

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :ACTUATION MECH-STAR TRACK FMEA NO 02-4F-032001-4 REV:02/17/88

ASSEMBLY :STAR TRACKER DOOR				CRIT. FUNC: 1R
P/N RI :MC621-0066				CRIT. HDW: 2
P/N VENDOR:A1047A010 ELLANEF	VEHICLE	102	103	104
QUANTITY :2	EFFECTIVITY:	X	X	X
:1 UPPER, 1 LOWER	PHASE(S):	PL	LD X	OO X DO X LS

		REDUNDANCY SCREEN: A-FAIL B-FAIL C-PASS
PREPARED BY:	APPROVED BY:	APPROVED BY (NASA):
DES R. H. YEE	DES <i>R.H. Yee for A.S. Ordway</i>	SSM <i>J.C. M... 2/25/88</i>
REL J. S. MULLEN	REL <i>J.S. Mullen</i>	REL <i>J.S. Mullen</i>
QE W. S. SMITH	QE <i>W.S. Smith</i>	QE <i>W.S. Smith</i>

ITEM:  
TORQUE LIMITER, DOOR DRIVE ACTUATOR

FUNCTION:  
TO PROTECT THE ACTUATOR MOTOR/GEARS BY ALLOWING PREDETERMINED SLIPPAGE WHEN THE STAR TRACKER DOOR MECHANISM STALLS OR JAMS.

FAILURE MODE:  
TORQUE LIMITER SLIPS AT LESS THAN MINIMUM TORQUE

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

EFFECT(S) ON:

- (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE
- (A) LOSS OF FUNCTION - DOOR UNABLE TO BE OPEN/CLOSED.
- (B) ONE DOOR FAILS TO OPEN - LOSS OF ONE STAR TRACKER. ONE DOOR FAILS TO CLOSE - LOCALIZED THERMAL DAMAGE DURING RE-ENTRY.
- (C) NONE - REMAINING STAR TRACKER WITH CREW OPTICAL ALIGNMENT SIGHT (COAS) BACKUP AVAILABLE TO PERFORM FUNCTION.
- (D) ONE DOOR FAILS TO OPEN - NONE; ONE DOOR FAILS TO CLOSE - NONE PER THERMAL STUDY - REF. IL SAS-AA&T-79-015 DATED 1-17-79; STUDY COVERS THE CASE OF ONE DOOR FAILING TO CLOSE. TWO DOORS FAILING TO CLOSE COULD CAUSE LOSS OF CREW/VEHICLE, DUE TO THERMAL FLOW THROUGH STAR TRACKER CAVITY.

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FAILS REDUNDANCY SCREEN "A" SINCE THERE ARE NO TURNAROUND TESTS TO VERIFY A FAILURE OF THE TORQUE LIMITER AND FAILS SCREEN "B" SINCE THERE IS NO VISUAL OR INSTRUMENTED WAY OF DETECTING A TORQUE LIMITER FAILURE WHILE IN FLIGHT.

DISPOSITION & RATIONALE:

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

(A) DESIGN

THE STAR TRACKER DOOR SUBSYSTEM CONSISTS OF A SEALED DOOR AND AN ELECTROMECHANICAL DOOR DRIVE ACTUATOR. THE DOOR DRIVE ACTUATOR CONSISTS OF A PLANETARY GEARBOX/DIFFERENTIAL AND A SPRING LOADED (4) BALL-DETENT TORQUE LIMITER DRIVEN BY TWO (REDUNDANT) 3-PHASE ELECTRIC MOTORS; EACH WITH AN INTEGRAL SPRING-LOADED BRAKE. LIMIT SWITCHES, SOFT (LEAF SPRING) STOPS AND HARD MECHANICAL STOPS CONTROL/LIMIT ACTUATOR MOVEMENT/ROTATION. HOUSING FABRICATED OF 6AL-4VT TI AND DESIGNED TO PRECLUDE THE ENTRY OF FOREIGN PARTICLES. GEARS MADE OF PH13-8MO AND 455 CRES; 4340 AND 9NI-4CO-.2C STL. BEARINGS MADE OF 440 AND OTHER CRES. DOORS AND TRACKS MADE OF 2219 AL. PARTS 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 ACTUATOR (TO LOOSEN STALLED/JAMMED MECHANISM). BRAKES ARE DESIGNED TO FAIL IN THE ENGAGED POSITION. DIFFERENTIAL IS DESIGNED TO DISTRIBUTE POWER FROM EITHER ONE OR BOTH (REDUNDANT) MOTORS. TORQUE LIMITER IS DESIGNED TO PROTECT MOTORS AND DRIVE TRAIN FROM AN OVERLOAD FAILURE. REF. STRESS ANALYSIS REPORT SD77-SH-0178, VOL. II.

