

SSME FA/CIL
REDUNDANCY SCREEN

Component Group: Pneumatic Controls
 CIL Item: G200-08
 Component: Pneumatic Control Assembly
 Part Number: R0019450
 Failure Mode: Insufficient or no helium purge flow.

Prepared: P. Lowrimore
 Approved: T. Nguyen
 Approval Date: 6/2/99
 Change #: 1
 Directive #: CCB0 MEJ-01-5213
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Phase	Failure / Effect Description	Criticality Hazard Reference
P 4.1	<p>Pneumatic control package fails to provide helium pressurant flow to HPOTP intermediate seal purge. Insufficient purge fails to maintain inerting purge barrier. Controller monitors HPOTP intermediate seal purge pressure sensor and detects out-of-limit condition. Engine ready is inhibited. Launch delay. Loss of vehicle due to HPOTP fire may result if failure to provide HPOTP IMSL purge is not detected.</p> <p>Redundancy Screens PNEUMATIC 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: Fail - Loss of redundant hardware items could result from a single credible event.</p>	<p>1R ME-C1S</p>
SMC 4.1	<p>Controller monitors intermediate seal purge pressure. Controller detects out-of-limit condition caused by loss or reduction of purge initiates engine shutdown. Loss of intermediate seal pressure barrier allows LOX and hot gases to mix and turbopump failure. Loss of vehicle.</p> <p>Redundancy Screens: SINGLE POINT FAILURE: N/A</p>	<p>1 ME-C1S, ME-C1M, ME-C1C, ME-C1A</p>

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SSME FMEA/CIL
DESIGN

Component Group: Pneumatic Controls
CIL Item: C200-08
Component: Pneumatic Control Assembly
Part Number: R0019450
Failure Mode: Insufficient or no helium purge flow.

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Design / Document Reference

FAILURE CAUSE: A: PCA component failure: PCA inlet helium filter blocked.
B: PCA component failure: HPOTP Intermediate seal purge control orifice blocked.
C: HPOTP Intermediate seal purge solenoid valve failure: Inlet filter blocked.
D: HPOTP Intermediate seal purge solenoid valve failure: Vent port poppet/seat leakage due to: Contamination.
E: HPOTP Intermediate seal purge solenoid valve failure: Vent port poppet/seat leakage due to: Armature or pushrod jammed.
F: HPOTP Intermediate seal purge pressure actuated valve: Piston jammed closed.
G: HPOTP Intermediate seal purge pressure actuated valve: Spacer/seal assembly jammed closed.
H: HPOTP Intermediate seal purge pressure actuated valve: Control cavity seal leakage due to: Contamination.
I: HPOTP Intermediate seal purge pressure actuated valve: Vent port poppet/seat leakage due to: Contamination.

DETAIL PARTS AND TEST FIXTURES ARE CLEANED (1) PRIOR TO ASSEMBLY (2). ASSEMBLY AND TEST ARE PERFORMED IN A CLEAN ROOM (3) LUBRICANTS ARE NOT ALLOWED FOR ASSEMBLY OR TEST (2) COMPONENT LEVEL TEST FLUIDS ARE NITROGEN AND HELIUM WHICH MEET THE HARDWARE CLEANLINESS REQUIREMENTS (1). THE COMPONENT PARTS AND SUBASSEMBLY ARE FREE OF VISIBLE FOREIGN PARTICLES AT THE TIME OF ASSEMBLY (2). AT THE ENGINE LEVEL, A 15-MICRON FILTER IN THE PNEUMATIC CONTROL ASSEMBLY (4) AND 15-MICRON FILTERS AT THE INLET AND OUTLET OF THE SOLENOID VALVE (5) ENSURE THAT CONTAMINANTS LARGER THAN 15-MICRONS WILL BE REMOVED. THE PRESSURE ACTUATED VALVE (6) AND SOLENOID VALVE (5) INCORPORATE TEFLON GUIDES WHICH PREVENT METAL-TO-METAL RUBBING AND METAL PARTICLE GENERATION. THESE DESIGN FEATURES PREVENT GENERATION OF METALLIC PARTICLES IN THE IMMEDIATE AREA WHICH COULD JAM THE SOLENOID ASSEMBLY ARMATURE, PUSHROD, OR STEM ASSEMBLY, AND THE PAV PISTON OR SHAFT. THE PISTON-POPPET L/D RATIO PREVENTS THE POSSIBILITY OF COCKING. THE PAV PISTON ASSEMBLY AND SHAFT ARE HELD IN ALIGNMENT AT EACH END (6). IN THE EVENT THAT METALLIC PARTICLES FROM ANOTHER SOURCE GET INTO THESE AREAS, THE PARTICLES BECOME IMBEDDED IN THE TEFLON SLEEVE. THIS PREVENTS GALLING BETWEEN THE BODY AND POPPET AND PREVENTS JAMMING.

