

SUBSYSTEM : LANDING DECELERATION FMEA NO 02-1F -G09 -A01 REV:06/27/88

ASSEMBLY : MLG-STRUT ACTUATOR CRIT. FUNC:  
 P/N RI : MC287-0034 CRIT. HDW:  
 P/N VENDOR: PARKER-BERTEA VEHICLE 102 103 104  
 QUANTITY : 2 EFFECTIVITY: X X X  
 : ONE FOR EACH OF TWO MAIN PHASE(S): PL LO OO DO X LS  
 : LANDING GEAR

PREPARED BY: REDUNDANCY SCREEN: A-N/A B-N/A C-N/A  
 DES N LEVERT APPROVED BY: APPROVED BY (NASA):  
 REL C NELSON DES *N. Levert* SSM *R. Balcer*  
 QE M SAVALA REL *[Signature]* QE *[Signature]*  
*7-25-88* *10/22/88*

ITEM:  
ACTUATOR, STRUT

FUNCTION:  
PROVIDE HYDROMECHANICAL MEANS FOR RETRACTING THE MAIN GEAR AND CONTROLLING THE TIME OF GEAR EXTENSION-WITHIN 10 SECONDS MAXIMUM AND SECONDS MINIMUM.

FAILURE MODE:  
EXTERNAL LEAKAGE

CAUSE(S):  
MATERIAL DEFECT (CYLINDER RUPTURE), DAMAGED PISTON ROD SEAL, TEMPERATURE TRANSDUCER BOSS LEAK, RETRACT FLOW CONTROL VALVE LEAK, EXTEND PORT LEAK, RETRACT PORT LEAK, CONTAMINATION

EFFECT(S) ON:  
 (A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE  
 (A) AT DOWN GEAR COMMAND - POSSIBLE JAMMED ACTUATOR. LOSS OF M NUME ONE DUE TO LOSS OF FLUID.  
 (B) GEAR MAY NOT EXTEND. IF GEAR DOES EXTENT, POSSIBLE EXCESS DEPLOYMENT VELOCITY RESULTING IN MINOR STRUCTURAL DAMAGE; SAFE LAND PROBABLE.  
 (C) NONE, COMMITTED TO LAND.  
 (D) POSSIBLE LOSS OF CREW AND VEHICLE IF GEAR DOES NOT DEPLOY.

DISPOSITION & RATIONALE:  
 (A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY (E) OPERATIONAL USE  
 (A) DESIGN  
 CYLINDER BURST FACTOR OF 2.5 - FRACTURE MECHANICS APPLIED. 9'-4-30 STEEL HEAT TREATED 240,000 PSI (PER BPS 4625, REF MIL-HDBK-5B) PROVIDES GOOD PHYSICAL PROPERTIES FOR HIGH ALLOWABLE STRESS. ALLOWABLE IS 174,600 PSI. THE ACTUAL CALCULATED CYLINDER HOOP STRESS IS 162,132 PSI. THE MARGIN OF SAFETY IS 0.076. CYLINDER DESIGN AVOIDS STRESS RISERS AND SUDDEN CHANGE IN SECTION IN CRITICAL AREAS. FLUID DEPLETION OF SYSTEM ONE, OTHER T

SUBSYSTEM : LANDING DECELERATION FMEA NO 02-1F -G09 -A01 REV:06/27

BY CYLINDER RUPTURE, WOULD TAKE APPROXIMATELY 61 SECONDS BASED ON ORIGINAL SIZE IN ACTUATOR EXTEND PORT AND RESERVOIR QUANTITY. 61 SECONDS WOULD APPROXIMATE AT ROLL STOP.

**(B) TEST**

QUALIFICATION-RANDOM VIBRATION AND ENDURANCE TESTS REPRESENTATIVE MISSION ENVIRONMENT. ACTUATOR EXTEND TIME TEST, PROOF PRESSURE TEST, PERFORMANCE RECORD TEST INCLUDING HIGH PRESSURE STATIC EXTERNAL LEAKAGE TEST, LOW PRESSURE STATIC EXTERNAL LEAKAGE TEST AND DYNAMIC SEAL LEAKAGE TEST.

