

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE  
NUMBER:02-6-EB24 -X**

**SUBSYSTEM NAME: HYDRAULICS**

**REVISION: 0 01/25/99**

**PART DATA**

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	<b>PART NAME VENDOR NAME</b>	<b>PART NUMBER VENDOR NUMBER</b>
<b>LRU</b>	<b>:ACCUMULATOR, HYDRAULIC BELLOWS SENIOR FLEXONICS, METAL BELLOWS DIV.</b>	<b>MC284-0597-0001 47162</b>

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**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:  
BELLOWS ACCUMULATOR, BOOTSTRAP, HYDRAULIC**

**QUANTITY OF LIKE ITEMS: 3  
ONE PER HYDRAULIC SYSTEM**

**FUNCTION:**

**ACCUMULATOR IS A PRESSURE VESSEL WITH A 1700 PSI GAS PRECHARGE. PURPOSE IS TO PROVIDE RESERVOIR PRESSURIZATION FOR POSITIVE HEAD PRESSURE ON MAIN PUMP INLET DURING APU STARTUP AND CIRCULATION PUMP INLET FOR THERMAL CONDITIONING ON-ORBIT. ASSEMBLY INCLUDES A PRESSURE GAUGE FOR GROUND OPERATIONS. THE GAS CHARGE IS PERMANENTLY SEALED AND DOES NOT REQUIRE MAINTENANCE.**

FAILURE MODES EFFECTS ANALYSIS FMEA - CIL FAILURE MODE

NUMBER: 02-6-EB24-02

REVISION#: 0 01/26/99

SUBSYSTEM NAME: HYDRAULICS

LRU: ACCUMULATOR, HYDRAULIC BELLOWS

CRITICALITY OF THIS

ITEM NAME: ACCUMULATOR, HYDRAULIC BELLOWS

FAILURE MODE: 1R2

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FAILURE MODE:

LOSS OF GAS CHARGE

MISSION PHASE:

PL PRE-LAUNCH  
LO LIFT-OFF  
OO ON-ORBIT  
DO DE-ORBIT  
LS LANDING/SAFING

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA  
103 DISCOVERY  
104 ATLANTIS  
105 ENDEAVOUR

CAUSE:

VIBRATION, FATIGUE, DEFECTIVE MATERIAL OR DEFECTIVE SEAL WELD IN HOUSING ASSEMBLY, STRUCTURAL DAMAGE FROM EXTERNAL SOURCE, LEAKING PRESSURE GAUGE, DEFECTIVE CHARGE TUBE.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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REDUNDANCY SCREEN

A) PASS  
B) PASS  
C) PASS

PASS/FAIL RATIONALE:

A)

OCCURRENCE OF FAILURE MODE CAN BE DETECTED DURING THE NORMAL GROUND TURNAROUND BY READING THE INSTALLED PRESSURE GAGE.

B)

OCCURRENCE OF FAILURE MODE IS DETECTABLE IN FLIGHT VIA VEHICLE INSTRUMENTATION (BOOTSTRAP ACCUMULATOR PRESSURE).

C)

THERE IS NO SINGLE CREDIBLE CAUSE RESULTING IN THE LOSS OF ALL REDUNDANT HARDWARE ITEMS.

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- FAILURE EFFECTS -

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(A) SUBSYSTEM:

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LOSS OF BOOTSTRAP PRESSURE WITH CORRESPONDING LOSS OF RESERVOIR PRESSURE (LOSS OF MAIN PUMP RESTART CAPABILITY) RESULTING IN LOSS OF ONE HYDRAULIC SYSTEM. IF FAILURE OCCURS DURING MAIN PUMP ASCENT/ENTRY OPERATIONS, MAIN PUMP STILL WOULD BE USED TO COMPLETE FLIGHT PHASE; BUT CAPABILITY TO RESTART MAIN PUMP WOULD BE DOUBTFUL DUE TO LOSS OF BOOTSTRAP/RESERVOIR PRESSURE. HOWEVER, AUTOMATIC RECHARGE CAPABILITY USING CIRCULATION PUMP IS AVAILABLE DURING MAJORITY OF ON-ORBIT PHASE.

