MAIN PROPULSION SYSTEM

ROCKWELL-LSS BRIEFING

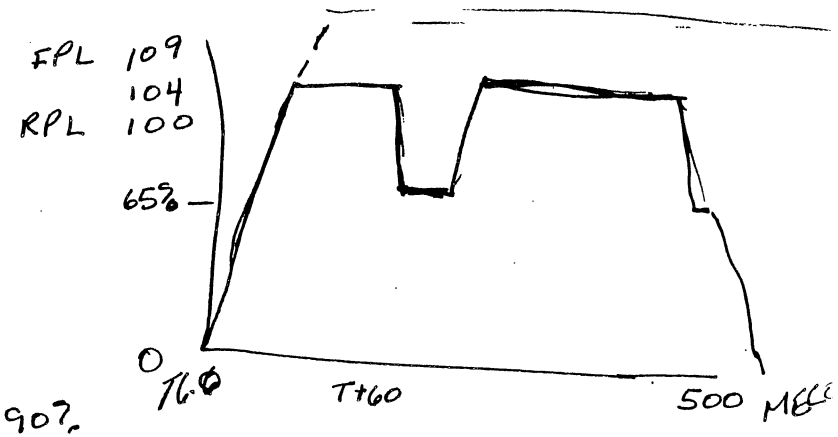
PREPARED 11-19-84

S. H. COESTER

Rockwell International

SHUTTLE MAIN PROPULSION SYSTEM

- CONSISTS OF 1. SSME, 2. ORBITER MAIN PROPULSION SYSTEM, 3. THE EXTERNAL TANK
  - SSME
    - NOZZLE AREA RATIO - 77.5:1
    - MIXTURE RATIO - 6:1 LBM_{LO_2} / LBM_{LH_2}
    - CHAMBER PRESSURE 3000 PSI
    - THRUST - 375,000 POUNDS AT SEA LEVEL
      - 470,000 POUNDS IN VACUUM
    - THROTTLABLE FROM 65-109 PERCENT
    - GIMBAL CAPABILITY $\pm$ 10.5° PITCH, $\pm$ 8.5° YAW
    - FUEL - LH_2
    - OXIDIZER - LO_2
  - ET
    - LO_2 - 19,728 FT^3/1,337,563 POUNDS OF PROPELLANT
    - LH_2 - 53,354 FT^3/224,493 POUNDS OF PROPELLANT
    - ALL SERVICING DONE THROUGH ORBITER



- GENERAL

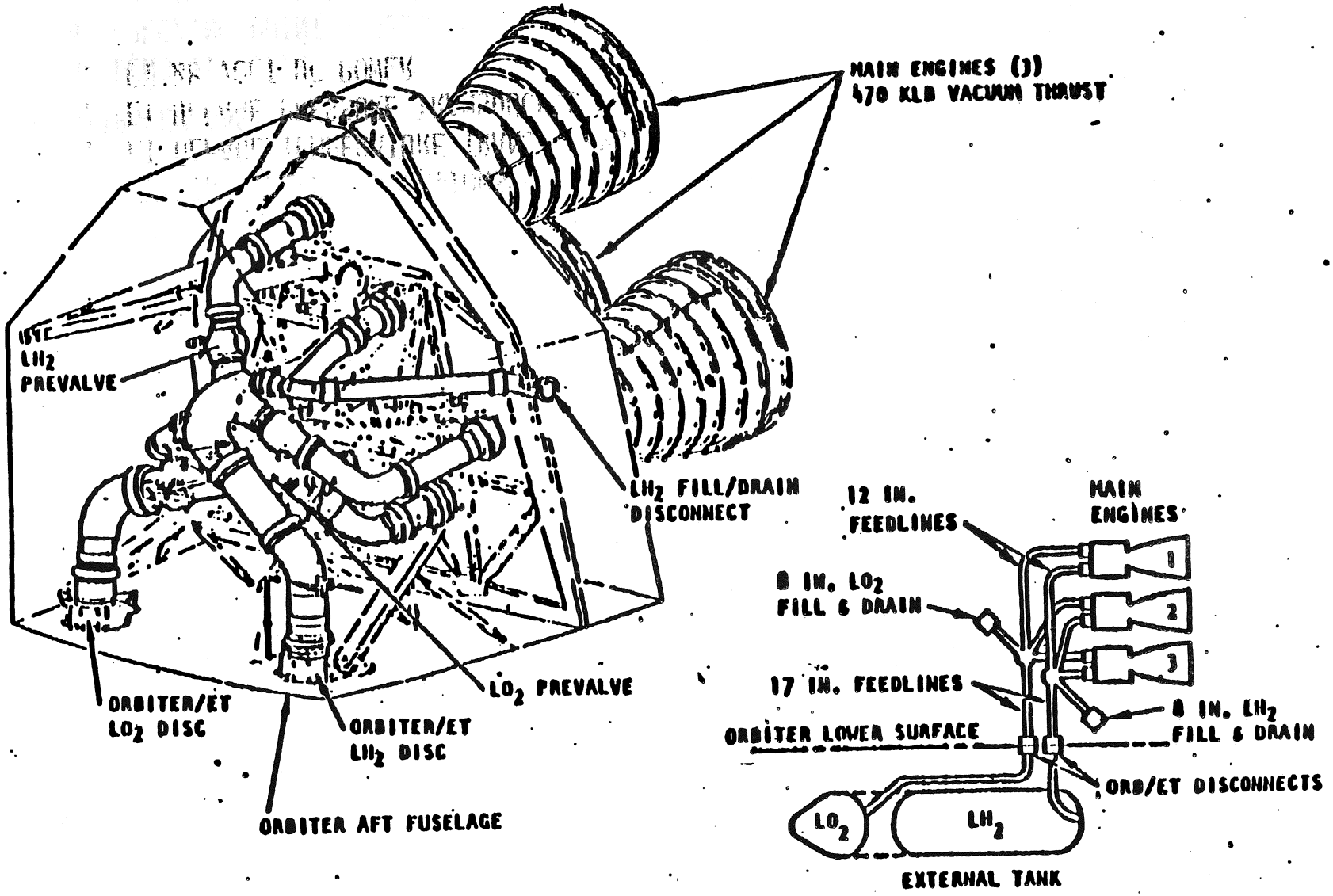
  - LH_2 (PARA)
    - DENSITY 4.419 LB/FT^3
    - SPECIFIC VOLUME .2263 FT^3/LB
    - BOILING POINT - 423.188°F.

  - LOX
    - DENSITY 71.212 LB/FT^3
    - SPECIFIC VOLUME .014043 FT^3/LB
    - BOILING POINT - 297.3460

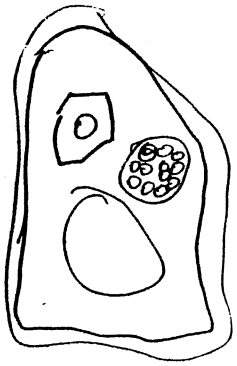
  - HELIUM GAS
    - DENSITY .011 LB/FT^3
    - FREEZING POINT - 452°F.
    - SPECIFIC VOLUME 96.71 FT^3/LB

- NITROGEN GAS
  - DENSITY .078 LB/FT^3
  - FREEZING POINT - 320.4°F.
  - SPECIFIC VOLUME 13.8 FT^3/LB

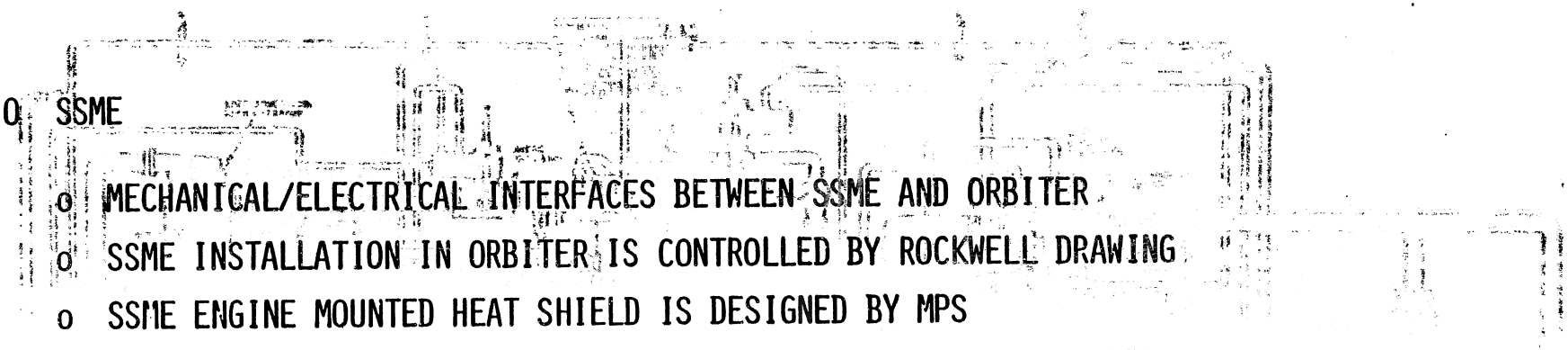
MAIN PROPULSION SUBSYSTEM



- ROCKWELL-LSS RESPONSIBILITIES TOWARD ET AND SSME



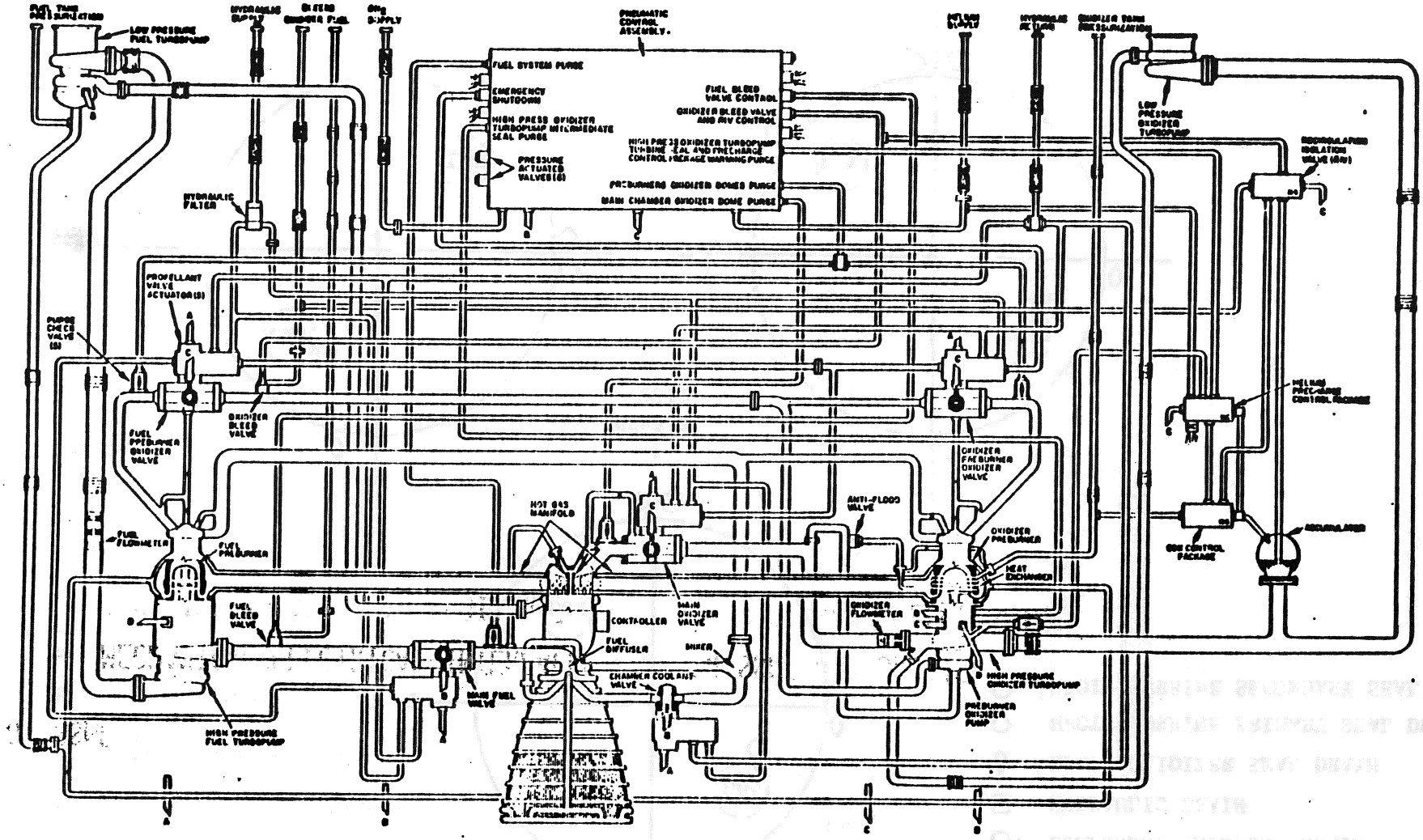
  - ET
    - ROCKWELL PROVIDES THE ET PROPELLANT DISCONNECT ASSEMBLIES TO MMC.
      - 17" DISCONNECTS
      - 4" DISCONNECTS
      - 2" DISCONNECTS
      - PURGE BARRIERS
      - FOAM INSULATION
  - ROCKWELL PROVIDES ET LIQUID LEVEL POINT SENSORS
  - ROCKWELL PROVIDES ELECTRONICS ON THE ORBITER FOR CONTROL OF...
    - POINT SENSORS
    - ET VENT VALVE INDICATIONS
    - ET ULLAGE TEMPERATURE TRANSDUCERS
    - ET ULLAGE PRESSURE TRANSDUCERS
    - ET 28-VOLT DC POWER



- SSME
  - MECHANICAL/ELECTRICAL INTERFACES BETWEEN SSME AND ORBITER
  - SSME INSTALLATION IN ORBITER IS CONTROLLED BY ROCKWELL DRAWING
  - SSME ENGINE MOUNTED HEAT SHIELD IS DESIGNED BY MPS
  - DOME HEAT SHIELD IS ROCKWELL STRUCTURES/INSTALLED BY LSOC/MPS
  - HYDRAULICS/ELECTRICAL INTERFACES
  - GNC GIMBAL CONTROL
  - SSME TESTING INTERFACES DIRECTLY WITH MPS/HYD/GNC/DPS/INS FUNCTIONS
  - FASCOS INTERFACE
  - SSME INSTALLATION & LRU GSE DESIGNED BY ROCKWELL-DOWNEY

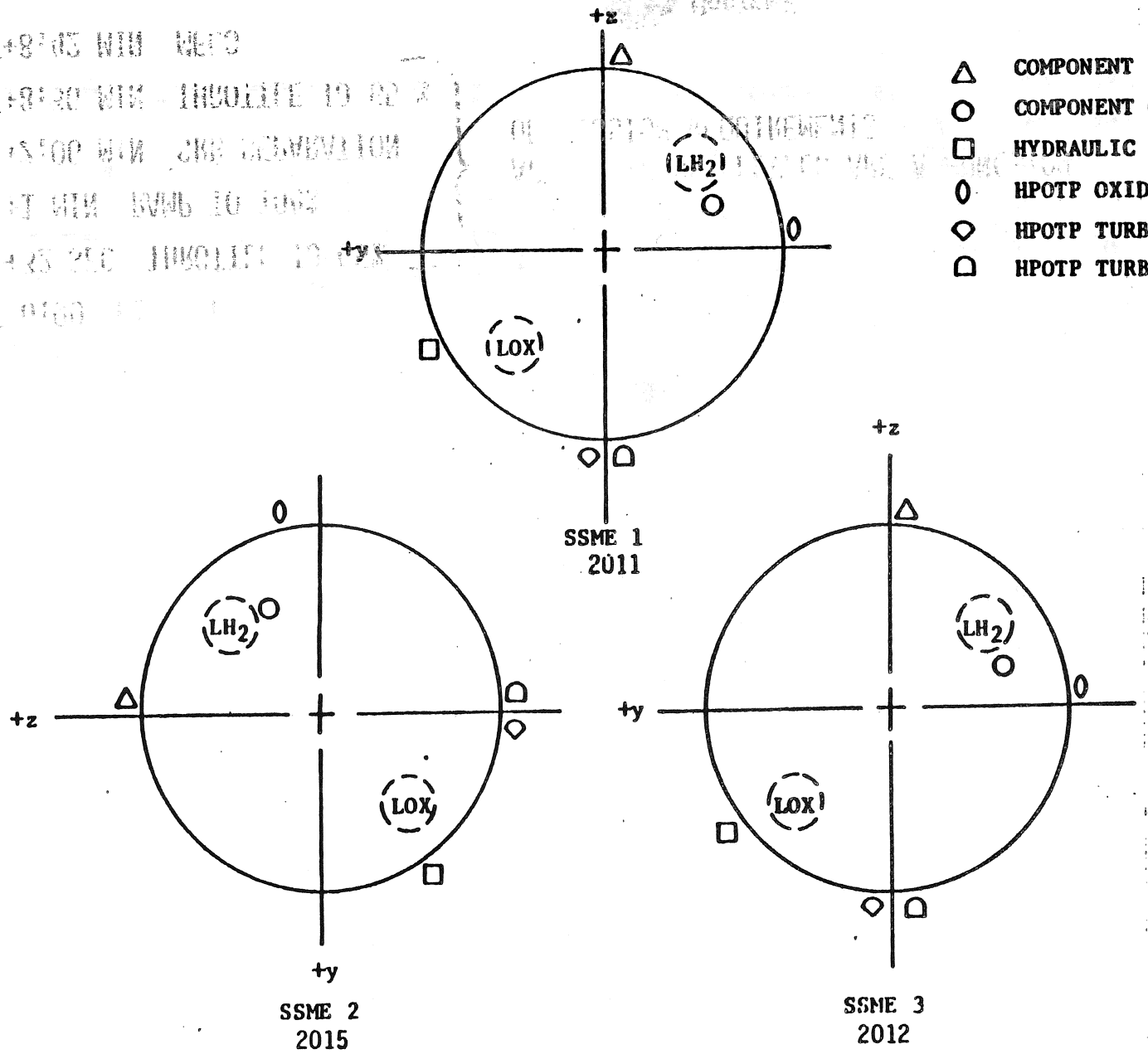
- ROCKWELL HAS AN INTEGRATION CONTRACT FOR ANALYSIS AND COORDINATION OF ALL MPS (ET/SSME/ORBITER) FUNCTIONS

SSME SYSTEM SCHEMATIC



A—HYDRAULIC DRAIN AND HELIUM VENT (5)
B—FUEL, TURBINE SECONDARY DRAIN AND HELIUM AND HYDROGEN VENT (5)
C—OXIDIZER DRAIN AND HELIUM AND NITROGEN VENT (4)
D—TURBINE PRIMARY DRAIN (2)

FOR TRAINING PURPOSES ONLY



△ COMPONENT FUEL DRAIN
○ COMPONENT OXIDIZER DRAIN
□ HYDRAULIC DRAIN
0 HPOTP OXIDIZER SEAL DRAIN
◇ HPOTP TURBINE PRIMARY SEAL DRAIN
∩ HPOTP TURBINE SECONDARY SEAL DRAIN

ENGINE/DRAINLINE ORIENTATION

AFT, LOOKING FORWARD

MPS MISSION FUNCTIONS

- T-34 MPS AND SSME FINAL PREPS
  - POST CLOSEOUT VALVE CYCLING/POSITIONING
  - SSME SENSOR C/O AND CAL
  - SSME PNEU C/O
  - SSME CONTROLLER FLIGHT LOAD
  - SSME GN_2 PURGE C/O
  - MFV HEATER SETUP

- T-6:30 HR SSME PSN 1, 2 & 3 AND GN2 HEATED PURGE INITIATION
- T-6:00 HR START LH_2 AND LO_2 ET PROPELLANT LOAD
- T-4:55 MIN TERMINATE LOX REPLENISH
- T-1:57 MIN TERMINATE LH_2 REPLENISH
- T-0:06.6 SEC SSME START
- T-0:00 LIFTOFF
- T+32 SEC THROTTLE TO 65%
- T+1 MIN RAMP TO 104%
- T+2:06 MIN SRB SEPARATION
- T+8:36 MIN THROTTLE TO 65 %
- T+8:42 MIN MECO

ACTUAL THRUST LEVELS ARE A FUNCTION OF MISSION REQUIREMENTS

MPS MISSION FUNCTIONS (CONT'D)

- MECO +16 SEC ET SEPARATION
- MECO +2 MIN LH_2/LOX DUMP SEQ (LH_2 THRU T-0, LOX THRU SSME)
- DUMP +130 SEC END OF DUMP SEQ
- ON ORBIT VACUUM INERTING
- RE-ENTRY MANIFOLD PRESSURIZATION AT GRV = 4500 FT/SEC
  - OMS POD PURGE AND LH_2 DISCONNECT PURGE
- PRESSURIZATION TERMINATED AT START +888 SECONDS (ON GROUND)

- SSME'S POSITIONED TO "RAIN DRAIN" ONLY IF WEATHER DICTATES (DFRF)
- SSME'S POSITIONED TO -2° PITCH PRIOR TO APU SHUTDOWN FOR INSTALLATION OF ACTUATOR LOCKS (KSC/VLS)

SSME PRE-START AND ENGINE READY REQUIREMENTS

FLIGHT 3B SOFTWARE

PARAMETER	LIMIT	FAILURE RESPONSE
REDLINE REDUNDANCY (BOTH REQ'D)		
HPOT Discharge Temp, ^{o}R	700 Max	MCF
HPFT Discharge Temp, ^{o}R	700 Max	MCF
HPOT Sec Seal Cavity Pressure, PSIA	0 Min 100 Max	MCF
HPOP IMSL Purge Pressure, PSIA	0 Min 650 Max	MCF
HPOP Primary Seal Drain Pressure, PSIA	0 Min 40 Max	MCF
PROPELLANT CONDITIONS (ONE OF TWO REQ'D)		
LPOP Discharge Pressure, PSIA	600 Max 95 Min	I
LPFP Discharge Pressure, PSIA	61 Max 47 Min	I
LPFP Discharge Temp, ^{o}R	42 Max 35 Min	I
PBP Discharge Temp, ^{o}R	186.5 Max - Min	I
PNEUMATIC AND HYDRAULIC SYSTEMS (ONE OF TWO REQ'D)		
Either Oxid or Fuel Preburner Purge Pressure, PSIA	50 Max - Min	I
MOV Hydraulic Temp, ^{o}R	- Max 490 Min	I
MFV Hydraulic Temp, ^{o}R	- Max 490 Min	I
Emergency S/D Pressure, PSIA	50 Max - Min	I
CONTROLLER FAILURES (SELF-TEST)	All OK	MCF
DCU		
Input/Output Electronics		
ACTUATOR POSITIONS (BOTH REQ'D)	All OK	MCF
OPOVA FPOVA MOVA MFVA CCVA	Position Within 6% of Command + Ch A Position Within 3% of Channel B Position	

SSME PRE-START AND ENGINE READY REQUIREMENTS - CONT-D

FLIGHT 3B SOFTWARE

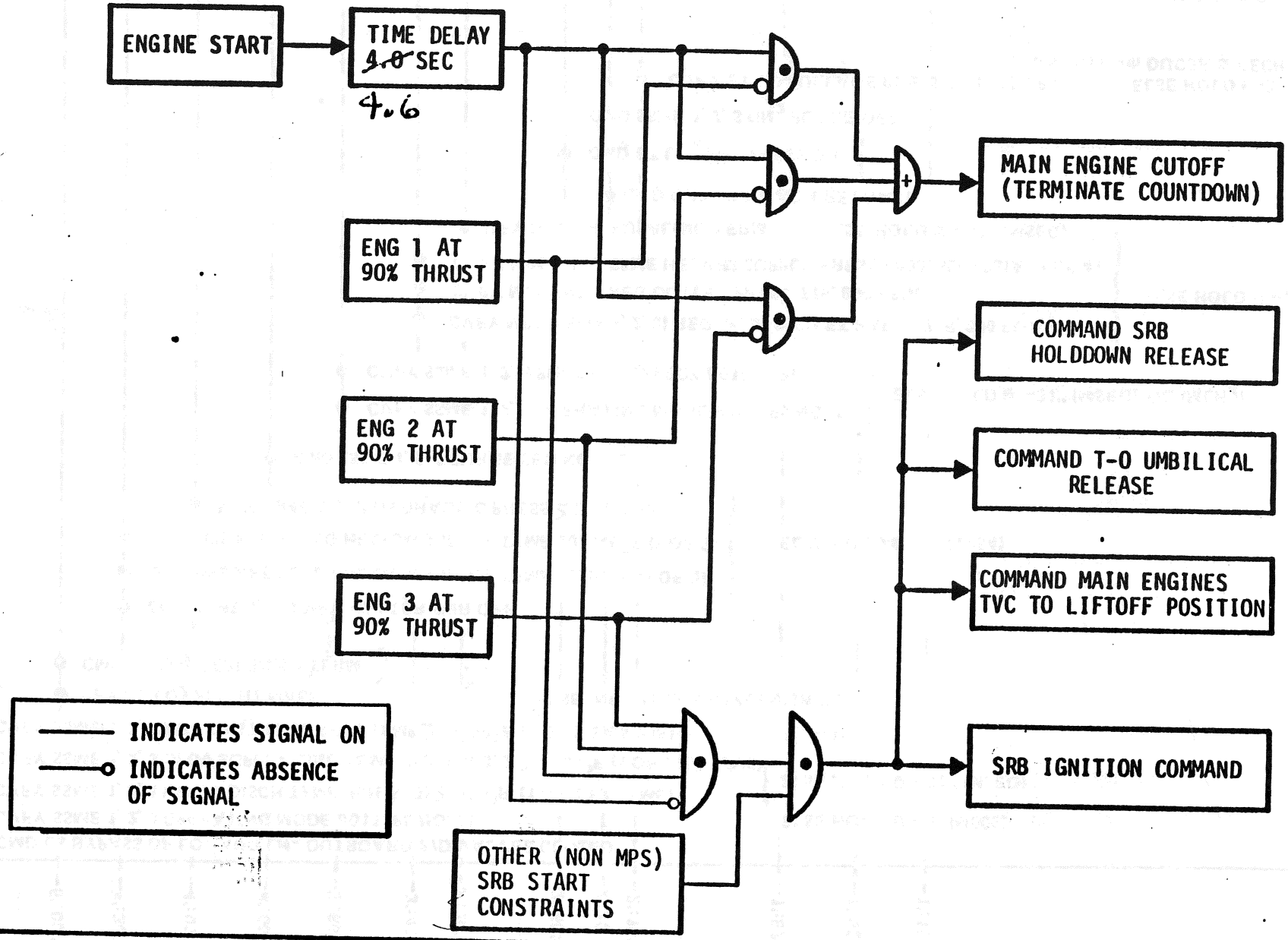
PARAMETER	LIMIT	FAILURE RESPONSE
PURGE & ANCILLARY MONITOR (ONE OF TWO REQ'D)		
Fuel System Purge, PSIA	200 Min	I
POGO Precharge Pr, PSIA	1425 Max	
MFV Hyd Outlet Temp, R	460 Min	
MOV Hyd Outlet Temp, R	450 Min	
PURGE & ANCILLARY MONITOR (ALL REQ'D)		
HPOP IMSL Purge, PSIA (2 Measurements)	170 Min	MCF
POGO RIV Position, % (1 Measurement)	20 Max	I
Fuel/Oxid Bleed Positions, % (1 Measurement/Valve)	80 Min	I
HEX Anti-Flood Valve, % (2 Measurements)	10 Max	I
CONTROL PARAMETERS (BOTH REQ'D)		I
MCC Pc - Channel Compare, PSIA	200 Max	
Fuel Flow Channel Compare, GPM	1800 Max	

NOTES: MCF = MAJOR COMPONENT FAILED

I = INHIBIT

MCF REQUIRES PROBLEM CORRECTION TO CONTINUE WHILE "INHIBIT" CAN BE BYPASSED WITH A "RESUME" COMMAND

LIFTOFF LOGIC
GPC CONTROLLED



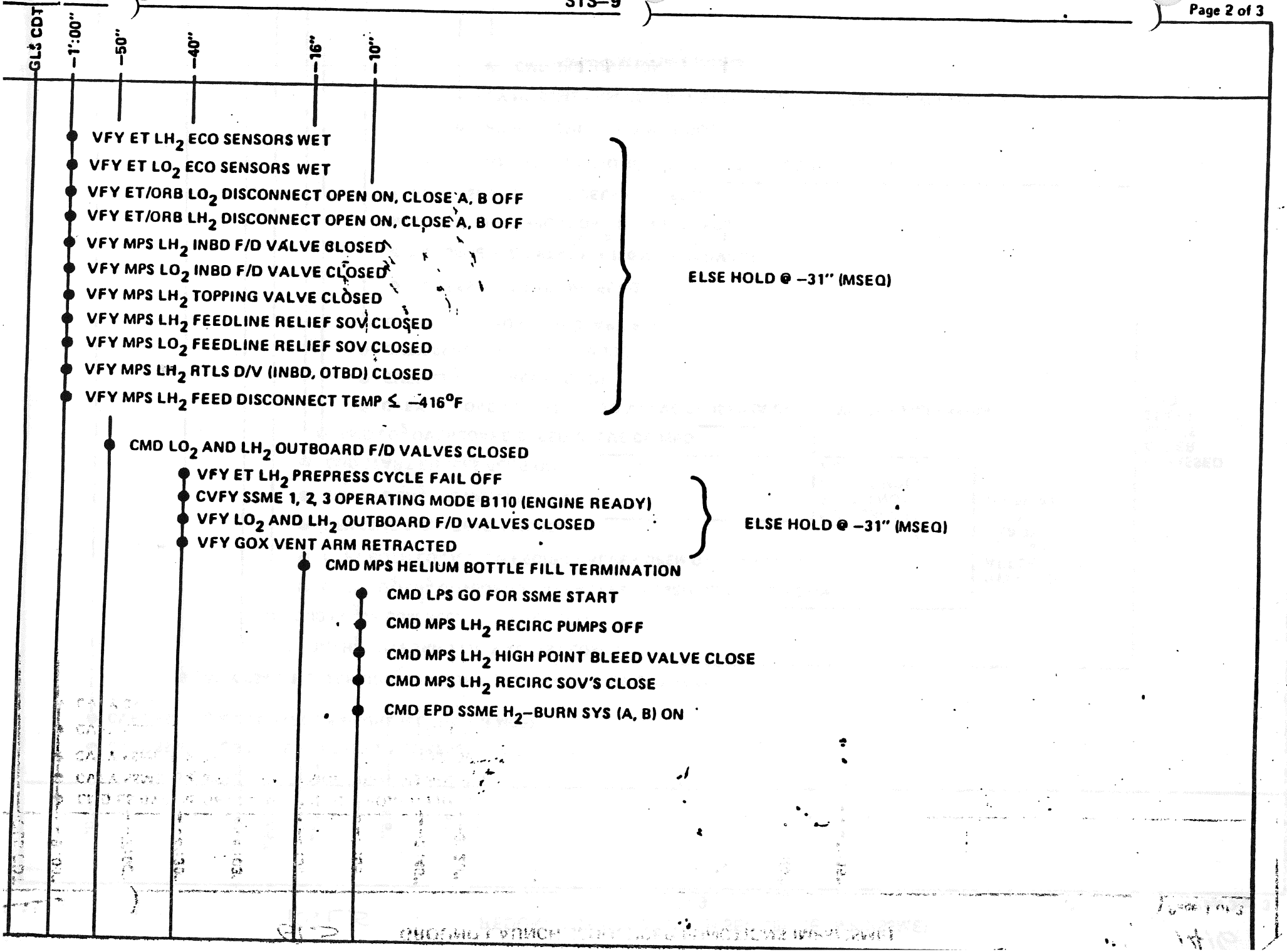
GLS GROUND LAUNCH SEQUENCER FUNCTIONS (MPS/SSME)

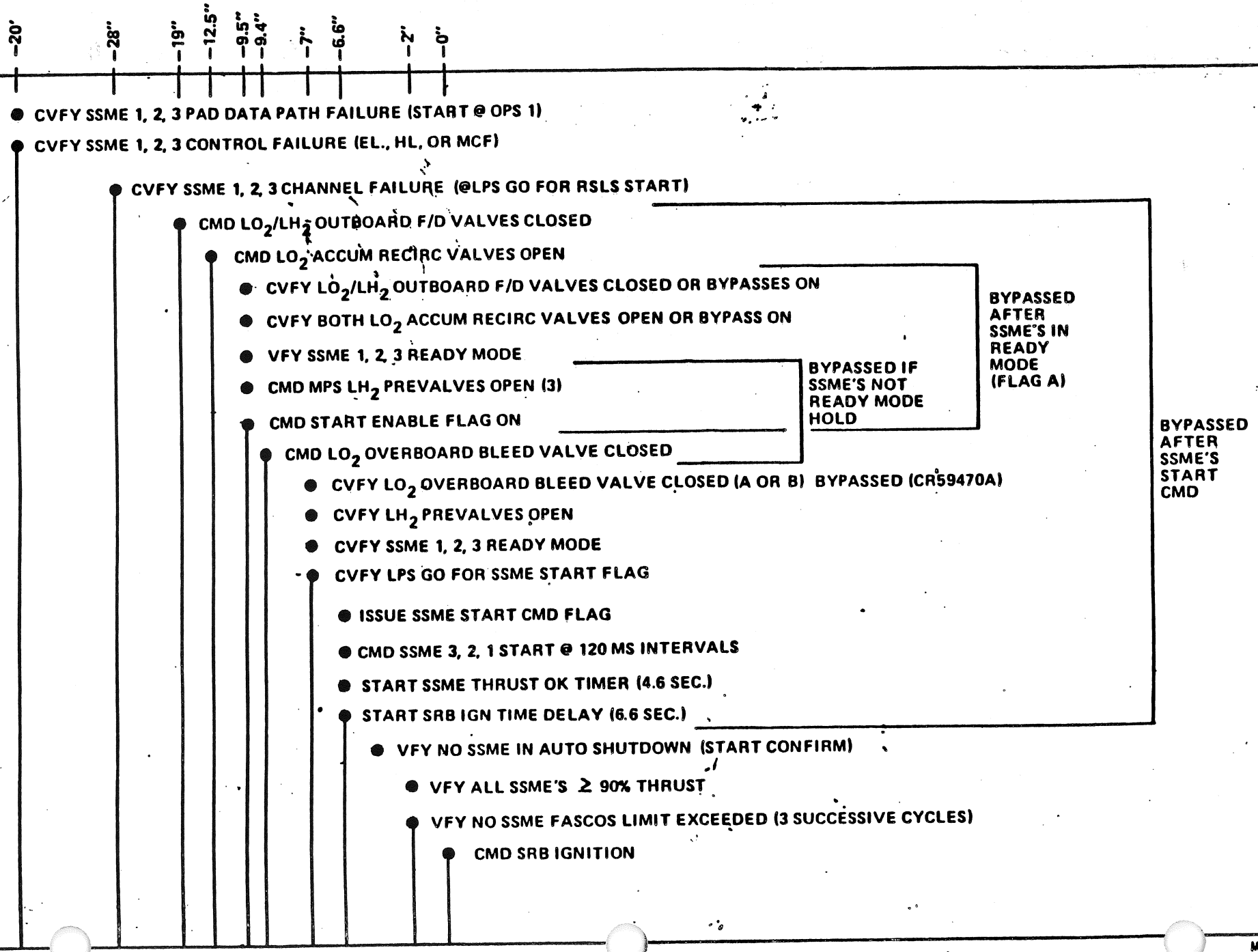
STS

GLS CDT | −9':00" | −5':00" | −4':30" | −4':03" | −4':00" | −3':55" | −3':45" | −3':20" | −2':55" | −2':30" | −2':15" | −1':57" | −1':52" | −1':15"

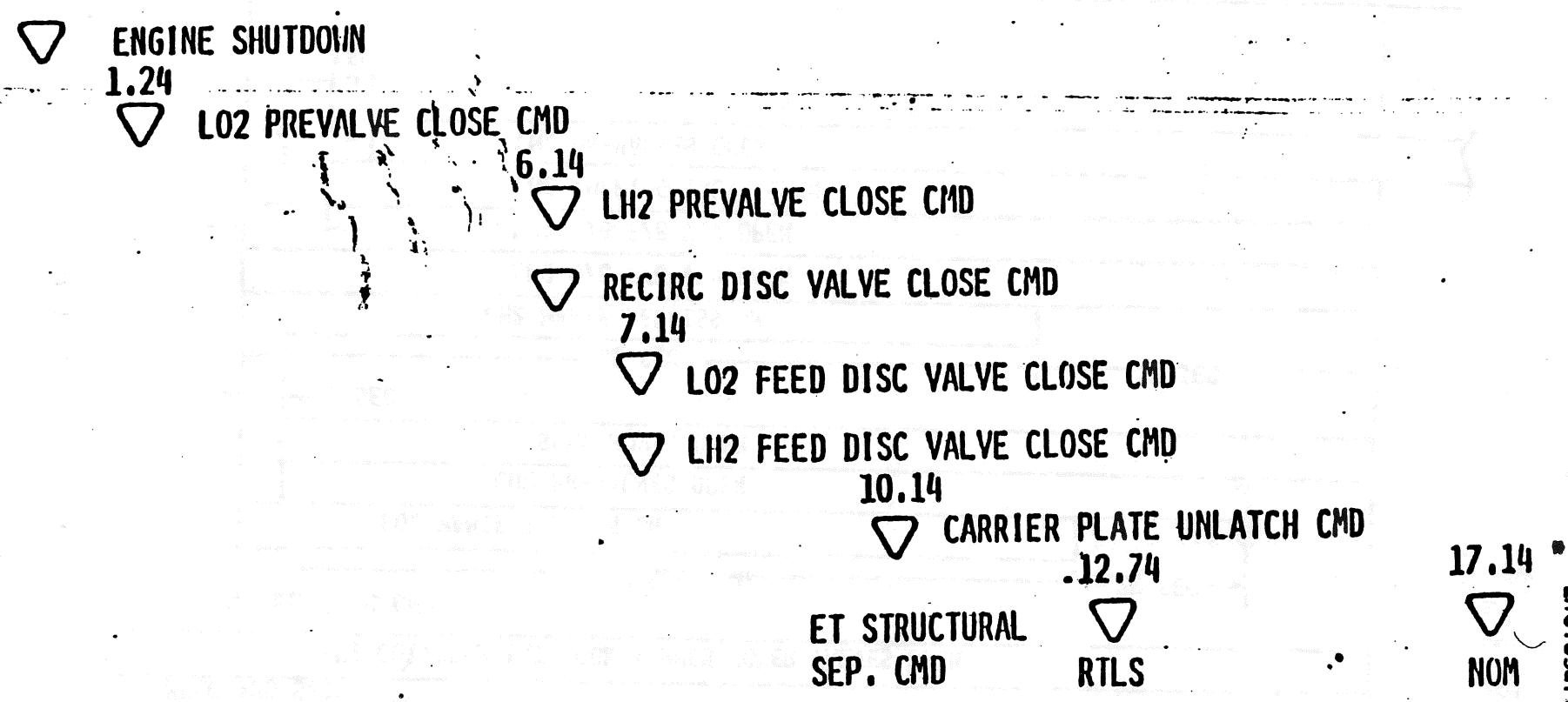
- CMD LS BYPASS OF LO_2 AND LH_2 OUTBOARD F/D VALVES CLOSED
- CVFY SSME 1, 2, 3 OPERATING MODE B011 (PS NO. 3) — ELSE HOLD @ −9' (M009)
- CVFY SSME 1, 2, 3 HPFTT DISCH TEMP. (CH A, B) ≥ 360°R (1 OF 2 EA SSME)
- CVFY SSME 1, 2, 3 OPOV SUPPLY LINE TEMP NO. 1, NO. 2 ≥ −160°F (1 OF 2 EA SSME) — ELSE HOLD @ −31" (MSEQ)
- CVFY SSME 1, 2, 3 MFV DNSTREAM SKIN TEMP ≥ −250°F (1 OF 2 EA SSME) — TIL −1'
- VFY ET LO_2 FLIGHT MASS — ELSE INHIBIT LO_2 REPLENISH TEAM
- CMD ET LO_2 REPLENISH TERM
- CMD SSME 1, 2, 3 MFV HEATER PWR OFF
- VFY MPS AFT FUSLG HELIUM SUPPLY TEMP 10, 95°F (1 OF 3)
- VFY MPS MID FUSLG HELIUM SUPPLY TEMP 60, 145°F (3 OF 3) — ELSE HOLD @ −4' (MPS4)
- VFY SSME 1, 2, 3 HYDRAULIC PRESS ≥ 2700 PSIA
- CMD SSME 1, 2, 3 PURGE SEQ NO. 4 ON
- CVFY SSME 1, 2, 3 OPERATING MODE B100 (PS NO. 4) — ELSE HOLD @ −31" (MSEQ) TIL (MLH_2)
- CVFY SSME 1, 2, 3 PHASE IN EFFECT B010 (S/P)
- CVFY MPS (SSME 1, 2, 3) REG A, B OUTLET PRESS 715, 800 PSIA
- CVFY MPS PNEU REG OUTLET PRESS 715, 800 PSIA
- CVFY MPS PNEU/SSME HELIUM SUPPLY PRESS 4000, 4500 PSIA (3 OF 4) — ELSE HOLD @ −31" (MSEQ)
- VFY HELIUM BUBBLING TERM — ELSE HOLD @ −31" (MSEQ)
- CMD GOX VENT ARM RETRACT
- CMD ET LO_2 PRE-PRESS ON
- CMD SSME 1, 2, 3 GN_2 PURGE OFF
- CVFY ET LO_2 ULLAGE PRESS 19.3, 22.5 PSIG — ELSE HOLD @ -31" (MSEQ) (INSERT 4th DUCER & RECHECK TIL −31")
- VFY ET LH_2 FLIGHT MASS — ELSE HOLD @ −1':57" (MLH_2)
- CMD ET LH_2 REPLENISH TERM ON
- ELSE HOLD @ −31" (MSEQ) — VFY ET LH_2 REPLENISH TERM
- ELSE HOLD @ −31" (MSEQ) — CVFY ET LH_2 ULLAGE PRESS 40.9, 44.1 PSIA
- (INSER H DUCER & RECHECK TIL −31")

MWV−473


GLS CDT
–1":00"
–50"
–40"
–16"
–10"
VFY ET LH_2 ECO SENSORS WET
VFY ET LO_2 ECO SENSORS WET
VFY ET/ORB LO_2 DISCONNECT OPEN ON, CLOSE A, B OFF
VFY ET/ORB LH_2 DISCONNECT OPEN ON, CLOSE A, B OFF
VFY MPS LH_2 INBD F/D VALVE CLOSED
VFY MPS LO_2 INBD F/D VALVE CLOSED
VFY MPS LH_2 TOPPING VALVE CLOSED
VFY MPS LH_2 FEEDLINE RELIEF SOV CLOSED
VFY MPS LO_2 FEEDLINE RELIEF SOV CLOSED
VFY MPS LH_2 RTLS D/V (INBD, OTBD) CLOSED
VFY MPS LH_2 FEED DISCONNECT TEMP ≤ –416°F
ELSE HOLD @ –31" (MSEQ)
CMD LO_2 AND LH_2 OUTBOARD F/D VALVES CLOSED
VFY ET LH_2 PREPRESS CYCLE FAIL OFF
CVFY SSME 1, 2, 3 OPERATING MODE B110 (ENGINE READY)
VFY LO_2 AND LH_2 OUTBOARD F/D VALVES CLOSED
VFY GOX VENT ARM RETRACTED
ELSE HOLD @ –31" (MSEQ)
CMD MPS HELIUM BOTTLE FILL TERMINATION
CMD LPS GO FOR SSME START
CMD MPS LH_2 RECIRC PUMPS OFF
CMD MPS LH_2 HIGH POINT BLEED VALVE CLOSE
CMD MPS LH_2 RECIRC SOV'S CLOSE
CMD EPD SSME H_2–BURN SYS (A, B) ON


-20'
-28"
-19"
-12.5"
-9.5"
-9.4"
-7"
-6.6"
-2"
-0"
CVFY SSME 1, 2, 3 PAD DATA PATH FAILURE (START @ OPS 1)
CVFY SSME 1, 2, 3 CONTROL FAILURE (EL., HL, OR MCF)
CVFY SSME 1, 2, 3 CHANNEL FAILURE (@LPS GO FOR RSLS START)
CMD LO2/LH2 OUTBOARD F/D VALVES CLOSED
CMD LO2 ACCUM RECIRC VALVES OPEN
CVFY LO2/LH2 OUTBOARD F/D VALVES CLOSED OR BYPASSES ON
CVFY BOTH LO2 ACCUM RECIRC VALVES OPEN OR BYPASS ON
VFY SSME 1, 2, 3 READY MODE
CMD MPS LH2 PREVALVES OPEN (3)
CMD START ENABLE FLAG ON
CMD LO2 OVERBOARD BLEED VALVE CLOSED
BYPASSED IF SSME'S NOT READY MODE HOLD
BYPASSED AFTER SSME'S IN READY MODE (FLAG A)
BYPASSED AFTER SSME'S START CMD
CVFY LO2 OVERBOARD BLEED VALVE CLOSED (A OR B) BYPASSED (CR59470A)
CVFY LH2 PREVALVES OPEN
CVFY SSME 1, 2, 3 READY MODE
CVFY LPS GO FOR SSME START FLAG
ISSUE SSME START CMD FLAG
CMD SSME 3, 2, 1 START @ 120 MS INTERVALS
START SSME THRUST OK TIMER (4.6 SEC.)
START SRB IGN TIME DELAY (6.6 SEC.)
VFY NO SSME IN AUTO SHUTDOWN (START CONFIRM)
VFY ALL SSME'S ≥ 90% THRUST
VFY NO SSME FASCOS LIMIT EXCEEDED (3 SUCCESSIVE CYCLES)
CMD SRB IGNITION

MPS ET SEPARATION SEQUENCE



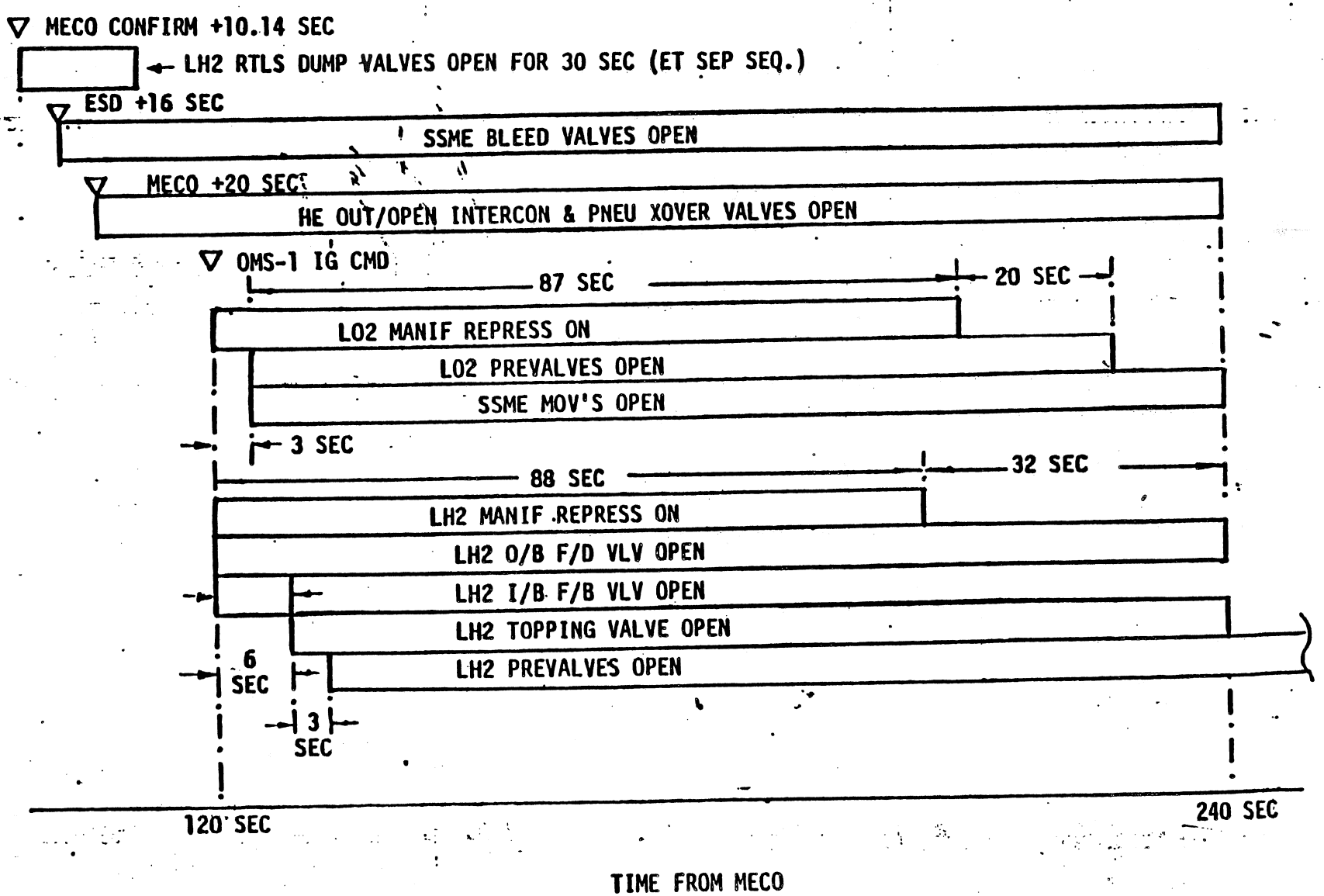
* IF AN ORBITER/ET 17-INCH PROPELLANT DISCONNECT VALVE FAILED OPEN, SEPARATION WILL BE MANUALLY INITIATED AT MECO + 6 MINUTES - FLIGHT RULE 5-50

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

TIME FROM MECO ~ SEC

Enclosure 2

MPS DUMP SEQUENCE - NOMINAL (STS-5 & SUBS)



