

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: 02-1D-190-X

SUBSYSTEM NAME: LANDING DECELERATION - NWS - MECHANISM

REVISION : 2 02/21/92

-----

PART NAME  
VENDOR NAME

PART NUMBER  
VENDOR NUMBER

■ LRU : INWS HYDRAULIC ACTUATOR ASSY MC621-0058-0019

-----

PART DATA

-----

■ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:  
HYDRAULIC ACTUATOR ASSEMBLY

■ QUANTITY OF LIKE ITEMS: 1  
ONE

■ FUNCTION:  
PROVIDES HYDRAULIC POWER STEERING AND SHIMMY DAMPING TO THE NOSE WHEEL  
ASSEMBLY.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE**  
NUMBER: 02-1D-190-01

SUBSYSTEM: LANDING DECELERATION - NWS - MECHANISM REVISION# 2 02/21/92 R  
LRU : INWS HYDRAULIC ACTUATOR ASSY  
ITEM NAME: INWS HYDRAULIC ACTUATOR ASSY CRITICALITY OF THIS FAILURE MODE: 1R3

■ FAILURE MODE:  
EXTERNAL LEAKAGE

MISSION PHASE:  
DO DE-ORBIT

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

■ CAUSE:  
DAMAGED OR FAULTY PISTON SEALS, RUPTURED TUBE ASSEMBLY

■ CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

■ REDUNDANCY SCREEN A) PASS  
■ B) FAIL  
■ C) PASS

PASS/FAIL RATIONALE:

■ A)  
■ B)  
FAILS SCREEN "B" SINCE INWS IS NOT POWERED UNTIL LANDING GEAR DOWN COM-  
MAND AND STEERING CANNOT BE ACTIVATED UNTIL WEIGHT ON NOSE GEAR.

■ C)

- FAILURE EFFECTS -

■ (A) SUBSYSTEM:  
LOSS OF NOSE WHEEL STEERING FUNCTION - SYSTEM WILL DOWNMODE THE FREE  
CASTER MODE.

■ (B) INTERFACING SUBSYSTEM(S):  
POSSIBLE LOSS OF THE ACTIVE HYDRAULIC SYSTEM (SYSTEM #1 OR #2).

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE  
NUMBER: 02-1D-190-01

- (C) MISSION:  
NO EFFECT WITH 1ST FAILURE.
- (D) CREW, VEHICLE, AND ELEMENT(S):  
POSSIBLE LOSS OF CREW/VEHICLE WITH TWO ADDITIONAL FAILURES - LOSS OF DIFFERENTIAL BRAKING (WHICH IS CONSIDERED UNLIKE REDUNDANCY).
- (E) FUNCTIONAL CRITICALITY EFFECTS:  
CRIT 1R BECAUSE LOSS OF NWS MAY ALLOW VEHICLE TO DEPART RUNWAY RESULTING IN POSSIBLE LOSS OF CREW/VEHICLE.

-----  
- DISPOSITION RATIONALE -  
-----

- (A) DESIGN:  
HYDRAULIC ACTUATOR IS DESIGNED TO WITHSTAND CYCLIC AND LEAK PROOF TESTS (PER MIL-C-5503) AT A SUPPLY PRESSURE OF 4,500 PSIG FOR 3 MINUTES; DESIGN REQUIREMENTS ARE: ZERO EXTERNAL LEAKAGE AND 0.45 GPM INTERNAL LEAKAGE MAXIMUM WHEN PISTON IS FULLY EXTENDED OR RETRACTED. THE ACTUATOR HYDRAULIC FILTER MODULE IS 5 MICRON NOMINAL AND 15 MICRON ABSOLUTE.

THE COMPONENT MOST LIKELY TO RUPTURE IS THE TUBE ASSEMBLY WHICH CARRIES HYDRAULIC FLUID FROM THE BYPASS VALVE TO THE ROD END SIDE OF THE PISTON. HOWEVER, THIS TUBE ASSEMBLY WAS DESIGNED AND BUILT TO WITHSTAND THE PREDICTED LOADS WITH A SAFETY FACTOR OF 3.20. TUBE AND FITTINGS ARE BRAZED TOGETHER PER MIL-B-7883 USING BRAZE NI 4.5 SI 2.9B ALLOY PER AMS 4778. FITTINGS ARE HEAT TREATED TO CONDITION H 1025 PER MIL-H-6875. BRAZE AND HEAT TREAT ARE DONE IN A HYDROGEN ATMOSPHERE AND THE ASSEMBLY IS PROOF PRESSURE TESTED AT 6,000 PSI & 100% X-RAY INSPECTED PER MIL-STD-453 AND MIL-B-7883.

