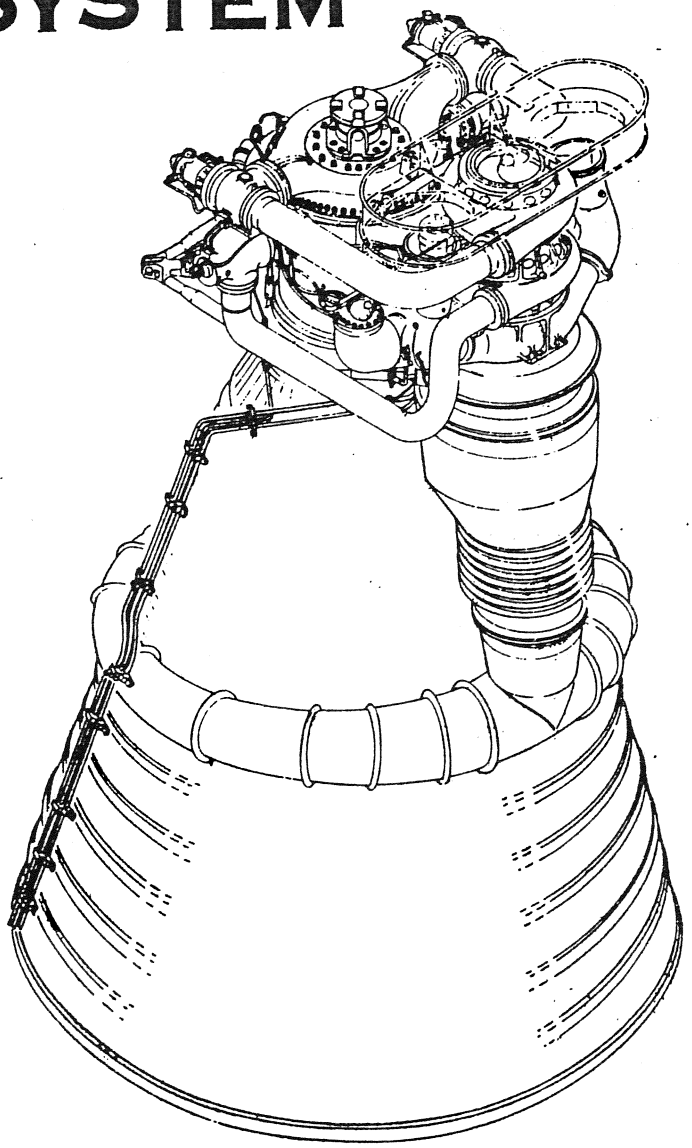
F-1 ENGINE SYSTEM



LAUNCH INFORMATION

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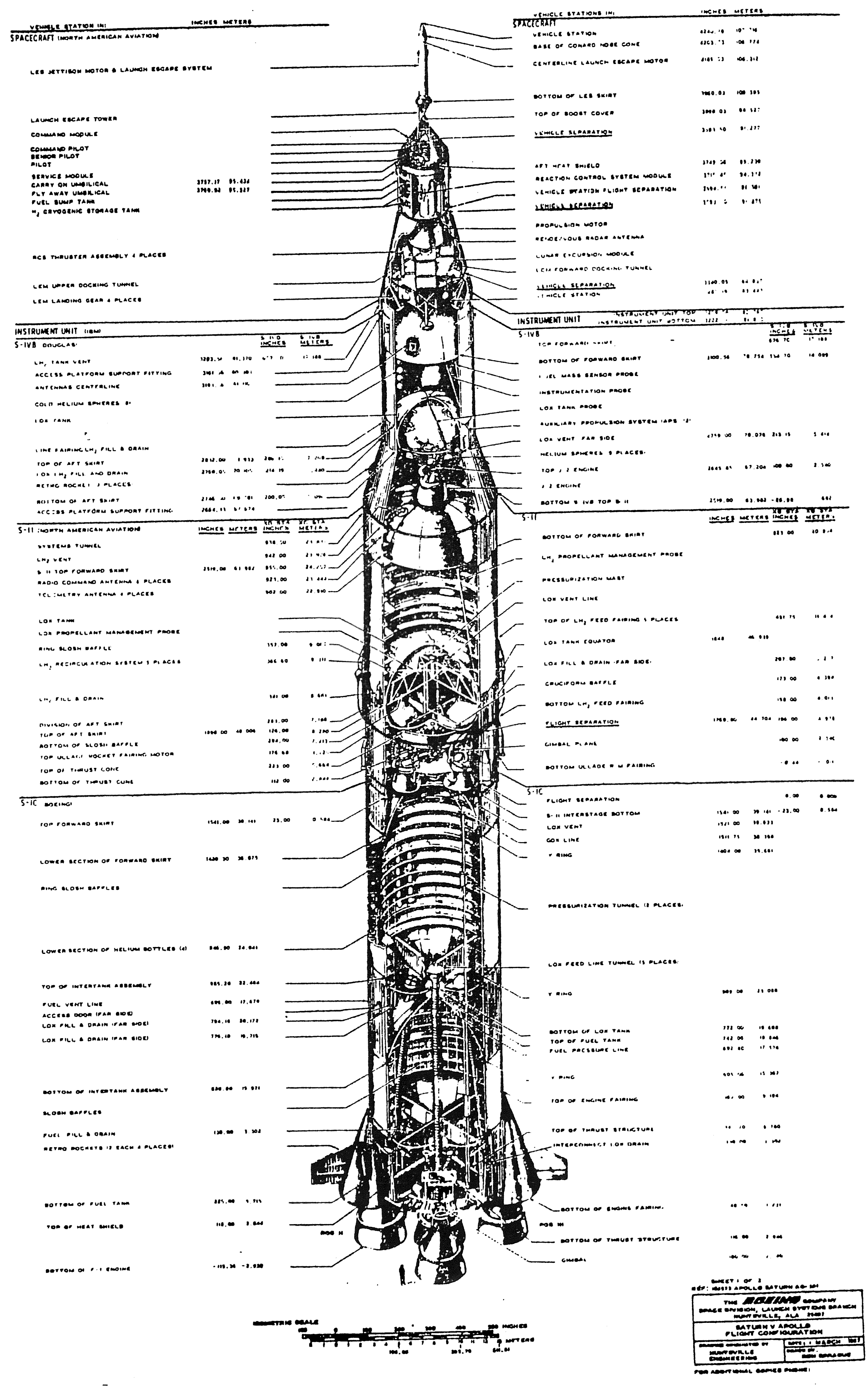
AS-511

SATURN V APOLLO FLIGHT CONFIGURATION


VEHICLE STATION IN. INCHES METERS
SPACECRAFT (NORTH AMERICAN AVIATION)
LES JETTISON MOTOR & LAUNCH ESCAPE SYSTEM
LAUNCH ESCAPE TOWER
COMMAND MODULE
COMMAND PILOT
SENIOR PILOT
PILOT
SERVICE MODULE
CARRY ON UMBILICAL
FLY AWAY UMBILICAL
FUEL SUMP TANK
RCS THRUSTER ASSEMBLY 4 PLACES
LEM UPPER DOCKING TUNNEL
LEM LANDING GEAR 4 PLACES
INSTRUMENT UNIT
S-IVB (DOUGLAS)
ACCESS PLATFORM SUPPORT FITTING
ANTENNAS CENTERLINE
COLD HELIUM SPHERES
LOX TANK
TOP OF AFT SKIRT
RETRO ROCKET 3 PLACES
BOTTOM OF AFT SKIRT
S-II (NORTH AMERICAN AVIATION)
SYSTEMS TUNNEL
S-II TOP FORWARD SKIRT
RADIO COMMAND ANTENNA 4 PLACES
TELEMETRY ANTENNA 4 PLACES
LOX TANK
LOX PROPELLANT MANAGEMENT PROBE
RING SLOSH BAFFLE
DIVISION OF AFT SKIRT
TOP OF AFT SKIRT
BOTTOM OF SLOSH BAFFLE
TOP OF THRUST CONE
BOTTOM OF THRUST CONE
S-IC (BOEING)
TOP FORWARD SKIRT
LOWER SECTION OF FORWARD SKIRT
RING SLOSH BAFFLES
LOWER SECTION OF HELIUM BOTTLES (4)
TOP OF INTERTANK ASSEMBLY
FUEL VENT LINE
ACCESS DOOR (FAR SIDE)
LOX FILL & DRAIN (FAR SIDE)
BOTTOM OF INTERTANK ASSEMBLY
SLOSH BAFFLES
FUEL FILL & DRAIN
RETRO ROCKETS (2 EACH 4 PLACES)
BOTTOM OF FUEL TANK
TOP OF HEAT SHIELD
BOTTOM OF F-1 ENGINE
VEHICLE STATION
BASE OF CANARD NOSE CONE
CENTERLINE LAUNCH ESCAPE MOTOR
BOTTOM OF LES SKIRT
TOP OF BOOST COVER
VEHICLE SEPARATION
AFT HEAT SHIELD
REACTION CONTROL SYSTEM MODULE
PROPULSION MOTOR
RENDEZVOUS RADAR ANTENNA
LUNAR EXCURSION MODULE
LEM FORWARD DOCKING TUNNEL
INSTRUMENT UNIT TOP
INSTRUMENT UNIT BOTTOM
S-IVB
TOP FORWARD SKIRT
BOTTOM OF FORWARD SKIRT
INSTRUMENTATION PROBE
LOX TANK PROBE
LOX VENT (FAR SIDE)
TOP J-2 ENGINE
J-2 ENGINE
S-II
BOTTOM OF FORWARD SKIRT
PRESSURIZATION MAST
LOX VENT LINE
LOX TANK EQUATOR
CRUCIFORM BAFFLE
FLIGHT SEPARATION
GIMBAL PLANE
S-IC
FLIGHT SEPARATION
S-II INTERSTAGE BOTTOM
LOX VENT
GOX LINE
Y RING
PRESSURIZATION TUNNEL (2 PLACES)
LOX FEED LINE TUNNEL (5 PLACES)
Y RING
BOTTOM OF LOX TANK
TOP OF FUEL TANK
FUEL PRESSURE LINE
Y RING
TOP OF ENGINE FAIRING
TOP OF THRUST STRUCTURE
INTERCONNECT LOX DRAIN
BOTTOM OF ENGINE FAIRING
POS III
BOTTOM OF THRUST STRUCTURE
GIMBAL
POS II
SATURN V APOLLO FLIGHT CONFIGURATION
ISOMETRIC SCALE
INCHES
METERS

APOLLO 16 MISSION SUMMARY

The Apollo 16, AS-511, mission is an Apollo Lunar Roving Vehicle (LRV) mission to the Descartes region of the moom. The launch window is a one-day window on 16 April 1972. The nominal mission profile is presented in the AS-511 Apollo 16 Mission Profile Figure.

REV	ITEM	DESCRIPTION
		HOLD/CUTOFF GUIDELINES:
	1-800	HOLDS (STOPPING THE COUNTDOWN CLOCK PRIOR TO T-3 MINUTES 7 SECONDS): A HOLD MAY BE REQUESTED BY THE LAUNCH VEHICLE TEST CONDUCTOR, THE SPACECRAFT TEST CONDUCTOR(S), THE LAUNCH OPERATIONS MANAGER, THE TEST SUPPORT CONTROLLER, THE SUPERINTENDENT OF RANGE OPERATIONS, THE GSFC USB STATION (GMIL), OR THE FLIGHT DIRECTOR. THE REQUEST FOR HOLD WILL BE MADE TO THE TEST SUPERVISOR (CVTS) OVER CHANNEL 111, WHO WILL STOP THE COUNTDOWN CLOCK AT THE MOST ADVANTAGEOUS TIME.
	1-801	CUTOFF (T-3 MINUTES 7 SECONDS TO T-45 SECONDS): PERSONNEL UNDER THE DIRECTION OF THE LAUNCH VEHICLE TEST CONDUCTOR WHO ARE IMPLEMENTING LAUNCH MISSION RULES WILL REPORT MISSION RULE VIOLATIONS THROUGH THE LAUNCH VEHICLE TEST CONDUCTOR WHO WILL RELAY THE REQUEST FOR "C1FR GIVE CUTOFF" OVER CHANNEL 121. IN AN EMERGENCY CONDITION, LAUNCH VEHICLE PERSONNEL WILL REQUEST CUTOFF BY DIRECTLY CALLING "C1FR GIVE CUTOFF" OVER CHANNEL 121. PERSONNEL UNDER THE DIRECTION OF THE SPACECRAFT TEST CONDUCTOR(S), THE TEST SUPPORT CONTROLLER, THE SUPERINTENDENT OF RANGE OPERATIONS, THE GSFC USB STATION (GMIL), AND THE FLIGHT DIRECTOR WHO ARE IMPLEMENTING LAUNCH MISSION RULES WILL REQUEST CUTOFF THROUGH ONE OF THE ABOVE (AS APPROPRIATE FOR THEIR RESPECTIVE AREA) WHO WILL RELAY THE REQUEST TO THE LAUNCH OPERATIONS MANAGER OVER CHANNEL 111. THE LAUNCH OPERATIONS MANAGER WILL DIRECT THE LAUNCH VEHICLE TEST CONDUCTOR TO IMPLEMENT THE CUTOFF, WHO WILL RELAY THE REQUEST FOR "C1FR GIVE CUTOFF" OVER CHANNEL 121.
	1-802	CUTOFF (T-45 SECONDS TO T-11 SECONDS): ALL PERSONNEL, WITH THE EXCEPTION OF PERSONNEL UNDER THE DIRECTION OF THE SPACECRAFT TEST CONDUCTOR(S), WHO ARE IMPLEMENTING LAUNCH MISSION RULES WILL REQUEST CUTOFF BY DIRECTLY CALLING "C1FR GIVE CUTOFF" OVER CHANNEL 121. PERSONNEL UNDER THE DIRECTION OF THE SPACECRAFT TEST CONDUCTOR(S) WHO ARE IMPLEMENTING LAUNCH MISSION RULES WILL REQUEST CUTOFF THROUGH THE SPACECRAFT TEST CONDUCTOR(S) WHO WILL RELAY THE REQUEST FOR "C1FR GIVE CUTOFF" OVER CHANNEL 121.

REV	ITEM	DESCRIPTION
		HOLD/CUTOFF GUIDELINES (Continued):
	1-803	CUTOFF (AFTER T-11 SECONDS): NO REQUESTS FOR CUTOFF WILL BE MADE AFTER T-11 SECONDS EXCEPT IF IGNITION DOES NOT OCCUR OR IF IGNITION OCCURS BUT THE VEHICLE FAILS TO LIFT OFF AND FAILS TO RECEIVE AUTOMATIC CUTOFF FROM THE ESE. AT IGNITION, THE SENIOR BOEING MECHANICAL ENGINEER WILL START A STOP WATCH. IF LIFTOFF DOES NOT OCCUR, THE SENIOR BOEING MECHANICAL ENGINEER WILL DIRECT C1FR TO GIVE CUTOFF AT IGNITION + 17 SECONDS. IF CUTOFF CANNOT BE ACCOMPLISHED THROUGH THE ESE, THE LAUNCH VEHICLE TEST CONDUCTOR (CLTC) WILL CALL THE CAPE KENNEDY RANGE SAFETY OFFICER (RSO) VIA POINT-TO-POINT PHONE AND BY CODE WILL REQUEST ENGINE SHUTDOWN. (REFERENCE "RANGE SAFETY RULES AND AGREEMENTS" SUBSECTION, ITEMS 1-501 AND 1-525.)
	1-804	IN ALL CASES AFTER INITIATING CUTOFF, C1FR WILL VERIFY CUTOFF GIVEN OVER CHANNEL 121.
	1-805	FOR CRITICAL EVENTS DURING THE FINAL 45 SECONDS OF THE COUNTDOWN, A 2 TO 3 SECOND TIME DELAY IS REQUIRED TO ALLOW SUFFICIENT OBSERVER/MONITOR/PANEL OPERATOR REACTION TIME BETWEEN A REQUEST FOR "C1FR GIVE CUTOFF" AND OBTAINING A MANUAL CUTOFF. E.G., T-19 SECONDS: 2.8 SECONDS PRIOR TO S-IC FORWARD UMBILICAL DISCONNECT; T-11 SECONDS: 2.1 SECONDS PRIOR TO S-IC TIME FOR IGNITION.

REV	ITEM	DESCRIPTION

SPACE VEHICLE FUNCTIONAL SEQUENCE:

THE SPACE VEHICLE FUNCTIONAL SEQUENCE DETAILS ACTIONS TO BE FOLLOWED IN THE EVENT MALFUNCTIONS OR OTHER PROBLEMS ARE ENCOUNTERED DURING THE COUNTDOWN. SPECIFIED TIMES REPRESENT RECOMMENDED HOLD-POINTS IF REQUIRED.

ITEM	TIME PERIOD	CONDITION	ACTION/COMMENT
1-900	T-24 HRS (L/V POWER UP) TO T-15 HRS (COMPLETION OF LM CABIN CLOSEOUT).	MALFUNCTION OF ANY REPAIRABLE SPACE VEHICLE ELEMENT OR OPERATIONAL SUPPORT ELEMENT.	PROCEED OR HOLD. PROCEED IF CORRECTION OF MALFUNCTION CAN BE ACCOMPLISHED IN PARALLEL WITH OTHER OPERATIONS; OTHERWISE HOLD FOR REPAIR OF MANDATORY OR HIGHLY DESIRABLE ITEMS PRIOR TO REMOVING ACCESS TO THE SYSTEM OR WHEN THE SYSTEM IS NECESSARY FOR COUNTDOWN CONTINUATION. HOLD AT T-15 HRS IF REPAIR CANNOT CONTINUE AFTER COMPLETION OF LM CABIN CLOSEOUT.
1-901	T-15 HRS (COMPLETION OF LM CABIN CLOSEOUT) TO T-11 HRS 30 MIN (START OF L/V SAFE-AND-ARM CONNECTION).	MALFUNCTION OF ANY REPAIRABLE SPACE VEHICLE ELEMENT OR OPERATIONAL SUPPORT ELEMENT.	PROCEED OR HOLD. PROCEED IF CORRECTION OF MALFUNCTION CAN BE ACCOMPLISHED IN PARALLEL WITH OTHER OPERATIONS; OTHERWISE HOLD FOR REPAIR OF MANDATORY OR HIGHLY DESIRABLE ITEMS PRIOR TO REMOVING ACCESS TO THE SYSTEM OR WHEN THE SYSTEM IS NECESSARY FOR COUNTDOWN CONTINUATION. HOLD AT T-11 HRS 30 MIN IF REPAIR CANNOT CONTINUE IN PARALLEL WITH OR AFTER COMPLETION OF L/V SAFE-AND-ARM CONNECTION.
1-902	T-11 HRS 30 MIN (START OF L/V SAFE-AND-ARM CONNECTION) TO T-11 HRS (DISCONNECT AUXILIARY DAMPER).	MALFUNCTION OF ANY REPAIRABLE SPACE VEHICLE ELEMENT OR OPERATIONAL SUPPORT ELEMENT.	PROCEED OR HOLD. PROCEED IF CORRECTION OF MALFUNCTION CAN BE ACCOMPLISHED IN PARALLEL WITH OTHER OPERATIONS; OTHERWISE HOLD FOR REPAIR OF MANDATORY OR HIGHLY DESIRABLE ITEMS PRIOR TO REMOVING ACCESS TO THE SYSTEM OR WHEN THE SYSTEM IS NECESSARY FOR COUNTDOWN CONTINUATION. HOLD AT T-11 HRS IF THE MSS IS REQUIRED FOR REPAIR.

REV	ITEM	DESCRIPTION

SPACE VEHICLE FUNCTIONAL SEQUENCE (Continued):

	TIME PERIOD	CONDITION	ACTION/COMMENT
1-903	T-11 HRS (DISCONNECT AUXILIARY DAMPER) TO T-8 HRS 15 MIN (START OF L/V CRYOGENIC LOADING).	MALFUNCTION OF ANY REPAIRABLE SPACE VEHICLE ELEMENT OR OPERATIONAL SUPPORT ELEMENT.	PROCEED OR HOLD. PROCEED IF CORRECTION OF MALFUNCTION CAN BE ACCOMPLISHED IN PARALLEL WITH OTHER OPERATIONS; OTHERWISE HOLD FOR REPAIR OF MANDATORY OR HIGHLY DESIRABLE ITEMS PRIOR TO REMOVING ACCESS TO THE SYSTEM OR WHEN THE SYSTEM IS NECESSARY FOR COUNTDOWN CONTINUATION. HOLD AT T-8 HRS 15 MIN IF REPAIR CANNOT CONTINUE IN PARALLEL WITH OR AFTER COMPLETION OF L/V CRYOGENIC LOADING.
1-904	T-8 HRS 15 MIN (START OF L/V CRYOGENIC LOADING) TO T-3 HRS 10 MIN (S/C, START OF CM CABIN CLOSEOUT); TO T-43 MIN (L/V).	MALFUNCTION OF ANY REPAIRABLE SPACE VEHICLE ELEMENT OR OPERATIONAL SUPPORT ELEMENT.	PROCEED OR HOLD. PROCEED IF CORRECTION OF MALFUNCTION CAN BE ACCOMPLISHED IN PARALLEL WITH OTHER OPERATIONS; OTHERWISE HOLD FOR REPAIR OF MANDATORY OR HIGHLY DESIRABLE ITEMS. IF REPAIR IS NOT POSSIBLE, REVIEW CRITICALITY, EVALUATE PERFORMANCE DEGRADATION, AND MAKE THE DECISION TO PROCEED, HOLD, OR SCRUB. HOLD AT T-3 HRS 10 MIN FOR COMPLETION OF INTERNAL CM WORK IF REQUIRED.
1-905	T-3 HRS 10 MIN (START OF CM CABIN CLOSEOUT) TO T-43 MIN (RETRACT ACCESS ARM TO PARK POSITION).	PROBLEM IN CM CABIN CLOSEOUT.	HOLD AT T-43 MIN FOR COMPLETION OF CM CABIN CLOSEOUT.

REV	ITEM	DESCRIPTION

SPACE VEHICLE FUNCTIONAL SEQUENCE (Continued):

ITEM	TIME PERIOD	CONDITION	ACTION/COMMENT
1-906	T-43 MIN (RETRACT ACCESS ARM TO PARK POSITION) TO T-22 MIN (2 SEC PRIOR TO S-II START BOTTLE CHILL-DOWN).	MALFUNCTION OF ANY REPAIRABLE SPACE VEHICLE ELEMENT OR OPERATIONAL SUPPORT ELEMENT.	PROCEED OR HOLD. PROCEED IF CORRECTION OF MALFUNCTION CAN BE ACCOMPLISHED IN PARALLEL WITH OTHER OPERATIONS; OTHERWISE HOLD FOR REPAIR OF MANDATORY OR HIGHLY DESIRABLE ITEMS. IF REPAIR IS NOT POSSIBLE, REVIEW CRITICALITY, EVALUATE PERFORMANCE DEGRADATION, AND MAKE THE DECISION TO PROCEED, HOLD, OR SCRUB.
1-907	T-22 MIN (2 SEC PRIOR TO S-II START BOTTLE CHILLDOWN) TO T-14 MIN 30 SEC (S-IVB START BOTTLE CHILLDOWN).	MALFUNCTION OF ANY MANDATORY OR HIGHLY DESIRABLE SPACE VEHICLE ELEMENT OR OPERATIONAL SUPPORT ELEMENT APPLICABLE TO THIS TIME PERIOD.	HOLD. THERE IS NO DEFINITE LIMITATION ON HOLD CAPABILITY OTHER THAN THE STORAGE CAPACITY OF THE GH2 FACILITY (SEE FIGURE 1) AND LAUNCH VEHICLE REDLINE REQUIREMENTS. IF A HOLD IS CALLED, S-II START BOTTLE CHILLDOWN OPERATIONS MAY CONTINUE UNINTERRUPTED OR BE TERMINATED AND REINITIATED WITH A NORMAL CHILLDOWN SEQUENCE. A MINIMUM OF 17 MINUTES AND 21 SECONDS UNINTERRUPTED S-II START BOTTLE CHILLDOWN IS REQUIRED ENDING WITH PRESSURIZATION. AFTER PRESSURIZATION, PERIODIC VENTING MAY BE REQUIRED BY USING START BOTTLE AND ENGINE HELIUM BOTTLE EMERGENCY VENT VALVES.

REV	ITEM	DESCRIPTION
		SPACE VEHICLE FUNCTIONAL SEQUENCE (Continued):
		TIME PERIOD / CONDITION / ACTION/COMMENT
	1-908	T-14 MIN 30 SEC (S-IVB START BOTTLE CHILLDOWN) TO T-8 MIN (2 SEC PRIOR TO S-II/S-IVB THRUST CHAMBER CHILLDOWN). / MALFUNCTION OF ANY MANDATORY OR HIGHLY DESIRABLE SPACE VEHICLE ELEMENT OR OPERATIONAL SUPPORT ELEMENT APPLICABLE TO THIS TIME PERIOD. / HOLD. THERE IS NO DEFINITE LIMITATION ON HOLD CAPABILITY OTHER THAN THE STORAGE CAPACITY OF THE GH2 FACILITY (SEE FIGURE 1) AND LAUNCH VEHICLE REDLINE REQUIREMENTS. IF A HOLD IS CALLED, S-II AND S-IVB START BOTTLE CHILLDOWN OPERATIONS MAY CONTINUE UNINTERRUPTED OR BE TERMINATED AND REINITIATED WITH A NORMAL CHILLDOWN SEQUENCE. IF S-IVB START BOTTLE CHILLDOWN IS TERMINATED, A MINIMUM WARMUP PERIOD OF 5 MINUTES IS REQUIRED PRIOR TO REINITIATION FOR STAGE FILL LINE WARMUP. A MINIMUM OF 17 MINUTES AND 21 SECONDS (S-II) AND A MINIMUM OF 9 MINUTES (S-IVB) UNINTERRUPTED START BOTTLE CHILLDOWN IS REQUIRED ENDING WITH PRESSURIZATION. AFTER PRESSURIZATION, PERIODIC VENTING MAY BE REQUIRED BY USING START BOTTLE AND ENGINE HELIUM BOTTLE EMERGENCY VENT VALVES. IF S-II/S-IVB START BOTTLE LIMITS ARE ESTIMATED TO BE EXCEEDED, AN ABBREVIATED RECHILL/RECHARGE MAY BE ACCOMPLISHED.

REV	ITEM	DESCRIPTION

SPACE VEHICLE FUNCTIONAL SEQUENCE (Continued):

ITEM	TIME PERIOD	CONDITION	ACTION/COMMENT
1-910	T-8 MIN (2 SEC PRIOR TO S-II/S-IVB THRUST CHAMBER CHILLDOWN) TO T-3 MIN 7 SEC (AUTOMATIC SEQUENCE START).	MALFUNCTION OF ANY MANDATORY OR HIGHLY DESIRABLE SPACE VEHICLE ELEMENT OR OPERATIONAL SUPPORT ELEMENT APPLICABLE TO THIS TIME PERIOD.	HOLD. AN ACCUMULATED HOLD OF 5 MINUTES MAXIMUM CAN BE TOLERATED WITHOUT WARMUP IF THRUST CHAMBER CHILLDOWN OPERATIONS CONTINUE UNINTERRUPTED AND PROPER THERMAL CONTROL MODE OPERATION IS ATTAINED ON 3 OF 4 S-II HYDRAULIC SYSTEMS. S-II AND S-IVB THRUST CHAMBER CHILLDOWN MAY BE TERMINATED IF A HOLD IS CALLED FROM T-8 MIN TO INITIATION OF AUTOMATIC SEQUENCE, AND RESUMED TO PROVIDE UNINTERRUPTED CHILLDOWN OF 7 MINUTES 40 SECONDS. TOTAL ACCUMULATED THRUST CHAMBER CHILLDOWN WILL NOT EXCEED 13 MINUTES (S-II) OR 20 MINUTES (S-IVB). PRIOR TO S-II THRUST CHAMBER CHILLDOWN REINITIATION, WARMUP TIMES SHOWN ON FIGURE 2 WILL BE USED TO VOID PREVIOUSLY ACCUMULATED THRUST CHAMBER CHILL TIME. THERE IS NO DEFINITE LIMITATION ON HOLD CAPABILITY OTHER THAN THE STORAGE CAPACITY OF THE GH2 FACILITY (SEE FIGURE 1) AND LAUNCH VEHICLE REDLINE REQUIREMENTS FOR START BOTTLE CHILLDOWN OPERATIONS. A MINIMUM OF 17 MINUTES AND 21 SECONDS (S-II) AND A MINIMUM OF 9 MINUTES (S-IVB) UNINTERRUPTED START BOTTLE CHILLDOWN IS REQUIRED ENDING WITH PRESSURIZATION. AFTER PRESSURIZATION, PERIODIC VENTING MAY BE REQUIRED BY USING START BOTTLE AND ENGINE HELIUM BOTTLE EMERGENCY VENT VALVES. IF S-II/S-IVB START BOTTLE LIMITS ARE ESTIMATED TO BE EXCEEDED, AN ABBREVIATED RECHILL/RECHARGE MAY BE ACCOMPLISHED. IF S-IVB START BOTTLE CHILLDOWN IS TERMINATED, A MINIMUM WARMUP PERIOD OF 5 MINUTES IS REQUIRED PRIOR TO REINITIATION.

NOTE: AN ACCUMULATED HOLD OF 5 MINUTES CAN BE TOLERATED BY THE CSM WITHOUT PERFORMING AN AZIMUTH UPDATE. FOR HOLDS OF 5 MINUTES TO 30 MINUTES DURATION, AN AZIMUTH UPDATE IS HIGHLY DESIRABLE AND WILL BE PERFORMED IF TIME IS AVAILABLE. FOR HOLDS LONGER THAN 30 MINUTES, AN AZIMUTH UPDATE IS MANDATORY.

REV	ITEM	DESCRIPTION

SPACE VEHICLE FUNCTIONAL SEQUENCE (Continued):

ITEM	TIME PERIOD	CONDITION	ACTION/COMMENT
1-911	T-3 MIN 7 SEC (AUTOMATIC SEQUENCE START) TO T-19 SEC (2.8 SEC PRIOR TO S-IC FORWARD UMBILICAL DISCONNECT).	MALFUNCTION OF ANY MANDATORY SPACE VEHICLE ELEMENT OR OPERATIONAL SUPPORT ELEMENT APPLICABLE AFTER START OF THE AUTOMATIC SEQUENCE.	CUTOFF. RECYCLE TO T-22 MIN. MAKE THE DECISION TO HOLD AND REPAIR OR SCRUB. A HOLD IS REQUIRED AFTER RECYCLING TO T-22 MIN IN ORDER TO ALLOW FOR S-II WARMUP TIMES SHOWN ON FIGURE 2 PRIOR TO REINITIATING THRUST CHAMBER CHILLDOWN AT T-7 MIN 58 SEC.
1-912	T-19 SEC (2.8 SEC PRIOR TO S-IC FORWARD UMBILICAL DISCONNECT) TO T-11 SEC (2.1 SEC PRIOR TO S-IC TIME FOR IGNITION).	MALFUNCTION OF ANY MANDATORY SPACE VEHICLE ELEMENT OR OPERATIONAL SUPPORT ELEMENT APPLICABLE AFTER S-IC FORWARD UMBILICAL DISCONNECT.	CUTOFF. RECYCLE TO T-22 MIN. MAKE THE DECISION TO HOLD AND REPAIR OR SCRUB. A HOLD IS REQUIRED AFTER RECYCLING TO T-22 MIN IN ORDER TO ALLOW FOR S-II WARMUP TIMES SHOWN ON FIGURE 2 PRIOR TO REINITIATING THRUST CHAMBER CHILLDOWN AT T-7 MIN 58 SEC. NOTE: S-IC TM LINKS F1 AND P1 WILL BE TURNED OFF DURING LAUNCH VEHICLE SAFING AND TURNED ON 3 MINUTES PRIOR TO PICKING UP THE COUNT AT T-22 MIN; RANGE SAFETY COMMAND RECEIVERS WILL NOT BE TURNED OFF; PROCEED WITH SERVICE ARM 2 IN LATCHED BACK POSITION.
1-913	T-11 SEC (2.1 SEC PRIOR TO S-IC TIME FOR IGNITION) TO T-0 (LIFTOFF).	NOT APPLICABLE.	NONE. NO HOLDS WILL BE CALLED. NO MANUAL CUTOFF WILL BE GIVEN EXCEPT IF IGNITION DOES NOT OCCUR OR IF IGNITION OCCURS BUT THE VEHICLE FAILS TO LIFT OFF AND FAILS TO RECEIVE AUTOMATIC CUTOFF FROM THE ESE. AN AUTOMATIC CUTOFF PRIOR TO IGNITION WILL REQUIRE THE DECISION TO RECYCLE TO T-22 MIN, HOLD AND REPAIR, OR SCRUB. AN AUTOMATIC OR MANUAL CUTOFF AFTER IGNITION WILL RESULT IN A SCRUB.

REV	ITEM	DESCRIPTION

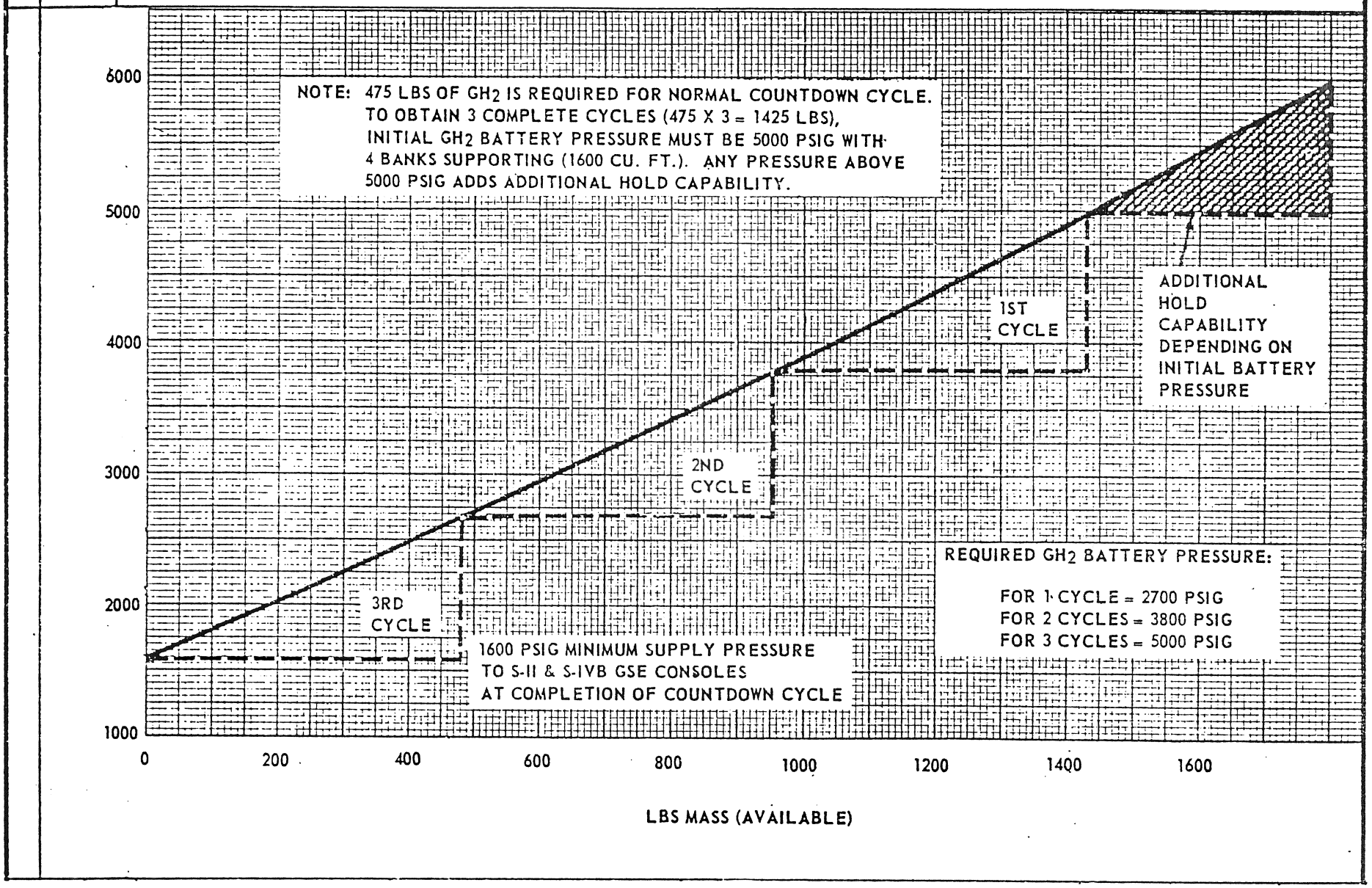


FIGURE 1

REV	ITEM	S-II THRUST CHAMBER WARMUP REQUIREMENTS

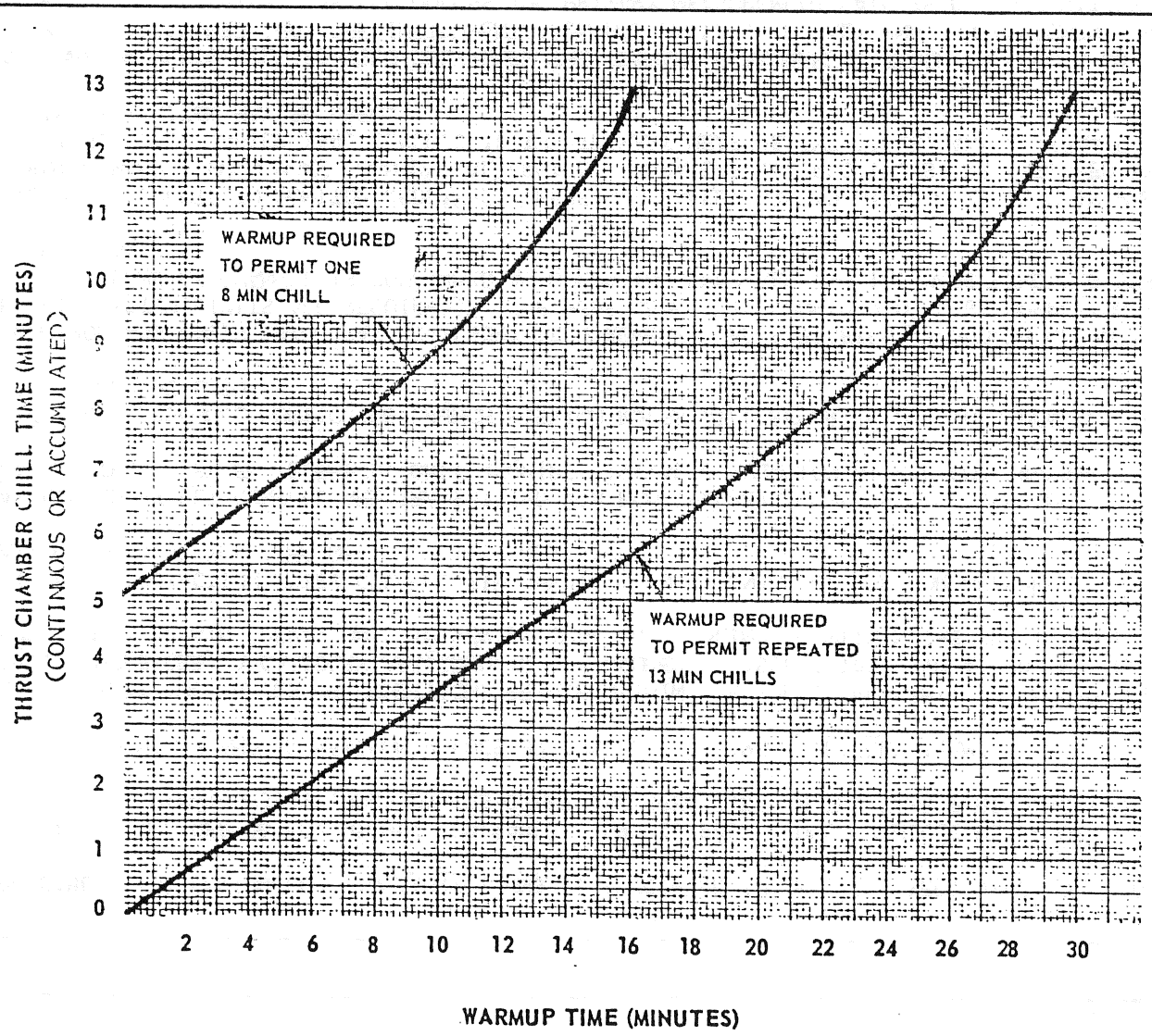


FIGURE 2

LAUNCH MISSION RULES

REV	ITEM	DESCRIPTION
	2-001	THE APPLICABLE TIME PERIOD FOR MANDATORY ITEMS IS SPECIFIED IN THE TIME PERIOD/ACTION/NOTES COLUMN.
	2-002	THE APPLICABLE TIME PERIOD FOR HIGHLY DESIRABLE ITEMS IS FROM LAUNCH VEHICLE POWER UP (APPROXIMATELY T-24:00 HOURS) UNTIL T-4 MINUTES 30 SECONDS UNLESS OTHERWISE SPECIFIED IN THE TIME PERIOD/ACTION/NOTES COLUMN.
	2-003	ALL REDLINES (MINIMUM AND/OR MAXIMUM VALUES OR CONDITIONS) ARE MANDATORY ITEMS.
	2-004	VERIFICATION THAT THE VALUES OR CONDITIONS REMAIN WITHIN THE SPECIFIED LIMITS OF ACCEPTABLE OPERATION IS MANDATORY. THEREFORE, A CATEGORY ASSIGNED TO A MEASUREMENT ASSOCIATED WITH A REDLINE INDICATES THAT THE MEASUREMENT MUST REMAIN OPERATIONAL TO VERIFY THAT THE REDLINE IS WITHIN THE SPECIFIED LIMITS.
	2-005	IN THE TIME PERIOD/ACTION/NOTES COLUMN, TIME PERIODS IN PARENTHESES ARE FOR REFERENCE ONLY AND REFLECT INFORMATION KNOWN AT THE TIME OF THE LATEST REVISION.
	2-006	ALL MEAS LISTED AS FLT CONTROL ARE TRANSMITTED VIA PCM TELEMETRY UNLESS OTHERWISE NOTED. ALL FLT CONTROL DATA TRANSMITTED ON FM-FM TELEMETRY ONLY REQUIRE DIGITAL CONVERSION AT KSC FOR TRANSMISSION TO MCC-H.
	2-007	LAUNCH VEHICLE PERSONNEL MONITORING LAUNCH MISSION RULES WILL REPORT VIOLATIONS PER THE HOLD CUTOFF GUIDELINES IN SECTION 1 OF THE LMRD.
	2-008	FLIGHT CONTROL AND ENGINEERING DATA CATEGORY REQUIREMENTS ARE SATISFIED BY PROPER OPERATION OF THE MEASUREMENT (NO SPECIFIC SYSTEM LIMITS ARE REQUIRED). THE MEASUREMENT IS CONSIDERED TO BE OPERATING PROPERLY AT A GIVEN TIME IF THE TELEMETRY CHANNEL IS CONFIRMED AS OPERATING PROPERLY AND THE MEASUREMENT GIVES A READING CONSISTENT WITH SYSTEM STATUS.
	2-009	ALTERNATE MEASUREMENTS TO MONITOR REDLINES, WHERE AVAILABLE, ARE IDENTIFIED AS SUCH IN PARENTHESES BELOW THE MEASUREMENT NUMBER. WHEN MORE THAN ONE ALTERNATE IS AVAILABLE, PRIORITIES ARE ASSIGNED BY USING NUMBERS, I.E., ALT #1, ALT #2, ETC. AFTER T-45 SECONDS IF THE PRIMARY MEASUREMENT FAILS, ANY ALTERNATE WHICH IS OBSERVED BY THE PRIMARY MONITOR MAY BE USED.
	2-010	ALTERNATE MEASUREMENTS WILL BE USED ONLY WHEN THE PRIMARY MEASUREMENT FAILS IN SUCH A WAY THAT IT CAN DEFINITELY BE DETERMINED THAT THE INSTRUMENTATION HAS FAILED. NO ALTERNATE MEASUREMENTS WILL REPLACE THE PRIMARY MEASUREMENTS AFTER T-45 SEC UNLESS THE PRIMARY MEASUREMENT FAILURE CAN DEFINITELY BE ESTABLISHED AS A HARD INSTRUMENTATION FAILURE AND THE ALTERNATE MEASUREMENTS CAN BE MONITORED BY THE SAME REDLINE OBSERVER.