(B) TEST

QUALIFICATION TESTS: COMPONENT QUAL-CERTIFIED PER CR-28-621-0066-0007. QUALIFICATION TESTS INCLUDE: HUMIDITY TEST (PER MIL-STD-810B), METHOD 507, PROCEDURE I), QUAL-ACCEPTANCE VIBRATION TEST (QAVT)(ACOUSTIC VIBRATIONS FROM 16-8,000 HZ FOR 5 MINUTES; ELECTRICAL CIRCUITS CHECKED WITH ACTUATOR CYCLED FROM CLOSED, TO OPEN, TO CLOSED POSITION), FLIGHT VIBRATION TEST (20-2,000 HZ FOR 71 MINUTES; 16-8,000 HZ FOR 34 MINUTES), EXPLOSIVE ATMOSPHERE TEST (ACTUATOR NOT TO EXCEED +352 DEG F OR EXPLODE WHILE IN A BUTANE ENVIRONMENT, DURING ONE EXTEND OR RETRACT STROKE), THERMAL CYCLING TEST (CYCLED FIVE TIMES BETWEEN -100 DEG F AND +350 DEG F, WITH AT LEAST 60 MINUTES DWELL AT EACH EXTREME), OPERATING LIFE TEST (ACTUATOR CYCLED 2,000 TIMES AT ROOM TEMP; INCLUDES MOTOR 1 AND MOTOR 2 CYCLED 200 TIMES EACH, ALONE, AND WITHIN 20 SEC/STROKE; AND 1,000 CYCLES WITH BOTH MOTORS AND WITHIN 10 SEC/STROKE) AND STALL/MAXIMUM TORQUE TEST (TORQUE LIMITER HOLDS AT 1,246 INCH-LB AND SLIPS AT 1,450 INCH-LB). POWER CONSUMPTION TEST, PRESSURE LEAK TEST AND FREE-PLAY TEST WERE CONDUCTED AS DEFINED IN THE ACCEPTANCE TESTS. CERTIFICATION BY ANALYSIS/SIMILARITY INCLUDED: FUNGUS, OZONE, ACCELERATION, TRANSPACKAGE, SAND/DUST, SALT SPRAY, LIGHTNING, SHOCK AND THERMAL VACUUM.

