

**FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE**

NUMBER: 06-3A-0608 -X

SUBSYSTEM NAME: ACTIVE THERMAL CONTROL

REVISION: 0

02/04/88

---

**PART DATA**

---

	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	: WATER SPRAY BOILER ASSEMBLY	MC250-0019 ITEM 634
SRU	: WATER TANK	SV766504-1

---

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

WATER TANK

**QUANTITY OF LIKE ITEMS:** 3

ONE EACH BOILER ASSEMBLY

**FUNCTION:**

PROVIDES STORAGE OF WATER AND A POSITIVE METHOD OF EXPULSION DURING WATER SPRAY BOILER OPERATION.

**FAILURE MODES EFFECTS ANALYSIS FMEA – CIL FAILURE MODE**

**NUMBER: 06-3A-0608- 02**

**REVISION#: 1 08/25/98**

**SUBSYSTEM NAME: ATCS - WATER SPRAY BOILER**

**LRU: WATER SPRAY BOILER ASSEMBLY**

**ITEM NAME: WATER TANK**

**CRITICALITY OF THIS  
FAILURE MODE: 1R2**

**FAILURE MODE:**

EXTERNAL LEAKAGE, NITROGEN

**MISSION PHASE:**

LO LIFT-OFF  
DO DE-ORBIT

**VEHICLE/PAYLOAD/KIT EFFECTIVITY:**

102 COLUMBIA  
103 DISCOVERY  
104 ATLANTIS  
105 ENDEAVOUR

**CAUSE:**

MECHANICAL SHOCK, VIBRATION, CORROSION

**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 NITROGEN - UNABLE TO PROVIDE THERMAL CONTROL IN ONE APU/HYD SYSTEM DUE TO LOSS OF CAPABILITY TO EXPEL WATER FROM STORAGE TANK.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE****NUMBER: 06-3A-0608-02****(B) INTERFACING SUBSYSTEM(S):**

POSSIBLE LOSS OR LIMITED RUN TIME OF ONE APU/HYD SYSTEM DUE TO LOSS OF COOLING. LIMITED RUN TIME MAY NOT ALLOW APU/HYD SYSTEM TO SUPPORT ENTIRE POWERED FLIGHT OR ENTRY PHASE. LOSS OF HYDRAULIC CAPABILITY TO THROTTLE ONE MAIN ENGINE, LOSS OF HYDRAULIC LANDING GEAR DEPLOY AND NOSEWHEEL STEERING IF SYSTEM ONE IS LOST, AND LOSS OF ONE OF THREE ET UMBILICAL RETRACT ACTUATORS FOR EACH UMBILICAL PLATE. LOSS OF REDUNDANT HYDRAULIC POWER SYSTEM FOR FOUR TVC ACTUATORS. LOSS OF ONE OF THREE HYDRAULIC POWER SYSTEMS TO FLIGHT CONTROL SURFACES AND BRAKES.

**(C) MISSION:**

ABORT DECISION - REMAINING TWO SYSTEMS PROVIDE SAFE RETURN.

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

NO EFFECT

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

FUNCTIONAL CRITICALITY EFFECT - POSSIBLE LOSS OF CREW/VEHICLE WITH THIS FAILURE PLUS LOSS OF A SECOND APU/HYD SYSTEM.

---

**-DISPOSITION RATIONALE-**

---

**(A) DESIGN:**

THE TANK HOUSING IS CONSTRUCTED OF 6061-T6 ALUMINUM WITH A 0.045 INCH WALLTHICKNESS. TANK END FITTING SEALS ARE MANUFACTURED OF VITON. GN2 REGULATOR/RELIEF VALVE PREVENTS TANK OVERPRESSURIZATION. DESIGN SAFETY FACTOR - 1.5 FOR PROOF PRESSURE AND 2.0 FOR BURST. MAXIMUM OPERATING PRESSURE IS 37 PSIG.

