# SSME FMEA/CIL
# REDUNDANCY SCREEN

Component Group: Pneumatic Controls
CIL Item: C200-11
Component: Pneumatic Control Assembly
Part Number: R0019450
Failure Mode: Failure to supply helium pressurant.

Prepared: P. Lowrimore
Approved: T. Nguyen
Approval Date: 8/2/99
Change #: 1
Directive #: CCBD ME3-01-5213



| Phase | Failure / Effect Description | Criticality Hazard Reference |
|---|---|---|
| P 4.1 | Helium pressurant is not applied to closing piston of main fuel valve actuator (MFVA). MFV may drift causing propellant leakage. MFV leakage results in fire, open air detonation and overpressure condition. Loss of vehicle.<br><br>Redundancy Screens: SINGLE POINT FAILURE: N/A | 1 ME-A1P, ME-A2P |
| C 4.1 | Failure to supply pneumatic pressurant would negate emergency engine shutdown. Engine shutdown would have to be accomplished by closing vehicle prevalve. Loss of vehicle.<br><br>Redundancy Screens: SINGLE POINT FAILURE: N/A | 1 ME-C1C, ME-C1A, ME-A1A, ME-A2A |

# SSME EA/CIL
# DESIGN

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|---|---|---|---|
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Design / Document Reference

FAILURE CAUSE: **A: PCA component failure: PCA inlet helium filter blocked.**
**B: PCA component failure: Emergency pneumatic orifice blocked.**
**G: Emergency shutdown solenoid valve failure: Armature jammed closed.**
**D: Emergency shutdown solenoid valve failure: Pushrod jammed closed.**
**F: Emergency shutdown solenoid valve failure: Vent port poppet/seat leakage due to: Contamination.**
**H: Emergency shutdown PAV failure: Vent port poppet/seat leakage due to: Contamination.**
**J: Emergency shutdown PAV failure: Vent port poppet/seat leakage due to: Flow passage blocked.**
**K: Emergency shutdown PAV failure: Vent port poppet/seat leakage due to: Damaged guide (contamination jammed between guides, piston, and body).**
**L: Emergency shutdown PAV failure: Control cavity seal 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 WHICH COULD JAM THE SOLENOID ASSEMBLY ARMATURE, PUSHROD OR STEM ASSEMBLY, AND THE PAV PISTON OR SHAFT. THE PISTON-POPPET LD RATIO PREVENTS 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 AND JAMMING.

(1) RL10001; (2) RL00270, RL00347; (3) RO0711-600 (4) R0019450; (5) R0010725; (6) RS008021

FAILURE CAUSE: **E: Emergency shutdown solenoid valve failure: Broken spring.**

THE SOLENOID VALVE SPRING (1) IS MANUFACTURED FROM ELGILOY WIRE. STRENGTH AND ELASTIC LIMIT TOGETHER WITH ELASTIC MODULUS, ARE THE PRIMARY REASONS FOR USING ELGILOY. THE MATERIAL IS CORROSION RESISTANT AND EXHIBITS ADEQUATE RESISTANCE TO STRESS CORROSION CRACKING (2) FOR THIS APPLICATION. THE SPRING IS STRAIN RELIEVED AND INCORPORATES CLOSED AND DEBURRED ENDS REDUCING STRESS CONCENTRATIONS THAT MAY CAUSE BREAKAGE.

(1) RS008074; (2) MSFC-SPEC-522, RSS-8582-6

FAILURE CAUSE: **G: Emergency shutdown solenoid valve failure: Vent port poppet/seat leakage due to: Damaged/defective sealing surface.**
**I: Emergency shutdown PAV failure: Vent port poppet/seat leakage due to: Damaged/defective sealing surface.**
**M: Emergency shutdown PAV failure: Control cavity seal leakage due to: Damaged/defective seal.**

TUNGSTEN CARBIDE IS USED TO MANUFACTURE THE EMSO 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 SEAT (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. THE PAV POPPET (4) IS MADE FROM 321 CRES. ADEQUATE STRENGTH AND DUCTILITY ARE THE PRIMARY REASONS FOR SELECTING 321 CRES. THIS MATERIAL IS CORROSION RESISTANT AND EXHIBITS A RESISTANCE TO STRESS CORROSION CRACKING (2). THE SEAT (5) IS MADE FROM 7075-T651 ALUMINUM ALLOY. LIGHTWEIGHT, STRENGTH AND A RESISTANCE TO STRESS CORROSION CRACKING (2) ARE THE REASONS FOR USING THIS MATERIAL. THE POPPET SEAL IS MADE FROM KEL-F(6). LOW COLD FLOW CHARACTERISTICS AND GOOD DUCTILITY ARE THE PRIMARY REASONS FOR USING KEL-F (2). THE CONTROL CAVITY SEAL (7) IS MADE FROM TFE TEFLON, WHICH WAS SELECTED FOR ITS WEAR RESISTANCE AND LOW COEFFICIENT OF FRICTION (2).

