

**SSME FMEA/CIL
REDUNDANCY SCREEN**

Component Group: Fuel Turbopumps
 CIL Item: B200-12
 Component: High Pressure Fuel Turbopump
 Part Number: RS007501
 Failure Mode: Excessive pump interstage seal leakage.

Prepared: D. Early
 Approved: T. Nguyen
 Approval Date: 4/21/98
 Change #: 1
 Directive #: CCBD ME3-01-5206
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Phase	Failure / Effect Description	Criticality Hazard Reference
S 4.1	Leakage results in reduced turbopump output. Decreased flow is sensed by the controller which increases the fuel preburner oxidizer flow. Excessive turbine discharge temperature will cause a redline shutdown. Mission scrub if detected by redline. Loss of vehicle due to HPFTP turbine failure may result if not detected. Redundancy Screens TURBOPUMP 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 items is detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.	1R ME-D1S,M
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**SSME FMEA/CIL
DESIGN**

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Design / Document Reference

FAILURE CAUSE: A: Fracture, distortion of interstage seal.
B: Excessive loss of bolt preload.

THERE ARE TWO PUMP INTERSTAGE SEALS (1) POSITIONED BETWEEN THE IMPELLERS TO CONTROL LEAKAGE BETWEEN STAGES AND TO PROVIDE ROTOR DAMPING. THEY ARE MANUFACTURED UTILIZING ALUMINUM ALLOY 6051-T651 BAR. THIS ALLOY WAS SELECTED FOR ITS RESISTANCE TO HYDROGEN ENVIRONMENT EMBRITTLEMENT CORROSION, AND STRESS CORROSION CRACKING (2). THE MATERIAL IS SOLUTION TREATED AND AGE-HARDENED. A HARD ANODIZE COATING IS APPLIED TO THE SEAL INSIDE DIAMETER AND COVERED WITH DRY-FILM LUBRICATION TO ENHANCE ITS RUBBING CHARACTERISTICS. THE REMAINDER OF THE SURFACES ARE CHROMIC OR SULFURIC ACID ANODIZED TO FURTHER INCREASE CORROSION RESISTANCE. THE FUNCTIONAL LENGTH OF THE SEAL INSIDE DIAMETER IS KNURLED FOR ROTORDYNAMIC STABILITY AND TAPERED TO COMPENSATE FOR DEFLECTIONS AND PROVIDE A CONSTANT RADIAL CLEARANCE WITH THE IMPELLER SLEEVES (3) IN OPERATION. THE SEALS ARE ATTACHED TO FLANGES ON THE DIFFUSERS (4); (5) BY 13 EACH A-286 CRES BOLTS (6) THREADED INTO THE SEAL AND LOCKED WITH A-286 CRES CUPWASHERS (7). A-286 CRES WAS SELECTED FOR ITS RESISTANCE TO HIGH-PRESSURE HYDROGEN DEGRADATION, MECHANICAL PROPERTIES, RETENTION OF TOUGHNESS AND DUCTILITY AT CRYOGENIC TEMPERATURES, AND ASSEMBLY TO PREVENT BOLT ROTATION. ASSEMBLY PROCEDURES FOR LOCKING DEVICES ENSURE DEFECT-FREE INSTALLATION (8). THE BOLTS ARE SILVER-PLATED AND DRY-FILM LUBRICATION IS APPLIED TO THE THREADS AT ASSEMBLY TO REDUCE THE FRICTIONAL FORCES RESULTING IN A MORE CONSISTENT CLAMPING LOAD. THE SEALS ARE RADIALLY PILOTED BY THE DIFFUSER INSIDE DIAMETERS. THE CLEARANCE BETWEEN THE SEALS AND THE SLEEVES ARE CONTROLLED TO MINIMIZE RUBBING WHILE REDUCING BYPASS LEAKAGE. THE MINIMUM FACTORS OF SAFETY MEET CEI REQUIREMENTS (9). THE HIGH AND LOW CYCLE FATIGUE LIFE OF THE INTERSTAGE SEALS MEET CEI REQUIREMENTS (10). THE INTERSTAGE SEALS PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NOE FLAW GROWTH SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (11). THE CONTROLLER SOFTWARE IS CONFIGURED TO DETECT AND RESPOND PROPERLY TO THE FAILURES IDENTIFIED AND COMMAND A SAFE ENGINE STATE (12). REFUSE OF PARTS DURING OVERHAUL IS CONTROLLED BY THE REQUIREMENTS OF THE OVERHAUL SPECIFICATION (13).

