

**SSM/ EA/CIL
REDUNDANCY SCREEN**

Component Group: Actuators
 CIL Item: E150-14
 Part Number: RES1008-7XXX
 Component: Chamber Coolant Valve Actuator
 FMEA Item: E150
 Failure Mode: Sequence valve leaks passing early control pressurant to downstream components.

Prepared: S. Heater
 Approved: T. Nguyen
 Approval Date: 6/9/00
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Phase	Failure / Effect Description	Criticality Hazard Reference
C 4.1	Control pressurant closes purge sequence PAV early terminating preburner shutdown purges, HPOTP intermediate seal purge, and pogo shutdown charge. Loss of pogo shutdown charge during MECO, at zero G condition and minimum NPSP, will result in cavitation/overspeed of HPOTP and/or LPOTP. Loss of vehicle. Redundancy Screens: PNEUMATIC SYSTEM - ACTUATOR SYSTEM: UNLIKE REDUNDANCY A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Fail - Loss of a redundant hardware items is not detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.	1R ME-A1A,C

SSME FMEA/CIL
DESIGN

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Design / Document Reference

FAILURE CAUSE: A: Damaged sequence valve.

THE SEQUENCE VALVE PISTON (1) IS MADE FROM CUSTOM 455. THE MATERIAL IS HEAT TREATED AND AGED TO THE H1000 CONDITION. CUSTOM 455 WAS SELECTED FOR ITS STRENGTH AND WEAR RESISTANCE (2). THE SLEEVE (3) MATERIAL IS ANODIZED 2024-T6 WHICH WAS SELECTED FOR ITS STRENGTH (2). THE SEQUENCE VALVE ROLLER IS HEAT TREATED CUSTOM 455 (4). THE MATERIAL WAS CHOSEN FOR ITS BEARING STRENGTH (2). THE PIN IS A-286 WHICH IS CHROME PLATED (5) FOR ADDITIONAL SURFACE HARDNESS (2). A-286 WAS CHOSEN FOR ITS SHEAR STRENGTH (2). BOTH MATERIALS ARE CORROSION AND STRESS CORROSION RESISTANT. THE PARTS ARE CLEANED PRIOR TO ASSEMBLY; THE ACTUATORS ARE ASSEMBLED IN A CONTAMINATION CONTROLLED AREA. THE HYDRAULIC FLUID IS FILTERED THROUGH A SYSTEM 25-MICRON FILTER AND THE HELIUM IS FILTERED THROUGH A 15-MICRON FILTER TO PREVENT DAMAGE CAUSED BY CONTAMINATION. THE ROLLER ON THE PISTON LIMITS THE SIDE LOADS, AND THE L/D OVER 2 ON THE PISTON PREVENTS DAMAGE CAUSED BY COCKING.

(1) 34000318; (2) RSS-8582; (3) 34000319; (4) 34000395; (5) 34000317

FAILURE CAUSE: B: Damaged sequence valve seals.

THE SEQUENCE VALVE SLEEVE (1) TO HOUSING (2) AND SLEEVE TO PISTON (3) SEALS ARE BUNA-N O-RINGS (4). THE MATERIAL WAS SELECTED FOR ITS ELASTIC CHARACTERISTICS AND RESISTANCE TO PERMANENT SET (5). THE O-RINGS ARE LUBRICATED WHEN INSTALLED ON THE SLEEVE. PNEUMATIC SEALS ARE LUBRICATED WITH DOW CORNING FS 1281 AND HYDRAULIC SEALS ARE LUBRICATED WITH HYDRAULIC OIL (4). THE DIMENSIONS AND SURFACE FINISHES FOR THE SLEEVE O.D. SEAL ARE APPLICABLE TO STATIC SEALS. THE SLEEVE I.D. AND PISTON DIMENSIONS AND SURFACE FINISHES ARE FOR A DYNAMIC SEAL. THE INTERSECTION OF THE HOLES THROUGH THE PISTON WALL WITH THE PISTON O.D. IS RADIUS TO PREVENT O-RING NIBBLING. THE SLEEVE MATERIAL IS 2024-T6 ALUMINUM ALLOY WHICH IS ANODIZED FOR CORROSION PROTECTION (5). THE PISTON L/D OF 2.5, MINIMIZES THE SIDE LOADS AND WEAR. THE CORNER CHAMFER ON THE PISTON, THE SURFACE FINISH OF THE PARTS AND THE LUBRICATION ALSO MINIMIZE THE WEAR WHICH COULD DAMAGE THE DYNAMIC SEAL. THE ACTUATOR PARTS ARE CLEANED PRIOR TO ASSEMBLY AND THE ACTUATOR IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA WHICH MINIMIZES THE POTENTIAL OF SEAL DAMAGE CAUSED BY CONTAMINATION (6).

