

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- GIL HARDWARE
NUMBER: 06-3A-0607 -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 ASSEMBLY	MC250-0019 ITEM 609
SRU	: NITROGEN REGULATOR	SV766509-1

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
NITROGEN REGULATOR**

QUANTITY OF LIKE ITEMS: 3
ONE EACH BOILER ASSEMBLY

FUNCTION:
PROVIDES NITROGEN UPON DEMAND TO THE WATER STORAGE TANK. A BUILT IN RELIEF VALVE PREVENTS OVER PRESSURIZATION OF SYSTEM DOWNSTREAM OF REGULATOR.

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SUBSYSTEM NAME: ATCS - WATER SPRAY BOILER

LRU: WATER SPRAY BOILER ASSEMBLY

ITEM NAME: NITROGEN REGULATOR

CRITICALITY OF THIS

FAILURE MODE: 1R2

FAILURE MODE:

RELIEF VALVE FAILS 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

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREENA) 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 LUBE
OIL/HYD SYSTEM DUE TO LOSS OF CAPABILITY TO EXPEL WATER FROM STORAGE TANK.

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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:

ABORT DECISION - REMAINING TWO SYSTEMS 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:

25 MICRON FILTER IS INCORPORATED DOWNSTREAM OF THE REGULATING SECTION OF THE REGULATOR WHICH PROTECTS THE RELIEF VALVE FROM CONTAMINATION. RELIEF VALVE POPPET SPRING IS DESIGNED TO MAINTAIN CONSTANT PRESSURE ON POPPET IN THE CLOSED POSITION AND THE LENGTH/DIAMETER OF POPPET PREVENTS IT FROM COCKING. RELIEF VALVE HOUSING IS COMPOSED OF 304 STAINLESS STEEL.

(B) TEST:

QUALIFICATION:

- NITROGEN REGULATORS SUBJECTED TO 10,000 OPERATIONAL CYCLES.
- 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

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AT MAXIMUM OPERATING PRESSURE (FULL GN2 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'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 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:

- NITROGEN RELIEF VALVES ARE TESTED PRIOR TO INSTALLATION INTO REGULATOR ASSEMBLY AS FOLLOWS: RELIEF VALVE PERFORMANCE TESTS (CRACK, RESEAT, AND FULL FLOW TESTS).
- 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 HELIUM 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.

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PRELAUNCH:

- 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

CLEANLINESS OF NITROGEN LINES IS VERIFIED BY INSPECTION. 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

WELDING IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

X-RAY AND PENETRANT INSPECTION ARE VERIFIED BY INSPECTION.

TESTING INSPECTION

POINTS PERFORMED DURING ACCEPTANCE TESTING ARE VERIFIED BY INSPECTION.

HANDLING/PACKAGING

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.

(AB9476-010) (1981) DURING ATP OF WSB S/N 7, RELIEF VALVE CRACKED LOW DUE TO MISPOSITIONED HELICAL SPRING CAUSED BY A BURR IN THE ASSEMBLY. UNIT WAS REASSEMBLED WITHOUT BURR AND RETEST RESULTED IN SPECIFIED CRACKING PRESSURE.

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(SHUTTLE INFLIGHT DATA AND ANOMALY LIST, STS-8 #17) (OV099, 1983) SYSTEM 1 GN2 REGULATOR OUTLET PRESSURE DECREASED 5 PSI IN 100 HOURS AFTER THE N2 ISOLATION VALVE WAS CLOSED DURING ON-ORBIT. THE FAILURE WAS ATTRIBUTED TO THE RELIEF VALVE NOT PROPERLY SEATING AFTER ASCENT. RESEATING TAKES PLACE DURING THE POWERED PHASE OF FLIGHT AND THE LOW RESEAT PRESSURE COULD BE CAUSED BY SIDE LOADING (G FORCES) OF THE POPPET AND SPRING. THIS CONDITION CANNOT BE DUPLICATED DURING GROUND CHECKS. THE VALVE WAS SUBSEQUENTLY FLOWN AS IT WAS.

(28F009-010) (1985) DURING FLIGHT ON OV-104, REGULATOR OUTLET PRESSURE DECAY FROM 40 PSIA TO 28 PSIA WAS RECORDED. EXCESSIVE LEAKAGE WAS CAUSED BY A FOREIGN PARTICLE (ALUMINUM WITH HIGH SILICONE CONTENT) WHICH PREVENTED PROPER RELIEF VALVE SEATING. THE PARTICLE MIGRATED TO THE REGULATOR POPPET SEAT WHEN THE RELIEF VALVE OPENED DURING ASCENT. THE SOURCE OF THE CONTAMINATE WAS SPECULATED TO BE FROM THE ASSEMBLY PROCESS. THIS WAS AN ISOLATED CASE, THE VALVE WAS REBUILT AND RE-ACCEPTANCE TESTED.

(AD0094-010) (1985) DURING CHECKOUT OF OV-102, RELIEF VALVE RESEAT PRESSURE WAS 27.6 PSIG (SPEC: 28 PSIG MIN). LOW PRESSURE WAS WAIVED.

(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. Kamura 8-25-98
 : 95-CIL-009_06-3A