**(B) TEST:****QUALIFICATION:**

- RANDOM VIBRATION TEST (BOILER AND VENT AREA) - ACCELERATION SPECTRAL DENSITY INCREASING AT RATE OF 6 DB/OCTAVE FROM 20 TO 50 HZ; CONSTANT AT 0.01 G SQ/HZ FROM 50 TO 2000 HZ FOR 48 MINUTES/AXIS (100 MISSION EQUIVALENCY). TEST PERFORMED WITH STORAGE TANK LOADED 100 PERCENT AND AT MAXIMUM OPERATING PRESSURE (FULL GN2 PRESSURE). HYDRAULIC AND APU LUBE OIL CIRCUITS PRESSURIZED TO MAX OPERATING PRESSURE THROUGHOUT

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 06-3A-0608-02**

TEST. PASS/FAIL CRITERIA: NO DAMAGE OR PERMANENT DEFORMATION, NO ELECTRICAL CIRCUIT INTERRUPTIONS DURING TEST.

- SHOCK TEST - (PER MIL-STD-810, METHOD 516.1, PROCEDURE 1) 18 SHOCKS TOTAL, 6 EACH AXIS, AT 15 G'S PEAK VALUE FOR 11 MS NOMINAL DURATION WITH FULL WATER LOAD. PASS/FAIL CRITERIA: UNIT MUST PASS SUBSEQUENT PERFORMANCE RECORD TEST.
- PERFORMANCE RECORD TEST INCLUDES:
  - DESIGN POINT CHECK - VERIFICATION OF WSB SYSTEM OPERATING PARAMETERS DURING POOL BOILING (SEA LEVEL TESTING) AND SPRAY BOILING (AT ALTITUDE). TESTING INCLUDES A WATER CARRY OVER EFFICIENCY TEST WHICH COMPARES ACTUAL VS THEORETICAL WATER USAGE AT ALTITUDE ONLY WITH A KNOWN HEAT SINK.
- MISSION PROFILE TEST AT ALTITUDE - SIMULATION OF A BASELINE FLIGHT PROFILE AT MAXIMUM HEAT LOAD AND NORMAL OPERATION TO VERIFY PROPER WSB PERFORMANCE (INCLUDING SPRAYING)
- THERMAL CYCLE TEST - TESTED AT OPERATING CONDITIONS AT 70 TO 275 TO 70 DEG F WITH DWELL OF 10 MINUTES AT EACH LEVEL FOR 5 CYCLES. ALSO TESTED WITH WSB NOT OPERATING AT 70 TO -65 TO 70 DEG F WITH A DWELL OF 3 HOURS AT EACH LEVEL FOR 3 CYCLES. PASS/FAIL CRITERIA: NO DAMAGE OR PERMANENT DEFORMATION (INCLUDING TANK FAILURE).

**ACCEPTANCE:**

- WATER TANK COMPONENT TESTED PRIOR TO WSB ASSEMBLY AS FOLLOWS: PROOF TEST TANK (58 PSIG) FOR 3 MINUTES, HELIUM LEAK TEST OF TANK, AND BURN IN/RUN IN (10 FULL STROKE CYCLES).
- EXAMINATION OF PRODUCT - VERIFICATION OF WORKMANSHIP, FINISH, DIMENSIONS, CONSTRUCTION, CLEANLINESS, IDENTIFICATION, TRACEABILITY LEVEL AND PROCESSES PER DRAWINGS AND MC250-0019 (WATER SPRAY BOILER PROCUREMENT SPEC).
- LOW SIDE N2 PROOF TEST - TESTED AT 51 PSIG FOR 15 MINUTES WITH NITROGEN AND CIRCUIT RELIEF VALVE PREVENTED FROM OPENING PASS/FAIL CRITERIA: NO EVIDENCE OF PERMANENT DEFORMATION AND PASSAGE OF SUBSEQUENT WATER AND N2 CIRCUIT LEAK CHECKS.
- LOW SIDE N2 LEAK CHECK - INCLUDES RELIEF VALVE CRACK TEST FOLLOWED BY N2 LEAK CHECK AT 28 PSIG WITH HELIUM. PASS/FAIL CRITERIA: 2.8 SCCM MAX HELIUM LEAKAGE.
- DESIGN POINT CHECK - VERIFICATION OF WSB SYSTEM OPERATING PARAMETERS DURING POOL BOILING (SEA LEVEL TESTING) AND SPRAY BOILING (AT ALTITUDE) TESTING INCLUDES A COMPLETE WATER LOAD EXPULSION TEST, PLUS A WATER CARRY OVER EFFICIENCY TEST WHICH COMPARES ACTUAL VERSUS THEORETICAL WATER USAGE AT ALTITUDE ONLY WITH A KNOWN HEAT SINK.