(1) RL10001; (2) RL00225, RL00346; (3) RQ0711-600; (4) R0019450; (5) RS010341; (6) R0011040

FAILURE CAUSE: E: HPOTP Intermediate seal purge solenoid valve failure: Vent port poppet/seat leakage due to: Damaged/defective sealing surface.
J: HPOTP Intermediate seal purge pressure actuated valve: Control cavity seal leakage due to: Damaged/defective seal.
L: HPOTP Intermediate seal purge pressure actuated valve: Vent port poppet/seat leakage due to: Damaged/defective sealing surface.

TUNGSTEN CARBIDE IS USED TO MANUFACTURE THE PURGE SOLENOID VALVE POPPET (1). TUNGSTEN CARBIDE WAS SELECTED FOR ITS RESISTANCE TO WEAR AND ITS VIRTUALLY POROSITY-FREE STRUCTURE. THE MATERIAL IS CORROSION RESISTANT AND, WHERE USED, IS NOT SUBJECT TO STRESS CORROSION CRACKING (2). THE SEAL (3) IS MANUFACTURED FROM 440C CRES BAR. HARDNESS AND WEAR RESISTANCE ARE THE PRIMARY REASONS FOR USING 440C CRES. THE MATERIAL ALSO EXHIBITS SUFFICIENT CORROSION RESISTANCE TO BE SUITABLE FOR THE APPLICATION (2). THE PAV PISTON AND SPACER SEALS ARE PRESSURE ASSISTED (4). THE SEAL MATERIAL IS TEFLON (5). THE TEFLON REDUCES GALLING AND PROVIDES A LOW COEFFICIENT OF FRICTION. THE SURFACE FINISH OF THE VALVE BODY BORE REDUCES SEAL WEAR AND PROVIDES A SMOOTH SURFACE FOR MOVING PARTS (6). THE PAV POPPET (7) IS MADE FROM 321 CRES. STRENGTH AND DUCTILITY ARE THE PRIMARY REASONS FOR SELECTING 321 CRES. THIS MATERIAL IS CORROSION RESISTANT AND EXHIBITS A RESISTANCE TO STRESS CORROSION CRACKING (8). THE PAV SEAL (5) IS MADE FROM 7075-T651 ALUMINUM ALLOY. LIGHT-WEIGHT, STRENGTH AND A RESISTANCE TO STRESS CORROSION CRACKING (2) ARE THE REASONS FOR USING THIS MATERIAL. THE POPPET SEAL IS MADE FROM KEL-F (9). LOW COLD-FLOW CHARACTERISTICS AND GOOD DUCTILITY ARE THE PRIMARY REASONS FOR USING KEL-F (2). BECAUSE OF THE KEL-F DUCTILITY, SMALL CONTAMINANT PARTICLES IMBED IN THE KEL-F AND DO NOT CAUSE LEAKAGE. LARGE PARTICLES PARTIALLY IMBED IN THE KEL-F WHICH MINIMIZES SEAL LEAKAGE.

(1) RS008103; (2) NSFC-SPEC-522, RSS-8582-6 (3) RS008080 (4) R0011040; (5) RES1365, RES1365; (6) R0011024; (7) RS008027; (8) RS008030; (9) RS008028

Component Group: Pneumatic Controls
CIL Item: C200-08
Component: Pneumatic Control Assembly
Part Number: R0019460
Failure Mode: Insufficient or no helium purge flow.