**(B) INTERFACING SUBSYSTEM(S):**

IMPACT IS ONLY FOR ENTRY/LANDING TIMEFRAME. HYDRAULIC LANDING GEAR DEPLOYMENT CAPABILITY WOULD BE LOST IF SYSTEM ONE WAS LOST. LOSS OF ONE OF TWO HYDRAULIC POWER SYSTEMS TO NOSE WHEEL STEERING. LOSS OF ONE OF THREE HYDRAULIC POWER SYSTEMS TO FLIGHT CONTROL SURFACES AND BRAKES.

**(C) MISSION:**

ASCENT/ENTRY- NO EFFECT FOR FIRST FAILURE. MAIN PUMP OPERATION WOULD MAINTAIN BOOTSTRAP PRESSURE. ORBIT-ABORT DECISION (POSSIBLE EARLY MISSION TERMINATION), OR COMMIT TO CONTINUOUS CIRCULATION PUMP OPERATION TO MAINTAIN PRESSURE IF POSSIBLE.

**(D) CREW, VEHICLE, AND ELEMENT(S):**

POSSIBLE LOSS OF CREW/VEHICLE AFTER 2 FAILURES:

- (1) LOSS OF ACCUMULATOR GAS CHARGE
- (2) LOSS OF SECOND HYDRAULIC SYSTEM

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

POSSIBLE LOSS OF CREW/VEHICLE WITH TWO FAILURES:

- (1) LOSS OF ACCUMULATOR GAS CHARGE WOULD RESULT IN LOSS OF HYDRAULIC SYSTEM OR REQUIRE CONTINUOUS CIRCULATION PUMP OPERATION ON ORBIT.
- (2) LOSS OF SECOND HYDRAULIC SYSTEM.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

INCONEL 718 HOUSING, HYDRAULIC END FITTING AND GAS END FITTING FORM THE PRESSURE VESSEL WHICH HOUSES THE BELLOWS. THE END FITTINGS ARE THREADED INTO THE HOUSING, THEN WELDED TO SEAL AGAINST LEAKAGE. THE BELLOWS IS WELDED TO A MOVEABLE SWEEPER AT THE GAS CHARGE END AND A FIXED END FITTING AT THE FLUID END FORMING A HERMETICALLY SEALED CHAMBER TO SEPARATE THE HYDRAULIC FLUID FROM THE GAS PRECHARGE. THE PRESSURE GAUGE IS THREADED INTO THE GAS END OF THE HOUSING, THEN WELDED TO SEAL AGAINST LEAKAGE. THE 300 CRES CHARGE TUBE END IS CRIMPED AND WELDED CLOSED TO PERMANENTLY SEAL GAS PRECHARGE AFTER UNIT IS PROPERLY PRESSURIZED. PRECHARGE IS 10% HELIUM, 90% NITROGEN 1700 +/- 25 PSIG AT 70 +/- 5 DEG F. THEN THE TUBE IS FORMED TO RECESS IT INTO THE GAS END FITTING CAVITY AND POTTED FOR VIBRATION RESISTANCE.

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**(B) TEST:**

QUALIFICATION (SRB BELLOWS ACCUMULATOR WITH SAME HOUSING EXCEPT DIFFERENCES IN HYDRAULIC PORT AND PRECHARGE PRESSURE):

- BURST TEST - 13,000 PSI AT 250 F. PASS/FAIL CRITERIA: NO EVIDENCE OF EXTERNAL LEAKAGE OR RUPTURE.
- RUPTURE TEST - INCREASE PRESSURE TO RUPTURE (RUPTURE OCCURRED AT 16,759 PSIG)
- OPERATING LIFE CYCLE TEST - 13,000 CYCLES FROM 2000 TO 3250 PSIG  
IMPULSE CYCLING - 50,000 CYCLES
- PERFORMANCE RECORD - INCLUDES OPERATIONAL CHECK AND HYDRAULIC FLUID AND GAS LEAK TEST

