

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0405 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 08/08/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	:LH2 4" DISCONNECT, RECIRC RTN (ET) VACCO INDUSTRIES	MC284-0390-0014
LRU	:LH2 4" DISCONNECT, RECIRC RTN (ORB) VACCO INDUSTRIES	MC284-0390-0056

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

DISCONNECT, LH2 RECIRCULATION RETURN, 4 INCH DIAMETER, ORBITER & ET HALF

REFERENCE DESIGNATORS: PD3

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

ET/ORBITER RECIRCULATION RETURN DISCONNECT PROVIDES THE PATH FOR LH2 RECIRCULATION. THE DISCONNECT IS A PNEUMATICALLY ACTUATED VALVE THAT IS DESIGNED TO REMAIN IN THE LAST ACTUATED POSITION (BISTABLE). THE DISCONNECT PROVIDES A MEANS FOR TOPPING AND REPLENISHING THE ET TANK, AND RECIRCULATION LH2. THE DISCONNECT VALVE IS CLOSED AFTER MAIN ENGINE CUT-OFF (MECO). THE DISCONNECT VALVE IS CLOSED FOR A PREMATURE ENGINE SHUTDOWN DURING ASCENT OR FOR A PAD ABORT. THE DISCONNECT VALVE IS CLOSED TO PREVENT PROPELLANT LEAKAGE THROUGH THE ENGINE FUEL BLEED VALVE (BLEED VALVE OPENS 16 SECONDS AFTER ENGINE SHUTDOWN). FLUID TRAPPED BETWEEN THE CLOSED ET AND ORBITER HALVES IS RELIEVED THROUGH EITHER THE ET OR ORBITER FLAPPERS. A SEVEN PLY NEGATOR SPRING CONFIGURATION, ATTACHED TO THE MAIN SHAFT, WILL CLOSE THE VALVE MECHANICALLY AT SEPARATION IF THE VALVE WAS NOT CLOSED BY RETRACTION OF THE ACTUATOR ARM.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0405-04

REVISION#: 1 08/08/00

SUBSYSTEM NAME: MAIN PROPULSION

LRU: LH2 4" DISCONNECT, RECIRC RTN (PD3)

ITEM NAME: LH2 4" DISCONNECT, RECIRC RTN (PD3)

CRITICALITY OF THIS

FAILURE MODE: 1R2

FAILURE MODE:

ERRONEOUS INDICATION - VALVE CLOSED/OPEN POSITION INDICATOR ON.

MISSION PHASE:

PL PRE-LAUNCH

LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

CAUSE:

PIECE PART STRUCTURAL FAILURE OF THE VALVE DRIVE MECHANISM

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) PASS

B) FAIL

C) PASS

PASS/FAIL RATIONALE:

A)

B)

FAILS SCREEN B BECAUSE OF VALVE PIECE PART STRUCTURAL FAILURE BETWEEN POSITION INDICATOR ASSEMBLY AND ORBITER FLAPPER.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

RESULTS IN LOSS OF REDUNDANCY TO RECIRCULATION RELIEF VALVE (RV7). THE RECIRCULATION MANIFOLD RELIEF VALVE (RV7) WILL RELIEVE ANY PRESSURE BUILD-UP IN RECIRCULATION LINE. PRESSURE BUILDUP WILL OCCUR BECAUSE THE ENGINE BLEED VALVES AND THE TOPPING VALVE (PV13) ARE CLOSED DURING ASCENT. VALVE OPEN

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0405-04**

POSITION INDICATION VERIFIED BY OMRSD REQUIREMENT WHEN VALVE IS OPENED PRIOR TO INITIATION OF PROPELLANT LOADING OPERATIONS.

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

PRELAUNCH FAILURE MAY CAUSE LAUNCH SCRUB IF ENGINE READY CONDITIONS ARE VIOLATED. LCC ONLY REQUIRES VALVE OPEN POWER ON AND VALVE CLOSED POWER OFF UNTIL T-31 SECONDS. VALVE OPEN POSITION INDICATION PRIOR TO LAUNCH IS NOT AN LCC REQUIREMENT.

(D) CREW, VEHICLE, AND ELEMENT(S):

NO EFFECT.

(E) FUNCTIONAL CRITICALITY EFFECTS:

1R/2 2 SUCCESS PATHS. TIME FRAME - PRELAUNCH, ASCENT

- 1) RECIRCULATION DISCONNECT (PD3) CLOSED BUT INDICATES OPEN (ERRONEOUS INDICATION).
- 2) RECIRCULATION MANIFOLD RELIEF VALVE (RV7) FAILS TO RELIEVE.

