	12	13	14	23	24	34	A	B	C	AB	AC	BC	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	1	2	3	1	2
	SRB PC(LT & RT)			1	2	3		12#	13#	1	23#	2	3				1	13#	23#	1	2	3		1	2	3		1	2	3									
PANEL R4	!! PRE-VALVES	LO2	C					Go	Go	Go	Go	Go	Go				*	Go	Go	Go	Go		Go	Go	Go	Go													
			L					Go	Go	Go	Go	Go	Go					Go	*						Go	Go	Go	Go	Go	Go									
			R					Go	Go	Go	Go	Go	Go				Go	*		Go	Go		Go					Go		Go	Go								
		LH2	C					G*	G*		G*						*			G*	G*					G*													
			L					G*		G*		G*							*						G*		G*	G*											
			R					G*		G*		G*						*			G*							G*			G*								
	FEEDLINE DISC'S		LO2								*I	*	*					*I	*I							*			*		*								
			LH2								*	*I	*					*I	*I							*			*		*								
	FEEDLINE LATCH		LO2								*	*	*					*	*								*		*		*								
			LH2								*	*	*					*	*								*		*		*								
PANEL R4	!! FILL & DRAIN	INB	LO2	Go	Gc		Go	G*	Go	Go	Gc	G*	Go		*		*	Go	*	Go	Gc		Go	*	*	*	*	Go	Gc		Go				Mo	M*			
			LH2	Gc	Go	Go		G*	G*	Gc	Go	Go	Go	*			*	*	Go	*	*	*	*	Gc	Go	Go		Gc	Go	Go		Mo	M*						
		OUT	LO2				G*			G*		G*	G*			*		*	*				G*				G*	*	*	*	*							M*	
			LH2		G*			G*			G*	G*			*		*		*		G*			*	*	*	*		G*						M*				
PANEL R4	!! FDLN RELIEF ISO (NO)		LO2					G	G		G							*	G	G		G							G										
			LH2						G	G			G				G	*		G			G							G									
	LH2	!!PR LN VT NC		LA				LA	LA	LA						*	LA	*	*	LA				LA				*	*	*	*							M	
		!!TOPPING NC		G				G	G	G				*			*	*		*	*	*	*	G				G						M					
		RECIRC DISC					*			*		*	*			*		*	*				*				*	*	*	*	*								
	LO2	POGO (NO)	#1	*		*		*	*	*	*		*	*			*	*		*	*	*	*	*		*		*		*									
			#2		*		*	*		*	*	*	*		*		*	*	*		*		*	*	*	*	*		*		*								
		OVB BLD (NO)									*	*	*					*	*							*			*		*								
PANEL R4	!! MANIFOLD REPRESS (NC)	LO2	#1			G			G		G		G			*		*	*			G				G		*	*	*	*							M	
			#2				G			G		G	G			*		*	*				G				G	*	*	*	*								M
		LH2	#1	G				G	G	G					*		*		*	G				*	*	*	*	G								M			
			#2		G			G			G	G			*		*		*		G			*	*	*	*		G								M		
RTLS	DUMP (NC)	IN							*	*			*					*				*						*			*								
		OUT							*	*			*					*				*						*			*								
	REPRS (NC)	#1							*	*			*					*				*						*			*								
		#2						*		*		*						*					*					*	*										
	ET ULLAGE FCV's (NO)	GO2		C	L		R	LC	C	CR	L	LR	R	C	L	R	LC	CR	LR	C	LC	C	CR	LC	L	L	LR	CR	LR	R	R								
		GH2		C	L		R	LC	C	CR	L	LR	R	C	L	R	LC	CR	LR	C	LC	C	CR	LC	L	L	LR	CR	LR	R	R								
PNL R2	!!H2 ULL PRS SW																																	C		L		R	
	!! DUMP SEQ MAN	NOM						FF																										*			*		
		3/U											FF																				*			*			

REV: 10/20/88

FA MDMs LOST-->	1	34	2
FF MDMs LOST-->	1	3	24

LA = LOSS OF GPC CONTROL THROUGH GROUND MDM

Figure 5.2.7-XI.- Multibus and MDM failures cue card (10/20/88).

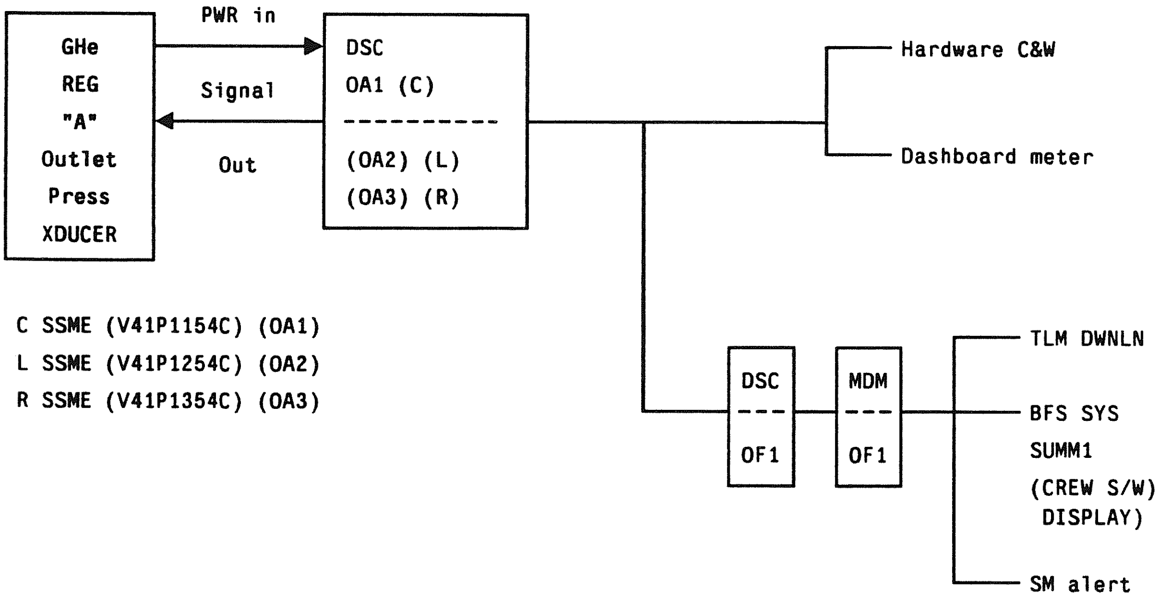


Figure 5.2.7-XII.- Helium REG A telemetry cue card.

TABLE 5.2.7-VIII.- ENTRY HELIUM CUE CARD

Time	Event	ENT purge required	Bonus information	FDF reference
TIG -1:38	C&W reset	N/A	R13 inhibit CH 69 LOX MANF P R13 " " 79 LH_2 MANF P R13 enable CH 39 C He REG P (0.30V/60.0 PSIA) R13 " " 49 L He REG P (0.30V/60.0 PSIA) R13 " " 59 R He REG P (0.30V/60.0 PSIA)	DEORB PREP: 1-17 FS 1-28
TIG -0:25	MPS reconfiguration	N/A	R2 MPS He ISOL A L, CTR, R (three) - OP R2 MPS He ISOL B L, CTR, R (three) - CL R2 MPS PNEU He ISOL - CL R4 MPS fill/drain LO_2 OUTBD - CL R4 MPS fill/drain LH_2 OUTBE - CL	ENT C/L 3-7
TIG -0:25	Regulator fails during procedure (crew may get MA and will isolate only the failed regulator)	Yes	R13 inhibit assoc C&W channel (see above)** If the failed reg is the left engine reg:** R2 MPS PNEU He ISOL - OP F6 CDR INST PWR - FLT/MPS (allows crew to watch PNEU reg since no C&W available)	ENT C/L 3-7
		No	R13 inhibit assoc C&W channel (see above)**	
After complete TIG -0:25 procedure until touchdown	Regulator fails (crew will get MA and will isolate only the failed regulator)	Yes At BSE discretion	Expect master alarms as regs bleed down after vent doors open ($V_{REL}<2400$ ft/sec):** R2 MPS PNEU He ISOL - OP F6 CDR INST PWR - FLT/MPS (allows crew to watch PNEU reg since no C&W available)	EPCL 9-11 AESP: MS 9-4 FB 12-25
		No	Expect master alarms as regs bleed down	
Post-touchdown APU/HYD shutdown	Take power off O/B Fill and drain CLS solenoids	N/A	R4 MPS fill/drain LO_2 OUTBD - GND R4 MPS fill/drain LH_2 OUTBD - GND	ENT C/L 5-11
1-orbit wave off	N/A	N/A	No action required	
24-hour wave off	Crew performs backout procedures	N/A	At (MCC/crew GO/NO GO for 24 hours) + 0:03: R2 MPS He ISOL A L, CTR, R (three) - GPC R2 MPS He ISOL B L, CTR, R (three) - GPC R2 MPS PNEU He ISOL - GPC R4 MPS fill/drain LO_2 OUTBD - GND R4 MPS fill/drain LH_2 OUTBD - GND	D/O PREP 2-5
			At (MCC crew GO/NO GO for 24 hours) + 0:50: R13 Inhibit CH 39 C He REG P R13 " " 49 L He REG P R13 " " 59 R He REG P	D/O PREP FS 2-15

**Ground call required (not in FDF)

TABLE 5.2.7-IX.- MPS PROPELLANT DUMP PERFORMANCE SUMMARY (NORMAL, ATO, AOA, MISSION)

	Propellant mass (lbm)	
	LO_2	LH_2
Propellant mass at MECO*	4801	365
Propellant loss from MECO to ET SEP		
SSME shutdown	172	58
Helium POGO injection (10 ft^3)	710	N/A
Disconnect closure (0.7 ft^3)	50	3
Propellant mass at ET SEP	3869	304
Propellant loss from ET SEP to start of dump		
HPOTP seal leakage (120 second)	270	N/A
LH_2 feedline venting (30 second)	N/A	51
Propellant mass at start of dump	3599	253
Propellant mass dumped	3400	250
Propellant mass at end of dump	<200	<3
Mass dumped during F/D line vacuum inerting	<200	<3
Propellant mass at touchdown	0	0

Note: Helium POGO injection displaces LO_2 into ET during SSME S/D

* The LO_2 propellant mass at MECO, for LLCO, is 4125 lbm (3 SSME at 65% power level) instead of the 4801 lbm for guided MECO

TABLE 5.2.7-X.- MPS PROPELLANT DUMP PERFORMANCE SUMMARY (RTLS ABORT)

	Propellant mass (lbm)	
	LO_2	LH_2
Propellant mass at MECO*	4801	365
Propellant loss from MECO to ET SEP		
SSME shutdown	172	58
Helium POGO injection (10 ft^3)	710	N/A
Disconnect closure (0.7 ft^3)	50	3
Propellant mass at ET SEP	3869	304
Propellant loss from ET SEP to start of dump		
HPOTP seal leakage (15 second)	35	N/A
LH_2 feedline venting (15 second)	N/A	29
Propellant mass at start of dump	3834	275
Propellant mass dumped	1134	206
Propellant mass at end of dump	2700	69
Mass dumped during F/D line vacuum inerting	2700	~68
Propellant mass at touchdown	0	<1

Note: Helium POGO injection displaces LO_2 into ET during SSME S/D

* The LO_2 propellant mass at MECO, for LLCO, is 4630 lbm (2 SSME at 65% power level) instead of the 4801 lbm for guided MECO

TABLE 5.2.7-XI.- MPS PROPELLANT DUMP PERFORMANCE SUMMARY (TAL ABORT)

	Propellant mass (lbm)	
	LO_2	LH_2
Propellant mass at MECO*	4801	365
Propellant loss from MECO to ET SEP		
SSME shutdown	172	58
Helium POGO injection (10 ft^3)	710	N/A
Disconnect closure (0.7 ft^3)	50	3
Propellant mass at ET SEP	3869	304
Propellant loss from ET SEP to start of dump		
HPOTP seal leakage (30 second)	69	N/A
LH_2 feedline venting (30 second)	N/A	51
Propellant mass at start of dump	3800	253
Propellant mass dumped	3800	250
Propellant mass at end of dump/vacuum inerting	0	~3
Propellant mass at touchdown	0	~3

Note: Helium POGO injection displaces LO_2 into ET during SSME S/D

* The LO_2 propellant mass at MECO, for LLCO, is 4255 lbm (2 SSME at 91% power level) instead of the 4801 lbm for guided MECO

TABLE 5.2.7-XII.- MPS VALVE CONFIGURATION - MECO CUE CARD

MECO

Time	Event	
MECO	HE INCON IN L, C, R	Open*
	LH_2 Feedline REL ISO	Open
	LO_2 Feedline REL ISO	Open
	PNEU XOVER	Open
	LH_2 RECIRC Disc	Closed
MECO + 1.158	LO_2 Prevalves	Closed
MECO + 5.6	LH_2 Prevalves	Closed
	LO_2 17" Latch	Unlocked
	LH_2 17" Latch	Unlocked
MECO + 6.6	LO_2 17" Disc	Closed
	LH_2 17" Disc	Closed
MECO + 10.4	RTLS Dump Valves	Open
	ET/ORB UMP Plates	Retract
MECO + 16.0	SSME Bleed Valves	Open
MECO + 17.44	ET SEP	
MECO + 20.0	He INCON IN L, C, R	Close
	He INCON OUT L, C, R	Open
MECO + 90.0	RTLS Dump Valves	Closed
MECO + 120.0	Dump Start	

* Interconnect if tank pressue < 2000 psi

RTLS V	Helium		L	C	R	P
IB 0 0	ISO A	0	0	0	0	0
OB 0 0	ISO B	0	0	0	0	0
	INT IN	0				
P1 0	INT OT	0				
P2 0	XVR/BD12		0			

Q	LO_2	LH_2
PV OP 0		
PV CL X	X X X	X X X
FD DSC	XX	XX
FD Latch	UU	UU
FD RIS 0	0	0
IB F/D X	X	X
OB F/D X	X	X
MN P1/20		
OVB/TOPX	X	X
R DSC X		X
P LN V 0		
POGO1/20	0/0	

MNA —— APC4 —— ALC1
MNB —— APC5 —— ALC2
MNC —— APC6 —— ALC3

TABLE 5.2.7-XIII.- MPS VALVE CONFIGURATION - DUMP SEQUENCE CUE CARD

Dump Seq

Manual dump	Auto dump	Event	
	MECO	PNEU XOVER	Open
	MECO + 20	L, C, R, He INT OT	Open
	Dump Start (MECO + 2:00)	LH_2 MAN P 1, 2	Open
		LH_2 IB F/D	Open
		LH_2 OB F/D	Open
		LO_2 MAN. P 1, 2	Open
		LO_2 L, C, R Prevalves	Open
		SSME MOV	Open
	Dump + 0:06	LH_2 IB F/D	Close
		LH_2 Topping Valve	Open
		LH_2 L, C, R Prevalves	Open
	Dump + 1:28	LH_2 MAN. P 1, 2	Close
Dump + 2:00	Dump + 1:30	LO_2 MAN. P 1, 2	Close
Dump + 2:21	Dump stop (Dump + 2:01)	SSME MOV	Close
		LH_2 Topping Valve	Close
		LH_2 OB F/D	Close
		LO_2 OVB BLEED	Open
		L, C, R He INT OUT	Close
		PNEU XOVER	Close

Proceed to inert cue card

RTLS V	Helium		L	C	R	P
IB 0	ISO A	0	0	0	0	0
OB 0	ISO B	0	0	0	0	0
	INT IN	0				
P1 0	INT OT	0	0	0	0	
P2 0	XVR/BD12		0			

Q	LO_2	LH_2
PV OP 0	0 0 0	0 0 0
PV CL X		
FD DSC	XX	XX
FD Latch	UU	UU
FD RIS 0	0	0
IB F/D X	X	X
OB F/D X	X	
MN P1/20	0/0	0/0
OVB/TOPX		
R DSC X		X
P LN V 0		
POGO1/20	0/0	

MNA ———— APC4 ———— ALC1
MNB ———— APC5 ———— ALC2
MNC ———— APC6 ———— ALC3

TABLE 5.2.7-XIV.- MPS VALVE CONFIGURATION - VACUUM INERT CUE CARD

Vacuum Inert

Time		Event		
15:00		MPS Engine PWR (six)	Off	*
		MPS He ISO (six)	Close	*
		PNEU He ISO	Open	
		He Interconnect	GPC	
Start	If LO_2 Manifold Pressure < 40			
		LO_2 O/B F/D	Open	*
		LO_2 I/B F/D	Open	*
	Else			
		Let LO_2 Manifold pressure bleed down then open LO_2 I/B & O/B F/D		
		LH_2 O/B F/D	Open	*
		LH_2 I/B F/D	Open	*
		LH_2 Topping VLV	Open	**
		LH_2 High PT Bleed	Open	**
		LH_2 Press Line Vent	Open	*
Start + 1:00		LH_2 Press Line Vent	GND	*
TIG - 5:00 (TIG - 10:00 for AOA)		Vacuum Inerting Terminate		
		LH_2 O/B F/D	Close	*
		LO_2 O/B F/D	Close	*
TIG - 4:50		LH_2 O/B F/D	GND	*
		LH_2 I/B F/D	GND	*
		LO_2 O/B F/D	GND	*
		LO_2 I/B F/D	GND	*
		PNEU He ISOL	GPC	*

*Switch throw
**Opened by the LH_2 I/B F/D switch

RTLS V	Helium	L	C	R	P
IB O	ISO A O				O
OB O	ISO B O				O
	INT IN O				
P1 O	INT OT O				
P2 O	XVR/BD12				

Q	LO_2	LH_2
PV OP O	O O O	O O O
PV CL X		
FD DSC	XX	XX
FD Latch	UU	UU
FD RIS O	O	O
IB F/D X		
OB F/D X		
MN P1/20	/	/
OVB/TOPX		
R DSC X		X
P LN V O		
POGO1/20	O/O	

MNA —— APC4 —— ALC1
MNB —— APC5 —— ALC2
MNC —— APC6 —— ALC3

TABLE 5.2.7-XV.- MPS VALVE CONFIGURATION - ENTRY CUE CARD

	Entry		
Time	Event	Vlv pos	
TIG - 25:00	PNEU ISO	Close	*
	He ISO B L, C, R	Close	*
	He ISO A L, C, R	Open	*
	LO_2 O/B F/D	Close	*
	LH_2 O/B F/D	Close	*
MM304 (EI - 5:00)	PNEU XOVER	Open	
	LH_2 Topping Valve	Open	
	LH_2 I/B F/D (Power)	Open	**
	He INC Out C, R	Open	
	He INC In L	Open	
	LH_2 RTLS Dump Valves	Open	
MM304 + 0:08	All Vent Doors Closed		
GRV < 20000 ft/sec	LO_2 I/B F/D (Power)	Open	**
GRV < 4500 ft/sec (MM304 + 17:32)	LO_2 Prevalves	Close	
	LH_2 RTLS Dump Valves	Close	
	He Blowdown Valves	Open	
	LO_2 Manifold Repress 1/2	Open	
	LH_2 Manifold Repress 1/2	Open	
GRV < 2400 ft/sec (MM304 + 19:36)	Vent Doors Open		
MM304 + 36:19	Touchdown		
MM304 + 38:03	He Blowdown Valves	Close	
APU/HYD Shutdown	LH_2 O/B F/D	GND	*
	LO_2 O/B F/D	GND	*

*Switch throw
**Valve open, but powered open

RTLS V	Helium	L	C	R	P
IB O	ISO A 0	0	0	0	
OB O	ISO B 0				
	INT IN 0	0			
P1 O	INT OT 0		0	0	
P2 O	XVR/BD12	0			

Q	LO_2	LH_2
PV OP O	0 0 0	0 0 0
PV CL X		
FD DSC	XX	XX
FD Latch	UU	UU
FD RIS O	0	0
IB F/D X		
OB F/D X	X	X
MN P1/20	/	/
OVB/TOPX		
R DSC X		X
P LN V O		
POGO1/20	0/0	

MNA —————— APC4 —————— ALC1
MNB —————— APC5 —————— ALC2
MNC —————— APC6 —————— ALC3

TABLE 5.2.7-XVI.- MPS VALVE CONFIGURATION - TAL DUMP CUE CARD

	TAL Dump		
Time	Event		
MM304	LH_2 Prevalves	Open	
	LH_2 I/B F/D Valve	Open	
	LH_2 O/B F/D Valve	Open	
	LH_2 Topping Valve	Open	
	LH_2 RTLS Dump Valves	Open	
	PNEU ISO	Open	**
	He ISO B L	Open	**
	PNEU XOVER	Open	
	He INC Out C, R	Open	
	He INC In L	Open	
	LO_2 Prevalves	Open	
	SSME MOV's	Open	
MM304 + 0:08	Vent Doors	Closed	
GRV < 20000	LO_2 O/B F/D Valves	Open	
	LO_2 I/B F/D Valves	Open	
MM304 + 17:32 GRV < 4,500	LH_2 O/B F/D Valves	Close	
	LH_2 RTLS Dump Valves	Close	
	LO_2 Prevalves	Close	
	LH_2 O/B F/D Valve	Close	
	He Blowdown Valves	Open	
	LO_2 Manifold Repress	Open	
	LH_2 Manifold Repress	Open	
MM304 + 19:36 GRV < 2,400	Vent Doors	Open	
MM304 + 26:42	Touchdown		
MM304 + 28:26	He Blowdown Valves	Close	
APU/HYD Shutdown	LH_2 O/B F/D	GND	*
	LO_2 O/B F/D	GND	*

*Switch throw
**Valve already powered open

RTLS V	Helium		L	C	R	P
IB 0 0	ISO A	0	0	0	0	0
OB 0 0	ISO B	0	0	0	0	0
	INT IN	0	0			
P1 0	INT OT	0		0	0	
P2 0	XVR/BD12		0			

Q	LO_2	LH_2
PV OP O	0 0 0	0 0 0
PV CL X		
FD DSC	XX	XX
FD Latch	UU	UU
FD RIS O	0	0
IB F/D X		
OB F/D X		
MN P1/20		
OVB/TOPX	X	
R DSC X		X
P LN V O		
POGO1/20	0/0	

MNA ——— > APC4 ——— > ALC1
MNB ——— > APC5 ——— > ALC2
MNC ——— > APC6 ——— > ALC3

TABLE 5.2.7-XVII.- MPS VALVE CONFIGURATION - RTLS MECO CUE CARD

RTLS MECO

Time	Event	
MECO	He INCON IN	Open*
	PNEU XOVER	Open
	LH_2 Feedline REL ISO	Open
	LO_2 Feedline REL ISO	Open
	LH_2 Recirc Disc	Closed **
MECO + 1.158	LO_2 Prevalves	Closed
MECO + 5.6	LH_2 Prevalves	Closed
	LO_2 17" Latch	Unlocked
	LH_2 17" Latch	Unlocked
MECO + 6.6	LO_2 17" Disc	Closed
	LH_2 17" Disc	Closed
MECO + 10.4	RTLS Dump Valves	Open
MECO + 13.2	ET SEP	
MECO + 16.0	SSME Bleed Valves	Open
MM602 Declared MECO + 25	He INCON Out L, C, R	Open
	LH_2 RTLS Repress Vlvs	Open
	LH_2 Prevalves	Open
	LO_2 Prevalves	Open
	SSME MOV's	Open
MM602 + 39 Q >= 20	LO_2 I/B F/D	Open
	LO_2 O/B F/D	Open
MM602 + 80	LH_2 RTLS Repress Vlvs	Closed
	LH_2 I/B F/D Vlv	Open
	LH_2 O/B F/D Vlv	Open
	LH_2 Topping Vlv	Open
GRV <= 4500	He Blowdown Vlvs	Open
GRV <= 3800	LH_2 RTLS Dump Vlvs	Closed
	LH_2 O/B F/D	Closed
	SSME Bleed Vlvs	Closed
	LO_2 O/B F/D	Closed
	LO_2 Prevalves	Closed
	SSME MOV's	Closed
	LO_2 Manifold Repress	Open
	LH_2 Manifold Repress	Open
	LO_2 Overboard Bleed Vlv	Open
Touchdown		
GRV 3800 + 650 Sec	He Blowdowns Vlvs	Closed
	He Out L, C, R	Closed

RTLS V	Helium		L	C	R	P
IB 0 0	ISO A	0	0	0	0	0
OB 0 0	ISO B	0	0	0	0	0
	INT IN	0				
P1 0 0	INT OT	0	0	0	0	
P2 0 0	XVR/BD12		0			

Q	LO_2	LH_2
PV OP 0	0 0 0	0 0 0
PV CL X		
FD DSC	XX	XX
FD Latch	UU	UU
FD RIS 0	0	0
IB F/D X		X
OB F/D X		X
MN P1/20	/	/
OVB/TOPX	X	X
R DSC X		X
P LN V 0		
POGO1/20	0/0	

MNA —— APC4 —— ALC1
MNB —— APC5 —— ALC2
MNC —— APC6 —— ALC3

* Interconnect FF tank pressure < 2000 psi
**Possibly closed prior to MECO

TABLE 5.2.7-XVIII.- RTLS VALVE CONFIGURATION - RTLS CONTINGENCY DUMP CUE CARD

RTLS CONTINGENCY DUMP 08-24-90 REV A

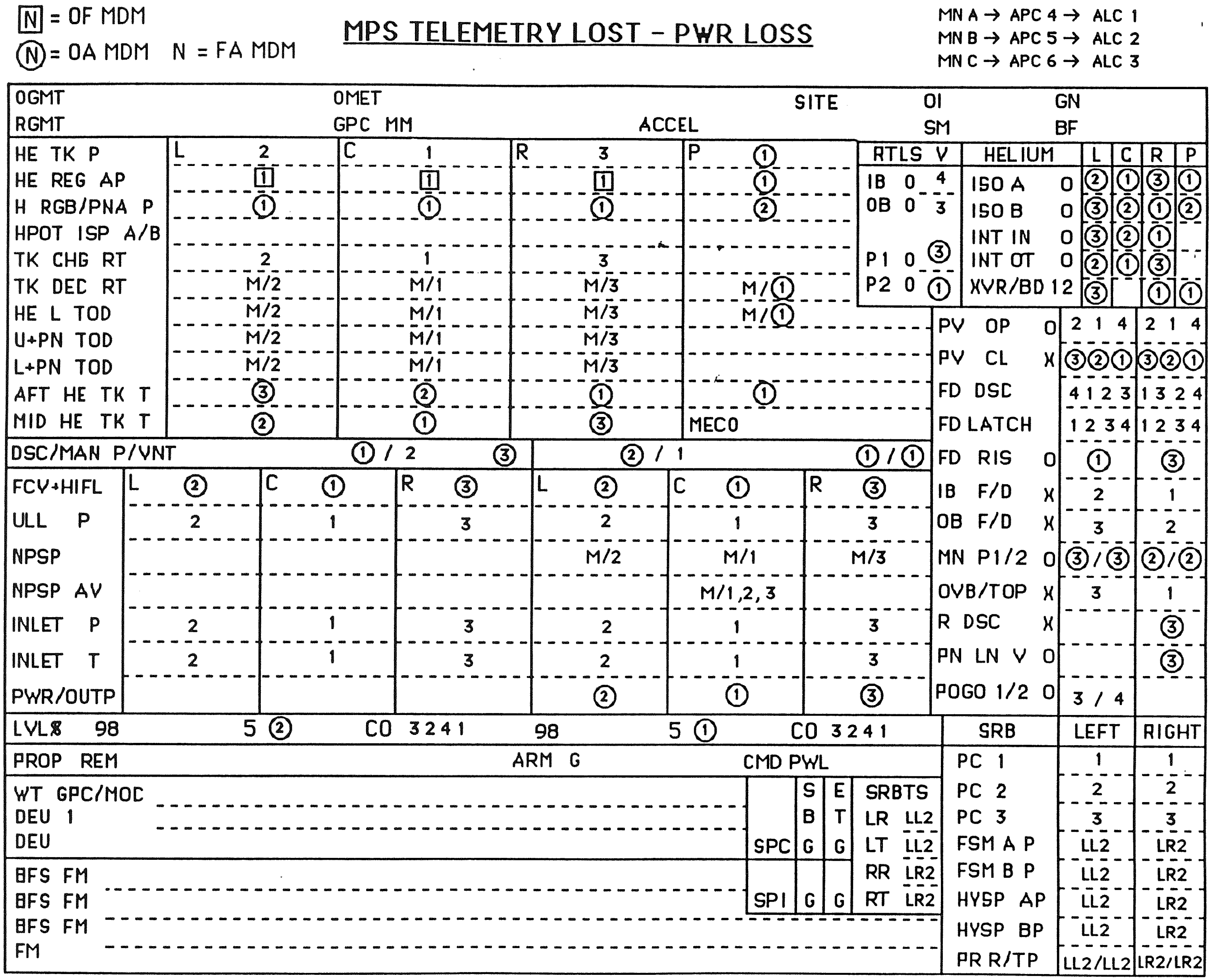
Time	Event	
***** DUMP SWITCH IN START BEFORE MM602 + 20 SEC *****		
MECO	He INCON IN L, C, R	OPEN*
	PNEU XOVER	OPEN
MECO + 10.4	RTLS DUMP VALVES	OPEN
MECO + 13.2	ET SEP	
MECO + 20.0	He INCON IN	CLOSED
MM602	He INON OUT L,C,R	OPEN
	LH2 I/B F/D VLVS	OPEN
	LH2 O/B F/D VLVS	OPEN
	LH2 TOPPING VLV	OPEN
	LH2 PREVALVES	OPEN
MM602 + 20 SEC	LH2 RTLS DUMP VLVS	CLOSED
	LH2 O/B F/D VLVS	CLOSED
	LO2 MANIFOLD REPRESS	OPEN
	LO2 MANIFOLD REPRESS	OPEN
GRV <= 4500 (FT/S)	He BLOWDOWN VLVS	OPEN
TOUCHDOWN		
GRV 4500 + 650 SEC	He BLOWDOWNS VLVS	CLOSED
	He OUT L,C,R	CLOSED
	He PNEU XOVER	CLOSED

RTLS V	Helium		L	C	R	P
IB 0	ISO A	0	0	0	0	0
OB 0	ISO B	0	0	0	0	0
	INT IN	0				
P1 0	INT OT	0	0	0	0	
P2 0	XVR/BD12	0	0		0	0

Q	LO_2	LH_2
PV OP O		0 0 0
PV CL X	X X X	
FD DSC	XX	XX
FD Latch	UU	UU
FD RIS O	0	0
IB F/D X	X	
OB F/D X	X	X
MN P1/20	0/0	0/0
OVB/TOPX		
R DSC X		X
P LN V O		
POGO1/20	0/0	

MNA ——— APC4 ——— ALC1
MNB ——— APC5 ——— ALC2
MNC ——— APC6 ——— ALC3

* OCCURS ONLY IF TANK PRESS < 2000 PSI
*** EFFECTIVE FOR RTLS CONTINGENCY
3 ENGINE OUT - YELLOW, ORANGE, GREEN
2 ENGINE OUT - ORANGE, GREEN



[N] = OF MDM
Ⓝ = OA MDM N = FA MDM

MPS TELEMETRY LOST - PWR LOSS

MN A → APC 4 → ALC 1
MN B → APC 5 → ALC 2
MN C → APC 6 → ALC 3

OGMT
RGMT
OMET
GPC MM
SITE
ACCEL
OI
SM
GN
BF

	L	C	R	P
HE TK P	2	1	3	①
HE REG AP	[1]	[1]	[1]	①
H RGB/PNA P	①	①	①	②
HPOT ISP A/B				
TK CHG RT	2	1	3	
TK DEC RT	M/2	M/1	M/3	M/①
HE L TOD	M/2	M/1	M/3	M/①
U+PN TOD	M/2	M/1	M/3	
L+PN TOD	M/2	M/1	M/3	
AFT HE TK T	③	②	①	①
MID HE TK T	②	①	③	MECO

RTLS		V
IB	0	4
OB	0	3
P1	0	③
P2	0	①

HELIUM		L	C	R	P
ISO A	0	②	①	③	①
ISO B	0	③	②	①	②
INT IN	0	③	②	①	
INT OT	0	②	①	③	
XVR/BD	12	③		①	①

DSC/MAN P/VNT	① / 2	③	② / 1	① / ①

	L	C	R	L	C	R
FCV+HIFL	②	①	③	②	①	③
ULL P	2	1	3	2	1	3
NPSP				M/2	M/1	M/3
NPSP AV					M/1,2,3	
INLET P	2	1	3	2	1	3
INLET T	2	1	3	2	1	3
PWR/OUTP				②	①	③

PV OP	O	2 1 4	2 1 4
PV CL	X	③②①	③②①
FD DSC		4 1 2 3	1 3 2 4
FD LATCH		1 2 3 4	1 2 3 4
FD RIS	O	①	③
IB F/D	X	2	1
OB F/D	X	3	2
MN P1/2	O	③/③	②/②
OVB/TOP	X	3	1
R DSC	X		③
PN LN V	O		③
POGO 1/2	O	3 / 4	

LVL% 98 5 ② CO 3241 98 5 ① CO 3241

PROP REM ARM G CMD PWL

WT GPC/MOC
DEU 1
DEU
BFS FM
BFS FM
BFS FM
FM

	S B	E T	SRBTS	
SPC	G	G	LR	LL2
			LT	LL2
			RR	LR2
SPI	G	G	RT	LR2

SRB	LEFT	RIGHT
PC 1	1	1
PC 2	2	2
PC 3	3	3
FSM A P	LL2	LR2
FSM B P	LL2	LR2
HYSP AP	LL2	LR2
HYSP BP	LL2	LR2
PR R/TP	LL2/LL2	LR2/LR2

Figure 5.2.7-XIII.- MPS telemetry lost cue card.

[N] = OF MDM
(N) = OA MDM   N = FA MDM

MPS TELEMETRY LOST - MDMs

[FA 1] [FA 2] [FA 3] [FA 4]

OGMT   OMET   SITE   OI   GN
RGMT   GPC MM   ACCEL   SM   BF

	L	C	R	P
HE TK P	2	1	3	①
HE REG AP	[1]	[1]	[1]	①
H RGB/PNA P	①	①	①	②
HPOT ISP A/B				
TK CHG RT	2	1	3	
TK DEC RT	M/2	M/1	M/3	M/①
HE L TOD	M/2	M/1	M/3	M/①
U+PN TOD	M/2	M/1	M/3	
L+PN TOD	M/2	M/1	M/3	
AFT HE TK T	③	②	①	①
MID HE TK T	②	①	③	MECO

RTLS	V
IB 0	4
OB 0	3
P1 0	③
P2 0	①

HELIUM		L	C	R	P
150 A	O	②	①	③	①
150 B	O	③	②	①	②
INT IN	O	③	②	①	
INT OT	O	②	①	③	
XVR/BD 12		③		①	①

DSC/MAN P/VNT	① / 2		③	② / 1		①/①
FCV+HIFL	L ②	C ①	R ③	L ②	C ①	R ③
ULL P	2	1	3	2	1	3
NPSP				M/2	M/1	M/3
NPSP AV					M/1,2,3	
INLET P	2	1	3	2	1	3
INLET T	2	1	3	2	1	3
PWR/OUTP				②	①	③

PV OP	O	2 1 4	2 1 4
PV CL	X	③②①	③②①
FD DSC		4 1 2 3	1 3 2 4
FD LATCH		1 2 3 4	1 2 3 4
FD RIS	O	①	③
IB F/D	X	2	1
OB F/D	X	3	2
MN P1/2	O	③/③	②/②
OVB/TOP	X	3	1
R DSC	X		③
PN LN V	O		③
POGO 1/2	O	3 / 4	

LVL% 98   5 ②   CO 3241   98   5 ①   CO 3241

PROP REM   ARM G   CMD PWL

WT GPC/MOC
DEU 1
DEU

BFS FM
BFS FM
BFS FM
FM

	S B	E T	SRBTS	
SPC	G	G	LR	LL2
			LT	LL2
			RR	LR2
SPI	G	G	RT	LR2

SRB	LEFT	RIGHT
PC 1	1	1
PC 2	2	2
PC 3	3	3
FSM A P	LL2	LR2
FSM B P	LL2	LR2
HYSP AP	LL2	LR2
HYSP BP	LL2	LR2
PR R/TP	LL2/LL2	LR2/LR2

Figure 5.2.7-XIV.- MPS telemetry lost for MDM failures.

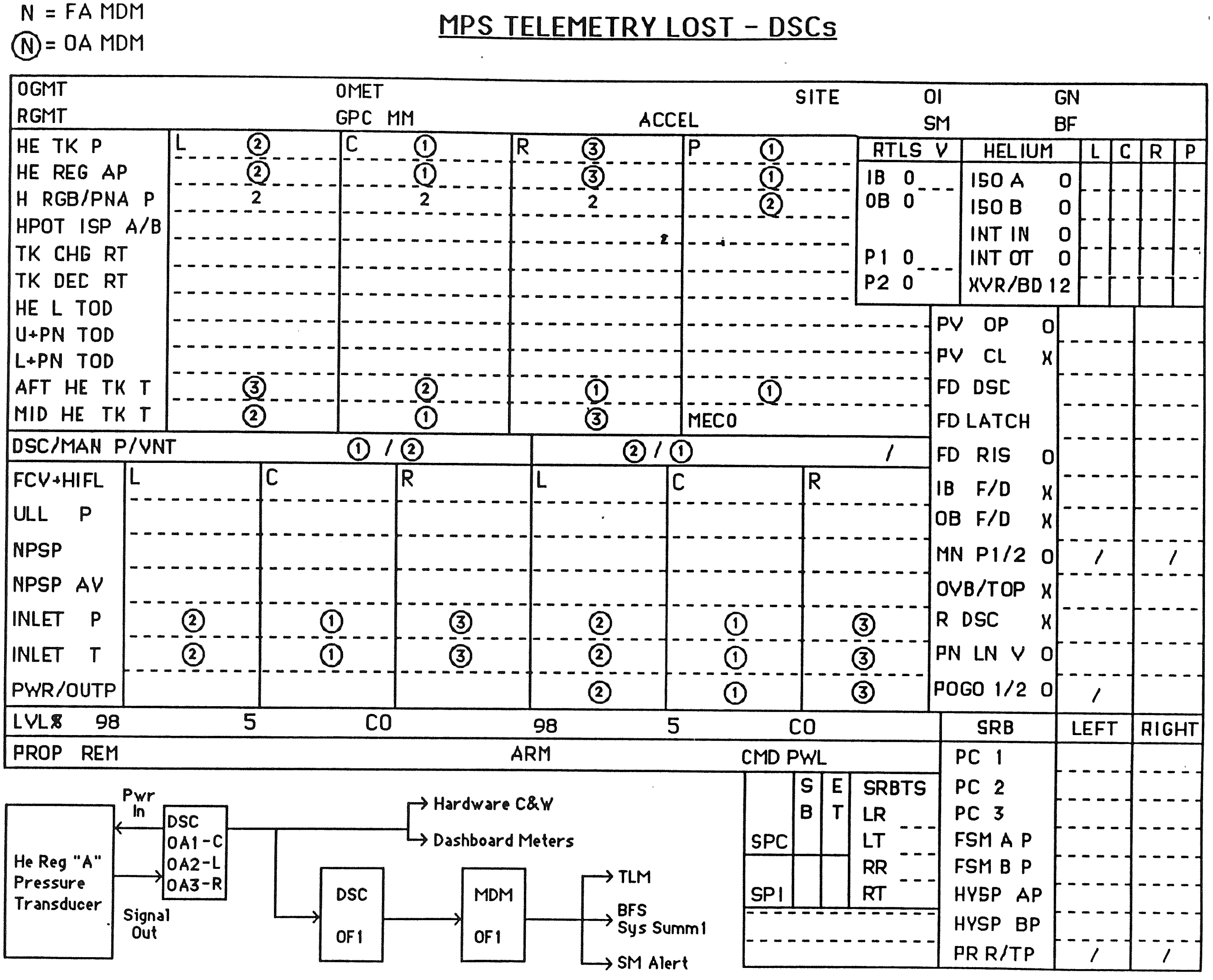


Figure 5.2.7-XV.- MPS DSC failure impacts cue card.

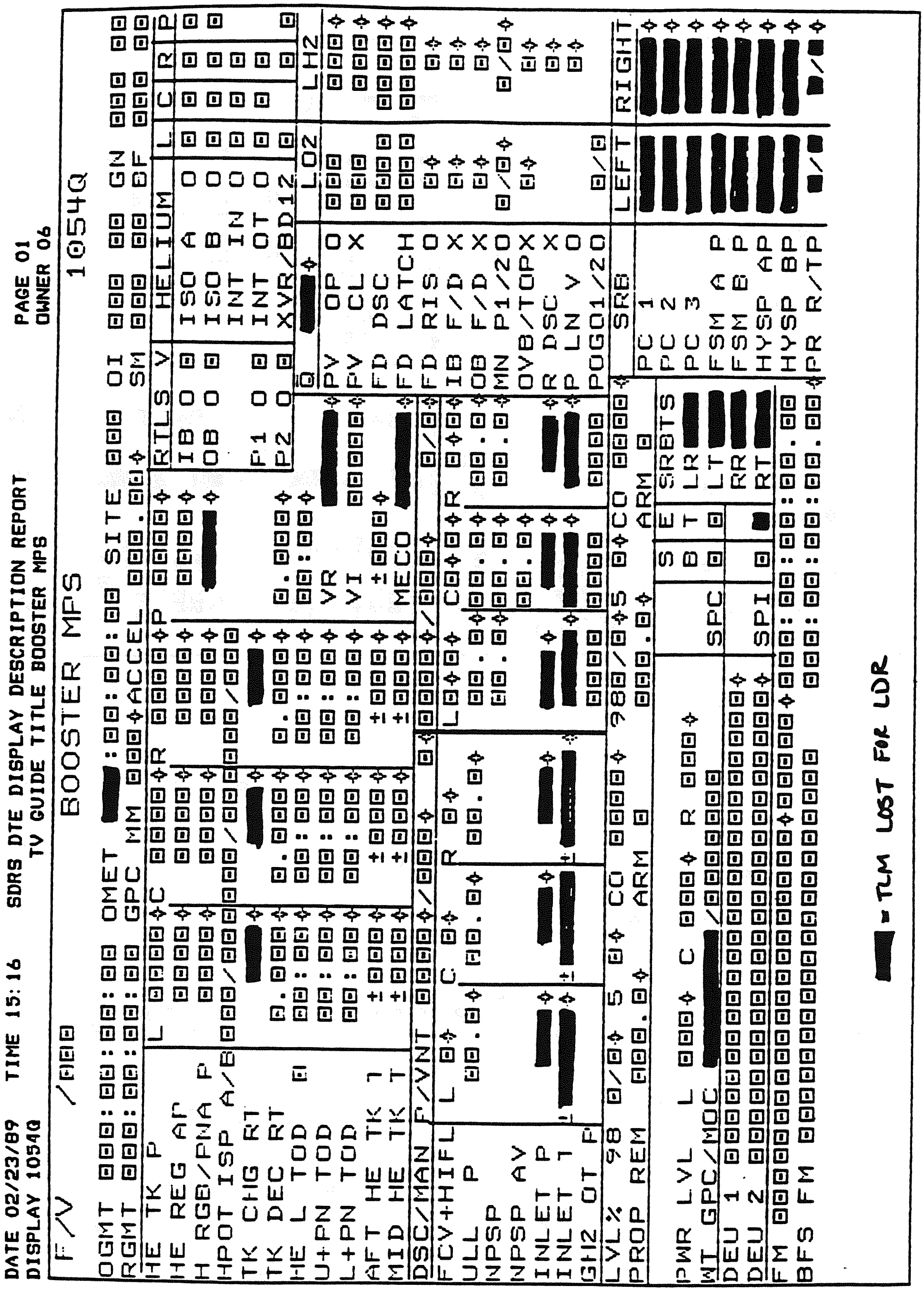
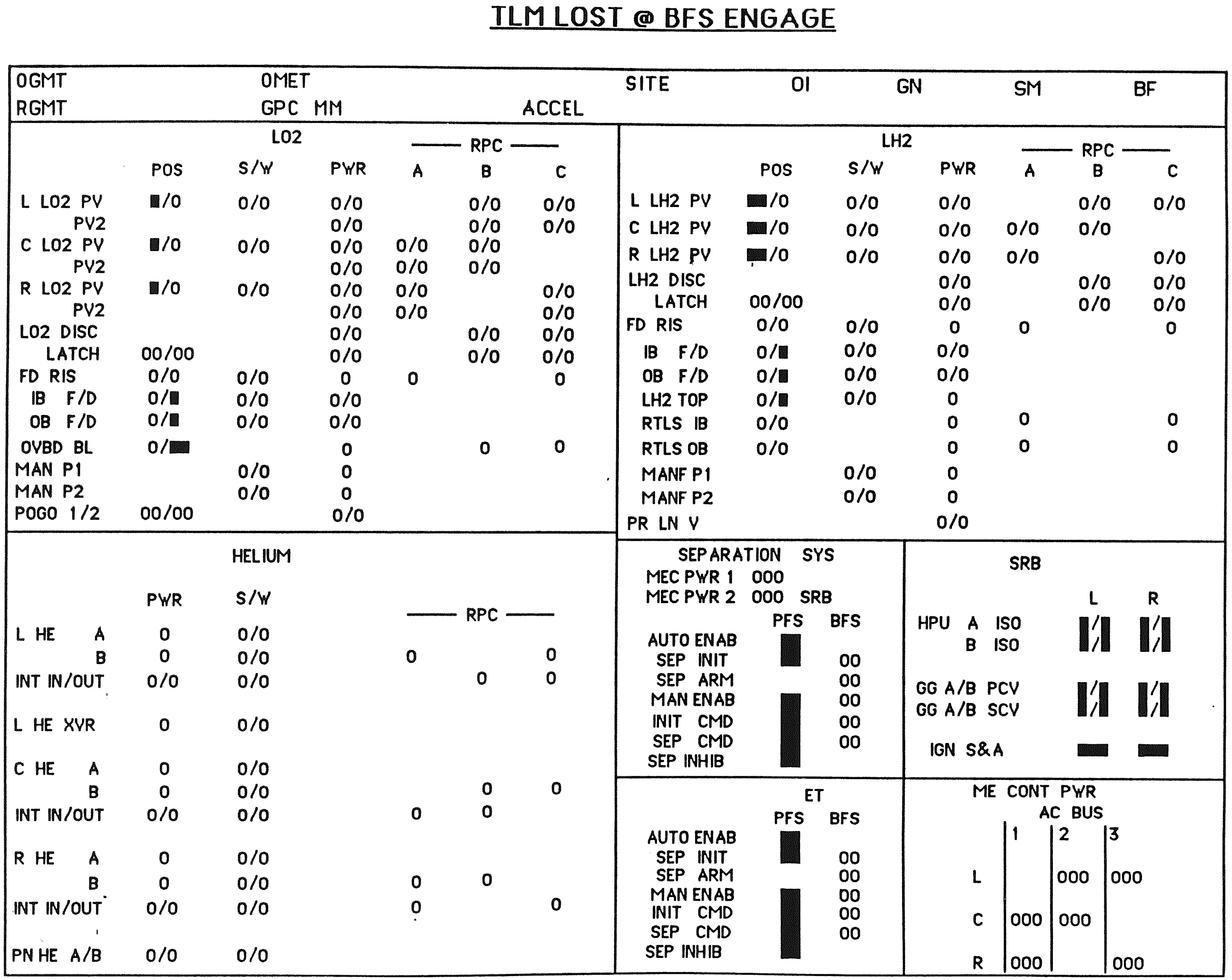


Figure 5.2.7-XVI.- MPS telemetry lost for LDR cue card.



TLM LOST @ BFS ENGAGE

OGMT OMET SITE OI GN SM BF
RGMT GPC MM ACCEL

LO2	POS	S/W	PWR	RPC A	RPC B	RPC C
L LO2 PV	■/0	0/0	0/0		0/0	0/0
PV2			0/0		0/0	0/0
C LO2 PV	■/0	0/0	0/0	0/0	0/0	
PV2			0/0	0/0	0/0	
R LO2 PV	■/0	0/0	0/0	0/0		0/0
PV2			0/0	0/0		0/0
LO2 DISC			0/0		0/0	0/0
LATCH	00/00		0/0		0/0	0/0
FD RIS	0/0	0/0	0	0		0
IB F/D	0/■	0/0	0/0			
OB F/D	0/■	0/0	0/0			
OVBD BL	0/■		0		0	0
MAN P1		0/0	0			
MAN P2		0/0	0			
POGO 1/2	00/00		0/0			

LH2	POS	S/W	PWR	RPC A	RPC B	RPC C
L LH2 PV	■/0	0/0	0/0		0/0	0/0
C LH2 PV	■/0	0/0	0/0	0/0	0/0	
R LH2 PV	■/0	0/0	0/0	0/0		0/0
LH2 DISC			0/0		0/0	0/0
LATCH	00/00		0/0		0/0	0/0
FD RIS	0/0	0/0	0	0		0
IB F/D	0/■	0/0	0/0			
OB F/D	0/■	0/0	0/0			
LH2 TOP	0/■	0/0	0			
RTLS IB	0/0		0	0		0
RTLS OB	0/0		0	0		0
MANF P1		0/0	0			
MANF P2		0/0	0			
PR LN V			0/0			

HELIUM	PWR	S/W	RPC A	RPC B	RPC C
L HE A	0	0/0			
B	0	0/0	0		0
INT IN/OUT	0/0	0/0		0	0
L HE XVR	0	0/0			
C HE A	0	0/0			
B	0	0/0		0	0
INT IN/OUT	0/0	0/0	0	0	
R HE A	0	0/0			
B	0	0/0	0	0	
INT IN/OUT	0/0	0/0	0		0
PN HE A/B	0/0	0/0			

SEPARATION SYS
MEC PWR 1 000
MEC PWR 2 000

SRB	PFS	BFS
AUTO ENAB	■	
SEP INIT		00
SEP ARM		00
MAN ENAB	■	00
INIT CMD		00
SEP CMD		00
SEP INHIB		

SRB	L	R
HPU A ISO	■/■	■/■
B ISO	■/■	■/■
GG A/B PCV	■/■	■/■
GG A/B SCV	■/■	■/■
IGN S&A	■	■

ET	PFS	BFS
AUTO ENAB	■	
SEP INIT		00
SEP ARM		00
MAN ENAB	■	00
INIT CMD		00
SEP CMD		00
SEP INHIB		

ME CONT PWR

AC BUS	1	2	3
L		000	000
C	000	000	
R	000		000

Figure 5.2.7-XVII.- MPS telemetry lost at BFS engage cue card.

$\boxed{N}$ = OF MDM
Ⓝ = OA MDM N = FA MDM

OGMT OMET SITE OI GN SM BF
RGMT GPC MM ACCEL

LO2	POS	S/W	PWR	RPC A	RPC B	RPC C
L LO2 PV	2/③	②/②	②/②		②/②	③/③
PV2			②/③		②/②	③/③
C LO2 PV	1/②	①/①	①/①	①/①	②/②	
PV2			①/②	①/①	②/②	
R LO2 PV	4/①	③/③	③/③	①/①		③/③
PV2			③/①	①/①		③/③
LO2 DISC			②/②		②/②	③/③
LATCH	12/34		③/②		②/②	③/③
FD RIS	①/①	③/①	③	①		③
IB F/D	②/ 2	②/②	②/②			
OB F/D	③/ 3	③/③	③/③			
OVBD BL	②/32		③		②	③
MAN P1		③/③	③			
MAN P2		③/③	③			
POGO 1/2	3 ①/4②		①/②			

LH2	POS	S/W	PWR	RPC A	RPC B	RPC C
L LH2 PV	24/③	②/②	②/②		②/②	③/③
C LH2 PV	13/②	①/①	①/①	①/①	②/②	
R LH2 PV	43/①	③/③	③/③	①/①		③/③
LH2 DISC			②/②		②/②	③/③
LATCH	12/34		③/②		②/②	③/③
FD RIS	③/③	③/①	③	①		③
IB F/D	①/ 1	①/①	①/①			
OB F/D	②/ 2	②/②	②/②			
LH2 TOP	①/ 1	①/①	①			
RTLS IB	①/ 4		③	①		③
RTLS OB	①/ 3		③	①		③
MANF P1		②/②	②			
MANF P2		②/②	②			
PR LN V			③/③			

HELIUM	PWR	S/W	RPC A	RPC B	RPC C
L HE A	②	②/②			
B	③	③/③	①		③
INT IN/OUT	③/②	③/②		②	③
L HE XVR	③	③/③			
C HE A	①	①/①			
B	②	②/②		②	③
INT IN/OUT	②/①	②/①	①	②	
R HE A	③	③/③			
B	①	①/①	①	②	
INT IN/OUT	①/③	①/③	①		③
PN HE A/B	①/②	①/②			

SEPARATION SYS
MEC PWR 1 ①
MEC PWR 2 ②

SRB	PFS	BFS
AUTO ENAB	00	
SEP INIT	00	00
SEP ARM		00
MAN ENAB	00	00
INIT CMD	00	00
SEP CMD	00	00
SEP INHIB	00	

ET	PFS	BFS
AUTO ENAB	00	
SEP INIT	00	00
SEP ARM		00
MAN ENAB	00	00
INIT CMD	00	00
SEP CMD	00	00
SEP INHIB	00	

SRB	L	R
HPU A ISO	0/0	0/0
B ISO	0/0	0/0
GG A/B PCV	0/0	0/0
GG A/B SCV	0/0	0/0
IGN S&A	000	000

ME CONT PWR

AC BUS	1	2	3
L		$\boxed{3}$	$\boxed{1}$
C	$\boxed{1}$	$\boxed{2}$	
R	$\boxed{3}$		$\boxed{2}$

Figure 5.2.7-XVIII.- MPS telemetry lost - MDM's (1055).

