# SSME FMEA/CIL
# REDUNDANCY SCREEN

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|---|---|---|---|
| Component Group: | Actuators | Prepared: | S. Heater |
| CIL Item: | E140-03 | Approved: | T. Nguyen |
| Part Number: | RES1008-6XXX | Approval Date: | 6/9/00 |
| Component: | Oxidizer Preburner Oxidizer Valve Actuator | Change #: | 1 |
| FMEA Item: | E140 | Directive #: | CCBD ME3-01-5624 |
| Failure Mode: | Actuates too fast or too slow. | Page: | 1 of 1 |

| Phase | Failure / Effect Description | Criticality Hazard Reference |
|---|---|---|
| M 4.2 | Following a channel A failure, controller switches to channel B (servovalve No. 2) all actuators; continuation of failure, controller initiates hydraulic lockup all actuators. Mission abort may result when hydraulic lockup occurs during Max Q throttling.<br><br>Redundancy Screens: ACTUATOR SYSTEM: LIKE REDUNDANCY<br><br>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround.<br>B: Pass - Loss of a redundant hardware items is detectable during flight.<br>C: Fail - Loss of redundant hardware items could result from a single credible event. | 1R ME-B6M |
| M 4.3 | Improper actuation may result in controller initiated shutdown due to engine limit exceeded if SEII fails to detect. Mission abort.<br><br>Redundancy Screens: ACTUATOR SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY<br><br>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround.<br>B: Pass - Loss of a redundant hardware items is detectable during flight.<br>C: Pass - Loss of redundant hardware items could not result from a single credible event. | 1R ME-B6M |

# SSME FMEA/CIL
# DESIGN

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|---|---|---|---|
| Component Group: | Actuators | Prepared: | S. Heater |
| CIL Item: | E140-03 | Approved: | T. Nguyen |
| Part Number: | RES1008-6XXX | Approval Date: | 6/9/00 |
| Component: | Oxidizer Preburner Oxidizer Valve Actuator | Change #: | 1 |
| FMEA Item: | E140 | Directive #: | CCBD ME3-01-5624 |
| Failure Mode: | Actuates too fast or too slow. | Page: | 1 of 3 |

Design / Document Reference

FAILURE CAUSE: **A: Actuator: Bearing failure.**

BALL BEARINGS ARE USED IN THE SHAFT BEARINGS (1) FOR THEIR FRICTION AND LOAD CAPACITY CHARACTERISTICS. THE BEARINGS ARE MS27642 CONFIGURATION WITH MINOR MODIFICATIONS. THE NICKEL PLATE IS ELIMINATED FROM THE OUTER SURFACES OF THE RACES AND THE SEALS AND SEAL RETAINERS ARE ELIMINATED (1). THE BALLS AND RACES ARE 52100 ALLOY STEEL WHICH IS HEAT TREATED FOR BEARING STRENGTH AND HARDNESS (2). CORROSION PROTECTION AND LUBRICATION ARE PROVIDED BY THE HYDRAULIC OIL IN THE ACTUATOR RETURN CAVITY (3). THE NORMAL OPERATION OF THE ACTUATOR DURING ENGINE OPERATION PRECLUDES BEARING FAILURES CAUSED BY HEAT GENERATION, WEAR, OR SPALLING.

