

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE  
NUMBER: 06-3A-0605 -X**

**SUBSYSTEM NAME: ACTIVE THERMAL CONTROL**

**REVISION: 0 02/04/88**

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**PART DATA**

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	<b>PART NAME VENDOR NAME</b>	<b>PART NUMBER VENDOR NUMBER</b>
LRU	: WATER SPRAY BOILER ASSEMBLY	MC250-0019 ITEM 607
SRU	: WATER SUPPLY VALVE	SV766507-1

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**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:  
WATER SUPPLY VALVE**

**QUANTITY OF LIKE ITEMS: 6  
TWO EACH BOILER ASSEMBLY**

**FUNCTION:**  
ELECTRICALLY OPERATED WATER CONTROL VALVE TO REGULATE THE RATE OF WATER SUPPLIED TO THE HYDRAULIC AND APU LUBE OIL HEAT EXCHANGER SECTION, ALSO ISOLATES WATER FROM THE HEAT EXCHANGER DURING ORBITAL OPERATIONS. VALVE HAS REDUNDANT COILS.

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

**NUMBER: 06-3A-0605- 02**

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

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

**LRU: WATER SPRAY BOILER ASSEMBLY**

**ITEM NAME: WATER SUPPLY VALVE**

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

**FAILURE MODE:**

FAILS TO OPEN

**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, PHYSICAL BINDING/JAMMING,  
CONTAMINATION, ELECTRICAL OPEN OR SHORT

**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/HYD SYSTEM DUE TO THE INABILITY TO TRANSFER WATER.

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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 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:**

POSSIBLE ABORT DECISION IF APU/HYD COOLING IS LOST. REMAINING TWO SYSTEMS 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 SYSTEM.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

40 MICRON FILTER IS INCORPORATED AT THE INLET TO EACH WATER SUPPLY VALVE. BI-FILAR WOUND SOLENOID WINDING PERMITS VALVE ACTUATION FROM EITHER CONTROLLER. VALVE HOUSING IS 304L STAINLESS STEEL/EBRITE 26-1. VALVE ARMATURE IS EBRITE 26-1. VALVE WAVE SPRING IS 302 STAINLESS STEEL. VALVE IS A NORMALLY CLOSED VALVE, REQUIRING ELECTRICAL SIGNAL TO OPEN. UPON REMOVAL OF SIGNAL, INTERNAL SPRING FORCE CLOSES VALVE. TESTING INDICATES THAT THERE IS SOME THERMAL CROSSTALK BETWEEN APU AND HYDRAULIC CIRCUITS IN THE EVENT OF A FAILED WATER SUPPLY VALVE. DESIGN IS SIMILAR TO THE PULSER VALVE IN THE FLASH EVAPORATOR SYSTEM WHICH RAN APPROXIMATELY 10 MILLION CYCLES DURING DEVELOPMENT TESTING.

**(B) TEST:**

QUALIFICATION:

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- WATER FEED VALVE LOW VOLTAGE TEST-VERIFY MAX PULL IN VOLTAGE OF 18 VDC.
- 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% AND AT MAX OPERATING PRESSURE. HYDRAULIC AND APU LUBE OIL CIRCUITS PRESSURIZED TO MAX OPERATING PRESSURE THROUGHOUT 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 PEAK VALUE FOR 11 MS NOMINAL DURATION WITH FULL WATER LOAD. PASS/FAIL CRITERIA: UNIT MUST PASS SUBSEQUENT PERFORMANCE TESTS.
- PERFORMANCE RECORD TEST INCLUDES:
  - ELECTRICAL POWER CHECK-INCLUDES ELECTRICAL FUNCTIONAL CHECK OF WATER SUPPLY VALVES.
  - 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)
- 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 VALVE FAILURE).

**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, PROOF TEST, AND VERIFY MAX PULL-IN VOLTAGE OF 18 VDC.
- WATER CIRCUIT PROOF PRESSURE TEST-TESTED AT 51 PSIG FOR 15 MINUTES MINIMUM WITH NITROGEN. PASS/FAIL CRITERIA: NO PERMANENT DEFORMATION PLUS PASSAGE OF SUBSEQUENT WATER AND NITROGEN CKT LEAK CHECKS.
- 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).

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- ELECTRICAL POWER CHECK - INCLUDES ELECTRICAL FUNCTIONAL CHECK OF WATER SUPPLY VALVES.
- LOW VOLTAGE VALVE ACTUATION TEST - VERIFICATION OF AUDIBLE VALVE ACTUATION AT 24 VDC (APPLIED TO CONTROLLER).
- 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**

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

**CONTAMINATION CONTROL**

CLEANLINESS OF WATER LINES IS VERIFIED BY INSPECTION. CONTAMINATION CONTROL PROCESSES AND PLANS AND CORROSION PROTECTION PROVISIONS ARE VERIFIED BY INSPECTION.

**CRITICAL PROCESSES**

WELDING IS VERIFIED BY INSPECTION.

**ASSEMBLY/INSTALLATION**

TORQUING PER DRAWING REQUIREMENTS IS VERIFIED BY INSPECTION. MANUFACTURING, INSTALLATION, AND ASSEMBLY OPERATIONS ARE VERIFIED BY INSPECTION. PART PROTECTION, COATING, AND PLATING ARE 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. ELECTRICAL POWER TO WATER VALVE FOR EVIDENCE OF OPEN/SHORT IS VERIFIED BY INSPECTION. PULL-IN AND DROP-OUT VOLTAGES VERIFIED BY INSPECTION DURING ACCEPTANCE TEST.

**HANDLING/PACKAGING**

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PROPER HANDLING AND STORAGE ENVIRONMENT ARE 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.

(AC8842-010) INTERGRANULAR CORROSION RESULTED IN FAILURE OF TWO VALVES TO PASS THEIR INSULATION RESISTANCE TEST WHILE A WSB WAS BEING ACCEPTANCE TESTED AT THE SUBCONTRACTOR. CORROSION ALLOWED WATER TO ENTER COIL AREA RESULTING IN A LOW RESISTANCE TO GROUND. THIS CONDITION, IF ALLOWED TO PROGRESS, COULD CAUSE VALVE TO FAIL OPEN. CORROSION CAUSED BY A CONTAMINATED LOT OF VALVE JACKETS. THREE OF EIGHT VALVES FROM THIS LOT HAVE EXPERIENCED CORROSION. FOUR WERE INSTALLED IN WSB S/N'S 00003, 00004 (REF VALVE S/N'S 004, 006, 008 AND 011), AND ONE VALVE IS INSTALLED IN WSB S/N 00014 (REF VALVE S/N 023). CORRECTIVE ACTION: WSB H2O SPRAY VALVES IR TEST (V58ALO.040) IS BEING PERFORMED AT INTERVALS OF 5 FLIGHTS PER VEHICLE TO CHECK FOR RESISTANCE BETWEEN COILS AND FROM COIL TO GROUND OF EACH WATER SPRAY VALVE. VALVES WILL BE CHANGED OUT ON AN ATTRITION BASIS.

**(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 IS KNOWN PRIOR TO DEORBIT.

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**- APPROVALS -**

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EDITORIALLY APPROVED  
TECHNICAL APPROVAL

: BNA  
: VIAL APPROVAL FORM

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