$\boxed{N}$ = OF MDM
Ⓝ = OA MDM N = FA MDM

OGMT	OMET		SITE	OI	GN	SM	BF
RGMT	GPC MM	ACCEL				

LO2	POS	S/W	PWR	RPC A	RPC B	RPC C
L LO2 PV	2/③	②/②	②/②		②/②	③/③
PV2			②/③		②/②	③/③
C LO2 PV	1/②	①/①	①/①	①/①	②/②	
PV2			①/②	①/①	②/②	
R LO2 PV	4/①	③/③	③/③	①/①		③/③
PV2			③/①	①/①		③/③
LO2 DISC	41/23		②/②		②/②	③/③
FD RIS	①/①	③/①	③	①		③
IB F/D	②/2	②/②	②/②			
OB F/D	③/3	③/③	③/③			
OVBD BL	②/32		③		②	③
MAN P1		③/③	③			
MAN P2		③/③	③			

HELIUM	S/W	PWR	RPC A	RPC B	RPC C
L HE A	②/②	②			
B	③/③	③	①		③
INT IN/OUT	③/②	③/②		②	③
L HE XVR	③/③	③			
C HE A	①/①	①			
B	②/②	②		②	③
INT IN/OUT	②/①	②/①	①	②	
R HE A	③/③	③			
B	①/①	①	①	②	
INT IN/OUT	①/③	①/③	①		③
PN HE A/B	①/②	①/②			
BD 1		①			
BD 2		①			

LH2	POS	S/W	PWR	RPC A	RPC B	RPC C
L LH2 PV	24/③	②/②	②/②		②/②	③/③
C LH2 PV	13/②	①/①	①/①	①/①	②/②	
R LH2 PV	43/①	③/③	③/③	①/①		③/③
LH2 DISC	13/24		②/②		②/②	③/③
FD RIS	③/③	③/①	③	①		③
IB F/D	①/1	①/①	①/①			
OB F/D	②/2	②/②	②/②			
LH2 TOP	①/1	①/①	①			
RTLS IB	①/4		③	①		③
RTLS OB	①/3		③	①		③
MANF P1		②/②	②			
MANF P2						
R DSC	③					
PR LN V	③					
RTLS V P1	③					
RTLS V P2	①					

	L	C	R	P
HE TK P	2	1	3	①
HE REG AP	$\boxed{1}$	$\boxed{1}$	$\boxed{1}$	①
H RGB/PNA P	①	①	①	②
TK DEC RT	M/2	M/1	M/3	M/①
AFT HE TK T	③	②	①	①
MID HE TK T	②	①	③	
LH2 INLET/MAN	2	1	3	1
LO2 INLET/MAN	2	1	3	2

VENT DOORS LEFT 1 0/0 RIGHT 1 0/0
2 0/0 2 0/0

VR 00000 Q 000 ALARM 0

Figure 5.2.7-XIX.- MPS telemetry lost - MDM's (1057).

ITEM	6-08-89 MAX OPERATING	PROOF	BURST
*** MPS FLOW LINES ***			
LH2 FEEDLINES (TYPE 1 AND 5)	55 PSIG	66 PSIG	83 PSIG
LO2 FEEDLINES (TYPE 1 AND 5)	260 PSIG	312 PSIG	390 PSIG
LH2 RECIRC LINE	55 PSIG	83 PSIG	110 PSIG
LH2 F/D LINE	105 PSIG	126 PSIG	158 PSIG
LO2 F/D LINE	275 PSIG	330 PSIG	413 PSIG
*** REGULATORS ***			
MPS HELIUM REG	715 PSIA TO 770 PSIA (0.8 LB/SEC MAX FLOW) WITH -0005 REGS	1550 PSIG (AT OUTLET)	3400 PSIG (AT OUTLET)
MANIFOLD REPRESS REGS (LH2 OR LO2)	20-25 PSIG (0.33 LB/SEC MAX HE FLOW)		

*** RELIEF VALVES ***		
LO2 FEEDLINE RELIEF ISO VALVE	CRACKS AT 190-220 PSIG MAX FLOW = 24 LBS/SEC LO2	
LH2 FEEDLINE RELIEF ISO VALVE	CRACKS AT 40-55 PSIG MAX FLOW = 2.4 LBS/SEC LH2	
ET TANK RELIEF VENT VALVES	CRACK	RESEAT
o LO2 ----	24.0 PSIG --	22 PSIG
o LH2 ----	36.0 PSIG --	34 PSIG
MPS HELIUM RELIEF VALVES	CRACKS AT 790 PSIG / FULL OPEN AT 850 RESEAT AT 785 PSIG MIN MAX FLOW = 1.0 LBS/SEC NOTE : IF REG FAILS OPEN AND RELIEF FAILS CLOSED HPOT ISP WILL RISE ABOVE NOMINAL BAND	
PREVALVE BACKFLOW RELIEF SETTINGS (LO2 AND LH2)	15 - 50 DELTA PSI	
FILL AND DRAIN BACKFLOW RELIEF (LO2 AND LH2)	15 - 70 DELTA PSI	

Figure 5.2.7-XX.- MPS hardware limits.

FLOW CONTROL VALVES

STS-30 LIMIT BANDS	LH2 ULL PRESSURE (AFTER T-0)	LH2 MASS LOST WITH FCV FAIL AT T-0	LO2 ULL PRESSURE (AFTER SRB SEP)	LO2 MASS LOST WITH FCV FAIL AT T-0
NOMINAL BAND	32-34	0	20-22	0
1 FCV FAILED OPEN	32-34	0	20-23	0
1 FCV FAILED CLOSED	32-34	0	19-21	0
2 FCV FAILED OPEN	34-36	341 LB	20-24	107 LB
2 FCV FAILED CLOSED	(29 AND DROPPING AT SRB SEP)	0	16-20	0
3 FCV FAILED OPEN	34-36	814 LB	23-25	444 LB
3 FCV FAILED CLOSED	(15 AND DROPPING AT SRB SEP)	0	14-16 (4 PSI AT T-0 + 30 SEC)	0

Figure 5.2.7-XX.- Continued.

OGMT OMET SITE OI GN
RGMT GPC MM ACCEL SM BF

	L	C	R	P
HE TK P	4100 - 4500	4100 - 4500	4100 - 4500	TYP to T-13s
HE REG AP	730 - 785	730 - 785	730 - 785	715 - 785
H RGB/PNA P	730 - 785	730 - 785	730 - 785	(1 of 2) to T-13s
HPOT ISP A/B	to T-13 sec			For Pneu
TK CHG RT				Reg & Accum
TK DEC RT				
HE L TOD				
U+PN TOD				
L+PN TOD				
AFT HE TK T	-5—65 °F	-5—65 °F	-5—65 °F	(1 of 3) -T-6 min - T - 5min
MID HE TK T	45—135 °F	45—135 °F	45—135 °F	MECO

RTLS V		
IB	0	
OB	0	
P1	0	Ⓜ
P2	0	Ⓜ

HELIUM		L	C	R	P
ISO A	O	Ⓜ	Ⓜ	Ⓜ	②
ISO B	O	Ⓜ	Ⓜ	Ⓜ	②
INT IN	O	Ⓜ	Ⓜ	Ⓜ	
INT OT	O	Ⓜ	Ⓜ	Ⓜ	
XVR/BD 12		Ⓜ		①	①

DSC/MAN P/VNT		/		/		/
FCV+HIFL	L ✓ off —— ✓ on (3 of 3)	C → to T-9m Prpr to RSLS	R S/W out T-:75-T-:10	L ✓ off —— ✓ on (3 of 3)	C → to T-9m Prpr to RSLS	R S/W out T-:75-T-:10
ULL P	17.3 - 20.5	17.3 - 20.5	Verify btwn	40.9 - 44.1	40.9 - 44.1	Verify btwn
NPSP	(3 of 3) Mand		T-133 sec	(3 of 3) Mand		T-75 sec
NPSP AV			& T-10 sec			& T-10 sec
INLET P						
INLET T	-287.7 MAX -289.2 MIN	T-34:55 - T-4:55 T-4:55 - T-:31				
PWR/OUTP		(T-75 sec)	All 4 Wet		(T-75 sec)	All 4 Wet
LVL%	98	5	CO ←	98	5	CO ←

PV OP	O	T-75sec	
PV CL	X	LH2 Recirc	2 of 3 & T-:75
FD DSC		1 of 2 T-75sec	1 of 2 T-75sec
FD LATCH		1 of 2 T-75sec	1 of 2 T-75sec
FD RIS	O	T-75sec	T-75sec
IB F/D	X	PWR-T-9m to RSLS	PWR T-75sec
OB F/D	X	PWR-T-9m &@	to T-:48 T-:34
MN P1/2	O	①/①	①/①
OVB/TOP	X		→
R DSC	X	← T-9m &@	to T-1:57 T-75sec
PN LN V	O		
POGO 1/2	O	/	

SRB	LEFT	RIGHT
PC 1	-7 - 33	RGA ↑
PC 2		to RSLS
PC 3		
FSM A P	350-425	to T-:31
FSM B P	> 300	T-:31-:10
HYSP AP	2800	- 3363
HYSP BP	Hyd up	to T-:10
PR R/TP	/	/

PROP REM ARM CMD PWL

		S	E	
WT GPC/MOC		B	T	SRBTS
DEU 1				LR >66.2
DEU	SPC			LT <77.8
				RR to
	SPI			RT IGN

BFS FM ① 1 of 2 Mand. for Confirm. Intr. (T-75 sec)
BFS FM ② 2 of 3 Mand. for & incl. Pneu Accum
BFS FM Ⓜ Manditory all 'OFF', except He Isols (T-75 sec)
FM

10 - 85 K to
MDM Lockout

Figure 5.2.7-XXI.- MPS "LCC".

TIME	EVENT	VLV POS.
T - 6.60	ENG #3 START COMMAND	
T - 6.48	ENG #2 START COMMAND	
T - 6.36	ENG #1 START COMMAND	——>
*** CENTER ENGINE OUT	***********************	
ENG #1 OUT	ENG #1 He INC OUT LH2 RECIRC DISC	OPEN CLOSED
*** LEFT ENGINE OUT	***********************	
ENG OUT + 1.158	ENG #2 He INC IN ENG #2 He XOVER	OPEN OPEN
ENG OUT + 1.3	TERMINATE PREPRESS	
*** RIGHT ENGINE OUT	***********************	
ENG OUT + 2.4	ENG #3 He INC OUT	OPEN
ENG OUT + 4.5	ENG #1 LO2 PREVALVES	CLOSED
ENG OUT + 5.6	ENG #2 LO2 PREVALVES	CLOSED
ENG OUT + 5.9	ENG #1 LH2 PREVALVES	CLOSED
ENG OUT + 6.9	ENG #3 LO2 PREVALVES	CLOSED
ENG OUT + 7.0	ENG #2 LH2 PREVALVES	CLOSED
ENG OUT + 8.3	ENG #3 LH2 PREVALVES	CLOSED
ENG OUT + 15.9	LO2 OVERBOARD BLEED	OPEN
ENG OUT + 16.0	ENG #1 BLEED VALVE	OPEN
ENG OUT + 17.1	ENG #2 BLEED VALVE	OPEN
ENG OUT + 18.4	ENG #3 BLEED VALVE	OPEN
ENG OUT + 30.0	POGO RECIRC VLVS NO LATER THAN 30 SEC. AFTER ENG OUT IF OVB CAN'T BE OPENED	CLOSED

RTLS V	HELIUM	L	C	R	P
IB O	ISO A O	O	O	O	O
OB O	ISO B O	O	O	O	O
	INT IN O				
P1 O	INT OT O				
P2 O	XVR/BD12 O				

Q	LO2	LH2
PV OP O	O O O	O O O
PV CL X		
FD DSC	O	O
FD LATCH		
FD RIS O		
IB F/D X	X	X
OB F/D X	X	X
MN P1/2O	/	/
OVB/TOPX	X	X
R DSC X		X
P LN V O		
POGO1/2O	O/O	

MNA ———> APC4 ———> ALC1
MNB ———> APC5 ———> ALC2
MNC ———> APC6 ———> ALC3

NOTE: REMEMBER				
	THE ENGINES START	RIGHT	LEFT	CENTER
	THE ENGINES SHUTDOWN	CENTER	LEFT	RIGHT

Figure 5.2.7-XXII.- Pad abort (NON-SSME FAILURE).

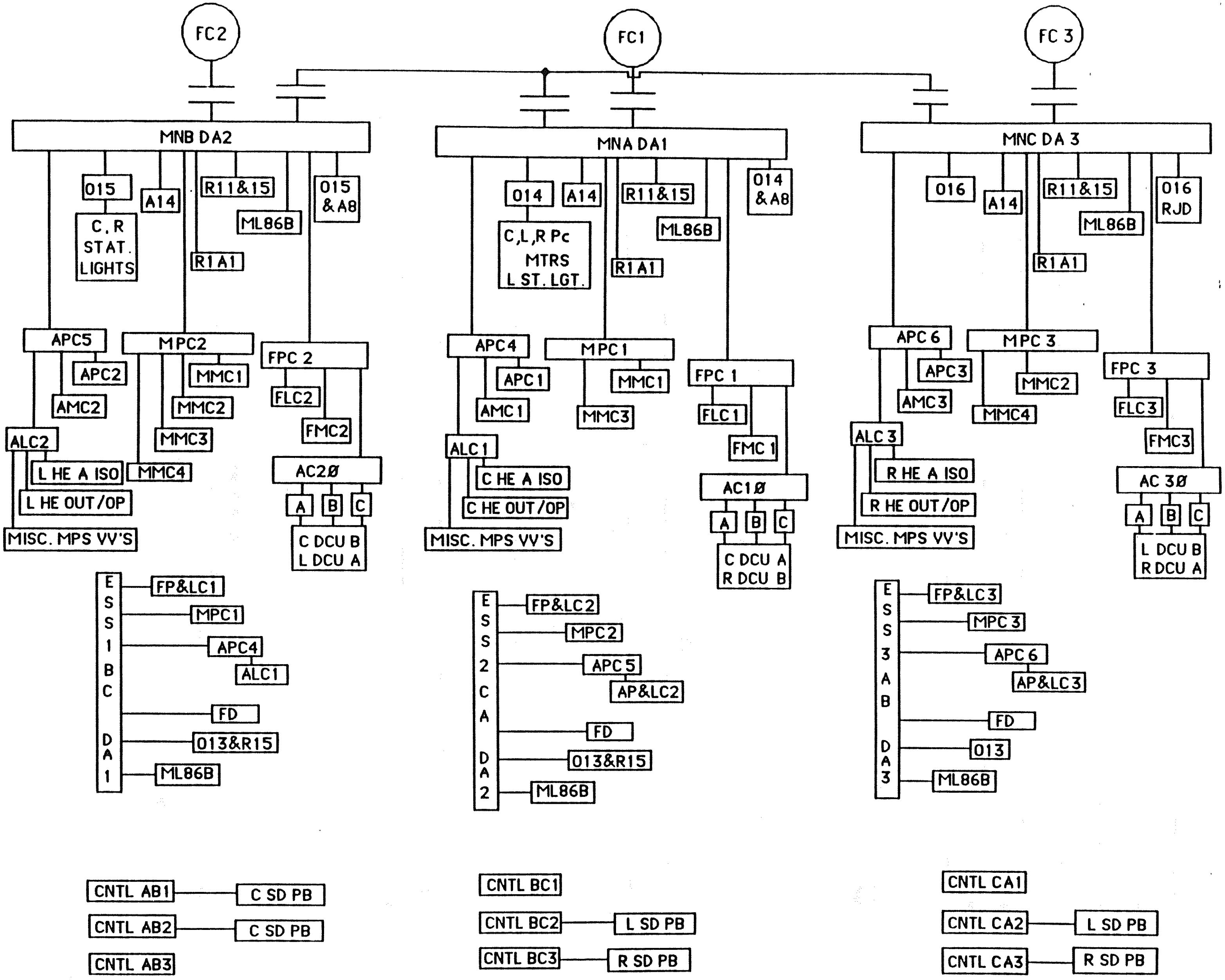


Figure 5.2.7-XXIII.- Main bus schematic.

SSME Shutdown/Lockup Failure Matrix (Block I)

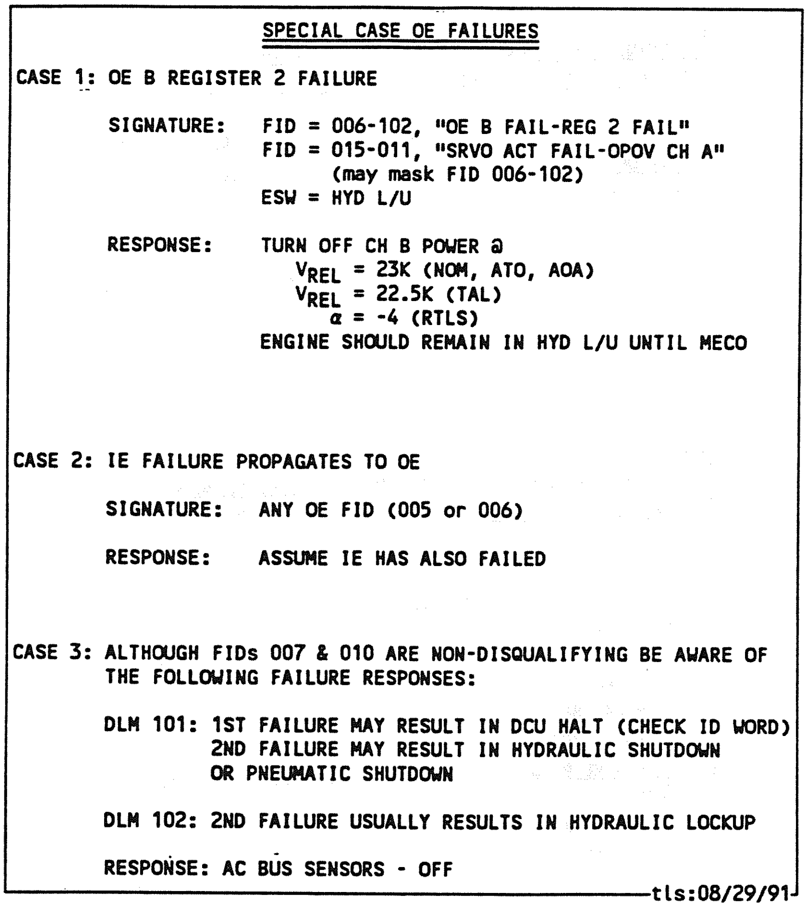
	CHANNEL B								
CHANNEL A	DCU/ CIE B	IE B	OE B	PSE B	MOVB	MFVB	CCVB	FPOVB	OPOVB
DCU/CIE A	X			X					
IE A	X**	X	X*	X	HL*	HL*	HL*	HL*	HL*
OE A		X*	X	X	HL	HL	HL	HL	HL
PSE A	X	X	X	X	HL	HL	HL	HL	HL
MOVA		HL*	HL	HL	HL	HL	HL	HL	HL
MFVA		HL*	HL	HL	HL	HL	HL	HL	HL
CCVA		HL*	HL	HL	HL	HL	HL	HL	HL
FPOVA		HL*	HL	HL	HL	HL	HL	HL	HL
OPOVA		HL*	HL	HL	HL	HL	HL	HL	HL

SSME Shutdown/Lockup Failure Matrix (Block II)

	CHANNEL B								
CHANNEL A	DCU/ CIE B	IE B	OE B	PSE B	MOVB	MFVB	CCVB	FPOVB	OPOVB
DCU/CIE A	X	X***	X	X	HL	HL	HL	HL	HL
IE A	X***	X	X	X	HL	HL	HL	HL	HL
OE A		X	X	X	HL	HL	HL	HL	HL
PSE A	X	X	X	X	HL	HL	HL	HL	HL
MOVA		HL	HL	HL	HL	HL	HL	HL	HL
MFVA		HL	HL	HL	HL	HL	HL	HL	HL
CCVA		HL	HL	HL	HL	HL	HL	HL	HL
FPOVA		HL	HL	HL	HL	HL	HL	HL	HL
OPOVA		HL	HL	HL	HL	HL	HL	HL	HL

X = SHUTDOWN DUE TO LOSS OF CONTROLLER REDUNDANCY
X* = SHUTDOWN DUE TO LOSS OF CONTROLLER REDUNDANCY IF IE FAILURE PROPAGATES TO OE
X** = SHUTDOWN DUE TO LOSS OF CONTROLLER REDUNDANCY IF IE A FAILURE ALSO DISQUALIFIED DCU A
X*** = SHUTDOWN DUE TO LOSS OF CONTROLLER REDUNDANCY IF IE A OR IE B FAILURE ALSO DISQUALIFIED IN-CHARGE DCU
HL = HYDRAULIC LOCKUP
HL* = HYDRAULIC LOCKUP IF IE FAILURE PROPAGATES TO OE
▨ = CHANGE FROM BLOCK I TO BLOCK II

Figure 5.2.7-XXIV.- Block I vs. Block II RM schemes.



SPECIAL CASE OE FAILURES

CASE 1: OE B REGISTER 2 FAILURE

SIGNATURE: FID = 006-102, "OE B FAIL-REG 2 FAIL"
FID = 015-011, "SRVO ACT FAIL-OPOV CH A"
(may mask FID 006-102)
ESW = HYD L/U

RESPONSE: TURN OFF CH B POWER @
V_{REL} = 23K (NOM, ATO, AOA)
V_{REL} = 22.5K (TAL)
α = -4 (RTLS)
ENGINE SHOULD REMAIN IN HYD L/U UNTIL MECO

CASE 2: IE FAILURE PROPAGATES TO OE

SIGNATURE: ANY OE FID (005 or 006)

RESPONSE: ASSUME IE HAS ALSO FAILED

CASE 3: ALTHOUGH FIDs 007 & 010 ARE NON-DISQUALIFYING BE AWARE OF THE FOLLOWING FAILURE RESPONSES:

DLM 101: 1ST FAILURE MAY RESULT IN DCU HALT (CHECK ID WORD)
2ND FAILURE MAY RESULT IN HYDRAULIC SHUTDOWN OR PNEUMATIC SHUTDOWN

DLM 102: 2ND FAILURE USUALLY RESULTS IN HYDRAULIC LOCKUP

RESPONSE: AC BUS SENSORS - OFF

tls:08/29/91

Figure 5.2.7-XXV.- Special case OE failures.

ENGINE STATUS WORD: BITS 1-8 4/19/88, REV. X

ESW BITS 1-8	INHIBIT LIMITS				ENABLE LIMITS			
	NO CHG	BCH	PH	ACC	NO CHG	BCH	PH	ACC
CHAN OK	00	20	40	60	01	21	41	61
ERROR CH. 1	04	24	44	64	05	25	45	65
2	08	28	48	68	09	29	49	69
3	10	30	50	70	11	31	51	71
1 & 2	0C	2C	4C	6C	0D	2D	4D	6D
1 & 3	14	34	54	74	15	35	55	75
2 & 3	18	38	58	78	19	39	59	79
1, 2 & 3	1C	3C	5C	7C	1D	3D	5D	7D

ENGINE STATUS WORD: BITS 9-16 4/19/88, REV. X

PHASE / MODE	OK	MCF	ELE
CHECKOUT			
STANDBY	25	26	note 1
COMPONENT CHECKOUT	31	32	note 1
START PREP			
PURGE SEQUENCE 1	45	46	note 1
PURGE SEQUENCE 2	49	4A	note 1
PURGE SEQUENCE 3	4D	4E	note 1
PURGE SEQUENCE 4	51	52	note 1
ENGINE READY	59	note 2	note 1
START			
START INITIATION	65	66	67
THRUST BUILDUP	69	6A	6B
ELECTRICAL LOCKUP	note 3	6E	6F
HYDRAULIC LOCKUP	note 3	72	73
FIXED DENSITY	note 3	76	77
MAINSTAGE			
NORMAL	85	86	87
THRUST LIMITING	note 3	8A	8B
ELECTRICAL LOCKUP	note 3	8E	8F
HYDRAULIC LOCKUP	note 3	92	93
FIXED DENSITY	note 3	96	97
SHUTDOWN			
THROTTLING TO MPL (65%)	A5	A6	A7
THROTTLING TO ZERO THRUST	A9	AA	AB
PROPELLANT VALVES CLOSED	AD	AE	AF
F/S PNEUMATIC S/D	note 3	B2	B3
POST SHUTDOWN			
STANDBY	C5	C6	C7
OXIDIZER DUMP	C9	CA	CB
TERMINATE SEQUENCE	DD	DE	DF

NOTES:

1. Limit shutdown monitoring not performed in this phase.
2. No MCF in ENGINE READY mode since an MCF during this time will cause the controller to revert to PSN4
3. Engine is not OK in this mode.

Figure 5.2.7-XXVI.- Engine status word.

TITLE

BSE CONSOLE LOCATION/CONFIGURATION

PURPOSE

The purpose of this SCP is to give the Booster console location and show the console configuration.

DESCRIPTION

The Booster consoles are the consoles numbered 304 and 404 in the second and third floor FCR's, respectively. Figure 5.3.1-I shows the Booster console configuration and identifies each module on the console. Each event light module has an assigned format number. The event light format number corresponding to each panel location for each flight phase is listed in table 5.3.1-I. The ascent formats should be verified prior to flight by comparing the ascent column in table 5.3.1-I to MSK 0071, the Digital Display Driver (DDD) guide display, for console 304 or MSK 0082, another page of the DDD guide, for console 404. The on-orbit/entry configuration is manually configured by the BSE after the first vacuum inerting.

REFERENCES

DF65 Data Pack

TABLE 5.3.1-I.- EVENT LIGHT FORMATS VERSUS PANEL LOCATION

Panel number	Flight phase	
	Ascent	On-orbit/entry
01	301	-
02	302	-
03	282	-
04	281	291
05	283	292
06	290	290
07	293	-
08	-	-
10	298	-
11	299	-
12	284	-
13	285	-

TITLE

BSE CONSOLE DRK OPERATIONS

PURPOSE

This SCP describes the Booster console display request keyboard (DRK) operations and the digital television equipment (DTE) displays assigned to each of the three booster DRK fields.

DESCRIPTION

The DRK is used exclusively to select and assign predesignated DTE displays to specific television monitors. Although the DRK does not have as much flexibility as the manual select keyboard (MSK), it is a faster method of selecting displays. The configurations described in this SCP are valid for Booster consoles 304 (FCR 1) and 404 (FCR 2).

PROCEDURES

There are three different fields on the booster DRK. The fields are labeled booster displays, booster universal plots, and general displays. The DTE displays assigned to each field are shown in figures 5.3.2-I, 5.3.2-II, and 5.3.2-III. These configurations are applicable for flight STS-43 and subsequent flights.

The procedure to select a display is as follows:

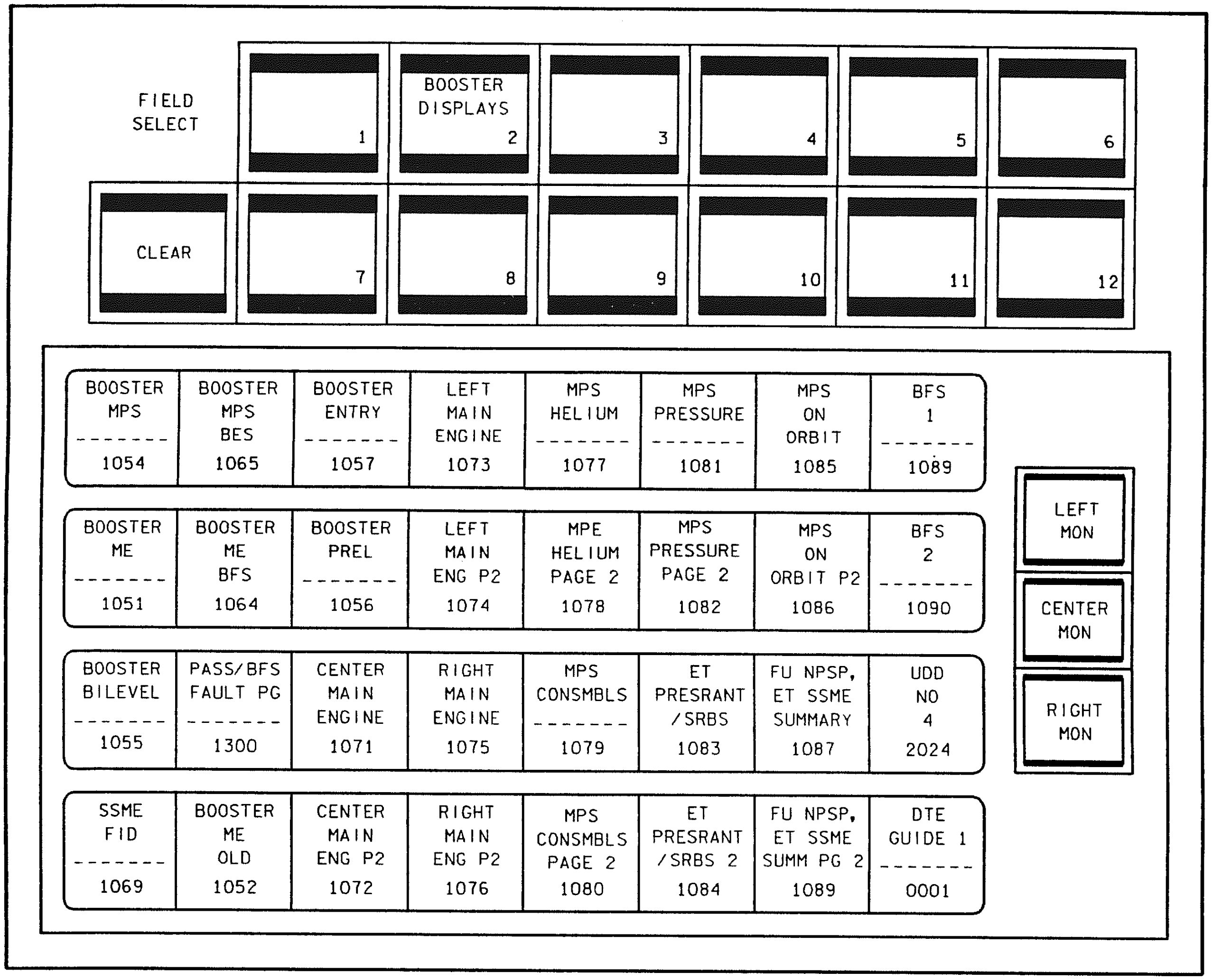
- Depress or verify the desired field-select PBI
- Depress the desired display request key
- Depress LEFT, CENTER, or RIGHT MON enter PBI

Note: The data type (SIM, RT, or PB) and the flight number selected on the MSK when the flight select mode was last executed will be the data source for the next displays selected with the DRK.

REFERENCES

1. DF65 Data Pack

2. The Display Request Keyboard (DRK) Workbook (UT DRK 2102), May 1, 1979.



BOOSTER MPS ------- 1054	BOOSTER MPS BES 1065	BOOSTER ENTRY ------- 1057	LEFT MAIN ENGINE 1073	MPS HELIUM ------- 1077	MPS PRESSURE ------- 1081	MPS ON ORBIT 1085	BFS 1 ------- 1089
BOOSTER ME ------- 1051	BOOSTER ME BFS 1064	BOOSTER PREL ------- 1056	LEFT MAIN ENG P2 1074	MPE HELIUM PAGE 2 1078	MPS PRESSURE PAGE 2 1082	MPS ON ORBIT P2 1086	BFS 2 ------- 1090
BOOSTER BILEVEL ------- 1055	PASS/BFS FAULT PG ------- 1300	CENTER MAIN ENGINE 1071	RIGHT MAIN ENGINE 1075	MPS CONSMBLS ------- 1079	ET PRESRANT /SRBS 1083	FU NPSP, ET SSME SUMMARY 1087	UDD NO 4 2024
SSME FID ------- 1069	BOOSTER ME OLD 1052	CENTER MAIN ENG P2 1072	RIGHT MAIN ENG P2 1076	MPS CONSMBLS PAGE 2 1080	ET PRESRANT /SRBS 2 1084	FU NPSP, ET SSME SUMM PG 2 1089	DTE GUIDE 1 ------- 0001

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Figure 5.3.2-I.- Booster displays, (Ascent/Entry), DRK field.

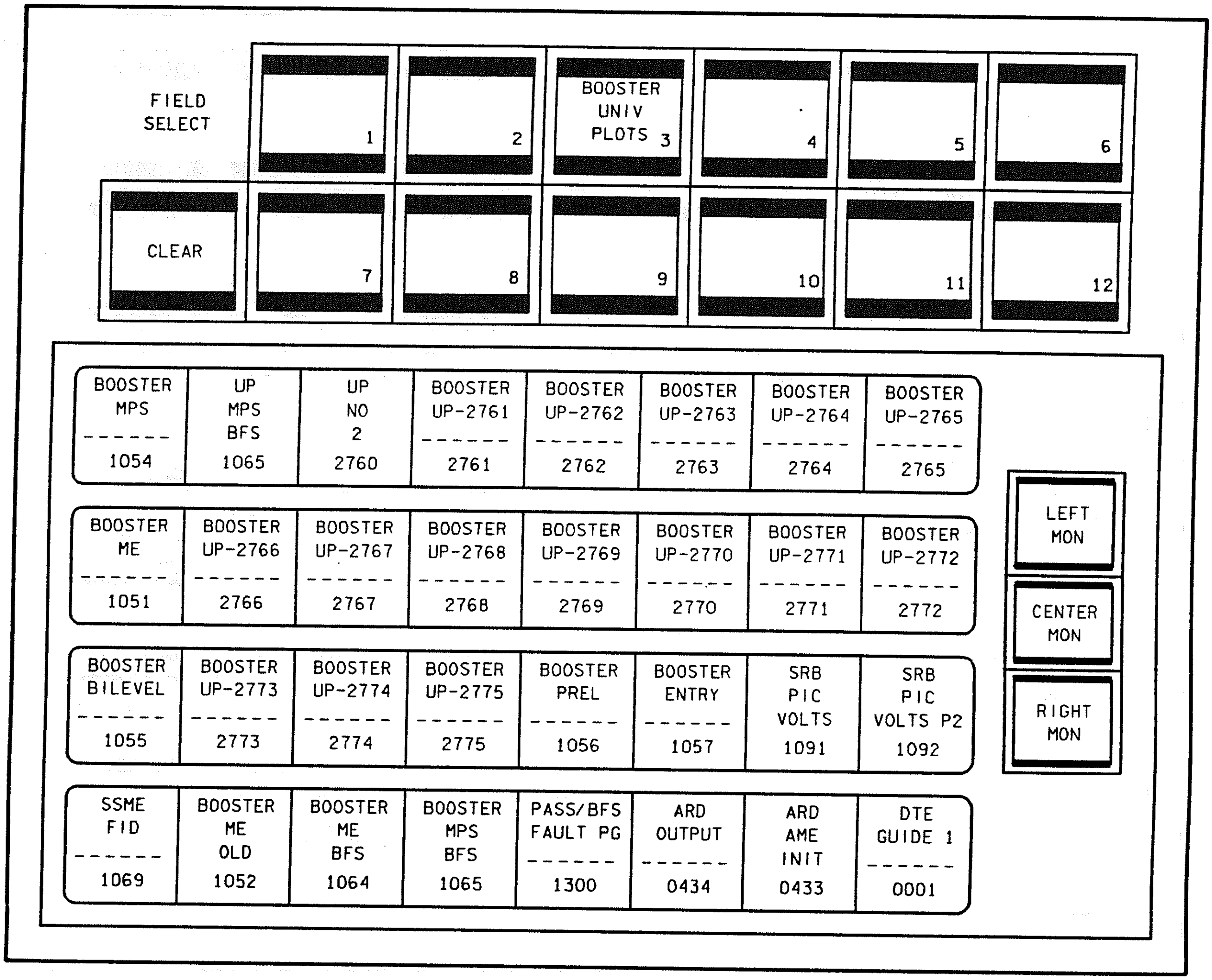
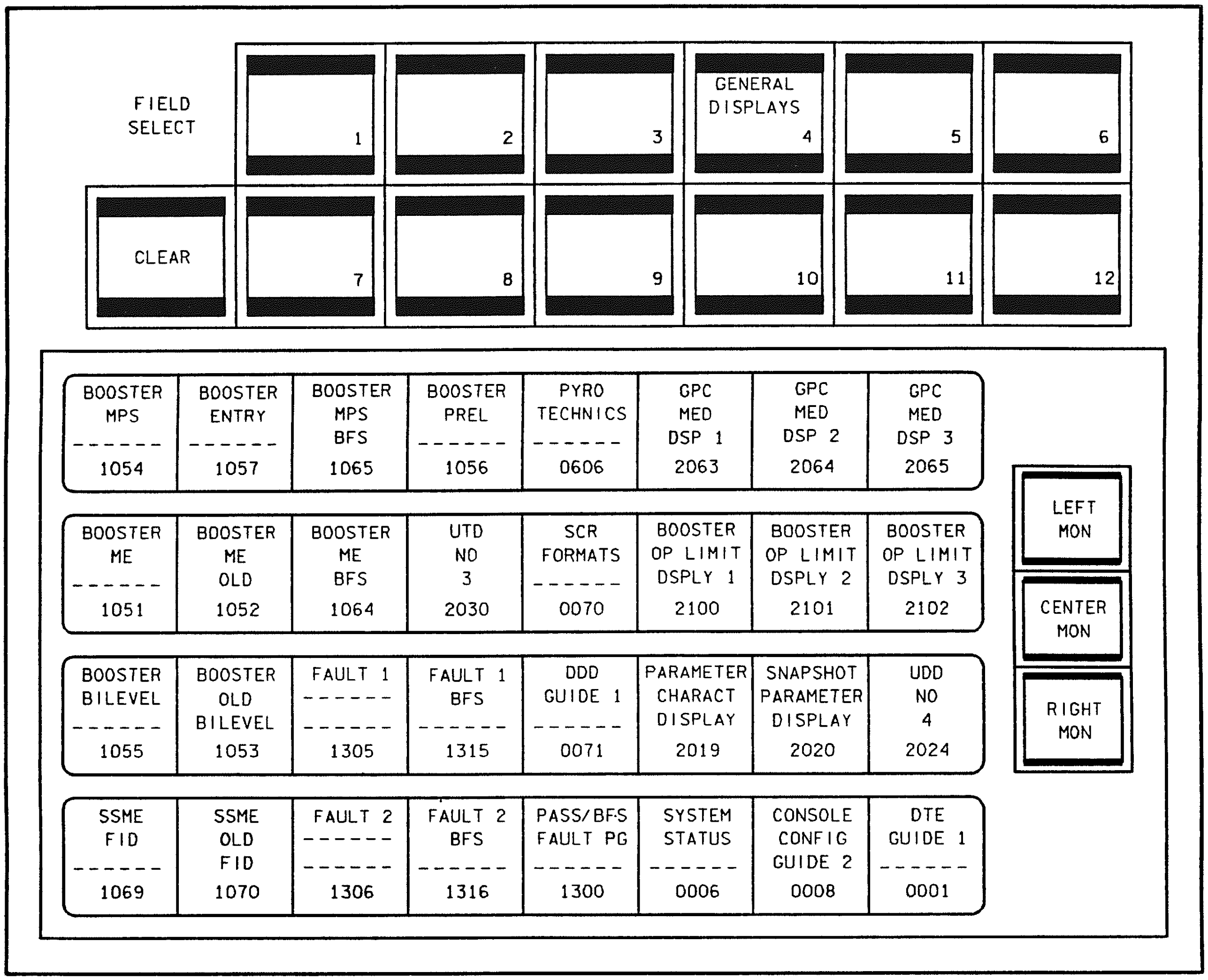


Figure 5.3.2.-II.- Booster universal plots, DRK field.



BOOSTER MPS ------ 1054	BOOSTER ENTRY ------ 1057	BOOSTER MPS BFS 1065	BOOSTER PREL ------ 1056	PYRO TECHNICS ------ 0606	GPC MED DSP 1 2063	GPC MED DSP 2 2064	GPC MED DSP 3 2065
BOOSTER ME ------ 1051	BOOSTER ME OLD 1052	BOOSTER ME BFS 1064	UTD NO 3 2030	SCR FORMATS ------ 0070	BOOSTER OP LIMIT DSPLY 1 2100	BOOSTER OP LIMIT DSPLY 2 2101	BOOSTER OP LIMIT DSPLY 3 2102
BOOSTER BILEVEL ------ 1055	BOOSTER OLD BILEVEL 1053	FAULT 1 ------ ------ 1305	FAULT 1 BFS ------ 1315	DDD GUIDE 1 ------ 0071	PARAMETER CHARACT DISPLAY 2019	SNAPSHOT PARAMETER DISPLAY 2020	UDD NO 4 2024
SSME FID ------ 1069	SSME OLD FID 1070	FAULT 2 ------ ------ 1306	FAULT 2 BFS ------ 1316	PASS/BFS FAULT PG ------ 1300	SYSTEM STATUS ------ 0006	CONSOLE CONFIG GUIDE 2 0008	DTE GUIDE 1 ------ 0001

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Note: The general displays for FCR-2 are the same as above except the field select key indicates "FCR-2" instead of "FCR-1" and the "DDD GUIDE 1, MSK 0071" key is replaced with "DDD GUIDE 13, MSK 0083".

Figure 5.3.2.-III.- General displays, (Booster prelaunch), DRK field.

TITLE

BSE/ME/MPS COMMUNICATION PANELS

PURPOSE

This SCP describes the communication loops that the booster system engineer (BSE) and the main engine (ME) and MPS operators use to communicate with other console operators in the MCC and the firing room at the KSC.

DESCRIPTION

The console communication panels in the MCC are designed to give the operator the capability to talk and listen to other operators in the control center. Each console can be configured with those loops required for an interface between operators. The communication panels are touch-sensitive digital voice intercommunication subsystem (DVIS). This SCP only gives an overview of the system. The operator should reference the DVIS Keyset Quick-Reference Guide (duplicated in figure 5.3.3-1).

The operator can configure 10 pages of 24 comm loops each. The DVIS has a verticle layout of three columns by eight rows of comm loops, and a horizontal layout of six columns by four rows of comm loops. The DVIS can be easily reconfigured if a needed loop is not available on one of the pages. All of the Booster Section DVIS keysets have the verticle layout except the prime keyset in the FCR used by the BSE. Two of the backroom DVIS keysets have a working speaker box.

Each comm loop is labeled to designate its primary function or user. The comm loops are also labeled to indicate talk/listen/monitor capability. A loop labeled M is a listen only (monitor only) loop. A HM loop is a high volume monitor loop. A TL is a talk/listen loop, and a TLM is a talk/listen/monitor loop. The M, HM, and TL loops are activated and deactivated by touch. When the M and HM loops indicate when they are active by highlighting the M and HM letters in reverse video. The TL loop indicates active by a blinking reverse video highlight of the TL letters. The TLM loop is activated by touch. These loops toggle between talk/listen mode (blinking) and monitor mode (nonblinking). These loops are deactivated by touching the RELEASE button.

DVIS KEYSET QUICK-REFERENCE GUIDE

SIGN ON

Note: If screen is blank, touch screen anywhere to activate sign-on menu.

1 Touch **SIGN ON** key.
2 At **ENTER USER ID>** prompt, enter 1- to 8-digit user ID code on pop-up keypad.
(**BACKSPACE** key enables correction of ID code entry.)
3 Touch **ENTER** key on pop-up keypad.

SIGN OFF

1 Touch **SIGN ON/OFF** key.
2 Touch **ENTER** key on sign on/off pop-up keypad.

CONFERENCE

Monitor or High Monitor Line Key Operation

1 Touch desired **M** or **HM** line key.
2 When finished, touch activated line key.

Talk/Listen Line Key Operation

1 Touch desired **TL** line key.
2 When finished, touch activated line key or any other line key.

Talk/Listen/Monitor Line Key Operation

Activating TLM Key

1 Touch desired **TLM** key once to activate monitor mode.
2 Touch selected **TLM** key second time to activate TL mode.
3 Subsequent touching alternates between monitor and TL modes.

Deactivating TLM Key

1 With either monitor or TL mode of **TLM** key activated, touch **RELEASE** key.
2 Touch activated **TLM** keys to deactivate.
3 After all desired **TLM** keys are deactivated, touch **RELEASE** key.

STATION-TO-STATION CALLING OR PABX CALLING

Placing Call

1 Touch **DIAL** or **PABX** line key.
2 Enter desired number on station-to-station pop-up keypad or **PABX** pop-up keypad.

Answering Call

1 **DIAL** or **PABX** line key flashes and ringer sounds.
2 Touch **DIAL** or **PABX** line key.
3 When call is finished, touch **DIAL** or **PABX** line key.

Placing Call on Hold

1 With **DIAL** or **PABX** line key in TL mode, touch **HOLD** key.
2 **DIAL** or **PABX** key displays **HOLD** legend with reverse video and no flashing.

Retrieving Call on Hold

1 Touch **DIAL** or **PABX** line key showing **HOLD** legend.
2 **HOLD** legend changes back to **TALK** legend.

NOTES:

1 **BUSY** legend indicates another keyset is using PABX line.
2 **KEYPAD** key may be used any time to recall PABX pop-up keypad to enable dialing.
3 **CANCEL** key erases pop-up keypad.

MULTIACCESS CONFERENCE

Accessing Multiaccess Conferences (3 Max)

1 Touch **MULTIACCESS** key.
2 Touch up to three **TL/TLM** line keys.

Adding Third Conference

1 Touch **MULTIACCESS** key.
2 Touch desired **TL/TLM** line key.

Terminating Multiaccess Conferences

1 Touch **RELEASE** key.
2 Touch **MULTIACCESS** key or, activate fourth TL/TLM key.

Multiaccess Conference Recall

1 To restore last multiaccess conference configuration, touch **MA RECALL** key.

CONFERENCES WITH SIGNALING OPERATION

Answering Incoming Signal

1 Line key flashes and ringer sounds.
2 Touch line key.
3 When finished, touch line key.

Sending Outgoing Signal

1 Touch desired line key to activate TL mode.
2 For manual signaling conferences, touch **RING** key. For VDL and auto signaling conferences, signal sent automatically.

Figure 5.3.3-1.- DVIS Keyset Quick-Reference Guide (sheet 1 of 2).

DVIS KEYSET QUICK-REFERENCE GUIDE

NOTE

Line key configuration or reconfiguration can be accomplished using ID entry procedure or loop directory procedure. Loop directory procedure provides the convenience of not having to remember the exact conference name or ID number.

Although all conferences are listed in the directory, user can only access those to which access rights are granted.

LINE KEY CONFIGURATION/ RECONFIGURATION USING ID ENTRY

1 Touch **CONFIGURE** key.
2 Key mode legends (**M, HM, TL, TLM, DIAL**, and **PABX**) appear on pop-up keypad along with numerals.
3 Touch desired conference line key. **ENTER NEW KEY ID >** prompt appears.
4 To add or change key:
   - Enter desired key mode (**M, HM, TL, TLM, BLACK DIAL, RED DIAL**, or **PABX**).
   - Enter 4-digit loop ID (not required for **DIAL OR PABX**).
5 Touch **ENTER** key.

LINE KEY CONFIGURATION/ RECONFIGURATION USING LOOP DIRECTORY

1 Touch **CONFIGURE** key.
2 Touch desired conference line key.
3 Touch desired **BLACK DIR** or **RED DIR** key on pop-up keypad.
4 ***To Change Partition:***
   - Touch **SELECT PARTITION** key.
   - Highlight desired partition, using arrow keys, and touch **ENTER** key.
5 ***To Highlight Conference in Loop Directory:***
   - Touch **SELECT ALPHA LIST** or **SELECT NUMERIC LIST** key.
     On alpha pop-up keypad, successively touch key containing first letter of selected conference until letter appears in **LIST START POINT** display key. Touch **ENTER** key.
     On numeric pop-up keypad, enter ID for general loop directory area of selected conference and observe entered ID appears in **LIST START POINT** display key. Touch **ENTER** key.
   - Touch screen in area of desired conference.
   - If required, touch arrow keys to move highlight to selected conference.
6 Configure/reconfigure conference by touching appropriate **SELECT M, HM, TL**, or **TLM** key.

LINE KEY DELETION

1 Touch desired line key to activate.
2 Touch **CONFIGURE** key.
3 Touch **DEL** key on pop-up keypad.
4 Touch **ENTER** key.

PAGE SELECTION

1 Touch **PAGE** key.
2 Successively touch **DECR** or **INCR** key until appropriate page appears.

RING, MONITOR, SPEAKER, AND HEADSET VOLUME CONTROL

1 Touch either **RING VOL, MON VOL, SPKR VOL**, or **HEADSET VOL** key.
2 Successively touch **DECR** or **INCR** key until desired volume level is reached (appropriate digit appears in **VOL** key).
3 When finished, touch activated **VOL** key.
4 If desired, touching **RING TEST** key enables user to hear ring volume at current setting.

PAGE SELECTION AND VOLUME CONTROL USING NUMERIC KEYPAD

1 Touch either **RING VOL, MON VOL, SPKR VOL, HEADSET VOL**, or **PAGE** key.
2 Touch **KEYPAD** key.
3 Touch desired number (0-7 for **VOL** or 1-10 for **PAGE**) on pop-up keypad.
4 When finished, touch activated **VOL** key.

CRITICAL ALARM VOLUME CONTROL

1 Touch **CONFIGURE** line key.
2 Touch **CRIT ALRM VOL** key.
3 Successively touch **DECR** or **INCR** key until desired **SCALE** or **HIGH** level volume indicator appears in **CRIT ALRM VOL** key.
   Scaled level is controlled using regular volume control procedures.
4 When finished, touch **CONFIGURE** key.

Figure 5.3.3-1.- DVIS Keyset Quick-Reference Guide (sheet 2 of 2).

DVIS SIGN-ON

The user signs on to the DVIS system by typing the keyset position number (fig. 5.3.3-2) and password (the password is optional). The user can sign on to any valid DVIS position from another DVIS keyset as long as the requested keyset is not in use by another operator. Calls can be made from one keyset to another by using the Idle Dial loop and entering the keyset position number. The Idle Dial loop on the receiving keyset flashes and the speaker generates a ringing tone.

Position Number

FCR/MPSR 1 (2nd floor)

		PRIME	OJT
Console 304	BSE	2812*	2811
348	ME	2842**	2841
350	MPS	2844	2843**

FCR/MPSR 2 (3rd floor)

		PRIME	OJT
Console 404	BSE	3812*	3811
466	ME	3842**	3841
467	MPS	3844	3843**

* - Horizontal layout
** - Speaker available

Figure 5.3.3-1.- DVIS position numbers.

There are three prebuilt pages available if the user signs on under the Booster password. The first page is for use during ascent, the second is for use during prelaunch, and the third is a page of comm loops used for reporting problems with the console. The remaining seven pages are assigned to be configured by specific operators according to their preference. See the section data pack manager (DPM) for the password and page assignments. The following is a list of general guidelines for using a keyset and configuring a DVIS page.

a. For best results, the headset volume should be set to the maximum (level 6 or 7), and the monitor volume set to the middle level (about 4). The ring volume should be turned down to 0 to avoid the loud ringing tone from nuisance calls during ascent.

b. The FCR operator must be able to talk to all other FCR operators (exceptions are MOD, Surgeon, PAO, Capcom, and Payloads).

The FCR operator must always monitor FD, Booster MPSR, MOCR SPEC (for calls from other FCR operators) and A/G.

The MPSR operators must always monitor FD, Booster MPSR, MOCR SPEC (to avoid calling the BSE when calls to and from other FCR operators are being made) and A/G.

Note: All three A/G loops do not have to be monitored simultaneously. The volume of the A/G loops will drown out all other loops if all three are monitored.

Since there are a large number of loops to monitor during prelaunch, the loops should be divided equally among all team members.

GENERAL
CONSOLE
OPERATIONS

TITLE

MSK OPERATIONS

PURPOSE

This SCP describes the capability of the Manual Select Keyboard (MSK) module.

DESCRIPTION

The MSK (fig. 6.1-I) is used to select the computer support function, to select displays to be viewed on the television monitors, to assign the overlays to the event modules, to format the strip chart recorders, to make hardcopies of the displays, and to specify whether the data is real-time or playback.

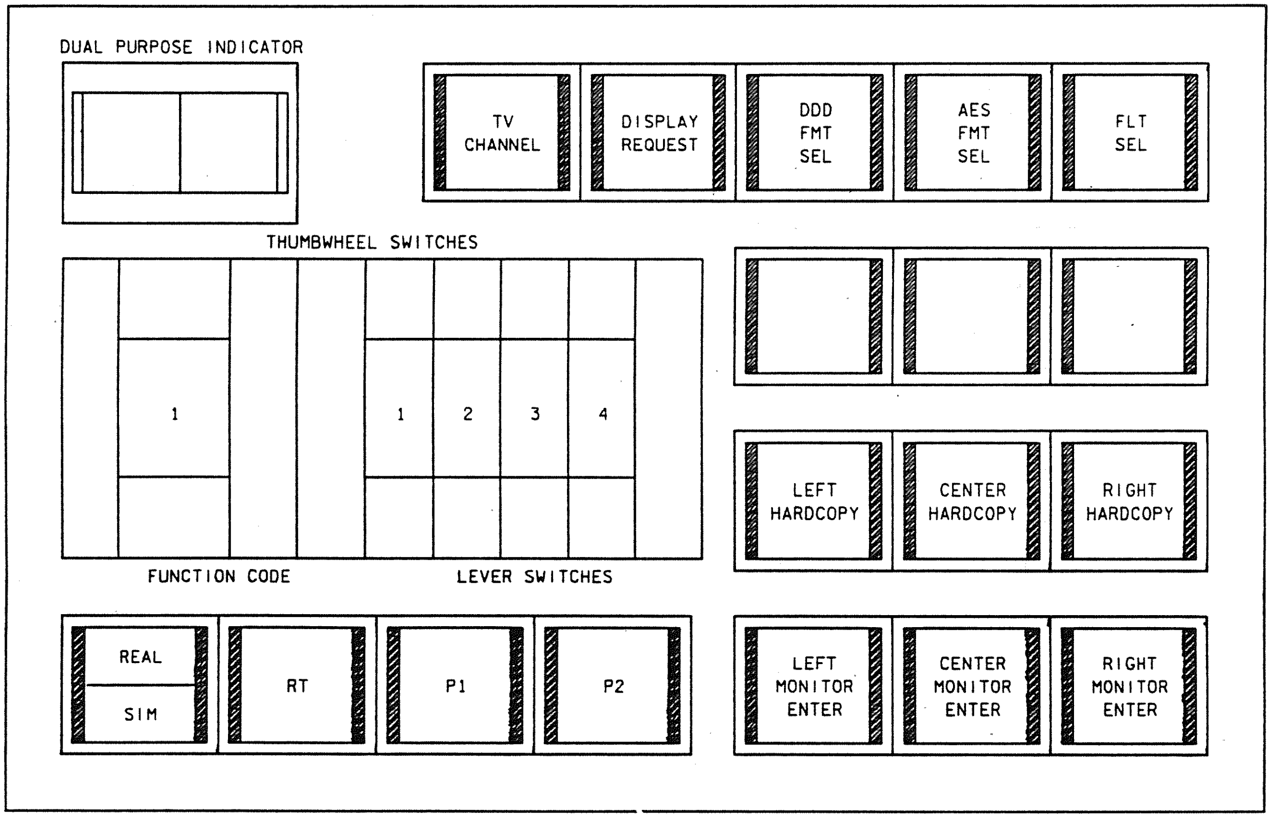

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FIGURE 6.1-I.- THE MSK MODULE.

