

SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group: Oxidizer Turbopumps
CIL Item: B800-09
Component: Low Pressure Oxidizer Turbopump
Part Number: RS007801
Failure Mode: Fretting of internal parts.

Prepared: C. Abesamis
Approved: T. Nguyen
Approval Date: 6/7/99
Change #: 2
Directive #: CCBD ME3-01-6214
Page: 1 of 1

Phase	Failure / Effect Description	Criticality Hazard Reference
SMC 4.1	Fire from ignition of internal parts. Loss of vehicle. Redundancy Screens. SINGLE POINT FAILURE: N/A	1 ME-C2S,A,M,C

SSME EA/CIL
DESIGN

Component Group: Oxidizer Turbopumps
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Page: 1 of 4

Design / Document Reference

FAILURE CAUSE: A: Relative motion of: Sleeve, Housing.

- (1) SLEEVE
- (2) HOUSING

THE SLEEVE (1) IS PILOTED BY THE HOUSING (2) INLET TUNNEL BY AN INTERFERENCE FIT THAT IS ENHANCED AT CRYOGENIC TEMPERATURES. THE SLEEVE IS K-MONEL WHILE THE HOUSING IS TENS-50 ALUMINUM. THE HOUSING SURFACES ARE CHROMIC ACID ANODIZED (2). THE SLEEVE IS PRESSED INTO THE TUNNEL DURING FABRICATION AND IS FINAL BORE MACHINED WHILE INSTALLED IN THE HOUSING. THE INTERFERENCE FIT SUPPLIED BY THE HOUSING AND THE DIFFERENTIAL HARDNESS AND MATERIALS AT THE INTERFACES WILL MINIMIZE FRETTING.

- (1) RS007802-053; (2) RS007802

FAILURE CAUSE: B: Relative motion of: Inducer/Spline, Rotor/Spline, Nut, Lockwasher.

- (1) INDUCER/SPLINE
- (2) ROTOR/SPLINE
- (3) NUT
- (4) LOCKWASHER

THE INDUCER (1) IS PILOTED BY THE ROTOR (2) AND IS RETAINED BY A NUT (3) AND LOCKWASHER (4). THE INDUCER AND ROTOR ARE K-MONEL. THE NUT IS A-286. THE LOCKWASHER IS 302 CRES. THE ROTOR PILOTS FOR THE INDUCER ARE CHROME PLATED FOR HARDNESS (1). DRY-FILM LUBRICATION IS UTILIZED ON THE ROTOR PILOTS AND THREADS (2), AND THE NUT (3). NUT FINAL TORQUE IS SPECIFIED (5). THE COMPRESSION SUPPLIED BY THE NUT, THE INTERFERENCE FIT BETWEEN THE ROTOR AND THE INDUCER, THE DIFFERENTIAL HARDNESS AND MATERIALS AT THE INTERFACES, AND THE USE OF DRY-FILM LUBRICATION WILL MINIMIZE FRETTING.

- (1) RS007812; (2) RS007805; (3) RS007829; (4) RS007830; (5) RS007801

FAILURE CAUSE: C: Relative motion of: Pump End Bearing, Rotor, Retainer Nut, Lockwasher.

- (1) PUMP END BEARING
- (2) ROTOR
- (3) RETAINER NUT
- (4) LOCKWASHER

THE PUMP END BEARING (1) INNER RACE IS PILOTED BY THE ROTOR (2) AND IS RETAINED BY A NUT (3) AND LOCKWASHER (4). THE BEARING INNER AND OUTER RACES ARE 440C CRES. THE ROTOR IS K-MONEL. THE NUT IS A-286 CRES. THE LOCKWASHER IS 302 CRES. THE ROTOR PILOT FOR THE BEARING JOURNAL IS CHROME PLATED FOR HARDNESS (2). DRY-FILM LUBRICATION IS UTILIZED ON THE ROTOR THREADS AND BEARING JOURNAL (2), AND THE NUT (3). NUT FINAL TORQUE IS SPECIFIED (5). THE COMPRESSION SUPPLIED BY THE NUT, THE INTERFERENCE FIT BETWEEN THE BEARING RACE AND THE ROTOR, THE DIFFERENTIAL HARDNESS AND MATERIALS AT THE INTERFACES, AND THE USE OF DRY-FILM LUBRICATION WILL MINIMIZE FRETTING.

- (1) RS007831; (2) RS007805; (3) RS007827; (4) RS007828; (5) RS007801

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Page: 2 of 4

Design / Document Reference

FAILURE CAUSE: D: Relative motion of: Pump End Bearing, Support, Shim, Spacer, Nut, Lockwasher.

