

SSME FMEA/CIL  
REDUNDANCY SCREEN

Component Group: Propellant Valves  
CIL Item: D140-05  
Component: Oxidizer Preburner Oxidizer Valve  
Part Number: RS008258  
Failure Mode: Piece part structural failure.

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

---

Phase	Failure / Effect Description	Criticality Hazard Reference
PSMCD 4.1	Fire from LOX impact or rubbing. Loss of vehicle  Redundancy Screens: SINGLE POINT FAILURE: N/A.	1 ME-C3P,D, ME-C3S, ME-C3M, ME-C3A,C

---

SSME FMEA/CIL  
DESIGN

Component Group: Propellant Valves  
CIL Item: D140-05  
Component: Oxidizer Preburner Oxidizer Valve  
Part Number: RS008258  
Failure Mode: Piece part structural failure.

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

Page: 1 of 1

Design / Document Reference

**FAILURE CAUSE:** A: Internal structural failure of: Ball seal, Shaft seal, Shaft, Bellows, Cam follower, Inlet sleeve, Outlet sleeve, Shaft bearing retainer, Cam bearing, Shaft bearing, Fasteners and cupwashers.

OPOV INTERNAL STRUCTURAL PARTS ARE THE SHAFT (1), BELLOW (2), CAM FOLLOWER (3), INLET SLEEVE (4), OUTLET SLEEVE (5), SHAFT BEARING RETAINERS (6), CAM BEARINGS (7), SHAFT BEARINGS (8), THRUST BEARING (9), BALL SEAL (10), SHAFT SEALS (11), INLET SLEEVE FASTENERS (12), AND CUPWASHERS (13), AND THE OUTLET SLEEVE FASTENERS (14) AND CUPWASHERS (15). HEAT TREATED INCONEL 718 IS USED FOR THE SHAFT, BELLOW, CAM FOLLOWER, THE INLET AND OUTLET SLEEVES (1), (2), (3), (4), (5). INCONEL 718 WAS SELECTED FOR ITS CRYOGENIC STRENGTH AND DUCTILITY AND FOR ITS WELDABILITY (16). THE INLET AND OUTLET SLEEVES ARE INSTALLED WITH 6 HEAT TREATED A-286 SCREWS. THE CUPWASHERS ON THE INLET SLEEVE ARE STAKED INTO THE SCREWHEAD AND THE SLEEVE FLANGE TO PREVENT LOSS OF SCREW TORQUE. THE OUTLET FLANGE SCREWS ARE LOCKED BY A FLAT ON THE CUP AND BY STAKING THE CUP INTO THE SCREWHEAD. THE CAM BEARINGS, SHAFT BEARINGS, AND THRUST BEARINGS HAVE HEAT TREATED 440C CRES ROLLERS AND RACES (7), (8), (17). THE MATERIAL IS USED FOR ITS HARDNESS AND WEAR RESISTANCE (16). THE SHAFT BEARINGS AND THRUST BEARINGS HAVE BE-CU RETAINERS WHICH SEPERATE THE ROLLERS AND PREVENT ROLLER SKEWING. BE-CU WAS CHOSEN FOR ITS WEAR RESISTANCE. THE SHAFT BEARING RETAINER RING IS 304 CRES (6). THE MATERIAL IS USED IN THIS APPLICATION FOR ITS DUCTILITY (16). THE BALL SEAL MATERIAL IS KEL-F (10). KEL-F IS USED FOR ITS CRYOGENIC STRENGTH, DUCTILITY, AND WEAR RESISTANCE (16). THE BALL SEAL O.D. IS A CLOSE FIT WITH THE BELLOW. WHEN OPOV INLET PRESSURE IS APPLIED THE SEAL DEFLECTION IS LIMITED AND THE HOOP LOAD IS PICKED UP BY THE BELLOW. THIS LIMITS THE HOOP STRESS IN THE SEAL AND PREVENTS STRUCTURAL FAILURE (18). THE BALL SEALS ARE LIMITED TO 27 STARTS (26). THE SHAFT SEAL MATERIAL IS GRAPHITE-FILLED POLYIMIDE (11). THE MATERIAL WAS SELECTED FOR ITS STRENGTH, CREEP RESISTANCE, AND WEAR RESISTANCE (16). THE INLET AND OUTLET FASTENERS AND CUPWASHERS ARE PREVENTED FROM ENTERING THE LOX FLOW AREAS BY THE ATTACHING DUCT FLANGES. THE INLET CUPWASHERS ARE MADE FROM ANEALD 302 CRES. THE OUTLET CUPWASHERS ARE MADE FROM ANEALD 321 CRES. BOTH MATERIALS ARE USED FOR THEIR DUCTILITY, CORROSION RESISTANCE AND STRENGTH. ALL OF THE INTERNAL STRUCTURAL PARTS MEET THE STANDARD LOX COMPATIBILITY REQUIREMENTS WITH THE EXCEPTION OF THE SHAFT AND BALL SEALS. THE SHAFT AND BALL SEALS HAVE BEEN VERIFIED TO BE LOX COMPATIBLE IN THEIR OPERATING ENVIRONMENT AND APPROVED FOR USE (19). HIGH AND LOW CYCLE FATIGUE LIFE FOR THE OPOV COMPONENTS MEET CEI REQUIREMENTS (20). THE MINIMUM FACTORS OF SAFETY FOR THE OPOV MEET CEI REQUIREMENTS (21). THE OPOV COMPONENTS WERE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (22). TABLE D140 LISTS ALL THE FMEA/CIL WELDS AND IDENTIFIES THOSE WELDS IN WHICH THE CRITICAL INITIAL FLAW SIZE IS NOT DETECTABLE, AND THOSE IN WHICH THE ROOT SIDE IS NOT ACCESSABLE FOR INSPECTION. THESE WELDS HAVE BEEN ASSESSED AS ACCEPTABLE FOR FLIGHT BY RISK ASSESSMENT (23). THE OPOV SUCCESSFULLY PASSED THE DESIGN VERIFICATION TESTING REQUIREMENTS (24), INCLUDING VIBRATION AND ENDURANCE TESTS (25).

