

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE****NUMBER: 03-1-0454 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1 08/08/00**PART DATA**

	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	:17" DISC ASSY, ORB, LH2/LO2	MC284-0389-1461 (LH2) MC284-0389-1561 (LO2)
	BOEING	
SRU	:17" DISC LATCH ASSY, LH2/LO2	5863431-101 (LH2) 5863431-102 (LO2)
	BOEING	
LRU	:17" DISCONNECT LATCH ACTUATOR, LH2/LO2	5863450-102 (LH2) 5863450-103 (LO2)
	BOEING	

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

VALVE LATCH ASSEMBLY, LH2/LO2 FEED DISCONNECT (PD1,PD2)  
ORBITER HALF ONLY.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY PARKER-HANNIFIN. BOEING IS A CERTIFIED ALTERNATE PRODUCTION AGENCY.

**REFERENCE DESIGNATORS:** PD1  
PD2

**QUANTITY OF LIKE ITEMS:** 2  
ONE EACH LO2, LH2

**FUNCTION:**

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 IS PLACED IN UNLOCKED POSITION FOR ALL FLAPPER OPEN OR CLOSE OPERATIONS. LATCH MECHANISM INCORPORATES A TOGGLE PIVOT WHICH ALLOWS FLAPPER CLOSURE DURING BACKUP MECHANICAL SEPARATION IF LATCH IS IN LOCKED POSITION. SEE DISCONNECT FMEA/CIL 0407/0408 FOR ADDITIONAL INFORMATION.

**FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE**

**NUMBER: 03-1-0454-09**

**REVISION#: 1 08/08/00**

**SUBSYSTEM NAME: MAIN PROPULSION**

**LRU: 17" DISC ASSY, ORB LH2, LO2**

**ITEM NAME: 17" DISC LATCH ASSY LH2, LO2**

**CRITICALITY OF THIS**

**FAILURE MODE: 1R3**

**FAILURE MODE:**

LOSS OF POSITION INDICATION - LOCKED POSITION INDICATION FAILS ON (LCC DECEPTION)

**MISSION PHASE:**

PL PRE-LAUNCH

LO LIFT-OFF

**VEHICLE/PAYLOAD/KIT EFFECTIVITY:**

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

**CAUSE:**

POSITION SWITCH PIECE PART FAILURE

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO**

**REDUNDANCY SCREEN**

A) PASS

B) FAIL

C) PASS

**PASS/FAIL RATIONALE:**

A)

B)

FAILS B SCREEN SINCE FAILURE INDICATION CANNOT BE READILY DISTINGUISHED FROM EXPECTED OUTPUT DURING LCC PERIOD.

C)

**- FAILURE EFFECTS -**

**(A) SUBSYSTEM:**

NO EFFECT. CAPABILITY OF LATCH TO RESTRAIN/RELEASE FLAPPER IS NOT AFFECTED.

LCC VERIFIES THAT ONE OF TWO LOCKED POSITION SWITCHES ARE ON AT T-31 SECONDS.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0454-09**

**(B) INTERFACING SUBSYSTEM(S):**

SAME AS A.

**(C) MISSION:**

FIRST FAILURE - NO EFFECT.

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

SAME AS C.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

1R/3 3 SUCCESS PATHS. TIME FRAME - ENGINE OPERATION.

- 1) 17-INCH DISCONNECT LATCH LOCKED POSITION SWITCH FAILS ON.
- 2) LATCH FAILS TO REMAIN LOCKED.
- 3) STRUCTURAL FAILURE OF DISCONNECT FLAPPER DRIVE MECHANISM.

LATCH POSITION LCC IS ERRONEOUSLY SATISFIED DUE TO FIRST FAILURE, EVEN IF REDUNDANT SWITCH FUNCTIONS PROPERLY (LCC REQUIRES ONE OF TWO LOCKED POSITION SWITCHES INDICATING ON). AT SSME START, INCREASED PROPELLANT FLOW CAUSES ABRUPT FLAPPER CLOSURE.

