

**SSME FMEA/CIL**  
**REDUNDANCY SCREEN**

Component Group: Actuators  
 CIL Item: E110-11  
 Part Number: RES1008-8XXX  
 Component: Main Fuel Valve Actuator  
 FMEA Item: E110  
 Failure Mode: Structural failure.

Prepared: S. Heater  
 Approved: T. Nguyen  
 Approval Date: 6/9/00  
 Change #: 1  
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Phase	Failure / Effect Description	Criticality Hazard Reference
PS 4.1	Major hydraulic fluid leak into aft compartment; loss of hydraulic pressure, loss of MFVA/MFV control. Fuel leakage results in fire, open air detonation and overpressurization condition. Loss of vehicle.  Redundancy Screens: SINGLE POINT FAILURE: N/A.	1 ME-E1P,S,A,M,C,D
SMC 4.1	Major hydraulic fluid leak into aft compartment; loss of hydraulic pressure; loss of MFVA/MFV control; MFVA/MFV closes resulting in LOX rich operation. Loss of vehicle.  Redundancy Screens: SINGLE POINT FAILURE: N/A.	1 ME-E1P,S,A,M,C,D

**SSME FMEA/CIL  
DESIGN**

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Design / Document Reference

**FAILURE CAUSE: A: Structural failure of housings, cover, or end caps.**

THE ACTUATOR HOUSING IS MACHINED FROM A FORGED 7175 ALUMINUM BILLET, HEAT TREATED TO CONDITION T736 (1). THIS ALLOY WAS SELECTED FOR ITS TENSILE STRENGTH AND FATIGUE STRENGTH. THE EXTERIOR OF THE HOUSING IS SHOT-PEENED TO ENHANCE THE STRESS CORROSION RESISTANCE (1) AND FATIGUE STRENGTH (2). THE HOUSING IS ANODIZED FOR CORROSION PROTECTION AND THE CYLINDER BORES ARE HARD ANODIZED FOR WEAR RESISTANCE (3). STANDARD LEE PLUGS ARE USED TO CLOSE OFF DRILLED PASSAGE ACCESS HOLES WHERE SECONDARY RETENTION IS AVAILABLE (SUCH AS BOLTING ANOTHER PART OVER THE PLUG). OTHERWISE, A "PIN PLUG" IS USED WHICH IS A LEE PLUG WITH THREADS ON THE IN-HOLE END FOR SECONDARY RETENTION (3). LEE PLUGS AND PIN PLUGS ARE ALUMINUM TO PREVENT GALVANIC CORROSION. EACH NEW ACTUATOR ASSEMBLY IS SUBJECTED TO A PROOF PRESSURE TEST (4). THE HOUSING COVER PLATE (5) MATERIAL MAY BE EITHER 2024-T651 OR 2024-T6511, ANODIZED TO PREVENT CORROSION (5). THE MATERIAL IS USED FOR ITS STRENGTH AND SIMILARITY IN THERMAL PROPERTIES TO THE HOUSING (2). TWO CYLINDER END CAPS ARE REQUIRED (6). THE HYDRAULIC AND PNEUMATIC CYLINDER END CAPS ARE MACHINED FROM 2024-T6 ALUMINUM ALLOY (7)(8). THE MATERIAL WAS SELECTED FOR ITS STRENGTH, STRESS CORROSION RESISTANCE, AND SIMILARITY TO THE HOUSING THERMAL CHARACTERISTICS (2). THE CAPS ARE ANODIZED FOR CORROSION PROTECTION. THE SHUTTLE VALVE END CAP (9) IS MADE FROM 7075-T73 ALUMINUM ALLOY. THE MATERIAL IS ANODIZED FOR GENERAL CORROSION PROTECTION. 7075-T73 ALLOY IS USED FOR ITS STRENGTH AND RESISTANCE TO STRESS CORROSION CRACKING (2). THE MATERIAL IS COMPATIBLE WITH HYDRAULIC FLUID AND HAS THERMAL PROPERTIES SIMILAR TO THE ACTUATOR HOUSING. THE SERVOVALVE AND SERVOSWITCH HOUSING (10) AND END PLATES (11) ARE MADE FROM 17-4PH CRES COND H1025. THE MATERIAL IS USED FOR ITS STRENGTH, CORROSION RESISTANCE, AND RESISTANCE TO STRESS CORROSION CRACKING (2). THE HIGH CYCLE AND LOW CYCLE FATIGUE LIFE OF THE ACTUATOR MEET CEI REQUIREMENTS (12). THE MINIMUM FACTORS OF SAFETY FOR THE ACTUATOR MEET CEI REQUIREMENTS (13). THE ACTUATOR WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (14). THE ACTUATOR HAS COMPLETED DESIGN VERIFICATION TESTING (15). DVS TEST RESULTS ARE DOCUMENTED (16). THE MFVA FROM ENGINE 2010 WAS DISASSEMBLED AND EXAMINED. THE ACTUATOR SHOWED NO DETRIMENTAL DEFECTS OR WEAR. THIS ACTUATOR HAD 10,332 SECONDS OF HOT FIRE TIME WITH 28 STARTS, INCLUDING 6,651 SECONDS AT FPL (17).

