

**SSME FTA/CIL
REDUNDANCY / SCREEN**

Component Group: Fuel Turbopumps
 CIL Item: B600-05
 Part Number: RS007601
 Component: Low Pressure Fuel Turbopump
 FMEA Item: B600
 Failure Mode: Loss of support or position control of rotating assembly.

Prepared: F. Cromwell
 Approved: T. Nguyen
 Approval Date: 11/1/99
 Change #: 4
 Directive #: CCBD ME3-01-5248

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Phase	Failure / Effect Description	Criticality Hazard Reference
S 4.1	<p>Loss of support or position control would result in performance degradation, increased vibration levels, and rubbing of turbopump components. Reduced LPFTP pump output results in reduced pressure and flow delivered to the HPFTP. In the event of HPFTP cavitation, excessive turbine discharge temperatures result in a premature engine shutdown. Mission scrub if detected by redline. Loss of vehicle due to HPFTP turbine failure may result if not detected.</p> <p>Redundancy Screens: TURBOPUMP SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY</p> <p>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.</p>	<p>IR ME-D:5,M</p>
M 4.1	<p>Loss of support or position control would result in performance degradation, increased vibration levels, and rubbing of turbopump components. Reduced LPFTP pump output results in reduced pressure and flow delivered to the HPFTP. In the event of HPFTP cavitation, excessive turbine discharge temperatures result in a premature engine shutdown. Mission abort if detected by redline. Loss of vehicle due to HPFTP turbine failure may result if not detected.</p> <p>Redundancy Screens: TURBOPUMP SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY</p> <p>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.</p>	<p>IR ME-D:5,M</p>

155-551

SSME FMEA/CIL
DESIGN

Component Group: Fuel Turbopumps
CIL Item: B600-05
Part Number: RS007601
Component: Low Pressure Fuel Turbopump
FMEA Item: B600
Failure Mode: Loss of support or position control of rotating assembly.

Prepared: F. Cramwell
Approved: T. Nguyen
Approval Date: 11/1/99
Change #: 4
Directive #: CGBD ME3-01-5240

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Design / Document Reference

FAILURE CAUSE: A: Bearing failure.
Ball failure.
Cage failure.
Loss of coolant.
Ring failure.
Corrosion.

THE TURBINE-END BEARING (1) IS AN ANGULAR CONTACT BALL BEARING AND THE PUMP END BEARINGS (2) ARE SPLIT INNER RING THRUST BALL BEARINGS. THE BEARINGS ARE INSTALLED WITH A CLOSE FIT ON THE INDUCER (3) JOURNALS.

THE PUMP-END BEARING PAIR IS DESIGNED TO ABSORB THE UNBALANCED ROTOR AXIAL THRUST. THE BEARING INNER RINGS ARE BOTTOMED BY THE SPACER (4) AGAINST THE INDUCER HUB. THE BEARING OUTER RINGS ARE RADIALLY PILOTED BY THE CARRIER (5) AND AXIALLY POSITIONED BY THE OUTER RINGS SHIM (6) AND THE CARRIER LIP.

THE TURBINE-END BEARING INNER RING IS BOTTOMED AGAINST THE SPACER BY THE BEARING NUT (7). THIS NUT IS TORQUED AT ASSEMBLY UNTIL THE REQUIRED INDUCER STRETCH IS ACHIEVED TO PRELOAD BOTH BEARINGS. THE NUT IS SECURED TO THE INDUCER BY ONE OF FOUR T-LOCKS (8). THE PUMP SEAL (9) IS POSITIONED TO ACHIEVE THE REQUIRED PRELOAD ON THE OUTER RING THROUGH THE OUTER RING SPACER (10) AND SPRING (11). THE BEARINGS ARE RADIALLY PILOTED BY THE MANIFOLD (12) BORE WHICH IS CHROME-PLATED FOR WEAR RESISTANCE.

