SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Pneumatic Controls
CIL Item: C300-02
Component: Helium Precharge Valve
Part Number: RS010180
Failure Mode: Failure to terminate helium pressurant flow to Pogo accumulator during propellant conditioning.

Prepared: P. Lowrimore
Approved: T. Nguyen
Approval Date: 6/2/99
Change #: 1
Directive #: CCBD ME3-01-5213
Page: 1 of 1

Phase	Failure / Effect Description	Criticality Hazard Reference
P 4.1	Pogo precharge helium continues to flow. Controller detects out-of-limit condition and inhibits next command. Launch delay. Loss of vehicle due to HPOTP overspeed may result if failure to terminate helium precharge is not detected. Redundancy Screens: PNEUMATIC SYSTEM - SENSOR SYSTEM. UNLIKE REDUNDANCY. 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: Pass - Loss of redundant hardware items could not result from a single credible event.	1R ME-C1S,M, ME-G10C,D

SSME EA/CIL
DESIGN

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		Page:	1 of 2

Design / Document Reference

FAILURE CAUSE: A: Solenoid valve failure: Armature jammed open.
B: Solenoid valve failure: Pushrod jammed open.
G: Helium precharge valve failure: Piston/poppet jammed 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, INLET AND OUTLET FILTERS IN THE SOLENOID VALVE (4) AND AN INLET FILTER IN THE HELIUM PRECHARGE VALVE (5) ENSURE THAT CONTAMINANTS LARGER THAN 15-MICRONS WILL BE REMOVED. THE SOLENOID VALVE (4) INCORPORATES TEFLON ARMATURE AND PUSHROD GUIDES WHICH PREVENT METAL-TO-METAL RUBBING AND PARTICLE GENERATION IN THE IMMEDIATE AREA OF THE ARMATURE OR PUSHROD INTERFACE. IN THE EVENT THAT METALLIC PARTICLES FROM ANOTHER SOURCE GET INTO THE INTERFACE, THE PARTICLES BECOME EMBEDDED IN THE TEFLON SLEEVE. THIS PREVENTS GALLING BETWEEN THE SOLENOID ASSEMBLY AND ARMATURE, OR SEAT AND PUSHROD, AND PREVENTS JAMMING. THE ARMATURE AND PUSHROD LENGTH/DIAMETER RATIOS PRECLUDE THE POSSIBILITY OF ARMATURE AND PUSHROD COCKING. SIMILARLY, THE HPV PISTON IS GUIDED BY A TEFLON GUIDE AND TEFLON PISTON AND SHAFT SEALS TO PREVENT METAL RUBBING AND PARTICLE GENERATION. THE HPV POPPET IS THREADED AND TORQUED INTO A SELF-LOCKING HELI-COIL INSERT TO PREVENT THE POPPET FROM UNSCREWING INTO AN OPEN POSITION. THE HPV PISTON RETAINER NUT IS A SELF-LOCKING TYPE NUT THAT IS TORQUED TO PREVENT IT BACKING OFF AND RESTRICTING PISTON/POPPET TRAVEL, THEREBY PREVENTING POPPET SEATING (5).

(1) RL10001, (2) RQ0711-600, (3) RL00226; (4) RS010341; (5) RS010180

FAILURE CAUSE: C: Solenoid valve failure: Broken spring
F: Helium precharge 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 RESISTANCE TO STRESS CORROSION CRACKING (2) FOR THIS APPLICATION. THE SPRING (3) IN THE HELIUM PRECHARGE VALVE (4) IS MANUFACTURED FROM 302 CRES WIRE. DUCTILITY, CORROSION RESISTANCE AND RESISTANCE TO STRESS CORROSION CRACKING (2) ARE THE PRIMARY REASONS FOR USING 302 CRES. BOTH SPRINGS ARE STRAIN RELIEVED AND INCORPORATE CLOSED AND DEBURRED ENDS, REDUCING STRESS CONCENTRATIONS THAT MAY CAUSE BREAKAGE.

