

**SSME FMEA/CIL
REDUNDANCY SCREEN**

Component Group: Propellant Valves
 CIL Item: O110-02
 Component: Main Fuel Valve
 Part Number: RS006256
 Failure Mode: Fails to move or moves slowly.

Prepared: P. Low/more
 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
S 4.2	When MFV failure is not detectable by SEII, the loss of fuel results in failure to establish ignition in one or more combustion chambers or in excessive preburner temperatures. Controller initiates shutdown. Mission scrub. Loss of vehicle due to ignition failure or LOX-rich operation may result if not detected. Redundancy Screens: VALVE SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Pass - Loss of a redundant hardware item is detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.	1R ME-B7S
S 4.3	When shaft or coupling fails during start transient, MFV closes. LOX propellant valves open per normal schedule causing LOX-rich operation. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A.	1 ME-B7S ME-B7M
C 4.2	When detected by SEII, controller switches to channel B; if valve position remains out-of-limits, controller initiates pneumatic shutdown; failure continues, fuel flow continues until vehicle closure of prevalve; post shutdown fire; open air detonation when premature shutdown occurs on launch pad. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A.	1 ME-A1A ME-B7A,C

SSME FMEA/CIL
DESIGN

Component Group: Propellant Valves
CIL Item: D110-02
Component: Main Fuel Valve
Part Number: RS008256
Failure Mode: Falls to move or moves slowly.

Prepared: P. Lowmore
Approved: T. Nguyen
Approval Date: 8/30/99
Change #: 2
Directive #: CCBDMFJ-01-5225
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Design / Document Reference

FAILURE CAUSE: A: Broken shaft or coupling.

THE 3 PIECE COUPLING TRANSFERS TORQUE FROM THE ACTUATOR TO THE MFV SHAFT (1) (2). THE COUPLING PREVENTS SIDE LOADS CAUSED BY ACTUATOR/VALVE CENTERLINE MISALIGNMENT. THE SHAFT, UPPER COUPLING (3), AND LOWER COUPLING (4) ARE HEAT TREATED INCONEL 718 WHICH WAS CHOSEN FOR ITS CRYOGENIC STRENGTH, DUCTILITY, AND CORROSION RESISTANCE (5). THE INTERMEDIATE COUPLING (5) IS HEAT TREATED NITRIDING STEEL. THIS PROVIDES CORE STRENGTH AND DUCTILITY TO TRANSMIT TORQUE AND SURFACE HARDNESS TO RESIST WEAR (5). THE INTERMEDIATE COUPLING IS DRY-FILM LUBRICATED TO REDUCE FRICTION AND WEAR (6).

(1) RS008256; (2) RS008271; (3) RS008084; (4) RS008083; (5) RSS-8576; (6) RS008180

FAILURE CAUSE: B: Seizure of MFV shaft/bearings.

THE MFV (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 AND ONE OPEN/CLOSE CYCLE PER TEST PRECLUDES SEIZURE CAUSED BY WEAR OR SPALLING. THE VALVE COMPONENTS ARE CLEANED PRIOR TO ASSEMBLY (5). THE VALVE IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA (6). FUEL SUPPLY TO THE ENGINE IS FILTERED TO 400-MICRONS (7). BINDING OR SEIZURE OF THE MAIN FUEL VALVE WILL BE DETECTED BY THE ACTUATOR RVDT CONTROLLER MONITORS AND RESULT IN A VEHICLE COMMANDED SHUTDOWN (8). THE SYSTEM IS COMPRISED OF REDUNDANT SENSOR ELECTRONICS, REDUNDANT HARNESS, AND REDUNDANT CONTROLLER CHANNELS.