COOLANT IS SUPPLIED TO BOTH BEARINGS BY HYDROGEN FLOW BETWEEN THE INDUCER AND HOUSING (13). THIS AXIAL GAP IS CONTROLLED BY DRAWING REQUIREMENTS. THE HYDROGEN FLOWS THROUGH THE PUMP-END BEARINGS AND CONTINUES ALONG THE SPACER OUTSIDE DIAMETER TO THE TURBINE-END BEARINGS. THE FLOW THEN CONTINUES BETWEEN THE INDUCER SPLINES, THROUGH THE SHAFT (14) AND INDUCER HUB, AND FINALLY RETURNS TO THE MAIN FLOW STREAM VIA FOUR HOLES IN THE INDUCER HUB NEAR THE VANE LEADING EDGES. THE NUMBER OF PARALLEL PASSAGES, THE SIZE OF THE PASSAGES, AND THE QUANTITY OF FLOW MAKE THE BEARING COOLANT CIRCUIT INSENSITIVE TO MINOR FLOW PASSAGE BLOCKAGE. THE PROPELLANT FILTER AT THE EXTERNAL TANK PRECLUDES CONTAMINANTS LARGE ENOUGH TO BLOCK THE PASSAGES (15).

THE BEARING BALLS AND RINGS ARE MANUFACTURED UTILIZING 440C CRES (16). THIS MATERIAL WAS SELECTED FOR ITS SURFACE HARDNESS, WEAR RESISTANCE, CORROSION RESISTANCE AND ITS INSENSITIVITY TO HYDROGEN ENVIRONMENT EMBRITTLEMENT AT TEMPERATURES BELOW -200 DEGREES F. THE MATERIAL IS HARDENED, COLD STABILIZED, TEMPERED, AND STRESS RELIEVED TO ACQUIRE THE DESIRED PROPERTIES. THE BALLS ARE POSITIONED BY AN ARMALON CAGE. THE CAGE IS FABRICATED FROM TFE (TEFLON) COATED FIBERGLASS FABRIC THAT IS HOT MANDREL WRAPPED. THE CAGE IS COATED WITH FEP (FLUORINATED ETHYLENE POLYMER) (17) AND MO. YBONUM DISULFIDE MIXTURE WHICH IS BAKED ON. THE FEP/MOLY COATING PROVIDES BEARING LUBRICATION. FEP WAS SELECTED FOR ITS LUBRICITY, IMPERMEABILITY, RESISTANCE TO CHEMICAL ATTACK, ADEQUATE WEAR CHARACTERISTICS AND SATISFACTORY MECHANICAL PROPERTIES AT CRYOGENIC TEMPERATURES (18). THE TFE (TEFLON) CONTAINED IN THIS MANDREL WRAPPED FIBERGLASS CAGE PROVIDES ADDITIONAL BEARING LUBRICATION. THE MATERIAL WAS SELECTED FOR ITS LUBRICITY, LOW WEAR CHARACTERISTICS, AND MECHANICAL PROPERTIES (18).

THE BEARINGS ARE CLEANED, PACKAGED, HANDLED, AND STORED (19) TO PRECLUDE INTRODUCTION OF CONTAMINANTS PRIOR TO SERVICE. THE ROTOR IS DYNAMICALLY BALANCED AT ASSEMBLY TO PRECLUDE EXCESSIVE LOADS DURING TEST (20). HOUSING MOUNTED ACCELEROMETERS MONITOR TURBOPUMP VIBRATIONS ON ALL GROUND TESTS. POST TEST TORQUE CHECKS WOULD DETECT A DEGRADED BEARING (21).

(1) RS007605 (2) RS007606 (3) RS007604; (4) RS007612; (5) RS007608; (6) RS007609; (7) RS007617; (8) RS007618; (9) RES1099, R0019865; (10) RS007615; (11) RS007614; (12) RS007603 (13) RS007632; (14) RS007628 (15) ICD 13M15000; (16) RSS-8577; (17) RA1608-011. (18) MPR-91-091; (19) RL00915; (20) RL00646; (21) RL00050-04

B - 562

Component Group: Fuel Turbopumps
CIL Item: B600-05
Part Numbr: RS007601
Component: Low Pressure Fuel Turbopump
FMEA Item: B600
Failure Mode: Loss of support or position control of rotating assembly.