(1) RS008078; (2) RSS-8582-6; (3) RS010187 (4) RS010180

FAILURE CAUSE: D: Solenoid valve failure: Excessive internal leakage due to: Contamination.
H: Helium precharge valve failure: Excessive internal leakage due to: Contamination.

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), INLET AND OUTLET FILTERS IN THE SOLENOID VALVE (5), AND AN INLET FILTER IN THE HELIUM PRECHARGE VALVE (6) ENSURE THAT CONTAMINANTS LARGER THAN 15-MICRONS WILL BE REMOVED.

(1) RL10001; (2) RQ0711-600; (3) RL00226; (4) R0019450; (5) RS010341; (6) RS010180

FAILURE CAUSE: E: Solenoid valve failure: Excessive internal leakage due to: Damaged/defective sealing surfaces.

TUNGSTEN CARBIDE IS USED TO MANUFACTURE THE POPPET (1). TUNGSTEN CARBIDE WAS SELECTED FOR ITS HIGH 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. HIGH HARDNESS AND WEAR RESISTANCE ARE THE PRIMARY REASONS OR USING 440C CRES. THE MATERIAL ALSO EXHIBITS SUFFICIENT CORROSION RESISTANCE TO BE SUITABLE FOR THE APPLICATION (2). THE PRESSURE CAVITY SEAL (4) IS MADE FROM 321 CRES WHICH HAS STRENGTH AND DUCTILITY, AS WELL AS A RESISTANCE TO STRESS CORROSION CRACKING (2). THE SEAL IS TEFLON COATED TO PRECLUDE LEAKAGE DUE TO SEAL CONTAMINATION (2).

(1) RS008106 (2) RSS-8582-6, (3) RS008080 (4) RS010341

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		Page:	2 of 2

Design / Document Reference

FAILURE CAUSE: I: Helium precharge valve failure: Excessive internal leakage due to: Damaged/defective sealing surface.

INCONEL 718 IS USED TO MANUFACTURE THE POPPET (1). IT HAS HIGH STRENGTH AND GOOD DUCTILITY. IT IS CORROSION RESISTANT AND EXHIBITS HIGH STRESS CORROSION CRACKING RESISTANCE (2). INCONEL 718 IS EASILY JOINED BY WELDING AND HAS A HIGH MODULUS OF ELASTICITY. THE POPPET SEALING SURFACE IS HARDFACED WITH TUNGSTEN CARBIDE. TUNGSTEN CARBIDE WAS SELECTED FOR ITS RESISTANCE TO WEAR (2). THE SEAT (3) IS MANUFACTURED FROM 440C CRES BAR. HIGH HARDNESS AND WEAR RESISTANCE ARE PRIMARY REASONS FOR USING 440C CRES. THE MATERIAL EXHIBITS SUFFICIENT CORROSION RESISTANCE TO BE SUITABLE FOR THE APPLICATION

(1) RS010189; (2) RSS-8582-6; (3) RS010183

FAILURE CAUSE: ALL CAUSES

THE HELIUM PRECHARGE VALVE HAS SUCCESSFULLY PASSED DESIGN VERIFICATION TESTING (1), ENDURANCE TESTING (2), AND VIBRATION TESTING (3). THE MINIMUM FACTORS OF SAFETY FOR THE HELIUM PRECHARGE VALVE MEET CEI REQUIREMENTS (4), EXCEPT FOR PROOF PRESSURE FACTOR WHICH IS ACCEPTED PER MAJOR WAIVER (5) THE HPV WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (6). A EXAMINATION OF ENGINE 2010 HPV (7) SHOWED NO EVIDENCE OF DEGRADATION OR WEAR OF DETAIL PARTS. THE VALVE ACCUMULATED OVER 13,300 SECONDS AND 43 STARTS.