LAUNCH MISSION RULES

REV	ITEM	DESCRIPTION
	2-011	WHEN VEHICLE BUS VOLTAGE REDLINE MEASUREMENTS ARE AVAILABLE ON BOTH HARDWIRE AND DDAS, EITHER SOURCE MAY BE USED FOR MONITORING THE REDLINE AS LONG AS THE SOURCE USED IS PERMANENTLY RECORDED.
	2-012	WHEN MEASUREMENTS ARE LISTED IN COMBINATION (I.E. 1 OF 2 M), AND ONE IS NOT LISTED AS AN ALTERNATE TO THE OTHER, EITHER MEASUREMENT MAY BE USED TO SATISFY THE RULE.
	2-013	THE RCA-110A OPERATOR WILL NOTIFY THE LAUNCH VEHICLE TEST CONDUCTOR IF THE RCA-110A FAILS TO SUPPORT FROM INITIATION OF AUTO SEQ TO T-19 SEC. THE DEE-6 AND DEE-3 OPERATORS WILL NOTIFY THE LAUNCH VEHICLE TEST CONDUCTOR IF EITHER OF THESE SYSTEMS FAIL TO SUPPORT FROM T-4 MIN 30 SEC TO T-33 SEC.
	2-014	IF THE DEE-3, DEE-6, OR RCA-110A IS REQUIRED TO MONITOR AN ALTERNATE BEYOND THE APPLICABLE TIME PERIOD FOR THE DEE-3, DEE-6, AND RCA-110A, THE ALTERNATE OBSERVER IS REQUIRED TO INFORM THE DEE-3, DEE-6, OR RCA-110A OPERATOR, THROUGH CLTC, THAT THEIR SYSTEMS ARE NOW MANDATORY FOR SUPPORT.
	2-015	DESIGNATED SENIOR LEVEL ENGINEERS ARE AUTHORIZED TO RECOMMEND OR COMMAND CUTOFF IN ACCORDANCE WITH THE LAUNCH MISSION RULE HOLD/CUTOFF GUIDELINES IF IN THEIR JUDGMENT A MISSION CRITICAL SITUATION OCCURS THAT IS NOT COVERED IN THE LAUNCH MISSION RULES.

LAUNCH MISSION RULES

REV	ITEM	MEAS TM NO.	DESCRIPTION	CATEGORY			REDLINE VALUES		TIME PERIOD ACTION NOTES
				FLT CONT	ENG DATA	PRE LAUNCH	MINIMUM	MAXIMUM	
	2-101		TM LINK AP1		HD				SEE ITEM 4-217
	2-110A		MULTIPLEXER A0		HD				
	2-111		MULTIPLEXER B0		HD				
	2-112		REMOTE DIGITAL SUBMULTIPLEXER		HD				
	2-115		DIGITAL RANGE SAFETY COMMAND RECEIVERS (2)			*M			FROM START OF LMRD UNTIL T-11 SEC. *RANGE SAFETY REQUIREMENT SEE ITEM 1-518 NOTE: THE RANGE SAFETY SUPERVISOR (CRSS) AT THE LCC WILL DETERMINE IF THE RECEIVERS ARE OPERATING PROPERLY FOR LAUNCH.

REV	ITEM	MEAS TM NO.	DESCRIPTION	CATEGORY			REDLINE VALUES		TIME PERIOD/ACTION NOTES
				FLT CONT	ENG DATA	PRE LAUNCH	MINIMUM	MAXIMUM	
	2-116	XC6-101	TEMP, OXID PUMP BEARING NO. 1 (ENG NO. 1)				-17.8°C	NONE	
		NONE (ALTERNATE)	S-1C ENGINE HEATER PANEL 601-106A3, TEMP OK AND TEMP HIGH LIGHT INDICATIONS (ENG NO.1)			1 OF 2 M	*	NONE	
	2-117	XC6-102	TEMP, OXID PUMP BEARING NO. 1 (ENG NO.2)				-17.8°C	NONE	
		NONE (ALTERNATE)	S-1C ENGINE HEATER PANEL 601-106A3, TEMP OK AND TEMP HIGH LIGHT INDICATIONS (ENG NO. 2)			1 OF 2 M	*	NONE	FROM START OF LOX LOADING UNTIL INITIATION OF AUTO SEQ.
	2-118	XC6-103	TEMP, OXID PUMP BEARING NO. 1 (ENG NO. 3)				-17.8°C	NONE	
		NONE (ALTERNATE)	S-1C ENGINE HEATER PANEL 601-106A3, TEMP OK AND TEMP HIGH LIGHT INDICATIONS (ENG NO. 3)			1 OF 2 M	*	NONE	*SYSTEM IS OUT OF TOLERANCE IF TEMP OK LIGHT AND TEMP HIGH LIGHT ARE OFF.
	2-119	XC6-104	TEMP, OXID PUMP BEARING NO. 1 (ENG NO. 4)				-17.8°C	NONE	
		NONE (ALTERNATE)	S-1C ENGINE HEATER PANEL 601-106A3, TEMP OK AND TEMP HIGH LIGHT INDICATIONS (ENG NO. 4)			1 OF 2 M	*	NONE	
	2-120	XC6-105	TEMP, OXID PUMP BEARING NO. 1 (ENG NO. 5)				-17.8°C	NONE	
		NONE (ALTERNATE)	S-1C ENGINE HEATER PANEL 601-106A3, TEMP OK AND TEMP HIGH LIGHT INDICATIONS (ENG NO. 5)			1 OF 2 M	*	NONE	

LAUNCH MISSION RULES

REV	ITEM	MEAS. TM NO.	DESCRIPTION	CATEGORY			REDLINE VALUES		TIME PERIOD ACTION NOTES
				FLT CONT	ENG DATA	PRE LAUNCH	MINIMUM	MAXIMUM	
	2-121	VXC20-323	TEMP, HYDRAULIC FLUID SUP (F-1 ENGINES)			1 OF 2 M	+60°F	+130°F	FROM ADMITTANCE OF LOX TO MAIN LOX VALVES UNTIL T-10 MIN.
		VXC21-323 (ALTERNATE)	TEMP, RETURN HYDRAULIC FLUID (F-1 ENGINES)				+65°F	+135°F	
	2-122	VXC197-115	TEMP, LOX SUCTION LINE, ENG NO. 1			1 OF 2 M	NONE	-172°C	FROM TEMP STABILIZATION AFTER INITIATION OF BUBBLING UNTIL INITIATION OF AUTO SEQ.
		VXC198-115 (ALTERNATE)	TEMP, LOX SUCTION LINE, ENG NO. 2						
	2-123	VXC199-115	TEMP, LOX SUCTION LINE, ENG NO. 3			1 OF 2 M	NONE	-172°C	
		VXC200-115 (ALTERNATE)	TEMP, LOX SUCTION LINE, ENG NO. 4						
	2-124	XC242-102	TEMP, ENVIRONMENT, ENG NO. 2			1 OF 5 M	-18°C	+54°C	FROM START OF LOX LOADING UNTIL INITIATION OF AUTO SEQ.
		XC242-101 (ALT #1)	TEMP, ENVIRONMENT, ENG NO. 1						
		XC242-103 (ALT #2)	TEMP, ENVIRONMENT, ENG NO. 3						
		XC242-104 (ALT #3)	TEMP, ENVIRONMENT, ENG NO. 4						
		XC242-105 (ALT #4)	TEMP, ENVIRONMENT, ENG NO. 5						

LAUNCH MISSION RULES

REV	ITEM	MEAS/TM NO.	DESCRIPTION	CATEGORY			REDLINE VALUES		TIME PERIOD ACTION NOTES
				FLT CONT	ENG DATA	PRE LAUNCH	MINIMUM	MAXIMUM	
	2-125	XC327-115	TEMP NO. 2, LOX PREVALVE, ENG NO. 2						*WITHIN TWO MIN FOLLOWING INITIATION OF FIRST PREVALVE PRESSURIZATION ONE OF FOUR MEASUREMENTS SHALL GO FROM ON SCALE TO OFF SCALE HIGH.
		XC331-115	TEMP NO. 2, LOX PREVALVE, ENG NO. 4						
		XC335-115	TEMP NO. 2, LOX PREVALVE, ENG NO. 1				*	*	
		XC339-115	TEMP NO. 2, LOX PREVALVE, ENG NO. 3						
			1 OF 4			1 OF 2 M			
		XD182-115 (ALTERNATE)	PRESSURE, HELIUM SUPPLY (PREVALVE)				290 PSIA	500 PSIA	WITHIN 15 SECONDS FOLLOWING INITIATION OF PREVALVE PRESSURIZATION UNTIL SHUTOFF OF POGO CONTROL VALVES.
	2-130	VXD6-322	HIGH PRESSURE PURGE						FROM SPHERE PRESSURIZATION COMPLETE UNTIL INITIATION OF AUTO SEQ.
		VXD5-322 (ALTERNATE)	STAGE HIGH PRESSURE CONTROL			1 OF 2 M	2700 PSIA	3300 PSIA	NOTE: ALTERNATE MEASUREMENT MAY BE USED ONLY AFTER PRIMARY MEASUREMENT HAS SHOWN SATISFACTORY REDLINE VALUE SUBSEQUENT TO SPHERE PRESSURIZATION.
	2-131	D8-101	PRESS, COMBUSTION CHAMBER			*HD			*RANGE SAFETY REQUIREMENT SEE ITEM 1-527
	2-132	D8-102	PRESS, COMBUSTION CHAMBER			*HD			
	2-133	D8-103	PRESS, COMBUSTION CHAMBER			*HD			
	2-134	D8-104	PRESS, COMBUSTION CHAMBER			*HD			
	2-135	D8-105	PRESS, COMBUSTION CHAMBER			*HD			

LAUNCH MISSION RULES

REV	ITEM	MEAS TM NO.	DESCRIPTION	CATEGORY			REDLINE VALUES		TIME PERIOD ACTION NOTES
				FLT CONT	ENG DATA	PRE LAUNCH	MINIMUM	MAXIMUM	
	2-135A	D9-322	PRESS, FUEL TANK ULLAGE			*			*SEE ITEM 2-138
	2-135B	D10-322	PRESS, LOX TANK ULLAGE			*			*SEE ITEM 2-139
	2-136	VXD16-101 (ALT #1)	PRESS, ENG GIMBAL SYS SUPPLY (ENG NO. 1)			1 OF 5 M	465 PSIA *	1865 PSIA *	*ANY TIME HYDRAULIC SYS IS IN OPERATION PRIOR TO START OF LOX LOADING. *(1) FROM JUST BEFORE START OF LOX LOADING UNTIL INITIATION OF AUTO SEQ. *(2) FROM INITIATION OF AUTO SEQ UNTIL T-19 SEC. NOTE: TWO OF THREE GROUND HYDRAULIC PUMPS ARE MANDATORY. *(3) MINOR FLUCTUATIONS IN HYDRAULIC PRESS MAY OCCUR. FLUCTUATIONS NO LOWER THAN 465 PSIA ARE NOT TO BE CONSIDERED AS EXCEEDING REDLINE VALUES. *(4) MINOR FLUCTUATIONS IN HYDRAULIC PRESS MAY OCCUR. FLUCTUATIONS NO LOWER THAN 500 PSIA ARE NOT TO BE CONSIDERED AS EXCEEDING REDLINE VALUES.
		VXD16-102 (ALT #2)	PRESS, ENG GIMBAL SYS SUPPLY (ENG NO. 2)				1465 PSIA *(1) & *(3)	1865 PSIA *(1)	
		VXD16-103 (ALT #3)	PRESS, ENG GIMBAL SYS SUPPLY (ENG NO. 3)				1465 PSIA *(2) & *(3)	1665 PSIA *(2)	
		VXD16-104 (ALT #4)	PRESS, ENG GIMBAL SYS SUPPLY (ENG NO. 4)						
		VXD30-323	PRESS, SUPPLY HYDRAULIC				500 PSIA *	1870 PSIA *	
							1510 PSIA *(1) & *(4)	1870 PSIA *(1)	
							1510 PSIA *(2) & *(4)	1670 PSIA *(2)	
	2-137	VXD31-323	PRESS, LOX DOME AND GG INJECTOR PURGE (F-1 ENGINES)			1 OF 2 M	200 PSIG	NONE	COMMIT AT T-33 SECONDS.
		NONE (ALTERNATE)	INDICATION, S-IC CONTROL AND PURGE PANEL, LOX DOME AND GG INJECTOR HIGH AND LOW PURGE ON LIGHT				*	NONE	*SYSTEM IN TOLERANCE IF EITHER LIGHT IS ON.

LAUNCH MISSION RULES

REV	ITEM	MEAS/TM NO.	DESCRIPTION	CATEGORY			REDLINE VALUES		TIME PERIOD ACTION NOTES
				FLT CONT	ENG DATA	PRE LAUNCH	MINIMUM	MAXIMUM	
	2-138	XD90-117 (HARDWIRE)	PRESS, FUEL TK ULLAGE			1 OF 3 M	27.0 PSIA	30.2 PSIA	FROM PREPRESSURIZATION COMPLETE UNTIL T-19 SEC.
		XD152-117 (ALT #1)	PRESS, FUEL TK ULLAGE						
		D9-322 (ALT #2)	PRESS, FUEL TK ULLAGE						
	2-139	XD94-119 (HARDWIRE)	PRESS, LOX TK ULLAGE			1 OF 3 M	NONE	20.0 PSIA	FROM INITIATION OF LOX FAST FILL UNTIL INITIATION OF REPLENISH PLUS 5 MIN.
							23.7 PSIA	30.2 PSIA	FROM PREPRESSURIZATION COMPLETE UNTIL T-19 SEC.
		XD153-119 (ALT #1)	PRESS, LOX TK ULLAGE						
		D10-322 (ALT #2)	PRESS, LOX TK ULLAGE						
	2-140	XD95-119 (HARDWIRE)	PRESS, HE STORAGE TK			1 OF 3 M	NONE	1600 PSIA	BEFORE LOX LOADING UNTIL BOTTLES COVERED WITH LOX.
							2800 PSIA	3200 PSIA	FROM HE FILL AFTER BOTTLES COVERED WITH LOX UNTIL INITIATION OF AUTO SEQ.
		XD144-119 (ALT #1)	PRESS, HE STORAGE TK						
		XD87-116 (ALT #2)	PRESS, HE CONTROL VALVE INLET FUEL TANK						

LAUNCH MISSION RULES

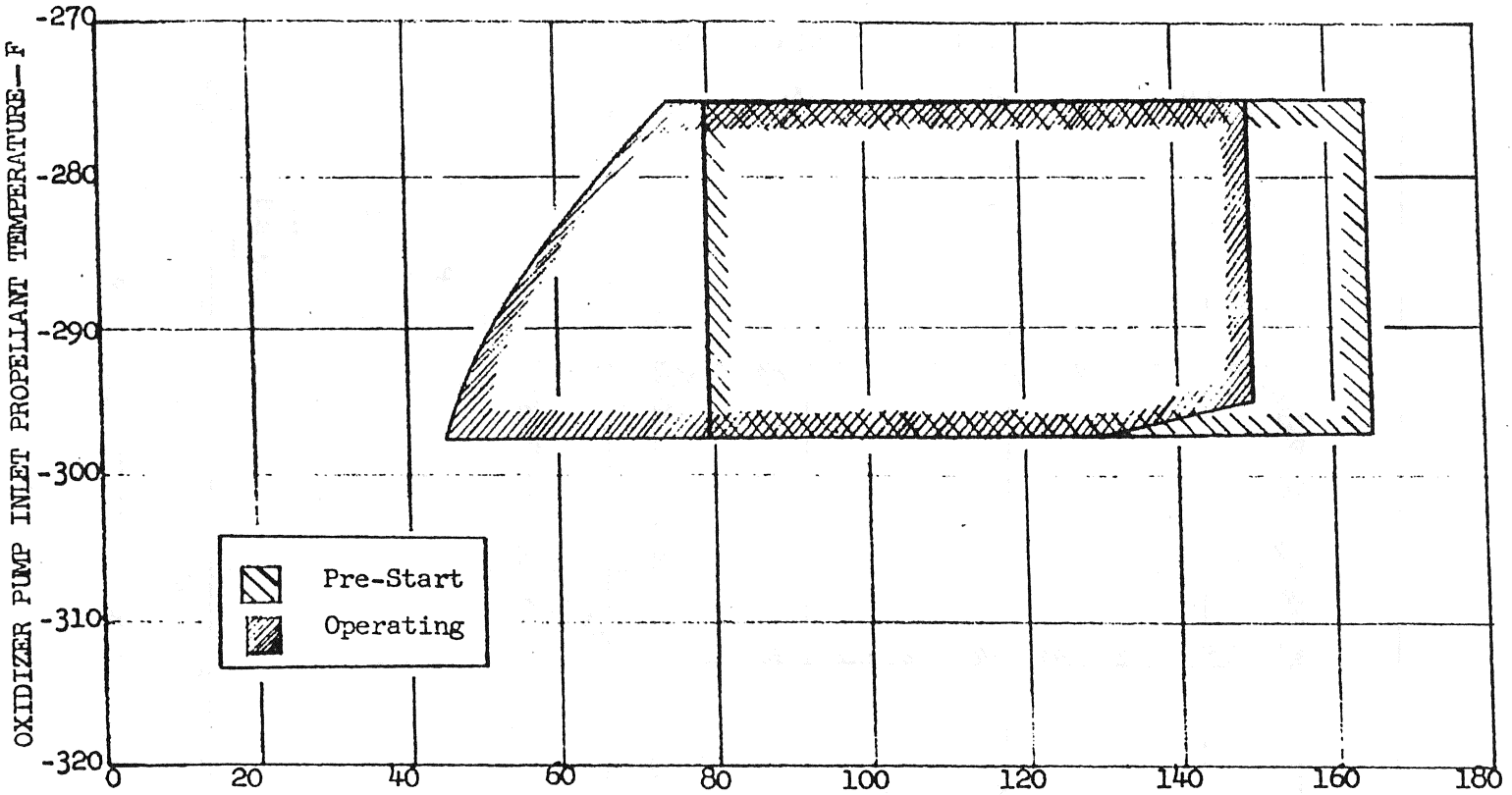
REV	ITEM	MEAS/TM NO.	DESCRIPTION	CATEGORY			REDLINE VALUES		TIME PERIOD/ACTION/NOTES
				FLT CONT	ENG DATA	PRE LAUNCH	MINIMUM	MAXIMUM	
	2-141	VXD124-115	PRESS, REGULATOR PURGE SYSTEM			1 OF 2 M	75 PSIA	115 PSIA	FROM JUST BEFORE START OF LOX LOADING UNTIL T-19 SEC.
		XD132-115 (ALTERNATE)	PRESS, TURBOPUMP LOX SEAL PURGE (ENG NO. 1)						
	2-141A	XD182-115	PRESS, HE SUPPLY (PREVALVE)			*			*SEE ITEM 2-125
	2-142	TV CAMERAS*	LEAKAGE, F-1 ENGINE LOX DRAIN LINES AND THRUST CHAMBER EXITS, VISUAL OBSERVATION (BY TV CAMERAS)			M	NONE	NO LIQUID LEAKAGE ALLOWABLE	FROM 90 MINUTES AFTER START OF S-IC LOX LOADING UNTIL ALL F-1 ENGINES LOX DRAIN LINES AND THRUST CHAMBER EXITS HAVE BEEN OBSERVED. IF LIQUID LEAKAGE OCCURS IT IS M THAT A HOLD BE CALLED TO EVALUATE CORRECTIVE ACTION TO STOP THE LEAK. *RECORD VIDEO IF LEAKAGE OCCURS. SEE ITEM 4-129.
	2-146	VK11-118	LOX LEVEL CUTOFF NO. 1			*M			*FROM START OF LMRD UNTIL START OF S-IC LOX LOAD. SYSTEM IN TOLERANCE IF NO MORE THAN (1) SENSOR INDICATES "WET".
		VK12-118	LOX LEVEL CUTOFF NO. 2						
		VK13-118	LOX LEVEL CUTOFF NO. 3						
		VK14-118	LOX LEVEL CUTOFF NO. 4						
	2-147	VK39-115	THRUST OK PRESS SW NO. 1, ENG 3			*HD			*RANGE SAFETY REQUIREMENTS SEE ITEM 1-527
	2-151	K54-I15	FINAL THRUST OK CUTOFF, ENG 3			*HD			

LAUNCH MISSION RULES

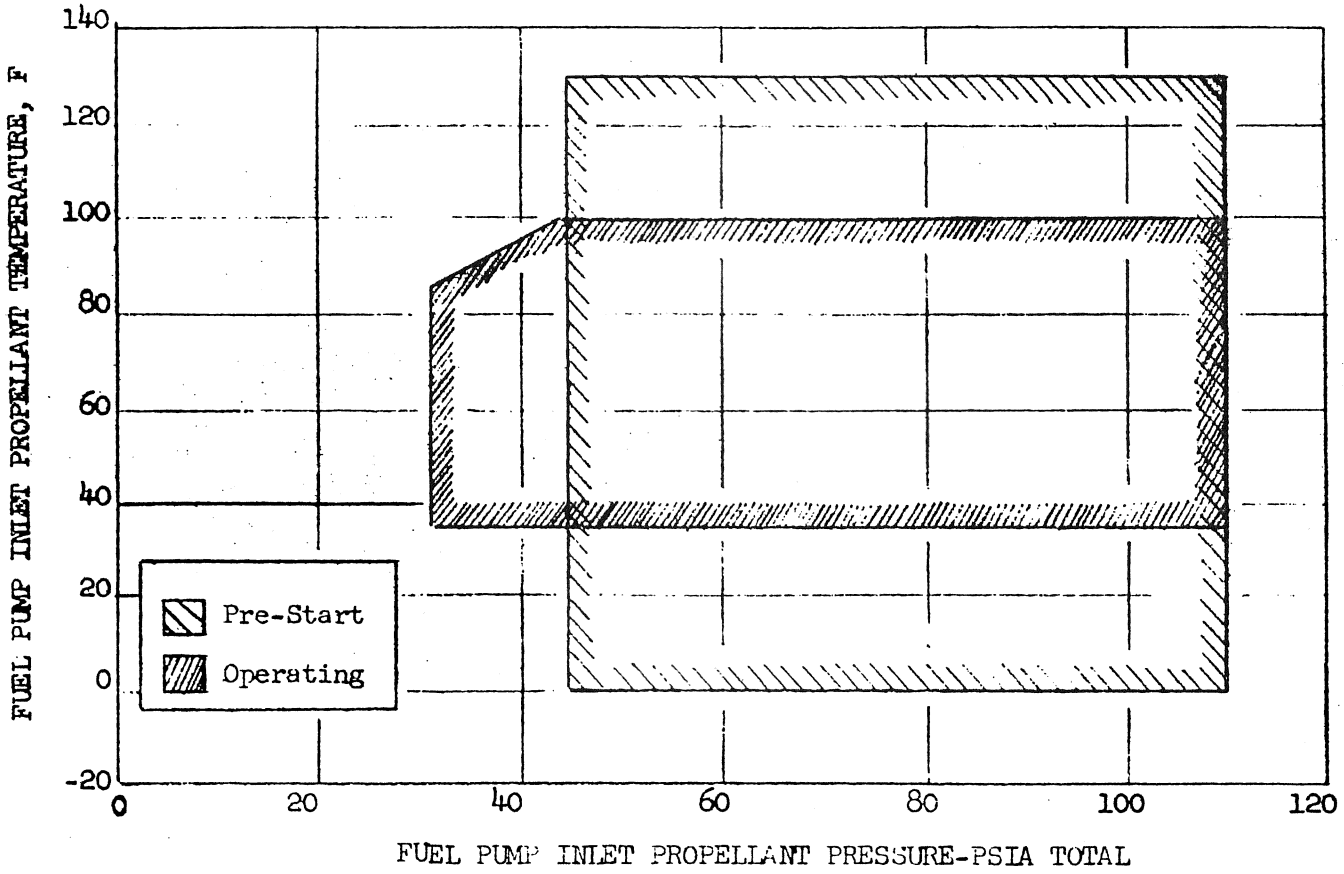
REV	ITEM	MEAS/TM NO.	DESCRIPTION	CATEGORY			REDLINE VALUES		TIME PERIOD ACTION NOTES
				FLT CONT	ENG DATA	PRE LAUNCH	MINIMUM	MAXIMUM	
	2-154	VK120-120	RSCR NO. 2, SIGNAL STRENGTH, LOW LEVEL			*M			FROM START OF LMRD UNTIL T-11 SEC. *RANGE SAFETY REQUIREMENT SEE ITEM 1-518 AND 1-527 NOTE: THESE MEAS. ARE MONITORED BY RANGE SAFETY SUPERVISOR'S REPRESENTATIVE AT THE LCC.
	2-155	VK125-120	RSCR NO. 1, SIGNAL STRENGTH, LOW LEVEL			*M			
	2-156	XM6111-343 (HARDWIRE)	VOLTAGE, S-IC VEHICLE BUS (1D11)						WHILE BUSES ARE ENERGIZED EITHER BY GROUND OR INTERNAL ELECTRICAL POWER UNTIL T-33 SEC. STAGE BATTERY OPEN CIRCUIT VOLTAGES WILL BE MONITORED AFTER BATTERY CONNECTION TO T-50 SEC AS PER STAGE PROCEDURE V-21204. TRANSIENTS THAT OCCUR WHEN VARIOUS LOADS ARE SWITCHED, DURING POWER TRANSFER TESTS AND AT POWER TRANSFER ARE NOT CONSIDERED AS DEVIATIONS FROM THE REDLINE LIMITS. *APPLICABLE ONLY AFTER POWER TRANSFER (T-50 SEC). ALTERNATE MEAS IS ON THE BATTERY SIDE OF THE POWER TRANSFER SWITCH.
		VM98-340 (ALT #1)	VOLTAGE, 1D11 ESE VEHICLE BUS			1 OF 3 M	26 VDC	32 VDC	
		*XM8-115 (HARDWIRE) (ALT #2)	VOLTAGE, BUS NO. 1						
	2-157	XM6112-343 (HARDWIRE)	VOLTAGE, S-IC VEHICLE BUS (1D21)						
		VM107-340 (ALT #1)	VOLTAGE, 1D21 ESE VEHICLE BUS			1 OF 3 M	26 VDC	32 VDC	
		*XM9-115 (HARDWIRE) (ALT #2)	VOLTAGE, BUS NO. 2						

LAUNCH MISSION RULES

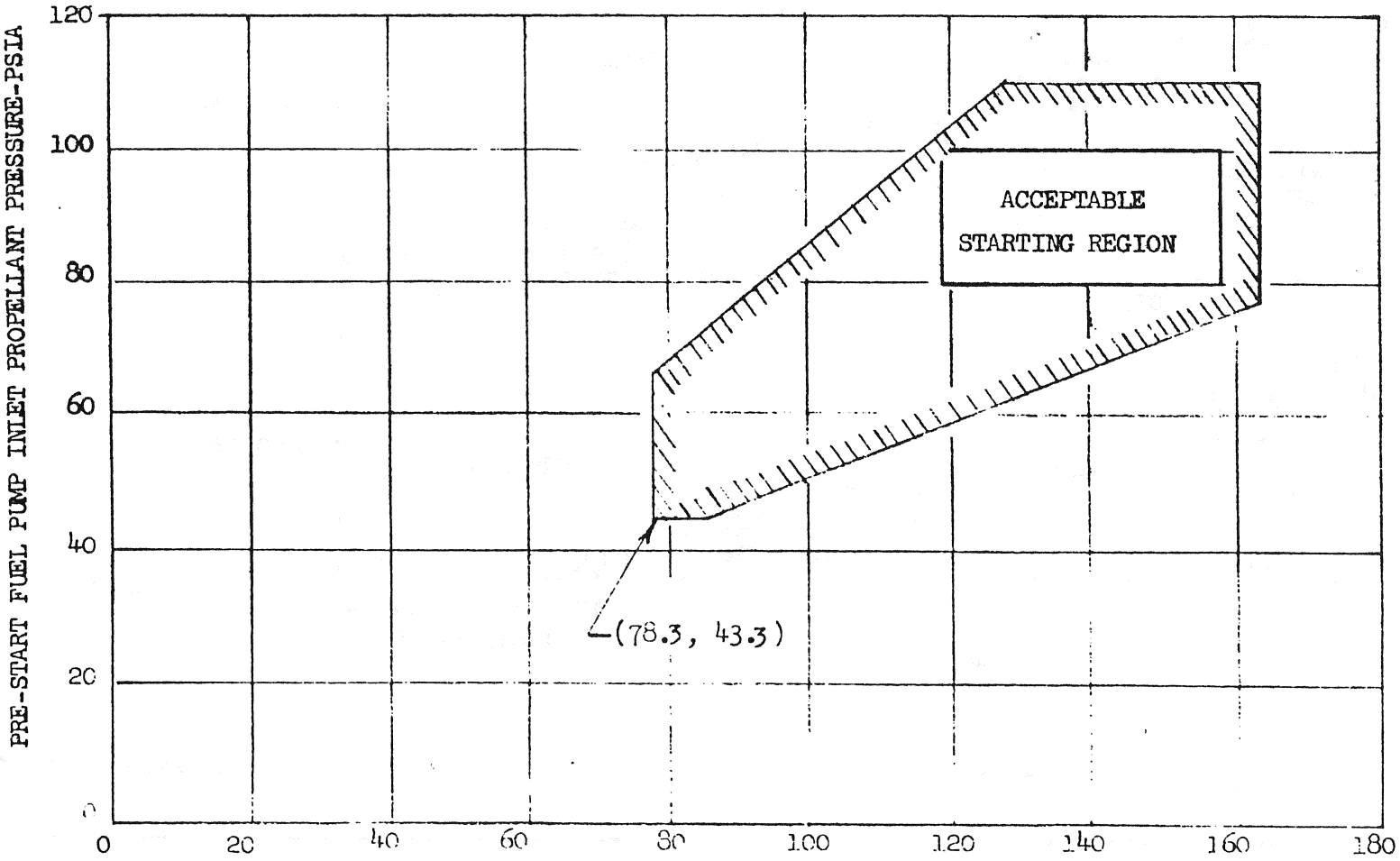
REV	ITEM	MEAS/TM NO.	DESCRIPTION	CATEGORY			REDLINE VALUES		TIME PERIOD ACTION NOTES
				FLT CONT	ENG DATA	PRE LAUNCH	MINIMUM	MAXIMUM	
	2-158	PTCS READOUT	LOX FLIGHT MASS			M	99.8%	100.2%	COMMIT AT INITIATION OF AUTO SEQ. NOTE: MAX AND MIN LIMITS ARE INDICATED PERCENTAGES OF PROPELLANT LOAD SPECIFIED IN PROPELLANT LOADING TABLES.
	2-159	PTCS READOUT	RP-1 FLIGHT MASS			M	99.8%	100.2%	COMMIT AT COMPLETION OF FINAL RP-1 LEVEL ADJUST. NOTE: MAX AND MIN LIMITS ARE INDICATED PERCENTAGES OF PROPELLANT LOAD SPECIFIED IN PROPELLANT LOADING TABLES.



