

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 02-5E-S02 -X**

SUBSYSTEM NAME: PAYLOAD RETEN & DEPLOY - LATCHES

REVISION: 1 10/16/00

PART DATA

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: STANDARD LONGERON LATCH ASSEMBLY (PRLA)	V073-544550
SRU	: MOTOR/BRAKE ASSEMBLY	MC287-0054-0001

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
MOTOR/BRAKE ASSEMBLY**

REFERENCE DESIGNATORS:

**QUANTITY OF LIKE ITEMS:
TWO PER LATCH**

FUNCTION:

STANDARD LONGERON LATCH REACTS FLIGHT LOADS ON PAYLOAD HORIZONTAL TRUNNION HELD BETWEEN TWO SPHERICAL HALF BEARINGS. REDUNDANT MOTORS ACT THROUGH A DIFFERENTIAL AND GEARBOX TO DRIVE THE LINKAGES AND HOOK. THE MOTORS INCORPORATE INTEGRAL BRAKE MECHANISMS AND ARE CONTROLLED BY POSITION SWITCHES LOCATED WITHIN THE LATCH. TWO OF THREE A/C PHASES ARE REQUIRED TO LIFT THE BRAKE AND POWER THE MOTOR. THERE ARE NO SINGLE FAILURE MODES WHICH WOULD ALLOW A FREE WHEELING MOTOR AFTER APPLICATION OF POWER.

THE LATCH NOW INCORPORATES AN EXTRAVEHICULAR ACTIVITY (EVA) MECHANISM TO DISCONNECT THE LATCH LINKAGES FROM THE MOTOR GEARBOX AND MANUALLY DRIVE LATCH LINKAGES/HOOK OPEN OR CLOSED. THIS IS A FEATURE TO PERMIT MANUAL LATCH OPERATION TO BYPASS PREVIOUS FAILURE OF TWO MOTORS OR GEARBOX.

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LRU: STANDARD LONGERON LATCH ASSEMBLY (PRLA)

ITEM NAME: MOTOR/BRAKE ASSEMBLY

CRITICALITY OF THIS FAILURE MODE: 1R3

**FAILURE MODE:
BRAKE FAILS TO ENGAGE**

**MISSION PHASE: OO ON-ORBIT
 DO DE-ORBIT**

**VEHICLE/PAYLOAD/KIT EFFECTIVITY: 102 COLUMBIA
 103 DISCOVERY
 104 ATLANTIS
 105 ENDEAVOUR**

**CAUSE:
ADVERSE TOLERANCES/WEAR, CONTAMINATION/FOREIGN OBJECT/DEBRIS, DEFECTIVE PART/MATERIAL OR MANUFACTURING DEFECT, FAILURE/DEFLECTION OF INTERNAL PART**

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

**REDUNDANCY SCREEN A) PASS
 B) FAIL
 C) PASS**

**PASS/FAIL RATIONALE:
A)**

**B)
FAILS REDUNDANCY SCREEN "B" SINCE THERE IS NO VISUAL OR INSTRUMENTED WAY OF DETECTING A FAILURE OF THE MOTOR/BRAKE ASSEMBLY IN FLIGHT.**

C)

- FAILURE EFFECTS -

**(A) SUBSYSTEM:
FIRST FAILURE - NONE. SECOND FAILURE - FAILURE OF ASSOCIATED MOTOR WILL ALLOW THE OTHER REDUNDANT MOTOR TO BACKDRIVE THROUGH THE FAILED BRAKE**

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AND LATCH POSITIONING CAPABILITY WOULD BE LOST. REQUIRES CREW TO PERFORM EVA FOR MANUAL LATCH CLOSE/OPEN.

(B) INTERFACING SUBSYSTEM(S):

FIRST FAILURE - NONE. SECOND FAILURE - FAILURE OF ASSOCIATED MOTOR WILL RESULT IN LOSS OF ABILITY TO DRIVE LATCH. REQUIRES CREW TO PERFORM EVA FOR MANUAL LATCH CLOSE/OPEN.

(C) MISSION:

FIRST FAILURE - NONE. SECOND FAILURE - FAILURE OF ASSOCIATED MOTOR WILL RESULT IN POSSIBLE LOSS OF MISSION DUE TO INABILITY TO RELEASE OR RESTRAIN PAYLOAD. REQUIRES CREW TO PERFORM EVA FOR MANUAL LATCH CLOSE/OPEN.

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

FIRST FAILURE - NONE. SECOND FAILURE - POSSIBLE LOSS OF CREW/VEHICLE DUE TO LOSS OF BOTH REDUNDANT PATHS FOR DRIVING LATCH WITH ELECTRICAL MOTORS. REQUIRES CREW TO PERFORM EVA FOR MANUAL LATCH CLOSE/OPEN.

