

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :ACTUATION MECH-RADIATORS FMEA NO 02-4G -153 -1 REV:03/07/88

ASSEMBLY :RADIATOR DEPLOYMENT		CRIT. FUNC: 1R
P/N RI :MC287-0037-0005		CRIT. HDW: 2
P/N VENDOR:15820-22 HOOVER ELECTRIC	VEHICLE 102 103 104	
QUANTITY :4	EFFECTIVITY: X X X	
:2 PER SIDE	PHASE(S): PL LO OO X DO LS	

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

PREPARED BY:	APPROVED BY:	APPROVED BY (NASA):
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ITEM:  
MOTORS, ROTATIONAL DRIVE

FUNCTION:  
THE ELECTRIC MOTORS ARE INSTALLED ON THE POWER DRIVE UNIT (PDU) AND PROVIDE THE DRIVE MOTION THRU TORQUE SHAFTS, ROTARY ACTUATORS AND BELLCRANKS FOR DEPLOYING THE RADIATOR.

FAILURE MODE:  
LOSS OF OUTPUT

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

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

(A) LOSS OF REDUNDANCY.

(B,C,D) NONE - REDUNDANT MOTOR CAPABLE OF DEPLOYMENT/RETRACTION AT REDUCED RATES. FAILURE OF SECOND MOTOR COULD RESULT IN LOSS OF CAPABILITY TO STOW RADIATOR RESULTING IN INTERFERENCE WITH CLOSING OF PAYLOAD BAY DOOR. POSSIBLE LOSS OF CREW VEHICLE.

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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. INSULATION RESISTANCE (IR) IS 50 MEGOHMS MINIMUM AT 500 VDC. 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 AND IF RADIATORS ARE FULLY DEPLOYED.

(B) TEST

QUALIFICATION TEST: A SIMILAR ACTUATOR HAS BEEN CERTIFIED BY CR-29-287-0037-0001G. QUALIFICATION TESTS INCLUDE: ACCEPTANCE TEST TO VERIFY CONFORMANCE WITH THE REQUIREMENTS NOTED BELOW FOR ACCEPTANCE TEST. HUMIDITY TEST - TEST 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 g<sup>2</sup>/HZ FROM 80 TO 350 HZ FOR 2.5 MINUTES PER AXIS; ORBITAL FLIGHT TEST - 20 TO 2,000 HZ RANGE WITH MAXIMUM OF 0.2 g<sup>2</sup>/HZ FROM 60 TO 300 HZ FOR 27 MINUTES PER AXIS AT LEVEL "B" AND WITH MAX OF 0.75 g<sup>2</sup>/HZ FROM 65 TO 300 HZ FOR 51 MINUTES PER AXIS AT LEVEL "A"; SHOCK TEST - TEST IN ACCORDANCE WITH MIL-STD-810B, METHOD 516.1, PROCEDURE I; THERMAL/VACUUM - THE ACTUATOR WAS THERMALLY CYCLED FIVE TIMES FROM +70 DEG F TO +330 DEG F TO +250 DEG F TO -167 DEG F TO -100 DEG F TO +70 DEG F IN A VACUUM OF 1 X 10<sup>-6</sup> TORR. DWELL AT EACH TEMPERATURE EXTREME WAS 60 MINUTES MINIMUM AFTER STABILIZATION. AT EACH +250 DEG F AND -100 DEG F, THE ACTUATOR WAS CYCLED 6 TIMES FOR DUAL MOTOR OPERATIONS AND 4 TIMES FOR SINGLE MOTOR OPERATIONS; ELECTRICAL CONTINUITY - MONITORED THROUGHOUT THE TEST. THERMAL TEST - THE ACTUATOR WAS THERMALLY CYCLED FIVE TIMES FROM +70 DEG F TO +330 DEG F TO +250 DEG F TO -167 DEG F TO -100 DEG F TO +70 DEG F. DWELL AT EACH TEMPERATURE EXTREME WAS 60 MINUTES MINIMUM AFTER STABILIZATION, AFTER EACH +250 DEG F AND -100 DEG F. THE ACTUATOR WAS CYCLED 6 TIMES FOR DUAL MOTOR OPERATIONS AND 4 TIMES FOR SINGLE MOTOR OPERATIONS. ELECTRICAL CONTINUITY MONITORED THROUGHOUT THE TEST.

