

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :ACTUATION MECH-ET/ORB DOOR FMEA NO 02-4D-013600-4 REV:02/17/88

ASSEMBLY	:ET/ORBITER UMBILICAL DOOR MECHANISMS	CRIT. FUNC:	1
P/N RI	:MC287-0041	CRIT. HDW:	1
P/N VENDOR:	15690 HOOVER ELECTRIC	VEHICLE	102 103 104
QUANTITY	:4 (2 LH2 & 2 LO2)	EFFECTIVITY:	X X X
	:(2 PER ACTUATOR)	PHASE(S):	PL LO X OO DO X LS

		REDUNDANCY SCREEN:	A-	B-	C-
PREPARED BY:		APPROVED BY:	APPROVED BY (NASA):		
DES	R. H. YEE	DES	R. H. YEE	SSM	E. Moran 5/25/88
REL	J. S. MULLEN	REL	J. S. Mullen	REL	J. S. Mullen
QE	W. S. SMITH	QE	W. S. Smith	QE	W. S. Smith

ITEM:

TORQUE LIMITER, DOOR "UNLOCK" LATCH ACTUATOR

FUNCTION:

TO PROTECT THE ACTUATOR MOTORS/GEARS AND LATCH LINKAGES BY ALLOWING PREDETERMINED SLIPPAGE DURING A STALL OR JAM CONDITION.

FAILURE MODE:

TORQUE LIMITER SLIPS AT LESS THAN MINIMUM ALLOWABLE TORQUE

USE(S):

ADVERSE TOLERANCES/WEAR, CHANGE IN MATERIAL PROPERTIES CONTAMINATION/ FOREIGN OBJECT/DEBRIS, DEFECTIVE PART/MATERIAL OR MANUFACTURING DEFECT LOSS OF SPRING FORCE, TEMPERATURE

EFFECT(S) ON:

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

(A) LOSS OF FUNCTIONS - LATCHES CANNOT FULLY ENGAGE.

(B) THERMAL GRADIENTS INTO COMPARTMENT.

(C,D) POSSIBLE LOSS OF CREW/VEHICLE DUE TO DAMAGE CAUSED BY THERMAL EFFECTS IF THE DOORS CANNOT BE CLOSED AND FULLY LATCHED FOR SAFE RE-ENTRY.

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DISPOSITION & RATIONALE:

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

(A) DESIGN

EACH ORBITER/ET UMBILICAL DOOR IS PULLED TO A FULLY CLOSED AND LATCHED POSITION BY THREE (3) FOUR-BAR/OVER-CENTER UPLOCK LATCHES DRIVEN BY AN ELECTROMECHANICAL ACTUATOR THROUGH A TORQUE TUBE, BELLCRANKS, AND CONNECTING RODS. EACH LATCH DRIVE ACTUATOR CONSISTS OF A PLANETARY GEARBOX/DIFFERENTIAL DRIVEN BY TWO (REDUNDANT) 3-PHASE ELECTRIC MOTORS; EACH MOTOR HAS AN INTEGRAL SPRING-LOADED FRICTION CLUTCH/BRAKE AND AN INTEGRAL SPRING-LOADED DUAL-DISC PLATE FRICTION TORQUE LIMITER; WITH LIMIT SWITCHES AND MECHANICAL STOPS TO CONTROL/LIMIT ACTUATOR MOVEMENT/ROTATION. THE ACTUATOR HOUSING IS DESIGNED TO PRECLUDE THE ENTRY OF FOREIGN PARTICLES. PARTS ARE CLEANED TO LEVEL 300, PER MA0110-301 (PRIOR TO ASSEMBLY); ASSEMBLED IN A CLASS 100,000 CLEAN ROOM (PER FED-STD-209). DUAL ROTATING SURFACES ON BEARINGS. SAFETY FACTOR 1.4 MINIMUM. PROVISION EXISTS TO CYCLE THE ACTUATOR (TO LOOSEN STALLED/JAMMED MECHANISM). BRAKES MUST BE ELECTRICALLY ENERGIZED TO DISENGAGE AND ARE DESIGNED TO FAIL IN THE ENGAGED POSITION. DIFFERENTIAL IS DESIGNED TO DISTRIBUTE POWER FROM EITHER ONE OR BOTH (REDUNDANT MOTORS). EACH TORQUE LIMITER IS DESIGNED TO PROTECT ITS MOTOR AND DRIVE TRAIN FROM AN OVERLOAD FAILURE. MOTORS DESIGNED TO OPERATE IN EMERGENCY 2-PHASE CONDITION.