THE SEALS WERE DESIGNED TO PERFORM UNDER FULL LOAD FOR THE LIFE OF THE PART. THE MANY HOURS OF COMMERCIAL FLIGHTS ON THESE TYPES OF SEALS AND THE RESULTS OF CYCLIC TESTING ON THE NWS ACTUATOR PROVIDE THE RATIONALE TO JUSTIFY NOT HAVING REDUNDANT SEALS IN THE NWS ACTUATOR.

- (B) TEST:  
QUALIFICATION TESTS: THE INWS QUAL TESTS INCLUDE: VIBRATION, ACCELERATION, SHOCK, THERMAL SHOCK, THERMAL VACUUM, THERMAL CYCLE AND ENDURANCE CYCLING. THE UNITS ARE SUBJECTED TO FUNCTIONAL TESTS BEFORE AND AFTER EACH ENVIRONMENT TEST. THE INWS WAS ALSO QUALIFIED BY SIMILARITY BY THE FOLLOWING TESTS: PROOF PRESSURE, SALT FOG, HUMIDITY, SAND AND DUST, EXPLOSIVE ATMOSPHERE, PRESSURE IMPULSE CYCLING, AND OPERATING LIFE CYCLING.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE  
NUMBER: 02-1D-190-01**

DURING SUPPLY PROOF PRESSURE TEST THE NWS ACTUATOR IS PRESSURIZED TO 4500 PSIG AT A TEMPERATURE OF +275 DEG. F. PRESSURE IS APPLIED FOR 5 MINUTES MINIMUM WHILE THE ACTUATOR IS IN IT'S FULLY EXTENDED POSITION. DURING RETURN PROOF PRESSURE TEST THE ACTUATOR IS PRESSURIZED AT IT'S RETURN PORT AS ABOVE. SYSTEM MODE SELECTOR IS OFF DURING THE RETURN PROOF PRESSURE TEST. NO DAMAGE OR LEAKAGE IS TOLERATED DURING THESE TESTS.

THE QUAL TEST UNIT IS CYCLED A MINIMUM OF 8000 CYCLES (15 CYCLES PER MINUTE) AT NORMAL FULL STROKE WITH NO LOAD AND 3000 PSI. CHANNEL 1 AND 2 ALTERNATED EVERY 10 MINUTES AND TURNED OFF FOR 1 MINUTE DURING CYCLING. THE UNIT WAS ALSO CYCLED A MINIMUM OF 13,500 CYCLES (15 CYCLES PER MINUTE) AT HALF STROKE WITH NO LOAD AND 3,000 PSI. CHANNEL 1 AND 2 ALTERNATED EVERY 10 MINUTES AND TURNED OFF FOR 1 MINUTE DURING CYCLING WITHOUT FAILURE, DEGRADATION IN PERFORMANCE OR LEAKAGE. THE UNIT WAS ALSO COMMANDED TO MIDSTROKE TURNING CHANNEL 1 OFF AND ON FOR 2,500 CYCLES MINIMUM. REPEATED WITH CHANNEL 2. NO FAILURE OCCURRENCES FOR 5,000 MINIMUM OFF/ON CYCLES.

ACCEPTANCE TESTS: ACCEPTANCE TESTS ARE PERFORMED ON ALL UNITS DELIVERED BY THE SUPPLIER WHICH INCLUDE; COMPONENT FUNCTIONAL TEST, ACCEPTANCE VIBRATION TEST, FLUID CLEANLINESS, PROOF PRESSURE TEST, AND ACTUATOR RESTRAINED PROOF TEST.