{1} RS007531; {2} RSS-8580-10; {3} RS007583, RS007504; {4} RS007527; {5} RS007532; {6} RS007792; {7} RS007794; {8} RL00351; {9} RSS-8546-16, CP320R0003B; {10} RL00592, CP320R0003B; {11} NASA TASK 117; {12} CP406RD002 PT 1 3.2.3.5.3; {13} RL0052B

**SSME FMEA/CIL
INSPECTION AND TEST**

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	SEAL, INTERSTAGE-HP FUEL TURBOPUMP		RS007531
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	
		THE SEAL IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
	HEAT TREAT	HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS.	RS007531
	SURFACE FINISH	KNURLING IS VERIFIED PER DRAWING REQUIREMENTS.	
		THE CHROMIC OR SULFURIC ACID ANODIZE OR HARD ANODIZE SURFACE FINISH IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1609-003
		THE DRY FILM LUBE IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0140-020
B	ASSEMBLY INTEGRITY	THE DIAMETERS OF THE SEAL AND SLEEVE ARE VERIFIED PER DRAWING REQUIREMENTS.	RS007531 RS007503
		THE ROTATING ASSEMBLY BALANCE IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RL00352
	SCREW CUPWASHER SEAL, INTERSTAGE		RS007792 R032220 RS007531
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS007792 RS007794 RS007531
	SURFACE FINISH	DRY FILM LUBE IS VERIFIED PER DRAWING REQUIREMENTS.	RS007792
ALL CAUSES	ASSEMBLY INTEGRITY	THE CUPWASHER DEFORMATION IS VERIFIED PER DRAWING REQUIREMENTS. SCREW TORQUE IS VERIFIED PER DRAWING REQUIREMENTS.	RS007501
	HPFTP		RS007501
	CLEANLINESS OF COMPONENTS	COMPONENTS ARE VERIFIED CLEANED PER SPECIFICATION REQUIREMENTS.	RL10001
ALL CAUSES	ASSEMBLY INTEGRITY	OPERATION/PERFORMANCE IS VERIFIED BY ENGINE HOT-FIRE TESTING AND 2ND E & M TESTS ON INSPECTIONS.	RL00050-04 RL00056-06 RL00056-07 RL00461
		THE PUMP SUBASSEMBLIES ARE INSPECTED DURING OVERHAUL PER SPECIFICATION REQUIREMENTS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, AND REPLACEMENT OF USAGE ITEMS AS APPLICABLE. PER OVERHAUL CLASSIFICATION.	RL0052B RA0115-116
		SHAFT TRAVEL IS PERFORMED PRIOR TO EACH FLIGHT. TORQUE CHECKS ARE PERFORMED PRIOR TO EACH FLIGHT.	OMRSD V41B50 020

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	ASSEMBLY INTEGRITY	DATA FROM PREVIOUS FLIGHT OR HOT FIRE IS REVIEWED FOR PROPER TURBOPUMP OPERATION/PERFORMANCE. (LAST TEST)	MSFC PLN 1228

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRAÇA)

Reference: NASA letter SA21/88/308 and Rocketdyne letter BRRC09761.

Operational Use: Not Applicable.

SSME FMEA/CIL
FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE

Component Group: Fuel Turbopumps
 Item Name: High Pressure Fuel Turbopump
 Item Number: B200
 Part Number: RS007501

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 Change #: 2
 Directive #: CCBD ME3-01-5208