RESULTS IN RUPTURE OF THE RECIRCULATION LINE (FH18). HAZARDS ASSOCIATED WITH LEAKAGE OF CRYOGENIC PROPELLANTS. LOSS OF CRITICAL FUNCTIONS DUE TO ADJACENT COMPONENT EXPOSURE TO CRYOGENICS. POSSIBLE AFT COMPARTMENT OVERPRESS AND FIRE HAZARD. ALSO RESULTS IN LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION CAUSING LOSS OF AFT COMPARTMENT PURGE. POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

A PNEUMATIC ACTUATOR MOUNTED ON THE ORBITER HALF OF THE DISCONNECT DRIVES THE ET FLAPPER THROUGH A GEAR LINKAGE ASSEMBLY. THIS ACTION IN TURN DRIVES A SECOND GEAR WHICH OPERATES THE ORBITER FLAPPER AND THE POSITION INDICATOR ASSEMBLY.

THE POSITION INDICATORS ARE MECHANICALLY ACTIVATED MICROSWITCHES. THEY ARE OPERATED BY A MECHANICAL CAM (304 CRES) ATTACHED TO THE ORBITER DISCONNECT FLAPPER DRIVE SHAFT (INCONEL 718).

THE DRIVE MECHANISM HAS A MINIMUM LIFE EQUIVALENT OF 100 ORBITER MISSIONS. THE ORBITER FLAPPERS HAVE A MINIMUM USEFUL LIFE OF 1400 CYCLES WHICH IS EQUIVALENT TO 100 ORBITER MISSIONS. THE ET FLAPPERS HAVE A MINIMUM LIFE OF 150

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0405-04**

CYCLES WHICH IS EQUIVALENT TO ONE ORBITER MISSION. STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATION; FRACTURE/FATIGUE ANALYSIS SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES EXPECTED LIFE (ET - 1 MISSION, ORBITER - 100 MISSIONS).

(B) TEST:

ATP

EXAMINATION OF PRODUCT

PROOF PRESSURE:

ACTUATOR: 1720 PSIG

ORBITER HOUSING: 156 PSIG, FLAPPERS OPEN AND CLOSED

ET HOUSING: 48 PSIG, FLAPPERS OPEN AND CLOSED

LEAKAGE - AMBIENT AND CRYO (-300 DEG F):

ACTUATOR (OPEN AND CLOSED POSITION) - 740 PSIG

BUMPER SEAL LEAKAGE; 740 PSIG

SHAFT SEAL LEAKAGE; 740 PSIG

CAP SEAL LEAKAGE; 740 PSIG (AMBIENT ONLY)

VALVE BODY

SHAFT SEAL LEAKAGE

ORBITER SECTION: 5, 20, 37, AND 120 PSIG

ET SECTION: 5, 20, AND 37 PSIG

CLOSURE SEAL (INTERNAL) LEAKAGE

ORBITER SECTION: 5, 20, 37, AND 120 PSIG

ET SECTION: 5, 20, AND 37 PSIG

MATING SEAL LEAKAGE (47 PSIG)

EXTERNAL LEAKAGE (37 PSIG)

RELIEF FUNCTION:

CRYO (-300 DEG F) CRACK AND RESEAT (.75 TO 10 PSID)

POSITION INDICATOR (AMBIENT):

VERIFICATION OF OPERATION

ELECTRICAL CHARACTERISTICS:

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0405-04**

CONTACT RESISTANCE
INSULATION RESISTANCE
DIELECTRIC STRENGTH

RESPONSE TIME:

AMBIENT AND CRYO (-300 DEG F)
400 AND 740 PSIG ACTUATION PRESSURE

CERTIFICATION

COMPONENT QUALIFICATION

INTERFACE CLAMPING FORCE APPLIED DURING ALL AMBIENT AND CRYO TESTING.

OPERATING LIFE:

AMBIENT
800 FLAPPER CLOSURE CYCLES AT 740 PSIG
200 FLAPPER CLOSURE CYCLES AT 400 PSIG

CRYO
300 CLOSURE CYCLES AT 750 PSIG (-400 DEG F)
100 CLOSURE CYCLES AT 400 PSIG (-400 DEG F)

VIBRATION - 3 AXES:

RANDOM VIBRATION (48 MINUTES IN EACH OF THREE AXES WITH CLOSURE IN OPEN POSITION WHILE PRESSURIZED TO 37 PSIG AND AT -300 DEG F (OPEN PRESSURE REMOVED IN LAST 10 MINUTES OF EACH AXIS).

ELECTRICAL CHARACTERISTICS:

CONTACT RESISTANCE
INSULATION RESISTANCE
DIELECTRIC STRENGTH

BONDING:

ELECTRICAL CONDUCTIVITY SHALL NOT EXCEED 100 MILLIOHMS.