(1) 84000369; (2) RSS-8582; (3) 41003720

FAILURE CAUSE: **B: Actuator: Hydraulic piston seizure.**

THE HYDRAULIC PISTONS ARE FABRICATED FROM AISI E 9310 (1). THE MATERIAL WAS SELECTED FOR ITS HARDNESS AND WEAR RESISTANCE (2). THE PISTONS ARE GAS CARBURIZED FOR ADDITIONAL SURFACE HARDNESS AND WEAR RESISTANCE. THE HOUSING IS FABRICATED FROM 7175-T736, HEAT TREATED AFTER ROUGH MACHINING (3). THE HOUSING BORES ARE HARD ANODIZED FOR WEAR AND CORROSION RESISTANCE. THE PISTONS ARE PROTECTED FROM CORROSION BY THE HYDRAULIC FLUID ENVIRONMENT. A L/D OF ONE, CHAMFERS ON THE PISTON ENDS, AND CLOSE DIAMETRICAL CLEARANCES PREVENT SEIZURE CAUSED BY COCKING. ALL DETAIL PARTS ARE CLEANED FOR HYDRAULIC SERVICE PRIOR TO ASSEMBLY. ASSEMBLY IS ACCOMPLISHED IN A CONTAMINATION CONTROLLED AREA (4). THE PARTS ARE LUBRICATED WITH HYDRAULIC FLUID DURING ASSEMBLY. THE HYDRAULIC FLUID SUPPLY IS FILTERED THROUGH A 25-MICRON FILTER (5).

(1) 34000309; (2) RSS-8582; (3) 34000694; (4) RC1008, RL10012; (5) RES1008-3003

FAILURE CAUSE: **C: Actuator: Hydraulic piston seal leakage.**

THE PISTON (1) AND HOUSING BORE (2) ARE AISI E 9310 AND HARD ANODIZED 7175-T163 ALUMINUM ALLOY. THE MATERIALS ARE WEAR RESISTANT TO PREVENT SEAL DAMAGE (3). ALL PARTS ARE CLEANED FOR HYDRAULIC SERVICE PRIOR TO ASSEMBLY (4). THE ACTUATOR IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA (4). THE HYDRAULIC FLUID SUPPLY IS FILTERED THROUGH A 25-MICRON FILTER TO REMOVE PARICULATE CONTAMINANTS (5). PISTON AND HOUSING DIMENSIONS AND SURFACE FINISHES ARE SELECTED FOR DYNAMIC SEAL APPLICATION (1) (2). THE VALVE ACTUATORS USE SHAMBAN SLIPPER SEALS (6). THE SHAMBAN SLIPPER SEAL DESIGN INCORPORATES A BUNA-N O-RING (5) WITH A TEFLON RING (6) BETWEEN THE O-RING AND THE HOUSING. THE BUNA-N O-RING PROVIDES PRESSURE ACTUATION OF THE SEAL, AND THE TEFLON RING PROVIDES LOW FRICTION WEAR RESISTANT CONTACT WITH THE CYLINDER BORE.

(1) 34000259; (2) 34000695; (3) RSS-8582; (4) RC1008; (5) RES1008; (6) 41003720

FAILURE CAUSE: **D: Servovalve: Nozzle or orifice restricted.**

HYDRAULIC LINES AND ACTUATOR DETAILS ARE CLEANED PRIOR TO ACTUATOR ASSEMBLY (1). THE HYDRAULIC FLUID USED FOR ASSEMBLY AND TEST IS EITHER IN ACCORDANCE WITH JSC SPECIFICATION REQUIREMENTS OR PER AN MSFC APPROVED WAIVER (2). THE HYDRAULIC FLUID CLEANLINESS IS CONTROLLED. THE SERVOVALVE AND ACTUATOR ASSEMBLY IS PERFORMED IN A CONTAMINATION CONTROLLED AREA (1). HYDRAULIC FLUID CLEANLINESS IS CONTROLLED IN COMPONENT TEST FACILITIES BOTH PRIOR TO INSTALLING ACTUATORS AND PRIOR TO REMOVING THEM AFTER COMPONENT LEVEL TESTS BY MAKING A PARTICLE COUNT (2). A 25-MICRON GLASS BEAD RATED FILTER (3) IS INSTALLED BETWEEN THE HYDRAULIC SUPPLY AND THE ACTUATOR. FILTER RATING IS VERIFIED ON EACH UNIT BY BUBBLE POINT TEST. IN ADDITION, THE SERVOVALVE (4) INCORPORATES A FILTER (5) TO PROTECT THE ORIFICES AND THE NOZZLES. THE ORIFICE FILTER IS DESIGNED TO CONTAIN ALL PARTICLES WHOSE TWO SMALLEST DIMENSIONS ARE 50-MICRONS OR LARGER. THE FILTER MUST ALSO RETAIN 95% OF ALL PARTICLES WHOSE TWO SMALLEST DIMENSIONS ARE 25-MICRONS (5).