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Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. B200-15 RS007502; CAUSE A, B200-24; RS007605; CAUSE A THE INNER AND OUTER BEARING RACES ARE EDDY CURRENT INSPECTED PER RL00743.	BEARING RACES RECEIVED FROM SUPPLIER SPLIT BALL BEARING INCORPORATED RECEIVED NO GENERAL EDDY CURRENT INSPECTION	GENERAL EDDY CURRENT INSPECTION OF RACES REPLACES TYPE IVC IN PENETRANT INSPECTION IN DETECTING SURFACE FLAWS USE AS IS RATIONALE: 1. RACES SUPPLIED BY SPLIT BALL BEARING INCORPORATED RECEIVED 10X VISUAL AND TYPE IVC PENETRANT INSPECTION INSTEAD OF GENERAL EDDY CURRENT INSPECTION. FLAW DETECTABILITY RELIABILITY LEVELS BETWEEN PENETRANT AND GENERAL EDDY CURRENT INSPECTIONS ARE 0.060 AND 0.057 RESPECTIVELY.	SEE DAR 2745 FOR VARIANT PART SERIAL NUMBERS.
2. B200-13 RS007527, RS007532, CAUSE A & B. B200-26; RS007532; CAUSE B. DIFFUSER HIDDEN SURFACES ARE PENETRANT INSPECTED PER RL00343.	SOME DIFFUSERS MAY NOT RECEIVE THE POST PROOF TEST HIDDEN SURFACE IIP PENETRANT INSPECTION	USE AS IS RATIONALE 1. IMPLEMENTATION OF HIDDEN SURFACE INSPECTION REQUIREMENT IS NOT A RESULT OF AN OBSERVED HARDWARE ANOMALY BUT AS A RESULT OF ROCKETDYNE'S STAND DOWN.	SEE DAR 2751 FOR VARIANT PART SERIAL NUMBERS
3 B200-14 CAUSE A, RS007568 B200-21 CAUSE B, RS007568 B200-26 CAUSE A, RS007568 WELD JOINTS RS007568 TABLE B200 HPFT FMEA/CIL WELD JOINTS RS007568 HOUSING CURRENT CONFIGURATION IS THE ONE(1) PIECE "113" CAP, USING FOUR (4) WELDS AND FOUR (4) WELD NUMBERS	SOME HOUSINGS (POSSIBLY TWO) MAY HAVE BEEN FABRICATED WITH THE TWO (2) PIECE "113" CAPS (THIS HAS AN EXTRA WELD: #13 AND THREE EXTRA WELD NUMBERS 13, 68 & 69)	TO REDUCE CONFUSION ON THE DRAWING AND ON THE MANUFACTURING FLOOR	SEE MCR 2524. SAME -113 DASH NUMBER.
4 B200-02; CAUSE A, RS007524 CAUSE B, RS007524; CAUSE C, RS007524	SOME TURBINE BEARING SUPPORTS (RS007524) ARE FABRICATED USING A WELDMENT OF HAYES 188 SHEET METAL INSTEAD OF THE EDM FORGING.	HIGH CYCLE FATIGUE INDUCED INLET SHEET METAL CRACKS DO OCCUR FROM THE OPERATIONAL ENVIRONMENT EXPERIENCED DURING ENGINE OPERATION. THE CRACKING IS CONTROLLED PER THE REQUIREMENTS OF THE SHEET METAL INSPECTION SPECIFICATION (RL00655) WHICH LIMITS THE CRACKING LENGTH, SPACING, AND SHAPE, TO PRECLUDE SHEET METAL PIECES FROM DISLODGING. THE CRITERIA IS BASED ON CRACK GROWTH RATES AND ENGINE TEST EXPERIENCE. ANY CRACKS, WHICH EXCEED THE SPECIFICATION LIMITS, ARE WELD REPAIRED (RF0001-007). THE TURBINE BEARING SUPPORT WITH WELDED SHEET METAL IS LIFE LIMITED BY MAJOR WAIVER DAR 2709.	RS007524-201 AND SUBS.

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Base Line Rationale	Variance	Change Rationale	Variant Dash Number
5 B200-18 CAUSE A, B200-17 CAUSE A, B200-18 CAUSE A, B200-19 CAUSE A, B200-22; CAUSE A,B,C,E	SOME LIFT-OFF SEAL HOUSING DRAIN LINES ARE FABRICATED USING INTERSECTING LINE DRILLED HOLES THE HOLE THAT INTERSECTS THE OUTSIDE DIAMETER OF THE HOUSING FLANGE HAS A PLUG INSTALLED. THE PLUG IS THEN WELDED AT THE HOUSING OUTSIDE DIAMETER TO FORM A TIGHT GAS SEAL	LOW CYCLE FATIGUE CRACKING HAS BEEN OBSERVED IN THE PLUG WELD. CRACK INITIATION AND PROPAGATION OCCURS AT SHUTDOWN/COOLDOWN ALL UNITS RECEIVE A STANDARD POST FLIGHT INSPECTIONS BY LEAK CHECK. LEAK CHECK POST FLIGHT WILL DETECT A CRACK PRIOR TO REFLIGHT. POST LEAKAGE AT THE DRAIN LINE IS LIMITED TO 10 SCIM. ALL FLIGHT UNITS WILL CONTINUE TO RECEIVE A LEAK CHECK POST FLIGHT FOR THE DRAIN LINE PLUG WELD UNTIL THE ENTIRE FLEET IS RETROFIT WITH THE EDM DRAIN LINE CONFIGURATION	R0019230-071 AND SUBS.