OMRSD: HYDRAULIC SYSTEM INSPECTION REQUIREMENTS; INSPECTS NWS LINES/ACTUATOR FOR LEAKS AND HYDRAULIC SYSTEM #1 & #2 SUPPLY/RETURN/CASE FILTERS FOR CONDITION & CLEANLINESS (TO LEVEL 190).

FREQUENCY - ALL VEHICLES AT GROUND TURNAROUND.

■ (C) INSPECTION:

RECEIVING INSPECTION

RAW MATERIAL AND PROCESS CERTIFICATION ARE VERIFIED BY INSPECTION. TEST REPORTS AND RECORDS ARE MAINTAINED.

CONTAMINATION CONTROL

ALL HYDRAULIC FLUID INTERNAL SURFACES ARE MAINTAINED AT LEVEL 190 CLEANLINESS. SYSTEM CLEANLINESS IS VERIFIED ON A REGULAR BASIS BY FLUID SAMPLING ANALYSIS. SYSTEM HYDRAULIC FLUID IS ANALYZED FOR WATER AND FREON CONTENT (100 PPM MAX).

ASSEMBLY/INSTALLATION

ALL DETAIL PARTS ARE INSPECTED AND FLUSHED WITH SOLVENT PRIOR TO ASSEMBLY. CRITICAL DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. SEALS ARE VISUALLY EXAMINED FOR CLEANLINESS AND DAMAGE. APPLICATION OF O-RING SEAL LUBRICANT IS VERIFIED BY INSPECTION. TORQUING AND LOCKWIRING OF FASTENERS ARE VERIFIED BY INSPECTION.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE  
NUMBER: 02-10-190-01

NONDESTRUCTIVE EVALUATION

MAGNETIC PARTICLE AND PENETRANT INSPECTION OF MACHINED PARTS ARE VERIFIED BY INSPECTION. X-RAYS OF BRAZED TUBE AND FITTINGS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES

SURFACE TREATMENTS SUCH AS PASSIVATION AND ANODIZING, PLATING, HEAT TREATMENT, SWAGING, BRAZING, ELECTRICAL BONDING ARE VERIFIED BY INSPECTION. SOLDERING PER MHB5300.4(3A) AND CONFORMAL COATING OF PRINTED WIRING BOARDS ARE VERIFIED BY INSPECTION.

TESTING

THE ATP WHICH IS WITNESSED AND VERIFIED BY INSPECTION INCLUDES FLUID CLEANLINESS VERIFICATION, PROOF PRESSURE AND LEAK TESTING, PULL-IN AND DROP OUT VOLTAGES, DIELECTRIC STRENGTH, INSULATION RESISTANCE, AND WINDING RESISTANCE.

HANDLING/PACKAGING

PACKAGING AND HANDLING FOR SHIPMENT IS VERIFIED BY INSPECTION TO BE IN ACCORDANCE WITH REQUIREMENTS.

■ (D) FAILURE HISTORY:

NO FAILURE HISTORY ASSOCIATED WITH THIS COMPONENT.

■ (E) OPERATIONAL USE:

CREW WILL USE AERO RUDDER AND DIFFERENTIAL BRAKING TO MAINTAIN DIRECTIONAL CONTROL. THE CORRECTIVE ACTION IS AUTOMATIC. IF THE SELECTED GPC MODE FAILS, THE PILOT AND COMMANDER WILL BE NOTIFIED VIA FAIL FLAG. THE MOST REASONABLE ACTION IS TO CONTINUE LANDING PROCEDURES USING THE FREE CASTOR MODE. CREW WILL USE DIFFERENTIAL BRAKING TO CONTROL THE VEHICLE DURING LANDING AND ROLLOUT.

- APPROVALS -

RELIABILITY ENGINEERING: G. T. TATE  
DESIGN ENGINEERING : D. G. MEYER  
QUALITY ENGINEERING : M. SAVALA  
NASA RELIABILITY :  
NASA SUBSYSTEM MANAGER :  
NASA QUALITY ASSURANCE :

: W. J. Ochoa  
: W. J. Ochoa 8/24/92  
: W. J. Ochoa 4/22/92  
: W. J. Ochoa 7/26/92 7/26/92  
: W. J. Ochoa 7/29/92  
: W. J. Ochoa 7-21-92