(B) TEST

QUALIFICATION TESTS: QUAL-CERTIFIED PER CR-45-287-0041-0001.
QUALIFICATION TESTS INCLUDED: HUMIDITY TEST, SHOCK TEST, QUALIFICATION ACCEPTANCE VIBRATION TESTS (QAVT), THERMAL VACUUM TEST, THERMAL CYCLING TEST, OPERATING LIFE TEST (2,000 CYCLES, 100-MISSION, 10-YEAR LIFE; EXPECT 500 CYCLES PER 100 MISSIONS), MECHANICAL STOP TEST, POWER CONSUMPTION TEST, FREEPLAY TEST, AND IRREVERSIBILITY TEST.

ACCEPTANCE TESTS: INCLUDES EXAMINATION OF PRODUCT (FOR WEIGHT, DIMENSIONS, CONSTRUCTION, CLEANLINESS AND FINISH), ACCEPTANCE VIBRATION TESTS (AVT) (20-2,000 HZ, 30 SEC TO 5 MINUTES, IN EACH OF THREE ORTHOGONAL AXES, WITH ELECTRICAL CIRCUITS MONITORED FOR CONTINUITY), ACCEPTANCE THERMAL TESTS (ATT) (CYCLED BETWEEN -80 DEG F AND +330 DEG F; MOTOR 1, MOTOR 2 AND DUAL MOTOR), POWER CONSUMPTION TEST (OPERATED AT MAXIMUM LOAD AT -50 DEG F, SINGLE MOTOR DEPLOYED WITHIN 12 SEC, DUAL MOTORS DEPLOYED WITHIN 6 SEC, 210 WATTS/MOTOR MAX, 0.83 AMPS/MOTOR MAX; 616 WATTS/MOTOR MAX STARTING POWER AND 3.5 AMPS/PHASE/MOTOR MAX STARTING CURRENT), INSULATION RESISTANCE TEST AND DIELECTRIC STRENGTH TEST (PER MF0004-002), CYCLING TEST (OPERATED AT RATED LOAD; SINGLE MOTOR, 20 CYCLES EACH FROM CW-CCW-CW ROTATION AT 12 SEC/DIRECTION; DUAL MOTOR, 60 CYCLES FROM CW-CCW-CW ROTATION AT 5 SEC/DIRECTION), FREEPLAY TEST (MAX ANGULAR FREEPLAY AT OUTPUT SHAFT +/-0.25 DEGREES ROTATION, WITH 10 INCH-LB OF REVERSING TORQUE), STALL/MAXIMUM TORQUE TEST (MAX ACTUATOR OUTPUT 6,000 INCH-LB), IRREVERSIBILITY TEST (ACTUATOR MUST BE IRREVERSIBLE TO THE STATIC LIMIT LOAD OF 950 INCH-LB, IN EITHER DIRECTION), MECHANICAL LIMITS TEST AND ELECTRICAL LIMITS TEST (ACTUATOR CYCLED THROUGH ITS FULL TRAVEL TO VERIFY COMPLIANCE WITH MECHANICAL AND ELECTRICAL LIMITS).

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OMRSD: LATCH/RELEASE OPERATIONAL CHECKOUT (UNDER LOAD) OF RIGHT-HAND/LEFT-HAND ET UNLOCK DOOR LATCHES; SINGLE MOTOR OPERATION (MOTOR 1, MOTOR 2) INSURES THAT OPERATIONAL CAPABILITY OF TORQUE LIMITER HAS A HIGH MARGIN OF SAFETY. FREQUENCY - ALL VEHICLES AT GROUND TURNAROUND.