(1) RL10012; (2) RC1008; (3) RES1008-3003; (4) 84000168; (5) 28003065

FAILURE CAUSE: **E: Servovalve: Filter O-ring leakage.**

THE FILTER O-RING IS BUNA-N (1). THE MATERIAL WAS SELECTED FOR ITS ELASTIC CHARACTERISTICS, RESISTANCE TO PERMANENT SET AND ITS COMPATIBILITY WITH HYDRAULIC FLUID, THE CONTACTING METAL COMPONENTS, AND THE OPERATING TEMPERATURES (2). THE ASSEMBLY DESIGN PERMITS VISUAL INSPECTION OF THE O-RING AFTER INSTALLATION (3).

(1) 82005510; (2) RSS-8582; (3) 84000168

Design / Document Reference

FAILURE CAUSE: **F: Servovalve: Torque motor contamination, open or short circuit.**

THE TORQUE MOTOR PARTS ARE CLEANED PRIOR TO ASSEMBLY. THE TORQUE MOTOR DAMPING FLUID CLEANLINESS IS CONTROLLED (1). THE SERVOVALVE IS ASSEMBLED IN A LAMINAR FLOW BENCH AREA TO PREVENT CONTAMINATION ENTRY (1). THE ELECTRICAL HARNESS WIRE AND THE SERVOVALVE COIL WIRE (1) ARE PROCURED TO GOVERNMENT SPECIFICATIONS. THE ELECTRICAL CONNECTORS ARE MADE TO ROCKETDYNE APPROVED SPECIFICATIONS (2). THE COILS ARE WOUND IN LAMINAR FLOW STATIONS TO REDUCE CONTAMINATION POTENTIAL. THE COIL IS WOUND TO ENSURE THAT COIL WIRES CANNOT CROSS THE LEADWIRE FROM THE OTHER END OF THE COIL (1) (3). ALL HARNESS WIRES ARE INSTALLED IN PROTECTIVE WIREWAYS. THE INTERFACE FASTENERS ARE LOCKWIRED AND THE WIREWAYS ARE SUPPORTED WITH CLAMPS. WIREWAYS ARE FILLED WITH PLASTIC POTTING COMPOUND. COIL AND LEADWIRE TERMINATIONS ARE ENCAPSULATED (4). TEFLON WIRE GUIDES, AND COIL AND WIRE POTTING MINIMIZES THE POSSIBILITY OF MECHANICAL DAMAGE TO THE INSULATION AND WIRE, AND VIBRATION INDUCED ELECTRICAL DISCONTINUITIES. ELECTRICAL CONTINUITY AT LEADWIRE-TO-CONNECTOR AND COIL-TO-LEADWIRE CONNECTIONS IS ENSURED BY SOLDERED JOINTS (4).

(1) RC1008; (2) RES1229; (3) 28006768, 28006769; (4) 41003720

FAILURE CAUSE: **G: Servovalve: Broken flapper, torque tube, or feedback wire.**

THE FLAPPER (1) AND TORQUE TUBE (2) ARE MADE FROM BERYLLIUM COPPER. THIS MATERIAL WAS SELECTED FOR ITS DUCTILITY, MODULUS OF ELASTICITY, AND YIELD STRENGTH (3). THE FLAPPER AND TORQUE TUBE ARE DEFLECTION LIMITED. THIS IN COMBINATION WITH THE MATERIAL PROPERTIES REDUCES THE POSSIBILITY OF LOW AND HIGH CYCLE FATIGUE. THE FEEDBACK WIRE (4) IS 17-7 PH. 17-7 PH IS USED FOR ITS SHEAR STRENGTH AND WEAR RESISTANCE (3). THE FEEDBACK WIRE BALL IS RESISTANCE WELDED TO THE FEEDBACK WIRE (5) FOR STRUCTURAL INTEGRITY.

