

SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Actuators
 CIL Item: E120-01
 Part Number: RES1008-5XXX
 Component: Main Oxidizer Valve Actuator
 FMEA Item: E120
 Failure Mode: Fails to respond to position commands.

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

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Phase	Failure / Effect Description	Criticality Hazard Reference
S 4.2	<p>MOVA/MOV fails to respond to position commands: Controller detects channel A and B actuator interrupts. Pneumatic engine shutdown is initiated by controller. Mission scrub. Loss of vehicle due to engine oxidizer duct rupture may result if MOVA/MOV closes and is not detected.</p> <p>Redundancy Screens: ACTUATOR SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Pass - Loss of a redundant hardware items is detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.</p>	1R ME-C3S
S 4.3	<p>MOVA/MOV travels in opposite direction from commanded position. MOVA/MOV closes causing oxidizer duct rupture. Loss of vehicle.</p> <p>Redundancy Screens: SINGLE POINT FAILURE: N/A</p>	1 ME-C3S
M 4.2	<p>Following channel A failure, controller switches to channel B (servo valve No. 2); if failure continues, controller initiates hydraulic lockup. Mission abort may result when hydraulic lockup occurs during Max Q throttling.</p> <p>Redundancy Screens: ACTUATOR SYSTEM: LIKE REDUNDANCY</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Pass - Loss of a redundant hardware items is detectable during flight. C: Fail - Loss of redundant hardware items could result from a single credible event.</p>	1R ME-C3M
C 4.2	<p>MOVA/MOV fails to close; all other valves close as required: if failure is detected by SEII, controller commands pneumatic shutdown. If failure continues, LOX flow is shutoff by vehicle closure of prevalve. LOX rich cutoff. Loss of vehicle.</p> <p>Redundancy Screens: SINGLE POINT FAILURE: N/A</p>	1 ME-B4A,C, ME-C3A,C

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**SSME FMEA/CIL
DESIGN**

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Design / Document Reference

FAILURE CAUSE: A: Actuator: Shaft, crank, crank pin, or pushrod failure.

THE ACTUATOR SHAFT (1) MATERIAL IS A-286 CRES. THE MATERIAL WAS SELECTED FOR ITS STRENGTH, ELASTIC MODULUS, THERMAL CHARACTERISTICS AND STRESS CORROSION RESISTANCE (3). THE SHAFT IS HEAT TREATED TO DEVELOP MATERIAL STRENGTH. THE SHAFT IS ALSO PASSIVATED TO DEVELOP ADDITIONAL CORROSION RESISTANCE. THE ACTUATOR CRANK (2) MATERIAL IS 18Ni MARAGING STEEL BAR. THE MATERIAL WAS SELECTED FOR ITS MECHANICAL STRENGTH (3). THE CRANK IS PROTECTED FROM CORROSION BY THE HYDRAULIC FLUID ENVIRONMENT. THE CRANK IS HEAT TREATED FOR MAXIMUM STRENGTH AND SHOT PEENED FOR ADDITIONAL STRESS CORROSION RESISTANCE (2) AND FATIGUE STRENGTH. THE CRANK PIN (4) MATERIAL IS VASCO MATRIX II CVM STEEL. THE CRANK PIN IS HEAT TREATED AFTER ROUGH MACHINING, AND STRESS RELIEVED AFTER FINAL MACHINING. THE MATERIAL WAS SELECTED FOR STRENGTH AND HARDNESS (3). THE CRANK PINS ARE LUBRICATED WITH DICRONITE NO. 25504 TO MINIMIZE FRICTION. THE PUSHRODS (5) ARE HEAT TREATED CUSTOM 455 CRES. THE MATERIAL WAS SELECTED FOR ITS STRENGTH AND HARDNESS (3). MONOBALL ROD END BEARINGS (6) WITH 440C BALLS AND 17-4 PH OUTER RACES ARE USED AT THE CRANK END OF THE PUSHRODS. THE BALLS AND RACES ARE DICRONITE COATED FOR REDUCED FRICTION. THE MONOBALL BEARING COMPENSATES FOR PISTON AND CRANK MISALIGNMENT AND ENSURES UNIFORM LOADING ON THE CRANK PIN. THE PUSHROD BALL END IS TUFFTRIDE SURFACE HARDENED TO PROVIDE RESISTANCE TO WEAR AND GALLING. THE END ALSO PROVIDES A PATH FOR HYDRAULIC FLUID LUBRICATION (5).

