SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Propellant Valves
CIL Item: D110-01
Component: Main Fuel Valve
Part Number: RS008255
Failure Mode: Internal leakage.

Prepared: P. Lowrimore
Approved: T. Nguyen
Approval Date: 6/30/99
Change #: 2
Directive #: CCBD ME1-01-5226

Phase	Failure / Effect Description	Criticality Hazard Reference
P 4.1	Leakage results in fire open air detonation and overpressure condition. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A.	1 ME-A1P
C 4.1	Leakage results in post shutdown fire; open air detonation and overpressure condition when premature shutdown occurs on the launch pad. Loss of Vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A.	1 ME-A1A

SSME F A/CIL DESIGN

Component Group:	Propellant Valves	Prepared:	P. Lowrimore
CIL Item:	D110-01	Approved:	T. Nguyen
Component:	Main Fuel Valve	Approval Date:	6/30/99
Part Number:	RS008256	Change #:	2
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Design / Document Reference

FAILURE CAUSE: A: Damage or failure of seal, ball, or bellows.

THE BALL SEAL IS LIFTED-OFF THE BALL (3) DURING THE FIRST FEW DEGREES OF ROTATION TO MINIMIZE BALL/SEAL RUBBING AND POTENTIAL WEAR OR DAMAGE. SEAL LIFT-OFF OCCURS BEFORE THE SEAL CROSSES THE HOLE THEREBY AVOIDING WEAR CAUSED BY UNEVEN LOADING (1). THE SEAL IS LOADED BY THE BELLOWS PRELOAD (2) FOR LOW PRESSURE SEALING AND BY SYSTEM PRESSURE FOR HIGH PRESSURE SEALING. THIS MINIMIZES THE SEAL LOAD AND WEAR DURING DRY ACTUATIONS. THE BALL MACHINED SURFACE FINISH IS SELECTED TO PREVENT SEAL WEAR. THE SEAL LIFT-OFF FEATURE PREVENTS THE ACCUMULATION OF CONTAMINANTS AT THE SEAL/BALL INTERFACE WHICH COULD DAMAGE THE SEAL/BALL DURING VALVE ACTUATION (4). THE BALL SEAL IS MADE OF KEL-F DUE TO ITS STRENGTH AND ELONGATION PROPERTIES AT CRYOGENIC TEMPERATURE AND COLD FLOW RESISTANCE AT AMBIENT TEMPERATURE (4). THE BALL SEAL IS SUPPORTED ON THE INSIDE DIAMETER BY THE BALL AND BELLOWS TO PREVENT FAILURE CAUSED BY PROPELLANT PRESSURE. THE SHAFT (BALL) IS INCONEL 718, HEAT TREATED TO PROVIDE HIGH STRENGTH AND RESISTANCE TO WEAR AND DAMAGE. THE BELLOWS IS FABRICATED FROM INCONEL 718 BAR AND SHEET (4). INCONEL 718 IS RESISTANT TO HYDROGEN ENVIRONMENT EMBRITTLEMENT AT THE NEAR -400F OPERATING ENVIRONMENT. THE BELLOWS IS FOUR PLY CONSTRUCTION. THE PLYS ARE DRAWN SEAMLESS TUBING OR WELDED SHEET STOCK WHICH IS ROLL REDUCED 35 PERCENT AFTER WELDING. AFTER FORMING, THE BELLOWS IS WELDED TO THE CAP AND FITTING, AND THE ASSEMBLY IS HEAT TREATED (2). HIGH CYCLE AND LOW CYCLE FATIGUE LIFE OF THE MFV BALL SEAL, BALL AND BELLOWS MEET CEI REQUIREMENTS (5). THE MINIMUM FACTORS OF SAFETY FOR THE BALL SEAL, BALL AND BELLOWS MEET CEI REQUIREMENTS (6). THE MFV INTERNAL COMPONENTS PARENT MATERIAL WERE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (7). TABLE D110 LISTS ALL THE FMEA/CIL WELDS AND IDENTIFIES THOSE WELDS IN WHICH THE CRITICAL INITIAL FLAW SIZE IS NOT DETECTABLE, AND THOSE WELDS IN WHICH THE ROOT SIDE IS NOT ACCESSIBLE FOR INSPECTION. THOSE WELDS HAVE BEEN ASSESSED AS ACCEPTABLE FOR FLIGHT BY RISK ASSESSMENT (8). THE VALVE SUCCESSFULLY COMPLETED DESIGN VERIFICATION TESTING (9), INCLUDING ENDURANCE AND VIBRATION, AND THE TEST RESULTS WERE REPORTED (10).

(1) RS008256; (2) RS008208; (3) RS008271; (4) RSS-8576; (5) RL00532, CP320R0003B; (6) RSS-8546, CP320R0003B; (7) NASA TASK 117, (8) RSS-8758; (9) DVS-SSME-515; (10) RSS-515-17, RSS-515-24

FAILURE CAUSE: B: Contamination.