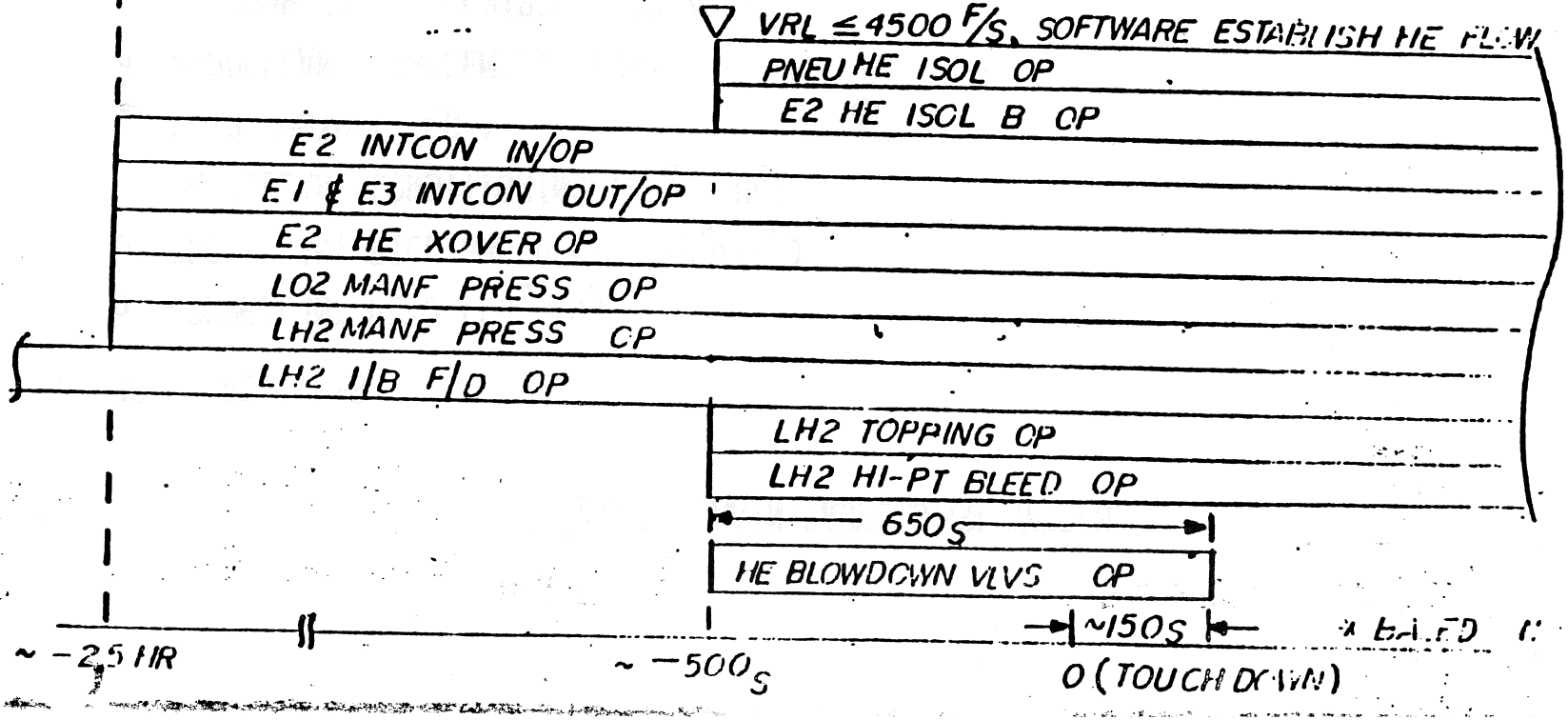
IL 289-300-82-023

MPS DEORBIT AND REENTRY PROCEDURES

▽ MPS DEORBIT PREP

CREW ACTIONS @ −2.5 HR

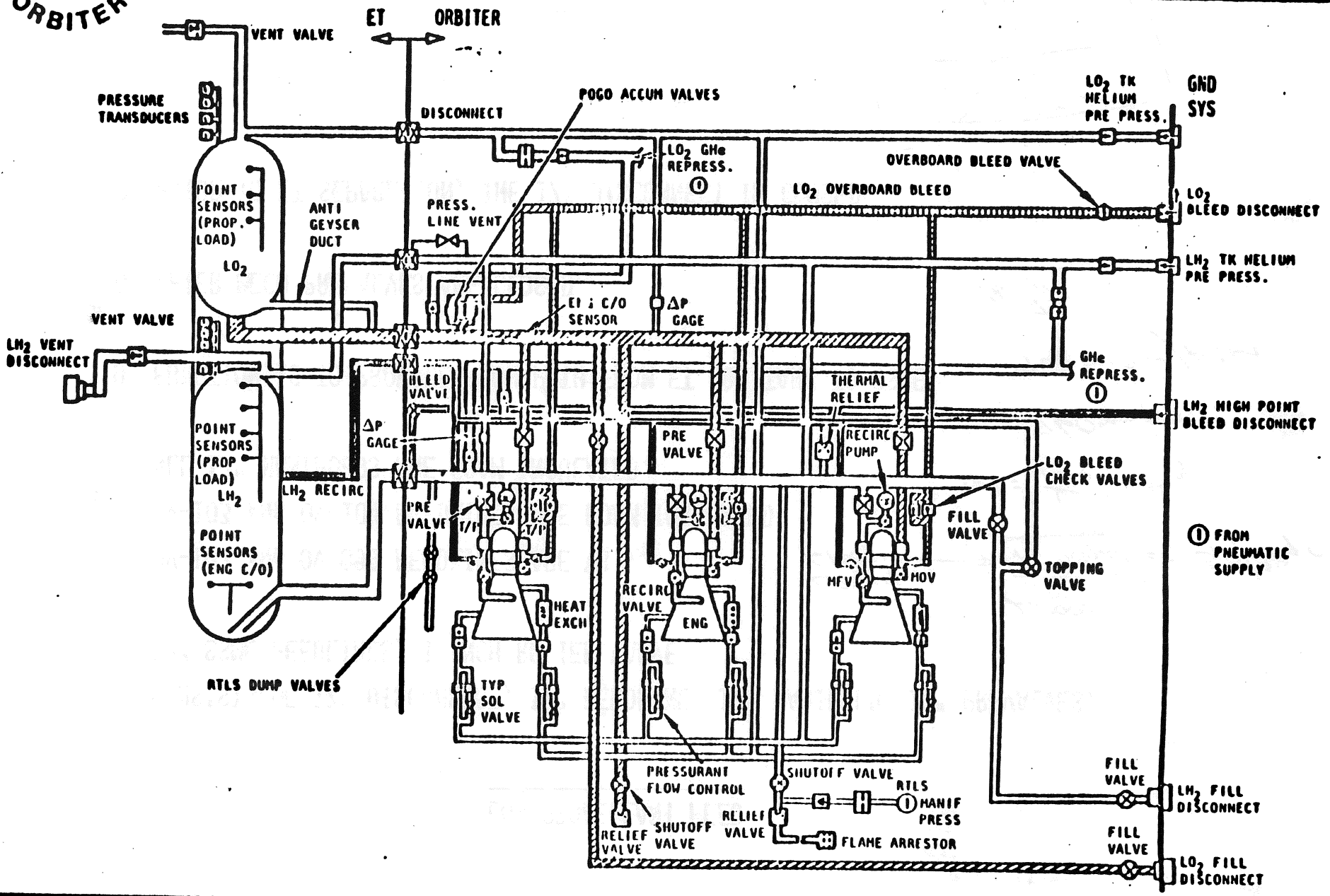
1. PLACE E2 HE ISOL A SWITCH FROM CL TO GPC
2. PLACE E2 HE ISOL B SWITCH FROM CL TO GPC
3. PLACE PNEU HE ISOL SWITCH FROM CL TO GPC
4. PLACE E2 INTCON SWITCH FROM GPC TO IN OP (LV61)
5. PLACE E1 & E3 INTCON SWITCH FROM GPC TO IN CL (LV60 & LV64)
6. PLACE E2 HE XOVER SWITCH FROM GPC TO OP (LV10)
7. PLACE LH2 MANF PRESS SWITCH FROM GPC TO OP (LV42 + 43)
8. PLACE LO2 MANF PRESS SWITCH FROM GPC TO OP (LV40 + 41)
9. PLACE LH2 I/B F/D VLV SWITCH FROM GPC TO OP (LV34, 39 + 79)



ORBITER MAIN PROPULSION SYSTEM

- MPS SUBSYSTEMS
  - PROPELLANT FEED (LH_2/LO_2)
  - PROPELLANT FILL AND DRAIN (LH_2/LO_2)
  - PROPELLANT CONDITIONING (LO_2, LH_2)
  - POGO CONTROL (LO_2)
  - PROPELLANT MANAGEMENT (LH_2)
  - PRESSURIZATION CONTROL (GH_2/GO_2)
  - PNEUMATIC SUPPLY AND CONTROL (GHE)
  - GN_2 PURGE
  - INSTRUMENTATION

MAIN PROPULSION SUBSYSTEM SCHEMATIC
(FLUID)



LO_2 PROPELLANT FEED

- CONSISTS OF 17" DISCONNECT, 17" FEEDLINE, 17" MANIFOLD, 12" PREVALVES, 12" SSME FEEDLINES, 1 INCH RELIEF VALVE

- OV-102 AND ~~OV-099~~ FEEDLINES ARE VJ
  OV-103 AND OV-104 FEEDLINES ARE FOAM INSULATED
  ALL 17" MANIFOLDS ARE FOAM INSULATED

- FUNCTION IS TO PROVIDE FLOW PATH FROM ET LOX TANK TO SSME

- AFTER MECO PREVALVES ARE CLOSED

- PRIOR TO ET SEPARATION, THE 17" DISCONNECT IS CLOSED

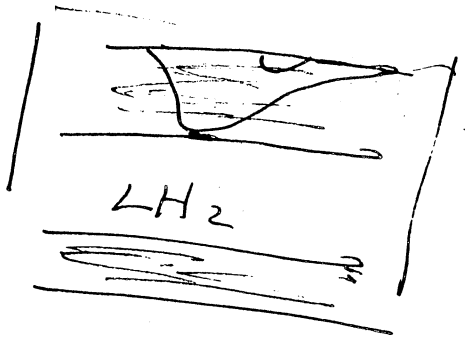
25000μ
<25μ
<100μ → 1000μ or 3μ/day rise

1μ = 1/1000 mm Hg

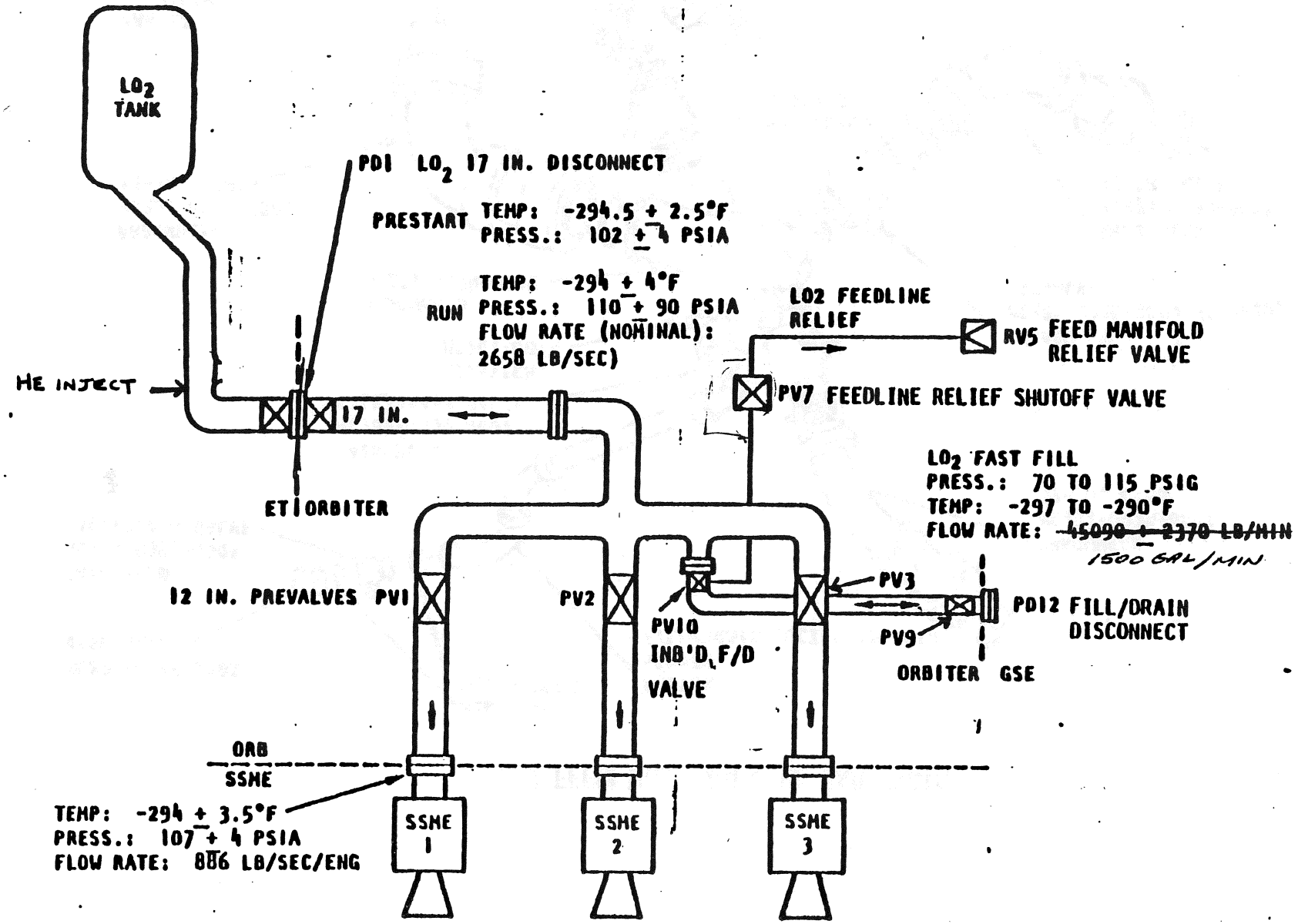
760mm/ATM

760000μ/ATM

10^{-7}μ

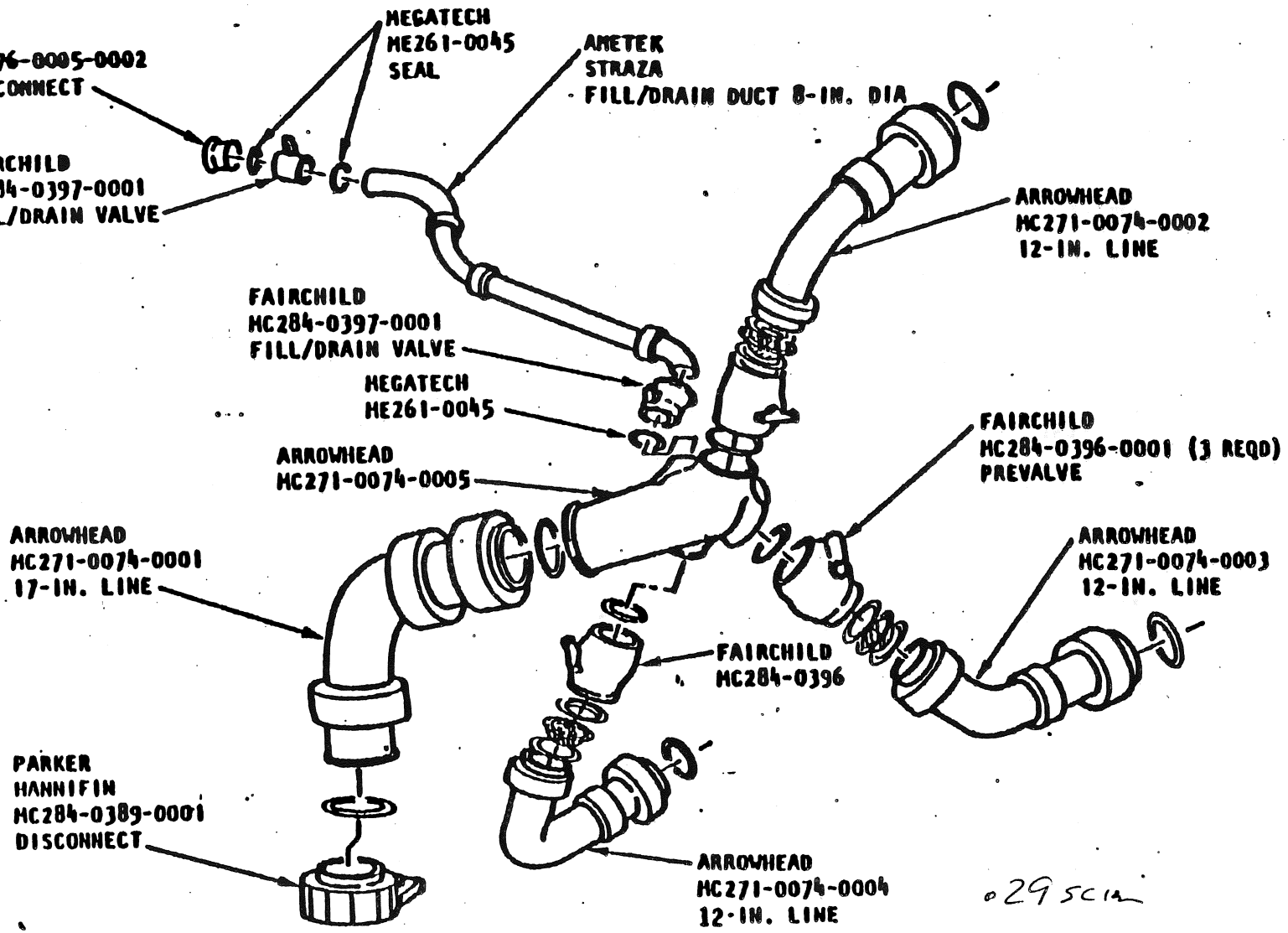


LO_2 FILL AND DRAIN, FEEDLINE RELIEF, AND FEED SYSTEM



90SSV96640

LO2 FEEDLINES AND FILL AND DRAIN

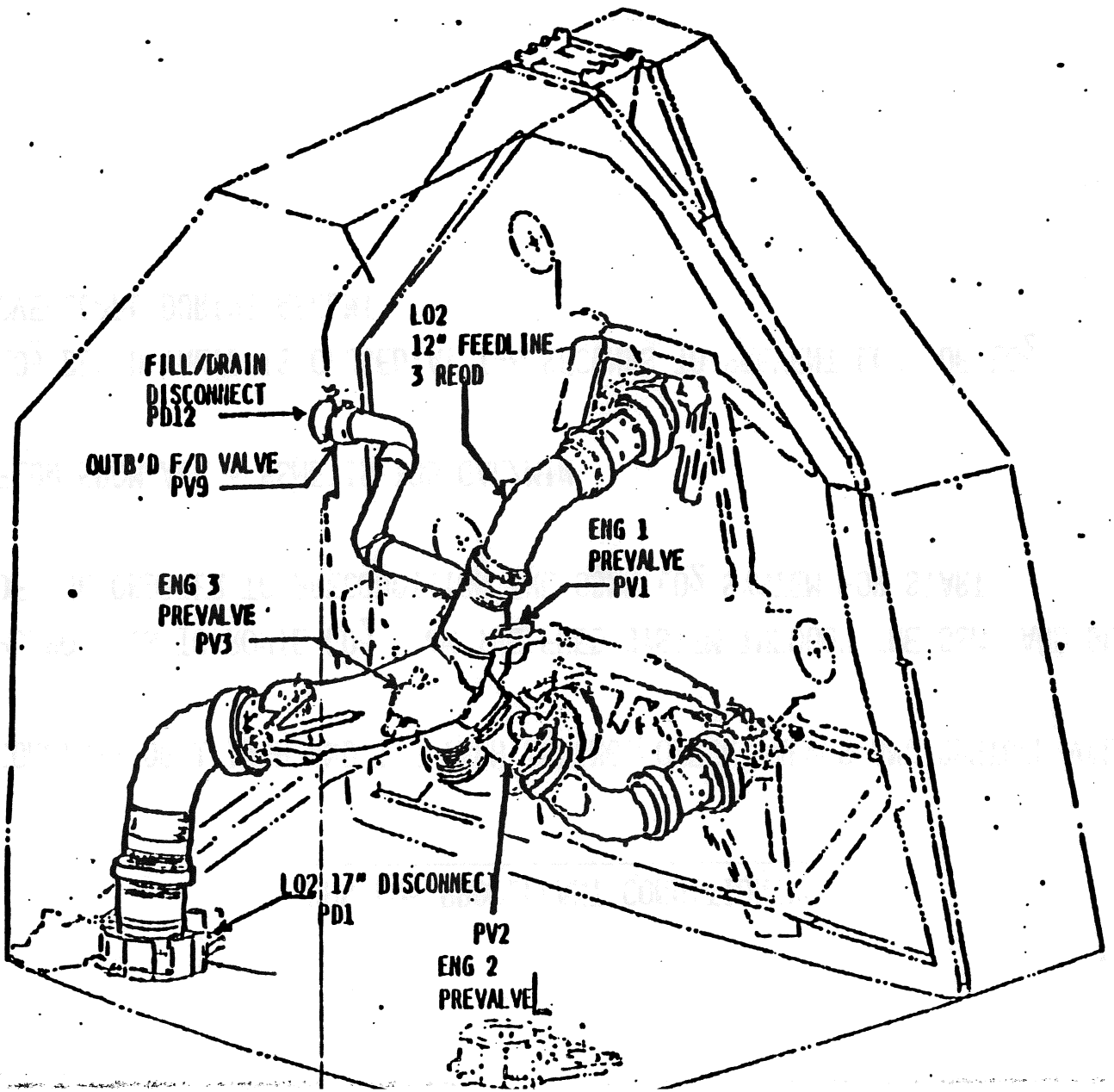


.29 SCIM

1×10^{-7} SCCS

TT-9

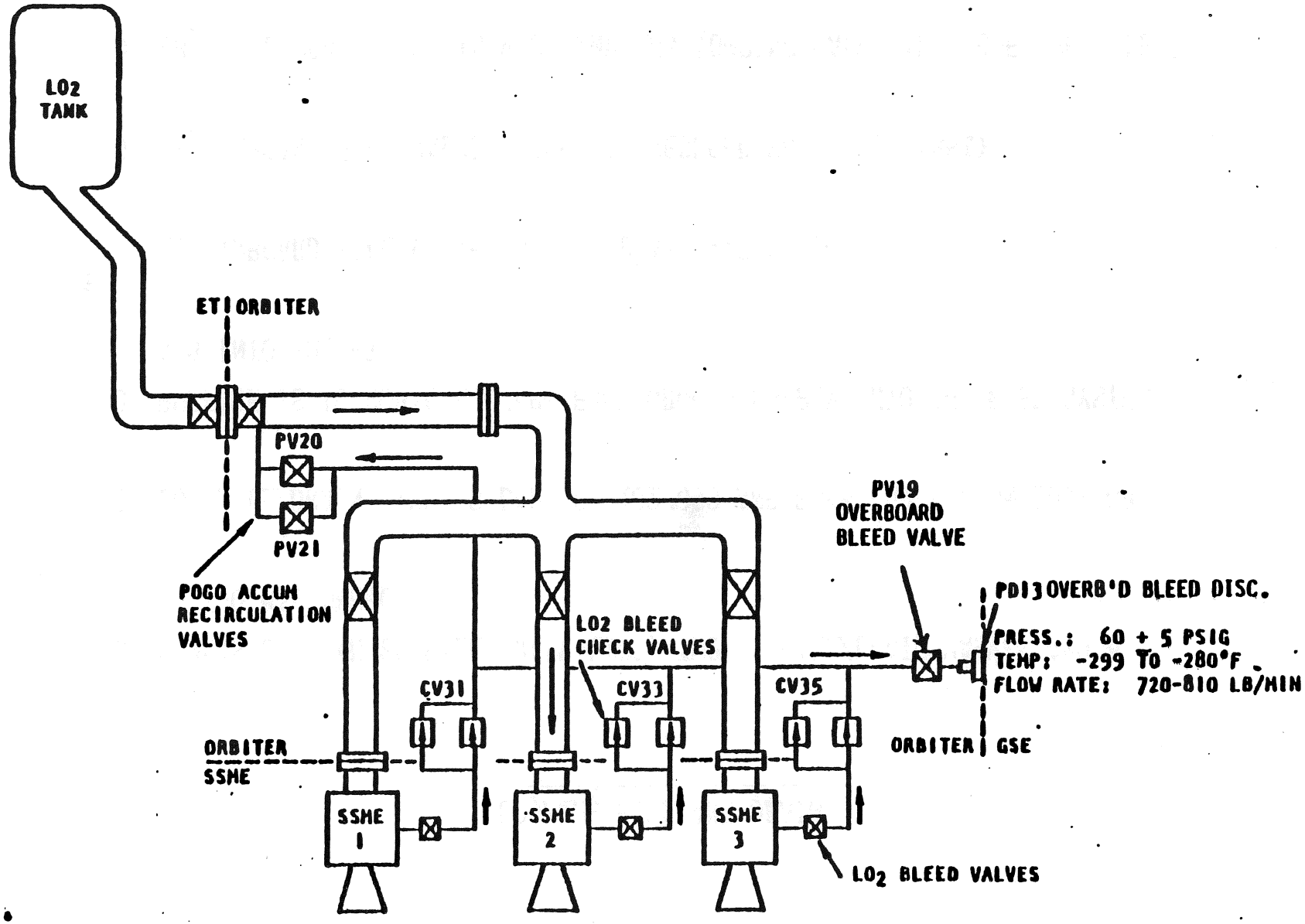
LO2 FEEDLINES AND FILL AND DRAIN LINE



MPS LO_2 PROPELLANT CONDITIONING

- CONSISTS OF 1 INCH AND 1.5 INCH TUBING, CHECK VALVES AND SHUTOFF VALVES
- PURPOSE IS TO ROUTE LO_2 FROM THE FEED SYSTEM THROUGH THE SSME AND OUT OF THE ORBITER TO PRECONDITION THE SSME LO_2 SYSTEM FOR START
- FLOW FROM ALL 3 SSME IS 105 GAL/MIN
- LO_2 BLEED VALVE IS CLOSED AT T-8 SECONDS TO PREVENT LOSS OF LO_2 OVERBOARD DURING ASCENT

LO_2 OVERBOARD BLEED AND POGO RECIRCULATION LINES



II-5

90SSV96641

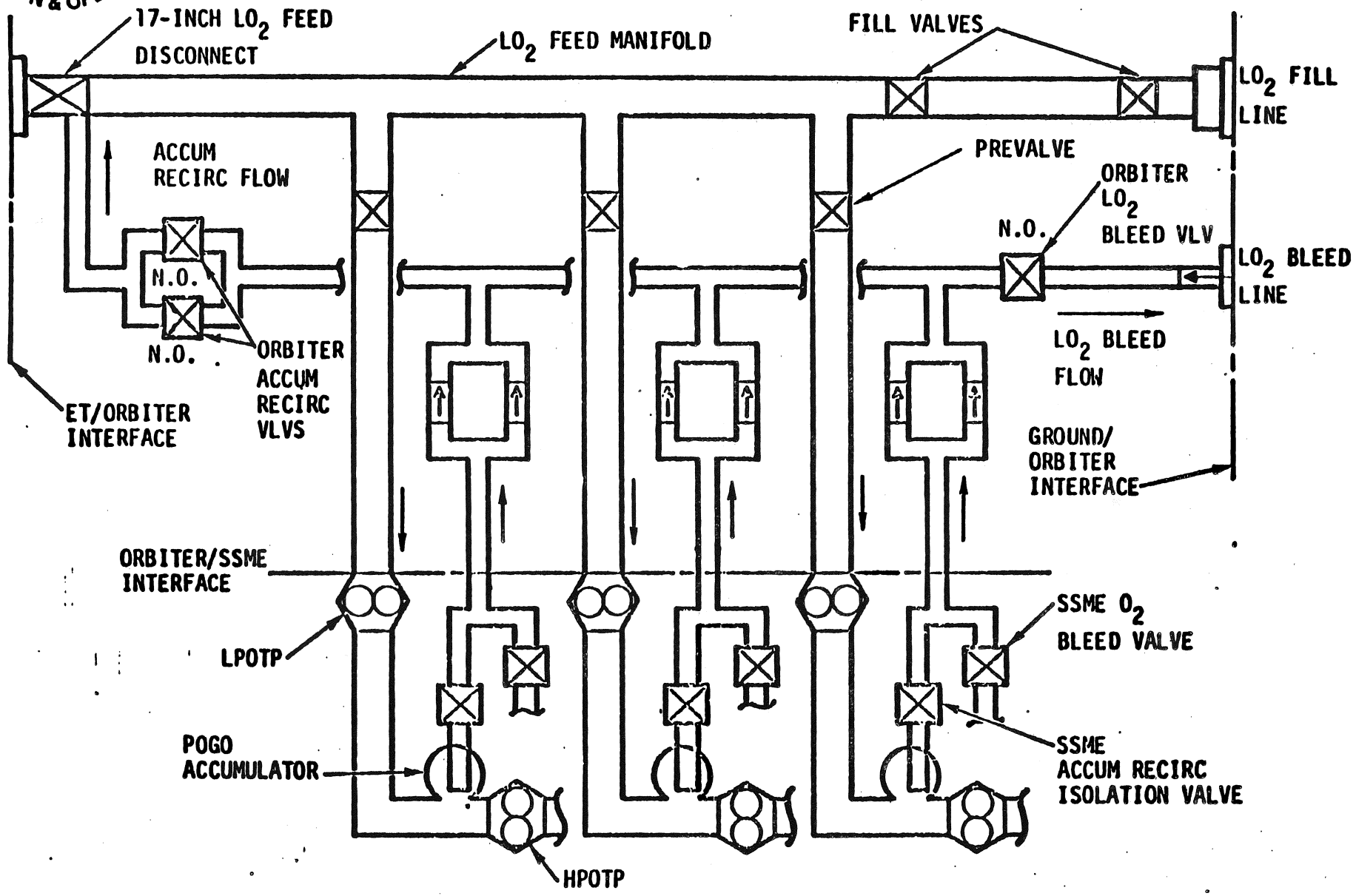
LO_2/LH_2 FILL AND DRAIN

- CONSISTS OF AN 8" FILL/DRAIN LINE, TWO 8" FILL/DRAIN VALVES AND A 8" T-0 DISCONNECT
- LOX FILL/DRAIN LINE IS BARE ON 102/099 AND FOAM COVERED ON 103/104
- PURPOSE IS TO ROUTE LO_2/LH_2 FROM GROUND SUPPLY INTO THE FEED SYSTEM AND INTO THE ET
- LOX INBOARD FILL VALVE IS CLOSED AT T-45 SECONDS (GLS)
- LH_2 INBOARD FILL VALVE CLOSES AT REDUCED FAST FILL (85%)
- LH_2 FILL/DRAIN LINE IS V.J. AND LH_2 TOPPING VALVE TEES OFF THE LINE

LO_2 POGO CONTROL

- UTILIZES SAME PIPING AS FOR LO_2 PROPELLANT CONDITIONING (BLEED)
- MPS POGO VALVES OPEN AT T-9.5 SECONDS TO ROUTE OVERFLOW LO_2 FROM THE SSME POGO ACCUMULATOR TO THE LO_2 FEED SYSTEM DURING ASCENT

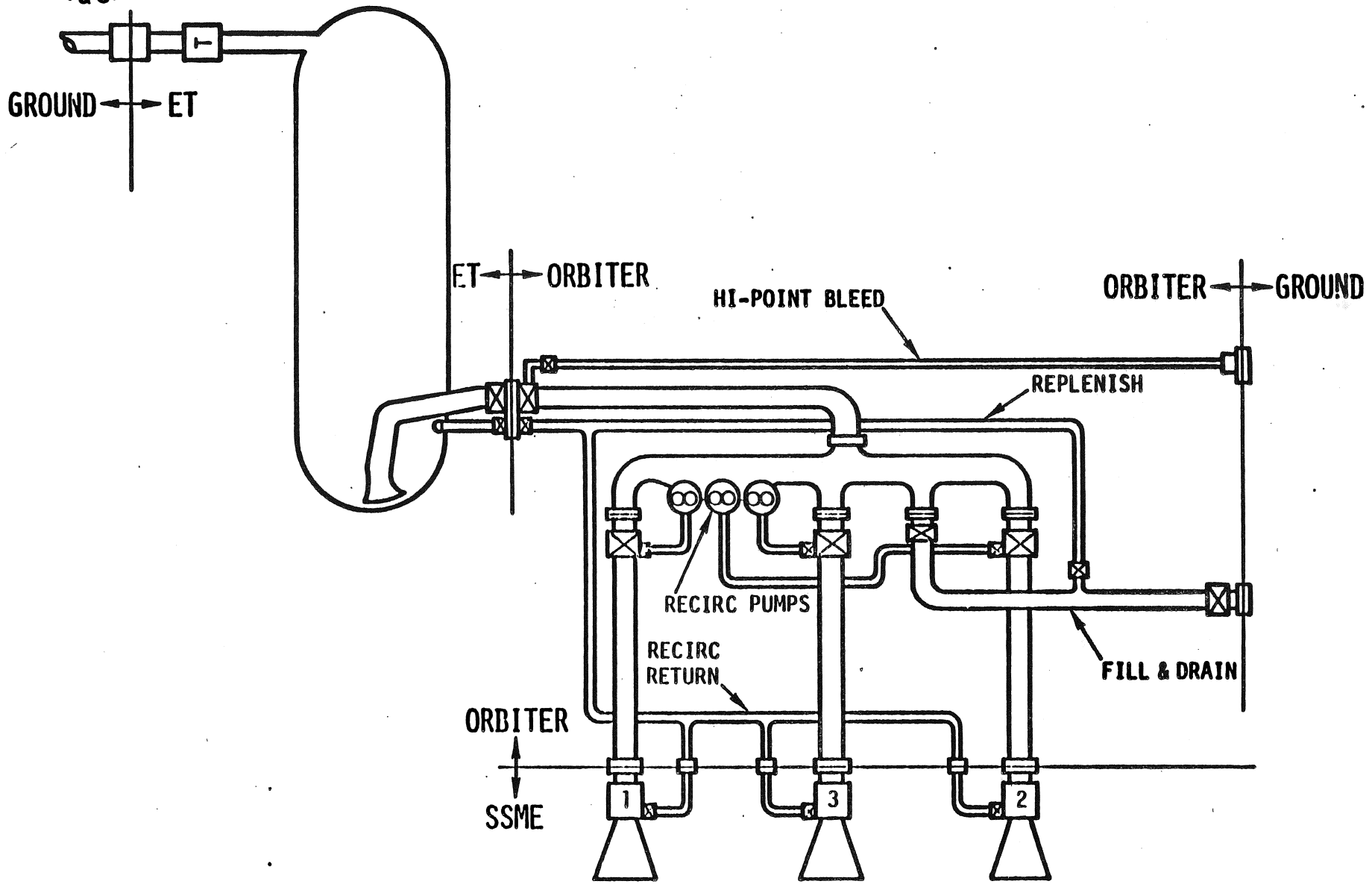
POGO SUPPRESSION SYSTEM



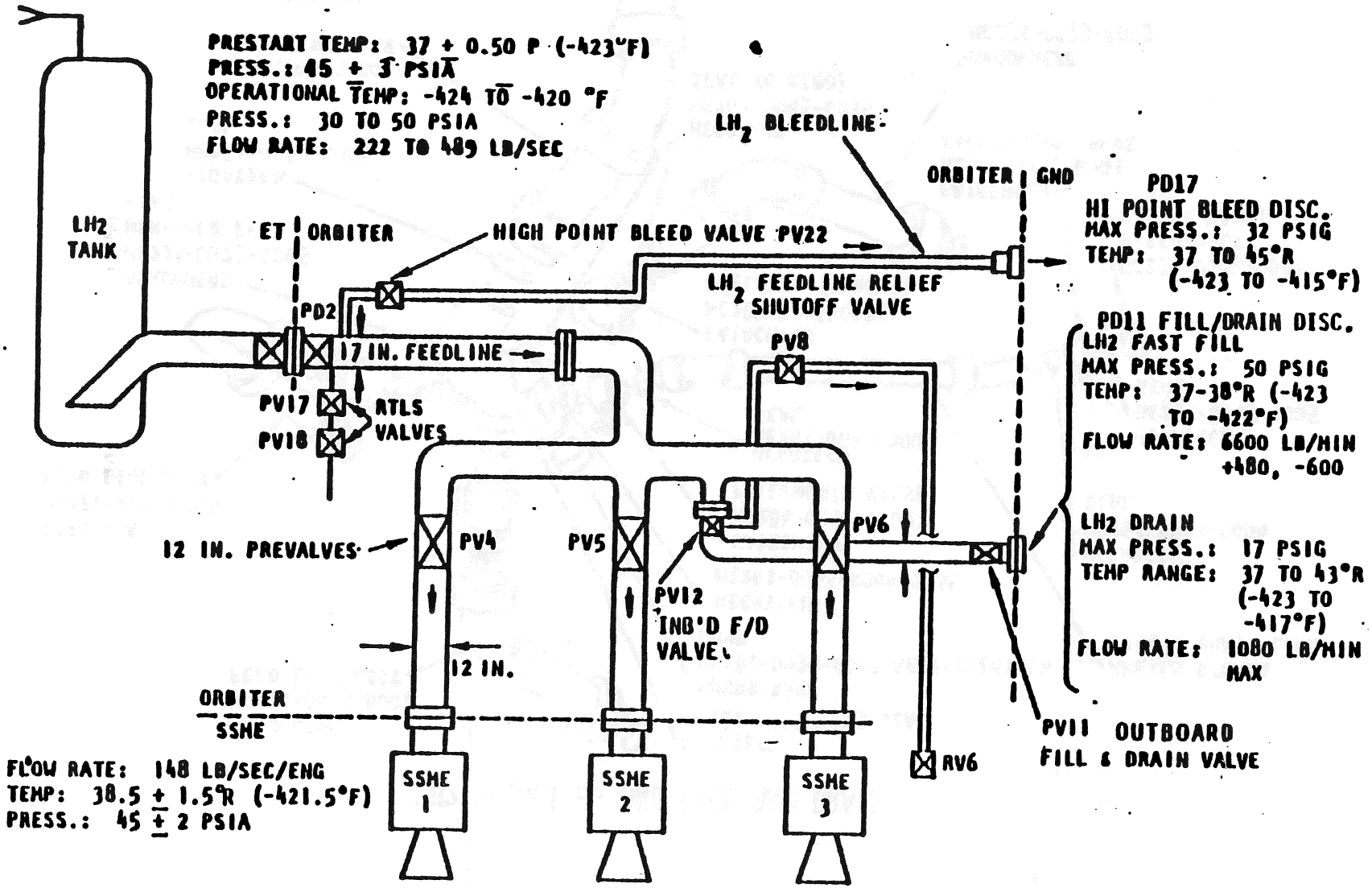
LH_2 PROPELLANT FEED

- CONSISTS OF 17" DISCONNECT, 17" FEEDLINE, 17" MANIFOLD, 12" PREVALVE, 12" SSME FEEDLINES.
- ALL LINES ARE VJ
- PURPOSE IS TO ROUTE THE LH_2 FROM THE ET TO THE SSME DURING SSME OPERATIONS
- THE LH_2 PREVALVES ARE OPENED AT T-9.5 SECONDS
- PREVALVES CLOSE AFTER MECO
- 17" DISCONNECT CLOSES PRIOR TO ET SEPARATION

LH_2 FILL AND DRAIN
PRESTART CONDITIONING AND PROPELLANT FEED



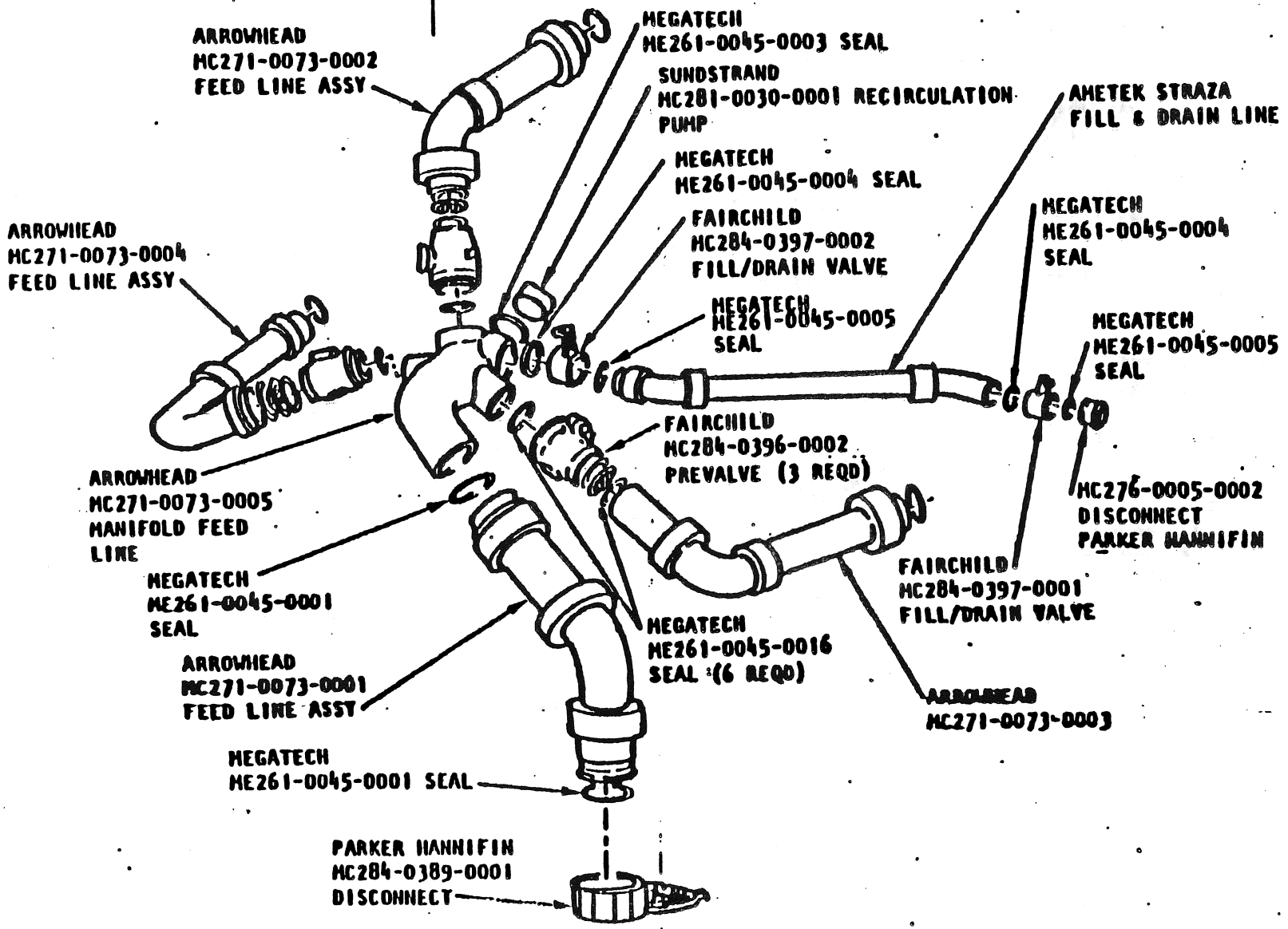
LH_2 FEED, FILL AND DRAIN, HIGH POINT BLEED, RTSL DUMP AND FILL LINE RELIEF



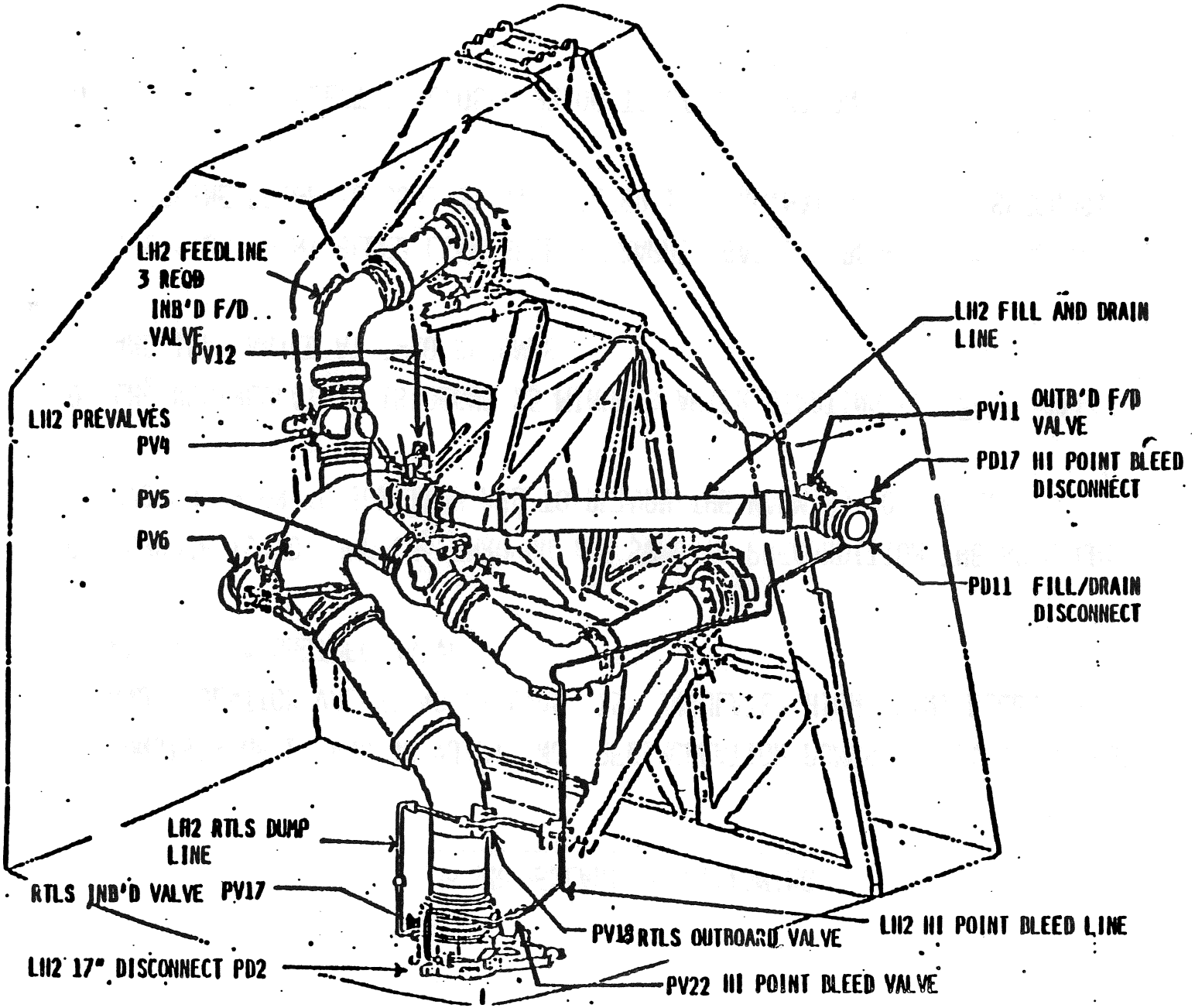
III-1

90SSV96638

LH2 FEEDLINES AND FILL AND DRAIN



LH_2 FEEDLINES AND FILL AND DRAIN LINE



LH_2 PROPELLANT CONDITIONING

- CONSISTS OF 2" AND 4" VJ PIPING, RECIRCULATION PUMPS, 4" ET DISCONNECT AND ISOLATION VALVES AS WELL AS .75" INSULATED HIGH POINT BLEED TUBING AND A 1.5" SHUTOFF VALVE

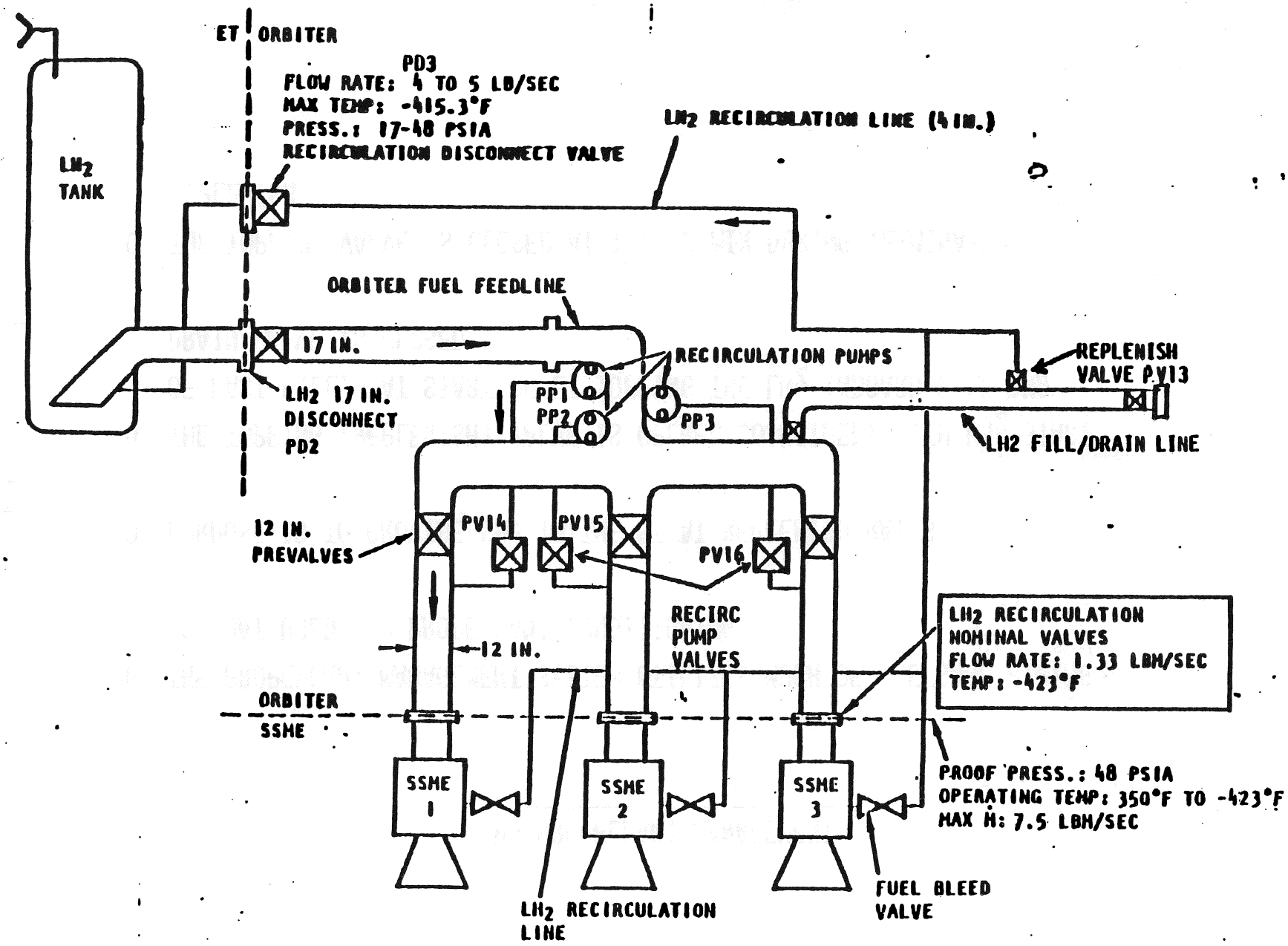
- PURPOSE IS TO PUMP LH_2 THROUGH THE SSME TO PRECONDITION THE SSME LH_2 SYSTEM PRIOR TO IGNITION AND TO RETURN THE WARM H_2 TO THE ET

- LH_2 RECIRCULATION IS BEGUN 25 MINUTES AFTER STARTING LH_2 FAST FILL AND TERMINATED AT T-10 SECONDS

- THE HIGH POINT BLEED LINE BLEEDS TRAPPED GAS OVERBOARD FROM THE 17" FEEDLINE PRIOR TO SSME START. BLEED IS TERMINATED AT T-10 SECONDS.