SURGE PRESSURE FROM VALVE CLOSURE MAY CAUSE DAMAGE OR RUPTURE TO THE MPS SYSTEM, DEPENDING ON THE RATE OF CLOSURE. RUPTURE OF MPS LINES WILL LEAK PROPELLANT INTO THE AFT COMPARTMENT. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD. POSSIBLE LOSS OF CRITICAL FUNCTIONS DUE TO ADJACENT COMPONENT EXPOSURE TO CRYOS. POSSIBLE LOSS OF CREW/VEHICLE.

---

**-DISPOSITION RATIONALE-**

---

**(A) DESIGN:**

THE ACTUATOR SWING ARM (INCONEL 718) TRANSFERS LATERAL MOVEMENT OF THE ACTUATOR PISTON INTO CIRCULAR MOVEMENT OF THE LATCH ARM ASSEMBLY AND ROTATION OF THE POSITION SWITCH CAM (AL ALLOY 6061-T6 ANODIZED). THE LATCH ARM AND TOGGLE ASSEMBLY IS SUPPORTED BY THE FLEXURE ASSEMBLY AND A BEARING INSERTED IN THE DISCONNECT HOUSING.

THE SWITCH ASSEMBLY CONSISTS OF FOUR SWITCHES (TWO LOCKED; TWO UNLOCKED) FOR REDUNDANCY. THEY ARE MECHANICALLY ACTIVATED MICROSWITCHES MOUNTED IN A SWITCH BRACKET, WITHIN THE ACTUATOR BODY. EACH GROUP OF SWITCHES INDICATES LATCHED OR UNLATCHED CONDITION. SWITCHES ARE HERMETICALLY SEALED. EACH SWITCH IS DESIGNED FOR A MINIMUM LIFE OF 10,000 CYCLES. ALL EXPOSED SURFACES ARE OF CORROSION RESISTANT MATERIALS/PLATED TO RESIST CORROSION. THE FLANGE ASSEMBLY WHICH ENCLOSED THE POSITION INDICATOR SWITCH COMPARTMENT OF ACTUATOR BODY IS OF 316 CRES WITH TEFLON (PER MIL-P-22214A)

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0454-09**

COVER GASKET TO PREVENT POSSIBLE FOREIGN OBJECT DAMAGE TO THE POSITION INDICATOR SWITCHES.

**(B) TEST:**  
ATP

LATCH ACTUATOR PROOF, AMBIENT 1275 PSIG

LATCH/SHAFT ASSEMBLY PROOF LOAD TEST:

- ORBITER FLAPPER/ET FLAPPER CLOSURE LOAD, 750 LBF
- ET FLAPPER CLOSURE LOAD, 596 LBF
- ET OVER TRAVEL RESTRAINT LOAD, 596 LBF

OPERATIONAL CYCLE: AMBIENT: 400 PSIG, 1 CYCLE; 740 PSIG, 5 CYCLES

OPERATIONAL: LN2 TEMPERATURE, 450 PSIG, 5 CYCLES; 740 PSIG, 5 CYCLES

LATCH SHAFT SEAL LEAKAGE: AMBIENT AND LN2 TEMPERATURES, 10 AND 50 PSIG, 80 SCIM OF GHE

LATCH ACTUATOR EXTERNAL LEAKAGE: AMBIENT AND LN2 (BODY TEMPERATURES) 740 PSIG, STATIC SEAL, 150 SCIM OF GHE, PISTON SHAFT SEAL, 1000 SCIM OF GHE

LATCH ACTUATOR INTERNAL LEAKAGE: AMBIENT AND LN2 TEMPERATURES, 740 PSIG, 400 SCIM OF GHE

LH2 UNIT ADDITIONAL TESTS:

OPERATIONAL CYCLES: AMBIENT TEMPS, 10 CYCLES AT 740 PSIG AND 10 CYCLES AT 400 PSIG

OPERATIONAL CYCLES: LH2 TEMPS, 10 CYCLES AT 740 PSIG AND 10 CYCLES AT 450 PSIG

LATCH SHAFT SEAL LEAKAGE: LH2 TEMPS, 0 TO 50 PSIG, 80 SCIM OF GH2

LATCH ACTUATOR EXTERNAL LEAKAGE: LH2 TEMPS (BODY), 740 PSIG, STATIC SEAL, 150 SCIM OF GHE, PISTON SHAFT SEAL, 1000 SCIM OF GHE

LATCH ACTUATOR INTERNAL LEAKAGE: LH2 TEMPS (BODY), 740 PSIG, 400 SCIM OF GHE

ELECTRICAL CHARACTERISTICS: INSULATION RESISTANCE, VOLTAGE DROP, AND DIELECTRIC STRENGTH

EXAMINATION OF PRODUCT:

VERIFY THE CLEARANCE BETWEEN TOE OF THE LATCH TO EDGE OF FLAPPER FAIRING DOME.