Prepared: T. Nguyen
Approved: T. Nguyen
Approval Date: 11/1/99
Change #: 4
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Design / Document Reference

FAILURE CAUSE: B: Failure of pump-end bearing carrier or excessive loss of bolt preload.

THE BEARING CARRIER (1) AXIALLY RETAINS AND RADIIALLY PILOTS THE OUTER RINGS OF THE PUMP-END BEARINGS (2). THE BEARING CARRIER FLANGE IS DESIGNED WITH EIGHT POCKETS ON THE HOUSING SIDE, WHICH EACH HAVE THROUGH HOLES TO THE INDUCER SIDE. THESE POCKETS PRECLUDE PRESSURE BUILD-UP BEHIND THE FLANGE. THE CARRIER IS MANUFACTURED UTILIZING AN INCONEL 718 FORGING (3) WHICH HAS THE REQUIRED CRYOGENIC STRENGTH AND RESISTANCE TO CORROSION AND STRESS CORROSION CRACKING. INCONEL 718 IS NOT SUSCEPTIBLE TO HYDROGEN ENVIRONMENT EMBRITTLEMENT AT CRYOGENIC TEMPERATURES. THE MATERIAL IS SOLUTION TREATED AND AGE-HARDENED. THE CARRIER IS ATTACHED TO THE HOUSING UTILIZING EIGHT BOLTS (4) AND CUPWASHERS (5). THE BOLTS ARE MANUFACTURED UTILIZING A-289 CRES BAR, WHICH WAS SELECTED FOR ITS CRYOGENIC STRENGTH AND RESISTANCE TO HYDROGEN ENVIRONMENT EMBRITTLEMENT (3). THE MATERIAL IS SOLUTION TREATED AND AGE-HARDENED. THE CUPWASHERS ARE MANUFACTURED UTILIZING 321 CRES, WHICH WAS SELECTED FOR ITS CRYOGENIC STRENGTH, DUCTILITY, AND ITS INSENSITIVITY TO HYDROGEN ENVIRONMENT EMBRITTLEMENT (3). THE MATERIAL IS ANNEALED TO IMPROVE MECHANICAL PROPERTIES. THE BOLT THREADS ARE LUBRICATED AT ASSEMBLY TO REDUCE FRICTION, PROVIDING A MORE CONSISTENT CLAMPING LOAD. THE CUPWASHERS ARE STAKED TO PREVENT BOLT ROTATION. ASSEMBLY PROCEDURES FOR LOCKING DEVICES ENSURE DEFECT-FREE INSTALLATION (6). THE BOLTS AND CUPWASHERS ARE NOT SERIALIZED OR TIME HISTORY TRACKED BUT HAVE INFINITE ALLOWABLE LIFE (7).

(1) RS007608; (2) RS007605; (3) RSS-8577; (4) RS007668; (5) RS007523; (6) RL00353; (7) RL00532, CP320R0003D

FAILURE CAUSE: C: Excessive loss of preload on bearing spacer.

THE BEARING SPACER (1) SUPPLIES THE PRELOAD TO THE PUMP-END (2) AND TURBINE-END BEARING (3) INNER RINGS. THE PRELOAD IS SET AT ASSEMBLY BY TORQUING THE TURBINE BEARING NUT (4) UNTIL THE DESIRED INDUCER (5) STRETCH IS ACHIEVED. THIS STRETCH ASSURES PROPER BEARING PRELOAD UNDER OPERATING CONDITIONS. THE BEARING SPACER INCORPORATES 4 AXIAL SLOTS ON THE TURBINE-END AND TWO DRILLED HOLES NEAR THE PUMP-END TO EQUALIZE THE PRESSURE AND TEMPERATURE ACROSS THE SPACER. EIGHT LOBES ON THE SPACER OUTSIDE DIAMETER ARE UTILIZED TO MAGNETICALLY RECORD SHAFT SPEED. THE SPACER IS MANUFACTURED UTILIZING K-MONEL BAR (6). THIS MATERIAL WAS SELECTED FOR ITS COMPRESSIVE STRENGTH AND MAGNETIC PROPERTIES REQUIRED TO ACTUATE THE SPEED TRANSDUCER. HYDROGEN ENVIRONMENT EMBRITTLEMENT IS NOT A PROBLEM IN THE SPACER'S OPERATING ENVIRONMENT. THE MATERIAL IS SOLUTION TREATED AND AGE-HARDENED.