Oxidizer Pump Inlet Pre-Start and Operating Propellant Conditions for the F-1 Engine



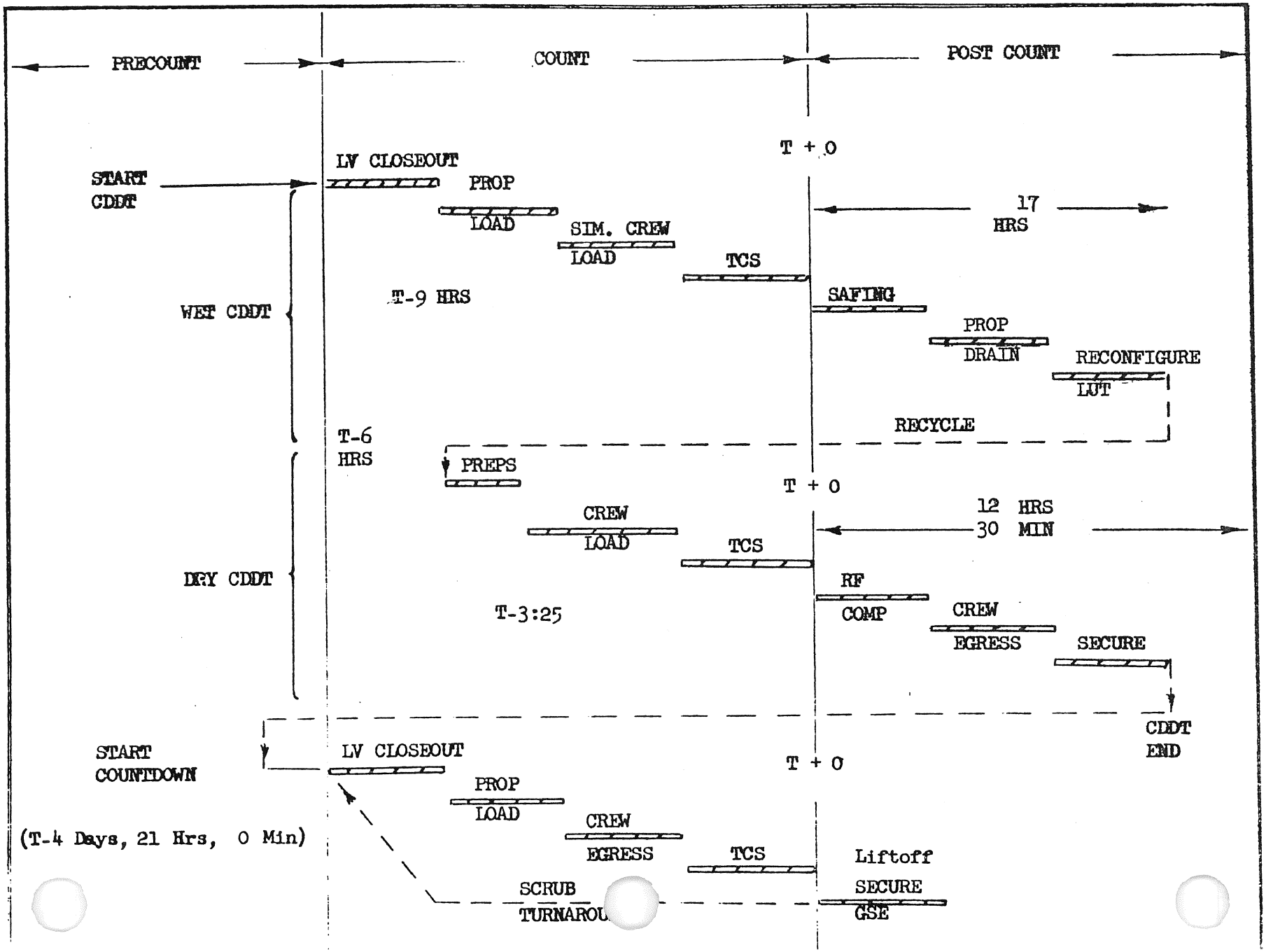
Fuel Pump Inlet Prestart and Operating Propellant Conditions for the F-1 Engine



Oxidizer vs Fuel Pump Inlet Propellant Pressures
Required for Starting the F-1 Engine

CDDT AND CD SEQUENCE SUMMARY

VEHICLE AS-511



COUNTDOWN DEMONSTRATION TEST

(WET)

CDDT
Ref: V-20060, Vol I & II

TIME	OPERATION
T- 4 days, 1 hr, 45 min	Apply S-IC Stage Power
T- 4 days, 1 hr, 30 min	Start Thrust Chamber Preps per V-34012
T- 3 days, 20 hrs, 30 min	Start Inert High Voltage Igniter Installation
T- 3 days, 17 hrs, 0 min	Inert High Voltage Igniter Installation Complete
T- 3 days, 14 hrs, 45 min	Start F-1 Engine Dummy Hypergol Igniter Installation
T- 3 days, 13 hrs, 15 min	S-IC Stage Power Removed
T- 3 days, 13 hrs, 0 min	F-1 Engine Dummy Hypergol Igniter Installation Complete
T- 2 days, 17 hrs, 15 min	Start Switch Scans
T- 2 days, 17 hrs, 5 min	Switch Scans Complete
T- 2 days, 9 hrs, 45 min	Verify Checkout Valve in Ground Position per V-21035
T- 1 day, 3 hrs, 30 min	Start Final Thrust Section Walkaround Inspection
T- 1 day, 2 hrs, 15 min	Start F-1 Engine Closeout per V-34012
T- 1 day, 1 hr, 15 min	Prepare Engine Service Platform for Lowering
T-24 hrs, 20 min	A. Apply S-1C Stage Power B. Start TCS Functional Test
T-24 hrs, 10 min	A. Lower Engine Service Platform B. Arm Igniters and Verify all Igniters and Hypergol Installed Lights On C. Start Propulsion System Functional Test per V-34012 Report When Complete
T-24 hrs, 0 min	A. Start Final Thrust Section Walk-around Inspection (Quad I) B. Remove Gimbal Platforms from Around Engines
T-23 hrs, 55 min	Start S-IC Pneumatic System Functional Test per V-24327

CDDT
Ref: V-20060, Vol I & II

TIME	OPERATION
T-23 hrs, 50 min	Verify TCS Functional Test is Complete
T-23 hrs, 16 min	Verify Engine Service Platform Removed
T-23 hrs, 0 min	Prepare S-IC Hydraulic Unit per V-34012, Report When Complete
T-22 hrs, 15 min	A. Verify S-IC Airborne GN_2 and Helium Bottles Charged to 1500 psig B. Verify Gimbal Platforms Removed C. Verify Pneumatic System Functional Test Complete
T-22 hrs, 0 min	Thrust Section Walk thru Inspection Complete
T-22 hrs, 0 min	A. Low LOX Dome Purge On B. Apply S-IC Hydraulics, Report When Com. C. Verify S-IC Engine Area Clear for Gimbaling
T-21 hrs, 55 min	Execute Flight Control Systems Gain Test (CTC1)
T-21 hrs, 45 min	A. Flight Control System Gain Test Complete B. Low LOX Dome Purge Off C. Start Final Installation of Base Heat Shield Access Panels
T-21 hrs, 17 min	A. Low LOX Dome Purge On B. Verify S-IC Engine Area Clear for Gimbaling
T-21 hrs, 15 min	Perform Power Transfer Test
T-21 hrs, 14 min, 30 sec	Power Transfer Test Complete
T-21 hrs, 12 min	A. Verify S-IC Hydraulics Supporting B. Verify/Accomplish Low LOX Dome Purge On C. Verify S-IC Engine Area Clear for Gimbaling
T-21 hrs, 9 min	Perform Flight Control Systems Gain Test (CTC1)
T-20 hrs, 35 min	A. CTC1 Test Complete B. Start Engine Null Test
T-20 hrs, 30 min	A. S-IC all Engines Null Test Complete B. Turn Off S-IC Hydraulic Unit C. Low LOX Dome Purge Off

TIME	OPERATION
T-18 hrs, 30 min	Verify Base Heat Shield Access Panel Installation Complete
T-18 hrs, 0 min	Start Flight Measurement Scans
T-17 hrs, 45 min	Prep LUT Level Platform for Lowering
T-17 hrs, 15 min	A. Turn On Low LOX Dome Purge B. Apply S-IC Hydraulics and Verify When Complete C. Low LOX Dome Purge Off After Hydraulic is Applied D. Lower LUT Level Platform (LLP) E. Flight Measurement Scans Complete
T-16 hrs, 45 min	A. LLP Lowering Complete B. Apply Low LOX Dome Purge, Turn Off S-IC Hydraulics, and then Turn Off Low LOX Dome Purge
T-13 hrs, 30 min	Clear LUT Zero Level in 15 Minutes for 40 min for RP-1 Replenish
T-13 hrs, 0 min	Start RP-1 Replenish
T-12 hrs, 20 min	Verify RP-1 Replenish Complete and Line Drain in Progress
T-12 hrs, 0 min	A. Igniters Installed Switch to Arm, Verif All Igniters and Hypergols Installed B. Verify Ignition Source Voltage OK C. RP-1 Line Drain Completed
T-10 hrs, 30 min	Perform Wast Thrust OK Pressure Switch Test
T-10 hrs, 15 min	A. Wast Thrust OK Pressure Switch Test Complete B. Mobile Service Structure in Motion
T- 9 hrs, 30 min	Verify Propulsion Preps Complete Except Prefill Topping per V-34012
T- 9 hrs, 15 min	Start Verification Status of Launch Mission Rules Highly Desirable S-IC Range Safety Measurements
T- 9 hrs, 5 min	All Highly Desirable Measurements are GO
T- 9 hrs, 0 min	NOTE Starting Scheduled Hold, Verify S-IC LUT ESE Launch Preps Complete 2 Hours Before Count Resumes Verify the following indications: T-187 LSE Preps Complete T-16.2 LSE Ready for S/A 2 Retract T-8.9 Ready for Ignition 1 Hour Before Count Resumes Apply Hydraulics to the F-1 Engines and Start Prefill Operations per V-34012

CDDT
Ref: V-20060, Vol I & II

TIME	OPERATION
	10 Minutes Before Count Resumes
	Verify S-IC Mechanical Preps Completed and Personnel Clearing Pad
	S-IC Electrical Launch Preps Complete
	Just Prior to Resuming Count
	Start Pad Clearing Operations
T- 8 hrs, 31 min	Verify Platform Transporter is at Launch Position and all Personnel Clear of Pad
T- 8 hrs, 20 min	A. Turbopump Heater Power On B. Note Heaters Cycling C. S-IC Ready for LOX Loading D. S-IC GN2 Control and Purge Bottles Pressurized to 3200 psi
T- 7 hrs, 5 min	Operate Thermal Conditioning Purge as Required to Maintain Engine Temperature
T- 6 hrs, 54 min	A. Low LOX Dome Purge Switch to Auto B. Start S-IC LOX Loading
T- 6 hrs, 51 min	A. Low LOX Dome Purge On for Flight Control System Checks B. Engine Gimbaling
T- 6 hrs, 46 min	A. Low LOX Dome Purge On B. Engine Gimbaling
T- 5 hrs, 45 min	A. Low LOX Dome Purge On B. Engine Gimbaling
T- 5 hrs, 29 min	A. S-IC LOX Loading Complete B. Pressurize He Bottles to 3200 psi
T- 5 hrs, 18 min	Low LOX Dome Purge Off
T- 4 hrs, 36 min	Low LOX Dome Purge On
T- 4 hrs, 30 min	A. Low LOX Dome Purge On B. Execute Flight Control System Gain Tests (CTC1)

CDDT
Ref: V-20060, Vol I & II

TIME	OPERATION
T- 3 hrs, 38 min	Launch Vehicle Cryo Loading is Complete and Normal Replenish is Established
T- 3 hrs, 25 min	LV Ready for Crew Ingress
T- 3 hrs, 20 min	Flight Control System Gain Test (CTC1) Complete
T- 3 hrs, 20 min	Low LOX Dome Purge Off
T- 3 hrs, 5 min	A. Low LOX Dome Purge On for CTC2 B. Engine Gimbaling
T- 2 hrs, 50 min	CTC2 Complete, Low LOX Dome Purge Off
T- 2 hrs, 40 min	NOTE: Time for Start of Flight Crew Ingress
T- 2 hrs, 0 min	Low LOX Dome Purge - Auto
T- 1 hr, 27 min	A. Low LOX Dome Purge On B. Select S-IC Burn Mode On Then Auto (Engine Gimbaling)
T- 1 hr, 0 min	Start RP-1 Level Adjust
T-52 min, 30 sec	A. Low LOX Dome Purge On B. Engine Gimbaling
T-51 min, 25 sec	Verify Thermal Conditioning Purge On and Maintain for the Remainder of the Count
T-47 min, 0 sec	A. Verify Low LOX Dome Purge On B. Execute Flight Control Test FT-10 (Ladder Output Test +/-2 Deg Pitch & Yaw, +/-5 Deg Roll)
T-42 min, 0 sec	A. Flight Control Test FT-10 Complete B. Execute Power Transfer Test
T-41 min, 30 sec	S-IC Power Transfer Test Complete
T-35 min, 0 sec	RP-1 Level Adjust Complete
T-26 min, 0 sec	A. Precharge POGO Suppression System B. LOX Bubbling to Ducts 1 & 3; Two Duct Bubbling Shall Remain on During Remainder of Count

CDDT
Ref: V-20060, Vol I & II

TIME	OPERATION
T-20 min, 0 sec	A. Verify S-IC GN_2 and Helium System Pressurized to Flight Pressure B. Verify/Accomplish Low LOX Dome Purge On
T-16 min, 20 sec	Engine Gimbaling
T-16 min, 0 sec	Arm Igniters Installed, Verify Hypergol and Igniters Installed Indications Remain On
T-11 min, 0 sec	Start S-IC Fuel Jacket Topping per V-34012
T-10 min, 45 sec	Verify/Accomplish S-IC LOX Bubbling to Duct 1 and 3
T- 7 min, 58 sec	A. Note Engines in Null Position B. Note Hydraulic Pressure 1590±80 psia C. Pressurize S-IC Fuel Tank to 2 psig
T- 6 min, 0 sec	A. Verify F-1 Engine Thrust Chamber Prefill Topping Complete B. S-IC Propulsion Preps Complete
T- 5 min, 30 sec	A. Note Hypergols Installed On B. Note Ordnance Prep Complete
T- 4 min, 30 sec	A. Arm TCS B. Note Ignition Source Voltage OK
T- 4 min, 0 sec	Cleared for Launch
T- 3 min, 40 sec	Preparations Complete On
T- 3 min, 10 sec	Initiate Firing Command and Verify
T- 3 min, 6 sec	Verify Firing Command is On
T- 1 min, 42 sec	A. S-IC Hydraulic Commit and Check B. Note Hydraulic Unit Comitted On
T- 1 min, 37 sec	S-IC Fuel Tank Prepress NOTE: S-IC Fuel Tank is Pressurizing
T- 1 min, 12 sec	A. S-IC Time for LOX Prepress NOTE: S-IC LOX Tank is Pressurizing B. LOX Bubbling Stops
T- 0 min, 50 sec	A. Power Transfer Internal B. Verify Power Transfer Complete

TIME	OPERATION
T- 0 min, 48 sec	A. NOTE: S-IC LOX Prepress is OK B. NOTE: S-IC Fuel Prepress is OK
T- 0 min, 40 sec	NOTE: S-IC Propellants Pressurized
T- 0 min, 30 sec	A. S-IC Engine Hydraulic Checkout Valve to Stage Position B. Note S-IC Engine Checkout Valves to Stage Position
T- 0 min, 22 sec	Prep Complete Off
T- 0 min, 20 sec	Close LOX Interconnect Valves
T- 0 min, 17 sec	Prep Complete On
T- 0 min, 16.2 sec	Ready for Ignition On
T- 0 min, 14 sec	A. Hold/Fire/Proceed to Hold Fire B. Ready for Ignition Off C. Prep Complete Off
T- 0 min, 12 sec	Give Cutoff if Ready for Ignition Still On
T- 0 min, 8.9 sec	A. S-IC Time for Ignition B. TCS Cutoff On C. Sequencer Failure On D. Cutoff On E. Start Ignition Sequence Off F. Firing Command Off G. TCS Reset On
CDDT ONLY	TERMINAL COUNTDOWN SEQUENCE WILL BE INTERRUPTED AT THIS TIME
T- 0 min, 0 sec	LAUNCH VEHICLE SAFING Note all Main Valves Closed Note all Checkout Valves in Ground Position LOX Flight Vents to Open Verify LOX Interconnect Valves 1, 3 & 4 Open and 2 Closed Verify LOX Bubbling Ducts 1 and 3 On, Continue 2 duct bubbling for 10 Minutes to Establish Thermal Pumping Verify LOX Dome Purge On Verify all LOX Duct Conditions Satisfactory ar Ready to Reset Cutoff Cutoff - Reset Verify Cutoff Off Note LOX Prevalves Open Note Interconnect Valves 1, 3 & 4 Open a 2 Closed Note Bubbling Ducts 1 and 3 On

TIME	OPERATION
	LAUNCH VEHICLE DRAIN OPERATIONS
T + 0 min, 0 sec	Continue Thermal Conditioning Purge and Engine Heater Operations Until Residual LOX Has Boiled Off
T + 10 min, 0 sec	S-IC LOX Drain Started
T + 2 hrs, 10 min, 0 sec	S-IC LOX Drain Complete LV Propellant Drain is Complete
T + 2 hrs, 40 min, 0 sec	Vent S-IC GN_2 Bottles to 1500 Psi
T + 2 hrs, 45 min, 0 sec	After Residual LOX has Boiled Off as Indicated by Measurements C242-101 thru -105 and Heaters Cycling, Turn Off Engine Heaters, Thermal Conditioning Purge and Heater Power
T + 2 hrs, 45 min, 0 sec	Secure Applicable Portions of S-IC Pneumatic Systems per V-24327

COUNTDOWN DEMONSTRATION TEST

(DRY)

DRY CDDT

Ref: V-20060, Vol. II

TIME	OPERATION
T + 3 hrs, 45 min	Start Preps for Dry CDDT
T + 3 hrs, 45 min	Position and Raise LUT Level Platform
T + 4 hrs, 15 min	Verify Ready for MSS Mate
T + 4 hrs, 30 min	Clear for Lowering MSS on its Mounts
T + 5 hrs, 0 min	MSS is on Mounts
T + 6 hrs, 45 min	A. Verify LUT Level Platform Raising Complete
	B. Start F-1 Engine Securing per V-34012, Report When Complete
	C. Raise Engine Service Platform
T + 8 hrs, 30 min	Verify ESP Raising Complete
T + 9 hrs, 0 min	Secure S-IC Pneumatics per V-24327
T + 9 hrs, 30 min	Verify F-1 Engine Securing Complete per V-34012 Remove Stage Power
T + 16 hrs, 35 min	Apply S-IC Stage Power
T + 17 hrs, 0 min	Start New Time Base

DRY CDDT
Ref: V-20060, Vol. II

TIME	OPERATION
T - 6 hrs, 0 min	The Countdown Clock will be Reset to T - 6 Hours 0 Min 0 Sec
T - 5 hrs, 45 min	A. Remove Gimbal Platforms from around Engine as Required by CIPE B. Set Up S-IC Stage Hydraulics per V-34012 Report When Complete C. Set Up Pneumatics per V-24327, Report When Complete D. Arm Igniters Installed to On, Then Auto. Verify Hypergols and Igniters Installed Indications On
T - 5 hrs, 0 min	A. Low LOX Dome Purge to On B. Turn On S-IC Hydraulic Unit and Maintain 1590 ± 80 PSIG
T - 4 hrs, 55 min	A. Verify S-IC Hydraulic On and Pressure OK B. Low LOX Dome Purge Off
T - 4 hrs, 45 min	Start Pad Clearing Operations
T - 3 hrs, 38 min	Launch Vehicle Cryo Loading Would be Complete at this Time and Normal Replenish Would be Established
T - 3 hrs, 25 min	Launch Vehicle is Ready for Crew Ingress
T - 2 hrs, 40 min	Note Time for Start of Flight Crew Ingress
T - 2 hrs, 35 min	Low LOX Dome Purge - Auto
T - 1 hr, 19 min	A. Low LOX Dome Purge On B. Engine Gimbaling
T - 0 hr, 55 min	Flight Instrumentation Calibration
T - 0 hr, 53 min, 30 sec	Verify Low LOX Dome Purge On
T - 0 hr, 52 min, 30 sec	A. Low LOX Dome Purge On for VAFC B. Engine Gimbaling
T - 0 hr, 47 min, 0 sec	Start Engine Gimbaling
T - 0 hr, 42 min, 0 sec	Engine Gimbaling Complete
T - 0 hr, 42 min, 0 sec	Start Power Transfer Test
T - 0 hr, 41 min, 30 sec	S-IC Power Transfer Test Complete
T - 0 hr, 20 min, 0 sec	Verify/Accomplish Low LOX Dome Purge On
T - 0 hr, 16 min, 20 sec	A. S-IC Control Computor in S-IC Burn Mode B. Engine Gimbaling
T - 0 hr, 16 min, 0 sec	Arm Igniters Installed On, Then Auto, Verify Hypergol and Igniters Installed Indications Remain On
T - 0 hr, 15 min, 0 sec	Engine Gimbaling Complete

DRY CDDT
Ref: V-20060, Vol. II

TIME	OPERATION
T - 0 hr, 8 min, 0 sec	A. Note Engines in Null Position
	B. Note Hydraulic Pressure 1590 ± 80 PSIA
T - 0 hr, 5 min, 30 sec	A. Note Hypergols Installed - On
	B. Note Ordnance Prep Complete
T - 0 hr, 4 min, 30 sec	A. Arm TCS
	B. Note Ignition Source Voltage OK
T - 0 hr, 4 min, 0 sec	Cleared for Launch

NOTE: ALL LAUNCH VEHICLE SYSTEMS WILL BE HELD AT THIS POINT UNTIL THE SPACECRAFT HAS REACHED T-0

DRY CDDT

Ref: V-20060, Vol. II

TIME	OPERATION
T + 0 hr, 0 min, 0 sec	Start Launch Vehicle Securing from DRY CDDT
T + 0 hr, 0 min, 0 sec	A. Secure S-IC Stage Hydraulics
	B. Low LOX Dome Purge Off
T + 0 hr, 45 min, 0 sec	A. Flight Crew Egress is Complete
	B. Secure S-IC Pneumatics per V-24327
	C. Install Gimbal Platform Around Engines
T + 1 hr, 15 min	Remove S-IC Stage Power
T + 6 hrs, 45 min	Start Removal of S-IC Inert Engines Ordnance per V-34012 and V-21014
T + 12 hrs, 30 min	Launch Vehicle CDDT Procedure Complete

LAUNCH COUNTDOWN

LAUNCH COUNTDOWN
REF: V-20060, Vol I & II

TIME	OPERATION
T- 4 days, 1 hr, 45 min	Apply S-IC Stage Power
T- 4 days, 1 hr, 30 min	Start Thrust Chamber Preps per V-34012
T- 3 days, 20 hrs, 30 min	Start High Voltage Igniter Installation
T- 3 days, 17 hrs, 0 min	High Voltage Igniter Installation Complete
T- 3 days, 14 hrs, 45 min	Start F-1 Engine Hpergol Igniter Installation
T- 3 days, 13 hrs, 15 min	S-IC Stage Power Removed
T- 3 days, 13 hrs, 0 min	F-1 Engine Hypergol Igniter Installation Complete
T- 2 days, 17 hrs, 15 min	Start Switch Scans
T- 2 days, 17 hrs, 5 min	Switch Scans Complete
T- 1 day, 3 hrs, 30 min	Start Final Thrust Section Walkaround Inspection
T- 1 day, 2 hrs, 15 min	Start F-1 Engine Closeout per V-34012
T- 1 day, 1 hr, 15 min	Prepare Engine Service Platform for Lowering
T- 24 hrs, 20 min	A. Apply S-IC Stage Power B. Start TCS Functional Test
T- 24 hrs, 10 min	A. Lower Engine Service Platform B. Arm Igniters and Verify all Igniters and Hypergol Installed Lights On C. Start Propulsion System Functional Test per V-34012, Report When Complete
T- 24 hrs, 0 min	A. Start Final Thrust Section Walkaround Inspection (Quad I) B. Remove Gimbal Platforms from Around Engines
T- 23 hrs, 55 min	Start S-IC Pneumatic System Functional Test per V-24327
T- 23 hrs, 50 min	Verify TCS Functional Test is Complete
T- 23 hrs, 16 min	Verify Engine Service Platform Removed
T- 23 hrs, 0 min	Prepare S-IC Hydraulic Unit per V-34012, Report When Complete

LAUNCH COUNTDOWN
Ref: V-20060, Vol I & II

TIME	OPERATION
T-22 hrs, 15 min	A. Verify S-IC Airborne GN_2 and Helium Bottles Charged to 1500 psig B. Verify Gimbal Platforms Removed C. Verify Pneumatic System Functional Test Complete
T-22 hrs, 0 min	A. Thrust Section Walk Thru Inspection Complete B. Low LOX Dome Purge On C. Apply S-IC Hydraulics. Report When Complete D. Verify S-IC Engine Area Clear for Gimbaling
T-21 hrs, 55 min	Execute Flight Control Systems Gain Test (CTC1)
T-21 hrs, 45 min	A. Flight Control System Gain Test Complete B. Low LOX Dome Purge Off C. Start Final Installation of Base Heat Shield Access Panels
T-21 hrs, 17 min	A. Low LOX Dome Purge On B. Verify S-IC Engine Area Clear for Gimbaling
T-21 hrs, 15 min	Perform Power Transfer Test
T-21 hrs, 14 min, 30 sec	Power Transfer Test Complete
T-21 hrs, 12 min	A. Verify S-IC Hydraulics Supporting B. Verify/Accomplish Low LOX Dome Purge On C. Verify S-IC Engine Area Clear for Gimbaling
T-21 hrs, 9 min	Perform Flight Control Systems Gain Test (CTC1)
T-20 hrs, 35 min	A. CTC1 Test Complete B. Start Engine Null Test
T-20 hrs, 30 min	A. S-1C All Engines Null Test Complete B. Turn Off S-1C Hydraulic Unit C. Low LOX Dome Purge Off
T-18 hrs, 30 min	Verify Base Heat Shield Access Panel Installation Complete
T-18 hrs, 0 min	Start Flight Measurement Scans
T-17 hrs, 45 min	Prep Lut Level Platform for Lowering
T-17 hrs, 15 min	A. Turn On Low LOX Dome Purge B. Apply S-IC Hydraulics and Verify When Complete C. Low LOX Dome Purge Off After Hydraulic is Applied D. Lower Lut Level Platform (LLP) E. Flight Measurement Scans Complete

LAUNCH COUNTDOWN
Ref: V-20060, Vol I & II

TIME	OPERATION
T-16 hrs, 45 min	A. LLP Lowering Complete B. Apply Low LOX Dome Purge, Turn Off S-IC Hydraulics, and Then Turn Off Low LOX Dome Purge
T-13 hrs, 30 min	Clear LUT Zero Level in 15 Minutes for 40 Minutes for RP-1 Replenish
T-13 hrs, 0 min	Start RP-1 Replenish
T-12 hrs, 20 min	Verify RP-1 Replenish Complete and Line Drain in Progress
T-12 hrs, 0 min	A. Igniters Installed Switch to Arm. Verify all Igniters and Hypergols Installed B. Verify Ignition Source Voltage OK C. RP-1 Line Drain Completed
T-10 hrs, 30 min	Perform Wast Thrust OK Pressure Switch Test
T-10 hrs, 15 min	A. Wast Thrust OK Pressure Switch Test Complete B. Mobile Service Structure in Motion
T-9 hrs, 30 min	Verify Propulsion Preps Complete Except Prefill Topping per V-34012
T-9 hrs, 15 min	Start Verification Status of Launch Mission Rules Highly Desirable S-IC Range Safety Measurements
T-9 hrs, 5 min	All Highly Desirable Measurements are GO
T-9 hrs, 0 min	Starting Scheduled Hold, Verify S-IC LUT ESE Launch Preps Complete
	2 Hours Before Count Resumes Verify the following indications: T-187 LSE Preps Complete T-16.2 LSE Ready for S/A 2 Retract T-8.9 Ready for Ignition
	1 Hour Before Count Resumes Apply Hydraulics to the F-1 Engines and Start Prefill Operations per V-34012
	10 Minutes Before Count Resumes Verify S-IC Mechanical Preps Completed and Personnel Clearing Pad
	S-IC Electrical Preps Complete
	Just Before Count Resumes Start Pad Clearing Operations
T-8 hrs, 31 min	Verify Mobile Platform Transporter is at Launch Position and All Personnel Clear of Pad

LAUNCH COUNTDOWN
Ref: V-20060, Vol I & II

TIME	OPERATION
T- 8 hrs, 20 min	A. Turbopump Heater Power On B. Note Heaters Cycling C. S-IC Ready for LOX Loading D. S-IC GN_2 Control and Purge Bottles Pressurized to 3200 psi
T- 7 hrs, 5 min	Operate Thermal Conditioning Purge as Required to Maintain Engine Temp
T- 6 hrs, 54 min	A. Low LOX Dome Purge Switch to Auto B. Start S-IC LOX Loading
T- 6 hrs, 51 min	A. Low LOX Dome Purge On for Flight Control System Checks B. Engine Gimbaling
T- 6 hrs, 46 min	A. Low LOX Dome Purge On B. Engine Gimbaling
T- 5 hrs, 45 min	A. Low LOX Dome Purge On B. Engine Gimbaling
T- 5 hrs, 29 min	A. S-IC LOX Loading Complete B. Pressurize He Bottles to 3200 psi
T- 5 hrs, 18 min	Low LOX Dome Purge Off
T- 4 hrs, 36 min	Low LOX Dome Purge On
T- 4 hrs, 30 min	A. Low LOX Dome Purge On B. Execute Flight Control System Gain Tests (CTC1
T- 3 hrs, 38 min	Launch Vehicle Cryo Loading is Complete and Normal Replenish is Established
T- 3 hrs, 25 min	LV Ready for Crew Ingress
T- 3 hrs, 20 min	Flight Control System Gain Test (CTC1) Complete
T- 3 hrs, 20 min	Low LOX Dome Purge Off
T- 3 hrs, 5 min	A. Low LOX Dome Purge on for CTC2 B. Engine Gimbaling
T- 2 hrs, 50 min	CTC2 Complete, Low LOX Dome Purge Off

LAUNCH COUNTDOWN
Ref: V-20060, Vol I & II

TIME	OPERATION
T- 2 hrs, 40 min	NOTE: Time For Start of Flight Crew Ingress
T- 2 hrs, 0 min	Low LOX Dome Purge Auto
T- 1 hr, 27 min	A. Low LOX Dome Purge On B. Select S-IC Burn Mode On Then Auto (Engine Gimbaling)
T- 1 hr, 0 min	Start RP-1 Level Adjust
T-52 min, 30 sec	A. Low LOX Dome Purge On B. Engine Gimbaling
T-51 min, 25 sec	Verify Thermal Conditioning Purge On and Maintain for the Remainder of the Count
T-47 min, 0 sec	A. Verify Low LOX Dome Purge On B. Execute Flight Control Test FT-10 (Ladder Output Test +/-2 Deg Pitch & Yaw, +/-5 Deg Roll)
T-42 min, 0 sec	A. Flight Control Test FT-10 Complete B. Execute Power Transfer Test
T-41 min, 30 sec	Power Transfer Test Complete
T-35 min, 0 sec	RP-1 Level Adjust Complete
T-26 min, 0 sec	A. Precharge Pogo Suppression System B. LOX Bubbling to Ducts 1 & 3. Two Duct Bubbling Shall Remain on During Remainder of Count
T-20 min, 0 sec	A. Verify S-IC GN_2 & Helium System Pressurized to Flight Pressure B. Verify/Accomplish Low LOX Dome Purge On
T-16 min, 20 sec	Engine Gimbaling
T-16 min, 0 sec	Arm Igniters Installed, Verify Hypergol and Igniters Installed Indications Remain On
T-11 min, 0 sec	Start S-IC Fuel Jacket Topping Per V-34012
T-10 min, 45 sec	Verify/Accomplish S-IC LOX Bubbling to Ducts 1 and 3

LAUNCH COUNTDOWN
Ref: V-20060, Vol I & II

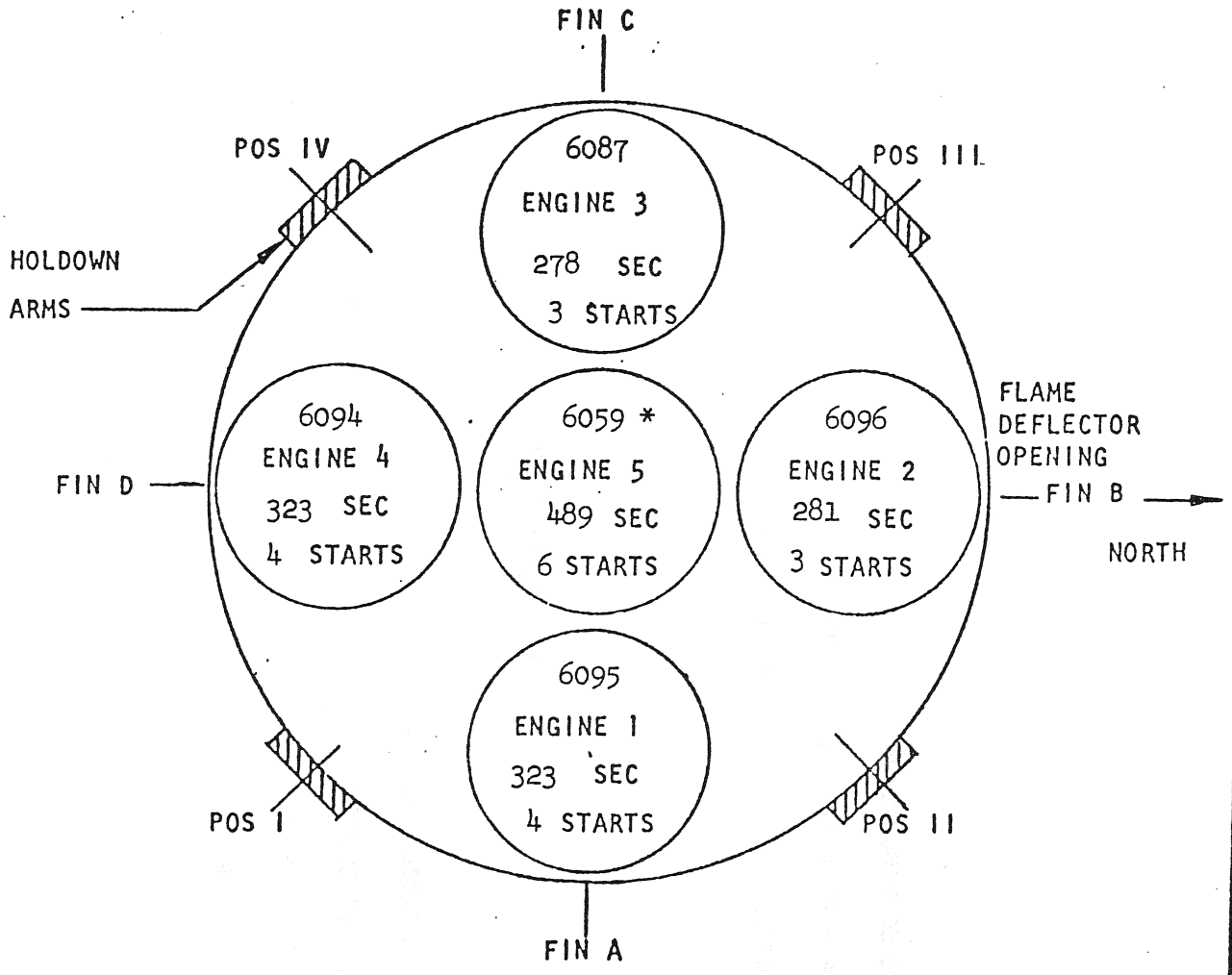
TIME	OPERATION
T-7 min, 58 sec	A. Note Engines in Null Position B. Note Hydraulic Pressure 1590±80 psia C. Pressurize S-IC Fuel Tank to 2 psig
T-6 min, 0 sec	A. Verify F-1 Engine Thrust Chamber Prefill Topping Complete B. S-IC Propulsion Preps Complete
T-5 min, 30 sec	A. Note Hypergols Installed ON B. Note Ordnance Prep Complete
T-4 min, 30 sec	A. Arm TCS B. Note Ignition Source Voltage OK
T-4 min, 0 sec	Cleared for Launch
T-3 min, 40 sec	Preparations Complete On
T-3 min, 10 sec	Initiate Firing Command and Verify
T-3 min, 6 sec	Verify Firing Command is On
T-1 min, 42 sec	A. S-IC Hydraulics Commit and Check B. Note Hydraulic Unit Committed On
T-1 min, 37 sec	S-IC Fuel Tank Prepress NOTE: S-IC Fuel Tank is Pressurizing
T-1 min, 12 sec	A. S-IC Time for LOX Prepress NOTE: S-IC LOX Tank is Pressurizing B. LOX Bubbling Stops
T-0 min, 50 sec	A. Power Transfer Internal B. Verify Power Transfer Complete
T-0 min, 48 sec	A. NOTE: S-IC LOX Prepress is OK B. NOTE: S-IC Fuel Prepress is OK
T-0 min, 40 sec	NOTE: S-IC Propellants Pressurized
T-0 min, 30 sec	A. S-IC Engine Hydraulic Checkout Valves to Stage Position B. Note S-IC Engine Checkout Valve to Stage Position
T-0 min, 22 sec	A. Preparation Complete Off
T-0 min, 20 sec	Close LOX Interconnect Valves
T-0 min, 17 sec	Preparation Complete On
T-0 min, 11 sec	Ready for Ignition On

LAUNCH COUNTDOWN
REF: V-20060, Vol I & II

TIME	OPERATION
T-0 min, 8.9 sec	A. S-IC Time for Ignition B. Ignition Sequence is Started C. Ignition Command On
T-0 min, 8.8 sec	Start S-IC Igniter No. 1
T-0 min, 8.7 sec	Start S-IC Igniter No. 2
T-0 min, 7.2 sec	A. Time for S-IC Links Burn B. Note Engines Armed On
T-0 min, 6.70 sec	Start S-IC Engine 105 NOTE: Engine 105 Start
T-0 min, 6.47 sec	Start S-IC Engine 104 NOTE: Engine 104 Start
T-0 min, 6.45 sec	Start S-IC Engine 101 NOTE: Engine 101 Start
T-0 min, 6.42 sec	Start S-IC Engine 103 NOTE: Engine 103 Start
T-0 min, 6.16 sec	Start S-IC Engine 102 NOTE: Engine 102 Start
T-0 min, 5 sec	S-IC Engine Start Solenoids Off NOTE: Engine 1-5 Start-Off
T-0 min, 4.7 sec	S-IC LOX Secondary Prepress On
T-0 min, 2.75 sec	S-IC Fuel Secondary Prepress On
T-0 min, 1.60 sec	All Engines Running
T-0 min, 0.05 sec	Time for Thrust Checks
T-0 min, 0 sec	S-IC Time for Commit Note Time for Commit Note All Holddown Arms Released Note S-IC Engine 101-105 Heater Power Off Note Commit On Hydraulic Pumping Unit Off
T+0 min, 0 sec	Note Liftoff

ENGINE LOCATIONS

AS -511



Note: Viewed from stage forward end.

* Engine static tested in stage S-IC-8. Engine removed post static test due to turbopump LOX seal leakage. Engine installed in stage S-IC-11 prior to second stage static test.

S-IC-11 ENGINE CONFIGURATION

QUAL II ENGINE CONFIGURATION

RIGID HIGH PRESSURE PROPELLANT DUCTS

QUAL CONFIGURATION THRUST CHAMBER INJECTORS

S-IC-11 ENGINE HISTORY

ROCKETDYNE ACCEPTANCE TESTING COMPLETE	8 MARCH 1967	- 9 JULY 1969
CUSTOMER ENGINE ACCEPTANCE	11 JULY 1969	- 22 JANUARY 1970
STAGE STATIC TEST COMPLETE	25 JUNE 1970	
STAGE RECEIVED AT KSC	17 SEPTEMBER 1971	

CONFIGURATION CHANGES BETWEEN AS-510 AND AS-511

ECP	DESCRIPTION	AS-511 INCORPORATION	VALIDATION ENGINES/UNITS	VALIDATION STARTS/SECONDS	
498 R2	INCORPORATE SERIES LUBE SYSTEM	F2095, F2096, F2094	24	532	53,571
512 R1	DELETE 2 UNUSED TEST INSTRUMENTATION TAPS ON T/C INJECTOR AND HYDRAULIC LINE	F2095, F2096, F2094	6	21	1,977
515 R1	IMPROVE MAIN OXIDIZER VALVE	F2095, F2096, F2094	20	76	6,994
	INDIVIDUAL CHANGES WERE TESTED AS FOLLOWS:				
	1) POTENTIOMETER DRIVE SYSTEM		10	234	29,916
	2) POPPET SPRING GUIDE		13	180	18,511
	3) SEAL RETAINER		11	332	40,405
	4) POT ARM & RETAINING SCREWS		3	89	8,676
	5) SEQUENCE VALVE METAL TO METAL SEAT		5	162	17,361
613	REPLACE NAFLEX SEAL AT HEAT EXCHANGER GOX & HELIUM RETURN LINE TO W/A JOINTS	F2095, F2096, F2087, F2059	4	22	2,659
618	REPLACE SEALS IN HEAT EXCHANGER GOX RETURN DUCT ASSEMBLY	ALL ENGINES	6	184	19,734

PROBLEM AND DISCREPANCY HISTORY

PROBLEM	ENGINE	ACTION TO RESOLVE
1) First stage static test terminated after 98.1 seconds due to fire on engine F6072. The fire resulted from fuel leakage caused by the stage contractor leaving a polyethylene shipping closure installed in the joint between the gimbal hydraulic supply flexline and gimbal filter manifold. After engine shutdown, two LOX duct gyser surges occurred in the engine position 105 duct resulting in failure of a stage LOX interconnect duct directly above engine position 102. This failure allowed LOX to flow to the stage closeout area and down on all the five engines. Extensive engine damage resulted from the combination of the fire and LOX dump.	F6049, F6045, F6072, F6060 and F6070	All engines were removed. The stage was refurbished and replacement engines were installed in the stage. The stage was subjected to a second static test with the replacement engines installed.
2) Second stage static test terminated after 70.6 seconds due to LOX tank ullage pressure dropping below the minimum redline value. Two ullage pressure measurements were being monitored. Both measurements indicated below minimum redline. Posttest inspection revealed the gland nut of the static test calibration hand valve to both measurements had backed off from the valve body and had dropped on the stage forward skirt ring frame. This allowed pressure to both measurements to vent to ambient.	F6095, F6096, F6087, F6094 and F6059	The static test was accepted by NASA as meeting all its intended objectives.
3) Post stage static test of S-IC-8 at MAF, noise was heard in the area of the engine F6059 LOX pump. This noise occurred when the stage LOX tank was pressurized to 3 psig. Rotation of the pump caused the noise to stop. Primary LOX seal leakage was measured at various pressure levels. Leakage was within limits at 10 psig but exceeded limits at 1.5 psig.	F6059	Engine was removed and replaced in stage. Turbopump primary LOX seal was removed and replaced. Problem resolved by incorporating low pressure leak test on seal. Engine installed in S-IC-11 prior to second stage static test.

