

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 06-3A-0604 -X**

SUBSYSTEM NAME: ACTIVE THERMAL CONTROL

REVISION: 0 07/28/88

PART DATA

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: WATER SPRAY BOILER ASSEMBLY	MC250-0019
SRU	: STEAM VENT ORIFICE	SV769947-3

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
STEAM VENT ORIFICE**

**QUANTITY OF LIKE ITEMS: 3
ONE EACH BOILER ASSEMBLY**

**FUNCTION:
PROVIDES VENT FOR STEAM FORMED DURING WSB OPERATION. BACK PRESSURE IS
MAINTAINED BY A FIXED ORIFICE AT THE EXIT OF THE NOZZLE.**

FAILURE MODES EFFECTS ANALYSIS FMEA - CIL FAILURE MODE

NUMBER: 06-3A-0604-01

REVISION#: 1 08/25/98

SUBSYSTEM NAME: ATCS - WATER SPRAY BOILER

LRU: WATER SPRAY BOILER ASSEMBLY

ITEM NAME: STEAM VENT ORIFICE

CRITICALITY OF THIS FAILURE MODE: 1R2

**FAILURE MODE:
RESTRICTED FLOW**

**MISSION PHASE: LO LIFT-OFF
 DO DE-ORBIT**

VEHICLE/PAYLOAD/KIT EFFECTIVITY: 102 COLUMBIA
 103 DISCOVERY
 104 ATLANTIS
 105 ENDEAVOUR

**CAUSE:
CONTAMINATION, FREEZING, INGESTED BLOW-OFF STEAM VENT PLUG**

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/HYD SYSTEM DUE TO INCREASE IN BACK PRESSURE IN HEAT EXCHANGER/CORE WITH RESULTANT REDUCTION IN HEAT TRANSFER CAPABILITY. POSSIBLE DAMAGE TO STEAM VENT SYSTEM DUE TO OVERPRESSURIZATION.**

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 06-3A-0604-01**

(B) INTERFACING SUBSYSTEM(S):

POSSIBLE LOSS OR LIMITED RUN TIME OF ONE APU/HYD SYSTEM DUE TO LOSS OF COOLING CAPABILITY. LIMITED RUN TIME MAY NOT ALLOW APU/HYD SYSTEM TO SUPPORT ENTIRE POWERED FLIGHT OR ENTRY PHASE. POSSIBLE 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:

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

-DISPOSITION RATIONALE-

(A) DESIGN:

REDUNDANT STEAM VENT NOZZLE HEATERS ARE INCORPORATED AND ARE LOCATED WITHIN THE NOZZLE REDUCING POSSIBILITY OF FREEZE-UP OF ORIFICE. THE STEAM VENT NOZZLE ASSEMBLY AND ORIFICE IS CONSTRUCTED OF 347 CRES WITH A MINIMUM INTERNAL DIAMETER OF 0.8 INCHES. SUPPLIER VACUUM TESTS HAVE SHOWN THAT WITH HEATERS DEACTIVATED AND WITH FULL TANK EXPULSION A HOLLOW CONE OF ICE FORMS AT THE ORIFICE. THIS ICE CONE WOULD PROBABLY NOT DECREASE WSB EFFICIENCY ENOUGH TO CAUSE LOSS OF SYSTEM. GSE PLUGS ARE UTILIZED DURING NON-OPERATIONS OF WSB TO PREVENT CONTAMINATION FROM ENTERING THE STEAM CIRCUIT. BLOW-OFF WSB STEAM VENT PLUGS INSTALLED PRIOR TO LAUNCH WILL HELP ELIMINATE CONTAMINATION OF ORIFICE. THE BLOW-OFF STEAM VENT PLUG IS A MOLDED SILICONE RUBBER DISK SHAPED TO FIT THE ORIFICE ADAPTOR IN THE VENT NOZZLE. DUE TO PLUG DESIGN, THE PLUG CAN BE FOLDED AND INADVERTENTLY INSERTED THROUGH THE ORIFICE INTO EXHAUST AREA. INSTALLATION PROCEDURES SHOULD PRECLUDE THIS POSSIBILITY.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 06-3A-0604- 01**