(1) 28003053; (2) 28003056; (3) RSS-8582; (4) 28003058; (5) 28003057

FAILURE CAUSE: **H: Servovalve: Spool seizure.**

THE SERVOVALVE SPOOL (1), AND SLEEVE (2) ARE 440C CRES. THE SPOOL AND SLEEVE ARE HEAT TREATED AND COLD STABILIZED (1) (2). THE MATERIAL WAS SELECTED FOR ITS HARDNESS AND WEAR RESISTANCE (3). 440C CRES IS CORROSION RESISTANT. THE SHARP EDGES OF THE SPOOL AND THE LAP FIT OF THE SPOOL AND SLEEVE REDUCE THE POSSIBILITY OF SEIZURE DUE TO CONTAMINANT PARTICLES. THE L/D GREATER THAN 8 AND CLOSE DIAMETRICAL CLEARANCES PREVENT SEIZURE CAUSED BY COCKING. THE SPOOL OPERATES IN HYDRAULIC FLUID, WHICH PROVIDES ADDITIONAL CORROSION PROTECTION AND LUBRICATION. THE ACTUATOR DETAIL PARTS ARE CLEANED FOR HYDRAULIC SERVICE (4), AND THE HYDRAULIC FLUID IS FILTERED THROUGH A 25-MICRON FILTER (5) WHICH IS UPSTREAM OF THE ACTUATOR. THE SERVOVALVE AND ACTUATOR ARE ASSEMBLED IN A CONTAMINATION CONTROLLED AREA (4). HYDRAULIC OIL CLEANLINESS IS VERIFIED BEFORE THE ACTUATOR IS INSTALLED IN A TEST FACILITY AND BEFORE THE UNIT IS REMOVED FROM THE SYSTEM (6). THE SERVOVALVE IS OPERATED PERIODICALLY DURING PROPELLANT CONDITIONING TO PREVENT SEIZURE CAUSED BY SILTING (7).

(1) 28003759; (2) 28003076; (3) RSS-8582; (4) RL10012; (5) RES1008-3003; (6) RC1008; (7) CP406R0002 PT 1 3.2.3:6.1.6

FAILURE CAUSE: **I: Servovalve: Loss of damping fluid.**

THE DAMPING FLUID IS CONTAINED BETWEEN THE TORQUE MOTOR COVER (1) AND THE SERVO-COMPONENT HOUSING (2). THE COVER-TO-HOUSING JOINT IS SEALED IN WITH AN O-RING SEAL. THE DAMPING FLUID IS SEALED FROM THE HYDRAULIC CIRCUIT BY AN O-RING BETWEEN THE HOUSING AND THE TORQUE MOTOR FRAME (3). THE TORQUE MOTOR CAVITY IS FILLED BY INJECTING A MEASURED AMOUNT OF FLUID. THE O-RING SEALS ARE MADE FROM BUNA-N. BUNA-N WAS SELECTED FOR ITS COMPATIBILITY WITH THE OPERATING ENVIRONMENT AND RESISTANCE TO PERMANENT SET (4). THE O-RINGS ARE LIFE LIMITED BY MAJOR WAIVER (5). THE TORQUE MOTOR WILL OPERATE SATISFACTORILY WITHOUT DAMPING FLUID. HOWEVER, DAMPING FLUID LOSS MAY REDUCE THE HIGH CYCLE FATIGUE LIFE OF THE TORQUE MOTOR ASSEMBLY.