(1) 41004588; (2) 41004701; (3) RSS-8575; (4) 41003903; (5) 34000402; (6) 84000378

FAILURE CAUSE: B: 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-8575; (3) 41003730

FAILURE CAUSE: C: 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) 34000259; (2) RSS-8575; (3) 34000695; (4) RC1008, RL10012; (5) RES1008-3003

FAILURE CAUSE: D: Servo valve: 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

E-04

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Design / Document Reference

FAILURE CAUSE: E: Servo valve: 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-8575; (3) 84000168

FAILURE CAUSE: F: Servo valve: 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) 41003730

FAILURE CAUSE: G: Servo valve: 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 17-7PH. 17-7PH 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-8575; (4) 28003058; (5) 28003057

FAILURE CAUSE: H: Servo valve: 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-8575; (4) RL10012; (5) RES1008-3003; (6) RC1008; (7) CP406R0002 PT 1 3.2.3:6.1.6

FAILURE CAUSE: I: Servo valve: 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-8575; (5) DAR 2988

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Prepared: S. Heat.
Approved: T. Nguyen
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Design / Document Reference

FAILURE CAUSE: J: Failsafe Servoswitch: 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 SERVO SWITCH AND ACTUATOR ASSEMBLY ARE 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 SERVO SWITCH (4) INCORPORATES A FILTER (5) TO PROTECT THE ORIFICES AND ALSO INCORPORATES 50-MICRON FILTERS IMMEDIATELY UPSTREAM OF THE NOZZLES FOR FILTERING THE FIRST STAGE FLUID SUPPLY. THE ORIFICE FILTER IS DESIGNED TO CONTAIN ALL PARTICLES WHOSE 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) 84000259; (5) 28003065

FAILURE CAUSE: K: Failsafe Servoswitch: Torque motor contamination, open or short circuit.

THE TORQUE MOTOR PARTS ARE CLEANED PRIOR TO ASSEMBLY. THE SERVO SWITCH IS ASSEMBLED IN A LAMINAR FLOW BENCH AREA TO PREVENT CONTAMINATION ENTRY (1). THE ELECTRICAL HARNESS WIRE AND THE SERVO SWITCH 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) 41003730

FAILURE CAUSE: L: Failsafe Servoswitch: Broken flapper or torque tube.

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 PREVENTS LOW AND HIGH CYCLE FATIGUE FAILURE.

(1) 28003504; (2) 28003056; (3) RSS-8575

FAILURE CAUSE: M: Failsafe Servoswitch: 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-8575; (3) 84000259

FAILURE CAUSE: N: Failsafe Servoswitch: 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-8575; (5) DAR 2988

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FAILURE CAUSE: P: Actuator: Pneumatic piston seizure.

THE PNEUMATIC PISTON (1) AND PNEUMATIC CAP (2) ARE FABRICATED FROM 2024-T6 ALUMINUM ALLOY. THE ALLOY WAS SELECTED FOR ITS STRENGTH AND THERMAL COMPATIBILITY WITH THE ADJACENT ACTUATOR MATERIALS. THE MATERIAL IS RESISTANT TO STRESS CORROSION AND IS ANODIZED FOR GENERAL CORROSION PROTECTION (3). THE PISTON OD IS HARD ANODIZED AND THE PISTON ENDS ARE CHAMFERED TO PREVENT WEAR OR GALLING AND PISTON SEIZURE. THE PISTON L/D, WHICH IS OVER 3, PREVENTS SEIZURE CAUSED BY COCKING. THE ACTUATOR PARTS ARE CLEANED FOR HYDRAULIC SERVICE PRIOR TO ACTUATOR ASSEMBLY (4). THE ACTUATOR IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA (4). THE PARTS ARE LUBRICATED FOR PNEUMATIC SERVICE PRIOR TO ASSEMBLY. THE PISTON SURFACE FINISHES ARE SELECTED FOR DYNAMIC SEALING REQUIREMENTS. THIS MINIMIZES WEAR AND GALLING POTENTIAL.

