

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : ACTUATION MECH-PBD FMEA NO 02-4B -200 -1 REV:03/08/88

ASSEMBLY : PBD ACTUATION  
 P/N RI : MC162-0008-0010 THRU -0029  
 P/N VENDOR: CURTISS-WRIGHT  
 QUANTITY : 36  
 : 18 PER SIDE

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

CRIT. FUNC: 1  
 CRIT. HDW: 1

PREPARED BY:  
 DES M. A. ALLEN  
 REL M. B. MOSKOWITZ  
 QE W. J. SMITH

REDUNDANCY SCREEN: A- B- C-  
 APPROVED BY:  
 DES *D. Campbell* APPROVED BY (NASA):  
 REL *[Signature]* SSM *R.C. Mead 3/18/88*  
 QE *[Signature]* REL *[Signature]*

ITEM:  
 TORQUE SHAFT, POWER DRIVE

FUNCTION:  
 TRANSMITS TORQUE FROM THE POWER DRIVE UNIT (PDU) MC162-0008-0034 (REF. FMEA/CIL 02-4B-202-1) TO THE ROTARY ACTUATORS.

FAILURE MODE:  
 STRUCTURAL FAILURE

CAUSE(S):  
 STRESS CORROSION, FATIGUE, OVERSTRESS DUE TO BINDING

EFFECTS ON:  
 (A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE  
 (A,B) LOSS OF FUNCTION- PAYLOAD BAY DOOR CANNOT BE CLOSED OR OPENED.  
 (C) POSSIBLE LOSS OF MISSION IF PAYLOAD BAY DOORS CANNOT BE OPENED.  
 (D) 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  
 TORQUE TUBES ARE 2024-T3 ALUMINUM ALLOY WITH 2024-T62 END FITTINGS. SHAFTS ARE SIZED FOR MAXIMUM TORQUE LIMITER SETTING. BEARINGS INCORPORATE MULTIPLE ROTATING SURFACES. DESIGN OF THE ACTUATION SYSTEM PERMITS PARTIAL WORKAROUND OF THIS FAILURE MODE 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 516.1, 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  $1 \times 10^{-6}$  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 NO LOADS; STIFFNESS TEST - MEASURED SPRING RATE OF ROTARY ACTUATOR, TORQUE SHAFT, PDU AND SHAFT HANGER - GREATER THAN  $0.5 \times 10^{-6}$  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 MLO308-0032 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<sup>2</sup>/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.

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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 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: GROUND TURNAROUND INCLUDES VISUAL INSPECTION OF HARDWARE TO INSURE THAT PARTS ARE NOT BROKEN OR DEFORMED AND MONITORING FUNCTIONAL TEST FOR EVIDENCE OF BINDING OR JAMMING. PROPER FUNCTION OF THE COMPONENTS IS VERIFIED PERIODICALLY AS PART OF THE MAINTENANCE SAMPLING PROGRAM.

(C) INSPECTION

RECEIVING INSPECTION

MATERIAL CERTIFICATION VERIFIED BY RECEIVING INSPECTION.

CONTAMINATION CONTROL

DETAIL PARTS ARE CLEANED TO A 300 LEVEL. SUPPLIER CONTAMINATION CONTROL AND CORROSION PROTECTION VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

ALL MACHINED PARTS ARE DEBURRED AND VERIFIED PER DRAWING. INSTALLATION PROCEDURE VERIFIED BY INSPECTION. DCAS MANDATORY INSPECTION POINTS (MIPS) IMPOSED ON MANUFACTURING, INSTALLATION, AND ASSEMBLY. DIMENSIONS VERIFIED BY INSPECTION. ROUGHNESS OF SPLINES VERIFIED BY INSPECTION. STRAIGHTNESS OF TUBES VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

FLUORESCENT PENETRANT INSPECTION PER MIL-I-6866 VERIFIED BY INSPECTION.

CRITICAL PROCESSES

HEAT TREATMENT OF 2024 ALUMINUM VERIFIED BY INSPECTION. ANODIZATION OF 2024 ALUMINUM PER MIL-A-8625 TYPE II VERIFIED BY INSPECTION. SWAGING OF END FITTINGS TO TUBES VERIFIED BY INSPECTION.

TESTING

ACCEPTANCE TESTING OF SHAFTS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

HANDLING AND PACKAGING REQUIREMENTS ARE VERIFIED.

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(D) FAILURE HISTORY

CAR NO. AB5748 : DURING QUALIFICATION TESTS OF THE PAYLOAD BAY DOOR DRIVE SYSTEM, THE BOLT THROUGH THE DRIVE SHAFT COUPLING BROKE OFF AT THE LOOP-PIN HOLE WHEN TORQUE WAS APPLIED; THE TYPE OF SELF-LOCKING NUT USED BY THE DRIVE SYSTEM SUPPLIER WAS UNSUITABLE FOR USE WITH DRILLED BOLTS BECAUSE OF FRICTION IN THE THREAD; BROKEN BOLTS REMOVED/REPLACED AND THE SUPPLIER NUTS WERE REPLACED WITH SUITABLE STANDARD NUTS.

(E) OPERATIONAL USE

EVA WORKAROUND IS POSSIBLE TO CLOSE DOOR IF PAYLOAD DOES NOT LIMIT ACCESS.