PROBLEM AND DISCREPANCY HISTORY

PROBLEM	ENGINE	ACTION TO RESOLVE
4) K-seals used in the heat exchanger GOX outlet duct were plated with lead/tin alloy. Laboratory tests show this alloy may be LOX impact sensitive if a sufficient amount of tin is present when used in a GOX environment.	F6095, F6096, F6087, F6094, and F6059	ECP F1-618 incorporated gold plated K-seals in place of the lead/tin alloy K-seals.
5) During performance of the AS-511 malfunction OATS test and Flight Readiness Test, the engine F6059 gas generator ball valve momentarily left the open position when the engines were being gimbaled. These tests gimbal the engines with the engine propellant valves open and the engine hydraulic return flow directed to the ground return reservoir. This return system is of high impedence resulting in high pressure surges during engine gimbaling. During flight, the hydraulic return flow is directed to the engine fuel pump inlet. This is a low impedence system which will not cause high pressure surges during gimbaling. However, the engine valves must remain closed during engine gimbaling with propellants in the engine prelaunch with the return flow directed to the ground return reservoir.	F6059	Conducted additional tests with special hydraulic system instrumentation to determine pressure surge magnitudes during prelaunch engine gimbaling with the valves closed. Data showed that hydraulic system was marginal; however, in all prelaunch gimbal cases, the valves should remain closed. These tests verified that with the valves open, the hydraulic pressure surges should cause the gas generator ball valve to leave the open position.
6) During the second static test of S-IC-11, the engine F6059 sea level thrust was 52 K-LB lower then predicted. The engine was retrofitted with a MOD 4 gas generator injector prior to the static test. The increased LOX injector pressure drop of the MOD 4 injector required resizing of the gas generator LOX line orifice. Component test data were utilized to determine the new gas generator LOX line orifice diameter.	F6059	Low thrust was attributed to a 30-psi error in component acceptance data for the MOD 4 gas generator injector. The engine was reorificed to target nominal thrust after the stage static test.

PROBLEM AND DISCREPANCY HISTORY

PROBLEM	ENGINE	ACTION TO RESOLVE
7) After completion of the KSC 1400-psi leak test of the S-IC-11 engine F6059 ignition monitor valve diaphragm, the hypergol simulator tool could not be completely inserted into the hypergol container and the hypergol installed switch remained activated. After approximately 3 hours the tool was installed without difficulty. The diaphragm leak test was repeated and the hypergol tool again could not be installed. The ignition monitor valve diaphragm was removed and replaced. The test was repeated without problem.	F6059	The ignition monitor valve diaphragm was removed and replaced. Examination of the diaphragm revealed 4 areas of crazing in the convolution with small holes through the first diaphragm ply in two of the areas. The problem resulted from gas entrapment between the plies of the diaphragm resulting in holding the ignition monitor valve in the actuated position. The integrity of the diaphragm is verified following the last application of GN_2 to the diaphragm prelaunch to preclude this problem being present.
8) During single engine checkout of engine F6095, two cc of fuel were found in the turbopump intermediate seal purge vent line. No fuel is allowable.	F6095	The engine turbopump was cleaned per EFIR F1-47I and F1-56A.

INDIVIDUAL F-1 ENGINE HISTORY

2095 ROCKETDYNE

3 acceptance tests: 252.3 seconds
Engine delivered with no deviation from Model Specification

MTF

1 stage static test: 70.6 seconds

2096 ROCKETDYNE

2 acceptance tests: 210.0 seconds
Engine delivered with no deviation from Model Specification

MTF

1 stage static test: 70.6 seconds

2087 ROCKETDYNE

2 acceptance tests: 207.0 seconds
Engine delivered with no deviation from Model Specification

MTF

1 stage static test: 70.6 seconds

2094 ROCKETDYNE

3 acceptance tests: 252.4 seconds
Engine delivered with no deviation from Model Specification

MTF

1 stage static test: 70.6 seconds

2059 ROCKETDYNE

4 acceptance tests: 292.9 seconds
Engine delivered with no deviation from Model Specification

MTF

2 stage static tests: 168.7 seconds
S-IC-8 98.1 seconds
S-IC-11 70.6 seconds

ENGINE COMPONENT REPLACEMENT AFFECTING

PERFORMANCE ACCOMPLISHED SUBSEQUENT TO ENGINE ACCEPTANCE TESTING

PRIOR TO STAGE STATIC TEST

ENGINE F2095	REPLACED GAS GENERATOR BALL VALVE
ENGINE F2087	REPLACED GAS GENERATOR BALL VALVE
	REPLACED GAS GENERATOR LOX BOOTSTRAP LINE
	RESIZED GAS GENERATOR LOX ORIFICE PER ECP F1-612
ENGINE F2094	RESIZED GAS GENERATOR LOX ORIFICE PER ECP F1-612
ENGINE F2059	REPLACED GAS GENERATOR INJECTOR - INSTALLED MD 4 TYPE PER ECP F1-596
	RESIZED GAS GENERATOR LOX ORIFICE DUE TO MD 4 GAS GENERATOR INJECTOR INSTALLATION

AFTER STAGE STATIC TEST

ENGINE F2059	RESIZED GAS GENERATOR LOX ORIFICE PER ECP F1-612

SEA LEVEL PREDICTED PERFORMANCE VALUES

AS-511

ENGINE POSITION		1	2	3	4	5	AVERAGE
ENGINE NUMBER		F2095	F2096	F2087	F2094	F2059 *	
THRUST	K-LB	1516	1523	1527	1534	1522	1524
TURBOPUMP SPEED	RPM	5482	5456	5544	5499	5526	5501
GAS GENERATOR FLOWRATE	LB/SEC	168	166	171	164	170	167.8
TURBINE MANIFOLD TEMPERATURE	°F	1571	1564	1618	1574	1592	1584
THRUST CHAMBER PRESSURE	PSIA	1119	1122	1128	1130	1131	1126
ENGINE LOX FLOW	LB/SEC	3950	3985	4001	3990	3984	3982
ENGINE FUEL FLOW	LB/SEC	1748	1754	1757	1775	1761	1759
ENGINE MIXTURE RATIO	OXID/FUEL	2.259	2.272	2.277	2.248	2.263	2.264
ENGINE SPECIFIC IMPULSE	SEC	266.0	265.4	265.2	266.1	264.9	265.5

NOTES:

1) SEA LEVEL CONDITION IS LISTED BELOW:

a)	Ambient Pressure, psia	14.7
b)	LOX pump inlet pressure, psiat	65.0
c)	Fuel pump inlet pressure, psiat	45.0
d)	LOX density, lb/cu.ft.	71.38
e)	Fuel density, lb/cu.ft.	50.45
f)	Fuel inlet temperature, °F	60.0

2) All data are taken over a 3-second time interval starting at approximately 35-seconds of mainstage operation.

* Engine reorificed to target a sea level thrust of 1522 K-LB per ECP F1-612 subsequent to stage static test.

S-IC ELECTRICAL INTERLOCK AND SAFETY CIRCUIT SCHEMATICS

The following schematics were abstracted from drawings 40M10616, Advanced Electrical System Schematic, S-1C ESE, Saturn V and SK 60B57201 KSC Functional Schematic.

Interlock Circuits

Safety Circuits

Cutoff Circuits

Engine and Engine Supporting Circuits

INTERLOCK CIRCUITS

Function	Interlock
S-1C Ready for RP-1 Loading	1. Fuel vent valve open 2. All main fuel valves closed 3. GG valves closed
Thrust Chamber Prefill	Low LOX dome purge ON
S-1C Ready for LOX Loading	1. Heater power enable 2. GG valves closed 3. All MFC closed 4. MLV closed 5. Other facility and stage-oriented indications
Firing Prep Complete	1. All MFV closed 2. GG valves closed 3. MLV closed 4. All pre-valves open 5. Exhaust igniters installed 6. GG igniters installed 7. Hypergols installed 8. Ignition source voltage OK 9. All checkout valves in ground return position 10. S-1C engines in null position 11. Other stage and vehicle-oriented indications
Ready for Ignition	1. All MFV closed 2. GG valves closed 3. S-1C engines in null position 4. Exhaust igniters installed 5. GG igniters installed 6. Hypergols installed 7. Propellant pressurized 8. Ignition source voltage OK 9. All checkout valves in stage return position 10. Launch support ready for ignition 11. Other stage and vehicle-oriented conditions
All Engines Running	Two (2) of three (3) thrust OK pressure switches
Launch Commit	1. All engines running 2. Cutoff has not occurred by facility or stage system

SAFETY CIRCUITS, EFFECTIVE FROM IGNITION COMMAND

1. Hypergol Installed Safety Circuit

   Anytime No. 1 and No. 2 main fuel valve leave the closed position, as indicated by the position switches, prior to loss of hypergol installed switch dropout, cutoff will occur.

2. Main Fuel Valve Failure Safety Circuit

   Anytime one main fuel valve reaches the open position and the other main fuel valve has not left the closed position, as indicated by position switches, cutoff will result. This safety circuit is deactivated after an indication that all MFV's are in the open position.

3. Igniter Links Burned Safety Circuit

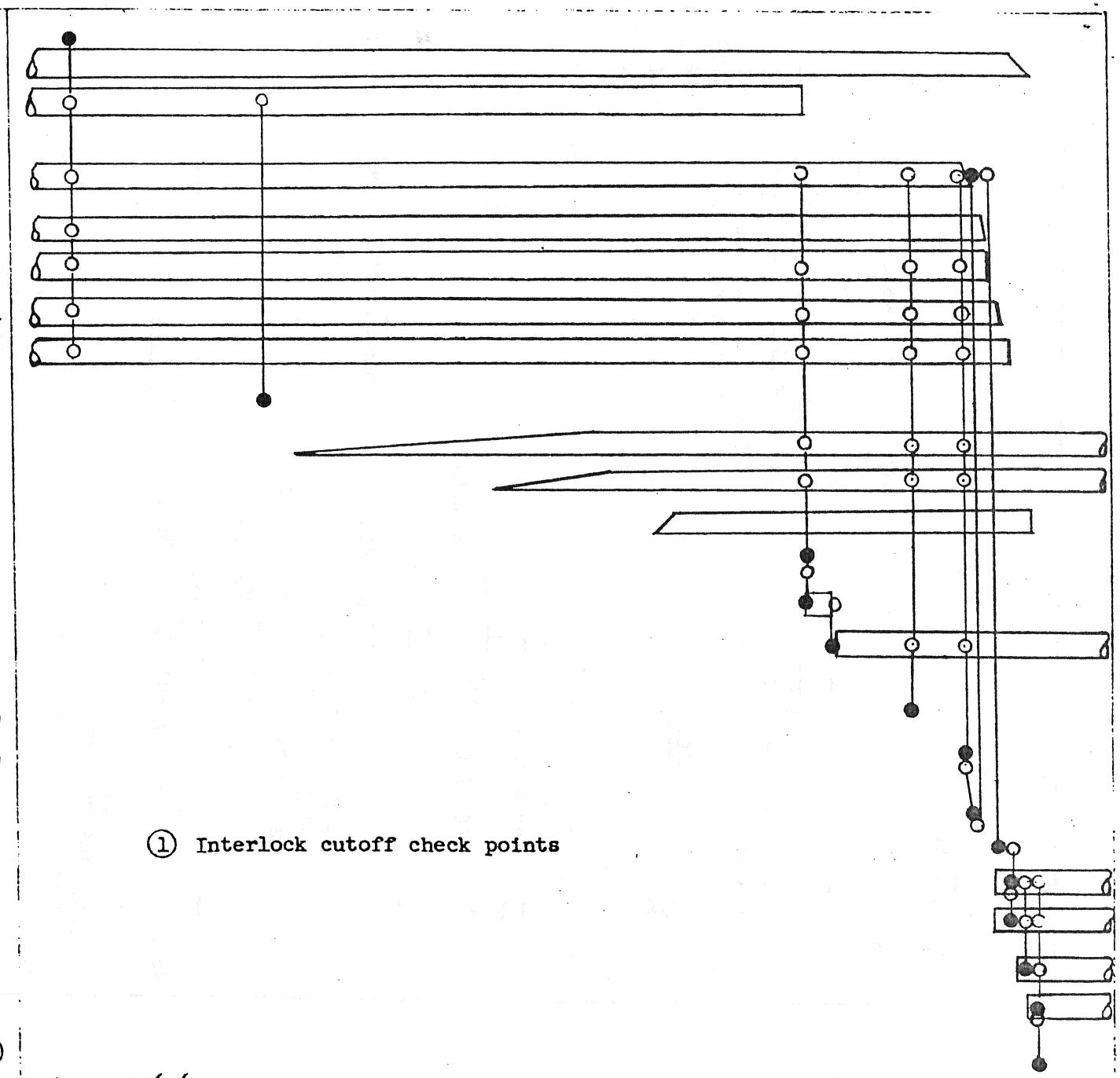
   Links burned failure will occur, resulting in cutoff, unless at T-6.7 sec on each engine at least one GG and one nozzle extension igniter link is broken. This safety circuit is deactivated at reset.

4. Thrust OK Pressure Switches Safety Circuit

   Two of three pressure switches per engine are required for S-1C stage commit sequence.

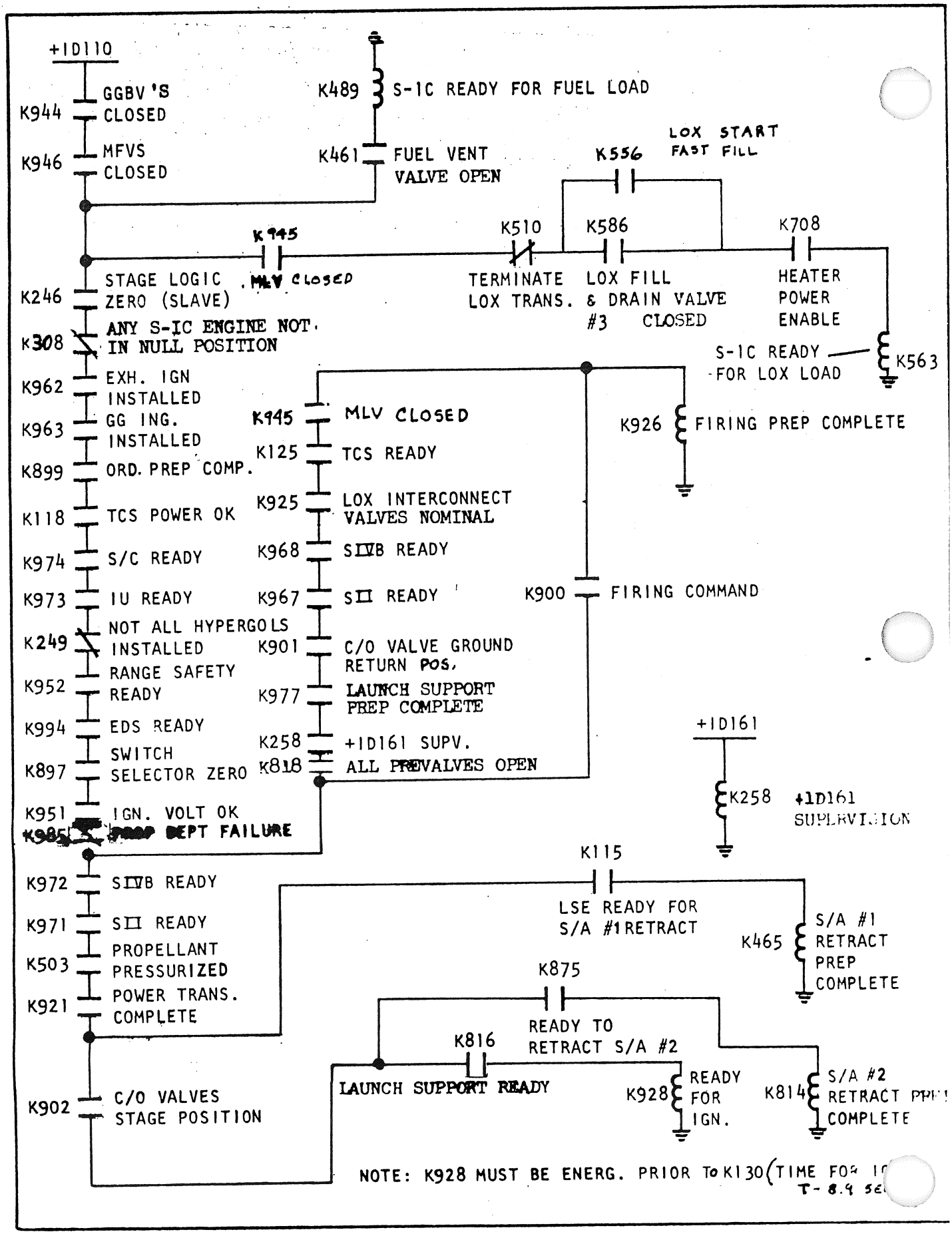
SATURN V F-1 ENGI OMATIC SEQUENCE

1) Start Automatic Sequence
2) Turbopump Heater Power On
3) Checkout Valve Ground Position Switch On
4) Gas Generator and Turbine Exhaust Igniter Link Continuity
5) Main Oxidizer Valves Closed
6) Gas Generator Valves Closed
7) Hypergol Installed Switch Energized
8) Main Fuel Valves Closed
9) Hydraulic Pumping Unit Commit
10) Fuel Tank Pressurized
11) LOX Tank Pressurized
12) LOX Dome-GG LOX Purge On
13) Intertank Umbilical Disconnect (1)
14) Checkout Valve to Stage Position
15) Checkout Valve Stage Position Switch On
16) Forward Umbilical Disconnect (1)
17) Ignition Command (1)
18) GG-Turbine Exhaust Firing Signal
19) Engine Control Valve Start Signal
20) Main Oxidizer Valves Open
21) Gas Generator Valves Open
22) Main Fuel Valves Open
23) Thrust OK Pressure Switches Pickup
24) Launch Commit (1)

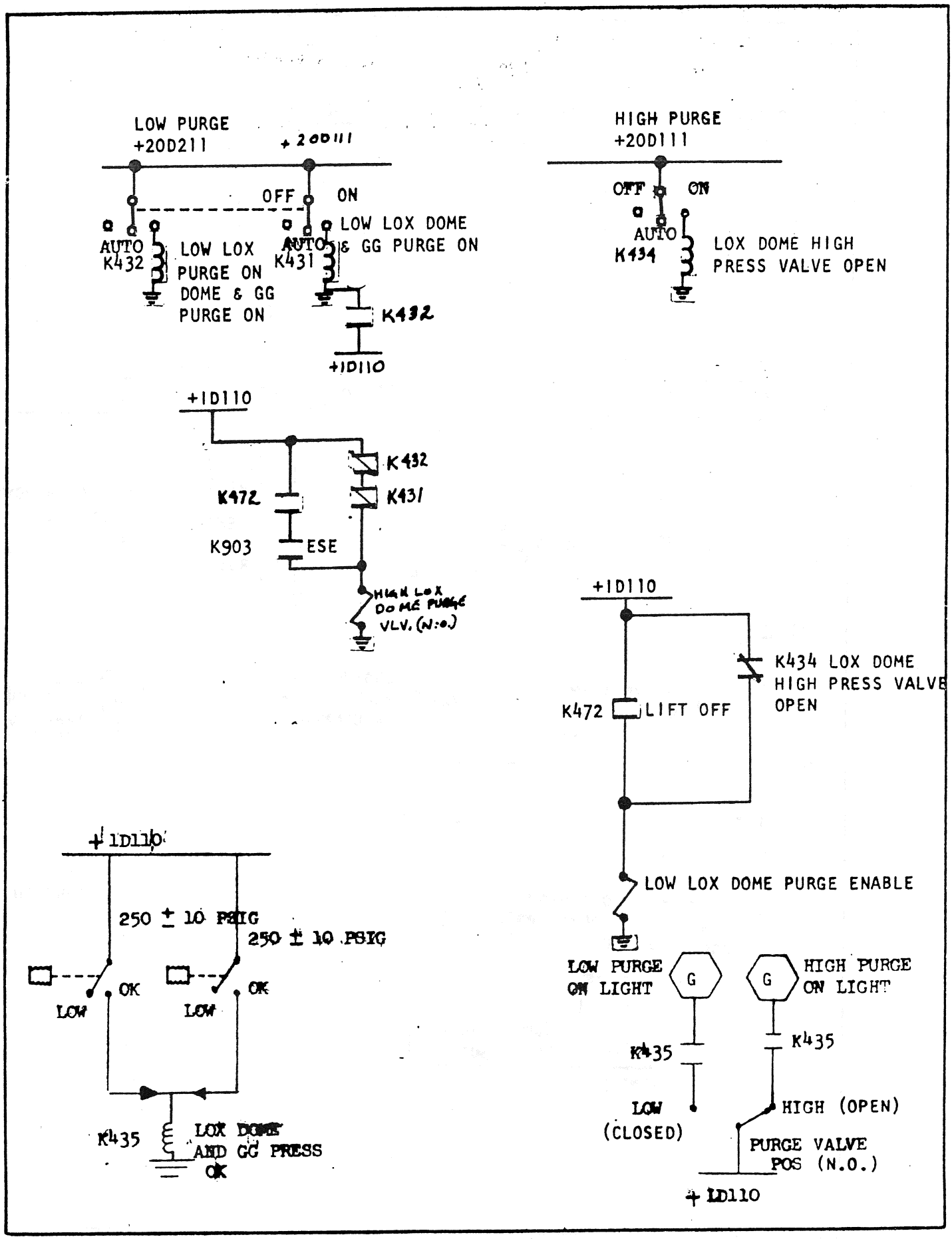


(1) Interlock cutoff check points

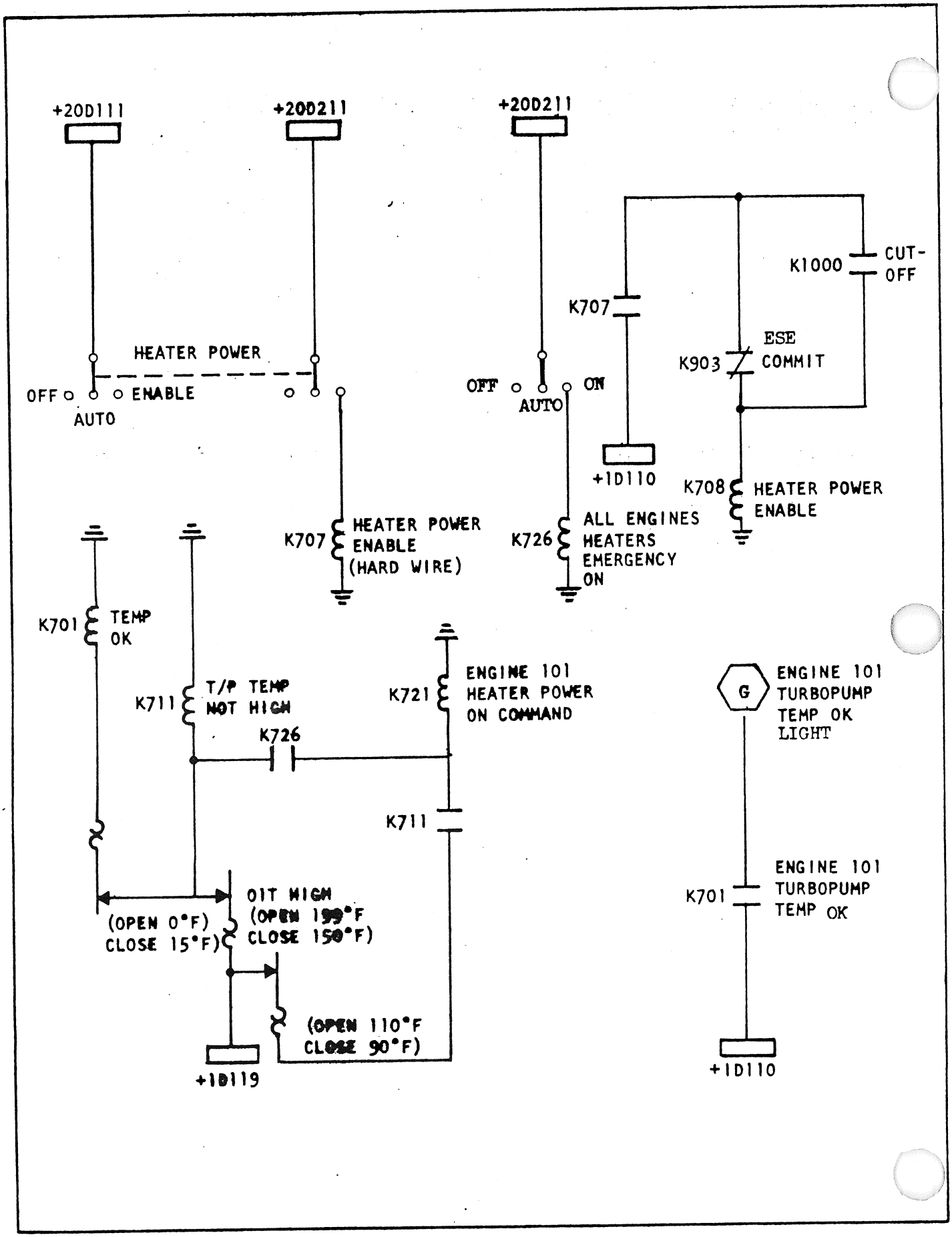
○ Initiating Event
● Resulting Event


+1D110
K944 GGBV'S CLOSED
K946 MFVS CLOSED
K489 S-1C READY FOR FUEL LOAD
K461 FUEL VENT VALVE OPEN
LOX START FAST FILL
K556
K945
K510
K586
K708
MLV CLOSED
TERMINATE LOX TRANS.
LOX FILL & DRAIN VALVE #3 CLOSED
HEATER POWER ENABLE
K246 STAGE LOGIC ZERO (SLAVE)
K308 ANY S-IC ENGINE NOT IN NULL POSITION
S-1C READY FOR LOX LOAD
K563
K962 EXH. IGN INSTALLED
K963 GG ING. INSTALLED
K899 ORD. PREP COMP.
K118 TCS POWER OK
K974 S/C READY
K973 IU READY
K249 NOT ALL HYPERGOLS INSTALLED
K952 RANGE SAFETY READY
K994 EDS READY
K897 SWITCH SELECTOR ZERO
K951 IGN. VOLT OK
K985 PREP DEPT FAILURE
K945 MLV CLOSED
K125 TCS READY
K925 LOX INTERCONNECT VALVES NOMINAL
K968 SIVB READY
K967 SII READY
K901 C/O VALVE GROUND RETURN POS.
K977 LAUNCH SUPPORT PREP COMPLETE
K258 +1D161 SUPV.
K818 ALL PREVALVES OPEN
K926 FIRING PREP COMPLETE
K900 FIRING COMMAND
+1D161
K258 +1D161 SUPERVISION
K115
LSE READY FOR S/A #1 RETRACT
K465 S/A #1 RETRACT PREP COMPLETE
K875
READY TO RETRACT S/A #2
K816
LAUNCH SUPPORT READY
K928 READY FOR IGN.
K814 S/A #2 RETRACT PREP COMPLETE
K972 SIVB READY
K971 SII READY
K503 PROPELLANT PRESSURIZED
K921 POWER TRANS. COMPLETE
K902 C/O VALVES STAGE POSITION
NOTE: K928 MUST BE ENERG. PRIOR TO K130 (TIME FOR IG
T- 8.9 SE

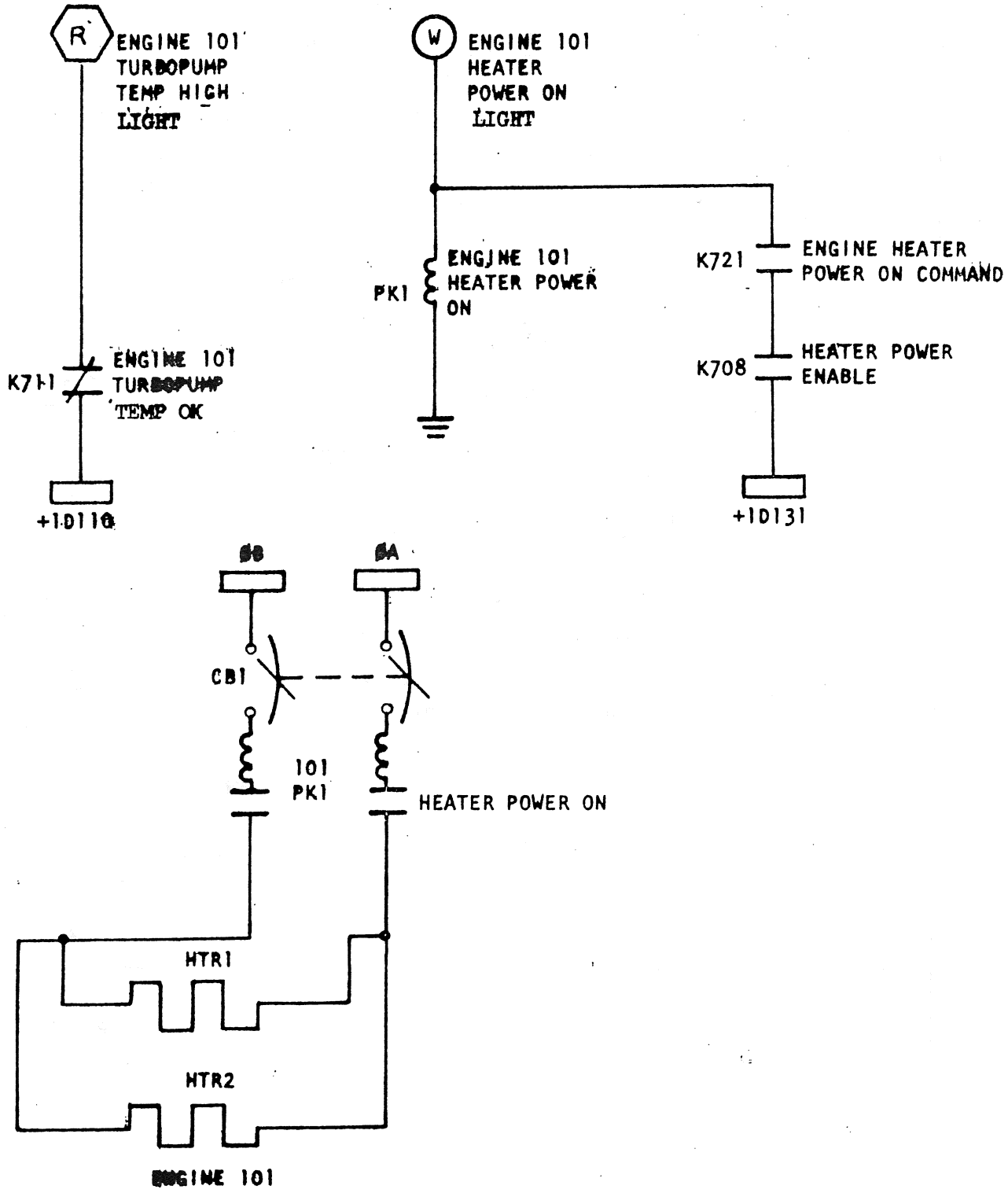
PREP LADDER



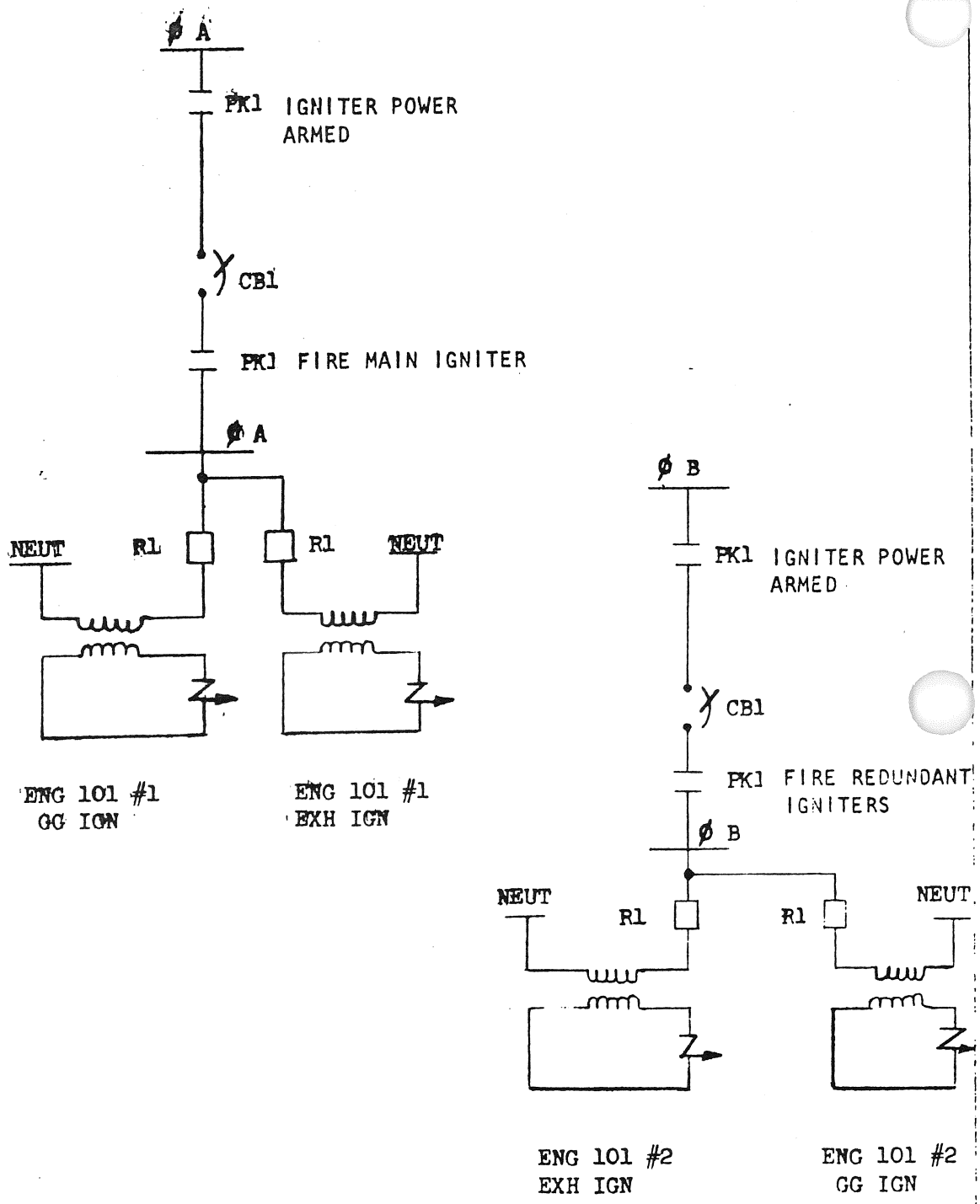
LOX DOME & G.G. PURGE



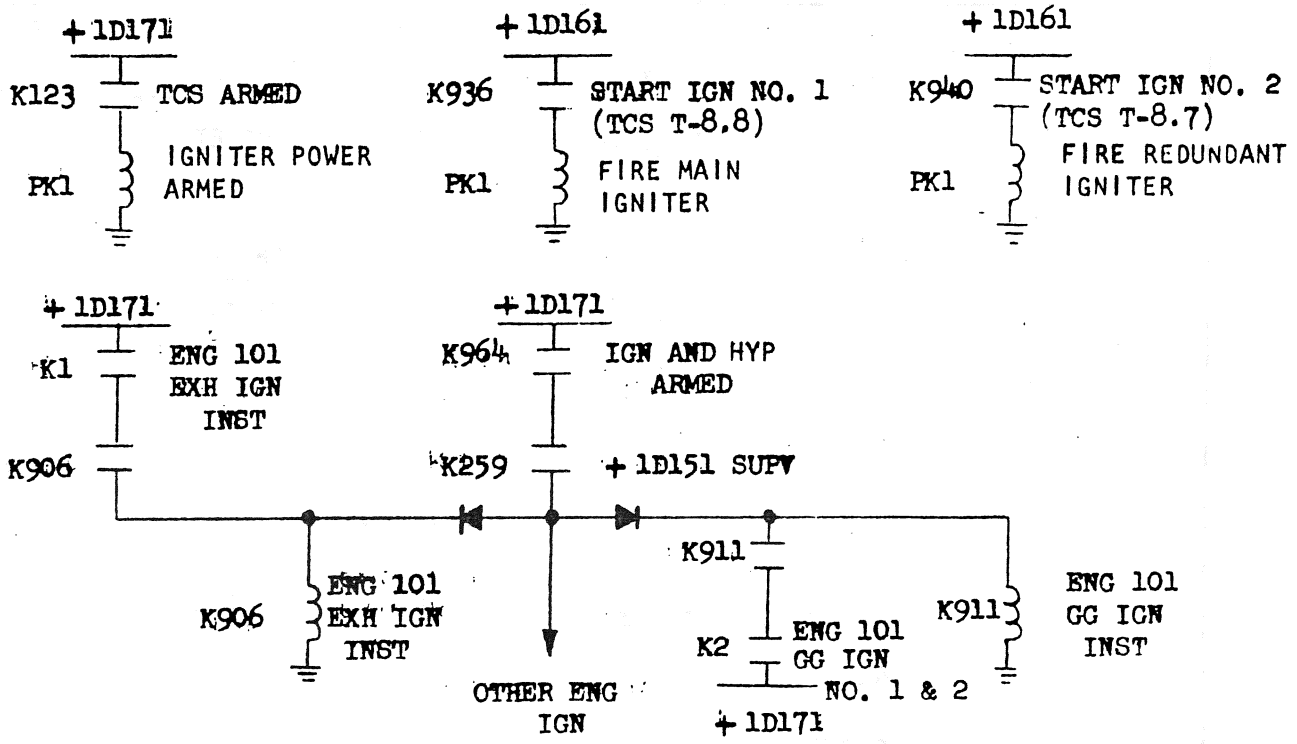
HEATER POWER, ENGINE 101
(TYPICAL ENGINES 1-5)

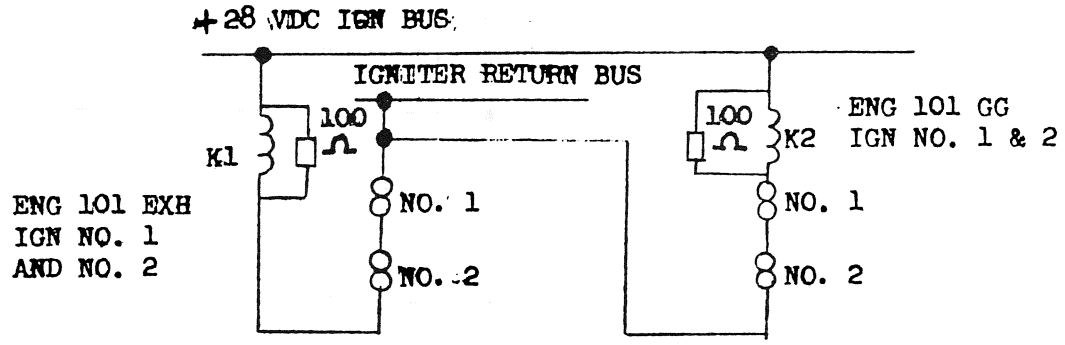


HEATER POWER, ENGINE 101
(TYPICAL ENGINES 1-5)

