SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :ACTUATION MECH-PBD FMEA NO 02-4B -206 -1 REV:03/08/88

ASSEMBLY :PBD ACTUATION
P/N RI :TE130-0001
P/N VENDOR:TULSA DIVISION
QUANTITY :26
:13 PER DOOR

CRIT. FUNC: 1R
CRIT. HDW: 2

VEHICLE	102	103	104
EFFECTIVITY:	X	X	X
PHASE(S):	PL LO	OO X DO	LS

REDUNDANCY SCREEN: A-FAIL B-FAIL C-PASS

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ITEM:
BEARING, DOOR HINGE

FUNCTION:
INTERFACE BETWEEN DOOR AND MIDFUSELAGE. FIVE OF THIRTEEN HINGES PER DOOR HAVE SHEAR LOAD CAPABILITY TO TRANSFER LOADS IN FORE AND AFT DIRECTION.

FAILURE MODE:
FAILS TO ROTATE

CAUSE(S):
ADVERSE TOLERANCES/WEAR, CONTAMINATION/FOREIGN OBJECT/DEBRIS, CORROSION, DEFECTIVE PART/MATERIAL OR MANUFACTURING DEFECT, EXCESSIVE LOAD

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

(A,B,C,D) NONE. REDUNDANT SURFACE AVAILABLE TO PERFORM FUNCTION. POSSIBLE LOSS OF CREW VEHICLE IF MULTIPLE FAILURES PREVENT DOOR CLOSURE.

FAILS REDUNDANCY SCREEN "A" SINCE THERE ARE NO TURNAROUND TESTS FOR VERIFYING THIS FIRST FAILURE AND FAILS SCREEN "B" SINCE THERE IS NO VISUAL OR INSTRUMENTED WAY OF DETERMINING WHEN ONE SURFACE OF THE BEARING FAILS TO ROTATE.

DISPOSITION & RATIONALE:
(A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY (E)OPERATIONAL USE

(A) DESIGN
THE PAYLOAD BAY DOORS HINGE BEARINGS ARE SELF ALIGNING SPHERICAL BEARINGS FABRICATED OF INCONEL 718 FORGING MATERIAL. A SOLID LUBRICANT IS UTILIZED BETWEEN THE BEARING BALL AND RACE. MULTIPLE ROTATING SURFACES ARE PROVIDED (BALL/RACE AND HINGE PIN/BALL).

(B) TEST

QUALIFICATION TESTS: THE QUALIFICATION DRIVE SYSTEM IS CERTIFIED PER CR-29-162-0008-0001E AND THE QUALIFICATION ACTUATION MECHANISM INSTALLATION CERTIFIED PER CR-29-59412S-001G. THE DRIVE SYSTEM QUALIFICATION TEST INCLUDES: HUMIDITY TEST - PER MIL-STD-810B METHOD 507 PROCEDURE IV, CYCLE PDU DURING SECOND AND FOURTH HUMIDITY CYCLE: QUALIFICATION VIBRATION TEST (QAVT) - 20 TO 2,000 HZ RANGE WITH MAXIMUM OF 0.067 g^2/HZ FROM 80 TO 350 HZ FOR 2 1/2 MINUTES/AXIS IN ACCORDANCE WITH SP-T-0023B, MONITOR ELECTRICAL CONTINUITY DURING VIBRATION; FLIGHT VIBRATION - 20 TO 2,000 HZ RANGE WITH MAX OF 0.03 g_2/HZ FROM 100 TO 250 HZ FOR 4.5 MINUTES/AXIS LEVEL "A", AND 0.008 g^2/HZ FROM 100 TO 250 HZ FOR 94 MINUTES/AXIS LEVEL "B"; SHOCK TEST - BASIC DESIGN SHOCK PER MIL-STD-810B METHOD 516.1, PROCEDURE I AND TRANSIENT SHOCK AT 5 TO 35 HZ +/- 0.25 g PEAK.