- THE 4" DISCONNECT IS CLOSED PRIOR TO ET SEPARATION

LH_2 RECIRCULATION SCHEMATIC



S-III

80SSV96639

LH_2 PROPELLANT MANAGEMENT

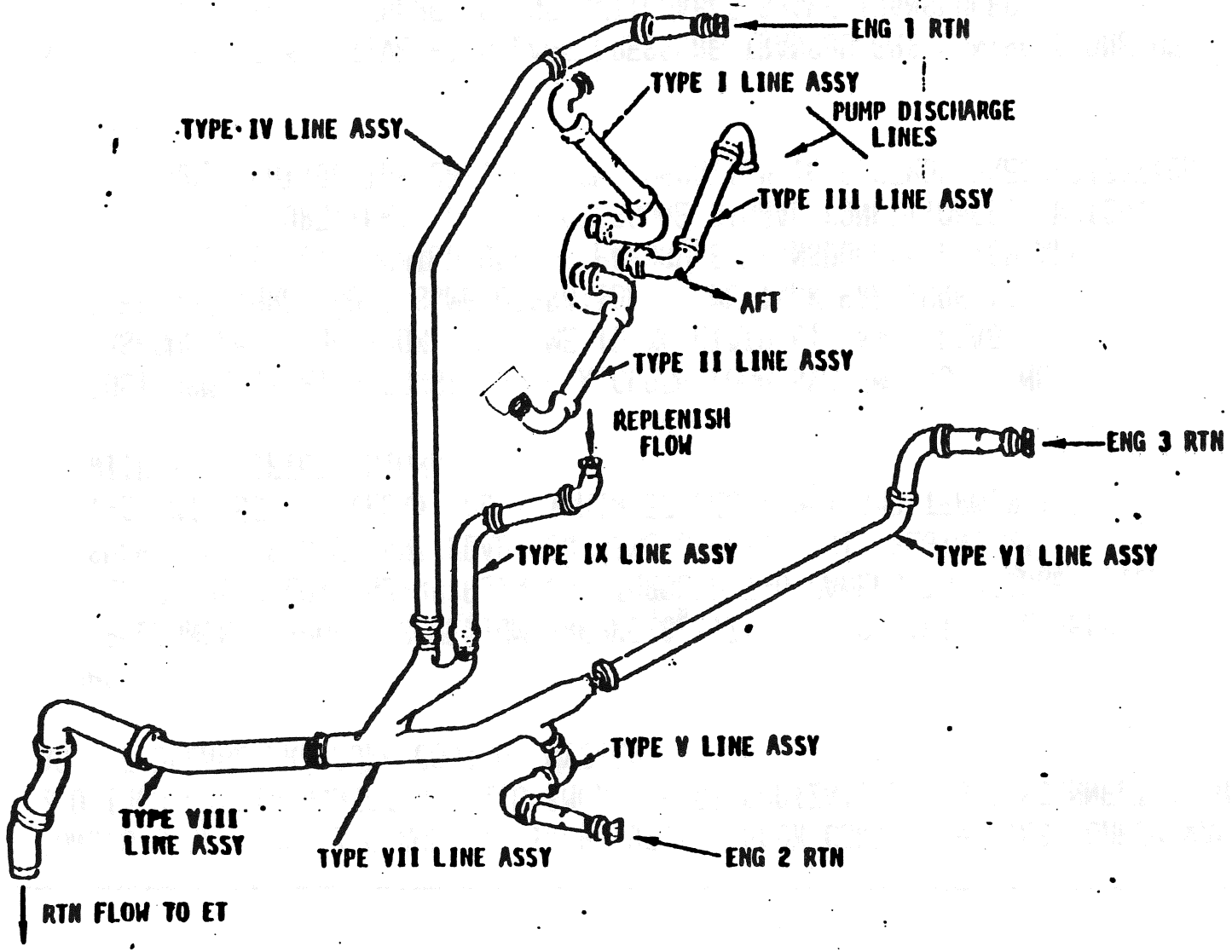
- THE PROPELLANT MANAGEMENT SYSTEM UTILIZES MUCH OF THE SAME PIPING AS THAT USED FOR PROPELLANT CONDITIONING

- PURPOSE IS TO PROVIDE LH_2 TO THE ET AT REPLENISH RATES

- THE TOPPING (REPLENISH) VALVE IS OPENED COINCIDENT WITH LH_2 START OF FAST FILL. AT START OF ET TOPPING THE LH_2 INBOARD FILL AND DRAIN VALVE IS CLOSED

- THE TOPPING VALVE IS CLOSED AT T-1:57 MIN DURING TERMINATE REPLENISH

LH2 RECIRCULATION SYSTEM LINE ASSEMBLY SYSTEM SCHEMATIC



GH_2/GO_2 PRESSURIZATION CONTROL SYSTEM

- CONSISTS OF .625, 1.0 AND 2.0 INCH TUBING, FLOW CONTROL VALVES, CHECK VALVES, 2.0 INCH ET DISCONNECT AND 1.0 INCH PREPRESSURIZATION T-0 DISCONNECT AS WELL AS THE ULLAGE PRESSURE CONTROL SYSTEM

- PURPOSE
  - PRELAUNCH - PROVIDES HELIUM PREPRESSURIZATION TO LIFTOFF LEVELS (19-22 PSIG LOX, 42-44 PSIA H_2) THROUGH T-0 PANELS TO ASSURE SUFFICIENT PROPELLANT HEAD FOR SSME START. THIS BEGINS AT T-2 MIN 55 SEC (LOX) AND T-1 MIN 57 SEC (LH_2) AND TERMINATES WITH THE LIFTOFF SIGNAL

  - POST SSME START - CONSISTS OF A CLOSE LOOP SYSTEM PROVIDING GASEOUS O_2 OR H_2 FROM THE SSME TO MAINTAIN ET TANK ULLAGE PRESSURE THROUGHOUT SSME OPERATION. THE TANK PRESSURE IS MONITORED BY ET MOUNTED ULLAGE PRESSURE TRANSDUCERS WHICH ARE READ BY THE ORBITER'S ULLAGE PRESSURE SIGNAL CONDITIONERS WHICH, IN TURN, CONTROL THE ORBITER FCV OPERATION TO CONTROL PRESSURIZATION RATE

  - EACH OF THE 3 ACTIVE ET ULLAGE PRESSURE TRANSDUCERS CONTROLS ONE OF THE THREE FCVs. THERE IS ONE SWITCHABLE SPARE TRANSDUCER

O_2 PREPRESSURIZATION AND PRESSURIZATION

T 4'35"
T 2:45

PD4
PRESSURIZATION DISC.
FLOW RATE: 1.8 TO 8 LB/SEC
TEMP: -160 TO 500°F
PRESS.: 100 TO 600 PSIA

PD9 DURING PREPRESS.
MAX PRESS.: 850 PSIG
TEMP: 20 TO 120°F
FLOW RATE: 33 ± 3 LB/MIN HELIUM

PREPRESS CHECK VALVE
CV16
GSE PREPRESS. CONTROL
ORBITER
GSE

20-22 PSIG

LO_2 ET

FLOW CONTROL VALVE

LV53
LV54
LV55

PRESSURIZATION CHECK VALVE
ORBITER

CV18
CV19
CV20

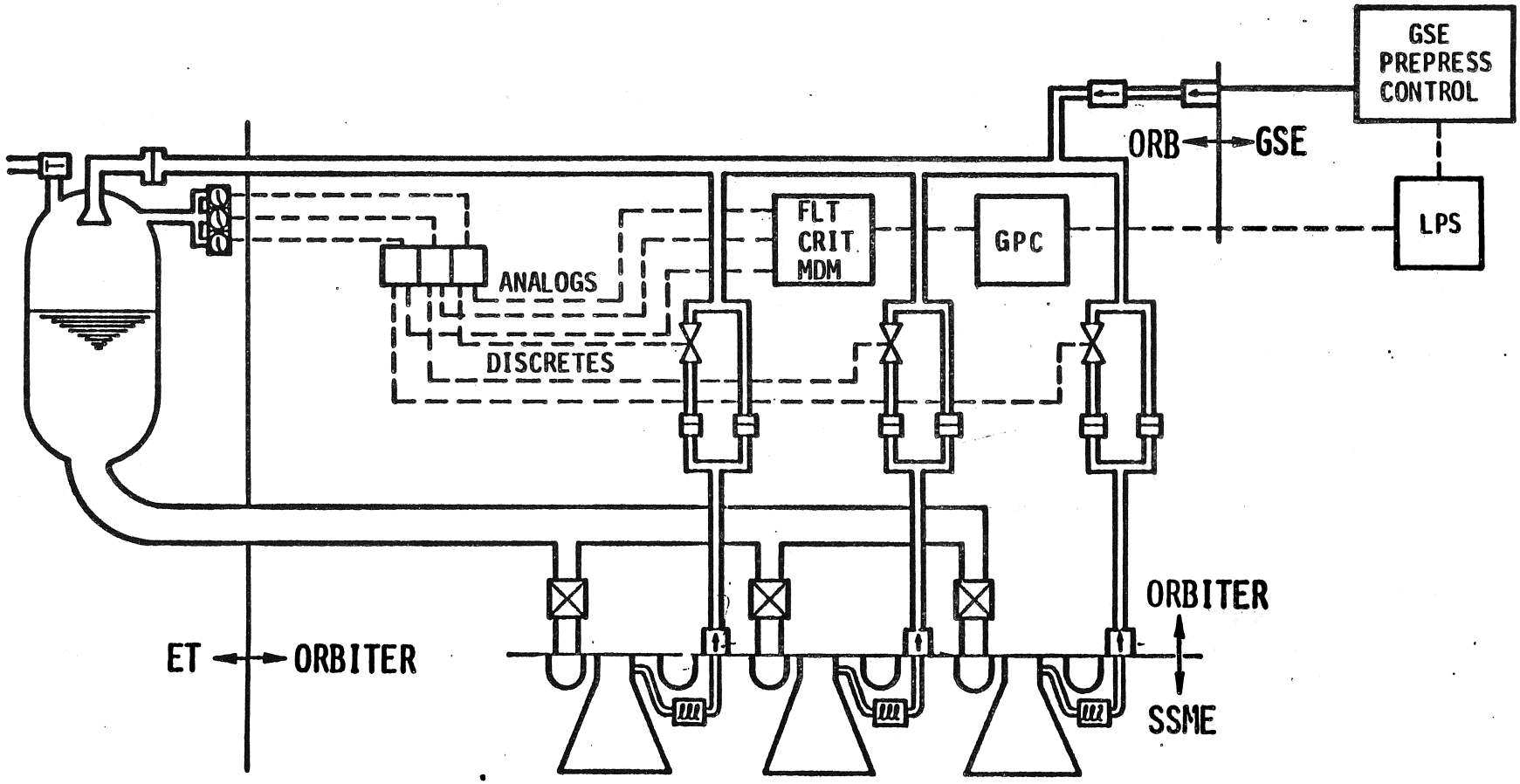
SSME 1
SSME 2
SSME 3
SSME

ET
ORBITER

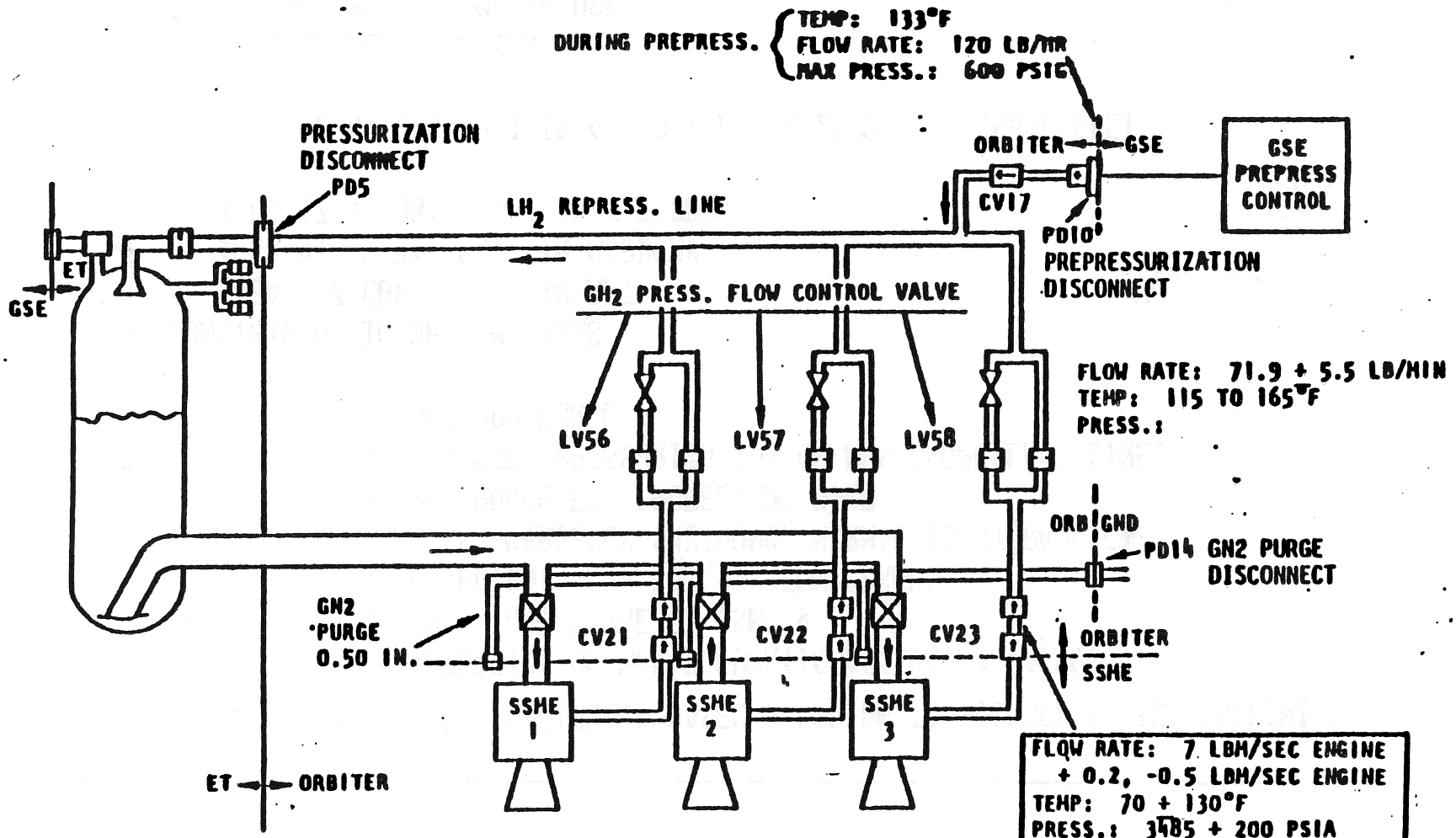
FLOW RATE: 1.55 LBM/SEC ENGINE
+0.67, -0.44 LBM/SEC ENGINE
TEMP: 390 + 50°F
PRESS.: 3600 ± 150 PSIA
LINE PROOF PRESS.: 9000 PSIG

90SSV96637

O_2 PREPRESSURIZATION AND PRESSURIZATION



LH_2 PREPRESSURIZATION, PRESSURIZATION AND GN_2 PURGE



MPS PNEUMATIC SYSTEM

FUNCTION: STORES AND DISTRIBUTES GASEOUS HELIUM TO ACCOMPLISH THE FOLLOWING

- o ACTUATION OF MPS PNEUMATIC ACTIVATED VALVES
- o IN-FLIGHT PURGE OF SSME's
- o PREFLIGHT SSME FUEL SYSTEM PURGES
- o SSME EMERGENCY SHUTDOWN (NORMAL IS HYDRAULIC)
- o MPS PURGE FOR PROPELLANT DUMP
- o RE-ENTRY PRESSURIZATION OF MPS PROPELLANT LINES
- o OMS POD PURGE

0 CONSISTS OF 10 HELIUM TANKS
- o 4 EA 4.7 CUBIC FOOT IN AFT
- o 3 EA 4.7 CUBIC FOOT IN MIDBODY
- o 3 EA 17.3 CUBIC FOOT IN MIDBODY

0 TOTAL LOAD AT 4400 PSI IS APPROXIMATELY 25000 STD CUBIC FEET

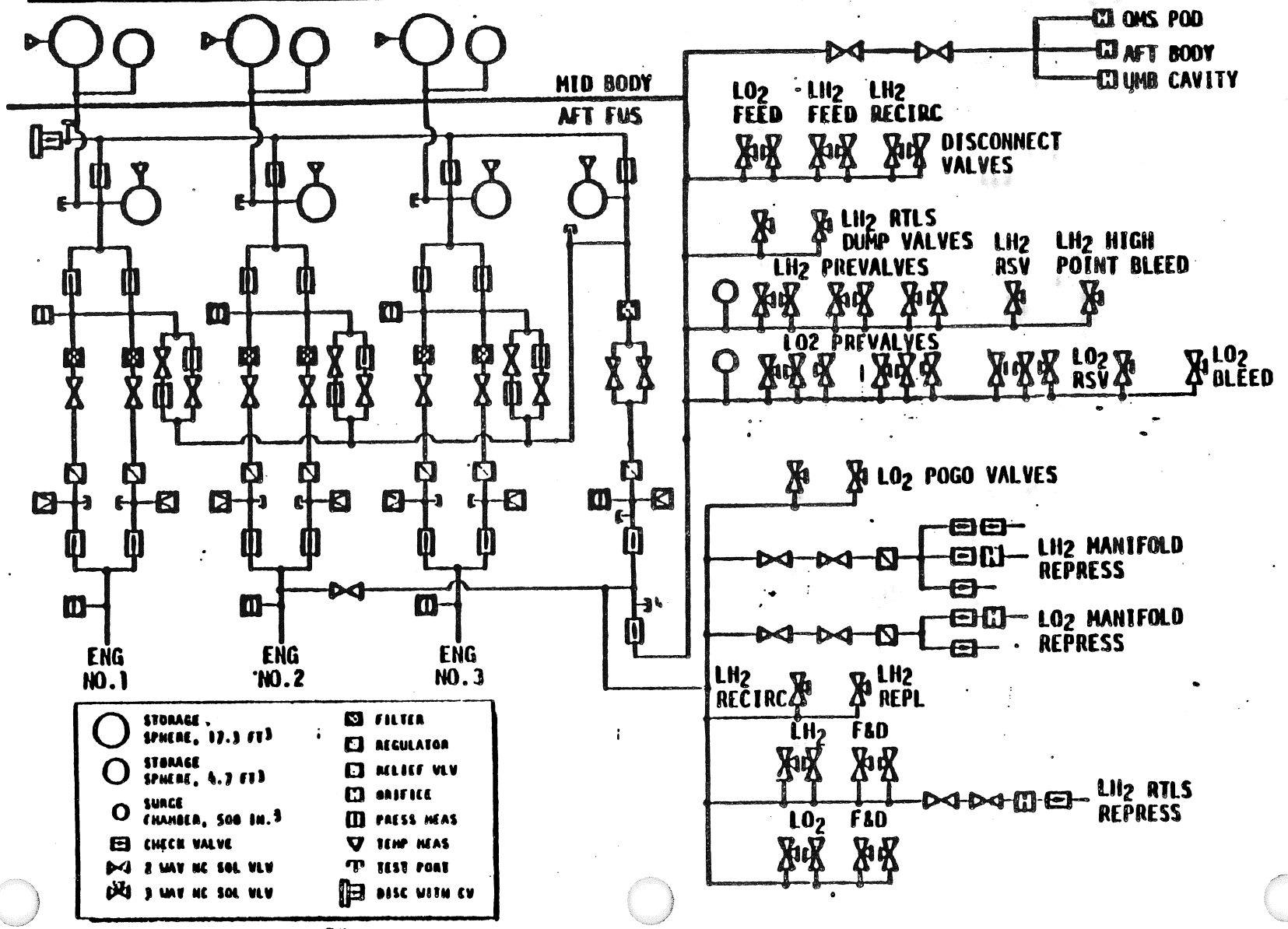
0 9 TANKS SUPPORT THE 3 SSME
0 1 TANK FOR MPS PNEUMATIC USE
ALL TANKS CAN BE INTERCONNECTED AND ISOLATED BY GROUPS IN CASE OF FAILURE OR FOR POST SHUTDOWN USE

MPS PNEUMATIC SYSTEM (CONT'D)

- EACH SSME PNEUMATIC SYSTEM (3 TANKS) IS TIED TO TWO PNEUMATIC CONTROL PANELS MOUNTED ON THE AFT FLOOR
  - EACH PANEL CONSISTS OF FILTERS, ISOLATION VALVE, INTERCONNECT VALVES, REGULATOR, RELIEF VALVE, CHECK VALVE AND INSTRUMENTATION
  - MPS PNEUMATIC PANEL (ONE EACH) IS SIMILAR TO SSME PANELS

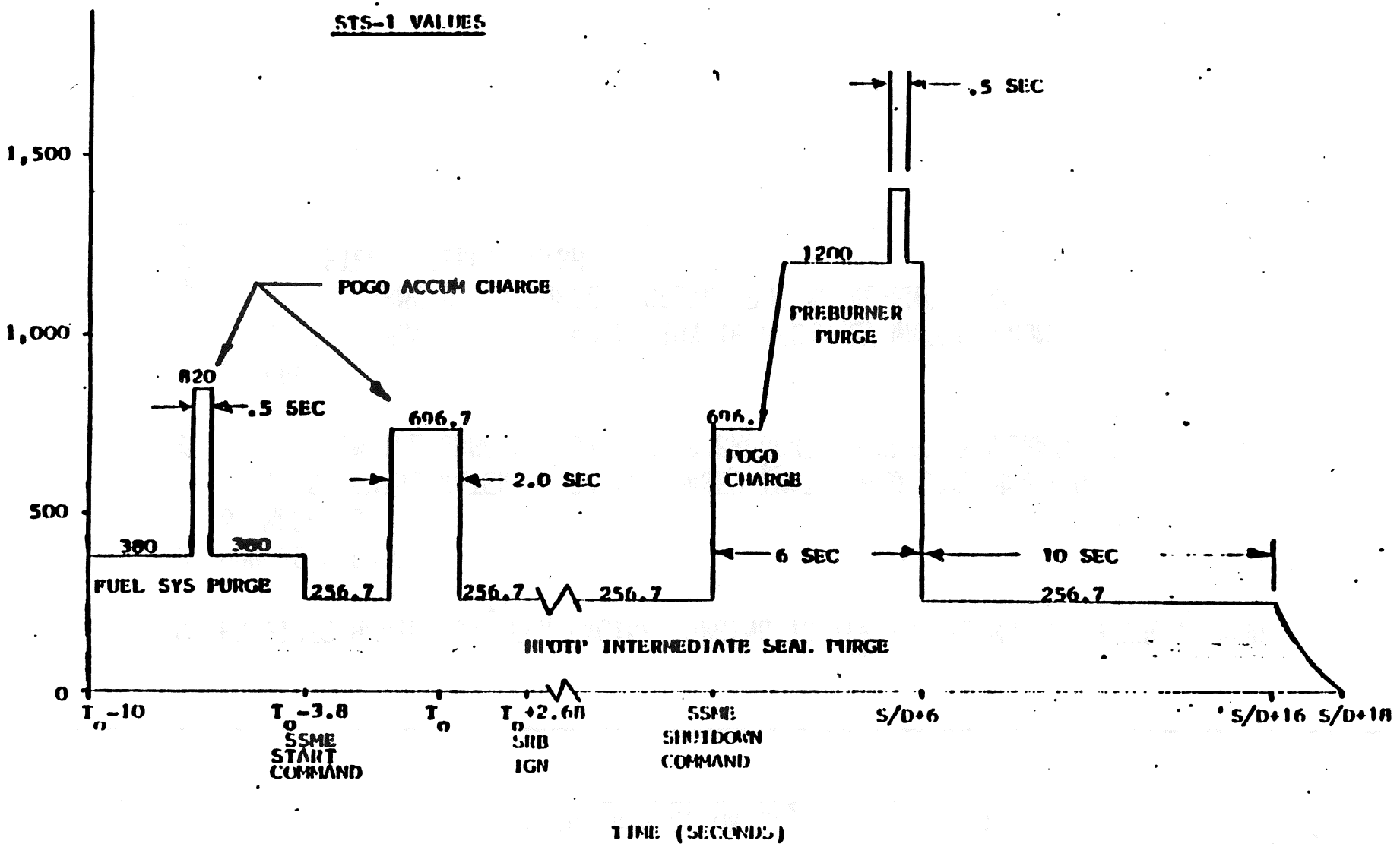
- PNEUMATIC SYSTEM CONTROL IS BY LPS, COCKPIT SWITCH, OR GPC

MAIN PROPULSION SYSTEM
HELIUM SUBSYSTEM SCHEMATIC



MPS HELIUM SYSTEM

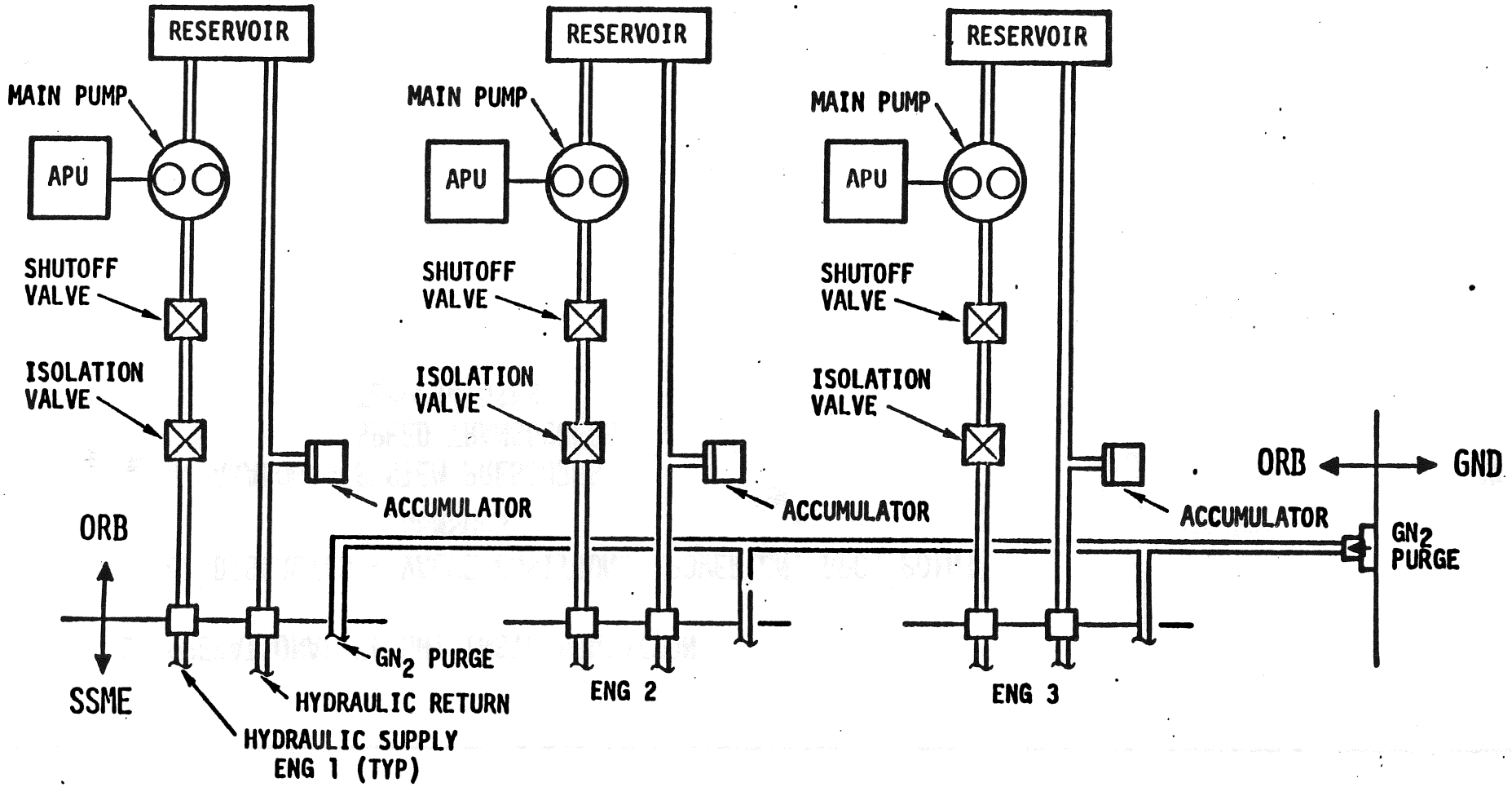
SSME HELIUM SUPPLY RATED FLOW VS. TIME



MAIN PROPULSION GN_2 PURGE SYSTEM

- PROVIDES HEATED GN_2 FOR ENGINE PURGING TO THE SSME'S WHILE ON THE GROUND
- PURGES USED FOR
  - MLP-PAD
    - REMOVING WATER VAPOR AND GASES THAT WOULD CONDENSE OUT WHEN THE SSME LO_2 SYSTEM IS BROUGHT TO CRYO TEMPERATURES
  - OPF
    - TO REMOVE ANY CONTAMINATION (ESPECIALLY WATER) FROM THE SSME'S THAT WERE INGESTED DURING RE-ENTRY OR AFTER A FERRY FLIGHT

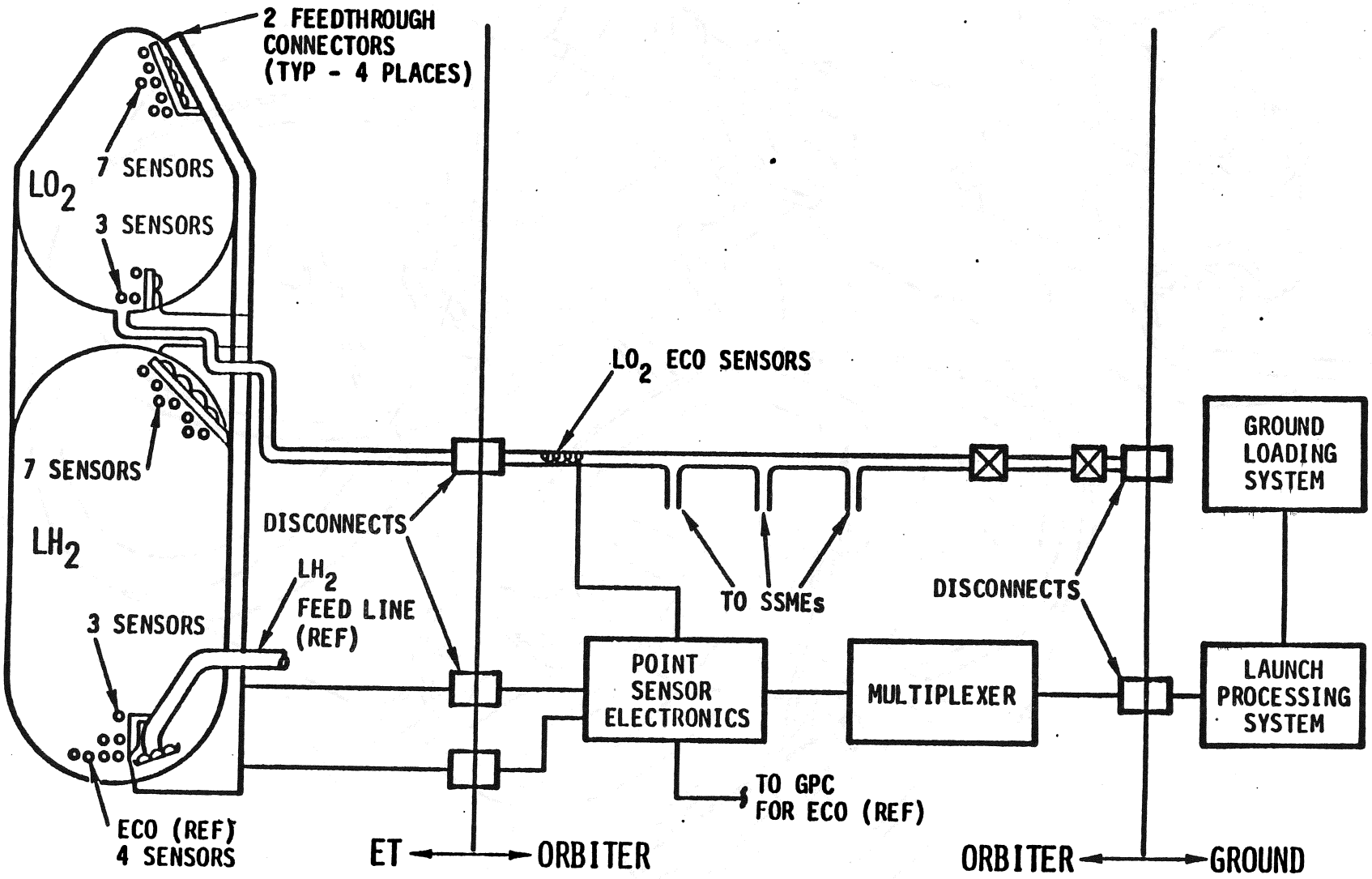
GN_2 PURGE AND HYDRAULIC SUPPLY

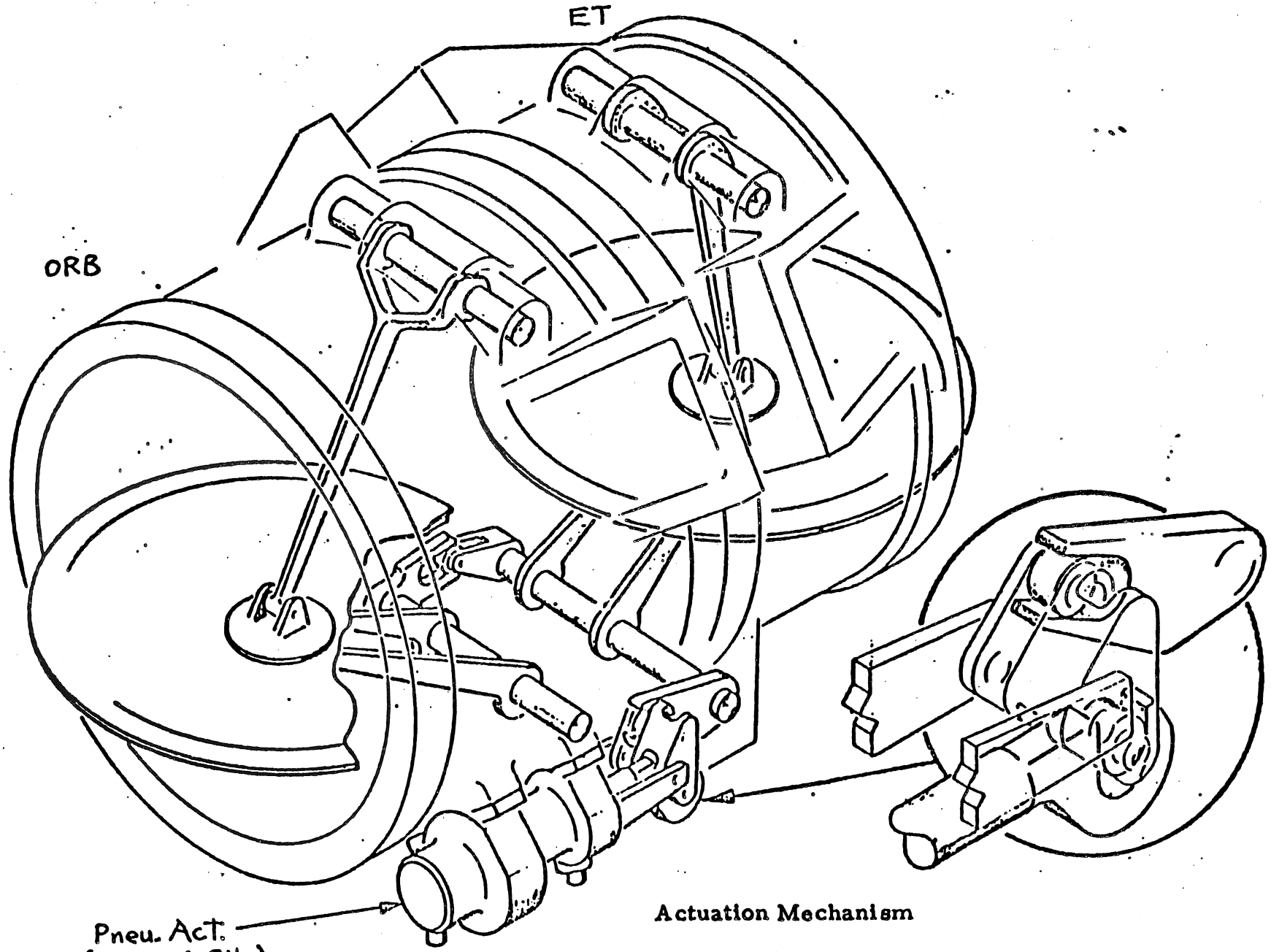


MPS INSTRUMENTATION

- OPERATIONAL FLIGHT INSTRUMENTATION
  - DISCRETES - VALVE POSITIONS, POWER ON, RPC, POINT SENSORS
  - ANALOG - SYSTEM PRESSURES
    SPEED TRANSDUCERS
    TEMPERATURES

PROPELLANT GAUGING SYSTEM





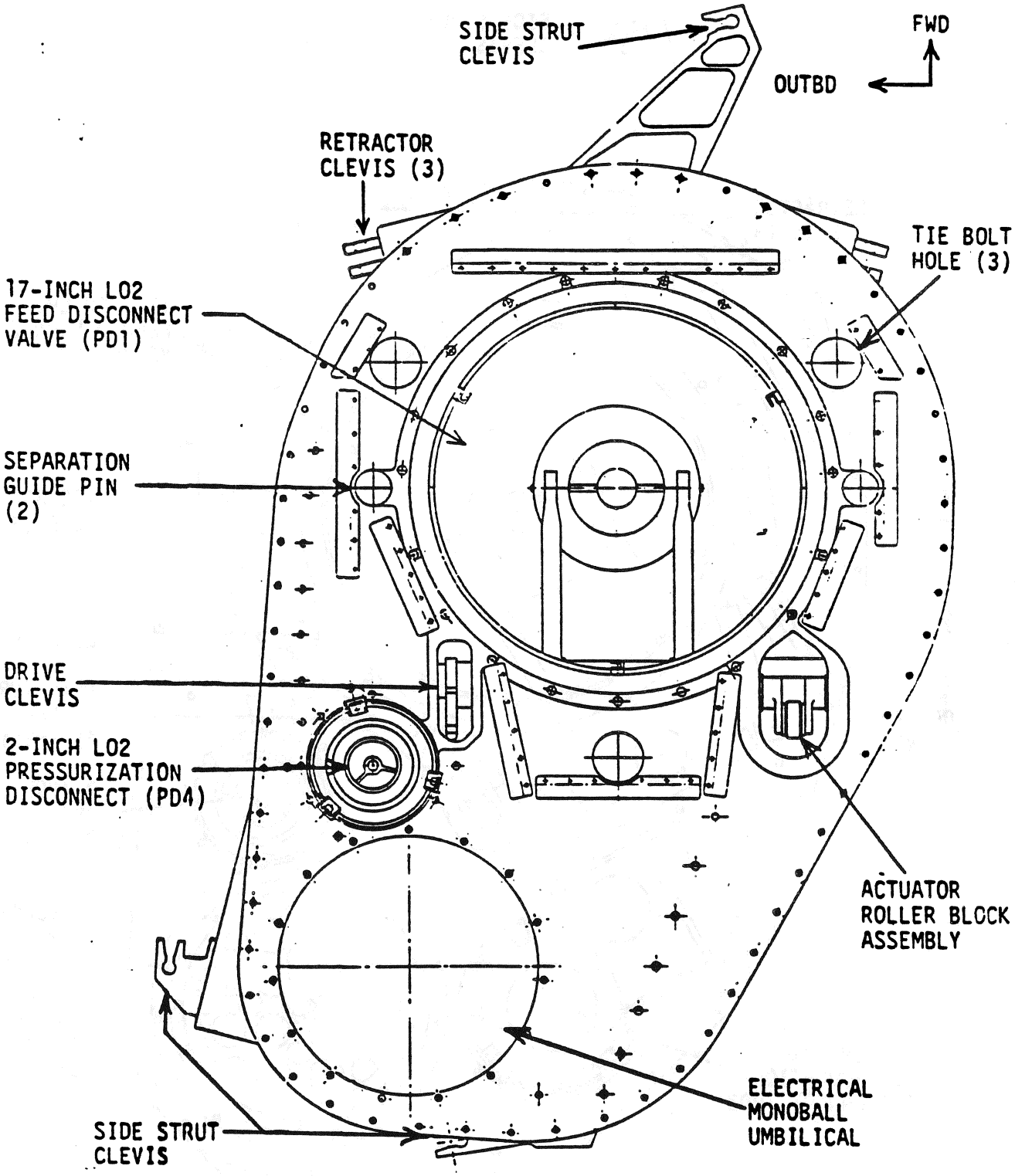
Actuation Mechanism

LO2 T-0 UMBILICAL PANEL
ORBITER RIGHT SIDE

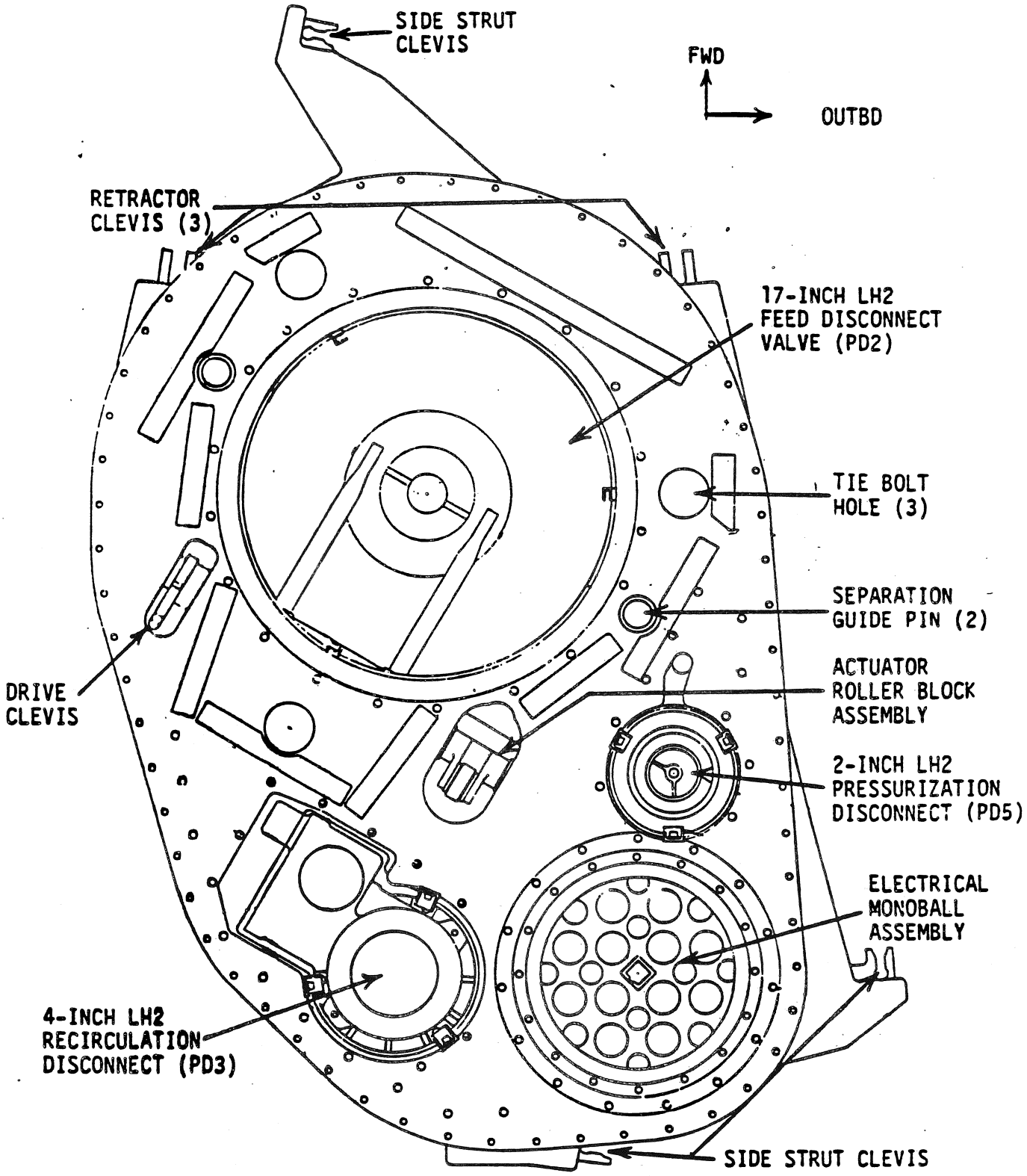
LH2 T-0 UMBILICAL PANEL
ORBITER LEFT SIDE

54

LO2 ORB/ET UMBILICAL
ORBITER HALF



LH2 ORB/ET UMBILICAL
ORBITER HALF



56

COMPONENT: LH_2 FEEDLINES

(MC271-0073)

TYPES I, II, III, IV AND V

- FUNCTION: LH_2 PROPELLANT FEED SYSTEM

  THE LINES DIRECT THE FLOW OF FUEL (LIQUID HYDROGEN) FROM THE ET/ORB DISCONNECT TO THE RESPECTIVE ENGINES.

- DESIGN PARAMETERS AND FEATURES:

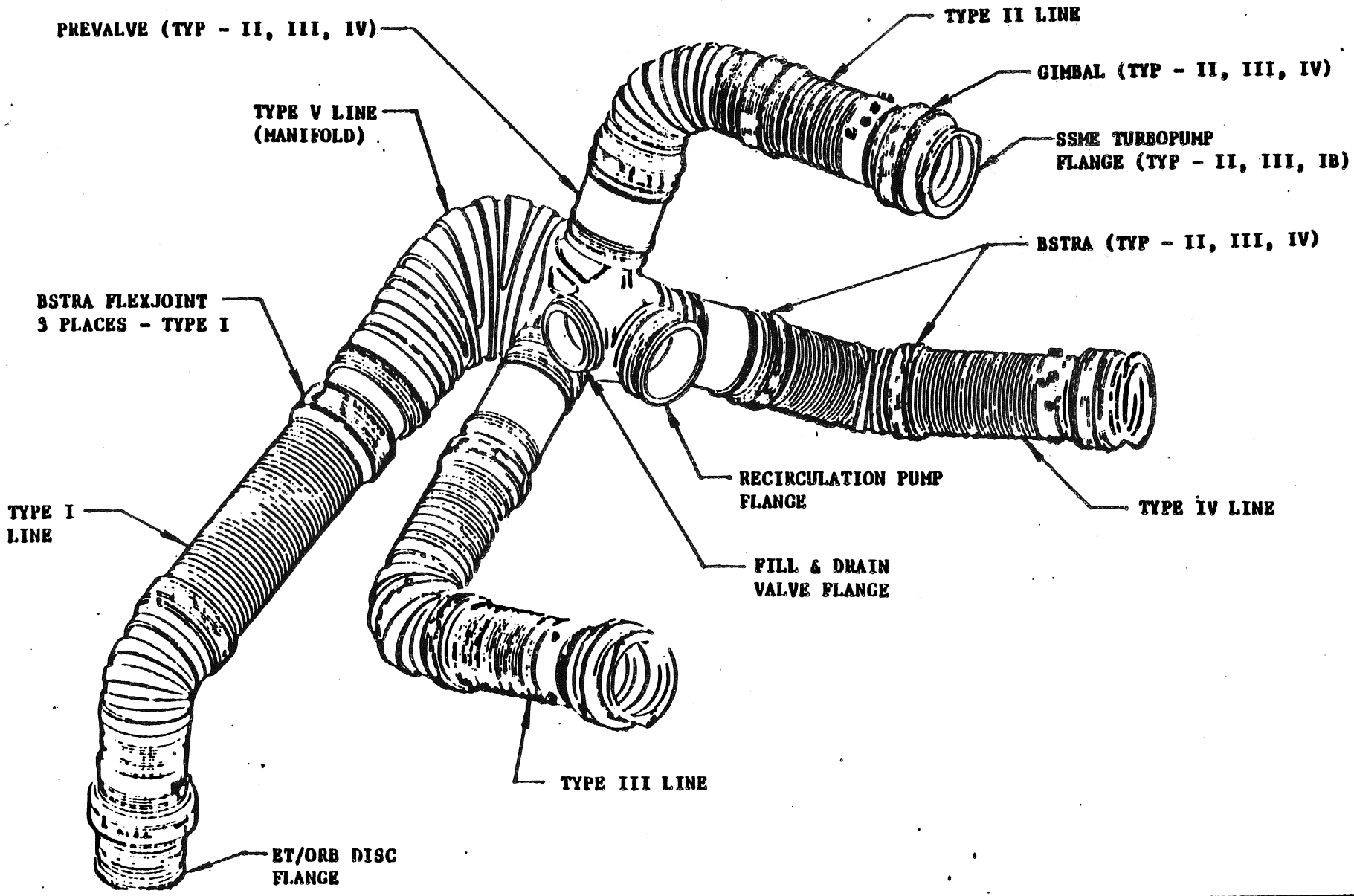
	TYPE I	TYPE II, III, IV	TYPE V
OPERATING PRESSURE, MAXIMUM:	55 PSIG	105 PSIG	55 PSIG
PROOF PRESSURE:	66 PSIG	126 PSIG	66 PSIG
BURST PRESSURE:	83 PSIG	158 PSIG	83 PSIG
LINE SIZE:			
PRESSURE CARRIER:	17-INCH ID	12-INCH ID	8 to 17-INCH
WEIGHT (MAXIMUM):	337 LBS.	269 LBS.	296 LBS.
INSULATION:	VACUUM JACKET	VACUUM JACKET	VACUUM JACKET

MAXIMUM VACUUM JACKET PRESSURE: 1000 MICRONS Hg (TYP ALL LINES)

COMPONENT: LH_2 FEEDLINES

(MC271-0073)

TYPES I, II, III, IV & V

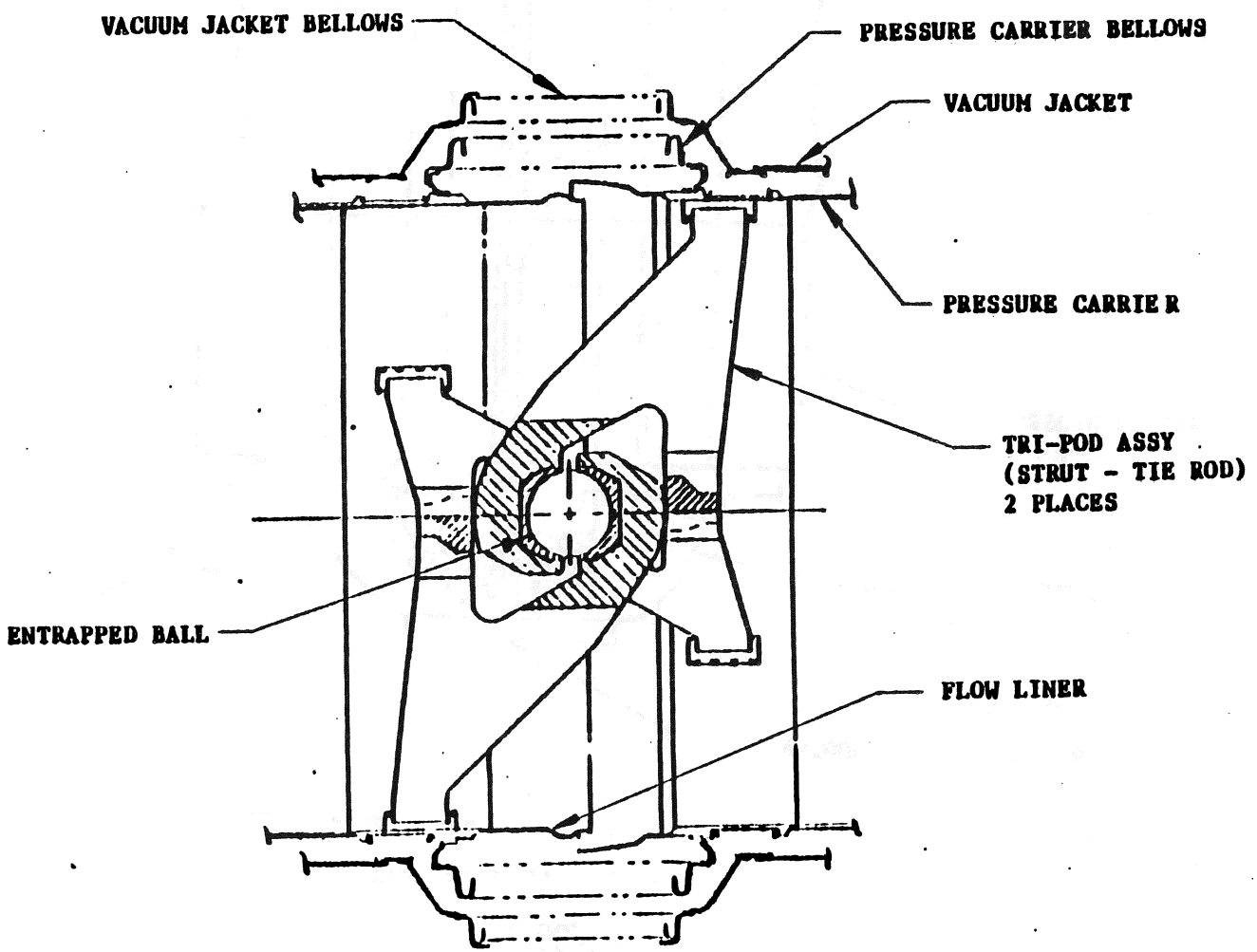


COMPONENT: LH_2 FEEDLINES

(MC271-0073)

TYPICAL BSTRA

(ALSO APPLICABLE TO LO_2 FEEDLINES)

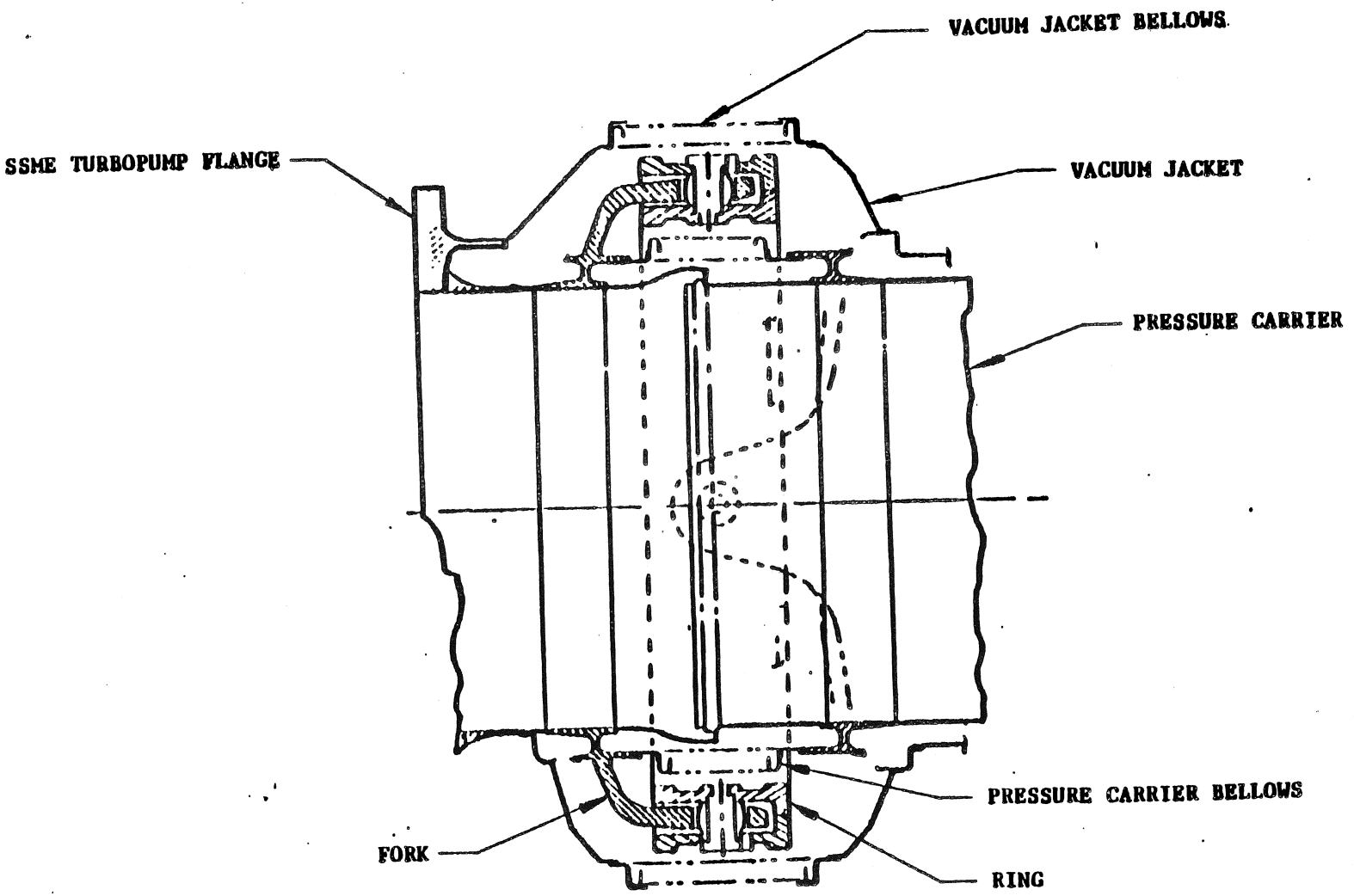


COMPONENT: LH_2 FEEDLINES

(MC271-0073)

TYPICAL GIMBAL JOINT

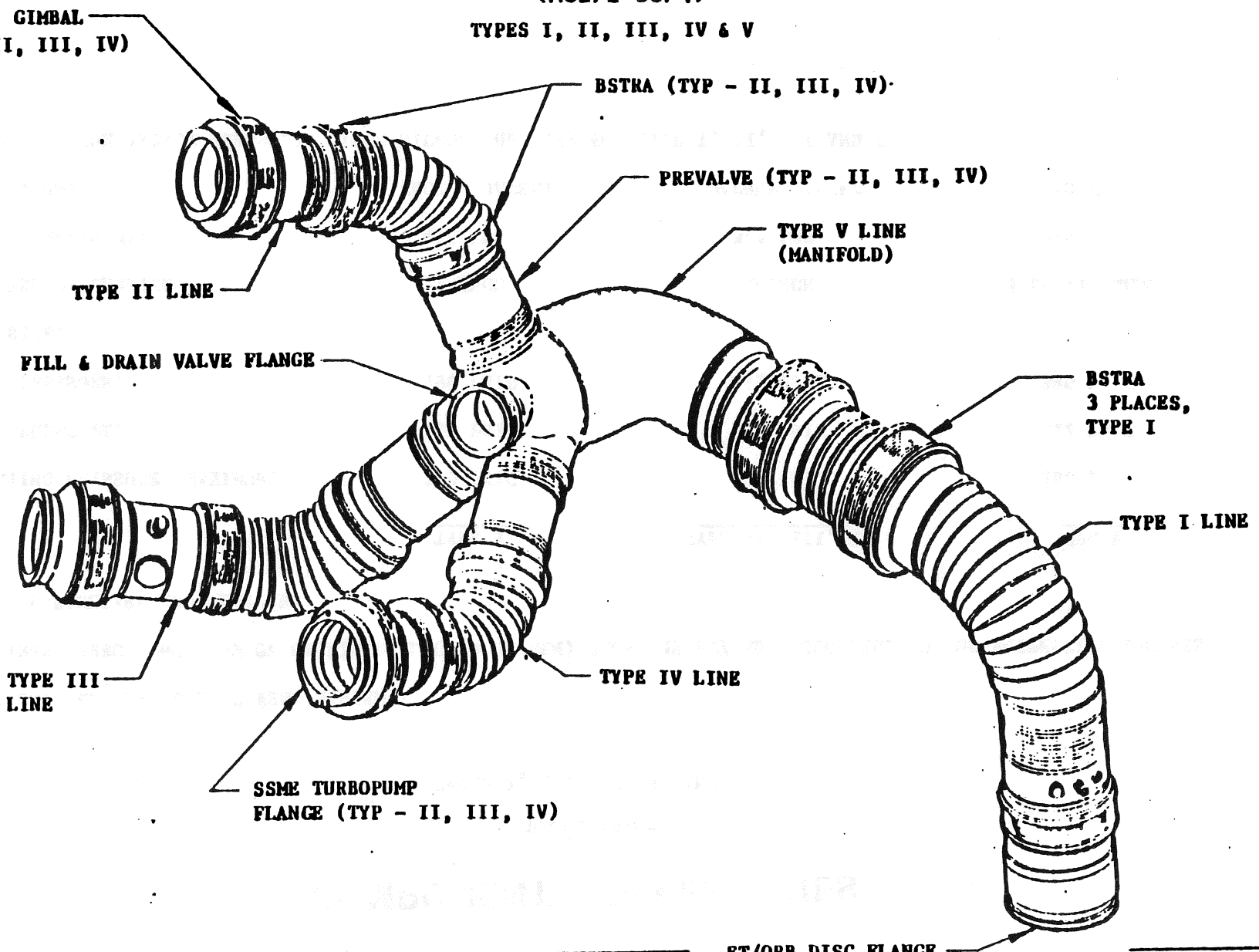
(ALSO APPLICABLE TO LO_2 FEEDLINES)



COMPONENT: LO_2 FEEDLINES

(MC271-0074)

TYPES I, II, III, IV & V



COMPONENT: LO_2 FEEDLINES

(MC271-0074)

TYPES I, II, III, IV AND V

- FUNCTION: LO_2 PROPELLANT FEED SYSTEM

  THE LINES DIRECT THE FLOW OF OXIDIZER (LIQUID OXYGEN) FROM THE ET/ORB DISCONNECT TO THE RESPECTIVE ENGINES.