Figure 6.1-I.- The MSK module.

PROCEDURES

A. Computer Support and Flight Function Selection

The function code thumbwheel (tw) is used to specify a computer support function that identifies the computer program processing the data for the console. For simulations or flight, this thumbwheel will be set according to which FCR is being used or if the flight is a DOD mission. For FCR-1, set the function code tw to 1 which will cause "NASA 1" to be displayed on the dual purpose indicator located above the function code tw. For FCR-2, set the function code tw to 3 which will cause "NASA 2" to be displayed in the dual purpose indicator. For DOD flights, set the function code tw to 2 which will cause "DOD" to be displayed.

To select the proper flight being flown or simulated, enter the MCC flight ID, per table 6.1-I, on the four lever switches. After setting the five tw switches, depress the LEFT MONITOR ENTER pushbutton indicator (PBI).

The dual purpose indicator also indicates the status of the display request system to accept a display requested at a console, since the system can only accommodate 64 displays at a time. If the indicator has a black background, displays can be requested. If the background is red, no additional displays can be requested.

TABLE 6.1-I.- FLIGHT IDENTIFICATION NUMBERS

Flight	MCC flight ID	Thumbwheel settings	
		Function code	Lever switches
STS-34	034	1	0034
STS-33	033	2	0030
STS-140	140	1	0140
STS-32	032	1	0032
STS-36	036	2	0036
STS-31	031	1	0031
STS-35	035	1	0035
STS-37	037	1	0037
STS-38	038	2	0038
STS-40	040	1	0040
STS-41	041	1	0041

B. Data Type Selection

The four data type pbi's are used to specify whether the data coming to the console is simulated, real time, or playback. The simulated (SM) PBI is not currently used. For simulations the REAL PBI will be depressed. For flight, the real-time (RT) PBI will be depressed. To monitor a playback, the Data Integrator console operator will notify the ME or MPS console operators of which playback (P1 or P2) PBI should be depressed before calling up the display, what time frame of mission data will be played back, and when the playback will be available at the console. The data type (RR, RT, P1, or P2) is displayed in the upper right hand corner of a display, immediately preceding the MSK number.

C. Display Selection

A display can be requested by depressing the DISPLAY REQUEST PBI and selecting the four-digit display MSK identification number with the four lever switches. If the dual purpose indicator background is black, then depress the ENTER PBI corresponding to the TV MONITOR (LEFT, CENTER, or RIGHT) upon which the display is to be viewed.

The selected display is assigned a TV channel number which is displayed at the top right corner of the display and on the TV guide display (MSK number 0001). To select a display which another console has previously selected, depress the TV CHANNEL PBI, select the TV channel number on the lever switches, and depress the appropriate ENTER PBI. Since only a finite number of channels can be used at one time in Mission Control Center (MCC) (typically 64 channels maximum, see FCOH section 2.1.1 for details), the TV channel attach mode should be used whenever possible. See table 6.1-II for Booster-related MSK display numbers.

D. Event Light Selection

To specify and assign a format for event lights to a specific event module, depress the DDD FMT SEL (digital display driver format select) PBI, set the format number with the three left lever switches, and select the desired event module by the right lever switch. A console can have a maximum of 19 event modules. For event modules 1-9, set the right-most lever switch to that module number (i.e., 1-9), and depress the LEFT MONITOR ENTER PBI. For event modules 10-19, set the right-most lever switch to 0-9,and depress the RIGHT MONITOR ENTER PBI. See table 6.1-III for available formats.

After the event light formats have been selected, a lamp test can be performed to verify that no burned out event lamps are present. To perform the lamp test, depress the DDD FMT SEL PBI, set the format number to 777, select the desired event module, and depress the appropriate ENTER PBI (the LEFT MONITOR ENTER PBI for modules 1-9 and the RIGHT MONITOR ENTER PBI for modules 10-19). The lamps will illuminate for approximately 10 seconds and then extinguish.

TABLE 6.1-II.- MANUAL SELECT KEYBOARD ENTRIES FOR BOOSTER DISPLAYS

Function	MSK	Title
General	0001	TV Guide
	0070	SCR Formats
	0071	DDD Formats - FCR 1
	0075	DDD Formats - MPSR 1
	0083	DDD Formats - FCR 2
	0086	DDD Formats - MPSR 2
Operations	1051	Booster MPS (OLD)
	1052	Booster ME
	1053	Booster Bilevel (OLD)
	1054	Booster MPS
	1055	Booster Bilevel
	1056	Booster Prelaunch
	1057	Booster Entry
	1064	Booster BFS
	1065	Booster BFS (ALTERNATE)
Miscellaneous	1305,6...	GPC Fault Sum page 1,2...
	1315,6...	BFS Fault Sum page 1,2...
	0516	Entry page
	0521	Entry page
	2020	Snapshot page
	2023	UDD page
	2024	UDD page
	0008	Console Config Guide
	0606	Shuttle Pyrotechnics
Limits	2100	Booster Limits
	2101	Booster Limits
	2102	Booster Limits
	2064	GPC MED Constants
	2065	GPC MED Constants
Tables	1069	SSME Hard Failure ID
	1070	SSME Hard Failure ID
	1071,2	Center Main Engine Table
	1073,4	Left Main Engine Table
	1075,6	Right Main Engine Table
	1077,8	MPS Helium Table
	1079,80	MPS Consumables
	1081,2	MPS Pressure
	1083,4	ET Pressurant/SRBS
	1085,6	MPS On Orbit
	1087,8	Fuel NPSP ET & SSME
	1089,90	BFS Table
	1091,2	SRB PIC Volts
Plots	2759	C HPOT TD/HPFT TD
	2760	L HPOT TD/HPFT TD
	2761	R HPOT TD/HPFT TD
	2762	GH2 Out Press and Accel
	2763	C PC/OPOV/FPOV
	2764	L PC/OPOV/FPOV
	2765	R PC/OPOV/FPOV
	2766	C,L,R MR
	2767	L He Tk P
	2768	C He Tk P
	2769	R He Tk P
	2770	L,C,R,P He Reg PA
	2771	L,C,R,P He Reg PB
	2772	L,C,R,P He Tk P
	2773	He DECRT
	2774	LO2 Inlet P/Manf P
	2775	LH2 Inlet P/Manf P

All DDD formats can be de-selected and all lights can be extinguished by pressing the DDD FMT SEL PBI, setting the four lever switches to 0000, and then depressing the LEFT MONITOR ENTER PBI.

TABLE 6.1-III.- BOOSTER DDD FORMATS

DDD FMT# (OLD)	Title
281	C SSME LIMIT SENSE
282	L SSME LIMIT SENSE
283	R SSME LIMIT SENSE
284	SSME EVENTS
285	SSME EVENTS
291	MPS ON ORBIT
292	MPS ON ORBIT
293	ME AUX DATA
298 (288)	MPS EVENT 1
299 (289)	MPS EVENT 2
300 (290)	MPS LIMIT STATUS
301 (286)	HELIUM
302 303 (287)	ET PRESS/PRPLNT

E. Strip Chart Recorder Selection

Strip chart recorder (SCR) formats are specified and assigned to specific SCR's by depressing the AES FMT SEL (analog event system format select) PBI, setting the format number with the three left lever switches, selecting the number of the desired SCR with the right lever switch, and depressing the LEFT MONITOR ENTER PBI to execute the operation (refer to table 6.1-IV). Reference SCP 6.6 for more information regarding SCR operations.

TABLE 6.1-IV.- BOOSTER SCR FORMATS

Control console	Format no.	SCR ID	Right lever	Location description	When used	Mon by
MPSR-1:						
347	114	623 (725)	?	Left of console 350	Ascent	ME
347	113	606 (627)	?	Right of console 350	Ascent	ME
347	115	622 (626)	?	Right of console 348	Ascent	ME
347	116	623 (725)	?	Left of console 350	MECO	MPS
347	117	606 (627)	?	Right of console 350	MECO	MPS
347	112	624	?	PROP console 347	Ascent	MPS
347	111	624	?	PROP console 347	SRB-SEP	MPS
MPSR-2:						
466	114	722	2	Right of console 466	Ascent	ME
465	113	723	1	Left of console 465	Ascent	ME
465	115	724	2	Right of console 465	Ascent	ME
466	116	706	1	Left of console 466	MECO	MPS
466	117	722	2	Right of console 466	MECO	MPS
466	112	706	1	Left of console 466	Ascent	MPS
466	111	706	1	Left of console 466	SRB-SEP	MPS
466	092	706	1	Left of console 466	MECO	OREO
466	094	722	2	Right of console 466	MECO	OREO

F. Hardcopy a Display

Each TV monitor has a corresponding hardcopy PBI. Depressing a hardcopy PBI makes a copy of the display. The hardcopy comes through the pneumatic tube system.

REFERENCE

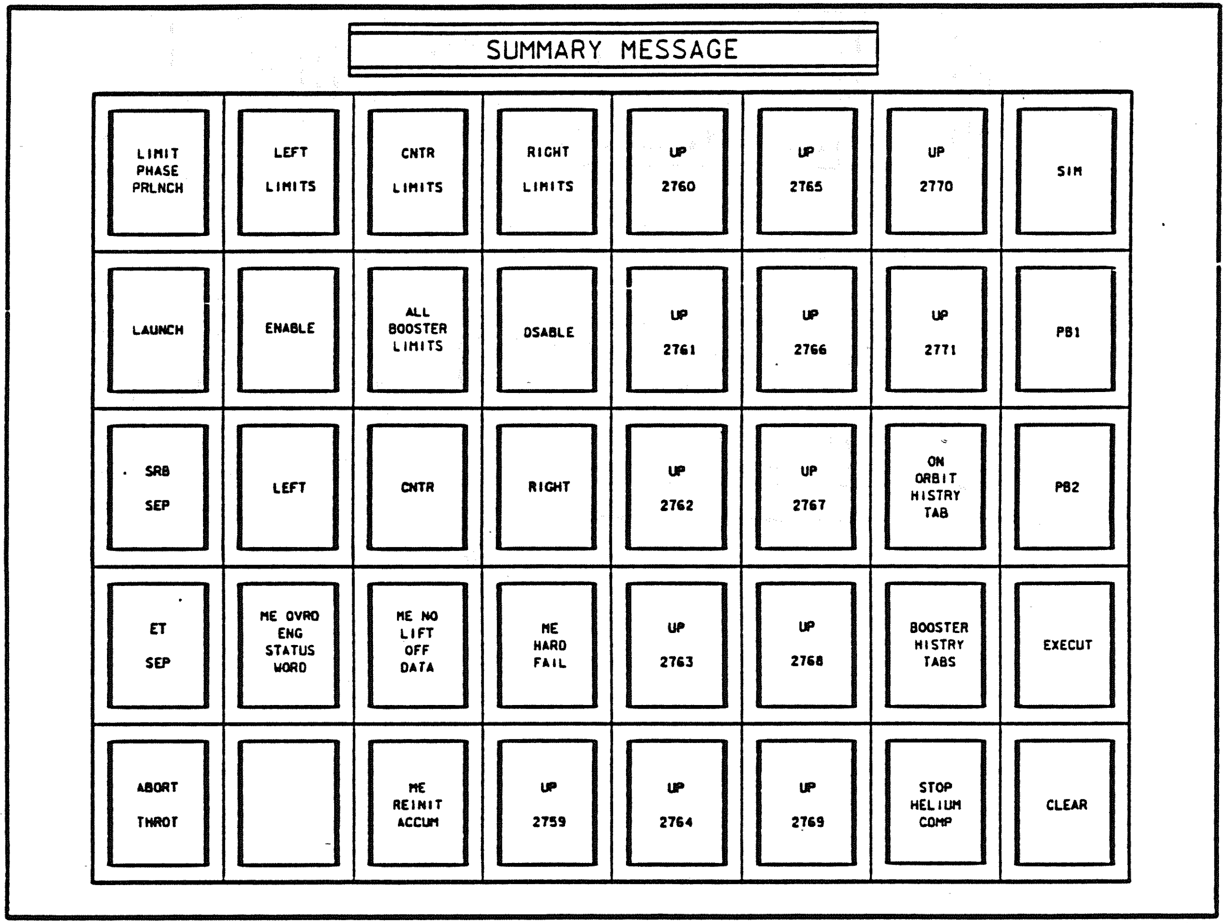
Booster Data Pack, as of Sept. 1, 1989

TITLE

SMEK OPERATIONS

PURPOSE

This SCP describes the capability of the Booster Systems Summary Message Enable Keyboards (SMEK's). There are three SMEK configurations: BOOSTER, figure 6.2-I; ME, figure 6.2-II; and MPS, figure 6.2-III. Each SMEK panel is located on its respective console.



0410F.ART, 12

Figure 6.2-I.- The BOOSTER SMEK panel.

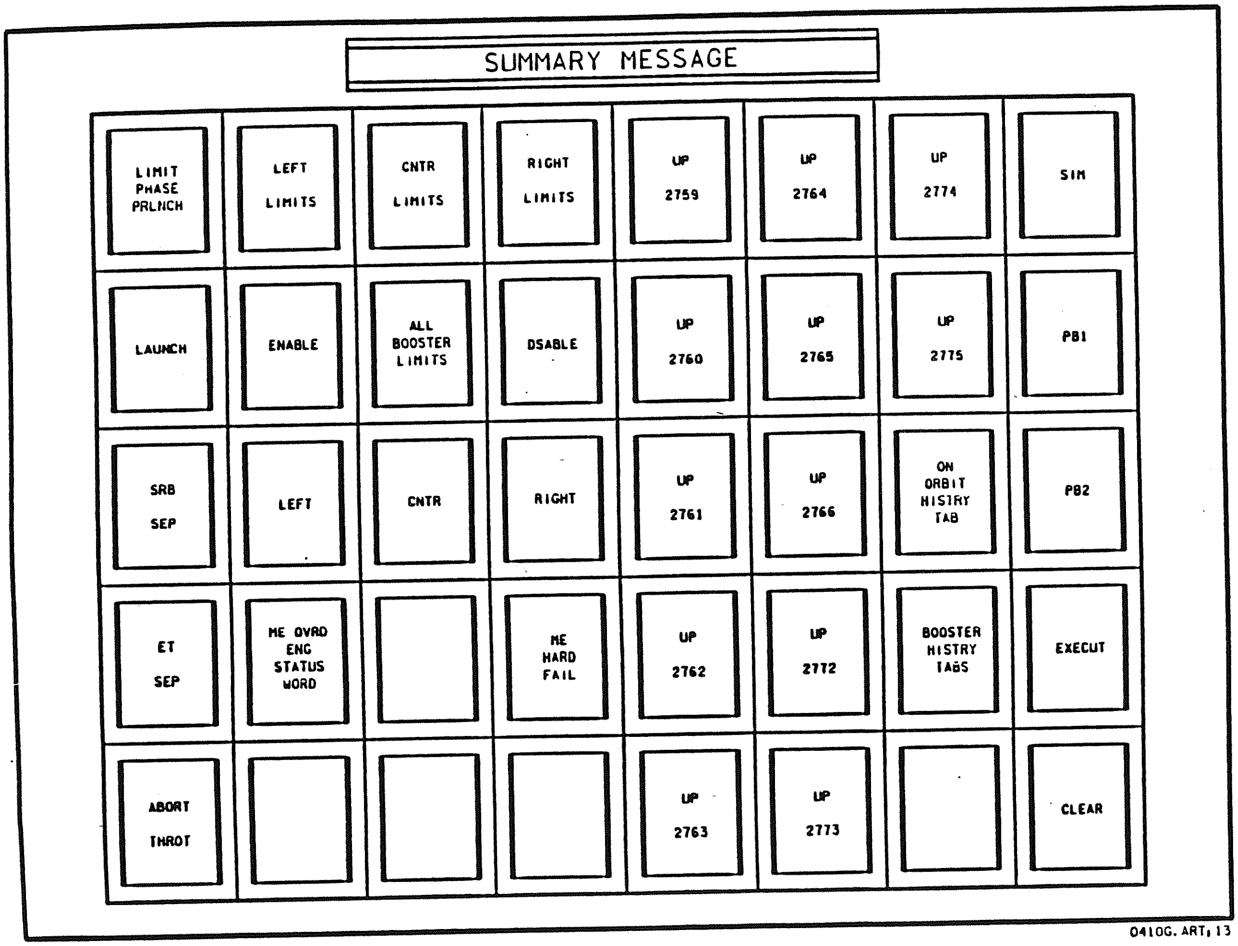
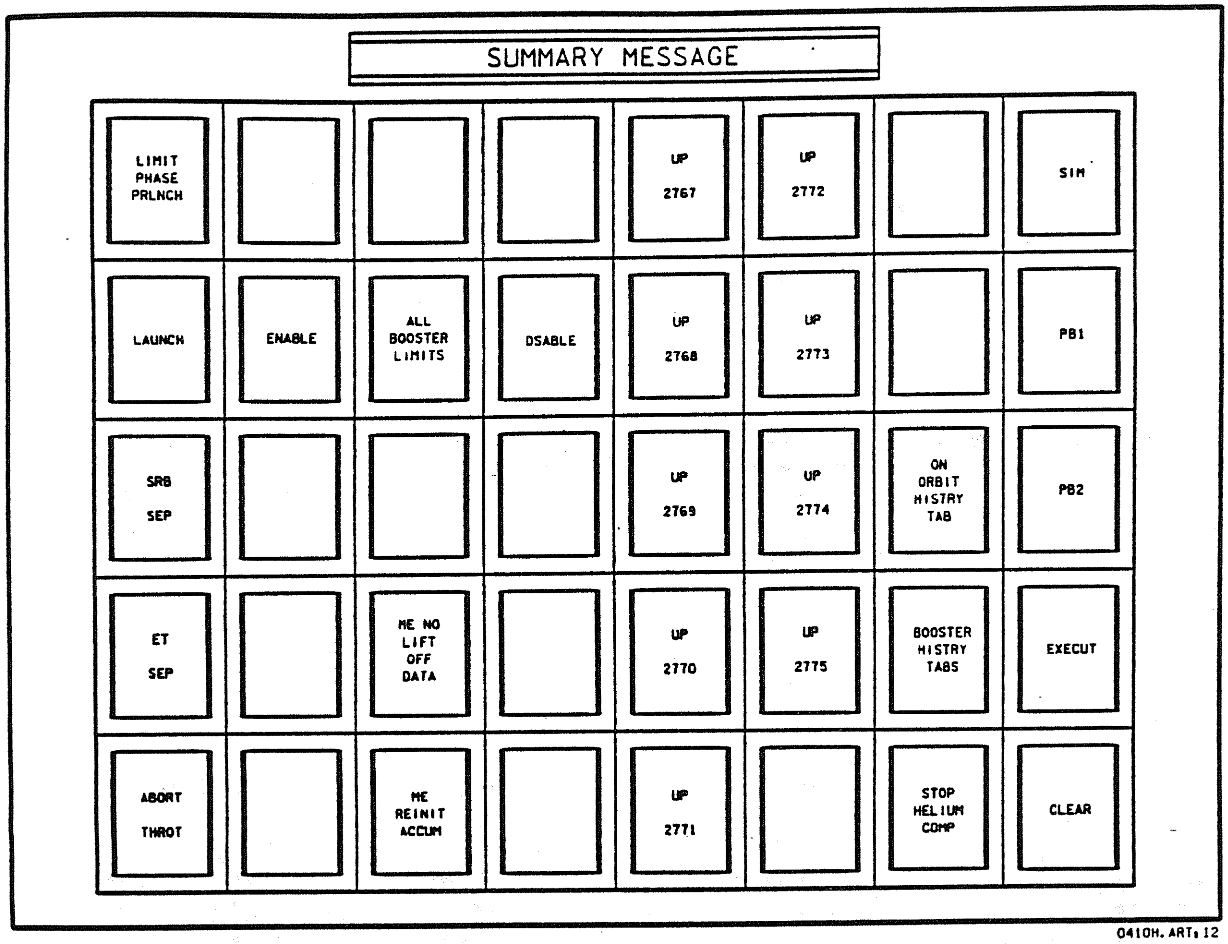


Figure 6.2-II.- The ME SMEK panel.



0410H.ART;12

Figure 6.2-II.- The MPS SMEK panel.

DESCRIPTION

The SMEK is used to transmit specific requests to the telemetry application program in the mission operations computer (MOC). These requests are acted upon by the telemetry application program to retain telemetry data for historical tabulation, enable or disable limit sensing for operational and critical telemetry parameters, select operational limit values, and initiate universal plots and special computations.

PROCEDURES

The function of each pushbutton indicator (PBI) on the SMEK will be described. When a PBI is depressed, the PBI remains latched and illuminated until the CLEAR PBI is depressed. A latched PBI permits the console operator to repetitively execute the same SMEK request. The CLEAR PBI will release all latched PBI's simultaneously.

The PBI's should remain unlatched when possible to prevent inadvertent function executions.

A. Operational Limit-Set Selection

The operational limit-set PBI's are used to select predefined operational limit values for the limit sensing parameters for the prelaunch, launch, SRB separation, ET separation, and abort-throttle phases of the flight. To input the limit sensing values for the prelaunch phase, depress the LIMIT PHASE PRLNCH PBI, depress the EXECUTE PBI, verify that the prelaunch event light is illuminated, depress the CLEAR PBI to unlatch the SMEK panel, and load the prelaunch limits using the megadata terminal. The same procedure is used to input the limits for the remaining flight phases.

B. Data-Type Selection

Data coming to the consoles can be real-time, simulated, or playback. For the simulations and flight, real-time data will be used, which does not require PBI selection. The SIM PBI is not currently being used. Playback 1 or Playback 2 data requires the appropriate PBI to be depressed.

C. Universal Plot Request

The universal plots provide a means of plotting and viewing parameter trends in real time or playback on the TV monitors. Each plot has a corresponding universal plot request PBI on the SMEK (identified by the MSK number of the plot) which is used to start the plot. To start the plot, depress the desired universal plot PBI, such as UP 2759, depress or verify the desired data-type select the PBI, depress the EXECUTE PBI, verify that the plot has been initiated, and depress the CLEAR PBI.

The universal plots 2759, 2760, 2761, 2762, 2763, 2764, 2765, and 2766 are used to monitor the SSME's and the remaining plots 2767, 2768, 2769, 2770, 2771, 2772, 2773, 2774, and 2775 are used to monitor the MPS.

D. History Tabulation Request

The history tabulation PBI's are used to tabulate the latest or current telemetry and place that telemetry in the first history column of the associated display. A maximum of 13 columns of history data (6 columns on one page of a display and 7 on second page of the display) may be retained at any one time. The SSME history tabulation displays include MSK 1071 to MSK 1076, and the MPS history tabulation displays include MSK 1077 to MSK 1088. MSK 1089 and MSK 1090 are the first and second pages, respectively, of the BFS history tabulation displays. A history tabulation for each of the above displays, except for MSK 1085 and MSK 1086, is taken simultaneously by depressing the BOOSTR HISTRY TABS PBI once on the Booster, ME, or MPS console. During ascent, the BOOSTR HISTRY TABS PBI is normally depressed once in thrust bucket, once on way out, and once per minute thereafter by the ME console operator. The MPS console operator monitors the helium system pressures and temperatures on MSK 1085, the MPS on-orbit display until the ascent shift handover. MSK 1086 is page 2 of the display. The MPS console operator depresses the "ON ORBIT HISTRY TAB" PBI once every site pass to enter a history tab on MSK 1085. From that entry, the pressures and temperatures of the left, center, and right helium tanks and of the pneumatics tank are used to compute the helium mass in the helium tanks. The MPS operator checks the helium mass daily, throughout the flight.

To make a history tab, depress the desired history tab PBI; select or verify the desired data-type select PBI; depress the "EXECUTE" PBI; and depress the CLEAR PBI.

E. Limit Sensing Selection

The limit sensing limits for the left, center, and right SSME's can be enabled or disabled by using the limit-sensing selection PBI's. To enable or disable the limits of an individual SSME the appropriate PBI - CNTR LIMITS, LEFT LIMITS, or RIGHT LIMITS - is depressed. To enable or disable all three SSME limits at once, the ALL BOOSTER LIMITS PBI is depressed. To execute the selection, the EXECUTE PBI is depressed. For an engine out during powered flight, the MPS console operator inhibits the limits of that engine.

F. Clearing the SSME Hard Failure Identification Display

The SSME hard failure identification displays (MSK's 1069 and 1070) have a column for each SSME. When a component failure occurs on an SSME, the failure is identified in the column for that SSME (reference SCP 3.1.2). When a column becomes completely filled with failure messages, additional failure messages will not be displayed; therefore, that column must be cleared. A column is cleared by depressing the appropriate PBI (LEFT, CNTR, or RIGHT), the ME HARD FAIL PBI, and the CLEAR PBI.

G. Special Computation Request

A special computation request PBI, such as the STOP HELIUM COMP PBI, initiates a specific predefined special computation in the telemetry program. The STOP HELIUM COMP PBI is used to start and stop the helium consumption's time-to-depletion computation. The results of this computation are displayed on MSK 1054 and MSK 1077. SCP 3.2.2 contains a detailed description of the time-to-depletion computation.

For loss of data at lift-off, NO ME LIFT-OFF DATA (PBI 14) must be depressed followed by the appropriate engine(s), PBI 8 for left, PBI 13 for center, and PBI 18 for right. This action will cause the first good flow rate data to be used to calculate approximate consumption from mainstage to acquisition of data for the appropriate engine(s). Therefore care must be exercised that first data are not acquired during the loads throttle back early in flight (i.e., execute PBI should not be actuated until satisfactory data are present and the throttle is at nominal mission power level). The consumption of fuel from mainstage is used to calculate fuel remaining and the fuel head portion of the LN_2 NPSP compution. If data is missing at lift-off and the NO ME LIFT-OFF DATA function is not exercised, the calculated fuel remaining, fuel head, and LN_2 NPSP values will be higher than the actual values.

Prior to lift-off, subsequent to test or calibration exercises, or after a scrubbed sim, PBI 15-ME REINIT ACCUM must be depressed to reinitialize the computation which zeroes out the value in the accumulator. This action allows the values in the computation to be correct every time the computation is started.

H. Inactive PBI's

The "MEOVRD ENG STATUS WORD" is not currently used.

REFERENCES

1. The Summary Message Enable Keyboard (SMEK) workbook (UT SMEK 2102), Nov. 1978

2. DF65 Data Pack

TITLE

MEGADATA TERMINAL OPERATIONS

PURPOSE

This SCP describes Megadata or manual entry device (MED) terminal operations used to initialize operational limits for the main engine (ME) and main propulsion system (MPS) consoles.

DESCRIPTION

The MED terminal is used to configure near real-time (NRT), universal plots, telemetry limit changes, and special computation (COMP) changes by both the ME and MPS consoles. Limits are changed by loading and transmitting the corresponding diskette menus. Parameter MSID's, and specific limit values for the ME console are contained in SCP 5.1.4: ME Console Limit Sensing/ Initialization. Parameter MSIDs and specific limit values for the MPS console are contained in SCP 5.2.4: MPS Console Limit Sensing control. NRT procedures are contained in SCP 5.1.5: NRT Data Processing Initialization. Only MED terminal operations are covered in the following SCP.

PROCEDURES

A. The following is a list of steps to be taken to input limits to the MOC via the MED terminal. The MPS parameters (all except for NRT) are preloaded in the MOC via RDCS. The following procedure need only be followed for MPS if, for some reason, the parameters do not show up. The MPS MED directory is shown in figure 6.3-I. The ME MED directory is shown in figure 6.3-II. Presently, the ME parameters still must be input manually by the following procedure.

   1. Before trying to log on to the Mission Operations Computer (MOC), make sure the POLL light is flashing. If not call "TM" on the TLM/MITS COORD loop. Get the MOC number for the current load from "GC" on the GC CALL loop. Log on to the MOC and DSC by typing:

      L MOCX <EXTEND FUNCTION + TRANSMIT UNPROTECT>

      where X is the MOC number for that load. A message should appear saying that logon is complete to the MOC and DSC.

   2. Load the ME diskette into the disk drive. Ensure that both the SELECTED and READY lights on the disk drive are ON, indicating that the diskette is selected and ready to read.

   3. Depress the DIRECTORY button and verify that the directory of ME menus is displayed (refer to fig. 6.3-II).

4. Using the cursor control keys, ↓ ← → ↑, move the cursor adjacent to the ME_INIT entry (350_INIT for the MPS console).

5. Depress the RECALL button and verify that the menu ME_INIT is displayed.

6. Verify that the KYBD LOCK/RESET button is OFF, that the SYSTEM AVAIL light is ON, and that the POLL and STATUS lights are flashing. Depress the TRANSMIT UNPROTECT button. The messages MOC INPUT DECODED and DSC INPUT DECODED accompanied by time updates will appear at the bottom of the screen. The DSC is not always operational; therefore, its message might not always appear.

7. Advance to the next format by simultaneously pressing the EXTEND FUNCTION and the RECALL buttons. Alternately the directory may be recalled and the cursor moved to the next menu using the cursor control keys, which is slower.

8. Repeat steps 6 and 7 until all menus in all limit sets (prelaunch, launch, SRB SEP, ET SEP, and ABORT THROT) have been transmitted.

B. ME universal plots (UP) and special computations may be initialized during any limit phase. These UP and special comp menus are designated by recalling format UP's and format COMPS, respectively, and are transmitted using the procedure above. ME NRT menus are not to be transmitted to the MOC. Refer to SCP 5.1.5 for NRT initialization.

C. Occasionally an operator will modify a parameter on a menu and inadvertently transmit it to the MOC and DSC prior to saving the changed menu on the diskette. When this happens, the MOC and DSC messages will wipe out the title of the menu. To restore the title of the menu, do the following:

1. Save the menu on your diskette if you have not already done so.

2. Depress the white NASA PROGRAM pushbutton indicator.

3. Depress the space bar.

4. Depress the DIRECTORY pushbutton.

5. Use the arrow keys and RECALL button to select the menu to be changed.

6. Move the cursor to the first character position of the last line.

7. Press the letter H.

8. Move the cursor back two spaces to the last character position of the next-to-the-last line.

9. Press the letter H.

10. Move the cursor back one space over the H just inserted.

11. Depress and hold the EXTEND FUNCTION key, momentarily press the TAB SET key, then release both keys.

12. Retype the menu name.

13. Store or replace the menu as desired.

D. It may be desirable to disable limit monitoring of a parameter that is indicating off-scale high or low, for example, in order to keep event lights off when no call is required. This action is done using the TLM Offscale Limit Sense Control Menu as follows:

1. Request blank menu V31 from the MOC by entering

   V31? TRANSMIT UNPROTECT

2. A blank V31 menu will be displayed.

3. Fill in the flight/type number, e.g., 034/RR.

4. Enter the MSID's of the parameters to be disabled under PARAMETER NUMBER.

5. Enter the CONTROL CODE for the limit function that is to be enabled or disabled, such as L to disable monitoring a parameter that is offscale low.

6. Optionally, you may enter a name for this menu and save it on your diskette along with other menus applicable to this mission phase.

7. Depress TRANSMIT UNPROTECT to send this menu to the MOC.

   Verify receipt of the usual MOC INPUT DECODED message. Recall that the DSC might not be active in some mission phases.

8. Verify that the event light for the offending parameter is off. A given parameter will continue to be displayed with an H or L if it is on a DTE display.

9. See figure 6.3-III for an example of a menu that disables offscale-low limit monitoring of LO2 manifold and inlet pressures for STS 51-C in real time.

10. Alternatively, fill out the center part of JSC form 480, TLM Limit Table Change Form, as you would the V31 menu. Keep a copy and send a copy to computer TM. Refer to figure 6.3-IV or FCOH figure 4.9.1.1 for an example of this form.

E. A floppy copy may be performed without interrupting communication with the MOC or NRT host. This procedure replaces the use of the NASA PROGRAM floppy copy function.

1. Insert the master disk to be copied into disk drive 0. In the old disk drives, do not insert the disk under the write enable switch. For the new floppy disks, uncover the write protect notch.

2. Insert the backup disk into disk drive 1. In the old disk drives, insert the backup disk under the write protect switch. For the new floppy disks, ensure that the write protect notch is covered.

3. Press and hold the EXTEND FUNCTION key, then press REPLACE twice, then release both keys.

F. If a new disk needs to be formatted for MED terminal use, follow these steps:

1. Insert the disk in the appropriate selected disk drive.

2. Press and hold the EXTEND FUNCTION key, then press DIRECTORY twice, then release both keys. When the disk is formatted, a blank directory should appear.

G. The megadata terminal can also be used: as a backup to the MSK panel, to flight-select a console, to assign DDD formats to a console, to execute the same functions as the SMEK panel such as changing limit sets and starting UP's, and to execute the same functions as a DRK panel. These functions are accomplished by transmitting a "D-MED" character string which can be saved on the Sim and Flight disks. In the future, the MASSCOMP's MED emulator can do all of the console initialization by running a program that sends the same D-MEDS. Examples of the MSK backup functions are included.

1. FLIGHT SELECT A CONSOLE VIA MED

COMMAND FORMAT: `D12,FID,CCC,NNN,AA$`

Where CCC = console number i.e., 348 for Main Engine, MPSR-1
350 for MPS, MPSR-1

NNN = Flight ID i.e., 034 for STS-34
032 for STS-32

AA = Data type i.e., RR
SR
R1
R2

Example: Flight-select MPS console for STS-34

```
D12,FID,350,034,RR$
```

2. SELECT DDD FORMATS VIA MED

COMMAND FORMAT: `D06,CCC,TTTT,A$`

Where CCC = Console number i.e., 348 for main engine, MPSR-1
350 for MPS, MPSR-1

TTTT = Thumb wheels Set the same way as the thumb wheels on the MSK. (format#:module#)

A = L - Left monitor
R - Right monitor
entered the same way as the MSK

Example: Select format 298 on MPS console module 18

```
D06,350,2988,R$
```

Example: Lamp test module 18 on MPS console

```
D06,350,7778,R$
```

Example: Deselect all formats on MPS console

```
D06,350,0000,L$
```

3. SMEK OR DRK FUNCTIONS VIA MED

COMMAND FORMAT: `D11,PBI,CCC,A,/NNNNNNNNNN/$`

Where CCC = Console number - used for DRK only

A = L - left monitor - DRK only
C - center monitor
R - right monitor

NNNNNNNNNN = 9 or 10 character MSID for SMEK or DRK PBI push button. Reference data pack on SMEK and DRK.

Example: Change limit set to launch limits

```
D11,PBI,,,/M60K0012P/$
```

Example: Start UP's 1827, 1828, and 1829

```
D11,PBI,,,/M51K0027P,M51K0028P,M51K0029P/$
```

Note: The D-MED codes will change with the 1.3 delivery for the MCC upgrade sometime in the distant future.
D06 becomes D56
D11 becomes D61
D12 becomes D62

```
                     DISC DIRECTORY OF STORED DISPLAYS
 350 INIT       DDD298          DDD299          DDD300          DDD301
 DDD302         DDD301T         DDD302T         DDD303T         DDD298T
 DDD299T        COMPS           V20-VEH W       V21-COMP        V20-NPSP
 V20-HE TO      UP'S            V40-2767        V41 2767        V40-2768
 V41 2768       V40-2769        V41 2769        V40-2770        V40-2771
 V40-2772       V40-2773        V40-2774        V40-2775        TLM OVR R
PRELAUNCH       V30 #1          V30 #2          V30 #3          LAUNCH
 V30 #1         V30 #2          V30 #3          V30 #4          SRB SEP
 V30 #1         V30 #2          V30 #3          V30 #4          ET SEP
 V30 #1         V30 #2          V30 #3          ABORT           V30 #1
 V30 #2         V30 #3          V30 #4          ON ORB          V30 #1
 V30 #2         ORB OVRD        ENTRY           V30 #1          ENT ENBL
 MEC PWR       PBI-BKUP         MEDS UDD2       MED UDD3        MED UDD4
 MEDS UDD1
```

Figure 6.3-I.- MPS MED directory display.

```
                     DISC DIRECTORY OF STORED DISPLAYS
ME INIT         DDD 293         DDD 284         DDD 285         DDD 282
 DDD 281        DDD 283         DDD 290         //////////      //////////
PRLO30SIM       CME71_1PL       CME71_2PL       LME73_1PL       LME73_2PL
 RME75_1PL      RME75_2PL       LAUNCH          CME71_1L_       CME71_2L_
 LME73_1L_      LME73_2L_       RME75_1L_       RME75_2L_       SRB SEP
 CME71_1S_      CME71_2S_       LME73_1S_       LME73_2S_       RME75_1S_
 RME75_2S_      ET SEP          CME71_1ET       CME71_2ET       LME73_1ET
 LME73_2ET      RME75_1ET       RME75_2ET       ABORT           CME71_1AB
 CME71_2AB      LME73_1AB       LME73_2AB       RME75_1AB       RME75_2AB
 UP'S_____      C_UP2759        L_UP2760        R_UP2761        ACCEL2762
 C PC 2763      L PC 2764       R PC 2765       MR_2766         V41_2759
 V41_2760       V41_2761        V41_2763        V41_2764        V41_2765
 COMPS_____     THRST_MED       LO2_MEDS        LH2_MEDS        AUG_PERF_
 AUTO_TL_1      AUTO_TL_2       AUTO_TL_3       AUTO TL 4       FPLSELECT
 UDD'S          MED UDD1        MED UDD2        MED UDD3        MED UDD4
 MED UDD5       MED UDD6        MED UDD7        MED UDD8        FID CLR1
 FID CLR2       FID CLR3
```

Figure 6.3-II.- ME MED directory display.

```
V31#

020/RR        TLM OFFSCALE LIMIT SENSE CONTROL MENU

           PARAMETER                  CONTROL  NOTE:  CONTROL CODE
           NUMBER                      CODE           DEFINITIONS ARE

           U41P1533C_ ,                 L ,    H = OFFSCALE HIGH
           U41P1130C_ ,                 L ,
           U41P1130C_ ,                 L ,    L = OFFSCALE LOW
           U41P1130C_ ,                 L ,
           ---------- ,                 - ,    R = OFFSCALE RESET
           ---------- ,                 - ,
           ---------- ,                 - ,
           ---------- ,                 - ,
           ---------- ,                 - ,
           ---------- ,                 - ,
           ---------- ,                 - ,
           ---------- ,                 - ,
           ---------- ,                 - ,
           ---------- ,                 - ,
           ---------- ,                 - ,
           ---------- ,                 -
                                        $
--------------        ENTER PM FOR PERMANENT MED
```

Figure 6.3-III.- TLM offscale limit sense control menu.

LIMIT CHANGE

FROM:______________
DATE:______________
TIME:______________

TO: COMPUTER TM
P-TUBE STA: 42

V30#
FLT/DT ____/____ TLM OPERATIONAL LIMIT CHANGE MENU

PARAMETER NUMBER, LOW VALUE, HIGH VALUE

/ __________ , __________ , __________ ,
__________ , __________ , __________ ,
__________ , __________ , __________ ,
__________ , __________ , __________ ,
__________ , __________ , __________ ,
__________ , __________ , __________ ,
__________ , __________ , __________ ,
__________ , __________ , __________ ,
__________ , __________ , __________ ,
__________ , __________ , __________ ,
__________ , __________ , __________ ,
__________ , __________ , __________ / $

ENTER PM FOR PERMANENT MED ___

V31#
FLT/DT ____/____ TLM OFFSCALE LIMIT SENSE CONTROL MENU

PARAMETER NUMBER, CONTROL CODE

/ _______ , __ ,
_______ , __ ,
_______ , __ ,
_______ , __ ,
_______ , __ ,
_______ , __ ,
_______ , __ ,
_______ , __ ,
_______ , __ ,
_______ , __ ,
_______ , __ ,
_______ , __ / $

NOTE: CONTROL CODE DEFINITIONS
H=OFFSCALE HIGH
L=OFFSCALE LOW
R=OFFSCALE RESET

ENTER PM FOR PERMANENT MED ___

V33#
FLT/DT ____/____ TLM CRITICAL LIMITS CHANGE MENU

PARAMETER NUMBER, LOW LIMIT, HIGH LIMIT, CONTROL CODE (E/D)

/ __________ , __________ , __________ , __ ,
__________ , __________ , __________ , __ ,
__________ , __________ , __________ , __ ,
__________ , __________ , __________ , __ ,
__________ , __________ , __________ , __ ,
__________ , __________ , __________ , __ ,
__________ , __________ , __________ , __ ,
__________ , __________ , __________ , __ ,
__________ , __________ , __________ , __ ,
__________ , __________ , __________ , __ ,
__________ , __________ , __________ , __ ,
__________ , __________ , __________ , __ / $

ENTER PM FOR PERMANENT MED ___

Figure 6.3-IV.- TLM limit change menu.

REFERENCES

1. UT MED 2102: Megadata Terminal Workbook, May 15, 1979.
2. SOP 11.2.5, MOC MED Access and Use, Flight Control Operations Handbook, Final, Jan. 16, 1987.
3. SOP 11.2.6, Permanent MED's, Flight Control Operations Handbook, Final, Jan. 16, 1987.
4. SOP 4.9.1, Limit Table Update, Flight Control Operations Handbook, Final, Jan. 16, 1987.

TITLE

CONSOLE OPERATIONS LOGS

PURPOSE

This SCP describes a standard to help maintain data for STS operations.

DESCRIPTION

The flight log is a vital place to document and gather all information regarding a flight. Each lead operator for flight shares the responsibility to ensure that critical information is recorded, organized, and stored. Records need to be kept on preflight information, each tanking attempt, flight information, problem analysis and resolution, and post-flight reporting.

PROCEDURES

A. Preflight Record Keeping

All documentation supporting flight planning will be kept in the first section of the flight log book. A minimum set of items to include in this section consist of the following:

1. Our preparation for the flight readiness review (FRR).
2. Copies of the Vehicle Integration Test Team (VITT) reports.
3. Memorandums of record of conversations with other agencies (including MSFC, KSC, Rocketdyne, etc.).
4. Our reports to management.
5. Copies of presentations received at the FRR. All need to be kept as flight data.
6. The baseline propellant inventories and the ET computations worksheet.
7. Copies of the launch limits and computations loaded into the MED.
8. SODB submittals that are flight specific.
9. Flight requirements document.
10. Other documents deemed essential by the Booster Systems Engineer.

B. Record Keeping for Launch Attempts

Each launch attempt will be fully documented and appended in the operations log book by section in chronological order. A minimum set of items to include for each section include:

1. L-1 day briefing material and associated flight controller notes.

2. Validation of the proper limits that were loaded into the MOC. Hard copies of the displays to validate these limits will be arranged by numerical order.

3. Prelaunch console notes. It is desirable that these notes be made on JSC form 1441. If you run short of these forms, additional ones may be obtained from the Ground Controller organization. Time of events may be logged as GMT or GET. For an example of a prelaunch log, please refer to figure 6.4-I or to previous operations logs contained in the Booster library.

4. Should the launch be scrubbed, the reasons will be fully documented. Problems with booster systems will be documented here and in section 4.

C. Flight log information

Each console operator will keep a daily log of JSC from 1441 (Flight Controller's Log). During the flight, the log will be kept in a binder at each console position. Each page in the log will be conspicuously numbered, day of mission recorded, and all entries tagged with GMT or MET (HR:MIN:SEC), site pass, and orbit number. The following data will be briefly noted in the log as appropriate:

1. Planned changes in the flight plan or crew procedures that affect booster systems, and the probable impact on the system.

2. Flight plan accomplishments, scheduled maintenance, and deviations from planned procedures.

3. Systems anomalies with recommendations, diagnostic procedures, corrective action, and the results of any action.

4. Telemetry and pertinent crew reports (transcripts of lengthy air to ground conversations should be obtained from the voice data manager and inserted in the log).

5. Problems with other systems (EECOM, DPS, etc.) that impact the booster systems and vice versa.

6. Instructions to the crew that have not been completed, and inflight maintenance planned for the next 24-hour period.

7. Individual console status (including problems with the COMM panel, event lights, chart recorders, etc. and the records of the required discrepancy reports submitted to address those problems.)

8. Problems with ground equipment (space tracking and data network (STDN), data computation complex (DCC), Shuttle data processing complex (SDPC), MED terminals, etc.) and records of discrepancy reports submitted.

9. Copies of all MED's and data playback forms.

10. SPAN CHITS, a brief description of the CHITS, and requirements for data. A clipboard containing open and closed CHITS will be maintained separately from the log.

11. Logs of integrated simulation runs will be maintained as desired by console operators and not kept with the console operations logbook.

12. The Booster, MPS, and ME console operators' logs are combined and filed by flight for future reference. Log books are presently kept in the Booster library located in building 4.

13. Hard copies of displays taken will be arranged by display number. All displays of the same MSK number will be chronologically sorted.

14. Cue cards used to support the flight will be documented. Cue cards include main engine tables, turbine temperature predictions, boundary charts, predicted key events, MPS parameter values, and any others developed and used.

15. The flight operations handbook, published by Rocketdyne, will be kept.

16. MPS performance predictions published by Rockwell are kept.

17. Figure 6.4-II shows an example of a flight log. In addition, you may refer to previous log books.

D. Problem tracking and resolution

Problem tracking and resolution is a vital part of MOD operations. Record keeping in this area is essential for trend analysis.

1. A summary sheet describing all flight problems that are booster systems related will be posted as the first part of this section.

2. All flight problems will be annotated on anomaly forms. Anomaly forms will follow the latest management guidance and will be approved by the booster engineer prior to submission to SPAN. Copies of the latest anomaly listing will be kept. An example of an anomaly list is figure 6.4-III. An instruction set on preparing anomaly reports is shown in figure 6.4-IV.

3. Anomalies will also be logged in the booster anomaly log book. This book is kept in the booster library.

4. Each anomaly will be fully documented. As a minimum include: copies of displays used to diagnose problems, additional plots and computations, diagnostic procedures used and the resulting effects, supporting documentation regarding the above, and any close-out reports.

5. The problem tracking list needs to be kept in chronological order.

E. Post-flight reports

1. Post-flight analysis reports from Rockwell, MSFC post-flight reports, and MPS performance reports need to be kept.

2. Booster flight summary briefings and supporting notes need to be kept.

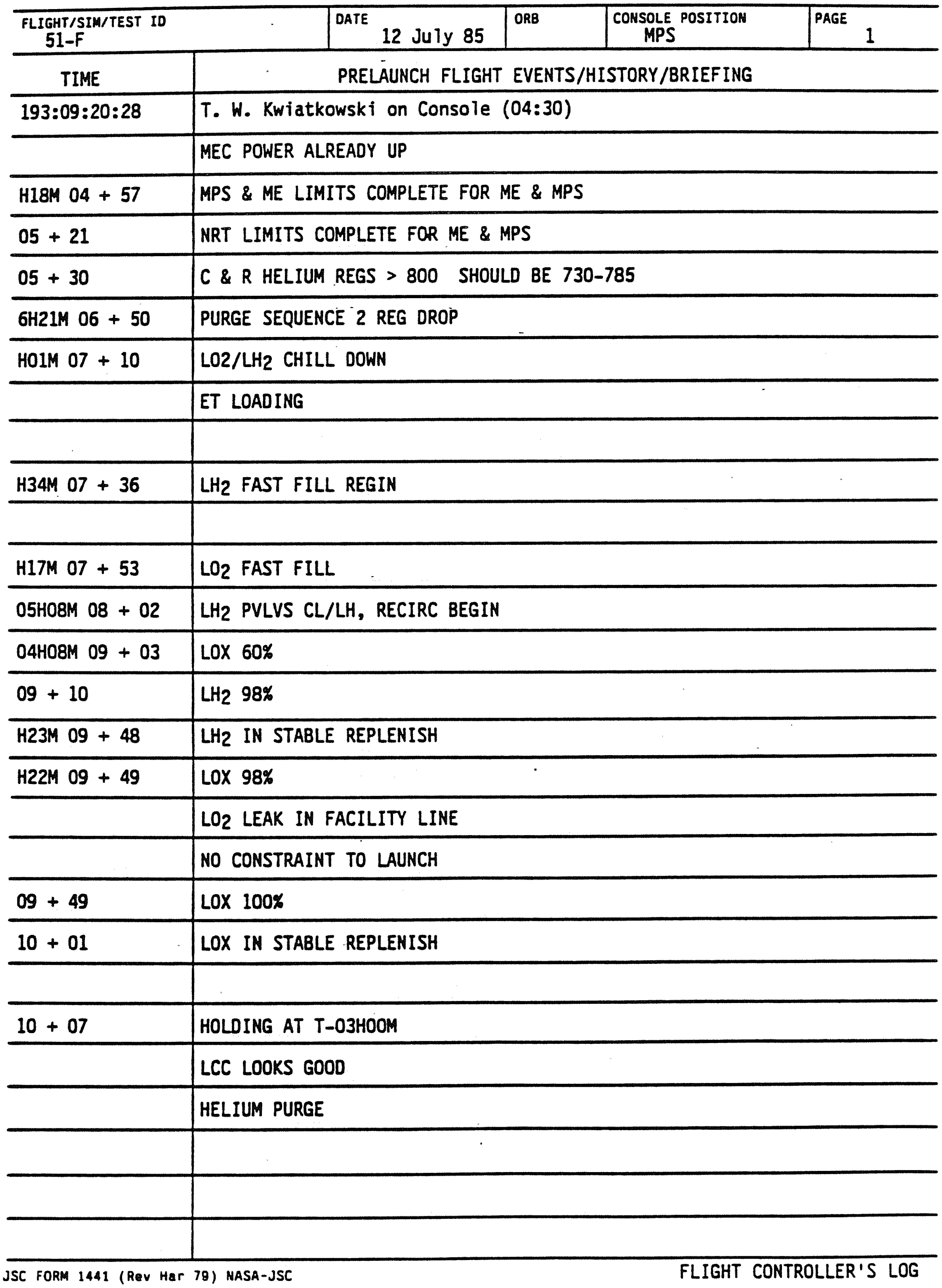
3. Notes of interest regarding the flight, both formal and informal, need to be copied and placed in the log. In addition, these notes of interest will be placed in the Note of Interest book and distributed to all section personnel. A section on "lessons learned" should be included as part of the note of interest.

F. Classified procedures

Classified data and logs will follow guidance received from the security representative and from the division Accountability Records Custodian (ARC). Volume II of the FCOH has pertinent information regarding the handling of classified data, and this information should be reviewed periodically and especially before handling classified data.

REFERENCE

FCOH, Volume II, JSC-12805, Jan 16, 1987.



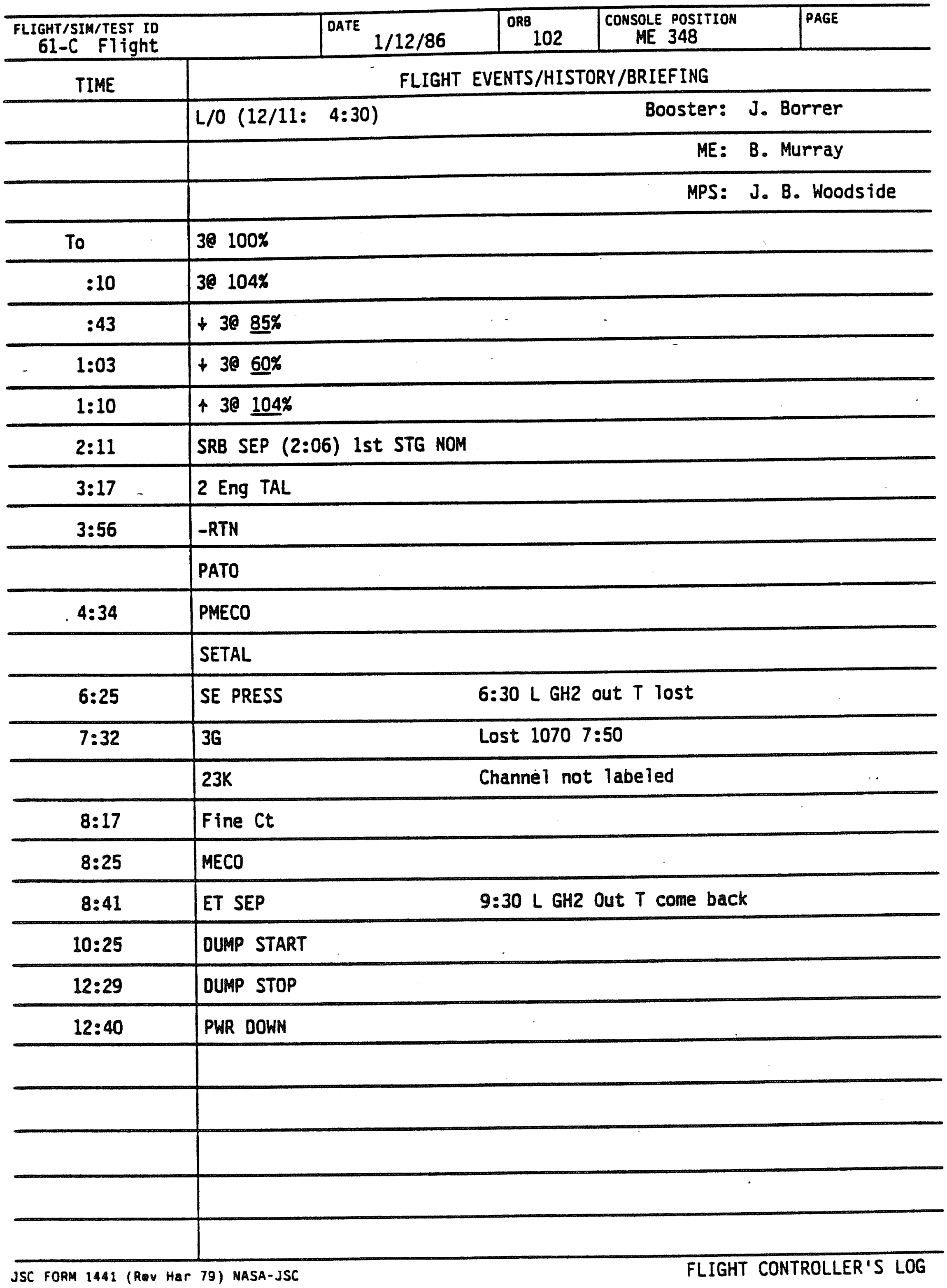
FLIGHT/SIM/TEST ID	DATE	ORB	CONSOLE POSITION	PAGE
51-F	12 July 85		MPS	1

TIME	PRELAUNCH FLIGHT EVENTS/HISTORY/BRIEFING
193:09:20:28	T. W. Kwiatkowski on Console (04:30)
	MEC POWER ALREADY UP
H18M 04 + 57	MPS & ME LIMITS COMPLETE FOR ME & MPS
05 + 21	NRT LIMITS COMPLETE FOR ME & MPS
05 + 30	C & R HELIUM REGS > 800 SHOULD BE 730-785
6H21M 06 + 50	PURGE SEQUENCE 2 REG DROP
H01M 07 + 10	LO2/LH_2 CHILL DOWN
	ET LOADING
H34M 07 + 36	LH_2 FAST FILL REGIN
H17M 07 + 53	LO_2 FAST FILL
05H08M 08 + 02	LH_2 PVLVS CL/LH, RECIRC BEGIN
04H08M 09 + 03	LOX 60%
09 + 10	LH_2 98%
H23M 09 + 48	LH_2 IN STABLE REPLENISH
H22M 09 + 49	LOX 98%
	LO_2 LEAK IN FACILITY LINE
	NO CONSTRAINT TO LAUNCH
09 + 49	LOX 100%
10 + 01	LOX IN STABLE REPLENISH
10 + 07	HOLDING AT T-03H00M
	LCC LOOKS GOOD
	HELIUM PURGE

JSC FORM 1441 (Rev Mar 79) NASA-JSC

FLIGHT CONTROLLER'S LOG

Figure 6.4-I.- Example of prelaunch log
(normally handwritten).

