

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 06-3A-0602 -X****SUBSYSTEM NAME: ACTIVE THERMAL CONTROL****REVISION: 0 02/04/88**

PART DATA

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
LRU WATER SPRAY BOILER	MC250-0019 ITEM 61 SV766500-4

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
WATER SPRAY BOILER ASSEMBLY**QUANTITY OF LIKE ITEMS: 3**
THREE INDEPENDENT BOILER ASSEMBLIES**FUNCTION:**
PROVIDES TRANSFER OF WASTE HEAT FROM ORBITER HYDRAULIC SYSTEM AND
AUXILIARY POWER UNIT LUBE OIL SYSTEM UTILIZING LATENT HEAT CAPACITY OF
WATER.

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REVISION#: 1 08/25/98

SUBSYSTEM NAME: ATCS - WATER SPRAY BOILER

LRU: WATER SPRAY BOILER ASSEMBLY

ITEM NAME: WATER SPRAY BOILER ASSEMBLY

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

FAILURE MODE:

RESTRICTED FLOW OF WATER

MISSION PHASE:

LO LIFT-OFF
DO DE-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA
103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:

EXCESSIVE CONTAMINATION, CORROSION, FREEZING

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 FUNCTION - UNABLE TO PROVIDE THERMAL CONTROL IN ONE APU LUBE OIL/HYDRAULIC SYSTEM.

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(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 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 SUBSYSTEMS PROVIDE SAFE RETURN.

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

NO EFFECT

(E) FUNCTIONAL CRITICALITY EFFECTS:

FUNCTIONAL CRITICALITY EFFECTS - POSSIBLE LOSS OF CREW/VEHICLE WITH THIS FAILURE PLUS LOSS OF A SECOND APU/HYD SYSTEMS

-DISPOSITION RATIONALE-

(A) DESIGN:

WSB IS SERVICED WITH DISTILLED OR DEIONIZED WATER WHICH IS PASSED THRU A 25 MICRON FILTER. THE WATER SUPPLY VALVES INCORPORATE 40 MICRON INLET FILTERS. ALL COMPONENTS ARE CONSTRUCTED OF MATERIALS WHICH ARE COMPATIBLE WITH WORKING FLUIDS: TANK BELLOWS ASSEMBLY - INCONEL 718; BELLOWS LINE INTERFACE - INCONEL 625; WATER LINES - STAINLESS STEEL (SS) 347; SPRAY BARS - SS 347; HEAT EXCHANGER (HX)/CORE SHELL - ALUMINUM 6061-T8 COATED WITH POLYCOAT; TUBE BUNDLE - SS 347. WATER SPRAY VALVE'S POPPET SEALING SURFACE IS VITON. THE HOUSING IS 304L SS/EBRITE 26-1. THE VALVE ARMATURE IS EBRITE 26-1. THE VALVE'S WAVE SPRING IS SS 302. REDUNDANT HEATERS ARE INCORPORATED ON THE WATER TANK, BOILER AND NOZZLE ASSEMBLY WHICH MINIMIZES FREEZING. STEAM DUCT NOZZLE ASSEMBLY REDESIGNED TO MINIMIZE FLASHING/FREEZING OF WATER IN WSB HX/CORE. SPRAY BARS HAVE 0.015 INCH ORIFICES ALONG LENGTH.

(B) TEST:

QUALIFICATION:

- PERFORMANCE RECORD TEST INCLUDES:

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- WATER CIRCUIT LEAK CHECK-TESTED AT 33.5 PSIG WITH HELIUM. PASS/FAIL CRITERIA: 0.933 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
- 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). PARAMETERS CHECKED: HYDRAULIC FLUID IN/OUT TEMPS, HYDRAULIC FLOW RATES, APU LUBE OIL HEAT LOADS AND FLOWRATES.
- THERMAL VACUUM TEST-AT 1×10^{-5} TORR PRESSURE WITH WALL TEMPERATURE OF -65 DEG F, HYDRAULIC FLOW OF 3 GPM AT 0 DEG F, AND 50% DUTY CYCLE. REPEAT TEST-AMBIENT PRESSURE WITH WALL TEMP OF -20 DEG F. PASS/FAIL CRITERIA: HX/CORE SHELL AND STORAGE TANK > FREEZING, ALL WATER CONTACTING SURFACES > 40 DEG F AND NO SURFACE > 500 F.