QUAL TESTS ALSO INCLUDE: THERMAL VACUUM TEST - THERMALLY CYCLED 5 TIMES BETWEEN -100 DEG F AND +157 DEG F AT A VACUUM OF 1 X 10 -6 TORR FOR 55 HOURS, DRIVE SYSTEM CYCLED AT EACH -65 DEG F AND +157 DEG F; THERMAL CYCLING TEST - CYCLED 5 TIMES BETWEEN -100 DEG F AND +340 DEG F WITH DRIVE SYSTEM CYCLED AT EACH -100 DEG F AND +157 DEG F WITH 60 MINUTES DWELL AT EACH TEMPERATURE EXTREME; OPERATING LIFE TEST - DRIVE SYSTEM CYCLED 1,800 TIMES AT ROOM TEMPERATURE, INCLUDES MOTOR 1 AND 2 CYCLED 150 TIMES EACH INDIVIDUALLY WITHIN 126 SECONDS/STROKE AND 1,500 TIMES WITH BOTH MOTORS DRIVING TOGETHER WITHIN 63 SECONDS/STROKE; MECHANICAL STOPS TEST - 100 TIMES WITH BOTH MOTORS INTO HARD STOP IN EACH DIRECTION AT NC LOADS; STIFFNESS TEST - MEASURED SPRING RATE OF ROTARY ACTUATOR, TORQUE SHAFT, PDU AND SHAFT HANGER - GREATER THAN 0.5 X 10 -6 INCH-LB/RADIAN AT ROTARY ACTUATOR ARM); POWER CONSUMPTION TEST, IRREVERSIBILITY TEST, FREEPLAY TEST WAS CONDUCTED AS DEFINED IN THE ACCEPTANCE TESTS.

CERTIFICATION BY ANALYSIS/SIMILARITY INCLUDED: FUNGUS, OZONE, PACKAGING, LIMIT/ULTIMATE LOAD, ACCELERATION, LANDING SHOCK, SYSTEM STIFFNESS, TEMPERATURES, HUMIDITY, LIFE, PRESSURE, SHOCK AND VIBRATION FOR ITEMS OF DRIVE SYSTEM NOT TESTED. THE PBD ACTUATING MECHANISM INSTALLATION WAS SUBJECTED TO SYSTEM QUALIFICATION TESTS ON THE 15 FOOT PBD TEST ARTICLES (087) AND ON A 60 FOOT TEST RIG, TESTS INCLUDED: ACCEPTANCE - TO CONFIRM ALL COMPONENTS HAVE BEEN ASSEMBLED AND RIGGED PER ML0308-0032 ON THREE TEST SPECIMENS.

TESTS ON FORWARD 15 FOOT PANEL INCLUDED: ORBITAL FUNCTIONS - 3 THERMAL CONDITIONS WITH SIMULATED THERMAL DISTORTIONS OF THE FORWARD BULKHEAD AND THE LH AND RH LONGERON SILLS, 2 MOTOR OPERATIONS 22 CYCLES AT LESS THAN 63 SECONDS PER STROKE, EACH MOTOR OPERATION 3 CYCLES AT LESS THAN 126 SECONDS/STROKE FOR EACH OF THE 3 ORBITAL FUNCTIONS; OPERATING LIFE TESTS - PBD MECHANISM CYCLED 93 TIMES, 55 TIMES WITH TWO MOTOR OPERATION AND 19 TIMES WITH SINGLE MOTOR OPERATIONS; ACOUSTIC TEST - 25 HZ TO 8,000 HZ FOR 5 MINUTES.

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TESTS ON AFT 15 FOOT PANEL INCLUDED: ORBITAL FUNCTIONS - 3 THERMAL CONDITIONS WITH SIMULATED THERMAL DISTORTIONS OF THE AFT BULKHEAD AND THE LH AND RH LONGERON SILL, 2 MOTOR OPERATIONS 27 CYCLES AT LESS THAN 63 SECONDS/STROKE, EACH MOTOR OPERATION 3 CYCLES AT LESS THAN 126 SECONDS/STROKE FOR EACH OF THE 3 ORBITAL FUNCTIONS; OPERATING LIFE TESTS - MECHANISM CYCLED 243 TIMES 205 TIMES WITH TWO MOTOR OPERATION AND 19 TIMES WITH SINGLE MOTOR OPERATIONS; ACOUSTIC TEST - 25 HZ TO 6,000 HZ FOR 5 MINUTES.

