

**SSME FMEA/CIL  
REDUNDANCY SCREEN**

Component Group: Propellant Valves  
 CIL Item: D140-02  
 Component: Oxidizer Preburner Oxidizer Valve  
 Part Number: RS006258  
 Failure Mode: Fails to move or moves slowly.

Prepared: P. Lowimore  
 Approved: T. Nguyen  
 Approval Date: 6/30/99  
 Change #: 2  
 Directive #: CCBD ME3-01-5226  
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Phase	Failure / Effect Description	Criticality Hazard Reference
M 4.1	<p>Out-of-limit valve position results in controller switch to channel B; continuation of failure mode results in hydraulic actuator lockup of all actuators. Mission abort may result when hydraulic lockup occurs during Max Q throttling.</p> <p>Redundancy Screens: VALVE SYSTEM - ACTUATOR SYSTEM: UNLIKE REDUNDANCY.</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround.            B: Pass - Loss of a redundant hardware items is detectable during flight.            C: Pass - Loss of redundant hardware items could not result from a single credible event.</p>	<p>1R ME-B6M, ME-G6M</p>
M 4.2	<p>When not detectable by SEII, OPOV failure causes reductions in OPB temperature, turbine power, and MCC Pc. Controller initiates engine shutdown. Mission abort.</p> <p>Redundancy Screens: VALVE SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY.</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround.            B: Pass - Loss of a redundant hardware items is detectable during flight.            C: Pass - Loss of redundant hardware items could not result from a single credible event.</p>	<p>1R ME-B6M, ME-G6M</p>
C 4.1	<p>Out-of-limit valve position results in controller switch to channel B; continuation of failure mode results in pneumatic shutdown mode; valve fails to move, the other propellant valves also remain open; engine fails to shutdown until vehicle pre- valve closure. Loss of vehicle.</p> <p>Redundancy Screens: SINGLE POINT FAILURE: N/A.</p>	<p>1 ME-G1A,C</p>
C 4.2	<p>When not detectable by SEII, OPOV remains open, other valves close normally causing overpressurization and subsequent rupture of LOX ducts. Loss of vehicle.</p> <p>Redundancy Screens: SINGLE POINT FAILURE: N/A.</p>	<p>1 ME-G3A,C</p>

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SSME F FAJIL  
DESIGN

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Design / Document Reference

**FAILURE CAUSE: A: Seizure of OPOV shaft/bearings.**

THE OPOV (1), THRUST (2), AND SHAFT BEARINGS (3) ARE ROLLER BEARINGS. THEY ARE USED FOR THEIR FRICTION AND LOAD CAPACITY CHARACTERISTICS. THE ROLLERS AND RACES ARE 440C (2) (3), WHICH WAS SELECTED FOR ITS HARDNESS, STRENGTH, AND CORROSION RESISTANCE (4). THE ROLLERS ARE SEPARATED BY A BE-CU RETAINER (2) (3). THE SHAFT BEARING RETAINERS ARE DRY-FILM LUBRICATED (4) TO REDUCE ROLLER-TO-RETAINER FRICTION (3). THE RETAINER PREVENTS ROLLER-TO-ROLLER CONTACT AND MINIMIZES THE ROLLER RUBBING VELOCITY. THE RETAINER PREVENTS SEIZURE CAUSED BY ROLLER SKEWING. THE LOW ROTATIONAL VELOCITY WITH LESS THAN 90 DEGREES TRAVEL PRECLUDES SEIZURE CAUSED BY WEAR OR SPALLING. THE VALVE COMPONENTS ARE CLEANED PRIOR TO ASSEMBLY (5). THE VALVE IS ASSEMBLED IN A CONTAMINATION CONTROLLED ENVIRONMENT (6). THE OXIDIZER SUPPLY IS FILTERED TO 800-MICRONS (7). BINDING OR SEIZURE OF THE OPOV WILL BE DETECTED BY THE ACTUATOR RVDT CONTROLLER MONITOR AND RESULT IN A VEHICLE COMMANDED SHUTDOWN (8). THE MONITOR SYSTEM IS COMPRISED OF REDUNDANT SENSOR ELECTRONICS, REDUNDANT HARNESS, AND REDUNDANT CONTROLLER CHANNELS.