(1) RS007612; (2) RS007605; (3) RS007606; (4) RS007617; (5) RS007604; (6) RSS-8577

FAILURE CAUSE: D: Excessive loss of preload on turbine bearing nut.

THE TURBINE BEARING NUT (1) SUPPLIES THE PRELOAD TO THE PUMP-END AND TURBINE-END BEARING INNER RINGS. THE NUT IS TORQUED AT ASSEMBLY TO ATTAIN THE REQUIRED INDUCER STRETCH SPECIFIED BY DRAWING REQUIREMENTS. THE MAXIMUM TORQUE IS LIMITED BY DRAWING REQUIREMENTS TO AVOID OVERSTRESSING THE NUT. THE NUT IS LOCKED IN PLACE BY ONE OF FOUR T-LOCKS (2). ASSEMBLY PROCEDURES FOR LOCKING DEVICES ENSURE DEFECT-FREE INSTALLATION (3). THE TURBINE BEARING NUT IS MANUFACTURED UTILIZING FORGED A-286 CRES (4), WHICH WAS SELECTED FOR ITS CRYOGENIC STRENGTH, RESISTANCE TO CORROSION AND STRESS CORROSION CRACKING, AND RESISTANCE TO HYDROGEN ENVIRONMENT EMBRITTLEMENT. THE MATERIAL IS SOLUTION TREATED AND AGE-HARDENED. THE LOCKS ARE MANUFACTURED UTILIZING 302 CRES SHEET (4) WHICH WAS SELECTED FOR ITS CRYOGENIC TENSILE STRENGTH, DUCTILITY, AND ITS INSENSITIVITY TO HYDROGEN ENVIRONMENT EMBRITTLEMENT. THE MATERIAL IS ANNEALED TO IMPROVE ITS MECHANICAL PROPERTIES. THESE PARTS ARE NOT SERIALIZED OR TIME HISTORY TRACKED AND HAVE INFINITE ALLOWABLE LIFE (5).

(1) RS007617; (2) RS007618; (3) RL00353; (4) RSS-8577; (5) RL00532, CP320R0003B

Component Group: Fuel Turbopumps
CIL Item: B600-05
Part Number: RS007601
Component: Low Pressure Fuel Turbopump
FMEA Item: B600
Failure Mode: Loss of support or position control of rotating assembly.

Prepared: F. Grinwell
Approved: T. Nguyen
Approval Date: 11/1/99
Change #: 4
Directive #: CCBD ME3-01-5248

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Design / Document Reference

FAILURE CAUSE: E: Excessive wear or failure of turbine-end bearing spring.
F: Positioning loss on pump seal.
Lock failure.