(E) FUNCTIONAL CRITICALITY EFFECTS:

LOSS OF LATCH OPERATION IN MID-TRAVEL POSITION WOULD RESULT IN UNRESTRAINED PAYLOAD DURING ENTRY/LANDING, AND COULD RESULT IN LOSS OF VEHICLE AND CREW. REQUIRES TWO FAILURES AND LOSS OF EVA CAPABILITY

DESIGN CRITICALITY (PRIOR TO DOWNGRADE, DESCRIBED IN (F)): 1R2

(F) RATIONALE FOR CRITICALITY DOWNGRADE:

CRITICALITY IS DOWNGRADED FROM THE DESIGN CRITICALITY, 1R/2, TO 1R/3 DUE TO CONSIDERATION OF THE EVA OPERATIONAL WORKAROUND CAPABILITY. WITH EVA CAPABILITY BUILT IN, THE CREW CAN OPEN OR CLOSE LATCHES MANUALLY

-DISPOSITION RATIONALE-

(A) DESIGN:

THE MOTOR HAS THE DESIGN REQUIREMENTS OF THREE PHASE, 400 HZ AC INDUCTION MOTOR AND INTEGRAL BRAKE THAT WILL BE USED IN A SPACE ENVIRONMENT. THE MOTOR IS ENCLOSED WITH COVER TO EXCLUDE CONTAMINATION. IT HAS FACTOR OF SAFETY OF 1.4 OVER LIMIT LOAD. MATERIALS AND PROCESSES FOR THE MOTOR ARE IN ACCORDANCE WITH MC999-0096. THIS MOTOR IS SAME AS USED ON ALL PAYLOAD RETENTION LATCHES.

PRLA EVA MODIFICATION DOES NOT MODIFY THE EXISTING MOTORS.

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(B) TEST:

ACCEPTANCE TESTS: THE FOLLOWING TESTS ARE PERFORMED FOR ALL FLIGHT ARTICLES AND WERE PERFORMED FOR EACH QUALIFICATION TEST ARTICLE: VIBRATION - RANGE 20 TO 2,000 HZ MAXIMUM LEVEL OF 0.04 G²/HZ FROM 80 TO 350 HZ, ALL AXES. THERMAL - STABILIZED RANGE FROM -100 DEG F TO +275 DEG F. FUNCTIONAL TESTS CONDUCTED AT -100 DEG F, +70 DEG F AND +275 DEG F. LOADS/ALIGNMENT - VERIFY RETENTION OF LATCHED POSITION AT 60% LIMIT LOAD, AS WELL AS SPHERICAL BEARING TORQUE RESISTANCE AND TRAVEL LIMITS. ELECTRICAL - VERIFY (WITHIN DESIGN LIMITS) CONTINUITY, DIELECTRIC STRENGTH, INSULATION RESISTANCE, AND SWITCH OPERATION.

EVA MODIFIED PRLA ACCEPTANCE TEST: THE FOLLOWING TESTS ARE PERFORMED ON ALL FLIGHT ARTICLES AND ARE PERFORMED ON QUALIFICATION TEST ARTICLE: ELECTRICAL CONTINUITY, FUNCTIONAL PERFORMANCE, FLIGHT VIBRATION, DIELECTRIC STRENGTH & INSULATION RESISTANCE, THERMAL CYCLING.

QUALIFICATION TESTS: THE FOLLOWING IS A SUMMARY OF TESTS CONDUCTED PER CR 44-287-0025-0001 TO INCLUDE BOTH NATURAL AND INDUCED ENVIRONMENTAL EFFECTS TO THE LATCH ASSEMBLY AND THE LATCH-TO- BRIDGE/TRUNNION FRICTION/LOAD INTERFACE. FUNCTIONAL TESTS WERE CONDUCTED DURING AND FOLLOWING EACH PHASE OF TESTING TO DETERMINE EFFECTS. ENVIRONMENTS ACCEPTED BY ANALYSIS INCLUDE FUNGUS, OZONE, SALT SPRAY, ACCELERATION, SOLAR RADIATION (THERMAL AND NUCLEAR), METEOROIDS, SAND AND DUST, STORAGE, FACTOR OF SAFETY, RELIABILITY, MAINTAINABILITY, MATERIALS AND PROCESSES, ELECTRICAL DESIGN AND SAFETY. CERTIFICATION BY SIMILARITY INCLUDED VACUUM, HUMIDITY, TRUNNION FRICTION AND EXPLOSIVE ATMOSPHERE. VIBRATION - QUALIFICATION ACCEPTANCE VIBRATION TEST (QAVT) RANGE OF 20 TO 2,000 HZ WITH MAXIMUM LEVEL OF 0.067 G²/HZ AT 80 TO 350 HZ, FOR ALL AXES. FLIGHT VIBRATION LEVEL - 20 TO 2,000 HZ WITH MAXIMUM LEVEL OF 0.03 G²/HZ AT 100 TO 250 HZ, ALL AXES, WHILE UNDER LOAD. SHOCK BENCH HANDLING TEST IN ACCORDANCE WITH MIL-STD-810C. THERMAL - STABILIZED RANGE FROM -100 DEG F TO +275 DEG F. FUNCTIONAL TESTS CONDUCTED AT -100 DEG F, AMBIENT, AND +275 DEG F, THERMAL VACUUM, AND HUMIDITY. LOAD TESTS - COMBINED AXIS LOADING TO 100% LIMIT LOAD. LIFE CYCLE TESTS - 1,000 CYCLES IN ADDITION TO CYCLES CONDUCTED DURING VARIOUS QUALIFICATION TESTING AT VARIOUS LOAD AND MOTOR CONDITIONS. TRUNNION/BRIDGE INTERFACE FRICTION - SINGLE AND COMBINED AXIS LOADING UP TO LIMIT IN BOTH DIRECTIONS THROUGHOUT THE ENTIRE TEMPERATURE RANGE, IN COMPLIANCE WITH INTERFACE CONTROL DOCUMENT.