(1) 34000262; (2) 41004165; (3) RSS-8575; (4) RC1008, RL10012

FAILURE CAUSE: Q: Bypass Valve: Spool seizure.

THE BYPASS VALVE SPOOL (1) AND SLEEVE (2) ARE HEAT TREATED CRES 440C MICRO-MELT. THE SPOOL AND SLEEVE ARE HEAT TREATED AND COLD STABILIZED (1) (2). THE MATERIAL WAS SELECTED FOR ITS HARDNESS AND WEAR RESISTANCE (3). CRES 440C MICRO-MELT IS CORROSION RESISTANT. THE BYPASS VALVE SPOOL OPERATES IN HYDRAULIC FLUID WHICH PROVIDES ADDITIONAL CORROSION PROTECTION AND LUBRICATION. THE ACTUATOR DETAIL PARTS ARE CLEANED FOR HYDRAULIC SERVICE (5) AND THE HYDRAULIC FLUID TO THE ACTUATOR IS FILTERED THROUGH A 25-MICRON FILTER (6). THE ACTUATOR IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA. HYDRAULIC OIL CLEANLINESS IS VERIFIED BEFORE THE ACTUATOR IS INSTALLED IN A TEST FACILITY AND BEFORE THE UNIT IS REMOVED FROM THE SYSTEM (5). 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 SPOOL L/D GREATER THAN 10 PREVENTS SEIZURE CAUSED BY COCKING (1). THE SPOOL IS KEYED TO THE SLEEVE TO PREVENT INDEXING THEREFORE REDUCING THE GENERATION OF CONTAMINATION PARTICLES (1) (2) (4).

(1) 41009422; (2) 41009423; (3) RSS-8575; (4) 41009498; (5) RC1008; (6) RES1008-3003

FAILURE CAUSE: R: Bypass Valve: Blocked pneumatic shutdown orifice or filter.

THE HYDRAULIC ACTUATOR DETAILS ARE CLEANED FOR HYDRAULIC SERVICE AND THE ACTUATOR IS ASSEMBLED IN A CONTAMINATION CONTROLLED ENVIRONMENT (1). THE HYDRAULIC FLUID IS FILTERED THROUGH A 25-MICRON FILTER PRIOR TO ENTERING THE ACTUATOR (2). A FILTER (3), WHICH REMOVES PARTICLES LARGE ENOUGH TO BLOCK THE ORIFICE, IS INCORPORATED UPSTREAM OF THE ORIFICE. THE ORIFICE FLOWS HYDRAULIC FLUID ONLY DURING PNEUMATIC SHUTDOWN AND THE FLOW IS LIMITED TO THE ACTUATOR VOLUME SWEEP DURING THE ACTUATOR CLOSING FUNCTION.

(1) RC1008, RL10012; (2) RES1008-3003; (3) 41004175

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 MOVA FROM ENGINE 2007 WAS DISASSEMBLED AND EXAMINED. NO DETRIMENTAL DEFECTS OR WEAR WERE NOTED. THIS ACTUATOR HAD FIVE FLIGHTS, 14 STARTS, AND 4,210 SECONDS HOT FIRE TIME (6). A FAILURE TO RESPOND TO POSITION COMMANDS IS DETECTED BY A SERVOACTUATOR ERROR INDICATION INTERRUPT (SEII) (7). DURING START, THE FAILURE WILL RESULT IN A VEHICLE COMMANDED ENGINE SHUTDOWN (8). DURING MAINSTAGE, THE FAILURE WILL RESULT IN A CONTROLLER INITIATED HYDRAULIC LOCKUP IF THE FAILURE CONTINUES IN CHANNEL B (8). THE SYSTEM IS COMPRISED OF REDUNDANT ACTUATOR POSITION SENSOR ELECTRONICS, REDUNDANT HARNESSSES, AND REDUNDANT CONTROLLER CHANNELS. DURING STORAGE THE 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) HAS-TM-409; (7) CP406R0002 PT 1 3.2.3:6.1.3; (8) CP406R0002 PT 1 3.2.3:6.1.3 3.2.3:1.7.2