**ACCEPTANCE:**

- EXAMINATION OF PRODUCT - WEIGHT, WORKMANSHIP, FINISH, DIMENSIONS AND CONSTRUCTION
- PROOF PRESSURE - 4,500 PSI AT HYDRAULIC PORT FOR 2 MINUTES AND REPEATED. PASS/FAIL CRITERIA: NO EXTERNAL LEAKAGE OR PERMANENT DEFORMATION.
- PERFORMANCE RECORD -
  - OPERATIONAL TEST- CYCLE FROM 2000 TO 3000 PSIG FOR 5 CYCLES; VERIFY SEPARATOR MOVES AT 1675 TO 1900 PSIG.
  - VERIFY ACCUMULATOR PASSED HELIUM MASS SPECTROMETER LEAK TEST AT ASSEMBLY LEVEL (MINUS FINAL CHARGE TUBE WELD). PASS/FAIL: LESS THAN  $1 \times 10^{-8}$  SCC/SEC OF HELIUM AT ONE ATMOSPHERE DELTA P
  - FINAL ASSEMBLY GAS LEAK TEST: ACCUMULATOR IS PLACED IN AN AIRTIGHT CONTAINER FOR 5 HOURS. PASS/FAIL: HELIUM LEVEL DOES NOT INCREASE ABOVE BACKGROUND READING. BACKGROUND READING MUST BE BELOW  $9 \times 10^{-4}$  SCC/SEC OF HELIUM

**(C) INSPECTION:**

RECEIVING INSPECTION

TEST REPORTS AND MATERIAL CERTIFICATIONS ARE MAINTAINED CERTIFYING MATERIAL AND PHYSICAL PROPERTIES.

CONTAMINATION LEVEL

CLEANLINESS LEVEL PER 190 PER MA0110-0301 IS VERIFIED BY INSPECTION.

CRITICAL PROCESSES

HOUSING AND END FITTINGS: PENETRANT INSPECTED. HEAT TREAT LOT TESTED FOR TENSILE, YIELD, ELONGATION, AND REDUCTION IN AREA.

STRUCTURAL WELDS VERIFIED BY INSPECTION.

NDE

MAGNETIC PARTICLE INSPECTION IS PERFORMED AND RESULTS ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

PARTS PROTECTION DURING FABRICATION OPERATION IS VERIFIED BY INSPECTION. MANUFACTURING/ASSEMBLY PROCESSES ARE VERIFIED BY INSPECTION.

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**TESTING**

LEAK TESTS ARE PERFORMED AT SEVERAL STAGES OF ASSEMBLY AND ARE VERIFIED BY INSPECTION. PASS/FAIL: LEAKAGE ACROSS ASSEMBLY NOT TO EXCEED  $1 \times 10^{-8}$  SCC/SEC OF HELIUM AT ONE ATMOSPHERE DELTA P.

**HANDLING/PACKAGING**

INSPECTION VERIFIES PACKAGING PRIOR TO SHIPMENT.

**(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 DATA BASE.

**(E) OPERATIONAL USE:**

RUN CIRCULATION PUMP TO ATTEMPT TO MAINTAIN BOOTSTRAP PRESSURE FOR MAIN PUMP START UP FOR ENTRY.

**- APPROVALS -**

SS & PAE MANAGER	: D.F. MIKULA	: <i>P. Hens for Mikula</i>
SS & PAE ENGINEER	: K.E. RYAN/C.S. PUTCHA	: <i>K.E. Ryan</i>
HYDRAULIC	: J. Y. KINOSHITA	: <i>J.Y. Kinoshita</i>
BNA SSM	: B. VAN METER	: <i>B. Van Meter</i>
JSC MOD	: <i>C. D. Feterosino</i>	: <i>C. D. Feterosino</i>
JSC NASA	: Brad Irbeck	: <i>Brad Irbeck</i>
NASA SRQA	: Jeffrey S. Goza	: <i>Jeffrey S. Goza</i>
USA/SAM	: <i>M.J. Rudolph</i>	: <i>M.J. Rudolph</i>
USA <i>Orbiter Element</i>	:	: <i>Jeffrey S. Goza</i>