

**SSME FMEA/CIL
REDUNDANCY SCREEN**

Component Group: Fuel Turbopumps
 CIL Item: B200-23
 Component: High Pressure Fuel Turbopump
 Part Number: RS007501
 Failure Mode: Loss of balancing capability.

Prepared: D. Early
 Approved: T. Nguyen
 Approval Date: 4/21/99
 Change #: 1
 Directive #: CCBD ME3-D1-5206
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Phase	Failure / Effect Description	Criticality Hazard Reference
SMC 4.1	Rubbing of turbine platform seals, and/or rubbing of third-stage impeller back shroud against low pressure orifice results in reduced turbopump performance, damage to rubbing parts, and reduced coolant flow to turbine. Failure of turbopump components leads to external damage. Possible pump inlet burst due to pressure surge. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A	1 ME-D1S,M, ME-D1A,C

**SSME FMEA/CIL
DESIGN**

Component Group: Fuel Turbopumps
CIL Item: B200-23
Component: High Pressure Fuel Turbopump
Part Number: R5007501
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Design / Document Reference

FAILURE CAUSE: A: High pressure orifice failure.

THE HIGH-PRESSURE ORIFICE RING (1) IS MANUFACTURED UTILIZING AN INCOLOY 903 FORGING (2). INCOLOY 903 IS AN IRON BASE ALLOY WHICH WAS SELECTED FOR ITS STRENGTH AND IMMUNITY TO HYDROGEN ENVIRONMENT EMBRITTLEMENT. THE MATERIAL IS SOLUTION TREATED AND AGE-HARDENED. THE HIGH-PRESSURE ORIFICE WORKS IN CONJUNCTION WITH THE LOW-PRESSURE ORIFICE (3) TO BALANCE THE ROTOR THRUST, BY CONTROLLING THE AMOUNT OF FLUID FLOW INTO THE BALANCE PISTON CAVITY. THE HIGH-PRESSURE ORIFICE RING THREADS INTO THE MAIN HOUSING (4) AT THE OUTSIDE DIAMETER OF THE BACKPLATE OF THE THIRD-STAGE IMPELLER (5). EACH HIGH-PRESSURE ORIFICE RING IS MATCHED MACHINED TO THE HOUSING BY DRILLING AN ALIGNMENT HOLE THROUGH THE ORIFICE RING AND INTO THE HOUSING WITH THE RING BOTTOMED. AT ASSEMBLY THE ORIFICE RING IS THREADED IN THE HOUSING UNTIL THE TWO HOLES ALIGN WITHIN A SPECIFIED RANGE TO ASSURE THE BOTTOMING. MOLYKOTE 6 LUBRICANT IS APPLIED TO THE THREADS TO REDUCE FRICTIONAL FORCES (6). THE ORIFICE RING IS THEN PINNED IN PLACE (7). THE ORIFICE IS DESIGNED TO TIGHTEN IN THE DIRECTION OF IMPELLER ROTATION, TO PRECLUDE FLUID FORCES FROM LOOSENING THE RING. THE ORIFICE RING DOES NOT MAKE CONTACT WITH THE THIRD-STAGE IMPELLER DURING ANY PHASE OF OPERATION. THE THRUST BEARING (8) IS SHIMMED AT ASSEMBLY SUCH THAT THE THRUST BALL (9) WILL ENGAGE THE SHAFT INSERT (10) DURING THE START AND SHUTDOWN TRANSIENTS TO PRECLUDE CONTACT BEING MADE BETWEEN THE IMPELLER AND HIGH-PRESSURE ORIFICE RING. BALANCE CAVITY PRESSURE IS MEASURED ON ALL GROUND TESTS TO MONITOR BALANCE PISTON OPERATION.

(1) R5007577, R5007693; (2) RSS-8580-10; (3) R5007559; (4) R5007577, R5007568; (5) R5007566; (6) RL00351; (7) MS-5562; (8) R5007606, R0019213; (9) RES1103; (10) R0019215; (11) RL00050-04

FAILURE CAUSE: B. Low pressure orifice failure.

