

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SYSTEM : AFT - REACTION CONTROL FMEA NO 03-2A -201030-2 REV:12/01/87

ASSEMBLY : PRESSURIZATION CRIT. FUNC: LR
 P/N RI : MC284-0418-0011, -0012 CRIT. HDW: 2
 P/N VENDOR: 74339000-011, -012 VEHICLE 102 103 104
 QUANTITY : 8 EFFECTIVITY: X X X
 : TWO PARALLEL, SERIES PHASE(S): PL LO X OO X DO X LS
 : REDUNDANT UNITS PER TANK

REUNDANCY SCREEN: A-PASS B-PASS C-FAIL

PREPARED BY: DES R GONZALEZ DES R. D. Beck APPROVED BY (NASA):
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ITEM:
 REGULATOR, PRESS, HE SERIES REDUNDANT. SET AT UNEQUAL OUTLET PRESSURES
 (PR 201/202/203/204 301/302/303/304).

FUNCTION:
 TO REGULATE STORED HELIUM PRESSURE FROM 4000 PSIG MAX TO ULLAGE PRESSURE
 OF 245 (+ OR - 4) PSIG FOR PURPOSE OF PROPELLANT FEED TO THRUSTERS. TWO
 PARALLEL PATHS WITH TWO SERIES REGS ARE PROVIDED FOR EACH PROPELLANT
 TANK. PRIMARY ELEMENT SET 11 PSI LOWER THAN SECONDARY. (PRIMARY-245
 PSI, SECONDARY-256 PSI)

FAILURE MODE:
 VALVES CLOSED, RESTRICTED FLOW

CAUSE(S):
 CORROSION, FROZEN MOISTURE, CONTAMINATION, VIBRATION, PILOT OR MAIN STAGE
 POPPET SPRING FAILURE, GALLING OF PISTON/STEM, PLUGGED RESTRICTOR
 ORIFICES, CONTAMINATED INLET/PILOT FILTER, CHECK VALVE FAILURE,
 PROPELLANT DECOMPOSITION/CONTAMINATION.

EFFECT(S) ON:
 (A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE

(A) LOSS OF REDUNDANCY (ONE OF 2 FLOW PATHS). CONTAMINATION MAY CAUSE
 DUAL REG FAILURE AT THE SAME TIME.

(B) NO EFFECT

(C) NO EFFECT

(D) NO EFFECT

(E) FUNCTIONAL CRITICALITY EFFECT - CONTAMINATION MAY CAUSE DUAL REG
 FAILURE WHICH MAY RESULT IN INABILITY TO UTILIZE RCS PROPELLANT DURING
 ENTRY IF ULLAGE IS INSUFFICIENT. FAILED CLOSED PARALLEL FLOW PATHS MAY
 RESULT IN VEHICLE LOSS. POSSIBLE CREW/VEHICLE LOSS DUE TO INABILITY TO
 UTILIZE RCS PROPELLANT DURING ENTRY. POSSIBLE LOSS OF CONTROL DURING
 MATED COAST/ET SEP IF ULLAGE IS INSUFFICIENT OR LOST (CROSSFEED IS A
 CONTINGENCY FOR ET SEP). CONTAMINATION CAN PLUG BOTH PRIMARY AND
 SECONDARY DOWNSTREAM SENSE PORTS WHICH WOULD FAIL BOTH REGULATORS
 CLOSED.

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DISPOSITION & RATIONALE:

(A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY (E) OPERATIONAL USE

(A) DESIGN

PARALLEL REGULATORS ARE PROVIDED TO LIMIT IMPACT OF CLOSE FAILURES. 25 MICRON INLET AND 10 MICRON PILOT FILTERS LIMIT CONTAMINATION. (THE 25 MICRON FILTER DOES NOT PROVIDE PROTECTION FOR REVERSE FLOW). CHECK VALVES LIMIT POTENTIAL FOR PROPELLANT MIGRATION TO THE REGULATOR.