(C) INSPECTION

RECEIVING INSPECTION

CERTIFICATION OF COMPLIANCE, TEST COUPONS, PHYSICAL AND CHEMICAL RECORDS ARE VERIFIED BY INSPECTION. RECEIVING INSPECTION PERFORMS VISUAL AND DIMENSIONAL EXAMINATION OF ALL INCOMING PARTS. GEARS ARE HARDNESS CHECKED AND VERIFIED BY INSPECTION.

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

HIGH STRESS PARTS, I.E., OUTPUT SHAFT, GEAR, ETC., ARE MAGNETIC OR FLUORESCENT PENETRANT INSPECTED.

CRITICAL PROCESSES

HEAT TREATING IS VERIFIED BY INSPECTION. INSPECTION VERIFIES THAT GEARBOXES ARE PROPERLY LUBRICATED.

TESTING

ACCEPTANCE TESTING IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

BAGGING OF PARTS IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY

CAR NO. AB8308: ENGINEERING EVALUATION TESTS WERE CONDUCTED ON FOUR DOOR LATCH ACTUATORS TO DETERMINE IF ACTUATOR OUTPUT TORQUE FALLS OFF WITH AGE. STALL/MAXIMUM TORQUE WAS FOUND TO BE WELL BELOW SPECIFICATION REQUIREMENTS AND WAS ATTRIBUTED TO CHANGES IN TORQUE LIMITER CHARACTERISTICS. THIS PROBLEM WAS CLOSED ON THE BASIS THAT UMBILICAL CLOSEOUT DOOR OPERATION IS VERIFIED PER OMI V1097 DURING GROUND TURNAROUND.

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CAR NO. AD3242: ENGINEERING EVALUATION TESTS WERE PERFORMED ON A SPARE ACTUATOR FROM KSC STOCK TO DETERMINE FALL OFF IN OUTPUT TORQUE WITH AGE. STALL/MAXIMUM TORQUE WAS WELL BELOW SPECIFICATION. THE SUPPLIER (HOOVER) HAS PROPOSED CHANGES TO THE TORQUE LIMIT CLUTCH CONSTRUCTION THAT ARE BEING EVALUATED BY RI. AN ALTERNATIVE IS ACCEPTANCE OF THE CONDITION FOR FLIGHT WITH PERIODIC RE-ACCEPTANCE TEST AND RE-ADJUSTMENT FOR ATP REQUIREMENTS (REF. MCR 12154).

CAR SUMMARY: THE ORIGINAL DESIGN REQUIREMENT FOR THE LATCH DRIVE TORQUE LIMITER MINIMUM SLIP POINT WAS BASED ON A CONSERVATIVE APPROACH AND WAS FAR IN EXCESS OF ANY OPERATIONAL REQUIREMENT. SINCE 1981 THE TORQUE LIMITERS HAVE DEMONSTRATED A CHARACTERISTIC DEGRADATION OF THE MINIMUM SLIP POINT AS A FUNCTION OF TIME. BASED ON TEST DATA FROM THE AVAILABLE ACTUATORS, IT APPEARS THAT THE TORQUE OUTPUT DEGRADES TO APPROXIMATELY ONE-HALF THE ACCEPTANCE TEST VALUE, THEN LEVELS OFF AND REMAINS STABLE. RECENT ANALYSIS INDICATES THAT THE WORST CASE OPERATIONAL REQUIREMENT IS FAR LESS THAN THE ORIGINAL DESIGN REQUIREMENT. WITH THE ASSUMPTION OF WORSE CASE TORQUE LIMITER DEGRADATION, THE ACTUATOR CAPABILITY EXCEEDS THE PRESENT OPERATIONAL REQUIREMENT BY A FACTOR OF 4. THIS FACTOR OF SAFETY IS DEMONSTRATED PRIOR TO EVERY FLIGHT BY PERFORMING A LATCH FULL TEST WITH APPLIED LOAD.

(E) OPERATIONAL USE
NONE.