QUAL TESTS ALSO INCLUDE: CYCLING AT HIGH TEMPERATURE +250 DEG F EXTREME INCLUDED OPERATION AT THE MAXIMUM HEAT DISSIPATING MODE; CYCLING AT THE LOW TEMPERATURE -100 DEG F EXTREME INCLUDED OPERATION AT THE MINIMUM HEAT DISSIPATING MODE. OPERATING LIFE TEST - THE ACTUATOR WAS CYCLED 1,500 TIMES AT ROOM TEMPERATURE. MOTOR NO. 1 AND NO. 2 WERE CYCLED 250 TIMES EACH INDIVIDUALLY WITHIN 60 SEC/STROKE. IT WAS ALSO CYCLED 100 TIMES WITH BOTH MOTORS DRIVING TOGETHER WITHIN 30 SECONDS/STROKE; MECHANICAL STOP TEST - THE ACTUATOR WAS OPERATED AT FULL RATE AND NO LOAD INTO MECHANICAL STOP FOR 100 TIMES IN EACH DIRECTION; CERTIFICATION BY ANALYSIS - THESE INCLUDED FUNGUS, OZONE, SALT SPRAY, SAND/DUST, TRANSPORTATION PACKAGING, ACCELERATION, LANDING SHOCK, EXPLOSIVE ATMOSPHERE AND MARGIN OF SAFETY. THE ACTUATORS WERE SUBJECTED TO SYSTEM QUALIFICATION TESTS PER RADIATOR LATCHING MECHANISM INSTALLATION V070-594450 (REF. CR-29-594450-001E) AND RADIATOR DEPLOYMENT MECHANISM INSTALLATION V070-594400 (REF. CR-29-594400-001D).

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ACCEPTANCE TESTS: ACCEPTANCE TESTS INCLUDE: EXAMINATION OF PRODUCT - WEIGHT, WORKMANSHIP, DIMENSION, CONSTRUCTION, CLEANLINESS, FINISH, IDENTIFICATION MARKING, TRACEABILITY AND USE OF APPROVED MATERIALS AND PROCESSES; ACCEPTANCE VIBRATION TEST - 20 TO 2,000 HZ WITH MAXIMUM OF 0.04 g<sup>2</sup>/HZ FROM 20 TO 350 HZ FOR 30 SECOND PER AXIS; ACCEPTANCE THERMAL TEST - THERMALLY CYCLED FROM 70 DEG F TO +310 DEG F TO +350 DEG F TO -147 DEG F TO -100 DEG F TO +310 DEG F TO +250 DEG F TO +70 DEG F. DWELL AT EACH TEMPERATURE WAS AT LEAST 60 MINUTES AFTER THERMAL STABILIZATION. AT EACH +250 DEG F AND -100 DEG F THE ACTUATOR WAS CYCLED 6 TIMES FOR DUAL MOTOR OPERATIONS AND 4 TIMES FOR SINGLE MOTOR OPERATIONS; POWER CONSUMPTION TEST - VERIFIED THE INPUT POWER DID NOT EXCEED 62 WATTS PER MOTOR AND THE INPUT CURRENT DID NOT EXCEED 0.36 AMP PER PHASE PER MOTOR WHEN OPERATING AT THE MAXIMUM LOAD. THE INPUT POWER REQUIREMENT OF 117 WATTS AND INPUT CURRENT OF 0.67 AMP WERE ALSO VERIFIED UNDER STARTING CONDITIONS; INSULATION RESISTANCE TEST - THE INSULATION RESISTANCE AT 500 VDS WAS MEASURED BETWEEN MUTUALLY INSULATED CONDUCTORS AND BETWEEN CONDUCTORS AND THE FRAME, CASE OR GROUND; DIELECTRIC STRENGTH TEST - 750 VRMS AT 60 HZ APPLIED BETWEEN EACH CONDUCTOR PIN AND THE CASE.

ACCEPTANCE TESTS ALSO INCLUDE: CYCLING - ACTUATOR WAS CYCLED 80 TIMES TOTAL WITH MOTORS NO. 1 AND NO. 2 CYCLED 10 TIMES EACH INDIVIDUALLY WITHIN 60 SECONDS/STROKE. IT WAS ALSO CYCLED 60 TIMES WITH BOTH MOTORS DRIVING TOGETHER WITHIN 30 SECOND/ STROKE; FREEPLAY TEST - FREEPLAY AT THE ACTUATOR OUTPUT SHAFT NOT TO EXCEED 2.0 DEGREES WITH 10 INCH-LB LOAD APPLIED IN EACH DIRECTION; STALL/MAXIMUM TORQUE - THE ACTUATOR'S STALL/MAXIMUM OUTPUT NOT TO EXCEED 100 INCH-LB OR BE LESS THAN 50 INCH-LB; IRREVERSIBILITY - THE ACTUATOR WAS CHECKED TO BE IRREVERSIBLE TO LOAD OF 50 INCH-LB; MECHANICAL STOP TEST - ACTUATOR OPERATED AT FULL RATE AND NO LOAD INTO ITS MECHANICAL STOPS FOR 100 TIMES IN EACH DIRECTION; ELECTRICAL/MECHANICAL LIMIT TEST -THE OUTPUT ARM OF THE ACTUATOR MOVED THROUGH THE FULL CLOCKWISE TO COUNTER-CLOCKWISE TO CLOCKWISE ELECTRICAL LIMIT TRAVEL.