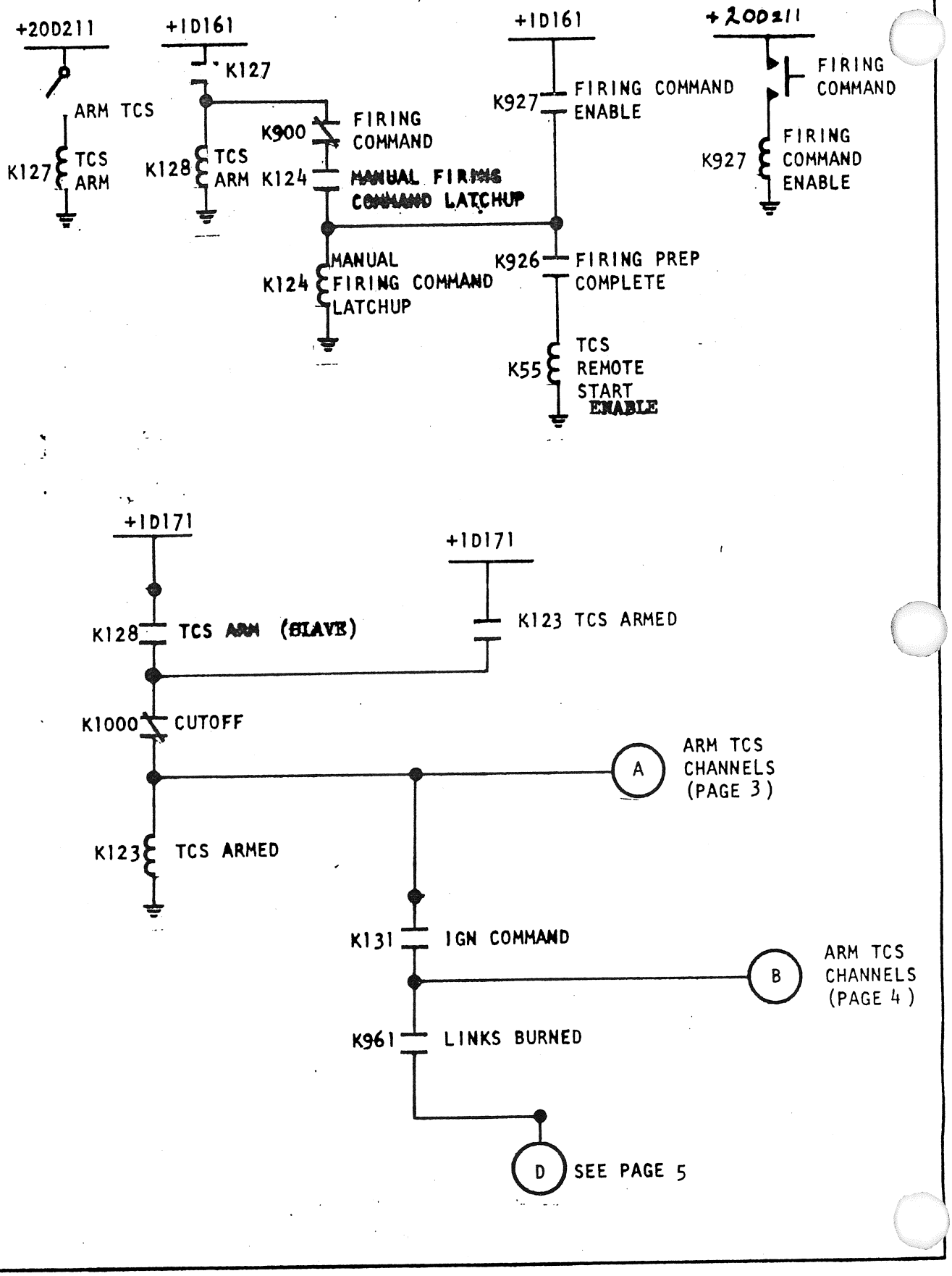


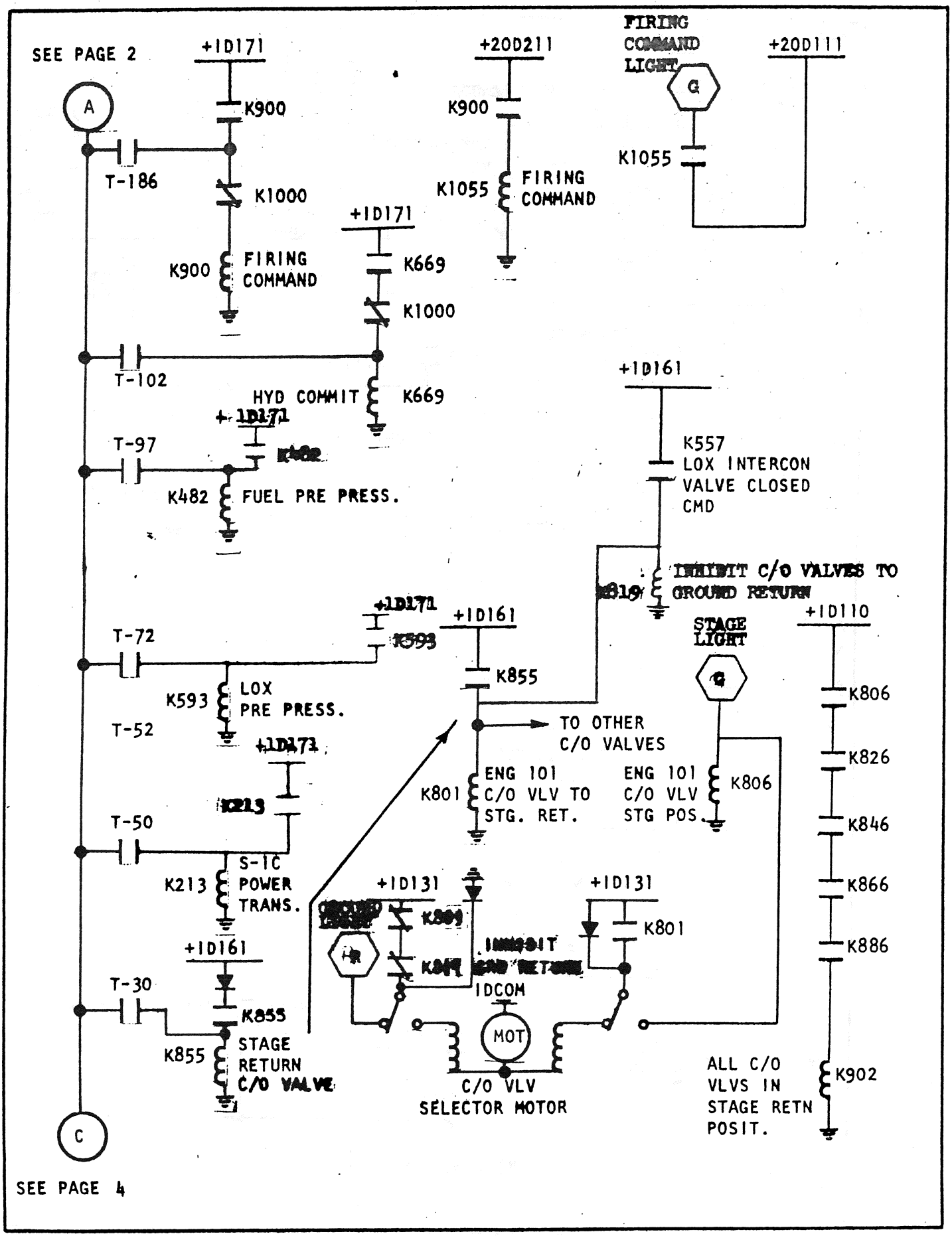
IGNITER CIRCUIT

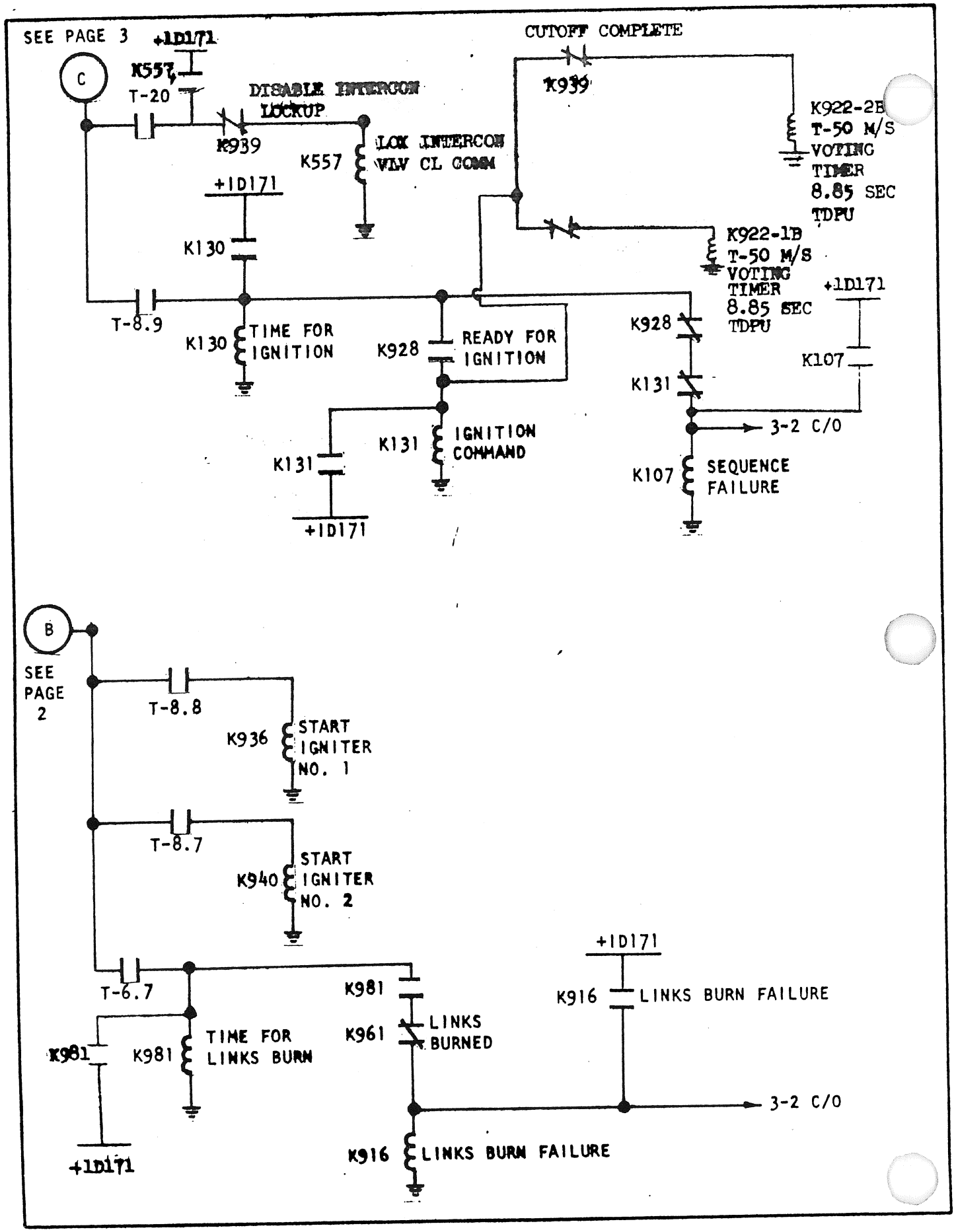




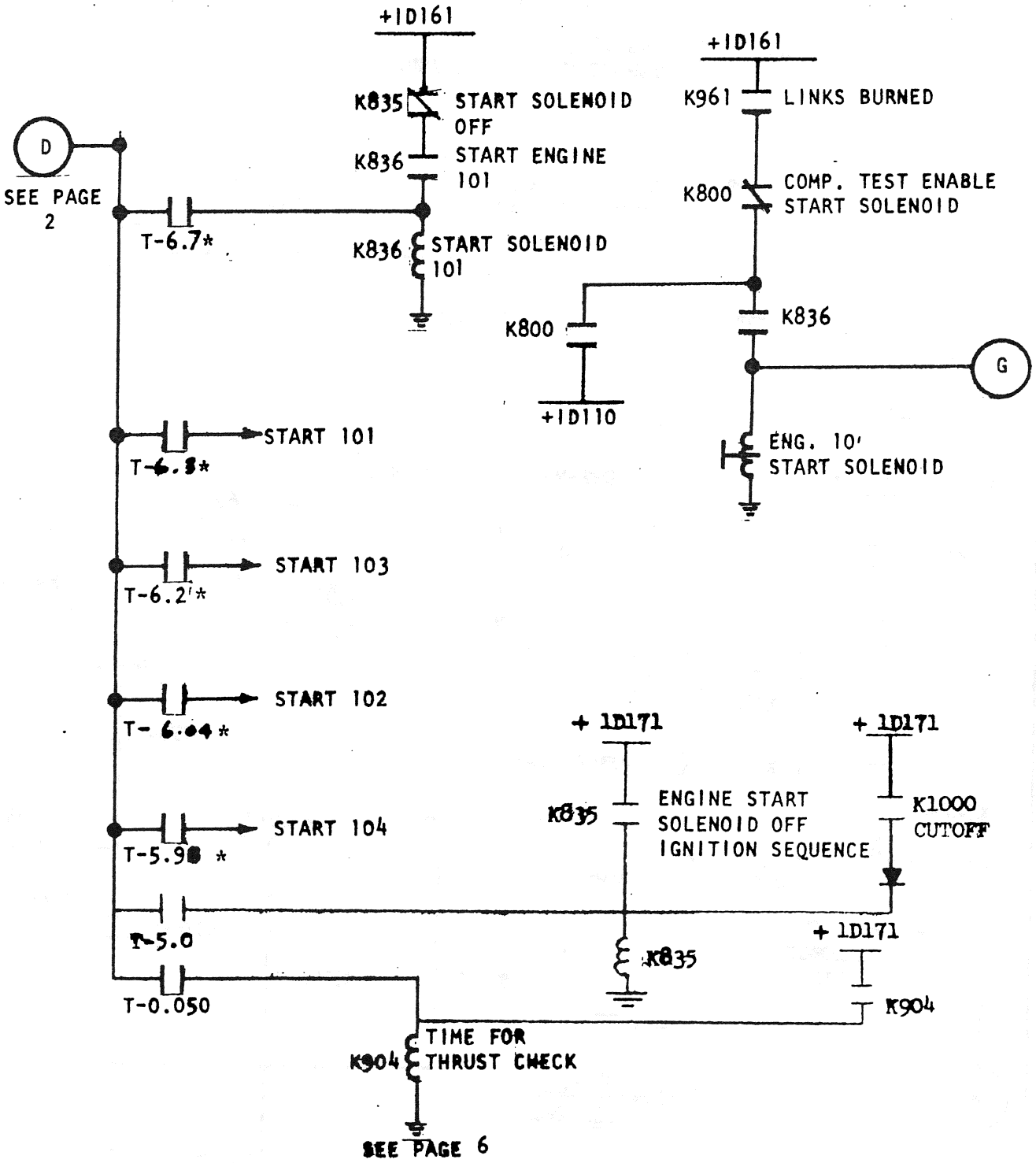
IGNITER CIRCUIT

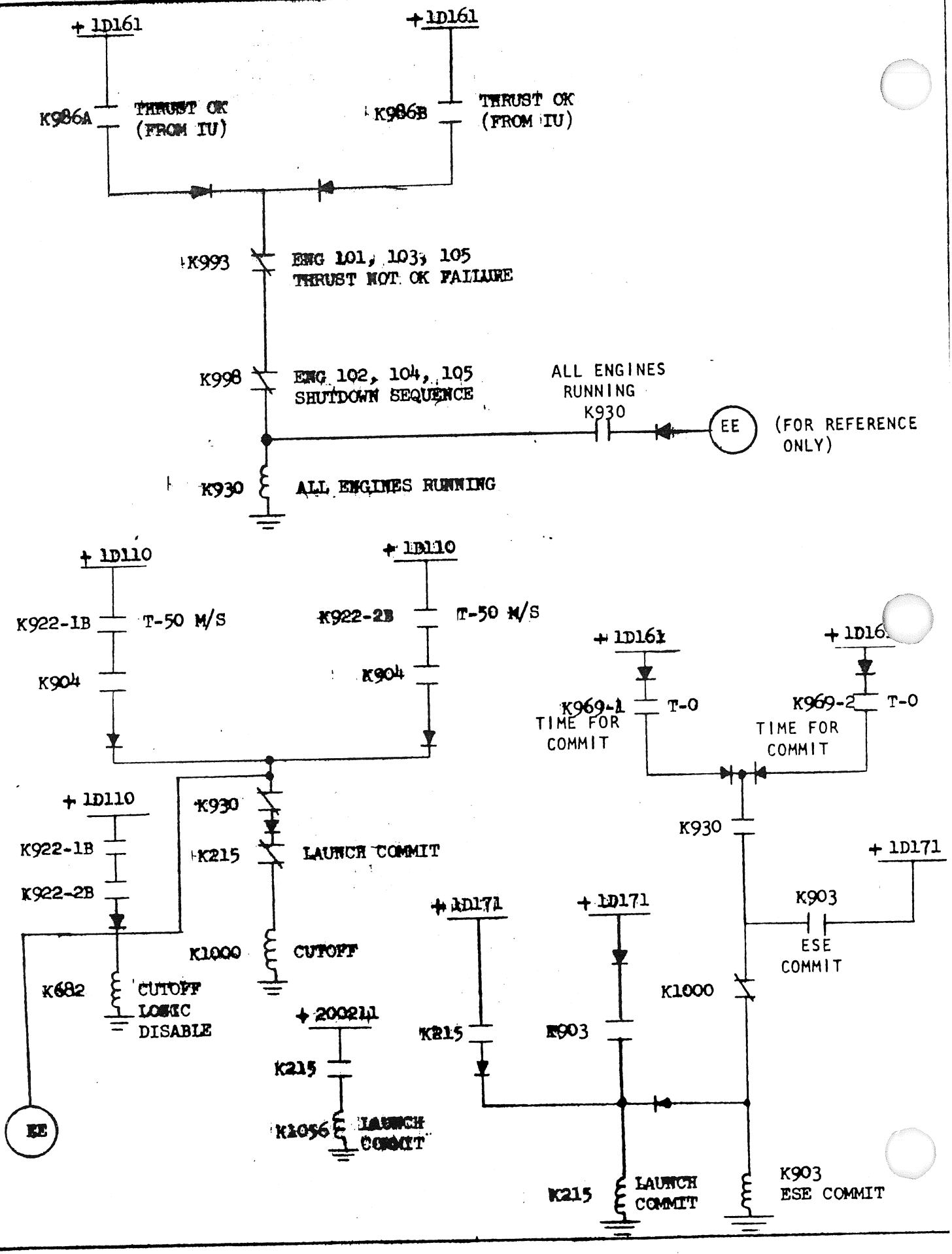

+20D211
ARM TCS
K127
TCS ARM
+1D161
K127
K128
TCS ARM
K900
FIRING COMMAND
K124
MANUAL FIRING COMMAND LATCHUP
K124
MANUAL FIRING COMMAND LATCHUP
+1D161
K927
FIRING COMMAND ENABLE
K926
FIRING PREP COMPLETE
K55
TCS REMOTE START ENABLE
+20D211
FIRING COMMAND
K927
FIRING COMMAND ENABLE
+1D171
K128
TCS ARM (SLAVE)
+1D171
K123 TCS ARMED
K1000
CUTOFF
A
ARM TCS CHANNELS (PAGE 3)
K123
TCS ARMED
K131
IGN COMMAND
B
ARM TCS CHANNELS (PAGE 4)
K961
LINKS BURNED
D
SEE PAGE 5

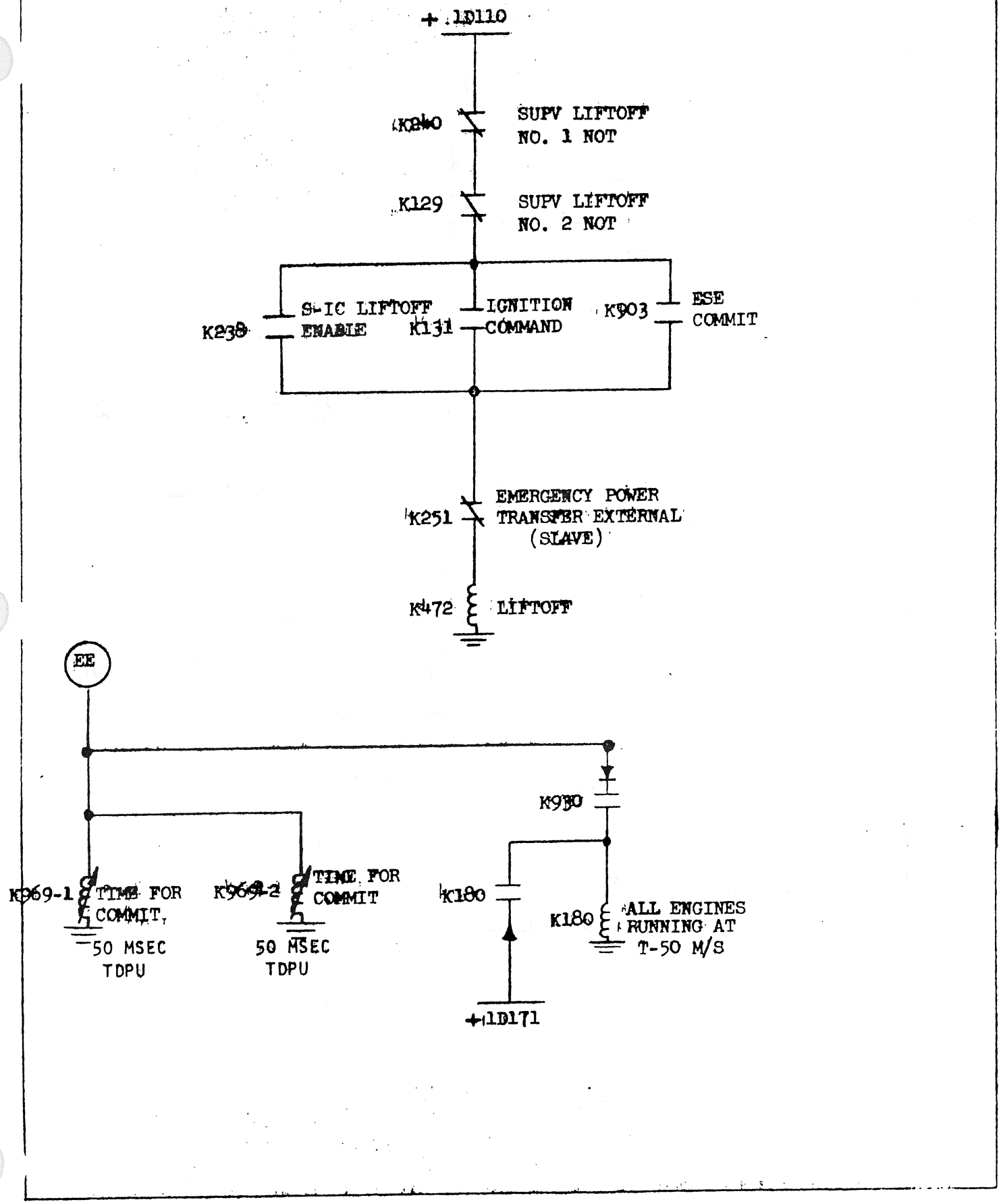

SEE PAGE 2
+1D171
K900
T-186
K1000
K900 FIRING COMMAND
+1D171
K669
K1000
T-102
HYD COMMIT K669
+1D171
T-97
K482 FUEL PRE PRESS.
+1D171
T-72
K593 LOX PRE PRESS.
T-52
+1D171
T-50
K213 S-IC POWER TRANS.
+1D161
T-30
K855
K855 STAGE RETURN C/O VALVE
C
SEE PAGE 4
+20D211
K900
K1055 FIRING COMMAND
FIRING COMMAND LIGHT
+20D111
K1055
+1D161
K557 LOX INTERCON VALVE CLOSED CMD
INHIBIT C/O VALVES TO GROUND RETURN
+1D161
K855
TO OTHER C/O VALVES
K801 ENG 101 C/O VLV TO STG. RET.
ENG 101 C/O VLV STG POS. K806
STAGE LIGHT
+1D110
K806
K826
K846
K866
K886
K902
ALL C/O VLVS IN STAGE RETN POSIT.
+1D131
+1D131
K801
IDCOM
MOT
C/O VLV SELECTOR MOTOR

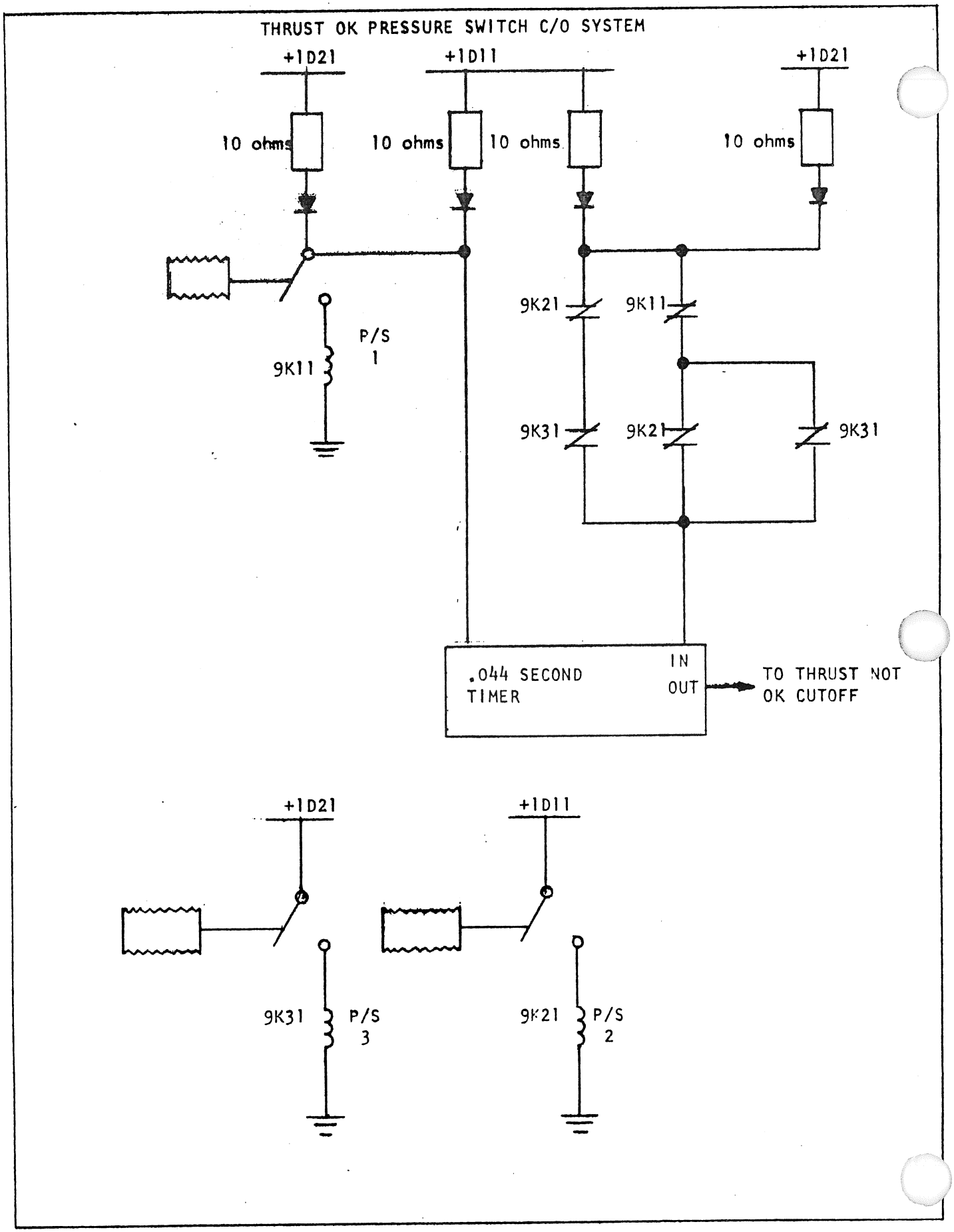

SEE PAGE 3
+1D171
K557
T-20
C
DISABLE INTERCOM LOCKUP
K939
K557
LOK INTERCOM VLV CL COMM
+1D171
K130
T-8.9
K130
TIME FOR IGNITION
K928
READY FOR IGNITION
K131
IGNITION COMMAND
K131
+1D171
CUTOFF COMPLETE
K939
K922-2B
T-50 M/S VOTING TIMER
8.85 SEC
TDPU
K922-1B
T-50 M/S VOTING TIMER
8.85 SEC
TDPU
+1D171
K928
K107
K131
3-2 C/O
K107
SEQUENCE FAILURE
B
SEE PAGE 2
T-8.8
K936
START IGNITER NO. 1
T-8.7
K940
START IGNITER NO. 2
T-6.7
K981
K981
TIME FOR LINKS BURN
K981
+1D171
K981
K961
LINKS BURNED
+1D171
K916
LINKS BURN FAILURE
3-2 C/O
K916
LINKS BURN FAILURE

*THESE TIMES ARE NOMINAL TIMES ONLY.
REFER TO SK60B57201, PAGE 68.

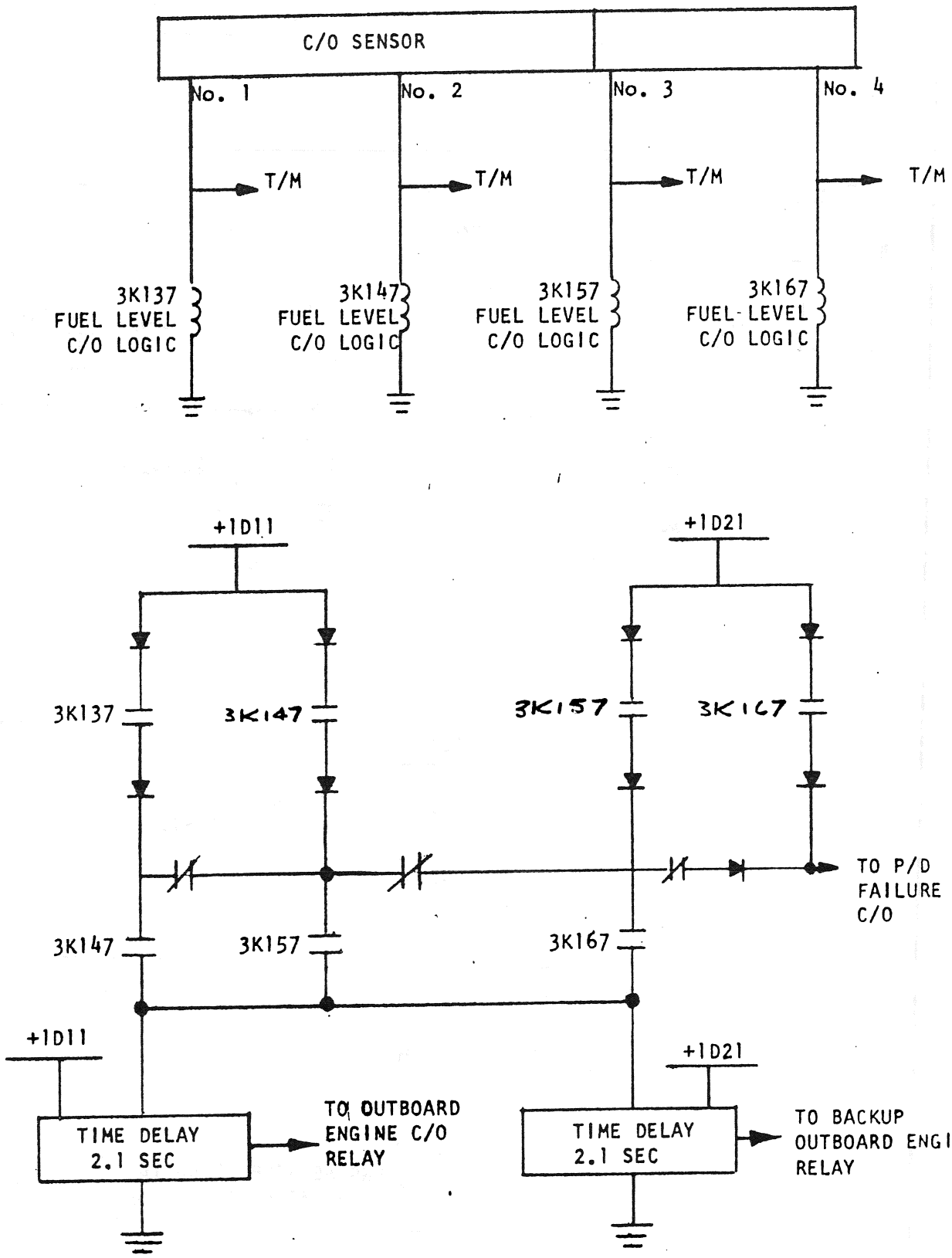


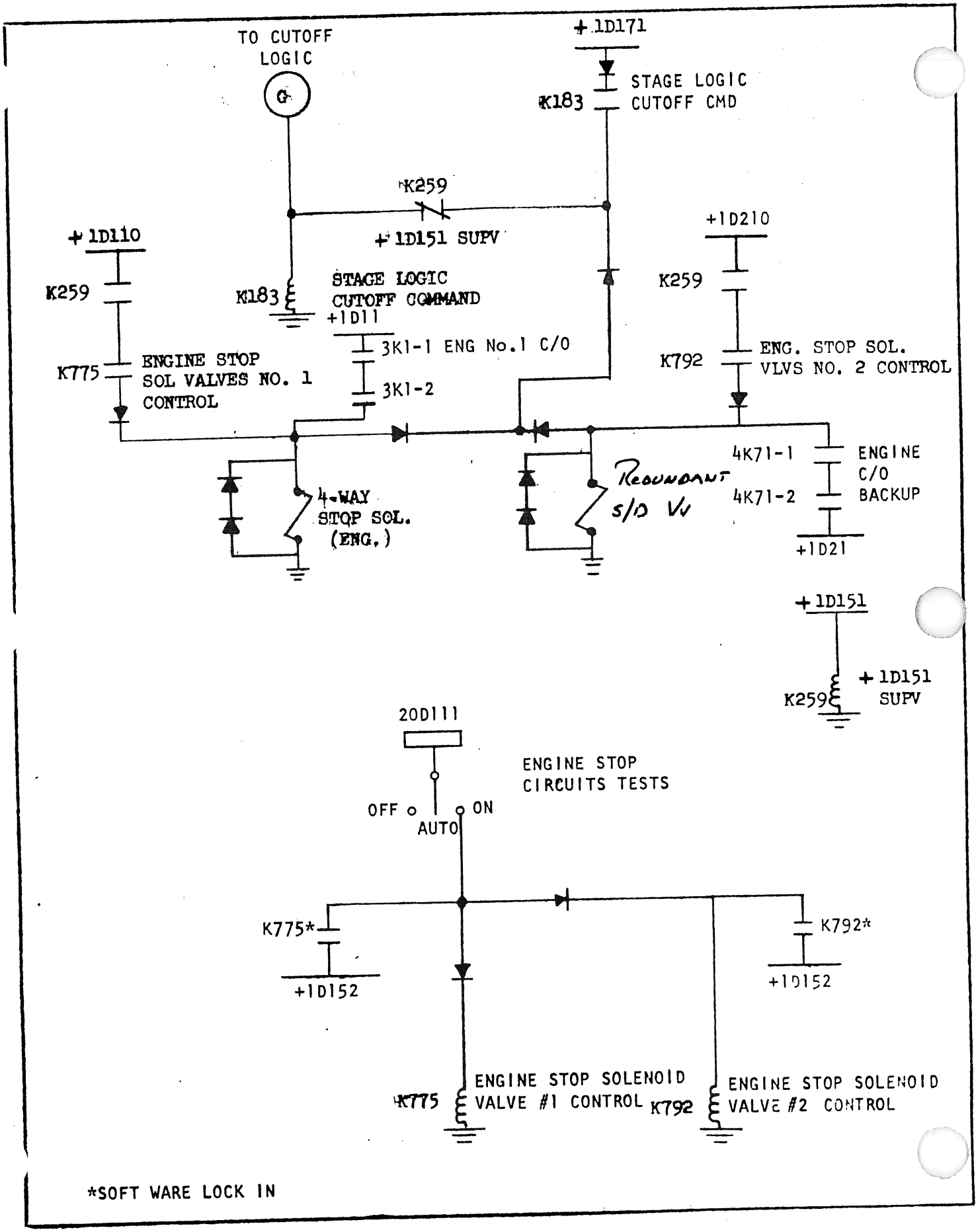

+1D161
+1D161
K986A
THRUST OK (FROM IU)
K986B
THRUST OK (FROM IU)
K993
ENG 101, 103, 105 THRUST NOT OK FAILURE
K998
ENG 102, 104, 105 SHUTDOWN SEQUENCE
ALL ENGINES RUNNING K930
EE
(FOR REFERENCE ONLY)
K930
ALL ENGINES RUNNING
+1D110
+1D110
K922-1B
T-50 M/S
K922-2B
T-50 M/S
K904
K904
+1D161
+1D161
K969-1
T-0
TIME FOR COMMIT
K969-2
T-0
TIME FOR COMMIT
+1D110
K930
K922-1B
K215
LAUNCH COMMIT
K922-2B
K930
+1D171
K903
ESE COMMIT
+1D171
+1D171
K1000
CUTOFF
K1000
K682
CUTOFF LOGIC DISABLE
+200211
K215
K903
K215
K1056
LAUNCH COMMIT
EE
K215
LAUNCH COMMIT
K903
ESE COMMIT


+1D110
K240
SUPV LIFTOFF NO. 1 NOT
K129
SUPV LIFTOFF NO. 2 NOT
K238
S-IC LIFTOFF ENABLE
K131
IGNITION COMMAND
K903
ESE COMMIT
K251
EMERGENCY POWER TRANSFER EXTERNAL (SLAVE)
K472
LIFTOFF
EE
K930
K969-1
TIME FOR COMMIT
50 MSEC TDPU
K969-2
TIME FOR COMMIT
50 MSEC TDPU
K180
K180
ALL ENGINES RUNNING AT T-50 M/S
+1D171


THRUST OK PRESSURE SWITCH C/O SYSTEM
+1D21
+1D11
+1D21
10 ohms
10 ohms
10 ohms
10 ohms
9K21
9K11
P/S
1
9K11
9K31
9K21
9K31
.044 SECOND
TIMER
IN
OUT
TO THRUST NOT
OK CUTOFF
+1D21
+1D11
9K31
P/S
3
9K21
P/S
2

