

**SSME FA/CIL  
REDUNDANCY SCREEN**

Component Group: Pneumatic Controls  
 CIL Item: C300-01  
 Component: Helium Precharge Valve  
 Part Number: RS010180  
 Failure Mode: Insufficient or no helium pressurant flow to Pogo accumulator.

Prepared: P. Lowmore  
 Approved: T. Nguyen  
 Approval Date: 8/2/99  
 Change #: 1  
 Directive #: CCBD ME3-01-5213  
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Phase	Failure / Effect Description	Criticality Hazard Reference
C 4.1	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: SINGLE POINT FAILURE: N/A  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. Fail - Loss of redundant hardware items could result from a single credible event.	1 ME-C1C, ME-C2C
C 4.2	Controller monitors Pogo precharge pressure and detects failure. Controller de-energizes EMSD solenoid enabling purge through the purge sequence PAV. Loss of vehicle due to oxidizer pump overspeed and failure may result if failure to provide pogo post-charge helium flow is not detected.  Redundancy Screens: SINGLE POINT FAILURE: N/A  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. Fail - Loss of redundant hardware items could result from a single credible event.	1R ME-C1C

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SSME FMEA/CIL  
DESIGN

Component Group: Pneumatic Controls  
CIL Item: C300-Df  
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**FAILURE CAUSE:** A: Solenoid valve failure: Armature or pushrod jammed closed.  
B: Solenoid valve failure: Blockage of internal filter or passages.  
D: Helium precharge valve failure: Internal passage blocked.  
E: Helium precharge valve failure: Piston/poppet jammed closed.  
F: Helium precharge valve failure: Inlet filter blocked.  
G: Piston seal leakage due to: Contamination.  
I: Piston seal leakage due to: HPV check valve fails to open.

DETAIL PARTS AND TEST FIXTURES ARE CLEANED PRIOR TO ASSEMBLY (1). ASSEMBLY AND TEST ARE PERFORMED IN A CLEAN ROOM (2). LUBRICANTS ARE NOT ALLOWED FOR ASSEMBLY OR TEST (3). 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 (3). AT THE ENGINE LEVEL, A 15-MICRON FILTER IN THE PNEUMATIC CONTROL ASSEMBLY (4), A 15-MICRON FILTER AT THE INLET AND OUTLET OF THE SOLENOID VALVE (5), AND A 15-MICRON FILTER AT THE INLET OF THE HELIUM PRECHARGE VALVE (6), ENSURE THAT CONTAMINANTS LARGER THAN 15 MICRONS WILL BE REMOVED. THE SOLENOID VALVE (5) INCORPORATES TEFLON ARMATURE AND PUSHROD GUIDES WHICH PREVENT METAL-TO-METAL RUBBING AND METAL PARTICLE GENERATION. THE CHECK VALVE POPPET (7) IS GUIDED BY THREE DOWEL PINS (8). THE SURFACE FINISH ON THE PINS AND THE SPHERICAL OD OF THE POPPET MINIMIZES THE FRICTION AND GALLING POTENTIAL. THE POPPET (440C) AND DOWEL PIN (410 OR 416 CRES) MATERIALS WERE SELECTED TO PROVIDE DIFFERENTIAL HARDNESS TO MINIMIZE THE POTENTIAL OF GALLING (9). THE THREE POINT GUIDE SYSTEM PREVENTS TRAPPING CONTAMINATION BETWEEN THE POPPET AND GUIDES AND INITIATING GALLING. A LOW LOAD RETURN SPRING (10) AND A SHORT STROKE ARE USED TO ENSURE THAT THE POPPET IS ACTUATED FULL OPEN AGAINST A STOP. THIS PREVENTS FLUTTER AND POPPET/GUIDE WEAR AND GALLING.

(1) RL10001; (2) RC0711-600; (3) RL00226, RL00458; (4) R0019450; (5) RS010341; (6) RS010180; (7) RS010192; (8) MS16555-619; (9) RSS-8582-6; (10) RS010193