CRYOGENIC RELIEF OPERATION:

CRACK AND RESEAT PRESSURE SHALL BE BETWEEN 0.75 AND 10 PSIG

ENGAGE/DISENGAGE CYCLING:

AMBIENT
100 DISENGAGEMENT CYCLES:
15 CYCLES WITH FLAPPERS OPEN USING ACTUATOR PRESSURE
15 CYCLES WITH FLAPPERS MECHANICALLY LATCHED OPEN
70 CYCLES WITH FLAPPERS CLOSED USING ACTUATOR PRESSURE

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0405-04**

CRYO

300 DISENGAGEMENT CYCLES, CRYO (-320 DEG F):
12 CYCLES WITH FLAPPERS OPEN USING ACTUATOR PRESSURE
12 CYCLES WITH FLAPPERS MECHANICALLY LATCHED OPEN
276 CYCLES WITH FLAPPERS CLOSED USING ACTUATOR PRESSURE

10 DISENGAGEMENT CYCLES, CRYO (-400 DEG F):
3 CYCLES WITH FLAPPERS OPEN USING ACTUATOR PRESSURE
3 CYCLES WITH FLAPPERS MECHANICALLY LATCHED OPEN
4 CYCLES WITH FLAPPERS CLOSED USING ACTUATOR PRESSURE

LEAKAGE - AMBIENT AND CRYO (-300 DEG F):

ACTUATOR (OPEN AND CLOSED POSITION)

BUMPER SEAL LEAKAGE; 740 PSIG

SHAFT SEAL LEAKAGE; 740 PSIG

VALVE BODY

SHAFT SEAL LEAKAGE
ORBITER SECTION: 5, 20, 37, AND 120 PSIG
ET SECTION: 5, 20, AND 37 PSIG

CLOSURE SEAL (INTERNAL) LEAKAGE
ORBITER SECTION: 5, 20, 37, AND 120 PSIG
ET SECTION: 5, 20, AND 37 PSIG

MATING SEAL LEAKAGE (47 PSIG)

EXTERNAL LEAKAGE (37 PSIG)

VALVE RESPONSE TIMES:

CRYO (-300 DEG F) AND AMBIENT
VALVE PRESSURIZED TO 5 PSIG AND AMBIENT PRESSURE
ACTUATOR PRESSURIZED TO 740 PSIG AND 400 PSIG

BURST TEST:

ORBITER SECTION 180 PSIG; FLAPPER IN CLOSED POSITION
ET SECTION 56 PSIG; FLAPPER IN CLOSED POSITION
ACTUATOR 3400 PSIG; SIMULTANEOUSLY APPLIED TO OPEN AND CLOSED PORTS.

THE CONSOLIDATED CONTROL VALVES WERE QUALIFIED BY SIMILARITY TO THE FOLLOWING TESTS THAT WERE PERFORMED ON AMETEK/CALMEC VALVES:

VIBRATION - 3 AXES:

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0405-04**

TRANSIENT VIBRATION (SINUSOIDAL SWEEP): 5 TO 35 HZ AT AMBIENT CONDITIONS

RANDOM VIBRATION (48 MINUTES IN EACH OF THREE AXES WITH CLOSURE IN OPEN POSITION WHILE PRESSURIZED TO 37 PSIG AND AT -300 DEG F (OPEN PRESSURE REMOVED IN LAST 10 MINUTES OF EACH AXIS).

SALT FOG: 48 HOURS, INTERNALLY PRESSURIZED TO 5 PSIG

SHOCK, BENCH HANDLING (DEMATED)

THERMAL CYCLE (3 CYCLES): +70 TO -400 TO -20 TO +70 DEG F

OPERATING LIFE:

AMBIENT

1500 FLAPPER CLOSURE CYCLES AT 740 PSIG
1000 FLAPPER CLOSURE CYCLES AT 400 PSIG

300 DISENGAGEMENT CYCLES:

50 CYCLES WITH FLAPPERS OPEN USING ACTUATOR PRESSURE
50 CYCLES WITH FLAPPERS MECHANICALLY LATCHED OPEN
150 CYCLES WITH FLAPPERS CLOSED USING ACTUATOR PRESSURE
50 CYCLES WITH ACTUATOR OPENING AND CLOSING PORTS PRESSURIZED
SIMULTANEOUSLY AND CLOSURE DEVICES OPEN

CRYO

700 CLOSURE CYCLES AT 740 PSIG (-400 DEG F)
300 CLOSURE CYCLES AT 400 PSIG (-400 DEG F)

10 DISENGAGEMENT CYCLES (-400 DEG F):

2 CYCLES WITH FLAPPERS OPEN USING ACTUATOR PRESSURE
2 CYCLES WITH FLAPPERS MECHANICALLY LATCHED OPEN
4 CYCLES WITH FLAPPERS CLOSED USING ACTUATOR PRESSURE
2 CYCLES WITH ACTUATOR OPENING AND CLOSING PORTS PRESSURIZED
SIMULTANEOUSLY AND CLOSURE DEVICES OPEN