(1) RS008263; (2) RS008230; (3) RS008310; (4) RS008311; (5) RS010353; (6) RS008306; (7) RES1095; (8) RES1027; (9) RES1032; (10) RS008309; (11) RES1147; (12) R0011948; (13) RD153-3003/RD153-3008; (14) RS010355; (15) RS010360; (16) RSS-8582; (17) RES1096; (18) RS008268; (19) RL10017; (20) RL00532, CP320R0003B; (21) RSS-8546, CP320R0003B; (22) NASA TASK 117; (23) RSS-8756; (24) DVS-SSME-515; (25) RSS-515-24A, RSS-515-17; (26) DAR 2761

**SSME FMEA/CIL  
INSPECTION AND TEST**

Component Group: Propellant Valves  
 CIL Item: 0140-05  
 Component: Oxidizer Preburner Oxidizer Valve  
 Part Number: RS008258  
 Failure Mode: Piece part structural failure.

Prepared: P. Lowmore  
 Approved: T. Nguyen  
 Approval Date: 6/30/99  
 Change #: 1  
 Directive #: CGBD ME3-01-6226  
 Page: 1 of 1

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	SEAL SEALS OUTLET SLEEVE FOLLOWER ASSEMBLY INLET SLEEVE SHAFT BEARING RETAINER BELLOWS ASSEMBLY SHAFT ASSEMBLY BEARING ASSEMBLY BEARING ASSEMBLY BEARING ASSEMBLY BEARING ASSEMBLY CONICAL WASHER CONICAL WASHER CUPWASHER SCREW FASTENER		RS008309 RES1147 RS010353 RS008310 RS008311 RS008306 RS008230 RS008263 RES1095 RES1096 RES1027 RES1032 RD153-3003 RD153-3006 RS010360 RS010355 R0011948
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS, INCLUDING LOX COMPATIBILITY.	RS008309 RES1147 RS010353 RS008310 RS008311 RS008306 RS008230 RS008263 RES1095 RES1096 RES1027 RES1032 RD153-3003 RD153-3006 RS010360 RS010355 R0011948 RL10017
		THE BALL SEAL MATERIAL IS EXAMINED FOR VOIDS, FISSURES, BUBBLES, AND STRESS CRACKS. TENSILE SPECIMENS ARE TAKEN FROM EACH TUBE OF MATERIAL AND TESTED AT CRYOGENIC TEMPERATURES TO ASSURE ADEQUATE STRENGTH AT THE OPERATING TEMPERATURES.	RB0130-094
		EACH LOT OR BATCH OF SHAFT SEAL MATERIALS IS INSPECTED FOR COLOR, SPECIFIC GRAVITY, FLEXURAL STRENGTH, AND TENSILE STRENGTH.	RB0130-090
		THE CAM FOLLOWER IS PENETRANT INSPECTED AFTER HEAT TREAT AND MACHINING	PAR146-116