- DESIGN PARAMETERS AND FEATURES

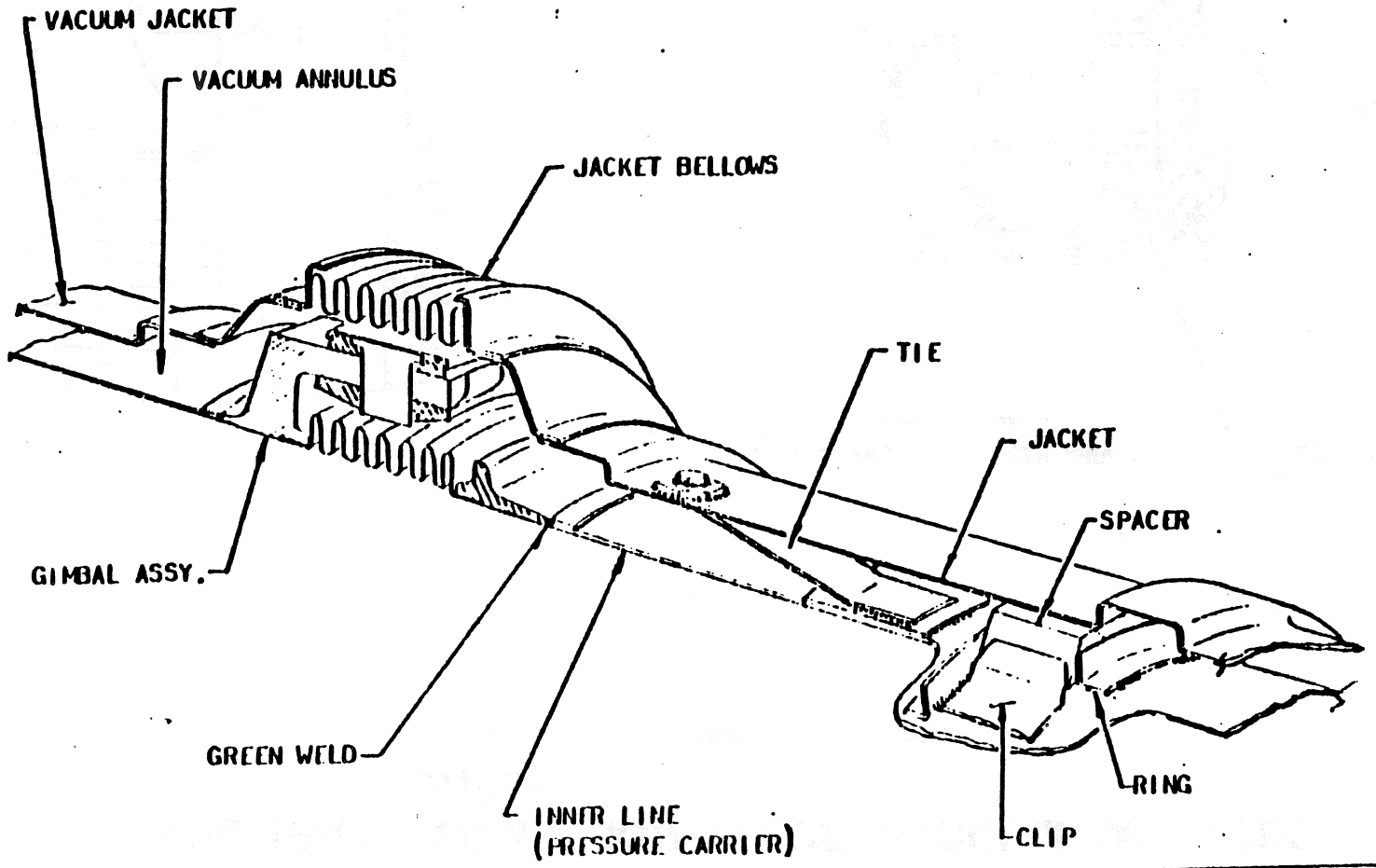
	TYPE I	TYPE II, III, IV	TYPE V
OPERATING PRESSURE, MAXIMUM:	260 PSIG	275 PSIG	260 PSIG
PROOF PRESSURE:	312 PSIG	330 PSIG	312 PSIG
BURST PRESSURE:	390 PSIG	413 PSIG	390 PSIG
LINE SIZE:			
PRESSURE CARRIER	17-INCH	12-INCH	8 to 17 INCHES
WEIGHT (MAXIMUM):	450 LBS.	311 LBS.	219 LBS.
INSULATION:	VACUUM JACKET	VACUUM JACKET	FOAM

MAXIMUM VACUUM JACKET PRESSURE: 1000 MICRONS Hg (TYP FOR TYPE I, II, III AND IV)

COMPONENT: LH_2 RECIRCULATION & REPLENISHMENT LINES

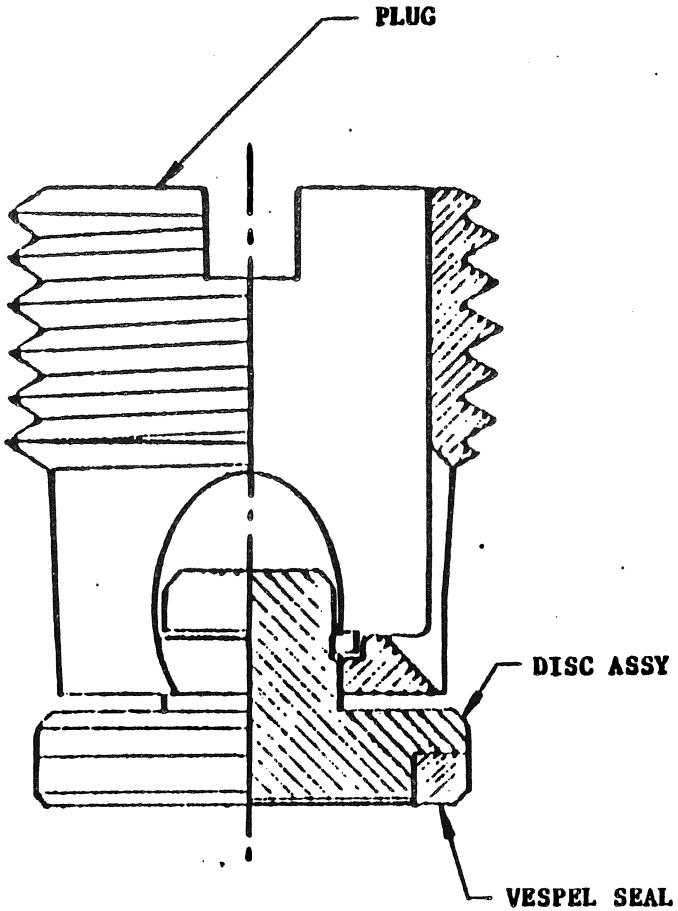
(MC271-0075)

TYPICAL VACUUM JACKET/PRESSURE CARRIER SECTION

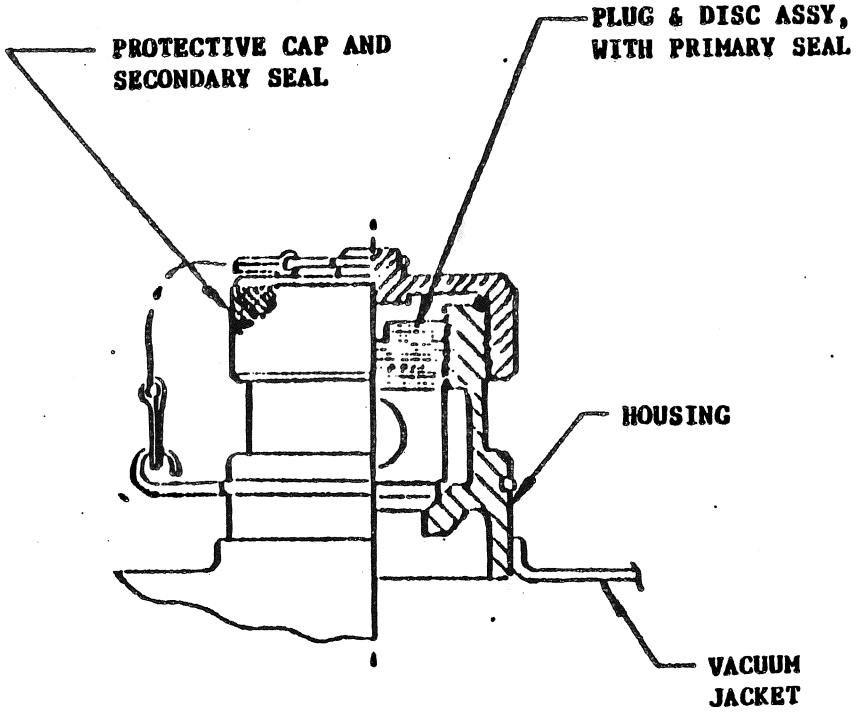


COMPONENT: EVACUATION VALVE (VACUUM JACKETED LINES)

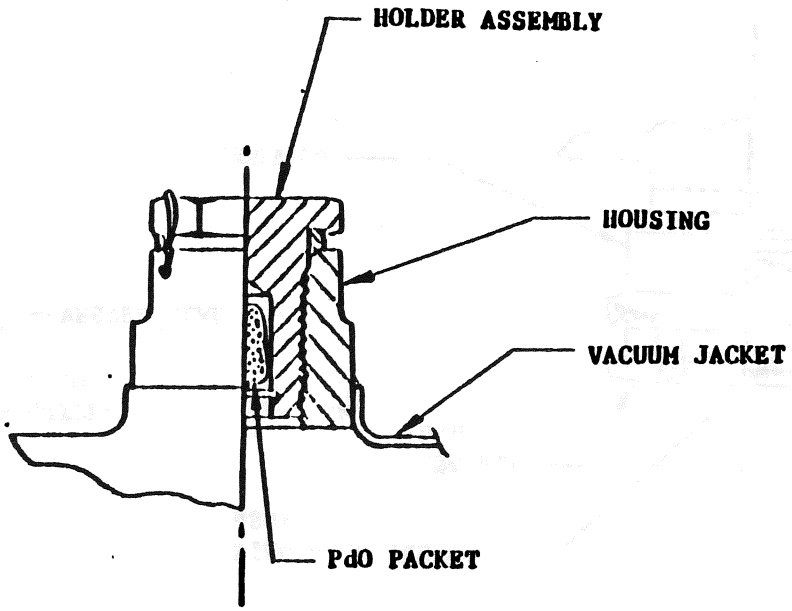
UTILIZED ON ALL VACUUM JACKETED LINES



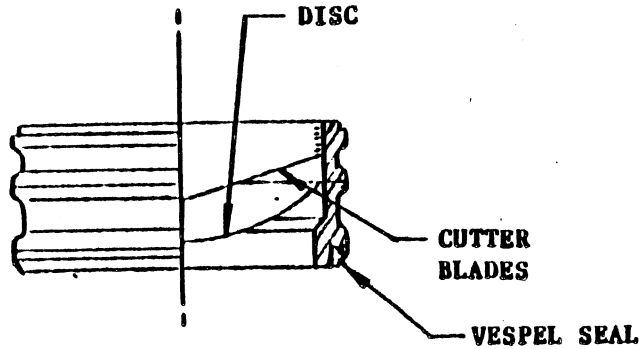
DETAIL - PLUG & DISC ASSEMBLY (REPLACEABLE PART)



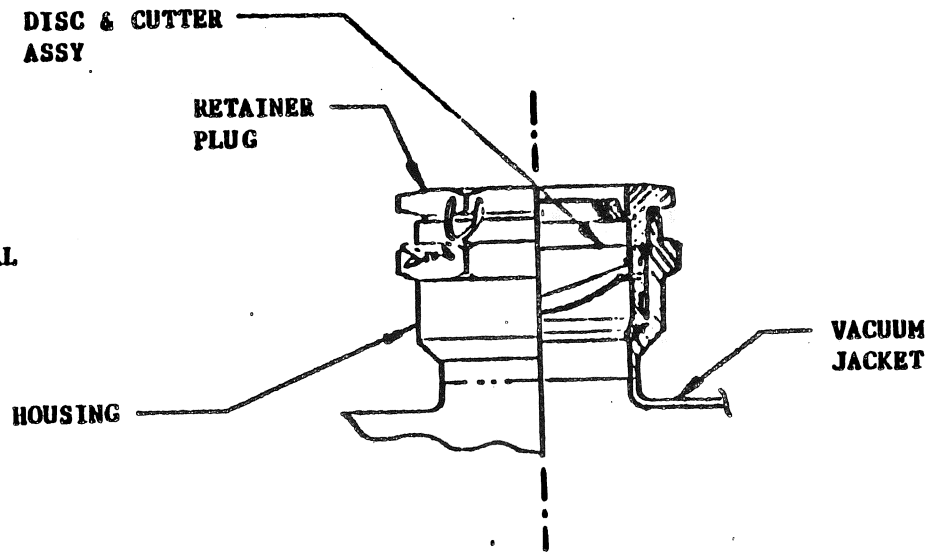
COMPONENT: GETTER CONTAINER (LH_2 RECIRCULATION & REPLENISHMENT LINES)



COMPONENT: BURST DISC ASSEMBLY (VACUUM JACKETED LINES)

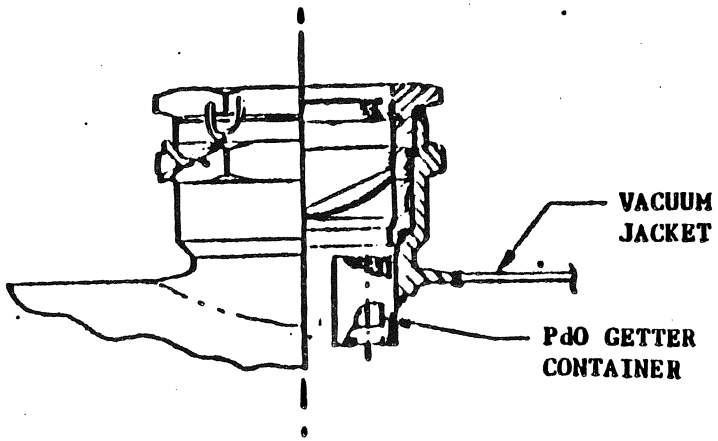


DETAIL - DISC & CUTTER ASSY (REPLACEABLE)



BASIC CONFIGURATION

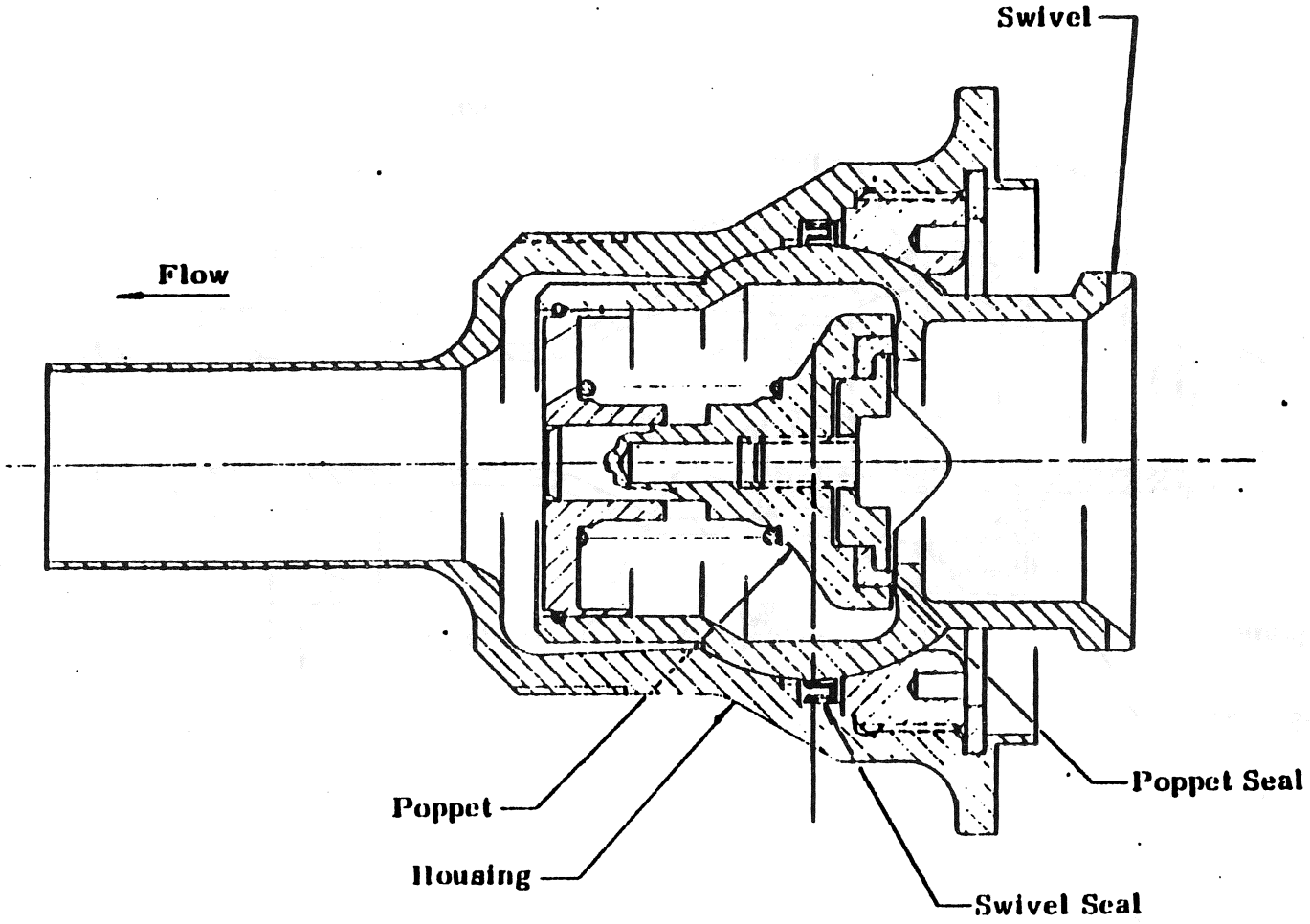
UTILIZED ON ALL VACUUM JACKETED LINES, EXCEPT AS NOTED



MPS FEEDLINE (ONLY) CONFIGURATION

COMPONENT: DISCONNECT 1-INCH HELIUM AND GASEOUS NITROGEN

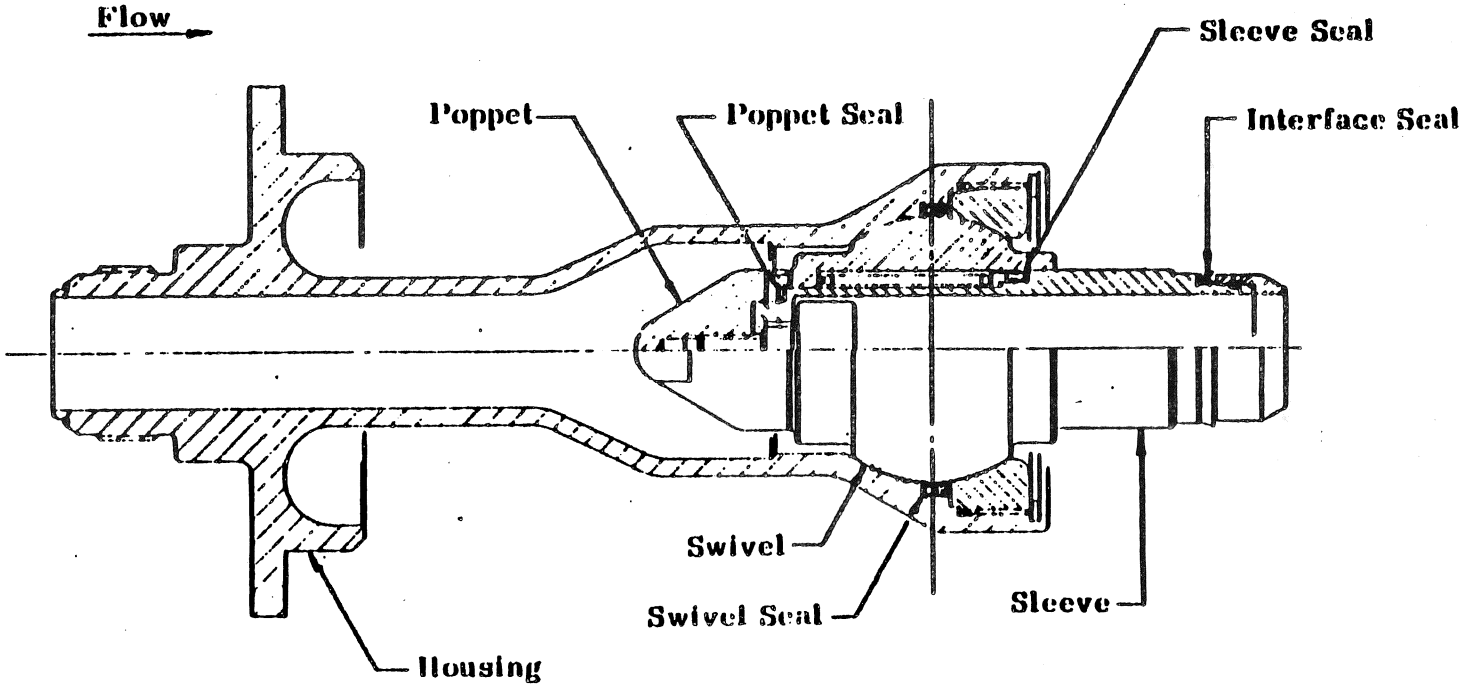
(MC276-0003)



TYPE I

COMPONENT: DISCONNECT 1-INCH HELIUM AND GASEOUS NITROGEN

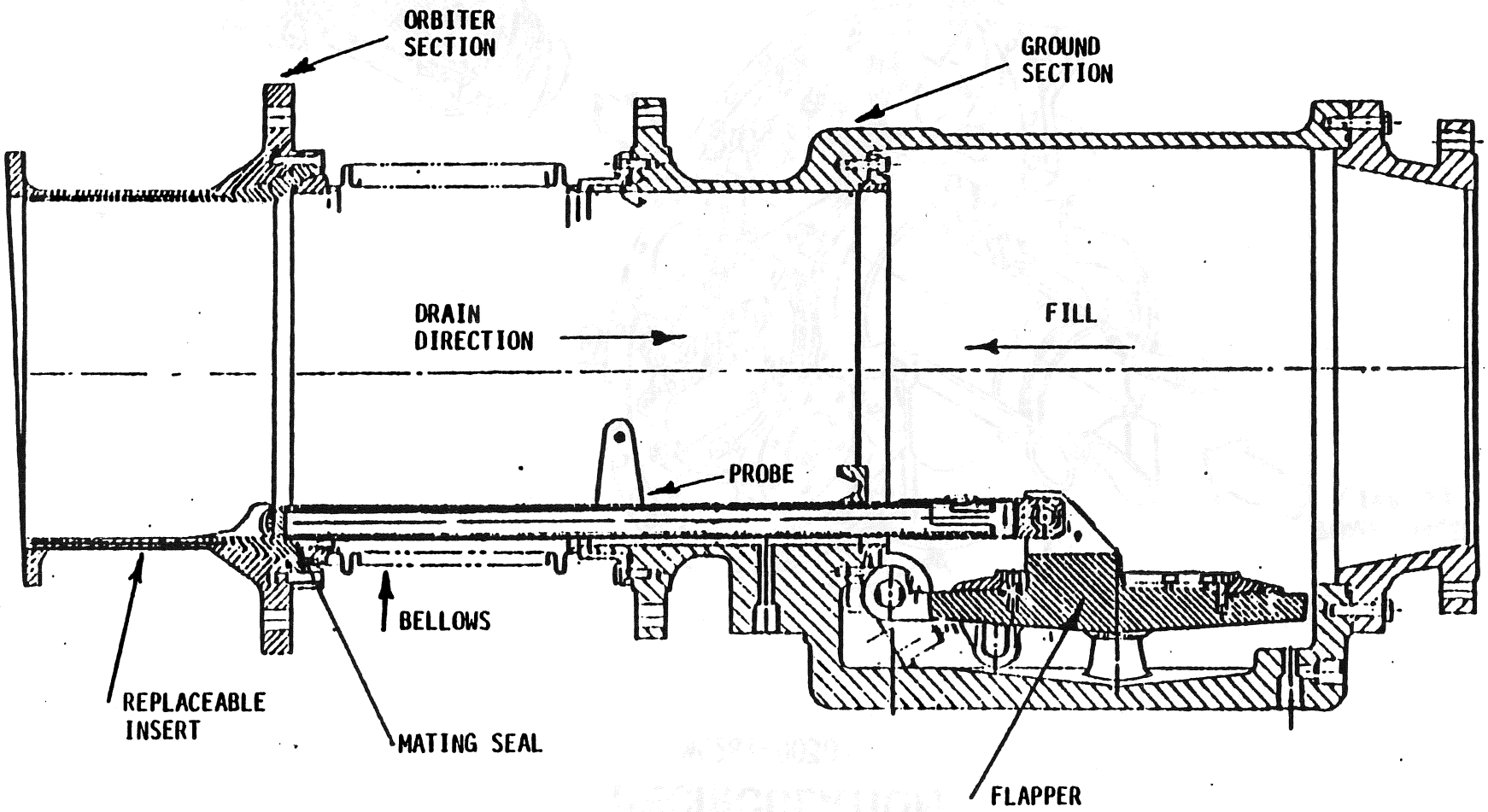
(MC276-0003)



TYPE II

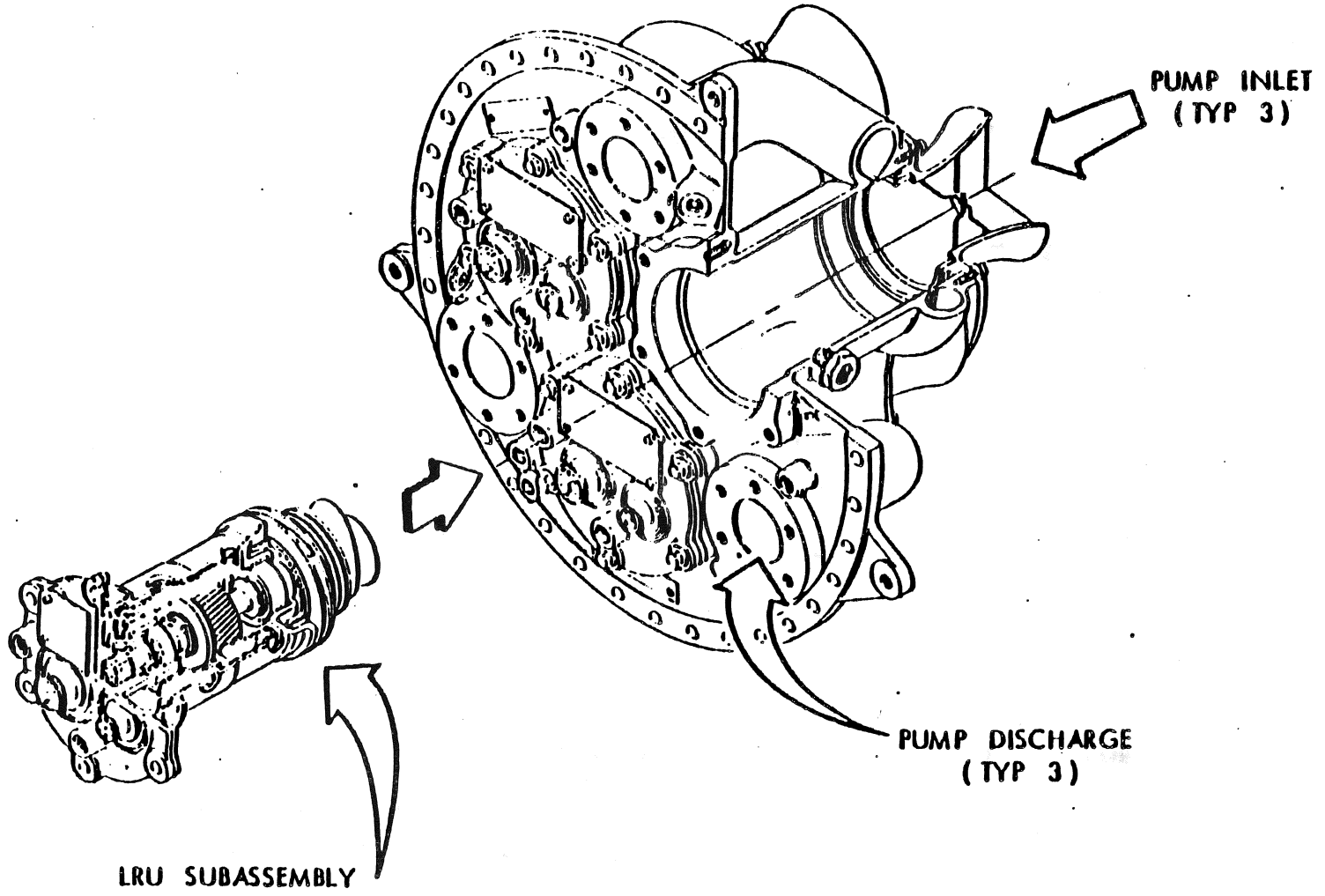
COMPONENT: DISCONNECT, 8 INCH FILL AND DRAIN, LO_2/LH_2

(MC276-0005)



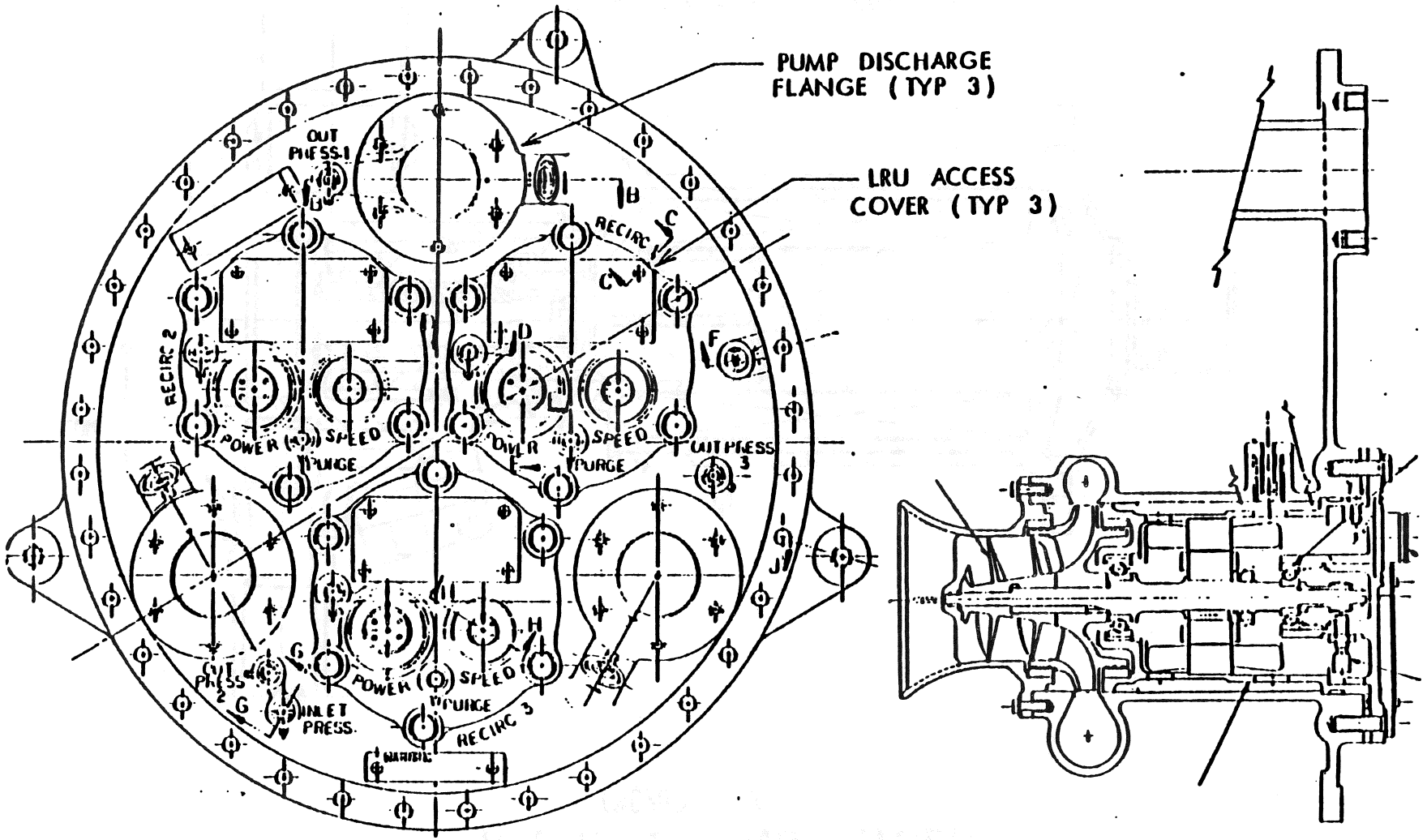
COMPONENT: PUMP ASSEMBLY, HYDROGEN, RECIRCULATION

(MC281-0030)



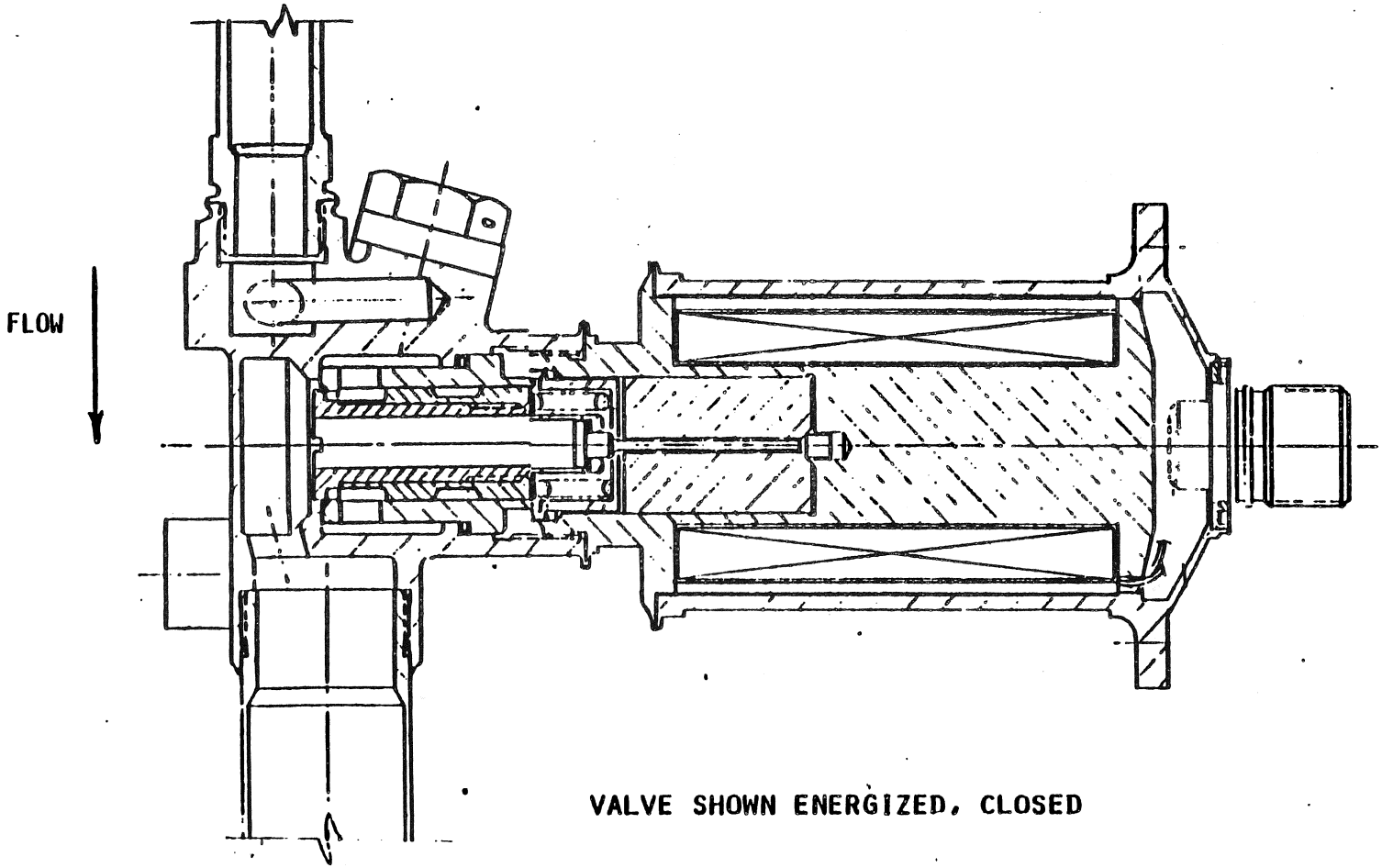
COMPONENT: PUMP ASSEMBLY, HYDROGEN, RECIRCULATION

(MC281-0030)



COMPONENT: VALVE, PRESSURANT FLOW CONTROL, HYDROGEN AND OXYGEN

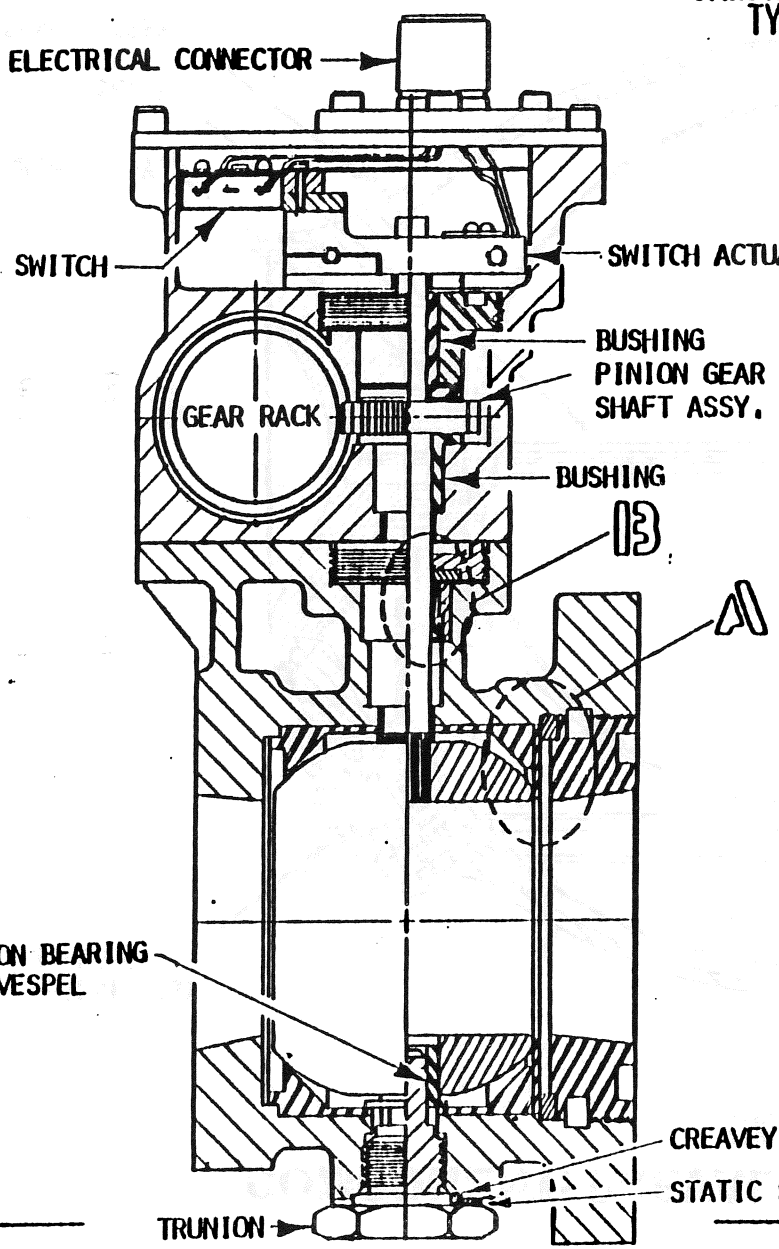
(MC280-0017)

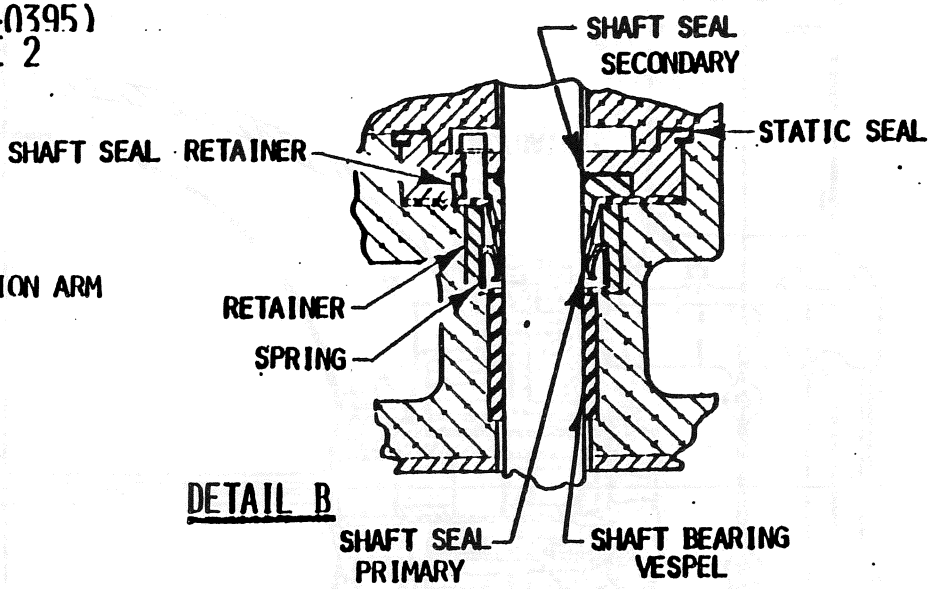


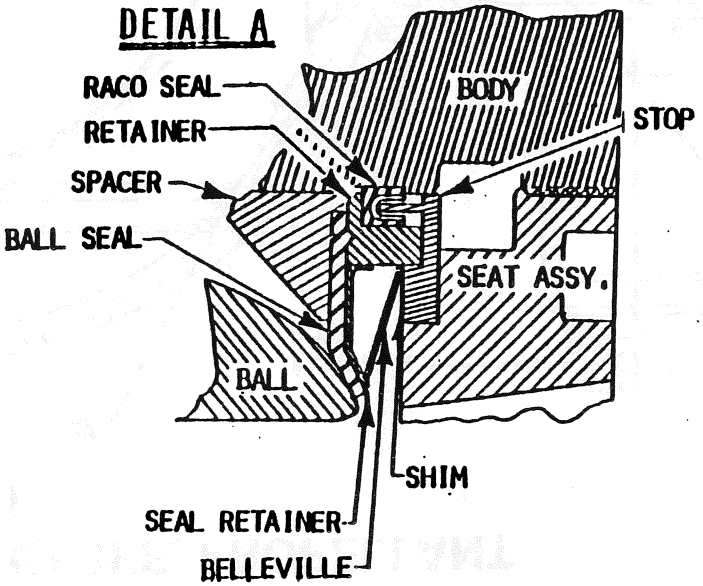
VALVE SHOWN ENERGIZED, CLOSED

COMPONENT: VALVE, SHUTOFF, LO_2 POGO

(MC284-0395)
TYPE 2

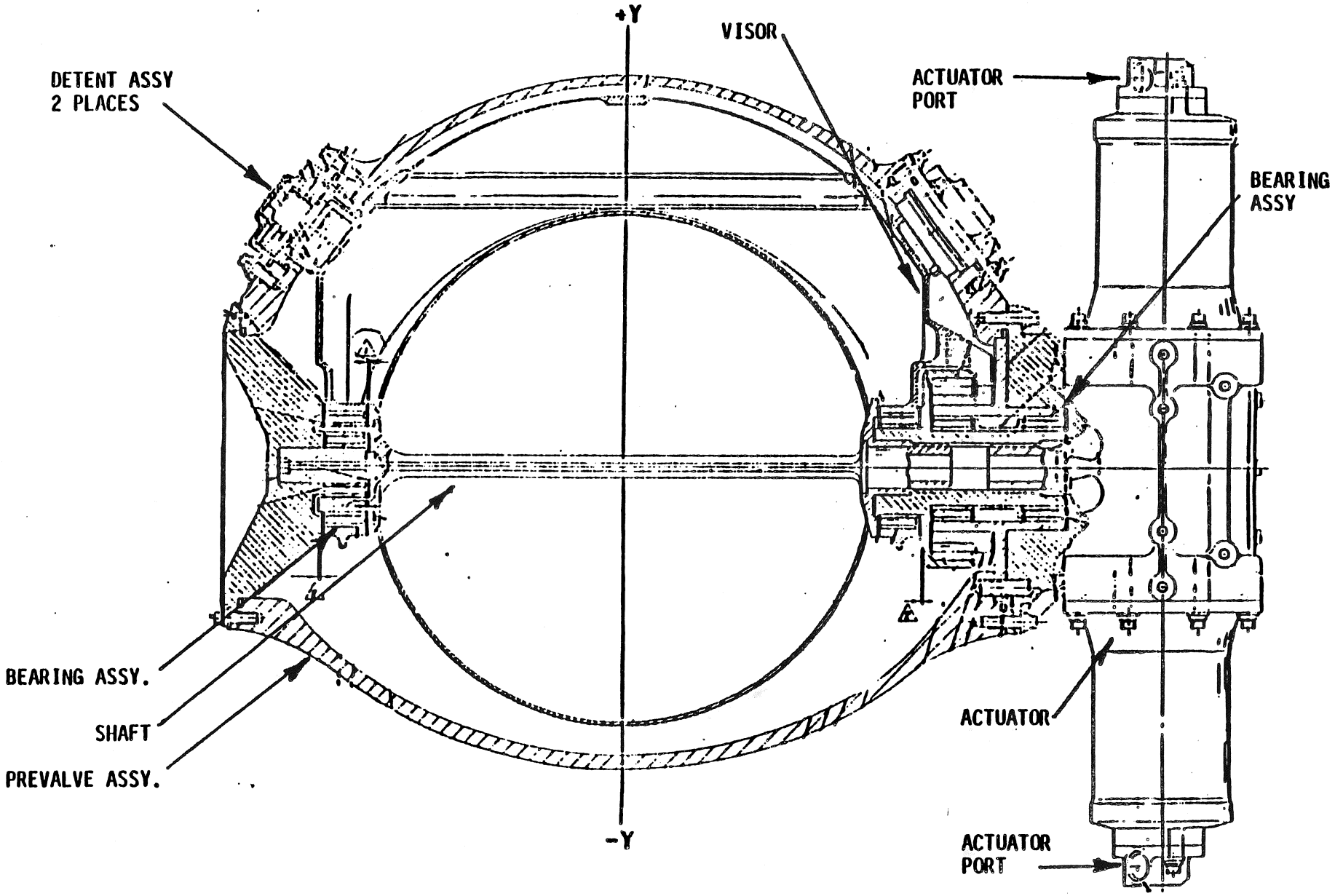






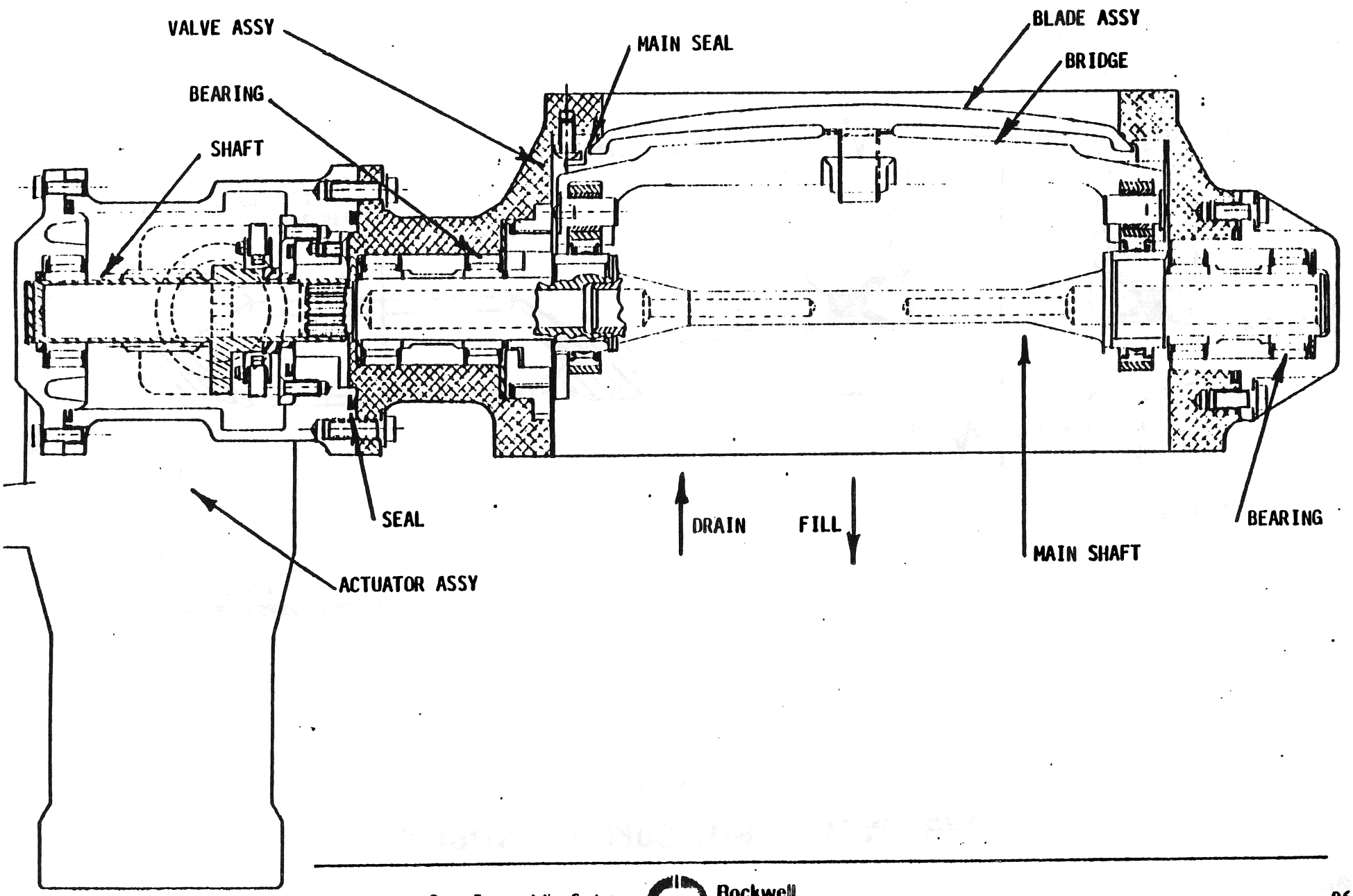
COMPONENT: PREVALVE, SHUTOFF, PROPELLANT

(MC284-0396)



