

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :ACTUATION MECH-PBD FMEA NO 02-4B -201 -1 REV:03/08/88

ASSEMBLY :PBD ACTUATION CRIT. FUNC: 1R
 P/N RI :MC162-0008-0004, -0034 CRIT. HDW: 2
 P/N VENDOR:181650-1 CURTISS-WRIGHT VEHICLE 102 103 104
 QUANTITY :4 EFFECTIVITY: X X X
 :2 PER DOOR ASSEMBLY PHASE(S): PL 10 00 X DO LS

REDUNDANCY SCREEN: A-PASS B-PASS C-PASS
 PREPARED BY: APPROVED BY: APPROVED BY (NASA):
 DES M. A. ALLEN DES *[Signature]* SSM *[Signature]* 3/17/88
 REL M. B. MOSKOWITZ REL *[Signature]* REL *[Signature]*
 QE W. J. SMITH QE *[Signature]* QE *[Signature]*

ITEM:
 MOTOR, ACTUATOR DRIVE

FUNCTION:
 TO PROVIDE POWER, THROUGH DIFFERENTIAL GEARING, FOR TRANSMISSION TO THE POWER DRIVE SHAFT FOR DEPLOYING THE PAYLOAD BAY DOORS TO POSITION.

FAILURE MODE:
 LOSS OF OUTPUT

CAUSE(S):
 CONTAMINATION/FOREIGN OBJECT/DEBRIS, DEFECTIVE PART/MATERIAL OR MANUFACTURING DEFECT, ELECTRICAL FAILURE- OPEN, SHORT, ETC., FAILURE/ DEFLECTION OF INTERNAL PART, BRAKE FAILS TO DISENGAGE

EFFECTS ON:
 (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE
 (A,B,C) NO EFFECT.

(D) REDUNDANT MOTOR DRIVES DOOR OPEN OR CLOSED. ACTUATION TIME DOUBLED WITH SINGLE MOTOR OPERATION. LOSS OF SECOND MOTOR RESULTS IN LOSS OF DRIVE SYSTEM CAPABILITY TO OPEN OR CLOSE PAYLOAD BAY DOOR. POSSIBLE LOSS OF CREW/VEHICLE IF PAYLOAD BAY DOORS CANNOT BE CLOSED.

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

(A) DESIGN
 MOTORS HAVE CAPABILITY FOR OPERATING WITH 2 OF 3 PHASES. MOTOR WITHSTANDS DIELECTRIC CHECK OF 1,000 VRMS FOR 60 SECONDS IN ACCEPTANCE TEST PROCEDURE (ATP) AND SUBSEQUENT CHECKS AT 750 VRMS, IR IS 50 MEGOHMS MINUTES AT 500 VDC. MOTOR WINDINGS ARE ENCAPSULATED. LIMIT SWITCHES ARE HIGH RELIABLE PARTS. DESIGN OF THE ACTUATION SYSTEM PERMITS PARTIAL WORKAROUND OF SECOND FAILURE (SEE EFFECTS) BY EXTRAVEHICULAR ACTIVITY (EVA) CREW IF PAYLOAD DOES NOT LIMIT ACCESS.

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(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-29-594125-001G. 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 516.2, 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 1×10^{-6} TORR FOR 55 HOURS, DRIVE SYSTEM CYCLED AT EACH -68 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 NO LOADS; STIFFNESS TEST - MEASURED SPRING RATE OF ROTARY ACTUATOR, TORQUE SHAFT, PDU AND SHAFT HANGER - GREATER THAN 0.5×10^{-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, CLEANLINES, 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 MFC004-002 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.

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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 5,200 TO 8,950 INCH-LB, OUTPUT LIMITS AT +157 DEG F AND -65 DEG F ARE 5,200 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: GROUND TURNAROUND INCLUDES SINGLE MOTOR FUNCTIONAL TESTS IN BOTH DIRECTIONS VERIFY INTEGRITY OF INDIVIDUAL BRAKE OPERATION.

