

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :ACTUATION MECH-RADIATORS FMEA NO 02-4G -155 -2 REV:03/07/88

ASSEMBLY :RADIATOR DEPLOYMENT ACTUATOR CRIT. FUNC: 1R
 P/N RI :MC287-0037-0005 CRIT. HDW: 3
 P/N VENDOR:15820-22 HOOVER ELECTRIC VEHICLE 102 103 104
 QUANTITY :4 EFFECTIVITY: X X X
 :TWO PER ACTUATOR PHASE(S): PL LO OO X DO LS
 :ONE ACTUATOR PER SIDE

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

PREPARED BY:		APPROVED BY:		APPROVED BY (NASA):	
DES	M. A. ALLEN	DES	<i>B. Campbell</i>	SSM	<i>R.C. Moore 3/18/88</i>
REL	M. B. MOSKOWITZ	REL	<i>M.B. Moskowitz</i>	REL	<i>M.B. Moskowitz</i>
QE	W. J. SMITH	QE	<i>W.J. Smith</i>	QE	<i>W.J. Smith</i>

ITEM:
 TORQUE LIMITER

FUNCTION:
 PROTECTS LINKAGE BY SLIPPING WHEN DEPLOYMENT MECHANISM IS STALLED OR JAMMED. ACTUATOR OUTPUT TORQUE IS LIMITED TO 50-100 INCH-LB. TWO TORQUE LIMITERS PER ACTUATOR ARE INSTALLED BETWEEN DRIVE MOTORS AND DIFFERENTIAL.

FAILURE MODE:
 FAILS TO SLIP AT MAXIMUM ALLOWABLE TORQUE

CAUSE(S):
 ADVERSE TOLERANCES WEAR, CHANGE IN MATERIAL PROPERTIES, CONTAMINATION/ FOREIGN OBJECT/DEBRIS, DEFECTIVE PART/MATERIAL OR MANUFACTURING DEFECT, TEMPERATURE

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

- (A) POSSIBLE DAMAGE TO DEPLOYMENT LINKAGE OR ACTUATOR MOTORS IF STALLED OR JAMMED CONDITION OCCURS.
- (B) POSSIBLE INABILITY TO RECYCLE RADIATOR DEPLOYMENT MECHANISM, TO STOW RADIATOR AND CLOSE PAYLOAD BAY DOORS.
- (C,D) POSSIBLE LOSS OF VEHICLE/CREW IF RADIATOR CANNOT BE STOWED RESULTING IN INTERFERENCE WITH CLOSING OF PAYLOAD BAY DOORS.

FAILS REDUNDANCY SCREEN "A" SINCE THERE ARE NO TURNAROUND TESTS FOR TORQUE SLIPPAGE AND FAILS SCREEN "B" SINCE TORQUE SLIPPAGE CANNOT BE VISUALLY DETECTED IN FLIGHT.

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DISPOSITION & RATIONALE:

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

(A) DESIGN

SPRING LOADED BALL CLUTCH WITH VESPEL AND STEEL CLUTCH DISKS. NO WEAR IN NORMAL OPERATION OF ACTUATOR - TORQUE LIMITING IS REQUIRED ONLY IN JAMMED OR OVERLOAD CONDITION. DEVELOPMENT TESTS SHOWED NEGLIGIBLE CHANGE IN TORQUE LIMITER OUTPUT AFTER 4 HOURS CONTINUOUS RUN. THE DRIVE ACTUATOR IS DESIGNED TO WITHSTAND FULL STALL TORQUE AT FULL INVERTOR AC POWER FOR A LIMITED TIME WITHOUT DAMAGE. MAXIMUM STALL TIMES FOR THE DEPLOYMENT ACTUATOR ARE 100 SECONDS FOR ONE MOTOR AND 50 SECONDS FOR TWO. TWO TORQUE LIMITERS ARE INCLUDED IN THE POWER DRIVE UNIT (PDU), EITHER OF WHICH WILL LIMIT THE OUTPUT TORQUE. DESIGN OF THE ACTUATION SYSTEM PERMITS PARTIAL WORKAROUND OF THE FAILURE MODE 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 g²/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 g²/HZ FROM 60 TO 300 HZ FOR 27 MINUTES PER AXIS AT LEVEL "B" AND WITH MAX OF 0.75 g²/HZ FROM 65 TO 300 HZ FOR 51 MINUTES PER AXIS AT LEVEL "A"; SHOCK TEST - TEST IN ACCORDANCE WITH MIL-STD-810B, METHOD S16.1, 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 10⁻⁶ 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.

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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).

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 CP 0.04 g²/HZ FROM 80 TO 350 HZ FOR 30 SECOND PER AXIS; ACCEPTANCE THERMAL TEST - THERMALLY CYCLED FROM 70 DEG F TO +310 DEG F TO +250 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.

QMRSD: NONE. ACTUATOR CANNOT BE CHECKED FOR THIS FAILURE MODE DURING SYSTEM FUNCTIONAL CHECK.

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(C) INSPECTION

RECEIVING INSPECTION

CERTIFICATION OF COMPLIANCE, TEST COUPONS, PHYSICAL AND CHEMICAL RECORDS ARE MAINTAINED IN THE MASTER FILE. HISTORICAL FOLDERS, WHICH INCLUDE INSPECTION RECORDS, ARE MAINTAINED FOR EVERY DETAIL PART. 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. SPRINGS ARE MANUFACTURED AND CHECKED BY HELCO SUPPLIERS. CERTIFICATION IS ON FILE.

CONTAMINATION CONTROL

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

ASSEMBLY/INSTALLATION

INSPECTION VERIFIES AND RECORDS DIMENSIONS OF ALL DETAIL PARTS. GEARS ARE HARDNESS CHECKED AND VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

ALL DETAIL PARTS MACHINED TO HCOVER 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

HEAT TREATING IS VERIFIED BY INSPECTION.

TESTING

STALL TORQUE IS VERIFIED IN ACCEPTANCE TESTS.

HANDLING/PACKAGING

POLYETHYLENE SHEETING, USED TO BAG AND SEAL PARTS AFTER CLEANING, IS VERIFIED BY INSPECTION. HANDLING AND PACKAGING REQUIREMENTS 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

EVA WORKAROUND IS POSSIBLE IF RADIATORS ARE FULLY DEPLOYED.