

PAGE: 1

PRINT DATE: 06/07/94

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL HARDWARE
NUMBER: 01-5B-380107-X**

SUBSYSTEM NAME: PURGE, VENT, & DRAIN - ACTRS

REVISION: 1 06/02/94

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: DOOR DRIVE ACTUATOR ELLANEF	MC147-0009 A1058A010
SRW	: GEARBOX/DIFFERENTIAL	
SRU	: TORQUE LIMITER	

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

FOR 01-5B-380107-01:

GEARBOX/DIFFERENTIAL, DOOR DRIVE ACTUATOR, VENTS 1 AND 2 (RCS & FWD)

FOR 01-5B-380107-02, 01-5B-380107-03:

TORQUE LIMITER, DOOR DRIVE ACTUATOR, VENTS 1 AND 2 (RCS & FWD)

QUANTITY OF LIKE ITEMS: 2

(1 RH & 1 LH)

(1 PER ACTUATOR)

FUNCTION:

FOR 01-5B-380107-01:

TO TRANSMIT/DISTRIBUTE PROPER POWER/TORQUE FROM EITHER ONE OR BOTH ELECTRIC MOTORS TO THE DOOR DRIVE MECHANISM (TO OPEN/CLOSE THE VENT DOORS).

FOR 01-5B-380107-02, 01-5B-380107-03:

TO PROTECT THE ACTUATOR MOTOR/GEARS BY ALLOWING PREDETERMINED SLIPPAGE WHEN THE VENT DOOR MECHANISM STALLS OR JAMS.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL FAILURE MODE
NUMBER: 01-5B-380107-01**

REVISION# 1 06/02/94

SUBSYSTEM NAME: PURGE, VENT, & DRAIN - ACTRS
LRU: DOOR DRIVE ACTUATOR
ITEM NAME: GEARBOX/DIFFERENTIAL

CRITICALITY OF THIS
FAILURE MODE: 1R2

FAILURE MODE:
PHYSICAL BINDING/JAMMING

MISSION PHASE:
DO DE-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY: 102 COLUMBIA
103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:
ADVERSE TOLERANCES/WEAR, CONTAMINATION/FOREIGN OBJECT/DEBRIS,
FAILURE/DEFLECTION OF INTERNAL PART, LOSS OF LUBRICANT, TEMPERATURE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN A) PASS
B) PASS
C) PASS

PASS/FAIL RATIONALE:

- A)
- B)
- C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
LOSS OF ABILITY TO CONTROL POSITION OF VENT DOORS.

(B) INTERFACING SUBSYSTEM(S):
NO EFFECT FIRST FAILURE

(C) MISSION:
NO EFFECT FIRST FAILURE

(D) CREW, VEHICLE, AND ELEMENT(S):
NO EFFECT FIRST FAILURE

(E) FUNCTIONAL CRITICALITY EFFECTS:
POSSIBLE LOSS OF CREW/VEHICLE AFTER TWO FAILURES (PHYSICAL
BINDING/JAMMING OF THE GEARBOX/DIFFERENTIAL AND THE OPPOSITE DOOR FAILS

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CLOSED) DUE TO STRUCTURAL DAMAGE FROM PRESSURE DIFFERENTIAL ON ENTRY. LOCALIZED THERMAL DAMAGE ONLY. IF DOORS ARE FAILED OPEN ON ENTRY; THERMAL ANALYSIS (SAS-TA-RCC-78-152, -79-012 AND 79-065) SHOWS THAT CREW AND VEHICLE WILL SURVIVE.

