FAILURE MODES EFFECTS ANALYSIS (FMEA) – CRITICAL HARDWARE
NUMBER: 03-1-0408-X

SUBSYSTEM NAME: MAIN PROPULSION
REVISION: 1 5/11/94

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	DISCONNECT, LO2, 17 INCH	MC284-0389-0551 (ORB HALF)
LRU	DISCONNECT, LO2, 17 INCH	MC284-0389-0552 (ET HALF)

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
DISCONNECT, LO2 FEED, 17 INCH, ORBITER & ET HALF. (PD1)

QUANTITY OF LIKE ITEMS: 1
ONE

FUNCTION:
ET/ORBITER FEED LINE DISCONNECT PROVIDES LO2 PROPELLANT TO THE MPS AND A MEANS OF LOADING AND DETANKING THE ET. EACH DISCONNECT HALF CONTAINS A PNEUMATICALLY ACTUATED FLAPPER CLOSURE DEVICE WHICH REMAINS IN ITS LAST ACTUATED POSITION (BISTABLE). THE VALVES ARE CLOSED AFTER MECO TO PREVENT PROPULSIVE VENTING LEADING TO ET/ORBITER RECONTACT, TILE/DOOR DAMAGE DUE TO EXPOSURE TO PROPELLANTS, LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION (RTLS/TAL ABORT CRITICAL), AND SYSTEM CONTAMINATION DURING ENTRY. DURING UMBILICAL SEPARATION, THE VALVE SYSTEM IS DESIGNED TO MECHANICALLY CLOSE BOTH THE ORBITER AND ET DISCONNECT FLAPPERS IF UNABLE TO CLOSE THEM PNEUMATICALLY (POST MECO). REDUNDANT OPEN AND CLOSE (TWO EACH) VALVE POSITION SWITCHES ARE LOCATED ON THE ORBITER HALF OF THE DISCONNECT. THE FLAPPER DRIVE MECHANISM IS DESIGNED TO ALLOW RELIEF OF PROPELLANTS TRAPPED BETWEEN THE FLAPPERS AFTER DISCONNECT CLOSURE.

A PNEUMATICALLY ACTUATED LATCH MECHANISM IS PROVIDED TO PREVENT THE VALVE FLAPPERS FROM CLOSING DURING FLOW CONDITIONS. THE LATCH IS BISTABLE AND IS CONTROLLED BY A SEPARATE PNEUMATIC ACTUATOR ASSEMBLY WITH REDUNDANT LOCK AND UNLOCK (TWO EACH) POSITION SWITCHES. LATCH MECHANISM INCORPORATES A TOGGLE PIVOT WHICH ALLOWS FLAPPER CLOSURE DURING BACK UP MECHANICAL SEPARATION WITH LATCH IN LOCKED POSITION. SEE LATCH FMEA/CIL 0454 FOR ADDITIONAL INFORMATION.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION FMEA NO:03-1 -0408 -9 REV:12/17/8

ASSEMBLY :
P/N RI :MC284-0389-XXXX
ORB HALF 0551
ET HALF 0552
P/N VENDOR:
QUANTITY :1
:ONE
:

CRIT. FUNC: 1R
CRIT. HDW: 2

VEHICLE EFFECTIVITY:	102 X	103 X	10 X
PHASE(S):	PL LO X OO	DO	LS

REDUNDANCY SCREEN: A-PASS B-FAIL C-PAS

PREPARED BY:		APPROVED BY:	APPROVED BY (NASA):
DES	J E OSLUND	DES	SSM
REL	L H FINEBERG	REL	REL
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ITEM:
DISCONNECT, LO2 FEED (WITH LATCH) 17 INCH, ORBITER & ET HALF. (PD1)

