

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : P/L RETEN & DEPLOY-MPM, MRL FMEA NO 02-5C-R02-1 REV:04/04/88

ASSEMBLY : MANIPULATOR RETENTION LATCH (MRL) CRIT. FUNC: 2
P/N RI : MC287-0027-0006 CRIT. HDW: 2
P/N VENDOR: A1059C010-6 VEHICLE 102 103 104
EFFECTIVITY: X X X
QUANTITY : 3 PHASE(S): PL LO OO X DO X LS

REDUNDANCY SCREEN: A- B- C-
PREPARED BY: APPROVED BY: *[Signature]* APPROVED BY (NASA):
DES D. S. CHEUNG DES *[Signature]* FOR G. CAMPBELL SSM *[Signature]*
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ITEM:
GEARBOX

FUNCTION:
THE MANIPULATOR RETENTION LATCHES ARE LOCATED AT EACH MANIPULATOR POSITIONING MECHANISM (MPM) PEDESTAL AND PROVIDES RETENTION AND STRUCTURAL SUPPORT FOR THE MANIPULATOR ARM DURING THE LAUNCH AND ENTRY/LANDING MISSION PHASES. EACH PEDESTAL LATCH MECHANISM IS INDEPENDENT AND IS DRIVEN BY A DUAL MOTOR/DIFFERENTIAL/TORQUE LIMITER/GEARBOX ASSEMBLY.

FAILURE MODE:
PHYSICAL BINDING/JAMMING

CAUSE(S):
ADVERSE TOLERANCES/WEAR, CONTAMINATION/FOREIGN OBJECT/DEBRIS, FAILURE/DEFLECTION OF INTERNAL PART, LOSS OF LUBRICANT, TEMPERATURE

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

(A) FAILURE WILL RESULT IN LOSS OF ABILITY TO LATCH/UNLATCH MANIPULATOR RETENTION LATCH (MRL). DIFFERENTIAL JAM WILL CAUSE MOTOR STALL UNTIL CREW REMOVES COMMAND AT SINGLE MOTOR TIME. GEARBOX JAM WILL CAUSE TORQUE TO FEED BACK INTO SYSTEM AND SLIP THE TORQUE LIMITERS.

(B) ENTRY/LANDING CAN SAFELY BE PERFORMED WITH ANY TWO OF THREE MRL LATCHED (REF. JSC 08934).

(C) FAILURE WILL RESULT IN POSSIBLE LOSS OF MISSION DUE TO INABILITY TO RELEASE MRL AND UNBERTH REMOTE MANIPULATOR SYSTEM (RMS).

(D) MULTIPLE PEDESTAL MRL FAILURES WILL REQUIRE EXTRAVEHICULAR ACTIVITY (EVA) OR JETTISON OF RMS TO PREVENT POSSIBLE LOSS OF CREW/VEHICLE DUE TO UNRESTRAINED RMS DURING ENTRY.

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DISPOSITION & RATIONALE:

(A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY (E) OPERATIONAL USE

(A) DESIGN

EACH MRL ACTUATOR UTILIZES TWO MOTORS DRIVING THROUGH A DIFFERENTIAL AND OUTPUT GEARING. THE DIFFERENTIAL DRIVES A GEAR TRAIN THROUGH A TORQUE LIMITER WHICH PROTECTS THE SYSTEM FROM OVER-LOAD. THE GEAR TRAIN SUPPLIES MOTION TO TWO IDENTICAL LINKAGE SYSTEMS DRIVING HOOKS TO PROVIDE THE DESIRED LATCHING KINEMATICS. THE GEARBOX IS ENCLOSED AND ASSEMBLED CLEAN TO EXCLUDE CONTAMINATION. GEAR TEETH EXHIBIT HIGH MARGINS OF SAFETY. DUAL ROTATION SURFACES AND RETENTION CONCEPTS HAVE BEEN EMPLOYED.

