

SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Actuators
CIL Item: E150-12
Part Number: RES1008-7XXX
Component: Chamber Coolant Valve Actuator
FMEA Item: E150
Failure Mode: Pneumatic shutdown piston or sequence valve leakage.

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
PCD 4.1	Contamination of hydraulic return fluid with helium gas. Loss of vehicle due to loss of hydraulic control of orbiter control surfaces during re-entry. Redundancy Screens: SINGLE POINT FAILURE: N/A	1 ME-G1P,S,M,C,D

**SSME EA/CIL
DESIGN**

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FAILURE CAUSE: A: Damaged pneumatic piston seals.

THE PNEUMATIC SHUTDOWN ASSEMBLY INCORPORATES DUAL PISTON SEALS WITH A VENT BETWEEN THEM TO PREVENT LEAKAGES PAST THE FIRST SEAL FROM CONTINUING PAST THE SECOND SEAL. THE PISTON SEAL DESIGN INCORPORATES A BUNA-N O-RING (1) WITH A TEFLON RING (2) BETWEEN THE O-RING AND THE PISTON. THE BUNA-N O-RING PROVIDES PRESSURE ACTUATION OF THE SEAL, AND THE TEFLON RING PROVIDES LOW FRICTION WEAR RESISTANT CONTACT WITH THE PISTON (3). THE PNEUMATIC PISTON O.D. (4) IS HARD ANODIZED, AND THE SURFACE FINISHES ARE MACHINED FOR DYNAMIC SEALS TO PREVENT WEAR WHICH MAY DAMAGE THE SEALS. THE HARD ANODIZE ALSO PREVENTS CORROSION AND PRECLUDES DAMAGE CAUSED BY CORROSION PRODUCTS ON THE DYNAMIC SEALING SURFACES. THE PISTON L/D GREATER THAN 3 MINIMIZES THE POTENTIAL OF DAMAGE TO THE SEAL CAUSED BY PISTON COCKING. ALL ACTUATOR PARTS ARE CLEANED PRIOR TO ASSEMBLY AND THE ACTUATOR IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA (5). THE CLEANLINESS OF THE PNEUMATIC AND HYDRAULIC FLUIDS ARE CONTROLLED (5).

(1) MS28775; (2) S13077; (3) RSS-8582; (4) 41003769; (5) RC1008

FAILURE CAUSE: B: Damaged pneumatic piston.

THE PNEUMATIC PISTON IS MADE FROM 2024-T6 ALUMINUM ALLOY (1). THE MATERIAL WAS SELECTED FOR ITS STRENGTH AND THERMAL COMPATIBILITY WITH THE PNEUMATIC CYLINDER AND ACTUATOR HOUSING. THE MATERIAL IS STRESS CORROSION RESISTANT AND IS ANODIZED FOR GENERAL CORROSION RESISTANCE (2). THE PISTON OUTSIDE DIAMETER IS HARD ANODIZED FOR PROTECTION AGAINST WEAR AND DAMAGE. THE L/D OF GREATER THAN 3 FOR THE PISTON PREVENTS DAMAGE CAUSED BY COCKING. ALL ACTUATOR PARTS ARE CLEANED PRIOR TO ASSEMBLY AND THE ACTUATOR IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA (3). THE CLEANLINESS OF THE PNEUMATIC AND HYDRAULIC FLUIDS ARE CONTROLLED (3).

(1) 41003769; (2) RSS-8582; (3) RC1008

FAILURE CAUSE: C: 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: D: Damaged sequence valve seals.

THE SEQUENCE VALVE HYDRAULICS AND PNEUMATICS ARE SEPARATED AT THE PISTON AND SLEEVE INTERFACE BY TWO GREENE TWEED SEALS (1). A DRAIN CAVITY BETWEEN THE TWO SEALS VENTS LEAKAGE FROM EITHER THE PNEUMATIC OR THE HYDRAULIC SEAL. THIS PREVENTS LEAKAGE PAST THE FIRST SEAL FROM PRESSURIZING THE SECOND SEAL. THE GREENE TWEED SEALS ARE USED FOR THEIR ABILITY TO SEAL AT LOW PRESSURES, YET NOT SEVERELY DEFORM AT HIGH PRESSURES (2). THE SEQUENCE VALVE SLEEVE TO HOUSING SEALS (3) ARE BUNA-N. THE SEALS ARE SEPARATED BY A DRAIN CAVITY TO PREVENT LEAKAGE PAST THE SECOND SEAL. BUNA-N IS USED FOR ITS ELASTIC CHARACTERISTICS, RESISTANCE TO PERMANENT SET, AND COMPATIBILITY WITH THE HYDRAULIC FLUID AT THE DESIGN OPERATING TEMPERATURE (2). THE SEQUENCE VALVE PISTON (4) IS MADE FROM CUSTOM 455 CRES. THE MATERIAL IS HEAT TREATED AND AGED. CUSTOM 455 CRES IS USED FOR ITS STRENGTH, HARDNESS, AND STIFFNESS (2). THE PISTON SLEEVE (3) MATERIAL IS 2024-T6 ALUMINUM. 2024-T6 ALUMINUM IS USED FOR ITS STRENGTH AND SIMILARITY OF THERMAL PROPERTIES TO THE 7175 ALUMINUM HOUSING (2). THE SLEEVE IS ANODIZED FOR GENERAL CORROSION RESISTANCE (2). DIFFERENTIAL HARDNESS, 2.5 L/D, AND SMALL CLEARANCES BETWEEN THE PISTON AND SLEEVE AND CORNER CHAMFER MINIMIZE THE POTENTIAL OF WEAR AND GALLING THAT COULD DAMAGE THE SEALS. THE ACTUATOR PARTS ARE CLEANED PRIOR TO ASSEMBLY. THE ACTUATOR IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA. THE HYDRAULIC FLUID AND HELIUM ARE FILTERED PRIOR TO ENTERING THE ACTUATOR (5). THE CLEANLINESS PROCEDURES MINIMIZE THE POTENTIAL OF SEAL DAMAGE CAUSED BY CONTAMINATION (6).