(1) DVS-SSME-517; (2) RSS-517-51; (3) RSS-517-63; (4) RL00532, CP320R0003B,. (5) DAR 2233; (6) NASA TASK 117; (7) SSME-86-1259

SSME FMEA/CIL
INSPECTION AND TEST

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Page: 1 of 3

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B, D, G, H	HELIUM PRECHARGE VALVE ASSEMBLY SOLENOID VALVE		RS010180 RS010341
	CLEANLINESS REQUIREMENTS	THE HELIUM PRECHARGE ASSEMBLY IS CLEANED TO OXYGEN/FUEL SERVICE PER SPECIFICATION REQUIREMENTS.	RL10001
		THE FOLLOWING TESTS ARE PERFORMED DURING MANUFACTURE AND ACCEPTANCE TESTING OF THE SOLENOID VALVE:	
		• FILTER INSTALLATION, CLEANING, AND DOWNSTREAM PARTICLE COUNT ARE VERIFIED. • ALL INTERNAL FLOW PATHS ARE VERIFIED.	RL00226 RL00226
		THE FOLLOWING TESTS ARE PERFORMED DURING MANUFACTURING AND ACCEPTANCE TESTING OF THE HELIUM PRECHARGE VALVE:	

Component Group: Pneumatic Controls
CIL Item: C308-02
Component: Helium Precharge Valve
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Page: 2 of 3

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B, D, G, H	CLEANLINESS REQUIREMENTS	- ALL INTERNAL FLOW PATHS ARE VERIFIED. - FILTER OPERATION IS VERIFIED BEFORE AND AFTER INSTALLATION.	RL00459 RL00459 RES1090
C, F	SPRING SPRING		RS008078 RS010187
	SPRING INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	
		AFTER MACHINING, SPRING CHARACTERISTICS ARE INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0102-012
		LOAD RANGE OF THE DEPRESSED SPRING IS TESTED PER DRAWING REQUIREMENTS.	RS008078 RS010187
E	POPPET SEAT		RS008106 RS008080
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS	
		HEAT TREAT IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS008080 RA1111-002
		SEALING SURFACES ARE INSPECTED PER DRAWING REQUIREMENTS.	RSC08106 RS0C8080 RLC0133
I	POPPET SEAT		RS010189 RS010183
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	
		POPPET HARDFACE IS INSPECTED PER SPECIFICATION REQUIREMENTS.	RA1603-049
		HEAT TREAT IS CONTROLLED BY DRAWING AND SPECIFICATION REQUIREMENTS.	RS010189 RA0611-020 RS010183

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1	MATERIAL INTEGRITY	SEALING SURFACES ARE INSPECTED PER DRAWING REQUIREMENTS.	RS010189 RS010183
		PENETRANT INSPECTION IS PERFORMED PER DRAWING REQUIREMENTS ON BOTH POPPET AND SEAT.	RA0115-116
	WELD INTEGRITY	ALL WELDS ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, RADIOGRAPHIC, ULTRASONIC, AND FILLER MATERIAL, AS APPLICABLE.	RL10011 RA0507-094 RA0115-116 RA0115-006 RA0115-127 RA1115-001
		WELD IS LEAK TESTED PER DRAWING REQUIREMENTS.	RS010189
ALL CAUSES	ASSEMBLY INTEGRITY	THE HPV ASSEMBLY IS VERIFIED DURING ACCEPTANCE TESTING.	RS010180 RL00459
		THE HPV ASSEMBLY SEALING FUNCTIONS ARE LEAK CHECKED EVERY FLIGHT.	OMRSD V41BQ0.091
		THE HPV ASSEMBLY FUNCTIONAL CHECKS ARE PERFORMED EVERY FLIGHT.	OMRSD V41AS0.020
	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 V41AS0.030 OMRSD S00FA0.211 OMRSD S00FA0.213

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
Reference: NASA letter SA21/86/308 and Rocketdyne letter 86RC09761.
Operational Use: Not Applicable