ACCEPTANCE:

- COMPONENTS FUNCTIONALLY TESTED PRIOR TO WSB ASSEMBLY AS FOLLOWS:
 - WATER SPRAY VALVES-FLOW DELTA PRESSURE TEST, PULSING TEST, INSULATION RESISTANCE TEST, INTERNAL/EXTERNAL LEAK TESTS, AND PROOF TEST.
 - HYD SPRAY BARS-FLOW DELTA PRESSURE TEST AT HX/CORE LEVEL ASSY (ALUM SHELL AROUND TUBE BUNDLE) WITH 10 LB/MIN. MINIMUM WATER INLET FLOW AND MAX DELTA P OF 16.5 PSID.
 - APU SPRAY BAR TEST-FLOW DELTA PRESSURE TEST AT HX/CORE LEVEL ASSEMBLY (ALUM SHELL AROUND TUBE BUNDLE) WITH 3.33 LB/MIN MINIMUM WATER INLET FLOW AND MAX DELTA P OF 16.5 PSID.
 - 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).
 - CLEANLINESS-VERIFICATION OF WATER SYSTEM CLEANLINESS BY CONTAMINATION SAMPLE PRIOR TO FINAL ATP TESTING (WATER-CLEANLINESS SPEC SE-S-0073).
 - 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.

GROUND TURNAROUND TEST

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

**(C) INSPECTION:
RECEIVING INSPECTION**

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RAW MATERIALS ARE VERIFIED BY LAB ANALYSIS. MATERIALS ARE VERIFIED BY INSPECTION PRIOR TO MACHINING.

CONTAMINATION CONTROL

ALL FLUIDS (WATER) ARE SAMPLED FOR CLEANLINESS. INTERNAL CLEANLINESS OF WATER LINES, BOILER AND TANK ASSEMBLY, STEAM DUMP NOZZLE ARE VERIFIED BY INSPECTION. CONTAMINATION CONTROL OF HARDWARE IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

MANUFACTURING, INSTALLATION AND ASSEMBLY OPERATIONS ARE VERIFIED BY INSPECTION. TORQUING PER DRAWING REQUIREMENTS AND CRITICAL DIMENSIONS IS VERIFIED BY INSPECTION.

CRITICAL PROCESSES

WELDING, HEAT TREATMENT, AND PASSIVATION ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

X-RAY AND PENETRANT INSPECTION ARE PERFORMED ON WELDS IN THE ASSEMBLY AND VERIFIED BY INSPECTION.

TESTING

ACCEPTANCE TESTING IS VERIFIED BY INSPECTION

HANDLING/PACKAGING

ABSENCE OF PHYSICAL DAMAGE AND DEFORMATION 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.

(SHUTTLE INFLIGHT DATA AND ANOMALY LIST, STS-9 #6) (OV102, 1984) WSB 3 LUBE OIL RETURN TEMPERATURE OVERSHOOT BEFORE PULSING. IT SHOULD HAVE CONTROLLED TO 253 DEG F, BUT HIT 287 DEG F BEFORE PULSING AND PROPERLY CONTROLLING. A FREEZING CONDITION COULD RESULT IN RESTRICTED FLOW OF WATER IN THE SPRAY BARS. THE FAILED CONTROLLER WAS REPLACED.

(AD1720-010) (1987) ALUMINUM HYDROXIDE IN HEAT EXCHANGER/CORE WAS DISCOVERED ON ALL THREE WSB ON OV104 (S/N 00013, 00014, 00015). SUBSEQUENT DISASSEMBLY OF S/N 00013 REVEALED EXCESSIVE CORROSION OF HEAT EXCHANGER SHELL IN SPRAY BAR AREAS (POTENTIAL FOR SPRAY BAR ORIFICE PLUGGING). FUTURE ATP WILL INCLUDE CHEMICAL ANALYSIS OF TEST WATER AFTER FINAL TESTING. CORRECTIVE ACTION IS STILL ONGOING.

(E) OPERATIONAL USE:

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

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

- APPROVALS -

EDITORIALLY APPROVED : BNA : J. Kumar 8-25-98
TECHNICAL APPROVAL : VIA APPROVAL FORM : 95-CIL-009_06-3A