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ACCEPTANCE TESTS: INCLUDES EXAMINATION OF PRODUCT (FOR WEIGHT, DIMENSIONS, CONSTRUCTION, CLEANLINESS AND FINISH), ACCEPTANCE VIBRATION TESTS (AVT) (16-9,000 HZ FOR 1 MINUTE; WITH DOORS CYCLED AND ELECTRICAL CIRCUITS VERIFIED), ACCEPTANCE THERMAL TESTS (ATT) (CYCLED BETWEEN -80 DEG F AND +330 DEG F), BONDING TEST (PER MF0004-002), POWER CONSUMPTION TEST (WITH TEMPERATURE BETWEEN -80 DEG F AND +330 DEG F, SINGLE MOTOR CYCLED WITHIN 20 SEC, DUAL MOTORS CYCLED WITHIN 10 SEC, 22 WATTS/MOTOR MAXIMUM, 400% MAXIMUM STARTING CURRENT AT RATED LOAD), INSULATION RESISTANCE TEST AND DIELECTRIC WITH STANDING VOLTAGE TEST (PER MF0004-002), PRESSURE LEAKAGE TEST (MAXIMUM 0.0148 LB/SEC FOR LOWER DOOR, MAXIMUM 0.0173 LB/SEC FOR UPPER DOOR, AT 5.5 PSID), CYCLING TEST (SINGLE MOTOR, 40 CYCLES EACH AT 20 SEC/STROKE; DUAL MOTOR, 120 CYCLES AT 10 SEC/STROKE), FREEPLAY TEST (MAXIMUM OF TWO DEGREES WITH 100 INCH-LB REVERSING TORQUE ON OPEN DOOR; NONE WITH DOOR CLOSED), STALL/MAXIMUM TORQUE (TORQUE LIMITER HOLD AT 1,246 INCH-LB AND SLIPS AT 1,450 INCH-LB), IRREVERSIBILITY TEST (DOOR IRREVERSIBLE FROM CLOSED POSITION, WITH MAXIMUM OPERATING LOAD PLUS A 5.1 PSI AIRLOAD ON EXTERIOR OF DOOR) AND TRAVEL LIMITS TEST (DOOR CYCLED OPEN AND CLOSED; STOPPED BY LIMIT SWITCHES).

OMRSD: NO PRACTICAL TEST IS AVAILABLE FOR THIS FAILURE MODE. PROPER FUNCTION OF THE TORQUE LIMITER IS VERIFIED PERIODICALLY AS PART OF THE MAINTENANCE SAMPLING PROGRAM.

### (C) INSPECTION

#### RECEIVING INSPECTION

MATERIAL AND PROCESS CERTIFICATIONS VERIFIED BY INSPECTION.

#### CONTAMINATION CONTROL

ALL PARTS ARE CLEANED BEFORE TORQUE LIMITER ASSEMBLY. THE TORQUE LIMITER IS ASSEMBLED IN A CLEAN ROOM. CLEANLINESS TO LEVEL 300 VERIFIED BY INSPECTION. CORROSION CONTROL PROVISIONS ARE VERIFIED BY INSPECTION.

#### ASSEMBLY/INSTALLATION

TORQUE LIMITER ASSEMBLY VERIFIED BY INSPECTION. SLIP TORQUE VERIFIED BY INSPECTION. SPRING DIAMETER AND FORCE VERIFIED BY INSPECTION.

#### NONDESTRUCTIVE EVALUATION

STRUCTURAL INTEGRITY OF DETAIL PARTS VERIFIED BY PENETRANT OR MAGNETIC PARTICLE INSPECTION. TECHNIQUES AND TECHNICIANS ARE CERTIFIED.

#### CRITICAL PROCESSES

HEAT TREATING, BEARING INSTALLATION AND LUBRICANT APPLICATION VERIFIED BY INSPECTION.

#### TESTING

GEAR HARDNESS TEST, ACROSS PIN MEASUREMENT AND REDLINE TEST FOR COMPOSITE ERROR ARE VERIFIED BY INSPECTION. A STALL/MAXIMUM TORQUE TEST, TO VERIFY CLUTCH SETTING IN THE ASSEMBLED UNIT, IS INSPECTED DURING ATP.

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(D) FAILURE HISTORY

THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD OR FLIGHT FAILURES ASSOCIATED WITH THIS FAILURE MODE.

(E) OPERATIONAL USE

IF FAILURE OCCURS WITH ONE (1) DOOR IN THE OPEN POSITION, THE REMAINING DOOR WILL BE CLOSED TO PRECLUDE A SECOND FAILURE RESULTING IN TWO DOORS BEING OPEN DURING RE-ENTRY. IMPACT TO MISSION: A SINGLE STAR TRACKER INERTIAL MEASURING UNIT (IMU) ALIGNMENT CAPABILITY REMAINS IF THE OTHER STAR TRACKER DOOR FAILS TO OPEN; IF A DOOR FAILS WHILE OPENING, THE REMAINING DOOR MUST BE CLOSED (REQUIRING THAT THE COAS BE USED FOR ALIGNMENT).