MANUAL ISOLATION VALVES ARE BEING CLOSED AND HELIUM SYSTEM BLOWDOWN PERFORMED TO PROVIDE FOR ADDITIONAL VAPOR MIGRATION PROTECTION DURING INACTIVE GROUND PERIODS. A MAXIMUM OPERATING PRESSURE OF 4000 PSIA PROVIDES A SAFETY FACTOR OF 1.5 FOR PROOF PRESSURE.

(B) TEST

THE QUALIFICATION TEST PROGRAM INCLUDED PROOF TEST (6000 PSI) AND BURST TEST (8000 PSI), LIFE CYCLES (100,000 CYCLES-PILOT STAGE AND 50,000 CYCLES MAIN STAGE), THERMAL CYCLING (-30 TO +155 DEG F), RANDOM VIBRATION, FUNCTIONAL TESTING, PARALLEL OPERATION AND PROPELLANT EXPOSURE (MATERIAL COMPATIBILITY VERIFIED).

THE RCS WAS ALSO QUALIFIED AS PART OF THE POD ASSEMBLY DURING VIBRO-ACOUSTIC TEST AT JSC (131 EQUIVALENT MISSIONS) AND HOT-FIRE TEST PROGRAM AT WSTF INCLUDED 24 EQUIVALENT MISSION DUTY CYCLES AND APPROXIMATELY 7 YEARS PROPELLANT EXPOSURE.

ACCEPTANCE TESTING INCLUDES PROOF PRESSURE, OPERATING PRESSURE, SET POINT VERIFICATION, FUNCTIONAL, BLOWDOWN (THERMAL), INTERNAL LEAKAGE, CLEANLINESS AND DRYING, AND TESTING OF THE SENSE RESPONSE IN FULL UP ASSEMBLY.

QRSD PERFORMS THE FOLLOWING: REGULATOR LEAK/FUNCTIONAL TESTS PRIOR TO EACH FLIGHT AND THEREAFTER ON A CONTINGENCY BASIS. MOISTURE CONTENT VERIFICATION AFTER THE FIRST FLIGHT AND THEREAFTER ON A CONTINGENCY BASIS. He SYSTEM SAMPLE BEFORE THE THIRD FLIGHT AND THEREAFTER EVERY THIRD FLIGHT. He SYSTEM ACTIVATION EACH FLIGHT. He SERVICING TO FLIGHT LOADS FOR EACH FLIGHT. RCS He OFF-LOADING FOR FWD AND APT THE SECOND FLIGHT AND FOR EACH FLIGHT THEREAFTER, THIS INCLUDES CLOSING THE MANUAL VALVE. A REGULATOR RESPONSE CHECK BEFORE EVERY FLIGHT. REGULATOR LOW PRESSURE RESPONSE TEST ON A CONTINGENCY BASIS.

(C) INSPECTION

RECEIVING INSPECTION

INSPECTION VERIFIES MATERIALS AND PHYSICAL PROPERTIES. CERTIFICATION, MATERIAL, AND HEAT TREATMENT ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL

CLEANLINESS TO LEVEL 100A IS VERIFIED BY INSPECTION. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

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ASSEMBLY/INSTALLATION

PISTONS ARE DIMENSIONALLY INSPECTED AND PISTON ASSEMBLY IS VERIFIED BY INSPECTION. TORQUING IS VERIFIED BY INSPECTION. SURFACE FINISHES ARE VERIFIED BY INSPECTION. SURFACE FINISH OF POPPET AND MAIN SPRING ARE INSPECTED UNDER 20X MAGNIFICATION.

NONDESTRUCTIVE EVALUATION

PENETRANT INSPECTION OF THE MAIN BELLOWS WELDS AND OF THE HOUSING FORGINGS AT THE FORGING LEVEL IS VERIFIED BY INSPECTION.