(1) 28003031; (2) 28003079; (3) 28003045; (4) RSS-8582; (5) DAR 2988

Design / Document Reference

FAILURE CAUSE: ALL CAUSES

THE HIGH CYCLE AND LOW CYCLE FATIGUE LIFE OF THE ACTUATOR MEET CEI REQUIREMENTS (1). THE MINIMUM FACTORS OF SAFETY FOR THE ACTUATOR MEET CEI REQUIREMENTS (2). THE ACTUATOR HAS BEEN CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (3). THE ACTUATOR HAS COMPLETED DESIGN VERIFICATION TESTING (4). DVS TEST RESULTS ARE DOCUMENTED (5). THE OPOVA FROM ENGINE 2010 WAS DISASSEMBLED AND EXAMINED. THE ACTUATOR SHOWED NO DETRIMENTAL DEFECTS OR WEAR. THIS ACTUATOR HAD 28 STARTS AND 10,332 SECONDS HOT FIRE TIME, INCLUDING 6,651 SECONDS AT FPL (6). ACTUATING TOO FAST OR TOO SLOW IS DETECTED BY SEII (7) WHICH, IF THE FAILURE CONTINUES, RESULTS IN CONTROLLER INITIATED HYDRAULIC LOCKUP OF ALL ACTUATORS (8). A FAILURE MAY ALSO BE DETECTED BY HPOTP OR HPFTP TURBINE DISCHARGE TEMPERATURE REDLINE LIMIT (9) WHICH RESULTS IN A CONTROLLER INITIATED ENGINE SHUTDOWN (10). THE SYSTEM IS COMPRISED OF REDUNDANT ACTUATOR POSITION SENSOR ELECTRONICS, REDUNDANT TEMPERATURE SENSORS, REDUNDANT HARNESSES, AND REDUNDANT CONTROLLER CHANNELS. DURING STORAGE, RESIDUAL HYDRAULIC FLUID IS LEFT IN THE ACTUATOR AND THE ACTUATOR OPENINGS ARE SEALED TO PREVENT CONTAMINATION ENTRY. THE HYDRAULIC FLUID FILM LEFT ON THE PARTS, AND THE SEALED ENVIRONMENT, PROVIDE CORROSION PROTECTION.

(1) RL00532, CP320R0003B; (2) RSS-8546, CP320R0003B; (3) NASA TASK 117; (4) DVS-SSME-512; (5) RSS-512; (6) SSME-82-2316; (7) CP406R0002 PT 1 3.2.3:6.1.3; (8) CP406R0002 PT 1 3.2.3:1.7.2; (9) CP406R0002 PT 1 3.2.3:5.3; (10) CP406R0002 PT 2 TABLE XL

# SSME F/ /CIL
# INSPECTION AND TEST

Component Group: Actuators
CIL Item: E140-03
Part Number: RES1008-6XXX
Component: Oxidizer Preburner Oxidizer Valve Actuator
FMEA Item: E140
Failure Mode: Actuates too fast or too slow.

Prepared: S. Heater
Approved: T. Nguyen
Approval Date: 6/9/00
Change #: 1
Directive #: CCBD ME3-01-5624



| Failure Causes | Significant Characteristics | Inspection(s) / Test(s) | Document Reference |
|---|---|---|---|
| A | BEARING | | 84000369 |
| | BEARING INTEGRITY | BEARINGS ARE VERIFIED PER MIL STANDARDS AND DRAWING REQUIREMENTS INCLUDING RADIAL ECCENTRICITY. | 84000369 |
| B | HOUSING FORGING<br>PISTON<br>HOUSING - FORMED<br>HOUSING ASSEMBLY | | 34000219<br>34000309<br>34000657<br>34000694 |
| | MATERIAL INTEGRITY | MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS. | 34000219<br>34000309<br>34000657<br>34000694 |
| | | GAS CARBURIZING OF THE PISTON IS INSPECTED PER DRAWING. | 34000309 |
| | | THE PISTON IS MAGNETIC PARTICLE INSPECTED PER DRAWING REQUIREMENTS. | 34000309 |
| | | THE HOUSING FORGING IS ULTRASONICALLY INSPECTED. | 34000219 |
| | | THE HOUSING HEAT TREAT AFTER ROUGH MACHINING IS VERIFIED PER DRAWING REQUIREMENTS. | 34000657 |
| | | THE HOUSING IS ETCHED AND PENETRANT INSPECTED AFTER HEAT TREATING. | 34000657 |
| | | THE HOUSING CYLINDER BORE HARD ANODIZE IS VERIFIED. | RC1008 |
| | | PISTON AND BORE SURFACE FINISHES ARE INSPECTED PER DRAWING REQUIREMENTS. | 34000309<br>34000694 |
| | ASSEMBLY CLEANLINESS | THE HOUSING ASSEMBLY CLEANLINESS IS VERIFIED. | RC1008, RL10012 |
| | | THE ASSEMBLY IN CONTAMINATION CONTROLLED AREA IS VERIFIED. | RC1008, RL10012 |
| | | HYDRAULIC FILTER IS INSPECTED FOR MICRON RATING AND CLEANLINESS. | RC1008 |
| | FUNCTIONAL INTEGRITY | FUNCTIONAL ACCEPTANCE TESTING VERIFIES PROPER PISTON OPERATION. | RC1008 |
| C | HOUSING FORGING<br>PISTON<br>HOUSING - FORMED<br>HOUSING ASSEMBLY | | 34000219<br>34000309<br>34000657<br>34000694 |
| | MATERIAL INTEGRITY | MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS. | 34000219<br>34000309<br>34000657<br>34000694 |
| | | THE PISTON IS MAGNETIC PARTICLE INSPECTED PER DRAWING REQUIREMENTS. | 34000309 |
| | | THE HOUSING FORGING IS ULTRASONICALLY INSPECTED | |