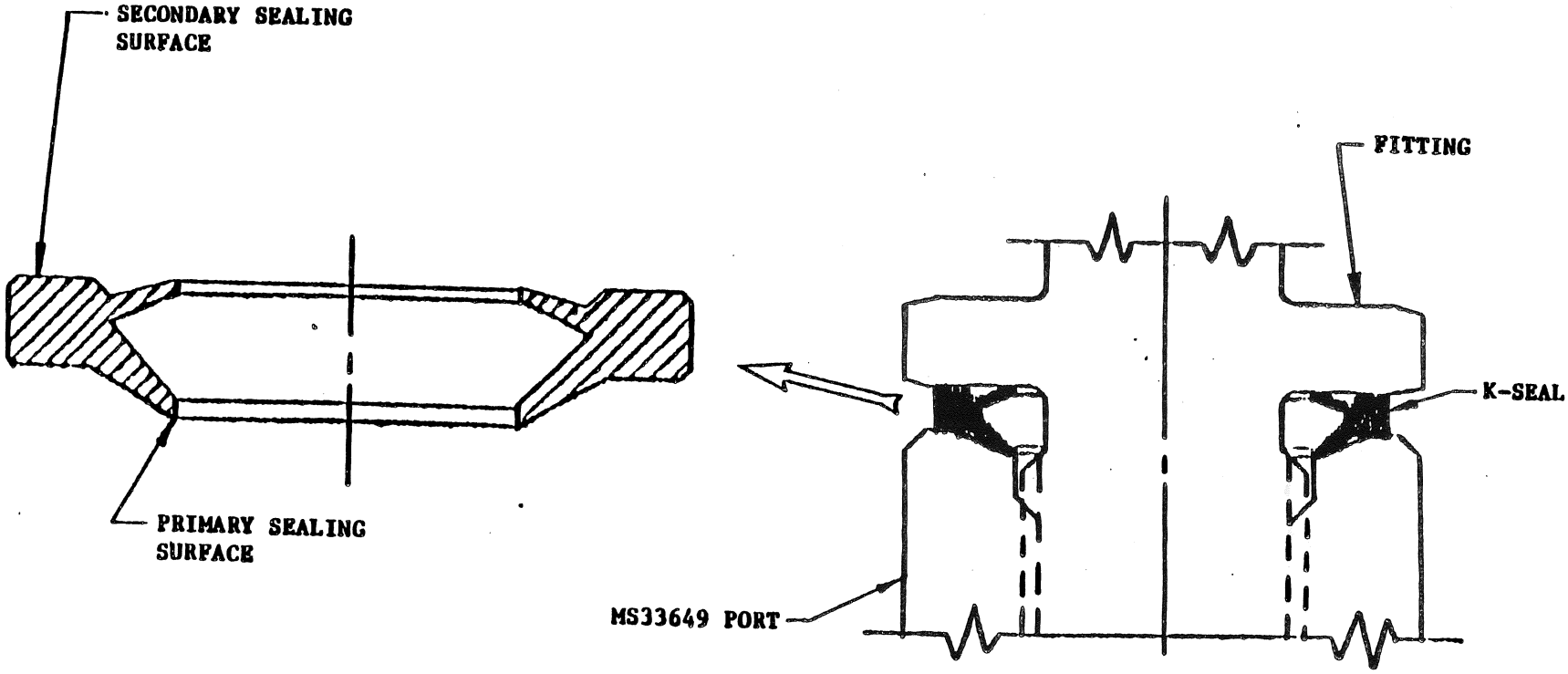
COMPONENT: VALVE, FILL AND DRAIN, PROPELLANT

(MC284-0397)



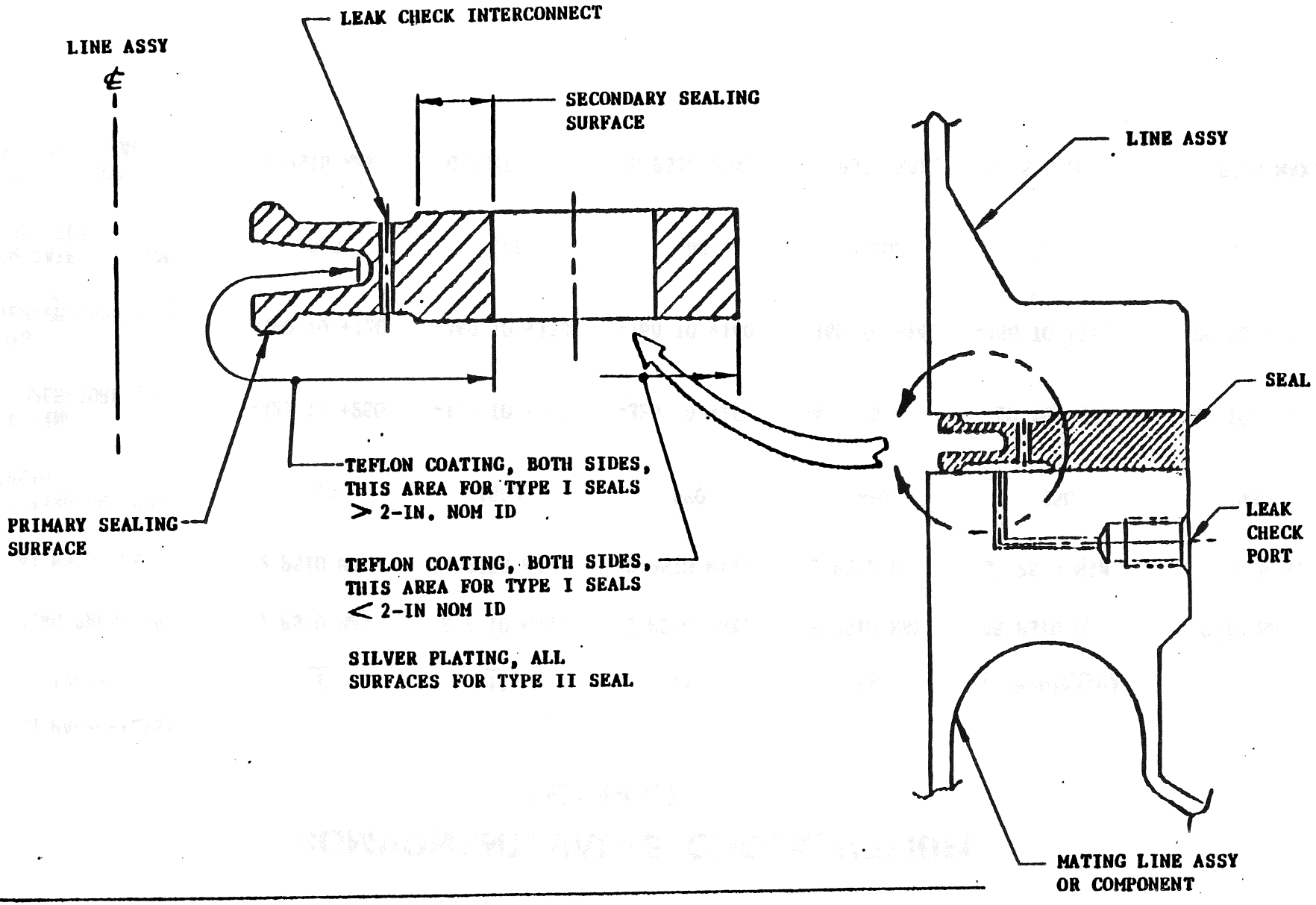
COMPONENT: MPS SUBSYSTEM SEALS

ME261-0003 K-SEAL TYPE I & II



COMPONENT: MPS SUBSYSTEM SEALS

ME261-0045 TYPE I & II



COMPONENT: VALVE, CHECK, HELIUM

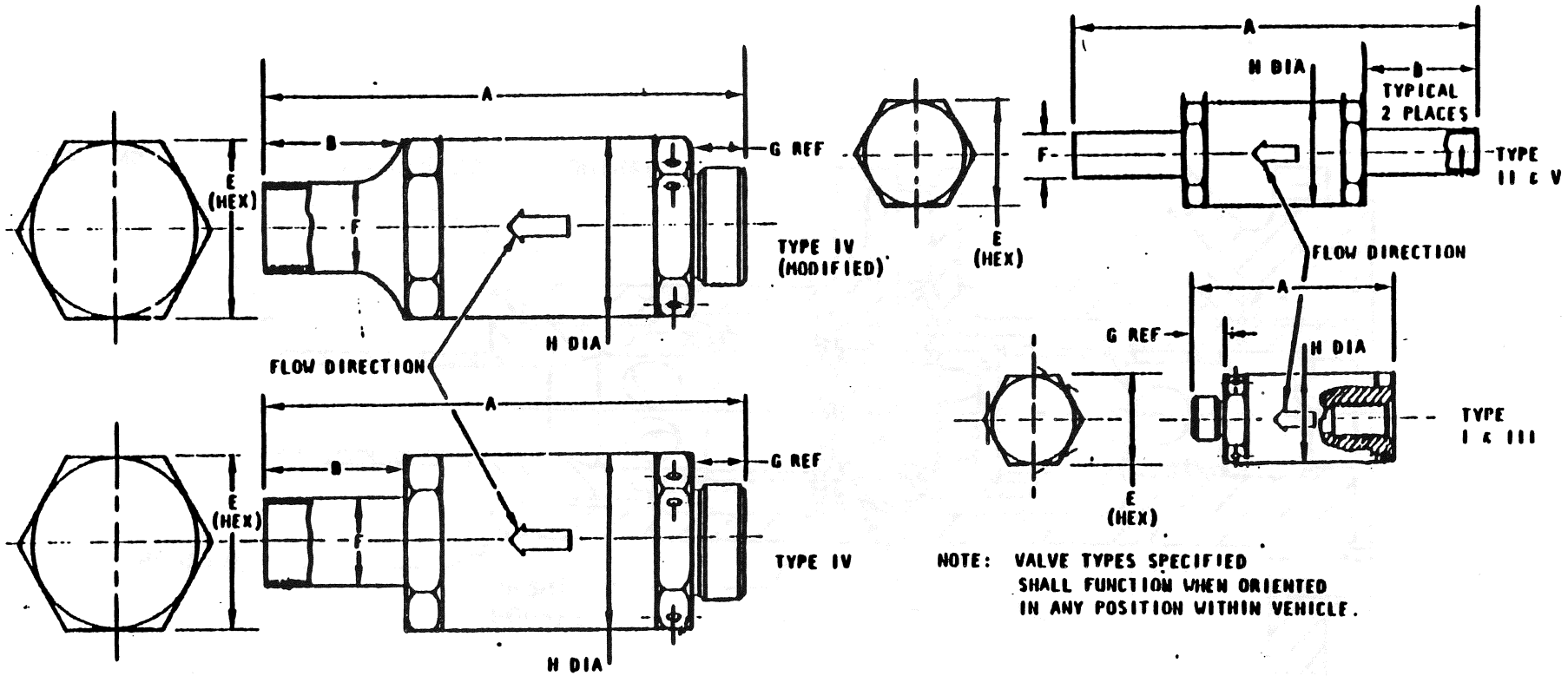
(MC284-0472)

DESIGN PARAMETERS:

TYPE:	I	II	III	IV	IV (MODIFIED)	V
CRACKING PRESSURE	5 PSID MAX.	5 PSID MAX.	5 PSID MAX.	5 PSID MAX.	.06 PSID MAX.	5 PSID MAX.
RESEAT PRESSURE	2 PSID MIN.	2 PSID MIN.	2 PSID MIN.	2 PSID MIN.	.01 PSID MIN.	2 PSID MIN.
OPERATING PRESSURE (PSIG)	650	4500	850	850	850	750
OPERATING TEMPERATURE (^{O}F)	-423 TO +250	-160 TO +250	-320 TO +250	-423 TO +250	-160 TO +250	-100 TO +350
FLUID TEMPERATURE (^{O}F)	-160 TO +130	-160 TO +130	-160 TO +140	-160 TO +140	-160 TO +140	+20 TO +120
FLOW RATE (HELIUM, LBS/SEC)	.005	.05	.08	0.202	.202	1.5
PRESSURE DROP AT RATE FLOW	11 PSID MAX.	10 PSID MAX.	10 PSID MAX.	44 PSID MAX.	15 PSID MAX.	167 PSID MAX.

COMPONENT: VALVE, CHECK, HELIUM

(MC284-0472)



NOTE: VALVE TYPES SPECIFIED SHALL FUNCTION WHEN ORIENTED IN ANY POSITION WITHIN VEHICLE.

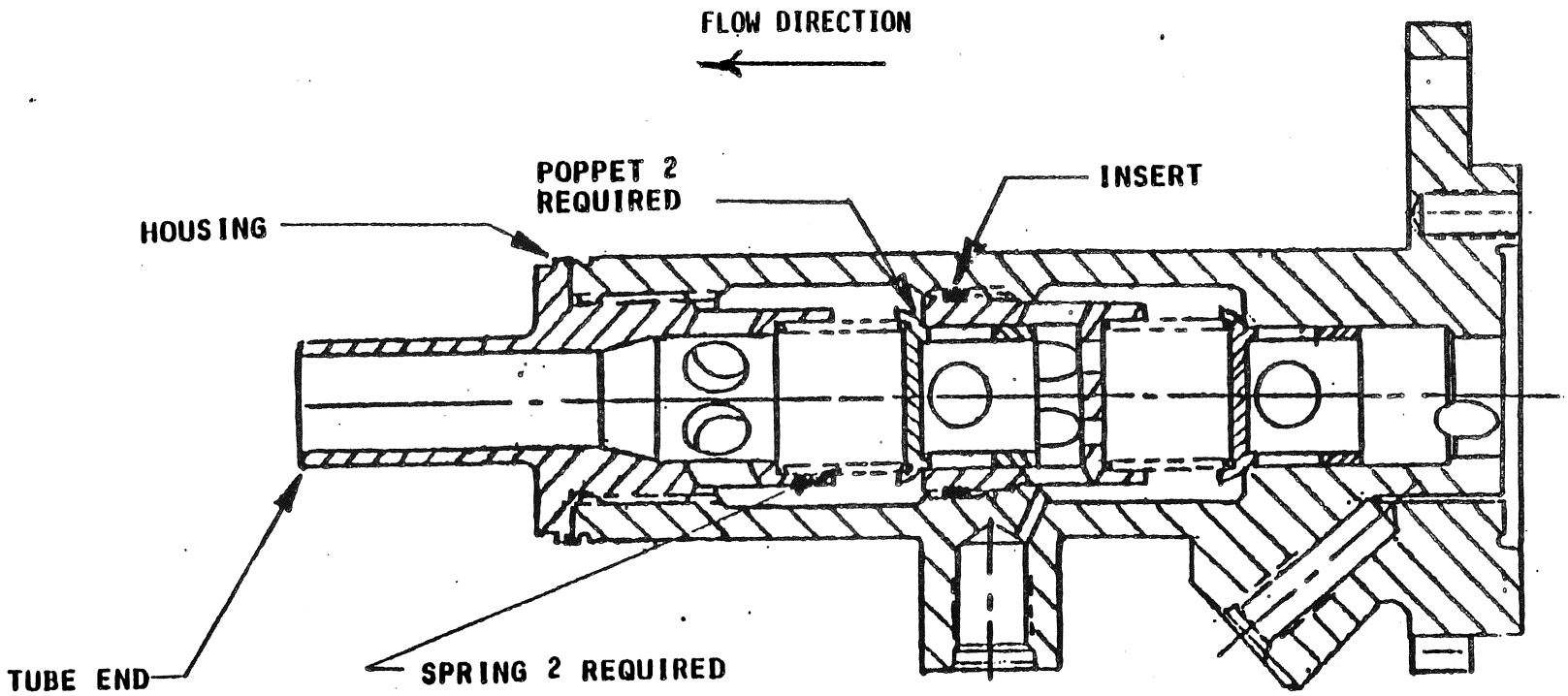
VALVE ENVELOPE

TYPE	CONTROL NO.	I&T	A	B	OUTLET	INLET	E MAX	F DIA	G REF	H DIA	T THICKNESS
I	ME284-0472	T_S	1.850 MAX 1.760 MIN	-- --	MP273-0002-1004	MS33649-04	.77	--	.290 MAX .260 MIN	.755 MAX .735 MIN	--
II	ME284-0472	T_S	3.715 MAX 3.615 MIN	1.030 MAX 1.010 MIN	BRAZE STUB	BRAZE STUB	.89	.378 MAX .375 MIN	--	.880 MAX .860 MIN	.042
III	ME284-0472	T_S	2.859 MAX 2.769 MIN	-- --	MP273-0002-1008	MS33649-08	1.02	--	.323 MAX .293 MIN	1.005 MAX .985 MIN	--
IV	ME284-0472	T_S	4.372 MAX 4.282 MIN	1.340 MAX 1.280 MIN	BRAZE STUB	MP273-0002-1012	1.52	.754 MAX .750 MIN	.427 MAX .397 MIN	1.505 MAX 1.485 MIN	.028
V	ME274-0472	T_S	5.680 MAX 5.580 MIN	1.620 --	WELD STUB	WELD STUB	2.00	1.004 MAX 1.000 MIN	--	2.0 MAX	.028
IV	ME284-0472	T_S	4.347 MAX 4.307 MIN	1.393 MAX 1.333 MIN	BRAZE STUB	MP273-0002-1012	1.875	.754 MAX .750 MIN	.427 MAX .397 MIN	1.890 MAX	.028

COMPONENT: VALVE, CHECK, ENGINE ISOLATION

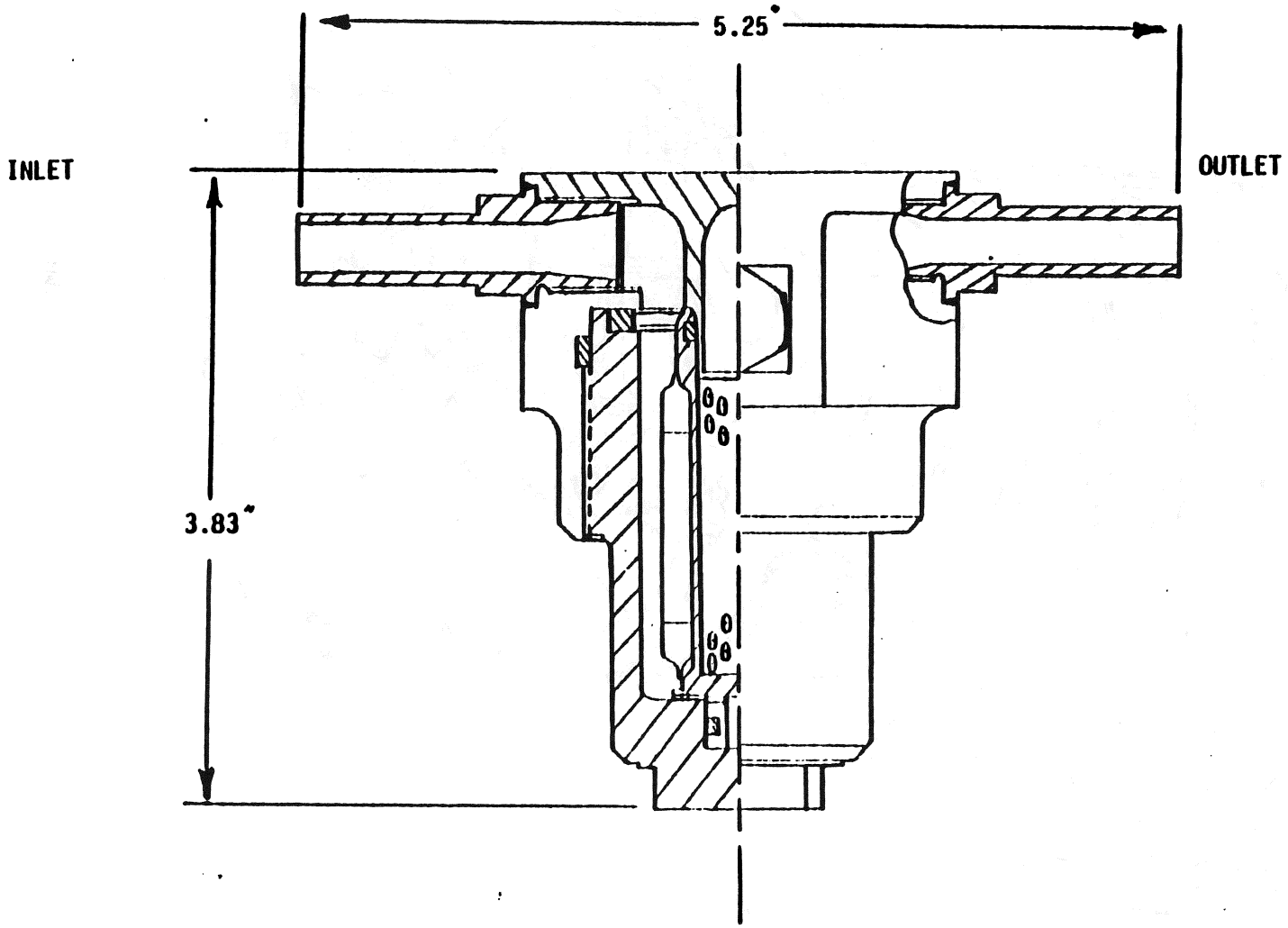
(ME284-0479)

(LH_2 TYPE)



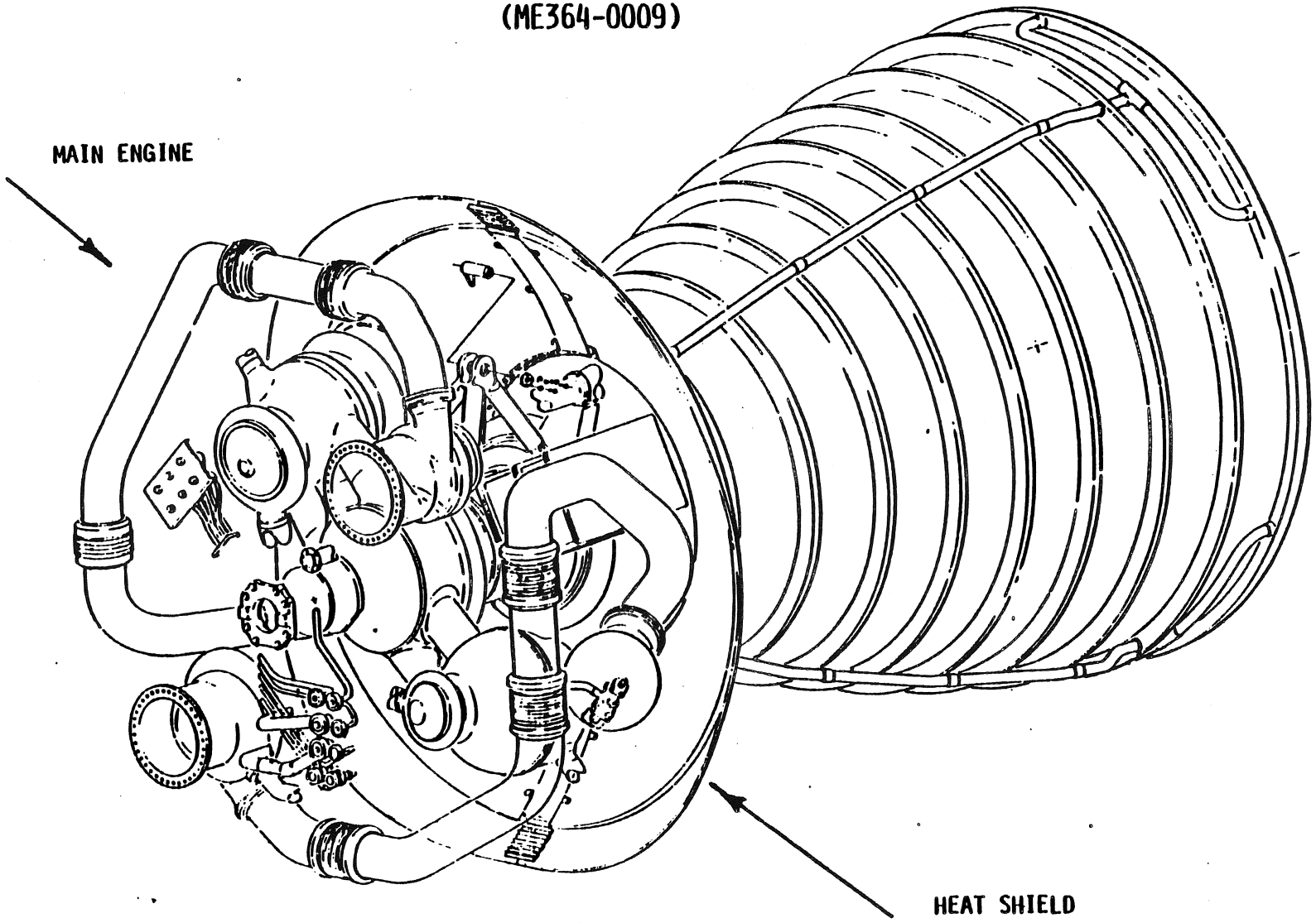
COMPONENT: FILTER, HELIUM

(ME286-0056)



COMPONENT: HEATSHIELD, ENGINE

(ME364-0009)



MAIN PROPULSION LINE REPLACEABLE UNITS

THE MPS LINE REPLACEABLE UNITS (LRU) ARE

- o ALL LO2/LH2 12" FEED LINES
- o LO2/LH2 17" FEED LINES
- o LH2 RECIRC MANIFOLD
- o ALL LH2 RECIRC LINES
- o LH2 TOPPING LINE
- o LO2/LH2 FILL AND DRAIN LINES
- o LH2 HIGH POINT BLEED LINE
- o LO2/LH2 FILL AND DRAIN DISC
- o LO2 BLEED DISC
- o LH2 HIGH POINT BLEED DISC
- o LO2/LH2 17" DISC ASSY
- o LO2/LH2 FILL AND DRAIN VALVES
- o LO2/LH2 PREVALVES
- o LH2 RECIRC VALVES
- o LH2 TOPPING VALVES
- o LO2 BLEED VALVE

MAIN PROPULSION LINE REPLACEABLE UNITS (CONT'D)

- LO2 POGO RECIRC VALVES
- LH2 HIGH POINT BLEED SHUTOFF VALVE
- LH2 RTLS DUMP VALVES
- LO2/LH2 RELIEF SHUTOFF VALVES
- LO2 DUAL CHECK VALVES
- LO2/LH2 RELIEF VALVES
- LH2 RECIRC PUMPS
- LH2 FLAME ARRESTER
- LO2 ECO SENSORS
- LO2/LH2 TEMPERATURE SENSORS
- LO2/LH2 PRESSURE SENSORS
- LO2/LH2 DELTA P SENSORS
- LO2/LH2 DELTA P SIGNAL CONDITIONER
- POINT SENSOR SIGNAL CONDITIONER
- LO2/LH2 INTERFACE SEALS
  - 17 INCH
  - 8 INCH
  - 4 INCH

MAIN PROPULSION TESTING

- OPF
  - V1009 - PERFORMS ELECTRICAL AND MECHANICAL CHECKOUT (LEAK CHECKS) OF MPS
  - V1011 - PERFORMS ELECTRICAL AND MECHANICAL CHECKOUT OF SSME
  - V1001 - PERFORMS INITIAL SSME ELECTRICAL CHECKOUT
  - V1063 - D&C CMD REDUNDANCY
  - V9018 - VJ MAINTENANCE
  - V1201 - MPS/SSME HELIUM SIGNATURE TEST
  - V1032 - PREPARES MPS FOR ROLLOUT

- VAB
  - S5009 - FOAMS ET INTERFACES
  - S0008 - DIRECTS ET AND T-0 LEAK CHECKS AND PERFORMS RECIRC PUMP DRY SPIN
  - V1149 - PERFORMS ET AND T-0 INTERFACE LEAK CHECKS

- PAD
  - V0009 - PAD VALIDATION - HARDWIRE CONTROL
  - S0017 - DRY CDDT
  - V1202 - HELIUM SIGNATURE TEST
  - S1005/S1006 - ET PROPELLANT TANK PRETANKING PURGE AND SAMPLE
  - V9018 - MPS/SSME PREPS FOR PROPELLANT LOAD
  - S1003/S1004 - LOX AND LH_2 PROPELLANT LOADING

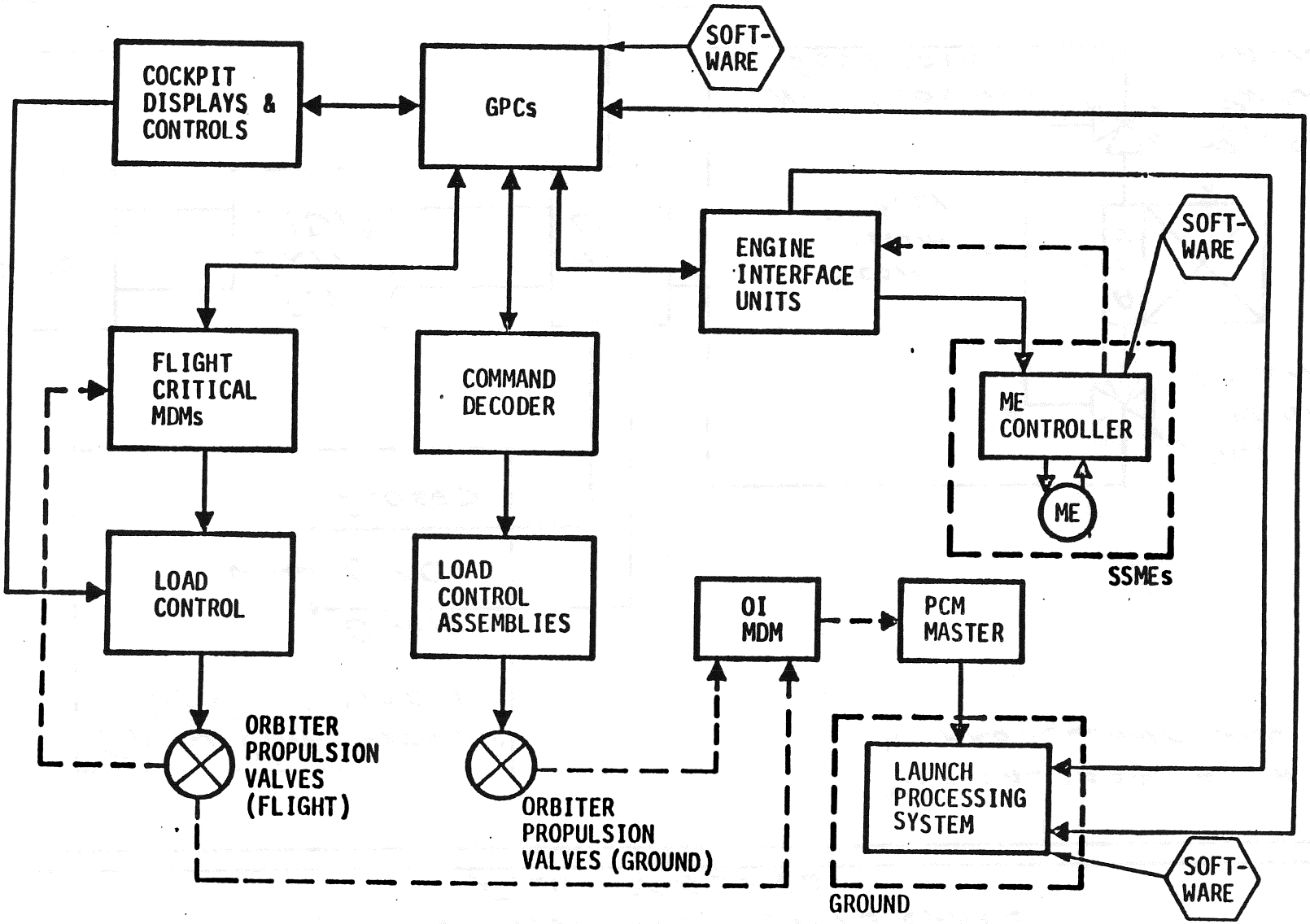
MAIN PROPULSION TESTING (CONT'D)

- o S1018 - POST-DRAIN LH_2 TANK PURGE
- o S0007 - LAUNCH COUNTDOWN

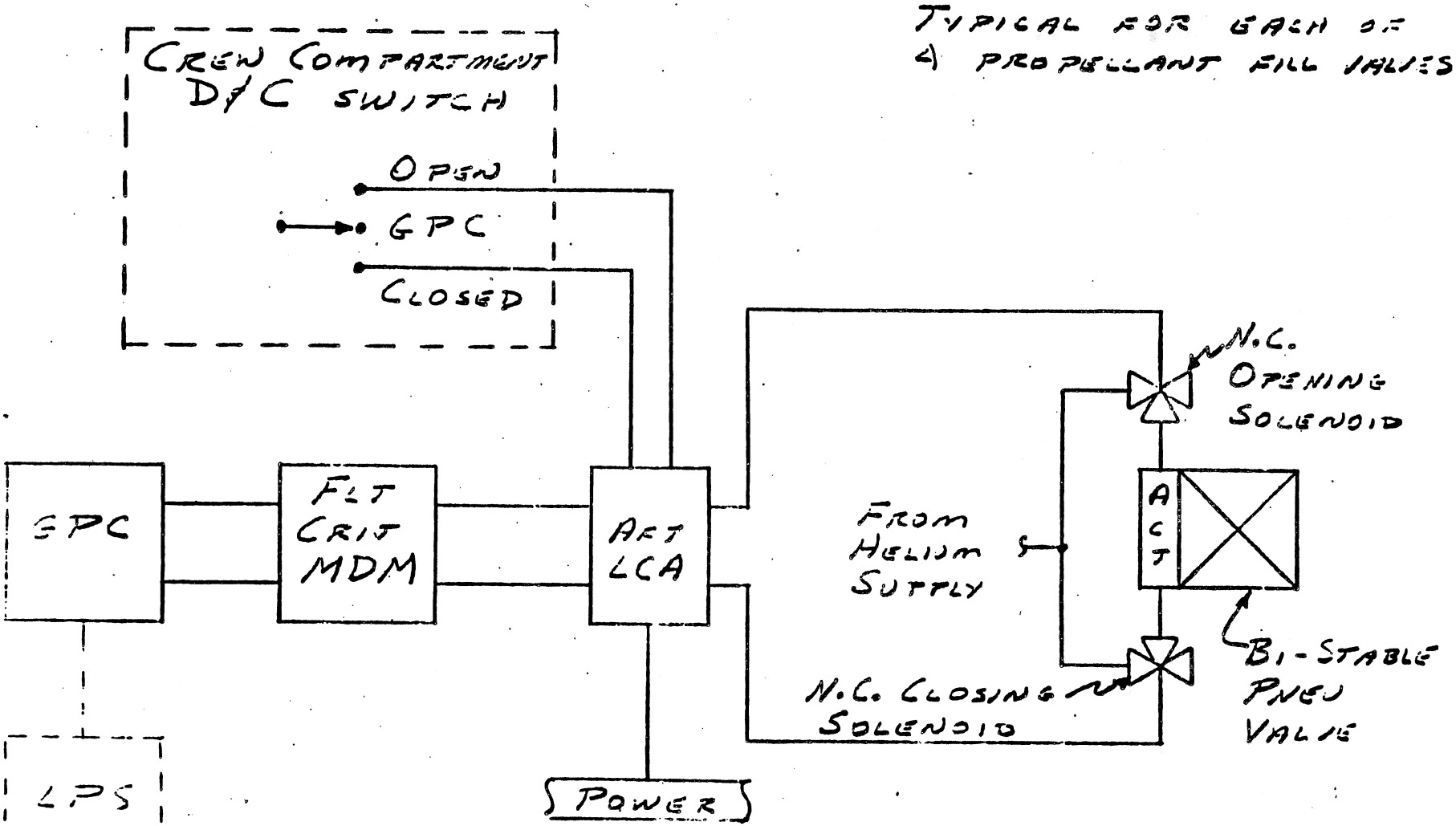
0 DFRF

- o V1038 - MPS/SSME POST-LANDING OPERATIONS AT DFRF

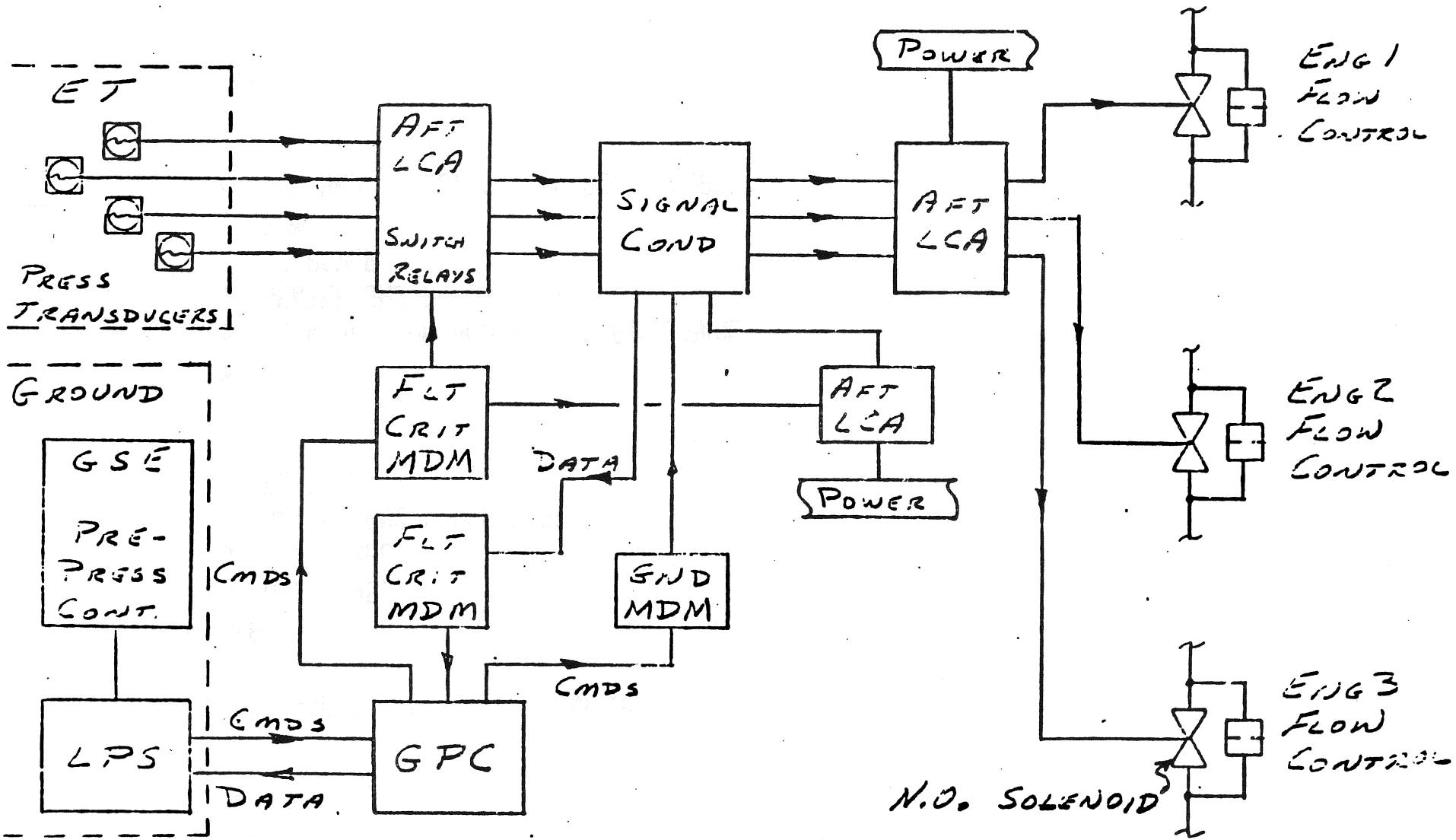
MAIN PROPULSION CONTROL INTERFACES



MPS AVIONICS INTERFACE
FILL VALVES



MPS Avionics Interface
LO_2 Tank Pressurization Flow Control



MAIN PROPULSION GSE

THE MPS GSE IS IN THE OPF AND MLP.

- OPF
  - O-1 PANEL
  - O-2 PANEL
  - HEATER GN2 PURGE PANEL
  - DC POWER

- MLP
  - HE REDUCTION AND BOTTLE FILL PANEL
  - HEATER GN2 PURGE PANEL
  - DC POWER
  - TSM
  - 400 HERTZ RECIRC PUMP POWER SUPPLY

- MISC. GSE

OPF MAIN PROPULSION GSE

- O-1 PANEL (S72-0695-2)
  - LO SYSTEM CHECKOUT
    - LO2 PREPRESS
    - LO2 PRESS MANIFOLD
    - LO2 BLEED
    - LO2 FILL AND DRAIN
  - GN2 LEAK CHECK SUPPLY

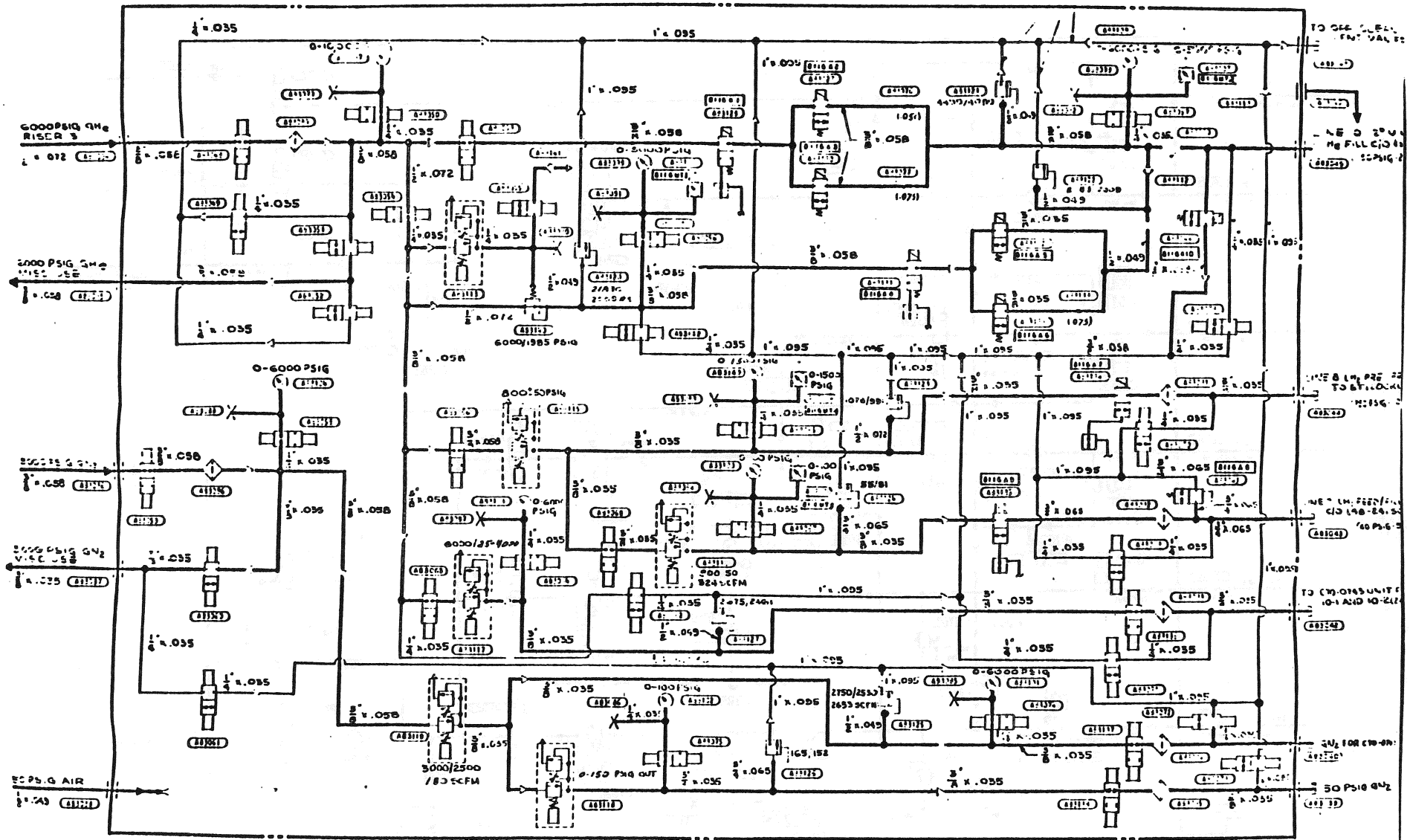
- O-2 PANEL (S72-0695-8)
  - HE BOTTLE FILL
    - FILL TO 2000 PSI
    - FILL TO 4400 PSI
  - LH2 SYSTEM CHECKOUT
    - LH2 PREPRESS
    - LH2 FEED/FILL & DRAIN
    - LH2 PREPRESS VENT
  - GHe UTILITY SUPPLY
  - GN2 UTILITY SUPPLY

OPF MAIN PROPULSION GSE (CONT'D)

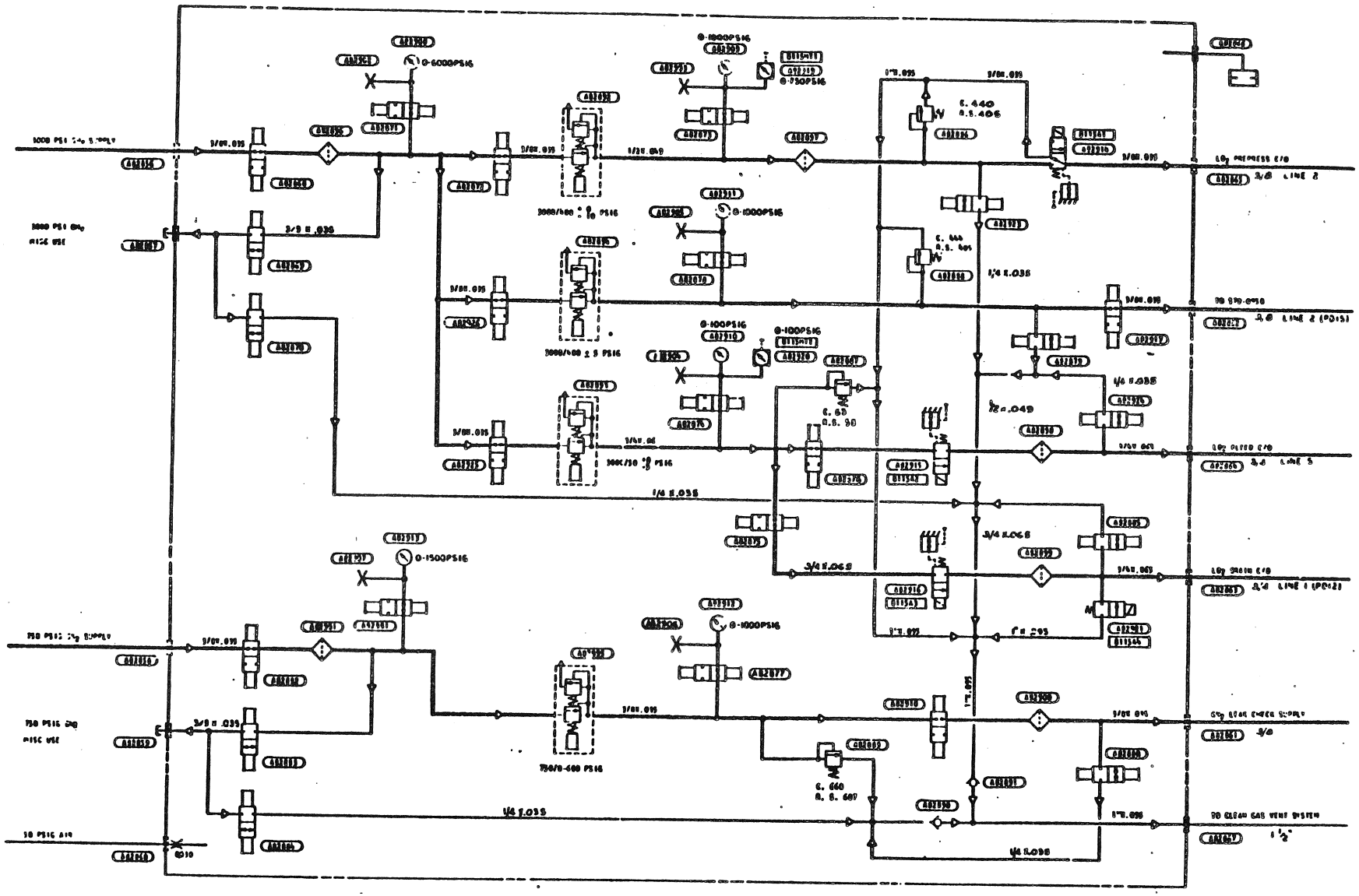
- HEATED GN2 PURGE PANEL (S72-0679-6 & -7)
  - SUPPLY HEATED GN2 TO THE 3 SSME'S TO DRY OUT THE ENGINE AFTER RE-ENTRY OR A FERRY MISSION
  - MPS GN2 SYSTEM LEAK CHECK

- DC POWER
  - SUPPLIES 28 VDC TO THE MPS OPF PANELS
    - FOR VALVE ACTUATION
    - FOR VALVE POSITION FEEDBACK
    - FOR PRESSURE/TEMPERATURE TRANSDUCER EXCITATION

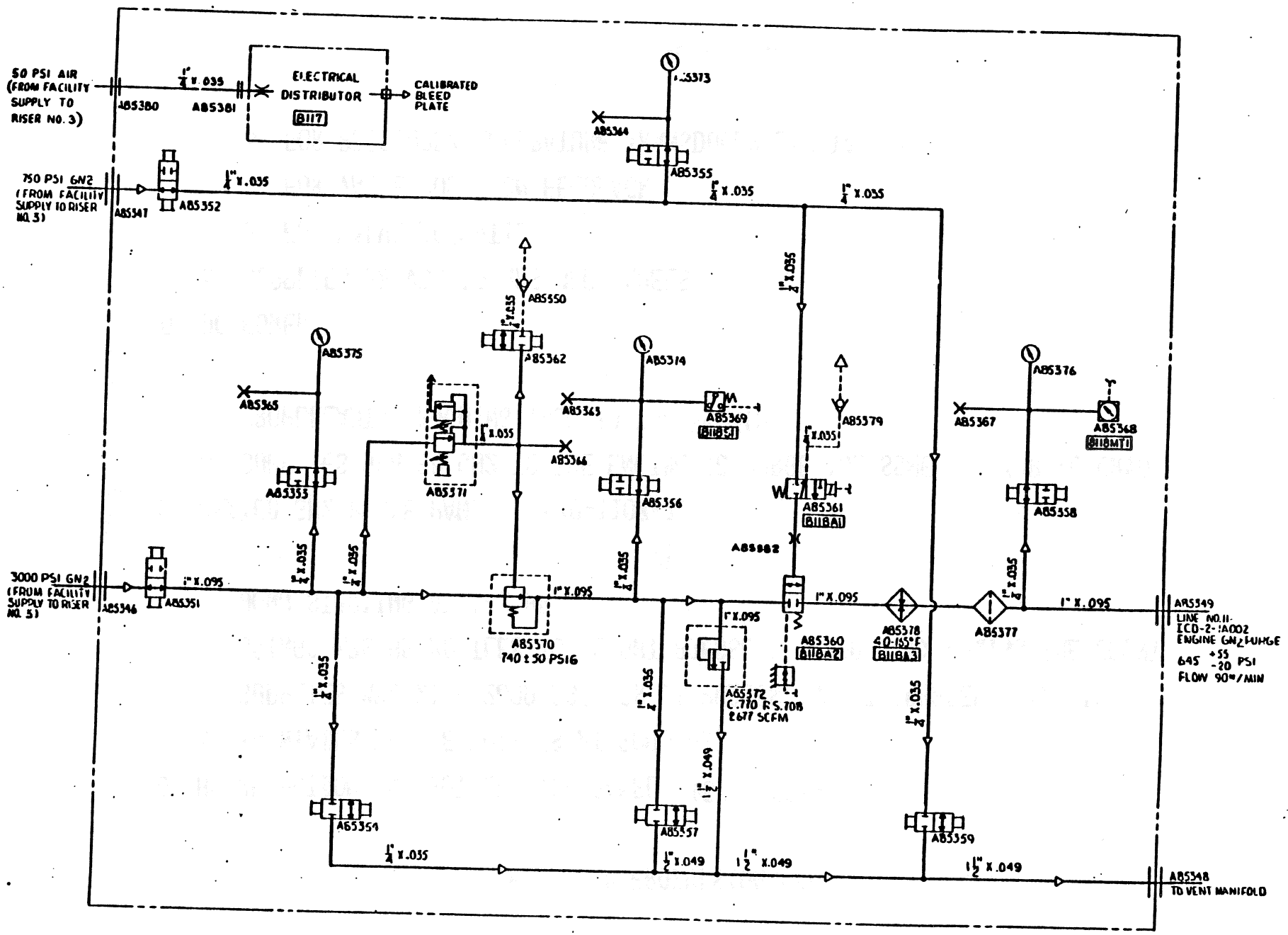
GN2/GHe MPS (O-2) OPF



GN2/GHe MPS (O-1) OPF



GN2 PANEL - OPF



MLP MAIN PROPULSION GSE

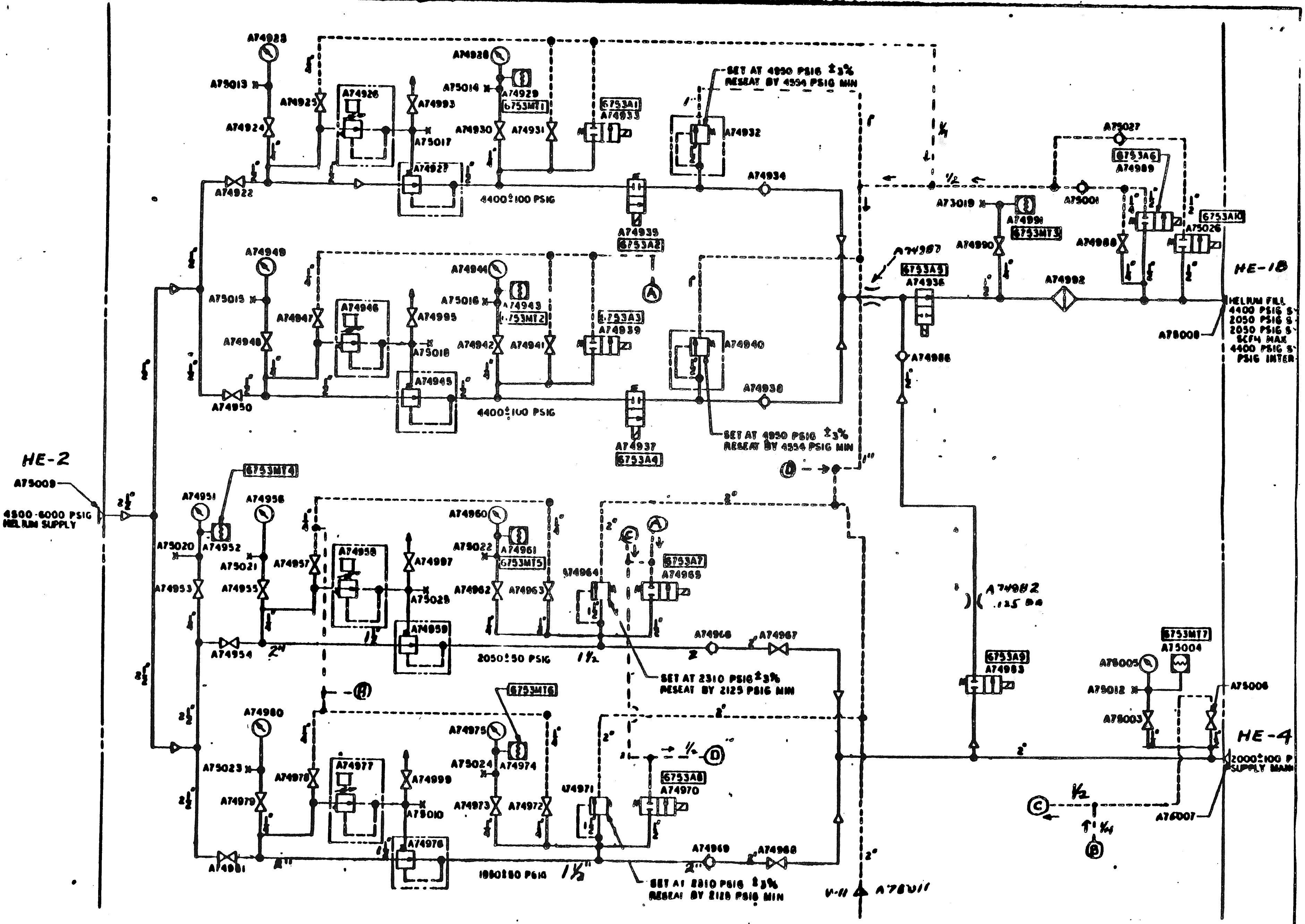
- HE REDUCTION AND BOTTLE FILL PANEL (S70-0685-1)
  - MAINTAINS MPS HE BOTTLES AT 2000 PSI
  - SUPPLIES MMC WITH 2000 PSI FOR ET PURGES AND ET PREPRESSURIZATION
  - BRINGS MPS HE BOTTLES TO FLIGHT PRESSURE (4400 PSI) DURING THE COUNTDOWN STARTING AT T-2 HR