FUNCTION
ET/ORBITER FEED LINE DISCONNECT PROVIDES LO2 PROPELLANT TO THE MPS AND MEANS OF LOADING AND DETANKING THE ET. EACH DISCONNECT HALF CONTAINS A PNEUMATICALLY ACTUATED FLAPPER CLOSURE DEVICE WHICH REMAINS IN ITS LAST ACTUATED POSITION (BISTABLE). THE VALVES ARE CLOSED AFTER MECO TO PREVENT PROPULSIVE VENTING LEADING TO ET/ORBITER RECONTACT, TILE/DOOR DAMAGE DUE TO EXPOSURE TO PROPELLANTS, LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION (RTLS/TAL ABORT CRITICAL), AND SYSTEM CONTAMINATION DURING ENTRY. DURING UMBILICAL SEPARATION, THE VALVE SYSTEM IS DESIGNED TO MECHANICALLY CLOSE BOTH THE ORBITER AND ET DISCONNECT FLAPPERS IF UNABLE TO CLOSE THEM PNEUMATICALLY (POST MECO). REDUNDANT OPEN AND CLOSE (TWO EACH) VALVE POSITION SWITCHES ARE LOCATED ON THE ORBITER HALF OF THE DISCONNECT. THE FLAPPER DRIVE MECHANISM IS DESIGNED TO ALLOW RELIEF OF PROPELLANTS TRAPPED BETWEEN THE FLAPPERS AFTER DISCONNECT CLOSURE.

A PNEUMATICALLY ACTUATED LATCH MECHANISM IS PROVIDED TO PREVENT THE VAI FLAPPERS FROM CLOSING DURING FLOW CONDITIONS. THE LATCH IS BISTABLE AN IS CONTROLLED BY A SEPARATE PNEUMATIC ACTUATOR ASSEMBLY WITH REDUNDANT LOCK AND UNLOCK (TWO EACH) POSITION SWITCHES. LATCH MECHANISM INCORPORATES A TOGGLE PIVOT WHICH ALLOWS FLAPPER CLOSURE DURING BACK UP MECHANICAL SEPARATION WITH LATCH IN LOCKED POSITION. SEE LATCH FMEA/CI 0454 FOR ADDITIONAL INFORMATION.

FAILURE MODE
FAILS TO RELIEVE (BOTH ET & ORBITER VALVES CLOSED) POST MECO, PRE UMBILICAL RETRACT

CAUSE(S)
BINDING

SUBSYSTEM :MAIN PROPULSION FMEA NO:03-1 -0408 -9 REV:12/17/87

EFFECT(S): ON
(A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:

(A,B)LO2 RELIEF CAPABILITY PROVIDED BY EACH DISCONNECT. (FLAPPER WILL LIFT OFF OF ITS SEAT). RELIEF CAN BE ACCOMPLISHED IN EITHER DIRECTION, TOWARD ET OR TOWARD ORBITER. FAILURE OF ONE FLAPPER, EITHER THE ORBITER OR ET HALF, TO RELIEVE LO2 TRAPPED BETWEEN THE TWO DISCONNECTS HAS NO EFFECT. FAILS B SCREEN BECAUSE THERE IS NO INSTRUMENTATION TO DETECT FAILURE MODE.

(C,D)NO EFFECT.

(E)FUNCTIONAL CRITICALITY EFFECTS

FAILURE OF BOTH DISCONNECTS TO RELIEVE WILL RESULT IN OVERPRESSURIZATION AND RUPTURE OF INTERFACE SEALS AND DAMAGE TO FLAPPER CLOSURES/MECHANISM. RESULTS IN LEAKAGE INTO UMBILICAL CAVITY, AFT COMPARTMENT, AND OVERBOARD. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND INTERNAL/EXTERNAL FIRE HAZARD (RTLS/TAL). POSSIBLE LOSS OF CREW/VEHICLE. ALSO RESULTS IN POSSIBLE TILE AND DOOR DAMAGE AT THE UMBILICAL AREA DUE TO CRYO EXPOSURE.

AFTER ET STRUCTURAL SEPARATION FAILURE WILL RESULT IN LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESS CAUSING LOSS OF AFT COMPARTMENT PURGE (RTLS AND TAL ABORT CRITICAL). ALSO RESULTS IN ORBITER/ET RECONTACT DUE TO PROPULSIVE VENTING AND ET IMPACT OUTSIDE ALLOWABLE FOOTPRINT.