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| Failure Causes | Significant Characteristics | Inspection(s) / Test(s) | Document Reference |
|---|---|---|---|
| C | MATERIAL INTEGRITY | THE HOUSING HEAT TREAT AFTER ROUGH MACHINING IS VERIFIED PER DRAWING REQUIREMENTS. | 34000657 |
| | | THE HOUSING IS ETCHED AND PENETRANT INSPECTED AFTER HEAT TREATING. | 34000657 |
| | | THE HOUSING CYLINDER BORE HARD ANODIZE IS VERIFIED. | RC1008 |
| | | PISTON AND BORE SURFACE FINISHES ARE INSPECTED PER DRAWING REQUIREMENTS. | 34000309<br>34000694 |
| | ASSEMBLY CLEANLINESS | THE HOUSING ASSEMBLY CLEANLINESS IS VERIFIED. | RC1008 |
| | | THE ASSEMBLY IN CONTAMINATION CONTROLLED AREA IS VERIFIED. | RC1008 |
| | | HYDRAULIC FILTER IS INSPECTED FOR FILTERING CAPABILITY. | RC1008 |
| | SEAL INTEGRITY | ACTUATOR SLEW RATE TESTING VERIFIES PROPER PISTON SEALING. | RC1008 |
| | ASSEMBLY INTEGRITY | ASSEMBLY ACCEPTANCE TESTING VERIFIES PROPER PISTON OPERATION. | RC1008 |
| D | NOZZLE<br>ORIFICE/FILTER ASSEMBLY<br>FILTER<br>SERVOVALVE | | 28003074<br>28006493<br>28003065<br>84000168 |
| | COMPONENT AND FLUID CLEANLINESS | FACILITY TEST FLUIDS ARE INSPECTED FOR PARTICULATES PRIOR TO AND AFTER ACTUATOR FUNCTIONAL TESTING. | RC1008 |
| | | THE ACTUATOR AND SERVOVALVE COMPONENTS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY. | RC1008, RL10012 |
| | | CONTAMINATION CONTROL OF THE ACTUATOR AND SERVOVALVE ASSEMBLY AREA IS VERIFIED. | RC1008, RL10012 |
| | FILTER INTEGRITY | THE SERVOVALVE FILTER IS VERIFIED TO MEET THE PARTICULATE FILTRATION REQUIREMENTS PER DRAWING. | 28003065 |
| | | SERVOVALVE NOZZLE IS EXAMINED FOR BURRS, RADIAL SCRATCHES, AND NICKS. | 28003074 |
| | FUNCTIONAL INTEGRITY | SERVOVALVE AND ACTUATOR FUNCTIONAL TESTING VERIFIES NOZZLE AND ORIFICE ARE NOT RESTRICTED. | RC1008<br>84000168 |
| E | SERVOVALVE<br>SEAL | | 84000168<br>82005510-005 |
| | SEAL INTEGRITY | THE FILTER O-RINGS ARE LOT SAMPLE INSPECTED PER MIL-STD-105 FOR VISUAL SURFACE QUALITY, PHYSICAL QUALITY, FLUID COMPATIBILITY, STRETCH, AND COMPRESSION. | 29000020, HRQP 5.150 |
| | ASSEMBLY INTEGRITY | THE FILTER O-RING INSTALLATION AND SEALING IS VERIFIED BY NULL SHIFT TESTING OF THE SERVOVALVE. | RC1008 |
| F | COIL<br>COIL<br>SERVOVALVE | | 28006768<br>28006769<br>84000168 |