(1) 34000319; (2) 34000694; (3) 34000318; (4) 41003740; (5) RSS-8582; (6) RC1008

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 WAS 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 (WHICH IS ESSENTIALLY THE SAME AS THE CCVA) WAS DISASSEMBLED AND EXAMINED. THE ACTUATOR SHOWED NO DETRIMENTAL WEAR OR DEFECTS AFTER 28 STARTS AND 10,332 SECONDS HOT FIRE TIME, INCLUDING 6,651 SECONDS AT FPL (6).

(1) RL00532, CP320R0003B; (2) RSS-8546, CP320R0003B; (3) NASA TASK 117; (4) DVS-SSME-512; (5) RSS-512; (6) SSME-82-2316

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**SSME FI /CIL
INSPECTION AND TEST**

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	HOUSING ASSY.		34000694
	PIN		34000317
	PISTON		34000318
	SLEEVE		34000319
	ROLLER		34000395
	MATERIAL INTEGRITY	MATERIAL INTEGRITY AND HEAT TREAT ARE VERIFIED PER DRAWING REQUIREMENTS.	34000694
			34000317
			34000318
			34000319
			34000395
		HOUSING AND SLEEVE ARE PENETRANT INSPECTED PER DRAWING REQUIREMENTS.	34000694
			34000319
		HOUSING AND SLEEVE ANODIZE IS INSPECTED TO DRAWING REQUIREMENTS.	34000694
			34000319
		THE PISTON IS MAGNETIC PARTICLE INSPECTED PER DRAWING REQUIREMENTS.	34000318
		THE PIN CHROME PLATE IS VERIFIED.	34000317
COMPONENT CLEANLINESS	COMPONENTS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY.	RC1008	
		RL10012	
	COMPONENT ASSEMBLY IS VERIFIED TO BE IN A CONTAMINATION CONTROLLED AREA.	RC1008	
		RL10012	
FUNCTIONAL INTEGRITY	SEQUENCE VALVE AND ACTUATOR FUNCTIONAL TESTS, INCLUDING PNEUMATIC SHUTDOWN SLEW RATE TESTS, VERIFY SEQUENCE VALVE OPERATION.	RC1008	
B	HOUSING ASSY.		34000694
	PISTON		34000318
	SLEEVE		34000319
	CCVA		41003740
	SURFACE FINISH	SURFACE FINISH IS VERIFIED PER DRAWING REQUIREMENTS.	34000319
			34000316
	ASSEMBLY	SEAL INSTALLATION AND LUBRICATION IS VERIFIED PER DRAWING REQUIREMENTS.	41003740
	CLEANLINESS IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RC1008	
FUNCTIONAL INTEGRITY	ASSEMBLY AND FUNCTIONAL TESTS, INCLUDING PNEUMATIC SHUTDOWN SLEW RATE, ARE VERIFIED PER ROCKETDYNE END ITEM CONTRACT SPECIFICATIONS.	RC1008	
	CCVA FUNCTIONAL TEST IS VERIFIED PERFORMED AND ACCEPTABLE.	RC1008	
ALL CAUSES	COMPONENT CLEANLINESS	ALL ACTUATOR DETAILS ARE VERIFIED TO BE CLEAN PRIOR TO INSTALLATION.	RC1008, RL10012

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ALL CAUSES	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 THE ACTUATOR CHECKOUT MODULE PRIOR TO EACH FLIGHT.	OMRSD V41AS0.010
		ACTUATOR OPERATION IS VERIFIED DURING FLIGHT READINESS CHECKOUT PRIOR TO EACH FLIGHT. (LAST TEST)	OMRSD V41AS0.030

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.

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SSMF IEA/CIL
FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE

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Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. E150-07 SHUTTLE AND BYPASS VALVE OPERATIONS ARE VERIFIED PER SPECIFICATION REQUIREMENTS (RC1008).	SOME ACTUATORS ARE USING THE NON-ANTI-ROTATION SHUTTLE AND BYPASS VALVE DESIGN.	THE NON-ANTI-ROTATION SHUTTLE AND BYPASS VALVE DESIGN IS MORE SUSCEPTIBLE TO GALLING. THE NEW DESIGN ADDED THE ANTI-ROTATION FEATURE, PRESSURE BALANCE AND USES CRES 440C MICRO-MELT (VERSUS 440C) TO MANUFACTURE THE SPOOLS AND SLEEVES. THIS DESIGN MINIMIZES THE POSSIBILITY OF SHUTTLE OR BYPASS VALVE GALLING. USE AS IS RATIONALE: 1. RISK ASSESSMENT OF THE NON-ANTI-ROTATION SHUTTLE AND BYPASS VALVE INDICATE THAT THE LIKELIHOOD OF A CRITICALITY 1 FAILURE DUE TO A GALLED BYPASS VALVE (WORST CASE) IS EXTREMELY LOW AND THEREFORE THERE ARE NO CURRENT AND FUTURE USAGE LIMITATIONS.	P/N 34000137 -102