OMRSD: GROUND TURNAROUND INCLUDES MONITORING FUNCTIONAL TEST TO VERIFY THAT DEPLOY/STOW INDICATORS ARE FUNCTIONING WHEN RADIATORS ARE ACTIVATED AND THAT DRIVES OPERATE WITHIN SPECIFICATION LIMITS. THESE TESTS ARE PERFORMED FIRST FLIGHT AND FOR EVERY FLIGHT WHERE THE RADIATORS WILL BE DEPLOYED.

(C) INSPECTION

RECEIVING INSPECTION

CERTIFICATION OF COMPLIANCE, TEST COUPONS, PHYSICAL AND CHEMICAL RECORDS ARE MAINTAINED IN THE MASTER FILE. RECEIVING INSPECTION PERFORMS VISUAL AND DIMENSIONAL EXAMINATION OF ALL INCOMING PARTS. QUALITY CONTROL MAINTAINS SURVEILLANCE OF RAW MATERIAL, LIMITED LIFE MATERIALS, CHEMICAL AND METALLURGICAL TESTS AND REPORTS. RECEIVING INSPECTION VERIFIES MATERIAL AND PROCESS CERTIFICATIONS.

02-46.15

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CONTAMINATION CONTROL

A CLASS 100,000 CLEAN ROOM FACILITY IS USED FOR ASSEMBLY. ALL METAL PARTS ARE VERIFIED BY INSPECTION TO BE CLEANED AND PROPERLY PACKAGED. FINAL INSPECTION INCLUDES CHECKS FOR CONTAMINATION USING BORESCOPES, 5X AND 10X MAGNIFICATION DEVICES, AND MEMBRANE FILTRATION METHODS.

ASSEMBLY/INSTALLATION

INSPECTION VERIFIES AND RECORDS DIMENSIONS OF ALL DETAIL PARTS.

NONDESTRUCTIVE EVALUATION

ALL DETAIL PARTS MACHINED TO HOOVER DRAWINGS ARE MAGNETIC PARTICLE INSPECTED PER MIL-I-6868 OR FLUORESCENT PENETRANT INSPECTED PER MIL-I-6866, DEPENDING ON ALLOY, VERIFIED BY INSPECTION.

CRITICAL PROCESSES

CRIMPING CONTROLS ARE MAINTAINED IN ACCORDANCE WITH MSC-SPEC-Q-1A. SOLDERING IS VERIFIED BY INSPECTION IN ACCORDANCE WITH NHB5300.4 (3A).

TESTING

ACCEPTANCE TESTING OF ACTUATOR VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PARTS ARE TRANSPORTED IN STAINLESS STEEL TRAYS OR TOTE BOXES. POLYETHYLENE SHEETING, USED TO BAG AND SEAL PARTS AFTER CLEANING, IS VERIFIED BY INSPECTION. HANDLING AND PACKAGING REQUIREMENTS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY

CAR NO. AB3569 : DURING QUALIFICATION VIBRATION TEST OF RADIATOR PANEL DRIVE ACTUATOR, THE CLUTCH HOUSING FRACTURED AT THE BASE ATTACHMENT FLANGE; CAUSE OF THE HOUSING FRACTURE WAS FATIGUE DUE TO MAGNITUDE AND DURATION OF VIBRATION LEVELS COMBINED WITH IMPROPER OR NO HEAT TREATMENT OF CASTING, AND SMALL FILLET RADIUS; FOR OV102 SEVENTH AND SUBSEQUENT FLIGHTS AND FOR SUBSEQUENT VEHICLES, AN INCREMENTAL QUALIFICATION VIBRATION TEST WILL BE PERFORMED ON RADIATOR LATCH ACTUATOR TO DETERMINE ACTUATOR LIFE. ACTUATOR LIFE FOR OV102 LIMITED TO 50 MISSIONS.

(E) OPERATIONAL USE

FOLLOWING SECOND FAILURE, EVA WORKAROUND IS POSSIBLE IF RADIATORS ARE FULLY DEPLOYED.