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| Failure Causes | Significant Characteristics | Inspection(s) / Test(s) | Document Reference |
|---|---|---|---|
| F | ELECTRICAL INTEGRITY | THE COIL WINDING IS INSPECTED TO ASSURE COIL WIRE ENDS DO NOT CROSS EACH OTHER OR THE OPPOSITE END LEADWIRE. | 28006768<br>28006769 |
| | | SOLDERING OF ELECTRICAL CONNECTIONS IS VERIFIED PER SPECIFICATION REQUIREMENTS. | RC1008, RL10009 |
| | | ELECTRIC COIL INSULATION, WIRE RESISTANCE, AND DIELECTRIC STRENGTH ARE TESTED. | RC1008 |
| | | COIL LEADWIRE TERMINATION ENCAPSULATION IS INSPECTED. | RC1008<br>RL10008 |
| | | VIBRATION, THERMAL, AND INDUCTION KICK TESTS ARE PERFORMED TO DETECT INCIPIENT SHORTS. | RC1008 |
| | | ELECTRICAL RESPONSE TESTING VERIFIES ELECTRICAL INTEGRITY. | RC1008 |
| | CLEANLINESS | COMPONENTS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY. | RC1008, RL10012 |
| | | TORQUE MOTOR AREA IS VERIFIED TO BE CLEAN PRIOR TO CLOSEOUT OF THE CAVITY. | 84000168 |
| G | FEEDBACK WIRE BALL ASSEMBLY<br>ARMATURE ASSEMBLY<br>FLAPPER<br>TORQUE TUBE<br>FEEDBACK WIRE<br>ARMATURE-CAP ASSEMBLY<br>ARMATURE-CAP/TUBE<br>SPACER ASSEMBLY | | 28003057<br>28003049<br>28003053<br>28003056<br>28003058<br>28003050<br>28003037 |
| | MATERIAL INTEGRITY | MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS. | 28003053<br>28003056<br>28003058 |
| | | HEAT TREAT OF FLAPPER, TORQUE TUBE, AND FEEDBACK WIRE IS VERIFIED PER DRAWING REQUIREMENTS. | 28003053<br>28003056<br>28003058 |
| | | RESISTANCE WELDING OF THE FEEDBACK WIRE TO BALL IS VERIFIED PER DRAWING REQUIREMENTS. | 28003057 |
| | | PULL TESTS OF THE FEEDBACK WIRE TO BALL RESISTANCE WELD VERIFY WELD INTEGRITY. | 28003057 |
| | | SILVER SOLDER BRAZING OF THE FLAPPER AND THE FEEDBACK WIRE TO THE TORQUE TUBE IS VERIFIED PER DRAWING REQUIREMENTS. | 28003049<br>28003037<br>28003050 |
| | | ARMATURE ASSEMBLY BRAZE JOINTS ARE LEAK CHECKED. | 28003049 |
| | FUNCTIONAL INTEGRITY | FUNCTIONAL TESTING OF ACTUATOR VERIFIES SERVOVALVE INTEGRITY. | RC1008 |
| H | SPOOL<br>SLEEVE<br>SERVOVALVE | | 28003759<br>28003076<br>84000168 |