ACCEPTANCE-ACTUATOR EXTEND TIME TEST, PERFORMANCE RECORD TEST INCLUDING HIGH PRESSURE STATIC EXTERNAL LEAKAGE TEST, LOW PRESSURE STATIC EXTERNAL LEAKAGE TEST AND DYNAMIC SEAL LEAKAGE TEST. UNIT CLEANLINESS TEST.

OMRSD-HYDRAULIC SYSTEM INSPECTION, PERFORMED PRIOR TO EACH MISSION; LEFT AND RIGHT HAND WHEEL WELL ZONAL INTERNAL DETAIL INSPECTION, PERFORMED PRIOR TO EACH MISSION; VISUAL INSPECTION FOR EVIDENCE OF LEAKAGE DAMAGE. POST LANDING HYDRAULIC RESERVOIR EFFLUENT SAMPLES, PERFORMED AFTER EVERY FLIGHT; VERIFY THAT RESULTS OF FLUID SAMPLE CONTAMINATION MEET SPECIFICATION. GENERAL REQUIREMENT 5.2, VERIFY ALL HYDRAULIC FLUID USED TO SERVICE VEHICLE IS PER MIL-H-83282.

**(C) INSPECTION**

**RECEIVING INSPECTION**

CERTIFICATION RECORDS AND CERTIFIED TEST REPORTS ARE MAINTAINED WITH CERTIFYING MATERIAL AND PHYSICAL PROPERTIES.

**CONTAMINATION CONTROL**

SUPPLIER TEST STAND FLUID PARTICLE COUNT CHECKED TWICE A DAY, IF APPLICABLE. FLUID CONTAMINATION PARTICLE COUNT CONDUCTED PRIOR TO AT

**CRITICAL PROCESSES**

CYLINDER INSPECTED PRIOR TO HEAT TREAT AND FOUR TENSILE TEST SPECIMENS ARE INCLUDED. CYLINDER IS NORMALIZED AND TEMPERED, CHECKED TO ROCKWELL HARDNESS 40. CADMIUM PLATING IS VERIFIED BY INSPECTION. SHOT PEEN (TO KEEP CHROME PLATING MICROCRACKS FROM REDUCING PARENT MATERIAL FATIGUE PROPERTIES) AND CHROME PLATING OF OUTPUT PISTON ROD ARE VERIFIED BY INSPECTION.

**NDE**

MAGNETIC PARTICLE INSPECTION OF THE CYLINDER IS VERIFIED BY INSPECTION. PENETRANT OR MAGNETIC PARTICLE INSPECTION OF DETAIL PARTS, DEPENDING ON THE ALLOY, IS VERIFIED BY INSPECTION.

**ASSEMBLY/INSTALLATION**

INSPECTION OF DIMENSIONS AT FINAL INSPECTION. QUALITY CONTROL WITNESSES SEAL AND BACKUP RING INSTALLATION. O-RING GROOVES AND SEAL FACE ARE INSPECTED FOR PROPER FINISH. ALL SEALS ARE INSPECTED PRIOR TO INSTALLATION. TORQUES ARE WITNESSED AND VERIFIED BY INSPECTION. ASSEMBLY OPERATIONS ARE VERIFIED BY INSPECTION.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : LANDING DECELERATION FMEA NO 02-1F -G09 -A01 REV:06/27/

**TESTING**

ATP IS WITNESSED BY RI SOURCE INSPECTION.

**HANDLING/PACKAGING**

HANDLING AND PACKAGING REQUIREMENTS ARE VERIFIED BY INSPECTION.

**(D) FAILURE HISTORY**

NOTE: THERE IS NO HISTORY OF FAILURE ON ANY FIELD HARDWARE, THE ONLY FAILURES HAVE BEEN DURING ACCEPTANCE AND QUALIFICATION TESTING.