**FAILURE CAUSE:** C: Solenoid valve failure: Dual open or short coil.

ELECTRICAL AND ELECTROMECHANICAL PARTS FOR THE CIRCUITS INVOLVED IN THIS FUNCTION HAVE BEEN SELECTED FROM THE CLASS S OR EQUIVALENT PARTS SELECTION AND CONTROL REQUIREMENTS FOR THE SPACE SHUTTLE ENGINES (1). THE SOLENOID COILS ARE WOUND ON SEPARATE SPOOLS (2). LEADWIRE PAIRS (3) ARE SEPARATELY ROUTED TO REMOTE ELECTRICAL RECEPTACLES. THE SOLENOID IS POTTED (4) TO PREVENT WIRE MOVEMENT OR MOISTURE PROBLEMS. DUAL COILS ARE PROVIDED TO PRECLUDE SINGLE POINT ELECTRICAL FAILURES. SOLENOID ELECTRICAL CONNECTORS ARE DESIGNED TO SEAL AGAINST MOISTURE/CONTAMINATION (5). SOLENOID RECEPTACLE PINS ARE NICKEL UNDERPLATED AND GOLD OVERPLATED TO PREVENT CORROSION (6). THE PNEUMATIC CONTROL ASSEMBLY HAS SUCCESSFULLY PASSED DESIGN VERIFICATION TESTING (7), WHICH INCLUDED PRESSURE TESTING (8) PRESSURE CYCLING (9), AND VIBRATION TESTING (10). THE HPOTP INTERMEDIATE SEAL PURGE PRESSURE REDLINE WILL LIMIT CRITICALITY OF FAILURE TO ENGINE SHUTDOWN. THE CONTROLLER MONITOR SYSTEM IS COMPRISED OF REDUNDANT SENSOR ELECTRONICS, REDUNDANT HARNESSSES, AND REDUNDANT CONTROLLER CHANNELS (11).

(1) 85M03529; (2) RS010348; (3) 40M39513; (4) RL00C93; (5) RS010341; (6) MIL-SPEC-522, MIL-SPEC-250; (7) DVS-58ME-610; (8) RSS-510-46; (9) RSS-510-51; (10) RSS-510-50; (11) CP406R0002 PT 1 3 2.3-6 2

**FAILURE CAUSE:** H: Piston seal leakage due to: Damage/defective sealing surface.

THE PISTON IS MADE FROM INCONEL 718 (1). THIS MATERIAL WAS SELECTED FOR ITS STRENGTH IN THE HEAT TREATED CONDITION. THE PISTON SEALS ARE MADE FROM GRAPHITE FILLED TEFLON (2). THIS MATERIAL WAS SELECTED FOR ITS LOW COEFFICIENT OF FRICTION AND ITS RESISTANCE TO COLD FLOW. A TEFLON GUIDE (3) IS PROVIDED IN THE PISTON BORE, PREVENTING THE GENERATION OF METALLIC PARTICLES WHICH COULD CAUSE SEAL DAMAGE/LEAKAGE. THE PISTON SEAL IS SPRING AND PRESSURE LOADED TO ENSURE PROPER SEALING UNDER TRANSIENT AND FULL OPERATING PRESSURES.

(1) RS010185; (2) RES1254, RES1255; (3) RS010188

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**FAILURE CAUSE: ALL CAUSES**

THE HELIUM PRECHARGE VALVE HAS SUCCESSFULLY PASSED DESIGN VERIFICATION TESTING (1), ENDURANCE TESTING (2), AND VIBRATION TESTING (3) HIGH CYCLE AND LOW CYCLE FATIGUE LIFE, AS WELL AS THE MINIMUM FACTORS OF SAFETY FOR THE HELIUM PRECHARGE VALVE, MEET GEI REQUIREMENTS (4), EXCEPT FOR PROOF PRESSURE FACTOR WHICH IS ACCEPTED PER MAJOR WAIVER (5). THE HPV WAS CLEARED FOR FRACTURE MECHANICS/NOF FLAW GROWTH, SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (6). A PARTIAL EXAMINATION OF ENGINE 2010 HPV SHOWED NO EVIDENCE OF DEGRADATION OR WEAR OF THE DETAIL PARTS. THE CONTROLLER MONITOR SYSTEM IS COMPRISED OF REDUNDANT SENSOR ELECTRONICS, REDUNDANT HARNESSSES, AND REDUNDANT CONTROLLER CHANNELS (7).

(1) DVS-SSME-517; (2) RSS-517-51; (3) RSS-517-53; (4) RL00532, CP320R0003B, RSS-8546; (5) DAR 2233; (6) NASA TASK 117; (7) CP406R0002 PT 1.3.2.3.6.4

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

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B, D, E, F, G, I	HELIUM PRECHARGE VALVE ASSEMBLY SOLENOID VALVE DOWEL PIN POPPET		RS010180 RS010341 MS16555-B19 RS010192
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS010192
	CLEANLINESS OF COMPONENTS	THE HELIUM PRECHARGE ASSEMBLY IS CLEANED TO OXYGEN/FUEL SERVICE PER SPECIFICATION AND DRAWING REQUIREMENTS.	RL10001 RS010180

THE FOLLOWING TESTS ARE PERFORMED DURING MANUFACTURE AND ACCEPTANCE TESTING OF THE SOLENOID VALVE:

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A, B, D, E, F, G, I	CLEANLINESS OF COMPONENTS	<p>THE FOLLOWING TESTS ARE PERFORMED DURING MANUFACTURE AND ACCEPTANCE TESTING OF THE SOLENOID VALVE:</p> <p>- FILTER INSTALLATION, CLEANING AND DOWNSTREAM PARTICLE COUNT ARE VERIFIED.            - ALL INTERNAL FLOW PATHS ARE VERIFIED.</p>	<p>RL00226            RL00226</p>
		<p>THE FOLLOWING TESTS ARE PERFORMED DURING MANUFACTURING AND ACCEPTANCE TESTING OF THE HELIUM PRECHARGE VALVE:</p> <p>- ALL INTERNAL FLOW PATHS ARE VERIFIED.            - FILTER OPERATION IS VERIFIED BEFORE AND AFTER INSTALLATION</p>	<p>RL00456            RL00459            RES1090</p>
	PNEUMATIC CONTROL SOLENOID RECEPTACLE		<p>RS010341            RES1231</p>