**SSME FMEA/CIL
WELD JOINTS**

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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	
SHIELD	R0012171	1,24, 28-52	GTAW	II	X			
SHIELD	R0012171	26	GTAW	II				
LIFT-OFF SEAL	R0019230	1, 2	GTAW	II	X			
SHIELD	R0019788	25, 28	GTAW	II				
SHIELD	R0019788	27, 50	GTAW	II	X			
SHIELD	R0019788	51, 52	GTAW	I				
SHIELD	R0019788	53, 55	GTAW	II				
BELLOWS	RS007505	1-4	GTAW	I		X		
BELLOWS	RS007505	5, 6	EBW	I		X		
INLET	RS007512	4	GTAW	I		X		
INLET	RS007512	5-6	GTAW	I				
INLET	RS007512	7-10, 12, 13	GTAW	I				
INLET	RS007512	11	EBW	II				
INLET	RS007512	14, 15	GTAW	I				
INLET	RS007512	16	GTAW	I		X		
BEARING SUPPORT	RS007524	14	EBW	I				
BEARING SUPPORT	RS007524	18	EBW	I	X			
BEARING SUPPORT	RS007524	29, 30	GTAW	I	X	X		
BEARING SUPPORT	RS007524	118	GTAW	I	X			
BEARING SUPPORT	RS007524	119, 121	EBW	I				
BEARING SUPPORT	RS007524	120	GTAW	II	X			
BEARING SUPPORT	RS007524	229-241	GTAW	II	X			
HOUSING	RS007568	75, 223, 228, 230, 298	GTAW	I	X	X	X	
HOUSING	RS007568	74	GTAW	I				
HOUSING	RS007568	48	EBW	I	X	X	X	
HOUSING	RS007568	43	GTAW	I	X			
HOUSING	RS007568	51	GTAW	II	X	X		
HOUSING	RS007568	52	GTAW	II	X			
HOUSING	RS007568	53	EBW	I				

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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	
HOUSING	RS007568	56	EBW	II	X			
HOUSING	RS007568	56	GTAW	II	X			
HOUSING	RS007568	57, 324, 325	GTAW	II				
HOUSING	RS007568	58	GTAW	II	X	X	X	
HOUSING	RS007568	59	EBW	I				
HOUSING	RS007568	74, 229, 297	GTAW	I	X	X	X	
HOUSING	RS007568	76, 77	GTAW	I		X		
HOUSING	RS007568	78-89	GTAW	II	X			
HOUSING	RS007568	90-101	GTAW	II	X			
HOUSING	RS007568	102	GTAW	I	X			
HOUSING	RS007568	139	GTAW	II	X			
HOUSING	RS007568	140	GTAW	II	X			
HOUSING	RS007568	150, 154	GTAW	II	X			
HOUSING	RS007568	174-185	GTAW	II	X			
HOUSING	RS007568	191, 192, 195, 196, 245, 455, 456	GTAW	II	X	X		
HOUSING	RS007568	193, 194, 197-202, 204-207	GTAW	II		X		
HOUSING	RS007568	203, 217, 218, 234, 236	GTAW	II	X	X		
HOUSING	RS007568	212, 213	GTAW	II				
HOUSING	RS007568	214, 215	GTAW	II	X			
HOUSING	RS007568	222, 239	GTAW	I		X		
HOUSING	RS007568	224, 225	GTAW	I		X	X	
HOUSING	RS007568	226, 227	GTAW	I		X		
HOUSING	RS007568	231, 232	GTAW	II	X	X		
HOUSING	RS007568	233	GTAW	II	X			
HOUSING	RS007568	237, 238	GTAW	II				
HOUSING	RS007568	246-248	GTAW	II				
HOUSING	RS007568	326-349	GTAW	II	X			
HOUSING	RS007568	374-397	GTAW	II	X			
HOUSING	RS007568	399	GTAW	I	X	X	X	