(1) RS008256; (2) RES1096; (3) RES1092, RES1097; (4) RSS-8576; (5) RL10001; (6) RQ0711-600; (7) ICD 13M15000; (8) CP406R0002 PT 1 3 2.3.6.1

FAILURE CAUSE: ALL CAUSES

HIGH CYCLE AND LOW CYCLE FATIGUE AS WELL AS MINIMUM FACTORS OF SAFETY FOR THE MAIN FUEL VALVE MEE I CEI REQUIREMENTS (1). THE MFV INTERNAL COMPONENTS PARENT MATERIAL WERE CLEARED FOR FRACTURE MECHANICS/FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (2). 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. THESE WELDS HAVE BEEN ASSESSED AS ACCEPTABLE FOR FLIGHT BY RISK ASSESSMENT (3). THE MAIN FUEL VALVE SUCCESSFULLY COMPLETED DVS TEST REQUIREMENTS (4), INCLUDING ENDURANCE (5), AND VIBRATION (6).

(1) RL00632, CP320R0003B, RSS-8546; (2) NASA TASK 117; (3) RSS-8756; (4) DVS-SSME-515; (5) RSS-515-17; (6) RSS-515-24

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**SSME FMEA/CIL
INSPECTION AND TEST**

Component Group: Propellant Valves
 CIL Item: D110-02
 Component: Main Fuel Valve
 Part Number: RS008256
 Failure Mode: Fails to move or moves slowly.

Prepared: P. Lowmore
 Approved: T. Nguyen
 Approval Date: 6/30/99
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 Directive #: CCB0 ME3-01-5226
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	SHAFT UPPER COUPLING LOWER COUPLING INTERMEDIATE COUPLING		RS008271 RS008084 RS008083 RS008180
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS. HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS. MACHINED PARTS ARE PENETRANT INSPECTED PER DRAWING REQUIREMENTS.	
	LUBRICATION	DRY-FILM COATING IS VERIFIED PER DRAWING REQUIREMENTS.	RS008180
B	MAIN FUEL VALVE SHAFT SHAFT BEARING SHAFT BEARING THRUST BEARING		RS008256 RS008271 RES1092 RES1097 RES1096
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS008271 RES1092 RES1097 RES1096
		HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS.	
	LUBRICATION	DRY-FILM COATING IS VERIFIED PER DRAWING REQUIREMENTS.	RES1092 RES1097
	ASSEMBLY TESTING	VALVE TORQUE IS VERIFIED DURING ASSEMBLY AND FUNCTIONAL TEST OF THE MAIN FUEL VALVE. VALVE IS ACTUATED AND RESPONSE TIME IS VERIFIED DURING CONTROLLER FLIGHT READINESS CHECKOUT, AND DURING ACTUATOR CHECKOUT PRIOR TO EACH FLIGHT. VALVE IS ACTUATED 10 TIMES PRIOR TO LAUNCH DURING HYDRAULIC CONDITIONING. (LAST TEST)	RL00453 OMRSD V41AS0.030 OMRSD V41AS0.010 OMRSD S00FA0.211
ALL CAUSES	MFV FUEL CLEANLINESS ASSEMBLY INTEGRITY	FUEL SUPPLY TO THE ENGINE IS FILTERED TO 400-MICRONS. FINISHED PARTS ARE VERIFIED CLEAN PER SPECIFICATION REQUIREMENTS. VALVE IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA. VALVE IS ASSEMBLED AND FUNCTIONALLY TESTED PER SPECIFICATION REQUIREMENTS.	RS008256 ICD 13M15000 RL10001 RQ0711 500 RL00453

D-7

Component: Propellant Valves
CII Item: 0110-02
Component: Main Fuel Valve
Part Number: RS006256
Failure Mode: Fails to move or moves slowly.

Prepared: F. Lozano
Approved: T. Nguyen
Approval Date: 6/30/99
Change #: 2
Directive #: CCBD ME3-01-5228
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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 88RC09781		
Operational Use:	Not Applicable.		

**SSME FACIL
WELD JOINTS**

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

Prepared: P. Lowrimore
 Approved: T. Ngruyen
 Approval Date: 6/30/99
 Change #: 1
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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	RS008208	3,4	EBW	II	X	X		
BELLOWS	RS008208	5-8	GTAW	I				
SHAFT	RS008271	1,2	EBW	II	X	X		