-DISPOSITION RATIONALE-

(A) DESIGN:

THE VENT DOOR SUBSYSTEM CONSISTS OF SEALED DOORS INTO THE FUSELAGE CAVITIES (THAT ARE OPENED OR CLOSED TO REGULATE INTERNAL PRESSURE) AND ARE POSITIONED BY ELECTROMECHANICAL DOOR DRIVE ACTUATORS CONNECTED TO TORQUE TUBES, BELLCRANKS AND CONNECTING-RODS. EACH VENT DOOR 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 MOTOR HAS AN INTEGRAL SPRING-LOADED FRICTION BRAKE: WITH LIMIT SWITCHES, SOFT (LEAF SPRING) STOPS AND HARD MECHANICAL STOPS TO CONTROL/LIMIT ACTUATOR MOVEMENT/ROTATION. THE ACTUATOR HOUSING IS FABRICATED OF 6AL-4V TI AND DESIGNED TO PRECLUDE THE ENTRY OF FOREIGN PARTICLES. GEARS MADE OF PH13-8MO AND 15-5PH CRES; INCONEL 718. BEARINGS MADE OF 440 AND OTHER CRES. 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 A 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. MOTORS ARE DESIGNED TO OPERATE IN AN EMERGENCY 2-PHASE CONDITION. THE TORQUE LIMITER IS DESIGNED TO PROTECT BOTH MOTORS AND THE DRIVE-TRAIN FROM AN OVERLOAD FAILURE.

(B) TEST:

QUALIFICATION TESTS: QUAL-CERTIFIED PER CR-28-147-0009-0003 (WHICH DELETES AND REPLACES CR-28-147-0009-0001). QUALIFICATION TESTS INCLUDE: HUMIDITY TEST (PER MIL-STD-810B), QUAL ACCEPTANCE VIBRATION TEST (QAVT) (ACOUSTIC VIBRATIONS FROM 20-2,000 HZ; PER MF0004-32), FLIGHT VIBRATION TEST (20-2,000 HZ FOR 70 MINUTES), SHOCK TEST (PER MIL-STD-810, PROCEDURE I, METHOD 516.1), THERMAL VACUUM TEST (0.000001 TORR FOR 55 HOURS, WITH TEMPERATURE CYCLED BETWEEN -170 DEG F AND +330 DEG F, AND ACTUATOR CYCLED), THERMAL CYCLE TEST (TEMPERATURE CYCLED BETWEEN -170 DEG F AND +330 DEG F; INCLUDES MOTOR 1 AND MOTOR 2 CYCLED 500 TIMES EACH, ALONE, AND WITHIN 10 SEC/DIRECTION UNDER LOAD FROM CLOSE-OPEN-CLOSE; 500 CYCLES WITH BOTH MOTORS AT 5 SEC/DIRECTION FROM CLOSE-OPEN-CLOSE; AND 250 CYCLES WITH BOTH MOTORS FROM CLOSE-OPEN-INTERMEDIATE-CLOSE) AND MECHANICAL STOPS TEST (ACTUATOR OPERATED AT FULL RATE AND WITH NO LOAD OR BRAKES; 100 TIMES IN EACH DIRECTION). POWER CONSUMPTION TEST, FREEPLAY TEST AND IRREVERSIBILITY TEST WERE CONDUCTED AS DEFINED IN THE ACCEPTANCE TESTS. CERTIFICATION BY ANALYSIS/SIMILARITY INCLUDED: FUNGUS, OZONE, SALT SPRAY, SAND/DUST, TRANSPACKAGE, ACCELERATION, LANDING SHOCK, MARGIN OF SAFETY AND EXPLOSIVE ATMOSPHERE.

ACCEPTANCE TESTS: INCLUDES EXAMINATION OF PRODUCTS (FOR WEIGHT, DIMENSIONS, CONSTRUCTION, CLEANLINESS AND FINISH), ACCEPTANCE VIBRATION

