

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : ACTUATION MECH-ADP FMEA NO 02-4E -052000-5 REV:02/17/88

ASSEMBLY : AIR DATA PROBE (ADP) CRIT. FUNC: 1R  
 P/N RI : MC147-0012 CRIT. HDW: 2  
 P/N VENDOR: A1045A010 ELLANEF VEHICLE 102 103 104  
 QUANTITY : 2 EFFECTIVITY: X X X  
 : 1 PER SIDE PHASE(S): PL LO OO DO X,LS

PREPARED BY: REDUNDANCY SCREEN: A-FAIL B-FAIL C-PASS  
 DES R. H. YEE APPROVED BY: APPROVED BY (NASA):  
 REL J. S. MULLEN REL *[Signature]* SSM *[Signature]*  
 QE W. S. SMITH QE *[Signature]* *[Signature]* 2/26/88

ITEM:  
 TORQUE LIMITER, DEPLOYMENT ACTUATOR

FUNCTION:  
 TO PROTECT THE ACTUATOR MOTOR/GEARBOX/DIFFERENTIAL BY ALLOWING  
 PREDETERMINED SLIPPAGE WHEN THE AIR DATA PROBE DEPLOYMENT 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, B) LOSS OF ONE AIR DATA PROBE (ADP).

(C, D) SECOND (REDUNDANT) ADP IS ADEQUATE FOR LANDING BY FLIGHT CONTROL.  
 POTENTIAL LOSS OF CREW/VEHICLE DUE TO FLIGHT CONTROL INSTABILITIES WHEN  
 ALL AIR DATA IS LOST.

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 FAILURE OF THE TORQUE LIMITER  
 WHILE IN FLIGHT.

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DISPOSITION & RATIONALE:

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

(A) DESIGN

THE DEPLOYMENT 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. HOUSING FABRICATED OF 6AL-4V TI AND DESIGNED TO PRECLUDE THE ENTRY OF FOREIGN PARTICLES. GEARS MADE OF PH13-8MO CRES; 4340 AND 9NI-4CO-.2C STL. BEARINGS MADE OF 440 AND OTHER CRES. 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.

(B) TEST

QUALIFICATION TESTS: QUAL-CERTIFIED PER CR-28-147-0012-0001.  
QUALIFICATION TESTS INCLUDED: SHOCK TEST (BASIC DESIGN SHOCK PER MIL-STD-810, METHOD 516.1, PROCEDURE I; TRANSIENT SHOCK AT +/-0.25 G'S PEAK AND 5 TO 35 HZ SINUSOIDAL VIBRATION), QUAL-ACCEPTANCE VIBRATION TEST (QAVT) (ACOUSTIC VIBRATIONS FROM 20-2,000 HZ FOR 30 SECONDS TO 1 MINUTE IN EACH OF THREE ORTHOGONAL AXES; ELECTRICAL CIRCUITS CHECKED WITH ACTUATOR CYCLED FROM STOWED, TO DEPLOYED, TO STOWED POSITION), RANDOM VIBRATION TEST (OFT) (20-2,000 HZ; 5 MIN. IN EACH X, Y AND Z-AXIS), 100-MISSION RANDOM VIBRATION TEST (20-2,000 HZ; 48 MINUTES IN EACH X, Y AND Z-AXIS), THERMAL CYCLING TEST (CYCLED FIVE TIMES BETWEEN -100 DEG F AND +350 DEG F, WITH 60 MINUTES DWELL AT EACH EXTREME) AND OPERATING LIFE TEST (ACTUATOR CYCLED 2,000 TIMES AT ROOM TEMPERATURE; INCLUDES MOTOR 1 AND MOTOR 2 CYCLED 400 TIMES EACH, ALONE, AND WITHIN 30 SEC/STROKE; AND 1,200 CYCLES WITH BOTH MOTORS AND WITHIN 15 SEC/STROKE). EXPECT 500 CYCLES PER 100-MISSION LIFE. POWER CONSUMPTION TEST, PRESSURE LEAK TEST, FREE-PLAY TEST AND IRREVERSIBILITY TEST WERE CONDUCTED AS DEFINED IN THE ACCEPTANCE TESTS. CERTIFICATION BY ANALYSIS/SIMILARITY INCLUDED: FUNGUS, OZONE, ACCELERATION, TRANSPACKAGE, SAND/DUST, SALT SPRAY, MARGIN OF SAFETY, HUMIDITY, THERMAL VACUUM, AND EXPLOSIVE ATMOSPHERE.

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ACCEPTANCE TESTS: INCLUDES EXAMINATION OF PRODUCTS (FOR WEIGHT, DIMENSIONS, CONSTRUCTION, CLEANLINESS AND FINISH), ACCEPTANCE VIBRATION TESTS (AVT) (20-2,000 HZ, 30 SEC TO 1 MINUTE, 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), BONDING TEST (PER MF0004-002), POWER CONSUMPTION TEST (WITH TEMPERATURE BETWEEN -80 DEG F AND +330 DEG F, SINGLE MOTOR DEPLOYED WITHIN 30 SEC, DUAL MOTORS DEPLOYED WITHIN 15 SEC, 22 WATTS/MOTOR MAXIMUM, 400% MAXIMUM STARTING CURRENT AT RATED LOAD), INSULATION RESISTANCE TEST AND DIELECTRIC WITHSTANDING VOLTAGE TEST (PER MF0004-002), PRESSURE LEAKAGE TEST (PNEUMATIC CHANNEL LEAKAGE IS 0.010 INCH-HG/MIN AT 80 INCH-HG APPLIED AIR PRESSURE), CYCLING TEST (SINGLE MOTOR, 40 CYCLES EACH AT 30 SEC/STROKE; DUAL MOTOR, 120 CYCLES AT 15 SEC/STROKE), FREEPLAY TEST (MAXIMUM ANGULAR FREEPLAY AT OUTPUT SHAFT +/- 0.025 DEGREES, WITH 78.8 INCH-LB REVERSING TORQUE; MAXIMUM LATERAL FREEPLAY OF ROTARY CARRIER +/- 0.001 INCH, WITH REVERSING LOAD OF 10 LB), STALL/MAXIMUM TORQUE TEST, IRREVERSIBILITY TEST (ACTUATOR MUST BE IRREVERSIBLE TO THE MAXIMUM OPERATING LOAD IN EITHER DIRECTION) AND TRAVEL LIMITS TEST (ACTUATOR AND OUTPUT ARM CYCLED FULL TRAVEL TO VERIFY COMPLIANCE WITH MECHANICAL AND ELECTRICAL LIMITS).

OMRSD: NO 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 AT SUB-ASSEMBLY. 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 ALL AIR DATA IS LOST, CREW MUST MAINTAIN PITCH ATTITUDE WITHIN "THETA" LIMITS DISPLAYED ON THE CATHODE RAY TUBE (CRT).