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C

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C	INTEGRITY OF ELECTRONICS AND SOLENOID RECEPTACLE PINS	<p>THE FOLLOWING ELECTRICAL INSPECTIONS ARE PERFORMED DURING THE MANUFACTURE OF THE COIL/SOLENOID:</p> <ul style="list-style-type: none"> <li>- SOLDERING OF THE ELECTRICAL CONNECTIONS AND COIL LEADS.</li> <li>- POTTING OF THE ELECTRICAL CONNECTIONS IN THE CONNECTOR.</li> <li>- PLATING OF THE RECEPTACLE PINS IS INSPECTED PER DRAWING REQUIREMENTS.</li> </ul> <p>THE FOLLOWING ELECTRICAL TESTS ARE PERFORMED ON THE COIL/SOLENOID DURING ACCEPTANCE TESTING AND ASSEMBLY:</p> <ul style="list-style-type: none"> <li>- INSULATION RESISTANCE BETWEEN PINS AND COILS IS VERIFIED TO BE WITHIN SPECIFICATION.</li> <li>- EACH COIL INTERNAL RESISTANCE IS VERIFIED TO BE WITHIN ACCEPTABLE RANGES.</li> <li>- BY TESTING INDIVIDUAL COIL, THE PULL-IN AND DROP-OUT CURRENT REQUIREMENTS ARE VERIFIED TO BE WITHIN SPECIFICATION. THE TEST IS REPEATED WITH BOTH COILS ENERGIZED SIMULTANEOUSLY.</li> <li>- ACTUATION AND DE-ACTUATION TIMING IS TESTED AND VERIFIED TO BE WITHIN ACCEPTABLE RANGES.</li> </ul>	<p>RL10009            RL10008            RES1231</p> <p>RL00225            RL00226            RL00228</p> <p>RL00226</p>
H	HELIUM PRECHARGE VALVE HPV BODY SEAL PISTON MATERIAL INTEGRITY	<p>MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.</p> <p>HEAT TREAT IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS</p> <p>THE HELIUM PRECHARGE VALVE BODY AND CAP ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS</p> <p>SURFACE FINISH OF THE BODY/PISTON IS VERIFIED PER DRAWING REQUIREMENTS.</p>	<p>RS010180            RS010181            RES1254            RS010185</p> <p>RS010181            RS010185            RES1254</p> <p>RS010181            RS010185            RA0511-020</p> <p>RA0115-116</p>
	ACCEPTANCE TESTING	<p>THE FOLLOWING TESTS ARE PERFORMED DURING MANUFACTURING AND VALVE ACCEPTANCE:</p> <ul style="list-style-type: none"> <li>- PISTON SEAL LEAKAGE IS VERIFIED TO BE WITHIN SPECIFICATION.</li> <li>- SEAT LEAKAGE IS VERIFIED TO BE WITHIN SPECIFICATION.</li> <li>- ACTUATION AND DEACTUATION OPERATION IS VERIFIED.</li> <li>- PROOF PRESSURE TEST IS PERFORMED WITH ALL INLET, OUTLET, VENT AND DRAIN PORTS PRESSURIZED.</li> </ul>	<p>RS010187            RS010185</p> <p>RL00459            RL00346            RL00346            RL00459</p>
ALL CAUSES	HELIUM PRECHARGE VALVE ASSEMBLY INTEGRITY	<p>VALVE IS FUNCTIONALLY TESTED AFTER COMPLETION OF ASSEMBLY.</p> <p>VALVE ASSEMBLY LEAK CHECK IS PERFORMED EACH FLIGHT FLOW.</p> <p>VALVE ASSEMBLY FUNCTIONAL CHECKS PERFORMED EVERY FLIGHT.</p>	<p>RS010180</p> <p>RL00459</p> <p>OMRSD V41BQ009</p> <p>OMRSD V41AS0020</p>

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Component: up: Pneumatic Controls  
 CIL Item: C300-D1  
 Component: Helium Precharge Valve  
 Part Number: RS019180  
 Failure Mode: Insufficient or no helium pressurant flow to Pogo accumulator.

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	PRE-FLIGHT CHECKOUT	PNEUMATIC 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. (LAST TEST)	OMRSD V41A.S0.030 OMRSD S00FA0.211 OMRSD S00FA0.213

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)

Reference: NASA letter SA21/88/308 and Rocketdyne letter 88RCD9761.

Operational Use: Not Applicable.