THE OUTER RING OF THE TURBINE-END BEARING IS PRELOADED BY THE BEARING SPACER (1), BEARING SPRING (2), AND THE PUMP SEAL (3). THE PUMP SEAL THREADS INTO THE TURBINE MANIFOLD AND IS LOCKED IN PLACE UTILIZING ONE OF FOUR T-LOCKS (4). ASSEMBLY PROCEDURES FOR LOCKING DEVICES ENSURE DEFECT-FREE INSTALLATION (5). THE PRELOAD ON THE BEARINGS IS SET BY THREADING THE PUMP SEAL INTO THE MANIFOLD TO THE DEPTH REQUIRED TO ACHIEVE THE INSTALLED SPRING HEIGHT SPECIFIED PER DRAWING REQUIREMENTS. THE BEARING SPACER AND PUMP SEAL HOUSING ARE MANUFACTURED UTILIZING A-286 CRES (5), WHICH WAS SELECTED FOR ITS COMPRESSIVE STRENGTH AND RESISTANCE TO HYDROGEN ENVIRONMENT EMBRITTLEMENT. THE MATERIAL IS SOLUTION TREATED AND AGE-HARDENED. THE SPRING IS MANUFACTURED UTILIZING INCONEL 718 (5), WHICH WAS SELECTED FOR ITS COMPRESSIVE STRENGTH AND ITS RESISTANCE TO CORROSION AND STRESS CORROSION CRACKING. INCONEL 718 IS NOT SUSCEPTIBLE TO HYDROGEN ENVIRONMENT EMBRITTLEMENT IN THE SPRING'S OPERATION ENVIRONMENT. THE MATERIAL IS SOLUTION TREATED AND AGE HARDENED. THE T-LOCKS ARE MANUFACTURED UTILIZING 302 CRES SHEET. THIS MATERIAL WAS SELECTED FOR ITS DUCTILITY, YIELD STRENGTH AT CRYOGENIC TEMPERATURES, AND ITS INSENSITIVITY TO HYDROGEN ENVIRONMENT EMBRITTLEMENT (5). THE MATERIAL IS ANNEALED TO IMPROVE MECHANICAL PROPERTIES. THE BEARING SPACERS AND SPRING AND T-LOCKS ARE NOT SERIALIZED OR TIME HISTORY TRACKED AND HAVE INFINITE ALLOWABLE LIFE (7).

(1) RS007615; (2) RSC07614; (3) RES1099, R0019065; (4) RS007618; (5) RL00353; (6) RSS-8577; (7) RL00532, CP320R0003B

FAILURE CAUSE: ALL CAUSES

THE HIGH AND LOW CYCLE FATIGUE LIFE FOR THE TURBINE-END BEARINGS, BEARING CARRIER, BEARING CARRIER BOLTS AND CUPWASHERS, BEARING SPACER (10), TURBINE BEARING NUT AND LOCK, BEARING SPRING, BEARING SPACER (10), AND PUMP SEAL AND LOCK MEET CEI REQUIREMENTS (1). PUMP END BEARINGS ARE LIFE LIMITED BY MAJOR WAIVER (5). THE MINIMUM FACTORS OF SAFETY FOR THESE PARTS MEET CEI REQUIREMENTS (2). THE HARDWARE PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/INDE FLAW GROWTH SINCE THEY CONTAIN NO FRACTURE CRITICAL PARTS (3). THE CONTROLLER SOFTWARE IS CONFIGURED TO DETECT AND RESPOND PROPERLY TO THE FAILURES IDENTIFIED AND COMMAND A SAFE ENGINE STATE (4).

(1) RL00532, CP320R0003B; (2) RSS-8546 CP320R0003B; (3) NASA TASK 117; (4) CP406R0002 PT 1.3.2.3.5.3; (5) DAR 2205

B - 55A

**SSME FMF OIL
INSPECTION AND TEST**

Component Group: Fuel Turbopumps
 CIL Item: B800-05
 Part Number: RS007601
 Component: Low Pressure Fuel Turbopump
 FMEA Item: B800
 Failure Mode: Loss of support or position control of rotating assembly.