(1) RS008258; (2) RES1032; (3) RES1027; (4) RSS-8582; (5) RL10001; (6) RQ0711-600; (7) ICD 10M15000; (8) CP406R0002 PT 1 3.2.3:5.1

**FAILURE CAUSE: B: Broken shaft or coupling.**

THE 3 PIECE COUPLING TRANSFERS TORQUE FROM THE ACTUATOR TO THE OPOV SHAFT (1) (2). THE COUPLING PREVENTS SIDE LOADS CAUSED BY ACTUATOR/VALVE CENTERLINE MISALIGNMENT. THE SHAFT, UPPER AND LOWER COUPLINGS (3) ARE INCONEL 718 WHICH WAS CHOSEN FOR ITS CRYOGENIC STRENGTH, DUCTILITY, AND CORROSION RESISTANCE (4). THE INTERMEDIATE COUPLING (5) IS HEAT TREATED NITRIDING STEEL. THIS PROVIDES CORE STRENGTH AND DUCTILITY TO TRANSMIT TORQUE AND SURFACE HARDNESS TO RESIST WEAR (4). THE INTERMEDIATE COUPLING IS DRY-FILM LUBRICATED TO REDUCE FRICTION AND WEAR (5).

(1) RS008258; (2) RS008263; (3) RS008318; (4) RSS-8582; (5) RS008320

**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 WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH. SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (2). THE OXIDIZER PREBURNER OXIDIZER VALVE SUCCESSFULLY COMPLETED DVS TEST REQUIREMENTS (3), INCLUDING ENDURANCE (4), AND VIBRATION (5).

(1) RL00632, CP320R00036, RSS-8546; (2) NASA TASK 117; (3) DVS-SSME-515; (4) RSS-515-17; (5) RSS-515-24

**SSME FMEA/CIL**  
**INSPECTION AND TEST**

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference	
A	OPB OXIDIZER VALVE		RS008258	
	SHAFT		RS008263	
	SHAFT BEARING		RES1027	
	THRUST BEARING		RES1032	
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RS008263	
		HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS.	RES1027	
	LUBRICATION	DRY-FILM COATING OF SHAFT BEARINGS IS VERIFIED PER DRAWING REQUIREMENTS.	RES1027	
ASSEMBLY INTEGRITY		DURING ASSEMBLY AND FUNCTIONAL TEST OF THE OPB OXIDIZER VALVE TORQUE ACTUATION IS VERIFIED.	RL00472	
		VALVE IS ACTUATED AND RESPONSE TIME IS VERIFIED DURING CONTROLLER FLIGHT READINESS CHECKOUT AND DURING ACTUATOR CHECKOUT.	OMRSD V41A50.030 OMRSD V41A50.010	
		VALVE IS ACTUATED 10 TIMES DURING HYDRAULIC CONDITIONING. (LAST TEST)	OMRSD S00FA0.211	
B	SHAFT		RS008263	
	COUPLING		RS008318	
	SLIDER		RS008320	
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.		
		HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS		
LUBRICATION		MACHINED PARTS ARE PENETRANT INSPECTED PER DRAWING REQUIREMENTS	RS008263 RS008320	
		DRY-FILM LUBRICATION IS VERIFIED PER DRAWING REQUIREMENTS.	RS008320	
ALL CAUSES	OPB OXIDIZER VALVE		RS008258	
	ASSEMBLY INTEGRITY		FINISHED PARTS ARE VERIFIED CLEAN PER SPECIFICATION REQUIREMENTS.	RL10001
			VALVE IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA.	RQ0711-600
			VALVE IS RE-FLOW TESTED WHENEVER IT IS REPLACED, OR OPOV OUTLET FLANGE FASTENERS ARE LOOSENEED.	OMRSD V41B00.190
			VALVE IS ASSEMBLED AND FUNCTIONALLY TESTED PER SPECIFICATION.	RL00472
		HOT FIRE TESTING AND 2ND E & M VERIFY SATISFACTORY VALVE OPERATION.	RL00050-04 RL00058-06 RL00056-07	
HOT-FIRE ACCEPTANCE	VALVE OPERATION IS VERIFIED THROUGH HOT-FIRE ACCEPTANCE TESTING. (LAST TEST)			

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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 B9RC09761.		
Operational Use:	FAILURE MODE CAN BE DETECTED IN REALTIME BY THE FLIGHT CONTROL TEAM WHO WILL EVALUATE EFFECTS UPON VEHICLE PERFORMANCE AND ABORT CAPABILITY. BASED ON THIS EVALUATION THE APPROPRIATE ABORT MODE OR SYSTEM CONFIGURATION WILL BE SELECTED. FAILURE DETECTION CUES AND ASSOCIATED SSME PERFORMANCE DATA HAVE BEEN COORDINATED BETWEEN THE ENGINEERING AND FLIGHT OPERATIONS ORGANIZATIONS WITH THE RESPONSES DOCUMENTED IN MISSION FLIGHT RULES.		

**SSME T/A/CIL  
WELD JOINTS**

Component Group: Propellant Valves  
 CIL Item: D140  
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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	RS008230	3,4	GTAW	II	X	X		
BELLOWS	RS008230	5-7	GTAW	I				
SHAFT	RS008263	1,2	EBW	II	X	X		