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|---|---|---|---|
| H | MATERIAL INTEGRITY | MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS. | 28003759<br>28003076 |
| | | HEAT TREAT OF SPOOL AND SLEEVE IS VERIFIED PER DRAWING REQUIREMENTS. | 28003759<br>28003076 |
| | | THE SPOOL METERING EDGES ARE REQUIRED TO BE SHARP, WITH NO BURRS OR FEATHER EDGES. | 28003759 |
| | | THE SLEEVE METERING SLOTS ARE REQUIRED TO BE FREE OF NICKS AND BURRS AT I.D. EDGE. | 28003076 |
| | SPOOL - SLEEVE FIT | PROPER CLEARANCE BETWEEN THE SERVOVALVE SPOOL AND SLEEVE IS VERIFIED. | 84000168 |
| | COMPONENT CLEANLINESS | ACTUATOR COMPONENTS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY. | RC1008 |
| | | ASSEMBLY AND TESTING IS VERIFIED TO BE PERFORMED IN A CONTAMINATION CONTROLLED AREA. | RC1008<br>RL10012 |
| | | SERVOVALVE FILTER IS VERIFIED TO MEET FILTRATION REQUIREMENTS, INCLUDING PARTICULATE FILTRATION AND CLEANLINESS. | 28006493 |
| | ASSEMBLY INTEGRITY | FUNCTIONAL TESTING, INCLUDING NULL SHIFT TESTING, VERIFIES SATISFACTORY SPOOL DIMENSIONS AND OPERATION. | RC1008 |
| I | SERVOVALVE | | 84000168 |
| | TORQUE MOTOR DAMPING | PROPER FILLING OF TORQUE MOTOR CAVITY WITH DAMPING FLUID IS VERIFIED. | 84000168 |
| | | SSME COMPONENTS EXTERNAL INSPECTION VERIFIES THERE IS NO EVIDENCE OF FLUID LEAKAGE PRIOR TO EACH FLIGHT. | OMRSD V41BU0.030 |
| ALL CAUSES | COMPONENT CLEANLINESS | ALL ACTUATOR DETAILS ARE VERIFIED TO BE CLEAN PRIOR TO INSTALLATION. | RC1008, RL10012 |
| | FUNCTIONAL INTEGRITY | HOTFIRE TESTING AND SECOND E & M INSPECTIONS VERIFY SATISFACTORY OPERATION. | RL00050-04<br>RL00056-06<br>RL00056-07 |
| | | ACTUATOR OPERATION IS VERIFIED PRIOR TO EACH FLIGHT DURING HYDRAULIC SYSTEM CONDITIONING. | OMRSD S00FA0.211 |
| | | ACTUATOR OPERATION IS VERIFIED DURING FLIGHT READINESS CHECKOUT PRIOR TO EACH FLIGHT. | OMRSD V41AS0.030 |
| | | ACTUATOR OPERATION IS VERIFIED DURING THE ACTUATOR CHECKOUT MODULE PRIOR TO EACH FLIGHT. | OMRSD V41AS0.010 |
| | | ACTUATOR POSITION SHIFT BETWEEN PURGE SEQUENCE 3 AND PURGE SEQUENCE 4 IS VERIFIED AS PART OF LAUNCH COMMIT CRITERIA. (LAST TEST) | JSC 16007 |

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| Compone oup: | Actuators | Prepared: | S. Hea' |
| CIL Item: | E140-03 | Approved: | T. Ngu, |
| Part Numbe.. | RES1008-6XXX | Approval Date: | 6/9/00 |
| Component: | Oxidizer Preburner Oxidizer Valve Actuator | Change #: | 1 |
| FMEA Item: | E140 | Directive #: | CCBD ME3-01-5624 |
| Failure Mode: | Actuates too fast or too slow. | Page: | 5 of 5 |

| Failure Causes | Significant Characteristics | Inspection(s) / Test(s) | Document Reference |
|---|---|---|---|

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
Reference: NASA letter SA21/88/308 and Rocketdyne letter 88RC09761.

Operational Use: FAILURE MODE CAN BE DETECTED IN REALTIME BY THE FLIGHT CONTROL TEAM WHO WILL EVALUATE EFFECTS UPON VEHICLE PERFORMANCE AND ABORT CAPABILITY. BASED ON THIS EVALUATION THE APPROPRIATE ABORT MODE OR SYSTEM CONFIGURATION WILL BE SELECTED. FAILURE DETECTION CUES AND ASSOCIATED SSME PERFORMANCE DATA HAVE BEEN COORDINATED BETWEEN THE ENGINEERING AND FLIGHT OPERATIONS ORGANIZATIONS WITH THE RESPONSES DOCUMENTED IN MISSION FLIGHT RULES.