1) CIL ITEM : B200-10
2) FMEA CODE : B200
3) COMPONENT : HPFTP
4) PART NUMBER : RS007501
5) SYSTEM/SUBSYSTEM : PUMPS/BXXX (FASCOS REDLINE ACTIVE)
6) FAILURE MODE : LOSS OF IMPELLER HEAD RISE

7) PREPARED : SSME RELIABILITY
8) APPROVED :
9) DATE : 04-19-96
10) REVISION/CHANGE : -001/0
11) EFFECTIVITY : -1091
12) HAZARD REFERENCE : SEE LISTINGS BELOW
13) CCBD # : M93-01-3285

PHASE	FAILURE DESCRIPTION/EFFECT	CRITICALITY
S	FAILURE RESULTS IN REDUCED TURBOPUMP OUTPUT AND ROTOR UNBALANCE. EXCESSIVE TURBINE DISCHARGE TEMPERATURE OR HIGH VIBRATION LEVELS WILL CAUSE A REDLINE SHUTDOWN. MISSION SCRUB. LOSS OF VEHICLE DUE TO TURBOPUMP FAILURE MAY RESULT IF EXCESSIVE VIBRATION OR TURBINE TEMPERATURE IS 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 ITEM IS DETECTABLE DURING FLIGHT. C: PASS. LOSS OF REDUNDANT HARDWARE ITEMS COULD NOT RESULT FROM A SINGLE CREDIBLE EVENT.	1R HAZARD REF: ME-D1S,M
M	FAILURE RESULTS IN REDUCED TURBOPUMP OUTPUT AND ROTOR UNBALANCE. EXCESSIVE TURBINE DISCHARGE TEMPERATURE OR HIGH VIBRATION LEVELS WILL CAUSE A REDLINE SHUTDOWN. MISSION ABORT. 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 ITEM IS DETECTABLE DURING FLIGHT. C: PASS. LOSS OF REDUNDANT HARDWARE ITEMS COULD NOT RESULT FROM A SINGLE CREDIBLE EVENT.	1R HAZARD REF: ME-D1S,M

