

**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-EB24-01**

**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:**

**HOUSING RUPTURE**

**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:**

**MATERIAL DEFECT, FATIGUE, STRUCTURAL DAMAGE FROM EXTERNAL SOURCE**

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES**

**RTLS RETURN TO LAUNCH SITE**

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**REDUNDANCY SCREEN**

**A) PASS  
B) PASS  
C) PASS**

**PASS/FAIL RATIONALE:**

**A)**

**OCCURRENCE OF FAILURE MODE IS DETECTABLE DURING NORMAL GROUND  
TURNAROUND BY READING THE INSTALLED PRESSURE GAUGE.**

**B)**

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

**C)**

**THERE IS NO SINGLE CREDIBLE CAUSE THAT CAN RESULT IN LOSS OF ALL REDUNDANT  
HARDWARE ITEMS.**

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

**FIRST FAILURE WILL CAUSE LOSS OF ONE HYDRAULIC SYSTEM.**

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

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LOSS OF HYDRAULIC POWER FOR ENGINE VALVE CONTROL FOR ONE ENGINE RESULTING IN LOSS OF ONE SSME THRUST CONTROL; HOWEVER, ENGINE VALVES WILL LOCK INTO POSITION AND ENGINE WILL CONTINUE TO OPERATE. LOSS OF REDUNDANT HYDRAULIC POWER SYSTEM FOR FOUR SSME TVC ACTUATORS. LOSS OF LANDING GEAR HYDRAULIC DEPLOYMENT CAPABILITY IF SYSTEM ONE IS LOST. LOSS OF REDUNDANT HYDRAULIC POWER TO NOSEWHEEL STEERING IF SYSTEM 1 OR 2 IS LOST. LOSS OF ONE OF THREE HYDRAULIC POWER SYSTEMS TO FLIGHT CONTROL SURFACES AND BRAKES. LOSS OF ONE OF THREE ET UMBILICAL RETRACT ACTUATORS FOR EACH UMBILICAL PLATE. HYDRAULIC FLUID ON TPS SCREED MAY CAUSE DEGRADED TPS BONDS.

**(C) MISSION:**

ABORT DECISION OR POSSIBLE EARLY MISSION TERMINATION AFTER FIRST FAILURE.

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

NONE.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

POSSIBLE LOSS OF CREW/VEHICLE WITH TWO FAILURES. THIS FAILURE, PLUS LOSS OF SECOND HYDRAULIC SYSTEM. CRITICALITY 1 FOR SSME INDUCED RTLS.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

THE BELLOWS ACCUMULATOR USES A DYNAMIC METAL BELLOWS AS THE SEPARATOR BETWEEN THE GAS PRECHARGE AND THE HYDRAULIC FLUID. THE BELLOWS ARE WELDED TO A MOVABLE SWEEPER AT THE GAS CHARGE END AND A FIXED END FITTING AT THE FLUID END FORMING A HERMETICALLY SEALED GAS CHAMBER IN WHICH GAS PRECHARGE IS MAINTAINED. ACCUMULATOR BELLOWS HOUSING IS DESIGNED TO A BURST FACTOR OF 4.0. HOUSING ASSEMBLY CONSISTS OF THE HOUSING, HYDRAULIC END FITTING, AND GAS FITTING. MATERIAL IS INCONEL 718, HEAT TREATED TO 180 KSI (MIL-H-6875(PYROMETRIC REQUIREMENTS) AND AMS 5862 (PRECIPITATION HARDENED)), WHICH PROVIDES GOOD PHYSICAL PROPERTIES FOR HIGH ALLOWABLE STRESS. ALLOWABLE STRESS IS 172.8 KSI. THE MAXIMUM CALCULATED STRESS IS 165.7 KSI AT THE PLUG SPHERICAL RADIUS (BURST 13,000 PSI). THE MARGIN OF SAFETY IS +0.04.

**(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).

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**ACCEPTANCE:**

- EXAMINATION OF PRODUCT – WEIGHT, WORKMANSHIP, FINISH, DIMENSIONS AND CONSTRUCTION.
- PROOF PRESSURE – 4500 PSI AT HYDRAULIC PORT FOR 2 MINUTES AND REPEATED. PASS/FAIL CRITERIA: NO EXTERNAL LEAKAGE OR PERMANENT DEFORMATION.
- PERFORMANCE RECORD TEST:  
OPERATIONAL TEST – CYCLE FROM 2000 TO 3000 PSIG FOR 5 CYCLES;  
VERIFY SEPARATOR MOVES AT 1675 TO 1900 PSIG.

**GROUND TURNAROUND TEST**

ANY TURNAROUND CHECKOUT TEST IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

**(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.

**TESTING**

PROOF PRESSURE TESTS ARE PERFORMED AS PART OF THE ACCEPTANCE TEST PROCEDURE AND ARE VERIFIED BY INSPECTION.

**HANDLING/PACKAGING**

INSPECTION VERIFIES PACKAGING PRIOR TO SHIPMENT.

**(D) FAILURE HISTORY:**

CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMOLIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATA BASE.

**(E) OPERATIONAL USE:**

NONE. RAPID LEAK RATE WOULD DEplete HYDRAULIC SYSTEM BEFORE ACTION COULD BE TAKEN.

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- APPROVALS -

SS & PAE MANAGER	: D.F. MIKULA	: <i>P. Hayes 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	: C. D. FOSTER/STEVE	: <i>C. D. Foster</i>
JSC NASA	: Brad Tolbeck	: <i>Brad Tolbeck</i>
NASA SRQA	: Jeffrey S. Gioza	: <i>Jeffrey S. Gioza</i>
USA/SAM	: M. W. BUCKHART	: <i>M. W. Buckhart</i>
USA <i>Orbiter Element</i>		: <i>Shirane State</i>