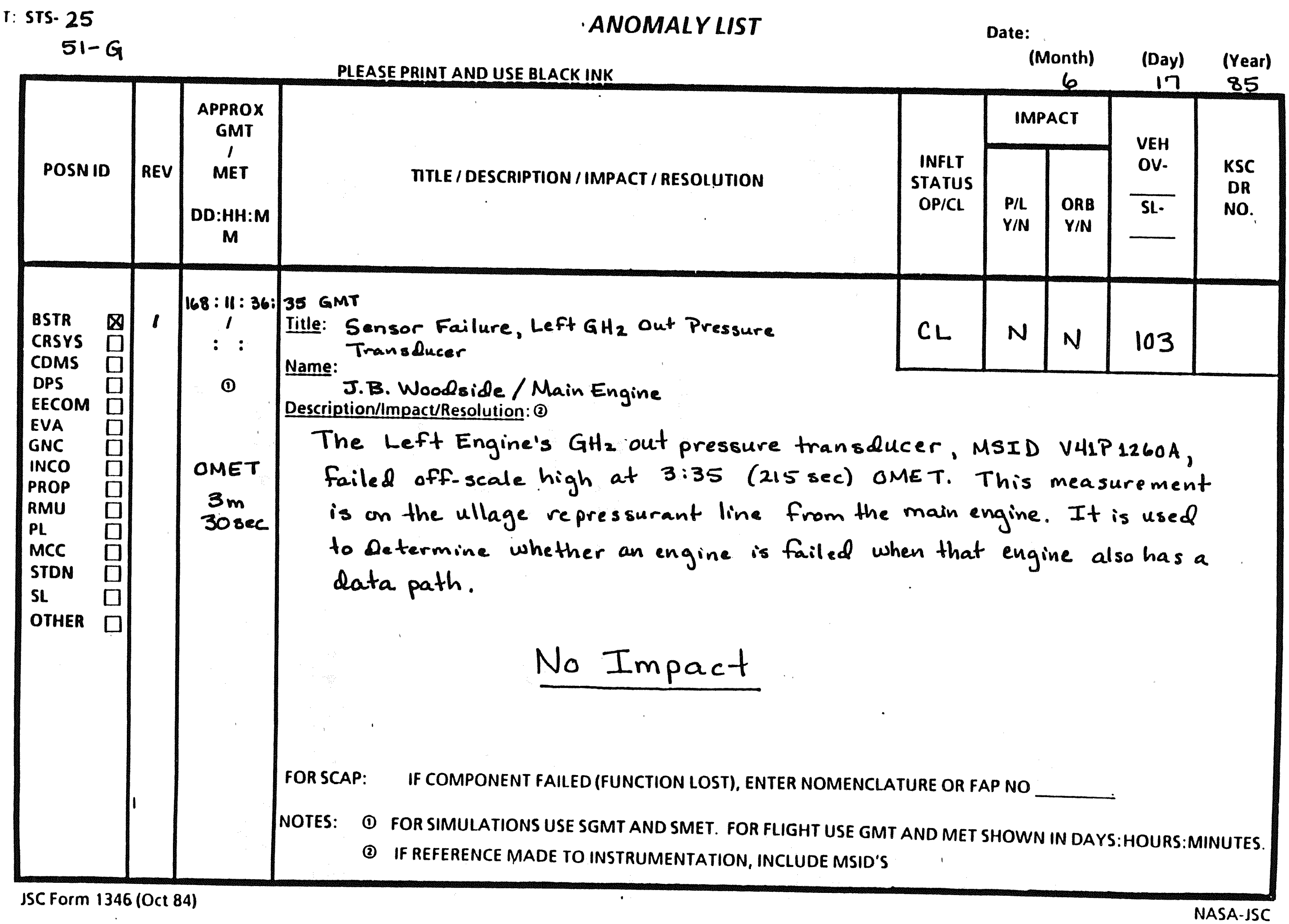


FLIGHT/SIM/TEST ID	DATE	ORB	CONSOLE POSITION	PAGE
61-C Flight	1/12/86	102	ME 348	

TIME	FLIGHT EVENTS/HISTORY/BRIEFING	
	L/O (12/11: 4:30)	Booster: J. Borrer
		ME: B. Murray
		MPS: J. B. Woodside
To	3@ 100%	
:10	3@ 104%	
:43	↓ 3@ 85%	
1:03	↓ 3@ 60%	
1:10	↑ 3@ 104%	
2:11	SRB SEP (2:06) 1st STG NOM	
3:17	2 Eng TAL	
3:56	-RTN	
	PATO	
4:34	PMECO	
	SETAL	
6:25	SE PRESS	6:30 L GH2 out T lost
7:32	3G	Lost 1070 7:50
	23K	Channel not labeled
8:17	Fine Ct	
8:25	MECO	
8:41	ET SEP	9:30 L GH2 Out T come back
10:25	DUMP START	
12:29	DUMP STOP	
12:40	PWR DOWN	

JSC FORM 1441 (Rev Mar 79) NASA-JSC
FLIGHT CONTROLLER'S LOG

Figure 6.4-II.- Example of flight log
(normally handwritten).



T: STS- 25
51-G

ANOMALY LIST

Date: (Month) 6 (Day) 17 (Year) 85

PLEASE PRINT AND USE BLACK INK

POSN ID	REV	APPROX GMT / MET DD:HH:MM	TITLE / DESCRIPTION / IMPACT / RESOLUTION	INFLT STATUS OP/CL	IMPACT P/L Y/N	IMPACT ORB Y/N	VEH OV- SL-	KSC DR NO.
BSTR ☒ CRSYS ☐ CDMS ☐ DPS ☐ EECOM ☐ EVA ☐ GNC ☐ INCO ☐ PROP ☐ RMU ☐ PL ☐ MCC ☐ STDN ☐ SL ☐ OTHER ☐	1	168 : 11 : 36 : 35 GMT / : : ① OMET 3m 30sec	**Title:** Sensor Failure, Left GH2 Out Pressure Transducer **Name:** J.B. Woodside / Main Engine **Description/Impact/Resolution:** ② The Left Engine's GH2 out pressure transducer, MSID V41P1260A, failed off-scale high at 3:35 (215 sec) OMET. This measurement is on the ullage repressurant line from the main engine. It is used to Determine whether an engine is failed when that engine also has a data path. No Impact	CL	N	N	103	

FOR SCAP: IF COMPONENT FAILED (FUNCTION LOST), ENTER NOMENCLATURE OR FAP NO ______

NOTES: ① FOR SIMULATIONS USE SGMT AND SMET. FOR FLIGHT USE GMT AND MET SHOWN IN DAYS:HOURS:MINUTES.
② IF REFERENCE MADE TO INSTRUMENTATION, INCLUDE MSID'S

JSC Form 1346 (Oct 84)

NASA-JSC

Figure 6.4-III.- Anomaly list example.

1. PREPARE THREE COPIES (MINIMUM)--TWO COPIES MUST BE SENT TO THE SPAN ROOM. PRIOR TO SENDING THE ANOMALY TO THE SPAN, IT MUST BE REVIEWED AND INITIALED BY THE BOOSTER. ONE COPY IS TO BE PLACED IN THE CONSOLE LOG.

2. CHECK DISCIPLINE INVOLVED AND WRITE NUMBER OF ANOMALY; E.G., 01, 02, 03, ETC.

3. REV COLUMN IS TO BE MARKED "A, B, C, ...," IF THIS IS A REVISION TO A PREVIOUS ANOMALY; AND INDICATES A TECHNICAL CHANGE TO THE ORIGINAL ANOMALY. INDICATE TIMES AND AUTHOR IF EITHER IS DIFFERENT THAN ORIGINAL ANOMALY.

4. MAKE THE TITLE SHORT, USE ABBREVIATIONS; E.G., XDCR, XFEED, HTR, RT, ETC.

5. AUTHOR: USE INITIAL OF FIRST NAME WITH LAST NAME; E.G., M. KIMBALL.

6. MAKE THE DESCRIPTION, IMPACT, AND RESOLUTION CONCISE AND TECHNICALLY COMPLETE (SINGLE OUT COMPONENT TO WHICH SYSTEM, OR WHICH COMPONENT WITHIN A SYSTEM). USE MSID NUMBER FOR EACH PIECE OF INSTRUMENTATION REFERENCED.

   SEPARATE IMPACT AND RESOLUTION FROM DESCRIPTION BY BLANK LINES AND PRINTING "IMPACT:" AND "RESOLUTION:".

   INCLUDE FAP NO. OR NOMENCLATURE WHERE APPROPRIATE IN SPACE PROVIDED.

7. INDICATE IN-FLIGHT STATUS OF ANOMALY. "OPEN" MEANS MORE INFORMATION MAY BECOME AVAILABLE DURING FLIGHT. "CLOSED" MEANS THAT NO MORE INFORMATION WILL SURFACE THE REST OF THE MISSION.

8. IMPACT FOR P/L OR ORBITER SHOULD BE MARKED "Y" IF THERE IS AN IN-FLIGHT IMPACT TO OPERATIONS OF EITHER ONE.

9. ORBITER OR SPACELAB NUMBER SHOULD BE PUT IN THE BLOCK UNDER THE HEAVY BLACK LINE.

10. LEAVE THE KSC DR NO. COLUMN BLANK. SPAN ASSIGNS A NUMBER IF ONE IS NEEDED.

NOTE: PLEASE WRITE CLEARLY. THE PEOPLE PROCESSING ANOMALY REPORTS ARE NOT FAMILIAR WITH YOUR SYSTEMS, ACRONYMS, ABBREVIATIONS, ETC. PAY SPECIAL ATTENTION TO THE FOLLOWING AS THEY ARE OFTEN TYPED INCORRECTLY:

Φ (PHASE) AND Ø (ZERO) [IT IS BEST NOT TO USE Ø FOR ZERO].
MAKE V DISTINCTLY SO IT IS NOT CONFUSED WITH U.
MAKE D DISTINCTLY SO IT IS NOT CONFUSED WITH O.
MAKE G DISTINCTLY SO IT IS NOT CONFUSED WITH C.

Figure 6.4-IV - Instructions for preparing anomaly reports.

TITLE

POSTLAUNCH DATA PLAYBACKS/REQUESTS

PURPOSE

This SCP explains the method by which Booster, MPS, and Main Engine console operators will make postlaunch data requests.

DESCRIPTION

Two types of data requests will normally be used. The first type consists of data playbacks on the console CRT's. These playbacks will be requested to cover those periods of time when station coverage is not available (LOS) and only recorded data is available. The second type of data request is a microfiche printout of predefined parameter groups. This type of printout can be requested in two forms: near real-time (NRT) and super THRIFT. The historical type data are available at sample rates of one sample per minute to one sample per second. A description of the data request forms for each type of data request is presented in this SCP. All forms must be filled out in triplicate. One form is kept by the originator and two copies are sent to the Data Integrator (DI) via the console pneumatic tube.

PROCEDURES

A. Playback

A playback of real-time data or dumped telemetry data may be requested from the DI via a Mission Data Request Form (MDRF) (reference FCOH procedure 10.1). Playbacks are useful when an operator wishes to review a problem seen earlier on real-time data, or if an operator wishes to review data that was recorded during an LOS period. For review of SSME and MPS data, the operator should specify the start and stop times (RGMT) on the MDRF. (Use SGMT during simulations.) The DI (DI) will coordinate the playback with the operator on either the MOCR PROP or DATA communication loop. Since the DI might have to process several playback requests, it is essential that the operator make a brief statement about the time criticality of the request. In some cases, a Booster playback might coincide with another request. For example, the Propulsion console operators will make a playback request which starts at OMS-1 ignition minus 1 min and will continue until after the MPS dump termination. No Booster request is necessary for this time period since the propulsion request is adequate to cover the Booster requirements. Data playbacks will be announced on the AFD Conference loop with times displayed on OGMT 1 and OGMT 2. Probably the earliest time that a Booster playback request will be honored will be at the Indian Ocean LOS on orbit 1. The playback from this data dump should cover from lift-off through the end of the MPS dump (MET=15 minutes). A typical example of an MDRF filled out for a data playback is shown in figure 6.5-I.

B. Microfiche Printout

(FCOH 4.8.1, 4.8.2)

Two types of telemetry history reports are available for operational use. Each type will be discussed below.

1. NRT (FCOH 4.8.1) - NRT products at a sample rate of 1 sample every minute are produced on a planned periodic basis every 4 hours during STS operations. No MDRF form is required since this NRT is an automatic support function. The data are delivered to the Main Engine console in microfiche form. Formats and parameters are defined premission and are described in SCP 5.1.6 for the main engine and in SCP 5.2.5 for the MPS. NRT can also be used to generate subsets of formats at non-standard intervals other than 4 hours. Microfiche outputs can be requested at sample rates from 1 s/s to 59 s/s (s/s = sample per second). The maximum time period is 30 minutes, and 30 formats can be requested. Nominally the main engine flight controller requests NRT at one sample per second for the ascent phase of flight. NRT may be requested by using the procedures in SCP 5.1.5 and the instructions in 4.8 and 10.1 of the FCOH.

2. Super THRIFT (FCOH 4.8.2) - Super THRIFT products are produced on the ODRC CYBER 174 computer in building 30 using a CCT on the TPC computer from data that contains all TLM parameters in the Orbiter TLM downlink at vehicle sample rates. These THRIFT products are provided only on request from format groups that are defined preflight. Super THRIFT outputs can be requested in line printer form, microfilm or microfiche form, or as a continuous form plot. The requesting operator must fill out an MDRF and ODRC form and transmit these forms to the DI.

   The FCOH states that Super THRIFT requests should be limited to approximately 10 minutes of data and two format groups, but large requests have been made in the past. The formats for super THRIFT are listed in SCP 5.1.7 for main engine parameters and SCP 5.2.6 for MPS parameters. An example of a Super THRIFT MDRF is given in figure 6.5-II and an example of the corresponding ODRC is shown in figure 6.5-III.

REFERENCE

Flight Control Operations Handbook (FCOH), Final, Rev. B, January 16, 1987.

TITLE

BOOSTER SCR FORMATS

PURPOSE

This SCP describes the strip chart recorder (SCR) formats available for use at the main engine (ME) and main propulsion system (MPS) consoles. Note that the real time data system (RTDS) and its VCR playback feature have essentially eliminated the use of SCR's at the ME and MPS consoles, but the SCR's are still available if needed.

DESCRIPTION

In MPSR-1: during ascent, the ME console (console number 348) can use SCR's 725, 627, and 626. The MPS console (console number 350) can use SCR 624 (PROP MPSR console 347). Note that the SCR's in MPSR-1 are slaved to console number 347 as follows: 725 slaved to 623, 627 slaved to 606, and 626 slaved to 622. In MPSR-2: during ascent, the ME console (console number 466) can use SCR's 722, 723, and 724. The MPS console can use SCR 706.

The MOC program does not initialize the SCR's; therefore, the console operators are responsible for initializing the SCR's. In MPSR-1: recorders 725, 627, 626, and 624 are configured by the OREO operator (console number 347). In MPSR-2: recorders 706 and 722 are configured by the ME operator (console number 466). Recorders 723 and 724 are configured by the OREO operator (console number 465). Each SCR is configured for flight by using the manual select keyboard (MSK) to assign a predefined format to the SCR. The MSK inputs required to configure the SCR's are described in SCP 6.1.

After MECO, the SCR's in MPSR-1 are nominally turned off, the SCR's in MPSR-2 are nominally reconfigured for further use by the OREO console position. However, if any anomalies occur in the MPS, the MPS operator can use formats 116 or 117 for troubleshooting (see table 6.6-I for details).

To interpret the time code recorded on the SCR paper, refer to section 4.2.3 in the Flight Control Operations Handbook.

The SCR formats available to each SCR for ascent are listed in table 6.6-I below.

TABLE 6.6-I.- BOOSTER SCR FORMATS

Control console	Format no.	SCR ID	Right lever	Location description	When used	Mon by
MPSR-1:						
347	114	623 (725)	?	Left of console 350	Ascent	ME
347	113	606 (627)	?	Right of console 350	Ascent	ME
347	115	622 (626)	?	Right of console 348	Ascent	ME
347	116	623 (725)	?	Left of console 350	MECO	MPS
347	117	606 (627)	?	Right of console 350	MECO	MPS
347	112	624	?	PROP console 347	Ascent	MPS
347	111	624	?	PROP console 347	SRB-SEP	MPS
MPSR-2:						
466	114	722	2	Right of console 466	Ascent	ME
465	113	723	1	Left of console 465	Ascent	ME
465	115	724	2	Right of console 465	Ascent	ME
466	116	706	1	Left of console 466	MECO	MPS
466	117	722	2	Right of console 466	MECO	MPS
466	112	706	1	Left of console 466	Ascent	MPS
466	111	706	1	Left of console 466	SRB-SEP	MPS
466	092	706	1	Left of console 466	MECO	OREO
466	094	722	2	Right of console 466	MECO	OREO

SCR pen assignments for each format are shown in table 6.6-II.

TABLE 6.6-II.- SCR PEN ASSIGNMENTS

Format no.	Pen ID	Measurement no.	Overlay label	Data type
111	A01	T41P1751C	L LO2 ULL P	PFCS
	A02	T41P1750C	C LO2 ULL P	PFCS
	A03	T41P1752C	R LO2 ULL P	PFCS
	A04	V41P1533C	LO2 ENG MANF P	PFCS
	A05	T41P1701C	L LH2 ULL P	PFCS
	A06	T41P1700C	C LH2 ULL P	PFCS
	A07	T41P1702C	R LH2 ULL P	PFCS
	A08	V41P1433C	LH2 ENG MANF P	PFCS
	E01	V41X1598E	L GO2 PSV CLP	OI
	E02	V41X1596E	C GO2 PSV CLP	OI
	E03	V41X1603E	R GO2 PSV CLP	OI
	E04	V41X1662E	L GH2 PSV CLP	OI
	E05	V41X1661E	C GH2 PSV CLP	OI
	E06	V41X1663E	R GH2 PSV CLP	OI
	E07	V41X1555E	LO2 CO SEN 1	PFCS
	T01	V91M7475PX	GNC MET	PFCS
	T02	V91M1999PX	ORBITER PRIME GPC-GMT	PFCS
112	A01	B47P1300C	L SRB PC 1	PFCS
	A02	B47P1301C	L SRB PC 2	PFCS
	A03	B47P1302C	L SRB PC 3	PFCS
	A04	B47P2300C	R SRB PC 1	PFCS
	A05	B47P2301C	R SRB PC 2	PFCS
	A06	B47P2302C	R SRB PC 3	PFCS
	A07	V41P1533C	LO2 ENG MANF P	PFCS
	A08	V41P1433C	LO2 ENG MANF P	PFCS
	E01	B58X1859X	L TILT P OK	PFCS
	E02	B58X1860X	L ROCK P OK	PFCS
	E03	B58X2859X	R TILT P OK	PFCS
	E04	B58X2860X	R ROCK P OK	PFCS
	E05	T41X1774E	LO2 VNT V CL	OI
	E06	T41X1724E	LH2 VNT V CL	OI
	E07	T41X1730X	LH2 CO SEN 1	PFCS
	T01	V91M7475PX	GNC MET	PFCS
	T02	V91M1999PX	ORBITER PRIME GPC-GMT	PFCS

TABLE 6.6-II.- Continued

Format no.	Pen ID	Measurement no.	Overlay label	Data type
113	A01	E41P1016B	C PC A	PFCS
	A02	E41P1017B	C PC B	PFCS
	A03	E41P1008B	C HPOT PR SL DR P A	PFCS
	A04	E41P1009B	C HPOT PR SL DR P B	PFCS
	A05	E41P1051B	C HPOT SEC SL CAV P A	PFCS
	A06	E41P1053B	C HPOT SEC SL CAV P B	PFCS
	A07	E41P1014B	C HPOT ISP P A	PFCS
	A08	E41P1015B	C HPOT ISP P B	PFCS
	E01	E41X1511B	C LIM CONT ENABLED	PFCS
	E02	E41X1505B	C DCU A DATA	PFCS
	E03	V91X2927XX	C EIU P1	PFCS
	E04	V91X2813XX	C EIU P4	PFCS
	E05	MZZT4061E	OI VALIDATION	OI
	E06	V41X1134X	C LO2 PV OP	PFCS
	E07	V90X8331X	SRB SEP & CMD FLAG	PFCS
	T01	V91M7475PX	GNC MET	PFCS
	T02	V91M1999PX	ORBITER PRIME GPC-GMT	PFCS
114	A01	E41P2016B	L PC A	PFCS
	A02	E41P2017B	L PC B	PFCS
	A03	E41P2008B	L HPOT PR SL DR P A	PFCS
	A04	E41P2009B	L HPOT PR SL DR P B	PFCS
	A05	E41P2051B	L HPOT SEC SL CAV P A	PFCS
	A06	E41P2053B	L HPOT SEC SL CAV P B	PFCS
	A07	E41P2014B	L HPOT ISP P A	PFCS
	A08	E41P2015B	L HPOT ISP P B	PFCS
	E01	E41X2511B	L LIM CONT ENABLED	PFCS
	E02	E41X2505B	L DCU A DATA	PFCS
	E03	V91X2930XX	L EIU P1	PFCS
	E04	V91X2817XX	L EIU P4	PFCS
	E05	MZZT1024XX	PFCS VALIDATION	PFCS
	E06	V41X1234X	L LO2 PV OP	PFCS
	E07	V90X8259X	ET SEP INH	PFCS
	T01	V91M7475PX	GNC MET	PFCS
	T02	V91M1999PX	ORBITER PRIME GPC-GMT	PFCS

TABLE 6.6-II.- Continued

Format no.	Pen ID	Measurement no.	Overlay label	Data type
115	A01	E41P3016B	R PC A	PFCS
	A02	E41P3017B	R PC B	PFCS
	A03	E41P3008B	R HPOT PR SL DR P A	PFCS
	A04	E41P3009B	R HPOT PR SL DR P B	PFCS
	A05	E41P3051B	R HPOT SEC SL CAV P A	PFCS
	A06	E41P3053B	R HPOT SEC SL CAV P B	PFCS
	A07	E41P3014B	R HPOT ISP P A	PFCS
	A08	E41P3015B	R HPOT ISP P B	PFCS
	E01	E41X3511B	R LIM CONT ENABLED	PFCS
	E02	E41X3505B	R DCU A DATA	PFCS
	E03	V91X2933XX	R EIU P1	PFCS
	E04	V91X2821XX	R EIU P4	PFCS
	E05	V41X1304X	R LH2 PV OP A	PFCS
	E06	V42X1334X	R LO2 PV OP	PFCS
	E07	V90X8250X	ET SEP CMD FLAG	PFCS
	T01	V91M7475PX	GNC MET	PFCS
	T02	V91M1999PX	ORBITER PRIME GPC-GMT	PFCS
116	A01	V41P1260A	L GH2 OUT P	OI
	A02	V41P1160A	C GH2 OUT P	OI
	A03	V41P1360P	R GH2 OUT P	OI
	A04	V41T1252A	L HE MID TK T	OI
	A05	V41T1251A	L HE TK T	OI
	A06	V41T1151A	C HE TK T	OI
	A07	V41T1351A	R HE TK T	OI
	A08	V41T1601A	PN HE TK T	OI
	E01			
	E02	T41X1762E	LO2 5%	OI
	E03			
	E04	T41X1712E	LH2 5%	OI
	E05			
	E06			
	E07			
	T01	V75W3504D	ORBITER MTU-1 GMT	OI
	T02	V75W3514D	ORBITER MTU-1 MET	OI

TABLE 6.6-II.- Concluded

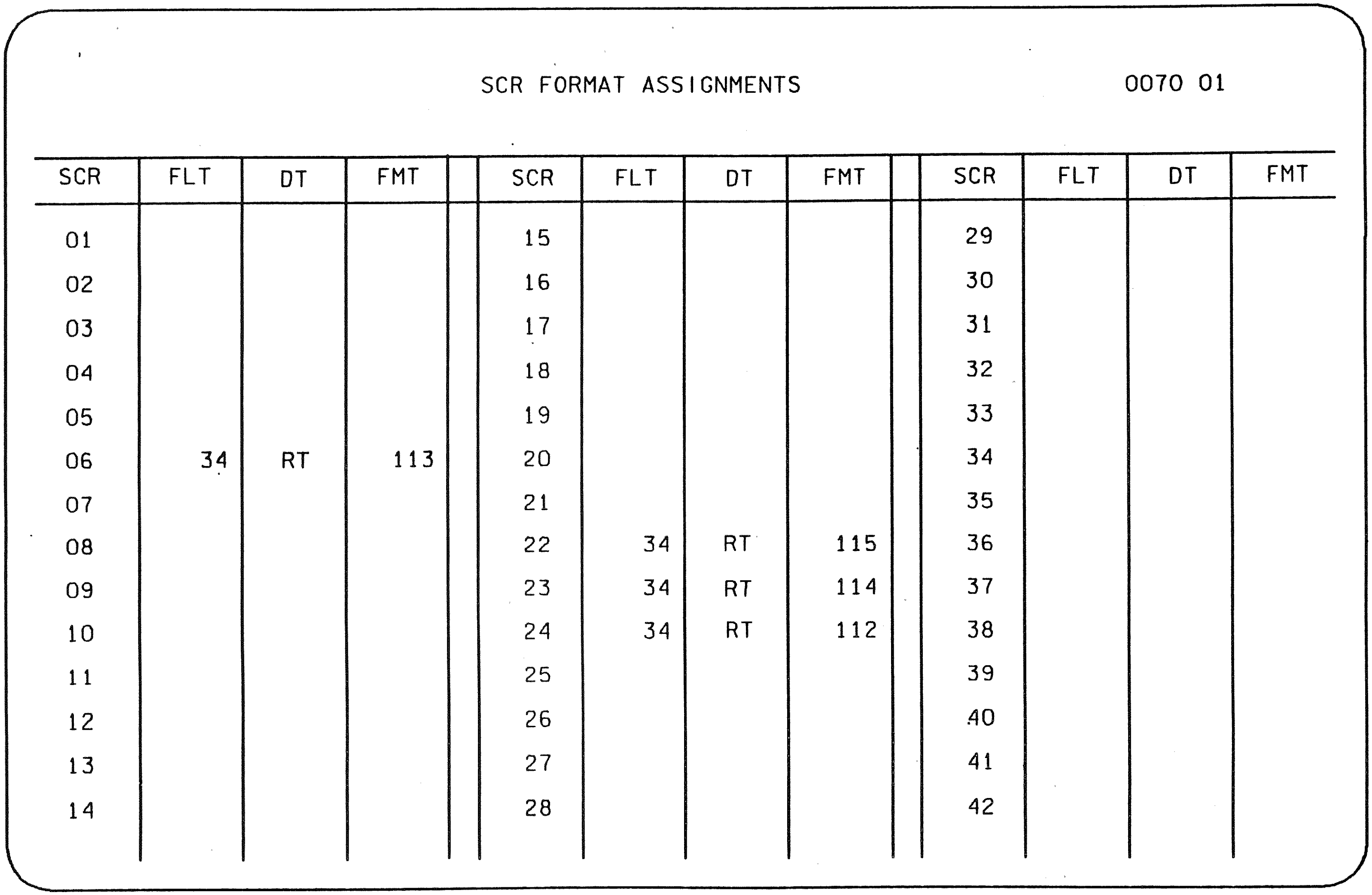
Format no.	Pen ID	Measurement no.	Overlay label	Data type
117	A01	E41P2023B	L PC	PFCS
	A02	E41P1023B	C PC	PFCS
	A03	E41P3023B	R PC	PFCS
	A04	V41T1201C	L LH2 IN T	PFCS
	A05	V41T1101C	C LH2 IN T	PFCS
	A06	V41T1301C	R LH2 IN T	PFCS
	A07	V95H0175C	ALTITUDE	PFCS
	A08	V90U1948C	PWR LVL CMD	PFCS
	E01	V41X1530X	LO2 FD DISC V CL A	PFCS
	E02	V41X1534X	LO2 FD DISC V CL B	PFCS
	E03	V41X1430X	LH2 FD DISC V CL A	PFCS
	E04	V41X1434X	LH2 FD DISC V CL B	PFCS
	E05	V72X4533X	BACK UP C & W	PFCS
	E06	V72X4526X	GNC ALERT	PFCS
	E07			
	T01	V91M7475PX	GNC MET	PFCS
	T02	V91M1999PX	ORBITER PRIME GPC-GMT	PFCS
118	A01	B46R1406C	L TRB SA1	PFCS
	A02	B46R1407C	L TRB SB1	PFCS
	A03	B46R1408C	L TRB SA2	PFCS
	A04	B46R1409C	L TRB SB2	PFCS
	A05	B46R2406C	R TRB SA1	PFCS
	A06	B46R2407C	R TRB SB1	PFCS
	A07	B46R2408C	R TRB SA2	PFCS
	A08	B46R2409C	R TRB SB2	PFCS
	E01	V41X1555X	LO2 CO SEN 1	PFCS
	E02	V41X1556X	LO2 CO SEN 2	PFCS
	E03	V41X1557X	LO2 CO SEN 3	PFCS
	E04	V41X1558X	LO2 CO SEN 4	PFCS
	E05	T41X1731X	LH2 CO SEN 2	PFCS
	E06	T41X1732X	LH2 CO SEN 3	PFCS
	E07	T41X1733X	LH2 CO SEN 4	PFCS
	T01	V91M7475PX	GNC MET	PFCS
	T02	V91M1999PX	ORBITER PRIME GPC-GMT	PFCS

Figures 6.6-I and 6.6-II show MSK 0070 (the SCR FORMAT ASSIGNMENTS display) for MPSR 1 and MPSR 2, respectively. On the display under SCR, the two-digit number represents the last two digits of the SCR. For example, SCR 606 will be found on the display as 06. The FLT column identifies the Shuttle flight number. The DT column identifies the data type (real time or playback) for the SCR. The FMT column shows the format number assigned to the SCR. This display should be checked prior to ascent to verify that the correct format has been assigned to each SCR used by the Booster system's consoles.

REFERENCES

1. Flight Control Operations Handbook, Final, Rev-B, JSC-12805, January 16, 1987.

2. Booster Data Pack, as of Sept. 1, 1989.

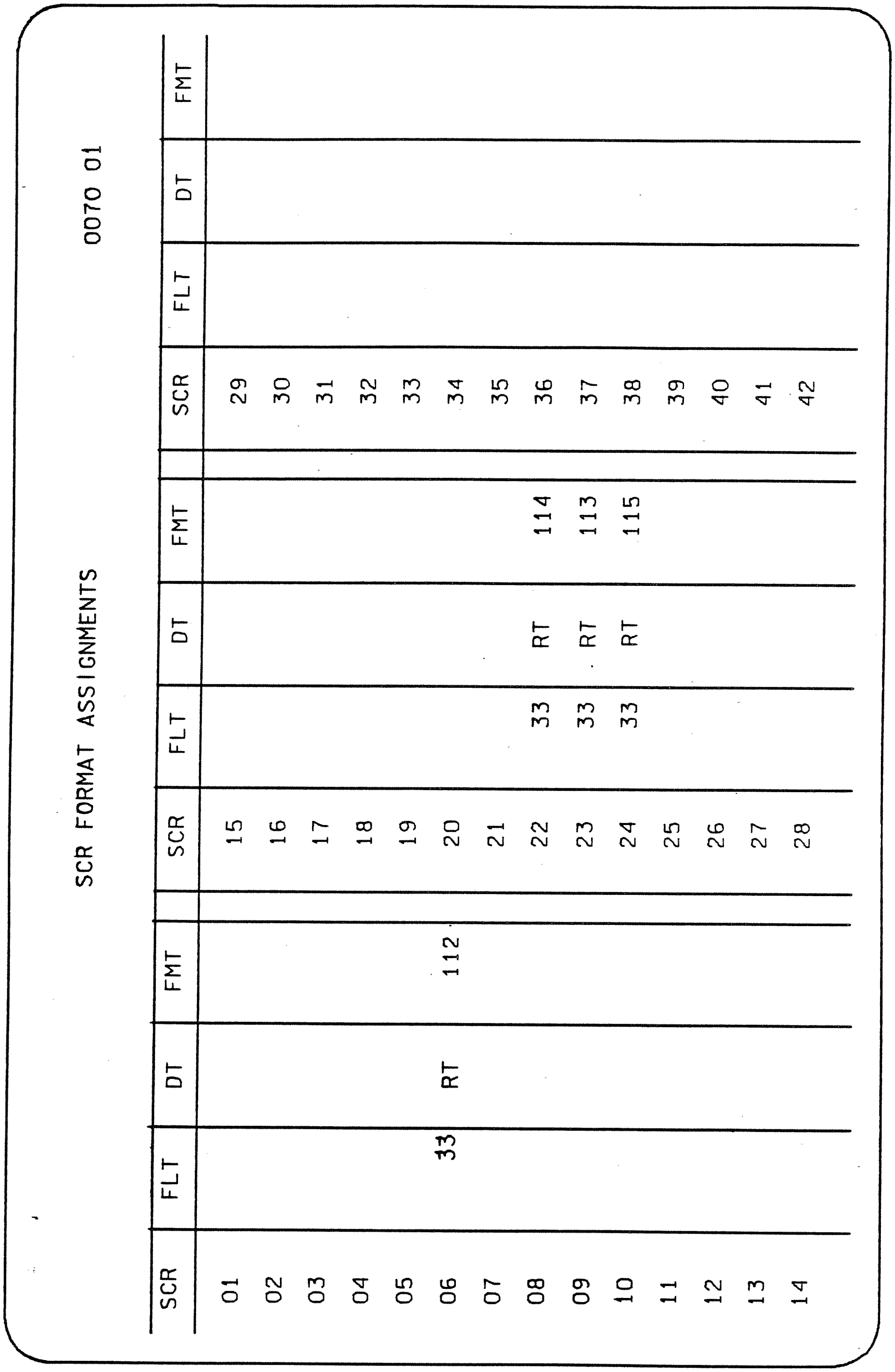


SCR FORMAT ASSIGNMENTS 0070 01

SCR	FLT	DT	FMT	SCR	FLT	DT	FMT	SCR	FLT	DT	FMT
01				15				29			
02				16				30			
03				17				31			
04				18				32			
05				19				33			
06	34	RT	113	20				34			
07				21				35			
08				22	34	RT	115	36			
09				23	34	RT	114	37			
10				24	34	RT	112	38			
11				25				39			
12				26				40			
13				27				41			
14				28				42			

0426. ART, 8

Figure 6.6-I.- MPSR 1 SCR format display.



SCR FORMAT ASSIGNMENTS

0070 01

SCR	FLT	DT	FMT	SCR	FLT	DT	FMT	SCR	FLT	DT	FMT
01				15				29			
02				16				30			
03				17				31			
04				18				32			
05				19				33			
06	33	RT	112	20				34			
07				21				35			
08				22	33	RT	114	36			
09				23	33	RT	113	37			
10				24	33	RT	115	38			
11				25				39			
12				26				40			
13				27				41			
14				28				42			

Figure 6.6-II.- MPSR 2 SCR format display.

TITLE

BOOSTER SUPPORT OF INTEGRATED LOAD CHECKOUTS

PURPOSE

This SCP describes our requirements for supporting an integrated load checkout.

DESCRIPTION

A. Definitions

Before discussing the support requirements and support procedures, a few key definitions are required. An integrated simulation is a procedural practice with simulated events and data combining the flight crew with mission support personnel and training personnel. The people and machines in building 30 and building 5 are networked together. To network the machines and to drive the displays, a large volume of software is relied upon. This software is termed a load. When new loads are delivered (put into the computer) they must be checked out (verified). The checkout includes verifying that the load does what it should do, that the load does not inadvertently change other parts of the system, and that the network can continue to do flight operations. Putting all this together defines what is meant by an integrated load checkout (ILC).

Further discussions rely on the terms "highly desirable" (HD) and "mandatory" (M). Mandatory means that the criteria listed for support or to meet verification requirements must be met for our acceptance of the load. Highly desirable means that the criteria should be met to ensure that the load is a good load. Every effort should be made to meet a highly desirable criteria.

B. Support Requirements

1. The checkout may be supported by a single operator. The operator should be ME and MPS certified (HD) or in certification process (M). Single operator support is possible only if the flight director will monitor the SPAN loop (M).

   Note: No FD - talk capability exists in the MPSR due to a reduction in capability required to support dual operation support. SPAN communication capability is present on both ME and MPS consoles.

2. If two operators support the ILC, one should be MPS certified and one should be ME certified or in the process of certification (M). The main engine certified operator should occupy the Booster FCR position because of the potential need to interface with the flight dynamics officer (FIDO) (HD).

3. Often during a load checkout, only part of the software delivery is changed. This process is called a delivery delta. Incorporation of delivery deltas should be done on a non-interference basis within the scope of the checkout. For example, new SMS or MOC capability may make it desirable to verify the SSME interface for the first 32 words of the vehicle data table for each engine. These deltas to the delivery may be tracked by simulator support requirements (SSR) and simulator modification requests (SMR).

C. Verification Requirements

1. Abort boundary times compare closely with flight predicted times.
2. All ME and MPS computations including ME performance computations and MPS Helium and NPSP computations work properly.
3. All DDD formats and all displays including displays 1052 and 1054 look proper and display the right information.
4. Universal plots should work properly.
5. New displays and DDD formats work as desired.
6. Strip chart recorder formats work properly. (Low priority)

D. Pre-ILC Preparation

Prior to the ILC, the data pack manager will prepare a status sheet that summarizes the changes that are in effect for that load. The status sheet is kept in the front of the data pack. The status sheet contains information on the following:

1. Displays - new displays
   - changes to existing displays
2. DDD's - new formats
   - changes to existing formats
   - applicable overlays
3. SCR's - new formats
   - changes to existing formats
   - applicable overlays
4. DRK or SMEK changes
5. Comm panel changes
6. CR's - changes to MOC comps - include changes to megadata disks
   - console hardware changes

E. ILC Check List

Figure 6.7-I is a blank form that is used during the ILC as a check list. Each step is checked off as it is completed. Any items with a discrepancy is circled and annotated on the form. Discrepancies are reported to the responsible console position. SMS problems are reported to Booster Monitor, console hardware problems are reported to Display, and console software or telemetry problems are reported to Computer TM. If the problem is serious enough, a Discrepancy Report (DR) is completed and sent to the Ground Controller (GC). These forms are obtained from GC. Be sure to use black ink and enclose a hard copy of MSK 0006, System Status. Xerox the DR for the data pack DR log. When the yellow copy comes back to the originator with the problem close out, it is filed in the DR log, which is located in the Booster Library.

ILC CHECK LIST
LOAD: STS - _____
FLIGHT: _________
FCR - __________
DATE: __________

Check Off the following items as they are completed
Circle any items where there is a problem
Return this form to the Data Pack Manager

1. Prepare MED disks with proper flight number and engine power level. Check SSME performance comp MED's against main engine table program.

2. Initialize Consoles

   Flight select console
   Select DDD's SCR formats, and displays
   Verify display request capability on DRK (BSE only)
   Verify talk/monitor capability on keysets
   Verify DDD's (MSK 0071, MSK 0075)
   Verify SCR's (MSK 0070)
   Load MED disks - NRT is not required
   Verify limits (MSK 2100 - 2102)
   Verify constants (MSK 2064 - 2065)
   Verify UP's (MSK 2759 - 2775)
   Verity WEX applications: helium and console config
   Verify RTDS operation: check ME and MPS display
   Compare RTDS and MOC telemetry

   MPS and ME "Go for Check Point"

3. After Lift-off verify the following:

   Main Displays, DDD's and SCR's - proper data shown

   SMEK functions - change limit sets
   - start UP's
   - update history tabs
   - enable/disable limits
   - clear FID's
   - start HE comp

   Special Comps - He TOD, NPSP, Prop Remaining
   - SSME PWR LVL, TFAIL, HARD FID,
   - MR, ISP, FUEL & LOX LBS/SEC

4. Cycle through all Booster displays, history tabs, and UP's

5. Report any discrepancies in telemetry on CRT's, DDD's, UP's or SCR's. Use DR form to document any hardware problem or telemetry discrepancy. Be sure to enclose a hard copy of MSK 0006 SYSTEMS STATUS with the DR.

   Xerox DR for Data Pack Manager log

Figure 6.7-I.- ILC check list.

TITLE

MISSION PLANNING

PURPOSE

This SCP documents what steps are taken to plan for a mission.

DESCRIPTION

Getting ready for a flight is a complex task. Reviewing documents and checking information is the first step. Preparing the main engine tables is another step. Predicting the expected turbine temperature profile is another mission planning task. We must prepare inputs for a flight readiness review and ensure that a flight team representative attends these meetings. Cue cards should be prepared or altered as necessary. Megadata (MED) inputs should be reviewed, discussed, and agreed upon. Finally, all mission documents should be reviewed as a final step to verify flight readiness.

PROCEDURES

A. Data Sources

The gathering of data is indispensable to the process of mission planning. Data sources include Marshall's engine tag predictions, Rocketdyne's turbine temperature and redline delta predictions, and system integration reports. Daily status reports from KSC are another helpful source of information, and previous flight data are reviewed. Understanding the flight rules and change requests in-work is essential. The flight data file and any proposed changes in-work are also important data sources. Any detailed test objectives (DTO's) proposed and any system handouts from system meetings are handy sources of information. Software change requests and memorandum concerning Orbiter software deltas are important. Finally, our booster library has many other sources of information which should be reviewed.

Documents, while important, are often not the best source of information; people are. We rely extensively on support from individuals throughout the main propulsion community. Rocketdyne representatives contribute vital information concerning current engines, engine developments, test history, and other engine concerns. The KSC SSME/MPS manager keeps close track of vehicle maintenance status, anomalies, and waivers for the flight. Senior booster personnel have extensive contacts and broad knowledge of system issues, and flight controllers in other sections can be relied upon when investigating the effects of certain failures on proposed actions.

B. Main Engine Tables

The main engine tables form an integral part of main engine and booster checklists. Their purpose is to predefine various cases of performance losses so that information can be quickly analyzed and passed to the flight dynamics officer (FIDO).

Prior to making the tables, the following information should be readily available: the flight number, the engine tags, the engine numbers, predicted turbine temperature values, the nominal power level for the flight, and the power level(s) for Max Q throttling. This information should be available from the previously mentioned data sources.

After collecting the data, sign onto a Masscomp computer in the second or third floor MPSR that has the "met" program loaded in its memory.

Enter the appropriate data for that mission and generate the tables. Reference SCP 7.1.2 for the program users guide.

Make three copies of the printout. The first copy is for the Main Engine position and replaces the current table. The second copy is for the Booster position. The third copy is for FIDO. The original is kept in a folder, titled "History of MET Program Tables."

Prior to each flight, predictions are made for each engine on the profile of the temperature transducers for the high pressure turbo-pump and for the high pressure liquid oxygen turbo-pump. This procedure is done so nominal or off-nominal engine performance can be easily monitored. Off-nominal turbine temperatures are used as cues to support off-nominal performance calls.

If the engines and the power level remain unchanged from the previous flight of that vehicle, then the previous flight data is most likely the best data to use for the tags.

After making the tables, compare them with historical and statistical data for consistency and reasonableness. Ensure the data for the HPOT and HPFT turbine temperatures are consistent with previous experience and prepare the cue card generated by the main engine table program. Distribute the cue card to the Main Engine position, to the Booster position, and to the history file.

C. Flight Readiness Review

The flight readiness review (FRR) is a review, completed prior to each flight, of pertinent flight and system information . Our section prepares inputs to the FRR, and members of our flight team attend the meetings. The FRR covers system anomalies since the last flight, equipment replacements, significant configuration differences, significant flight data file changes, significant changes in flight rules, unresolved anomalies, system waivers, and other pertinent issues.

The booster flight team prepares inputs for the Systems Division to present. Data are gathered from the sources mentioned previously. When preparing the FRR inputs, review previous FRR inputs to ensure consistency, and review anomalies that might show a trend. FRR is draft reviewed by the flight team and submitted to the Systems Division's technical advisor.

After writing the inputs, representatives are sent to the pre-FRR meetings and to the FRR. The representatives note system issues that concern our section and gather data that are presented. Most of the information is available as hand-outs. This information is used to assist in planning for the current mission, and to track future issues and problems.

D. MPS Cue Card Preparation

As part of mission planning, a cue card is prepared entitled "MPS Parameters and Performance Values." This card predicts values for pressurization flow, relief settings, and helium regulator out pressures. It includes LH2 and LO2 masses at various times, the predicted residuals, some key events, and other pertinent information (see the example from a previous flight). Many of the cue card parameters are vehicle dependent and do not change from flight to flight. An occasional check of flight data should be made to update the helium regulator out pressures.

The predicted events times and level-sensor-uncover times are obtained from the Rockwell preflight prediction analysis prepared by Rockwell's MPS Integration group. This analysis is submitted to JSC a few days before flight. The analysis includes a predicted SRB motor temperature from which the predicted Pc is adjusted using the following equation: $Pc = Pc(1 + .0011\Delta T)$

The maximum drainback time is obtained from the Level II performance prediction group.

E. Review MED Inputs

Another important part of flight readiness is the preparation of limits that will be loaded in Megadata terminals for the mission operations computer (MOC). Limits are prepared using previous flight disks, rationale, the results of previous limits set for flights, and careful reviews of the Launch Commit Criteria and flight limits. The Main Engine and Main Propulsion System operators revise these limits and discuss them with the Booster Systems engineer. The flight team agrees on the values, and they are put onto the floppy disk to be loaded for flight and/or simulations. Details on how to operate the MED terminals are listed in SCP 6.3. The Megadata hardware will be replaced in the future. The Masscomp can perform the same functions as the Megadata. Until the hardware is replaced, a consistant set of MED UP's and limits will be stored for both machines.

F. Final Review

The flight step in readying for a flight is to review mission documents and flight preparation items. Individuals on the flight team should review the Launch Commit Criteria, flight rules, the flight data file, and any proposed detailed tests to be done on their system. Flight checklists, cue cards, and limits should be reviewed. Data and documents to support the flight should be gathered and arranged for speedy information retrieval. Last minute system problems should be discussed and resolved. By completing these steps, you can feel confident that you have prepared for the flight.

TITLE

BOOSTER CONSOLE DOCUMENTATION STORAGE, UPDATE, AND CONTROL

PURPOSE

This SCP describes the configuration control and documentation procedures for console cue cards, overlays (SCR and DDD), and other console documentation.

DESCRIPTION

The following documents are available at the Booster FCR 1 and 2 for reference. These and all documents are updated as soon as a new version is released.

Booster Console Handbook (SCP's)
Booster Software Handbook
Booster Systems Briefs
Flight Data File (FDF)
Flight Controllers Operations Handbook (FCOH) Vol. I and II
Flight Procedures Handbook
Launch Commit Criteria (LCC)
MPS Components Manual
MPS Measurements Location Document
OI MDM/DSC Failure Impacts
Operations and Maintenance Instructions (OMI)
Redundant Computer Set Logic Flow Diagrams (Lockheed Flows)
Shuttle Calibration Data Book
Space Shuttle Systems Handbook
Space Shuttle Main Engine Controller Software: Books 1 and 2
STS Operational Flight Rules

In addition to the documents listed above, the MPSR 1 and 2 contain the following:

Command and Control Subsystems (CCS) Control Users Guide (Part 3: MED List)
Flight Software - Program Notes and Waivers
Ground-Based Space Systems MCC Workstation Executive Users Notebook
Shuttle Operations Data Book (SODB)
Shuttle Operations Data Book (SODB) Request-Post 51-L

The following documents are not available at the Booster FCR and MPSR, but are taken over for each flight.

Flight Software - Program notes and Waivers
Space Shuttle External Tank - System Definition Handbook Vol. I and II
SRB Flight Measurements Location Document
SSME Flight Operations Handbook (The White Book)

DDD (Digital Display Driver) Overlays

The DDD overlays are stored in a file folder on console. The prime operators are responsible for having the correct overlays in place.

Console Cue Cards

The individual operators are responsible for determining which cue cards they will require and having them available at console. The cue cards frequently used are listed in SCP 5.2.7.

TITLE

BOOSTER POSTMISSION DUTIES

PURPOSE

This SCP documents the flight control team's postmission duties.

DESCRIPTION

Postmission duties include:

- Anomaly Report Submission
- Flight Data Assembly
- MEWS Data Acquisition
- Quick Look Report Preparation
- Postflight Report Preparation
- Postflight Crew Debriefing
- Postflight Data Analysis

These duties not only document the mission, but also can assist the next flight's team in its preparation. These duties are shared by all of the flight team members.

PROCEDURES

Anomaly Report Submission

Reports are submitted to document any anomalous conditions that may have been present during real-time operations. These reports are written by the multipurpose support room (MPSR) operators, reviewed by the flight control room (FCR) operator, and submitted to the spacecraft analysis room (SPAN). These reports are reviewed by the engineering community, located in the mission evaluation room (MER). Any anomaly that is an explained or expected condition will be closed. This closure will be coordinated between MOD and the MER. If the anomaly is not expected or is not explained, the engineering community will include this in the MER problem tracking list. The anomalies should be resolved prior to the next mission.

Flight Data Assembly

Once all of the flight data is gathered, the flight control team will assemble this material into the flight log book. The flight log book will contain the Booster FRR data pack, the L-1 day briefing, Booster hardcopies, any necessary data requests, and postflight reports. If the mission was secure, secret data should not be included in the log book. Also, all materials that are not classified but are marked "secret" should be declassified.

MEWS Data Acquisition

There are certain groups of parameters that are logged for postflight analysis. These parameters are established, grouped, and verified during premission planning using the workstation executive (WEX) utilities. The necessary procedures for requesting MEWS data are outlined in SCP 6.14.

Quick Look Report preparation

The Quick Look Report is prepared by the FCR operator or his/her designee and is documented using the format shown in figure 6.10-I. This is a sample report from STS-29. This report is a management overview of the significant problems that were encountered during the mission. Also, any documentation changes that may be required as a result of these problems should be included in this presentation. This is not intended to be an anomaly report discussion.

Postflight Report Preparation

The Ascent Booster officer will summarize the prelaunch, ascent, orbit, and entry activities. This report requires inputs from the prelaunch and entry Booster officers as well as the MPSR operators. The information required in this report includes:

- Any prelaunch or loading problems
- Ascent performance
- Any LCC problems or waivers
- Any anomalous conditions
- On-orbit configuration
- Any real-time FDF or procedural changes that were required
- Helium mass available for entry
- Helium mass flowrate for the SSME baggy purge
- Entry system performance

This report should be completed no later than one week after landing. The postflight reports are filed in the Booster Systems library.

Postflight Crew Debriefing

The postflight crew debriefing is usually held the week after landing and is supported by the FCR operator or his/her designee. The anomalies that occurred during the mission are discussed and any MER comments and questions are addressed. The operator should be prepared to present to the flight crew any anomalies that were written concerning the Booster systems.

STS 29
QUICK LOOK REPORT
BOOSTER

- FDF CHANGES REQUIRED - None
- LCC CHANGES REQUIRED
    - * 6.2.1-03 MPS Helium Tank Pressure
        - upper limit of 4500 psia (maximum system design operating pressure)
        - limit exceeded by 10 psia for approximately 4 seconds during helium loading at T-3 hours
        - not a safety concern, rather a life cycle concern
        - waiver was processed
- FLIGHT RULE CHANGES REQUIRED - None
- MCC PROBLEMS
    - * RTDS - At approximately 1:30 MET the Booster FCR IGP terminated during display cycling. It was restarted and worked fine for the remainder of powered flight. Problem has since been fixed.

      MPSR terminal operated fine
    - * NRT - Capacity not as advertised
    - * Hardcopy quality very poor
- GENERAL OPERATIONS ISSUES - None

Figure 6.10-I.- Quick Look Report example.

Postflight Data Analysis

After each mission, the Booster, Main Engine, and MPS operators review the Mission Operation Computer (MOC) hardcopies and all data gathered from the various sources. This data is then reviewed to determine if there are any anomalous conditions present that were not detected during real-time operations. Conditions such as off-nominal valve closure time and sensor biases are typical postflight analysis results.

