

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- GIL HARDWARE**

NUMBER: 06-3A-0607 -X

**SUBSYSTEM NAME:** ACTIVE THERMAL CONTROL**REVISION:** 0 02/04/88

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**PART DATA**

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	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	: WATER SPRAY BOILER ASSEMBLY	MC250-0019 ITEM 609
SRU	: NITROGEN REGULATOR	SV766509-1

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**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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NUMBER: 06-3A-0607-04

REVISION#: 1 08/25/98

SUBSYSTEM NAME: ATCS - WATER SPRAY BOILER

LRU: WATER SPRAY BOILER ASSEMBLY

ITEM NAME: NITROGEN REGULATOR

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

FAILS IN OPEN POSITION OR INTERNAL LEAKAGE

**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 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. NON REGULATED FLOW WILL CAUSE RELIEF VALVE TO OPEN  
RESULTING IN EVENTUAL LOSS OF N2 SUPPLY.

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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 NOSE WHEEL 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. AN ADDITIONAL FAILURE OF THE ASSOCIATED WSB N2 RELIEF VALVE (R/V FAILING CLOSED) MAY RESULT IN DAMAGE TO SURROUNDING SYSTEMS AND/OR STRUCTURE AS A RESULT OF OVERPRESSURIZATION OF THE WATER TANK

**(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 TWO FAILURES: THIS FAILURE, RESULTING IN LOSS OF ONE APU/HYD SYSTEM; PLUS GN2 RELIEF VALVE FAILED CLOSED, RESULTING IN POSSIBLE WATER TANK BURST WITH SUBSEQUENT LOSS OF ADJACENT WATER TANK AND SECOND APU/HYD SYSTEM.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

25 MICRON FILTER IS INCORPORATED AT THE INLET TO EACH REGULATOR. THE LENGTH/DIAMETER OF THE STEM WHICH DRIVES OPEN THE BALL (POPPET) MINIMIZES BINDING/JAMMING. ALL VALVE COMPONENTS ARE COMPATIBLE WITH WORKING FLUIDS. REGULATOR COMPONENTS ARE: HOUSING - 304 STAINLESS STEEL (SS), VALVE SEAT - VESPEL SP-1, BALL - TUNGSTEN CARBIDE, STEM - 17-4 PH SS, SPRING - 302 SS. THE REGULATOR IS A SINGLE STAGE, SELF-RELIEVING AND FLOW LIMITING DESIGN. THE RELIEF VALVE CRACKING PRESSURE IS 30 PSIG MINIMUM, THE RELIEF VALVE FULL FLOW PRESSURE IS 33.5 PSIG MAXIMUM. RESEAT PRESSURE IS 28 PSIG MINIMUM.

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**(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 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 TESTS.
- 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 0 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 HOURS AT EACH LEVEL FOR 3 CYCLES. PASS/FAIL CRITERIA: NO DAMAGE OR PERMANENT DEFORMATION (INCLUDING VALVE FAILURE).

**ACCEPTANCE:**

- NITROGEN REGULATORS ARE TESTED PRIOR TO INSTALLATION INTO WSB ASSEMBLY AS FOLLOWS; PROOF TEST, LEAK TEST (SEAT LEAK AND EXTERNAL LEAK), RELIEF VALVE PERFORMANCE, REGULATION/FLOW TEST (INLET PRESSURE VS FLOW/OUTLET PRESSURE).
- 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).
- HIGH SIDE N2 PROOF TEST - TESTED AT 4770 PSIG FOR 15 MINUTES WITH HELIUM AND CIRCUIT RELIEF VALVE PREVENTED FROM OPENING (REGULATOR PRESSURE IS MONITORED DURING TEST). PASS/FAIL CRITERIA: NO EVIDENCE OF PERMANENT DEFORMATION AND PASSAGE OF SUBSEQUENT WATER AND N2 CIRCUIT LEAK CHECKS

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- HIGH SIDE N2 LEAK CHECK - TESTED AT 3180 PSIG WITH HELIUM AND CIRCUIT RELIEF VALVE PREVENTED FROM OPENING (REGULATOR PRESSURE IS MONITORED DURING TEST). PASS/FAIL CRITERIA: 2.8 SCCM MAXIMUM 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:**

- 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.

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**(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.

(AC4143-010) (1982, OV099) DURING CHECKOUT OF OV-099, REGULATOR DID NOT MAINTAIN REQUIRED OUTLET PRESSURE. SHREDS OF A LOCKING KEL-F INSERT ACROSS THE REGULATOR SEAT WERE IDENTIFIED AS THE CAUSE. THE LOCK PLUG HOLES HAVE BEEN ELIMINATED TO PREVENT RECURRENCE OF PROBLEM FROM ALL NEWLY MANUFACTURED AND REBUILT REGULATORS.

(AC5054-010) (1983, OV099) DURING CHECKOUT OF OV-099, REGULATOR PRSSURE CYCLED BETWEEN 39 AND 44 PSIA. OMRSD SPECIFICATION V58AKO 022 FOR WSB N2 REGULATOR OUTLET PRESSURE DURING GROUND CHECK OUT WAS CHANGED TO REFLECT ACTUAL ACCEPTABLE EXPERIENCE OF 44 PSIA MAXIMUM (1987). FOR ADDITIONAL EXPLANATION AND CORRECTIVE ACTION, SEE AC4143-010.

(AC8219-010) (1984, OV103) DURING CHECKOUT FOR FIRST FLIGHT OF OV-103, REGULATOR OUTLET PRESSURE LOCKED UP AT 44 PSIA. REGULATOR WAS CYCLED FIVE TIMES AT COMPLETION OF FLIGHT AND FOUND TO BE IN SPEC (39-41 PSIA). PROBABLE CAUSE: REGULATOR WAS NEW AND REQUIRED CYCLING IN ORDER TO SEAT IT PROPERLY. OMRSD SPECIFICATION V58AKO.022 FOR WSB N2 REGULATOR OUTLET PRESSURE DURING GROUND CHECK OUT WAS CHANGED TO REFLECT ACTUAL ACCEPTABLE EXPERIENCE OF 44 PSIA MAXIMUM (1987). FOR ADDITIONAL EXPLANATION AND CORRECTIVE ACTION, SEE AC4143-010.

**(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.

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**- APPROVALS -**

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EDITORIALLY APPROVED  
TECHNICAL APPROVAL

: BNA  
: VIA APPROVAL FORM

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