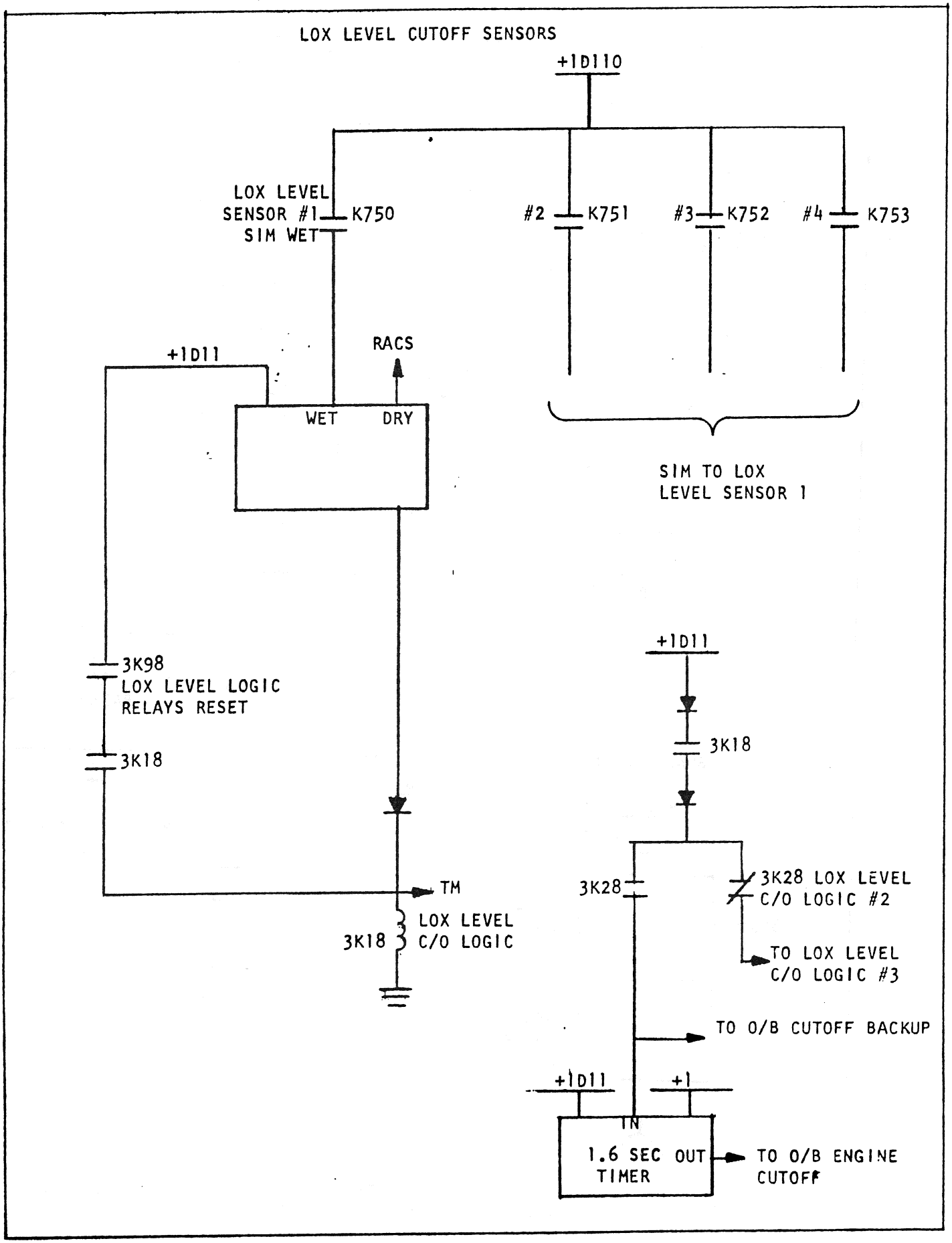
FUEL DEPLETION SENSORS C/O

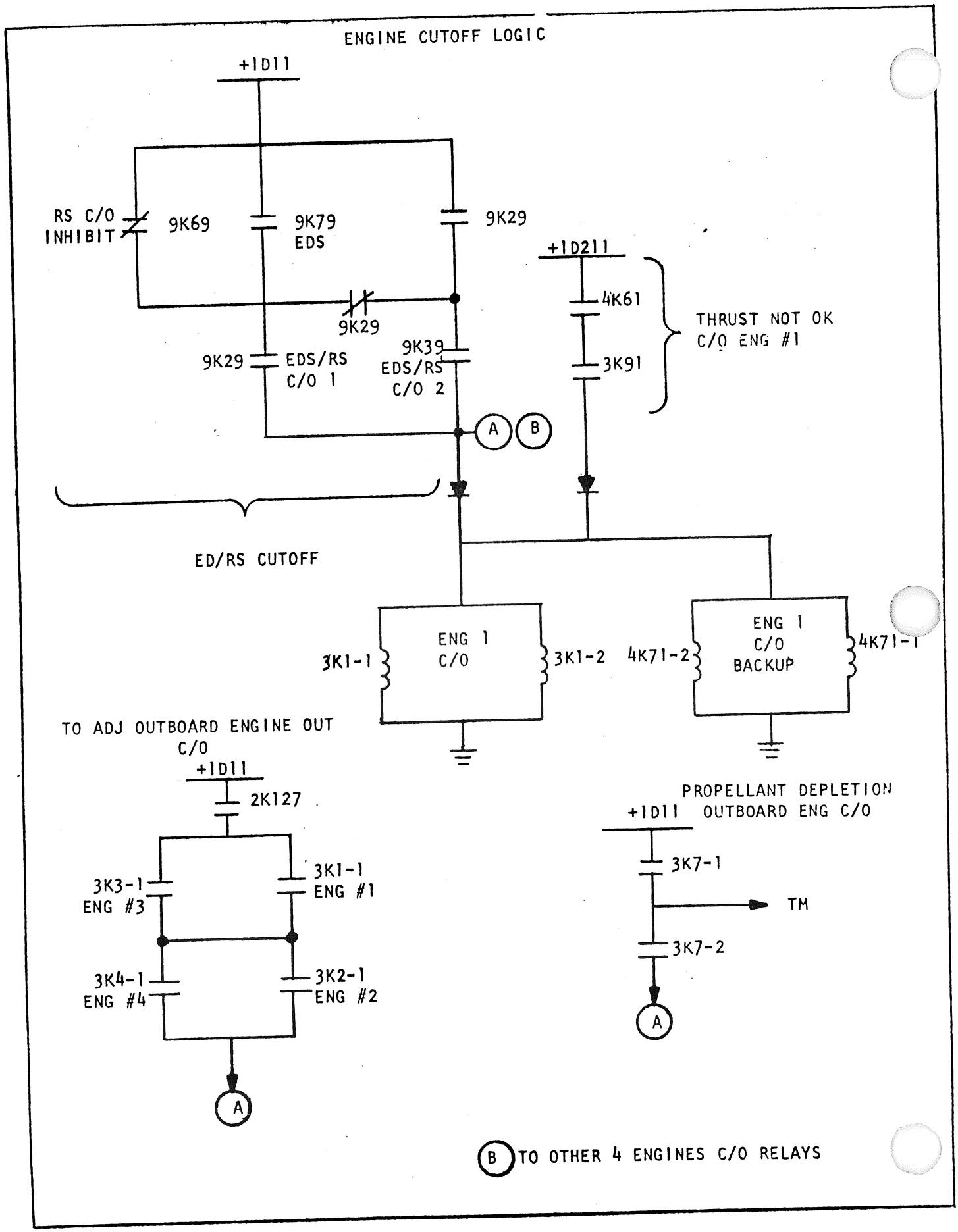


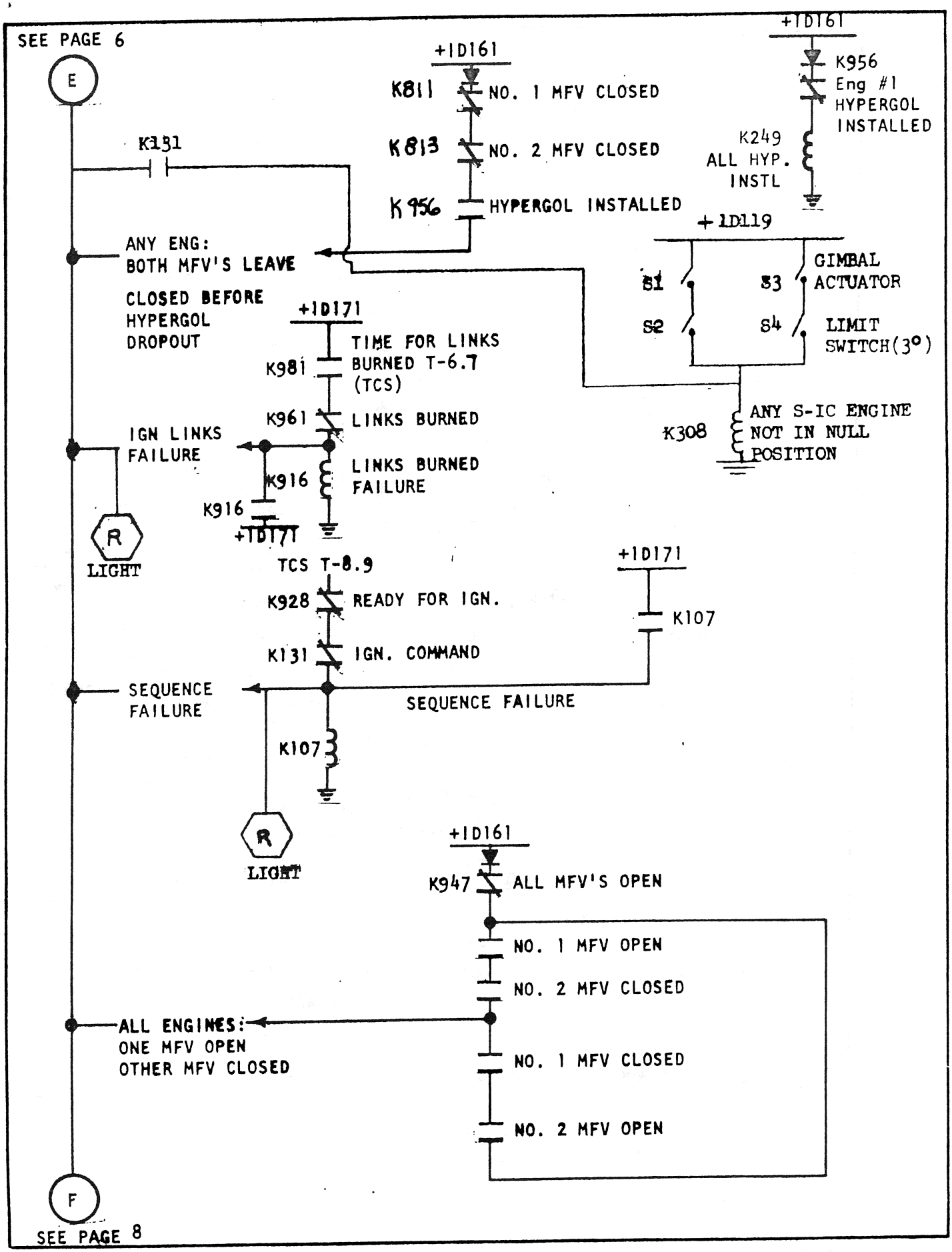


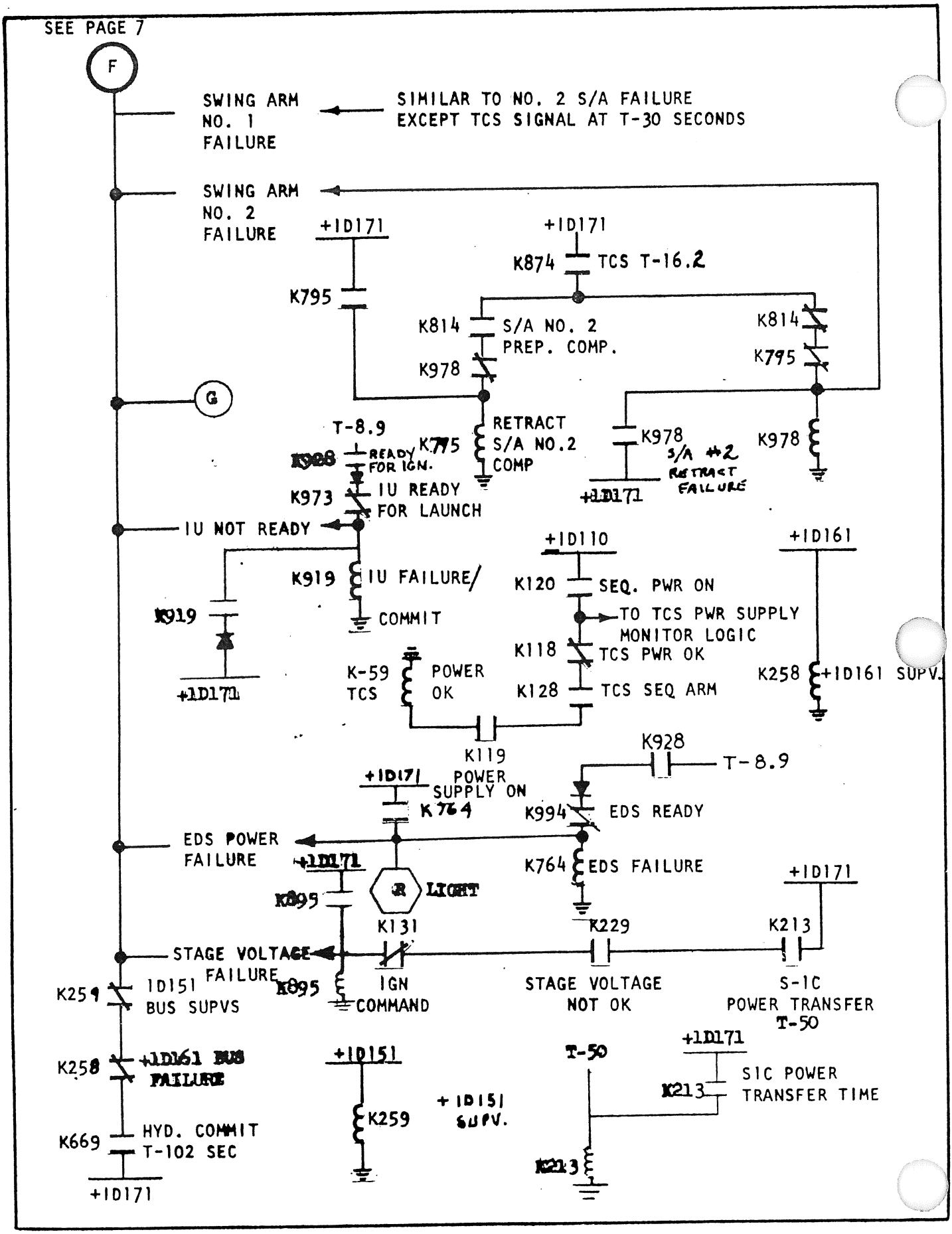
*SOFT WARE LOCK IN

STAGE LOGIC CUTOFF


LOX LEVEL CUTOFF SENSORS
+1D110
LOX LEVEL SENSOR #1 K750
SIM WET
#2 K751
#3 K752
#4 K753
SIM TO LOX LEVEL SENSOR 1
+1D11
RACS
WET
DRY
3K98
LOX LEVEL LOGIC RELAYS RESET
3K18
TM
3K18
LOX LEVEL C/O LOGIC
+1D11
3K18
3K28
3K28 LOX LEVEL C/O LOGIC #2
TO LOX LEVEL C/O LOGIC #3
TO O/B CUTOFF BACKUP
+1D11
+1
IN
1.6 SEC OUT TIMER
TO O/B ENGINE CUTOFF


ENGINE CUTOFF LOGIC
+1D11
RS C/O INHIBIT
9K69
9K79 EDS
9K29
9K29
9K29 EDS/RS C/O 1
9K39 EDS/RS C/O 2
+1D211
4K61
3K91
THRUST NOT OK C/O ENG #1
A
B
ED/RS CUTOFF
3K1-1
ENG 1 C/O
3K1-2
4K71-2
ENG 1 C/O BACKUP
4K71-1
TO ADJ OUTBOARD ENGINE OUT C/O
+1D11
2K127
3K3-1 ENG #3
3K1-1 ENG #1
3K4-1 ENG #4
3K2-1 ENG #2
A
PROPELLANT DEPLETION OUTBOARD ENG C/O
+1D11
3K7-1
TM
3K7-2
A
B TO OTHER 4 ENGINES C/O RELAYS


SEE PAGE 6
E
+1D161
K811
NO. 1 MFV CLOSED
K813
NO. 2 MFV CLOSED
K956
HYPERGOL INSTALLED
+1D161
K956
Eng #1 HYPERGOL INSTALLED
K249
ALL HYP. INSTL
K131
+1D119
S1
S3
GIMBAL ACTUATOR
S2
S4
LIMIT SWITCH(3°)
ANY ENG: BOTH MFV'S LEAVE CLOSED BEFORE HYPERGOL DROPOUT
+1D171
K981
TIME FOR LINKS BURNED T-6.7 (TCS)
K961
LINKS BURNED
K308
ANY S-IC ENGINE NOT IN NULL POSITION
IGN LINKS FAILURE
K916
LINKS BURNED FAILURE
K916
+1D171
R
LIGHT
TCS T-8.9
+1D171
K928
READY FOR IGN.
K107
K131
IGN. COMMAND
SEQUENCE FAILURE
SEQUENCE FAILURE
K107
R
LIGHT
+1D161
K947
ALL MFV'S OPEN
NO. 1 MFV OPEN
NO. 2 MFV CLOSED
ALL ENGINES: ONE MFV OPEN OTHER MFV CLOSED
NO. 1 MFV CLOSED
NO. 2 MFV OPEN
F
SEE PAGE 8


SEE PAGE 7
F
SWING ARM NO. 1 FAILURE
SIMILAR TO NO. 2 S/A FAILURE EXCEPT TCS SIGNAL AT T-30 SECONDS
SWING ARM NO. 2 FAILURE
+1D171
K795
+1D171
K874
TCS T-16.2
K814
S/A NO. 2 PREP. COMP.
K978
K814
K795
G
T-8.9
K928
READY FOR IGN.
K973
IU READY FOR LAUNCH
K795
RETRACT S/A NO.2 COMP
K978
S/A #2 RETRACT FAILURE
+1D171
K978
IU NOT READY
K919
IU FAILURE/ COMMIT
K919
+1D171
+1D110
K120
SEQ. PWR ON
TO TCS PWR SUPPLY MONITOR LOGIC
K118
TCS PWR OK
K-59 TCS
POWER OK
K128
TCS SEQ ARM
K119
+1D161
K258
+1D161 SUPV.
K928
T-8.9
+1D171
POWER SUPPLY ON
K764
K994
EDS READY
EDS POWER FAILURE
+1D171
K695
R
LIGHT
K764
EDS FAILURE
+1D171
K131
K229
K213
STAGE VOLTAGE FAILURE
K259
1D151 BUS SUPVS
K695
IGN COMMAND
STAGE VOLTAGE NOT OK
S-1C POWER TRANSFER T-50
K258
+1D161 BUS FAILURE
+1D151
K259
+1D151 SUPV.
T-50
+1D171
S1C POWER TRANSFER TIME
K213
K669
HYD. COMMIT T-102 SEC
+1D171
K213

INSTRUMENTATION LIST

C Denotes Temperature Measurement
D Denotes Pressure Measurement
E Denotes Vibration Measurement
F Denotes Flow Measurement
K Denotes Event Signal Measurement
T Denotes Turbopump Speed Measurement
* Denotes Rocketdyne Flight Measurement

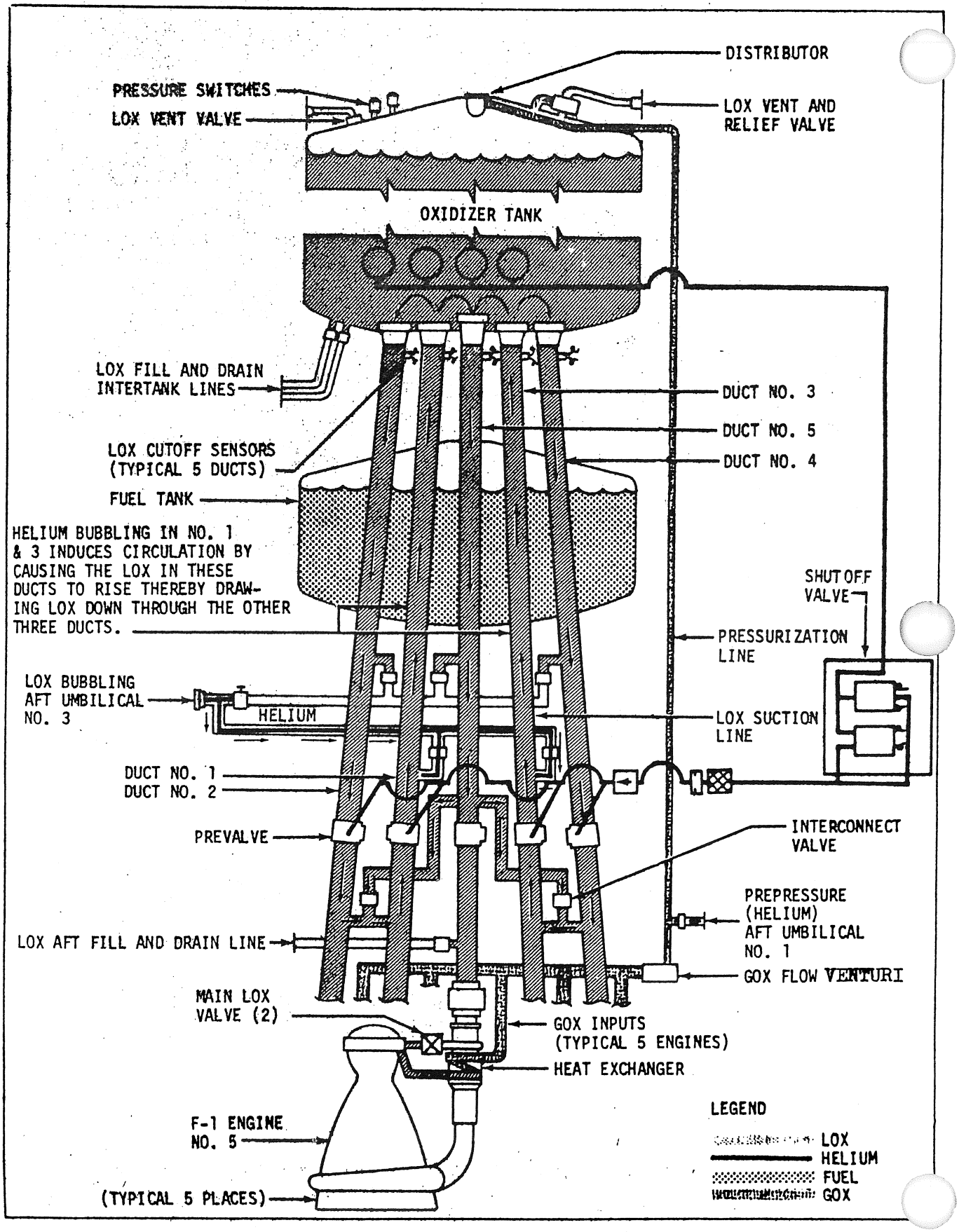
Measurement Number	Measurement Name	Range
* C003-101/105	Turbine Manifold	-15/1100 C
C004-119	LOX Bulk (Tank)	-190/-165 C
* C006-101/105	LOX Pump Bearing No. 1	-35/205 C
C192-115	Fuel Suction Line-Engine 1	0/25 C
C194-115	Fuel Suction Line-Engine 3	0/25 C
C196-115	Fuel Suction Line-Engine 5	0/25 C
C197-115	LOX Suction Line-Engine 1	-185/-155 C
C198-115	LOX Suction Line-Engine 2	-185/-155 C
C199-115	LOX Suction Line-Engine 3	-185/-155 C
C200-115	LOX Suction Line-Engine 4	-185/-155 C
C201-115	LOX Suction Line-Engine 5	-185/-155 C
C203-115	Ambient Thrust Frame	-60/50 C
* C242-101/105	Engine Environmental	-60/260 F
C20-323	Hydraulic Supply	
C21-323	Hydraulic Return	
* D003-101/105	LOX Pump Oulet No. 2	0/2000 psia
* D004-101/105	Fuel Pump Inlet No. 1	0/200 psia
* D007-101/105	Fuel Pump Outlet No. 2	0/2500 psia
* D008-101/105	Thrust Chamber	0/1500 psia
* D009-101/105	Gas Generator Combustor	0/1500 psia
* D010-101/105	Turbine Outlet	0/100 psia
* D013-101/105	LOX Pump Bearing Jet	0/1000 psia
D016-101/104	Gimbal System Hydraulic Supply	0/2500 psia
D021-101/104	Pitch Actuator Differential	± 2500 psid
D022-101/104	Yaw Actuator Differential	± 2500 psid
D067-115	GN_2 Purge Sphere	0-3500 psia
D124-115	Purge Regulator Outlet	0/150 psia
* D126-101/105	Engine Hydraulic Control System Return	0/500 psia
D127-115	LOX Suction Line-Engine 1	0/200 psia
D128-115	LOX Suction Line-Engine 2	0/200 psia
D129-115	LOX Suction Line-Engine 3	0/200 psia
D130-115	LOX Suction Line-Engine 4	0/200 psia
D131-115	LOX Suction Line-Engine 5	0/200 psia
D30-323	Hydraulic Supply	
D31-323	LOX Dome and GG Injector Purge	
D90-117	Fuel Tank Ullage	0/45 psia
D152-117	Fuel Tank Ullage	0/45 psia
D94-119	LOX Tank Ullage	0/45 psia
D153-119	LOX Tank Ullage	0/45 psia

INSTRUMENTATION LIST
(Cont'd)

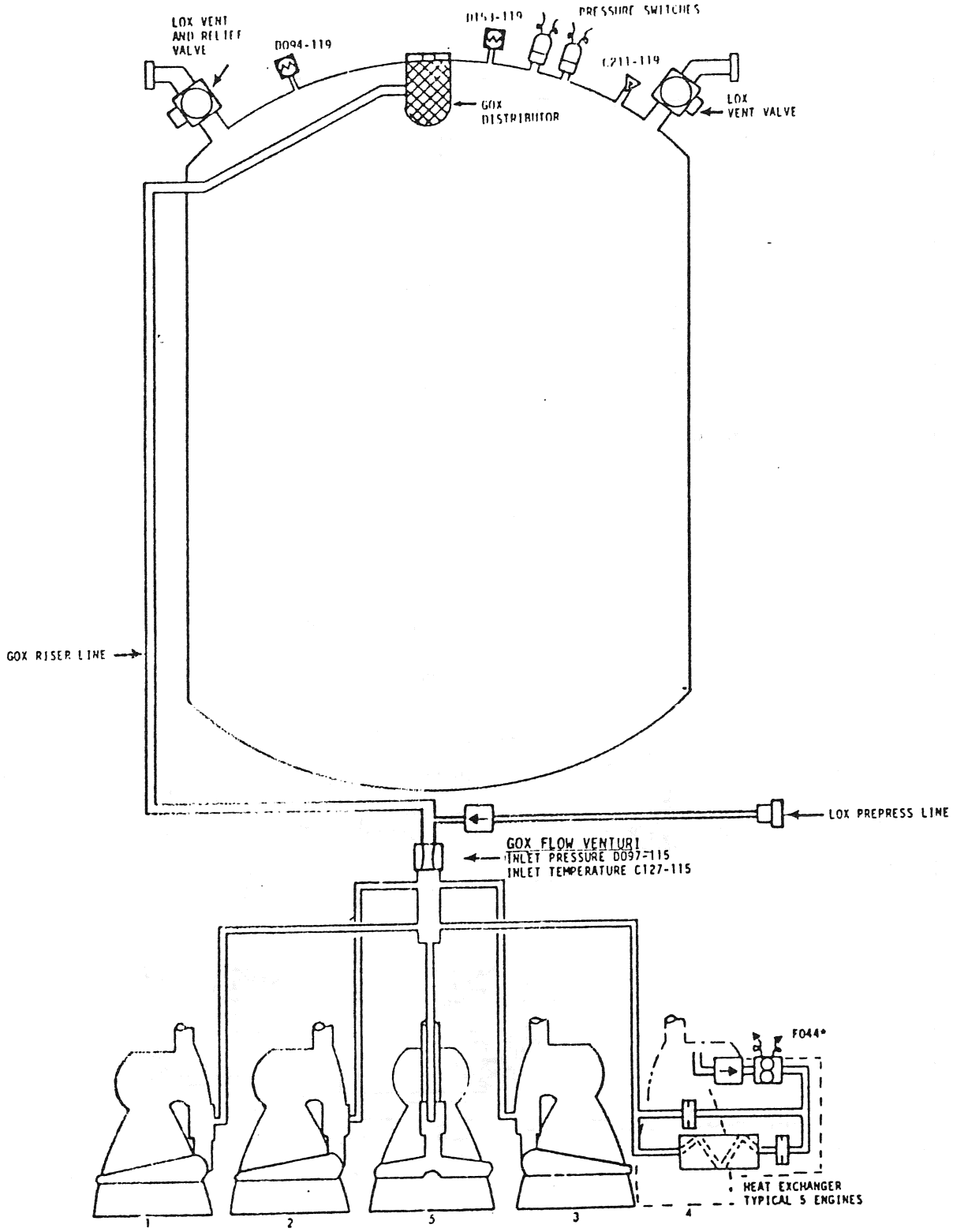
	Measurement Number	Measurement Name	Range
	D182-115	Helium Supply	0/800 psia
	D132-115	Turbopump LOX Seal Purge-Engine 1	0/150 psia
	D097-119	GOX Venturi Inlet	0/1500 psia
	D145-115	Helium Inlet Manifold	0/400 psia
	D146-115	Fuel Suction Line Inlet	0/300 psia
	D154-116	Heat Exchanger Helium Manifold Outlet	0/200 psia
	D155-116	Helium Flow Control Valve Outlet	0/400 psia
*	F0044-101/105	Flow Rate LOX Heat Exchanger Inlet DC	0/14 lb/sec
	K003-115	Outboard Cutoff Signal	On/Off
	K004-115	Engine 105 Cutoff Signal Stop Solenoid #1	On/Off
*	K006-101/105	Limit Switch Gas Generator Valve	Open/Closed
*	K007-101/105	Limit Switch Fuel Valve No. 1	Open/Closed
*	K008-101/105	Limit Switch Fuel Valve No. 2	Open/Closed
*	K009-101/105	Limit Switch LOX Valve No. 1	Open/Closed
*	K010-101/105	Limit Switch LOX Valve No. 2	Open/Closed
*	K033-115	Thrust OK Pressure Switch #1, Engine 1	On/Off
*	K034-115	Thrust OK Pressure Switch #2, Engine 1	On/Off
*	K035-115	Thrust OK Pressure Switch #3, Engine 1	On/Off
*	K036-115	Thrust OK Pressure Switch #1, Engine 2	On/Off
*	K037-115	Thrust OK Pressure Switch #2, Engine 2	On/Off
*	K038-115	Thrust OK Pressure Switch #3, Engine 2	On/Off
*	K039-115	Thrust OK Pressure Switch #1, Engine 3	On/Off
*	K040-115	Thrust OK Pressure Switch #2, Engine 3	On/Off
*	K041-115	Thrust OK Pressure Switch #3, Engine 3	On/Off
*	K042-115	Thrust OK Pressure Switch #1, Engine 4	On/Off
*	K043-115	Thrust OK Pressure Switch #2, Engine 4	On/Off
*	K044-115	Thrust OK Pressure Switch #3, Engine 4	On/Off
*	K045-115	Thrust OK Pressure Switch #1, Engine 5	On/Off
*	K046-115	Thrust OK Pressure Switch #2, Engine 5	On/Off
*	K047-115	Thrust OK Pressure Switch #3, Engine 5	On/Off
	K050-115	Fuel Level Cutoff Sensor No. 1	On/Off
	K051-115	Fuel Level Cutoff Sensor No. 2	On/Off
	K052-115	Final Thrust OK Cutoff Engine 1	On/Off
	K053-115	Final Thrust OK Cutoff Engine 2	On/Off
	K054-115	Final Thrust OK Cutoff Engine 3	On/Off
	K055-115	Final Thrust OK Cutoff Engine 4	On/Off
	K056-115	Final Thrust OK Cutoff Engine 5	On/Off
	K057-115	Final LOX Level Cutoff Outboard	On/Off
	K059-118	Helium Flow Control Valve No. 1 Open	On/Off
	K060-118	Helium Flow Control Valve No. 2 Open	On/Off
	K061-118	Helium Flow Control Valve No. 3 Open	On/Off
	K062-118	Helium Flow Control Valve No. 4 Open	On/Off
	K063-118	Helium Flow Control Valve No. 5 Open	On/Off
	K064-120	LOX Tank Vent Valve Open	On/Off
	K065-118	Fuel Tank Vent Valve Open	On/Off
	K085-120	LOX Tank Vent Valve Close	On/Off
	K086-118	Fuel Tank Vent Valve Close	On/Off
	K092-115	Engine #1, Cutoff Signal, Stop Solenoid #1	On/Off

INSTRUMENTATION LIST
(Cont'd)

Measurement Number	Measurement Name	Range
K093-115	Engine #2, Cutoff Signal, Stop Solenoid #1	On/Off
K094-115	Engine #3, Cutoff Signal, Stop Solenoid #1	On/Off
K095-115	Engine #4, Cutoff Signal, Stop Solenoid #1	On/Off
K097-115 thru K106-115	LOX Pre-valve Open and Closed, Engine 1-5	On/Off
K107-115 and K108-115	Fuel Pre-valve #1, Engine 2, Open & Closed	On/Off
K109-115 and K110-115	Fuel Pre-valve #2, Engine 2, Open & Closed	On/Off
K111-115 and K112-115	Fuel Pre-valve #1, Engine 5, Open & Closed	On/Off
K113-115 and K114-115	Fuel Pre-valve #2, Engine 5, Open & Closed	On/Off
K124-120	LOX Tank Vent Valve	Open/Closed
K0169-115	Engine 1 C/O Stop Solenoid 2	On/Off
K0170-115	Engine 2 C/O Stop Solenoid 2	On/Off
K0171-115	Engine 3 C/O Stop Solenoid 2	On/Off
K0172-115	Engine 4 C/O Stop Solenoid 2	On/Off
K0173-115	Engine 5 C/O Stop Solenoid 2	On/Off
K174-118	LOX Level Cutoff No. 5	On/Off
K175-115	Outboard Cutoff Signal	On/Off
K187-115	Final Fuel Level Cutoff-Outboard	On/Off
M0001-115	Measuring Voltage No. 1	0/5 VDC
M0002-115	Measuring Voltage No. 2	0/5 VDC
XM0008-115	Voltage Bus 1	24/32 VDC
XM0009-115	Voltage Bus 2	24/32 VDC
XM0010-115	Battery Current 1	0/50 AMPS
XM0011-115	Battery Current 2	0/50 AMPS
T0001-101/105	Turbopump RPM-Engine 1-5	0/6000 RPM

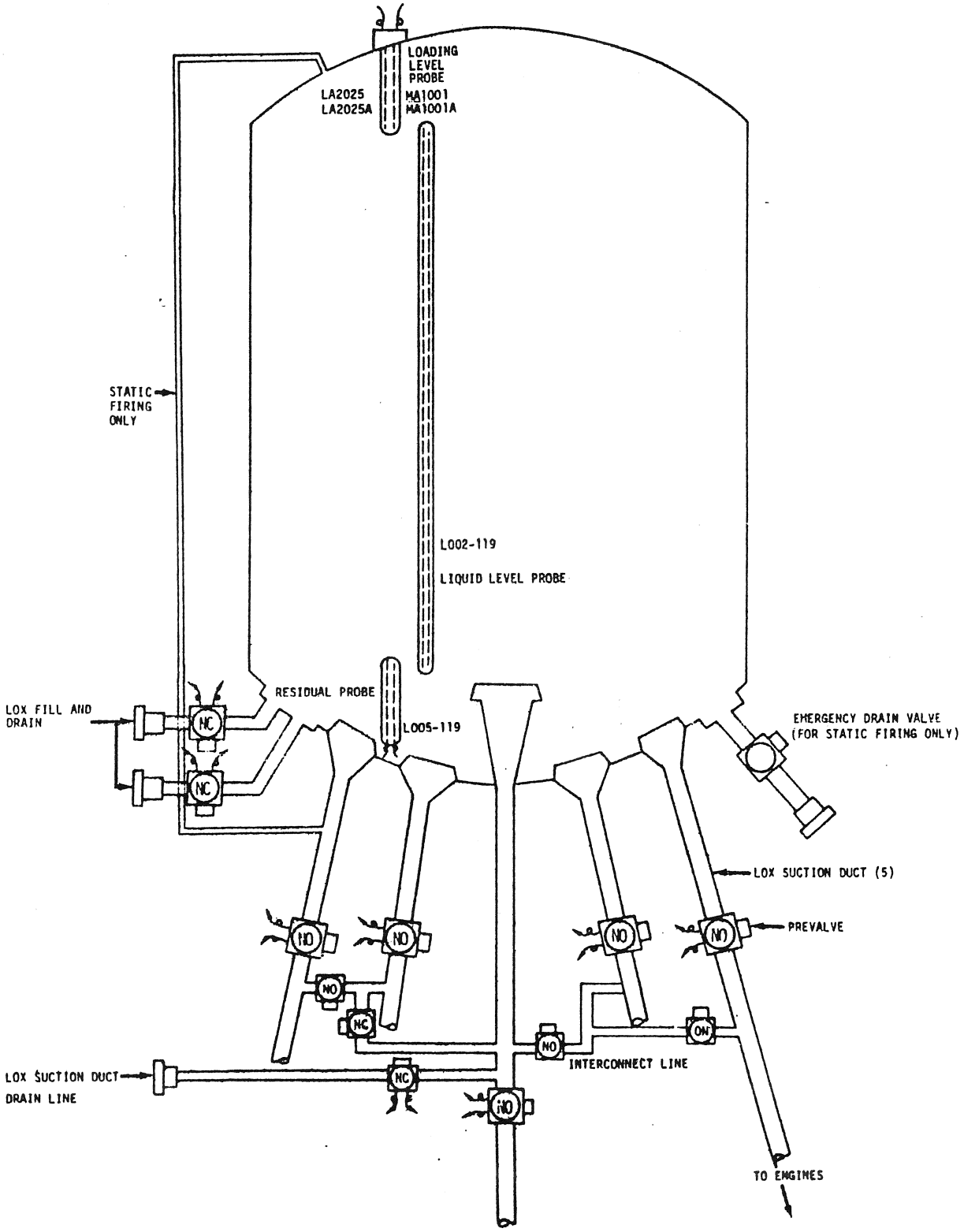

DISTRIBUTOR
PRESSURE SWITCHES
LOX VENT VALVE
LOX VENT AND RELIEF VALVE
OXIDIZER TANK
LOX FILL AND DRAIN INTERTANK LINES
DUCT NO. 3
DUCT NO. 5
DUCT NO. 4
LOX CUTOFF SENSORS (TYPICAL 5 DUCTS)
FUEL TANK
HELIUM BUBBLING IN NO. 1 & 3 INDUCES CIRCULATION BY CAUSING THE LOX IN THESE DUCTS TO RISE THEREBY DRAWING LOX DOWN THROUGH THE OTHER THREE DUCTS.
SHUT OFF VALVE
PRESSURIZATION LINE
LOX BUBBLING AFT UMBILICAL NO. 3
HELIUM
LOX SUCTION LINE
DUCT NO. 1
DUCT NO. 2
PREVALVE
INTERCONNECT VALVE
PREPRESSURE (HELIUM) AFT UMBILICAL NO. 1
LOX AFT FILL AND DRAIN LINE
GOX FLOW VENTURI
MAIN LOX VALVE (2)
GOX INPUTS (TYPICAL 5 ENGINES)
HEAT EXCHANGER
F-1 ENGINE NO. 5
(TYPICAL 5 PLACES)
LEGEND
LOX
HELIUM
FUEL
GOX