Once the flight team has completed its analysis, any undetected anomalous or suspect conditions should be discussed with the appropriate members of the engineering community. Corrective actions and/or fly-as-is rationale should then be coordinated prior to the next flight. The appropriate members of the engineering community are:

Solid Rocket Booster (SRB)	MSFC/SRB Project
Main Propulsion System (MPS)	JSC/Engineering and Design
External Tank (ET)	JSC/Engineering and Design MSFC/ET Project
Space Shuttle Main Engine (SSME)	MSFC/SSME Project

The phone numbers for each of these organizations are provided in the Booster telephone directory.

TITLE

NEAR REAL TIME DATA PROCESSING INITIALIZATION

PURPOSE

This SCP provides a procedure for sign-on, initialization of parameters recorded in NRT, and signoff, using a Megadata terminal. This procedure does not include use of the MITS local area network.

DESCRIPTION

Near real time (NRT - pronounced "nert") data recording replaces regular and special THRIFT data processing, formerly a MOC function, for STS-7 and subsequents. The NRT program runs separately from the MOC software, and must be independently initialized. NRT software has absolutely no visibility to console inputs such as SMEK. Raw data are received by NRT, limit sensed, special comps are performed, and then the results are stored in the NRT data base. Limits and special comps must be initialized as described herein. Data are retrieved using the procedures of SCP 5.1.5 or 5.1.6, and FCOH SOP 10.1, using a standard MDRF form.

PROCEDURES

Refer to figure 6.11-I - Megadata keyboard in the following section. To log on to NRT, make sure the blue POLL light is blinking, then:

A. Depress ERASE DISPL

The following display will result:

```
NO DEF


                 WELCOME TO THE COMMAND AND CONTROL SYSTEM

                ****************CAUTION*********************
                DURING INITIALIZATION AND RESTART/SELECTOVER
                FUNCTIONS-HOLD ALL INPUTS UNTIL CLEARED BY
                THE COMPUTER SUPERVISOR OR THE
                GROUND CONTROLLER
                ********************************************

                MENUS ARE REQUESTED FOR DISPLAY
                BY ENTERING IN THE UPPER LEFT HAND CORNER
                THE THREE CHARACTER MENU ID FOLLOWED BY A ?
```

B. Call HISTORY on SDP TLM to make sure your MED is authorized for NRT.

C. Enter LOGOFF TRANSMIT UNPROTECT

The display will clear and the following message will result:

```
NASA/JSC SDP4 168 - MVV/SP ACF/VTAH R3 ACCEPTING LOGONS
```

D. To sign on, you must coordinate with HISTORY on SDP TLM to determine which computer is running NRT. In this example, assume SDP computer 6 is running NRT, so to log on NRT, you would enter

L NRT6 | TRANSMIT UNPROTECT |

The following display will result:

```
NO DEF




              WELCOME TO THE COMMAND AND CONTROL SYSTEM

             ******************CAUTION*******************
             DURING INITIALIZATION AND RESTART/SELECTOVER
             FUNCTIONS-HOLD ALL INPUTS UNTIL CLEARED BY
             THE COMPUTER SUPERVISOR OR THE
             GROUND CONTROLLER
             ********************************************

             MENUS ARE REQUESTED FOR DISPLAY
             BY ENTERING IN THE UPPER LEFT HAND CORNER
             THE THREE CHARACTER MENU ID FOLLOWED BY A ?
```

Note: If a checkpoint is performed, you must sign off NRT and sign back on to the MOC. If the MOC goes down unexpectedly, your terminal will also be logged off. When the MOC comes back, the MED will automatically be reauthorized and connected to it. You must then contact HISTORY on SDP TLM for your MED to be reauthorized to talk to NRT. You may then sign off the MOC and sign back on to NRT.

E. Notice that the above display does not tell you which system is talking to your MED terminal. To find out, enter

D01,007,RR$ | TRANSMIT UNPROTECT | where for this example 007 is the flight number which should result in a message such as the following at the bottom of the page:

```
132:17:51:31   NRT6 INPUT DECODED
```

You are now assured that your MED is talking to NRT in SDP computer 6.

F. You may now transmit NRT formats to NRT. Notice that NRT formats are similar but not identical to MOC formats. MOC formats will result in errors if transmitted to NRT. For a given MOC format, the corresponding NRT format (if it exists) has the same format number except that the "V" is replaced by a "Z." Blank formats may be requested from NRT by entering the format number followed by "?" and TRANSMIT UNPROTECT

For example, format V20 is used to transmit special comp constants to the MOC. The corresponding format for NRT is Z20, which looks like this:

```
Z20#

007/RR        NRT SPECIAL COMP CHANGE (EU) FORM

              ONE RUN OR ALL RUNS OPTION - ___;

               PARAMETER           EU
                NUMBER            VALUE

              _________ ; ________________ ;
              _________ ; ________________ ;
              _________ ; ________________ ;
              _________ ; ________________ ;
              _________ ; ________________ ;
              _________ ; ________________ ;
              _________ ; ________________ ;
              _________ ; ________________ ;
              _________ ; ________________ ;
              _________ ; ________________ / $

              EU VALUE INCLUDES DECIMAL POINT AND SIGN
```

Notice that the above NRT format has:

1. Another entry - the "ONE RUN OR ALL RUNS" option. Always type "ALL" in this option. The "ONE" option is not currently supported.
2. Fewer entries for constants. Enter MSID and value as you would with a MOC format.

3. No label for your disk directory. To add a label to your format, do exactly the following:

   a. Press the "home" cursor control key H

   b. Press ↑ ← ←

   c. Press EXTEND FUNCTION TAB SET

   d. Press →

   e. Type a letter "K."

   The cursor should now be in the lower left-hand corner of the display.

   f. Enter a suitable label up to 15 characters long. Only the first 10 characters will be picked up for the directory.

   g. Use ← to move the cursor over the "K" you typed in step (e) above, and hit EXTEND FUNCTION TAB SET

   The letters of your title will appear double bright. You may now save your format on your diskette, print it, or transmit it to NRT just as you would any MOC format.

G. Unlike the MOC, the NRT program has the capability to support only one limit set at a time.

H. A list of NRT formats currently supported is presented in figure 6.11-II. This list may be obtained by transmitting ZOO?

Note: NRT formats may be requested <u>from</u> the MOC but cannot be transmitted <u>to</u> the MOC.

I. To log off NRT, type LOGOFF and then press TRANSMIT UNPROTECT. You may then log on to the MOC.

J. Problems: If you typed L NRT6 above and got the message

APPLICATION INACTIVE OR TERMINAL IN USE

then either NRT is not running or nothing is talking to your MED terminal. Call HISTORY on SDP TLM for help with this problem or questions concerning how to use NRT.

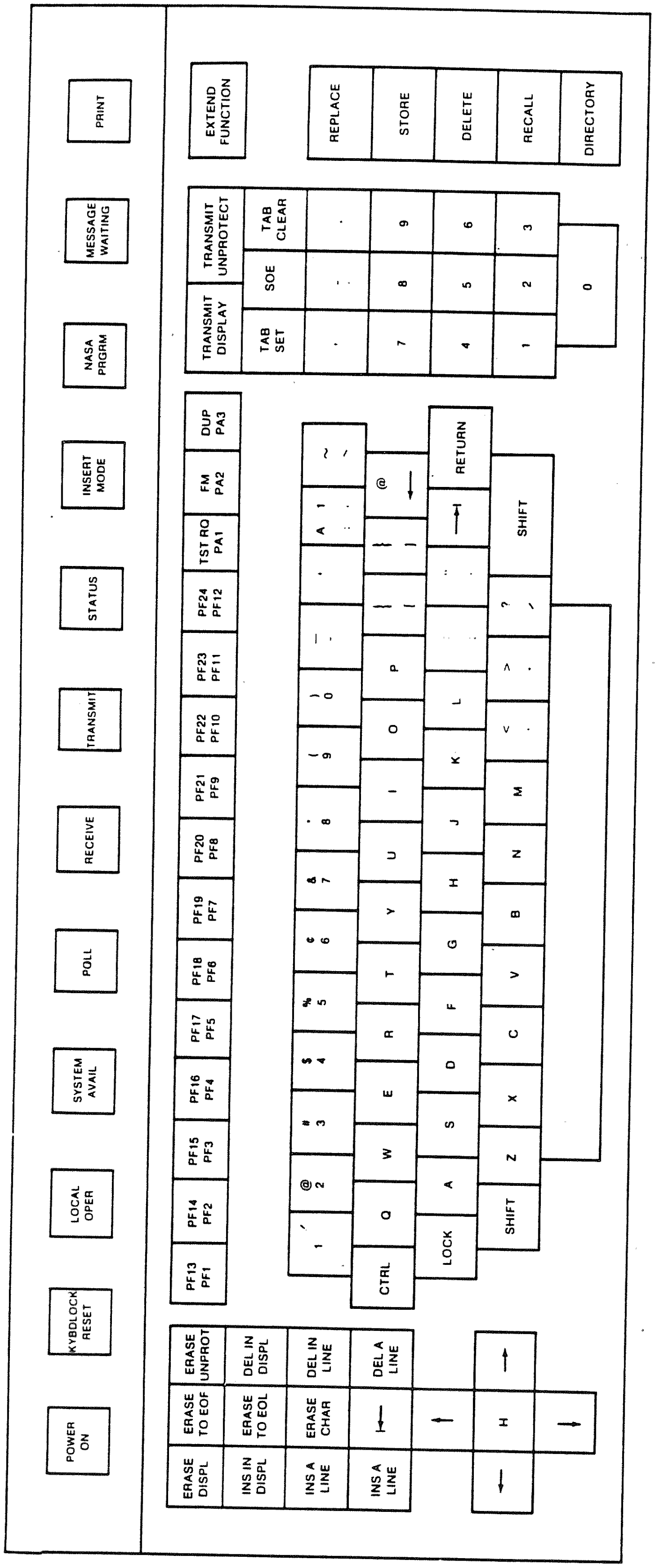


Figure 6.11-I.- Megadata keyboard.

Z00# 007/RR NRT SELECTION MED LIST

NON RESTRICTED MEDS

Z07 - FORMAT MENU CALL-UP
Z11 - CALIBRATION CHANGE (SCALES)
Z12 - CALIBRATION CHANGE (COEFFICIENTS)
Z13 - CALIBRATION CHANGE (DATA POINTS)
Z14 - MULTI-CALIBRATION
Z20 - SPECIAL COMP CONSTANT CHANGE (EU)
Z21 - SPECIAL COMP CHANGE (TIME)
Z22 - HEXADECIMAL MASK CHANGE
Z23 - SPECIAL COMP TEXT CHANGE
Z24 - PBI CONTROL
Z30 - OPERATIONAL LIMIT CHANGE
Z60 - RUN INITIATION/FORMAT SELECT
Z62 - VERTICAL TAB RECONFIGURATION
Z63 - HORIZONTAL TAB RECONFIGURATION
Z64 - BILEVEL RECONFIGURATION
Z65 - PLOT RECONFIGURATION
Z67 - RUN SUMMARY TO MICROFICHE
Z68 - UPDATE RATE/DELOG CONTROL
Z70 - PLAYBACK/NOPLAYBACK CONTROL
Z71 - SPECIAL FORMAT TIME CONTROL
Z73 - DISK/TAPE TOC DELIMITING FORM
Z74 - RUN SUMMARY DISPLAY CHANGE
Z80 - STATUS DISPLAY CONTROL
Z81 - LIMIT DISPLAY CONTROL
Z82 - MENU INITIALIZATION FORM
L50 - NRT TABLE SNAPS
L52 - RUN PROCESSOR SNAPS

RESTRICTED MEDS

Y58 - RESOURCE CONSTANT FORM
Y59 - RUN MANAGEMENT FORM
Y66 - HISTORY DATA LOAD
Y72 - NRT AUTHORIZATION
Y76 - DATA BLOCK DELETE

Figure 6.11-II.- Current NRT formats.

REFERENCES

Flight Control Operations Handbook, JSC-12805, Vol. I, Final, Rev-B, January 16, 1987.

TITLE

DATA PACK MANAGER OVERVIEW

PURPOSE

This SCP describes the duties and responsibilities of the data pack manager (DPM). Also described are the documents used and maintained by the DPM, and the resources commonly accessed by the DPM.

BACKGROUND

The data pack manager is responsible for developing, implementing, and documenting changes to the Mission Control Center (MCC) console hardware and software. These changes are made using three data pack tools. The Reconfiguration Data Collection System (RDCS) is used for console format requirements and mission operations computer (MOC) telemetry processing requirements. Second, the Shuttle Display Reconfiguration System (SDRS) used for MCC display requirements and MOC near real time (NRT) format requirements for regular and super thrift. Finally, the STSOC change request (CR) process for all other MCC hardware and MOC software changes.

PROCEDURES

I. General Responsibilities

A. MCC Configuration

1. Reconfiguration Checklist

The data pack manager uses the reconfiguration checklist, shown in figure 6.12-I, to ensure that all activities have been accomplished. All CR's being implemented for the upcoming flight are evaluated for MCC configuration impacts and the appropriate STSOC CR's are generated and any RDCS or SDRS changes are made. Any other changes to the MCC configuration that have been identified by the section are also made.

Note: The intent of all data pack changes <u>must</u> be approved by section consensus (corrections may be assumed to have section approval since the original requirement has not yet been met).

Since the front room console is used by other sections, the data pack manager must coordinate with the EVA and RMS sections and implement the changes on this console, since Booster owns the console. The data pack manager must complete these activities prior to the deadline given on the MOD reconfiguration schedule.

An example of this schedule is figure 6.12-II. These schedules are obtained form the branch secretary on the Star system.

2. STSOC CR Identification

STSOC CR's are generated whenever the required change affects MOC software or hardware. MOC software is anything that the MOC does to the telemetry stream before it is formatted for display on the MCC consoles (e.g., leak computations, DDD computations). These CR's are usually required to be in the system at least one year prior to implementation to allow for approval by the configuration control panel (CCP) budget allocation, and implementation. Complex computations and major hardware purchases may require a longer lead time.

3. RDCS Change Identification

RDCS changes are required whenever a new telemetry parameter is to be processed by the MOC. Any parameter that is to be displayed (on CRT, DDD, etc) must be in the SPL data base. Any new parameter is added to the SPL via RDCS. RDCS changes are also made to change a digital display driver (DDD) format, stripchart (SCR) format, display request keyboard (DRK) field callout, keyset voice-loop arrangement, (comm loops) or summary message enable keyset (SMEK) pushbutton assignment. Changes to comm loops or the front room console DRK must be coordinated with the other users of the Specialist console, RMS and EVA. Parameter limit sensing values may also be predefined using RDCS inputs. Copies of the changes are filed in the data pack log (see paragraph II.A).

4. SDRS Change Identification

SDRS inputs are made to create or modify a MCC display or history tab, or to create or modify a NRT format. Copies of the flight change request (FCR) form, change inputs, and final output reports are filed in the front of the section for that display/history tab in the display data pack notebooks. Only the latest version of each display is kept in the notebook. The authors of the appropriate display or history tab SCP are notified of the changes. Changes made to NRT formats are reported to the authors of the regular/special thrift SCP and the Booster telemetry list SCP.

5. Film Product Delivery

Film products are made for each flight for all stripchart formats and for any DDD formats that were changed for the flight. These products are usually available one week prior to the integrated load checkout (ILC) and should be picked up as soon as possible after notification from the RDCS products distribution coordinator in building 30. SCR overlays are stored in the cabinet in the second floor MPSR. DDD overlays are kept in the folder on console since the overlays are load specific.

6. Flight/Long Sim Preparation Responsibilities

Prior to each flight or long simulation, the MED disks must be updated with proper limits and special comp constants.

B. ILC Coordinator

The DPM serves as the ILC coordinator. As such, the DPM maintains the ILC status sheet and the ILC SCP (6.7), and performs all the tasks detailed in that SCP.

C. Discrepancy Report Coordinator

The DPM serves as the MCC discrepancy report (DR) coordinator. As such, the DPM maintains the DR log. This log contains a copy of all DR's submitted in the MCC. These copies are kept behind the "Open DR" tab until the yellow copy of the DR form is returned to the originator with the problem close-out. The copy of the DR and the yellow form are then filed behind the "Closed DR" tab.

D. CR Coordinator

The DPM is responsible for filing a copy of all STSOC CR's submitted by anyone in the section. The data pack manager also maintains a CR status sheet in the front of the CR file. The approve/disapprove status of all DF65 CR's and CR's submitted by other sections that impact the Booster section is kept on the status sheet. CR status can be obtained using the MODIS (CISD) application from the CIN network on the office PC's.

II. Documentation Responsibilities

A. Data Pack Log

The data pack log contains printouts of all RDCS formats and lists owned by Booster. New printouts are added whenever an RDCS change is made. New printouts are added directly in front of the old printout. Old printouts are purged when the configuration it represents is no longer used in any flight or build for use in sims. The book is divided into sections representing each RDCS transaction type that Booster can control. The book is a users guide to RDCS, as well as a complete record of the RDCS Booster data base. A step-by-step guide on how to log-in is kept in the front of the book. Each screen of the long and complicated log-in process is hardcopied and kept here along with helpful hints annotated in the margins. Changes to the RDCS data base are made by redlining the appropriate sheet in the data pack. These changes are coordinated with the section or other sections as needed. When the appropriate window opens, the changes are made and the printouts are annotated and logged in the data pack.

Two document sleeves are located in the front of the data pack log. The first division in the log contains a working copy of the summary of build-changes worksheets and attachments. A list of changes to be made in future RDCS reconfiguration cycles is also kept here. The second division contains the RDCS users guide. This guide is an excellent source of information on how to use the "unfriendly" RDCS system as well as other useful information on telemetry MSID's and telemetry formats.

B. Display and NRT Book

The display book contains printouts of the latest version of all the displays owned by Booster. Copies of all FCR forms and attachments are also filed here. The FCR forms are filed by what software load the display or NRT changes is in effect. This book contains an SDRS user guide and blank display and NRT FCR forms. Changes to the displays or NRT formats are redlined on a copy of the print out. These changes must be coordinated with the section. After section approval is obtained, an FCR is filled out. A copy of the FCR is logged in the display book and the original FCR is given to FCR coordinator in building 30. After they make the change, a printout of the new display is sent back to the author along with a sign-off sheet. If the changes are correct, the sign-off sheet is returned to building 30 and the new display is put in the book. The old version of the display is purged.

C. SCP Inputs

The DPM is responsible for ensuring that updates are made to the SCP's affected by telemetry, RDCS, SDRS, and MOC computation changes. If he is not directly responsible for the affected SCP(s), he must provide the appropriate information to the SCP's author.

D. Fiche

The DPM is responsible for filing the microfiche that is delivered for each reconfiguration cycle. The microfiche file can be used in case the RDCS system is not available from the office PC's. The fiche contains information on keysets, DRK's, SMEK's, SCR's and limits only.

III. Resources

The most frequently used resources are described in this section.

A. Systems Division Guide to Data Pack Managing

A copy of this document is given to each DPM by the Systems Division data pack coordinator. This copy is kept in the front of the RDCS data pack book. The purpose of the guide is to provide the DPM with a general understanding of the reconfiguration process, the STSOC CR process and the telemetry process. It also gives detailed descriptions of each RDCS transaction used by Systems Division personnel including when the transaction is used and the information that is required to complete the transaction. The RDCS log-on process and schedule is also discussed.

B. SDRS User's Guide

A copy of this document is given to each DPM by the Systems Division data pack coordinator. It is kept in the front of the Display and NRT book. The purpose of the guide is to provide the DPM with a general understanding of the SDRS and instructions for using the system. However, changes to displays and NRT formats can be made without ever using the SDRS system. The FCR process described in the Display and NRT documentation paragraph above can be used instead of using the SDRS system.

C. MCC Level B and C Requirements for Shuttle Telemetry Data Processing Document

This document, JSC-11028, is kept in the Systems Division data pack library. Volume I, section 5 contains the requirements for all MOC telemetry processing. Other volumes describe the trajectory processing requirements, the MCC software requirements, the MCC hardware requirements, and the interface requirements within the MCC data processing and distribution system.

D. Systems Division Data Pack Library

The Systems Division data pack library is located in building 4, room 1026. The two bookshelves and filing cabinet contain documents of interest to Systems Division DPM's. A list of the library's contents may be found in the front of the top drawer with the library circulation records. Included in this library are copies of the MCC Level B and C Requirements for Shuttle Telemetry Data Processing Document, SDRS User's Guide, and Systems Division Guide to Data Pack Managing. Blank forms used for developing, submitting, and documenting data pack changes can be found in the file cabinet.

E. MOD Reconfiguration Schedule

The MOD reconfiguration schedule is updated every Friday. A copy of this schedule can be obtained by any secretary from the ALL SCHEDULES drawer in the STAR. This schedule gives all the deadline information needed by the DPM for future flights. It also provides the flight number, vehicle, payload summary, flight software release (FSR), flight control room (FCR), ILC date, and launch date. An example of this schedule is shown in figure 6.12-II. The Integrated Sim schedule contains information on ILC's and the loads used for each sim.

F. Miscellaneous

Other useful resources are: the Flight Controller Operations Handbook (FCOH), which contains information on the MCC telemetry system in section 4; and the master measurements list (MML), which contains the MSID and nomenclature for all vehicle, engine, tank, and SRB parameters. The Megadata work book, SCP's, Work Station Console Handbook, and the Comm Loop Directory are also sources of data pack information.

DATA PACK
RECONFIGURATION CHECKLIST
BUILD (FLT/OI REL) ______________
DATE _____________

- IDENTIFY ALL CR's BEING IMPLEMENTED FOR THIS LOAD
  - _ CR's submitted by DF65
  - _ CR's submitted by other sections that impact Booster

- IDENTIFY STSOC CRs
  - _ MOC COMPUTATIONS
  - _ HARDWARE CHANGES/ACQUISITIONS
  - _ SPECIAL DISPLAYS

- IDENTIFY RDCS CHANGES
  - _ DDDs
  - _ DRK
  - _ KEYSET
  - _ LIMIT SENSE
  - _ AES (Strip Chart Recorders)
  - _ SMEK
  - _ SPL
  - _ MSK TITLES

- IDENTIFY SDRS CHANGES
  - _ DISPLAYS
  - _ HISTORY TABS
  - _ NRT FORMATS

- SUBMIT STSOC CRs

- SUBMIT SDRS FCRs

- COMPLETE RDCS CHANGES
  - _ also, implement any changes for RMS and EVA
  - _ pay careful attention to open and close windows for:
    Comm Loop changes
    SPL and MSK titles
    RDCS changes

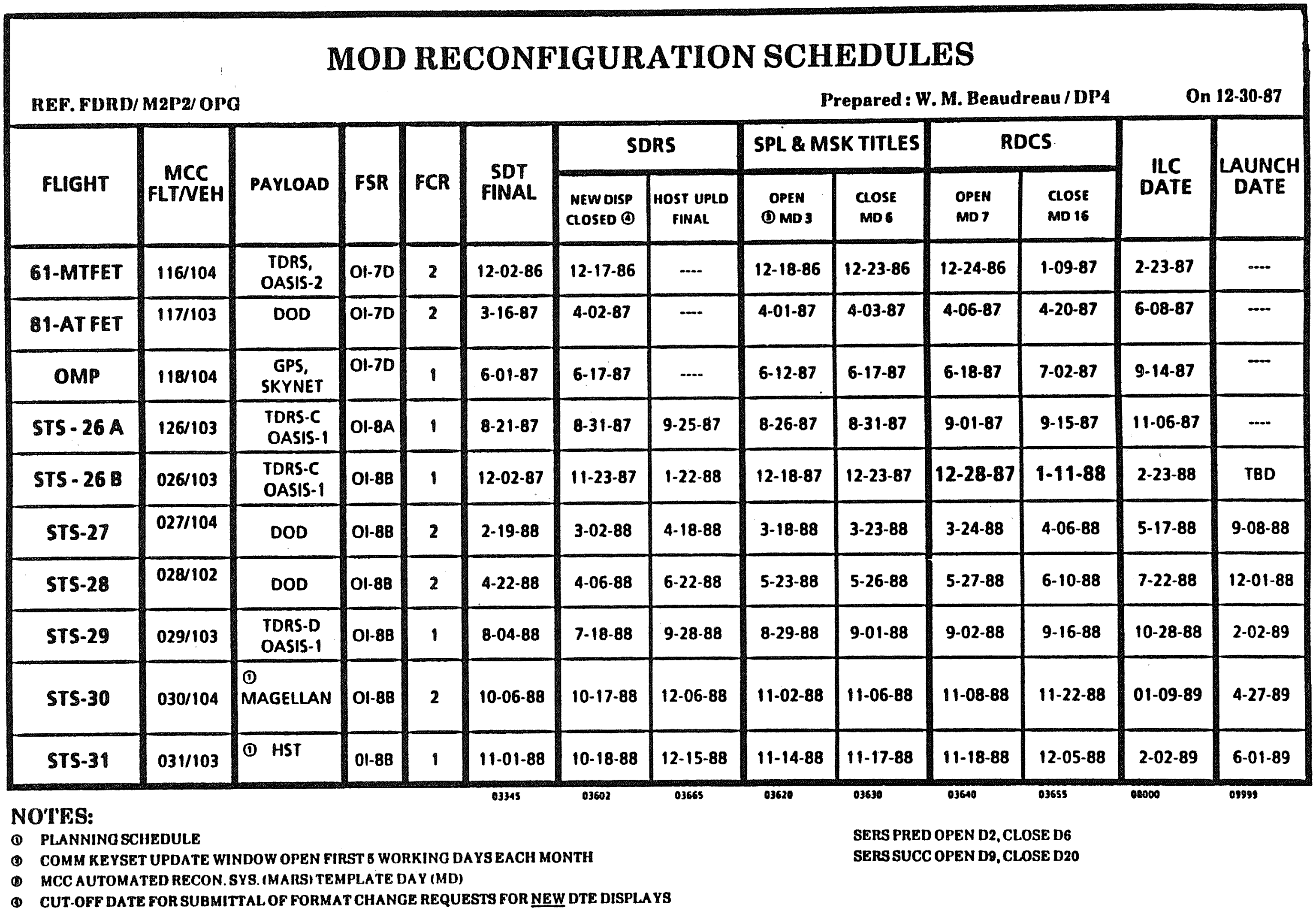
- COMPLETE ILC SUMMARY OF BUILD CHANGES WORKSHEET (SCP 6.7)

- PLACE OVERLAYS ON CONSOLE

- PREPARE MED DISKS

- LOG ALL DR's

Figure 6.12-I.- Data pack reconfiguration checklist.



MOD RECONFIGURATION SCHEDULES

REF. FDRD/ M2P2/ OPG

Prepared : W. M. Beaudreau / DP4

On 12-30-87

FLIGHT	MCC FLT/VEH	PAYLOAD	FSR	FCR	SDT FINAL	SDRS		SPL & MSK TITLES		RDCS		ILC DATE	LAUNCH DATE
						NEW DISP CLOSED ④	HOST UPLD FINAL	OPEN ③ MD 3	CLOSE MD 6	OPEN MD 7	CLOSE MD 16		
61-MTFET	116/104	TDRS, OASIS-2	OI-7D	2	12-02-86	12-17-86	----	12-18-86	12-23-86	12-24-86	1-09-87	2-23-87	----
81-AT FET	117/103	DOD	OI-7D	2	3-16-87	4-02-87	----	4-01-87	4-03-87	4-06-87	4-20-87	6-08-87	----
OMP	118/104	GPS, SKYNET	OI-7D	1	6-01-87	6-17-87	----	6-12-87	6-17-87	6-18-87	7-02-87	9-14-87	----
STS - 26 A	126/103	TDRS-C OASIS-1	OI-8A	1	8-21-87	8-31-87	9-25-87	8-26-87	8-31-87	9-01-87	9-15-87	11-06-87	----
STS - 26 B	026/103	TDRS-C OASIS-1	OI-8B	1	12-02-87	11-23-87	1-22-88	12-18-87	12-23-87	**12-28-87**	**1-11-88**	2-23-88	TBD
STS-27	027/104	DOD	OI-8B	2	2-19-88	3-02-88	4-18-88	3-18-88	3-23-88	3-24-88	4-06-88	5-17-88	9-08-88
STS-28	028/102	DOD	OI-8B	2	4-22-88	4-06-88	6-22-88	5-23-88	5-26-88	5-27-88	6-10-88	7-22-88	12-01-88
STS-29	029/103	TDRS-D OASIS-1	OI-8B	1	8-04-88	7-18-88	9-28-88	8-29-88	9-01-88	9-02-88	9-16-88	10-28-88	2-02-89
STS-30	030/104	① MAGELLAN	OI-8B	2	10-06-88	10-17-88	12-06-88	11-02-88	11-06-88	11-08-88	11-22-88	01-09-89	4-27-89
STS-31	031/103	① HST	01-8B	1	11-01-88	10-18-88	12-15-88	11-14-88	11-17-88	11-18-88	12-05-88	2-02-89	6-01-89
					03345	03602	03665	03620	03630	03640	03655	08000	09999

NOTES:

① PLANNING SCHEDULE
② COMM KEYSET UPDATE WINDOW OPEN FIRST 5 WORKING DAYS EACH MONTH
③ MCC AUTOMATED RECON. SYS. (MARS) TEMPLATE DAY (MD)
④ CUT-OFF DATE FOR SUBMITTAL OF FORMAT CHANGE REQUESTS FOR NEW DTE DISPLAYS

SERS PRED OPEN D2, CLOSE D6
SERS SUCC OPEN D9, CLOSE D20

Figure 6.12-II.- Example of the MOD reconfiguration schedule printout.

TITLE

SCAP OPERATIONS

PURPOSE

This SCP introduces the user to the Shuttle Configuration Analysis Program (SCAP). The use and purpose of the SCAP in the mission environment will be discussed.

DESCRIPTION

The SCAP is a collection of computer programs designed to assist flight controllers in providing flight operations support of Space Shuttle systems. SCAP consists of the following programs: the Failure Analysis Program (FAP)#, the OI MDM/DSC program, and the Flight Critical MDM Channelization Program.

FAP allows a user to rapidly assess the impact to the Shuttle's powered equipment and functions and the result of various losses of Space Shuttle components or subsystems. The OI MDM/DSC and Flight Critical MDM Channelization Programs were primarily designed for fault isolation. This is accomplished by examination of Measurement/Stimulus Identification (MSID's) that are generated based on user's menu selections and displayed in report formats.

Accessing SCAP under WEX

SCAP is now available on two different systems. The first and most likely place that a user will want to run SCAP is on any WEX machine in the control center. To run SCAP on WEX, all that needs to be done is to log on to WEX and click twice on the process window. This will bring up a menu of programs that can be run. Just click on the word SCAP and the program will run.

Accessing SCAP from the CIN network

The second place that SCAP is available is the CIN network. To run SCAP on the CIN network the user will need to type SCAP on the CIN top page (fig. 6.13-I). SCAP will then prompt the user for their id and password. Once the user has been accepted onto the system, the first of three information pages about SCAP will come on the screen. At the bottom of each screen the user will see three asterisks (***). Whenever this happens SCAP is asking the user to hit the return key.

Running the SCAP program

After paging through the three information pages, the first SCAP menu will be displayed on the screen (fig. 6.13-II). On the top menu the user willfill in the appropriate user group. SCAP will then ask the user to enter the number of the program to run.

Available SCAP applications

1. FAILURE ANALYSIS PROGRAM (FAP)

SCAP INSTRUMENTATION RETRIEVALS

2. SCAP CHANNELIZATION
3. SCAP LRU
4. FULL TELEMETRY
5. CALIBRATION DATA

E. EXIT

A brief description about each program

FAP - FAP allows a user to rapidly assess the impact to the Shuttle's powered equipment and functions and the result of various losses of Space Shuttle components or subsystems.

SCAP CHANNELIZATION - The channelization program is most useful when a user needs to know what telemetry is on any MDM or what MDM's a specific MSID goes through.

SCAP LRU - The LRU program is run when a user wants to know what items are located in a specific area of the Shuttle. The user inputs the location he wishes to know about and the program will list each piece of hardware located in that area.

FULL TELEMETRY - The full telemetry program tells the user the start and stop bit, number of bits used, and the software name. The software name can be especially useful when the user needs to locate a specific parameter in the Space Shuttle software code.

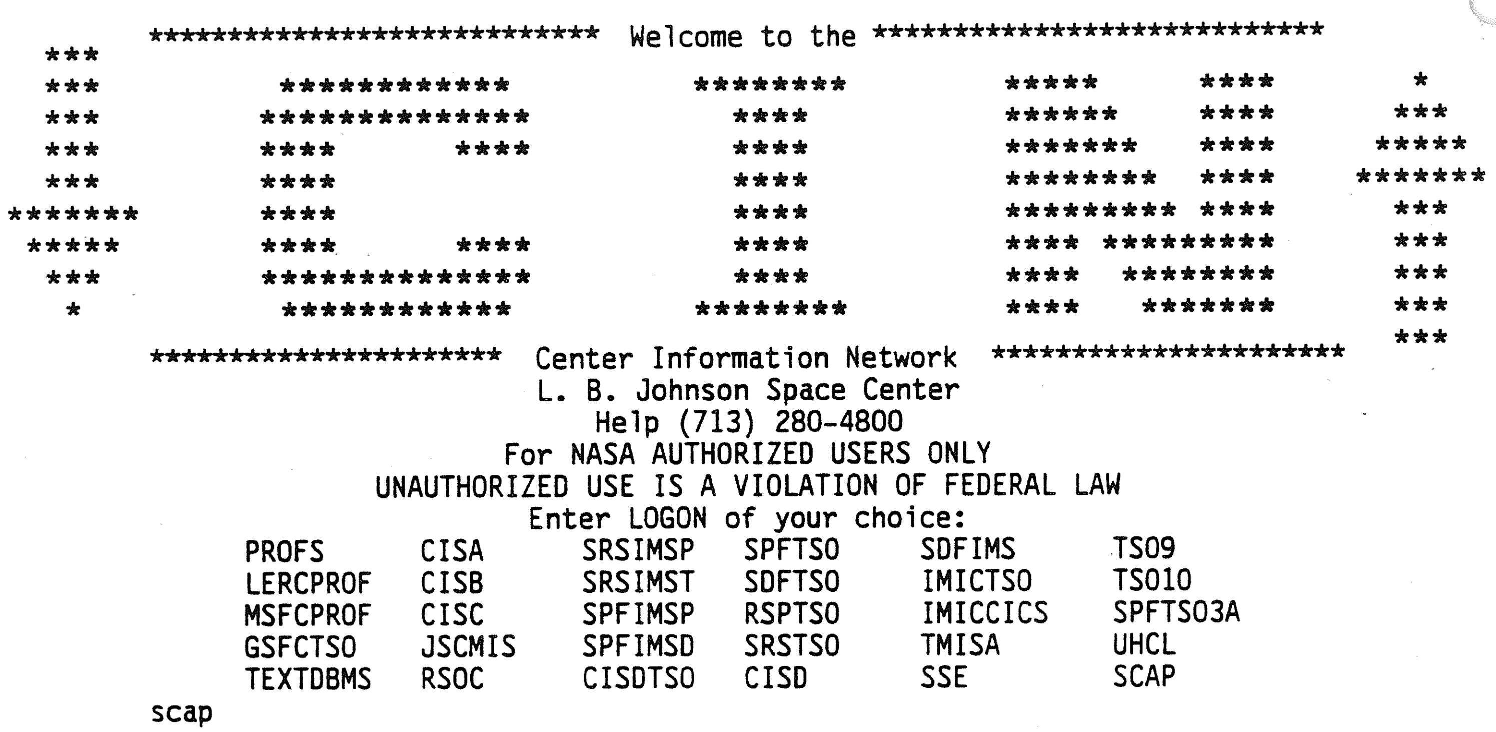
CALIBRATION DATA - The calibration data program allows a user to find out what type of calibration is being performed on a specific MSID.

How to get a hardcopy from SCAP

Once a subprogram has been run and the information displayed on the screen, SCAP will ask the user if he or she would like a hardcopy. At this point the user will answer yes and be given a choice of where to send the hardcopy. When using SCAP in building 4, the best place to send the hardcopies is the room 131 laser printer. If the user is running SCAP from a WEX terminal in the control center, the user should pick the printer that is on line with his CPU.

How to logoff SCAP

To stop SCAP on the MASSCOMP enter the blue area of the screen and hit the left mouse button. Select the word delete from the menu and place the target symbol over the SCAP window. This will terminate the SCAP. To stop SCAP on the CIN network just hit exit until the screen in figure 6.13-III shows up. This menu automatically defaults to the proper configuration and all user needs to do is to hit the return key. After hitting the return key, the user will see a message telling him that his .LIST file was deleted. On the following line the user will see the word READY. The user then types the word "logoff". This will stop SCAP and return the user to the CIN screen.



```
      ****************************** Welcome to the ******************************
 ***
 ***         *************         *********        *****     ****        *
 ***        ***************          ****           ******    ****       ***
 ***        ****      ****           ****           *******   ****      *****
 ***        ****                     ****           ********  ****     *******
*******     ****                     ****           ********* ****       ***
 *****      ****      ****           ****           **** *********       ***
 ***        ***************          ****           ****  ********       ***
  *          *************         *********        ****   *******       ***
      ***********************  Center Information Network  ***********************  ***
                                 L. B. Johnson Space Center
                                    Help (713) 280-4800
                                For NASA AUTHORIZED USERS ONLY
                           UNAUTHORIZED USE IS A VIOLATION OF FEDERAL LAW
                                  Enter LOGON of your choice:
           PROFS       CISA      SRSIMSP   SPFTSO     SDFIMS     TS09
           LERCPROF    CISB      SRSIMST   SDFTSO     IMICTSO    TS010
           MSFCPROF    CISC      SPFIMSP   RSPTSO     IMICCICS   SPFTSO3A
           GSFCTSO     JSCMIS    SPFIMSD   SRSTSO     TMISA      UHCL
           TEXTDBMS    RSOC      CISDTSO   CISD       SSE        SCAP
      scap
```

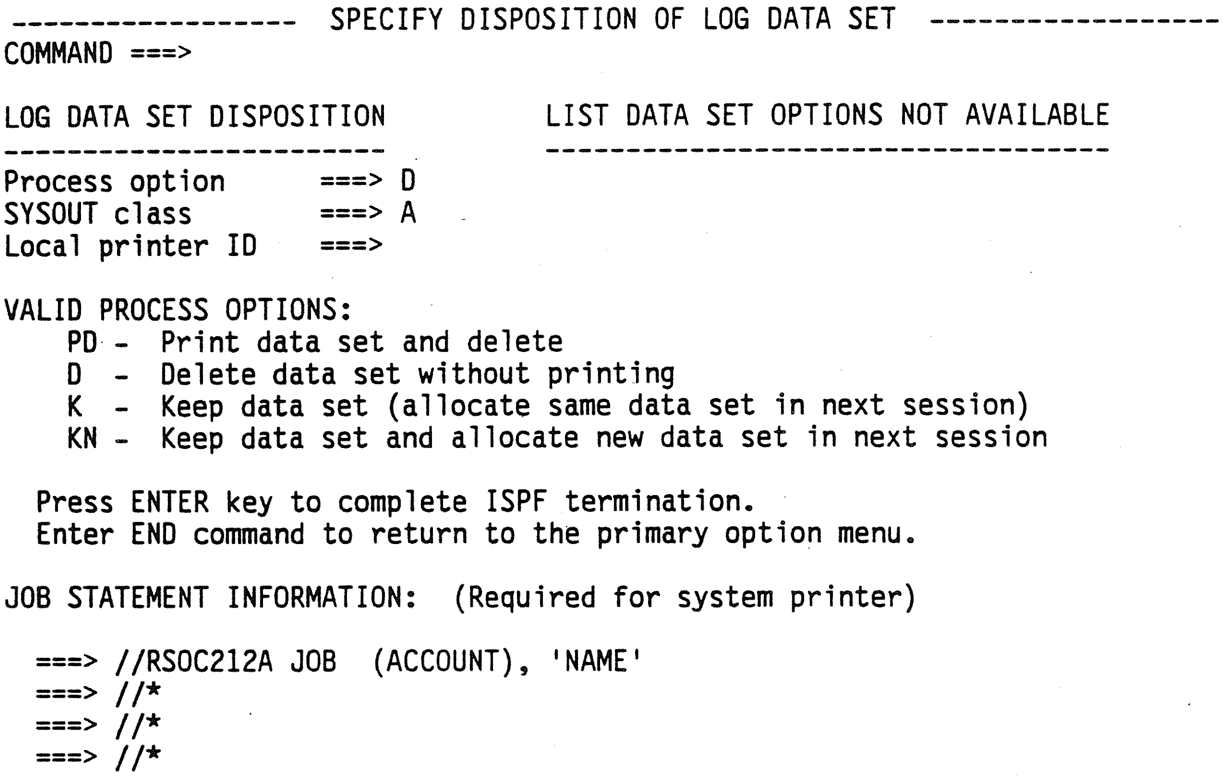
Figure 6.13-I.- Center Information Network.

```
                1. PROP                    8. BOOST
                2. EECOM                   9. SPACELAB
                3. MMACS                  10. PAYLOAD
                4. RMS                    11. BUSSES
                5. INCO                   12. PWRMGR
                6. GNC                    13. SMESS
                7. DPS

                           H. HELP
                           E. EXIT

         ENTER THE NUMBER CORRESPONDING TO YOUR SCAP ID,
           'H' FOR HELP MENU, OR 'E' TO EXIT  ===>
```

Figure 6.13-II.- Shuttle configuration analysis programs - available disciplines panel.



```
------------------  SPECIFY DISPOSITION OF LOG DATA SET  ------------------
COMMAND ===>

LOG DATA SET DISPOSITION          LIST DATA SET OPTIONS NOT AVAILABLE
------------------------          -----------------------------------
Process option      ===> D
SYSOUT class        ===> A
Local printer ID    ===>

VALID PROCESS OPTIONS:
    PD -  Print data set and delete
    D  -  Delete data set without printing
    K  -  Keep data set (allocate same data set in next session)
    KN -  Keep data set and allocate new data set in next session

  Press ENTER key to complete ISPF termination.
  Enter END command to return to the primary option menu.

JOB STATEMENT INFORMATION:  (Required for system printer)

  ===> //RSOC212A JOB  (ACCOUNT), 'NAME'
  ===> //*
  ===> //*
  ===> //*
```

Figure 6.13-III.- Log off screen.

TITLE

WORKSTATION EXECUTIVE (WEX) OPERATIONS

PURPOSE

The purpose of this procedure is to provide instructions for using the workstation executive (WEX 2.5) environment. The procedures described below enable users to logon and execute MEWS data requests and other WEX applications as well as the booster off-line programs MET, HELIUM, CCONFIG, and CRANS.

DESCRIPTION

WEX is the common name given to the configuration management system used on the console Masscomp workstations. WEX allows only flight-certified programs to be run in the operational mode. In this mode, programs cannot be modified. In the test mode the user may develop and test noncertified programs but may not write to or read over the local area network (LAN) access to the CM, NRT and other hosts. For additional information on WEX, consult the WEX Users Guide found on console.

LOGON

The Masscomps in the booster MPSR's should be up and running ahead of time. In MPSR I, the Masscomp is named SNOOPY, in MPSR II, the Masscomp is called BREWSTER.

To login to WEX, the user enters the following information:

a. Move the mouse into the Userid box, enter your individual user ID (i.e., xxxbse, where xxx are your initials).

b. Move the mouse into the Password box (or use the TAB key), enter your individual password.

c. On the right-hand side of the screen, click on the desired flight number and associated host/hosts (typically select "BOTH" for host).

d. Moving the mouse to the boxes for Access Type, CM Database, and Software Certification Level, click on the desired modes (typically for simulations: Test, Operational, and Simulation, respectively).

e. To complete the logon procedure, either click the mouse in the Click to Log In box, or simultaneously press <ctrl> and <rtn>.

After login is completed, the user sees a grey background screen and a white Unix shell window in the upper left corner. You may see instead a WEX Information window, and Advisory Display window, and a small clock in the upper right corner. The left center and right mouse buttons control most functions in WEX.

MOUSE BUTTON OPERATIONS AND FUNCTIONS

Note: The configurations described below are subject to rapid change. Do not be surprised if they are different when you log into WEX. Holding down the left mouse button (LMB) reveals the Window Management-> selection. The -> signifies additional selections are available by sliding the mouse to the right (or left). Additional selections are Cursors->, Bitmaps->, Preferences->, and Screen/Window Print. These are listed with asterisks (*) at the bottom of the selection window.

Under Window Management are the following:

New Window	Makes a new window, hold LMB to position, let up, window appears (type exit to delete).
Move	Move a window, hold LMB to move.
Resize	Hold LMB.
Bury	Click LMB in window you wish to move beneath the others.
Uncover	Reverse of Bury.
Circular Uncover	Systematic uncover for the entire screen.
Circular Bury	Systematic bury for the entire screen.
(De)iconify	Shrink/unshrink a window to/from an icon (click LMB).
Assign Keyboard	?
Freeze screen	?
Thaw screen	?
Redraw screen	Redraws (refreshes) entire screen.
Redraw window	Redraws (refreshes) a single window.
Restart	?
Kill	My favorite - used to kill (delete) windows.
Cursors *	Additional selection - slide mouse right or left.
Left Arrow	Upward angled left facing pointer.
Right Arrow	Upward angled right facing pointer.
Bitmaps *	Background color.
Grey	
Light Pink	
Dark Red	

Preferences *

Bell Loud	Does not work.	
Bell Normal	Does not work.	
Bell Off	Does not work.	
Click Loud	Soft Click.	I am not kidding.
Click Soft	Loud Click.	
Click Off	No click.	
Lock On	Capitals lock on - does not work.	
Lock Off	Capitals lock off - does not work.	
Mouse Fast	Mouse response speed.	
Mouse Normal	Mouse response speed.	
Mouse Slow	Mouse response speed.	
Beep	Test the bell.	

Screen/Window Print*	This is actually useful - it dumps a hardcopy of either the entire screen or a single selected window (click LMB).	
Screen->Genicom 5010	(Large Printer)	Use these.
Window->Genicom 5010	(Large Printer)	
Screen->Genicom 6140	(Small Printer)	
Window->Genicom 6140	(Small Printer)	

Holding down the center mouse button (CMB) reveals the applications-> selection. WSA applications selection resides under here. "Applications" are strictly WEX applications with no real user adjustable features. "WSA Applications" have user adjustable features.

Applications->

WSA Applications *

Comp Builder	WEX comp builder/manager - we do not use these.
Comp Manager	
Fault Msg Display	
DD_SAC	?
DTE Emulation	Emulates the MOC DTE's.
Display Builder	WEX display builder/manager - we do not use these.
Display Manager	
GDR PPL Editor	For GDR data acquisition.
HS display	Workstation health and status diagnostics (icon) - click in icon to activate.
HS delog	Log of health and status - avoid this, it is voluminous.
MEDs	A MED emulator - use CCONFIG instead.
NRT View Report	?
RMT_WS_HS	Health and status of a remote workstation.
RMT_WS_HS delog	Health and status log of remote workstation.
RT_LAN_Interface	This is where you select which real-time data streams you want.

SCAP	Shuttle Configuration Analysis Programs.
3287 Print	N/A
MPCC Command Menu	N/A
Command IOP	These are all vehicle commanding functions - do not use.
Command Output MGR	
Command Reconfig	
Command State Chng	
Advisory	Wex advisory message line - just let up the LMB.
CM Menu	Menu of CM available.
Communication Stat	Gives status of EMAIL and FTAM - can enable/disable them here.
Electronic Mail	For flight notes, etc.
File Manager	Probably do not need to use.
Flight List	Gives list of active flights on hosts and CM.
GPLAN WNTF	GP-LAN workstation network test facility (diagnostics for the GP-LAN).
Integrity Check	Diagnostic.
Log Status	Status of LAN logging.
Loop Test	LAN diagnostic.
MITS WNTF	MITS-LAN workstation network test facility (diagnostics for the MITS-LAN).
Position Status	Tells who is logged into WEX.
Shift Change	Allows the old user to log off of WEX and the new user to log into WEX without having to stop all the applications and leave WEX. This will be used for prelaunch to launch team handover but is primarily intended for on orbit operations.
WEX Display MGR	Do not use.
WEX Info	Information line - date/time, position, data type, flight, CM data base, mode, cert level, LAN active.
WEX Log (ascii)	Avoid - long.
WEX Log (hex)	Avoid - long.
WEX Log (full)	Avoid - long.
WEX Snap	A WEX snap (snapshot) is required when you write WEX DR. The snap puts a list of the W/S configuration onto a floppy or the hard-drive. This is similar to a copy of MSK 0006 for the MOC.
3270 Emulation	This will allow CIN access from the workstations (eventually).

HELP	This is an overall WEX help listing which can be useful. Click on the item of interest, then position the help window where you like.
LOGOUT	This is one of several ways to get out of WEX.

Holding down the right mouse button (RMB) reveals BOOSTER Applications. These are the in-house applications we have created. These will be changed as flights progress (see "Menu Updates and Downloading" below for how to change these).

Helium (OP)	On orbit helium mass remaining computation - Operational version.
CRANS	Configurable Real-time Analysis program.
Helium (TEST)	On orbit helium mass remaining computation - Test version.
ME Tables (OP)	Main Engine Tables - Operational version.
ME Tables (TEST)	Main Engine Tables - Test version.
MEWS	Mission Engineering Workstation Software.
Console Config SIM	CCONFIG program for simulations.
Console Config SIM 43	CCONFIG program for STS-43 simulations.
Console Config SIM 45	CCONFIG program for STS-45 simulations.
Console Config SIM 49	CCONFIG program for STS-49 simulations.
Console Config 042	CCONFIG program for STS-42 flight.
Console Config 044	CCONFIG program for STS-44 flight.
Console Config 045	CCONFIG program for STS-45 flight.
Console Config 049	CCONFIG program for STS-49 flight.
Clock	Displays a small analog clock.
Small Xterm	Same as "New Window" under window management.

BOOSTER-RELATED APPLICATIONS

The following applications are found under the RMB "BOOSTER Applications" unless otherwise noted.

HELIUM

The HELIUM program, when provided MPS system helium temperatures and pressures, calculates the remaining mass of MPS helium. The HELIUM program is used on orbit to ensure sufficient helium mass exists for entry. Details about the helium program are found in SCP 7.2.1.

CRANS

The configurable real-time analysis (CRANS) program is a real-time failure matrix program. For example, if an FA MDM fails, CRANS can be programmed to tell you what telemetry is lost - much more complicated scenarios can be accommodated. For more details see SCP 7.2.2.

MAIN ENGINE TABLES

The main engine tables (MET) program is used to generate tables of off-nominal performance data to be used during flight. Specific main engine tag data is entered, and tables with the corresponding redlines, engine performance levels, etc. are generated. The procedure for using MET is described in SCP 7.1.2.

MEWS

The Mission Engineering Workstation Software (MEWS) is a software package that allows for retrieval and analysis of near real-time shuttle data via plots and tabulations of the data. Refer to SCP 6.18.

CONSOLE INITIALIZATION

Console initiation can be performed simply by running the program CCONFIG created by MMACS with data files created by booster. See SCP 6.17 for instructions on how to initialize the consoles using CCONFIG.

SCAP

The Shuttle Configuration Analysis Programs (SCAP) is a collection of computer programs designed to assist flight controllers in providing flight operations support of Space Shuttle systems.

SCAP is accessed by depressing the CMB, sliding the mouse to the right (or left) to select WSA applications, then select SCAP.

SCAP is described in SCP 6.13.

WEX Snap

Snap is a debugging tool for IBM. Snap is used to provide information to accompany DR's. The program dumps a series of files to a floppy disk to aid troubleshooters in solving problems.

To use snap

a. Insert a blank formatted floppy into SNOOPY or BREWSTER's (depending upon which MPSR you are in) disk drive (a box of blank formatted floppies is kept in the cabinet in each MPSR).

b. Depress the CMB.

c. Select WEX Snap.

Snap dumps the necessary files, including the user logs, to the floppy. The screen will say "completed" when the task is finished; the user may then delete the window.

If the disk is not formatted: (test mode only)

a. Insert floppy into the SNOOPY's (or BREWSTER's) disk drive.

b. Go to UNIX shell window.

c. After the "#" prompt type "diskfmt" (this is an alias for flp format/ dev/flp). When the task is completed, the "#" prompt will reappear, and the user may move out of the window and proceed with the SNAP program.

MENU UPDATES

To add an entry to the menu

a. Go to the Unix shell.

b. Move to /user/booster directory.

c. Edit file .uwmrc

d. Add in the new application name and its path.

e. Exit, logoff, and log back in.

UPLOADING AND DOWNLOADING TO/FROM THE CM HOST

All of boosters current applications reside in the CM and are listed in our configuration down list (CDL) - this means that our applications should be downloaded automatically. If manual downloading is necessary or if new versions need to be uploaded the following procedures should be followed.

a. Hold down the CMB.

b. Select CM Menu.

c. Place the Configuration Management (CM) window where you want.

Along the left-hand side of the CM window are listed the various CM options available.

• Process CDLs	Send new CDLs to the CM.
• Delete from database	Delete CDL or other files in the CM.
• Download	Download a single file from the CM.
• Download list	Show a list of downloadable files which you can select from.
• Upload add	Upload a totally new file to the CM.
• Upload replace	Upload a replacement version of a file to the CM.
• Redisplay inputs - OFF/ON	When "ON" information entered on right hand side is retained when changing between the above options. When "OFF" it is not retained.
• Clear fields	Clears out all information entered into fields on the right-hand side of the CM window.

Along the right-hand side of the CM window are data fields the user can fill in. Fields not required by the CM option selected on the left side are highlighted in grey. Fields that may be required are left in a white background. Fields on the right side include

- File name
- File type
- Function mews
- Group
- Version
- Flight ID's
- CPU ID
- Restricted Download
- Certification Level
- Upload Directory
- Download Directory

- SETUID Bit
- SETGID Bit
- Access ID
- Access Password

I.e., to download MEWS enter mews in the Function box.

At the top is an indication of which CM database you are logged into.

- CM Database: OPERATIONAL

In the bottom right corner is a large

- ENTER

box - click in here to process your selected request.

LOGGING OFF

Move the mouse pointer to the UNIX shell window and type in "logoff" or "exit" and <rtn>.

Or, hold down the CMB and select LOGOUT.