(A5300-010) DURING ACCEPTANCE TESTING, LEAKAGE WAS DETECTED AT SHUTTLE VALVE CAP INSTALLATION. AT DISASSEMBLY, IT WAS NOTED THAT SEAL CONTAINED A SLIGHTLY DAMAGED SEALING SURFACE ADJACENT TO A SMALL METALLIC PARTICLE. IT WAS DETERMINED THAT THE SEAL DAMAGE WAS INCURRED BY CONTACT WITH THE METALLIC PARTICLE AT THE TIME OF ASSEMBLY. ASSEMBLY PERSONNEL WERE CAUTIONED TO CAREFULLY FOLLOW THE ORBITER ACTUAL ASSEMBLY INSTRUCTIONS.

(A5773-010) DURING ACCEPTANCE TESTING, WHILE PERFORMING THE LOW PRESSURE LEAK TEST, LEAKAGE WAS DETECTED AT THE CHECK VALVE. DISASSEMBLY REVEALED A FIBROUS CONTAMINANT UNDER THE O-RING SEAL WHICH INTERFERED WITH PROPER SEATING OF THE SEAL. THE CONTAMINANT MUST HAVE BEEN PRESENT DURING INSTALLATION OF THE CHECK VALVE. THE SEAL AND BACKUP RING WERE REPLACED AND THE SUBASSEMBLY WAS SUBJECTED TO A REPEAT OF THE VACUUM TEST AND PASSED. LEAKAGE OF THIS TYPE IS READILY DETECTABLE DURING THE ACCEPTANCE TESTS WHICH ACTS LIKE A SCREEN FOR THIS TYPE OF PROBLEM. ASSEMBLY PERSONNEL WERE CAUTIONED TO EXERCISE PARTICULAR CARE DURING SUBSEQUENT EXAMINATION PRIOR TO INSTALLATION.

(AC5501-010) DURING ACCEPTANCE TESTING, WHILE PERFORMING THE LOW PRESSURE STATIC TEST, LEAKAGE WAS DETECTED AT THE EXTEND PORT OF THE ACTUATOR. DISASSEMBLY REVEALED MINOR IRREGULARITIES IN THE MICROSEAL SURFACE. HOWEVER, THEY WERE CONSIDERED TO MEET THE FINISH REQUIREMENTS. THE TEST WAS REVISED TO INCLUDE A VACUUM TEST OF THE CHECK VALVE WHICH WILL MORE CLOSELY REPRESENT THE CONDITIONS IMPOSED DURING THE ACTUATOR ACCEPTANCE TEST.

(A5850-010) DURING QUALIFICATION TESTING, WHILE PERFORMING THE HIGH PRESSURE TEST, LEAKAGE WAS DETECTED AT THE TRANSFER TUBE. THE CAUSE OF THE SEAL BACKUP RINGS (SCARF-CUT VIRGIN TEFLON RING) HAD EXTRUDED IN CERTAIN AREAS OF THE SCARF CUT TO A SUFFICIENT DEGREE TO ALLOW FAILURE OF THE ASSOCIATED O-RING SEAL. THE SUPPLIER WAS DIRECTED TO MODIFY THE ACTUATOR DESIGN TO UTILIZE SOLID (UNCUT) NYLON BACKUP RINGS FOR ALL L AND T SIZE APPLICATIONS. THIS COMBINATION HAS DEMONSTRATED THE ABILITY TO SURVIVE THE HIGHER THERMAL/PRESSURE ENVIRONMENT. THERE WERE 6 FAILURES COVERED BY THIS CORRECTIVE ACTION REPORT.

(A6791-010) DURING QUALIFICATION TESTING, WHILE PERFORMING DYNAMIC CYCLING, LEAKAGE WAS DETECTED. THE LEAKAGE WAS CAUSED BY THE LACK OF A GLAND SEAL VENT HOLE WHICH ALLOWED PRESSURE BUILDUP BETWEEN THE REDUNDANT SEALS AND RESULTED IN PUMPING OF THE FLUID AS THE ACTUATOR WAS CYCLED DURING TESTING. THE SUPPLIER REVISED THEIR MANUFACTURING DOCUMENTATION TO REQUIRE A 15X OPTICAL INSPECTION OF THE GLAND SEAL GROOVES AND SEAL SURFACES PRIOR TO ASSEMBLY. ALSO, A MANDATORY INSPECTION POINT WAS

SUBSYSTEM : LANDING DECELERATION FMEA NO 02-1F -G09 -A01 REV:06/27

INCORPORATED TO VERIFY PROPER POSITIONING OF THE SEAL VENT HOLE.