290 DISENGAGEMENT CYCLES (-300 DEG F):

50 CYCLES WITH FLAPPERS OPEN USING ACTUATOR PRESSURE
50 CYCLES WITH FLAPPERS MECHANICALLY LATCHED OPEN
140 CYCLES WITH FLAPPERS CLOSED USING ACTUATOR PRESSURE
50 CYCLES WITH ACTUATOR OPENING AND CLOSING PORTS PRESSURIZED
SIMULTANEOUSLY AND CLOSURE DEVICES OPEN

ELECTRICAL CHARACTERISTICS:

CONTACT RESISTANCE
INSULATION RESISTANCE
DIELECTRIC STRENGTH

BONDING:

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0405-04**

ELECTRICAL CONDUCTIVITY SHALL NOT EXCEED 100 MILLIOHMS.

BURST TEST:

ORBITER SECTION 180 PSIG; FLAPPER IN CLOSED POSITION
ET SECTION 56 PSIG; FLAPPER IN CLOSED POSITION
ACTUATOR 3400 PSIG; SIMULTANEOUSLY APPLIED TO OPEN AND CLOSED PORTS.

UMBILICAL SEPARATION TEST

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 LH2. THE DISCONNECT WAS ALSO SUBJECTED TO UMBILICAL RETRACT TESTS AT BOTH NOMINAL CONDITIONS AND SIMULATED HYDRAULIC RETRACT ACTUATOR FAILURE CONDITIONS. THE DISCONNECT WAS ALSO SUBJECTED TO 5 BACKUP MODE CLOSURE TESTS.

GROUND TURNAROUND TEST

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL

CONTAMINATION CONTROL PROCESSES AND CORROSION PROTECTION PROVISIONS ARE VERIFIED. INTERNAL SURFACES CLEANING TO LEVEL 400 IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

COMPONENT

ALL DETAIL PARTS ARE INSPECTED UNDER 40X MAGNIFICATION FOR BURRS, DAMAGE, AND CONTAMINATION. CRITICAL DIMENSIONS, CLEARANCE, AND SURFACE FINISHES ARE VERIFIED. SEALS ARE VISUALLY EXAMINED PRIOR TO INSTALLATION FOR DAMAGE AND CLEANLINESS. FLAPPER SPRINGS ARE INSTALLED AND VERIFIED BY INSPECTION AFTER LOAD TEST. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

UMBILICAL ASSEMBLY

HEAT TREATED AND DRY FILM LUBE COATED BELLEVILLE SPRINGS ARE VISUALLY INSPECTED AND LOAD TESTED PRIOR TO ASSEMBLY. CORRECT INSTALLATION OF THE BELLEVILLE WASHERS IS A MANDATORY INSPECTION POINT. THE SHIMS, WHICH ARE REQUIRED TO SET THE HEIGHT OF THE 4 INCH DISCONNECT MATING SURFACE ABOVE THE 17 INCH DISCONNECT MATING SURFACE AS EXTERNAL FORCE IS APPLIED TO THE 4 INCH DISCONNECT, ARE DIMENSIONALLY INSPECTED. THE SHIMS, WHICH ARE REQUIRED TO SET THE PRELOAD IN THE UNMATED CONDITION, ARE DIMENSIONALLY INSPECTED.

CRITICAL PROCESS

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0405-04**

PARTS PASSIVATION, HEAT TREATMENT, AND ANODIZING ARE VERIFIED. ETCHING OF AL ALLOY, CLEANING AL SAND CASTINGS, BRUSH CLEANING, AND SOLDERING ARE VERIFIED BY INSPECTION. DRY FILM LUBRICANT APPLICATION IS VERIFIED.

NONDESTRUCTIVE EVALUATION
CASTING AND ROUGH MACHINING OF THE BODY ARE INSPECTED BY X-RAY AND DYE PENETRANT.

TESTING
ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING
IN-PROCESS OPERATIONS ARE VERIFIED BY INSPECTION TO PROTECT PARTS AND PRECLUDE MISHANDLING. PARTS PACKAGING IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

CURRENT DATA ON TEST FAILURE, FLIGHT FAILURE, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATABASE.

(E) OPERATIONAL USE:

NO CREW ACTION CAN BE TAKEN.

- APPROVALS -

S&R ENGINEERING	: W.P. MUSTY	: /S/ W. P. MUSTY
S&R ENGINEERING ITM	: P. A. STENGER-NGUYEN	: /S/ P. A. STENGER-NGUYEN
DESIGN ENGINEERING	: MIKE FISCHER	: /S/ MIKE FISCHER
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: BILL LANE	: /S/ BILL LANE
USA SAM	: MIKE SNYDER	: /S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	: /S/ ERICH BASS