POSSIBLE LOSS OF CREW/VEHICLE/LIFE/PROPERTY.

DISPOSITION & RATIONALE:
(A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY (E) OPERATIONAL USE:

(A) DESIGN
THE FLAPPER DISC SEAL (SEAL FLEXES) PROVIDES THE PRIMARY PRESSURE RELIEF OF LO2 OR GO2 TRAPPED BETWEEN THE FLAPPERS OF THE DISCONNECT WHILE ORBITER AND ET SECTIONS ARE MATED. THE DISC SEAL IS OF INCONEL 718 WITH TEFLON COATING. DESIGN RELIEF MECHANISM HAS A MINIMUM FLOW CAPACITY OF 1.8 POUNDS PER SECOND OF GO2 AT -290 DEG F AT A PRESSURE NOT TO EXCEED 5.0 PSID. DESIGN CRACKING AND RESEAT PRESSURE IS BETWEEN 0.1 AND 5 PSID AT AMBIENT TEMPERATURE. THE DISCONNECT FOLLOWER ARM TORSION BAR MECHANISM PERMITS THE FLAPPER TO LIFT OFF THE SEAT AT A PRESSURE DIFFERENTIAL OF APPROXIMATELY 0.2 PSI. BOTH VALVES ARE DESIGNED SUCH THAT THERE IS VERY LITTLE SURFACE AREA AVAILABLE FOR BINDING.

(B) TEST

ATP (ACTUATOR)

PROOF: AMBIENT, 1275 PSIG

OPERATIONAL (TWO CYCLES): AMBIENT; 400, 740, 780 PSIG

RESPONSE TIME (OPENING/CLOSING): ROOM AMBIENT/-300 DEG F
RESPONSE TIME AT 400, 700 AND 780 PSIG

LEAKAGE: EXTERNAL AND INTERNAL, AMBIENT AND CRYO

ATP - ET/ORBITER MATED DISCONNECT ASSEMBLY

FLAPPER ANGLE: ET 4.5 +/- 0.25 DEG, ORB 3.0 +/- 0.25 DEG

TIP LOAD: ET 55 LB MINIMUM, ORB 40 LB MINIMUM

POSITION SWITCH VERIFICATION: LATCH IN LOCKED POSITION. ROTATION FROM FLAPPER POSITION OF REST ON DOWNSTRIKE SURFACE TO FLAPPER POSITION WHERE OPEN INDICATOR LIGHT TURNS ON MUST BE 4 DEG, MINIMUM.

PROOF: AMBIENT, 1275 PSIG, ACTUATOR
286 PSIG FOR ORBITER CLOSURE DEVICE
58 PSIG FOR ET CLOSURE DEVICE

OPERATIONAL CYCLE: CRYO, -300 DEG F, ACTUATOR PRESSURE 740 PSIG FOR 8 CYCLES AND 450 PSIG FOR 5 CYCLES
AMBIENT, He AT 400 PSIG (1 CYCLE) AND 740 PSIG (5 CYCLES)

CLEANLINESS VERIFICATION: MOISTURE FREE AND CLEANED TO LEVEL 400A OF MA 0110-301

LEAKAGE: EXTERNAL
VALVE: LN2/AMBIENT TEMPS: 50 SCIMS OF GHE AT 10 PSIG, 5(
SCIMS OF GHE AT 50 PSIG; LATCH SHAFT SEAL, 80 SCIMS (
GHE; 150 SCIMS OF GN2 AT 185 PSIG; LATCH SHAFT SEAL,
80 SCIMS OF GN2
VALVE ACTUATOR:
CRYO (BODY TEMP AT -300 DEG F, ACTUATOR AT -200 T
0 DEG F)/AMBIENT TEMPS; 100 SCIMS OF GHE AT 740 PSIG