(B) TEST

QUALIFICATION TESTS: THE LATCH HAS BEEN CERTIFIED BY CR-44-287-0027-0003D. QUALIFICATION TESTS INCLUDE: ACCEPTANCE TEST - TO VERIFY CONFORMANCE WITH THE REQUIREMENTS NOTED BELOW FOR ACCEPTANCE TEST. HUMIDITY TEST - TESTED IN ACCORDANCE WITH MIL-STD-810B, METHOD 507, PROCEDURE IV. QUALIFICATION ACCEPTANCE VIBRATION TEST (QAVT) - 20 TO 2,000 HZ RANGE WITH MAXIMUM OF 0.067 g²/HZ FROM 80 TO 350 HZ FOR 5 MINUTES PER AXIS. ORBITAL FLIGHT VIBRATION TEST - 20 TO 2,000 HZ RANGE WITH MAXIMUM OF 0.047 g²/HZ FROM 50 HZ TO 250 H FOR 5 MINUTES PER AXIS AT LEVEL "A" AND WITH MAXIMUM OF 0.05 g²/HZ FROM 40 HZ TO 150 HZ FOR 2 MINUTES PER AXIS AT LEVEL "B". SHOCK TEST - TESTED IN ACCORDANCE WITH MIL-STD-810C, METHOD 516.2 PROCEDURE I. EXPLOSIVE ATMOSPHERE TEST - TESTED IN ACCORDANCE WITH MIL-D-810C, METHOD 511.1, PROCEDURE I EXCEPT USING BUTANE AS THE TEST FLUID. THERMAL CYCLE TEST - THE ASSEMBLY WAS THERMALLY CYCLED 5 TIMES FROM +70 DEG F TO +280 DEG F TO +180 DEG F TO -100 DEG F TO +70 DEG F. DWELL AT EACH TEMPERATURE EXTREME WAS 60 MINUTES MINIMUM AFTER STABILIZATION. AT EACH TEMPERATURE +180 DEG F AND -100 DEG F, THE ASSEMBLY WAS CYCLED 2 TIMES EACH AT THE MAXIMUM HEAT DISSIPATING MODE AND MINIMUM HEAT DISSIPATING MODE.

QUAL TESTS ALSO INCLUDE: OPT OPERATION LIFE - THE ASSEMBLY WAS CYCLED 125 TIMES EACH INDIVIDUALLY FOR 18 SECONDS WITH SYSTEMS 1 AND 2 AT AMBIENT TEMPERATURE. IT WAS ALSO CYCLED 540 TIMES WITH BOTH SYSTEMS 1 AND 2 FOR 7.5 SECONDS. MECHANICAL STOP TEST - THE ASSEMBLY WAS OPERATED AT FULL RATE AND NO LOAD INTO ITS MECHANICAL STOP FOR 100 TIMES IN EACH DIRECTION. PACKAGE QUALIFICATION - INSPECTED PER FED-STD-101 FOR EVIDENCE OF DAMAGE OR DEGRADATION. POWER CONSUMPTION - VERIFIED INPUT POWER TO THE DEPLOYMENT MOTOR TO BE 345 VA; POWER FACTOR NOT LESS THAN 0.7 LAGGING; STARTING POWER FACTOR NOT LESS THAN 0.25 LAGGING; STARTING CURRENT NOT LESS THAN 400% OF THE CURRENT AT RATED LOAD.

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QUAL TESTS ALSO INCLUDE: STALL/MAXIMUM TORQUE - VERIFIED THE TORQUE LIMITER NOT TO SLIP WITH 33 INCH-OUNCES TORQUE APPLIED AND SLIP WITH 40 INCH-OUNCES TORQUE OR GREATER APPLIED. IRREVERSIBILITY - THE ACTUATOR WAS CHECKED FOR IRREVERSIBILITY WITH A LOAD OF 40 INCH-OUNCES MINIMUM. MECHANICAL LIMIT - THE ASSEMBLY HOOKS WERE CHECKED BY MOVING THROUGH THEIR FULL MECHANICAL TRAVEL TO VERIFY COMPLIANCE WITH THE MAXIMUM HOOK ENVELOPE. CERTIFIED BY ANALYSIS - THESE INCLUDED STORAGE/OPERATING LIFE, FACTOR OF SAFETY, RELIABILITY, MAINTAINABILITY, OZONE, FUNGUS, SALT FOG, ELECTRICAL DESIGN REQUIREMENT, SAFETY, ACCELERATION AND THERMAL VACUUM. THE ASSEMBLY WAS SUBJECTED TO SYSTEM QUALIFICATION TESTS PER MANIPULATING POSITIONING MECHANISM INSTALLATION V082-000002 (REF CR-44000002-001E).