S-IC LOX TANK PRESSURIZATION SYSTEMS SCHEMATIC

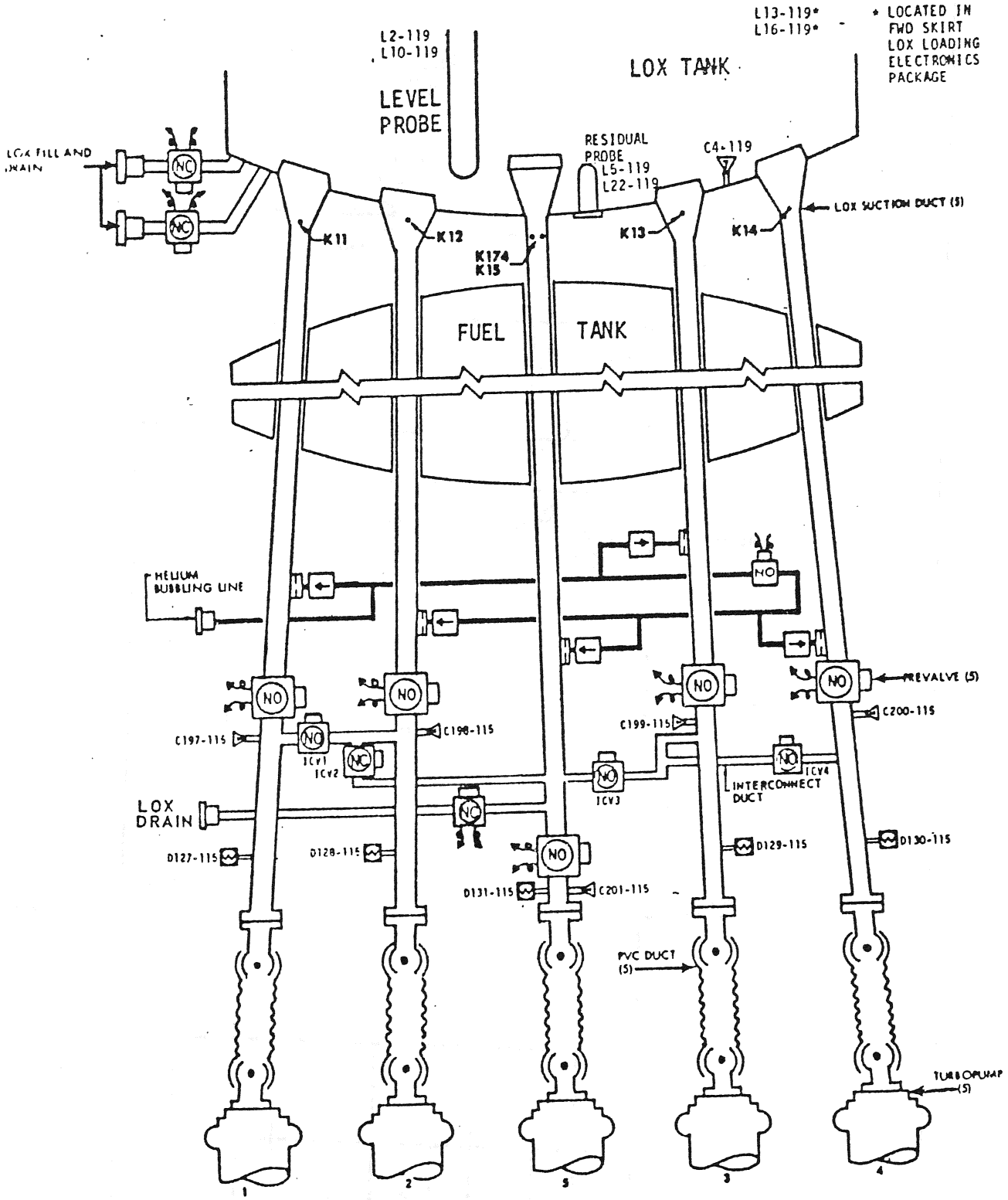


*TYPICAL OF INSTRUMENTATION IN THE FIVE HEAT EXCHANGERS

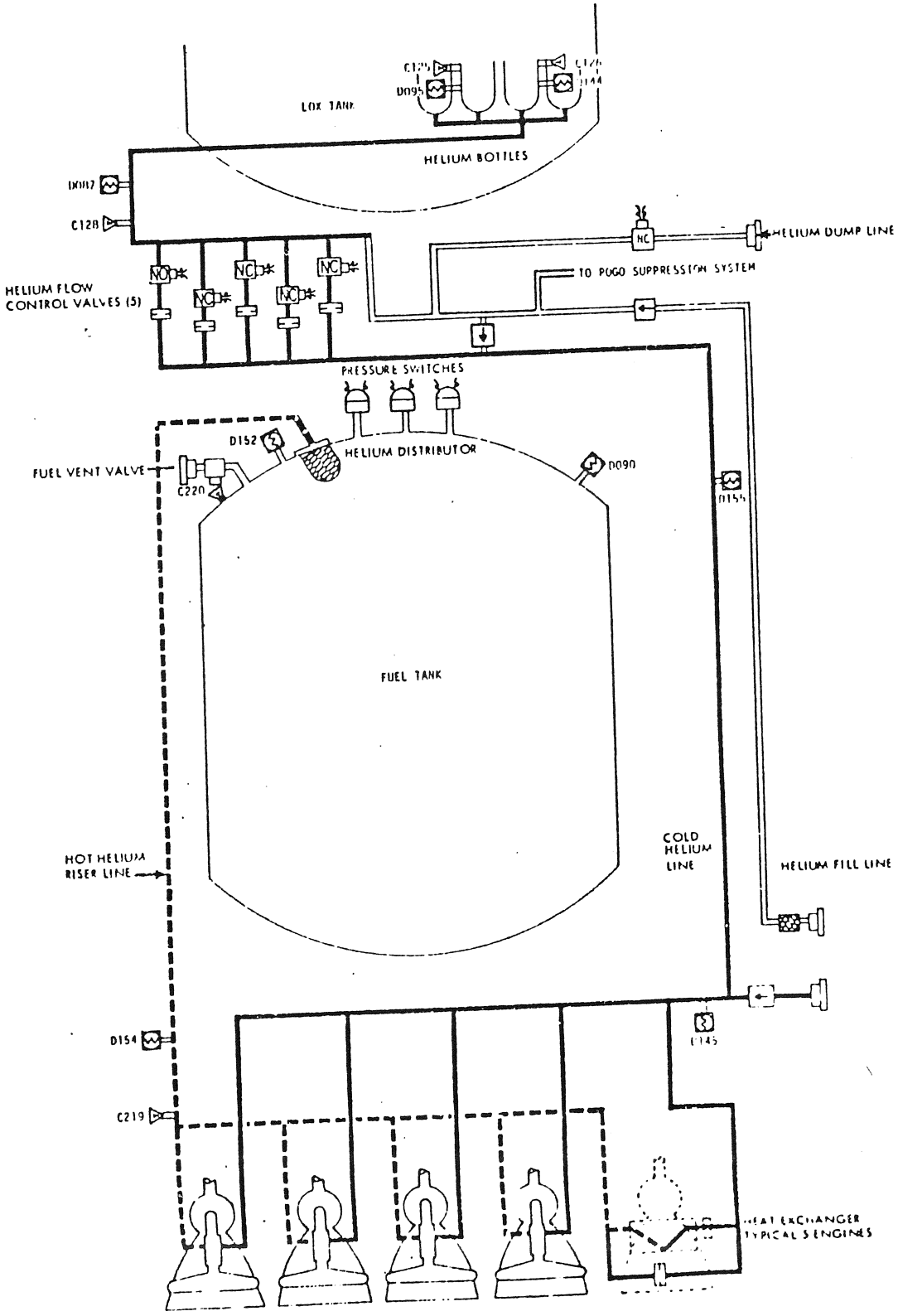
LOX SYSTEMS
LOX FILL AND DRAIN SYSTEMS



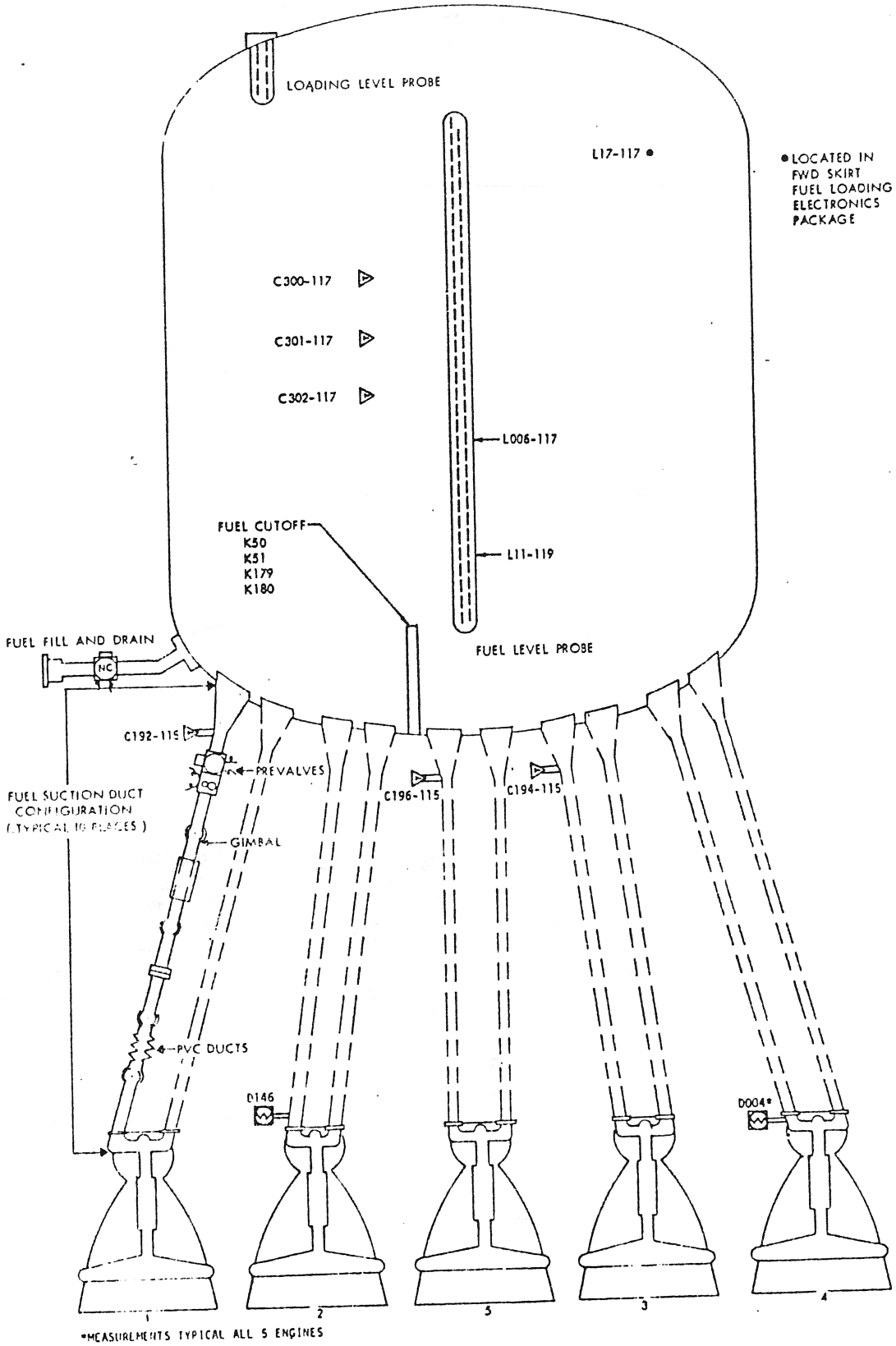
LOX FILL AND DELIVERY/HELIUM BUBBLING SCHEMATIC



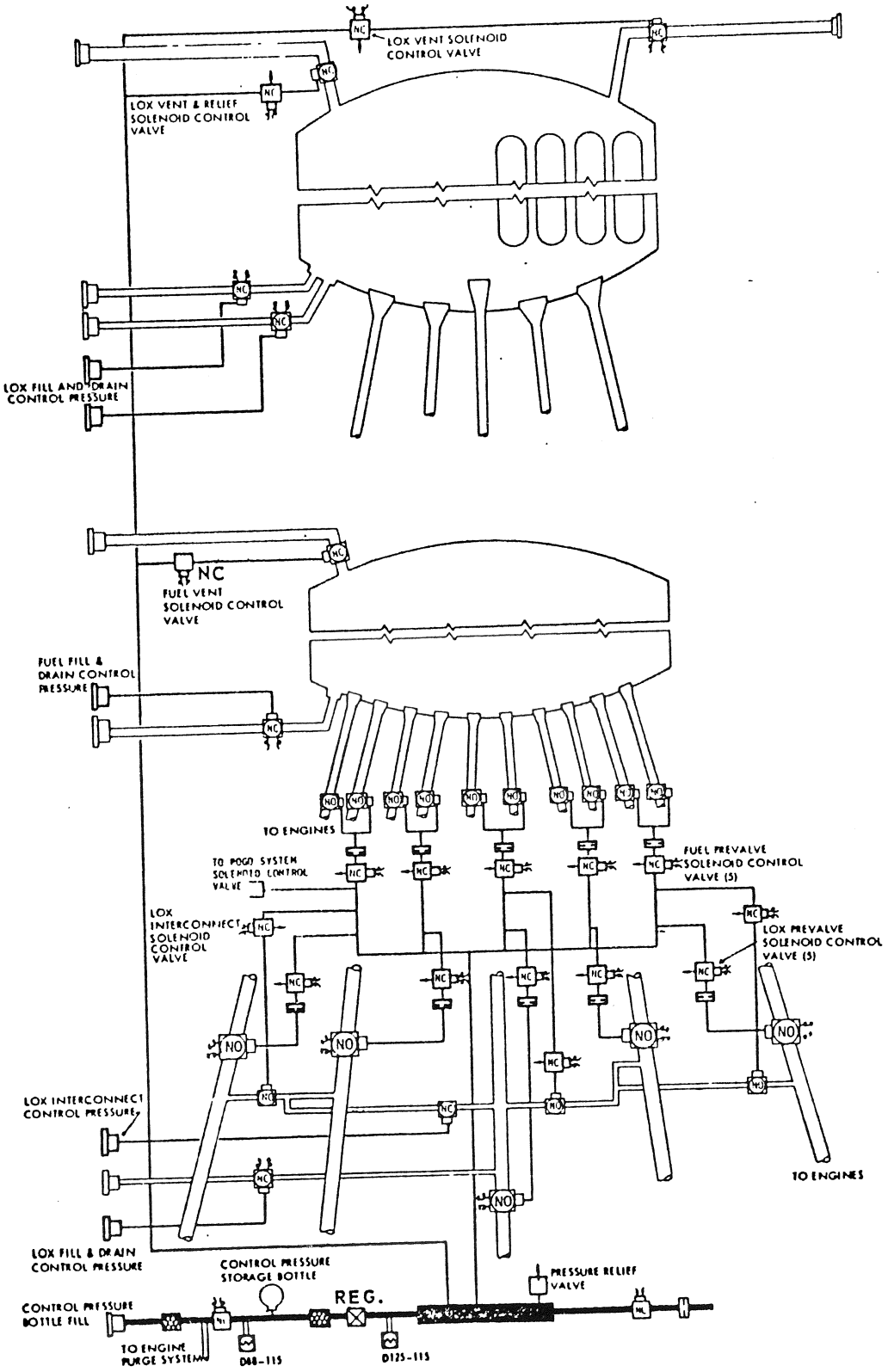
S-IC FUEL TANK PRESSURIZATION SYSTEMS SCHEMATIC



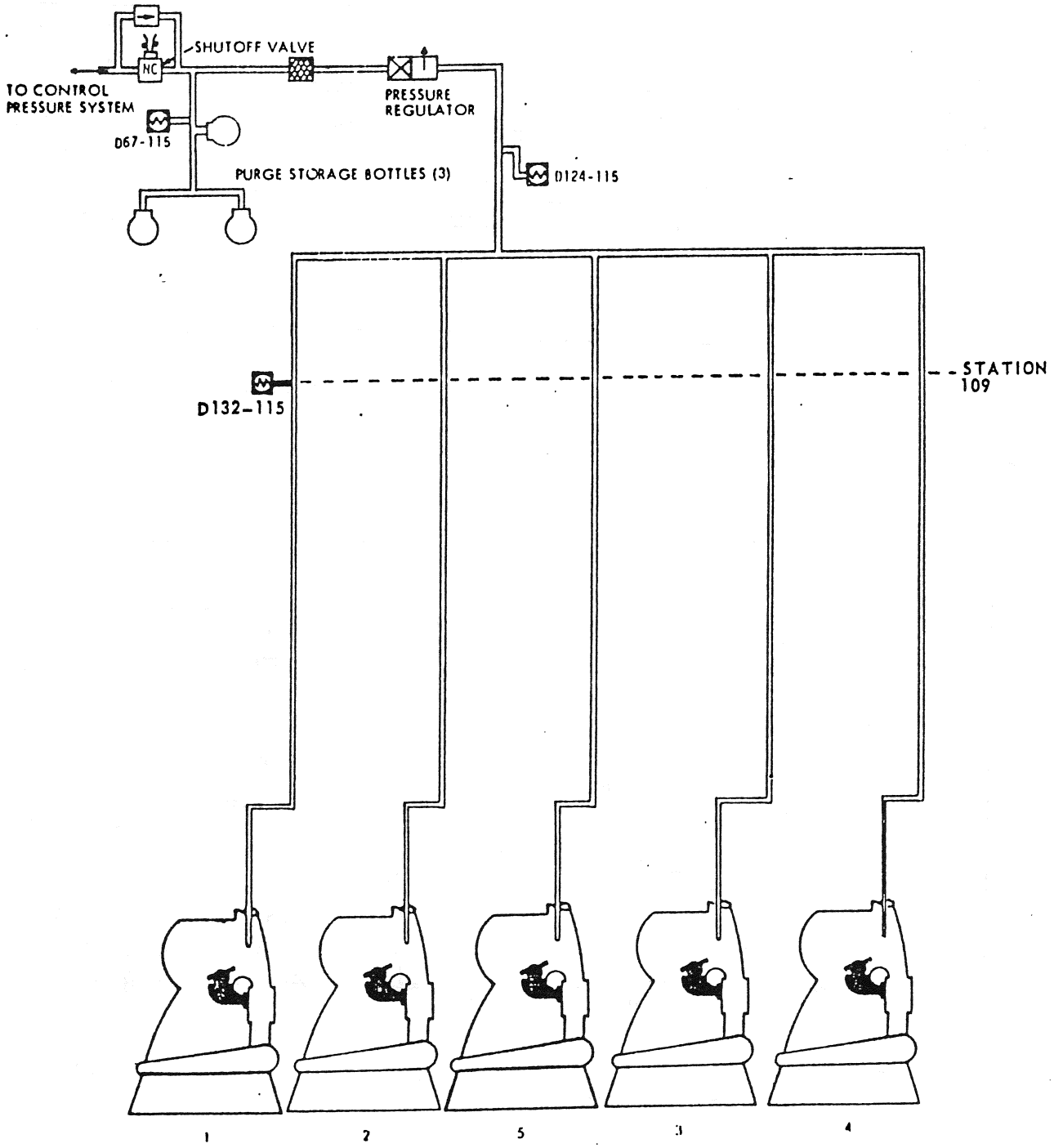
FUEL FILL AND DELIVERY SYSTEM



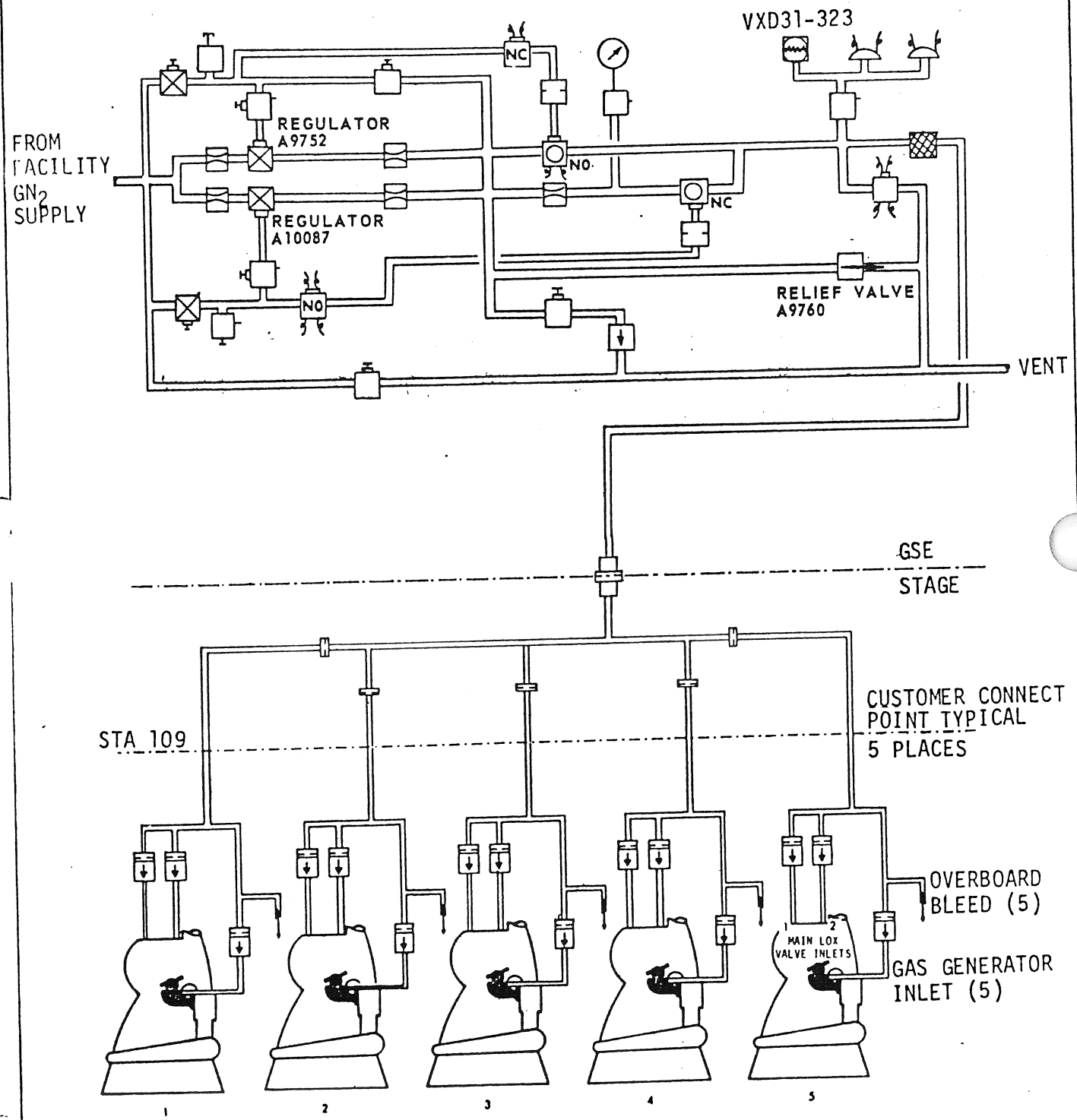
S-IC CONTROL PRESSURE SYSTEMS SCHEMATIC



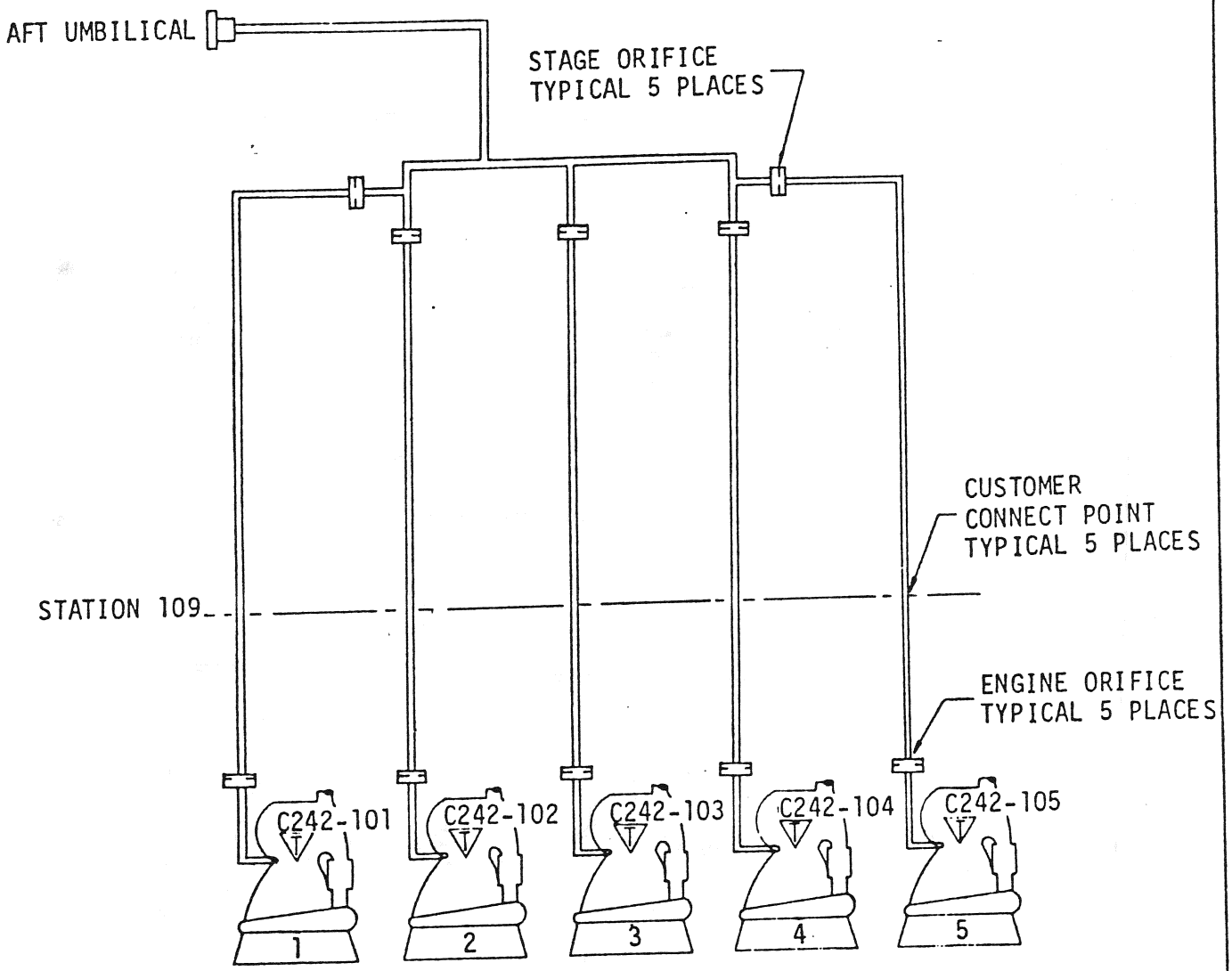
S-IC PURGE SYSTEMS
TURBOPUMP LOX SEAL PURGE SCHEMATIC



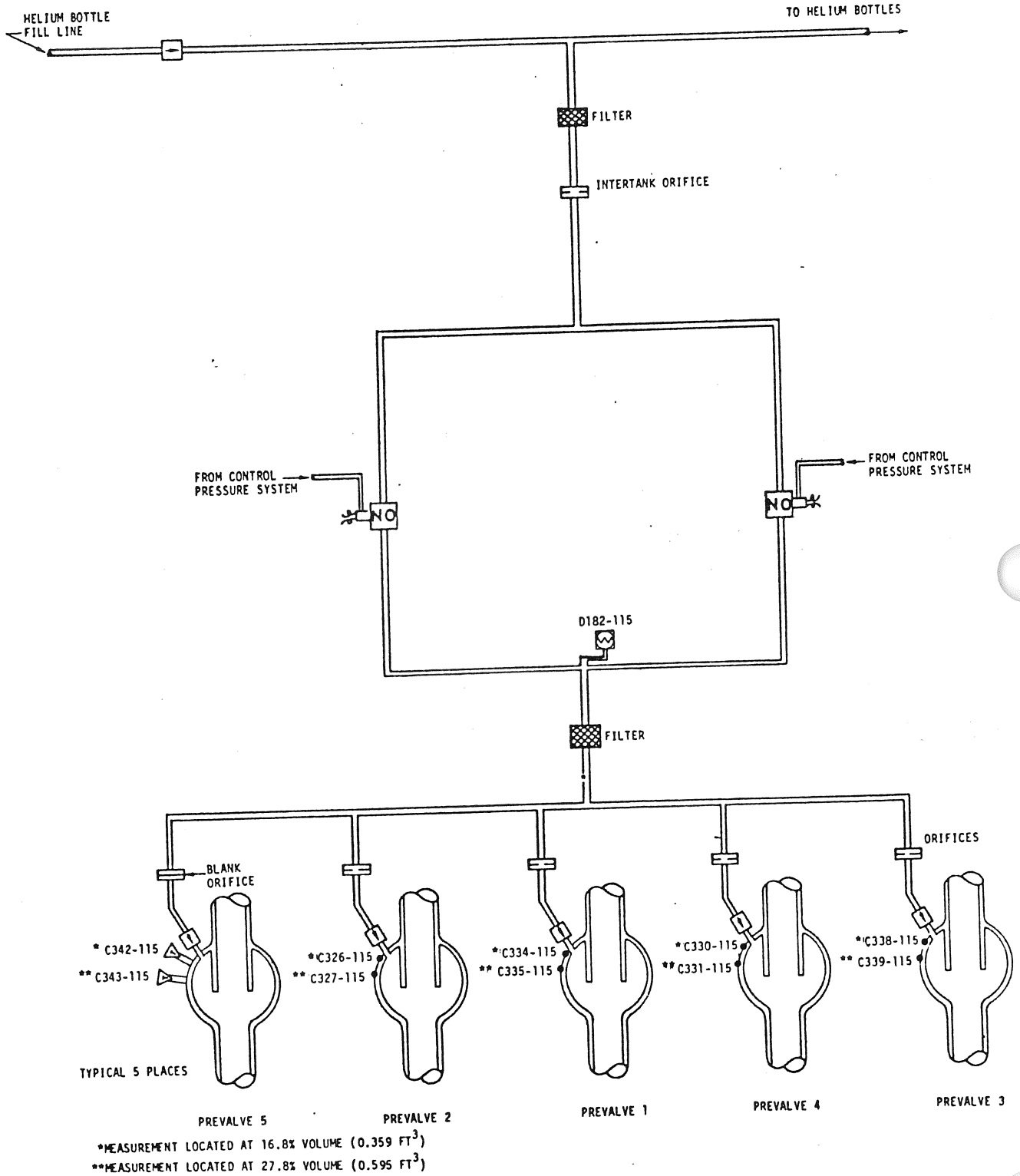
S-IC PURGE SYSTEMS
LOX DOME AND GAS GENERATOR LOX INJECTOR PURGE SCHEMATIC



S-IC PURGE SYSTEMS
ENGINE COCOON THERMAL CONDITIONING PURGE SCHEMATIC



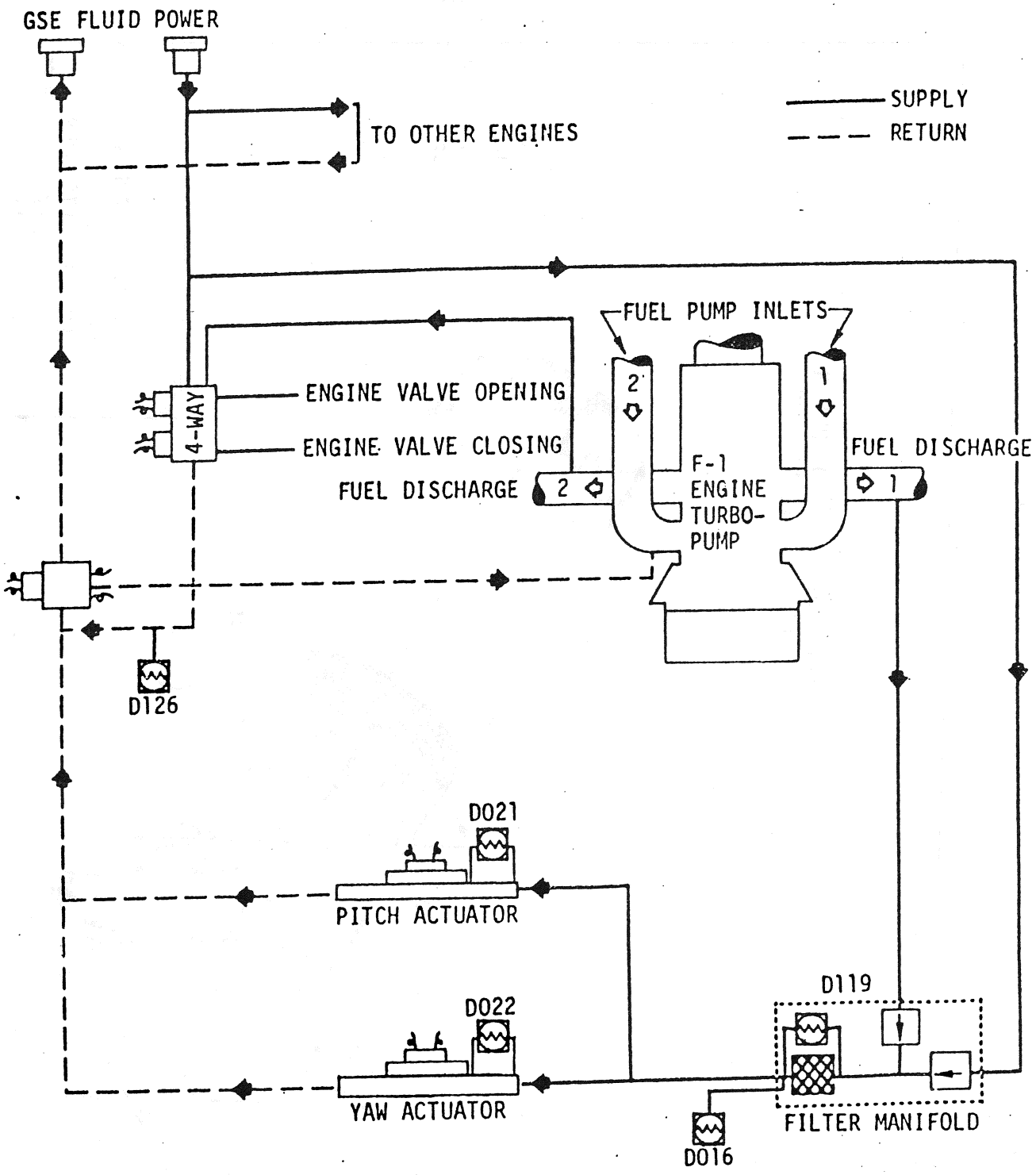
S-IC POGO SUPPRESSION SYSTEM SCHEMATIC



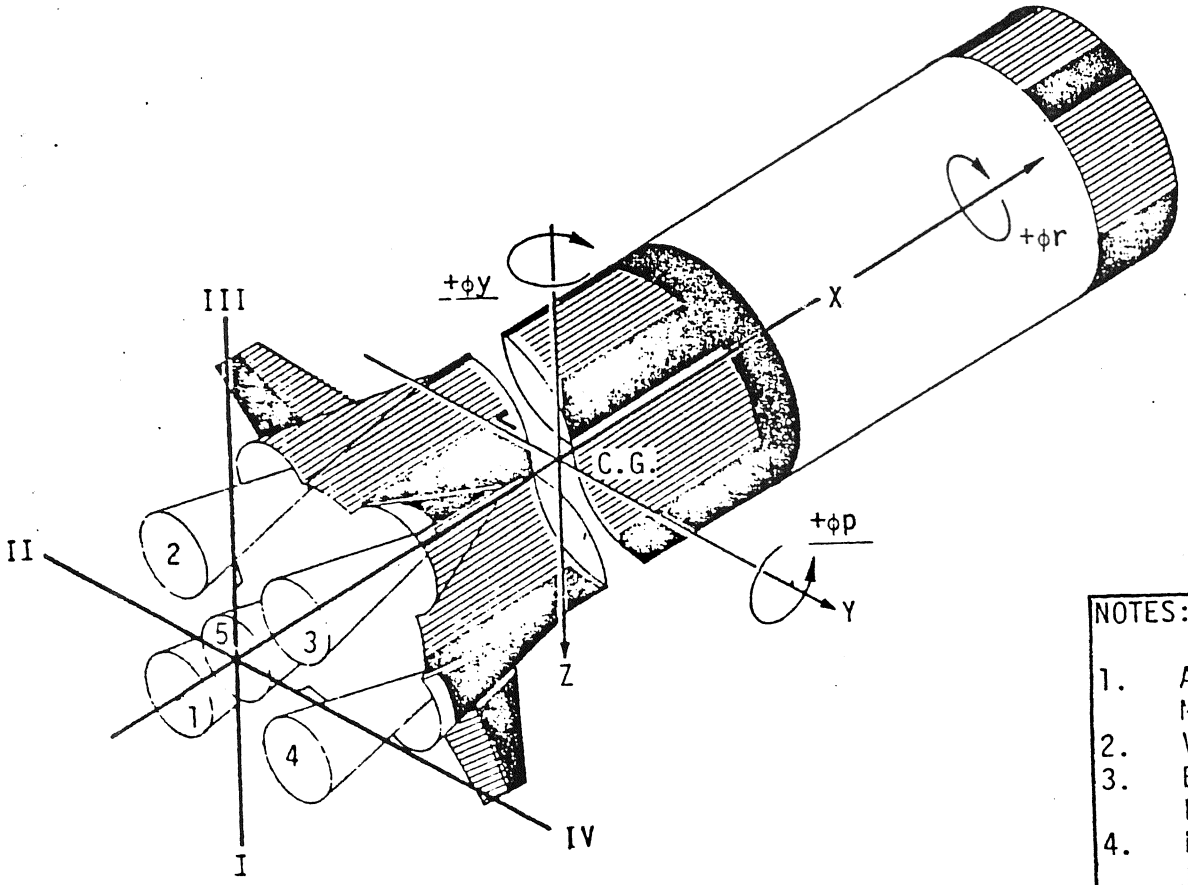
*MEASUREMENT LOCATED AT 16.8% VOLUME (0.359 FT^3)

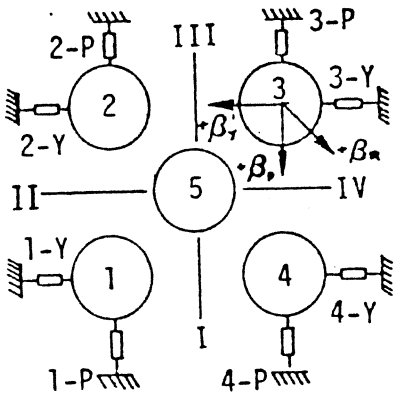
**MEASUREMENT LOCATED AT 27.8% VOLUME (0.595 FT^3)

S-IC HYDRAULIC SYSTEMS
FLUID POWER SCHEMATIC



S-IC GUIDANCE AND CONTROL ACTUATOR ORIENTATION





ACTUATOR NO.	POLARITY TABLE		
	+φr	+φy	+φp
1-Y	RET	RET	
1-P	EXT		RET
2-Y	EXT	RET	
2-P	RET		EXT
3-Y	RET	EXT	
3-P	EXT		EXT
4-Y	EXT	EXT	
4-P	RET		RET

NOTES:

1. ALL SIGNAL ARROWS INDICATE POSITIVE VEHICLE MOVEMENTS.
2. VEHICLE TILTS OVER POSITION I.
3. ENGINE ACTUATOR LAYOUTS SHOWN AS VIEWED FROM AFT END OF VEHICLE.
4. DIRECTIONS & POLARITIES SHOWN ARE TYPICAL FOR ALL STAGES.
5. + β INDICATES ENGINE DEFLECTION REQUIRED TO CORRECT FOR POSITIVE VEHICLE MOVEMENT.

APOLLO/Saturn MISSIONS

APOLLO/ SATURN	BOOSTER STAGE	APOLLO MISSION	MISSION OBJECTIVES	S-IC ENGINE (F-1)					ENGINES
				1	2	3	4	5	
AS-201 2-26-66	S-IB	APOLLO 1	UNMANNED -CHECKOUT OF ABLATIVE MATERIAL FOR NOSE CONE						H-1
AS-202 8-25-66	S-IB	APOLLO 2	UNMANNED - CHECKOUT OF ABLATIVE MATERIAL FOR NOSE CONE						H-1
AS-203 7-5-66	S-IB	APOLLO 3	UNMANNED - HYDROGEN EXPERIMENT-ORBIT (EARTH)						H-1
AS-501 11-19-67	S-IC	APOLLO 4	UNMANNED - QUALIFY SATURN V VEHICLES APOLLO SPACECRAFT, AND GROUND SYSTEMS	F2013	F2015	F2016	F2012	F2011	F-1
AS-204 1-22-68	S-IB	APOLLO 5	UNMANNED - CHECKOUT OF LEM - NO SERVICE MODULE OR CSM						H-1
AS-502 4-4-68	S-IC	APOLLO 6	UNMANNED - CHECKOUTS OF SIVB AND GROUND COMMAND CAPABILITY	F2017	F2018	F2019	F2021	F2020	F-1
AS-205 10-11-68	S-IB	APOLLO 7	MANNED - FIRST MANNED LAUNCH - 14 DAY ORBIT (EARTH)						H-1
AS-503 12-21-68	S-IC	APOLLO 8	MANNED - FIRST LUNAR ORBIT	F2024	F2022	F2025	F2026	F2027	F-1
AS-504 3-3-69	S-IC	APOLLO 9	MANNED - CSM/LEM EXPERIMENT IN EARTH ORBIT	F2029	F2032	F2031	F2033	F2030	F-1
AS-505 5-18-69	S-IC	APOLLO 10	MANNED - LUNAR ORBIT AND LEM CHECKOUTS	F2035	F2041	F2040	F2042	F2034	F-1
AS-506 7-16-69	S-IC	APOLLO 11	MANNED - FIRST LUNAR LANDING - LUNAR SURFACE EXPERIMENTS	F2043	F2046	F2051	F2054	F2044	F-1
AS-507 11-14-69	S-IC	APOLLO 12	MANNED - SECOND LUNAR LANDING-LUNAR SURFACE EXPERIMENTS	F2048	F2052	F2047	F2053	F2050	F-1

APOLLO/SATURN MISSIONS

APOLLO/ SATURN	BOOSTER STAGE	APOLLO MISSION	MISSION OBJECTIVES	S-IC ENGINE (F-1)					ENGINES
				1	2	3	4	5	
AS-508 4-11-70	S-IC	Apollo 13	Manned - Third Lunar Landing - Lunar Surface Experiments	F6055	F6058	F6057	F6078	F6056	F-1
AS-509 1-31-71	S-IC	Apollo 14	Manned - Fourth Lunar Landing - Lunar Surface Experiments	F6061	F6064	F6063	F6065	F6062	F-1
AS-510 7-26-71	S-IC	Apollo 15	Manned - Fifth Lunar Landing - Lunar Surface Experiments	F6088	F6069	F6068	F6071	F6073	F-1

TIME BASE TABLE

Prelaunch sequencing of Vehicle and GSE is controlled from the Launch Control Center/Mobile Launcher Complex Utilizing Manual and Automatic Control; however, after the umbilicals are disconnected, the sequencing is primarily controlled by the flight program within the Launch Vehicle Digital Computer and is divided into various time bases as follows:

	Initiated At
Time Base No. 1 (T1)	Liftoff
Time Base No. 2 (T2)	S-1C Inboard Engine C/O
Time Base No. 3 (T3)	S-1C Outboard Engine C/O
Time Base No. 4 (T4)	S-II Engines C/O
Time Base No. 5 (T5)	S-IVB Engines C/O (First Burn)
Time Base No. 6 (T6)	S-IVB Restart Preps Signal
Time Base No. 7 (T7)	S-IVB Engines C/O (Second Burn)
Time Base No. 8 (T8)	Maneuver to S-IVB Evasive Attitude

The Saturn V operation sequence starts during the prelaunch phase at approximately T-24 hours, when the electrical power from the ground support equipment is applied to all stages of the launch vehicle. During this time, the sequencing is controlled from the launch control center/mobile launcher complex, utilizing both manual and automatic control to check out the functions of the entire launch vehicle. After the umbilicals are disconnected, the sequencing is primarily controlled by the flight program within the LVDC.