Prepared: F. Cromwell
 Approved: T. Nguyen
 Approval Date: 11/1/99
 Change #: 4
 Directive #: CCBD ME3-01-5248

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	FORWARD BEARING AFT BEARING		RSC07605 RSC07606
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RBD130-013 RB0160-054 RS007605 RSC07606
		THE BEARING BALLS AND INNER AND OUTER RINGS ARE EDDY CURRENT INSPECTED PRIOR TO INSTALLATION	RS007605 RS007606 RA1615-032 RA1615-034
	HEAT TREAT	THE INNER AND OUTER RINGS ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
	ASSEMBLY INTEGRITY	THE BEARING BALLS AND INNER AND OUTER RINGS ARE HEAT TREATED PER SPECIFICATION REQUIREMENTS.	RA1611-005
		THE BEARING BALLS, CAGE, AND INNER AND OUTER RINGS ARE INSPECTED VISUALLY PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007605 RS007606 RL00916
		THE BEARING BALLS ARE INSPECTED PER DRAWING REQUIREMENTS TO AFDMA STANDARDS FOR SIZE AND GRADE.	RSC07605 RS007606
		BEARINGS ARE ASSEMBLED AND DISASSEMBLED PER SPECIFICATION REQUIREMENTS.	RL00916
		THE INNER AND OUTER RINGS ARE VERIFIED TO BE COPLANAR PER DRAWING REQUIREMENTS	RS007605 RSC07606
		THE BEARING CAGE FABRIC LAYERS ARE INSPECTED PER DRAWING REQUIREMENTS.	
		FEP COATING IS APPLIED TO BEARING CAGE PER SPECIFICATION REQUIREMENTS.	RA1609-011
	CLEANLINESS OF COMPONENTS	THE BEARING RINGS AND BALLS ARE VERIFIED CLEANED PER SPECIFICATION REQUIREMENTS.	RA1610-051
		THE CAGE IS INSPECTED FOR ORGANIC FLUIDS PER DRAWING REQUIREMENTS	RSC07605 RSC07606
		THE BEARINGS ARE INSPECTED FOR CORROSION PRIOR TO PACKAGING, BEFORE ASSEMBLY, AND BEFORE INSTALLATION IN THE PUMP PER SPECIFICATION AND DRAWING REQUIREMENTS.	RL00916 RL00353 RSC07605 RS007606 RS007601
		THE UPSTREAM COMPONENTS AND THE BEARING ASSEMBLY ARE VERIFIED CLEANED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RL10001 RS007501 RS007605 RSC07606

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Component Group: Fuel Turbopumps
 CIL Item: B600-05
 Part Number: RS007601
 Component: Low Pressure Fuel Turbopump
 FMEA Item: B600
 Failure Mode: Loss of support or position control of rotating assembly.

Prepared: F. Cromwell
 Approved: T. Nguyen
 Approval Date: 11/1/99
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 Directive #: CCBD ME3 01-5248

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
B	CARRIER ROIT CUPWASHER VOLUTE		RS007608 RS007668 RS007523 R0019864
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	MS9677 RS007523 RB0170-099 R00170-153 RS007508 RS007668 R0019864
		CARRIER FORGING IS ULTRASONIC AND PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-012 RA0115-116
		CARRIER IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-115
		BOLTS ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	AMS2645
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RS007668 AMS 5731
	SURFACE FINISH	THE BOLTS DRY FILM LUBRICATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007668 RA0112-003
	ASSEMBLY INTEGRITY	BOLT TORQUE IS VERIFIED PER DRAWING REQUIREMENTS.	RS007601
		THE CUPWASHERS DEFORMATION IS VERIFIED PER DRAWING REQUIREMENTS.	
		SUBASSEMBLIES ARE VERIFIED AS BOTTOMED PER SPECIFICATION REQUIREMENTS.	RLC0363
C, D	SPACER NUT T-LOCK		RS007612 RS007617 RS007618
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RB0170-051 RS007612 RS007617 RS007618
		THE SPACER IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
	HEAT TREAT	SPACER HEAT TREAT IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS	RS007612 RA0611-020
		NUT HARDNESS IS VERIFIED PER DRAWING REQUIREMENTS.	RS007617

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Component Group: Fuel Turbopumps
 CIL Item: B600-05
 Part Numbr: RS007601
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 Failure Mode: Loss of support or position control of rotating assembly.