VERIFY THE DEMATED VALVE FLAPPER MOVEMENT PAST LATCH TOGGLE.

MEASURE EDGE CLEARANCE FROM FULL OVER TOGGLE TO THE FLAPPER.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0454-09**

TOGGLE SHALL MOVE FREELY AT AMBIENT AND CRYOGENIC CONDITIONS.

POSITION INDICATOR SWITCH REDUNDANCY SWITCH PICKUP WITHIN THE LIMITS BAND.

LATCH ACTUATOR SWITCH HOUSING VENT CHECK VALVE RELIEF SET PRESSURE.

MEASURE GAP BETWEEN BOTTOM OF LATCH AND TOP OF FLAPPER SEAL RETAINER RINGS.

MEASURE OVERLAP BETWEEN END OF LATCH AND END OF ET FLAPPER SEAL RETAINER RING.

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

CERTIFICATION

COMPONENT QUALIFICATION

THERMAL CYCLE; 3 CYCLES, AMBIENT TO -400 DEG F TO AMBIENT

VIBRATION:RANDOM 20 TO 2000 HZ

5.0 GRMS FOR Z-AXIS

5.2 GRMS FOR X AND Y-AXIS

48 MINUTES PER AXIS

CONDITIONS:MATED, NO FLOW, FLAPPERS OPEN, LATCH LOCKED, PRESSURIZED TO 10 PSIG, AND FILLED WITH LN2 (DONE PRIOR TO LH2 LEAKAGE TEST). DURING THE LAST TWO MINUTES OF RANDOM VIBRATION IN EACH AXIS, LATCH ACTUATOR PNEUMATIC SUPPLY PRESSURE IS RELIEVED.

ELECTRICAL CHARACTERISTICS: INSULATION RESISTANCE AND VOLTAGE DROP BONDING; ELECTRICAL BONDING PER MIL-B-5087

ULTIMATE LOADS; LATCH ASSEMBLY, TOGGLE LOAD, ET SIDE AND FLAPPER OVER TRAVEL RESTRAINT, ET SIDE

ACTUATOR BURST PRESSURE: 1700 PSIG

SEQUENCE ERROR/RIGGING ERROR:

DOWNSTRIKE IMPACT: 8 CYCLES, FLAPPERS CLOSED, ACTUATE LATCH TO LOCKED POSITION, ACTUATE FLAPPERS OPEN, THEN CLOSE  
FLAPPERS CLOSED AGAINST LATCH: 8 CYCLES, FLAPPER OPEN AND LATCHED, COMMAND FLAPPER CLOSED, THEN OPEN

MISRIGGING: 4 CYCLES, ACTUATE FLAPPERS OPEN, COMMAND LATCH TO ENGAGED POSITION, COMMAND LATCH TO DISENGAGE

ORBITER ANGLE LOW:  
ORB: 1.46 DEG

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0454-09**

ET: 4.5 DEG

ET ANGLE LOW:  
ORB: 3.0 DEG  
ET: 2.85 DEG

ET ANGLE HIGH:  
ORB: 3.0 DEG  
ET: 8.16 DEG

MECHANICAL CLOSURE (LO2, ORBITER, DEMATED): MANUALLY OPEN FLAPPER, ENGAGE LATCH, MANUALLY CLOSE FLAPPER. AT POINT WHERE LATCH BEGINS TO RELEASE FLAPPER, HOLD FLAPPER IN PLACE WHILE ROTATING TOGGLE TO EXTREME POSITION. MEASURE TOGGLE/FLAPPER CLEARANCE AT POINT OF RELEASE.