THE FUEL SUPPLY TO THE MFV IS FILTERED TO 40-MICRON MAXIMUM PARTICLE SIZE (1). THE BALL SEAL LIFTS-OFF FROM THE BALL AFTER THE FIRST FEW DEGREES OF ROTATION, THIS HELPS WASH ANY CONTAMINANT OFF THE SEAL AND BALL (2). THE VALVE SUBASSEMBLIES AND THE ENGINE SYSTEM HARDWARE ARE REQUIRED TO BE CLEAN PRIOR TO INSTALLATION (3). THE VALVE IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA (4). DURING PROPELLANT CONDITIONING, THE GN2 PURGE MAY CAUSE NITROGEN ICE TO BE DEPOSITED ON THE BALL. A CONTINUOUS FUEL SYSTEM PURGE PREVENTS ICING (5).

(1) ICD 13M15000; (2) RS008256; (3) RL10001; (4) RQ0711-600; (5) OMRSD S00FB0.320

SSME FMEA/CIL
INSPECTION AND TEST

Component Group: Propellant Valves
CIL Item: D110-01
Component: Main Fuel Valve
Part Number: RS008256
Failure Mode: Internal leakage.

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Approved: T. Nguyen
Approval Date: 6/30/99
Change #: 2
Directive #: CCBD ME3-01-5226

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	SEAL SHAFT ASSEMBLY BELLOWS ASSEMBLY		RS008034 RS008271 RS008256
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	
		EACH LOT OF KEL-F FOR THE RS008034 SEAL IS SUBJECTED TO A MOLTEN SALT BATH EXAMINATION, VISUAL EXAMINATION, CONTAMINATION INSPECTION, TENSILE STRENGTH AND ELONGATION TESTS, AND INFRARED ANALYSIS.	RB0130-009
		THE SHAFT (BALL) ASSEMBLY DETAILS ARE PENETRANT INSPECTED AFTER MACHINING.	RA0115-116
	WELD INTEGRITY	THE WELDS ON THE SHAFT (BALL) AND BELLOWS ASSEMBLY ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, RADIOGRAPHIC, ULTRASONIC, AND FILLER MATERIAL, AS APPLICABLE.	RL10011 RA0607-094 RA0115-116 RA0115-006 RA0115-127 RA1115-001
	HEAT TREAT	THE BELLOWS ASSEMBLY AND SHAFT HEAT TREATMENTS ARE VERIFIED PER SPECIFICATION REQUIREMENTS	RA1611-002 RL00272 RA0611-020
	BELLOWS INTEGRITY	THE BELLOWS ARE DIMENSIONALLY INSPECTED, PROOF PRESSURE TESTED, LEAK TESTED, AND LOAD DEFLECTION TESTED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS008208 RL00272
		ONE OF EVERY 25 DELIVERABLE BELLOWS SUBASSEMBLIES IS SECTIONED AFTER ACCEPTANCE TESTING AND INSPECTED.	RL00272
	SEALING SURFACES	THE MACHINED SEALING SURFACES ARE INSPECTED PER THE DRAWING REQUIREMENTS.	RS008034 RS008271 RS008208
B	VALVE AND UPSTREAM COMPONENT CLEANLINESS	UPSTREAM COMPONENTS ARE VERIFIED CLEAN TO FUEL SERVICE OR BETTER REQUIREMENTS.	RL10001
		VALVE COMPONENTS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY.	RL10001 RS008256
		THE VALVE ASSEMBLY IS VERIFIED TO BE ACCOMPLISHED IN A CONTAMINATION CONTROLLED AREA.	RQ0711-500
ALL CAUSES	ASSEMBLY INTEGRITY	THE VALVE IS FUNCTIONAL AND ACCEPTANCE TESTED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS008256 RL00453
		THE BALL SEAL IS LEAK TESTED PRIOR TO EACH FLIGHT FOLLOWING LAST ACTUATION. (LAST TEST)	OMRSD V41BQQ.010 OMRSD S00FA0.212

Component Grp: Propellant Valves
CIL Item: D110-01
Component: Main Fuel Valve
Part Number: RS008256
Failure Mode: Internal leakage.

Prepared: P. Lowrim
Approved: T. Nguyen
Approval Date: 6/30/99
Change #: 2
Directive #: CCSD ME3-01-5226
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference

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.

SSME FMEA/CIL
WELD JOINTS

Component Group: Propellant Valves
CIL Item: D110
Component: Main Fuel Valve
Part Number: RS008256

Prepared: P. Lowrimore
Approved: T. Nguyen
Approval Date: 6/30/99
Change #: 1
Directive #: CCBD ME3-01-5226

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable HCF	Critical Initial Flaw Size Not Detectable LCF	Comments
BELLOWS	RS008208	3,4	EBW	II	X	X		
BELLOWS	RS008208	5-8	GTAW	I				
SHAFT	RS008271	1,2	EBW	II	X	X		