

SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Propellant Valves
 CIL Item: D120-05
 Component: Main Oxidizer Valve
 Part Number: RS000255
 Failure Mode: Piece part structural failure.

Prepared: P. Lowimore
 Approved: T. Nguyen
 Approval Date: 8/30/99
 Change #: 1
 Directive #: CCBD ME3-01-5228
 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 F/A/CIL
DESIGN

Component Group: Propellant Valves
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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.

MOV 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), AND THE INLET AND OUTLET SLEEVE CUPWASHERS (12) AND FASTENERS (13). THE CUPWASHERS ARE MADE FROM ANEALD 302 CRES. 302 CRES WAS SELECTED FOR ITS DUCTILITY AND STRENGTH (14). THE INLET AND OUTLET SLEEVES ARE INSTALLED WITH 16 AND 8 HEAT TREATED A-286 SCREWS (13). 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. HEAT TREATED INCONEL 718 IS USED FOR THE SHAFT, BELLOW, AND CAM FOLLOWER (1), (2), (3). INCONEL 718 WAS SELECTED FOR ITS CRYOGENIC STRENGTH AND DUCTILITY AND FOR ITS WELDABILITY (14). THE INLET AND OUTLET SLEEVES ARE FABRICATED FROM ARMCO 21-6-9 (4) (5). THE MATERIAL WAS SELECTED FOR STRENGTH AND MACHINABILITY (14). THE CAM BEARINGS, SHAFT BEARINGS, AND THRUST BEARINGS HAVE HEAT TREATED 440C CRES ROLLERS AND RACES (7), (8), (9). THE MATERIAL IS USED FOR ITS HARDNESS AND WEAR RESISTANCE (14). 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 302 CRES (6). THE MATERIAL IS USED IN THIS APPLICATION FOR ITS DUCTILITY (14). THE BALL SEAL MATERIAL IS KEL-F (10). KEL-F IS USED FOR ITS CRYOGENIC STRENGTH, DUCTILITY, AND WEAR RESISTANCE (14). THE BALL SEAL O.D. IS A CLOSE FIT WITH THE BELLOW. WHEN MOV 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 (15). THE SHAFT SEAL MATERIAL IS GRAPHITE-FILLED POLYIMIDE (11). THE MATERIAL WAS SELECTED FOR ITS STRENGTH, CREEP RESISTANCE, AND WEAR RESISTANCE (14). 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 (16). HIGH CYCLE AND LOW CYCLE FATIGUE LIFE OF THE MOV COMPONENTS MEET CEI REQUIREMENTS (17). THE MINIMUM FACTORS OF SAFETY FOR THE MOV MEET CEI REQUIREMENTS (18). THE MOV COMPONENTS WERE CLEARED FOR FRACTURE MECHANICS/NDI FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (19). TABLE D120 LISTS ALL THE FMEACIL 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 (20). THE MOV SUCCESSFULLY PASSED THE DESIGN VERIFICATION TESTING REQUIREMENTS (21), INCLUDING VIBRATION AND ENDURANCE TESTS (22).

(1) RSD08271; (2) RSD08211; (3) RS008165; (4) RS008186; (5) RS008091; (6) RS008192; (7) RES1118; (8) RES1097, RES1092; (9) RES1096; (10) RSD08184; (11) RES1149 (12) RD153-3003/ RD153-3008; (13) R0011948; (14) RSS-8575; (15) RS008255; (16) RL10017; (17) RL00632, CP320R0003B; (18) RSS-8546, CP320R0003B; (19) NASA TASK 117; (20) RSS-8755; (21) DVS-SSME-515; (22) RSS-515-24A, RSS-515-17

**SSME FMEACIL
INSPECTION AND TEST**

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 Page: 1 of 3

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	BALL SEAL SHAFT 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 SCREW MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS, INCLUDING LOX COMPATIBILITY.	RS008184 RES1149 RS008091 RS008185 RS008186 RS008192 RS008211 RS008271 RES1092 RES1096 RES1097 RES1118 RD153-3003 RD153-3008 R0011948 RS008184 RES1149 RS008091 RS008185 RS008186 RS008192 RS008211 RS008271 RES1092 RES1096 RES1097 RES1118 RD153-3003 RD153-3008 R0011948 RL10017 R00130-094 R00130-090 RA0115-116 RS008185 RAD611-020
		EACH LOT OF KEL-F FOR THE RS008184 SEAL IS SUBJECTED TO A MOLTEN SALT BATH EXAMINATION, VISUAL EXAMINATION, CONTAMINATION INSPECTION, TENSILE STRENGTH AND ELONGATION TESTS, INFARED ANALYSIS, AND LOX COMPATIBILITY.	
		EACH LOT OR BATCH OF SHAFT SEAL MATERIALS IS INSPECTED FOR COLOR, SPECIFIC GRAVITY, FLEXURAL STRENGTH, AND TENSILE STRENGTH.	
		THE CAM FOLLOWER IS PENETRANT INSPECTED AFTER HEAT TREAT AND MACHINING.	
		DRY-FILM LUBE OF CAM FOLLOWER IS VERIFIED PER DRAWING REQUIREMENTS.	
		HEAT TREAT OF FOLLOWER IS VERIFIED PER SPECIFICATION REQUIREMENTS	

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 Page: 2 of 3

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference	
A	MATERIAL INTEGRITY	THE BELLOWS HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1611-002 RA0611-020	
		DRY-FILM LUBRICANT OF THE BELLOWS IS INSPECTED PER DRAWING REQUIREMENTS.	RS008211	
		BELLOWS SPRING RATE/LOAD AND ELASTIC RETURN ARE TESTED PER DRAWING REQUIREMENTS		
		ONE OUT OF EVERY 25 DELIVERABLE BELLOWS IS SECTIONED AFTER ACCEPTANCE TESTING AND INSPECTED.	RS008211 RL00271	
		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.	RES1092 RES1097	
		BEARING HEAT TREATMENT IS VERIFIED PER DRAWING REQUIREMENTS.	RES1118 RES1092 RES1097	
		BELLOWS ASSEMBLY		RS008211
		SHAFT ASSEMBLY		RS008271
		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.	RL10011 RA0607-094 RA0115-116 RA0115-006 RA0115-127 RA1115-001
		ASSEMBLY INTEGRITY	THE INLET AND OUTLET SLEEVE FASTENER TORQUE AND STAKING ARE INSPECTED PER SPECIFICATION. THE ASSEMBLED VALVE IS OPERATION/FUNCTION TESTED DURING MANUFACTURING.	RL00436
HOT-FIRE ACCEPTANCE TESTING (GREEN RUN)	VALVE OPERATION IS VERIFIED THROUGH HOT-FIRE ACCEPTANCE TESTING. VALVE ACTUATION IS VERIFIED DURING PRE-LAUNCH FRT AND ACTUATOR CHECKOUT.	RL00461		
	A BALL SEAL LEAK TEST IS PERFORMED PRIOR TO EACH LAUNCH. (LAST TEST)	OMRSD V41AS0 010 OMRSD V41AS0 030 OMRSD S00FA0.211 OMRSD V41BQ0 120 OMRSD S00FA0.214		

D-30

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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 Rockaldyne letter 88RC09761.		
Operational Use:	Not Applicable.		

SSME / FA/CIL
WELD JOINTS

Component Group: Propellant Valves
 CIL Kent: D120
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Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable		Comments
						HCF	LCF	
BELLOWS	RS008211	3,4	EBW	II	X	X	X	
BELLOWS	RS008211	5-8	GTAW	I				
SHAFT	RS008271	1,2	EBW	II	X	X		