

SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Propellant Valves
 CIL Item: D140-01
 Component: Oxidizer Preburner Oxidizer Valve
 Part Number: RS008258
 Failure Mode: Internal leakage.

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

Phase	Failure / Effect Description	Critical to Hazard Reference
C 4.1	Oxidizer continues to flow into oxidizer preburner sustaining combustion. Damage to preburner, HPOTP turbine, and heat exchanger. Possible powerhead burn through. Loss of vehicle.	1 ME-A2A, ME-B6A,C
Redundancy Screens: SINGLE POINT FAILURE: N/A		

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DESIGN

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Page: 1 of 1

Design / Document Reference

FAILURE CAUSE: A: Damage or failure of seal, ball, or bellows.
C: Friction latching of seal and bellows end cap (for engine shutdown <1.5 seconds).

THE BALL SEAL IS LIFTED-OFF THE BALL (1) 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 (2). THE SEAL IS LOADED BY THE BELLWS PRELOAD (3) 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 (5) 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 OUTER DIAMETER BY THE BELLWS TO PREVENT FAILURE CAUSED BY PROPELLANT PRESSURE. THE BALL SEALS ARE LIMITED TO 27 STARTS (6). THE SHAFT (BALL) IS INCONEL 718, HEAT TREATED TO PROVIDE HIGH STRENGTH AND RESISTANCE TO WEAR AND DAMAGE. THE BELLWS IS FABRICATED FROM INCONEL 718 BAR AND SHEET (4). THE BELLWS IS THREE-PLY CONSTRUCTION. THE PLYS ARE DRAWN SEAMLESS TUBING OR WELDED SHEET STOCK WHICH IS ROLL REDUCED 35 PERCENT AFTER WELDING. AFTER FORMING, THE BELLWS IS WELDED TO THE CAP AND FITTING. AND THE ASSEMBLY IS HEAT TREATED (3).

(1) RS008253; (2) RS008258; (3) RS008230; (4) RSS-8582; (5) RS008309; (6) DAR 2761

FAILURE CAUSE: B: Contamination.

THE OXIDIZER SUPPLY TO THE OPOV IS FILTERED TO 800-MICRON MAXIMUM PARTICLE SIZE (1). THE BALL SEAL LIFTS-OFF FROM THE BALL AFTER THE FIRST FEW DEGREES OF ROTATION. THIS HELPS WASH ANY CONTAMINATION 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).

(1) ICD 13M15000; (2) RS008258; (3) RL10001; (4) RQD711-800

FAILURE CAUSE: ALL CAUSES

HIGH CYCLE AND LOW CYCLE FATIGUE AS WELL AS MINIMUM FACTORS OF SAFETY FOR THE OXIDIZER PREBURNER OXIDIZER VALVE MEET CEI REQUIREMENTS (1). THE OPOV COMPONENTS WERE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (2). TABLE D140 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. THESE WELDS HAVE BEEN ASSESSED AS ACCEPTABLE FOR FLIGHT BY RISK ASSESSMENT (3). THE OXIDIZER PREBURNER OXIDIZER VALVE SUCCESSFULLY COMPLETED DVS TEST REQUIREMENTS (4) INCLUDING ENDURANCE (5), AND VIBRATION (6).

(1) RL00532, CP320R00038, RSS-8546; (2) NASA TASK 117; (3) RSS-8756; (4) DVS-SSME-515; (5) RSS-515-17; (6) RSS-515-24

**SSME FMEA/CIL
INSPECTION AND TEST**

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Page: 1 of 2

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, C	SEAL SHAFT ASSEMBLY BELLOWS ASSEMBLY		RS008309 RS008263 RS008230
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	
		EACH LOT OF KEL-F FOR THE RS008309 SEAL IS SUBJECTED TO A MOLTEN SALT BATH EXAMINATION, VISUAL EXAMINATION, CONTAMINATION INSPECTION, TENSILE STRENGTH AND ELONGATION TESTS, AND INFRARED ANALYSIS.	RB0130-094
		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 RA0611-020
	BELLOWS INTEGRITY	THE BELLOWS ARE DIMENSIONALLY INSPECTED, PROOF PRESSURE TESTED, LEAK TESTED, AND LOAD DEFLECTION TESTED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS008230 RL00273/ RL01122
		ONE OF EVERY 25 DELIVERABLE BELLOWS SUBASSEMBLIES IS SECTIONED AFTER ACCEPTANCE TESTING AND INSPECTED.	RL00273/ RL01122
	SEALING SURFACES	THE MACHINED SEALING SURFACES ARE INSPECTED PER THE DRAWING REQUIREMENTS	RS008309 RS008230 RS008263

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 Page: 2 of 2

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
B	VALVE AND UPSTREAM COMPONENT CLEANLINESS	VALVE COMPONENTS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY. THE VALVE ASSEMBLY IS VERIFIED TO BE ACCOMPLISHED IN A CONTAMINATION CONTROLLED AREA.	RL10001 RS008258 R00711-600
ALL CAUSES	ASSEMBLY INTEGRITY	THE VALVE IS FUNCTIONAL AND ACCEPTANCE TESTED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS008258 RL00472
	HOT-FIRE ACCEPTANCE TESTING (GREEN RUN)	VALVE OPERATION IS VERIFIED THROUGH HOT-FIRE ACCEPTANCE TESTING. THE BALL SEAL IS LEAK TESTED PRIOR TO EACH FLIGHT. (LAST TEST)	RL00461 OMRSD V41BQ0.120 OMRSD S00FA0.214

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 TTA/CIL
WELD JOINTS**

Component Group: Propellant Valves
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 Page: 1 of 1

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable		Comments
						HCF	LCF	
BELLOWS	RS008230	3,4	GTAW	II	X	X		
BELLOWS	RS008230	5-7	GTAW	I				
SHAFT	RS008263	1,2	EBWJ	II	X	X		