**PRELAUNCH:**

**FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL FAILURE MODE**

**NUMBER: 06-3A-0608- 02**

- WSB IS OPERATING DURING PRELAUNCH PHASE AND INTEGRITY IS VERIFIED BEFORE LAUNCH USING VEHICLE INSTRUMENTATION

**GROUND TURNAROUND TEST**

- ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

**(C) INSPECTION:**

**RECEIVING INSPECTION**

RAW MATERIALS ARE VERIFIED BY LAB ANALYSIS. VERIFICATION OF MATERIAL AND EQUIPMENT CONFORMING TO CONTRACTS IS PERFORMED BY INSPECTION.

**CONTAMINATION CONTROL**

CONTAMINATION CONTROL PROCESSES AND PLANS AND CORROSION PROTECTION PROVISIONS ARE VERIFIED BY INSPECTION. CLEANLINESS OF INTERNAL WATER AND INTERNAL NITROGEN PRIOR TO ASSEMBLY AND AFTER ASSEMBLY ARE VERIFIED BY INSPECTION.

**ASSEMBLY/INSTALLATION**

MANUFACTURING, INSTALLATION, AND ASSEMBLY OPERATIONS ARE VERIFIED BY INSPECTION. PART PROTECTION, COATING, AND PLATING ARE VERIFIED BY INSPECTION.

**CRITICAL PROCESSES**

WELDING IS VERIFIED BY INSPECTION.

**NONDESTRUCTIVE EVALUATION**

EXAMINATION OF SURFACE WELDS FOR SURFACE AND SUBSURFACE DEFECTS IS VERIFIED BY X-RAY AND DYE PENETRANT INSPECTION.

**TESTING**

INSPECTION POINTS PERFORMED DURING ACCEPTANCE TESTING ARE VERIFIED BY INSPECTION.

**HANDLING/PACKAGING**

PROPER HANDLING AND STORAGE ENVIRONMENT IS 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 DATA BASE. THE FAILURE HISTORY DATA PROVIDED BELOW IS NO LONGER BEING KEPT UP-TO-DATE.

(AD3382-010) (1987) DURING ACCEPTANCE TESTING. WSB EXHIBITED EXTERNAL LEAKAGE IN ITS LOW PRESSURE NITROGEN SYSTEM. THERE WERE TWO LEAKS, ONE AT

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 06-3A-0608-02**

THE NITROGEN TANK BOSS ADAPTOR, AND ONE AT THE LOW PRESSURE SIDE OF THE WATER TANK FLUID FITTING NUT. THE FIRST WAS DUE TO A VERY SMALL HOLE IN THE PARENT METAL OF THE ADAPTOR. THE ADAPTOR WAS REPLACED AND SUBSEQUENTLY PASSED ALL LEAKAGE AND PROOF PRESSURE TESTS. THE SECOND LEAK WAS DUE TO A DAMAGED "O" RING SEAL. THE FLUID FITTING WAS REASSEMBLED WITH A NEW "O" RING AND ALSO PASSED SUBSEQUENT LEAKAGE TESTS. THESE FAILURES ARE ATP SCREENABLE.

**(E) OPERATIONAL USE:**

ASCENT: SHUT DOWN AFFECTED APU/HYD SYSTEM AT AN APPROPRIATE TIME BASED ON FLIGHT PHASE AND SYSTEM TEMPERATURES.

ENTRY: SHUT DOWN AFFECTED APU/HYD SYSTEM OR DELAY APU START IF FAILURE KNOWN PRIOR TO DEORBIT.

---

**- APPROVALS -**

---

EDITORIALLY APPROVED  
TECHNICAL APPROVAL

: BNA  
: VIA APPROVAL FORM

: J. Kimura 8-25-98  
: 95-CIL-009\_06-3A