**(B) TEST:
QUALIFICATION**

- ORIFICE WAS ADD-ON UNIT REQUIRING DELTA QUAL:
 - STRUCTURAL TESTING (VIBRATION) ON STEAM VENT NOZZLE ASSY ONLY.
 - PERFORMANCE QUAL OF WSB WITH ORIFICE INSTALLED. QUAL INCLUDED:
 - STEADY STATE, ASCENT ATTITUDE AT 50 TO 400 BTU/MIN WITH NO PRELOAD (LUBE OIL ONLY).
 - APU SHUTDOWN TEST IN ORBITAL ATTITUDE AT 30 AND 50 BTU/MIN WITH A 14 AND 30 MINUTE OFF.
 - TRANSIENT ASCENT ATTITUDE WITH 3.5 LB PRELOAD AT 50 TO 450 BTU/MIN (LUBE OIL ONLY).
 - MAXIMUM HEAT REJECTION IN ORBITAL ATTITUDE AT 70 TO 2,675 BTU/MIN. VACUUM (LUBE OIL AND HYDRAULIC FLUID).
 - MAXIMUM HEAT REJECTION IN DESCENT ATTITUDE AT 975 TO 3,075 BTU/MIN, SEA LEVEL (LUBE OIL AND HYDRAULIC FLUID)
- STEAM VENT PLUG COLLAPSE PRESSURE (WOULD CAUSE INGESTION) TESTED AT 1 PSID NEGATIVE PRESSURE DIFFERENTIAL. PASS/FAIL CRITERIA: NO INGESTION INTO THE VENT NOZZLE.

ACCEPTANCE:

- NOZZLE HEATER ELEMENT DIELECTRIC STRENGTH TEST - TESTED AT 500 VOLTS RMS FOR ONE MINUTE.
- NOZZLE HEATER INSULATION RESISTANCE TEST - TESTED AT 100 VOLTS.
- NOZZLE HEATER ELEMENT RESISTANCE TEST.
- EARLY BOILERS WERE ACCEPTANCE TESTED WITH 1.25 INCH ORIFICE. THEREFORE, A TWO PART ATP IS PERFORMED ON NEW BOILERS FOR DATA COMPARISON:
 - DESIGN POINT CHECK WITHOUT 0.8 INCH ORIFICE INSTALLED-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 VERSUS THEORETICAL WATER USAGE AT ALTITUDE ONLY.
 - REPEAT OF DESIGN POINT CHECK WITH 0.8 INCH ORIFICE INSTALLED (VERIFICATION OF WSB EFFICIENCY WITH INCREASED BACK PRESSURE IN HEAT EXCHANGER ASSEMBLY DUE TO DECREASED VENT AREA).

GROUND TURNAROUND TEST

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

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 06-3A-0604- 01**

(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

ALL FLUIDS (WATER) ARE SAMPLED FOR CLEANLINESS. CONTAMINATION CONTROL PROCESSES AND PLANS AND CORROSION PROTECTION PROVISIONS ARE 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.

CRITICAL PROCESSES

BRAZING IS VERIFIED BY INSPECTION AS BEING IN ACCORDANCE WITH REQUIREMENTS.

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.

(32F011-010) STEAM VENT NOZZLE HEATER FAILED OPEN DURING MISSION 61-C. NOZZLE TEMPERATURE RECOVERED BY SWITCHING TO REDUNDANT HEATER. HAD THE FAILURE NOT BEEN CORRECTED, FREEZING OF THE STEAM VENT ORIFICE COULD HAVE OCCURED. THE PROBLEM WAS ISOLATED TO AN OPEN CIRCUIT LOCATED IN CLOSE PROXIMITY TO A BRAZE JUNCTION ON ONE OF THE HEATING ELEMENT CONDUCTORS. THE BRAZE JUNCTION WAS FOUND TO BE WITHIN AN UNSUPPORTED 90 DEGREE BEND WHICH WOULD BE SUBJECTED TO VIBRATION AND THERMAL STRESSES. PROBLEM WAS CORRECTED BY A DRAWING CLARIFICATION WHICH SPECIFIED THAT THE BRAZE JUNCTION WOULD NOT BE LOCATED WITHIN THE 90 DEGREE BEND AND WOULD BE POSITIONED TO PHYSICALLY CONTACT THE STEAM VENT NOZZLE WALL FOR SUPPORT AND A THERMAL SINK.

(E) OPERATIONAL USE:

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

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE

NUMBER: 06-3A-0804- 01

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

- APPROVALS -

EDITORIALLY APPROVED

: BNA

TECHNICAL APPROVAL

: VIA APPROVAL FORM

: *J. Kamura 8-25-98*

: 95-CIL-009_06-3A