Prepared: P. Lowrie
Approved: T. Nguyen
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Design / Document Reference

FAILURE CAUSE: ALL CAUSES

THE PNEUMATIC CONTROL ASSEMBLY HAS SUCCESSFULLY PASSED DESIGN VERIFICATION TESTING (1), WHICH INCLUDED PRESSURE TESTING (2), PRESSURE CYCLING (3) AND VIBRATION TESTING (4). HIGH CYCLE AND LOW CYCLE FATIGUE LIFE, AS WELL AS THE MINIMUM FACTORS OF SAFETY FOR THE PCA, MEET CEI REQUIREMENTS (5). THE PCA WAS CLEARED FOR FRACTURE MECHANICS/INDE FLAW GROWTH, SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (6). THE DESIGN HAS BEEN FURTHER VERIFIED BY VALVES BEING REMOVED FROM ENGINE 0107 AND DISASSEMBLED. THE VALVES SHOWED NO DEGRADATION OR WEAR OF DETAIL PARTS (7). THESE VALVES HAD ACCUMULATED OVER 3,000 SECONDS AND 13 STARTS. THE HPOTP INTERMEDIATE SEAL PURGE PRESSURE REDLINE WILL LIMIT NON-"WORST CASE" FAILURES TO ENGINE SHUTDOWN. THE CONTROLLER MONITOR SYSTEM IS COMPOSED OF REDUNDANT SENSOR ELECTRONICS, REDUNDANT HARNESSSES, AND REDUNDANT CONTROLLER CHANNELS (8).

(1) DVS-SSME-510; (2) RSS-510-46; (3) RSS-510-51; (4) RSS-510-50; (5) RL00532, CP320R0003B, RSS-8546; (6) NASA TASK 117; (7) SSME-83-0230; (8) CP406R0002 PT 1 3.2.3;5.4

SSME FMEA/CIL
INSPECTION AND TEST

Component Group: Pneumatic Controls
 CIL Item: C200-08
 Component: Pneumatic Control Assembly
 Part Number: R0019450
 Failure Mode: Insufficient or no helium purge flow.

Prepared: P. Lowimore
 Approved: T. Nguyen
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B, C, D, F, G, H, I, K	PNEUMATIC CONTROL SOLENOID FILTER PRESSURE ACTUATED VALVE		RS010341 RS1107 R0011040

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CLEANLINESS OF COMPONENTS

THE PNEUMATIC CONTROL ASSEMBLY, THE PRESSURE ACTUATED VALVES, AND THE SOLENOID VALVES ARE CLEANED TO OXYGEN/FUEL SERVICE PER SPECIFICATION AND DRAWING REQUIREMENTS

RL10001
R0019450
R0011040
RS010341

DURING MANUFACTURE AND ACCEPTANCE TEST OF THE SOLENOID VALVE THE FILTER INSTALLATION, VALVE CLEANING, AND CLEAN FLUSH PARTICLE COUNT IS INSPECTED PER SPECIFICATION.

RL00226

Component: Pneumatic Controls
 CIL Item: C203-08
 Component: Pneumatic Control Assembly
 Part Number: R0019450
 Failure Mode: Insufficient or no helium purge flow.

Prepared: P. Lowrin
 Approved: T. Nguyen
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B, C, D, F, G, H, I, K	CLEANLINESS OF COMPONENTS	DURING MANUFACTURE AND ACCEPTANCE TEST OF THE SOLENOID VALVE THE FILTER INSTALLATION, VALVE CLEANING, AND CLEAN FLUSH PARTICLE COUNT IS INSPECTED PER SPECIFICATION	RLC0226
		DURING ASSEMBLY OF THE PRESSURE ACTUATED VALVE THE ACTUATION AND DEACTUATION OPERATION IS VERIFIED. OPERATION OF THE VALVE VERIFIES NO CONTAMINATION BLOCKAGE IN MOVING PARTS.	RL00346
	FILTER INTEGRITY	FILTERS ARE INSPECTED TO MEET FLOW AND FILTRATION REQUIREMENTS PER SPECIFICATION.	RC1093 RC1107
E, J, L	PISTON SEAL VALVE BODY SPACER SEAL VALVE BODY POPPET POPPET CAP		RES1365 R0011024 RES1360 RS010359 RS008105 R0011031 R0011026