(1) RS008106; (2) MSFC-SPEC-522, RSS-8582-6; (3) RS008141, (4) RS008027; (5) RS008030; (6) RS008028; (7) RES1355

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|---|---|---|---|
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| CIL Item: | C200-11 | Approved: | T. Nguyen |
| Component: | Pneumatic Control Assembly | Approval Date: | 6/2/99 |
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Design / Document Reference

FAILURE CAUSE: ALL CAUSES

THE PNEUMATIC CONTROL ASSEMBLY IS CAPABLE OF PNEUMATICALLY SHUTTING DOWN THE ENGINE IN THE EVENT OF TOTAL ELECTRICAL FAILURE AND OF TERMINATING THE SHUTDOWN PURGES AND POGO ACCUMULATOR HELIUM POST CHARGE (1)(2) THE EMERGENCY SHUTDOWN SOLENOID VALVE (3) IS A NORMALLY OPEN, DUAL COIL VALVE. IN NORMAL OPERATION THE VALVE IS ENERGIZED (CLOSED). UPON COMMANDING PNEUMATIC SHUTDOWN, THE CONTROLLER DE-ENERGIZES (OPENS) THE VALVE SUPPLYING CLOSING PRESSURE TO THE MAIN VALVES. ANY ELECTRICAL FAILURE IN THE SOLENOID VALVE WOULD CAUSE THE VALVE TO DE-ENERGIZE (OPEN) AND ALLOW THE COMMANDED PNEUMATIC SHUTDOWN. HIGH CYCLE AND LOW CYCLE FATIGUE LIFE, AS WELL AS THE MINIMUM FACTORS OF SAFETY FOR THE PCA, MEET CEI REQUIREMENTS (4). THE PCA WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (5). THE PNEUMATIC CONTROL ASSEMBLY HAS COMPLETED DESIGN VERIFICATION TESTING (6), INCLUDING PRESSURE TESTING (7), PRESSURE CYCLING (8), AND VIBRATION TESTING (9). 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 (10). THESE VALVES HAD ACCUMULATED OVER 19,000 SECONDS AND 58 STARTS.

(1) DVS-SSME-510 (2) R0019450, (3) R0010725; (4) RL00532, CP320R0003B, RSS-8546; (6) NASA TASK 117; (6) DVS-SSME-510; (7) RSS-510-46; (8) RSS-510-51; (9) RSS-510-50; (10) SSME-83-0230

# SSME FM CIL
# INSPECTION AND TEST

Component Group: Pneumatic Controls
CIL Item: C200-11
Component: Pneumatic Control Assembly
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Prepared: P. Lowrimore
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| Failure Causes | Significant Characteristics | Inspection(s) / Test(s) | Document Reference |
|---|---|---|---|
| A, B, C, D, F, H, J, K, L | PNEUMATIC CONTROL ASSEMBLY<br>PNEUMATIC CONTROL SOLENOID<br>PRESSURE ACTUATED ASSEMBLY<br>FILTER<br>FILTER | | R0019450<br>R0010725<br>RS008021<br>RES1090<br>RES1107 |
| | CLEANLINESS OF COMPONENTS | THE PNEUMATIC CONTROL ASSEMBLY, THE PRESSURE ACTUATED VALVES, AND THE SOLENOID VALVES ARE CLEAN TO OXYGEN/FUEL SERVICE PER SPECIFICATION AND DRAWING REQUIREMENTS. | RL10301<br>R0019450<br>R0010725<br>RS008021 |
| | | DURING MANUFACTURE AND ACCEPTANCE TEST OF THE SOLENOID VALVE, THE FILTER INSTALLATION, VALVE CLEANING, AND CLEAN FLUSH PARTICLE COUNT IS INSPECTED PER SPECIFICATION. | RL00278 |