Eight (8) primary time bases are used in the Saturn Vehicle Flight Sequence Program in order to achieve an optimum vehicle mission with suitable sequential operation and timing of flight vehicle events. Five (5) alternate time bases are also programmed for use should a need arise.

Safeguards are used where necessary to prevent premature initiation of time bases.

Proper establishment of time bases provides a safe and reliable vehicle on the pad and throughout the flight. Each time base will be established by the normal method when the required criteria has been received by the Launch Vehicle Digital Computer (LVDC).

If a time base is not established, subsequent time bases cannot be started and the vehicle mission cannot be completed. Therefore, to further increase mission reliability in the absence of the normal time base signals, backup methods are used for establishing time bases.

Both the normal and backup methods for starting each time base are explained in the following paragraphs.

Time Base #1 (T_1)

Time Base #1 (T_1) is initiated by a liftoff signal provided by the deactuation of the liftoff relay in the IU at the umbilical disconnect. However, as a safety measure, the Launch Vehicle Digital Computer (LVDC) will not recognize the liftoff signal and start T_1 prior to receiving Guidance Reference Release plus 16.0 seconds (Liftoff -1.0 second).

A backup method for starting T_1 is provided should the LVDC fail to receive or recognize the liftoff signal. If T_1 is not initiated within 17.5 seconds after Guidance Reference Release, the LVDC shall monitor the vertical accelerometer. If a significant positive acceleration (in excess of 1 g) exists, the LVDC assumes liftoff has occurred and begins T_1. A time adjustment is made by the computer.

No "Negative Backup" (i.e., provisions for the LVDC to return to prelaunch conditions) is provided because the Saturn V vehicle could safely complete T_1 on the pad without catastrophic results, in the event T_1 began by error.

Time Base #2 (T_2)

The S-IC inboard engine shall be cutoff by the LVDC through the S-IC switch selector on Time Base #1 at T_1 + 138.0 seconds. At T_1 + 138.1 seconds, the LVDC shall monitor the downrange accelerometer. If sufficient downrange velocity exists, the LVDC shall start Time Base #2 (T_2).

However, if Guidance Reference Failure (GRF) has occurred the LVDC will bypass the Velocity Test and initiate Time Base #2.

Use of the downrange velocity reading provides a safeguard against starting T_2 on the pad should T_1 be started without liftoff. Furthermore if T_2 is not established, no subsequent time bases can be started. This insures a safe vehicle requiring at least one additional failure to render the vehicle unsafe on the pad.

Time Base #3 (T_3)

After arming the S-IC outboard engines propellant depletion cutoff sensors through the S-IC switch selector, the LVDC shall initiate Time Base #3 (T_3) upon receiving either of two redundant outboard engines cutoff signals. The S-IC Outboard Engines Cutoff "A" signal from the S-IC depletion circuitry is the primary signal for starting T_3. The S-IC Outboard Engines Cutoff "B" signal from the backup depletion circuitry is a backup signal.

Time Base #4 (T_4)

After arming the S-II LOX depletion cutoff sensors through the S-II switch selector, the LVDC shall initiate Time Base #4 (T_4) upon receiving either of two signals, S-II Engines Cutoff or S-II Engines Out. The S-II engines cutoff signal from the S-II depletion cutoff circuitry is the primary signal for starting T_4. The S-II engines out signal from the thrust OK circuitry is a backup.

A redundant S-II Engines Cutoff command is issued at the start of T_4 (T_4 + 0.1), as a safeguard against having started T_4 with the thrust of the S-II engines present.

Time Base #4a (T_{4a})

Alternate Time Base #4a (T_{4a}) shall be programmed for use in early staging of the S-IVB stage. This time base shall be initiated by the LVDC upon receiving either of two signals, S/C Initiation of S-II/S-IVB Separation "A" or S/C Initiation of S-II/S-IVB Separation "B". The starting of T_{4a} shall be inhibited until T_3 + 2.4 seconds.

Time Base #5 (T_5)

After a predetermined time on T_4 or T_{4a} (T_4 + 10.0 or T_{4a} + 15.0), sufficient to allow the S-IVB engine to establish thrust OK, the LVDC shall start T_5 after receiving any two of four functions monitored by the LVDC. The functions are (1) S-IVB Engine Out "A" (2) S-IVB Engine Out "B" (3) S-IVB Velocity Cutoff which is issued by the LVDC through the S-IVB switch selector (4) Loss of thrust determined by LVDC using accelerometer readings.

Redundant S-IVB engine cutoff commands are issued at the start of T_5 (T_5 + 0.1 and T_5 + 0.2) as a safeguard against having started T_5 with the thrust of the S-IVB engine present.

Time Base #6 (T_6)

After a predetermined time on Time Base #5, Time Base #6 shall be initiated by the LVDC upon solving the restart equation.

The LVDC shall also have the capability to initiate Time Base #6 by use of a target update. When this is used, solving the restart equation shall be inhibited.

However, the above starting logic for T_6 shall be inhibited by the following:

(1) Translunar Injection Inhibit signal from the spacecraft (S/C)
(2) Guidance Failure "A" or "B" signals
(3) DCS command for TD&E enable.

Also, if the DCS command for TD&E enable is received, by the LVDC, the starting of Time Base #6 shall be permanently inhibited.

In the event of Guidance Failure and S/C Control of Saturn, Time Base #6 shall be initiated by the LVDC after T_5 + 100.0 seconds by the S-IVB Ignition Sequence Start signal from the S/C. This logic shall be inhibited only by the DCS command for TD&E enable.

Alternate Time Base #6a (T_{6a})

Alternate Time Base #6a (T_{6a}) shall be programmed for use should the O_2-H_2 burner malfunction between the times T_6 + 48.0 seconds to T_6 + 341.3 seconds. This alternate time base shall be initiated by the LVDC upon receiving "O_2-H_2 Burner Malfunction" signal from the S-IVB stage. After completion of this alternate sequence, the LVDC shall return to Time Base #6.

Alternate Time Base #6b (T_{6b})

Alternate Time Base #6b (T_{6b}) shall be programmed for use should the O_2-H_2 burner malfunction between the time T_6 + 341.3 seconds to T_6 + 496.7 seconds. This alternate time base shall be initiated by the LVDC upon receiving a "O_2-H_2 Burner Malfunction" signal from the S-IVB stage. After completion of this alternate sequence, the LVDC shall return to Time Base #6.

Time Base #6c (T_{6c})

Alternate Time Base #6c (T_{6c}) shall be programmed for use should a failure occur which would require a delay in the S-IVB restart attempt.

The LVDC shall be programmed to look for the Translunar Injection Inhibit signal at T_6 + 41.0 seconds, at which time T_{6c} shall be initiated if the signal is present.

The LVDC shall also be programmed to look for the Translunar Injection Inhibit signal at T_6 + 497.3 and then once per computer cycle (once per second) between the times T_6 + 497.3 and T_6 + 560.0 seconds. If the signal is present the LVDC shall initiate T_{6c}.

The LVDC shall also be programmed to initiate T_{6c} between T_6 + 584.0 and T_6 + 590.0 seconds after receiving any two of four functions monitored by the LVDC. The functions are: (1) S-IVB Engine Out "A", (2) S-IVB Engine Out "B", (3) Loss of thrust determined by LVDC using accelerometer readings, (4) S-IVB Velocity Cutoff which is issued by the LVDC. This logic shall be inhibited by the LVDC at T_6 + 590.0 seconds.

Upon completion of Time Base #6c, the LVDC shall return to Time Base #5 updated by the time elapsed in Time Base #6 and Alternate Time Base #6c.

Alternate Time Base #6d (T_{6d})

Alternate Time Base #6d shall be programmed for use should a failure in the S-IVB LOX chilldown system occur during restart preparations.

A DCS Command shall be required to initiate T_{6d}. This DCS command shall be accepted by the LVDC between the times T_6 + 250.0 and T_6 + 457.8 seconds. The LVDC shall check one (1) time for this DCS command at T_6 + 457.8 seconds, if the DCS command is present, T_{6d} shall be initiated. If the DCS command is not present, then the LVDC shall inhibit the logic for T_{6d}.

Time Base #7 (T_7)

After a predetermined time, (T_6 + 590.0 sec) the LVDC shall start T_7 after receiving any two of four functions monitored by the LVDC. The functions are: (1) S-IVB Engine Out "A", (2) S-IVB Engine Out "B", (3) S-IVB velocity cutoff which is issued by the LVDC through the S-IVB switch selector, (4) loss of thrust determined by the LVDC using accelerometer readings.

Redundant S-IVB Engine cutoff commands are issued at the start of T_7 (T_7 + 0.1 and T_7 + 0.2) as a safeguard against having started T_7 with the thrust of the S-IVB engine present.

Time Base #8 (T_8)

The start of Time Base #8 shall be inhibited in the LVDC. This inhibit must be removed by DCS command. However, the LVDC shall not accept the DCS command to remove the inhibit (S-IVB Propellant Dump Inhibit) until 480 seconds after the DCS evasive maneuver command has been received.

The LVDC shall not accept the DCS evasive maneuver command until after T_7 + 3600 seconds.

If the inhibit is removed, the LVDC shall initiate Time Base #8.

Additional Flight Sequence Requirements

The IU telemetry and S-IVB telemetry shall be calibrated after first insertion by using a special sequence. This special sequence of events consists of IU and S-IVB Telemetry Calibration Commands and shall be initiated by the LVDC using special tracking station acquisition logic. The first telemetry calibrate command shall be issued 60.0 seconds after station acquisition as determined by the LVDC.

The S-II Stage Mixture Ratio Shift from 5.5 to 4.8 shall be initiated by the LVDC based on Program Logic (When $T_{1i} = 0$). MR Shift shall occur when T_3 = (IGM initiated + T_{1i}) seconds + a comp cycle, -0.

Since T_{1i} is changed for S-II Engine out, this logic delays the MR Shift and provides for TLI capability with one S-II Engine Out.

During the S-IVB first burn the LVDC is programmed to initiate an S-IVB engine purge by issuing the command "Engine Pump Purge Control Valve Enable On" through the switch selector 9.0 seconds $\pm$ 1.0 second prior to Velocity Cutoff of the S-IVB Engine. The purpose of this purge is to remove the moisture in the seal cavities.

After liftoff plus 480 seconds the water coolant valve shall be switched open or closed by the LVDC through the IU switch selector. The LVDC shall be programmed to open the coolant valve with either of two thermal switches mounted in the water/methanol system closed and to close the valve when both of the switches are open. This shall not interfere with other events in the flight sequence.

If Alternate Time Base 6c (T_{6c}) is initiated after T_6 + 41.3 seconds, certain functions on Time Base #6 will not be issued by the LVDC during the second S-IVB restart attempt.

LUNAR DESCRIPTION

Terrain - Mountainous and crater-pitted, the former rising thousands of feet and the latter ranging from a few inches to 180 miles in diameter. The craters are thought to be formed by the impact of meteorites. The surface is covered with a layer of fine-grained material resembling silt or sand, as well as small rocks and boulders.

Environment - No air, no wind, and no moisture. The temperature ranges from 243 degrees in the two-week lunar day to 279 degrees below zero in the two-week lunar night. Gravity is one-sixth that of Earth. Micrometeoroids pelt the Moon (there is no atmosphere to burn them up). Radiation might present a problem during periods of unusual solar activity.

Dark Side - The dark or hidden side of the Moon no longer is a complete mystery. It was first photographed by a Russian craft and since then has been photographed many times, particularly by NASA's Lunar Orbiter and Apollo spacecrafts.

Origin - There is still no agreement among scientists on the origin of the Moon. The three theories: (1) the Moon once was part of Earth and split off into its own orbit, (2) it evolved as a separate body at the same time as Earth, and (3) it formed elsewhere in space and wandered until it was captured by Earth's gravitational field.

Physical Facts

Diameter	2,160 miles (about 1/4 that of Earth)
Circumference	6,790 miles (about 1/4 that of Earth)
Distance from Earth	238,857 miles (mean; 221,463 minimum to 252,710 maximum)
Surface temperature	+243°F (Sun at zenith) -279°F (night)
Surface gravity	1/6 that of Earth
Mass	1/100th that of Earth
Volume	1/50th that of Earth
Lunar day and night	14 Earth days each
Mean velocity in orbit	2,287 miles per hour
Escape velocity	1.48 miles per second
Month (period of rotation around Earth)	27 days, 7 hours, 43 minutes

TEMPERATURE CONVERSION TABLE

°K	°C	°F	°R
0.	-273.16	-459.69	0.
3.16	-270.	-454.00	5.69
5.38	-267.78	-450.	9.69
5.55	-267.61	-449.69	10.
10.	-263.16	-441.69	18.00
10.94	-262.22	-440.	19.69
11.11	-262.05	-439.69	20.
13.16	-260.	-436.00	23.69
16.49	-256.67	-430.	29.69
16.67	-256.49	-429.69	30.
20.	-253.16	-423.69	36.00
22.05	-251.11	-420.	39.69
22.22	-250.94	-419.69	40.
23.16	-250.	-418.00	41.69
27.60	-245.56	-410.	49.69
27.78	-245.38	-409.69	50.
30.	-243.16	-405.69	54.00
33.16	-240.	-400.	59.69
33.33	-239.83	-399.69	60.
38.72	-234.44	-390.	69.69
38.89	-234.27	-389.69	70.
40.	-233.16	-387.69	72.00
43.16	-230.	-382.00	77.69
44.27	-228.89	-380.	79.69
44.44	-228.72	-379.69	80.
49.83	-223.33	-370.	89.69
50.	-223.16	-369.69	90.
53.16	-220.	-364.00	95.69
55.38	-217.78	-360.	99.69
55.56	-217.60	-359.69	100.
60.	-213.16	-351.69	108.00
60.94	-212.22	-350.	109.69
61.11	-212.05	-349.69	110.
63.16	-210.	-346.00	113.69
66.49	-206.67	-340.	119.69
66.67	-206.49	-339.69	120.
70.	-203.16	-333.69	126.00
72.05	-201.11	-330.	129.69
72.22	-200.94	-329.69	130.
73.16	-200.	-328.00	131.69
77.60	-195.56	-320.	139.69
77.78	-195.38	-319.69	140.
80.	-193.16	-315.69	144.00
83.16	-190.	-310.	149.69
83.33	-189.83	-309.69	150.
88.72	-184.44	-300.	159.69
88.89	-184.27	-299.69	160.
90.	-183.16	-297.69	162.00
93.16	-180.	-292.00	167.69
94.27	-178.89	-290.	169.69
94.44	-178.72	-289.69	170.
99.83	-173.33	-280.	179.69
100.	-173.16	-279.69	180.

°K	°C	°F	°R
100.	-173.16	-279.69	180.
103.16	-170.	-274.00	185.69
105.38	-167.78	-270.	189.69
105.56	-167.60	-269.69	190.
110.	-163.16	-261.69	198.00
110.96	-162.20	-260.	199.69
111.11	-162.05	-259.69	200.
113.16	-160.	-256.00	203.69
116.49	-156.67	-250.	209.69
116.67	-156.49	-249.69	210.
120.	-153.16	-243.69	216.00
122.05	-151.11	-240.	219.69
122.22	-150.94	-239.69	220.
123.16	-150.	-238.00	221.69
127.60	-145.56	-230.	229.69
127.78	-145.38	-229.69	230.
130.	-143.16	-225.69	234.00
133.16	-140.	-220.	239.69
133.33	-139.83	-219.69	240.
138.72	-134.44	-210.	249.69
138.89	-134.27	-209.69	250.
140.	-133.16	-207.69	252.00
143.16	-130.	-202.00	257.69
144.27	-128.89	-200.	259.69
144.44	-128.62	-199.69	260.
149.83	-123.33	-190.	269.69
150.	-123.16	-189.69	270.
153.16	-120.	-184.00	275.69
155.38	-117.78	-180.	279.69
155.56	-117.60	-179.69	280.
160.	-113.16	-171.69	288.00
160.94	-112.22	-170.	289.69
161.11	-112.05	-169.69	290.
163.16	-110.	-166.00	293.69
166.49	-106.67	-160.	299.69
166.67	-106.49	-159.69	300.
170.	-103.16	-153.69	306.00
172.05	-101.11	-150.	309.69
172.22	-100.94	-149.69	310.
173.16	-100.	-148.00	311.69
177.60	-95.56	-140.	319.69
177.78	-95.38	-139.69	320.
180.	-93.16	-135.69	324.00
183.16	-90.	-130.	329.69
183.33	-89.83	-129.69	330.
188.72	-84.44	-120.	339.69
188.89	-84.27	-119.69	340.
190.	-83.16	-117.69	342.00
193.16	-80.	-112.00	347.69
194.27	-78.89	-110.	349.69
194.44	-78.72	-109.69	350.
199.83	-73.33	-100.	359.69
200.	-73.16	-99.69	360.

°K	°C	°F	°R
200.	-73.16	-99.69	360.
203.16	-70.	-94.00	365.69
205.38	-67.78	-90.	369.69
205.56	-67.60	-89.99	370.
210.	-63.16	-81.69	378.00
210.94	-62.22	-80.	379.69
211.11	-62.05	-79.69	380.
213.16	-60.	-76.00	383.69
216.41	-56.67	-70.	389.69
216.67	-56.49	-69.69	390.
220.	-53.16	-63.69	396.00
222.05	-51.11	-60.	399.69
222.22	-50.94	-59.69	400.
223.16	-50.	-58.00	401.69
227.60	-45.56	-50.	409.69
227.78	-45.38	-49.69	410.
230.	-43.16	-45.69	414.00
233.16	-40.	-40.	419.69
233.33	-39.83	-39.69	420.
238.72	-34.44	-30.	429.69
238.89	-34.27	-29.69	430.
240.	-33.16	-27.69	432.00
243.16	-30.	-22.00	437.69
244.27	-28.89	-20.	439.69
244.44	-28.72	-19.69	440.
249.83	-23.33	-10.	449.69
250.	-23.16	-9.69	450.
253.16	-20.	-4.00	455.69
255.38	-17.78	0.	459.69
255.56	-17.60	+.31	460.
260.	-13.16	+8.31	468.00
260.94	-12.22	10.	469.69
261.11	-12.05	10.31	470.
263.16	-10.	14.00	473.69
266.49	-6.67	20.	479.69
266.67	-6.49	20.31	480.
270.	-3.16	26.31	486.00
272.05	-1.11	30.	489.69
272.22	-.94	30.31	490.
273.16	0.	32.00	491.69
277.60	+4.44	40.	499.69
277.78	4.62	40.31	500.
280.	6.84	44.31	504.00
283.16	10.	50.	509.69
283.33	10.17	50.31	510.
288.72	15.56	60.	519.69
288.89	15.73	60.31	520.
290.	16.84	62.31	522.00
293.16	20.	68.00	527.69
294.27	21.11	70.	529.69
294.44	21.28	70.31	530.
299.83	26.67	80.	539.69
300.	26.84	80.31	540.

°K °C	°R °F
1	1.8
2	3.6
3	5.4
4	7.2
5	9.0
6	10.8
7	12.6
8	14.4
9	16.2
10	18.0

°R °F	°K °C
1	0.56
2	1.11
3	1.67
4	2.22
5	2.78
6	3.33
7	3.89
8	4.44
9	5.00
10	5.56
11	6.11
12	6.67
13	7.22
14	7.78
15	8.33
16	8.89
17	9.44
18	10.00

TEMPERATURE CONVERSION TABLE

°K	°C	°F	°R
600.	326.84	620.31	1080.
603.16	330.	626.00	1085.69
605.38	332.22	630.	1089.69
605.56	332.40	630.31	1090.
610.	336.84	638.31	1098.00
610.94	337.78	640.	1099.69
611.11	327.95	640.31	1100.
613.16	340.	644.00	1103.69
616.41	343.33	650.	1109.69
616.67	343.51	650.31	1110.
620.	346.84	656.31	1116.00
622.05	348.89	660.	1119.69
622.22	349.06	660.31	1120.
623.16	350.	662.00	1121.69
627.60	354.44	670.	1129.69
627.78	354.62	670.31	1130.
630.	356.84	674.31	1134.00
633.16	360.	680.	1139.69
633.33	360.17	680.31	1140.
638.72	365.56	690.	1149.69
638.89	365.73	690.31	1150.
640.	366.84	692.31	1152.00
643.16	370.	698.00	1157.69
644.27	371.11	700.	1159.69
644.44	371.28	700.31	1160.
649.83	376.66	710.	1169.69
650.	376.84	710.31	1170.
653.16	380.	716.00	1175.69
655.38	382.22	720.	1179.69
655.56	382.40	720.31	1180.
660.	386.84	728.31	1188.00
660.94	387.78	730.	1189.69
661.11	387.95	730.31	1190.
663.16	390.	734.00	1193.69
666.49	393.33	740.	1199.69
666.67	393.51	740.31	1200.
670.	396.84	746.31	1206.00
672.05	398.89	750.	1209.69
672.22	399.06	750.31	1210.
673.16	400.	752.00	1211.69
677.60	404.44	760.	1219.69
677.78	404.62	760.31	1220.
680.	406.84	764.31	1224.00
683.16	410.	770.	1229.69
683.33	410.17	770.31	1230.
688.72	415.56	780.	1239.69
688.89	415.73	780.31	1240.
690.	416.84	782.31	1242.00
693.16	420.	788.00	1247.69
694.27	421.11	790.	1249.69
694.44	421.28	790.31	1250.
699.83	426.67	800.	1259.67
700.	426.84	800.31	1260.

°K	°C	°F	°R
700.	426.84	800.31	1260.
703.16	430.	806.00	1265.69
705.38	432.22	810.	1269.69
705.56	432.40	810.31	1270.
710.	436.84	818.31	1278.00
710.94	437.78	820.	1279.69
711.11	437.95	820.31	1280.
713.16	440.	824.00	1283.69
716.41	443.33	830.	1289.69
716.67	443.51	830.31	1290.
720.	446.84	836.31	1296.00
722.05	448.89	840.	1299.69
722.22	449.06	840.31	1300.
723.16	450.	842.00	1301.69
727.60	454.44	850.	1309.69
727.78	454.62	850.31	1310.
730.	456.84	854.31	1314.00
733.16	460.	860.	1319.69
733.33	460.17	860.31	1320.
738.72	465.56	870.	1329.69
738.89	465.73	870.31	1330.
740.	466.84	872.31	1332.00
743.16	470.	878.00	1337.69
744.27	471.11	880.	1339.69
744.44	471.28	880.31	1340.
749.83	476.66	890.	1349.69
750.	476.84	890.31	1350.
753.16	480.	896.00	1355.69
755.38	482.22	900.	1359.69
755.56	482.40	900.31	1360.
760.	486.84	908.31	1368.00
760.94	487.78	910.	1369.69
761.11	487.95	910.31	1370.
763.16	490.	914.00	1373.69
766.49	493.33	920.	1379.69
766.67	493.51	920.31	1380.
770.	496.84	926.31	1386.00
772.05	498.89	930.	1389.69
772.22	499.06	930.31	1390.
773.16	500.	932.00	1391.69
777.60	504.44	940.	1399.69
777.78	504.62	940.31	1400.
780.	506.84	944.31	1404.00
783.16	510.	950.	1409.69
783.33	510.17	950.31	1410.
788.72	515.56	960.	1419.69
788.89	515.73	960.31	1420.
790.	516.84	962.31	1422.00
793.16	520.	968.00	1427.69
794.27	521.11	970.	1429.69
794.44	521.28	970.31	1430.
799.83	526.67	980.	1439.69
800.	526.84	980.31	1440.

°K	°C	°F	°R
800.	526.84	980.31	1440.
803.16	530.	986.00	1445.69
805.38	532.22	990.	1449.69
805.56	532.40	990.31	1450.
810.	526.84	998.31	1458.00
810.94	537.78	1000.	1459.69
811.11	537.95	1000.31	1460.
813.16	540.	1004.00	1463.69
816.41	543.33	1010.	1469.69
816.67	543.51	1010.31	1470.
820.	546.84	1016.31	1476.00
822.05	548.89	1020.	1479.69
822.22	549.06	1020.31	1480.
823.16	550.	1022.00	1481.69
827.60	554.44	1030.	1489.69
827.78	554.62	1030.31	1490.
830.	556.84	1034.31	1494.00
833.16	560.	1040.	1499.69
833.33	560.17	1040.31	1500.
838.72	565.56	1050.	1509.69
838.89	565.73	1050.31	1510.
840.	566.84	1052.31	1512.00
843.16	570.	1058.00	1517.69
844.27	571.11	1060.	1519.69
844.44	571.28	1060.31	1520.
849.83	576.66	1070.	1529.69
850.	576.84	1070.31	1530.
853.16	580.	1076.00	1535.69
855.38	582.22	1080.	1539.69
855.56	582.40	1080.31	1540.
860.	586.84	1088.31	1548.00
860.94	587.78	1090.	1549.69
861.11	587.95	1090.31	1550.
863.16	590.	1094.00	1553.69
866.48	593.33	1100.	1559.69
866.67	593.51	1100.31	1560.
870.	596.84	1106.31	1566.00
872.05	598.89	1110.	1569.69
872.22	599.06	1110.31	1570.
873.16	600.	1112.00	1571.69
877.60	604.44	1120.	1579.69
877.78	604.62	1120.31	1580.
880.	606.84	1124.31	1584.00
883.16	610.	1130.	1589.69
883.33	610.17	1130.31	1590.
888.72	615.56	1140.	1599.69
888.89	615.73	1140.31	1600.
890.	616.84	1142.31	1602.00
893.16	620.	1148.00	1607.69
894.27	621.11	1150.	1609.69
894.44	621.28	1150.31	1610.
899.83	626.67	1160.	1619.69
900.	626.84	1160.31	1620.

°K	°C	°F	°R
900.	626.84	1160.31	1620
903.16	630.	1166.00	1625.69
905.38	632.22	1170.	1629.69
905.56	632.40	1170.31	1630.
910.	636.84	1178.31	1638.00
910.94	637.78	1180.	1639.69
911.11	637.95	1180.31	1640.
913.16	640.	1184.00	1643.69
916.41	643.33	1190.	1649.69
916.67	643.51	1190.31	1650.
920.	646.84	1196.31	1656.00
922.05	648.89	1200.	1659.69
922.22	649.06	1200.31	1660.
923.16	650.	1202.00	1661.69
927.60	654.44	1210.	1669.69
927.78	654.62	1210.31	1670.
930.	656.84	1214.31	1674.00
933.16	660.	1220.	1679.69
933.33	660.17	1220.31	1680.
938.72	665.56	1230.	1689.69
938.89	665.73	1230.31	1690.
940.	666.84	1232.31	1692.00
943.16	670.	1238.00	1697.69
944.27	671.11	1240.	1699.69
944.44	671.28	1240.31	1700.
949.83	676.66	1250.	1709.69
950.	676.84	1250.31	1710.
952.16	680.	1256.00	1715.69
955.38	682.22	1260.	1719.69
955.56	682.40	1260.31	1720.
960.	686.84	1262.31	1722.00
960.94	687.78	1270.	1729.69
961.11	687.95	1270.31	1730.
963.16	690.	1274.00	1733.69
966.49	693.33	1280.	1739.69
966.67	693.51	1280.31	1740.
970.	696.84	1286.31	1746.00
972.05	698.89	1290.	1749.69
972.22	699.06	1290.31	1750.
973.16	700.	1292.00	1751.69
977.60	704.44	1300.	1759.69
977.78	704.62	1300.31	1760.
980.	706.84	1304.31	1764.00
983.16	710.	1310.	1769.69
983.33	710.17	1310.31	1770.
988.72	715.56	1320.	1779.69
988.89	715.73	1320.31	1780.
990.	716.84	1322.31	1782.00
993.16	720.	1328.00	1787.69
994.27	721.11	1330.	1789.69
994.44	721.28	1330.31	1790.
999.83	726.67	1340.	1799.69
1000.	726.84	1340.31	1800.

TEMPERATURE CONVERSION TABLE

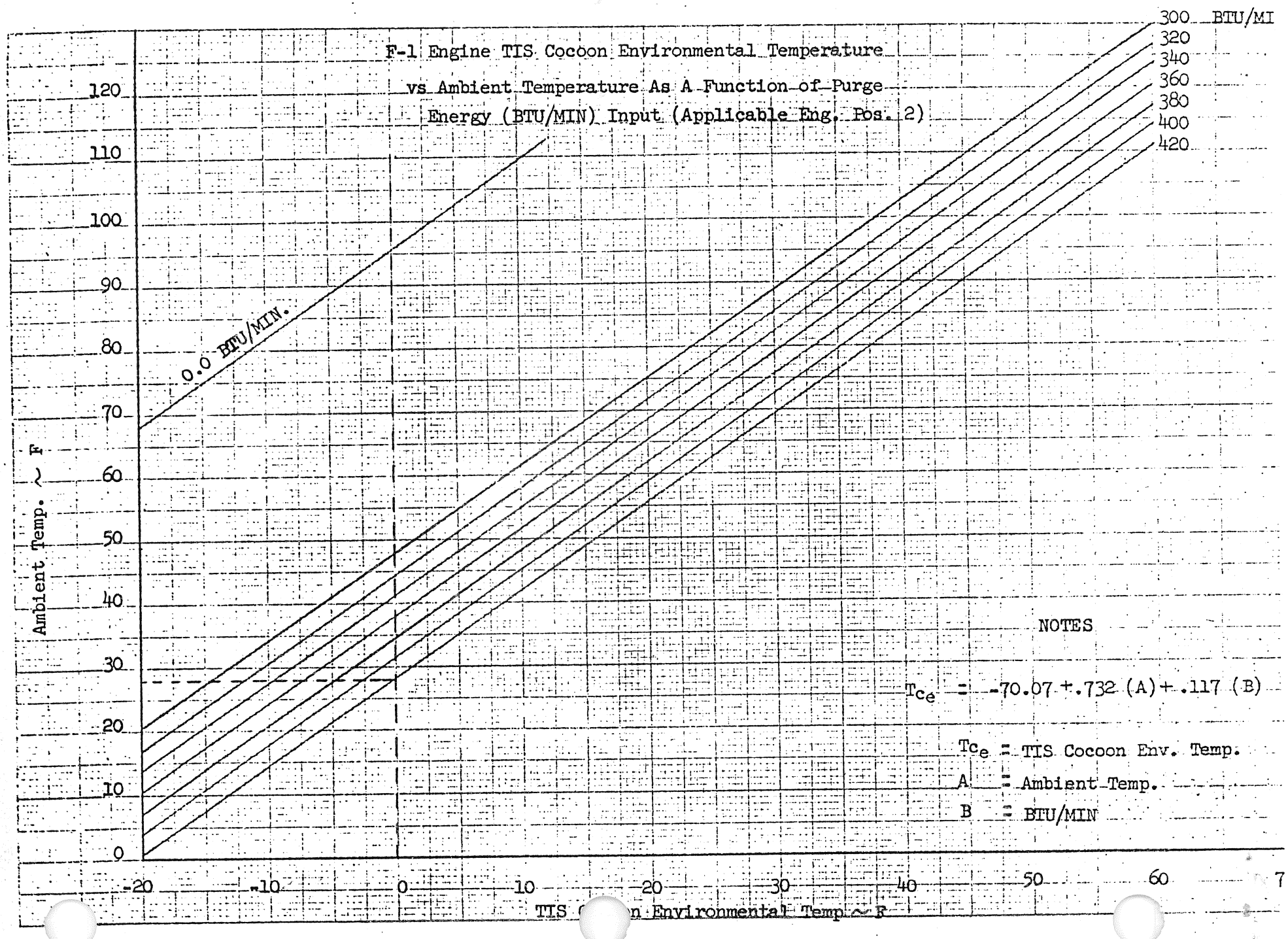
°K	°C	°F	°R
300.	26.84	80.31	540.
303.16	30.	86.00	545.69
305.38	32.22	90.	549.69
305.56	32.40	90.31	550.
310.	36.84	98.31	558.00
310.94	37.78	100.	559.69
311.11	37.95	100.31	560.
313.16	40.	104.00	563.69
316.41	43.33	110.	569.69
316.67	43.51	110.31	570.
320.	46.84	116.31	576.00
322.05	48.89	120.	579.69
322.22	49.06	120.31	580.
323.16	50.	122.00	581.69
327.60	54.44	130.	589.69
327.78	54.62	130.31	590.
330.	56.84	134.31	594.00
333.16	60.	140.	599.69
333.33	60.17	140.31	600.
338.72	65.56	150.	609.69
338.89	65.73	150.31	610.
340.	66.84	152.31	612.00
343.16	70.	158.00	617.69
344.27	71.11	160.	619.69
344.44	71.28	160.31	620.
349.83	76.67	170.	629.69
350.	76.84	170.31	630.
353.16	80.	176.00	635.69
355.38	82.22	180.	639.69
355.56	82.40	180.31	640.
360.	86.84	188.31	648.00
360.94	87.78	190.	649.69
361.11	87.95	190.31	650.
363.16	90.	194.00	653.69
366.49	93.33	200.	659.69
366.67	93.51	200.31	660.
370.	96.84	206.31	656.00
372.05	98.89	210.	669.69
372.22	99.06	210.31	670.
373.16	100.	212.00	671.69
377.60	104.44	220.	679.69
377.78	104.62	220.31	680.
380.	106.84	224.31	684.00
383.16	110.	230.	689.69
383.33	110.17	230.31	690.
388.72	115.56	240.	699.69
388.89	115.73	240.31	700.
390.	116.84	242.31	702.00
393.16	120.	248.00	707.69
394.27	121.11	250.	709.69
394.44	121.28	250.31	710.
399.83	126.67	260.	719.69
400.	126.84	260.31	720.

°K	°C	°F	°R
400.	126.84	260.31	720.
403.16	130.	266.00	725.69
405.38	132.22	270.	729.69
405.56	132.40	270.31	730.
410.	136.84	278.31	738.00
410.94	137.78	280.	739.69
411.11	137.95	280.31	740.
413.16	140.	284.00	743.69
416.41	143.33	290.	749.69
416.67	143.51	290.31	750.
420.	146.84	296.31	756.00
422.05	148.89	300.	759.69
422.22	149.06	300.31	760.
423.16	150.	302.00	761.69
427.60	154.44	310.	769.69
427.78	154.62	310.31	770.
430.	156.84	314.31	774.00
433.16	160.	320.	779.69
433.33	160.17	320.31	780.
438.72	165.56	330.	789.69
438.89	165.73	330.31	790.
440.	166.84	332.31	792.00
443.16	170.	338.00	797.69
444.27	171.11	340.	799.69
444.44	171.28	340.31	800.
449.83	176.66	350.	809.69
450.	176.84	350.31	810.
453.16	180.	356.00	815.69
455.38	182.22	360.	819.69
455.56	182.40	360.31	820.
460.	186.84	368.31	828.00
460.94	187.78	370.	829.69
461.11	187.95	370.31	830.
463.16	190.	374.00	833.69
466.49	193.33	380.	839.69
466.67	193.51	380.31	840.
470.	196.84	386.31	846.00
472.05	198.89	390.	849.69
472.22	199.06	390.31	850.
473.16	200.	392.00	851.69
477.60	204.44	400.	859.69
477.78	204.62	400.31	860.
480.	206.84	404.31	864.00
483.16	210.	410.	869.69
483.33	210.17	410.31	870.
488.72	215.56	420.	879.69
488.89	215.73	420.31	880.
490.	216.84	422.31	882.00
493.16	220.	428.00	887.69
494.27	221.11	430.	889.69
494.44	221.28	430.31	890.
499.83	226.67	440.	899.69
500.	226.84	440.31	900.

°K	°C	°F	°R
500.	226.84	440.31	900.
503.16	230.	446.00	905.69
505.38	232.22	450.	909.69
505.56	232.40	450.31	910.
510.	236.84	458.31	918.00
510.94	237.78	460.	919.69
511.11	237.95	460.31	920.
513.16	240.	464.00	923.69
516.41	243.33	470.	929.69
516.67	243.51	470.31	930.
520.	246.84	476.31	936.00
522.05	248.89	480.	939.69
522.22	249.06	480.31	940.
523.16	250.	482.00	941.69
527.60	254.44	490.	949.69
527.78	254.62	490.31	950.
530.	256.84	494.31	954.00
533.16	260.	500.	959.69
533.33	260.17	500.31	960.
538.72	265.56	510.	969.69
538.89	265.73	510.31	970.
540.	266.84	512.31	972.00
543.16	270.	518.00	977.69
544.27	271.11	520.	979.69
544.44	271.28	520.31	980.
549.83	276.66	530.	989.69
550.	276.84	530.31	990.
553.16	280.	536.00	995.69
555.38	282.22	540.	999.69
555.56	282.40	540.31	1000.
560.	286.84	548.31	1008.00
560.94	287.78	550.	1009.69
561.11	287.95	550.31	1010.
563.16	290.	554.00	1013.69
566.49	293.33	560.	1019.69
566.67	293.51	560.31	1020.
570.	296.84	566.31	1026.00
572.05	298.89	570.	1029.69
527.22	299.06	570.31	1030.
573.16	300.	572.00	1031.69
577.60	304.44	580.	1039.69
577.78	304.62	580.31	1040.
580.	306.84	584.31	1044.00
583.16	310.	590.	1049.69
583.33	310.17	590.31	1050.
588.72	315.56	600.	1059.69
588.89	315.73	600.31	1060.
590.	316.84	602.31	1062.00
593.16	320.	608.00	1067.69
594.27	321.11	610.	1069.69
594.44	321.28	610.31	1070.
599.83	326.67	620.	1079.69
600.	326.84	620.31	1080.

°K °C	°R °F
1	1.8
2	3.6
3	5.4
4	7.2
5	9.0
6	10.8
7	12.6
8	14.4
9	16.2
10	18.0

°R °F	°K °C
1	0.56
2	1.11
3	1.67
4	2.22
5	2.78
6	3.33
7	3.89
8	4.44
9	5.00
10	5.56
11	6.11
12	6.67
13	7.22
14	7.78
15	8.33
16	8.89
17	9.44
18	10.00


F-1 Engine TIS Cocoon Environmental Temperature
vs Ambient Temperature As A Function of Purge
Energy (BTU/MIN) Input (Applicable Eng. Pos. 2)
300 BTU/MI
320
340
360
380
400
420
0.0 BTU/MIN.
Ambient Temp. ~ F
120
110
100
90
80
70
60
50
40
30
20
10
0
-20
-10
0
10
20
30
40
50
60
NOTES
$T_{ce} = -70.07 + .732\,(A) + .117\,(B)$
T_{ce} = TIS Cocoon Env. Temp.
A = Ambient Temp.
B = BTU/MIN