SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Fuel Turbopumps
CIL Item: B200-02
Component: High Pressure Fuel Turbopump
Part Number: RS007501
Failure Mode: Energy loss at turbine inlet.

Prepared: D. Early
Approved: T. Nguyen
Approval Date: 4/21/99
Change #: 1
Directive #: CCBD ME3-01-5206

Phase	Failure / Effect Description	Criticality Hazard Reference
S 4 1	Loss in turbine power reduces turbopump speed, flow and discharge pressure. Decreased flow is sensed by controller which increases fuel preburner oxidizer flow. Excess turbine discharge temperature will cause 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
M 4 1	Loss in turbine power reduces turbopump speed, flow and discharge pressure. Decreased flow is sensed by controller which increases fuel preburner oxidizer flow. Excess turbine discharge temperature will cause redline shutdown. Mission abort 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

SSME FMEA/CIL
DESIGN

Component Group:	Fuel Turbopumps	Prepared:	D. Early
CIL Item:	B200-02	Approved:	T. Nguyen
Component:	High Pressure Fuel Turbopump	Approval Date:	4/21/99
Part Number:	RS007501	Change #:	1
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Design / Document Reference

FAILURE CAUSE: **A: Thermal or mechanical distortion of inlet sheet metal or thermal shield.**
B: Fatigue cracking of inlet sheet metal or welds resulting in loss of pieces.
C: Thermal shield damage causing flow blockage.

ONE OF THE FUNCTIONS OF THE TURBINE BEARING SUPPORT (1) AND THERMAL SHIELD (2) IS TO DIRECT HIGH TEMPERATURE PREBURNER COMBUSTION GASES INTO THE INLET OF THE FIRST-STAGE TURBINE NOZZLE. THE THERMAL SHIELD AND WASHERS (3) ARE SUPPORTED BY AND FASTENED (4) TO THE "KAISER CAP" (5). THE THERMAL SHIELD PROTECTS THE CAP FROM DIRECT EXPOSURE TO THE HIGH VELOCITY, HIGH TEMPERATURE PREBURNER COMBUSTION GASES. TWO WASHERS (3) ARE UTILIZED TO REINFORCE THE SHIELD AT THE POINT OF THE CLAMPING FORCE FROM THE NUT (4). SEVERAL SMALLER WASHERS (3) ARE UTILIZED TO SPACE THE SHIELD TO PRECLUDE INTERFERENCE WITH THE INLET MANIFOLD (17). THE SHIELD DESIGN INCORPORATES 4 HOT-GAS VENT HOLES, WHICH REDUCES THE PRESSURE DIFFERENTIAL DURING MAINSTAGE AND PROVIDES A RAPID PRESSURE DECAY TO PRECLUDE A REVERSE PRESSURIZATION DURING TRANSIENTS. THE SHIELD AND WASHERS ARE MANUFACTURED UTILIZING HAYNES 188 (6), WHICH HAS THE REQUIRED TENSILE STRENGTH AT ELEVATED TEMPERATURES, LOW CYCLE FATIGUE LIFE, AND RESISTANCE TO DEGRADATION AND OXIDATION IN A HIGH-PRESSURE, HYDROGEN RICH STEAM ATMOSPHERE. THE MATERIAL IS ANNEALED TO IMPROVE MECHANICAL PROPERTIES. TURBINE BEARING SUPPORT STRUCTURAL SURFACES, WHICH WOULD BE EXPOSED TO THE HIGH VELOCITY, HIGH TEMPERATURE PREBURNER GAS, ARE PROTECTED BY AN ELECRO-DISCHARGE MACHINED (EDM) LINER THAT FORMS THE TURBINE INLET MANIFOLD (17). THE MANIFOLD DUCTS THE HIGH VELOCITY, HIGH TEMPERATURE PREBURNER GAS INTO THE 1st STAGE OF THE TURBINE. THE LINER IS FABRICATED FROM A SINGLE FORGING, FIRST USING BOTH CONVENTIONAL AND EDM MATERIAL REMOVAL PROCESS. CHEM-MILLING IS USED TO REMOVE EDM RECAST LAYER. THE PART IS MEDIA FINISHED TO ENHANCE THE HIGH CYCLE FATIGUE LIFE AND HEAT TRANSFER CHARACTERISTICS. THE LINER IS THEN SPLIT INTO TWO DETAILS THAT ARE THEN CLAM-SHELLED AROUND THE SUPPORT STRUCTURAL SURFACES. CLOSE-OUT WELDS ARE USED TO REJOIN THE TWO DETAILS. THE EDM INLET DESIGN REPRESENTS A SIGNIFICANT IMPROVEMENT OVER EARLIER CONFIGURATIONS DUE TO THE INCREASED CROSS SECTIONAL THICKNESS OF THE LINER, INCREASED FILLET RADII OF THE STRUT CANS AND A REDUCTION IN THE NUMBER OF WELDS FROM 97 TO 15 TOTAL FOR THE SUB-ASSEMBLY. THIS LINER IS MANUFACTURED UTILIZING HAYNES 188 FOR THE SAME REASONS IT IS USED FOR THE THERMAL SHIELD. THE ANNULUS BETWEEN THE BEARING SUPPORT AND THE INLET MANIFOLD IS VENTED TO TURBINE INLET PRESSURE TO MINIMIZE THE POSSIBILITY OF DISTORTION. HIGH CYCLE FATIGUE INDUCED INLET MANIFOLD CRACKS DO OCCUR FROM THE OPERATIONAL ENVIRONMENT. THE CRACKING IS CONTROLLED PER THE REQUIREMENTS OF THE SHEET METAL INSPECTION SPECIFICATION (7) 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. A SIGNIFICANT REDUCTION IN LINER CRACKING HAS BEEN REALIZED OVER THE PREVIOUS DESIGNS. THE THERMAL SHIELD IS LIFE LIMITED BY MAJOR WAIVER (15). THE TURBINE BEARING SUPPORT IS LIFE LIMITED BY MAJOR WAIVER (16). CONTINUED USE WITH DISCREPANCIES IN THE INLET MANIFOLD RESULTING FROM OPERATION IS EVALUATED AND CONTROLLED PER THE REQUIREMENTS OF THE MAINTENANCE CONTROL DOCUMENT (10). THE BEARING CAP MEETS THE CEI HIGH AND LOW CYCLE FATIGUE LIFE (8) AND MINIMUM FACTORS OF SAFETY CEI REQUIREMENTS (9). THE SHIELD, WASHER AND SUPPORT PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH SINCE THEY CONTAIN NO FRACTURE CRITICAL PARTS (11). THE FMEA/CIL WELDS ARE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH BY THE WELD ASSESSMENT (12). 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 (12). THE CONTROLLER SOFTWARE IS CONFIGURED TO DETECT AND RESPOND PROPERLY TO THE FAILURES IDENTIFIED AND COMMAND A SAFE ENGINE STATE (13). REUSE OF PARTS DURING OVERHAUL IS CONTROLLED BY THE REQUIREMENTS OF THE OVERHAUL SPECIFICATION (14).

