

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0454 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 08/08/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
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.

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LRU: 17" DISC ASSY, ORB LH2, LO2

ITEM NAME: 17" DISC LATCH ASSY LH2, LO2

CRITICALITY OF THIS

FAILURE MODE: 1R2

FAILURE MODE:

LOSS OF POSITION INDICATION (EITHER LO2 OR LH2 LATCHES) LOADING, ASCENT

MISSION PHASE:

PL PRE-LAUNCH

LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

CAUSE:

POSITION SWITCH ASSEMBLY FAILURE, ELECTRICAL POWER LOSS

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) PASS

B) PASS

C) PASS

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

PIECE PART STRUCTURAL FAILURE OF CAM FAILS TO ACTUATE BOTH UNLOCK POSITION SWITCHES (POST-MECO). VEHICLE SOFTWARE WILL NOT COMMAND FLAPPERS CLOSED. BACKUP MECHANICAL FEATURE WILL CLOSE FLAPPERS UPON ORBITER/ET UMBILICAL RETRACTION.

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(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

NO EFFECT. PRELAUNCH LCC REQUIRES TWO OF TWO UNLOCK SWITCHES TO INDICATE "OFF" AND ONE OF TWO LOCK SWITCHES TO INDICATE "ON". RESULTS IN LAUNCH SCRUB.

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

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

CASE 1:

1R/2 2 SUCCESS PATHS. TIME FRAME - POST MECO, PRE ET SEP

- 1) PIECE PART STRUCTURAL FAILURE OF CAM FAILS TO ACTUATE BOTH UNLOCK POSITION SWITCHES.
- 2) MECHANICAL CLOSURE SEPARATION DEVICE FAILS TO CLOSE VALVE. (ET OR ORB FORK STRUCTURAL FAILURE)

VEHICLE SOFTWARE WILL INHIBIT ET STRUCTURAL SEPARATION SINCE BOTH DISCONNECT CLOSED SWITCHES WILL PROPERLY INDICATE ORBITER FLAPPER FAILURE TO CLOSE. FOR NOMINAL, ATO, AND AOA MISSIONS ET SEPARATION IS DELAYED FOR SIX MINUTES TO VENT RESIDUAL PROPELLANT THROUGH FAILED DISCONNECT. THIS IS TO PREVENT ORB/ET RECONTACT DUE TO PROPULSIVE VENTING AT SEPARATION. POSSIBLE TILE AND DOOR DAMAGE AT THE ORB/ET UMBILICAL AREA DUE TO CRYO EXPOSURE. FOR RTLS, TAL, AND MISSIONS WHERE OMS BURN CANNOT BE DELAYED, ET STRUCTURAL SEPARATION IS NOT DELAYED AND ET/ORB RECONTACT IS LIKELY. ALSO RESULTS IN LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESS CAUSING POSSIBLE LOSS OF AFT COMPARTMENT PURGE. POSSIBLE LOSS OF CREW/VEHICLE.

CASE 2:

1R/2 2 SUCCESS PATHS. TIME FRAME - LOADING

- 1) LOSS OF LATCH POSITION INDICATION.
- 2) LEAKAGE/FIRE REQUIRING ISOLATION OF EXTERNAL TANK BY CLOSURE OF THE 17" DISCONNECT.

FAILURE OF LATCH POSITION INDICATION WILL PREVENT CLOSE COMMAND TO THE 17" DISCONNECT, RESULTS IN FIRE/EXPLOSION HAZARD. 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

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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) 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

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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.

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

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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
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)

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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)

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 100% DIMENSIONALLY INSPECTED.

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

CONTAMINATION CONTROL

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INSPECTION VERIFIES CLEANLINESS TO LEVEL 400A.

INSPECTION VERIFIES THE CONTAMINATION CONTROL PLAN.

ASSEMBLY/INSTALLATION

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

INSPECTION VERIFIES FASTENERS ARE TORQUED TO REQUIREMENTS.

INSPECTION VERIFIES IMPLEMENTATION OF CORROSION PROTECTION PROVISIONS.

INSPECTION VERIFIES SURFACE FINISHES TO DRAWING REQUIREMENTS.

INSPECTION VERIFIES SEAL INSTALLATION WHICH INCLUDES:

SEAL MATING PART (MATERIAL, SURFACE FINISH, 100% DIMENSIONAL INSPECTION)
ASSEMBLY (COMPONENT INTEGRITY, SEALS AND SURFACE LUBRICATED,
ASSEMBLY TECHNIQUE, SEAL INSTALLATION IN CLEANROOM)

QUALIFIED AND CERTIFIED PERSONNEL AND SPECIAL DESIGNATED TOOLS UTILIZED

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 VERIFIES PARTS PASSIVATION AND HEAT TREATMENT

INSPECTION VERIFIES SOLDERING MEETS REQUIREMENTS IMPOSED

NONDESTRUCTIVE EVALUATION

100% DYE PENETRANT AND X-RAY INSPECTION IS PERFORMED ON ANY PARTS
DESIGNATED FRACTURE CRITICAL.

TESTING

INSPECTION VERIFIES ATP REQUIREMENTS (NOTE PRIMARY VERIFICATIONS AND
WITNESSING).

HANDLING/PACKAGING

INSPECTION VERIFIES IMPLEMENTATION OF HANDLING, PACKAGING, AND STORAGE
REQUIREMENTS.

(D) FAILURE HISTORY:

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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 IS REQUIRED (FIRST FAILURE).

- 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