INTERNAL
VALVE: AMBIENT TEMPS: 1000 TO 2000 SCIMS OF GHE AT 1 TO
15 PSIG; 2500 SCIMS OF GN2 AT 200 PSIG
LN2 TEMPS: 2500 SCIMS OF GHE AT 60 PSIG; 2500
SCIMS OF GN2 AT 200 PSIG
VALVE ACTUATOR:
CRYO (BODY TEMP AT -300 DEG F, ACTUATOR AT -200 T
0 DEG F)/AMBIENT TEMPS: 100 SCIMS OF GHE AT 740 PSIG

RELIEF OPERATION: -300 DEG F, CRACKING/RESEAT PRESSURE, 0.1-5 PSID (ET ONLY)

ELECTRICAL CHARACTERISTICS (INSULATION RESISTANCE AND VOLTAGE DROP), AN DIELECTRIC STRENGTH

FLOW LINER - ROUNDNESS VERIFICATION (FREE END EIGHT POINTS MEASUREMENT)

CERTIFICATION

COMPONENT QUALIFICATION (INCLUDES TESTING FROM PREVIOUS CONFIGURATION WITHOUT LATCH)

SALT FOG

VIBRATION - THREE AXES:

SINUSOIDAL: 5 TO 35 HZ AT 0.25 G, ZERO TO PEAK

RANDOM: 20 TO 2,000 HZ 5.7 G RMS FOR X-AXIS, 5.2 G RMS FOR Y AND Z-AXIS, NO FLOW (LN2), FLAPPERS OPEN, LATCH ENGAGED

THE DISCONNECT IS CHILLED WITH LN2 AND STABILIZED AT -300 DEG F. 10 PSIG DISCONNECT, 740 PSIG ACTUATOR. THESE CONDITIONS ARE MAINTAINED THROUGHOUT SINUSOIDAL AND RANDOM VIBRATION. ACTUATOR VENTED DURING LAST TWO MINUTES OF VIBRATION.

THERMAL CYCLE: -400 TO 150 DEG F, 3 CYCLES

OPERATING LIFE: AMBIENT, 740 PSIG HE FOR A TOTAL OF 2,400 CYCLES FOR ORBITER AND 100 CYCLES FOR ET.
THE RELIEF MECHANISM WAS CYCLED DURING ET VALVE CYCLING.

CRYO, 740 PSIG HE, -400 DEG F FOR A TOTAL OF 1000 CYCLES FOR ORBITER AND 50 CYCLES FOR THE ET.
THE RELIEF MECHANISM WAS CYCLED DURING ET VALVE CYCLING.

ELECTRICAL CHARACTERISTICS (INSULATION RESISTANCE AND VOLTAGE DROP)

LEAKAGE: EXTERNAL AND INTERNAL, AMBIENT AND CRYO

ENGAGE - DISENGAGE: ENGAGE FORCE = 1000 LBS MAX, DISENGAGE FORCE = 6000 LBS MAX

BURST TEST: PNEUMATIC ACTUATOR, 1700 PSIG HYDROSTATIC PRESSURE FOR 2 MINUTES

TYPE I AND TYPE II MATED (OPEN POSITION) 450 PSIG HYDROSTATIC PRESSURE FOR 2 MINUTES

TYPE I AND TYPE II DEMATED (CLOSED POSITION) 330 PSID TO TYPE I, 68 PSID TO TYPE II FOR 2 MINUTES

UMBILICAL SEPARATION TEST: (WITHOUT LATCH)

THE DISCONNECT WAS INSTALLED IN THE UMBILICAL ASSEMBLY DURING THE SEPARATION TEST PROGRAM. THE UMBILICAL ASSEMBLY WAS SUBJECTED TO RANDOM VIBRATION TESTS (4.4 HOURS PER AXIS) WHILE FILLED WITH LN2. THE DISCONNECT WAS ALSO SUBJECTED TO UMBILICAL RETRACT TESTS AT BOTH NOMINAL CONDITIONS AND SIMULATED HYDRAULIC RETRACT ACTUATOR FAILURES.