(1) 7113FR-160-T; (2) RSS-8582; (3) MS28775; (4) 34000316; (5) 34000319; (6) RC1008

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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 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

**SSME FI CIL
INSPECTION AND TEST**

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	PISTON PNEUMATIC CYLINDER		41003769
			34000344
	SEALING SURFACE INTEGRITY	THE PNEUMATIC PISTON AND CYLINDER ASSEMBLY HARD ANODIZE IS VERIFIED PER DRAWING REQUIREMENTS.	41003769
			34000344
		THE PISTON SURFACES ARE PENETRANT INSPECTED PER DRAWING REQUIREMENTS.	41003769
		THE SURFACE FINISH OF PNEUMATIC PISTON IS INSPECTED.	41003769
	O-RING/CAP SEAL ASSEMBLY	THE O-RING/CAP SEAL SURFACE FINISH IS INSPECTED DURING ASSEMBLY.	RC1008
	PISTON AND CAP ASSEMBLY CLEANLINESS IS VERIFIED PER DRAWING REQUIREMENTS.	RC1008 RL10012	
	COMPONENT ASSEMBLY IS VERIFIED TO BE IN A CONTAMINATION CONTROLLED AREA.	RC1008 RL10012	
	FUNCTIONAL TESTING VERIFIES PNEUMATIC PISTON SEAL INTEGRITY.	RC1008	
B	PISTON MATERIAL INTEGRITY		41003769
			41003769
		PISTON IS PENETRANT INSPECTED PER DRAWING REQUIREMENTS.	41003769
		ANODIZE AND HARD ANODIZE OF PISTON IS VERIFIED PER DRAWING REQUIREMENTS.	41003769
		THE SURFACE FINISH OF PNEUMATIC PISTON IS INSPECTED.	41003769
		PISTON AND CAP CLEANLINESS IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RC1008 RL10012
	COMPONENT ASSEMBLY IS VERIFIED TO BE IN A CONTAMINATION CONTROLLED AREA.	RC1008 RL10012	
	FUNCTIONAL TESTING VERIFIES PNEUMATIC PISTON OPERATION.	RC1008	
C, D	PISTON SLEEVE HOUSING, MACHINED HOUSING ASSY. MATERIAL INTEGRITY		34000316
			34000319
		34000657	
		34000694	
		34000316	
		34000319	
		34000657	
		34000316	
		34000657	

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference	
C, D	MATERIAL INTEGRITY	THE HOUSING AND SLEEVE ARE PENETRANT INSPECTED AFTER MACHINING.	34000319 34000694	
		SLEEVE ANODIZE IS VERIFIED PER DRAWING REQUIREMENTS.	34000319	
		THE HOUSING, PISTON, AND SLEEVE SURFACE FINISHES ARE VERIFIED PER DRAWING REQUIREMENTS.	34000316 34000319 34000694	
	COMPONENT CLEANLINESS	THE PISTON IS MAGNETIC PARTICLE INSPECTED PER DRAWING REQUIREMENTS.	34000316	
		COMPONENTS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY.	RC1008 RL10012	
	FUNCTIONAL INTEGRITY	CONTAMINATION CONTROL OF THE COMPONENT ASSEMBLY IS VERIFIED.	RC1008 RL10012	
		SEQUENCE VALVE ALIGNMENT IN THE HOUSING IS VERIFIED.	41003720	
		SEQUENCE VALVE AND ACTUATOR FUNCTIONAL TESTS, INCLUDING PNEUMATIC SHUTDOWN SLEW RATE, VERIFY SEQUENCE 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.	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	
PNEUMATIC SEALS ARE LEAK-CHECKED EVERY FLIGHT.			OMRSD V41BQ0.170	
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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