(A6863-010) DURING QUALIFICATION TESTING, WHILE PERFORMING THE PRESSURE STATIC (VACUUM) LEAKAGE TEST, LEAKAGE WAS DETECTED. THE CAUSE WAS DETERMINED TO BE AN INCORRECTLY MACHINED HOUSING CAVITY WHICH ALLOWED IMPROPER PLACEMENT OF THE CHECK VALVE WHICH ALLOWED THE VALVE POPPET DRIVE THE SPRING PAST SOLID HEIGHT, WHICH BROKE THE SPRING. THIS ALLOWED THE VALVE'S CRACKING PRESSURE TO LOWER, RESULTING IN THE LEAKAGE. CHECK VALVE WAS REPLACED, AND ALL HOUSINGS AT THE SUPPLIER WERE INSPECTED TO VERIFY PROPER STOP MACHINING. A MANDATORY INSPECTION POINT WAS INCORPORATED TO PROVIDE FOR INSPECTION OF STOP DEPTH FOLLOWING MACHINING.

(AB3114-010) DURING QUALIFICATION TESTING, WHILE PERFORMING THE PRESSURE STATIC TEST, LEAKAGE WAS DETECTED AT THE END GLAND. DISASSEMBLY REVEALED NO DISCREPANCIES IN THE SEALS. THE CAUSE OF THE FAILURE WAS CONCLUDED TO BE REDUCTION OF SEAL ELASTICITY AT -65 DEGREES F AFTER EXPOSURE TO THE 275 DEGREES F TEMPERATURE OF THE 72 HOUR IMMERSION TEST. THE SPECIFICATION WAS REVIEWED BY THE ENGINEERING COMMUNITY AND THE SUPPLIER WAS DIRECTED TO MODIFY THE IMMERSION TEST TO 36 HOURS AT -65 DEGREES F AND 36 HOURS AT 200 DEGREES F.

(AB4328-010) DURING QUALIFICATION TESTING, LEAKAGE WAS DETECTED AT THE END GLAND. THE CAUSE WAS DETERMINED TO BE THE GREEN TWEED SEAL, WHICH EXPERIENCED PERMANENT SET AT THE 275 DEGREES F TEMPERATURE IMPOSED DURING THERMAL VACUUM TESTING. WHEN THE UNIT SUBSEQUENTLY EXPERIENCED THE -65 DEGREES F TEMPERATURE, ITS CONTRACTION WAS NOT SUFFICIENT TO OVERCOME THE ORIGINAL EXPANSION AND EFFECT A PROPER SEAL. THE SPECIFICATION WAS REVIEWED BY THE ENGINEERING COMMUNITY AND WAS FOUND TO BE TOO STRICT, SO THE SPECIFICATION WAS REVISED TO LOWER THE HIGH TEMPERATURE REQUIREMENT IN THE THERMAL VACUUM TEST AND THERMAL CYCLE TEST TO 250 DEGREES F.

(AB5130-010) DURING QUALIFICATION TESTING, WHILE PERFORMING THE PRESSURE STATIC LEAKAGE TEST, LEAKAGE WAS DETECTED AT THE STATIC END GLAND SEAL. CAUSE OF THE FAILURE WAS ATTRIBUTED TO LOSS OF SEAL CAPABILITY AT LOW TEMPERATURE (-65 DEGREES F) DUE TO EXPOSURE TO -65 DEGREES F FOR EXTENDED PERIODS. THE SPECIFICATION WAS REVIEWED BY THE ENGINEERING COMMUNITY AND WAS FOUND TO BE TOO STRICT, SO THE SPECIFICATION WAS REVISED TO CHANGE THE LOW TEMPERATURE TO -35 DEGREES F.

(E) OPERATIONAL USE  
NONE