LIFE CYCLE, AMBIENT: 2400 CYCLES (UNLOCK TO LOCK TO UNLOCK)  
CRYOGENIC: 1000 CYCLES, -400 DEG F BODY TEMPERATURE

ACTUATOR AND LATCH SHAFT SEAL LEAKAGE: AMBIENT AND CRYO (LN2 AND LH2)

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.

LATCH WATER FLOW TESTS: (LH2 CONFIGURATION)

ELEVEN (11) EXPLORATORY TEST SERIES (FLOW 4000 TO 14800 GPM)

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

TWO PROOF TESTS - 15650 GPM AND 15850 GPM

LATCH WATER FLOW TESTS: (LO2 CONFIGURATION)

TWENTY-FOUR (24) EXPLORATORY TEST SERIES (FLOW 4000 TO 22100 GPM)

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

TWO TEST SERIES IN FILL DIRECTION (FLOW 4000 TO 6400 GPM), LATCH PNEUMATIC PRESSURE VENTED (BISTABILITY)

PROOF TEST - 23200 GPM

LATCH CRYO FLOW TESTS: (LH2 VALVE QUALIFIED BY SIMILARITY TO LO2)

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0454-09**

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

DISCONNECT FLAPPER STABILITY/LOADS

CAVITATION

FRICION 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.

GROUND TURNAROUND TEST

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

**(C) INSPECTION:**

RECEIVING INSPECTION

ALL HARDWARE DIMENSIONALLY INSPECTED.

INSPECTION VERIFIES CERTIFICATIONS OF RAW MATERIAL ARE PART PROTECTION, COATING, AND PLATING REQUIREMENTS VERIFIED BY INSPECTION.

CONTAMINATION CONTROL

INSPECTION VERIFY CLEANLINESS TO LEVEL 400A.

INSPECTION VERIFY THE CONTAMINATION CONTROL PLAN.

ASSEMBLY/INSTALLATION MANUFACTURING PROCESSES, INSTALLATION, AND ASSEMBLY OPERATIONS VERIFIED BY INSPECTION, INCLUDING PARTS PROTECTION.

INSPECTION VERIFY FASTENERS ARE TORQUED TO REQUIREMENTS.

INSPECTION VERIFY IMPLEMENTATION OF CORROSION PROTECTION PROVISIONS.

INSPECTION VERIFY SURFACE FINISHES TO DRAWING REQUIREMENTS.

INSPECTION VERIFY SEAL INSTALLATION WHICH INCLUDES:

SEAL MATING PART (MATERIAL, SURFACE FINISH, DIMENSIONAL INSPECTION)

ASSEMBLY (COMPONENT INTEGRITY, SEALS AND SURFACE LUBRICATED,

ASSEMBLY TECHNIQUE, SEAL INSTALLATION IN CLEANROOM)

QUALIFIED AND CERTIFIED PERSONNEL AND SPECIAL DESIGNATED TOOLS UTILIZED

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0454-09**

SEAL PHOTOS (BLIND INSTALLATION, SINGLE BACKUP RINGS, AND "L" SEALS) AND CORRECT SEAL IDENTIFICATION (PART NO., LOT NO., MATERIAL CONDITION, AGE, CRITICAL CHARACTERISTICS).

CRITICAL PROCESSES  
INSPECTION VERIFY PARTS PASSIVATION AND HEAT TREATMENT

INSPECTION VERIFY SOLDERING MEETS REQUIREMENTS IMPOSED

NONDESTRUCTIVE EVALUATION  
DYE PENETRANT AND X-RAY INSPECTION IS PERFORMED ON ANY PARTS DESIGNATED FRACTURE CRITICAL.

TESTING  
INSPECTION VERIFY ATP REQUIREMENTS (NOTE PRIMARY VERIFICATIONS AND WITNESSING).

HANDLING/PACKAGING  
INSPECTION VERIFY IMPLEMENTATION OF HANDLING, PACKAGING, AND STORAGE REQUIREMENTS.

**(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:**  
FLIGHT:  
NO CREW ACTION REQUIRED

GROUND:  
GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE OXYGEN AND HYDROGEN SYSTEMS.

---

**- 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	: KOUROSH ANVARI	: /S/ KOUROSH ANVARI
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