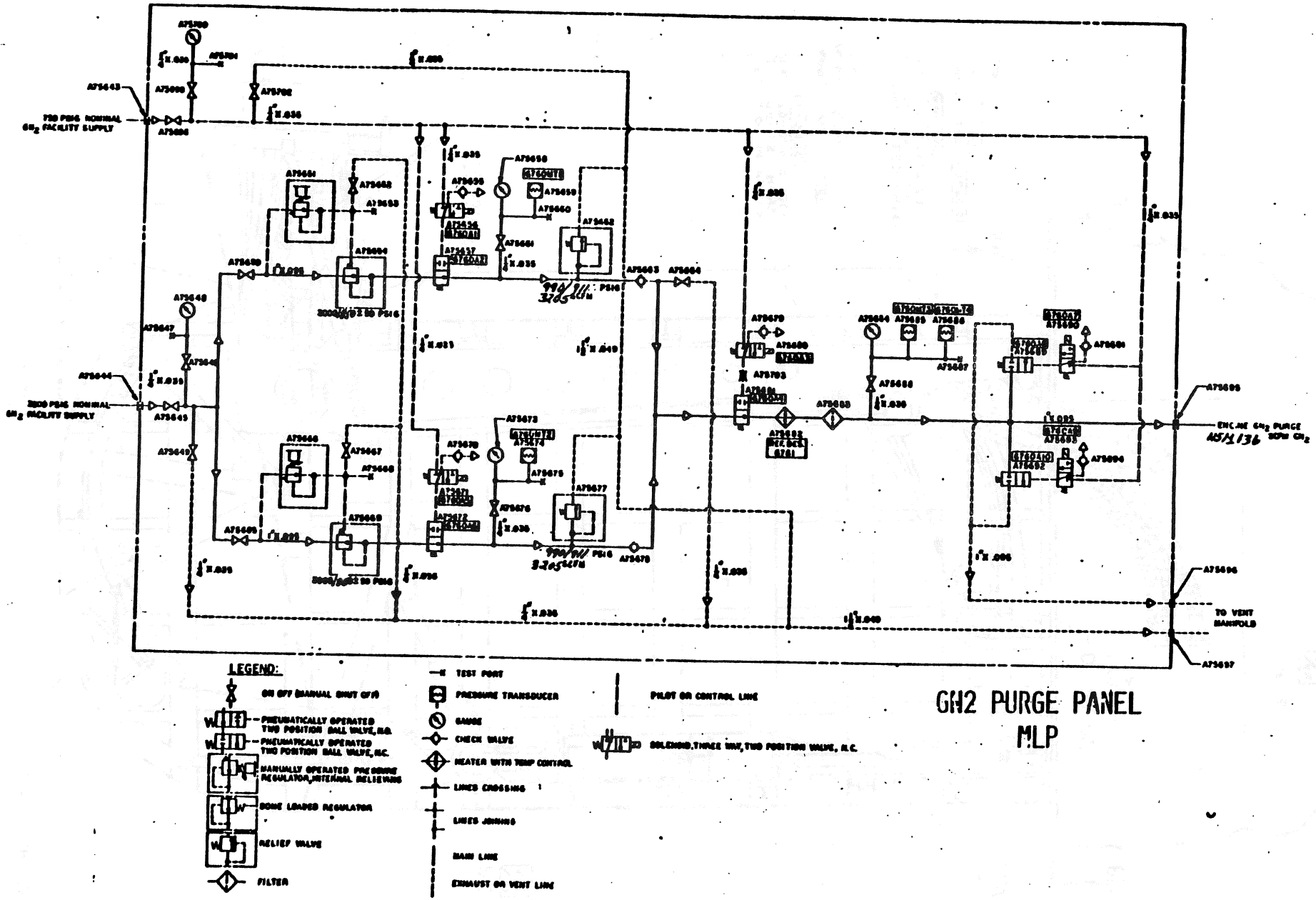
- HEATED GN2 PURGE PANEL (S70-1107-1)
  - SUPPLIES HEATED GN2 TO THE ENGINE TO PURGE THE SSME'S PRIOR TO CRYO PROPELLANTS REACHING THEM TO T-2:55 MIN

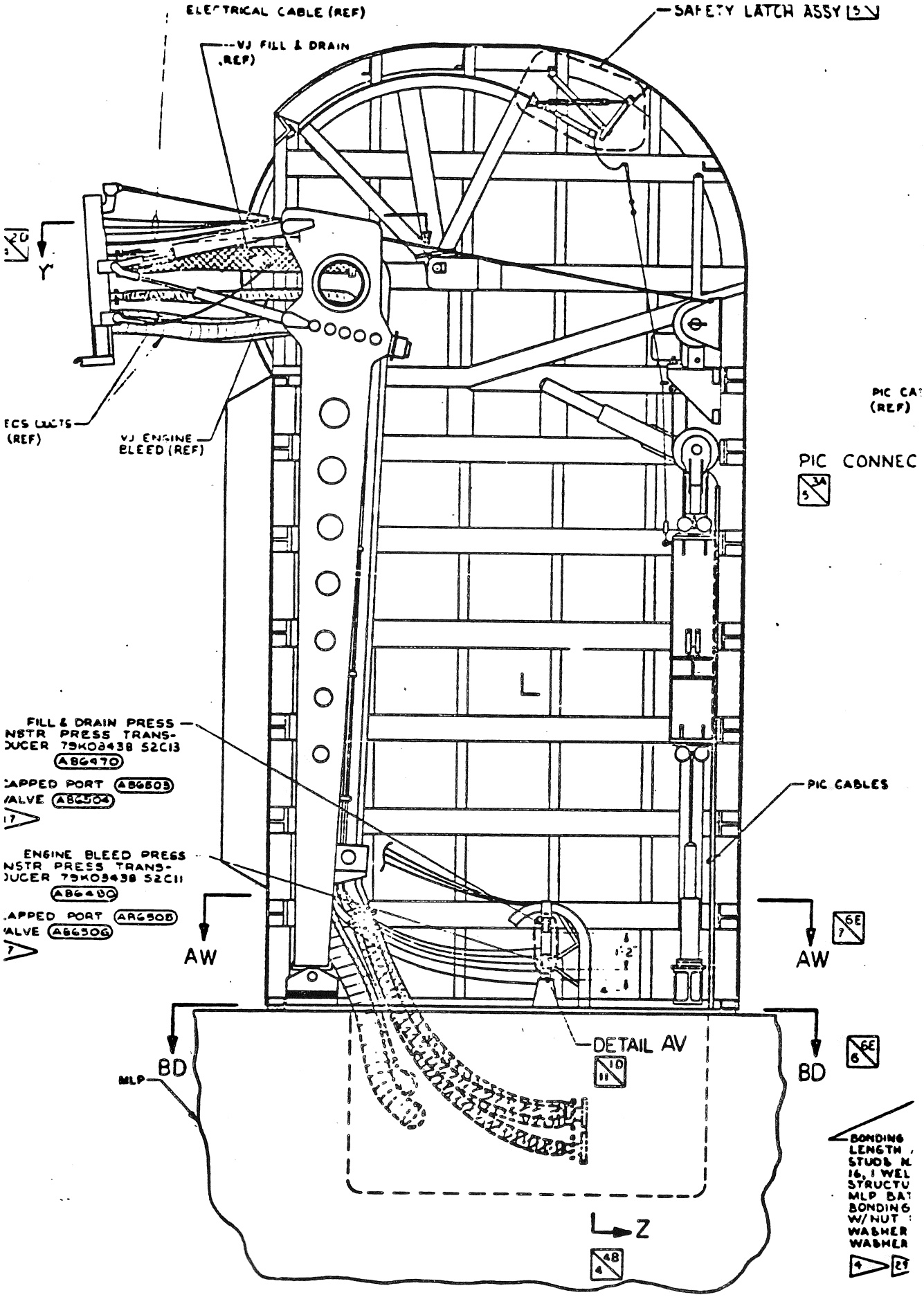
- DC POWER
  - SUPPLIES 28 VDC TO MPS MLP PANELS
    - FOR VALVE ACTUATION
    - FOR VALVE POSITION FEEDBACK
    - FOR PRESSURE/TEMPERATURE TRANSDUCER EXCITATION

MLP MAIN PROPULSION GSE (CONT-D)

- TSM
  - INTERFACES ORBITER WITH GROUND PROPELLANT SYSTEMS
    - LO2 TSM
      - LO2 PROPELLANT FILL AND DRAIN
      - LO2 ET HE PREPRESS
      - LO2 BLEED
    - LH2 TSM
      - LH2 PROPELLANT FILL AND DRAIN
      - LH2 ET HE PREPRESS
      - LH2 HIGH POINT BLEED
      - HE BOTTLE FILL
      - SSME GN2 PURGE
  - PROVIDES PROTECTION TO ALL LINES AND THE CARRIER PLATES DURING LAUNCH


HE-2
A75009
4500-6000 PSIG HELIUM SUPPLY
HE-1B
HELIUM FILL
HE-4
A75008
A75007
A75006
4400±100 PSIG
4400±100 PSIG
2050±50 PSIG
1980±50 PSIG
SET AT 4950 PSIG ±3% RESEAT BY 4554 PSIG MIN
SET AT 4950 PSIG ±3% RESEAT BY 4554 PSIG MIN
SET AT 2310 PSIG ±3% RESEAT BY 2125 PSIG MIN
SET AT 2310 PSIG ±3% RESEAT BY 2125 PSIG MIN
A74982 .125 DIA
A74987
V-11 A78U11
6753A1
6753A2
6753A3
6753A4
6753A5
6753A6
6753A7
6753A8
6753A9
6753A10
6753MT1
6753MT2
6753MT3
6753MT4
6753MT5
6753MT6
6753MT7


LEGEND:
ON OFF (MANUAL SHUT OFF)
PNEUMATICALLY OPERATED TWO POSITION BALL VALVE, N.O.
PNEUMATICALLY OPERATED TWO POSITION BALL VALVE, N.C.
MANUALLY OPERATED PRESSURE REGULATOR, INTERNAL RELIEF
DOME LOADED REGULATOR
RELIEF VALVE
FILTER
TEST PORT
PRESSURE TRANSDUCER
GAUGE
CHECK VALVE
HEATER WITH TEMP CONTROL
LINES CROSSING
LINES JOINING
MAIN LINE
EXHAUST OR VENT LINE
PILOT OR CONTROL LINE
SOLENOID, THREE WAY, TWO POSITION VALVE, N.C.
GH2 PURGE PANEL
MLP


ELECTRICAL CABLE (REF)
VJ FILL & DRAIN (REF)
SAFETY LATCH ASSY
Y
ECS DUCTS (REF)
VJ ENGINE BLEED (REF)
PIC CA (REF)
PIC CONNEC
FILL & DRAIN PRESS NSTR PRESS TRANS-DUCER 79K03438 S2C13
AB6470
APPED PORT AB6503
ALVE AB6504
ENGINE BLEED PRESS NSTR PRESS TRANS-DUCER 79K03438 S2C11
AB6400
APPED PORT AB6508
ALVE AB6506
PIC CABLES
L
AW
AW
DETAIL AV
BD
BD
MLP
Z
BONDING
LENGTH
STUDS
16, I WEL
STRUCTU
MLP BA
BONDING
W/NUT
WASHER
WASHER

MISCELLANEOUS, MAIN PROPULSION GSE

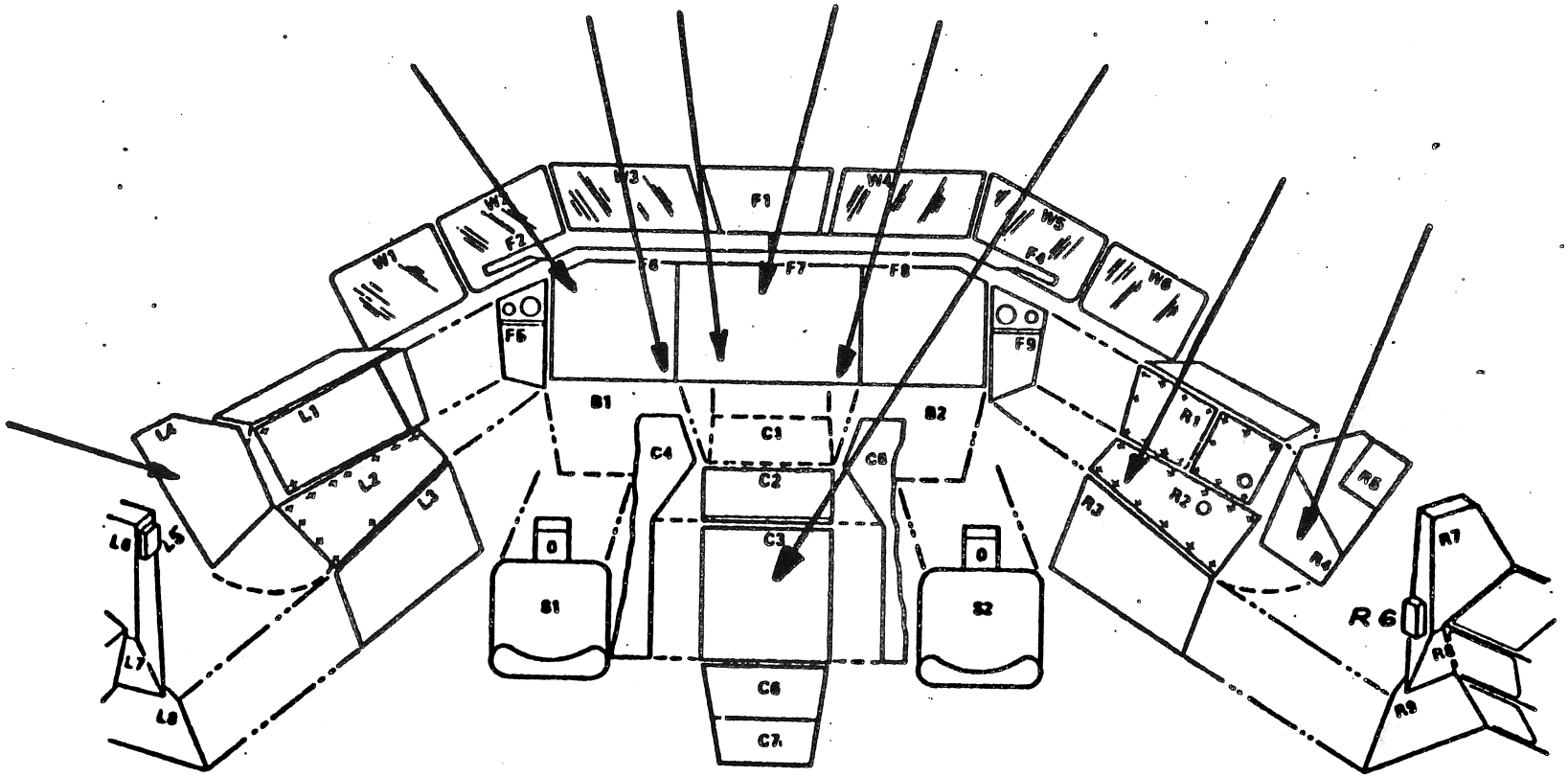
- CAP & PLUG SET (A70-0640)
  - TEST AND CHECKOUT (-3)
  - FERRY SET (-5)

- LRU HARDWARE
  - TO FACILITATE LRU REMOVAL/INSTALLATION

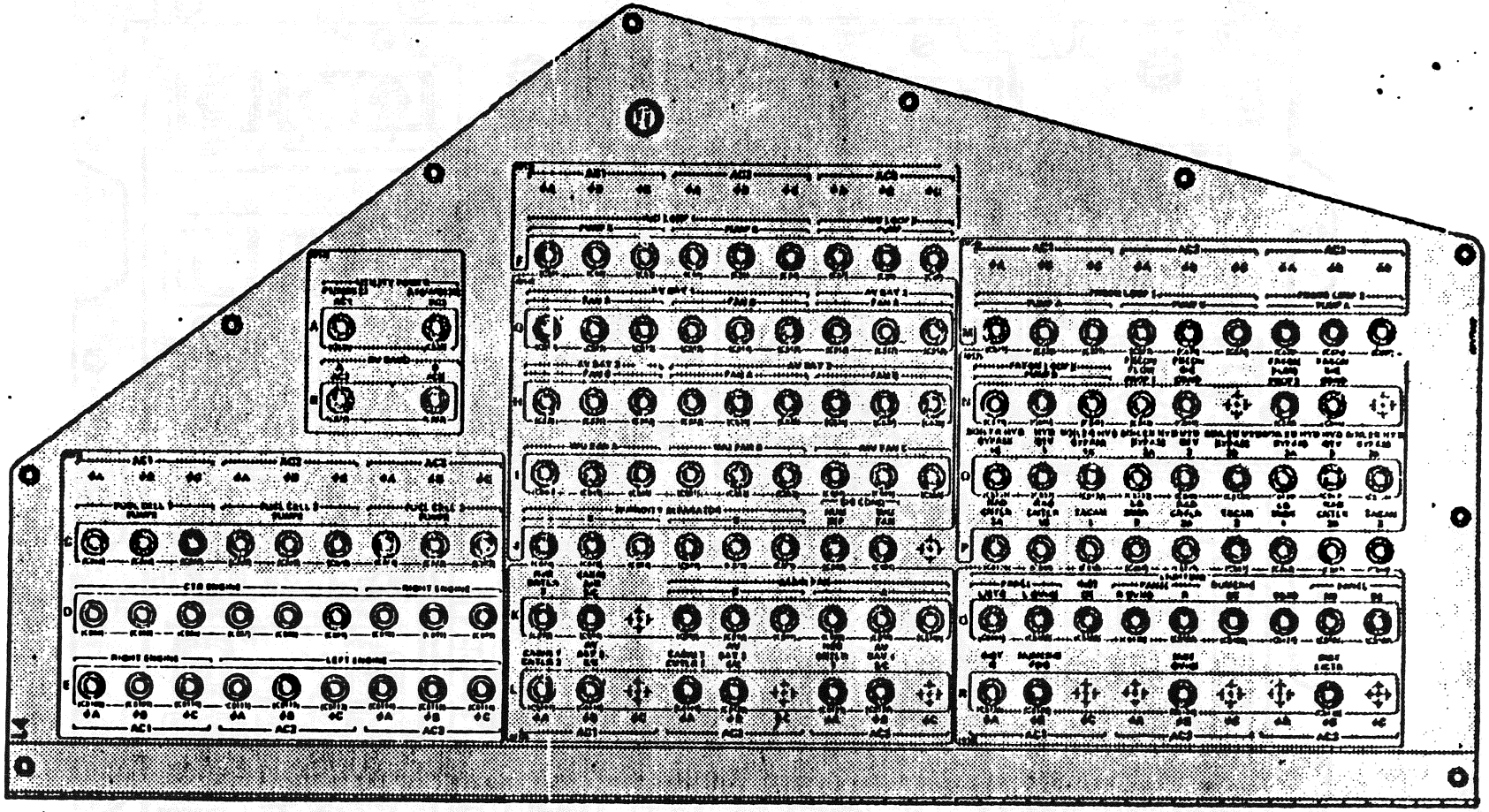
- VACUUM JACKETED LINE PURGE/VACUUM UNIT (S7-37)
  - CHECK VJ LINE VACUUM
  - BACK FILL WITH CO2 AND RE-EVACUATE AS NEEDED

- OTHER MPS GSE FOR CHECKOUT
  - FLOW METERS
  - MASS SPECTROMETER - EXTERNAL LEAK CHECK
  - PROTECTIVE COVERS
  - ELECTRICAL INTERFACE UNITS

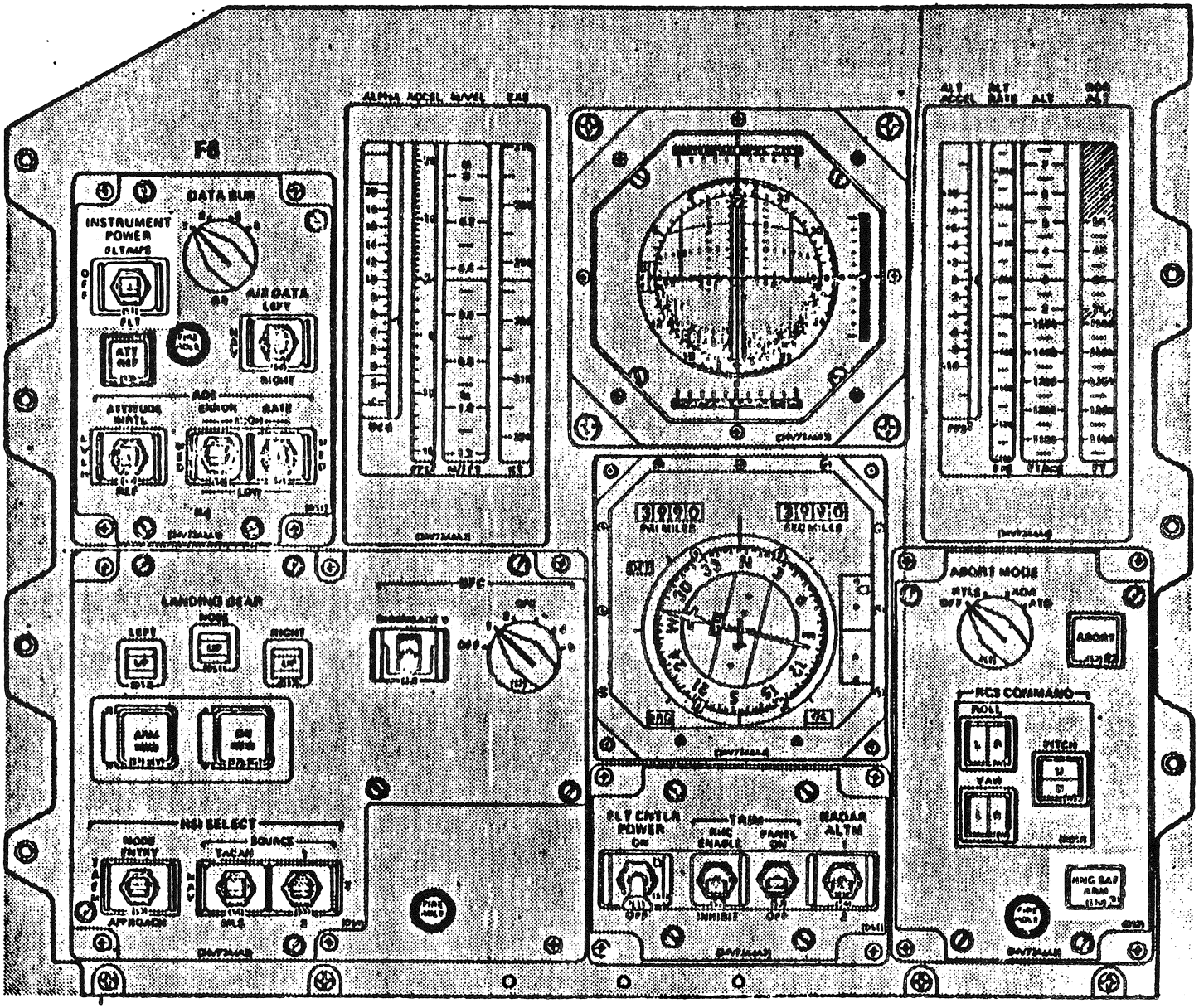
MPS PANEL LOCATIONS – FLIGHT STATION



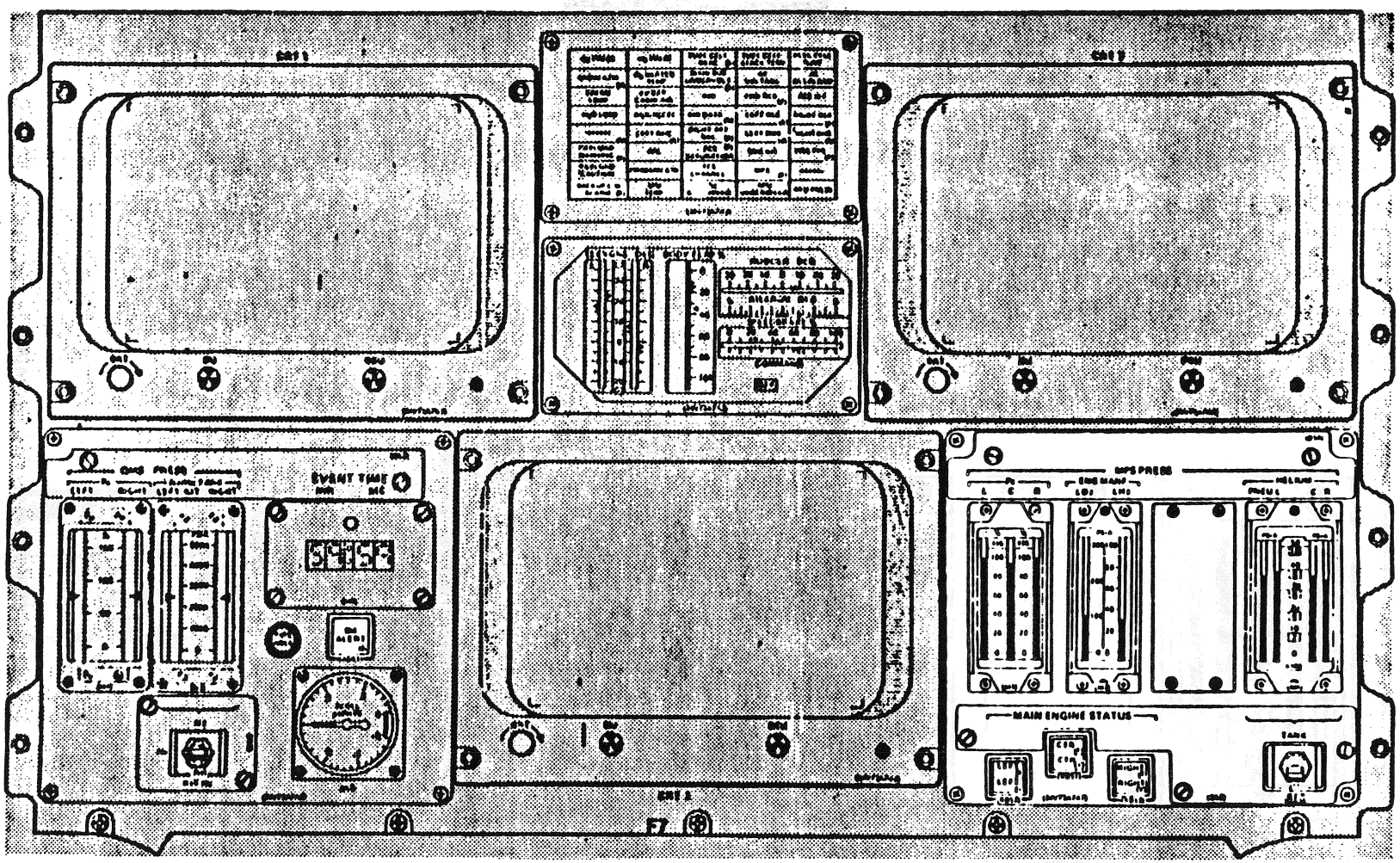
MPS CIRCUIT BREAKERS - PANEL 14



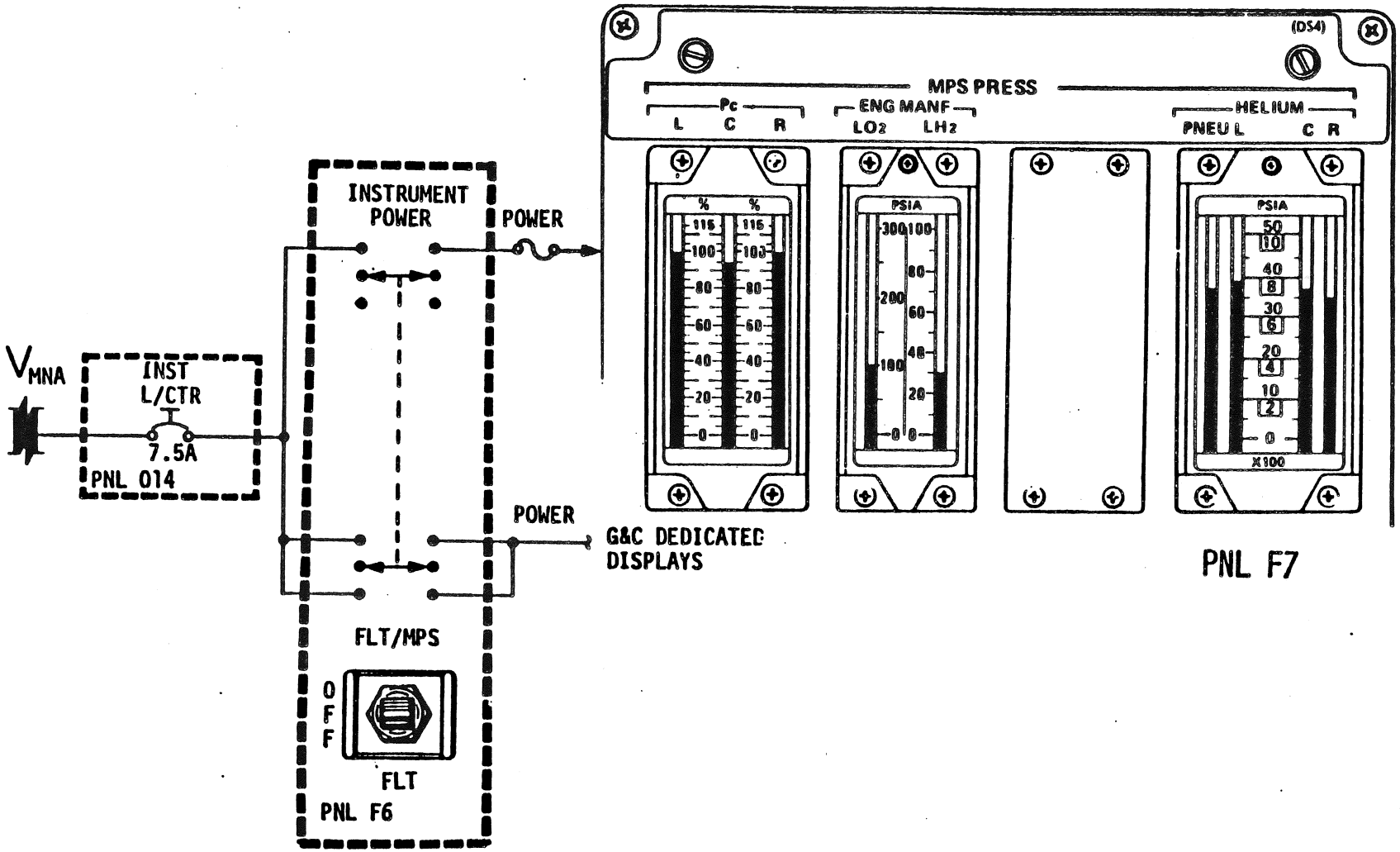
MPS CONTROLS - PANEL F6



MPS CONTROLS & DISPLAYS
PANEL F7

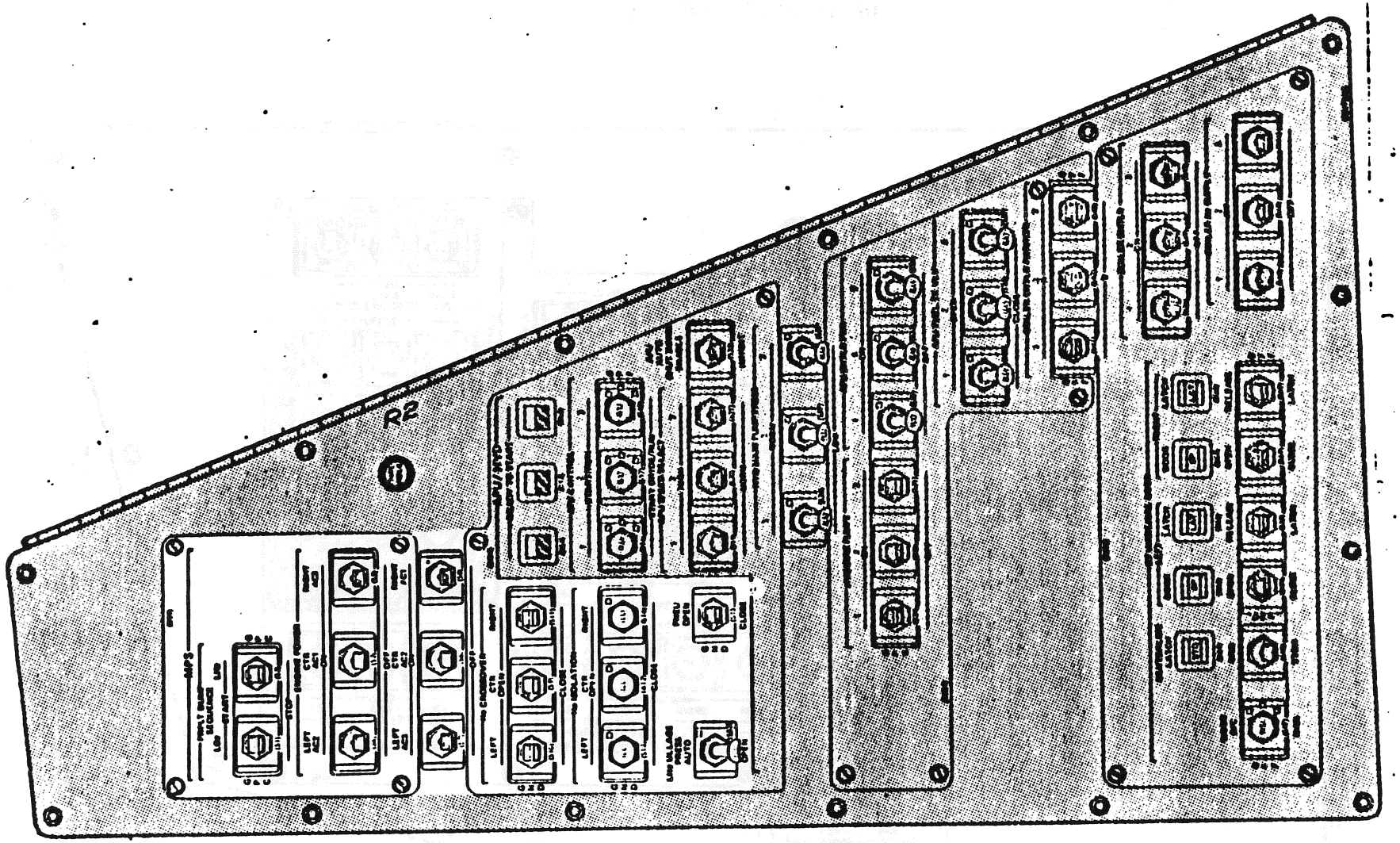


MPS METERS POWER

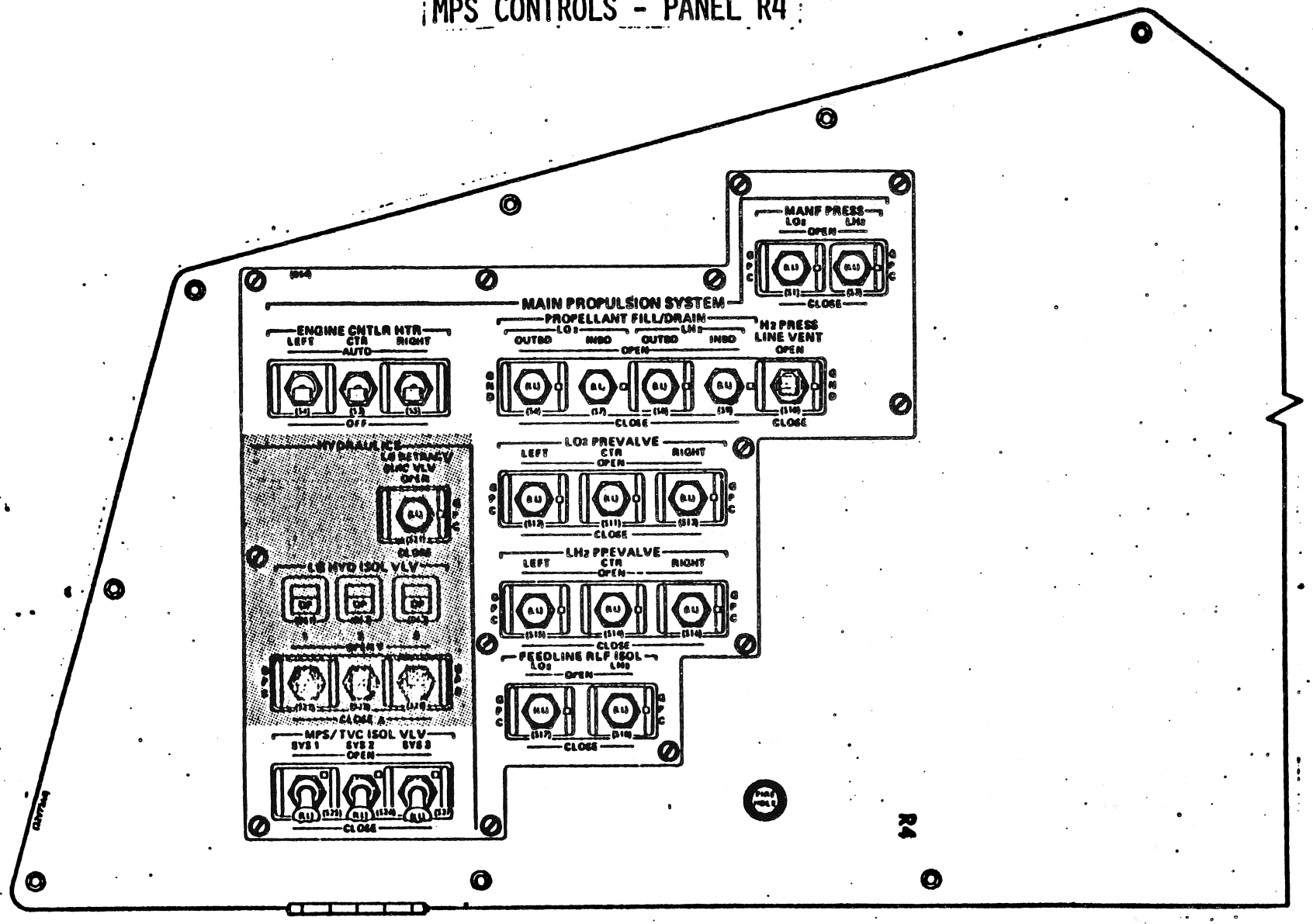


11/1/77

IMPS CONTROLS - PANEL R2

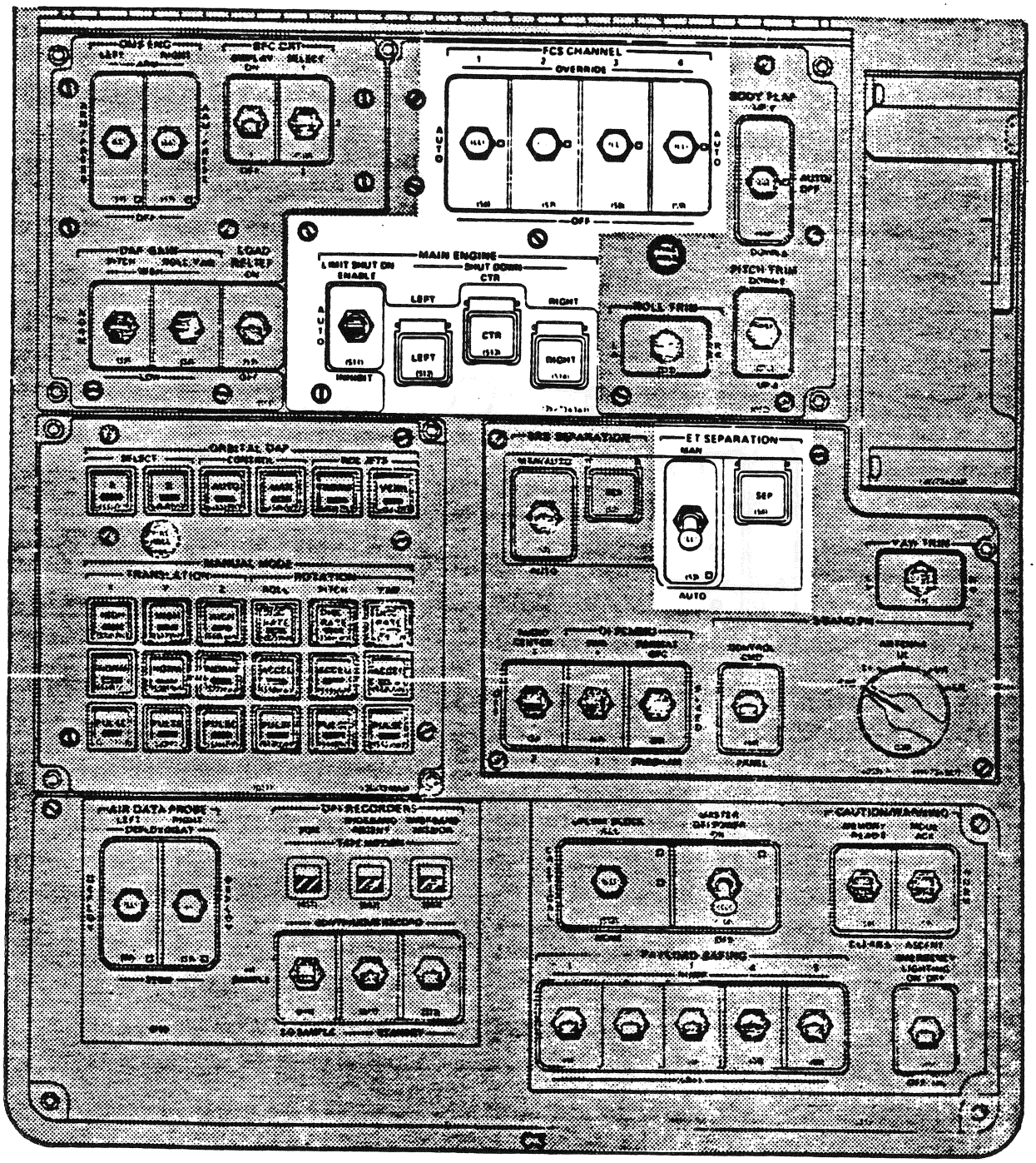


MPS CONTROLS - PANEL R4



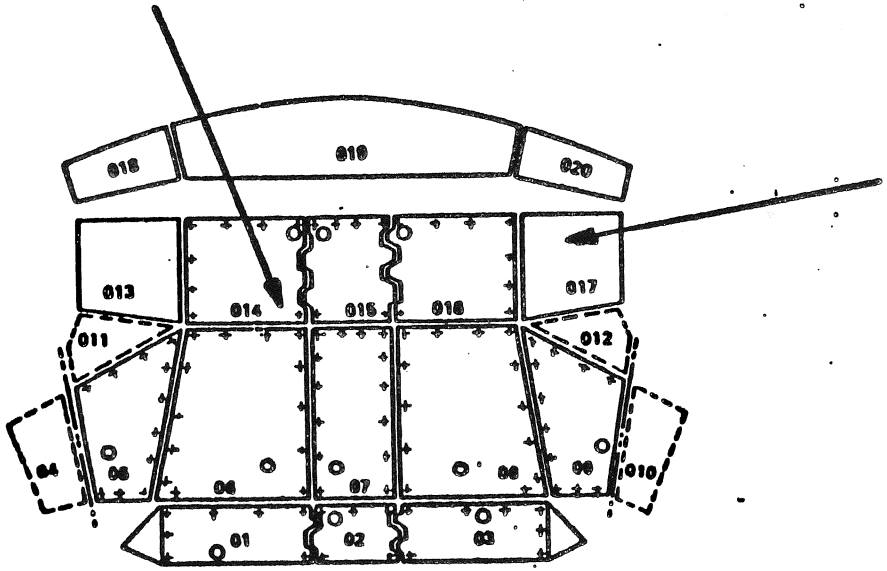
MPS CONTROLS - PANEL C3

11/1/77



11/1/77
110

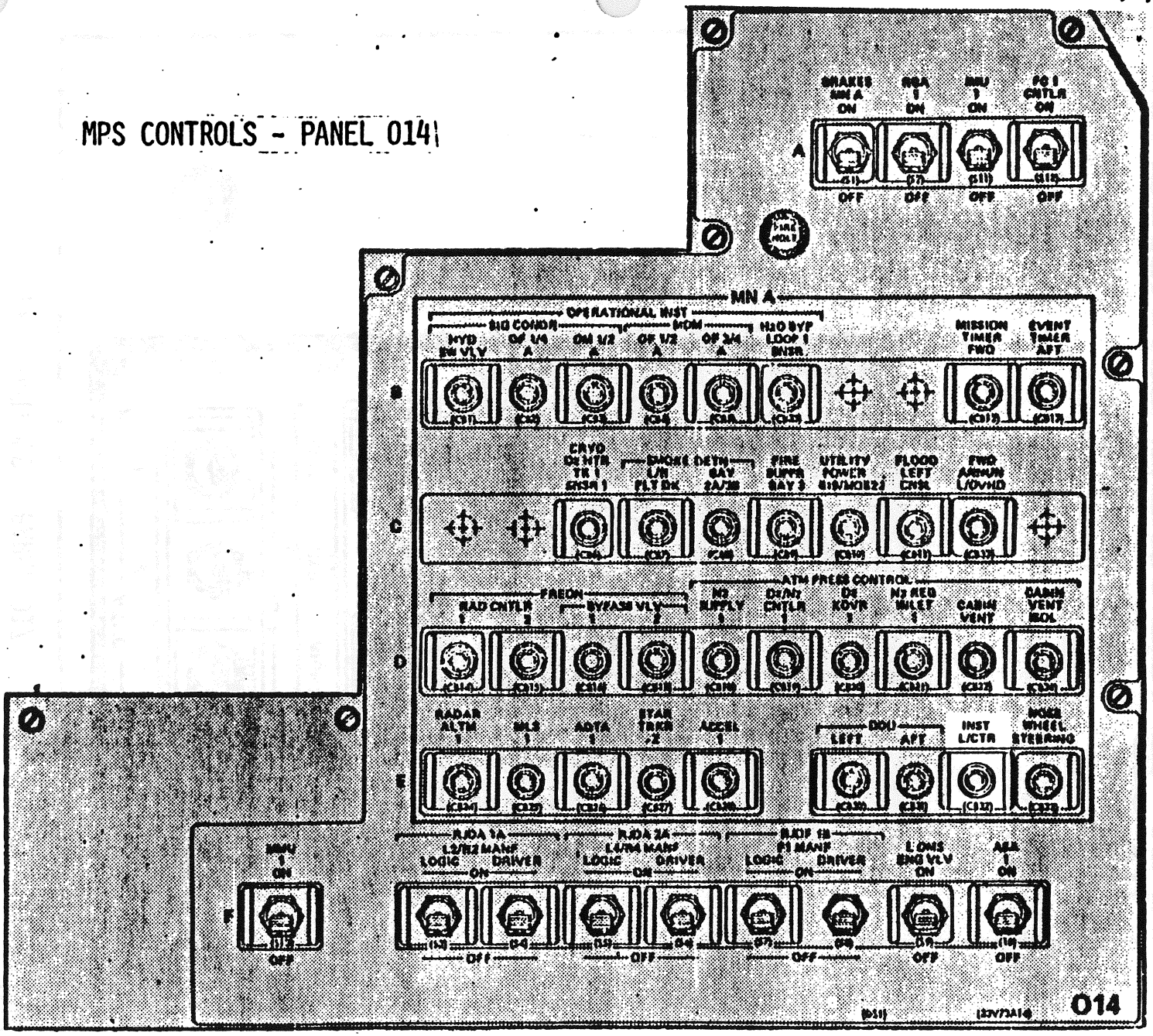
MPS PANEL LOCATIONS – OVERHEAD



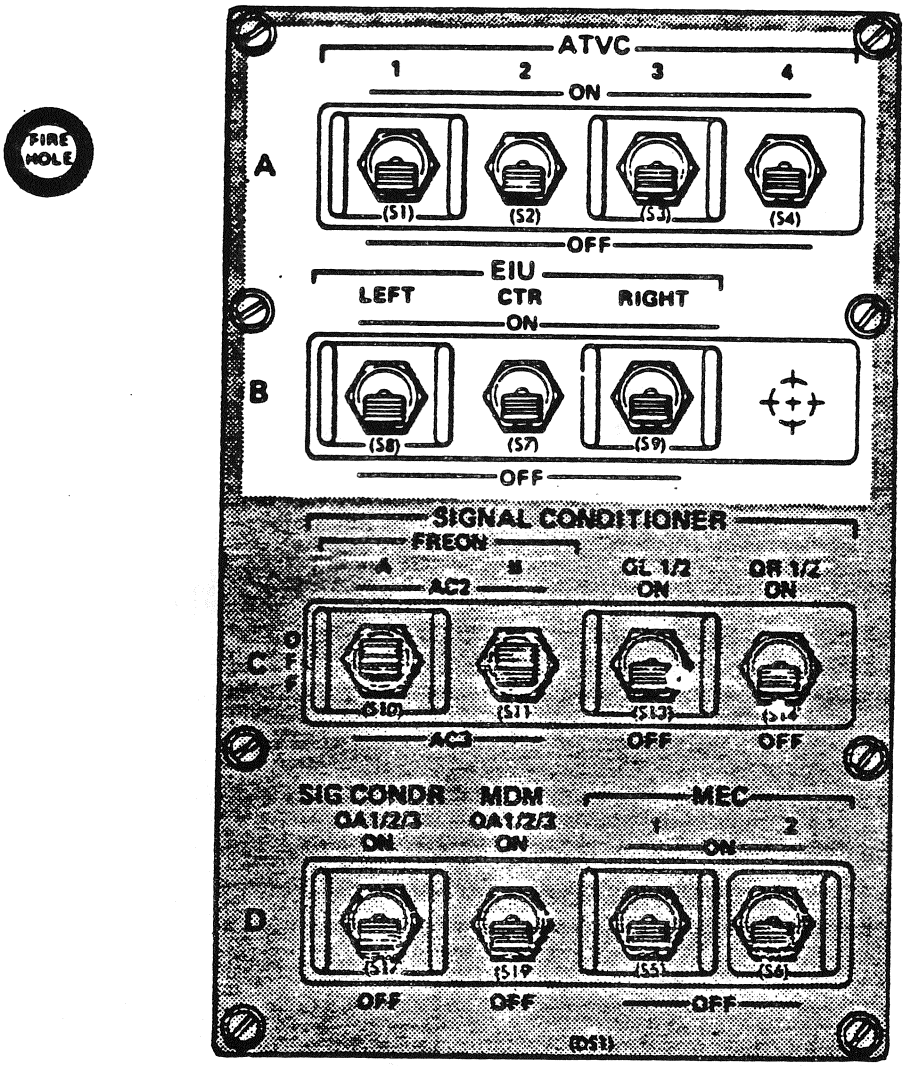
11/1/77

111

MPS CONTROLS - PANEL O14



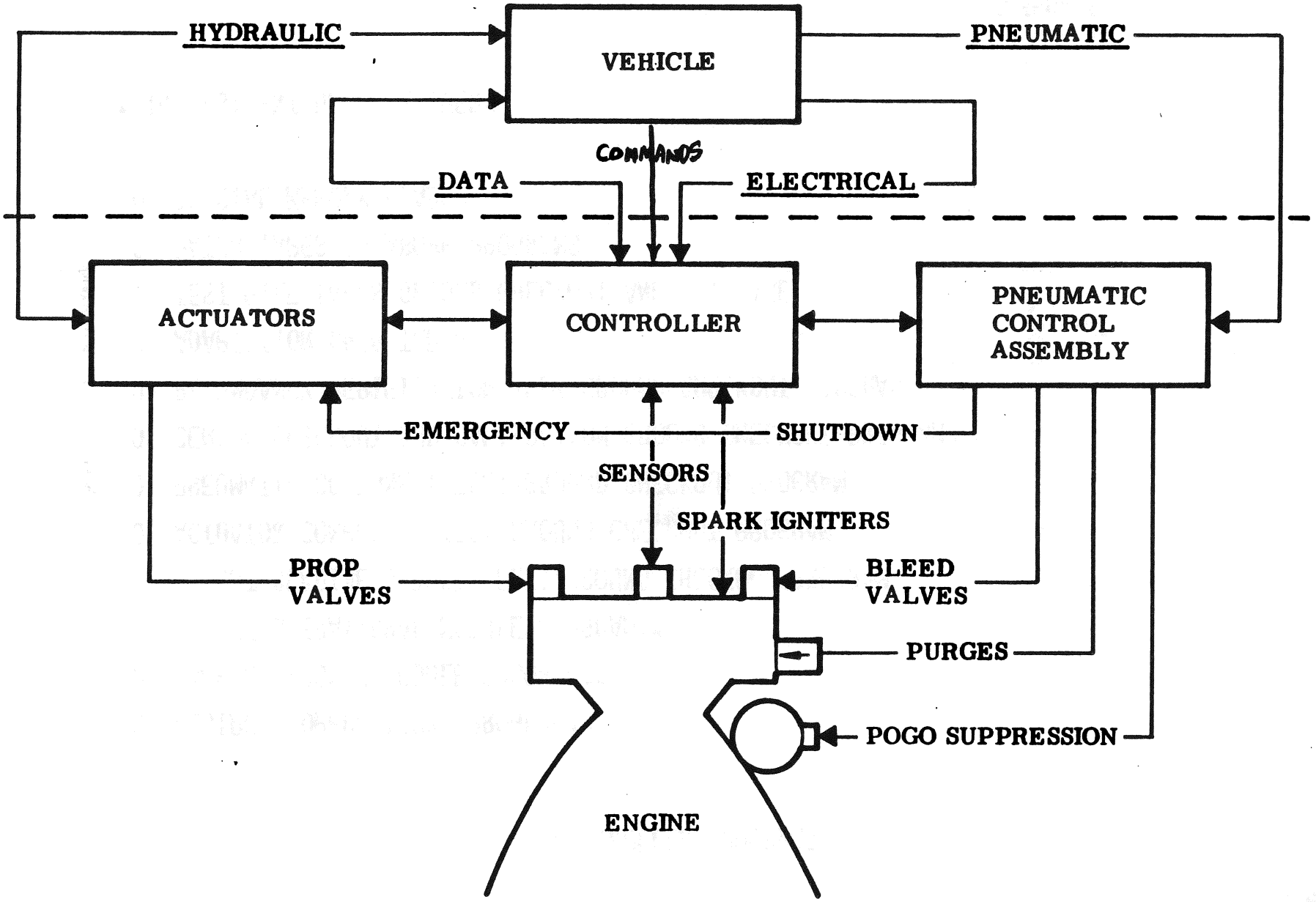
MPS CONTROLS - PANEL 017



017

(33V73A17)

SSME CONTROL SYSTEM



SSME CONTROLLER PROGRAMS

- RESIDENT OPERATIONAL PROGRAM**
- SAMPLE PROBLEM MODULE PROGRAM**
- FLIGHT OPERATIONAL MODULE PROGRAM**
- FLIGHT READINESS TEST (FRT) GROUND CHECKOUT PROGRAM
- ACTUATOR COMPONENT TEST GROUND CHECKOUT PROGRAM
- PNEUMATIC COMPONENT TEST GROUND CHECKOUT PROGRAM
- SENSOR CHECKOUT AND CALIBRATION GROUND CHECKOUT PROGRAM
- REDUNDANCY VERIFICATION TEST GROUND CHECKOUT PROGRAM
- ADAPTATION DATA TAPES
- TEST FILE TAPES GROUND CHECKOUT AND HOT-FIRE
- PATCH TAPES TO ABOVE PROGRAMS
- SPECIAL MEMORY LOADER

** IN RESIDENT UPON DELIVERY

CONTROL SYSTEM FUNCTIONS

- CHECKOUT
  - UTILIZE OVERLAY MODULES FOR COMPONENT CHECKOUT
    - SENSOR CALIBRATION AND CHECKOUT
    - PNEUMATIC CHECKOUT
    - ACTUATOR CHECKOUT
    - REDUNDANCY VERIFICATION, I, II
    - SAMPLE PROBLEM
  - FRT FOR MISSION SIMULATION

- START PREPARATION
  - SEQUENCE ENGINE PURGES UPON COMMAND
  - TIMING CONTROLLED BY VEHICLE
  - ASSURE PROPER PROPELLANT CONDITIONS FOR ENGINE READY

CONTROL SYSTEM FUNCTIONS

- START PREPARATION (CONT'D)
  - PURGE SEQUENCE 1
    - VEHICLE/FACILITY CONTROLLED GN2 PURGE
    - HPOT INTERMEDIATE SEAL PURGE
  - PURGE SEQUENCE 2
    - ADD FUEL SYSTEM PURGE
  - PURGE SEQUENCE 3
    - HELIUM PURGES OFF
    - BLEED VALVES OPEN
  - PURGE SEQUENCE 4
    - FUEL SYSTEM PURGE
    - OPEN CCV
    - VENT EMERGENCY SHUTDOWN SYSTEM
    - PROPELLANT CONDITIONING
    - ENERGIZE ALL ACTUATOR FAIL SAFE COILS
    - VALID THRUST LEVEL COMMAND RECEIVED FROM GPC
  - ENGINE READY

TABLE XVIII

ENGINE STATUS WORD (ESW)

WORD FORMAT DATA WORD 3, E41MXOC3PE (PARENT WORD) X=1, 2, 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

DEFINES ENGINE SELF-TEST STATUS

DEFINES OPERATING MODE WITHIN PHASE

DEFINES PHASE IN EFFECT

LIMIT CONTROL INHIBIT/ENABLE

FRT STATUS

CHANNEL STATUS

COMMAND STATUS

MEMORY LOAD STATUS

NOTE: Word Length Equals 16 Bits (Excluding Parity Bit). Bit 1 is the MSB in the DCU.

