SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Pneumatic Controls
CIL Item: C200-07
Component: Pneumatic Control Assembly
Part Number: R0019450
Failure Mode: Insufficient or no nitrogen purge flow during propellant conditioning.

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

Phase	Failure / Effect Description	Criticality Hazard Reference
PS 4 1	Reduced nitrogen flow causes loss of oxidizer dome purge. Moisture not cleared. Ice formed. LOX orifices block causing combustion within the post post burn through and extensive erosion during start. Uncontained engine damage. Reduced flow causes loss of intermediate seal purge. Moisture not cleared. Ice formed during propellant drop Ice damages HPOTP intermediate seal, seal fails. LOX and hot-turbine gases mix, uncontained engine damage during start. Loss of purge reduces the purge flow below acceptable limits for nerting propellant leakage at ICD limits. Potential open air fire. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A	1 ME-C1S, ME-A1A, ME-A1P, ME-B4S

SSME CA/CIL
DESIGN

Component Group:	Pneumatic Controls	Prepared:	P. Lowrimore
CIL Item:	C200-07	Approved:	T. Nguyen
Component:	Pneumatic Control Assembly	Approval Date:	6/2/99
Part Number:	R0019450	Change #:	1
Failure Mode:	Insufficient or no nitrogen purge flow during propellant conditioning.	Directive #:	CCBD ME3-01-5213
		Page:	1 of 1

Design / Document Reference

FAILURE CAUSE: A: PCA component failure: PCA inlet nitrogen filter blocked or restricted.
C: PCA component failure: HPOTP intermediate seal purge control orifice blocked or restricted.
D: PCA component failure: MCC oxidizer dome purge control orifice blocked or restricted.
E: Oxidizer system purge pressure activated valve failure: Control cavity seal leakage due to: Contamination.
G: Oxidizer system purge pressure activated valve failure: Control cavity seal leakage due to: Flow passage blocked.
H: Oxidizer system purge pressure activated valve failure: Vent port poppet/seat leakage due to: Contamination.
J: Oxidizer system purge pressure activated valve failure: Vent port poppet/seat leakage due to: Damaged guide (contamination jammed between guides, piston, and body).

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) ENSURES THAT CONTAMINANTS LARGER THAN 15-MICRONS WILL BE REMOVED. THE PRESSURE ACTUATED VALVE (5) INCORPORATES TEFLON GUIDES WHICH PREVENT METAL-TO METAL RUBBING AND METAL PARTICLE GENERATION. THESE DESIGN FEATURES PREVENT GENERATION OF METALLIC PARTICLES IN THE IMMEDIATE AREA OF THE PISTON OR SHAFT. THE I/D OF THE PISTON ASSEMBLY/SHAFT PRECLUDES THE POSSIBILITY OF COCKING. 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) RL00226, RL00347; (3) RQ0711-600, (4) R0019450; (5) R0011040, RS008021

FAILURE CAUSE: B: PCA component failure: PCA oxidizer system burst diaphragm ruptured.

THE PCA BURST DIAPHRAGM (1) IS MADE FROM 1100-0 ALUMINUM ALLOY. WEIGHT, WELDABILITY, AND PREDICTABLE RUPTURE CHARACTERISTICS OF 1100-0 ALUMINUM ARE THE PRIMARY REASONS FOR SELECTING THIS ALLOY AS PART OF THE BURST DIAPHRAGM ASSEMBLY (2). IN ADDITION, THIS MATERIAL EXHIBITS CORROSION RESISTANCE AND RESISTANCE TO STRESS CORROSION CRACKING (2) AT THE EXPOSURE TEMPERATURE RANGE. CHEMICAL FILM COATING IS USED FOR ADDITIONAL PROTECTION FROM GENERAL CORROSION (1).

(1) RES1356, (2) RSS-8582-6, MSFC-SPEC-522

FAILURE CAUSE: F: Oxidizer system purge pressure activated valve failure: Control cavity seal leakage due to: Damaged/defective seal.
I: Oxidizer system purge pressure activated valve failure: Vent port poppet/seat leakage due to: Damaged/defective sealing surface.

THE POPPET IS MADE FROM 303F CRES (1). GOOD MACHINABILITY, WHEN COMPARED WITH OTHER 300-SERIES CRES ALLOYS, IS THE PRIMARY REASON FOR SELECTING 303F CRES. THE MATERIAL IS CORROSION RESISTANT AND, IN THE APPLICATIONS LISTED, PROVIDES SUFFICIENT STRENGTH. 303F IS USED IN A WORK-HARDENED CONDITION TO ACHIEVE WEAR RESISTANCE. THE CAP IS MADE FROM 7075-T651 ALUMINUM ALLOY (2). WEIGHT, STRENGTH AND RESISTANCE TO STRESS CORROSION CRACKING (3) ARE THE PRIMARY REASONS FOR USING 7075-T651 ALUMINUM ALLOY. THE MATERIAL IS COMPATIBLE WITH ALL OF THE USAGE ENVIRONMENTS AT THE ANTICIPATED TEMPERATURES. IT IS SOLUTION TREATED AND AGED, AND PROVIDES HIGH TENSILE STRENGTH AND YIELD (3). THE SEAL (4) IS MADE FROM KEL-F, WHICH EXHIBITS GOOD SEALING CAPABILITY AND WEAR CHARACTERISTICS (3). THE CONTROL CAVITY SEAL (5) IS MADE FROM TFE TEFLON. IT WAS SELECTED FOR WEAR RESISTANCE AND LOW COEFFICIENT OF FRICTION (3).