Or, hold down the LMB, select Kill, and then kill the Unix Shell window.

The most "graceful" way is probably selecting LOGOUT under the CMB.

TITLE

BOOSTER REAL-TIME DATA SYSTEM (RTDS) OPERATIONS

PURPOSE

This document serves as a reference for operating the booster real-time data system (RTDS) software, version 7.0, on both the RTDS and 2.5 workstations.

BACKGROUND

The Booster RTDS is used during flight and simulation operations to display real-time (RT) data to the workstation monitor. The software processes the incoming telemetry, TM, to perform computations and highlight outputs that are out of operational limits. There are seven displays available, with data being displayed in plot and tabular formats. Each display is equivalent to one MOC MSK, high density display, and four MOC UP's, plots.

The RTDS workstation receives data from a Loral ADS-500, which processes data in parallel with the MOC. The data are decommutated, bit and frame synchronized, and sent to the workstation. The RTDS data interface software, version 3, on the workstation takes the tags and data and assembles them into MSID-indexed arrays accessible to any application program through a standardized interface.

The 2.5 workstation receives MOC RT data from the 'cross-libraries'. The 'cross-libraries' retrieve MOC RT data off the RT LAN in the 2.5 format and converts the data to the RTDS interface format.

DISPLAYS

The seven displays available are described below. The keyboard inputs for the displays are shown in table 6.15-I.

1. Main Engine display - The display consists of a pseudo MSK 1052 and plots of HPFT and HPOT turbine discharge temperatures, SSME Pc, GH2 outlet pressure and vehicle acceleration. This display is selected using the PF1 key, and is one of two displays that can also be called during program initialization. The MPS display can be called up during initialization. Both SSME telemetry and calculated performance are displayed; MR, power level, Isp, and LO2 and LH2 flowrates, are calculated using the same equations that are used in the MOC. The SSME's are evaluated for off-nominal performance, if off-nominal performance is detected the flight average MR and power level are calculated.

Again, the average performance computations are based on the MOC requirements. The software evaluates the SSME data for LH2 flowmeter and dual MCC Pc shift conditions, which is not performed by the MOC software. The off-nominal conditions evaluated are shown in table 6.15-II, along with the software criteria. The SSME TM plots are toggled by using the PF3 key to display the SSME tag delta plots. The tag delta plots are the calculated delta between the preflight tag prediction adjusted for inlet conditions and the corresponding TM value. The tag delta plots are scaled such that when the upper or lower red line on the plot is exceeded, for all values in the same direction, a level one LH2 flowmeter condition exist.

2. Main Engine display with tag data - This display can only be selected after the Main Engine display is selected. Selection of this display will result in the delta between SSME tag values (preflight or flight replacement) and the corresponding TM value being displayed. A negative delta value indicates the actual TM is (cold) below the tag value, and a positive delta indicates the TM is (hot) above the tag value. The tag values will have a slightly darker blue background and will be displayed where the LPFT DP, LPFT DT, HPOT intermediate seal and MPS helium parameters are displayed. This display is selected, deselected, and toggled, using the PF2 key.

3. MPS display - The display consists of a pseudo MSK 1054 and time plots of MPS helium tank pressure and mass flowrate, and LH2 NPSP, and a plot of helium mass flowrate versus tank pressure. This display is selected using the PF9 key, and is the second of two displays that can be called during program initialization. Both MPS TM and computations pertaining to the MPS helium system, LH2 NPSP and propellant remaining in percent are displayed. The helium TOD values are calculated during mainstage operation, and are based on the leak type, upper or lower system, and the helium flowrate. When the TOD values are not displayed the helium mass is displayed. The LH2 NPSP values displayed are based on the ratio of the engine's LH2 flowrate to the total LH2 flowrate and the values assume a constant inlet temperature. The 'aero' NPSP value displayed is based on the left ME characteristics, flowrate and line loss, and the LH2 manifold temperature. The 'aero' NPSP value is primarily for trend monitoring to determine the LH2 inlet condition. The propellant remaining computations are to provide the operator with a rough indication of the amount of usable propellant remaining in the ET.

4. SSME FID display - The display consists of a pseudo MSK 1069. When selected the display replaces the existing pseudo MSK and leaves the existing plots operating, ME or MPS plots. This display is selected using the PF4 key.

5. Booster Prelaunch display - The display consists of a pseudo MSK 1056. When selected, the display replaces the existing pseudo MSK, and displays plots of the helium tank and LO2 inlet temperatures and the LO2 and LH2 ullage pressures. This display is selected using the PF10 key.

6. Booster Bilevel display - The display consists of a pseudo MSK 1055. When selected, the display replaces the existing pseudo MSK and leaves the existing plots operating (ME or MPS plots). This display is selected using the PF11 key.

7. Booster BFS display - The display consists of a pseudo MSK 1056. When selected, the display replaces the existing pseudo MSK, and displays plots of the helium tank and LO2 inlet temperatures and the LO2 and LH2 ullage pressures. This display is selected using the PF11 key. The helium TOD displayed is identical to that displayed on the MPS display.

8. SSME tag delta display - This displays the SSME operational parameters, both preflight predictions and actual values, and the delta between two. When selected, the display replaces the existing pseudo MSK and leaves the existing plots operating. This display is selected using the PF5 key.

INITIALIZATION

A. RTDS initialization

Initialization of the software on the RTDS workstation is accomplished by following the steps below.

1. Initialize the workstation interface software. Log on to the workstation, giving your login and password. Type in **v3ps** to see if the interface software is operating, and the following will be displayed:

```
Active stuffer processes:
Active send/receive processes:
```

Two processes will appear under 'Active stuffer processes' if the interface software is operating, or a single process under 'Active send/receive processes' if the TM is being sent from another workstation. If the interface software is not operating, initialize the software by typing in **v3setup**. The current setup will be displayed (see below). If the current setup is the desired setup, then depress the Control and C keys simultaneously to exit from the setup process. If the setup is changed, respond to the prompts and press the return key after each response.

```
...CURRENT SETUP
.....Mode............ rcv
.....Flight.......... 49
.....Phase........... def
.....Vehicle......... 105
```

```
.....Receive from.... taurus
.....Start Sender ... NO
.....Start G2 GSI ... NO
.....Tables Dir Name  RGVTBL
.....Tables Directory /user/rtds/v3/Tbl/m49
```

The mode is either **pb** or **rcv** for playback, or **dma** or **pb** for RTflight or simulation data. The flight is the two digit number corresponding to the STS flight number. The phase is **def** for default, it is not required to type **pa** for prelaunch and ascent phases to receive the ascent data. If the mode is playback the playback file must be specified (this includes the path). Additional prompts will appear for starting the Network Send program and the G2 GSI processes. The response to both of these is 'no' provided the desire is only to have RTDS data on the local workstation. The rcv mode allows for data to be transmitted from a specified workstation, the 'send' workstation. The 'send' workstation must be set up to send/transmit.

When the setup is complete, type in **v3go** to initiate the RTDS interface. It takes approximately 1 minute for initialization, a prompt will appear when it is complete. The following lines will be displayed while the RTDS interface is being initialized, these inform the user of the interface files that are being used.

```
LOADING DTC for RTDS Version 3    Flight: 48  Vehicle: 103
Loading databases from ... /user/rtds/v3/Tbl/m48
Loading msid-list ........ /user/rtds/v3/Tbl/m48/m48def.msids
Loading format-list ...... /user/rtds/v3/Tbl/m48/m48def.fmts

Loading the PBI (PDA) shared memory
Starting Tstuffer in playback mode
Starting Dstuffer, playback-mode
```

The RTDS interface is two processes, a ring stuffer (tstuff) and a data stuffer (dfstuff). Verify that the two processes have been started by typing in **ps -e** at the prompt to list the processes running on the CPU. If multiple stuffers are running, kill all the stuffers and restart. Type in **kill** followed by the process ID number to kill the process. **v3kill** can be used on most workstations as a short cut to kill all of the interface processes with one command.

2. Initialize the workstation software. Type in **bse-v7** at the prompt. This results in the user selecting the mode of operation, flight, simulation or testing**, the SSME FID tables (block 1 or 2) and console configuration to be displayed, MPS or ME. The console configuration can be changed at any time during operation by depressing the appropriate PF key. The software can be terminated by depressing the PF14 or q key.

B. 2.5 initialization

Initialization of the software on the 2.5 workstation is accomplished by following the steps below.

1. Initialize the workstation interface software, the 'cross-libraries.' The 'cross-libraries' are on the 2.5 CM host. Download the 'cross-libraries' CM host, they are in the function **cross** and are at the **mission** certification level (select certification level as **mission**). The 'cross--libraries' should be downloaded in to 'directory specified at upload', /user/cross, since there are multiple files and a subdirectory created. Once the files are downloaded, change to the /user/cross directory and source the file **env.CC.** Type in **source env.CC**, then go to the /user/cross/Bin directory and type in **v3go. v3go** starts the data interface, converting the incoming 2.5 data to the RTDS, version 3, data type.

2. Initialize the Booster workstation software. The software, bse-v7, is on the CM host under the booster function and group. After the software is downloaded, and the interface software is initialized, the bse-v7 software can be initialized. The software is downloaded into the '/user/booster/XBSE-V7' directory, unless specified otherwise. **bse-v7** will initialize the software, and a blue query box will appear. The query boxes require the user to select the mode of operation, flight, simulation or testing**, the SSME FID tables (Block 1 or 2) and console configuration to be displayed, MPS or ME. The console configuration can be changed at any time during operation by depressing the appropriate PF key. The software can be terminated by depressing the PF14 or q key.

SOFTWARE OPERATIONS

The output display is selected by the operator. The operator can select one of seven displays, as shown in table 6.15-I below.

TABLE 6.15-I.-OUTPUT DISPLAYS

Display	Keyboard input	
ME	PF1 or	e
SSME Tag Overlay*	PF2	c
SSME Tag-Delta Plots*	PF3	f
SSME FID	PF4	f
SSME TAG	PF5	t
SSME Operational Plot	PF6	j
SSME Performance Plot	PF7	k
SSME Redline Plot	PF8	l
MPS	PF9	m
Prelaunch	PF10	p
MPS Bilevel	PF11	v
Booster BFS	PF12	b

* Keyboard input will toggle between the ME display with and without the SSME tag overlay.

** After the mode of operation is selected, flight or simulation, the telemetry limits and computational constants are read in. The data are read in from the '/user/booster/BSE-DATA' directory. All the data files end with a **.d** extension (the data files are listed below). The data read in is written back to files with a **.ver** extension. The **.ver** files allow the user to verify the values read in. The reading and writing of the data files takes approximately 20 seconds and delays the display of the next query box for the FID selection.

Data files:

abort_vi.d	No comm. abort boundaries
bse_lmt_flt(sim).d	Telemetry limit sets
comp_lmt_flt(sim).d	Computation limit sets
helium.d	Helium comp. constants
meds_flt(sim).d	SSME comp. constants
npsp.d	LH2 NPSP constants
ssme_lmt_flt(sim).d	SSME redline limits
veh_mass_flt(sim).d	Vehicle mass comp. constants

The output displays are similar to the MOC displays, except for the SSME tag overlay and SSME tag displays. The SSME tag overlay displays deltas between the SSME tag values, adjusted for LO2 inlet pressure and power level, and the actual flight values in the position that the LPFT DT and DP, HPOT ISP and SEC P's, and HPFT CLLN P's are displayed. This allows the operator to compare the flight values with the deltas. A positive delta number indicates the actual value is higher than the tag value, while a negative delta indicates the actual value is lower. The SSME tag display displays the SSME tag values, the corresponding RT values and the delta between the two values.

The ME, MPS, prelaunch and BFS each have four plots associated with the display. The ME display has one plot for each SSME that contains the SSME Pc A and B, HPOT TD T A and B, and the HPFT TD T A and B values. The fourth plot contains the GH2 outlet pressure values and the vehicle acceleration. The plots for the MPS display are (1) the helium supply pressures, (2) helium mass flowrate (lb/sec), (3) LH2 NPSP, and (4) helium supply pressure plotted against the helium mass flowrate. The prelaunch display has plots of (1) the helium tank temperatures, (2,3) the LO2 and LH2 ullage pressures and (4) the LO2 inlet temperatures. The BFS display contains the (1) helium tank supply pressures (based on BFS TM), (2) helium mass flowrates, (3) LO2 and LH2 mid-value select ullage pressures, and (4) the GH2 outlet pressure and the BFS SSME power level.

The predicted SSME tag values are adjusted for LO2 inlet pressure (g-effects) and for power level. The adjusted tag values are used by the SSME performance logic to evaluate for off-nominal SSME operation. The adjusted tag values are used primary to determine the direction of Pc shift, the type of 'thrust limiting', HPOT efficiency loss or LH2 nozzle leak, and to determine an LH2 flowmeter shift case. The SSME off-nominal cases evaluated for are contained in the table below which contains the criteria for each case.

Since the predicted tag values may be in error, the software evaluates the values after the thrust bucket to determine if they should be replaced by the flight values. If the flight values are within two-sigma of the predicted tag values, and there is not a performance case for 20 consecutive passes, the flight values replace the preflight values.

The software evaluates SSME performance using both the preflight values and the replacement values (if the replacement occurs). The replacement tag values are the prime values (automatically replaced by the software) and the predicted tag values the secondary values used for evaluating SSME performance. If an off-nominal condition is detected by the replacement values, the failure will be annunciated in text to the ME display and the SSME performance values will be based on the replacement values (if applicable). If the failure is detected by the preflight tags, the failure number will appear on the ME display to indicate the failure type. The operator can depress the number key corresponding to the SSME (1 for E1, etc.) to allow the replacement tag values to be prime (used to drive failure annunciation and computations). Selecting the replacement tags as the prime values cause the background for the associated SSME data to be a lighter shade of blue. Depressing the same number key twice toggles from one set of tag values to the other set and back to the first set. Similarly, the outputs to the ME tag overlay and SSME tag displays are influenced by the selection of the tag values using the number keys.

The MPS helium TOD computation is available for both the MPS and BFS displays during powered flight. The computation is only active when the display is selected. If a high helium flowrate is detected, the software evaluates the flowrate to determine the leak type (a constant flowrate is considered a lower system, regulated leak and a decreasing flowrate is considered an upper system leak). The leak type is indicated by a **U** for upper system, a **L** for lower system, and an **S** single regulator operation. The operator can override the software selected leak type, upper or lower only, by depressing the number key associated with that SSME system (1 for E1, etc.). Selecting the number key while the MPS display is selected toggles from the leak type displayed, allowing the user to go full circle. The helium mass flowrate is active during all phases of the flight and is displayed to the ME, MPS, prelaunch and BFS displays. When the helium TOD is not being displayed, prior to lift-off and after Major Mode 104, the MPS helium mass is output to the MPS and BFS displays.

The LH2 NPSP computation provides the four values of NPSP to the MPS display, one for each SSME and the 'aero' NPSP. The NPSP values for each SSME are calculated based on the SSME's LH2 flowrate and line loss, and the total LH2 flowrate. These factors allow the for accurate calculation of the NPSP when SSME's are throttled and when an SSME has failed.

Any discrepancies with the software should by noted. IDR forms should be used for problem reporting and for software enhancements (fig. 6.15-I).

<table>
<tr><td colspan="2"></td><td colspan="6">REAL-TIME DATA SYSTEM CHANGE FORM</td><td colspan="2">#</td></tr>
<tr><td colspan="4">ORIG:</td><td colspan="2">DATE:</td><td colspan="4">CHANGE/ENHANCEMENT/DISCREPANCY</td></tr>
<tr><td colspan="10">TITLE:</td></tr>
<tr><td colspan="10">DESCRIPTION OF CHANGE/RECOMMENDED SOLUTION:</td></tr>
<tr><td colspan="10">CHANGES MADE/PROBLEM CLOSE OUT:</td></tr>
<tr><td>CONCURRENCE:</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="8">SIGNATURE:</td><td colspan="2">DATE:</td></tr>
</table>

Figure 6.15-I.- Real-time data system change form.

TABLE 6.15-II.- RTDS SOFTWARE IDENTIFICATION OF SSME OFF-NOMINAL OPERATION FLIGHT MISSION MONITORING

	OFF-NOMINAL SITUATIONS											
	LH2 NOZZLE LEAK	HPOT EFF. SHIFT	Pc SENSOR SHIFT HIGH	DUAL Pc SENSORS SHIFT HIGH	Pc SENSOR SHIFT LOW	DUAL Pc SENSORS SHIFT LOW	F/M TEMP SENSOR SHIFT	FIXED DENSITY	ELEC LOCKUP	HYD LOCKUP	LH2 F/M SHIFT LOW	LH2 F/M SHIFT HIGH
ESW	OPOV LMT FLAG -- AND--	OPOV LMT FLAG -- AND--						FIXED DEN FLAG	ELEC. LOCKUP FLAG	HYD. LOCKUP FLAG		
HPOT TD T	168° ABOVE ADJ TAG	168° BELOW ADJ TAG	ONE TEMP 55° LESS THAN ADJ TAG -- OR --	BOTH TEMP.S 130° THAN THAN ADJ TAG -- AND --	BOTH TEMP.S 55° GTR THAN ADJ TAG -- OR --	BOTH TEMP.S 130° GTR THAN ADJ TAG -- AND --					BOTH T s 130° BELOW ADJ. TAG -- AND --	BOTH T s 130° ABOVE ADJ. TAG -- AND --
HPOT DS P			45 PSI LESS THAN ADJ. TAG -- AND --	45 PSI LESS THAN ADJ. TAG	45 PSI GTR THAN ADJ. TAG -- AND --	45 PSI GTR THAN ADJ. TAG					25 PSI BELOW ADJ. TAG	25 PSI ABOVE ADJ. TAG
MCC Pc			40 PSID BETWEEN Pc A AND B		40 PSID BETWEEN Pc A AND B							
LPFT DS T							REASONABLE	FAIL REAS				
LPFT DS P								-- OR -- FAIL REAS				
OPOV POS.				-- AND -- 1% BELOW ADJ. TAG		-- AND -- 1% ABOVE ADJ TAG					-- AND -- 1% BELOW ADJ TAG	-- AND -- 1% ABOVE ADJ TAG
FPOV POS.				-- AND -- WITHIN 2% OF ADJ. TAG		-- AND -- WITHIN 2% OF ADJ. TAG				-- OR --	-- AND -- 2% ABOVE ADJ TAG	-- AND -- 2% BELOW ADJ TAG
OTHER							LPFT DT 1° BELOW LPFT DT MID-VAL SELECT			HYD. P LESS THAN 1000 PSIA		

TITLE

OPS RECORDER USAGE FOR SSME DATA

PURPOSE

The purpose of this SCP is to document OPS-1 recorder usage for recording main engine data through the end of the MPS dump.

DESCRIPTION

During ascent, the OPS-1 recorder is configured to record main engine data and the OPS-2 recorder is configured to record orbiter data. For a nominal ascent and an AOA, the EIU 60 kbps data is recorded until completion of the MPS dump which normally occurs at MECO plus 4 minutes (approximately 12:30 MET). If the MPS dump is delayed, the recording stops at 16 minutes MET for 28.5° inclination missions. This allows 1 minute to reconfigure the OPS recorders before the Dakar ground station acquisition of signal (AOS). The orbiter OI data must be protected, so the OPS-1 recorder is reconfigured to record orbiter data while the OPS-2 recorder begins dumping orbiter ascent data over the Dakar ground station. If a higher inclination mission is flown, the OPS recorder reconfiguration will occur no earlier than 16 minutes MET. For RTLS or TAL abort cases, the OPS-1 recorder is not stopped.

The OPS-1 recorder engine data are dumped within the first 24 hours of the mission. The engine data are dumped through the Tracking and Data Relay Satellite (TDRS) with the exception of mission-specific Ku-band constraints that would violate the 24-hour timeframe. In this case the dump is completed via the Continental United States (CONUS) ground station network. The engine data are written over until MSFC verifies that the quality of the data is good.

If the OPS-1 recorder fails prelaunch, the launch is not scrubbed (ref. LCC 6.9.6-02). The real-time FM downlink of the EIU 60 kbps will be available for recording on the ground until the Bermuda ground station loss of signal (LOS). Bermuda LOS occurs at 11:30 MET for 28.5° inclination missions and occurs earlier for higher inclination missions. If the OPS-2 recorder fails prelaunch, the OPS-1 recorder is tape-limited to 20 minutes (due to a necessary speed change), which should meet all of the main engine requirements. If the OPS-1 recorder fails during ascent, the recorders are not reconfigured and the main engine data recording stops.

REFERENCE

NASA Memo, EP2-89-M102, July 17, 1989

TITLE

CONSOLE CONFIGURATION (CCONFIG) OPERATIONS

PURPOSE

The purpose of this procedure is to explain console initialization operations for boosters when using the CCONFIG software in the workstation executive (WEX) environment.

DESCRIPTION

Console initialization can be simply done with the selection of Console Config SIM XX, or Console Config XXX under the right mouse button (XX and XXX being the flight number desired). These selections run the program CCONFIG created by MMACS with data files created by booster. The main function of CCONFIG is to act as an automated version of a Megadata terminal (to send MED's to the MOC and NRT hosts).

When one of these selections is executed, two toggle boxes appear at the top of the display. Click the left mouse button with the pointer in the box to change the contents of these toggle boxes. The toggle boxes in the main display have the following functions:

SIMULATION MEDS/FLIGHT MEDS

This toggle box has no utility for booster since we have totally separate CCONFIG files for sim and flight MED's (this was found to be a safer way of operating).

NO FLIGHT SELECT/FLIGHT SELECT

This toggle box disables/enables flight selection of the booster, main engine, and MPS consoles.

In the middle of the screen are grey toggle boxes that act as "main MED file" selectors:

BSE DDDs
ALL DDDs
ORBIT LIMITS
TIMERS V90
ET SEP DISCRETE
ME DDDs
MOC/DSC MEDs/UPs
NRT MEDs
TELEMETRY OVERRIDES
HELIUM MEDs STS39
MPS DDDs
ASCENT LIMITS
FID CLR
UDDs
OTHER

Click the mouse on the main MED file desired and choose a function from the command line below to execute on those files (i.e., SEND). Each of the above files contains a number of "individual MED files".

At the bottom of the screen is a command line, which contains the following buttons:

->EDIT/LIST

This button allows the user to select a main MED file and list the file or edit the contents of the file (referred to below as "edit" mode). "Main" mode will be when the screen containing the grey main MED file selectors is displayed. When in edit mode, the user must select which MED number type of individual MED's is to be displayed (this is selected at the top of the edit mode display (i.e., V41, etc.)).

SEND FILE

(Main) Automatically sends the main MED file selected in the middle of the "main" screen to the selected host (either MOC/DSC or NRT).

(Edit) Sends the currently selected individual MED file to the host selected.

PRINT FILE

(Main) The entire contents of the main MED file selected in the middle of the screen is output to the local laser printer. The output will consist of a series of unformatted positional MED's.

(Edit) The currently selected individual MED file is output to the local laser printer in the same format as on the display.

->EXIT

Selecting this button exits from the CCONFIG program and returns to the WEX 2.5 environment.

Several more buttons are exclusive to the edit mode.

STORE

Stores the displayed individual MED file in the currently selected main MED file (changing the name and then storing will create a new individual MED file).

DELETE

Deletes the displayed individual MED file from the currently selected main MED file.

REPLACE

Replaces the individual MED file retrieved with the individual MED file currently displayed.

NEXT and PREVIOUS

Allows the user to page back and forth amongst the individual MED files.

MAIN

Sends the user back to main mode.

CONSOLE INITIALIZATION STEPS

1. Login, following the login procedure described in SCP 6.14.
2. After obtaining the white UNIX shell window (or the WEX advisory line, etc.), hold down the right mouse button.
3. From the menu displayed, select Console Config-Sim XX, or Console Config-XXX, as required (XX and XXX are the flight numbers).
4. The console configuration window discussed previously should appear.
5. Move the mouse pointer inside the window to activate.
6. Using the mouse and its buttons to move around and select, select the following values for the toggle boxes:

   FLIGHT MEDS/FLIGHT SELECT

7. Select a main MED file to be sent to the selected host. Any of the main MED files can be sent by either the ME console or the MPS console but they should only be sent once. Especially avoid sending ASCENT LIMITS simultaneously from both consoles as this will switch limit sets at the wrong point in sending limit values. Note: DO NOT SEND THE TELEMETRY OVERRIDES DURING FLIGHTS. Another tip: Wait to send the ET SEP DISCRETE after the UDD's have been sent. Use EDIT mode to send the individual UDD MED's, otherwise 2/3 of the UDD's will be written over. ALL DDDs can be sent instead of the BSE DDDs, ME DDDs, and MPS DDDs. And, wait to send FID CLR until after a hard copy of MSK's 1069 and 1051 have been taken on the MOC.
8. Click on SEND FILE to send the selected main MED file to the selected host. Messages indicating the transmittal of the MED file to the host should scroll past in the WEX advisory window.
9. Note that in order to send the NRT MEDs file to the NRT host, the NRT host must be selected in place of the MOC/DSC host. This is best accomplished by logging off and logging back on again, selecting NRT on the subsequent login (see SCP 6.14).

10. If errors are found in MED values sent to the host, select the erroneous main MED file name and enter into edit mode by clicking on the ->EDIT button. In edit mode, select the individual MED file type (i.e., V41), then select the individual MED from the list displayed. Once the error is fixed, use the REPLACE button to change the value in the saved file. SEND can then be selected to send the individual MED to the host. There is no need to resend the entire main MED file.

TITLE

MISSION EVALUATION WORKSTATION SYSTEM (MEWS) OPERATIONS

PURPOSE

The purpose of this procedure is to explain booster operations when using the MEWS software. The procedures described below enable users to make booster MEWS data requests via the Workstation Executive (WEX).

DESCRIPTION

MEWS is used to produce graphical plots and tabular lists of near real time (NRT) flight data.

It should no longer be necessary to download MEWS from the CM host, but should the user wish to do so see SCP 6.14 for the necessary steps.

MEWS is accessed from the Right Mouse Button (RMB) as follows:

Log on to WEX (see SCP 6.14).

In order to pull flight data from the NRT host, you must log on in operational mode.

Click and hold down the Right Mouse Button - this will reveal the "Booster Applications" menu. Within this menu is listed:

MEWS

Drag the mouse indicator down over this selection (it will be highlighted). Release the mouse button - this will initiate the MEWS software. The MEWS window will appear - using the left mouse button, place it where you wish.

Items marked with an * below are the basic commands - start with these. Use the left mouse button to access options below.

Inside the MEWS window the following options are available:

File
Applications
Utilities
Help

The underbar (_) above indicates that further options are available "underneath" those particular options. Be patient while the selected option is being processed - sometimes this can take a minute or more (particularly when selecting NRT Interface, Plot, or Tab under Applications).

Under "File" the following options are available:

* Reset MEWS configuration

Selecting this option will popup the "MEWS Environment Settings" window. If defaults are not selected, follow the instructions in the window to select which "MEWS Flight" (i.e. 42) and which "MEWS Subsys" (subsystem - i.e., SSME or MPS) you desire. If defaults are active and you wish to change them, click on the title of the default you wish to change and then select your new default. Click on "OK" when complete.

* Exit

Select this when you wish to exit from the MEWS program.

Under "Applications" the following options are available:

* NRT Interface

When first entering the NRT Interface a status window appears, if all information is correct, click on Ok, if not, correct it then click on Ok. Note that when options are displayed by MEWS in a lighter text, it usually indicates the function is not operational in your current configuration.

Files

Load Config File	Load a configuration file.
File Utilities ->	(The -> means more beneath)
Copy	Copy files.
Move	Move files.
Delete	Delete files.
Media Access	Access floppies and cartridge tapes. Not operational.
Edit Events	
Exit Program Ctrl+E	Exits you from the NRT Interface and sends you back to the main MEWS window.

	MEWS Subsystem	(i.e., SSME, click to change)
	MEWS Flight	(i.e., STS-042, click to change)
*	Request	
*	Data From MEWS Formats	Request data from MEWS plot and tabular formats, as well as from individual MSIDs. Files can be listed, selected, or entered manually. Data sample rate, start and stop times, and output datafile names must be supplied as well. Click on Request to send request to the NRT host.
*	Data From NRT PLISTS	Similar to above, only the Plist name must be entered manually.
	Missing MASTER Segment	For requesting MASTER Plist intervals that were missed for various reasons (see Auto below).
	Cancel a NRT Data Request	Allows user to cancel a NRT data request prior to completion, but you must know the request number.
	P-list	Can only use these options during the "PNP Open" period - usually a week or two prior to flight.
	Create a Parameter List	Allows the user to create parameter lists at the CM host.
	Delete a Parameter List	Allows the user to delete parameter lists at the CM host.

	Insert/Remove Parameters	Allows the user to insert or remove parameters from the parameter lists at the CM host.
*	Status	Allows the user to observe real time the status of NRT data requests, etc.
*	Workstation Data Request Status	Status of NRT requests - includes three advisory lines.
	NRT Host Status Display Pages	Not operational.
*	Review Data Request Advisories	Summary of data request advisory log.
	Auto	
	Start Automatic Requester	Sends MASTER Plist requests every 20 minutes.
	Stop Automatic Requester	Stops MASTER Plist requests.
	Kill Auto Requester	Disables all NRT requests.
	Delete Deblocker Log	Not operational.
	Define MASTER Plist	Defines a new MASTER Plist and deletes the old one at the CM.
	Change System MPL Name	Change the MASTER Plist name at the CM host.
	Help	Help utility (see Help below).

* Plot

Options under the Plot utility allow the user to create plots of data using pulled NRT data and user defined plot formats.

	Files	Same as under "NRT Interface".
	MEWS Subsystem	(i.e., SSME, click to change)
	MEWS Flight	(i.e., STS-042, click to change)
	Data	
*	Select Data	Select datafile from which the data is to be plotted (must be done prior to plotting).
	Select Data Overlay	Select datafile from which the overlay data is to be plotted.
	Format	
*	Select format	Select format in which data is to be plotted (also must be done prior to plotting).
	Select family	Select a family of formats.
	Modify format	Change details of a plot format.
	Modify family	Add or delete formats in the family list.
*	Create format	Make a new plot format.
	Create family	Specify plot formats in a family.

	Scaling	
	Change Time Period	Change time period of data displayed - can be used to zoom on the X-axis when its variable is time, or to change the time interval for the data when plotting a different parameter on the X-axis.
	Set Time Reference... ->	
	GMT	(selectable button)
	MET	(selectable button)
	Temporary Y-Axis Scale	Temporarily change the Y-axis scale.
	X-Axis Zoom (mouse)	Mouse zoom on X-axis.
	Y-Axis Zoom (mouse)	Mouse zoom on Y-axis.
	Slide Time (overlay only)	Slide overlay data.
*	Plot	
*	View Plot	Execute the plot. Use "resize" under the LMB to enlarge the window.
	Auto Plot	Auto plot a family of plots
	Replot	Re-execute the plot once changes in scaling, etc. are made. Erases labels.
	Label	
	Data Label	Will automatically track data points with the mouse cursor giving X and Y coordinates - then allows user to place a label on the plot.
	Text Label	Place a plain text label on the plot.

	Remove Label	Click and hold LMB, then rubberband the deletion window around the label you wish to erase.
*	Print	
*	Produce Hardcopy	Sends a hardcopy of the displayed plot to the Genicom printer (this takes a few minutes to print out each plot).
	Change Printer...	Not operational.
	Help	Help utility (see Help below).

* Tab

Options under the Tab utility allow the user to create tables of data using pulled NRT data and user defined table formats.

	Files	Same as under "NRT Interface" and "Plots."
	MEWS Subsystem	(i.e., SSME, click to change)
	MEWS Flight	(i.e., STS-042, click to change)
*	Data	
*	Select Data Source...	Select datafile from which the table is to be created (must be done prior to displaying the table).
	Format	
	Select Format...	Select tabular format file.
	Modify Format...	Modify a tabular format file.
	Create Format...	Create a tabular format file.

Option	
Change Time Period	Change time period of data displayed.
Set Time Reference... ->	
GMT	(selectable button)
MET	(selectable button)
Tab	
Tab to Screen...	Display the table to the screen.
Tab to Printer	Print the table on the printer.
Help	Help utility (see Help below).

Under "Utilities" the following options are available:

Add a Flight	Add a flight number to those available.
Add a Subsystem	Add a new subsystem to those available.
Uncompress Nomenclature Files	This is only to be performed during the first MEWS run for a flight (do not mess with this unless you know what you are doing).

Under "Help" the following is found:

On MEWS system...	Not operational.

Note: see table 6.18-1 for a cross reference of which plot formats correspond to which Plist.

ALLEGEDLY "FOOL PROOF" INSTRUCTIONS FOR PULLING FLIGHT DATA WITH MEWS AND P-LISTS

Log on to the SNOOPY workstation in MPSR-1 (or in MPSR-2 the BREWSTER workstation) following the instructions in SCP 6.14.

To pull **ASCENT** data associated with the **MAIN ENGINE** console, perform the following while in MEWS software:

Click on "Applications"
Click on "NRT Interface"
Wait. Place the window with the LMB. Click on Ok.

Check to be sure "SSME" is displayed in the MEWS subsystem display area at the top of the screen. If MPS or another subsystem is displayed, click on it then follow the instructions to change it to SSME.

Click on "Request"
Click on "Data From NRT PLISTS"

Now enter the name of the NRT P-list, the timeframe of flight to be pulled, the sample rate (1 sample/second), and the name of the data file you wish the data to be stored in, as follows:

Note: You will need to know the GMT time corresponding to any T- time in order to pull that data.

P-list name: **ME**
Time frame: From: **T- 5:00 min** (in GMT)
To: **T+ 10:00 min** (in GMT)
Data file name: **ME##-ASC** (## is the flight number)

Click on "Request" to send this data request to the NRT host.

Note: To facilitate the archival nature of this data, you must conform to the above data file name standard (i.e., use ME31-ASC for the main engine data for STS-31)

If you wish to see the status of your data request, perform the following:

Click on "Status"
Click on "Workstation Data Request Status"

Now retrieve the remaining data:

Click on "Request"
Click on "Data from NRT PLISTS"

P-list name: **EIU**
Time frame: From: **T- 5:00 min** (in GMT)
To: **T+ 10:00 min** (in GMT)
Data file name: **EIU##-ASC** (## is the flight number)

Click on "Request" to send this data request to the NRT host.

To pull **ASCENT** data associated with the **MAIN PROPULSION SYSTEM** console, perform the following:

Click on "Applications"
Click on "NRT Interface"
Wait. Place the window with the LMB. Click on Ok.

Check to be sure "MPS" is displayed in the MEWS subsystem display area at the top of the screen. If SSME or another subsystem is displayed, click on it then follow the instructions to change it to MPS.

Click on "Request"
Click on "Data From NRT PLISTS"

Now enter the name of the NRT P-list, the timeframe of flight to be pulled, the sample rate (1 sample/second), and the name of the data file you wish the data to be stored in, as follows:

Note: You will need to know the GMT time corresponding to any T- time in order to pull that data.

P-list name: **SRB**
Time frame: From: **T- 5:00 min** (in GMT)
To: **T+ 3:00 min** (in GMT)
Data file name: **SRB##-ASC** (## is the flight number)

Click on "Request" to send this data request to the NRT host.

Note: To facilitate the archival nature of this data, you must conform to the above data file name standard (i.e., use SRB31-ASC for the SRB data for STS-31)

If you wish to see the status of your data request, perform the following:

Click on "Status"
Click on "Workstation Data Request Status"

Now retrieve the remaining data:

Click on "Request"
Click on "Data from NRT PLISTS"

P-list name: **HELIUM**
Time frame: From: **T- 5:00 min** (in GMT)
To: **T+ 10:00 min** (in GMT)
Data file name: **HE##-ASC** (## is the flight number)

Click on "Request" to send this data request to the NRT host.

Click on "Request"
Click on "Data from NRT PLISTS"

P-list name: **EXTERNTK**
Time frame: From: **T- 5:00 min** (in GMT)
To: **T+ 10:00 min** (in GMT)
Data file name: **ET##-ASC** (## is the flight number)

Click on "Request" to send this data request to the NRT host.

Click on "Request"
Click on "Data from NRT PLISTS"

P-list name: **LO2**
Time frame: From: **T- 5:00 min** (in GMT)
To: **T+ 30:00 min** (in GMT)
Data file name: **LO2##-ASC** (## is the flight number)

Note: The "to" time may need to be extended if a second vacuum inert is necessary.

Click on "Request" to send this data request to the NRT host.

Click on "Request"
Click on "Data from NRT PLISTS"

P-list name: **LH2**
Time frame: From: **T- 5:00 min** (in GMT)
To: **T+ 30:00 min** (in GMT)
Data file name: **LH2##-ASC** (## is the flight number)

Note: The "to" time may need to be extended if a second vacuum inert is necessary.

Click on "Request" to send this data request to the NRT host.

To pull **ENTRY** data associated with the **MAIN PROPULSION SYSTEM** console, perform the following:

Click on "Applications"
Click on "NRT Interface"
Wait. Place the window with the LMB. Click on Ok.

Check to be sure "MPS" is displayed in the MEWS subsystem display area at the top of the screen. If SSME or another subsystem is displayed, click on it then follow the instructions to change it to MPS.

Click on "Request"
Click on "Data From NRT PLISTS"

Now enter the name of the NRT P-list, the timeframe of flight to be pulled, the sample rate (1 sample/second), and the name of the data file you wish the data to be stored in, as follows:

Note: You will need to know the MET time corresponding to both the TIG time and the wheel stop time in order to pull entry data.

P-list name: **HELIUM**
Time frame: From: **TIG- 25:00 min** (in MET)
To: **WHEEL STOP** (in MET)
Data file name: **HE##-ENT** (## is the flight number)

Click on "Request" to send this data request to the NRT host.

Note: To facilitate the archival nature of this data, you must conform to the above data file name standard (i.e. use HE31-ENT for the helium data for STS-31)

If you wish to see the status of your data request, perform the following:

Click on "Status"
Click on "Workstation Data Request Status"

Now retrieve the remaining data:

Click on "Request"
Click on "Data from NRT PLISTS"

P-list name: **LO2**
Time frame: From: **TIG- 25:00 min** (in MET)
To: **WHEEL STOP** (in MET)
Data file name: **LO2##-ENT** (## is the flight number)

Click on "Request" to send this data request to the NRT host.

Click on "Request"
Click on "Data from NRT PLISTS"

	P-list name:	LH2	
Time frame:	From:	TIG- 25:00 min	(in MET)
	To:	WHEEL STOP	(in MET)
	Data file name:	LH2##-ENT	(## is the flight number)

Click on "Request" to send this data request to the NRT host.

To get out of MEWS:

In the main MEWS window, click on "File", then click on "Exit".

POSTFLIGHT ACTIVITIES

Once all the data for a flight has been pulled, it needs to be archived in a convenient place for backup. This place is under the /user/booster directory in test mode. Many other things that need to be periodically backed up are stored under /user/booster - only one command need be used to archive all this information onto one streamer tape; this makes backups less painful. Follow these instructions:

In operational mode, MEWS data is stored by MEWS in directory:

```
/user/mews/flights/###/data/subsystem/cod
```

Where ### is the flight number (i.e., 042), and subsystem is either SSME or MPS, etc.

In order to archive the MEWS data, the user needs to log into WEX in the test mode. When you log into test mode, the above directory is accessed using the Unix "cd" command as follows:

```
cd /WEX/Ops/user/mews/flights/###/data/subsystem/cod
```

Where again ### is the flight number, and subsystem is either SSME or MPS, etc.

When the Unix "pwd" command is executed, the following will be observed:

```
/WM/WEX2.5/Ops/user/mews/flights/###/data/subsystem/cod
```

While in test mode, perform the Unix "cp" (copy) command as follows:

```
cp * /user/booster/MEWS/STS-##
```

Where ## again is the flight number (i.e., 42). Do this for both the MPS and SSME systems - all data will be archived in one location.

If the /user/booster/MEWS/STS-## directory does not exist, you will need to create it using the Unix "mkdir" command as follows:

```
mkdir /user/booster/MEWS/STS-##
```

Again, this all needs to be done in test (aka. development) mode.

If you wish to save any of the data files you have created off onto floppy disk or streamer tape, perform the following while in test mode as well:

To save data files, "cd" to:

```
/WEX/Ops/user/mews/flights/###/data/subsystem/cod
```

Where ### is the flight number, and subsystem is either SSME or MPS, etc.

Use "tar -cvf /dev/rflp *" for floppies.

Use "tar -cvf /dev/rctp *" for cassette tapes.

Individual filenames can be substituted for the wildcard * above if individual files are desired.

Plot format files are found in directory:

```
/WEX/Ops/user/mews/subsystems/subsystem/plot
```

Subsystem again is either SSME or MPS, etc.

Tabular format files are found in directory:

```
/WEX/Ops/user/mews/subsystems/subsystem/tab
```

Subsystem again is either SSME or MPS, etc.

In the future floppy/tape archiving will be available from operational mode under "Applications", and under either "NRT Interface", "Plot", or "Tab", click on "Files".

Under "Files", selections will be available to move files to/from floppies/cassette tapes - this is not yet operational.

TABLE 6.18.I - LIST OF BOOSTER STANDARD PARAMETER LISTS (P-LISTS).

P-LIST:	ME	EIU	SRB	EXTERNTK	HELIUM	LO2	LH2
Target data-file names:	ME##-ASC	EIU##-ASC	SRB##-ASC	ET##-ASC	HE##-ASC HE##-ENT	LO2##-ASC LO2##-ENT	LH2##-ASC LH2##-ENT
For plot formats:	C,L,R_PC'S	(none yet)	SRB-HYD	ET-VENT	HE-TK-TEMP	LO2-INTEMP	LH2-INTEMP
	CCV_POS		SRB-TUBSP	ECO-SENS	HE-TK-P	ECO-SENS	DISC-PRESS
	CLPFPD_T,P		SRB-FSM	HE-REG-A	DISC_LATCH	PREVVS	
	C_OX,FU_FL				HE-REG-B	DISC-PRESS	MAN_VV
	C_PC,PLVL					MAN_VV	MAN_VV2
	FPOV_POS					MAN_VV2	LH2-OUTPR
	FU_FLOWRT					LO2_PV	LH2-MN-INP
	GH2_OUT_P					LO2-ULLFCV	LH2-INTEMP
	GO2_OUT_T					LO2-MAN-IN	
	HPFPCLLN_P					LO2-INTEMP	
	HPFT_TDT						
	HPOT_ISP						
	HPOT_SSL_P						
	HPOT_TDT						
	HYD_P						
	LLPFPD_T,P						
	L_OX,FU_FL						
	L_PC,PLVL						
	MFV_POS						
	MOV_POS						
	MSK_2759						
	MSK_2760						
	MSK_2761						
	MSK_2762						
	MSK_2763						
	MSK_2764						
	MSK_2765						
	MSK_2766						
	OPOV_POS						
	OX_FLOWRT						
	PWR_LVL						
	RLPFPD_T,P						
	R_OX,FU_FL						
	R_PC,PLVL						

Note: ## above refers to the flight number (i.e., ME##-ASC would be ME31-ASC for the STS-31 data).

TITLE

DISCREPANCY REPORT FORM

PURPOSE

The purpose of this SCP is to help console operators fill of MOC/SMS hardware/software discrepancy reports (DR's).

DESCRIPTION

A problem does not officially exist with your console until it is documented. The proper form of documentation is the DR (form RSO 8900-A). If the DR is not filled out properly, the form is sent back and your problem will not be fixed. The DR form has many confusing blocks. The enclosed figures should help in filling out the form correctly. Submit all DR's to the GC. Hard copies of relevant MOC display should be enclosed. Always enclose a hard copy of MCC display MSK 0006 SYSTEM STATUS. This helps the people who will try to recreate your problem locate the MCC log tape of the simulation run with the data of the problem.

Always make a copy of your DR and record its number. DR's have been known to get lost in the system. All DR's should be filed with the section console Data Pack Manager (DPM). When the DR is closed out, the yellow copy will be returned to the originator. The yellow copy should also be filed with the DPM.

PROCEDURE

1. Obtain DR form from GC console and fill out as shown in figure 6.19-I.

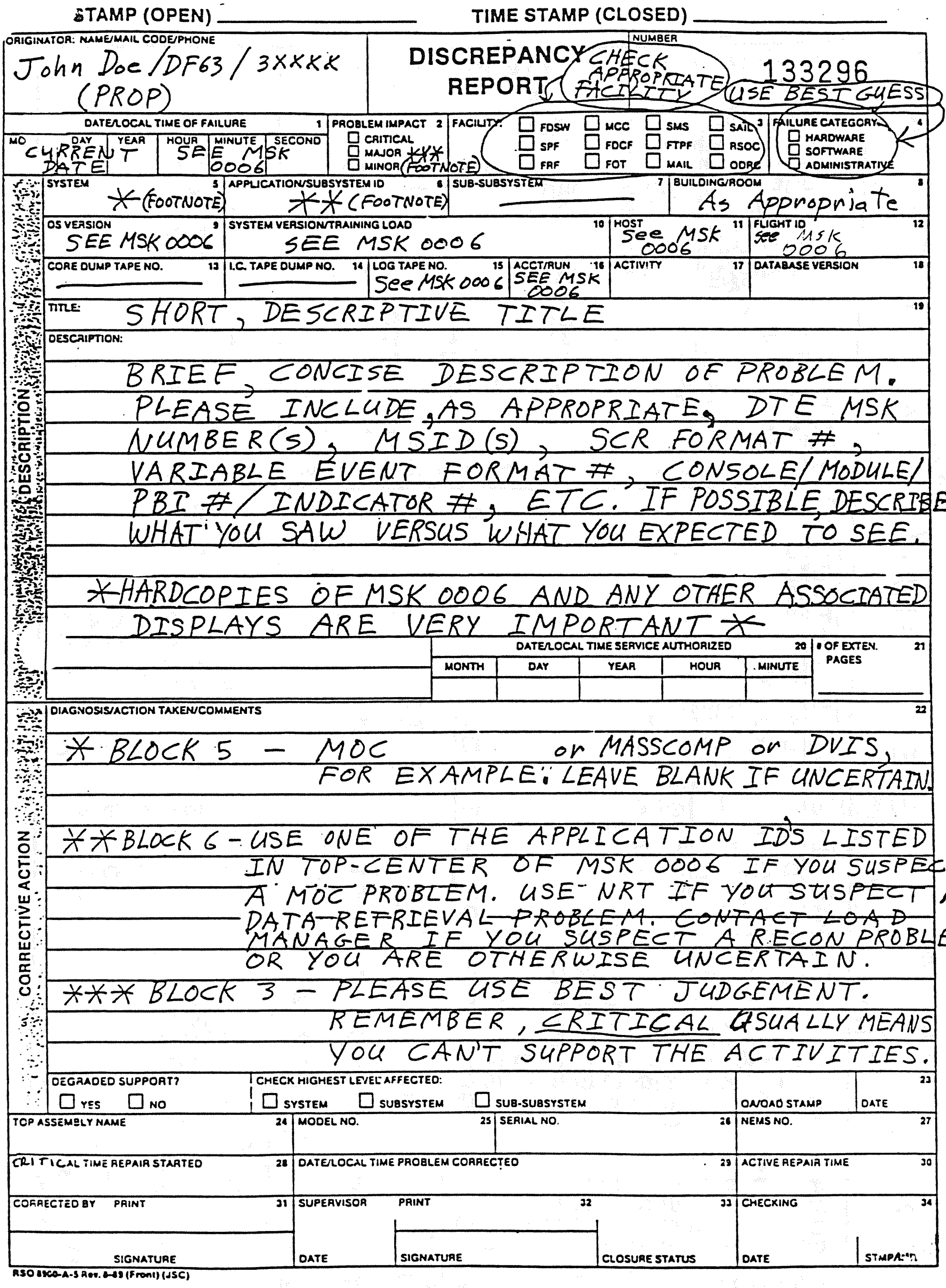
Special block instructions

Block number	Block name	Instruction
2	Problem Impact	Check Critical or Major
3	Facility	Check MCC, SMS, or both
4	Failure Category	Check Hardware or Software
5	System	Use MOC, Masscomp, DVIS, SMS, etc.
6	Application/Subsystem ID	Obtain data from MSK 0006
9	OS Version	Obtain data from MSK 0006
10	System Version/Training Load	Obtain data from MSK 0006
11	Host	Obtain data from MSK 0006
12	Flight ID	Obtain data from MSK 0006
15	Log Tape Number	Obtain data from MSK 0006
16	ACCT/Run	Obtain data from MSK 0006
17	Activity	Use ILC, flight, simulation, etc.
19	Title	Use a short title
	Description	As applicable

2. Copy DR form and file in Section Data Pack.

3. Submit DR to GC console. Enclose hard copy of MSK 0006 and other MOC displays as appropriate.

4. File yellow copy when DR is closed out.



STAMP (OPEN) ____________ TIME STAMP (CLOSED) ____________

ORIGINATOR: NAME/MAIL CODE/PHONE: John Doe /DF63 / 3XXXX (PROP)

DISCREPANCY REPORT CHECK APPROPRIATE FACILITY

NUMBER: 133296 USE BEST GUESS

DATE/LOCAL TIME OF FAILURE 1 MO DAY YEAR: CURRENT DATE HOUR MINUTE SECOND: SEE MSK 0006	PROBLEM IMPACT 2 ☐ CRITICAL ☐ MAJOR *** ☐ MINOR (FOOTNOTE)	FACILITY: 3 ☐ FDSW ☐ MCC ☐ SMS ☐ SAIL ☐ SPF ☐ FDCF ☐ FTPF ☐ RSOC ☐ FRF ☐ FOT ☐ MAIL ☐ ODRC	FAILURE CATEGORY 4 ☐ HARDWARE ☐ SOFTWARE ☐ ADMINISTRATIVE	
SYSTEM 5 * (FOOTNOTE)	APPLICATION/SUBSYSTEM ID 6 ** (FOOTNOTE)	SUB-SUBSYSTEM 7 ——	BUILDING/ROOM 8 As Appropriate	
OS VERSION 9 SEE MSK 0006	SYSTEM VERSION/TRAINING LOAD 10 SEE MSK 0006	HOST 11 See MSK 0006	FLIGHT ID 12 See MSK 0006	
CORE DUMP TAPE NO. 13 ——	I.C. TAPE DUMP NO. 14 ——	LOG TAPE NO. 15 See MSK 0006	ACCT/RUN 16 SEE MSK 0006	ACTIVITY 17 / DATABASE VERSION 18

TITLE: SHORT, DESCRIPTIVE TITLE 19

DESCRIPTION:

BRIEF, CONCISE DESCRIPTION OF PROBLEM. PLEASE INCLUDE, AS APPROPRIATE, DTE MSK NUMBER(S), MSID(S), SCR FORMAT #, VARIABLE EVENT FORMAT #, CONSOLE/MODULE/PBI #/INDICATOR #, ETC. IF POSSIBLE, DESCRIBE WHAT YOU SAW VERSUS WHAT YOU EXPECTED TO SEE.

HARDCOPIES OF MSK 0006 AND ANY OTHER ASSOCIATED DISPLAYS ARE VERY IMPORTANT

DATE/LOCAL TIME SERVICE AUTHORIZED 20					# OF EXTEN. PAGES 21
MONTH	DAY	YEAR	HOUR	MINUTE	

DESCRIPTION

DIAGNOSIS/ACTION TAKEN/COMMENTS 22

* BLOCK 5 – MOC or MASSCOMP or DVIS, FOR EXAMPLE; LEAVE BLANK IF UNCERTAIN.

**BLOCK 6 – USE ONE OF THE APPLICATION ID'S LISTED IN TOP-CENTER OF MSK 0006 IF YOU SUSPECT A MOC PROBLEM. USE NRT IF YOU SUSPECT A DATA RETRIEVAL PROBLEM. CONTACT LOAD MANAGER IF YOU SUSPECT A RECON PROBLEM OR YOU ARE OTHERWISE UNCERTAIN.

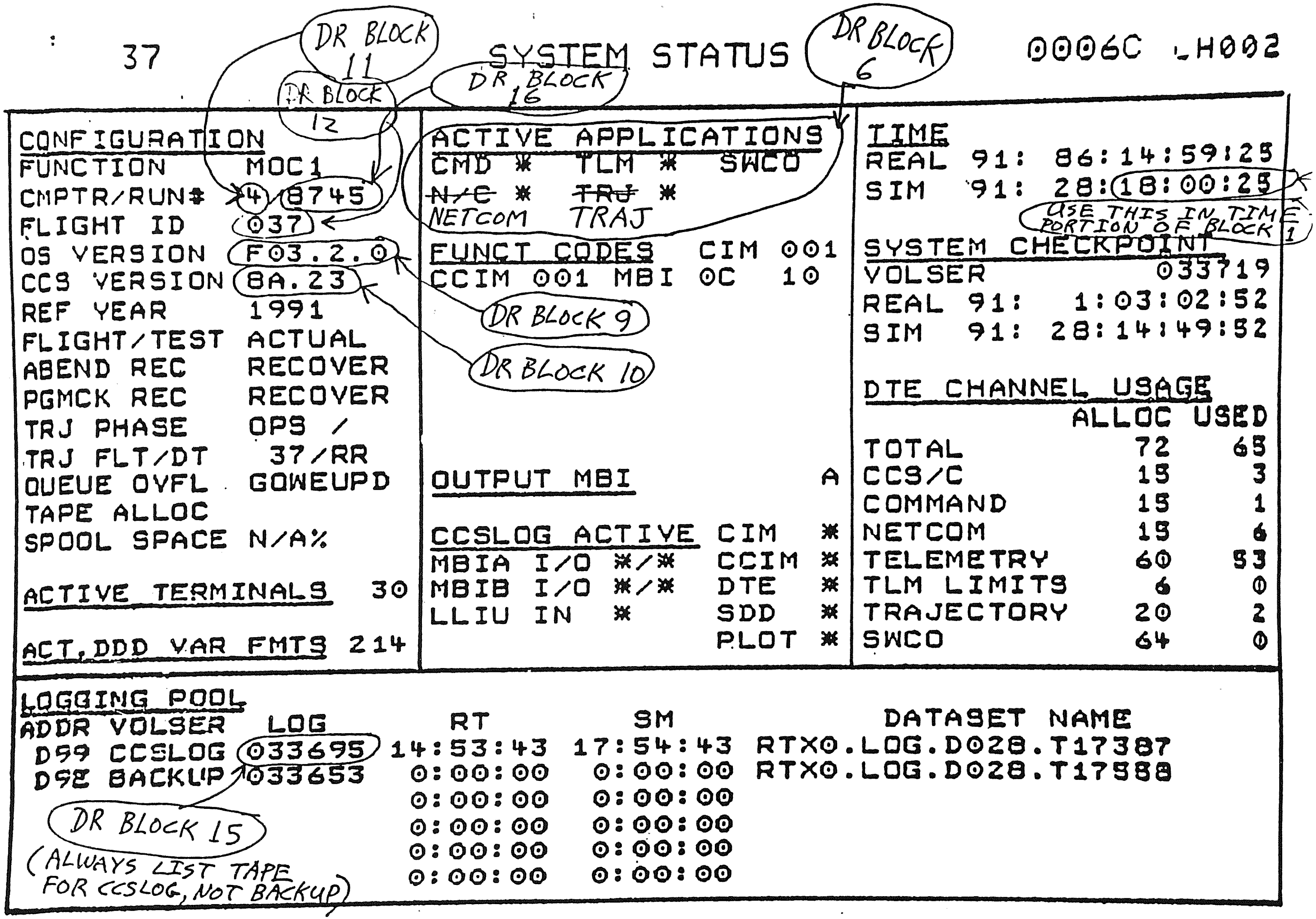
*** BLOCK 3 – PLEASE USE BEST JUDGEMENT. REMEMBER, CRITICAL USUALLY MEANS YOU CAN'T SUPPORT THE ACTIVITIES.

