

**SSME FMEA/CIL**  
**REDUNDANCY SCREEN**

Component Group: Igniters and Sensors  
CIL Item: J781-02  
Component: Fuel Flowmeter  
Part Number: R0014001  
Failure Mode: Piece part failure.

Prepared: M. Olivar  
Approved: T. Nguyen  
Approval Date: 3/30/99  
Change #: 1  
Directive #: CCBD ME3-01-4984  
Page: 1 of 1

Phase	Failure / Effect Description	Criticality Hazard Reference
SMC 4.1	Blockage of fuel flow; possible cavitation of HPFTP; LOX-rich combustion with burn through and fire. Loss of vehicle  Redundancy Screens: SINGLE POINT: N/A	1 ME-D1S,M,A,C

SSME EA/CIL  
DESIGN

Component Group: Igniters and Sensors  
CIL Item: J701-02  
Component: Fuel Flowmeter  
Part Number: R0014001  
Failure Mode: Piece part failure.

Prepared: M. Oliver  
Approved: T. Nguyen  
Approval Date: 3/30/99  
Change #: 1  
Directive #: CGBO MEJ-01-4994

Page: 1 of 1

Design / Document Reference

FAILURE CAUSE: A: Structural failure of internal part: Rotor blades  
B: Structural failure of internal part: Straightening vanes  
C: Structural failure of internal part: Fatigue; parent material failure.

A TURBINE-TYPE FLOWMETER DESIGNED FOR HIGH-VELOCITY FLUID FLOW, LOW DRAG, AND LOW PRESSURE DROP IS USED AS A FLOWRATE SENSOR. THE FLOWMETER IS IN THE LOW-PRESSURE FUEL PUMP DISCHARGE DUCT AND IS DOWNSTREAM OF A FLOW STRAIGHTENER ASSEMBLY IN THE DUCT. BOTH THE FLOW STRAIGHTENER AND METER ARE WELDED-IN SECTIONS OF THE DUCT. THE FLOWMETER LONG AND SHORT SLEEVE AND HUB (1) ARE MADE FROM 321 CRES. THE FLOWMETER SHAFT (2) IS MADE FROM 347 CRES. IT WAS SELECTED BECAUSE OF ITS BRAZABILITY (3). THE FLOW STRAIGHTENER AND HOUSING (4) ARE MADE FROM ARMCO 21-6-9. THIS MATERIAL IS USED BECAUSE OF ITS STRENGTH AT CRYOGENIC TEMPERATURES (3). THE HOUSING IS SHOT-PEENED AFTER FINAL MACHINING. THE ROTOR (5) IS MADE FROM NICKEL 200. THIS MATERIAL WAS SELECTED PRIMARILY FOR ITS MAGNETIC PERMEABILITY PROPERTIES AND CRYOGENIC TOUGHNESS (3). THE FLOWMETER ROTOR OPERATES IN A CRYOGENIC FLUID, THEREFORE HYDROGEN ENVIRONMENT EMBRITTLEMENT IS NOT A PROBLEM. THE BEARING RACES AND BALLS (6) ARE MADE FROM 440C CRES. THE HIGH HARDNESS AND WEAR RESISTANCE ARE THE PRIMARY REASONS FOR USING THIS MATERIAL FOR BALL BEARING COMPONENTS (3). THE HYDROGEN EFFECT IS NOT A CONSIDERATION AT THE CRYOGENIC TEMPERATURES AT WHICH THE BEARINGS OPERATE. THE BEARING CAGE IS MADE FROM POLYTETRAFLUOROETHYLENE (PTFE) IMPREGNATED GLASS FABRIC. THIS MATERIAL WAS SELECTED BECAUSE OF LOW FRICTION, AND STRUCTURAL PROPERTIES AT LOW TEMPERATURES (3). THE PREVIOUS FLOWMETER DESIGN HAS COMPLETED DESIGN VERIFICATION TESTING (7) INCLUDING PRESSURE CYCLING (8). THIS DESIGN HAS BEEN CERTIFIED BY SIMILARITY AND TEST (9). HIGH CYCLE AND LOW CYCLE FATIGUE LIFE AS WELL AS THE MINIMUM FACTORS OF SAFETY FOR THE FUEL FLOWMETER, MEET CEI REQUIREMENTS (10). THE CONTROLLER MONITOR SYSTEM IS COMPRISED OF REDUNDANT SENSOR ELECTRONICS, REDUNDANT HARNESSSES, AND REDUNDANT CONTROLLER CHANNELS (11).

(1) RSD00240, RSD00249, RS008250; (2) RS008246; (3) RSS-8582-6; (4) R0014003, R0014002; (5) RSD09247; (6) RES1011; (7) DVS-SSME-511, RSS-8660; (8) RSS-511-31, RSS-511-45; (9) RSS-8660; (10) RL00532, CP320R0003B, RSS-8548; (11) CP405R0002 PT1 3,2,3 5

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

Component Group: Igniters and Sensors  
 CIL Item: J701-02  
 Component: Fuel Flowmeter  
 Part Number: R0014001  
 Failure Mode: Piece part failure.

Prepared: M. Oliver  
 Approved: T. Nguyen  
 Approval Date: 3/30/99  
 Change #: 1  
 Directive #: CCBD ME3-01-4094

Page: 1 of 1

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	FUEL FLOWMETER ASSEMBLY		R0014001
	CLEANLINESS REQUIREMENTS	ALL MATERIAL IN THE ASSEMBLY IS CLEANED TO FUEL SERVICE PER SPECIFICATION REQUIREMENTS	R0014001 RL10001
	FUEL FLOWMETER HOUSING FLOW STRAIGHTENER		R0014002 R0014003
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS. THE HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS. A PENETRANT INSPECTION IS PERFORMED ON THE HOUSING.	RA0111-018 RA0115-116 RS008247
	ROTOR		
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS. AN ULTRASONIC INSPECTION IS PERFORMED PRIOR TO MACHINING PER DRAWING REQUIREMENTS. A PENETRANT INSPECTION IS PERFORMED ON THE ROTOR PER DRAWING REQUIREMENTS. PROOF PRESSURE TEST IS PERFORMED ON THE LPFTP DISCHARGE DUCT ASSEMBLY PER DRAWING REQUIREMENTS.	RA0115-012 RA0115-116 RS007019
	HOT FIRE ACCEPTANCE TESTING (GREEN RUN)	THE LPFTP DISCHARGE DUCT ASSEMBLY IS HOT FIRE ACCEPTANCE TESTED. SCREENING REQUIREMENTS VERIFY ACCEPTABILITY. FLOWMETER OPERATION IS VERIFIED BY DATA REVIEW FROM THE PREVIOUS FLIGHT OR GREEN RUN. (LAST TEST)	RL00461 MSFC PLN 1228

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)  
 Reference: NASA letter SA21/88/30B and Rocketdyne letter 88RC09761

Operational Use: Not Applicable.

J - 207