(1) 34000658; (2) RSS-8576; (3) 34000695; (4) RC1008; (5) 41003913; (6) 41003730; (7) 41003739; (8) 41004165; (9) 34000149; (10) 28003079; (11) 28003183, 28003062; (12) RL00532, CP320R0003B; (13) RSS-8546, CP320R0003B; (14) NASA TASK 117; (15) DVS-SSME-512; (16) RSS-512; (17) SSME-82-2316

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**SSME FMEA/CIL**  
**INSPECTION AND TEST**

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference	
A	SV & SSW END PLATE		28003183	
	SV & SSW END PLATE		28003062	
	HOUSING, SV & SSW		28003080	
	HOUSING, ACTUATOR		34000658	
	HOUSING, ASSY.		34000695	
	HOUSING COVER		41003913	
	CAP, HYDRAULIC		41003739	
	CAP, PNEUMATIC		41004165	
	END CAP, SHUTTLE VALVE		34000149	
	HOUSING FORGING		34000228	
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.		28003183
				28003062
				28003080
				34000658
				41003913
				41003739
				41004165
				34000149
		HOUSING FORGING IS ULTRASONIC INSPECTED PER DRAWING REQUIREMENTS.		34000228
	HEAT TREAT	HEAT TREAT OF HOUSINGS, COVER, AND END PLATES IS VERIFIED TO MEET DRAWING REQUIREMENTS.		28003183
			28003062	
			28003080	
			34000658	
			41003913	
			41003739	
			41004165	
			34000149	
		ANODIZE IS VERIFIED PER DRAWING REQUIREMENTS.	34000695	
			41003913	
			41003739	
			41004165	
			34000149	
		SERVOVALVE AND SERVOSWITCH HOUSING AND END PLATES PASSIVATION IS INSPECTED PER DRAWING REQUIREMENTS.	28003080	
			28003062	
			28003183	
		SHOT PEENING OF HOUSING AND PNEUMATIC CAP EXTERIOR IS VERIFIED PER DRAWING REQUIREMENTS.	34000658	
			41004165	
		THE HOUSING AND THE SHUTTLE VALVE END CAP ARE PENETRANT INSPECTED AFTER MACHINING.	34000149	
			34000695	
		THE SERVOVALVE/SERVOSWITCH HOUSING IS MAGNETIC PARTICLE AND X-RAY INSPECTED PER	28003080	

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	PROOF TEST	PROOF PRESSURE TESTING VERIFIES INTEGRITY OF HOUSING, COVER, AND END CAPS.	RC1008
	FUNCTIONAL INTEGRITY	HOTFIRE TESTING AND SECOND E & M INSPECTIONS VERIFY SATISFACTORY OPERATION.	RL00050-04 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: Not Applicable.