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 -4 REV:02/19/88

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

CRIT. FUNC: 1
CRIT. HDW: 1

VEHICLE EFFECTIVITY:	102	103	104
	X	X	X

PHASE(S): PL X LO X CO DO LS

REDUNDANCY SCREEN: A- B- C-

PREPARED BY:
DES J E OSLUND
REL L H FINEBERG
QE E M GUTIERREZ

APPROVED BY:
DES
REL
QE

APPROVED BY (NASA):
SSM
REL
QE

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 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.

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FAILURE MODE
EXTERNAL LEAKAGE (ET/ORBITER UMBILICAL INTERFACE) DURING LOADING/DRAINING AND ENGINE OPERATION

CAUSE(S)
CONTAMINATION, DAMAGED INTERFACE SEAL/SEALING SURFACES, IMPROPER ENGAGEMENT

SUBSYSTEM :MAIN PROPULSION FMEA NO:03-1 -0408 -4 REV:02/19/

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

(A,B)RESULTS IN LO2 LEAKAGE INTO THE UMBILICAL CAVITY. MAJOR PORTION OF LO2/GO2 WILL ENTER THE AFT COMPARTMENT CAUSING POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD. LO2/GO2 LEAKAGE EXTERNAL TO THE UMBILICAL MAY CAUSE DAMAGE TO THE VEHICLE AN FIRE/EXPLOSION HAZARD. SECONDARY SEAL IS NOT CONSIDERED REDUNDANT SINCE IT WAS NOT DESIGNED TO SERVE AS A BACKUP TO THE PRIMARY SEAL. SECONDARY SEAL WILL PREVENT EXCESSIVE LEAKAGE. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. LEAKAGE IS DETECTABLE DURING PROPELLANT LOADING BY HAZARDOUS GAS DETECTION SYST (HGDS).

(C)ON GROUND, VIOLATION OF THE HGDS LCC WILL RESULT IN LAUNCH SCRUB.

(D)POSSIBLE LOSS OF CREW/VEHICLE.

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

(A) DESIGN
DESIGN FACTORS OF SAFETY FOR INTERNAL PRESSURE ARE: 1.3 PROOF, 1.5 BURST. PRIMARY MATING SEAL IS DESIGNED FOR LEAKAGE NOT TO EXCEED 310 SCIM OF GO2 AT 0 TO 200 PSIG AND 500 SCIM OF GO2 AT 265 PSIG. A STEEL RETAINING BAND AROUND THE PRIMARY SEAL (TEFLON) PREVENTS SEAL BLOW-OUT DURING SEPARATION.

THE SEALING SURFACES OF THE ORBITER AND ET DISCONNECT ARE FINISHED TO 3 MICROINCH.

SECONDARY SEAL WILL PREVENT EXCESSIVE LEAKAGE BUT IS NOT DESIGNED TO SERVE AS A BACKUP TO THE PRIMARY SEAL. LEAKAGE PAST THE SECONDARY SEAL IS DESIGNED NOT TO EXCEED 10 SCIM OF GHE AT 0 TO 10 PSIG AND 70 TO 160 DEG F. SECONDARY SEAL IS A FEP TEFLON TUBE WITH 302 CRES SPRING. THE MAIN PURPOSE OF THE SECONDARY SEAL IS TO PROVIDE A BARRIER FOR LEAK CHECKING THE PRIMARY SEAL.

LEAK DETECTION CAPABILITY IS PROVIDED BETWEEN SEALS FOR AMBIENT CHECKOUT GUIDE PINS ARE PROVIDED FOR PROPER ENGAGEMENT.

(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

SUBSYSTEM :MAIN PROPULSION FMEA NO:03-1 -0408 -4 REV:02/19/88

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, 50 SCIMS OF GHE AT 50 PSIG; LATCH SHAFT SEAL, 80 SCIMS OF 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 TO 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 TO 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), AND DIELECTRIC STRENGTH

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

SUBSYSTEM :MAIN PROPULSION FMEA NO:03-1 -0408 -4 REV:02/19/

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 SINUSOIDA AND RANDOM VIBRATION. ACTUATOR VENTED DURING LAST T 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 HYDROSTAT 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.

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 SER
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 GP

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% T 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), LAT ENGAGED. LO2 (100%, 104% AND 109% OF RATED POWER LEVEL), LATCH ENGAGED AND NOT ENGAGED.

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

SUBSYSTEM :MAIN PROPULSION FMEA NO:03-1 -0408 -4 REV:02/19/88

OMRSD

V41BV0.020 MPS ORB/ET DISC CLEANING (EVERY FLT)
V41BV0.030 ORB/ET UMBILICAL DISC AND SEAL INSPECTION (EVERY FLT)
V41BV0.050 PD1/PD2 17" DISC SEAL REPLACEMENT (EVERY FLT)
S00000.080 LH2 ORB/ET I/F LEAK CHECKS (EVERY FLT)
S00HC0.400 VERIFY ET/ORB DISC POSITIONS (PRIOR TO MATING) (EVERY FLT)
T41QAL.060 INSPECT ORB/ET SEALING SURFACES PRIOR TO ORB MATE (EVERY FLT)
T41QAL.100 LO2/LH2 17" DISCONNECT CLEANING (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 SEAL GROOVES ARE INSPECTED FOR CLEANLINESS AND EVIDENCE OF DAMAGE.

ASSEMBLY/INSTALLATION
THREADED INSERTS AND CRITICAL DIMENSIONS VERIFIED BY INSPECTION. SEALING SURFACES ARE VISUALLY INSPECTED FOR DEFECTS. REPAIRED AND REWORKED ITEMS ARE DIMENSIONALLY CHECKED. LOG OF CLEAN ROOM VERIFIED. ALL ENGINEERING-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.

(D) FAILURE HISTORY
EXCESSIVE EXTERNAL LEAKAGE WAS OBSERVED AT THE ORB/ET UMBILICAL INTERFACE ON OV-099 FLT 8 (REFERENCE CAR AC9421). THE SEAL WAS REDESIGNED WITH TIGHTER DIMENSIONAL TOLERANCES AND NO FURTHER INCIDENTS HAVE OCCURRED.

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

GROUND: OMI S1003 SEQUENCE TITLED "EMERGENCY PROCEDURE FOR A MAJOR LE OR FIRE IN THE ORBITER MPS" CONTAINS SAFING SEQUENCE OF EVENTS FOR MAJ LEAKS IN THE OXYGEN SYSTEM.