CORRECTIVE ACTION

DEGRADED SUPPORT? ☐ YES ☐ NO	CHECK HIGHEST LEVEL AFFECTED: ☐ SYSTEM ☐ SUBSYSTEM ☐ SUB-SUBSYSTEM	QA/QAD STAMP	DATE 23
TOP ASSEMBLY NAME 24	MODEL NO. 25	SERIAL NO. 26	NEMS NO. 27
CRITICAL TIME REPAIR STARTED 28	DATE/LOCAL TIME PROBLEM CORRECTED 29		ACTIVE REPAIR TIME 30
CORRECTED BY PRINT 31 SIGNATURE	SUPERVISOR PRINT 32 DATE / SIGNATURE	33 CLOSURE STATUS	CHECKING 34 DATE / STAMP

RSO 8900-A-5 Rev. 8-89 (Front) (JSC)

Figure 6.19-I.- Sample DR.



```
   37                    SYSTEM STATUS                   0006C  H002
CONFIGURATION          ACTIVE APPLICATIONS          TIME
FUNCTION      MOC1     CMD  *   TLM  *   SWCO       REAL  91:  86:14:59:25
CMPTR/RUN#    4 8745   N/C  *   TRJ  *              SIM   91:  28:18:00:25
FLIGHT ID     037
OS VERSION    F03.2.0  FUNCT CODES      CIM  001    SYSTEM CHECKPOINT
CCS VERSION   8A.23    CCIM 001 MBI     0C    10    VOLSER            033719
REF YEAR      1991                                  REAL  91:    1:03:02:52
FLIGHT/TEST   ACTUAL                                SIM   91:   28:14:49:52
ABEND REC     RECOVER
PGMCK REC     RECOVER                               DTE CHANNEL USAGE
TRJ PHASE     OPS /                                             ALLOC  USED
TRJ FLT/DT     37/RR                                TOTAL          72    65
QUEUE OVFL    GOWEUPD  OUTPUT MBI             A     CCS/C          15     3
TAPE ALLOC                                          COMMAND        15     1
SPOOL SPACE   N/A%     CCSLOG ACTIVE    CIM   *     NETCOM         15     6
                       MBIA  I/O  */*   CCIM  *     TELEMETRY      60    53
ACTIVE TERMINALS   30  MBIB  I/O  */*   DTE   *     TLM LIMITS      6     0
                       LLIU  IN   *     SDD   *     TRAJECTORY     20     2
ACT,DDD VAR FMTS  214                   PLOT  *     SWCO           64     0

LOGGING POOL
ADDR VOLSER   LOG       RT         SM            DATASET NAME
 D99 CCSLOG  033695  14:53:43   17:54:43   RTX0.LOG.D028.T17387
 D9E BACKUP  033653   0:00:00    0:00:00   RTX0.LOG.D028.T17588
                      0:00:00    0:00:00
                      0:00:00    0:00:00
                      0:00:00    0:00:00
                      0:00:00    0:00:00
```

~~N/C~~ NETCOM

~~TRJ~~ TRAJ

DR BLOCK 11

DR BLOCK 12

DR BLOCK 16

DR BLOCK 6

USE THIS IN TIME PORTION OF BLOCK 1

DR BLOCK 9

DR BLOCK 10

DR BLOCK 15

(ALWAYS LIST TAPE FOR CCSLOG, NOT BACKUP)

Figure 6.19-II.- MSK 0006.

TITLE

VEHICLE WEIGHT WORKSHEET

PURPOSE

This SCP calculates the vehicle weight at liftoff and at low-level cutoff for use in the RTDS percent propellant remaining and the propellant time-of-depletion computations. This SCP also gives the same inputs to the RTDS as the GPC for the onboard 2 percent prop remaining throttledown cue (R2_FINAL_WT & TOTAL_PRPLT).

DESCRIPTION

All necessary data for this worksheet comes form the flight-specific Trajectory Design Data Package (TDDP) and vehicle I-Loads document. The vehicle weight at low-level cutoff (W_LO) is computed from the sum of orbiter dry-weight data (see TDDP, page 4, vehicle summary weight statement) and unusable propellant data on the MPS Propellant Inventory is shown in TDDP table A6, sheet 2 of 2. Examples of these two tables are provided. Total propellant above the low-level sensors (H2_USE + O2_USE) is also computed from table A.6, sheet 2 of 2, shown in this SCP. A blank sheet and an example for STS-49 is provided.

REFERENCES

STS Trajectory Design Data Package, Mission Specific Flight Systems Design Engineering Office.

Space Shuttle Flight Software Initialization Load, Flight Cycle, Fight Specific Specification Requirements, Contract NAS9-18000.

VEHICLE SUMMARY WEIGHT STATEMENT*

STS-___ VEHICLE WEIGHT WORKSHEET

Prepared by ____________________

Date ____/____/____

Input data: page 4 Vehicle Summary Weight Statement
Table A.6-2 MPS Propellant Inventory

Vehicle Weight at Low-Level Cutoff

Orbiter plus cargo at SRB ignition + ______________ lb

ET (dry) + ______________ lb
ET buoyancy + ________ lb
MPS pressurant + ________ lb
Ice/frost, etc. + ________ lb

Shuttle systems losses to MECO - ________ lb

Unusable propellant (total) + ______________ lb

Bias (LH2) + ________ lb

Vehicle weight at low-level cutoff ______________ lb (W_LO)

****

Total Propellant Above Low-level Sensors

		LH2		LO2	
Usable reserves					
ORB line (FPR)	+	_______	+	_______	lb
ET (FPR)	+	_______	+	_______	lb
Usable impulse	+	_________	+	_________	lb
Total usable propellant		_________		_________	lb
		(H2_USE)		(O2_USE)	

****

2 Percent Prop Remaining (Onboard Comp)

Input data: I-Loads

V97U6913C (R2_FINAL_WT) _________ lb

V97U6927C (TOTAL_PRPLT) _________ lb

VEHICLE SUMMARY WEIGHT STATEMENT

PAGE 4 PRINTED: 02/27/92 VEHICLE SUMMARY WEIGHT STATEMENT GB:02/25/92 TDDP : PFLAF49

DESCRIPTION	WEIGHT LBS	(CENTER OF GRAVITY-IN) X	Y	Z	(MOMENTS/PRODUCTS OF INERTIA - SLUG*FEET*FEET) IX	IY	IZ	PXY	PXZ	PYZ
OV-105(1) 30JAN92	152140	1061.1	-0.4	366.5	938579	5245301	5405042	2684	89009	7921
SSME X 3 INERT	21151	1495.3	0.5	384.4	24225	19887	18106	67	-2600	162
BUOYANCY	80	1114.1	-0.3	368.7	0	0	0	0	0	0
CREW COMPARTMENT	7344	501.7	-7.6	375.3	4529	6350	5140	266	431	184
ORBITER WITHOUT CONSUMABLES	180715	1089.2	-0.6	369.0	968768	6598911	6754394	11324	111807	8258
NON-PROP CONSUM AT SRB IGN	6195	998.7	-3.8	337.7	10537	123233	124862	-3242	13989	-25
MPS PROPELLANT AT SRB IGN	5166	1409.0	6.8	354.4	4453	6120	5524	-677	1100	-433
OMS FUEL LEFT	3733	1425.5	-71.5	500.7	233	396	394	-9	5	-1
OMS FUEL RIGHT	3733	1425.5	71.5	500.7	233	396	394	9	5	1
OMS OXIDIZER LEFT	6167	1425.4	-109.5	461.4	396	655	667	0	21	3
OMS OXIDIZER RIGHT	6167	1425.4	109.5	461.4	396	655	667	0	21	-3
RCS PROPELLANT - FWD	2446	318.0	5.3	365.3	274	0	274	1	0	0
RCS PROPELLANT - AFT	4970	1345.3	0.0	470.3	8661	1022	9135	0	76	1
ORBITER MODULE TOTAL AT SRB IGN	219292	1121.7	-0.4	379.7	1092064	7731671	7878983	8680	292592	8026
CARGO MODULE	37275	1099.0	0.5	406.2	25393	213259	212898	-4021	16303	-591
CARGO BUOYANCY	30	1099.0	0.5	406.2	0	0	0	0	0	0
CARGO MODULE TOTAL	37305	1099.0	0.5	406.2	25393	213259	212898	-4021	16303	-591
★ ORBITER PLUS CARGO AT SRB IGN	256597	1118.4	-0.2	383.5	1122298	7953332	8095454	4519	304742	7599
★ ET ACTUAL	66781	1354.7	2.7	424.3	354005	3931932	3927930	3689	156493	7002
★ ET BUOYANCY	175	1354.7	2.7	424.3	0	0	0	0	0	0
MPS FUEL AT SRB IGN	229651	1607.2	0.0	400.0	0	3782594	3782594	0	0	0
MPS LOX AT SRB IGN	1367793	729.5	0.6	401.3	74487	4867066	4816462	136226	315654	26981
★ MPS PRESSURANT	121	725.5	0.0	400.0	0	2333	2333	0	0	0
★ ICE/FROST/LIQ AIR+N2+TPS H2O	317	1352.6	2.6	424.5	0	0	0	0	0	0
ET MODULE TOTAL AT SRB IGN	1664838	875.8	0.6	402.1	436162	48757297	48695181	132514	585239	34712
SRB LEFT SEPARATION	187584	1811.0	-250.9	401.0	192659	12020278	12024593	-29313	4221	515
SRB LEFT INFLIGHT LOSSES	1111611	1695.5	-250.5	399.9	732955	35080401	35080419	1900	-436	0
SRB LEFT IGN PREFLT	1299195	1712.2	-250.6	400.1	925657	47562634	47566933	-28816	7993	502
SRB RIGHT SEPARATION	187211	1810.2	250.9	401.0	192157	12021304	12025258	28537	4038	-528
SRB RIGHT INFLIGHT LOSSES	1111577	1695.5	250.5	400.1	732931	35088332	35088530	-1967	119	2
SRB RIGHT IGN PREFLT	1298788	1712.0	250.6	400.2	925122	47564953	47569080	27961	7866	-515
TOTAL MASS PROPERTIES AT SRB IGNITION	4519418	1412.4	0.2	419.0	43945702	322048398	352031083	-6177	8458657	42102

★ SHUTTLE SYSTEM LOSSES TO MECO : 503

ORBITER AND CARGO IN ORBITER COORDINATE SYSTEM. ET, SRB, AND SHUTTLE TOTAL IN SHUTTLE COORDINATE SYSTEM.

```
PAGE A5                       TABLE A6                      TDDP:PFLAF49
                               RELEASED
 12/21/90    7.8357        LOAD SHEET                      SHEET 2 OF 2
               MPS PROPELLANT INVENTORY  STS GEN    REV CC
*************************NOM *******************************************
FUEL BIAS =      983. THROTTLE SETTING NOM/AOA = 104/104 MR    = 6.0227
TOTAL FPR =     4671. % ULL O2 = 1.58  SIGMA = 3.00       OBMR = 6.0391
DELTA FPR =        0. % ULL H2 = 1.53          LH2       LO2       TOTAL
************************************************************************
LOADED                                        231853.  1387828.  1619680.
-----------------------------------------------------------------------
   ORB LINES                                     249.     3304.     3553.
   SSME X 3                                       58.     1325.     1383.
   ET(HXT=1044.6HUP=.15LXT=412.58LUP=0.78) 231546.  1383199.  1614744.
-----------------------------------------------------------------------
LOSS PRIOR TO ENG START CMD DBT    4.M:55.S     104.     5800.     5904.
-----------------------------------------------------------------------
   BOILOFF,DRAINBACK,ETC.                        104.     5800.     5904.
-----------------------------------------------------------------------
LOAD AT ENGINE START COMMAND                  231749.  1382028.  1613776.
-----------------------------------------------------------------------
   ORB LINES                                     249.     3304.     3553.
   SSME X 3                                       58.     1325.     1383.
   ET                                         231442.  1377399.  1608840.
   --------------------------------------------------------------------
     TRANSFERRED FROM ET TO SSME X 3              58.      172.      230.
   --------------------------------------------------------------------
LOSS FOR THR BUILDUP AND SRB IGN DELAY          1733.     9434.    11167.
-----------------------------------------------------------------------
LOAD AT SRB IGNITION COMMAND                  230016.  1372594.  1602609.
-----------------------------------------------------------------------
   ORB LINES                                     249.     3304.     3553.
   SSME X 3                                      116.     1497.     1613.
   ET                                         229651.  1367793.  1597443.
-----------------------------------------------------------------------
***********************************************************************
★ UNUSABLE                                      2087.     4683.    [6770.]
-----------------------------------------------------------------------
   ORB LINES(LOX ECO T=0.398 NPSP=6.4)           249.      513.      762.
   SSME X 3                                       58.     1325.     1383.
   ET WET WALLS,BELLOWS                            0.      175.      175.
   ET : LH2 LINES AND TANK; LOX LINES            720.        0.      720.
   FLIGHT PRESS                                 1060.     2670.     3730.
-----------------------------------------------------------------------
USABLE RESERVES                                 1647.     4007.     5654.
-----------------------------------------------------------------------
  ★ORB LINES (FPR)                              [0.]    [2791.]     2791.
   SSME X 3                                        0.        0.        0.
  ★ET (FPR)                                    [664.]    [1216.]     1880.
  ★BIAS                                        [983.]        0.      983.
-----------------------------------------------------------------------
★USABLE IMPULSE                              [226282.] [1363903.]  1590185.
-----------------------------------------------------------------------
   USED AT OBMR                               225597.  1362408.  1588005.
   SHUTDOWN CONSUMPTION                          627.     1323.     1950.
   --------------------------------------------------------------------
     0 SSME FROM NOM PCT THROTTLE SETTING          0.        0.        0.
     3 SSME FROM  67 PCT THROTTLE SETTING        627.     1323.     1950.
   --------------------------------------------------------------------
   VENTED AFTER SSME VALVE CLOSURE                58.      172.      230.
```

STS-49 VEHICLE WEIGHT WORKSHEET

Prepared by Mark Jenkins

Date 04/01/92

Input data:	TDDP page 4	Vehicle Summary Weight Statement
	Table A.6-2	MPS Propellant Inventory

Vehicle Weight at Low-Level Cutoff

Orbiter plus cargo at SRB ignition	+	256597	lb	
ET (dry)	+	66781	lb	
ET buoyancy	+	175	lb	
MPS pressurant	+	121	lb	
Ice/frost, etc.	+	317	lb	
Shuttle systems losses to MECO	-	503	lb	
Unusable propellant (total)	+	6770	lb	
Bias (LH2)	+	983	lb	

Vehicle weight at low-level cutoff		331241	lb	(W_LO)

****

Total Propellant Above Low-level Sensors

Usable reserves		LH2		LO2	
ORB lines (FPR)	+	0	+	2791	lb
ET (FPR)	+	664	+	1216	lb
Usable impulse	+	226282	+	1363903	lb
		(H2_USE)		(O2_USE)	

****

2 Percent Prop Remaining (Onboard COMP)

Input data: I-Loads

V97U6913C (R2_FINAL_WT)	311354	lb
V97U6927C (TOTAL_PRPLT)	1593486	lb

WORKSTATION
COMPUTATION

7

7 WORKSTATION COMPUTATION

TITLE

AVERAGE VEHICLE PERFORMANCE FOR SSME VALVE DRIFT DURING HYDRAULIC LOCKUP

This SCP has been deleted.

TITLE

MAIN ENGINE TABLE (MET) PROGRAM

PURPOSE

This SCP serves as the user's guide to the MET program.

BACKGROUND

The MASSCOMP program MET is used to create the main engine tables used on console as cue cards. These tables predict SSME performance impacts for electrical lockup, hydraulic lockup, and other off-nominal performance cases. Prior to each flight, MSFC supplies engine specific TAG data. This data is the estimated turbine performance for each SSME at a mission elapse time of 200 seconds. The MET program manipulates the TAG data to create off-nominal SSME performance predictions. The tables are printed and supplied to the ME, BSE, and FDO console operators. The procedures for recognizing SSME problems and using the main engine tables are documented in SCP 2.1.1 Sample output can be found in the MET program documentation folder.

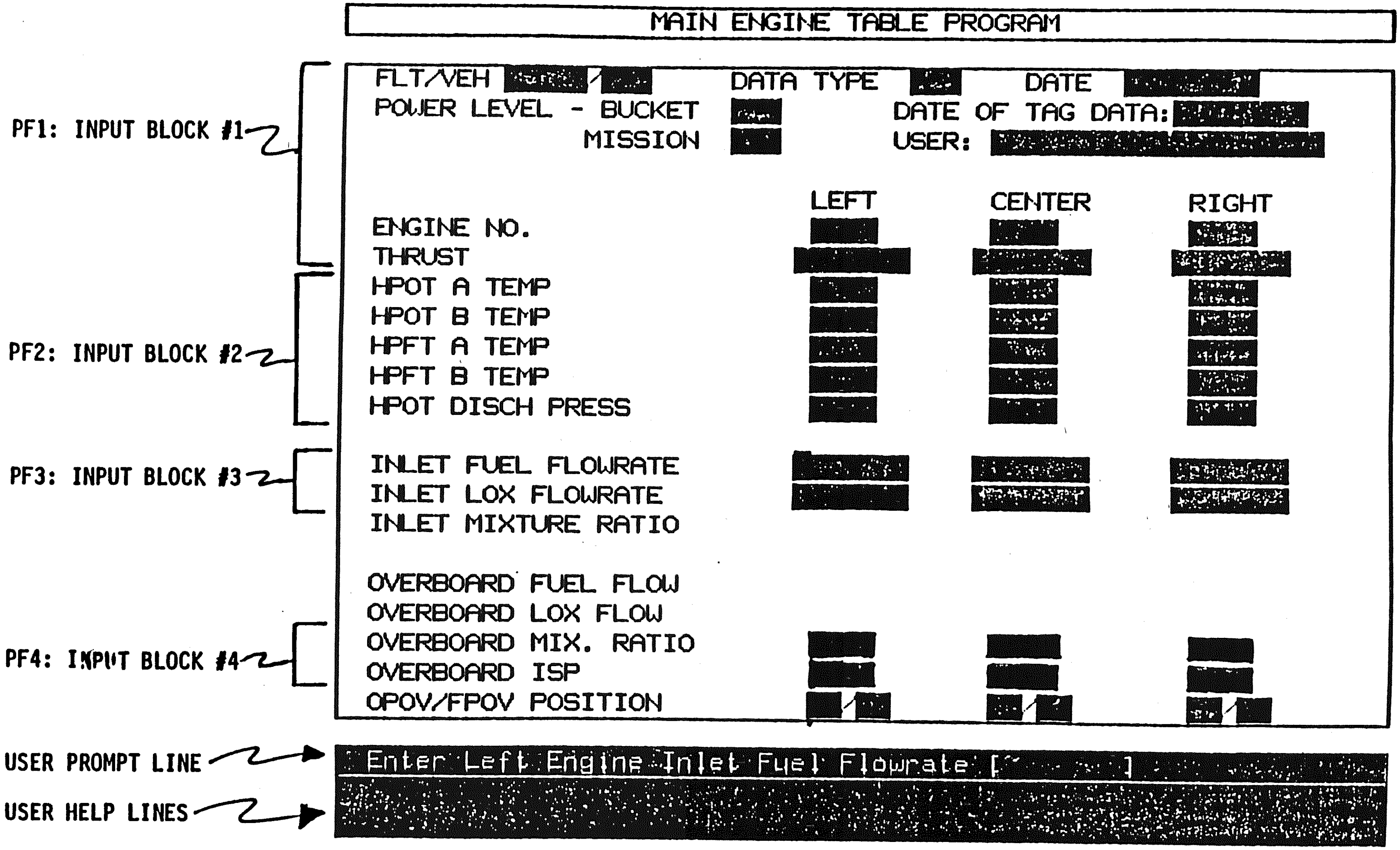
USER PROCEDURES

In order to run the main engine table program, select MET from the menu, or enter MET <RETURN> from the operating system prompt. The input/output display page, as shown in figure 7.1.2-1, is generated with the cursor positioned in the input section 1 (main data). The user must input the appropriate data in all of the highlighted boxes of each section as they are selected. Each section must be filled completely to give the program the information needed to predict engine performance. The specific input data needed in each section and how to move between each section is explained below. The USER PROMPT LINE displays helpful messages to the user and explains how to continue or what is wrong if a problem has arisen. A HELP line is generated at the bottom of the display page to give the user information on the keys needed to run the program.

The appropriate information should be entered after the boxes in the desired section are highlighted and the cursor appears in the upper left-hand corner box of the section. The user can move between the desired sections with the use of the control function (PF) keys found on the top row of the workstation's keyboard. The cursor can be moved between each of the highlighted boxes within a single section by using any of the arrow keys or the return key. Key options, as described on the HELP line, include:

I. ESCAPE = EXIT

Terminates execution of the program. The screen is cleared and terminal control returns to the main operating system.



MAIN ENGINE TABLE PROGRAM

FLT/VEH / DATA TYPE DATE
POWER LEVEL - BUCKET DATE OF TAG DATA:
MISSION USER:

	LEFT	CENTER	RIGHT
ENGINE NO.			
THRUST			
HPOT A TEMP			
HPOT B TEMP			
HPFT A TEMP			
HPFT B TEMP			
HPOT DISCH PRESS			
INLET FUEL FLOWRATE			
INLET LOX FLOWRATE			
INLET MIXTURE RATIO			
OVERBOARD FUEL FLOW			
OVERBOARD LOX FLOW			
OVERBOARD MIX. RATIO			
OVERBOARD ISP			
OPOV/FPOV POSITION	/	/	/

Enter Left Engine Inlet Fuel Flowrate [ ]

Figure 7.1.2-I.- Display page setup.

II. PF1 = MAIN DATA = INPUT SECTION 1

This function key moves the cursor into the section of basic overview data. When the program is run initially, all of the input blocks in this field will be highlighted and the cursor will appear in the flight number box. The data needed for input in this section is:

FLT Flight number. The number of the flight for which this engine configuration appears. If this is a simulation, then use the flight number of the next flight. (Example: STS-26)

VEH This is the number of the Shuttle to be used on the flight named above. Use one of the following numbers:

102	Coumbia
103	Discovery
104	Atlantis
105	Endeavor

DATA TYPE This category tells whether the tables that are generated are to be used on a real flight or as an integrated simulation. Use RR for a real flight and SIM for a simulation.

DATE Input today's date in the format of MM/DD/YY.

POWER LEVEL - BUCKET Enter the expected engine power level percentage in the thrust bucket. This percentage power level is usually 65, but can be between 65 and 100.

POWER LEVEL - MISSION Enter the expected mission power level (MPL) percentage, This percentage power level is usually 104, but can be between 100 and 109.

DATE OF TAG DATA Enter the date that the TAG data from MSFC was created. This should be in the format of MM/DD/YY.

USER Enter your own name. You only have 20 characters, so try to keep it short.

ENGINE NO. (L,C,R) This represents the individual SSME identification number. This number should be in the format of ####, such as 2022.

THRUST (L,C,R) This represents the rated thrust level for the given engine in a vacuum. This number should be between 480,000 and 510,000 lb.

III. PF2 = TEMP DATA = INPUT SECTION 2

This function key moves the cursor into the second input section. All of the blocks within this field should be highlighted and the cursor should move into the position of the LEFT HPOT A TEMP. The data needed for input in this section is:

HPOT A TEMP (L,C,R) This represents the high pressure oxidizer turbopump temperature from transducer A. This value should be between 1000 and 1760 degrees Farenheit.

HPOT B TEMP (L,C,R) This represents the high pressure oxidizer turbopump temperature from transducer B. This value should be between 1000 and 1760 degrees Farenheit.

HPFT A TEMP (L,C,R) This represents the high pressure fuel turbopump temperature from transducer A. This value should be between 1400 and 1960 degrees Farenheit.

HPFT B TEMP (L,C,R) This represents the high pressure fuel turbopump temperature from transducer B. This value should be between 1400 and 1960 degrees Farenheit.

HPOT DISC PRESS (L,C,R) This represents the high pressure oxidizer turbopump discharge pressure. This number should be between 3500 and 4500 psi.

IV. PF3 = TAG DATA = INPUT SECTION 3 OR INPUT SECTION 4

This function key will ask a question on the USER PROMPT LINE as to whether the overboard mixture ratio is given. If it is given, the program will proceed to input section 4, highlight the needed input value boxes, and put the cursor in the box of the left overboard mixture ratio. If it is not given, the program will proceed to input block 3, highlight the needed input value boxes, and put the cursor in the box of the left inlet lox flowrate. The user is given only one of the possibilities in the TAG data sent from MSFC. Any nonhighlighted spaces that are left blank will be filled in as output after the program is run. The data needed for input in these sections are:

A. <u>OVERBOARD MIXTURE RATIO NOT GIVEN</u>: INPUT SECTION 3

INLET FUEL FLOWRATE (L,C,R) This is the fuel flowrate into the low pressure fuel turbopump. This number should be between 140 and 170 lb/sec.

INLET LOX FLOWRATE (L,C,R) This is the oxidizer flowrate into the low pressure oxidizer turbopump. This number should be between 850 and 950 lb/sec.

OPOV/FPOV POSITION (L,C,R) This tells the percentage open of the oxidizer preburner oxidizer valve or the fuel preburner oxidizer valve. This number is nominally 67 percent for the OPOV and 77 percent for the FPOV.

B. OVERBOARD MIXTURE RATIO GIVEN: INPUT BLOCK 4

OVERBOARD MIX. RATIO (L,C,R) This is the overboard mixture ratio. This number should be between 5.8 and 6.2

OVERBOARD ISP (L,C,R) This is the specific impulse of the engine. This number should be between 440 and 460 seconds.

OPOV/FPOV POSITION (L,C,R) This tells the percentage open of the oxidizer preburner oxidizer valve or the fuel preburner oxidizer valve. This number is nominally 67 percent for the OPOV and 77 percent for the FPOV. (Note: This needs to be input for either case of input block 3 or input block 4.)

V. PF4 = RUN

This control key runs the program, fills in the rest of the display page with output estimates, and generates output tables into the file SSME_data in the /user/booster/DATA subdirectory.

VI. PF5 = PRINT

This control key prints the output tables which are stored in the subdirectory /user/booster/DATA in the file SSME_data. This is the same file which was created when the program was run using the PF4 key. The program will prompt the user as to whether a printed output of the file is desired. If the user responds yes, the output will be printed on the line printer belonging to the MASSCOMP that the user is logged into. The program will also prompt the user as to whether the data file should be deleted. The user should always respond NO to this for this would destroy the formal copy of what was created. This copy may be necessary for reference or reproduction purposes at a later time.

USER PROMPT MESSAGES

The following is a list of the messages which appear on the USER PROMPT LINE as the user moves the cursor from input box to input box and from input section to input section. These messages aid the user in inputting the correct information in each of the boxes.

Description

Enter FLIGHT NUMBER

Enter VEHICLE NUMBER

Enter FLIGHT DATA TYPE (SIM or RR)

Enter Date

Enter Power Level in the bucket

Enter Rated Power Level for this mission

Enter Date Of the Tag Data

Enter your last name (20 char. max)

Enter X Engine Number

Enter X Engine Thrust

Enter X Engine HPOT A Temp

Enter X Engine HOPT B Temp

Enter X Engine HPFT A Temp

Enter X Engine HPFT B Temp

Enter X Engine Inlet Fuel Flowrate

Enter X Engine Inlet LOX Flowrate

Enter X Engine Overboard Mixture Ratio

Enter X Engine Overboard ISP

Enter X Engine OPOV position

Enter X Engine FPOV position

Where X = Left, Center, or Right

ERROR MESSAGES

The following is the error message which appears on the USER PROMPT LINE and advises the user of an incorrect form of input:

Invalid data type -> (whatever you typed appears here)

This prevents the user from inputting garbage such as "sshg" or any combination not recognizable by the program. After the PF4 button is pushed and before the output is created, the program checks to make sure that each of the inputs are within their range of validity. This range is specific to each parameter and is displayed in the error message. After the error message is displayed on the USER PROMPT LINE, the program waits until the return key is pressed and then proceeds to the erroneous value's box on the display page. The possible error messages are listed below:

ERROR: No turbine temps; Select key PF2 to input <RETURN>

ERROR: No Marshall TAG data; Select key PF3 to input <RETURN>

ERROR: Power level in bucket is invalid [65-100] <RETURN>

ERROR: Mission power level is invalid [100-109] <RETURN>

ERROR: X engine thrust is invalid [480,000-510,000] <RETURN>

ERROR: X HPOT A temperature is invalid [1000-1760] <RETURN>

ERROR: X HPOT B temperature is invalid [1000-1760] <RETURN>

ERROR: X HPFT A temperature is invalid [1400-1960] <RETURN>

ERROR: X HPFT B temperature is invalid [1400-1960] <RETURN>

ERROR: X overboard MR is invalid [5.8-6.2] <RETURN>

ERROR: X overboard ISP is invalid [440-460] <RETURN>

ERROR: X inlet fuel flowrate is invalid [140-170] <RETURN>

ERROR: X inlet LOX flowrate is invalid [850-950] <RETURN>

ERROR: X HPOT discharge temperature is invalid <RETURN>

Where X = Left, Center, or Right

EQUATIONS

A formal discussion of the methodology and logic behind the MET program can be found in the source code and in the verification testing section of the MET program documentation folder. Refer to the source code listings for the following modules: average (), curve_fit (), e_lk_up(), fm_go_hi(), fm_go_lo(), high_low(), hpot_eff(), lck_up(), low_high(), lpft_dt_lo(), med_page(), noz_lk(), off_nom(), pc_hpot_dp(), tag_data(), and temp_vlv().

TITLE

MPS ON-ORBIT HELIUM REMAINING COMPUTATION

PURPOSE

This procedure serves as a user's guide to the HELIUM MASS REMAINING program.

DESCRIPTION

The MASSCOMP program "xhelium" is used to calculate the helium remaining onboard in the main propulsion system postvacuum inert. The Booster operator records these results in the flight log. These results are used for documentation and daily comparisons to determine the health of the helium system.

PROCEDURES

EXECUTION: Select "helium" from the menu, or enter "xhelium" <RETURN>.

PROGRAM: The input/output display is generated, with the cursor being positioned in the first input field.

ENTER: The appropriate information should be entered after the cursor is moved to the desired field (fig. 7.2.1-I). The cursor is moved by using either the up/down arrow keys, the enter key, the tab key, or the left or center mouse buttons. The center mouse button will also clear any old information remaining in the field. All information which is entered is verified to be valid. If the data fails the validity check, an error window will pop up showing which data are invalid. The error message must be acknowledged to proceed. The data must be corrected or the program will not perform the mass calculations. (Note: Cursor will have been advanced one field and must be replaced to the field that needs correction). Data entry errors can be corrected prior to proceeding to the next field by using the delete, backspace, or clear keys.

After the information has been entered, click the left mouse key on the COMPUTE button. The mass remaining for each of the helium systems, as well as the total mass remaining will be displayed. The input and the output data will be stored in a file called "he_mass" in the /user/booster/DATA directory.

EXITING: Click the left mouse button on the 'X' button in the upper left hand corner.

DIAGNOSTICS

ERROR MESSAGE: BEEP
Input is not a valid data type (i.e., not a number), or exceeds number of valid characters (4).

ERROR MESSAGE: "The entered value < >
for 'X HELIUM PRESSURE' is out of range!
Valid range is [0,5000]"

ERROR MESSAGE: "The entered value < >
for 'X AFT(MIDBODY) TEMPERATURE' is out of range!
Valid range is [-325,325]"

ERROR MESSAGE: "X HELIUM PRESSURE is required!"
All pressure fields must have data.

ERROR MESSAGE: "X AFT(MIDBODY) TEMPERATURE is required!"
All temperature fields must have data.

ERROR MESSAGE: "< > DATE Invalid
[MM/DD/YY]"
Input is not in valid format.

ERROR MESSAGE: "< > MET Invalid
[DDD:HH:MM:SS]"
Input is not in valid format.

ERROR MESSAGE: "The entered value < >
for X HELIUM PRESSURE is invalid!
Entry must be a FLOAT type number"

ERROR MESSAGE: "The entered value < >
for X AFT(MIDBODY) TEMPERATURE is invalid!
Entry must be a FLOAT type number"

EQUATIONS

Using the helium system tank temperature (T) and pressure (P) readings from MSK 1057 or MSK 1085, and the known tank volumes (V), the mass remaining is calculated using the ideal gas equation with a compressibility factor, Z, to measure the deviation of the helium gas from ideal gas behavior.

i = L, C, R, or Pneumatics

COMPRESSIBILITY FACTOR:

$$Z_i = (-B_i + (B_i^2 - 4*A_i*C_i)^{1/2}) / 2*A_i$$

where

$$A_i = 61.849*T_i - 9567.6$$

$$B_i = 21345.1 - 78.803*T_i$$

$$C_i = 16.995*T_i - P_i - 11761.6$$

MASS CALCULATIONS:

Midbody Tanks (L,C,R) -

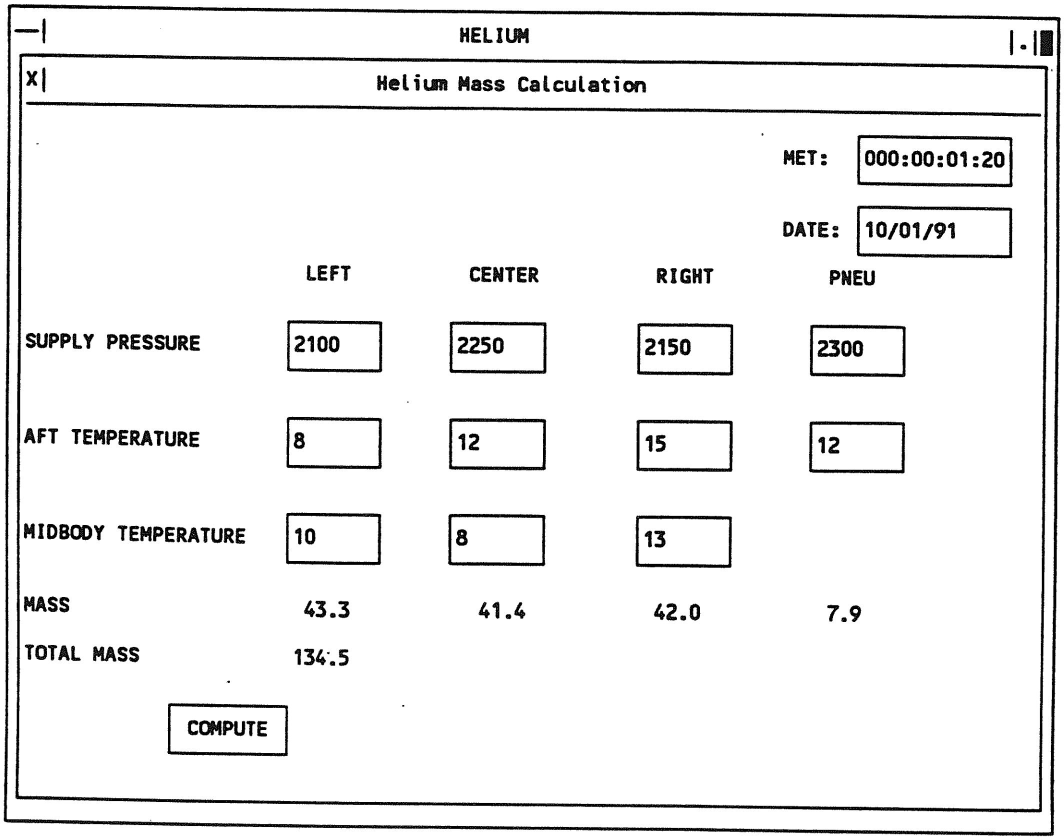
$$M_{i\text{-mid}} = (144*P_i*22.07) / (385.9605*Z_i*T_i)$$

Aft Tanks (L,C,R,P) -

$$M_{i\text{-aft}} = (144*P_i*4.73) / (385.9605*Z_i*T_i)$$

Tank Totals -

$M_i = M_{i\text{-mid}} + M_{i\text{-aft}}$ (L,C,R)
$M_P = M_{P\text{-aft}}$ (P)
$M_{total} = M_L + M_C + M_R + M_P$



MET: 000:00:01:20

DATE: 10/01/91

	LEFT	CENTER	RIGHT	PNEU
SUPPLY PRESSURE	2100	2250	2150	2300
AFT TEMPERATURE	8	12	15	12
MIDBODY TEMPERATURE	10	8	13	
MASS	43.3	41.4	42.0	7.9
TOTAL MASS	134.5			

Figure 7.2.1-I.- Helium mass remaining computation window.

TITLE

CONFIGURABLE REAL-TIME ANALYSIS SYSTEM

DESCRIPTION

The Configurable Real-time Analysis System (CRANS) program provides a means of representing logically interconnected items in a matrix format. A matrix consists of rows and columns of item names with colored backgrounds that show the item's logic status (failed/on or not-failed/off). The program allows for toggling of an item's logic status by selection of the item within a matrix via the mouse device. Upon selection of an item, the entire logic framework is tested for further status changes and the results of these changes are displayed in the matrix or matrices as appropriate. A "help" mode and a reference check provide the user with a means of exploring an item's underlying logic from within the program. A commonality check determines single-point failures for an item or group of items. In WEX 2.5, real-time telemetry can be accessed by the program for use in the logic (i.e., MSID's can be logic items).

PROCEDURES

Information regarding MSID's and real-time data refers only to the real-time data version of **crans**. Lines below that contain real-time specific information are denoted by an 'RT' in the right margin. The program uses four data files (1) logic (2) matrix (3) help, and (4) configuration. The logic file describes the logic tree; i.e., how all the logic items are interconnected. The matrix file defines the placement of logic items in the matrices. This file also has entries to change certain program default values (described below). The help file contains text messages associated with logic items displayed in the program's help mode. The configuration file contains matrix position information and is generated by the program via user request. This information is used to restore the matrix configuration for subsequent sessions. The logic and matrix files are required; the help and configuration files are optional. Additionally, the program writes a temporary file, **crans.temp**, to the current directory when a print command is issued. This file is erased when the program exits.

The user is allowed to change a number of the program parameters. These parameters, and their default values, are as follows:

Parameter	Default	
logic file name	DATA/crans.logic	
matrix file name	DATA/crans.matrix	
help file name	DATA/crans.help	
configuration file name	DATA/crans.config	
show duplicate items	TRUE	
real-time update rate	1 second/sample	RT
start iconified	FALSE	

Parameter	Default
alert tone volume	100%
font name	9x15
icon font name	8x13
background color	black
border color	white
border width	2 pixels
window size and position	9/10 screen size
display name/ID	NULL

Two methods are available of changing the parameter default values; command line inputs and entries in the **.Xdefaults** file.

The **.Xdefaults** file, found in the user's home directory, can contain parameter values for a number of programs. The syntax for a parameter setting in this file for the crans program is as follows:

```
crans*<parameter name>:  <value>
```

<parameter name> is one of the valid parameter names and **<value>** is the new value of the parameter. The parameter names are the same as the command line options (without the preceding - character; see below); however, the abbreviated forms cannot be used in the **.Xdefaults** file. An example entry to set the background color would be:

```
crans*background:  midnightblue
```

The command line options to change the parameter defaults can appear in any order on the command line. The syntax for these commands is as follows:

-logic (or -l) **<logic file name>**
Instructs the program to use the file, **<logic file name>**, as the logic file. Multiple logic files may be concatenated by separating the names by a + character with no intervening spaces (e.g., **-logic <file name 1>+<file name 2>...**).

-matrix (or -m) <matrix file name>
Instructs the program to use the file, **<matrix file name>**, as the matrix file. Multiple matrix files may be concatenated by separating the names by a + character with no intervening spaces (e.g., **-matrix <file name 1>+<file name 2>...**).

-help (or -h) **<help file name>**
Instructs the program to use the file, **<help file name>**, as the help file. Multiple help files may be concatenated by separating the names by a + character with no intervening spaces (e.g., **-help <file name 1>+<file name 2>...**).

-config (or -c) **<configuration file name>**
Instructs the program to use the file, **<configuration file name>**, as the configuration file.

-showduplicates (or **-sd**) <FALSE>
Instructs the program to ignore duplicate logic item names and suppress the duplicate item warning message(s). If two or more items have the same name only the first one encountered is used. This option is useful when concatenating logic files that contain common items.

-rate (or **-r**) **<update rate>** RT
Sets the initial real-time data acquisition rate in RT
seconds per sample. Values less than 1 cause the RT
program to update as fast as possible. The rate can be RT
changed via command menu option (see below). RT

-iconic (or **-i**) **<x,y>**
Instructs the window manager to iconify the program window initially; the x-y coordinates specify the location of the icon.

-volume (or **-v**) **<volume>**
Sets the volume of the alert tone given whenever a dialog box is generated. The volume should be from 0 (no tone) to 100 (full volume) percent; values outside this range are adjusted to the nearest valid value.

-font (or **-fn**) **<font name>**
The program uses the font specified for drawing the main title bar, command menu, and help, commonality, and reference mode displays.

-iconfont (or **-ifn**) **<icon font name>**
The program uses the font specified to draw the icon window text.

-background (or **-bg**) **<background color>**
Specifies the background color of the main window. RGB values are accepted.

-bordercolor (or **-bd**) **<border color>**
Specifies the color of the main window border. RGB values are accepted.

-borderwidth (or **-bw**) **<border width>**
Specifies the width, in pixels, of the main window border.

-geometry (or **-gm**) **<widthxheight+x+y>**
Instructs the program to set the initial main window size (in pixels) and/or position. The entire set of values need not be specified (e.g., just the size could be set). For initial main window size the precedence is (lowest to highest): the default size, the **-geometry** specified size, the the mouse-selected size (using the middle mouse button), then the size saved in the configuration file. The window can be resized as desired using the mouse once the program is running.

The window manager will prevent sizing the window smaller than the area required to display the main title bar and all the matrices in an iconified state.

-display (or **-ds**) **<display name/ID>**
Sets the display on which the program window is shown.

LOGIC FILE FORMAT

Every logic item used in the logic and matrix files must have a logic item definition. A logic item definition begins with the logic item name itself (see logic item name operator description below). The name must be placed on a line by itself, starting in the first column. The item's logic statement (if it has one) is placed on a subsequent line or lines that are indented at least one space/tab. The format, therefore, is as follows:

```
LOGIC ITEM NAME

    LOGIC ITEM STATEMENT
```

The logic statement defines the conditions by which the logic item is failed: if the statement evaluates to TRUE/1, the logic item fail state is set to failed/on; if the statement evaluates to FALSE/0, the logic item fail state is set to not failed/off. The logic statement generally consists of logic item names separated by operators. It can be broken into multiple lines if desired; the only restrictions are that an item name cannot be split over multiple lines and a logic statement cannot be split between multiple files. The operators are explained below in the logic operator reference guide. The format for this reference guide is given below.

Operator :	Character(s) used to denote operation in logic statement.
Operation :	Title of operation.
Usage :	Generic method of use.
Description:	Explanation of operation and special restrictions.
Syntax :	Legal operators that can precede the operator in question (within braces {}), the operator itself, then those operators that can follow it (within braces {}). "None" indicates that a logic statement can begin and/or end with that operator.
Examples :	Examples of operator use within a logic statement.

Operator : **{ITEM}**

Operation : **Logic Item Name**

Usage : {OPERATOR} **{ITEM}** {OPERATOR}

Description: A logic item name in a logic statement represents the fail state of that logic item (TRUE/1 or FALSE/0) which in turn is used in interpreting the logic statement. Almost any character can be used within a logic item name with the following exceptions/restrictions:

- An item name cannot begin with a @, space, or tab character. These characters can be used within a name.
- A name beginning with a ' must be placed within double quotes. An name beginning with a " must be placed within single quotes. This applies to names referenced in a logic statement or in the matrix file.
- Only those spaces/tabs within logic item names (i.e., bounded by other valid characters) are significant; other spaces/tabs within the logic statement are ignored, but are useful for improving readability.
- A name beginning with a ^ or {, or containing the characters : or , must be placed within single or double quotes when referenced in the matrix file.
- Names containing the characters ()+|~^:><= must be RT
  placed within single or double quotes when referenced in a logic statement (see quoted logic item name operator description).
- Item names that begin with a number, -, or . must be RT
  placed within single or double quotes when following RT
  a >, <, or = operator (see quoted logic item name RT
  operator description). RT
- Names beginning with the # character are RT
  considered MSID's (see MSID logic item name operator RT
  description). This applies even if the name is quoted. RT
- Logic item names are case sensitive (e.g., ITEM, Item, and item are treated as separate logic items).

Syntax : {None, (, +, |, ~, ^, >, <, =} {ITEM} RT
{None,), +, |, :, ~, >, <, =} RT

Examples : **MNA DA1 + MDM FF1**
~" < 6 MID VENTS "

Operator : "
'

Operation : **Quoted Logic Item Name**

Usage : " {ITEM} "
' {ITEM} '

Description: A logic item name can be placed within single or double quotes (only when referenced in a logic statement, not when the logic item is defined) to ensure that the name is correctly interpreted. The quote characters and any surrounding spaces or tabs are not considered part of the item name. The cases where quotes must be used are as follows:

- Logic item names containing the characters ()+| ~^:><= must be placed within quotes to avoid having the special character evaluated as an operator.
- Names beginning with 0-9, ., or - must be quoted when following a >, <. or = operator to avoid being evaluated as constants. RT RT RT
- Names beginning with a ' must be placed within double quotes. Names beginning with a " must be placed within single quotes.

Syntax : {None, (, +, |, ~, ^, >, <, =} " {ITEM} " RT
{None,), +, |, :, ~, >, <, =} RT

{None, (, +, |, ~, ^, >, <, =} ' {ITEM} ' RT
{None,), +, |, :, ~, >, <, =} RT

Examples : ITEM A + " ITEM(1) "
'1+ ITEMS' + #V46S0123E RT
" 'ITEM A' "

Operator : **#** RT

Operation : **MSID Logic Item Name** (real-time version) RT

Usage : **#** **{MSID}** RT

Description: A logic item name preceded by a # character is treated RT
as a MSID. Note that the # character and any interven- RT
ing spaces or tabs are considered part of the item's RT
name (but not part of the MSID). If the real-time data RT
source cannot be accessed, the MSID logic items are RT
evaluated as "normal"logic items (TRUE/1 or FALSE/0) RT
and are initialized to the not failed/FALSE state. RT
With real-time data active, the value of the MSID is RT
used in logic statements using comparison operators RT
(>, <, =, and combinations of these). In other oper- RT
ations (+, |, etc.) the MSID logic items are treated RT
as "normal" logic items. RT

Syntax : {None, (, +, |, ~, ^, >, <, =} **#** **{MSID}** RT
{None,), +, |, :, ~, >, <, =} RT

Examples : #V46P0100A > 110 RT
 # V46S1199E + # V46S1299E + # V46S1399E : 2 RT

Operator : **0-9, ., -** RT

Operation : **Constant (Numeric) Value**

Usage : {OPERATOR} **{CONSTANT}** {OPERATOR}

Description: Constants can contain the characters 0 - 9, ., and RT
-. Any fractional component in a filter value RT
(see fractional AND operator description) is
ignored.

Syntax : {:, >, <, =} **{CONSTANT}** RT
{None,), +, |, ~, >, <, =} RT

Examples : #V58P0105A >= **-32.2** RT
ITEM A + ITEM B + ITEM C : 2

Operator : +

Operation : **Logical AND**

Usage : {RESULT A} + {RESULT B}

Description: The statement evaluates TRUE if RESULT A is TRUE (failed/on) and RESULT B is TRUE (failed/on).

Syntax : {ITEM, ", ', #MSID, CONSTANT,)} + RT
{ITEM, ", ', #MSID, (, ~, ^} RT

Examples : ITEM + #V46P0110A RT
(ITEM A | ITEM B) + ~ITEM C

Operator : |

Operation : **Logical OR**

Usage : {RESULT A} | {RESULT B}

Description: The statement evaluates TRUE if RESULT A is TRUE (failed/on) or RESULT B is TRUE (failed/on).

Syntax : {ITEM, ", ', #MSID, CONSTANT,)} | RT
{ITEM, ", ', #MSID, (, ~, ^} RT

Examples : #V46S0222E | ITEM RT
ITEM A | (ITEM B + ~ITEM C)

Operator : ~

Operation : **Logical NOT**

Usage : ~ {RESULT}

Description: The statement evaluates TRUE if RESULT is FALSE (not failed/off).

Syntax : {None, (, +, |, >, <, =} ~ RT
{ITEM, ", ', #MSID, (, ^, >, <, =} RT

Examples : ~ #V58S0100E RT
~(ITEM A | ITEM B)

Operator : :

Operation : **Fractional AND**

Usage : {RESULT A} + ... + {RESULT n} : **{CONSTANT}**

Description: The statement evaluates TRUE if the number of preceding ANDed RESULTs (on the same nest level) that are TRUE equals or exceeds CONSTANT. CONSTANT must be greater than or equal to 2. See left/right parenthesis operator descriptions for definition of nest level.

Syntax : {ITEM, ", ', #MSID, CONSTANT,)} : RT
{CONSTANT}

Examples : ITEM A + (#V46P0100A > 180.0) + ~ITEM B : 2 RT
(#V58P0315A>-5+ITEM A+ITEM B+ITEM C : 3) | ITEM C RT

Operator : ^

Operation : **Hard-fail**

Usage : ^ **{ITEM}**

Description: The statement evaluates TRUE if the logic item indicated has been hard-failed (i.e., failed by direct mouse input as opposed to soft-failed, where an item is failed indirectly due to its logic).

Syntax : {None, (, +, |, ~, >, <, =} ^ RT
{ITEM, ", ', #MSID} RT

Examples : ^ #V46S1199E RT
ITEM A | ~ ^'ITEM B'

Operator : (

Operation : **Left Parenthesis**

Usage : ({RESULT})

Description: Start a new nest level. The logic within a nest level is evaluated prior to being used in the level above and is always interpreted from left to right.

Syntax : {None, (, +, |, ~, >, <, =} (RT
{ITEM, ", ', #MSID, (, ~, ^} RT

Examples : ITEM A + (ITEM B | ITEM C)
((ITEM A | ITEM B) + ITEM C) | ITEM D

Operator :)

Operation : **Right Parenthesis**

Usage : ({RESULT})

Description: End the current nest level. The boolean result of the logic within the parentheses is passed to the preceding level for incorporation. The number of left and right parentheses in a logic string must be the same.

Syntax : {ITEM, ", ', #MSID, CONSTANT,)}) RT
{None, +, |, :, ~, >, <, =} RT

Examples : (ITEM A | ITEM B) + #V72X2123Y RT
ITEM + (#V46P0100A > 100) RT

Operator : > RT

Operation : **Greater Than** RT

Usage : {RESULT A} > {RESULT B} RT

Description: The statement evaluates TRUE if RESULT A is RT
greater than RESULT B. When the > operator is RT
followed by the = operator (>=) then the logic is RT
TRUE if RESULT A is greater than or equal to RT
RESULT B. Additionally, the ~ operator may RT
precede the > operator (for "not greater than", RT
etc.). When MSID's or constants are involved, RT
the actual values are used, otherwise the failure RT
state of the logic item is compared (TRUE/1 or RT
FALSE/0). RT

Syntax : {ITEM, ", ', #MSID,), ~} > RT
{ITEM, ", ', #MSID, CONSTANT, ~, ^, =} RT

Examples : #V58T0393A > # V58T0293A RT
ITEM A ~>= (ITEM B | #V37S0123E) RT

Operator : < RT

Operation : **Less Than** RT

Usage : {RESULT A} < {RESULT B} RT

Description: The statement evaluates TRUE if RESULT A is less RT
than RESULT B. When the < operator is followed by RT
the = operator (<=) then the logic is TRUE if RT
RESULT A is less than or equal to RESULT B. RT
Additionally, the ~ operator may precede the < RT
operator (for "not less than", etc.). When MSID's RT
or constants are involved the actual values RT
are used, otherwise the failure state of the logic RT
item is compared (TRUE/1 or FALSE/0). RT

Syntax : {ITEM, ", ', #MSID,), ~} < RT
{ITEM, ", ', #MSID, CONSTANT, ~, ^, =} RT

Examples : #V09T1600A < 275 RT
(ITEM A | ITEM B) <= # V46S1399E RT

Operator : = RT

Operation : **Equal To** RT

Usage : {RESULT A} = {RESULT B} RT

Description: The statement evaluates TRUE if RESULT A is equal RT
to RESULT B. This operator can follow the > or < RT
operators (see greater than and less than operator RT
descriptions). Additionally, the ~ operator may RT
precede the = operator (for "not equal to"). When RT
MSID's or constants are involved the actual RT
values are used, otherwise the failure state of RT
the logic item is compared (TRUE/1 or FALSE/0). RT

Syntax : {ITEM, ", ', #MSID,), ~, >, <} = RT
{ITEM, ", ', #MSID, CONSTANT, ~, ^} RT

Examples : ITEM = ~(#V46S0333E + ~ ^#V46S0333E) RT
#V46R0135A ~= 103 RT

Operator : % RT

Operation : **Bit Mask** RT

Usage : MSID A % MSID B or CONSTANT RT

Description: The statement evaluates TRUE if the result of RT
bitwise-ANDing MSID A with MSID B (or CONSTANT) is RT
equal to MSID B (or CONSTANT). In other words, if RT
the ON bits represented by MSID B (or CONSTANT) RT
are ON in MSID A then the statement is TRUE. The RT
~ operator may precede the % operator, in which RT
case the statement is TRUE if none of the ON bits RT
in MSID B (or CONSTANT) is ON in MSID A. The RT
values of the MSID's are used. CONSTANT in this RT
case is a one- or two-word hexadecimal value with RT
up to eight digits per word (if two words, RT
separate by spaces; if less than eight digits, RT
leading zeros are assumed). RT

Syntax : {#MSID} % RT
{#MSID, CONSTANT} RT

Examples : #V72M7919P % 1000 RT
#V72M7926P ~% 20000000 a0fff RT

The arrangement of the logic item definitions in the file can determine the interpretation of the logic. An example is:

```
ITEM 1
  ~ITEM 2
ITEM 2
  ~ITEM 1
```

On the first pass through the logic (no items failed) ITEM 1 would be failed since ITEM 2 is not failed. Then, ITEM 2 will take on the inverse of ITEM 1's logic state (i.e., not failed). If the order was changed to:

```
ITEM 2
  ~ITEM 1
ITEM 1
  ~ITEM 2
```

the outcome would instead be ITEM 2 failed and ITEM 1 not failed. Though the logic statements are the same for the individual items, the position in the file caused the opposite result to happen. This "positional interpretation" can only occur when inverse (NOT) logic is involved.