GROUP CODE

MEMORY LOAD STATUS: (BIT 1) E41X1507B1, E41X2507B1, E41X3507B1

1 SOFTWARE LOAD MODE. Commands interpreted per format of Table XXI

0 NON SOFTWARE LOAD MODE. Commands interpreted per format of Table XVI

COMMAND STATUS: (BITS 2-3) E41J1508B1, E41J2508B1, E41J3508B1

BIT CODE	COMMAND STATUS
00	NO COMMAND SINCE LAST STATUS/RECORDER CHANNEL TRANSMISSION
01	COMMAND REJECTED, NOT VALIDATED BY BCH OR VOTING
10	COMMAND REJECTED, INCOMPATIBLE WITH CURRENT OPERATING MODE OR NOT IN TABLE OF COMMANDS
11	COMMAND ACCEPTED

TABLE XVIII (Continued)

ENGINE STATUS WORD (ESW) (Continued)

CHANNEL STATUS: (BITS 4-6) E41J1509B1, E41J2509B1, E41J3509B1

BIT CODE	CHANNEL STATUS
000	ALL CHANNELS OK
001	MESSAGE ERROR, CHANNEL 1
010	MESSAGE ERROR, CHANNEL 2
011	MESSAGE ERROR, CHANNELS 1 & 2
100	MESSAGE ERROR, CHANNEL 3
101	MESSAGE ERROR, CHANNELS 1 & 3
110	MESSAGE ERROR, CHANNELS 2 & 3
111	MESSAGE ERROR, CHANNELS 1, 2, & 3

FRT STATUS: (BIT 7) E41X1510B1, E41X2510B1, E41X3510B1

BIT CODE	FRT STATUS
0	NORMAL OPERATION
1	FRT

LIMIT CONTROL INHIBIT/ENABLE: (BIT 8) E41X1511B1, E41X2511B1, E41X3511B1

BIT CODE	LIMIT CONTROL
0	INHIBIT
1	ENABLE

PHASE: (BITS 9-11) E41J1512B1, E41J2512B1, E41J3512B1

BIT CODE	PHASE
000	(NOT USED)
001	CHECKOUT
—010	START PREPARATION
011	START
100	MAINSTAGE
101	SHUTDOWN
—110	POST SHUTDOWN
111	(SPARE)

TABLE XVIII (Continued)

ENGINE STATUS WORD (ESW) (Continued)

MODE BY PHASE (BITS 12-14) E41J1513B1, E41J2513B1, E41J3513B1

BIT CODE	CHECKOUT	START PREPARATION	PHASE: START	MAINSTAGE	SHUTDOWN	POST SHUTDOWN
000			NOT USED			
001	STANDBY	PURGE SEQ. NO. 1	START INITIATION	NORMAL CONTROL	THROTTLING TO MPL	STANDBY
R" 010	SPARE	PURGE SEQ. NO. 2	THRUST BUILDUP	THRUST LIMITING	THROTTLING TO ZERO THRUST	OXIDIZER DUMP
R" 011	SPARE	PURGE SEQ. NO. 3	ELECTRICAL LOCKUP	ELECTRICAL LOCKUP	PROPELLANT VALVES CLOSED	SPARE
100	COMPONENT CHECKOUT	PURGE SEQ. NO. 4	HYDRAULIC LOCKUP	HYDRAULIC LOCKUP	FAILSAFE PNEUMATIC	SPARE
101	SPARE	SPARE	SPARE	SPARE	SPARE	SPARE
110	SPARE	ENGINE READY	SPARE	SPARE	SPARE	SPARE
111	SPARE	SPARE	SPARE	SPARE	SPARE	TERMINATE SEQUENCE

SELF-TEST STATUS: (BITS 15-16) E41J1514B1, E41J2514B1, E41J3514B1

R" BIT CODE	ENGINE STATUS
00	FASCOS LIMIT EXCEEDED
01	ENGINE OK
10	MAJOR COMPONENT FAILED
11	ENGINE LIMIT EXCEEDED

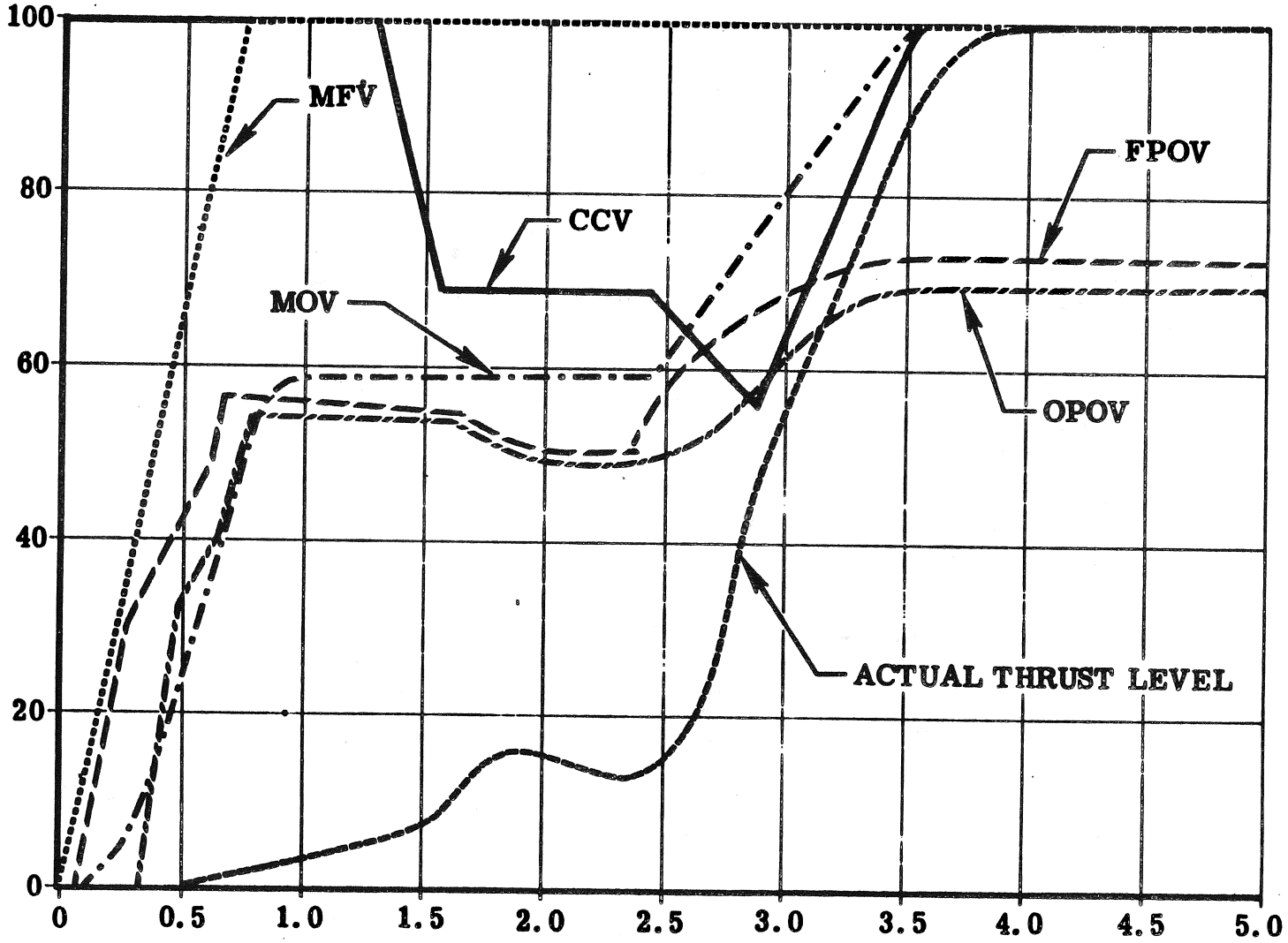
TYPICAL ENGINE START SEQUENCE TO RPL

START CONTROL PHASE

OPEN-LOOP

CLOSED-LOOP THRUST CONTROL

CLOSED-LOOP M/R CONTROL



CONTROL SYSTEM FUNCTIONS

- POWERED OPERATION
  - START
    - START ENABLE FOLLOWED BY START COMMAND
    - INITIAL SEQUENCE IS OPEN LOOP
    - PROPORTIONAL CONTROL OF Pc AT 0.74 SEC
    - INTEGRAL CONTROL OF Pc ADDED AT 2.4 SEC
    - SCHEDULED CONTROL OF CCV AT 3.2 SEC
    - CLOSED LOOP MIXTURE RATIO CONTROL AT 3.5 SEC
    - SCHEDULE CONTROL OF MOV AND MFV AT 5.0 SEC
    - MAINSTAGE AT 5.0 SEC

CONTROL SYSTEM FUNCTIONS

- POWERED OPERATION (CONT'D)
  - MAINSTAGE
    - TWO CLOSED LOOP CONTROL VALVES
      - OPOV FOR Pc CONTROL
        - CROSS-FEED COMPENSATION TO MIXTURE RATIO LOOP
      - FPOV FOR MIXTURE RATIO CONTROL
        - MEASURED VOLUMETRIC FLOW
        - DENSITY CORRECTED FOR PRESSURE AND TEMPERATURE
      - THREE SCHEDULED VALVES
        - MOV, MFV, AND CCV
        - SCHEDULE AS FUNCTION OF Pc COMMAND

CONTROL SYSTEM FUNCTIONS

- POWERED OPERATION (CONT'D)
  - SHUTDOWN
    - INITIATION
      - SHUTDOWN ENABLE FOLLOWED BY SHUTDOWN COMMAND
      - ENGINE INITIATED
    - TYPES
      - HYDRAULIC
        - THROTTLING TO MPL
        - OPEN LOOP SEQUENCE BELOW MPL
      - PNEUMATIC
        - SEQUENCED PNEUMATIC CLOSING OF VALVES

MPS
PROPELLANT LOADING

LO2/LH2 PROPELLANT LOADING

- LOADING OPERATIONS ARE DEFINED BY
  - LOX LOADING CRITERIA 79K05735
  - LH2 LOADING CRITERIA 79K05896
- LOADING IS AUTOMATICALLY PERFORMED BY GOAL SOFTWARE
- SOFTWARE DESIGN (APPROXIMATELY 400 PROGRAMS PER SYSTEM)
  - ACTUAL LOAD PERFORMED BY FACILITY PROPELLANTS PERSONNEL
  - SCHEDULERS
    - INITIALIZE SYSTEM AND PROVIDE CHOICE OF OPERATIONS
  - DISPLAY DRIVER PROGRAMS
  - SEQUENCES
    - STANDBY
    - AUTO FILL
    - AUTO REPLENISH
    - AUTO DRAIN
    - STOP FLOW/REVERT
    - COMPONENT FUNCTIONAL
    - MISC
  - COMPONENT PROGRAMS
  - TASK PROGRAMS

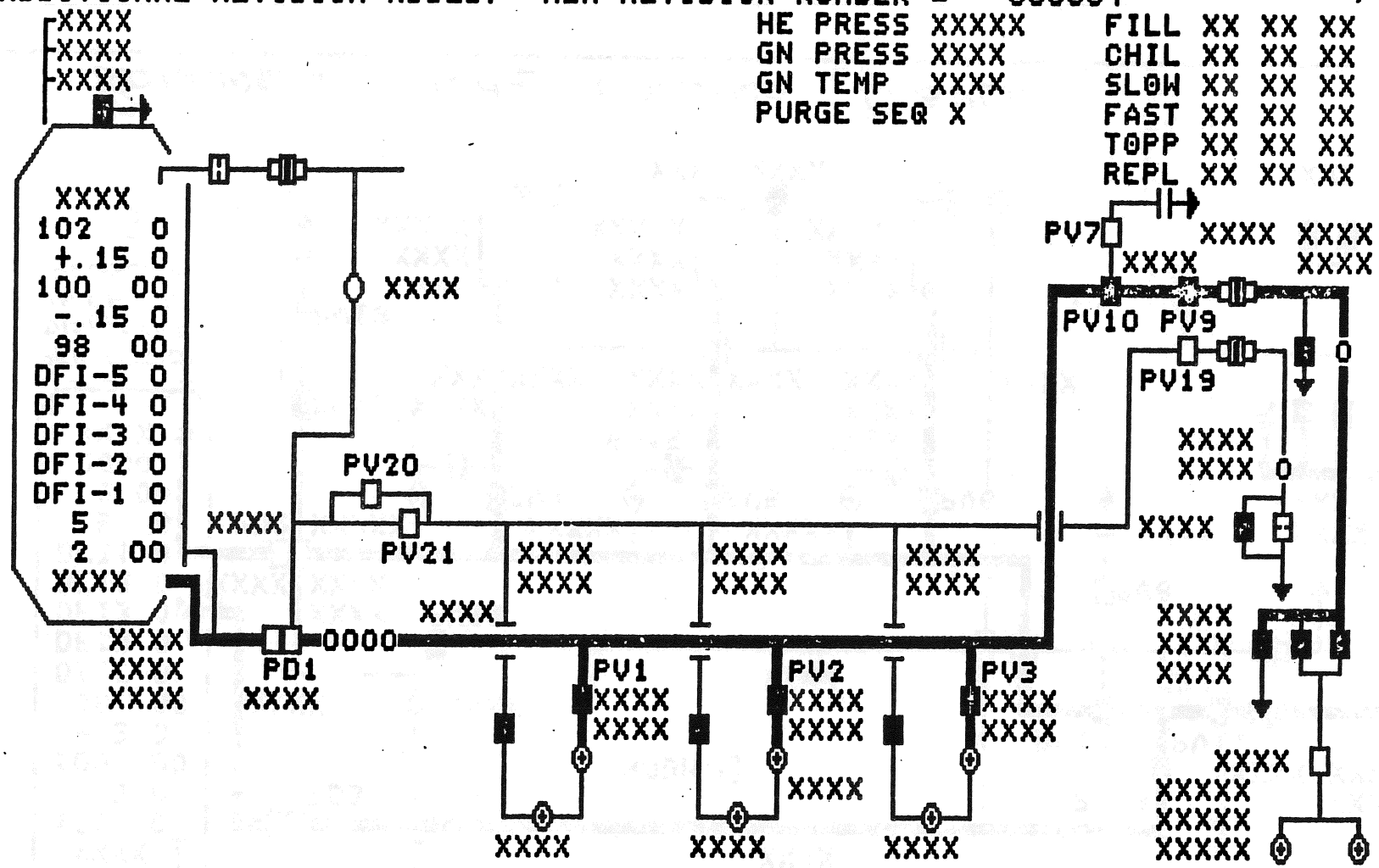
LO2/LH2 PROPELLANT LOADING (CONT'D)

- o CONTROL LOGIC
- o INTERRUPT PROGRAMS

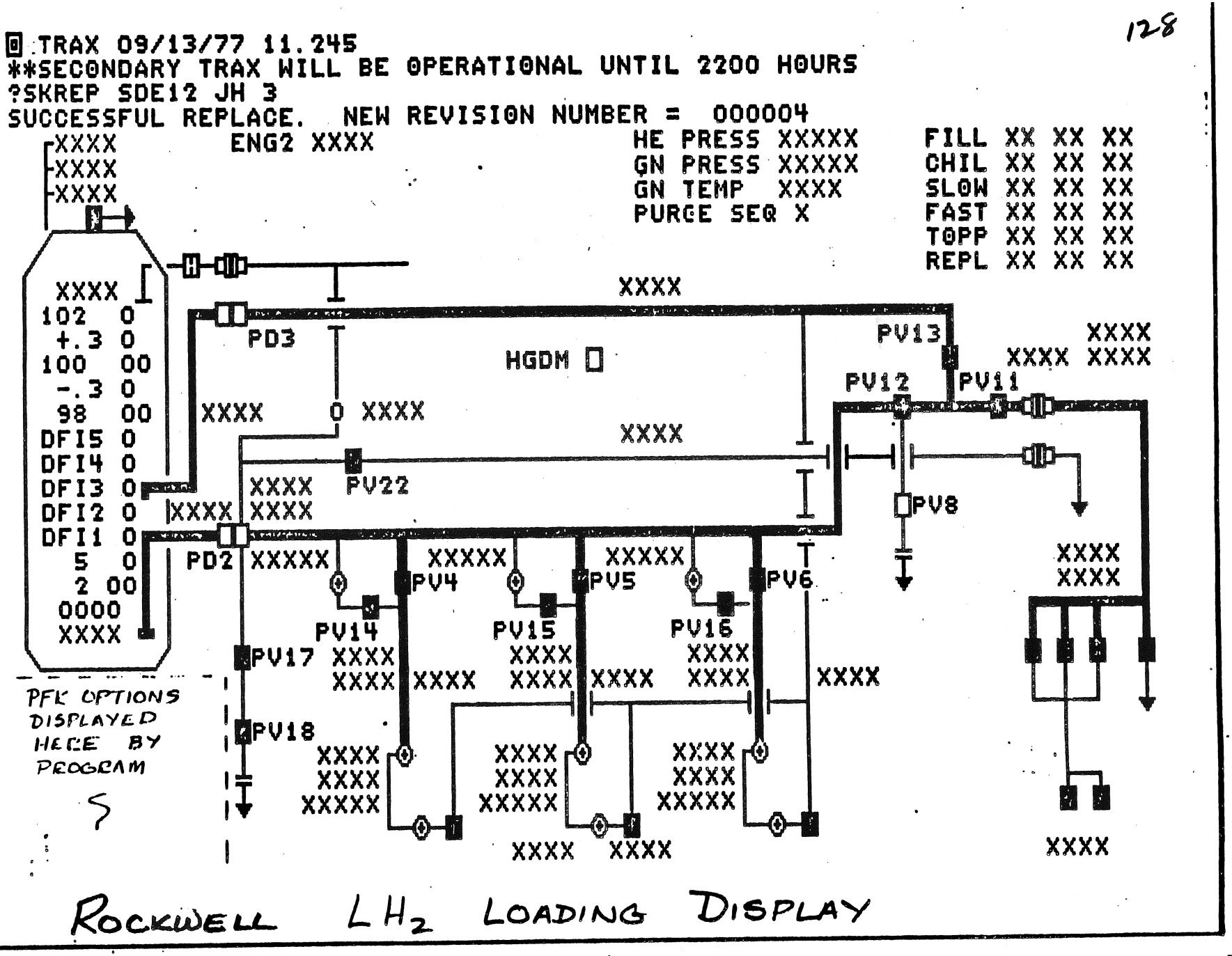
0 MPS PROPELLANT LOADING SUPPORT PERFORMED BY

- o VAE38 SSME CONTROL AND MONITOR
- o SAE02 MPS LO2 CONTROL AND MONITOR
- o SAE12 MPS LH2 CONTROL AND MONITOR
- o VAE18 MPS GHe CONTROL AND MONITOR

```
TRAX 09/13/77 10.926
**SECONDARY TRAX WILL BE OPERATIONAL UNTIL 2200 HOURS
?SKADD SDE02 LS
ADDITIONAL REVISION ADDED.  NEW REVISION NUMBER =   000004
```

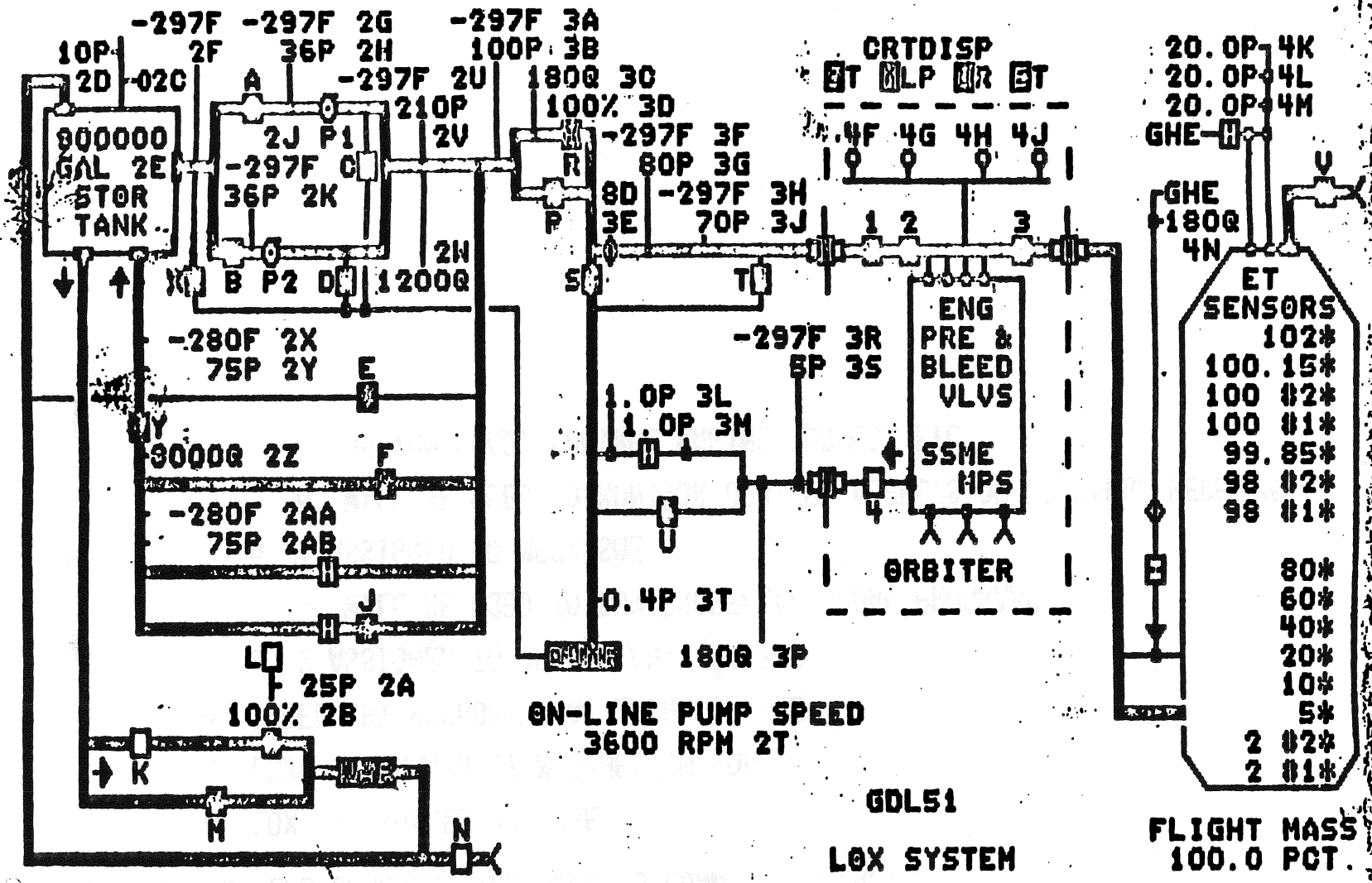


ROCKWELL LOX LOADING DISPLAY



ROCKWELL LH_2 LOADING DISPLAY

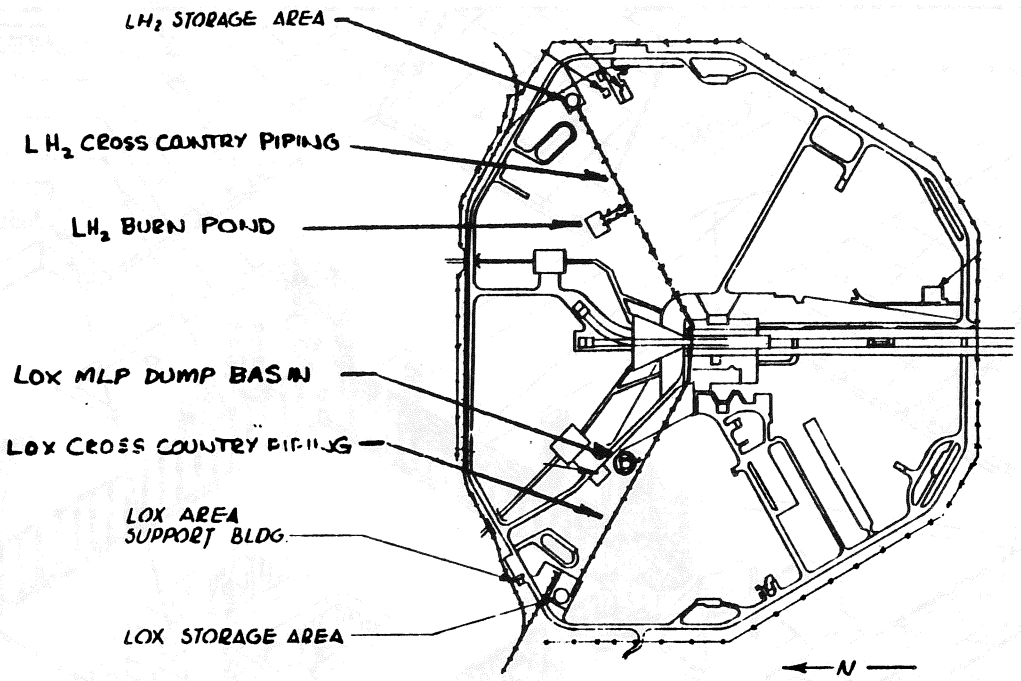
TRAX 01/30/78 [illegible]/072 SECONDARY
TRAX WILL BE OPERATIONAL TILL 2400 HRS.
?SKDSKL GDL51



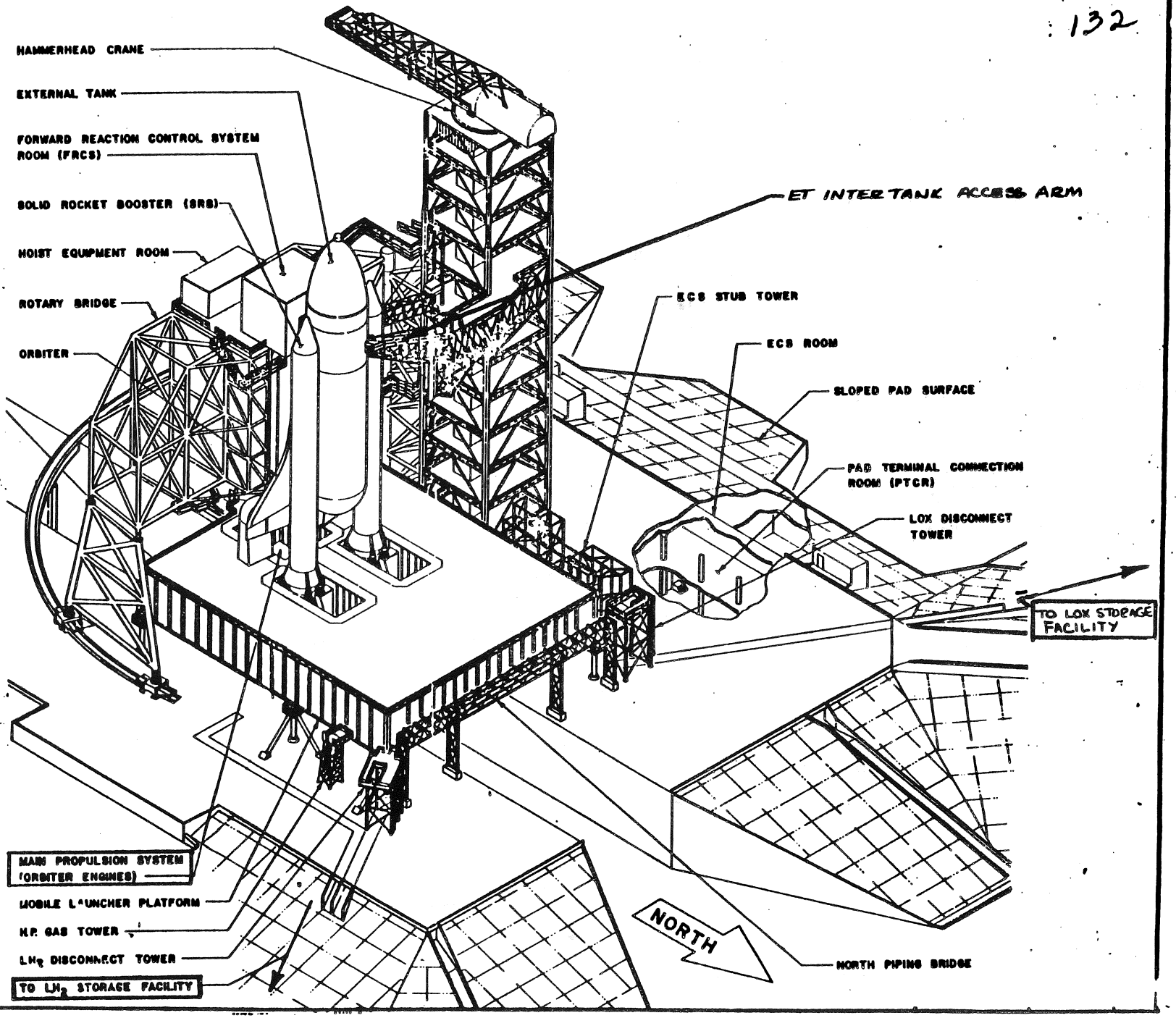
LOX PROPELLANT LOADING OVERVIEW
(DE PRODUCED — MMC OPERATED)

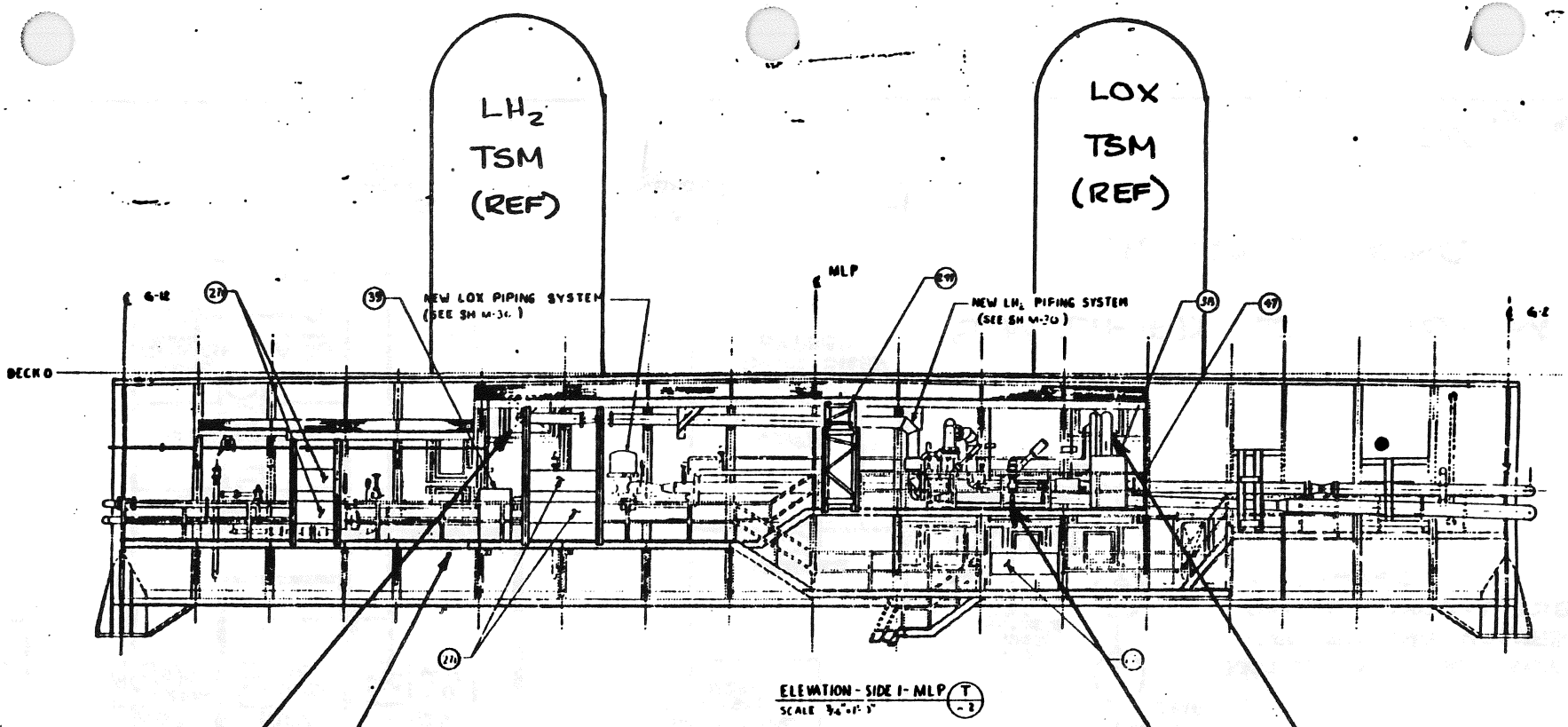
PROPELLANT LOADING OPERATIONAL PHILOSOPHY

- TWO LPS CONSOLES ARE USED TO LOAD PROPELLANTS
  - LOX - SHARED BY SSME
  - LH2 - SHARED BY MPS/HELIUM LOAD
  - THREE CRT/KEYBOARDS AT EACH CONSOLE
    - 2 ASSIGNED TO PROPELLANT LOADING
      - WILL BE USED TO RUN PROPELLANT LOAD PROGRAMS
    - 1 ASSIGNED TO MPS/SSME
      - WILL BE USED TO MONITOR ORBITER ASPECTS OF LOADING, PERFORM HELIUM LOAD, CONTROL ENGINE PURGES, ETC.



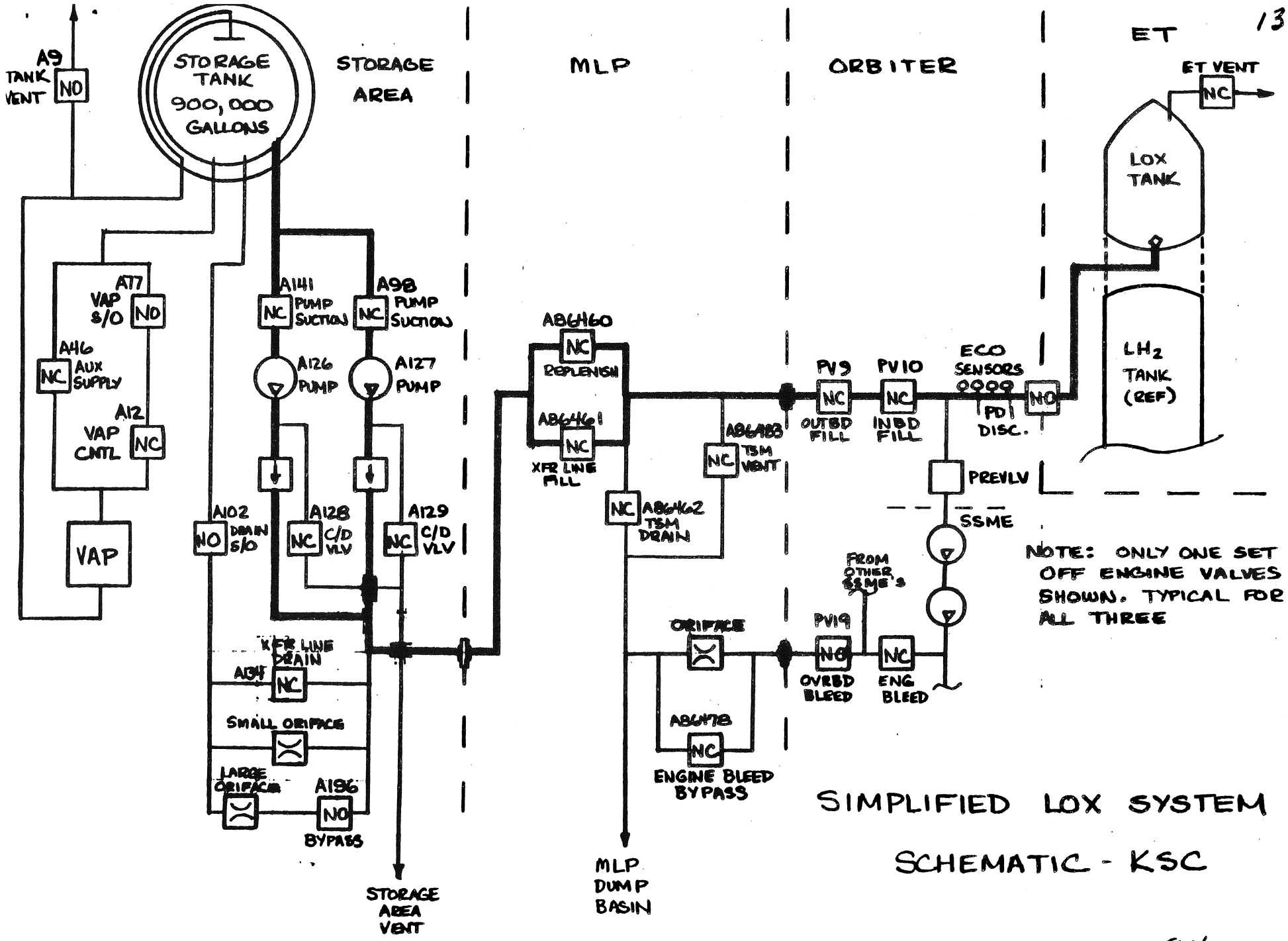
LAUNCH PAD 39A PROPELLANT SYSTEMS LOCATION PLAN


HAMMERHEAD CRANE
EXTERNAL TANK
FORWARD REACTION CONTROL SYSTEM ROOM (FRCS)
SOLID ROCKET BOOSTER (SRB)
HOIST EQUIPMENT ROOM
ROTARY BRIDGE
ORBITER
ET INTERTANK ACCESS ARM
ECS STUB TOWER
ECS ROOM
SLOPED PAD SURFACE
PAD TERMINAL CONNECTION ROOM (PTCR)
LOX DISCONNECT TOWER
TO LOX STORAGE FACILITY
MAIN PROPULSION SYSTEM (ORBITER ENGINES)
MOBILE LAUNCHER PLATFORM
H.P. GAS TOWER
LH2 DISCONNECT TOWER
TO LH2 STORAGE FACILITY
NORTH
NORTH PIPING BRIDGE



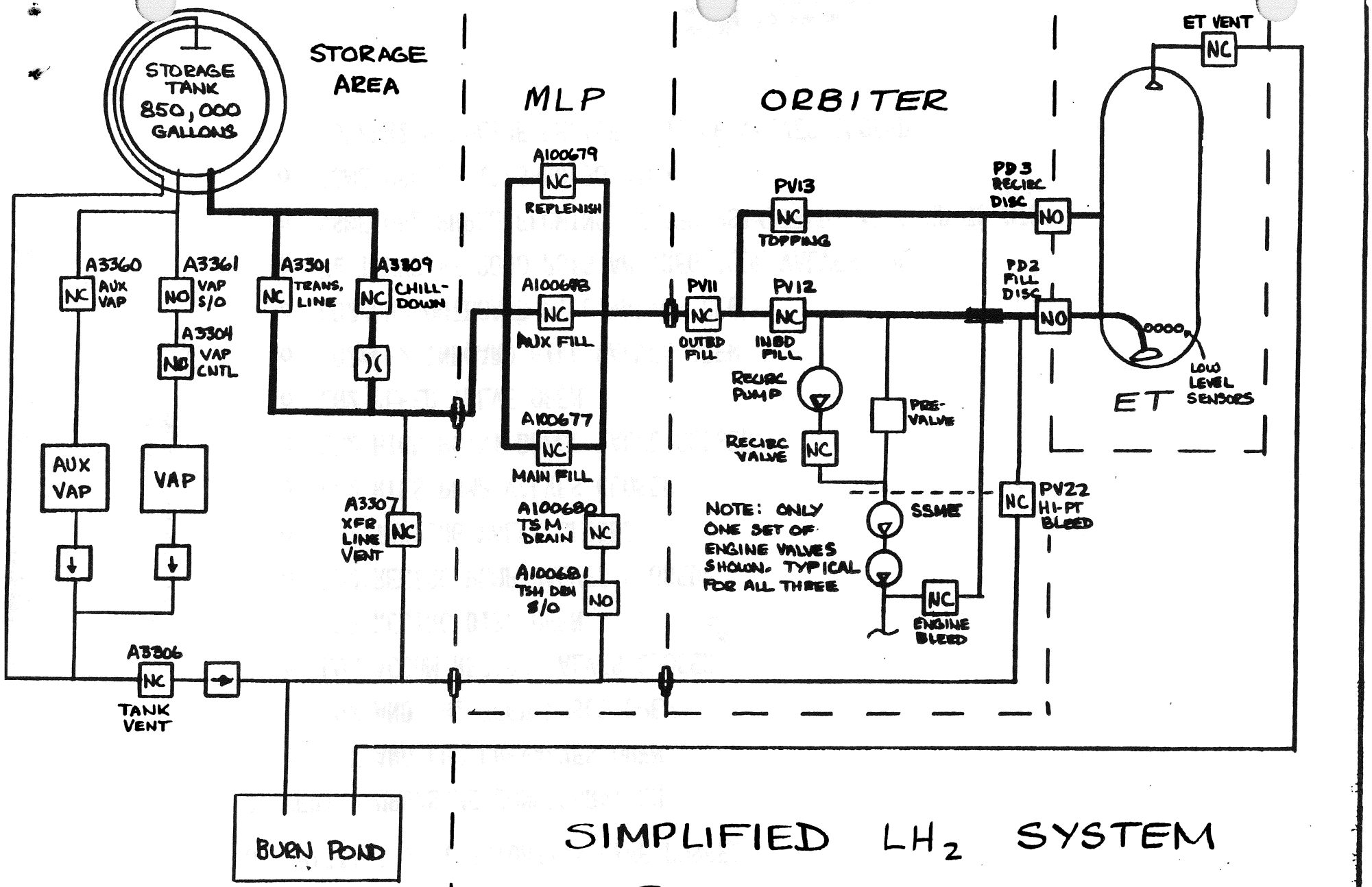
SIDE 1 — MLP

PROPELLANT VALVE COMPLEX



NOTE: ONLY ONE SET OFF ENGINE VALVES SHOWN. TYPICAL FOR ALL THREE

SIMPLIFIED LOX SYSTEM SCHEMATIC - KSC



SIMPLIFIED LH_2 SYSTEM SCHEMATIC – KSC

85 WAH 4/78

LOX LOADING

- INITIATE VENT ACTUATION LINE PURGES
- VERIFY MPS/SSME CONFIGURATION
  - LOX AND LH2 PREVALVES OPEN
  - LOX AND LH2 FEED DISCS OPEN
  - LOX ACCUM RECIRC VALVES CLOSED
  - LH2 RECIRC DISC OPEN
  - LH2 RECIRC PUMP VALVES CLOSED
  - LH2 TOPPING VALVE CLOSED
  - LH2 RTLS DUMP VALVES CLOSED
  - LH2 HIGH POINT BLEED VALVE CLOSED
  - LH2 BLEED VALVE OPEN
  - LO2/LH2 INBOARD FILL VALVES OPEN
  - LO2/LH2 OUTBOARD FILL VALVES CLOSED
  - He TANKS AT 2000 PSIG AND REG ISOL VALVES OPEN
  - SSME GN2 PURGE FLOWING AT 650 PSI/130°F. (T-6 HR 30 MIN)
  - SSME PSN 3 (T-6 HR 30 MIN)
  - LOX/LH2 FEEDLINE RELIEF SHUTOFF VALVES CLOSED

LOX LOADING (CONT'D)

- VERIFY MIDBODY/PAYLOAD BAY/AFT/ET INTERTANK O2 AND H2 CONCENTRATIONS (O2 <10000 PPM, H2 <200 PPM)

- VERIFY INSTRUMENTATION OPERATIONAL

- VERIFY PURGES
  - ET/ORB DISC PURGES
  - CARRIER PLATE PURGES
  - NOSE CONE HEATED PURGE
  - LOX/LH2 ANTI-ICING PURGES
- LO2 MANUAL PUMP/SUCTION LINE CHILLDOWN
- LO2 ORB/ET CHILLDOWN (T-6 HR PER S1003)
  - TSM DRAIN, TSM VENT OPEN
  - MAIN FILL, REPLENISH OPEN
  - 1000 RPM FOR 2 MIN
  - INCREASE PUMP TO 2850 RPM
  - PUMP CHILLDOWN VALVE CLOSED

LOX PROPELLANT LOADING (CONT'D)

- o AFTER 2 MIN, CLOSE TSM DRAIN, MAIN FILL
- o REPLENISH VALVE TO 70%
- o MONITOR FOR ORBITER INLET 34 PSIG OR SKID OUTLET 56 PSIG
- o CLOSE REPLENISH VALVE
- o DRAIN BACK THROUGH TSM DRAIN VALVE AND SSME BLEED UNTIL ORB INLET 10 PSIG OR 12 MINUTES
- o OPEN REPLENISH VALVE, MAIN FILL, TSM DRAIN AND FLOW FOR 3 MINUTES
- o CLOSE TSM DRAIN AND MAIN FILL
- o WHEN ORBITER INLET 10 PSIG CLOSE TSM VENT

