

SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Fuel Turbopumps
 CHL Item: B200-14
 Component: High Pressure Fuel Turbopump
 Part Number: RS007501
 Failure Mode: Fragmentation of volute liner.

Prepared: D. Early
 Approved: T. Nguyen
 Approval Date: 4/21/99
 Change #: 1
 Directive #: CCBP ME3-01-5206
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Phase	Failure / Effect Description	Criticality Hazard Reference
SMC 4 1	Volute liner fragment causes WFM restriction, rapid reduction in fuel flow; LOX-rich operation and engine failure. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE N/A	1 ME-B7S, ME-B7M, ME-B7A,C

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DESIGN

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Design / Document Reference

FAILURE CAUSE: A: Volute liner sheet metal failure.

THE PUMP DISCHARGE VOLUTE SECTION OF THE MAIN HOUSING (1) IS THE STRUCTURAL MEMBER THAT CARRIES THE HIGH PRESSURE PUMP DISCHARGE PRESSURE LOAD, DISCHARGE OF HIGH-PRESSURE LIQUID HYDROGEN FROM THE VOLUTE SUPPLIES COOLANT TO THE MAIN COMBUSTION CHAMBER, MAIN NOZZLE, AND FUEL TO THE PREBURNERS. THE VOLUTE LINER (2) IS A WELDMENT OF 12 DETAILS MANUFACTURED UTILIZING INCONEL 718 SHEET METAL. INCONEL 718 WAS SELECTED FOR ITS STRENGTH, RESISTANCE TO CORROSION AND STRESS CORROSION CRACKING, AND IS RESISTANT TO HYDROGEN EMBRITTLEMENT AT CRYOGENIC TEMPERATURES (3). THE MATERIAL IS SOLUTION TREATED AND AGE-HARDENED. THE FLOW PASSAGES ARE HYDRODYNAMICALLY SHAPED FOR CONSTANT ANGULAR MOMENTUM TO MINIMIZE DIFFUSION LOSSES. VENT HOLES IN THE LINER EQUALIZE PRESSURE ON BOTH SIDES OF THE LINER, MINIMIZING VOLUTE LINER PRESSURE LOADS. THE SHEET METAL COMPONENTS OF THE VOLUTE LINER ARE FUSION-WELDED AND FLUSHED TO MINIMIZE FLOW DISTORTION. THE VOLUTE LINER MEETS CEI HIGH AND LOW CYCLE FATIGUE LIFE REQUIREMENTS (4). THE LINER MINIMUM FACTORS OF SAFETY MEET CEI REQUIREMENTS (5). THE LINER PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/INDE FLAW GROWTH SINCE IT IS NOT A FRACTURE CRITICAL PART (6). THE FMEA/CIL WELDS ARE CLEARED FOR FRACTURE MECHANICS/INDE FLAW GROWTH BY THE WELD ASSESSMENT (7). TABLE B200 LISTS ALL 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. THOSE WELDS IN WHICH THE CRITICAL INITIAL FLAW SIZE IS NOT DETECTABLE ARE ACCEPTABLE FOR FLIGHT BY RISK ASSESSMENT (7). THE HOUSING IS PROOF PRESSURE TESTED TO VERIFY ITS STRUCTURAL INTEGRITY (8). THE HOUSING HAS BEEN DESIGN VERIFICATION TESTED FOR STRESS SAFETY FACTORS, LOW CYCLE FATIGUE LIFE, AND DEFLECTION (9). REUSE OF PARTS DURING OVERHAUL IS CONTROLLED BY THE REQUIREMENTS OF THE OVERHAUL SPECIFICATION (10).

(1) RSC07577, RS007568 (2) RS007674; (3) RSS-8590-10; (4) RL00532, CP320R0003B; (5) RSS-8548-16, CP320R0003B; (6) NASA TASK 117; (7) RSS-8756; (8) RL00023; (9) RSS-404-25; (10) RL00528

**SSME FMEA/CIL
INSPECTION AND TEST**

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	VOLUTE LINER		RS007674
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-154
		THE VOLUTE LINER DETAIL PARTS ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
		THE HOUSING IS PROOF PRESSURE TESTED PER SPECIFICATION REQUIREMENTS.	RL00023
	HEAT TREAT	HOUSING HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
	WELD INTEGRITY	ALL WELDS ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, RADIOGRAPHIC, ULTRASONIC AND FILLER MATERIAL, AS APPLICABLE	RL10011 RA0607-094 RA0115-116 RA0115-006 RA1115-001 RA0115-127
	ASSEMBLY INTEGRITY	THE VOLUTE LINER SHAPE, CONTOUR, AND SURFACE FINISH ARE INSPECTED PER DRAWING REQUIREMENTS.	RS007674 RS007568
	CLEANLINESS OF COMPONENTS	COMPONENTS ARE VERIFIED CLEANED PER SPECIFICATION REQUIREMENTS.	RL10001
	HPFTP		RS007501
	ASSEMBLY INTEGRITY	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	RL00528 RA0115-116
		THE VOLUTE LINER IS BORESCOPE INSPECTED AT EACH TURBOPUMP REMOVAL OR PER, TIME/CYCLE REQUIREMENTS.	OMRSD V41BU0.080 OMRSD C00BA0.015
		THE VOLUTE LINER IS PENETRANT INSPECTED PER TIME/CYCLE REQUIREMENTS.	RA0115-116 RL00050-04 OMRSD V41BU0.080 OMRSD C00BA0.015
		OPERATION/PERFORMANCE IS VERIFIED BY ENGINE HOT FIRE TESTING AND 2ND E & M TESTS ON INSPECTIONS.	RL00050-04 RL00056-06 RL00055-07 RL00461
	DATA FROM PREVIOUS FLIGHT OR HOT FIRE IS REVIEWED FOR PROPER TURBOPUMP OPERATION/PERFORMANCE. (LAST TEST)	MSFC PLN 1228	

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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 SA21/89/308 and Rocketdyne letter B8RC09761.		
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
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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	