ACCEPTANCE TESTS: EXAMINATION OF PRODUCTION - WEIGHT, WORKMANSHIP, DIMENSION, CONSTRUCTION, CLEANLINESS, FINISH, IDENTIFICATION MARKING, TRACEABILITY AND USE OF APPROVED MATERIALS AND PROCESSES. VIBRATION TEST - 20 TO 2,000 HZ RANGE WITH MAXIMUM OF 0.04 g²/HZ FROM 80 HZ TO 350 HZ FOR 30 SECONDS PER AXIS. THERMAL TEST - THE ASSEMBLY WAS THERMALLY CYCLED FROM +70 DEG F TO +260 DEG F TO +180 DEG F TO +70 DEG F. DWELL AT EACH LIMIT TEMPERATURE WAS AT LEAST 60 MINUTES AFTER THERMAL STABILIZATION. AT TEMPERATURE +180 DEG F AND -80 DEG F, THE ASSEMBLY WAS CYCLED 10 TIMES EACH FOR SINGLE MOTOR OPERATIONS AND 30 TIMES FOR 30 TIMES FOR DUAL MOTORS OPERATIONS. POWER CONSUMPTION - SEE QUALIFICATION TEST ABOVE. INSULATION RESISTANCE TEST - THE INSULATION RESISTANCE AT 500 VDC WAS MEASURED BETWEEN MUTUALLY INSULATED CONDUCTORS AND BETWEEN CONDUCTORS AND THE FRAME, CASE, OR GROUND.

ACCEPTANCE TESTS ALSO INCLUDE: CYCLING TEST - THE ASSEMBLY WAS CYCLED 10 TIMES EACH INDIVIDUALLY WITHIN 18 SECONDS/STROKE. IT WAS ALSO CYCLED 30 TIMES WITH BOTH MOTORS DRIVING TOGETHER WITHIN 7.5 SECONDS/STROKE. BONDING (ELECTRICAL) - ELECTRICAL BONDING PER MF0004-002 TO VERIFY THE RESISTANCE NOT TO EXCEED 0.0025 OHMS BETWEEN ENCLOSURES OR STRUCTURAL COMPONENTS. FREEPLAY TEST - THE ASSEMBLY WAS CHECKED TO VERIFY FREEPLAY TO BE 0.008 MAXIMUM IN THE VERTICAL DIRECTION AND 0.020 MAXIMUM IN THE HORIZONTAL DIRECTION. STALL/MAXIMUM TORQUE - SEE QUALIFICATION TEST ABOVE. IRREVERSIBILITY - SEE QUALIFICATION TEST ABOVE. MECHANICAL LIMIT - SEE QUALIFICATION TEST ABOVE.

OMRSD: GROUND TURNAROUND INCLUDES RELEASE PORT MRL (SYSTEM 1), LATCH PORT MRL (SYSTEM 1), RELEASE PORT MRL (SYSTEM 2), LATCH PORT MRL (SYSTEM 2), RELEASE PORT MRL (SYSTEMS 1 AND 2), AND LATCH PORT MRL (SYSTEMS 1 AND 2).

(C) INSPECTION

RECEIVING INSPECTION

MATERIAL AND PROCESS CERTIFICATIONS ARE VERIFIED BY INSPECTION. ALL PURCHASED PART DATA PAKS ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL

CLEANLINESS PER SPECIFICATION TO LEVEL 300 OF MA0110-301 AND A CLASS 100,000 CLEAN ROOM IN ACCORDANCE WITH FED-STD-209 ARE VERIFIED BY INSPECTION.

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ASSEMBLY/INSTALLATION

DIMENSIONS ARE VERIFIED BY INSPECTION. LUBRICANT APPLICATION IS VERIFIED BY INSPECTION. LATCH FORCES AND VOLTAGES ARE VERIFIED BY INSPECTION. GEARBOX ASSEMBLY AND BEARING INSTALLATION ARE VERIFIED BY INSPECTION. GEARS ARE HARDNESS CHECKED AND VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

MAGNETIC PARTICLE AND DYE-PENETRANT INSPECTION ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES

HEAT TREAT AND PASSIVATION OF STAINLESS STEEL ARE VERIFIED BY INSPECTION.

TESTING

ATP IS VERIFIED PER PROCEDURE.

HANDLING/PACKAGING

HANDLING AND PACKAGING REQUIREMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY

THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD OR FLIGHT FAILURES ASSOCIATED WITH THIS FAILURE MODE.

(E) OPERATIONAL USE

ACTUATOR MAY BE RECYCLED TO ATTEMPT TO CLEAR JAM. CREW CAN PERFORM EVA PROCEDURES FOR MANUAL RMS TIEDOWN. RMS JETTISON MAY BE PERFORMED IF MULTIPLE MRL FAILURES PRECLUDE SAFE ENTRY/LANDING. NO EVA CAPABILITY EXISTS TO UNLATCH MRL.