UMBILICAL SEPARATION TEST: (WITH LATCH)

FLAPPER PNEUMATICS/LATCH PNEUMATICS/PYROS/RETRACTOR HYDRAULICS

(1) PNEUMATIC CLOSURE (NORMAL) - 4 CYCLES
(2) MECHANICAL CLOSURE (BACKUP) - 5 CYCLES

BOTH PERFORMED AT AMBIENT, LN2 AND LH2 CONDITIONS.

TERMINAL DRAIN: (SATURATED LO2) (65% AND 109%) LATCH ENGAGED AND NOT ENGAGED.

FLOW LINER WATER FLOW TESTS:

DESIGN FLOW TO 19,600 GPM
ALLOWABLE DELTA P IS 10 PSID AT THE LINER

TO DETERMINE THE STABILITY OF THE FLOW LINER. THE FLOW TUBE HAD NO PERMANENT DAMAGE AFTER BEING SUBJECTED TO WATER FLOWS UP TO 20,000 GPM (TEST TIME OF 2 MINUTES / 6 RUNS MINIMUM). AFTER VERIFYING PERFORMANCE AT 20,000 GPM, THE UNIT WAS SUBJECTED TO 22,700 GPM TO VERIFY DESIGN MARGIN (NO PERMANENT DAMAGE).

FLAPPER ANGLE STABILITY MARGIN WATER FLOW TESTS:

FOURTEEN (14) EXPLORATORY TEST SERIES (FLOW 4,000 TO 20,800 GPM)
E.T. FLAPPER SETTING VARYING FROM 1.6 TO 5.8 DEG.
ORB. FLAPPER SETTING VARYING FROM 0.9 TO 5.4 DEG.

CERTIFICATION TEST RUN AT WORST CASE PRODUCTION SETTING (FLOW RANGE TO 109% POWER LEVEL).

PROOF TEST SERIES - MAXIMUM FLOW 22,700 GPM, AT ANGLES BELOW MINIMUM FLIGHT SETTINGS

PRODUCTION ANGLE SETTINGS
E.T. 4.5 +/- 0.25 DEG
ORB. 3.0 +/- 0.25 DEG

FLAPPER TIP LOAD MARGIN WATER FLOW TEST:

EIGHT (8) EXPLORATORY TEST SERIES (FLOW RANGE TO 109% POWER LEVEL)

FLOW 4,000 TO 20,600 GPM
ORBITER: 3.0 +/- 0.1 DEG FOR SEVEN SERIES, 4.1 +/- 0.1 FOR ONE SERIES
TIP LOAD RANGE: 20 TO 62 LBS

ET: 3.95 +/- 0.1 DEG
TIP LOAD RANGE: 23 TO 61 LBS

RECOMMENDED TIP LOAD:

ORBITER: 40 LBS MINIMUM
ET: 55 LBS MINIMUM

LATCH WATER FLOW TESTS:

TWENTY-FOUR (24) EXPLORATORY TEST SERIES (FLOW 4,000 TO 22,100 GPM)

CERTIFICATION TEST RUN AT MINIMUM PRODUCTION SETTING (FLOW RANGE TO 109% POWER LEVEL).

TWO TEST SERIES IN FILL DIRECTION (FLOW 4,000 TO 6,400 GPM), LATCH PNEUMATIC PRESSURE VENTED (BISTABILITY)

PROOF TEST - 23,200 GPM

LATCH CRYO FLOW TESTS:

SIXTEEN (16) TESTS WITH LN2/LO2 (FLOWS VARY FROM ONE ENGINE AT 65% TO THREE AT 109%):

DISCONNECT FLAPPER STABILITY/LOADS

CAVITATION

FRICTION PRESSURE LOSS

ENGINE CUTOFF SENSOR RESPONSE

STEADY STATE TEST: LN2 (65% AND 109% OF RATED POWER LEVEL), LATCH ENGAGED. LO2 (100%, 104% AND 109% OF RATED POWER LEVEL), LATCH ENGAGED AND NOT ENGAGED.

TERMINAL DRAIN: (SATURATED LO2) (65% AND 109%) LATCH ENGAGED AND NOT ENGAGED.