TESTS ON 60 FOOT TEST RIG INCLUDED: AMBIENT CYCLING - 3 THERMAL CONDITIONS WITH THERMAL DISTORTIONS OF THE SILL LONGERON, 2 MOTOR OPERATIONS 22 CYCLES AT LESS THAN 63 SECONDS/STROKE; 10 WITHOUT DISTORTION SIMULATION; EACH SINGLE MOTOR OPERATION 3 WITHOUT DISTORTION AND 6 WITH DISTORTION AT LESS THAN 126 SECONDS/STROKE; TEMPERATURE CYCLING - 3 THERMAL CONDITIONS WITH THERMAL DISTORTIONS OF THE SILL LONGERON, 2 MOTOR OPERATIONS 22 CYCLES AT -42 DEG F AT LESS THAN 63 SECONDS/STROKE; 10 WITHOUT DISTORTION SIMULATION, EACH SINGLE MOTOR OPERATION 3 WITHOUT DISTORTION SIMULATION AND WITH DISTORTION AT LESS THAN 126 SECONDS/STROKE AT -42 DEG F; ORBITAL FUNCTIONAL TEST - REPEAT THE ABOVE AMBIENT AND -42 DEG F TESTS FOR A TOTAL OF 80 MECHANISM CYCLES. CERTIFICATION BY ANALYSIS/SIMILARITY INCLUDES FUNGUS, OZONE, PACKAGING, THERMAL/VACUUM, SALT SPRAY, ACOUSTIC, SHOCK, LIMIT/ULTIMATE LOADS, ACCELERATION, SAND/DUST AND MARGIN OF SAFETY.

ACCEPTANCE TEST: TESTS ON THE MC162-0008 COMPONENTS INCLUDES: EXAMINATION OF PRODUCT - WEIGHT, WORKMANSHIP, DIMENSIONS, CONSTRUCTION, CLEANLINESS, FINISH, IDENTIFICATION, MARKINGS, TRACEABILITY AND USE OF CERTIFIED MATERIALS AND PROCESSES; ACCEPTANCE VIBRATION (AVT) - 20 TO 2,000 HZ RANGE WITH MAXIMUM OF 0.04 g^2/HZ FROM 80 TO 350 HZ FOR 30 SECONDS/AXIS MINIMUM, ELECTRICAL CONTINUITY MONITORED DURING TESTS AND PDU CYCLED BEFORE AND AFTER VIBRATION; ACCEPTANCE THERMAL TEST (ATT) - THERMALLY CYCLED FROM +70 DEG F TO +320 DEG F, TO +157 DEG F, TO -80 DEG F, TO +320 DEG F, TO +157 DEG F, TO 70 DEG F WITH CONTINUITY MONITORED THROUGHOUT, PDU WAS CYCLED 6 TIMES AT EACH +157 DEG F AND 6 TIMES AT -80 DEG F AT LESS THAN 63 SECONDS/STROKE TWO MOTOR OPERATIONS AND 126 SECONDS/STROKE SINGLE MOTOR OPERATIONS; POWER CONSUMPTION TESTS -INPUT POWER MAX OF 450 WATTS/MOTOR AT RATED LOAD AND SINGLE MOTOR TIME OF 126 SECONDS/STROKE AND 63 SECONDS/STROKE DUAL MOTOR OPERATION; INSULATION RESISTANCE, DIELECTRIC STRENGTH - PER MF0004-002 EXCEPT TEST VOLTAGE WAS 750 VRMS. CYCLING TEST - SINGLE MOTOR DRIVE 20 CYCLES EACH AND DUAL MOTORS 40 CYCLES. FREEPLAY TEST - MAXIMUM OF 1.0 DEGREES WITH 10 IN LBS REVERSING TORQUE ON EACH ACTUATOR; ACTUATOR STALL - CONTINUOUS STALL FOR 126 SECONDS AT FULL INVERTOR POWER 120 VOLTS AC.