0 LO2 SLOW FILL TO 2 PCT

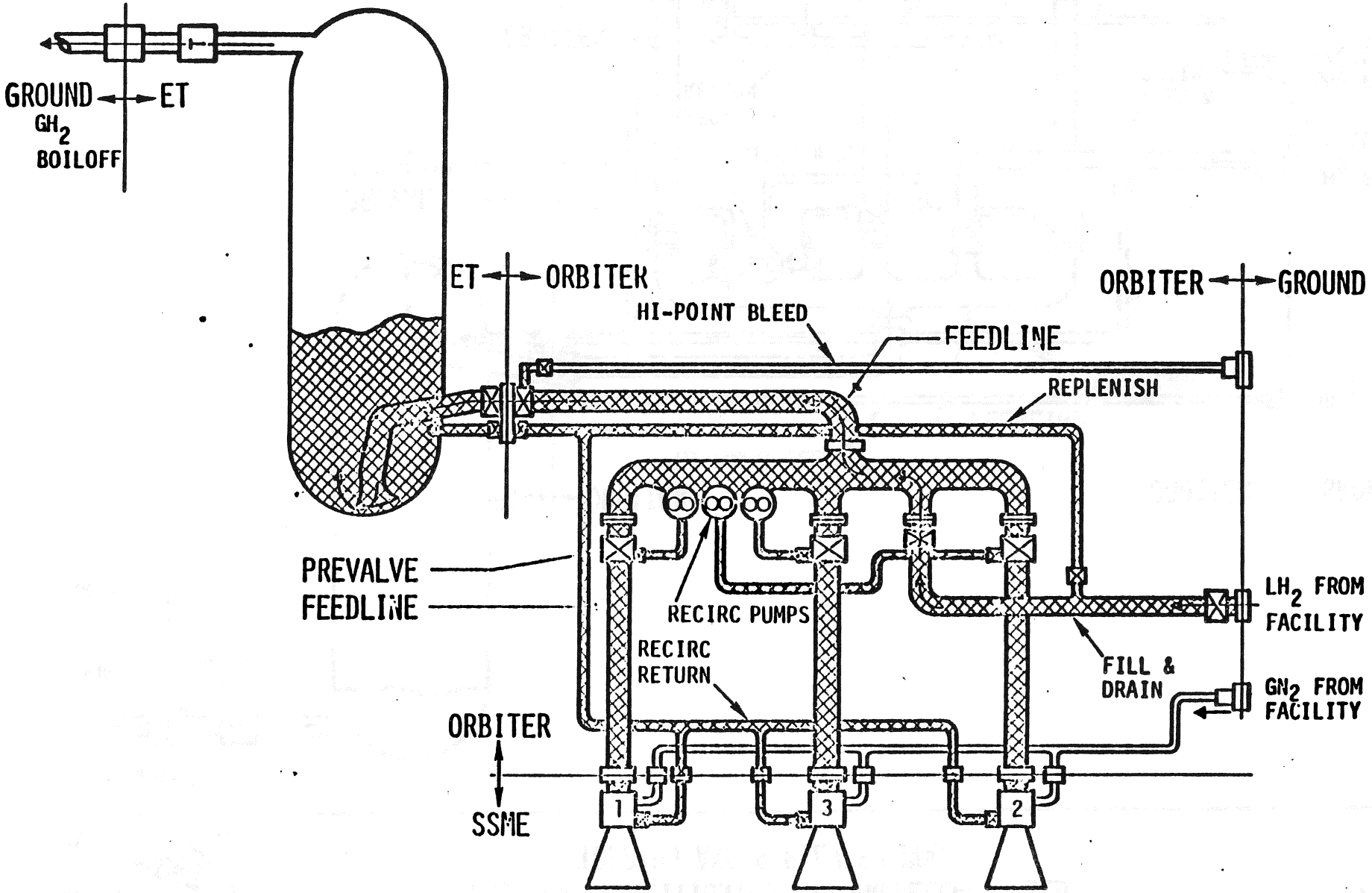
LO2 LOADING (CONT'D)

- LOX FAST FILL TO 98 PCT
  - AT 2 PCT, OPEN MAIN FILL
  - INCREASE PUMP TO 3450 RPM
  - TURN OFF SSME GN2 HTR 30 MIN AFTER START FAST FILL
  - MONITOR 98 PCT
- LOX TOPPING TO 100 PCT
  - CHANGE PUMP SPEED TO 3100 RPM
  - CLOSE MAIN FILL, OPEN REPLENISH VALVE
  - PERFORM MPS PV19 CYCLE TEST
  - MONITOR 100 PCT
- LOX REPLENISH
  - REDUCE PUMP SPEED TO 2850 RPM
  - THROTTLE REPLENISH VALVE

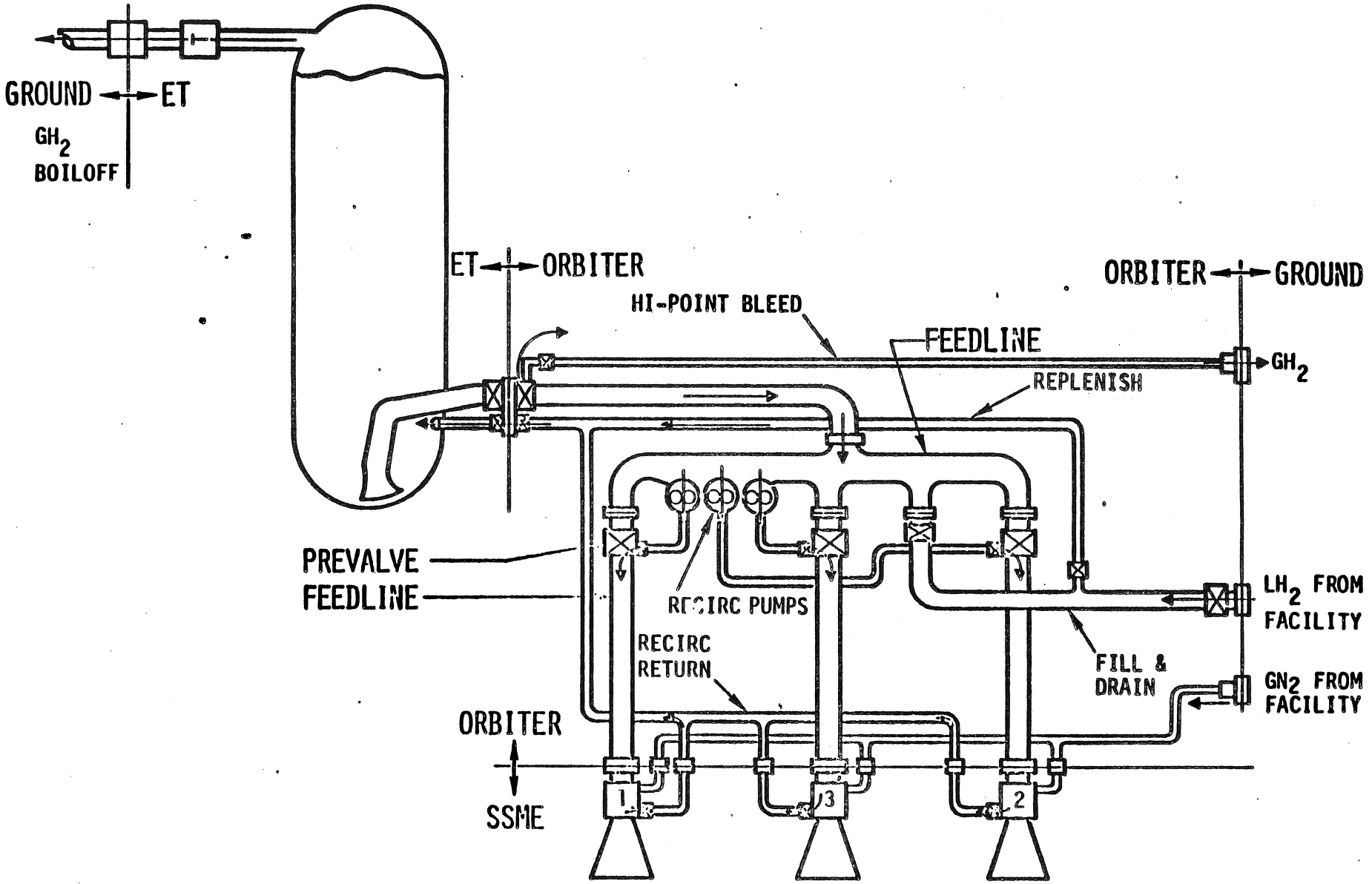
LOX LOADING (CONT'D)

- TERMINAL COUNT (T-4 MIN 55 SEC - VARIABLE)
  - CLOSE REPLENISH VALVE
  - CLOSE PV10 (INBD FILL VALVE)
  - OPEN TSP VENT, TSM DRAIN
  - TURN OFF H_E BUBBLING
  - START LO_2 ET PREPRESS (T-2 MIN 35 SEC)
  - CLOSE PV9 (OUTBD FILL) (T-45 SEC)
  - OPEN PV20/21 (LOX RECIRC VALVES) (T-12 SEC)
  - CLOSE PV19 (LOX BLEED) (T-95 SEC)

LH_2 FILL AND DRAIN
PRESTART CONDITIONING AND PROPELLANT FEED CHILLDOWN, SLOW FILL, AND FAST FILL MODE



LH_2 FILL AND DRAIN
PRESTART CONDITIONING AND PROPELLANT FEED
TOPPING AND REPLENISH MODE



LH2 PROPELLANT LOADING

- PRECHILLDOWN
  - PURGES
    - ET/IT PURGE
    - UMB CARRIER
    - TSM TUNNEL
    - ET VENT DISC
    - TSM EMERG PURGE
- FACILITY/ORBITER CHILLDOWN
  - CLOSE STORAGE TANK VENT
  - OPEN TSM DRAIN, TRANSFER LINE DRAIN FOR 1 MIN TO VENT BLANKET PRESS, THEN CLOSE
  - OPEN PV11, 12 LH2 FILL VALVES
  - OPEN ET LH2 VENT FOR 1 MIN 45 SEC
  - OPEN MAIN FILL, CHILLDOWN, TRANSFER LINE VALVE
    - 4 MINUTE CHILLDOWN
- SLOW FILL TO 2 PCT (percent = PCT)
  - CLOSE TRANSFER LINE VALVE

LH2 PROPELLANT LOADING (CONT'D)

- o ENABLE MAIN VAPORIZER
- o PRESSURIZE STORAGE TANK TO 66 PSIG
- o CLOSE CHILLDOWN VALVE
- o PRESSURIZE ET TO 43.7 PSIA
- o OPEN CHILLDOWN VALVE
- o TURN ON LH2 PREPRESS ANTI-ICE PURGE
- o WHEN ECO SENSORS ARE WET, OPEN PV22 (HIGH PT BLEED)
- o FLOW 5 MINUTES AFTER ECO SENSORS WET

0 FAST FILL TO 98 PCT

- o OPEN TRANSFER LINE VALVE
- o OPEN PV13 (TOPPING VALVE)
- o START LH2 RECIRCULATION 25 MINUTES AFTER START FAST FILL
- o TURN ON MFV HEATERS
- o 33 MINUTES AFTER START FAST FILL, REDUCE STORAGE TANK PRESSURE TO 50-55 PSIG (APPROX. 72 PCT)

LH2 PROPELLANT LOADING (CONT'D)

- o 40 MINUTES AFTER START FAST FILL (85%) LOWER FLOW RATE
  - o OPEN REPL VALVE
  - o MAIN FILL TO REDUCED POSITION
  - o CLOSE PV12 (INBOARD FILL VALVE)

0 TOPPING (98 PCT)
- o VENT ET LH2 TANK TO 1.2 PSIG
- o CLOSE MAIN FILL VALVE

0 REPLENISH
- o THROTTLE REPLENISH VALVE TO MAINTAIN 100 PCT
- o PERFORM LH2/LO2 LIQUID LEVEL SENSOR TEST

0 TERMINAL COUNT
- o 1 MIN 57 SEC CLOSE REPLENISH VALVE
- o CLOSE PV13 TOPPING VALVE
- o OPEN TSM DRAIN
- o CLOSE ET VENT VALVE
- o INITIATE DRAIN ASSIST PURGE

LH2 PROPELLANT LOADING (CONT'D)

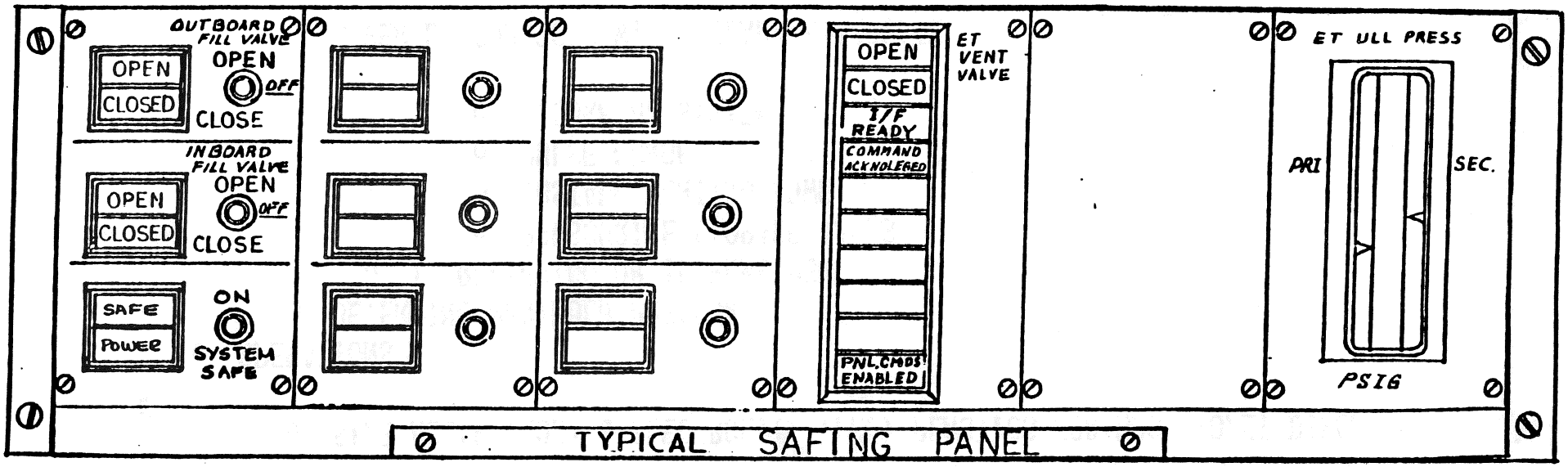
- CLOSE PV11 (OUTBD FILL VALVE) T-45 SEC
- TERMINATE RECIRC PUMPS T-125 SEC
- CLOSE HIGH POINT BLEED VALVE T-10 SEC
- OPEN PREVALVES T-9 SEC

- PROPELLANT LOADING MAY BE TERMINATED AT ANY TIME
  - AUTOMATICALLY -- IF SOFTWARE DETECTS MALFUNCTION
  - MANUALLY -- AT OPERATOR'S DISCRETION
  - TWO DISTINCT SEQUENCES -- STOP FLOW OR REVERT
  - LOX AND LH_2 ARE COMPLETELY SEPARATE
    - LOX REVERT DOES NOT IMPACT LH_2
      VICE-VERSA
- STOP FLOW
  - PREPROGRAMMED, LPS CONTROLLED ACTION
  - TERMINATES FLOW ONLY
  - DOES NOT ISOLATE ORBITER FROM GSE
  - PLANNED TO ALLOW EASY RE-INITIATION OF FILL
- REVERT
  - PREPROGRAMMED, LPS CONTROLLED ACTION
  - TERMINATES FLOW AND ISOLATES ORBITER

- LOX REVERT SECURES LOX PUMPS ALSO
- MORE DIFFICULT AND TIME CONSUMING TO RE-INITIATE

- ONE OTHER "LAST RESORT" -- HARDWARE SAFING
  - DESIGNED TO BE USED IN EVENT OF LPS FAILURE
  - SINGLE SWITCH CAPABILITY FROM PANEL ON CONSOLE
  - TOTALLY DISCONNECTS ALL LPS COMMAND CAPABILITY TO SYSTEM
  - DRIVES SYSTEM TO PREDETERMINED "SAFE" CONFIGURATION
- EXACT DETAILS OF SEQUENCES CONTAINED IN CRITERIA DOCUMENTS

HARDWIRE SAFING PANEL



TYPICAL SAFING PANEL

HARDWIRE CONTROL TO "SAFE" PROPELLANT SYSTEMS AND PERFORM A MANUAL PROPELLANT DRAIN IN THE EVENT OF AN LPS FAILURE.

MPS-SSME OPERATIONS AT DFRF

- S0026 POST LANDING CONVOY OPERATIONS - DFRF
  - PREOPS
    - S70-1289-1 PANEL SETUP AND H_E DISCONNECT/FILTER ASSY
      - LOAD ON CONVOY VEHICLE
    - ASSEMBLE G070-005925-001 (LOX) & G070-005925-002 (LH2)
    - ASSEMBLE SSME PROTECTIVE CLOSURES (3) THROAT PLUGS
    - SIZE ACCAR (LO2) & ELECTROLITE (LH2) PLASTICS FOR MPS T-0/ET DISCS
  - OPERATIONS
    - DETERMINE MANIFOLD PRESSURES
      - IF RELIEVING OR INCREASING
        - PRESSURIZE STORAGE TANKS
        - INSTALL VENTING HDWE
        - PULSE PURGE
        - SECURE H_E SYSTEM
    - COVER DISCONNECTS WITH ACLAR/LECTROLITE
    - INSTALL SSME CLOSURES
      - OXIDIZER DRAIN LINE
      - MCC
      - DRAIN PLUGS

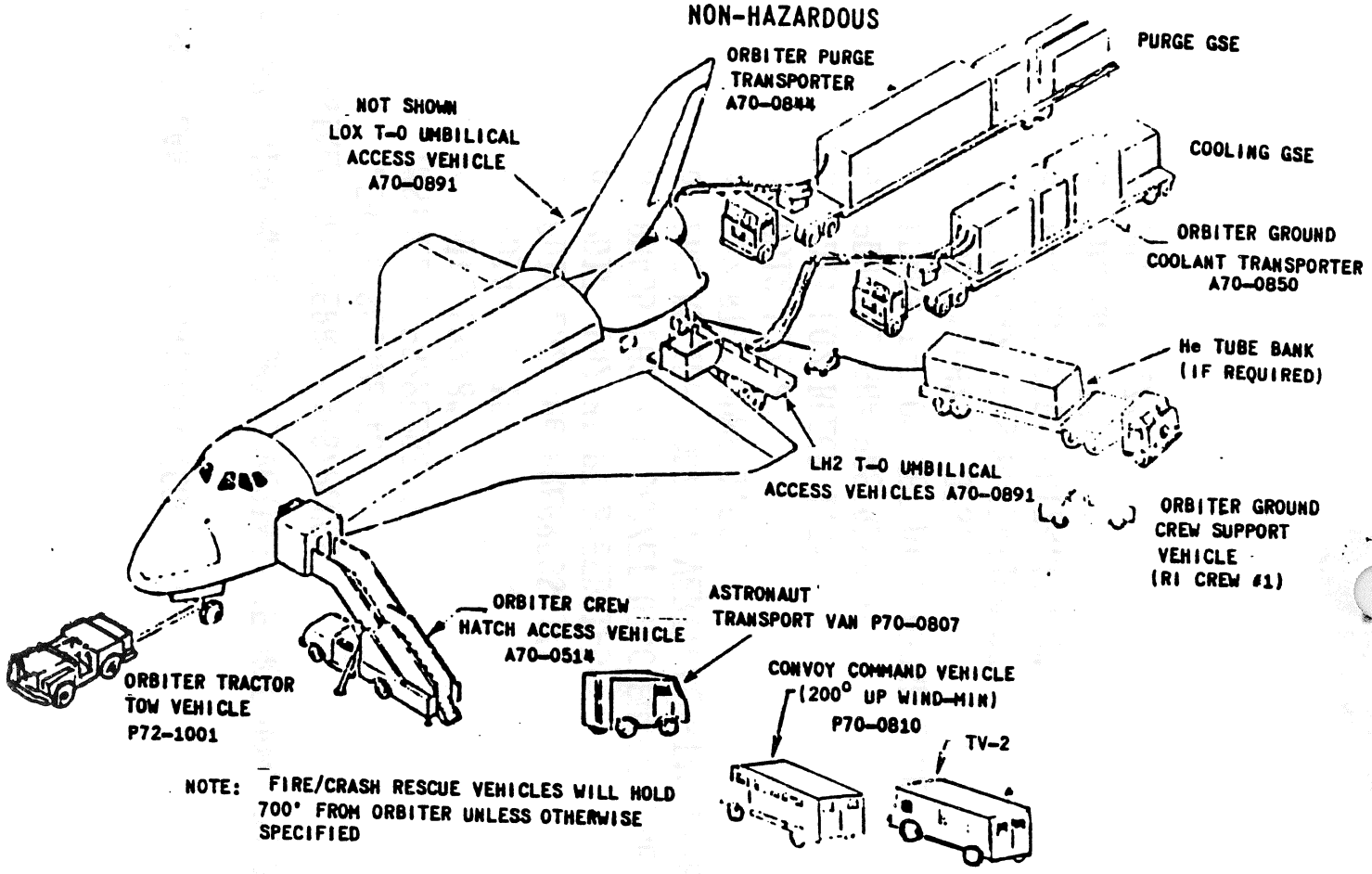


FIGURE 6 - CONVOY NON-SCAPE OPERATIONS (FOR REFERENCE ONLY)

V1038 MPS/SSME LANDING OPERATIONS (CONT'D)

- MPS DISCONNECT PORT COVERING (IF NOT DONE ON RUNWAY PER S0026)
- INSTALL MPS FERRY CAPS/PLUGS
  - CLEAN DISCONNECTS
  - INSTALL CAPS/PLUGS TO
    - PD11 LH2 8"
    - PD14 GN2 1"
    - PD10 LH2 GHe PREPRESS 1"
    - PD17 LH2 HI PT BLEED 1-5"
    - PD405 LH2 T-0 ORB/ET DISC PURGE LINE
    - LH2 RELIEF PORT AT VERTICAL STABILIZE
    - LH2 RTLS DUMP 1.0"
    - PD12 LO2 8"
    - PD13 LO2 BLEED 1.5"
    - PD9 LO2 GHe PREPRESS 1"
    - PD406 T-0 ORB/ET DISC PURGE LINE
    - PD3 4" LH2 ET DISC
    - PD5 GH2 PRESSURIZATION 2"
    - PD4 GO2 PRESSURIZATION 2"
    - PD2 LH2 17"
    - PD1 LO2 17"

V1038 MPS/SSME LANDING OPERATIONS

- PREOPS
  - S70-1247-1 GHe/GN2 SETUPS
  - TVC LOCK CLEANING/ASSY
  - KITTING OF PARTS REQUIRED (MPS AND SSME)
  - INSTRUCTIONS ON PREPARING SEPARATE MPS AND SSME BUY BOOKS

- OPERATIONS
  - MPS/SSME ENGINEERING WALKDOWN
    - DAMAGED INSULATION
    - DAMAGED VJ LINES
    - DAMAGED ELECTRICAL CONNECTIONS
    - DAMAGED FLEX HOSES, BELLOWS, GIMBALS
    - DAMAGED TUBING/PIPING
  - PRESSURIZE MPS HELIUM TANKS TO 2000 PSI (S70-1247-1)
  - PRESSURIZE MPS LOX & LH2 MAINFOLDS USING ON-BOARD HELIUM
  - SSME HPFTP BEARING PURGE WITHIN 24 HOURS
  - SSME FERRY FLIGHT SET INSTALLATION
    - SSME LEAK CHECKS
    - MPS DECAY CHECKS
  - SSME TVC FERRY LOCK INSTALLATION
    - SSME POSITIONED TO FERRY POSITION PER V9005

V1038 MPS/SSME LANDING OPERATIONS (CONT'D)

- COCKPIT SWITCH POSITIONING FOR FERRY (PRIOR TO SCA MATE)
  - ALL PNEU ISOL VALVES CLOSED
  - HE INTERCONNECTS - GPC
  - MANIFOLD PRESSURIZATION - GPC
  - FILL & DRAIN VALVES - GND
  - PREVALVES - GPC
  - FEEDLINE RELIEF ISOL VALVES - OPEN
- INSTALL SSME BELLOWS COVERS
- MPS LH2 & LO2 MANIFOLD PURGE & INERT (CONTINGENCY ONLY)
- MPS LH2 & LO2 MANIFOLD SAMPLING (CONTINGENCY ONLY)
- FINAL COCKPIT SWITCH SETUP FOR FERRY PER V5022 TO PROVIDE MPS MANIFOLD PRESSURIZATION DURING FERRY
  - PNEU HELIUM ISOL - OPEN
  - HELIUM INTERCONNECTS - OUT OPEN
  - LO2 & LH2 MANIFOLD PRESS - OPEN

SHUTTLE/CENTAUR OVERVIEW

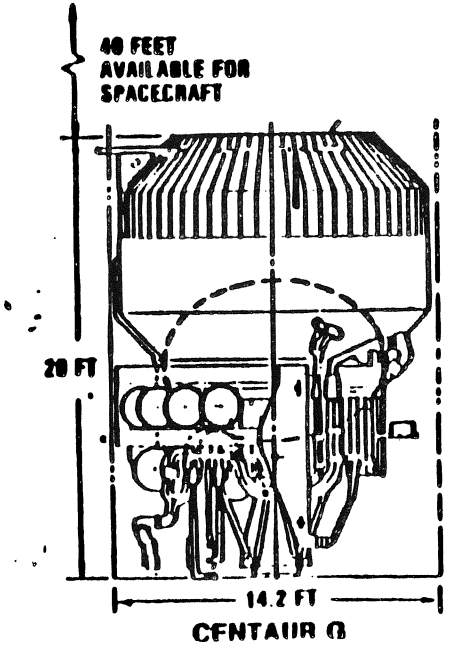
Rockwell International

PREPARED BY	TITLE	DATE
S. T. BLACK	SHUTTLE/CENTAUR PROJECT OVERVIEW	APRIL 1984

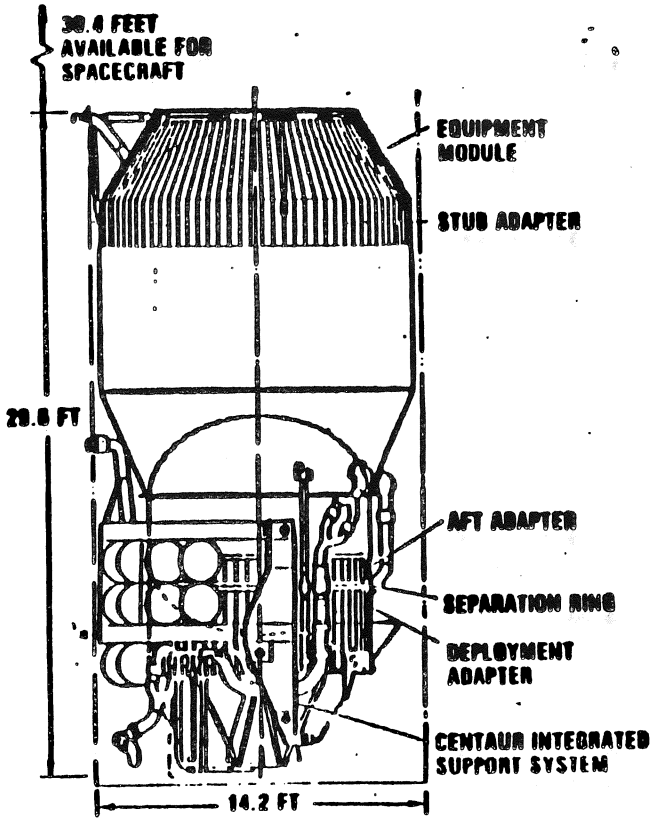
CENTAUR/RTG COOLING AND GN_2 PURGE (ORBITER REQUIREMENTS)
PRELIMINARY DESIGN REVIEWS (PDRs)

TECHNICAL OVERVIEW

- CENTAUR CONFIGURATIONS



CENTAUR G

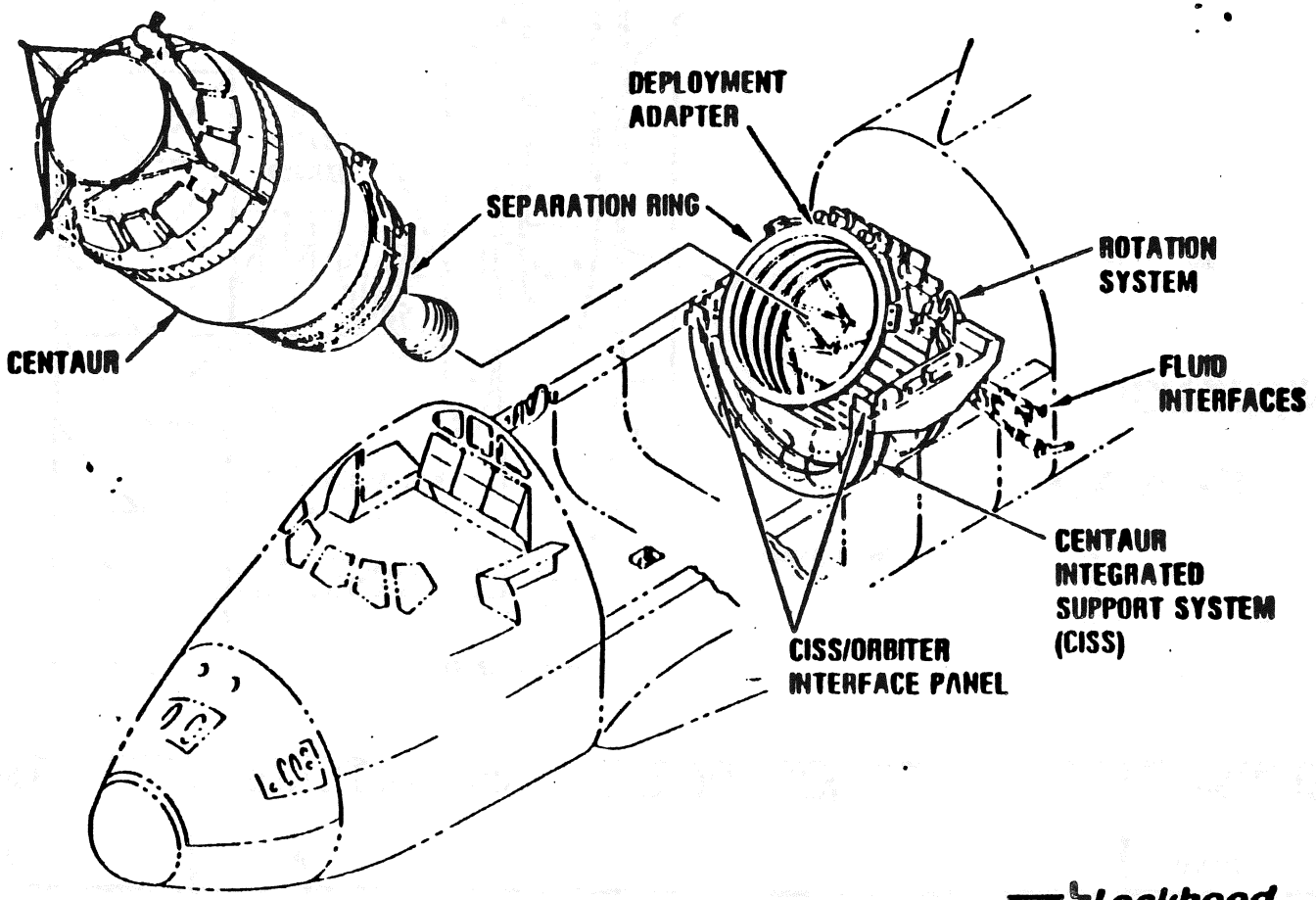


CENTAUR G-PRIME

Lockheed
Space Operations Company

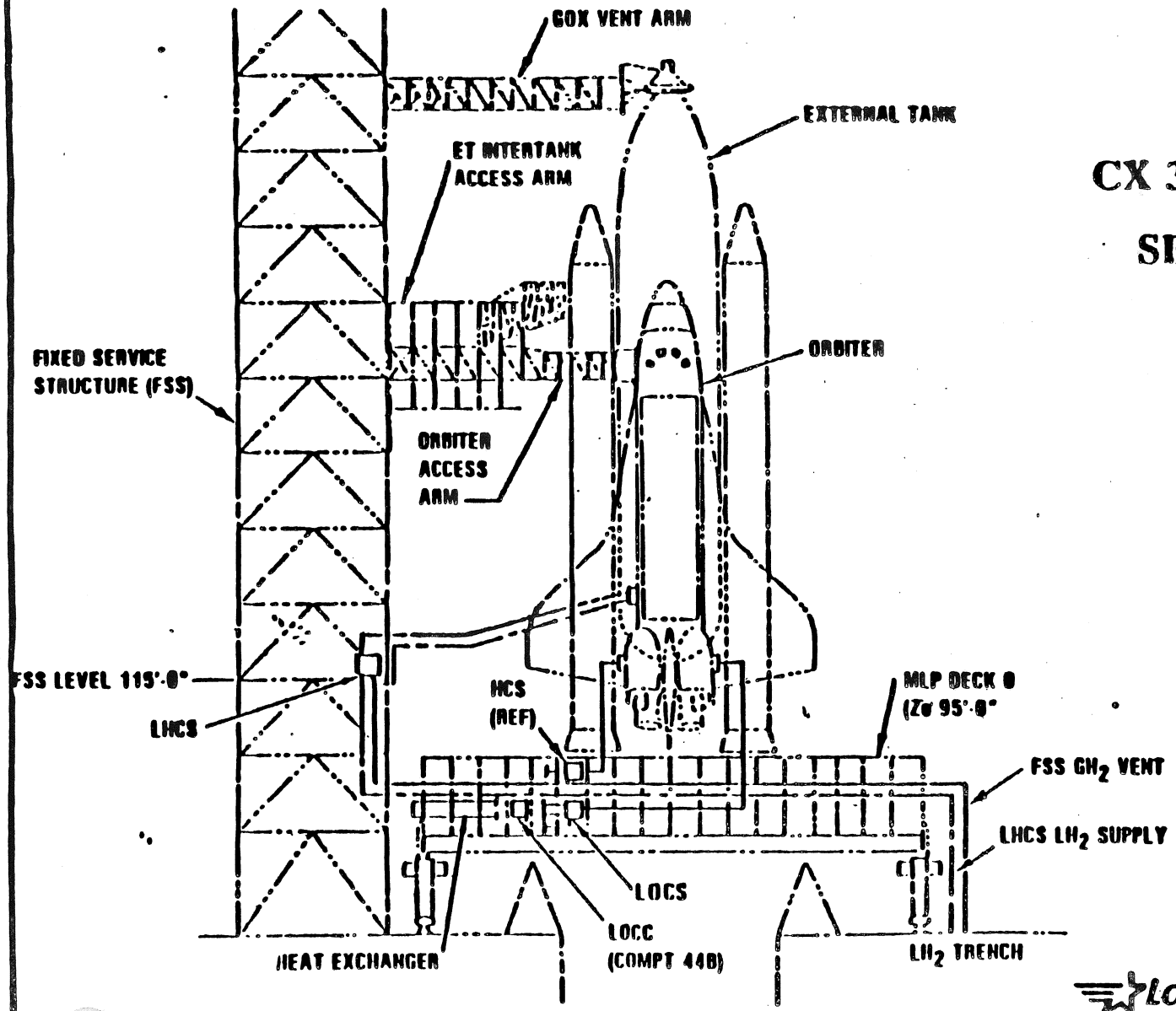
PREPARED BY	TITLE	DATE
S. T. BLACK	SHUTTLE/CENTAUR PROJECT OVERVIEW	APRIL 1984

CISS/CENTAUR/PAYLOAD COMBINATION IS CARRIED IN THE SHUTTLE CARGO BAY



Lockheed
Space Operations Company

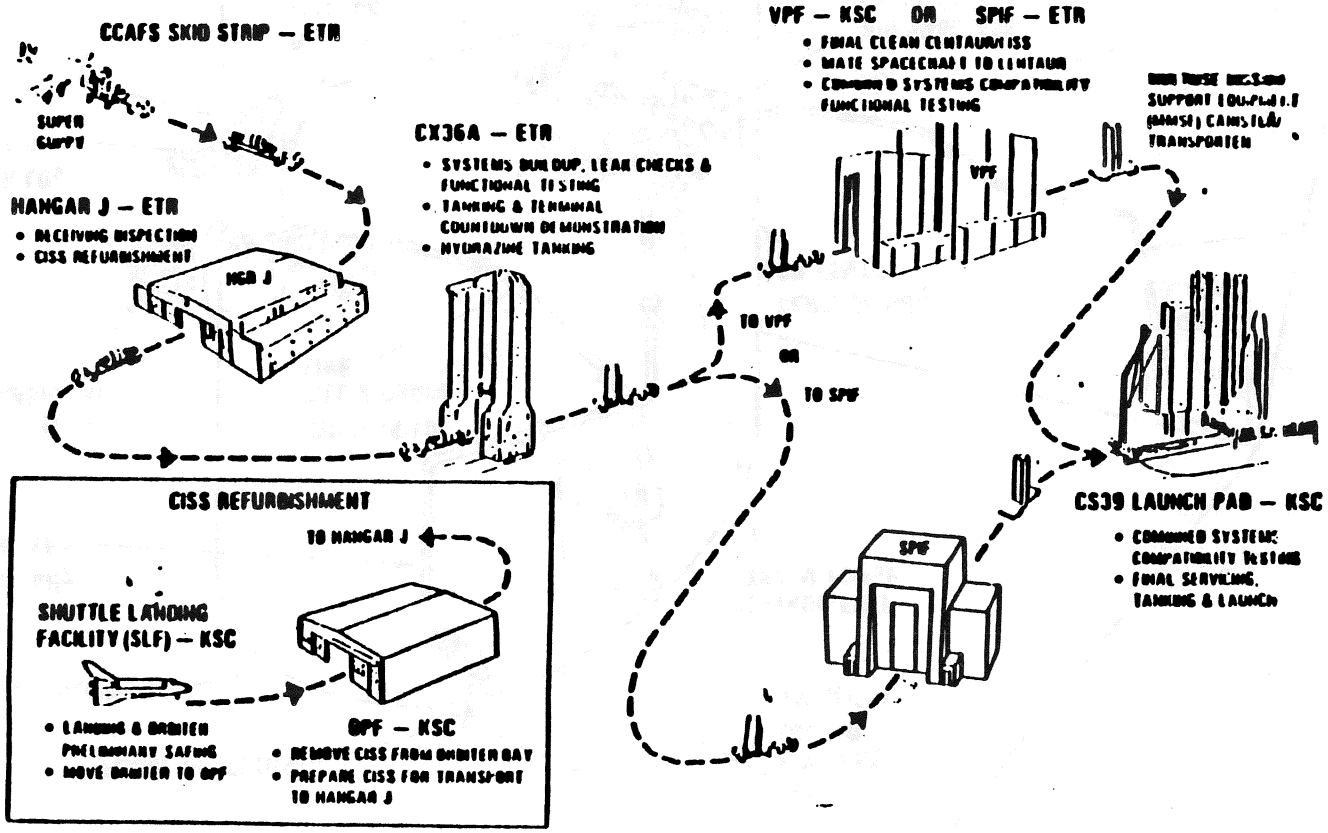
PREPARED BY	TITLE	DATE
S. T. BLACK	SHUTTLE/CENTAUR PROJECT OVERVIEW	APRIL 1984



CX 39 CENTAUR SERVICING

Lockheed Space Operations Company

PREPARED BY	TITLE	DATE
S. T. BLACK	SHUTTLE/CENTAUR PROJECT OVERVIEW	APRIL 1984



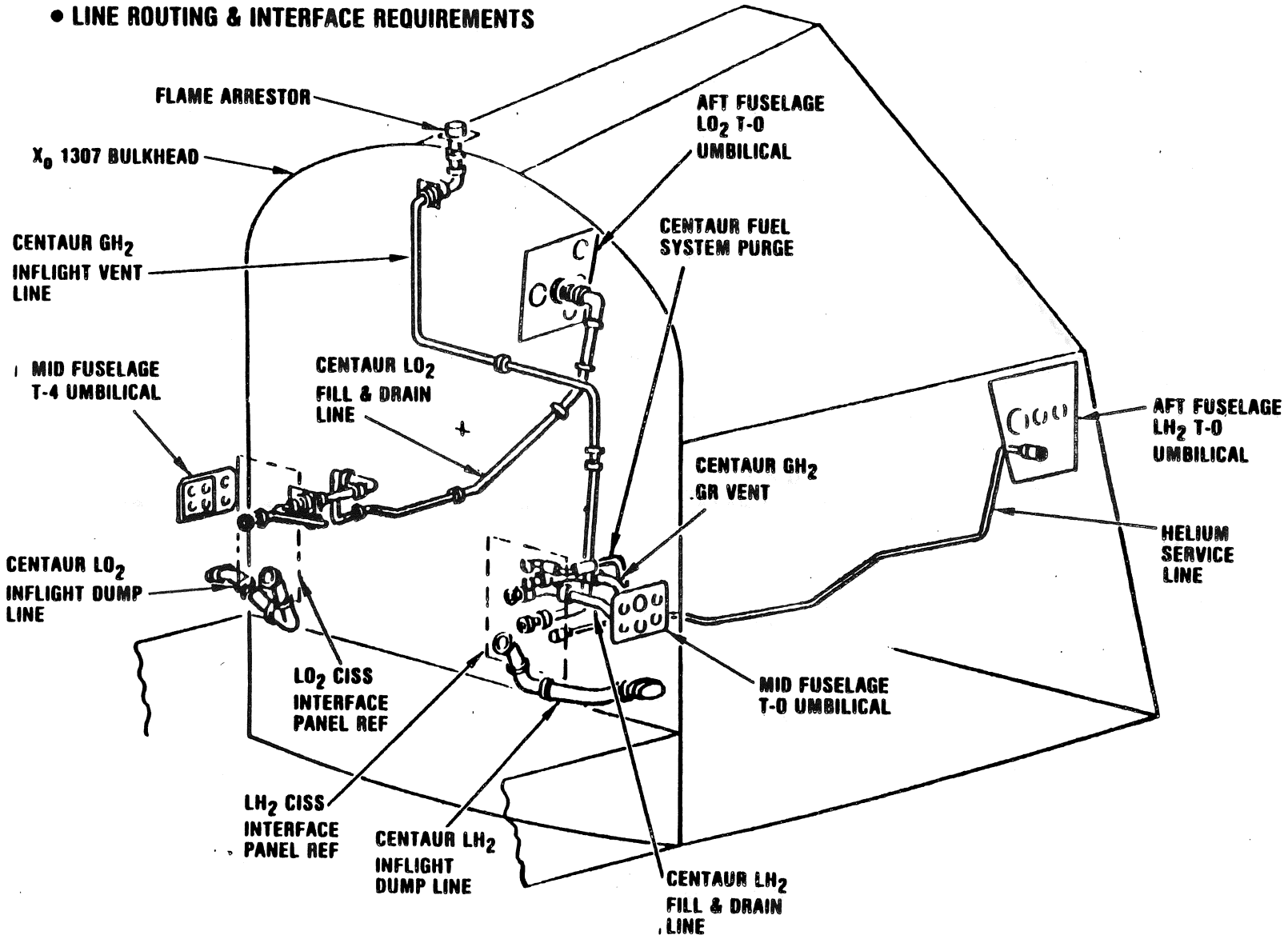
Shuttle/Centaur Launch Operations Flow

Lockheed
Space Operations Company

CENTAUR/RTG COOLING AND GN_2 PURGE CRITICAL DESIGN REVIEWS (CDRs)

MID FUSELAGE

- LINE ROUTING & INTERFACE REQUIREMENTS

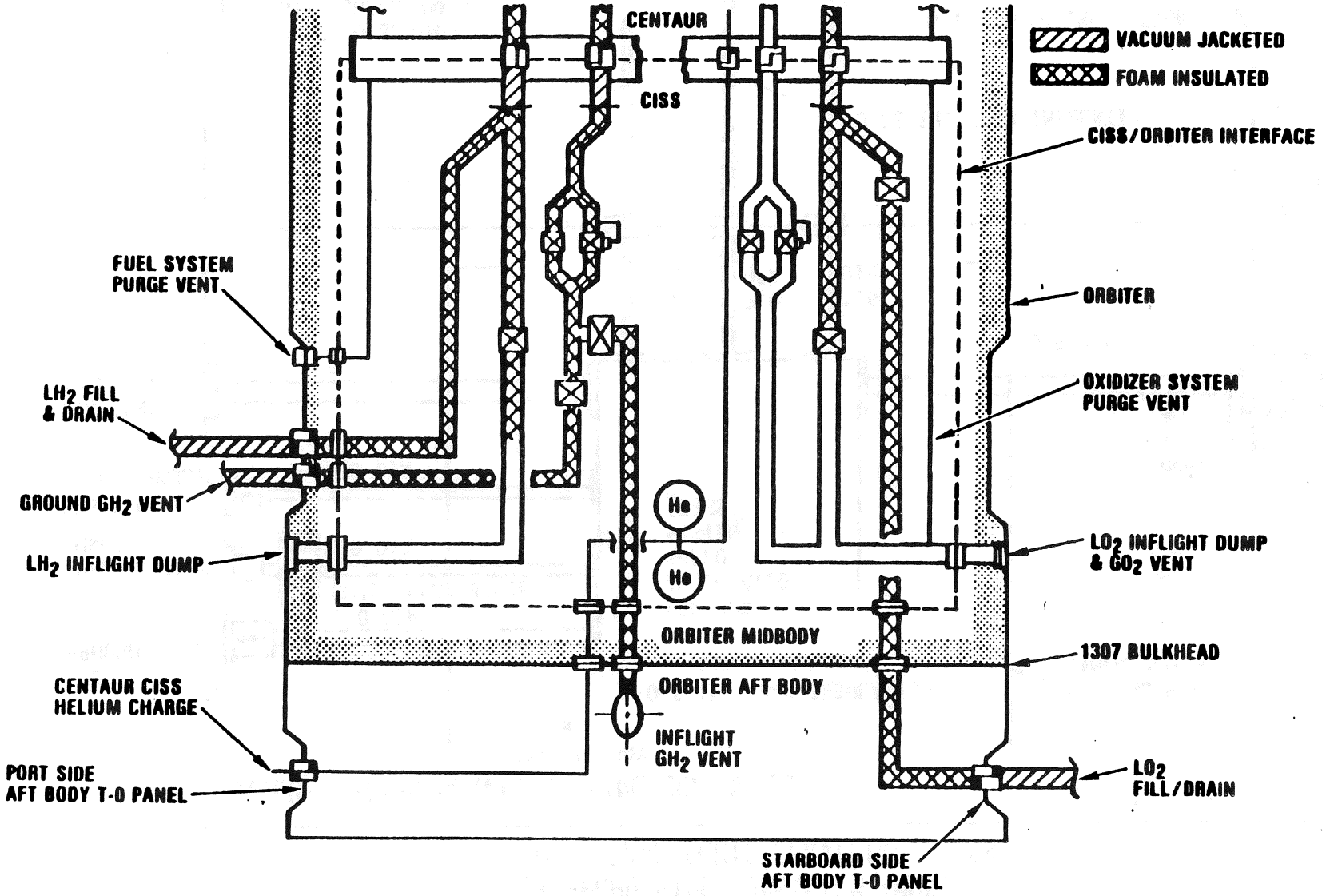


2 over ALSO

CENTAUR/RTG COOLING AND GN_2 PURGE CRITICAL DESIGN REVIEWS (CDRs)

MID FUSELAGE

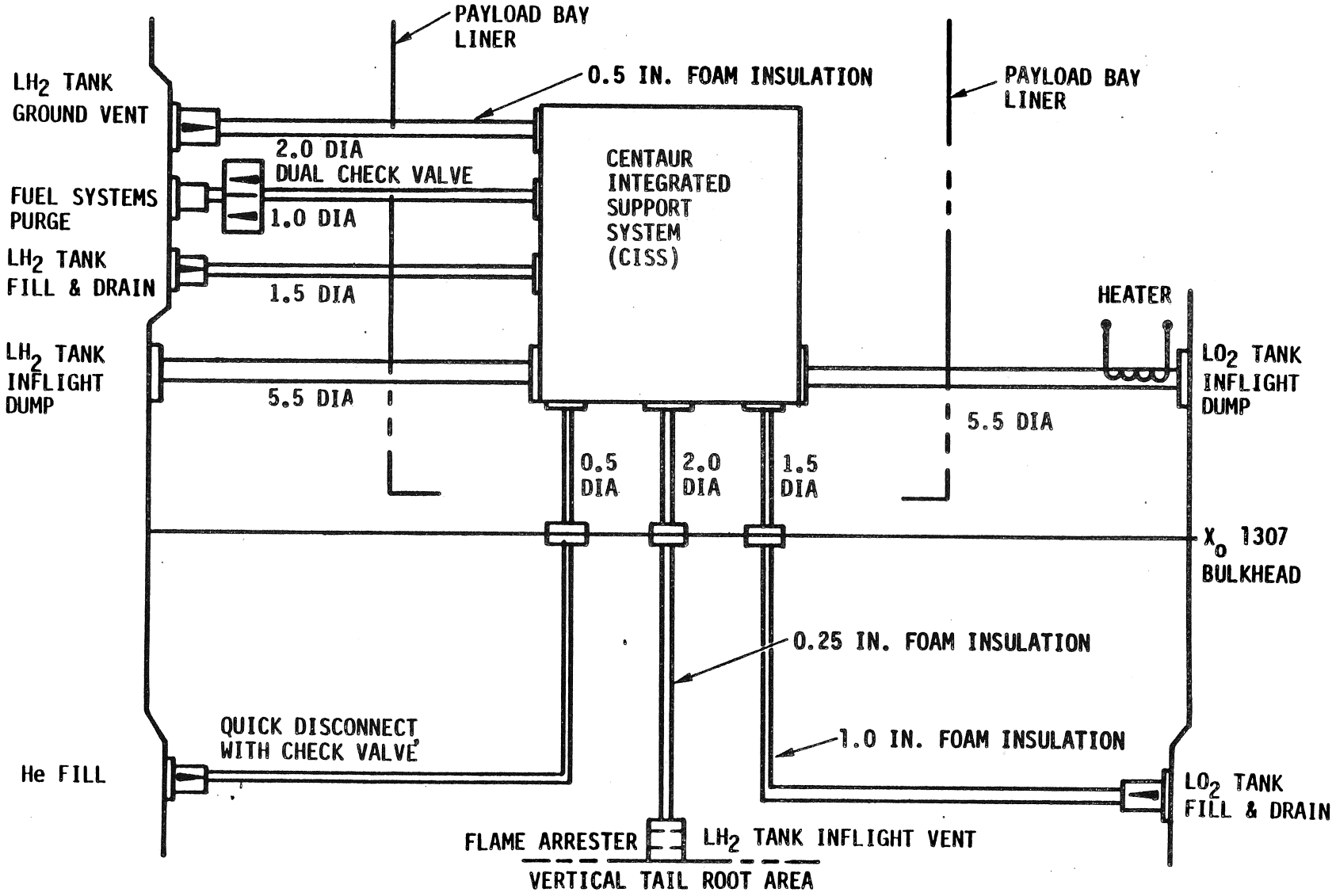
- FLUID INTERFACE REQUIREMENTS

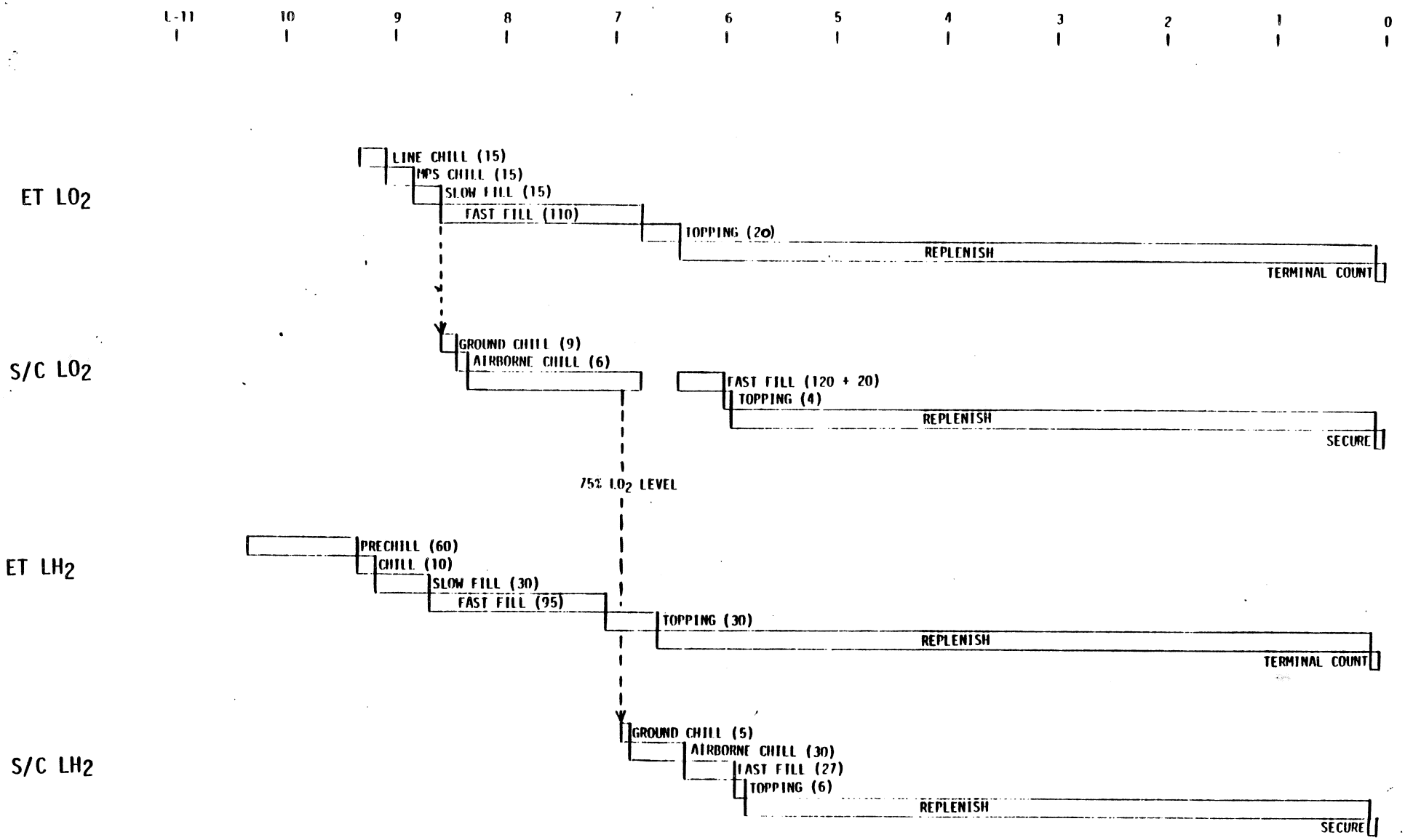


CENTAUR/RTG COOLING AND GN_2 PURGE CRITICAL DESIGN REVIEWS (CDRs)

MAIN PROPULSION SUBSYSTEM (MPS)
ORBITER/CENTAUR FLUID SERVICING LINES

- ORBITER/CENTAUR SERVICING LINE SCHEMATIC





G-PRIME TANKING TIMELINE