SSME FMEA/CIL
INSPECTION AND TEST

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	SHAFT		41004588
	CRANK		41004701
	CRANK PIN		41003903
	PUSHROD		34000402
	MONOBALL		84000378
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	41004588
			41004701
			41003903
			34000402
			84000378
		HEAT TREATMENTS OF SHAFT, CRANK, CRANK PIN, MONOBALL, AND PUSHROD ARE VERIFIED TO MEET DRAWING REQUIREMENTS.	41004588
			41004701
			41003903
		34000402	
		84000378	
	THE CRANK, CRANK PIN, AND PUSHROD ARE MAGNETIC PARTICLE INSPECTED.	41004701	
		41003903	
		34000402	
	THE SHAFT IS PENETRANT INSPECTED PER DRAWING REQUIREMENTS.	41004588	
	TUFFTRIDE SURFACE HARDENING OF THE PUSHROD BALL END IS VERIFIED PER DRAWING REQUIREMENTS.	34000402	
	SHOT PEENING OF THE CRANK IS VERIFIED PER DRAWING REQUIREMENTS.	41004701	
LUBRICATION	DICRONITE COATING OF THE CRANK PIN AND MONOBALL ARE VERIFIED.	41003903	
		84000378	
ASSEMBLY INTEGRITY	ACCEPTANCE TESTING OF ACTUATOR VERIFIES PART INTEGRITY.	RC1008	
B	BEARING		84000369
	BEARING		84000379
	BEARING INTEGRITY	BEARINGS ARE VERIFIED PER MIL STANDARDS AND DRAWING REQUIREMENTS INCLUDING RADIAL ECCENTRICITY.	84000369
		84000379	
C	HOUSING FORGING		34000228
	PISTON		34000259
	HOUSING FORMED		34000658
	HOUSING ASSEMBLY		34000695
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	34000228
		34000259	
		34000658	

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Component Group: Actuators
 CIL Item: E120-01
 Part Number: RES1008-5XXX
 Component: Main Oxidizer Valve Actuator
 FMEA Item: E120
 Failure Mode: Fails to respond to position commands.

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

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference	
C	MATERIAL INTEGRITY	GAS CARBURIZING OF THE PISTON IS INSPECTED PER DRAWING.	34000259	
		THE PISTON IS MAGNETIC PARTICLE INSPECTED.	34000259	
		THE HOUSING FORGING IS ULTRASONICALLY INSPECTED.	34000228	
		THE HOUSING HEAT TREAT AFTER ROUGH MACHINING IS VERIFIED PER DRAWING REQUIREMENTS.	34000658	
		THE HOUSING IS ETCHED AND PENETRANT INSPECTED AFTER HEAT TREATING.	34000658	
		THE HOUSING CYLINDER BORE HARD ANODIZE IS VERIFIED.	RC1008	
		PISTON AND BORE SURFACE FINISHES ARE INSPECTED PER DRAWING REQUIREMENTS.	34000259 34000695	
	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		
D	NOZZLE ORIFICE/FILTER ASSEMBLY FILTER SERVOVALVE		28003074 28006493 28003065 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 84000168	
E	SERVOVALVE SEAL		84000168 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	

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Component Group: Actuators
 CIL Item: E120-01
 Part Number: RES1008-5XXX
 Component: Main Oxidizer Valve Actuator
 FMEA Item: E120
 Failure Mode: Fails to respond to position commands.

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

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

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Component Group: Actuators
 CIL Item: E120-01
 Part Number: RES1008-5XXX
 Component: Main Oxidizer Valve Actuator
 FMEA Item: E120
 Failure Mode: Fails to respond to position commands.