ACCEPTANCE TESTS ALSO INCLUDE: IRREVERSIBILITY TEST - 650 INCH-LB AT PDU OUTPUT SHAFT; TRAVEL LIMIT TEST - ACTUATOR STOPPED BY LIMIT SWITCHES AND BY HARD STOPS WITH SWITCHES DEENERGIZED; MANUAL OPERATIONS - LESS THAN 100 INCH-LB TORQUE TO ENGAGE AND DISENGAGE THE PDU; BACKDRIVE - FORCE AT ACTUATOR OUTPUT ARM ROD ATTACH POINT LESS THAN 150 POUNDS; TORQUE LIMITS - ROTARY ACTUATOR OUTPUT LIMITS AT ROOM AMBIENT ARE 6,200 TO 8,950 INCH-LB, OUTPUT LIMITS AT +157 DEG F AND -65 DEG F ARE 6,200 TO 10,000 INCH-LB; PROOF LOAD TESTS - 3/4 O.D. DRIVE SHAFTS TESTED TO 325 INCH-LB AND 1.0 O.D. DRIVE SHAFTS TESTED TO 650 INCH-LB; FRICTION TORQUE TEST - TORQUE ON SHAFT SUPPORT IS LESS THAN 1.0 INCH-LB. EACH TORQUE SHAFT IS PROOF LOADED DURING ACCEPTANCE.

OMRSD: NONE. NO PRACTICAL OMRSD TEST TO DETECT FIRST FAILURE. PROPER FUNCTION OF THE COMPONENTS IS VERIFIED PERIODICALLY AS PART OF THE MAINTENANCE SAMPLING PROGRAM.

(C) INSPECTION

RECEIVING INSPECTION
MATERIAL AND PROCESS CERTIFICATIONS VERIFIED BY INSPECTION.

CONTAMINATION CONTROL
INSPECTION VERIFIES CLEANLINESS AND CORROSION CONTROL REQUIREMENTS.

ASSEMBLY/INSTALLATION
BEARING INSTALLATION VERIFIED BY INSPECTION. BEARINGS ARE VERIFIED AND ACCEPTED TO ENGINEERING DRAWINGS. HINGE ASSEMBLY LOCATION/SPACING/ ALIGNMENT IS CONTROLLED BY INTERFACE CONTROL TOOLS AND VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
MACHINED HINGE IS PENETRANT INSPECTED, VERIFIED BY INSPECTION.

CRITICAL PROCESSES
HEAT TREATMENT IS VERIFIED BY INSPECTION. SOLID LUBRICANT APPLICATION VERIFIED BY INSPECTION.

TESTING
INSTALLATION OF BEARINGS INTO HINGES IS TESTED FOR PROOF LOAD AND TORQUE; VERIFIED BY INSPECTION.

HANDLING/PACKAGING
HANDLING AND PACKAGING REQUIREMENTS ARE VERIFIED.

(D) FAILURE HISTORY

CAR NO. AB3989 : DURING LIFE CYCLE TESTING, THE PAYLOAD BAY DOOR HINGE BEARING EXHIBITED A COEFFICIENT OF FRICTION WHICH EXCEEDED THE MAXIMUM REQUIREMENT OF 0.25; THE FAILURE WAS CAUSED BY WEAR DEBRIS BUILD-UP AND A WEAROUT OF THE VITROLUBE ON THE HINGE PIN WHICH RESULTED IN PIN/BEARING METAL-TO-METAL CONTACT AND CONSEQUENT INCREASE IN COEFFICIENT OF FRICTION; THE HINGE PIN WAS STRIPPED DOWN TO THE CHROME PLATE SURFACE AND WAS RECOATED WITH VITROLUBE PER DRAWING.

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CAR NO. AC3286 : DURING QUALIFICATION TEST, THE COEFFICIENT OF FRICTION EXCEEDED THE DESIGN REQUIREMENT: HIGH FRICTION OCCURRED WHEN TRANSLATIONAL SLIDE MOTION TOOK PLACE BETWEEN THE PIN AND BEARING BORE; CORRECTIVE ACTION WAS A REDESIGN OF THE BEARING WITH THE ENDS OF THE LINER IN THE BORE HAVING A RADIUS INSTEAD OF A SHARP EDGE.

(E) OPERATIONAL USE
NONE.