(C) INSPECTION

RECEIVING INSPECTION

MATERIAL CERTIFICATION VERIFIED BY RECEIVING INSPECTION. SUPPLIER AND SUPPLIER PERSONNEL CERTIFIED TO PERFORM SURFACE FINISH. ALL PURCHASED PARTS DATA PACKAGES INSPECTED BY RECEIVING INSPECTION.

CONTAMINATION CONTROL

BEARINGS INSPECTED PRIOR TO INSTALLATION FOR CONTAMINATION. DETAIL PARTS ARE CLEANED TO A 300 LEVEL AT SUPPLIER. SUPPLIER CONTAMINATION CONTROL AND CORROSION PROTECTION PROVISIONS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

BEARING LUBRICATION AND SEAL INSTALLATION VERIFIED BY INSPECTION. ALL MACHINED PARTS ARE DEBURRED VERIFIED BY INSPECTION. INSTALLATION PROCEDURE VERIFIED BY INSPECTION. DCAS MANDATORY INSPECTION POINTS (MIPS) IMPOSED ON MANUFACTURING, INSTALLATION, AND ASSEMBLY OF ACTUATORS. ASSEMBLY OF POWER DRIVE UNIT (PDU) PER CPS 6916 VERIFIED BY INSPECTION.

CRITICAL PROCESSES

ENCAPSULATION OF MOTOR WINDINGS IS VERIFIED BY INSPECTION.

TESTING

ATP OF PDU PER CPS 6884 VERIFIED BY INSPECTION.

HANDLING/PACKAGING

HANDLING AND PACKAGING REQUIREMENTS VERIFIED BY INSPECTION.

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(D) FAILURE HISTORY

CAR NO. A8563 : DURING ONE MOTOR OPERATION ACCEPTANCE TESTING, THE DIFFERENTIAL LOCKED UP AND THERE WAS NO OUTPUT FROM THE ACTUATOR; FAILURE CAUSED BY ONE OF FOUR SPUR GEAR BUSHINGS IN THE DIFFERENTIAL ASSEMBLY WHICH HAD SEIZED ON ITS INNER RACE (PIN) AND THE INNER RACE (PIN) SEIZED IN THE CARRIER DUE TO "PICKING-UP" BRONZE FROM THE BUSHING; ALUMINUM BRONZE BUSHINGS IN THE SPUR GEAR/BUSHING SUB-ASSEMBLIES WERE REPLACED.

CAR NO. A86393 : SYSTEM "B" MOTOR IN PAYLOAD BAY DOOR DRIVE ACTUATOR WOULD NOT OPERATE DURING LIFE CYCLE TEST OF FORWARD PAYLOAD BAY DOOR TEST ARTICLE; FAILURE CAUSED BY A LOOSE SET SCREW (WHICH WAS NOT REMOVED AFTER DRILLING AND PINNING THE BLOCK) WHICH JAMMED BETWEEN THE ROTOR AND THE HOUSING; THE ACTUATOR MOTOR SUPPLIER CHANGED ASSEMBLY DRAWINGS, MANUFACTURING PROCEDURES, AND INSPECTION PROCEDURES TO REQUIRE VERIFICATION OF REMOVAL OF THE SET SCREW AFTER DRILLING AND PINNING BLOCK TO SHAFT.

CAR NO. AC6212 : DURING ACCEPTANCE FUNCTIONAL TEST OF PAYLOAD BAY DOOR DRIVE ACTUATOR, ONE OF THE TWO MOTORS BECAME LOCKED UP AND WOULD NOT RUN; CAUSE OF THE LOCKED-UP MOTOR WAS FAILURE OF THE BRAKE TO RELEASE WHEN THE MOTOR ENERGIZED (BRAKE FAILURE CAUSED BY MELTED POTTING MATERIAL FROM THE BRAKE COILS CONTACTING THE BRAKE DISC); PROPER CONTROLS ESTABLISHED FOR MIXING AND CURING OF BRAKE COIL EPOXY COMPOUND AT THE SUPPLIER.

(E) OPERATIONAL USE

FOLLOWING SECOND FAILURE, IVA WORKAROUND IS POSSIBLE TO CLOSE DOOR.