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 Approved: T. Nguyen
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
C, D	HEAT TREAT	NUT HARDNESS IS VERIFIED PER DRAWING REQUIREMENTS.	RS007617
	SURFACE FINISH	THE NUT THREADS AND BEARING MATING SURFACES DRY FILM LUBRICATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007617 RA0112-002 RL00353
	ASSEMBLY INTEGRITY	THE INDUCER HUB STRETCHING IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007601 RL00353
		NUT TORQUE IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	
E, F		T-LOCK INSTALLATION IS VERIFIED PER DRAWING REQUIREMENTS.	RS007601
	SPRINGS SPACER T-LOCK PUMP SEAL		RS007614 RS007615 RS007618 RES1099, R0019965
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007615 RS007618 RES1099, R0019965 RB0170-154
	HEAT TREAT	SPRING AND SPACER HEAT TREAT IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RA0611-020 RS007615 RES1099, R0019965
	ASSEMBLY INTEGRITY	SPRING CHARACTERISTICS ARE VERIFIED PER DRAWING REQUIREMENTS.	RS007614
		SPRING PRELOAD IS VERIFIED PER DRAWING REQUIREMENTS	RS007601
	THE T-LOCK INSTALLATION IS VERIFIED PER DRAWING REQUIREMENTS.		
ALL CAUSES	1 PFTF		RS007601

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Component Group: Fuel Turbopumps
 CIL Item: B600-05
 Part Number: RS007501
 Component: Low Pressure Fuel Turbopump
 FMEA Item: B600
 Failure Mode: Loss of support or position control of rotating assembly.

Prepared: H. Ironwell
 Approved: T. Nguyen
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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>TORQUE CHECKS ARE 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>RLC053*</p> <p>RAC 15-116</p> <p>RL00050-04</p> <p>RI 00056-05</p> <p>RL00056-07</p> <p>RL00461</p> <p>OMRSD V419S3 010</p> <p>MSTC PLN 1225</p>

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA).
 Reference: NASA letter SA2703/308 and Rocketdyne letter 88RC09761.

Operational Use: Not Applicable.

B - 558

**SOME F A/CIL
D JOINTS**

Component Group: Fuel Turbopumps
 CIL Item: B600
 Part Number: RS007601
 Component: Low Pressure Fuel Turbopump
 FMEA Item: B600

Prepared: F. Cromwell
 Approved: T. Nguyen
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 Change #: 2
 Directive #: CCBD ME3-01-5248
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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	
MANIFOLD	RS007603	1	EBW	Ia	X			
MANIFOLD	RS007603	2	GTAW	I				
MANIFOLD	RS007603	5,8,10	GTAW	II	X	X		
MANIFOLD	RS007603	9,10	GTAW	II	X			
MANIFOLD	RS007603	13	GTAW	I				
MANIFOLD	RS007603	17	EBW	II	X	X	X	
MANIFOLD	RS007603	18	GTAW	I	X	X	X	

B - 580

SSME FMEA/CIL
FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE

Component Group: Fuel Turbopumps
 Item Name: Low Pressure Fuel Turbopump
 Item Number: B600
 Part Number: RS007601

Prepared: F. Cromwell
 Approved: T. Nguyen
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 Change #: 3
 Directive #: CCBD ME3-01-5248