OMRSD

V41AYO.010 LO2 EXTERNAL LEAK TEST (I5)
V41AYO.130 LO2 DECAY TEST (EVERY FLT)
V41AYO.221 HELIUM SIGNATURE TEST (EVERY FLT)
V41AYO.260 LO2 SHAFT SEAL LEAK CHECK (I5)
V41BIO.240 ORB/ET DISC RESPONSE TIME (POST FLT DATA ANALYSIS)
V41BUO.280 DISCONNECT FLAPPER ANGLE VERIFICATION (EVERY FLT)
V41BUO.280 DISCONNECT FLAPPER ANGLE VERIFICATION (EVERY FLT)
V41BUO.320 DISCONNECT INSPECTION AND TIP LOAD VERIF (EVERY FLT)
V41BUO.330 MPS COMPONENT CAVITY INSPECTION (EVERY FLT)
V41BUO.370 ORB/ET DISC PREPARATION FOR OPF ROLLOUT (EVERY FLT)
V41BVO.020 MPS ORB/ET DISC CLEANING (EVERY FLT)
V41BVO.030 ORB/ET UMBILICAL DISC AND SEAL INSPECTION (EVERY FLT)
T41FUN.040 OPENING TORQUE BEFORE MATING (EVERY FLT)
T41FUN.061 ET 17" TIP LOAD/FLAPPER ANGLE INSPECTION (EVERY FLT)
T41QAL.090 LO2/LH2 17" DISCONNECT INSPECTION (EVERY FLT)
T41QAL.100 LO2/LH2 17" DISCONNECT CLEANING (EVERY FLT)
S00HC0.400 VERIFY ET/ORB DISC POSITIONS (PRIOR TO MATING) (EVERY FLT)
S00000.090 PD1 RESPONSE TIME (MATED) (EVERY FLT)

(C) INSPECTION

RECEIVING INSPECTION
RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION. ALL MACHINED ITEMS ARE DIMENSIONALLY INSPECTED AND VERIFIED (MIL-STD-105). CHEMICAL/MECHANICAL PROPERTIES AND RECORDS OF RECEIVED MATERIALS ARE RETAINED FOR VERIFICATION. BODY FORGING IS ULTRASONICALLY AND DYE PENETRANT INSPECTED.

CONTAMINATION CONTROL
CLEANLINESS LEVEL TO 400A VIA FREON FLUSH AND SAMPLE VERIFIED. ALL SEA GROOVES ARE INSPECTED FOR CLEANLINESS AND EVIDENCE OF DAMAGE.

ASSEMBLY/INSTALLATION
THREADED INSERTS AND CRITICAL DIMENSIONS VERIFIED BY INSPECTION. SEALI SURFACES ARE VISUALLY INSPECTED FOR DEFECTS. REPAIRED AND REWORKED ITE ARE DIMENSIONALLY CHECKED. LOG OF CLEAN ROOM VERIFIED. ALL ENGINEERIN DEFINED FEATURES AND SURFACE FINISHES AND TORQUE REQUIREMENTS ARE COMPLETELY INSPECTED AND VERIFIED.

THE PRIMARY INTERFACE SEAL IS CHECKED FOR ID, OD AND ROUNDNESS. ALL DIMENSIONS DEFINED IN DRAWING ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES
HEAT TREATMENT AND PART PASSIVATION ARE VERIFIED BY INSPECTION.

NON-DESTRUCTIVE EVALUATION
PARTS ARE RADIOGRAPHICALLY AND DYE PENETRANT INSPECTED AS IMPOSED BY ENGINEERING IN THE DRAWING REQUIREMENTS.

TESTING
ATP AND TEST MEASUREMENT EQUIPMENT CALIBRATION VERIFIED BY INSPECTION.

HANDLING/PACKAGING
PACKAGING FOR SHIPMENT VERIFIED BY INSPECTION.

(O) FAILURE HISTORY
THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD OR FLIGHT FAILURES ASSOCIATED WITH THIS FAILURE MODE.

(E) OPERATIONAL USE
NO CREW ACTION CAN BE TAKEN.