Inverse logic can also result in an infinite logic loop (the program detects this condition; see ERROR MESSAGES below). An example is:

```
ITEM 1
  ~ITEM 1
```

Blank lines can be used to separate logic item definitions and statements for clarity. Lines with the @ character in the first column are ignored and are used to denote comment lines. Maximum line length in the logic file is limited to 500 characters. A sample logic file is shown in figure 7.2.2-1.

MATRIX FILE FORMAT

The matrix file contains the information regarding placement of logic items in the matrices, the color map for the matrix boxes, the main window title, and the main window's icon name. The color map is required and must precede any matrix definitions. At least one matrix definition is required (the total number of matrices allowed is limited only by the amount of memory available). The title and icon name are optional (see below for default values). The matrix file commands must begin in the first column and are described below.

Command : **TITLE**

Usage : TITLE: <main window title>

Description: Set the main window title. The text given is displayed in the center portion of the main window header bar. This command is optional; no title (null string) is used if none is specified. The title cannot begin with a :. If more than one title is defined the latter one is used.

Example : TITLE: Systems Failure Analysis

Command : **ICON NAME**

Usage : ICON NAME: <main window icon name>

Description: Set the program's icon name. The icon name given is displayed when the program window is iconified. The name length is essentially unlimited, but shorter names are preferred since they determine the icon's size. The default icon name is "CRANS". The icon name cannot begin with a :. If more than one icon name is defined the latter one is used.

Example : ICON NAME: FAILURES

Command : **COLOR MAP**

Usage :
```
COLOR MAP: <box> [= <#RGB or color>] : <text>
           [<box> [= <#RGB or color>] : <text>] etc.
```

Description: This command defines the box/text color combinations used in the matrices: a box of color <box> will have text of color **<text>** drawn on it. The color map is made up of one or more color definition statements in the format shown above (only the first line must contain the color map command **"COLOR MAP:"**, with subsequent lines indented at least one space/tab). The box colors are those referenced in the matrix definitions for the failed and not-failed colors (see the **MATRIX** command definition). The color map must precede any matrix definitions and any color referenced in a matrix must be defined in the color map. Multiple color map commands are allowed, but should be unnecessary. The various components of this command are as follows:

- **<box>** can be a name from the standard X-Windows color database, in which case the optional **<#RGB>** and **<color>** are not used. See figure 7.2.2-4 for a listing of the standard color data base, or look in the file **/usr/lib/X11/rgb/rgb.txt** on the machine being used; color names from this data base are case insensitive. If **<#RGB>** or **<color>** is supplied, then **<box>** can be any name the user chooses.

- If **<color>** is used, it must be a name from the standard color data base; in this case **<box>** will be identical to the color named (this is useful to shorten a name from the data base; e.g., Green = DarkOliveGreen).

- **<#RGB>** is used to set the actual red/green/blue intensities. The RGB format (signified by a leading # character) must be either #RGB, **#RRGGBB**, **#RRRGGGBBB**, or **#RRRRGGGGBBBB** where **R**, **G**, and **B** are single-digit hexadecimal values (the higher the number, the stronger the color). Values are automatically filled out to 12 digits by adding trailing zeroes so that **#RGB** becomes **#R000G000B000**, etc.

- **<text>** must either come from the standard color data base, be an RGB value in the format listed above, or be one of the box color names (upper/lower case must match in the last case).

Color names cannot contain the characters :, =, }, or ,. Names beginning with a # are treated as RGB values.

Example :
```
COLOR MAP: Black  : Blue
           Red    = #cf0000     : White
           Blue = mediumblue : #888
```

Command : **MATRIX**

Usage : MATRIX: [<group>], <name>, <font> [, <minimum width>]

Description: Define a matrix of logic items. **<group>** is an optional name that can be supplied that is displayed in the matrix icon. It can be used to identify several matrices as containing related logic items, for example. If no name is supplied, then no group name is displayed. Note that the command must contain the trailing comma whether a group name is supplied or not. **<name>** is the name displayed in the matrix header bar when the matrix is deiconified and is also used to identify the matrix when iconified. Different matrices can have the same name. **<font>** is the name of the font used to draw the matrix, and thus determines the size of the matrix (upper and/or lower case is acceptable). Any X-Windows font is allowed. The optional **<minimum width>** instructs the program to draw the boxes no smaller than the width (in characters) specified. However, if the item names or the header dictate larger boxes then the larger size is used.

Matrix box definition entries follow the matrix command on separate lines and must be indented at least one space/tab. The box definition format for a single box is:

{<item name>, <not-failed color>, <failed color>}

where **<item name>** is an item name from the logic file (all item names referenced must be defined in the logic file; item names are case sensitive). A blank box is allowed; just leave out the item name between the { and ,. Preceding the logic item name with a ^ character will cause that item in that matrix box to be hard-fail protected (i.e., the item cannot be directly failed). Item names that begin with a ^ or {, or contain a : or , must be enclosed within single or double quotes (the quotes are not displayed in the matrix).

The **<not-failed color>** is the name of the color (one of the box colors from the color map; see **COLOR MAP:** command above) that the box background will show when the logic item is not failed. The **<failed color>** is the color that the background shows when the logic item is failed. An empty (blank) box can be defined by leaving the item name out. The not-failed/failed colors must still be given. The arrangement in the file of the box definitions directly correlates with the displayed position. A matrix with three rows of four columns would be placed in the file as:

```
{ } { } { } { }
{ } { } { } { }
{ } { } { } { }
```

Each '{ }' represents a single box definition (boxes on the same row must be defined on the same line in the matrix file; box definitions for boxes in the same column do not have to align as shown). Each matrix may contain any number of box definitions in any combination of rows and columns.

A special type of box definition is the **multilevel box.** This type of box is driven by two or more logic items in a prioritized manner (the highest priority item failed is displayed; if no item is failed then the highest priority item name is displayed using the not-failed color). The format for a multilevel is similar to a normal box:

{<logic item name 1> [: <logic item name x>],
<not-failed color>, <failed color 1>
[: <failed color x>]}

where the item names are separated by colons (:). A fail color must be specified for each item and separated by colons (or commas). The priority is first name (highest) to last name (lowest). Blank items can be placed in multilevel boxes; just leave out the item name.

Examples :

```
MATRIX: EPS, Bus, 7x9
  {MNA DA1,Green,Red}{,Black,Black}{CNTLAB1,Green
,Yellow} MATRIX:,Systems,9x15,10
  {A:B:C,Blue,Red:Orange:Yellow}{D, Grey, Black}
  {E : F, Blue, Red: Orange} { ,Blue,Blue}
```

Blank lines, spaces, and tabs can be inserted in the matrix file, except where noted above, to improve clarity. Lines with the @ character in the first column are ignored and are used to denote comment lines. Maximum line length in the matrix file is limited to 3000 characters. A sample matrix file is shown in figure 7.2.2-2.

HELP FILE FORMAT

The help file contains text messages to be displayed with a logic item while the program is in the help mode (described below). Only those items with messages need an entry in the help file. A help file entry is shown below.

<logic item name>
<text message line 1>
[<text message line x>]
etc.

The **<logic item name>** is a name from the logic file (case sensitive) and must begin in the first column. The text message line(s) must be indented at least one space/tab (this first character is ignored; further spacing is assumed to be part of the message). Before displaying the text, all tab characters are converted to single spaces. The size of the message is limited by the size of the program window. All characters are allowed. When the help mode is active and the item selected has a text message reference in the help file, the message will be displayed along with the item, just as it is appears in the file.

Blank lines can be used to separate lines for clarity. Lines with the @ character in the first column are ignored and are used to denote comment lines. Maximum line length in the help file is limited to 500 characters. A sample help file is shown in figure 7.2.2-3.

CONFIGURATION FILE FORMAT

The configuration file is created/updated by the program when the user selects the "Save Config" option from the command menu (described below). The program saves the total number of matrices, the main window width and height, and for each matrix it saves the iconification state and matrix/icon x-y coordinates. When the program is executed, it looks for the configuration file (either the default or the user-specified file name). If found, the file is read and the saved window size and matrix/icon positions are restored; otherwise, the matrices are initially iconified and placed along the right side of the main window.

PROGRAM OPERATION

When the program is executed the user is allowed to position/size the main program window using the mouse (unless the **-iconic** option is used; the program icon appears in this case). There is a brief delay while the program reads the logic, matrix, and configuration file contents and checks for errors. If no errors are detected, the main window header is displayed containing the program name, the user-specified title (from the matrix file), and the command menu title. The matrices are positioned as described above in 'Configuration File Format'. The matrix icons show the matrix group name (if any) and the matrix name (from the matrix definition). The mouse pointer turns into an orbiter while within the main program window.

Error and warning messages are displayed in a dialog box, that appears as required, centered over the program window. When a dialog box is displayed, no further processing is possible until the message is acknowledged. See 'Dialog box "OKAY"/"NO" button' descriptions to follow.

The mouse button and keyboard now perform the following functions (other pointer/button/keyboard combinations are ignored by the program):

Location: Matrix logic item box

Button : Left button

Action : If the box is a multilevel then see 'Matrix multilevel pop-up menu' below on logic item selection. In either case (multilevel or single item box) the logic item selected has its fail state toggled (off -> on or on -> off) if the item has not been hard-fail protected in the matrix box definition. The box color changes, depending on the box definition in the matrix file, to reflect the new logic state (not-failed or failed). A * character is displayed in the first column of the box if the item displayed is hard-failed in this manner (the * is removed when the fail state is toggled off). A logic check is performed to reflect changes in other items' logic states. Failed items that are tagged (see 'Matrix logic item box - Right button' below) have the tag removed. The results are reflected immediately in the matrices and the matrix icons (the icon name color is green if no items in the matrix are failed and red otherwise).

Location: Matrix logic item box

Button : Two or more buttons simultaneously

Action : The box suppression state is toggled on/off. When a box is "suppressed" the text color is changed to the background color and the background color is changed to black. Reselecting the box restores the normal color configuration. If a box is suppressed and the item or items (if the box is a multilevel) driving that box change logic state then the normal color mode takes affect. The box can then be resuppressed if desired. Box suppression is a means of acknowledging a failure, and helps to unclutter a "busy" matrix.

Location: Matrix logic item box

Button : Middle button

Action : If the box is a multilevel then see 'Matrix multilevel pop-up menu' below on logic item selection. In either case (multilevel- or single-item box) the help mode is initiated for the item selected. A box that does not contain an item name cannot be selected. The main header changes to reflect that the help mode is in effect. The command menu item "Save Config" changes

to "Help Off" (see below). The matrices are erased and the
display shows the logic item with its associated logic
(or sub-items) underneath, similar to its arrangement
in the logic file ("or" is used in place of |, etc. to
improve readability). The color of the item names reflect
the item's fail state: green = not-failed, red = failed.
Hard-fail and tag status is shown as in the matrices
(* and ~ characters). Constant values are shown in
white. If real-time data are active then MSID items are RT
displayed with their current values beside them. If RT
the help file exists and contains a reference for the
logic item selected, the text message is displayed
to the right side of the logic. To review a item's logic
tree see 'Help mode logic item - Middle button' below.

Location: Matrix logic item box

Button : Right button

Action : If the box is a multilevel, see 'Matrix multilevel pop-up menu' below on logic item selection. In either case (multilevel- or single-item box) the selected logic item's tagged state is toggled on/off if the item is not failed. A box that does not contain a name cannot be tagged. A ~ character is displayed in the last column of the box when it is tagged (the ~ is removed when the fail status is toggled on). The tag determines which item(s) is used for a commonality or reference check. See 'Command menu item "Commonality" ' and 'Command menu item "Reference" ' below on how to perform these checks.

Location: Matrix multilevel pop-up menu

Button : Any button

Action : If a multilevel box is selected, a pop-up menu showing all the items represented by the box is displayed. The pointer is used to indicate the item desired (the item is highlighted) and the mouse button is released to select the item. Some items may not be selectable depending on which button is pressed. Items that are hard-fail protected cannot be selected if the left button is pressed and failed items are not taggable with the right button. Empty (no item name) positions specified in the multilevel are not selectable.

Location: Help mode logic item

Button : Left button

Action : The logic item selected has its fail state toggled (off -> on or on -> off). An item that is hard-fail protected in a matrix can be hard-failed in this mode. A logic check is performed to reflect changes in other items' logic states and the results are reflected immediately in the help display.

Location: Help mode logic item

Button : Middle button

Action : To travel forward through a logic item's logic tree, position the pointer over one of the subitems displayed (an outline surrounds the subitem name) and press a button. The program window is cleared and the subitem selected has its logic displayed as described above. Repeat this procedure to continue down the logic tree. Selecting the item name itself has no effect. To travel back through the tree see 'Help mode BACK box' below. An item's entire logic tree can be examined in this way.

Location: Help mode logic item

Button : Right button

Action : The selected logic item's tagged state is toggled on/off if the item is not failed. A ˜ character is displayed at the end of the item name when it is tagged. The tag determines which item(s) is used for a commonality or reference check. See 'Command menu item "Commonality" ' and 'Command menu item "Reference" ' below on how to perform these checks.

Location: Help mode BACK box

Button : Any button

Action : When a subitem is selected, the 'BACK' box appears to the left of the logic information. When this box is selected, the preceding logic item from which the current item was chosen is redisplayed. Repeat this procedure to continue back up the logic tree. When the original item is reached, the 'BACK' box will disappear. This box is also removed if either the reference or commonality mode is entered.

Location: Help mode constant value

Button : Any button RT

Action : Constant values (not including filter numbers used in RT
fractional AND statements and bit masks) can be RT
changed while the program is operating. Select a RT
constant by placing the pointer over the number (an RT
outline surrounds it) and press a button. A dialog RT
box appears that displays the current value. The RT
keyboard is used to change the constant. Using RT
the pointer, select the dialog box "OKAY" button to RT
accept the change or the "NO" button to ignore it. RT
The logic is then reevaluated and the help display is RT
updated to reflect the change. RT

Location: Commonality mode logic item

Button : Middle button

Action : The help mode (as described above) is initiated for the item selected (an outline surrounds the item name). The 'BACK' box, if present, is removed. To return to the commonality mode, see 'Command menu item "Commonality" ' below.

Location: Commonality mode logic item

Button : Right button

Action : The selected logic item's tagged state is toggled on/off. A ~ character is displayed at the end of the item name when it is tagged. The tag determines which item(s) is used for a commonality or reference check. See 'Command menu item "Commonality" ' and 'Command menu item "Reference" ' below on how to perform these checks.

Location: Commonality mode BACK box

Button : Any button

Action : When a commonality check is performed from within the commonality mode (and the item(s) tagged have changed), the 'BACK' box appears to the left of the commonality information. When this box is selected, the preceding commonality check is reinstated (the former tags are restored). Repeat this procedure to continue back up the 'commonality' tree. When the originally performed check is reached, the 'BACK' box will disappear. This box is also removed if either the reference or help mode is entered.

Location: Reference mode logic item

Button : Middle button

Action : The help mode (as described above) is initiated for the item selected (an outline surrounds the item name). The 'BACK' box, if present, is removed. To return to the reference mode, see 'Command menu item "Reference" ' below.

Location: Reference mode logic item

Button : Right button

Action : The selected logic item's tagged state is toggled on/off. A ˜ character is displayed at the end of the item name when it is tagged. The tag determines which item(s) is used for a commonality or reference check. See 'Command menu item "Commonality" ' and 'Command menu item "Reference" ' below on how to perform these checks.

Location: Reference mode BACK box

Button : Any button

Action : When a reference check is performed from within the reference mode (and the item(s) tagged have changed) the 'BACK' box appears to the left of the reference information. When this box is selected, the preceding reference check is reinstated (the former tags are restored). Repeat this procedure to continue back up the 'reference' tree. When the originally performed check is reached, the 'BACK' box will disappear. This box is also removed if either the commonality or help mode is entered.

Location: Matrix icon

Button : Any button

Action : This "deiconifies" a matrix; the icon is removed and the matrix it represents is displayed. If the button is held, the pointer turns into a four-pointed arrow and a full-sized dashed outline of the matrix appears. The mouse is used to position the deiconified matrix. The matrix outline must not extend outside of the main program window or over the main window header.

Releasing the button returns the pointer to its previous shape and the matrix is drawn. The matrix window is raised to the top of the matrix stack if it is overlapped by another matrix. If insufficient window space is available, a dialog box is displayed and the matrix remains in icon form.

If the control key was pressed in unison with the button, the icon itself enters the "move" mode instead of deiconifying the matrix. The icon's outline is displayed and can be repositioned as described above for the matrix. The icon window is placed at the bottom of the stack of matrices/icons (if applicable).

Location: Matrix iconify box

Button : Any button

Action : When the pointer is positioned over the iconify box (located at the right side of the matrix header), the box is highlighted. Pressing a button at this point causes the matrix to be reiconified (it returns to its former icon position). The icon window is placed at the bottom of the stack of matrices/icons (if applicable).

Location: Matrix header

Button : Any button

Action : If the button is pressed and held, the pointer turns into a four-pointed arrow and a full-sized outline of the matrix appears. The mouse can then be used to reposition the matrix. The matrix outline must not extend outside of the main program window or over the main window header. Releasing the button returns the pointer to its previous shape and moves the matrix to the outline's position. The matrix window is raised to the top of the matrix stack if it is overlapped by another matrix.

If the control key was pressed in unison with the button, the pointer can be anywhere within the matrix window for repositioning to take place as described.

Location: Command menu title ("Commands") in main window header

Button : Any button

Action : When the pointer is positioned over "Commands" (located at the right side of the main window header), the text is highlighted. If a button is pressed, the command pull-down menu appears and the pointer turns into a hand (the button must be held down). Position the pointer over one of the commands (only those commands that highlight can be executed) and release the button pressed to initiate the command. See below for descriptions of the various commands. Releasing the button elsewhere performs no action. The pull-down menu is erased and the pointer restored in either case.

Location: Command menu item "Commonality"

Button : Any button

Action : If at least one item is tagged, a check is performed to determine if any single point failures exist for the tagged item or common to the tagged items (see 'Matrix logic item box - Right button', above). The program takes into account the current failure state of all the logic items when searching for single point failures (i.e., an item that normally is not a single point failure for the item(s) tagged could become so if other failures are input). The matrices are replaced (if the normal mode is active) by a window showing the item(s) tagged and the single-point failures ("None" is displayed if there are no single-point failures). Only the lowest common items are shown; common items further up the logic tree are not displayed (see 'Commonality mode logic item - Right button', above, on how to tag items and continue down a commonality tree). If a commonality check is performed from within the commonality mode (and the item(s) tagged have changed), the 'BACK' box appears to the left of the commonality information (see 'Commonality mode BACK box' above).

The main header changes to reflect that Commonality mode is in effect. The command menu item "Save Config" changes to "Common Off" (see below).

Location: Command menu item "Common Off"

Button : Any button

Action : Commonality mode is turned off and the normal mode is resumed (the matrices/icons reappear). Pressing the control key and any button simultaneously while the pointer is in the commonality display area also terminates commonality mode.

Location: Command menu item "Reference"

Button : Any button

Action : If at least one item is tagged then all logic items that directly reference all the tagged items are displayed ("None" is displayed if the tagged item(s) is not referenced by any of the logic items in the logic file). Note that the tagged item is not necessarily a single-point failure for the items displayed. See 'Reference mode logic item - Right button', above, on how to tag items and continue down a reference tree). If a reference check is performed from within the reference mode (and the item(s) tagged have changed), the 'BACK' box appears to the left of the reference information (see 'Reference mode BACK box').

The color of the item names reflect the item's fail state: green = not-failed, red = failed (by definition the tagged item(s) cannot be in a failed state). The main header changes to reflect that reference mode is in effect. The command menu item "Save Config" changes to "Refer Off" (see below).

Location: Command menu item "Refer Off"

Button : Any button

Action : Reference mode is turned off and the normal mode is resumed (the matrices/icons reappear). Pressing the control key and any button simultaneously while the pointer is in the commonality display area also terminates reference mode.

Location: Command menu item "Help Off"

Button : Any button

Action : Help mode is turned off and the normal mode is resumed (the matrices/icons reappear). Pressing the control key and any button simultaneously while the pointer is in the help display area also terminates help mode.

Location: Command menu item "Clear Fails"

Button : Any button

Action : The user is asked to verify this command via a dialog box before continuing. If verified, all failure statuses are set to "not-failed" and a logic test is performed to reset the logic states. The results are reflected immediately in the matrices, the matrix icons, and in the help or reference modes (if active).

Location: Command menu item "Clear Tags"

Button : Any button

Action : All tagged statuses are reset (to untagged). The results are reflected immediately in the matrices. If the help mode is active, then any tags shown are removed. If the commonality or reference mode is in effect, then the normal mode is resumed (the matrices/icons reappear).

Location: Command menu item "Print Data" - main mode

Button : Any button

Action : A summary of input and resultant failed item names is
output to the printer. If real-time data are active, RT
the current MSID values are also output. RT

Location: Command menu item "Print Data" - help mode

Button : Any button

Action : The contents of the help display are output to the printer (items truncated due to the size of the program window will be printed).

Location: Command menu item "Print Data" - commonality mode

Button : Any button

Action : The contents of the commonality display are output to the printer (items truncated due to the size of the program window will be printed).

Location: Command menu item "Print Data" - reference mode

Button : Any button

Action : The contents of the reference display are output to the printer (items truncated due to the size of the program window will be printed).

Location: Command menu item "Save Config"

Button : Any button

Action : The user is asked to verify this command via a dialog box before continuing. If verified, the current main window size and matrix state/position information is saved to the configuration file (either the file name specified with the command line option or the default file name, **DATA/crans.config**).

Location: Command menu item "Update Rate" RT

Button : Any button RT

Action : If real-time data are being taken by the program, a RT
dialog box is generated with an input window showing RT
the current real-time data acquisition rate in RT
seconds per sample. The user types in the new rate RT
and selects the "OKAY" box to accept it. RT

Location: Command menu item "Exit CRANS"

Button : Any button

Action : The user is asked to verify this command via a dialog box before continuing. If verified the program window is erased and the program exits.

Location: Dialog box "OKAY" button

Button : Any button

Action : Acknowledging a dialog box message is done by placing the pointer (which now resembles a hand) over the "OKAY" button (which highlights to show its selection) and pressing any button. The dialog box disappears and the program continues (or exits, depending on the circumstances). See <u>ERROR MESSAGES</u> below for a description of the dialog box error and warning messages.

Location: Dialog box "NO" button

Button : Any button

Action : The "NO" button is displayed when the dialog box requires a yes-or-no answer to the dialog box message. Selecting the "NO" box indicates a negative response to the message and is done by placing the pointer (which now resembles a hand) over the "NO" button (which highlights to show its selection) and pressing any button. The dialog box disappears and the program continues (or exits, depending on the circumstances).

The X-Windows window manager can be used to move, resize, and (de)iconify the entire **crans** program window. Depending on the window manager, the window cannot be sized smaller than is allowed to contain the main header information and all of the matrices in icon form. When a resize occurs the icons are repositioned along the right side of the window and the matrices are moved an amount proportional to the window size change. If the window is sized too small to contain a matrix, a dialog box message is issued and the matrix is automatically reiconified. When the entire program is iconified the main window disappears and is replaced by the **crans** icon with the icon name (defined in the matrix file) underneath. When deiconified the main window returns with all the matrices unchanged.

EXAMPLES

The following are examples of the three file types (logic, matrix, and help). The files are not complete but demonstrate the various formats described above.

```
@ CRANS logic file

MNA DA1

MNA FPC1
  MNA DA1
MNA FLC1
  MNA FPC1
AC1
  (AC1 A + AC1 B + AC1 C) |
  MNA FPC1

@ This is failed when 2 of the 3 AC phases are failed
@ At least 2 of 3 are required for motor operations
AC1 2/3
  AC1 A + AC1 B + AC1 C : 2

@ PLBD motor logic

C/L 1-4 M1
  MNA MMC3 |
  AC1 MMC3 | AC1 2/3 |
  CNTLAB2 |
  MDM PL1

@ This determines number of landing gear deploy
@ methods lost
1 GEAR DEPLOY LOST
  ' HYD DEPLOY ' | PYRO SYS 1 | PYRO SYS 2
2 GEAR DEPLOY LOST
  HYD DEPLOY + PYRO SYS 1 + PYRO SYS 2 : 2
NO GEAR DEPLOY
  HYD DEPLOY + PYRO SYS 1 + PYRO SYS 2

@ This determines if APU 1 has insufficient tank          RT
@ pressure for a restart and handles bad telemetry        RT
MDM OA1                                                   RT
#V46P0100A                                                RT
  MDM OA1                                                 RT
APU 1 LOW TANK P                                          RT
  (#V46P0100A < 107) + #V46P0100A                         RT
```

Figure 7.2.2-1.- Example logic file.

```
@ CRANS matrix file

@ Main window title definition
TITLE: Mechanical Systems

@ Main window icon name
ICON NAME: FAILURES

@ Matrix color map
COLOR MAP:  Green              : Black
            Red    = #d00000   : White

@ Use dark grey text over yellow
            Yellow             : #111

@ The blue used is the one below (= mediumblue)
            Orange = #c00050   : Blue

@ Use standard map's medium blue for just 'blue'
            Blue = mediumblue  : White

@ This matrix would be 2 rows by 3 columns
MATRIX: , Bus/MDM, 7x9
  {MNA DA1,Green,Red} {MNB DA2,Green,Red} {MNB DA3,
Green,Red}
@ Put an empty (blank) box under MNB DA2
  {MNA FPC1,Green,Red} { ,Green,Black} {MNC FPC3,
Green,Red}

@ This matrix has a single multilevel box
@ The first two items are hard-fail protected
@ Force the box to a larger size
MATRIX: Entry, Brakes, 9x15, 30
  {^"GEAR DEPLOY" : ^NO GEAR DEPLOY : 2 GEAR DEPLOY LOST
: 1 GEAR DEPLOY LOST,Blue, Blue: Red : Orange : Yellow}
```

Figure 7.2.2-2.- Example matrix file.

```
@ CRANS help file

1 GEAR DEPLOY LOST
 One of the following methods
 of gear deploy has been lost:

    Hydraulic (System 1 only)
    Pyro System 1
    Pyro System 2

2 GEAR DEPLOY LOST
 Two of the following methods
 of gear deploy have been lost:

    Hydraulic (System 1 only)
    Pyro System 1
    Pyro System 2

 Enter first day/next PLS per
 flight rule 10-174

NO GEAR DEPLOY
 No method remains for deploying
 the landing gear!
```

Figure 7.2.2-3.- Example help file.

ERROR MESSAGES

The following error and warning messages can be generated within the program. Causes and corrective actions are given. The error messages are listed below in alphabetical order.

ERROR: Bad color '<color name>' RGB format in matrix file '<file name>'
Cause: The RGB color definition shown is in the wrong format (too many/few R's, G's, and/or B's). Program terminates.
Resolution: Correct the RGB format.

ERROR: Cannot access MSID keys RT
Cause: The ds_getkeys() call to obtain MSID information for real-time data access was unsuccessful. Program terminates. RT RT RT
Resolution: Check real-time data source status and MSID names. RT

ERROR: Cannot connect to X server
Cause: Program executed outside of the X-Windows environment, or server error. Program terminates. Since the program window is never displayed this message does not appear in a dialog box, but in the standard output window (if it exists).
Resolution: Execute the program while in X-Windows.

ERROR: Cannot open file '<file name>'
Cause: The logic or matrix file specified could not be opened. Program terminates.
Resolution: Check for correct file name spelling and path.

ERROR: Cannot open '<font name>' font
Cause: The font listed cannot be found. Program terminates.
Resolution: Check current font path (to make sure all available font directories are included) and font name spelling.

ERROR: Color '<color name>' undefined in matrix file '<file name>'
Cause: The color name shown cannot be found in the standard color data base or the '#' character was left off the RGB format. Program terminates.
Resolution: Check spelling/syntax (add '#' to RGB format).

ERROR: Color map syntax error in matrix file '<file name>'
Cause: The matrix file color map has incorrect syntax (too few or too many color names). Program terminates.
Resolution: Correct the color map syntax.

ERROR: Configuration file '<file name>' data missing
Cause: The number of matrix data sets in the configuration file does not match the total number of matrices. Program terminates.
Resolution: Remove the configuration file or save the current configuration.

ERROR: Illegal command line option/syntax
Cause: Excess character(s) or no value listed after option on command line, or illegal command line option. Program terminates.
Resolution: Correct the command line syntax.

ERROR: Infinite loop found
Cause: Logic that would result in an infinite loop (e.g., A is failed by NOT A) has been detected. This is determined in the program by the logic routine being unable to 'converge' within a specified number of loops. This can only occur with the use of inverse (NOT) logic.
Resolution: Remove the logic causing the loop from the logic file.

ERROR: Insufficient memory space available
Cause: Insufficient memory could be allocated for program variables. Program terminates.
Resolution: Terminate other processes and/or clear some disk space.

ERROR: Item '<name>' filter value < 2 in logic file '<file name>'
Cause: The filter value for the item named is less than 2. Program terminates.
Resolution: Increase the filter value.

ERROR: Item '<name>' has illegal '<operator>' in logic file '<file name>'
Cause: The logic statement for the item named contains the operator shown in an illegal context. Program terminates.
Resolution: Correct the logic syntax.

ERROR: Item '<name>' has illegal constant in logic file '<file name>' RT
Cause: A filter number or constant value is placed illegally in RT
the logic item named. Program terminates. RT
Resolution: Correct the logic syntax. RT

ERROR: Item '<name>' has illegal ending operator in logic file '<file name>'
Cause: The logic string for the item referenced is terminated with an operator that is illegal in that context. Program terminates.
Resolution: Correct the logic syntax.

ERROR: Item '<name>' has illegal item name in logic file '<file name>'
Cause: A logic item name is placed illegally in the logic for the item named. Program terminates.
Resolution: Correct the logic syntax.

ERROR: Item '<name>' has illegal MSID item in logic file '<file name>' RT
Cause: A MSID item name is placed illegally in the logic for RT
the item named. Program terminates. RT
Resolution: Correct the logic syntax. RT

ERROR: Item '<name>' has no name following quote in logic file '<file name>'
Cause: An item name was expected following a single or double quote in the logic file. Program terminates.
Resolution: Delete the quote or put an item name after it.

ERROR: Item '<name>' has too few ('s in logic file '<file name>'
Cause: The number of right parentheses exceeds the number of left parentheses at some point in the logic string for the item named (reading left to right). Program terminates.
Resolution: Add/subtract parentheses as required to correct syntax.

ERROR: Item '<name>' has too few)'s in logic file '<file name>'
Cause: The number of left parentheses exceeds the number of right parentheses at some point in the logic string for the item named (reading left to right). Program terminates.
Resolution: Add/subtract parentheses as required to correct syntax.

ERROR: Item '<name>' undefined in logic file '<file name>'
Cause: A subitem is not listed as a separate item in the logic file. Program terminates.
Resolution: Put an entry for the item in the logic file or check spelling.

ERROR: Item '<name>' is not a valid MSID in logic file '<file name>' RT
Cause: A MSID logic item name (an item beginning with a #) is RT
not a valid MSID. Program terminates. RT
Resolution: Correct the item name indicated. RT

ERROR: Item '<name>' mask value missing in logic file '<file name>' RT
Cause: The logic statement of the item indicated is missing RT
the required mask value. Program terminates. RT
Resolution: Correct the bad logic statement. RT

ERROR: Item '<name>' mask value too large in logic file '<file name>' RT
Cause: The logic statement of the item indicated contains a RT
mask word value larger than eight digits. Program RT
terminates. RT
Resolution: Correct the bad logic statement. RT

ERROR: Matrix '<matrix name>' box definition color name missing in matrix file '<file name>'
Cause: Insufficient color names are given in a box definition in the matrix indicated.
Resolution: Provide a fail color for each item represented in the matrix box in addition to a single not-fail color.

ERROR: Matrix '<matrix name>' box definition syntax error in matrix file '<file name>'
Cause: A box definition in the matrix indicated contains too many color names or has excess characters.
Resolution: Remove the excess characters.

ERROR: Matrix '<matrix name>' color '<color name>' undefined in matrix file '<file name>'
Cause: The color name in the specified matrix has not been defined in the matrix file color map. Program terminates.
Resolution: Add an entry for the color, or check spelling.

ERROR: Matrix '<matrix name>' font name missing in matrix file '<file name>'
Cause: The matrix indicated does not have a font name specified.
Resolution: Provide the missing font name.

ERROR: Matrix '<matrix name>' has no boxes defined in matrix file '<file name>'
Cause: No box definitions exist in the matrix file for the matrix specified. Program terminates.
Resolution: Define boxes for the matrix or remove the matrix command.

ERROR: Matrix '<matrix name>' item '<item name>' in matrix file '<file name>' undefined in logic file
Cause: Matrix item specified in matrix file could not be found in the logic file. Program terminates.
Resolution: Add entry in logic file for matrix item, or delete matrix item, or check spelling.

ERROR: Matrix '<matrix name>' rows have unequal number of columns in matrix file '<file name>'
Cause: Number of columns in one row of a matrix does not equal the number of columns in the preceding rows of that matrix. Matrices must be symmetrical. Program terminates.
Resolution: Fill out columns with empty boxes (no name, and not fail/fail colors set to black).

ERROR: Matrix definition name missing in matrix file '<file name>'
Cause: A matrix definition does not include a matrix name.
Resolution: Provide the missing matrix name.

ERROR: MSID '<MSID name>' has invalid type RT
Cause: An MSID logic item does not return with a binary, RT
integer, floating point, or parent word value. RT
Program terminates. RT
Resolution: Remove the MSID specified from the files. RT

ERROR: MSID item name '<MSID name>' too long in logic file '<file name>' RT
Cause: The MSID portion of the MSID logic item (item's RT
beginning with a '#' character are assumed to be RT
MSID's) indicated contains too many characters RT
(10 characters maximum). Program terminates. RT
Resolution: Correct the MSID logic item name specified. RT

ERROR: No color map defined before matrix definition
Cause: A matrix definition precedes the color map, or no color map is present in the matrix file. Program terminates.
Resolution: Place the color map ahead of any matrix definitions in the file.

ERROR: No logic items defined in logic file(s)
Cause: The logic file(s) does not contain any logic item definitions (item names beginning in the first column). Program terminates.
Resolution: Supply correctly formatted logic file.

ERROR: No matrices defined in matrix file(s)

Cause: No matrix definitions were found in the matrix file. Program terminates.

Resolution: Add at least one matrix definition to the matrix file.

ERROR: No room in color map

Cause: The color map is full and no new colors can be defined (box or text). Program terminates.

Resolution: Reduce the number of colors defined. Try to use names from the standard color data base, if possible, to increase the chance of interclient color sharing.

ERROR: Syntax error in matrix file '<file name>'

Cause: A line in the matrix file that is not an identifier or a comment line was found. Program terminates.

Resolution: Delete excess lines.

WARNING: Bad input value; ignored RT
Cause: A number entered in the input dialog box is RT
incorrectly formatted (imbedded spaces, improperly RT
placed decimal points or minus signs). The bad RT
value is ignored and the dialog box is removed. RT
Resolution: Reenter the constant value correctly. RT

WARNING: Cannot connect to data source; continue (no real-time)? RT
Cause: The ds_connect() call to connect to the real-time RT
data source was unsuccessful. If the dialog 'OKAY' RT
box is selected then the program continues RT
operation, but no real-time data are processed (all RT
MSID logic items are initialized to not-failed). RT
If 'NO' is selected the program terminates. RT
Resolution: Check real-time data source status. RT

WARNING: Cannot initialize WEX; continue (no real-time)? RT
Cause: The EXwexinit() call to initialize WEX was RT
unsuccessful. If the dialog 'OKAY' box is selected RT
then the program continues operation, but no real- RT
time data is processed (all MSID logic items are RT
initialized to not-failed). If 'NO' is selected RT
the program terminates. RT
Resolution: Execute program in the WEX 2.5 environment. RT

WARNING: Cannot obtain flight number; continue (no real-time)? RT
Cause: The EXflight() call to obtain the current flight RT
number was unsuccessful. If the dialog 'OKAY' box RT
is selected, the program continues operation, RT
but no real-time data are processed (all MSID logic RT
items are initialized to not-failed). If 'NO' is RT
selected the program terminates. RT
Resolution: Select a flight number for real-time data access. RT

WARNING: Cannot open configuration file '<file name>'
Cause: Configuration file cannot be opened. Program continues operation (configuration is not saved).
Resolution: Bad subdirectory; check file pathname.

WARNING: Cannot open output file 'crans.temp'
Cause: The temporary output file used for print requests could not be opened. No output is generated. Program continues operation.
Resolution: Reattempt request. Possible Unix problem.

WARNING: Configuration file '<file name>' data mismatch
Cause: The number of matrices saved in the configuration file does not match the number of matrix definitions in the matrix file. Program continues operation (the configuration file is ignored).
Resolution: Remove the configuration file, save the current configuration, or specify another configuration file name on the command line.

WARNING: Insufficient window size for matrix '<matrix name>'
Cause: The size of the main window is too small to contain the matrix when deiconified. Program continues operation (the matrix remains iconified).
Resolution: Resize the main window larger.

WARNING: Insufficient window size to display all information
Cause: The program window size is too small to contain all the help, commonality, or reference display information (which is truncated). The program continues operation.
Resolution: Resize the program window larger.

WARNING: Item '<name>' in logic file '<file name>' already defined; continue (ignore)?
Cause: A logic item has two (or more) definitions in the logic file(s). If the dialog 'OKAY' box is selected then the program continues operation and the duplicate entry is ignored. If 'NO' is selected then the program terminates.
Resolution: Remove duplicate logic item entries from the logic file(s). The option "-showduplicates FALSE" will inhibit this warning message.

WARNING: Main window too small
Cause: The program window is too small to contain the main window header or the largest icon. The program continues operation.
Resolution: The window manager should prevent resizing the window too small to contain the header or largest icon. Start the program with a larger window size, or shorten the main title or matrix name(s).

USAGE NOTES

Except for error checking noted above, the program expects to find correct file syntax. Incorrect syntax could produce unexpected results (program hangs, error messages, etc.).

TITLE

RTC SAFING PROCEDURES FOR LOSS OF LPS/LDB CAPABILITY

PURPOSE

To provide the procedures necessary to safe the orbiter when there is a loss of Launch Processing System/Launch Data Bus (LPS/LDB) capability.

PART I - BACKGROUND INFORMATION

BACKGROUND

The LO_2 overboard bleed allows propellant to bleed through and condition the main engines prior to SSME start. Subsequent to stable replenish of the liquid oxygen in the external tank, the LO_2 enters the orbiter through the fill and drain (F/D) lines, conditions the engines, exits the engines through their bleed valves, and exits the orbiter through the LO_2 overboard bleed valve. Without this bleed path, there is no means of removing heat from the engines. The LO_2 in the engines would become stagnant and heat buildup would cause the LO_2 to vaporize. This vapor accumulation could then rise through the "downcomer." If enough vapor collects and forms a pocket, this pocket could cause a void in the LO_2 downcomer resulting in a geyser. This geyser could in turn cause MPS feedline damage and possible LO_2 tank collapse.

The only other method of draining the orbiter LO_2 is through the F/D valves. The F/D valves can be opened by LPS command or manually by the crew (Panel R4). Crew action was established by a permanent deviation (Dev. no. 131/01) to OMI Procedure S0007, vol. 5, seq. no. 131, which was approved on April 10, 1990 for the second launch flow of STS-31. This deviation states that if bleed flow cannot be established because of the loss of firing room control (loss of LPS/LDB), the crew takes manual action by opening the F/D valves on Panel R4. The RTC's are currently a backup procedure to the manual procedures. The procedure is written to open the outboard (O/B) F/D valve first, and then proceed by opening the inboard (I/B) F/D valve. It is important that the O/B F/D valve be opened first. If the I/B F/D valve is opened first, a water hammer occurs at the O/B F/D valve causing possible valve and/or line damage. Manually opening the F/D valves will override any commands to the valves.

The firing room sends commands to the orbiter from the launch processing system software (LPS) across the launch data bus (LDB). If the LDB/LPS is unable to transmit commands to the orbiter, KSC will be unable to open the overboard bleed valve if there is a launch hold beyond T - 9.4 seconds. The overboard bleed valve is commanded closed at T - 9.4 seconds by the RSLS. Concern was sparked by an incident on April 2, 1990 when a pipe burst spilling water onto a 4000-V motor control assembly. This shorted out the motor causing the LPS firing room power to go down.

If the LPS loses power between T - 28 seconds and T - 10 seconds, the engines will never get the LPS "Go for SSME Start Flag" set at T - 7 seconds. At T - 9.4 seconds, the RSLS commands the overboard bleed valves closed. The engine bleed valves close because the engine has received the start enable command from the RSLS at 10 seconds. The RSLS sequence marches down to T - 7 seconds where it looks for the "LPS SSME Start Flag," which was never set at T - 10 seconds. At this point, an RSLS hold is issued with the orbiter and engine bleed valves closed.

Two scenarios exist whereby the loss of bleed capability for more than 2 minutes can result in a potential catastrophic situation. Bleed capability can be lost through a hardware failure of the overboard bleed valve or all three of the engine bleed valves (failed closed). It can also be lost if firing room control (LDB/LPS) is lost beyond T - 9.4 seconds. Note that the engine bleed valves can be reopened by cycling the main engine controller power in a sequential manner. If the overboard bleed and the POGO recirculation valves can be opened, and the LO_2 prevalves can be closed within the 9- to 12- minute time frame, the vehicle will be in a safe configuration. Note that the Recirculation Isolation Valves (POGO valves) must be opened to establish bleed flow. If the overboard bleed valve or the POGO valves cannot be opened or the LO_2 prevalves cannot be closed, the F/D valves must be opened within 9 to 12 minutes, depending on the failure scenario. This provides for heat dissipation (preventing an LO_2 geyser) to safe and vehicle. In both scenarios, helium injection is insufficient to prevent geysering and is included in the problem resolution.

In the first scenario, a hold occurs after T - 9.4 seconds, but before SSME start. In this case, the overboard bleed valve is closed and heat transfer occurs through the engine hardware. Heat is transferred from the LO_2 in the engine system, because the engine is not isolated by LO_2 prevalve closure. This results in the formation of vapor pockets that will eventually produce a geyser resulting in rupture the LO_2 feedlines or severely damage engine components. This failure scenario would occur if F/D or bleed capability cannot be reached within 12 minutes.

In the second scenario, there is a pad abort beyond SSME start. In this configuration, the LO_2 prevalves are commanded closed, but the overboard bleed valve is commanded open by the ground launch sequencer (GLS) which has failed in this scenario, and the overboard bleed valve that cannot be opened. Heat soakback from the engines causes LO_2 vaporization to form in the engine feedlines which forces the prevalve release mechanisms to lift off their seats. This allows the vapor to escape into the downcomer, creating a possible geyser situation. This failure scenario would occur if fill and drain or bleed capability cannot be reached within 9 minutes. The safing times are similar because the engine is cooled by hydrogen purges that are initiated postshutdown. Reference FMEA CIL no. 03-1-0452-1. Recirculation Isolation Valve command capability was added prior to STS-49 to ensure that the recirculation isolation valves would be in the open state. The inclusion of these commands into the set of MPS Safing commands will ensure that the LO_2 system is safed from a Geyser standpoint.

There is also concern that if the F/D valves are opened, there could be damage to the LO_2 loading facility due to an LO_2 "water hammer." This water hammer is produced by the LO_2 head pressure combined with ullage pressure that rapidly forces a heavy column of LO_2 to flow into the LO_2 fill system as it exits the F/D line. This water hammer has the potential of causing severe damage to the LO_2 facility.

A helium purge is initiated into the LO_2 F/D lines, upstream of the facility debris plate and exits through the tail service mast (TSM) vent and drain valves which are open at this time. This purge is supplied to the F/D valves at T - 80 seconds to cushion the LO_2 water hammer in the potential situation where the overboard bleed cannot be opened.

After 10 to 15 seconds of providing the helium purge to the F/D valves, the helium cushion has had time to diminish the effect of the water hammer to the LO_2 facility. At this point, the MPS operator at KSC throws the master safing switch on his console. This operation closes the TSM vent and drain valves and reroutes the helium, which was being supplied to the F/D valves, to repressurize the ET. This prevents ET collapse and places the orbiter in a good configuration for hardwire drain. Note that after ET prepress is initiated, the ET may vent through the LO_2 relief/vent valve. If/when the safing panel ullage pressure gauge becomes available, the MPS operator at KSC will begin ET prepress cycling. This should eliminate cycling of the ET relief valve.

PROBLEM DISCUSSION

At T - 80 seconds, a helium purge was initiated by a deviation to S1003 (LO_2 Loading Procedures), during the second launch attempt of STS-31. This purge is manually initiated from the MPS console in KSC firing room. A software system, "the prerequisite logic," runs in parallel with the LPS to verify prelaunch configuration. This logic checks the helium purge valves' position discretes. If the valves show an open discrete, the O/B F/D valve is not closed. These helium valves are normally closed, powered open, but are powered by hardware interface modules (HIM's) which are not on the same power source as the LDB/LPS. This logic was not tested in conjunction with the manual initiation of the helium purge, due to the lack of verification time between launch attempts. During this launch attempt, the LO_2 O/B F/D valve did not close at T - 48 seconds which caused an LCC violation when the valves were checked by the ground launch sequencer (GLS) at T - 35 seconds. The MPS console operator at KSC, realizing the cause of the hold, manually bypassed the control logic of the LPS software. A command was then manually sent to toggle the LO_2 O/B F/D power which closed the valve and placed the orbiter in a proper launch configuration.

PART II - VEHICLE SAFING

VEHICLE SAFING VIA REAL-TIME COMMANDS

On May 4, 1990, Level II approved the action to build a real-time command (RTC) load to open the overboard bleed valve and close the LO_2 prevalves, should KSC lose uplink capability. POGO valve commanding was approved to be included in this load prior to the flight of STS-49. Implementation of the RTC's is a backup procedure to the crew procedure documenting the initiation of drain via the F/D valves. The crew procedure is presented in further detail following the discussion of the RTC procedure. If the crew is unavailable to initiate drain using the F/D valves, the MPS Safing commands will be uplinked to the orbiter following a transition to Operations Sequence (OPS) 9. The transition to OPS 9 will be accomplished through the MCC DPS Officer's implementation of a Display Electronics Unit (DEU) equivalent of the crew's implementation of the OPS 901 PRO command. This action has level II approval and was tested during the STS-38 Terminal Countdown Demonstration Test (TCDT). The POGO valve commands were verified in the Shuttle Avionics Integration Laboratory (SAIL) prior to STS-49. A manual detank procedure (discussed in the next section), through the F/D valves, will be used as a backup to the RTC procedure. This was the procedure in place for the first launch attempt of STS-35 (May 29, 1989). In this scenario, a KSC ground call would be made to open the LO_2 F/D's (outboard first) in order to drain the orbiter. This would prevent a catastrophic failure due to LO_2 geysering, and facility water hammer.

When the F/D valves are opened, there is a chance that the ullage pressure in the LO2 give will evacuate such that the LO_2 tank may collapse. Therefore, 10 to 15 seconds after initiating the leak check purge, the MPS operator at KSC will throw the master safing switch which will initiate helium prepress of the LO_2 tank and commence the helium purge at the F/D valves. At this time, because of the configuration of the safing panel, the main fill valve will open and the TSM drain and vent valve will close. This will place KSC in a good configuration for a hardwire drain of the LO_2 tank. This type of LO_2 drain is performed by manually actuating the necessary drain valves which are wired to the MPS console at KSC. Once initiated, the LO_2 tank remains in hardwire drain for the duration of drain, irrespective of whether or not they reestablish power. A smooth transition cannot be made between a hardware and a software drain. The LPS will still be used to monitor drain conditions.

VEHICLE SAFING VIA IMPLEMENTATION OF MANUAL PROCEDURE

The PSIG has worked to develop the manual procedure for LO_2 Geyser prevention. The procedure is as follows:

Time period	Action	Valve configuration
T - 9	Set bypass of ground control logic (GCL) 18 (O/B F/D Prereq. Logic)	No change
T - 4:55	Terminate replenish	I/B F/D Closed
T - 1:20	Activate transfer line leak check	Leak check purge on
T - :48	Close O/B F/D - PV 9	PV 9 - Close
T - :31 - T - :10	(Window for LPS failure causing scrub with bleed terminated)	TSM Drn & Vent - OP
LPS issues the "Go for SSME Start" at T-10 sec. - the RSLS searches for it at T - 7 sec.		Mn fill valve - CL Leak check purge on Prepress - On or off depending on failure timing ET vent - CL I/B & O/B F/D - CL
Failure to scrub + 2 min.	Configure safing pnl: Mn Fill Valve - OP Helium prepress - ON ET vent - CL Verify power status Lights for MLP & PTCR NASA test director (NTD) completes assessment and decides to initiate flight crew procedure:	
	Panel R4 - PV 9 - OP	PV 9 - OP (Wait 10 seconds) (Open 1st)
	PV 10 - OP	PV 10 - OP
	PV 10 - I/B F/D PV 9 - O/B F/D	

Time period	Action	Valve configuration
	Panel - R2 engine power CTR AC1 SW - OFF CTR AC2 SW - OFF LFT AC2 SW - OFF LFT AC3 SW - OFF RHT AC3 SW - OFF RHT AC1 SW - OFF CTR AC1 SW - ON CTR AC2 SW - ON LFT AC2 SW - ON LFT AC3 SW - ON RHT AC3 SW - ON RHT AC1 SW - ON	SSME's in purge sequence 3
PV 10 + (10 to 15 sec)	Throw Master Safing Switch - MPS Console	TSM Drn & Vnt - CL Mn Fill VV - OP Lk Check Purge - OFF Prepress - ON ET Vnt VV - CL

If/when safing panel ullage pressure gauge becomes available, begin prepress cycling from the MPS console at KSC.

Eventually, the overboard bleed valve will be hardwired to the KSC MPS console as a permanent fix.

PART III - RTC PROCEDURE

PARTICIPATION

FLIGHT DIRECTOR
INCO
COMMAND
DPS
BOOSTER
NASA TEST DIRECTOR (NTD)

PROCEDURE

1. The NTD will determine if KSC has lost LPS/LDB capability and MPS safing must be performed via MCC command capability.

2. Upon recognition of this case, a call is made to the Houston flight director to transition to OPS 9. The transition is accomplished through the uplink of a DEU equivalent (digital select matrix (DSM) 20101). The INCO Officer sends the DEU equivalent on a call from the DPS officer. The DEU equivalent contains the "OPS 901 PRO" command which is interpreted by the GPC's. Upon receiving the command, the GPC's will transition to OPS 9. The DPS officer verifies that a successful OPS 9 transition has been made and report this to the Flight Director before the safing commands are sent.

3. The call from the NTD to the Houston Flight Director will include the vehicle safing (close the LO2 prevalves, open the overboard bleed valve, and open the POGO valves) multiple real-time commands (MRTC's) - (DSM 7050, 1515, 7051, 7052, 7053). The INCO will request that the COMMAND Officer unsafe these commands if it has not been done. The INCO then sends the MRTC's (from his console) to configure these valves. The Booster Officer verifies that these valves are positioned correctly and that the LO_2 inlet temperatures are dropping. The Booster Officer then informs the flight director of the status of the configuration. If the valves are in the proper configuration and the LO_2 inlet temperatures are dropping, then the orbiter is in a safe configuration until LPS/LDB capability can be restored.

4. The flight director informs the NTD the procedure is completed.

5. Attached is a list of the RTC's which combine to form the MRTC's used to configure the LO_2 prevalves, the overboard bleed valves, and the POGO valves. These commands are grouped in tables 7.2.3-I and 7.2.3-II, respectively.

TABLE 7.2.3-III.- POGO RECIRC VALVES' COMMAND LIBRARY

DSM	RTC Title	MDM	Reset	Set	MSID
1022	TERM POGO1 CL CMD A	FA1	BIT 1 - 1	BIT 1 - 0	V41K1815X
1023	TERM POGO1 CL CMD B	FA3	BIT 1 - 1	BIT 1 - 0	V41K1816X
1024	TERM POGO2 CL CMD A	FA2	BIT 1 - 1	BIT 1 - 0	V41K1825X
1025	TERM POGO2 CL CMD B	FA4	BIT 1 - 1	BIT 1 - 0	V41K1826X

DSM	MRTC Command title
1515	TERM POGO COMMANDS