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Component Group: Pneumatic Controls
 QIL Part: Q200-08
 Component: Pneumatic Control Assembly
 Part Number: R0019450
 Failure Mode: Insufficient or no helium purge flow.

Prepared: P. Low/more
 Approved: T. Nguyen
 Approval Date: 8/2/98
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
E, J, L	PISTON SEAL		RES1365
	VALVE BODY		RC011024
	SPACER SEAL		RES1366
	VALVE BODY		RS010359
	POPPET		RS008106
	POPPET		R0011031
	CAP SEAL		R0011026 RS008028
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	
	SEALING SURFACES	THE SURFACE FINISH OF THE SEALS ARE INSPECTED PER DRAWING REQUIREMENTS.	RES1365 RES1366 RS008028
		THE SEALING SURFACE FINISHES ARE INSPECTED PER DRAWING REQUIREMENTS	R0011024 RS010359 R0011026
		THE PISTON AND SPACER SEAL LEAKAGE IS VERIFIED TO BE WITHIN SPECIFICATION REQUIREMENTS.	RL00346 RS00225
		DURING ASSEMBLY AND ACCEPTANCE TEST, THE VALVE ACTUATION AND DEACTUATION OPERATION AND SEALING ARE VERIFIED.	RL00346 RL00226
ALL CAUSES	PNEUMATIC CONTROL ASSEMBLY ASSEMBLY TESTING	THE FOLLOWING TESTS ARE PERFORMED DURING ASSEMBLY AND FUNCTIONAL TESTING OF THE PNEUMATIC CONTROL ASSEMBLY:	R0019450

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Component up: Pneumatic Controls
 CIL Item: C200-08
 Component: Pneumatic Control Assembly
 Part Number: R0019450
 Failure Mode: Insufficient or no helium purge flow.

Prepared: P. Lowrie
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 Approval Date: 6/2/99
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	ASSEMBLY TESTING	- SEAT LEAKAGE IS VERIFIED TO BE WITHIN SPECIFICATION FOR BOTH ENERGIZED AND DE-ENERGIZED OPERATION - ASSEMBLY OPERATION IS VERIFIED BY TESTING EACH FUNCTION OF THE PNEUMATIC CONTROL ASSEMBLY. - ASSEMBLY FUNCTION IS VERIFIED BY INSPECTION OF THE RATE AND PRESSURE DURING FLOW CHECK.	RL00344 RL00344 RL00344
	HOT-FIRE ACCEPTANCE TESTING (GREEN RUN)	PNEUMATIC CONTROL ASSEMBLY OPERATION IS VERIFIED THROUGH HOT-FIRE ACCEPTANCE TESTING.	RI00461
	PRE-FLIGHT CHECKOUT	HPOTP INTERMEDIATE SEAL PURGE OPERATION IS VERIFIED DURING SSME ELECTRICAL CHECKOUT PRIOR TO FLIGHT OR AFTER ANY REPLACEMENT OF RELATED COMPONENTS BY PERFORMING THE FOLLOWING OMRSD REQUIREMENTS: - FLIGHT READINESS TEST INCLUDING PNEUMATIC SHUTDOWN. - FLIGHT READINESS TESTS AND VALVE CYCLE VERIFICATION. - PRE-CRYO LOADING. - PURGE SEQUENCE NUMBER 4 (LAST TEST)	OMRSD V41AS0 030 OMRSD S00FAC.211 OMRSD S00FAC.213 OMRSD S00FM0.250

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Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
 Reference: NASA letter SA21/98/306 and Rocketdyne letter 86RC09761.
 Operational Use: Not Applicable.