CRITICAL PROCESSES

VISUAL INSPECTION OF THE TUNGSTEN INERT GAS (TIG) WELDS WITHIN THE PILOT ACTUATOR ASSEMBLY AND WITHIN THE PILOT POPPET ASSEMBLY ARE VERIFIED BY INSPECTION. ADDITIONAL TIG WELD INSPECTIONS INCLUDE THE WELDS THAT JOIN THE TUBING, BOTTOM CAPS, PILOT POPPET ASSEMBLY, PILOT ACTUATOR ASSEMBLY, AND THE MAIN BELLOWS TO THE BODY. THE ELECTRON BEAM (EB) WELDS OF THE PILOT ACTUATOR BELLOWS INTO THE PILOT ACTUATOR ASSEMBLY ARE VERIFIED BY INSPECTION. THE PROOF PRESSURE TEST/LEAK TEST PROVIDES FURTHER VERIFICATION OF THE WELD INTEGRITY. HEAT TREATMENT OF THE DETAIL PARTS, INCLUDING THE HOUSING FORGING TO DRAWING REQUIREMENTS IS VERIFIED BY INSPECTION. THE FORGING SUPPLIER CERTIFIES THAT THE HOUSING FORGINGS MEET THE REQUIREMENTS OF MIL-F-7190, AMENDMENT 1, GRADE A. TESTING OF EACH FORGING LOT FOR CHEMISTRY, AFTER HEAT-TREATMENT HARDNESS AND AFTER HEAT-TREATMENT TENSILE STRENGTH IS VERIFIED BY INSPECTION. CADMIUM PLATING OF BELLEVILLE WASHERS TO DRAWING REQUIREMENTS IS VERIFIED BY INSPECTION.

TESTING

ATP IS WITNESSED AND VERIFIED BY INSPECTION.

HANDLING/PACKAGING

RETURNED AND ACCEPTED GOODS PLACED IN BONDED AREA. PACKAGING IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY

CAR ADO419:

DURING HELIUM SERVICING OF STS-61A (OV-99), A MINI-SLAM HELIUM ACTIVATION (750 PSI) ON LEG "A" FUEL REGULATOR (PR 303) RESULTED IN SYSTEM OVERPRESSURE WHEN THE UNIT FAILED TO LOCKUP WITHIN THE ALLOWABLE OMRSD REQUIREMENTS, AND RESULTED IN THE BURST DISC OF RELIEF VALVE (RV 302) TO RUPTURE AT APPROXIMATELY 338 PSIG.

BOTH LEG "A" AND "B" REGULATORS WERE CHECKED PRIOR TO LAUNCH. THE LEG "B" REGULATOR (PR 301) PRIMARY AND SECONDARY STAGES CHECK OUT NOMINALLY UNDER LOW FLOW CONDITIONS. LEG A REGULATOR PRIMARY RESPONSE WAS SLUGGISH AND THE SECONDARY STAGE RESPONSE WAS ALSO SLUGGISH BUT ACCEPTABLE. THIS DATA WAS LIMITED TO ONE SAMPLE PER SECOND. THE PREFLIGHT PLAN WAS TO FLY AS IS BUT CLOSE THE HELIUM ISOLATION LEG "A" VALVE WHEN ORBIT OPERATIONS WERE ESTABLISHED.

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DURING THE MISSION WHEN BOTH "A" AND "B" REGULATORS FAILED TO MAINTAIN TANK PRESSURE. THE RARCS FUEL TANK ULLAGE PRESSURE DROPPED TO 208 PSIA DURING ET SEPARATION WITH BOTH "A" AND "B" HELIUM REGULATORS ON LINE OPEN (OUTLET PRESS. DROPPED TO 203 PSIA). THE TANK ULLAGE PRESSURE THEN INCREASED PAST SECONDARY REGULATOR LOCKUP (264 PSIG TO 275 PSIA). THE HELIUM ISOLATION "A" VALVE WAS CLOSED (PREFLIGHT PLAN) AND TANK ULLAGE PRESSURE DROPPED TO 214 PSIA WITH PROPELLANT USAGE. THE HELIUM ISOLATION "A" VALVE WAS OPENED TO PREVENT LOSS OF TANK (200 PSIA) ULLAGE. THE PRESSURE INCREASED TO 290 PSIA THEN DROPPED AND HELD AT 246 PSIA. THE RARCS TO LARCS CROSSPEED WAS ESTABLISHED TO PROVIDE BLOWDOWN CAPABILITY. A RARCS REGULATOR TEST TO SIMULATE ENTRY DEMAND WAS PERFORMED ON FLIGHT 7 WITH BOTH "A" AND "B" HELIUM ISOLATION VALVES OPEN AND IN RARCS TO LARCS CROSSPEED. THE TANK PRESSURE DURING TEST WERE ACCEPTABLE FOR ENTRY OPERATION. THE REGULATORS PERFORMANCE WERE ACCEPTABLE BUT SLUGGISH DURING ENTRY WITH BOTH "A" AND "B" HELIUM ISOLATION VALVES OPEN.