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

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, AND THE MINIMUM FACTORS OF SAFETY FOR THE PCA, MEET CEI REQUIREMENTS (5). THE PCA WAS CLEARED FOR FRACTURE MECHANICS/NDE 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 VALVE SHOWED NO DEGRADATION OR WEAR OF DETAIL PARTS (7).

(1) DVS-SSME-510; (2) RSS-510-46; (3) RSS-510-51; (4) RSS-510-53; (5) RL00532, CP320R00038, RSS-8545, (6) NASA TASK 117; (7) SSME-83-0230

SSME FMEA/CIL
INSPECTION AND TEST

Component Group: Pneumatic Controls
CIL Item: C200-07
Component: Pneumatic Control Assembly
Part Number: R0019450
Failure Mode: Insufficient or no nitrogen purge flow during propellant conditioning.

Prepared: P. Lowrimore
Approved: T. Nguyen
Approval Date: 6/2/99
Change #: 1
Directive #: CCBD ME3-01-5211

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, C, D, E, G, H, J	FILTER PRESSURE ACTUATED VALVE PNEUMATIC CONTROL ASSEMBLY		RES1090 RS008021 R0019450
	CLEANLINESS OF COMPONENTS	THE PNEUMATIC CONTROL ASSEMBLY AND THE PRESSURE ACTUATED VALVE ARE CLEANED TO OXYGEN/FUEL SERVICE PER SPECIFICATION AND DRAWING REQUIREMENTS.	RL10001 R0019450 RS008021
		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

Component Group: Pneumatic Controls
CIL Item: C200-07
Component: Pneumatic Control Assembly
Part Number: R0019450
Failure Mode: Insufficient or no nitrogen purge flow during propellant conditioning.

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

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, C, D, E, G, H, J	FILTER INTEGRITY	FILTERS ARE INSPECTED TO MEET FLOW AND FILTRATION REQUIREMENTS PER SPECIFICATION.	RC1090
B	BURST DIAPHRAGM		RES1356
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	
		MATERIAL IS PROTECTED FROM GENERAL CORROSION WITH A CHEMICAL FILM PER DRAWING REQUIREMENTS.	RES1356 RA1605-004
	WELD INTEGRITY	WELDS ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS, INCLUDING MASS SPECTROMETER LEAK TEST.	RL10011 RA0115-005
	ASSEMBLY TESTING	AFTER A PRODUCTION RUN IS STARTED, EVERY SIXTH DIAPHRAGM IS TESTED UNTIL AT LEAST 50 SERVICEABLE DIAPHRAGMS ARE COMPLETED, WHEREUPON EVERY ELEVENTH DIAPHRAGM COINED IS TESTED FOR THE DURATION OF THE RUN.	RL00111
A, I	POPPET CAP (VENT SEAT) SEAL SEAL PAV BODY		RS008027 RS008030 RS008028 RES1356 RS008011
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	
		SEALING SURFACE FINISHES ARE INSPECTED PER DRAWING REQUIREMENTS.	RS008027 RS008030 RS008028 RS008011
ALL CAUSES	PNEUMATIC CONTROL ASSEMBLY		R0019450

Component Group:	Pneumatic Controls	Prepared:	P. Lowrimore
CIL Item:	C200-07	Approved:	T. Nguyen
Component:	Pneumatic Control Assembly	Approval Date:	6/2/98
Part Number:	R0019450	Change #:	1
Failure Mode:	Insufficient or no nitrogen purge flow during propellant conditioning.	Directive #:	CCBD ME3-01-5213
		Page:	3 of 3

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	ASSEMBLY TESTING	THE FOLLOWING TESTS ARE PERFORMED DURING ASSEMBLY AND FUNCTIONAL TESTING OF THE PNEUMATIC CONTROL ASSEMBLY: - SEAT LEAKAGE IS VERIFIED TO BE WITHIN SPECIFICATION FOR BOTH ACTUATED AND DEACTUATED OPERATION. - ASSEMBLY OPERATION IS VERIFIED BY TESTING EACH FUNCTION OF THE PNEUMATIC CONTROL ASSEMBLY. - ASSEMBLY FUNCTION IS VERIFIED BY INSPECTION OF THE FLOW 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.	RL00461
	FLIGHT FLOW TESTING	NITROGEN PURGE SYSTEM OPERATION IS VERIFIED EACH FLIGHT FLOW BY PERFORMING THE FOLLOWING OMRSD REQUIREMENTS: - PROPELLANT SYSTEM DRYING. - DRYNESS VERIFICATION. - OXIDIZER SYSTEM PURGE. (LAST TEST)	OMRSD V41CB0.060 OMRSD V41CB0.061 OMRSD S00FB0.300

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.