EVA MODIFIED PRLA QUALIFICATION TEST: FOLLOWING TESTS WERE PERFORMED PER CR 60-44-544550-007 ON THE EVA MODIFIED PRLA: ELECTRICAL CONTINUITY, FUNCTIONAL PERFORMANCE WITH OPPOSING FORCE FROM TRUNNION WITH SINGLE MOTOR AND DUAL MOTORS OPERATIONS, FLIGHT VIBRATION QUALIFICATION ACCEPTANCE VIBRATION TEST (QAVT) RANGE OF 20 TO 2,000 HZ WITH MAXIMUM LEVEL OF 0.04G²/HZ AT 80 TO 350 HZ, FOR ALL AXES WHILE NO LOAD APPLIED. OPERATING LIFE CYCLE 100 CYCLES IN ADDITION TO CYCLES CONDUCTED DURING QUALIFICATION TESTING AT VARIOUS LOAD AND MOTOR CONDITIONS, MECHANICAL STOPS/STALL WITH BOTH MOTORS DRIVEN AT NO-LOAD SPEED INTO THE MECHANICAL STOP THREE (3) TIMES IN EACH DIRECTION, DIELECTRIC STRENGTH AT 750 VAC, 60 HZ FOR 10±2 SECONDS, INSULATION RESISTANCE AT 500VDC, THERMAL CYCLING STABILIZED RANGE FROM -200 DEG F TO +275 DEG F FIVE (5) TIMES, EVA OPERATION TESTS CONDUCTED AT

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-100 DEG F, AMBIENT, AND +275 DEG FOR LATCH OPEN AND CLOSE OPERATIONS. THE LATCH WAS THEN PARTIALLY DISASSEMBLED AND INSPECTED

GROUND TURNAROUND TEST: ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

MATERIAL AND PROCESS CERTIFICATIONS ARE VERIFIED BY INSPECTION. INSPECTION VERIFIES THAT A SAMPLE FROM EACH LOT OF MATERIAL IS SPECTROSCOPICALLY ANALYZED TO VERIFY MATERIAL CHEMISTRY.

CONTAMINATION CONTROL

ALL PARTS ARE CLEANED BEFORE ENTERING STOCK ROOM AND RECLEANED BEFORE ENTERING CLEAN ROOM, VERIFIED BY INSPECTION. MOTOR/BRAKE ASSEMBLY IS ASSEMBLED IN A CLASS 10,000 CLEAN ROOM, VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

ALL PARTS ARE DIMENSIONALLY INSPECTED, VERIFIED BY INSPECTION. ASSEMBLY OPERATIONS ARE VERIFIED BY INSPECTION. RTV APPLICATION TO KEEP MOISTURE OUT OF THE MOTOR IS VERIFIED BY INSPECTION.

CRITICAL PROCESSES

HEAT TREATING AND SOLDERING IS VERIFIED BY INSPECTION. PASSIVATION OF STAINLESS STEEL PARTS IS VERIFIED BY INSPECTION. EXAMINATION OF SOLDER JOINTS BEFORE THEY ARE CLOSED UP AND SEALED IN WINDINGS IS A MANDATORY INSPECTION POINT. HEAT TREATING OF SHAFTS IS VERIFIED BY HARDNESS TEST.

TESTING

ATP (INCLUDING TESTING AT EXTREME TEMPERATURES, AT VARIOUS LOADS AND AT VARIOUS POSITIONS) IS VERIFIED PER PROCEDURE. WINDING RESISTANCE TEST IS VERIFIED BY INSPECTION. HIGH POTENTIAL TEST IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

HANDLING AND PACKAGING REQUIREMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

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

(E) OPERATIONAL USE:

FIRST FAILURE - NONE. SECOND FAILURE WILL REQUIRE CREW TO PERFORM EVA PROCEDURES FOR MANUAL LATCH OPEN/CLOSE

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- APPROVALS -

S&R ENGINEER
CARGO/INTEG. ITM
DESIGN ENGINEER
SUBSYSTEM MANAGER
MOD
USA SAM
USA ORBITER ELEMENT
USA CARGO ELEMENT

: A. T. NGUYEN
: C. VONGSOUTHY
: D. E. HAEHLKE
: P. REESE
: E. SMITH
: N. WOODWORTH

: *A. T. Nguyen*
: *C. Vongsouthy*
: *D. E. Haehlke*
: *P. Reese*
: *E. Smith*
: *N. Woodworth*
: *Harry Matthews*