CARS AD1221 AND AD1264:

THE PRIMARY STAGE OF BOTH REPLACEMENT REGULATORS FOR PR301 AND 302 ALSO EXHIBITED A LOW PRESSURE DROP DURING A SPECIAL HIGH FLOW DEMAND CONDITION TEST INSTITUTED ON ALL INSTALLED REGULATORS. RETEST OF PR303 DID NOT REPEAT THE CONDITION BUT PR301 WAS REMOVED AND THE RESTRICTOR SENSING PART WAS PARTIALLY CLOGGED.

CARS AD9181 (OV102) AND AD1569 (OV103):

TWO OTHER CASES OF SLUGGISH REGULATOR RESPONSE HAVE BEEN RECORDED ONE ON OV102 AND ONE ON OV103. IN ALL THE ABOVE CASES COMPOUNDS LEFT FROM A SOAP RESIDUE WAS FOUND IN THE RESTRICTOR TUBE WHICH REACTED WITH MME AND FORMED A SOLID RESIDUE SUFFICIENT TO PARTIALLY CLOG THE TUBE. TEST LATER DEMONSTRATED THAT THE SURFACE FINISH ALSO CONTRIBUTED TO FORMING THE MME SOLID RESIDUE.

CORRECTIVE ACTION INVOLVES INCREASED MEASURE OF PROTECTION OF REGULATOR FROM PROPELLANT VAPORS AND BETTER DETERMINATION OF REGULATOR TRANSIENT PERFORMANCE DURING GROUND CHECKOUT. CORRECTIVE ACTION INCLUDES PERFORMANCE OF HELIUM PURGE OF THE PRESURIZATION SYSTEM UPON LANDING TO REMOVE RESIDUAL PROPELLANT VAPORS, CLOSE THE MANUAL VALVES AND LEAVE CLOSED UNTIL PROPELLANT SERVICING ON THE PAD AND REVISE THE REGULATOR CHECKOUT PROCEDURES TO MEASURE TRANSIENT RESPONSE AND PERFORMANCE PRIOR TO EACH FLIGHT. THE SUPPLIER HAS ALSO REVISED THEIR RESTRICTOR TUBE PROCESSING TO ASSURE PROPER CLEANING AND FLUSHING OF THE TUBE EFFECTIVE WITH ALL NEW AND REPAIRED REGULATORS.

CARS AB5925 AND A0993:

ONE UNIT EXHIBITED CORROSION IN BELLOWS CAVITIES AND PILOT AREA DURING POST QUAL INSPECTION. FOURTEEN OTHER UNITS WERE ALSO IDENTIFIED THAT COULD HAVE THIS PROBLEM. FIVE WERE RETURNED FOR REWORK AND OTHER NINE RESTRICTED TO GROUND USE. ONE UNIT RECENTLY RETURNED FROM OV103 (REF CAR AD1569) ALSO SHOWS SIGNS OF THIS TYPE OF CORROSION. THE PROCEDURES WERE REVISED TO PRECLUDE MOISTURE CONTAMINATION DURING WELDING OF PILOT STEM.

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(E) OPERATIONAL USE

IF FAILURE OCCURS DURING ON-ORBIT OPEN ISO VALVE TO USE OTHER REGULATOR.

DURING ASCENT AND ENTRY BOTH ISO VALVES ARE ALREADY OPEN SO NO FURTHER ACTION IS REQUIRED. THE SOFTWARE FOR CI-8A WILL AUTOMATICALLY CROSSFEED FOR LOW PROPELLANT TANK PRESSURE DURING ET SEP.

DURING MOST MISSION PHASES CROSSFEED PLUS BLOWDOWN OF FAILED SYSTEM WOULD BE ACCEPTABLE FOR A NOMINAL ENTRY.