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Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. B600-06. RS007606, RS007605; CAUSE A. THE INNER AND OUTER BEARING RINGS ARE EDDY CURRENT INSPECTED PER RA1615-034.	BEARING RINGS RECEIVED FROM SUPPLIER SPLIT BALL BEARING INCORPORATED RECEIVED NO GENERAL EDDY CURRENT INSPECTION.	GENERAL EDDY CURRENT INSPECTION OF RINGS REPLACES TYPE IVC IN PENETRANT INSPECTION IN DETECTING SURFACE FLAWS. USE AS IS RATIONALE: 1. RINGS ARE 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. B600-10. THE HOUSING INSULATION IS PROTECTED BY A KEVLAR COMPOSITE SURFACE WITH L-T-80 FIRE RETARDANT ALUMINUM TAPE APPLIED TO THE KEVLAR SURFACE	CERTAIN FLIGHT HOUSINGS HAVE NICKEL PLATED INSULATION WITH COPPER PLATED TIE-IN AREAS.	THE BLOCK I AND PHASE II HAVE NICKEL PLATING TO PROTECT THE INSULATION FROM MECHANICAL DAMAGE AND PROVIDE A MOISTURE BARRIER. THE HOUSING IS COPPER PLATED AT THE INSULATION CLOSE-OUT AREAS TO IMPROVE THE NICKEL BOND. THE MINIMUM FACTORS OF SAFETY FOR THE INSULATED HOUSING MEET C.E.I. REQUIREMENTS. DAR 2068 ADDRESSES THE TIME CONSTRAINTS FOR NICKEL PLATED INSULATION WITH COPPER PLATED TIE-IN CONFIGURATIONS.	RS007632-171, -181, -201, -211
3. B600-05. THE BALLS ARE POSITIONED BY AN FEP COATED ARMALON CAGE. FEP COATING ON CAGES USED TO REDUCE POCKET AND BALL WEAR THUS INCREASING BEARING LIFE.	BLOCK I AND PHASE II PUMPS DO NOT HAVE FEP COATED CAGES.	BLOCK I AND PHASE II CAGES HAVE TEFLON CONTAINED IN THE FIBERGLASS CAGE THAT PROVIDES BEARING LUBRICATION.	RS007605-027 RS007606-007, -025
4. B600-01. BLOCK II NOZZLE ASSEMBLY ALLOWS A MINIMUM OF 12 OF THE 43 NOZZLE PASSAGES TO BE BLOCKED.	BLOCK I PHASE II NOZZLE ASSEMBLY ALLOWS A MINIMUM OF 16 OF THE 43 NOZZLE PASSAGES TO BE BLOCKED	THE BLOCK I PHASE II NOZZLE ASSEMBLY DOES NOT VIOLATE THE REQUIREMENTS OF THE BLOCK II NOZZLE ASSEMBLY. BLOCK I PHASE II NOZZLE MEETS CEI NOZZLE VANE REQUIREMENTS.	R0019793-091
6. B600-02. CAUSE B,C THE SECOND STAGE ROTOR BRAZE JOINT INTEGRITY IS ULTRASONIC INSPECTED PER DRAWING REQUIREMENTS.	CERTAIN SECOND STAGE ROTORS RECEIVED NO ULTRASONIC INSPECTION OF THE BRAZE JOINT.	THE BRAZE JOINTS OF ALL SECOND STAGE ROTORS HAVE RECEIVED A VISUAL AND PENETRANT INSPECTION. ALL PARTS SUSPECTED TO HAVE BRAZE JOINT ANOMALIES HAVE BEEN ADDRESSED.	RS007625-031
6. B600-02. CAUSE D NOZZLE COPPER PLATING ADHESION IS VERIFIED PER DRAWING REQUIREMENTS.	CERTAIN NOZZLES DID NOT RECEIVE A BAKE TEST.	ADHESION BAKE TEST IS NOT REQUIRED FOR NOZZLES WHICH HAVE BEEN PREVIOUSLY HOT FIRE TESTED. THE HOT FIRE ENVIRONMENT ADEQUATELY VERIFIES THE COPPER PLATING ADHESION INTEGRITY.	RS007622-025 R0019783-023
7. B600-02. CAUSE E. THE STATOR COPPER PLATING ADHESION IS VERIFIED PER DRAWING REQUIREMENTS	CERTAIN STATORS DID NOT RECEIVE A BAKE TEST.	ADHESION BAKE TEST IS NOT REQUIRED FOR STATORS WHICH HAVE BEEN PREVIOUSLY HOT FIRE TESTED. THE HOT FIRE ENVIRONMENT ADEQUATELY VERIFIES THE COPPER PLATING ADHESION INTEGRITY	RS007623-031

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