CIL ITEM: B200-10	DESIGN	DOCUMENT REF.
	FAILURE CAUSE A: FRACTURE, DISTORTION OF IMPELLER VANE FAILURE CAUSE B: FRACTURE, DISTORTION OF IMPELLER SHROUD THE THREE IMPELLERS (1) (2) (3) ARE MANUFACTURED UTILIZING A TITANIUM 5Al-2.5Sn (ELI) FORGING. TITANIUM WAS SELECTED FOR ITS STRENGTH, TOUGHNESS, FATIGUE PROPERTIES, AND ITS INSENSITIVITY TO HYDROGEN ENVIRONMENT EMBRITTLEMENT AT OPERATING TEMPERATURES (4). THE MATERIAL IS ANNEALED TO IMPROVE MECHANICAL PROPERTIES. GRAIN DIRECTION IS SPECIFIED BY DRAWING REQUIREMENTS TO ACHIEVE MAXIMUM MATERIAL PROPERTIES IN THE DIRECTION OF THE HIGHEST LOADS. THE 3 IMPELLERS PRODUCE THE REQUIRED HEAD RISE TO PROVIDE COOLANT FOR THE MAIN COMBUSTION CHAMBER, AND MAIN NOZZLE, AND FUEL TO THE PREBURNERS. EACH IMPELLER IS SHROUDED AND HAS 6 FULL, 6 LONG PARTIAL, AND 12 SHORT PARTIAL VANES. THE VANE FILLETS ARE RADIUSED TO ELIMINATE STRESS RISERS. LABYRINTHS ON THE FRONT AND REAR SHROUDS OF THE FIRST- AND SECOND-STAGES AND FRONT SHROUD OF THE THIRD-STAGE MATE WITH NON-ROTATING SEALS TO CONTROL PARASITIC LEAKAGE FLOW. BLEED HOLES IN THE HUBS ALLOW DOWNSTREAM LEAKAGE FLOW TO RETURN TO THE IMPELLER INLETS TO AID THE AXIAL THRUST CONTROL. RECIRCULATION FLOW THROUGH THE FIRST-STAGE IS USED TO COOL THE PUMP BEARINGS. RECIRCULATION FLOW IN THE THIRD-STAGE IS SPLIT OFF BETWEEN THE BALANCE PISTON AND THE TURBINE COOLANT. TORQUE IS TRANSMITTED TO THE IMPELLERS BY A SPLINED SLEEVE. BAKED ON DRY FILM LUBRICANT IS APPLIED TO THE SLINGER TO PREVENT FRETTING BETWEEN THE SLINGER FACE AND THE IMPELLER HUB. THE CORNER EDGE BREAK AND SURFACE FINISH ARE TIGHTLY CONTROLLED TO ELIMINATE STRESS CONCENTRATIONS. EACH IMPELLER IS INDIVIDUALLY SPUN PER DRAWING REQUIREMENTS AS PART OF THE MANUFACTURING PROCESS TO VERIFY ITS STRUCTURAL INTEGRITY. MATERIAL IS REMOVED FROM CONTROLLED AREAS OF THE FRONT AND REAR SHROUDS FOR ROTOR BALANCING (5). THE HIGH AND LOW CYCLE FATIGUE LIFE OF THE SECOND STAGE IMPELLER MEETS CEI REQUIREMENTS (6). THE FIRST STAGE IMPELLER IS LIFE LIMITED BY MAJOR WAIVER (13). THE MINIMUM FACTORS OF SAFETY FOR THE IMPELLERS MEET CEI REQUIREMENTS (7). THE FIRST, SECOND, AND THIRD-STAGE IMPELLERS PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH BY CRITICAL INITIAL FLAW SIZE DETECTABILITY (8). THE FACTOR OF SAFETY ON BURST WAS BEEN DEMONSTRATED BY DESIGN VERIFICATION TESTS (9). THE ROTATING ASSEMBLY HAS BEEN DESIGN VERIFICATION TESTED FOR SPRING RATE (LOAD DEFLECTION) AND NATURAL FREQUENCY (VIBRATION) DETERMINATION (10). THE CONTROLLER SOFTWARE IS CONFIGURED TO DETECT AND RESPOND PROPERLY TO THE FAILURES IDENTIFIED AND COMMAND A SAFE ENGINE STATE (11). REUSE OF PARTS DURING OVERHAUL IS CONTROLLED BY THE REQUIREMENTS OF THE OVERHAUL SPECIFICATION (12).	(1) R0019226 (2) RS007555 (3) RS007556 (4) RSS-8580-10 (5) RL00075 (6) RL00532, CP320R0003B (7) RSS-8546-16, CP320R0003B (8) NASA TASK 117 (9) RSS-404-36 (10) RSS-404-37 (11) CP406R0008 3.2.3:5.3 (12) RL00528 (13) DAR 1695

CIL ITEM: B200-10	INSPECTION AND TEST		
POSSIBLE CAUSES	SIGNIFICANT CHARACTERISTICS	INSPECTION(S)/TEST(S)	DOCUMENT REF.
FAILURE CAUSE A, B:	R0019226 - FIRST-STAGE IMPELLER RS007555 - SECOND-STAGE IMPELLER RS007556 - THIRD-STAGE IMPELLER		R0019226 RS007555 RS007556
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	R80170-152