THE LOW-PRESSURE ORIFICE RING (1) IS MANUFACTURED UTILIZING A HIGH LEADED TIN BRONZE SAND CASTING (2). THIS MATERIAL WAS SELECTED FOR ITS LOW WEAR RATE UNDER CONDITIONS OF NO LUBRICATION AT CRYOGENIC TEMPERATURES. HYDROGEN ENVIRONMENT EMBRITTLEMENT IS NOT A CONCERN IN THE ORIFICE RINGS OPERATING ENVIRONMENT. THE LOW-PRESSURE ORIFICE WORKS IN CONJUNCTION WITH THE HIGH-PRESSURE ORIFICE (3), TO BALANCE THE ROTOR THRUST BY CONTROLLING THE AMOUNT OF FLUID FLOW OUT OF THE BALANCE PISTON CAVITY. THE ORIFICE RING IS SHIMMED (4) AT ASSEMBLY TO SET THE SHAFT TRAVEL. THE ORIFICE RING AND THE SHIM ARE BOTTOMED IN THE HOUSING (5) BY TWELVE SCREWS (6) AND CUPWASHERS (7). THE CUPWASHERS ARE STAKED AT ASSEMBLY TO PREVENT BOLT ROTATION. ASSEMBLY PROCEDURES FOR LOCKING DEVICES ENSURE DEFECT-FREE INSTALLATION (8). THE PART IS DESIGNED TO FUNCTION AS A SACRIFICIAL WEAR RING. DURING START-UP AND MAINSTAGE THERE IS NO CONTACT WITH THE THIRD-STAGE IMPELLER, HOWEVER, RUBBING OCCURS DURING SHUTDOWN. THE WEAR ON THE ORIFICE RING IS MONITORED BY SHAFT TRAVEL CHECKS AFTER EACH TEST/FLIGHT (9).

(1) R5007559; (2) RSS-8580-10; (3) R5007577-003, R5007693; (4) R5007560; (5) R5007577, R5007568; (6) R5007521; (7) R5007523; (8) RL00351; (9) RL00050-04, OM/RSD V418S0-025

FAILURE CAUSE: ALL CAUSES

THE HIGH AND LOW CYCLE FATIGUE LIFE FOR THE HIGH-PRESSURE ORIFICE RING AND THE LOW-PRESSURE ORIFICE RING MEET CEI REQUIREMENTS (1). THE MINIMUM FACTORS OF SAFETY FOR THESE PARTS MEET CEI REQUIREMENTS (2). THE HIGH AND LOW-PRESSURE ORIFICE RING PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/INDE FLAW GROWTH SINCE THEY CONTAIN NO FRACTURE CRITICAL PARTS (3). REUSE OF PARTS DURING OVERHAUL IS CONTROLLED BY THE REQUIREMENTS OF THE OVERHAUL SPECIFICATION (4).

(1) RL00532, CP320R0003B; (2) RSS-8546-16, CP320R0003B; (3) NASA TASK 117; (4) RL00528

SSME FMEA/CIL
INSPECTION AND TEST

Component Group: Fuel Turbopumps
 CIL Item: B200-23
 Component: High Pressure Fuel Turbopump
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B	INSERT RING		RS007693 RS007559
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED BY SPECIFICATION REQUIREMENTS	RB0170-186 RBD170-094
		THE INSERT FORGING IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
		THE INSERT IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	
	HEAT TREAT	HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS	RS007693
	SURFACE FINISH	INSERT AND RING SURFACE FINISH ARE VERIFIED PER DRAWING REQUIREMENTS	RS007693 RS007559
	CLEANLINESS OF COMPONENTS	COMPONENTS ARE VERIFIED CLEANED PER SPECIFICATION REQUIREMENTS.	RL1000
	ASSEMBLY INTEGRITY	INSERT AND HOUSING MATCH SET IS VERIFIED PER DRAWING REQUIREMENTS	RS007577 RS007693
		INSERT TORQUE IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007568 RL00351
		INSERT PIN STAKING IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	
		RING SHIMMING IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS	RS007501 RL00351
ALL CAUSES	HPFTP		RS007501

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C.L. Item: B200-23
 Component: High Pressure Fuel Turbopump
 Part Number: RS007501
 Failure Mode: Loss of balancing capability.

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	ASSEMBLY INTEGRITY	<p>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</p> <p>OPERATION/PERFORMANCE IS VERIFIED BY ENGINE HOT FIRE TESTING AND 2ND E & M TESTS ON INSPECTIONS.</p> <p>SHAFT TRAVEL IS PERFORMED PRIOR TO EACH FLIGHT.</p> <p>DATA FROM PREVIOUS FLIGHT OR HOT FIRE IS REVIEWED FOR PROPER TURBOPUMP OPERATION/PERFORMANCE (LAST TEST)</p>	<p>RL00528 RAD115-116</p> <p>RL00050-04 RL00056-06 RL00056-07 RL00461</p> <p>OMRSD VB41BS0.020 MSFC PLN 1228</p>

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
 Reference: NASA letter SA21/89/308 and Rocketdyne letter BBRC09761.

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

Prepared: D. Early
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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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 Item Name: High Pressure Fuel Turbopump
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 Part Number: RS007501

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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**

Component Group: Fuel Turbopumps
 CIL Item: B200
 Component: High Pressure Fuel Turbopump
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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	49	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	