Component: Propellant valves  
 CIL Rem: D140-05  
 Component: Oxidizer Preburner Oxidizer Valve  
 Part Number: RS008258  
 Failure Mode: Piece part structural failure.

Prepared: F. Lowman  
 Approved: T. Nguyen  
 Approval Date: 6/30/99  
 Change #: 1  
 Directive #: CGBD ME3-01-5228

Page: 2 of 3

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	MATERIAL INTEGRITY	HEAT TREAT OF FOLLOWER IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RAC511-020
		THE INLET SLEEVE IS PENETRANT INSPECTED AFTER MACHINING.	RA0115-116
		DRY-FILM LUBE OF THE INLET SLEEVE IS VERIFIED PER DRAWING REQUIREMENTS.	RS008311
		THE BELLOWS HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1611-002
		DRY-FILM LUBRICANT OF THE BELLOWS IS INSPECTED PER DRAWING REQUIREMENTS.	RS008230
		BELLOWS SPRING RATE/LOAD AND ELASTIC RETURN ARE TESTED PER DRAWING REQUIREMENTS.	
		ONE OF EVERY 25 DELIVERABLE BELLOWS IS SECTIONED AFTER ACCEPTANCE TESTING AND INSPECTED.	RS008230 RL00273 RL01122
		THE BELLOWS ASSEMBLY IS PROOF PRESSURE TESTED AND LEAK CHECKED.	
		SHAFT HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
		SHAFT DETAILS ARE PENETRANT INSPECTED.	RA0115-116
		DRY-FILM LUBE OF THE SHAFT BEARING RETAINERS IS VERIFIED PER DRAWING REQUIREMENTS.	RES1027
		BEARING HEAT TREATMENT IS VERIFIED PER DRAWING REQUIREMENTS.	RES1095 RES1027
		BELLOWS ASSEMBLY SHAFT ASSEMBLY SHAFT AND BELLOWS 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.
ASSEMBLY INTEGRITY	TORQUE AND STAKING OF INLET AND OUTLET FASTENERS ARE INSPECTED. THE ASSEMBLED VALVE IS OPERATION/FUNCTION TESTED DURING MANUFACTURING. HOT FIRE TESTING AND 2ND E & M INSPECTIONS VERIFY SATISFACTORY VALVE OPERATION.	RL00472 RL00058-C4 RL00058-C6 RL00058-C7	
HOT-FIRE ACCEPTANCE TESTING (GREEN RUN)	VALVE OPERATION IS VERIFIED THROUGH HOT-FIRE ACCEPTANCE TESTING. VALVE ACTUATION IS VERIFIED DURING PRE-LAUNCH FRT CHECKOUT. (LAST TEST) BALL SEAL LEAKAGE IS TESTED PRIOR TO LAUNCH. (LAST TEST)	RL00461 OMRSD V41AS0.033 OMRSD S00FA0 211 OMRSD V41BQ0.120 OMRSD S00FA0 214	

D-82

Component Group: Propellant Valves  
CIL Item: D140-05  
Component: Oxidizer Preburner Oxidizer Valve  
Part Number: RS008258  
Failure Mode: Piece part structural failure.

Prepared: P. Lowrmore  
Approved: T. Nguyen  
Approval Date: 6/30/99  
Change #: 1  
Directive #: CGBD ME3-01-5226  
Page: 3 of 3

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 TTA/CIL  
WELD JOINTS**

Component Group: Propellant Valves  
 CIL Item: D140  
 Component: Oxidizer Preburner Oxidizer Valve  
 Part Number: RS008258

Prepared: P. Lowrmore  
 Approved: T. Nguyen  
 Approval Date: 6/30/99  
 Change #: 1  
 Directive #: CCBD ME3-01-5228  
 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		