(1) RS007524; (2) RS007549 (3) RS007676, MS9549; (4) R0015246, RS007566 R0015244; (5) RS007535; (6) RSS-8580-10; (7) RL00655; (8) RL00532, CP320R0003B; (9) RSS-8546-16, CP320R0003B; (10) RSS-8793; (11) NASA TASK 117; (12) RSS-8756; (13) CP406R0002 PT 1 3.2.3:5.3; (14) RL00528; (15) DAR 2198; (16) DAR 2967; (17) R035520

SSME FMEA/CIL
INSPECTION AND TEST

Component Group: Fuel Turbopumps
CIL Item: B208-02
Component: High Pressure Fuel Turbopump
Part Number: RS007501
Failure Mode: Energy loss at turbine inlet.

Prepared: O. Early
Approved: T. Nguyen
Approval Date: 4/21/98
Change #: 1
Directive #: CCBD ME3-01-5206

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B, C	SHIELD WASHER SUPPORT INLET MANIFOLD		RS007549 RS007676 RS007524 R035620
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	
		INLET MANIFOLD DETAIL PARTS ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
	HEAT TREAT	BEARING SUPPORT 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 THERMAL SHIELD SHIMMING IS VERIFIED PER DRAWING REQUIREMENTS	RS007501
	HPFTP		
	ASSEMBLY INTEGRITY	THE PUMP SUBASSEMBLIES ARE INSPECTED DURING OVERHAUL PER SPECIFICATION REQUIREMENTS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, AND	RL00528 RA0115-116

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				