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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 -150 DEG F AND +350 DEG F; MOTOR 1, MOTOR 2 AND DUAL MOTOR), POWER CONSUMPTION TEST (OPERATED AT RATED LOAD, SINGLE MOTOR DEPLOYED WITHIN 10 SEC, DUAL MOTORS DEPLOYED WITHIN 5 SEC, 95 WATTS/MOTOR MAXIMUM, 400% MAXIMUM STARTING CURRENT AT RATED LOAD), INSULATION RESISTANCE TEST AND DIELECTRIC STRENGTH TEST (PER MF0004-002), CYCLING TEST (SINGLE MOTOR, 20 CYCLES EACH FROM CLOSE-OPEN-CLOSE AT 10 SEC/DIRECTION; DUAL MOTOR, 40 CYCLES FROM CLOSE-OPEN-CLOSE AT 5 SEC/DIRECTION; DUAL MOTOR, 20 CYCLES FROM INTERMEDIATE-OPEN-CLOSE), FREEPLAY TEST (MAXIMUM ANGULAR FREEPLAY AT OUTPUT SHAFT \pm 0.015 DEGREES, WITH 10.0 INCH-LB REVERSING TORQUE), STALL/MAXIMUM TORQUE TEST (STALL/MAXIMUM OUTPUT NOT TO EXCEED 1.5 TIMES MAX OPERATING TORQUE OF 311.7 INCH-LB), IRREVERSIBILITY TEST (ACTUATOR MUST BE IRREVERSIBLE TO THE MAXIMUM OPERATING LOAD IN EITHER DIRECTION), MECHANICAL LIMITS TEST AND ELECTRICAL LIMITS TEST (ACTUATOR AND OUTPUT ARM CYCLED FULL TRAVEL TO VERIFY COMPLIANCE WITH MECHANICAL AND ELECTRICAL LIMITS).

GROUND TURNAROUND TEST:
ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION
MATERIAL AND PROCESS CERTIFICATIONS ARE VERIFIED BY INSPECTION. ALL PURCHASED PART DATA PACKAGES ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL
PARTS ARE CLEANED TO A 300 LEVEL PER MA0110-301 IS VERIFIED BY INSPECTION. ASSEMBLY IN A CLASS 100,000 CLEAN ROOM PER FED-STD-209.

ASSEMBLY/INSTALLATION
TORQUE LIMITER ASSEMBLY IS VERIFIED BY INSPECTION. BEARING INSTALLATION, SPRING DIAMETERS AND SPRING FORCE ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
STRUCTURAL INTEGRITY VERIFIED BY PENETRANT OR MAGNETIC PARTICLE INSPECTION. TECHNIQUES AND TECHNICIANS ARE CERTIFIED.

CRITICAL PROCESSES
HEAT TREAT IS VERIFIED BY INSPECTION.

TESTING
ATP IS VERIFIED BY INSPECTION

HANDLING/PACKAGING
HANDLING AND PACKAGING REQUIREMENT ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATABASE.

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(E) OPERATIONAL USE:

THE GROUND CREW MAY USE REAL TIME COMMANDS (RTC) TO CYCLE THE VENT DOOR (TO ATTEMPT TO DISLodge DEBRIS OR LOOSEN A STALLED/JAMMED MECHANISM), DEPENDING ON THE FAILURE MODE (OPEN, CLOSED) AND MISSION PHASE REQUIREMENT. RTC CAPABILITY IS ONLY AVAILABLE ON ORBIT AND POST-LANDING (OPERATIONS SEQUENCE 2 AND 9). THE SPEC 51 OVERRIDE PROVIDES LIMITED COMMAND CAPABILITY TO FLIGHT CREW TO OPEN OR CLOSE THE VENT DOORS IN OPS 3 TO OPEN.

- APPROVALS -

PAE MANAGER	: K. L. PRESTON	: <u>Stall Jr 6/8/94</u>
PRODUCT ASSURANCE ENG.	: T. AI	: <u>[Signature]</u>
DESIGN ENGINEERING	: A. P. YSON	: <u>Rob Yson 6/2/94</u>
NASA SSMA	:	: <u>DR Hoove 7/6/94</u>
NASA SUBSYSTEM MANAGER	:	: <u>PE [Signature] 7/6/94</u>