CIL ITEM: 8200-10		INSPECTION AND TEST	
POSSIBLE CAUSES	SIGNIFICANT CHARACTERISITICS	INSPECTION(S)/TEST(S)	DOCUMENT REF.
		THE FORGING IS PENETRANT AND ULTRASONIC INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116 RA0115-012
		THE FORGINGS GRAIN DIRECTION IS VERIFIED PER DRAWING REQUIREMENTS.	RS007586
		THE IMPELLER SPIN TEST VERIFIES MAXIMUM GROWTH PER DRAWING AND SPECIFICATION REQUIREMENTS.	R0019226 RS007555 RS007556 RL00075
		THE IMPELLER IS PENETRANT INSPECTED AFTER THE SPIN TEST PER SPECIFICATION REQUIREMENTS.	RA0115-116
	ASSEMBLY INTEGRITY	SPLINE MEASUREMENTS ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	R0019226 RS007555 RS007556 RA0115-143
		VANE RADII AND COORDINATE MEASUREMENTS ARE VERIFIED PER DRAWING REQUIREMENTS.	R0019226 RS007555 RS007556
		SLINGER DRY FILM LUBE IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0112-003
		SLINGER IS BURNISHED PER SPECIFICATION REQUIREMENTS.	RA0112-007
		SLINGER IS VERIFIED AS BOTTOMED PER SPECIFICATION REQUIREMENTS.	RL00351
	SURFACE FINISH	IMPELLER CORNER EDGE BREAK AND SURFACE FINISH ARE VERIFIED PER DRAWING REQUIRMENTS.	R0019226 RS007555 RS007556
	CLEANLINESS OF COMPONENTS	COMPONENTS ARE VERIFIED CLEANED PER SPECIFICATION REQUIREMENTS.	RL10001

CIL ITEM: B200-10		INSPECTION AND TEST	
POSSIBLE CAUSES	SIGNIFICANT CHARACTERISTICS	INSPECTION(S)/TEST(S)	DOCUMENT REF.
	RS007501 - HPFTP		RS007501
	ASSEMBLY INTEGRITY	OPERATION/PERFORMANCE IS VERIFIED BY ENGINE HOT-FIRE TESTING AND 2ND E & M TESTS ON INSPECTIONS.	RL00050-06 RL00056-06 RL00056-07 RL00461
		IMPELLERS ARE INSPECTED DURING OVERHAUL PER SPECIFICATION REQUIREMENTS.	RF0004-302
		THE IMPELLER HUB AND BORE ARE VISUALLY INSPECTED PER SPECIFICATION REQUIREMENTS AT INTERVALS DEFINED BY MAJOR WAIVER.	RF0004-302 DAR 2061
		SHAFT TRAVEL IS PERFORMED PRIOR TO EACH FLIGHT. TORQUE CHECKS ARE PERFORMED PRIOR TO EACH FLIGHT.	OMRSD V41BSD.020 OMRSD V41BSO.020
		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/PRACA).
REFERENCE: NASA LETTER SA21/88/308 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

Prepared: D. Early
Approved: T. Nguyen
Approval Date: 4/21/99
Change #: 2
Directive #: CCBD ME3-01-5208

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 IIa PENETRANT INSPECTION	USE AS IS RATIONALE 1 IMPLEMENTATION OF HIDDEN SURFACE INSPECTION REQUIREMENT IS NOT A RESULT OF AN OBSERVED HARDWARE ANAOMALY 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 HPFTP 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 HAYFS 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.

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

Prepared: D. Early
Approved: T. Nguyen
Approval Date: 4/21/99
Change #: 2
Directive #: CCBD ME3-01-5206

Base Line Rationale	Variance	Change Rationale	Variant Dash Number
5 B200-16 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 UNITL 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
Part Number: RS007501

Prepared: D. Early
Approved: T. Nguyen
Approval Date: 4/21/99
Change #: 2
Directive #: CCBD ME3-01-5206

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable HCF	LCF	Comments
SHIELD	R0012171	1-24, 28-62	GTAW	II	X			
SHIELD	R0012171	26	GTAW	II				
LIFT-OFF SEAL	R0019230	1, 2	GTAW	II	X			
SHIELD	R0019788	26, 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	1*8	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				

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable HCF	LCF	Comments
HOUSING	RS007568	55	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	153, 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	