Component Group: Pneumatic Controls
CIL Item: CZ00-11
Component: Pneumatic Control Assembly
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Approval Date: 6/2/99
Change #: 1
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| Failure Causes | Significant Characteristics | Inspection(s) / Test(s) | Document Reference |
|---|---|---|---|
| A, B, C, D, F, H, J, K, L | 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. | RL00278 |
| | | DURING ASSEMBLY OF THE PRESSURE ACTUATED VALVE, THE ACTUATION AND DEACTUATION OPERATION AND SEALING ARE VERIFIED. OPERATION OF THE VALVE VERIFIES NO CONTAMINATION BLOCKAGE IN MOVING PARTS. | RL00347 |
| | FILTER INTEGRITY | FILTERS ARE INSPECTED TO MEET FLOW AND FILTRATION REQUIREMENTS PER SPECIFICATION. | RC1090<br>RC1107 |
| E | SPRING | | |
| | MATERIAL INTEGRITY | MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS. | RS008074 |

| Failure Causes | Significant Characteristics | Inspection(s) / Test(s) | Document Reference |
|---|---|---|---|
| E | MATERIAL INTEGRITY | LOAD RANGE OF THE DEPRESSED SPRING IS TESTED PER DRAWING REQUIREMENTS. | RS008074 |
| G, I, M | SOLENOID POPPET<br>SEAT<br>PAV POPPET<br>CAP<br>SEAL<br>PAV BODY<br>SEAL | | RS008106<br>RS008141<br>RS008027<br>RS008030<br>RES1355<br>RS008011<br>RS008028 |
| | MATERIAL INTEGRITY | MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS. | |
| | | HEAT TREAT IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS. | RS008141<br>RA1111-002 |
| | SEALING SURFACES | SEALING SURFACES ARE INSPECTED PER DRAWING REQUIREMENTS. | RS008027<br>RS008141<br>RS008106<br>RS008030<br>RS008011<br>RS008028 |
| | | THE PISTON SEAL LEAKAGE IS VERIFIED TO BE WITHIN SPECIFICATION REQUIREMENTS. | RL00278<br>RL00347 |
| | | DURING ASSEMBLY AND ACCEPTANCE TEST, THE VALVE ACTUATION AND DEACTUATION OPERATION IS VERIFIED. | |
| ALL CAUSES | PNEUMATIC CONTROL ASSEMBLY | | R0019450 |

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| Failure Causes | Significant Characteristics | Inspection(s) / Test(s) | Document Reference |
|---|---|---|---|
| ALL CAUSES | ASSEMBLY INTEGRITY | THE FOLLOWING TESTS ARE PERFORMED DURING ASSEMBLY AND FUNCTIONAL TESTING OF THE PNEUMATIC CONTROL ASSEMBLY:<br>- SEAT LEAKAGE IS VERIFIED TO BE WITHIN SPECIFICATION FOR BOTH ENERGIZED AND DE-ENERGIZED OPERATION.<br>- ASSEMBLY OPERATION IS VERIFIED BY TESTING EACH FUNCTION OF THE PNEUMATIC CONTROL ASSEMBLY.<br>- FILTER OPERATION IS VERIFIED BEFORE AND AFTER INSTALLATION. | RL00344<br>RL00344<br>RL00344 |
| | HOT-FIRE ACCEPTANCE TESTING (GREEN RUN) | PNEUMATIC CONTROL ASSEMBLY OPERATION IS VERIFIED THROUGH HOT-FIRE ACCEPTANCE TESTING | RL00461 |
| | PRE-FLIGHT CHECKOUT | EMERGENCY PNEUMATIC SHUTDOWN OPERATION IS VERIFIED DURING SSME ELECTRICAL CHECKOUT PRIOR TO FLIGHT OR AFTER ANY REPLACEMENT OF RELATED COMPONENTS BY PERFORMING THE FOLLOWING OMRSD REQUIREMENTS.<br>- FLIGHT READINESS TEST INCLUDING PNEUMATIC SHUTDOWN.<br>- PCA FUEL SIDE INTERNAL LEAK CHECK.<br>- PCA LOX SIDE INTERNAL LEAK TEST<br>- FLIGHT READINESS TESTS AND VALVE CYCLE VERIFICATION. (LAST TEST) | OMRSD V41AS0.030<br>OMRSD V41BQ0.090<br>OMRSD V41BQ0.091<br>OMRSD S00FA0.211 |

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.