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

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
H	SPOOL		28003759
	SLEEVE		28003076
	SERVOVALVE		84000168
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	28003759
		HEAT TREAT OF SPOOL AND SLEEVE IS VERIFIED PER DRAWING REQUIREMENTS.	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 RL10012
ASSEMBLY INTEGRITY		SERVOVALVE FILTER IS VERIFIED TO MEET FILTRATION REQUIREMENTS, INCLUDING PARTICULATE FILTRATION AND CLEANLINESS.	28006493
		FUNCTIONAL TESTING, INCLUDING NULLSHIFT 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
J	NOZZLE		28003074
	ORIFICE/FILTER ASSEMBLY		28006493
	FILTER		28003065
	SERVOSWITCH		84000259
	COMPONENT AND FLUID CLEANLINESS	FACILITY TEST FLUIDS ARE INSPECTED FOR PARTICULATES PRIOR TO AND AFTER ACTUATOR FUNCTIONAL TESTING.	RC1008
		THE ACTUATOR AND SERVOSWITCH COMPONENTS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY.	RC1008, RL10012
		CONTAMINATION CONTROL OF THE ACTUATOR AND SERVOSWITCH ASSEMBLY AREAS IS VERIFIED.	RC1008, RL10012
FILTER INTEGRITY		SERVOSWITCH FILTER IS VERIFIED TO MEET THE PARTICULATE FILTRATION REQUIREMENTS PER DRAWING.	28003065 28006493
		SERVOSWITCH NOZZLE IS EXAMINED FOR BURRS, RADIAL SCRATCHES, AND NICKS.	28003074

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Component: Actuators
 CIL Item: E120-01
 Part Number: RES1008-5XXX
 Component: Main Oxidizer Valve Actuator
 FMEA Item: E120
 Failure Mode: Fails to respond to position commands.

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

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
K	COIL		28006769
	COIL		28006768
	SERVOSWITCH		84000259
	ELECTRICAL INTEGRITY	THE COIL WINDING IS INSPECTED TO ASSURE COIL WIRE ENDS DO NOT CROSS EACH OTHER OR THE OPPOSITE END LEADWIRE.	28006769 28006768
		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 RL10008
	VIBRATION, THERMAL, AND INDUCTION KICK TESTS ARE PERFORMED TO DETECT INCIPENT SHORTS.	RC1008	
	ELECTRICAL RESPONSE TESTING VERIFIES ELECTRICAL INTEGRITY.	RC1008	
	THE TORQUE MOTOR AREA IS VERIFIED TO BE CLEAN PRIOR TO CLOSEOUT OF THE CAVITY.	84000259	
L	FLAPPER		28003504
	TORQUE TUBE		28003056
	ARMATURE ASSEMBLY		28003508
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	28003504 28003056
		HEAT TREAT OF THE FLAPPER AND TORQUE TUBE IS VERIFIED PER DRAWING REQUIREMENTS.	28003504 28003056
	BRAZE INTEGRITY	BRAZING OF THE FLAPPER AND TORQUE TUBE IS INSPECTED PER DRAWING REQUIREMENTS.	28003508
	BRAZE INTEGRITY IS VERIFIED BY LEAK TEST PER DRAWING REQUIREMENTS.	28003508	
ASSEMBLY TESTING	FLAPPER AND TORQUE TUBE INTEGRITY IS VERIFIED BY SERVOSWITCH AND ACTUATOR ACCEPTANCE TESTING.	RC1008	
M	SERVOSWITCH		84000259
	SEAL		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	FILTER O-RING INSTALLATION AND SEALING ARE VERIFIED BY SERVOSWITCH "PULL IN" AND "DROPOUT" TESTS.	RC1008 84000259	
N	SERVOSWITCH		84000259
	TORQUE MOTOR DAMPING	PROPER FILLING OF TORQUE MOTOR CAVITY WITH DAMPING FLUID IS VERIFIED.	84000259
		SSME COMPONENTS EXTERNAL INSPECTION VERIFIES THERE IS NO EVIDENCE OF FLUID LEAKAGE PRIOR TO EACH FLIGHT.	OMRSD V41BU0.030

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Component Group: Actuators
 CIL Item: E120-01
 Part Number: RES1008-5XXX
 Component: Main Oxidizer Valve Actuator
 FMEA Item: E120
 Failure Mode: Fails to respond to position commands.

Prepared: S. Heater
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 Change #: 1
 Directive #: CCBD ME3-01-5624

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference	
P	PISTON CAP		34000262 41004165	
	MATERIAL INTEGRITY	THE PISTON AND CAP MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	34000262 41004165	
		THE PISTON AND CAP ARE PENETRANT INSPECTED PER DRAWING REQUIREMENTS.	34000262 41004165	
		THE PISTON HARD ANODIZE IS INSPECTED PER DRAWING REQUIREMENTS.	34000262	
		PISTON AND CAP SURFACE FINISHES ARE INSPECTED PER DRAWING REQUIREMENTS.	34000262 41004165	
		COMPONENT CLEANLINESS	THE PISTON AND CAP ASSEMBLY CLEANLINESS IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RC1008
	FUNCTIONAL INTEGRITY	COMPONENT ASSEMBLY IS VERIFIED TO BE IN A CONTAMINATION CONTROLLED AREA.	RC1008	
		FUNCTIONAL TESTING VERIFIES PNEUMATIC PISTON OPERATION.	RC1008	
	Q	SLEEVE SPOOL SPOOL/SLEEVE ASSY		41009423 41009422 41009426
		MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	41009423 41009422
HEAT TREAT AND COLD STABILIZATION OF SLEEVE AND SPOOL ARE VERIFIED PER DRAWING REQUIREMENTS.			41009423 41009422	
THE SPOOL AND SLEEVE ARE MAGNETIC PARTICLE INSPECTED.			41009423 41009422	
THE SPOOL AND SLEEVE ARE VERIFIED BY BORESCOPE TO HAVE PROPER FINISHES AND EDGE GEOMETRY, WITH NO DETRIMENTAL BURRS OR SURFACE DEFECTS.			41009423 41009422	
THE SPOOL/SLEEVE ASSEMBLY IS INSPECTED TO ASSURE 100% CLEANUP ON THE SLEEVE DIAMETER.			41009426	
THE SPOOL TO SLEEVE LAP FIT CLEARANCE IS VERIFIED.			41009426	
COMPONENT CLEANLINESS			VALVE COMPONENTS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY.	RC1008
ASSEMBLY INTEGRITY		THE VALVE ASSEMBLY IS VERIFIED TO BE IN A CONTAMINATION CONTROLLED AREA.	RC1008 RL10012	
		FIT OF SPOOL TO SLEEVE AND MAINTENANCE AS A MATCHED SET IS VERIFIED.	41009426	
		ASSEMBLY AND FUNCTIONAL TESTING OF ACTUATOR VERIFIES SATISFACTORY BYPASS VALVE OPERATION.	RC1008	
R		ACTUATOR ASSEMBLY		41003730
		COMPONENT CLEANLINESS	THE ACTUATOR DETAILS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY.	RC1008

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Component Group: Actuators
 CIL Item: E120-01
 Part Number: RES1008-5XXX
 Component: Main Oxidizer Valve Actuator
 FMEA Item: E120
 Failure Mode: Fails to respond to position commands.

Prepared: S. Heat
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 Change #: 1
 Directive #: CCBD ME3-01-5624

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
R	COMPONENT CLEANLINESS	THE ACTUATOR ASSEMBLY IS VERIFIED TO BE IN A CONTAMINATION CONTROLLED AREA.	RC1008 RL10012
		THE FILTERING CAPABILITY AND CLEANLINESS OF THE HYDRAULIC SYSTEM FILTER IS VERIFIED.	RES1008-3003
		CLEANLINESS OF TEST FLUIDS IS VERIFIED BOTH PRIOR TO AND AFTER FUNCTIONAL TESTING.	RC1008 RL10012
		THE ACTUATOR RETURN CAVITY IS FLUSHED AND VERIFIED CLEAN AFTER FUNCTIONAL TESTING.	RC1008
		ASSEMBLY FUNCTIONAL TESTING VERIFIES SATISFACTORY BYPASS VALVE OPERATION.	RC1008
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.	RL00056-04 RL00056-06 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

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.