- (1) PUMP END BEARING
- (2) SUPPORT
- (3) SHIM
- (4) SPRING
- (5) DEFLECTOR

THE PUMP END BEARING (1) OUTER RACE IS PILOTED BY THE SUPPORT (2) AND IS RETAINED TIGHT AGAINST THE SUPPORT SHOULDER, ALONG WITH A TWO SHIMS (3) AND A SPRING (4), AND IS SECURED IN PLACE BY THE DEFLECTOR (5). THE BEARING RACES ARE 440C CRES. THE SUPPORT AND DEFLECTOR ARE INCONEL 718. THE SHIMS AND THE SPRING ARE INCOLOY 903. THE BEARING JOURNAL ON THE SUPPORT IS CHROME PLATED FOR HARDNESS (2). DRY-FILM LUBRICATION IS UTILIZED ON THE JOURNAL (2) THE COMPRESSION SUPPLIED BY THE SUPPORT (2) AND THE DEFLECTOR (5), THE DIFFERENTIAL HARDNESS AND MATERIALS AT THE INTERFACES, AND THE USE OF DRY-FILM LUBRICATION WILL MINIMIZE FRETTING.

(1) RS007831; (2) R033573; (3) R033576; (4) R033575; (5) R033574

FAILURE CAUSE: E: Relative motion of: Support, Nozzle, Housing, Pressure-assisted Seal, Oxidizer Seal, Bolts, Lockwashers.

- (1) SUPPORT
- (2) NOZZLE
- (3) HOUSING
- (4) FORWARD PRESSURE-ASSISTED SEAL
- (5) OXIDIZER SEAL
- (6) BOLTS
- (7) LOCKWASHERS
- (8) DEFLECTOR

THE SUPPORT (1) IS PILOTED BY THE DEFLECTOR (8), WHICH IN TURN IS PILOTED BY THE NOZZLE (2), WHICH IN TURN IS PILOTED BY THE HOUSING (3). A TEFLON COATED WIDE TIP FORWARD PRESSURE-ASSISTED SEAL (4) IS UTILIZED BETWEEN THE NOZZLE AND HOUSING. THE OXIDIZER SEAL (5) IS PILOTED BY THE DEFLECTOR AND NOZZLE. THE BEARING SUPPORT PACKAGE AND NOZZLE IS SECURED TO THE HOUSING BY 30 BOLTS (6) AND LOCKWASHERS (7). THE SUPPORT, DEFLECTOR, FORWARD PRESSURE ASSISTED SEAL, AND NOZZLE ARE INCONEL 718. THE HOUSING IS TENS-50 ALUMINUM. THE OXIDIZER SEAL IS SILVER. THE BOLTS ARE A-286 CRES. THE WASHERS ARE 321 CRES. THE HOUSING SURFACES ARE CHROMIC ACID ANODIZED (3). THE PRESSURE-ASSISTED SEAL IS TEFLON COATED (4). DRY-FILM LUBRICATION IS UTILIZED ON THE SUPPORT BEARING JOURNAL, THE DEFLECTOR PILOT DIAMETERS, AND THE BOLT (6). BOLT FINAL TORQUE IS SPECIFIED (9). THE COMPRESSION SUPPLIED BY THE MULTIPLE BOLTS THE DIFFERENTIAL HARDNESS AND MATERIALS AT THE INTERFACES, AND THE USE OF DRY-FILM LUBRICATION WILL MINIMIZE FRETTING.

(1) R033573; (2) RS007810; (3) RS007802; (4) R035534; (5) RS007816; (6) RS007833; (7) MS9880; (8) R033574; (9) RS007801

FAILURE CAUSE: F: Relative motion of: AFT Pressure-assisted Seal, Nozzle, Housing, Backing Ring.

- (1) AFT PRESSURE-ASSISTED SEAL
- (2) NOZZLE
- (3) HOUSING
- (4) BACKING RING

AFT PRESSURE-ASSISTED SEAL (1) IS USED TO PREVENT LEAKAGE BETWEEN THE NOZZLE (2) AND HOUSING (3) AND IS RETAINED BY A BACKING RING (4). THE SEAL IS INCONEL X-750. THE HOUSING IS TENS-50 ALUMINUM. THE NOZZLE AND RING ARE INCONEL 718. THE HOUSING SURFACES ARE CHROMIC ACID ANODIZED (3). THE SEAL IS SILVER PLATED (1). THE COMPRESSION SUPPLIED BY THE SEAL ACTUATION AND THE DIFFERENTIAL HARDNESS AND MATERIALS USED AT THE INTERFACES WILL MINIMIZE FRETTING.

(1) RS007801; (2) RS007810; (3) RS007802; (4) RS007816

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Page: 3 of 4

Design / Document Reference

FAILURE CAUSE: G: Relative motion of: Stator, Nozzle, Nut, Locks, Housing.

- (1) STATOR
- (2) NOZZLE
- (3) NUT
- (4) LOCKS
- (5) HOUSING

THE THREE STATOR SEGMENTS (1) ARE PILOTED BY THE NOZZLE (2) AND SECURED BY A NUT (3) AND LOCKS (4). THE NUT IS PILOTED BY THE HOUSING (5). THE NOZZLE IS INCONEL 718. THE STATORS ARE K-MONEL. THE HOUSING IS TENS-50 ALUMINUM. THE NUT IS A-286 CRES. THE LOCKS ARE 302 CRES. THE HOUSING SURFACES ARE CHROMIC ACID ANODIZED (5). THE NUT IS DRY-FILM LUBRICATED (3). NUT FINAL TORQUE IS SPECIFIED (6). THE COMPRESSION SUPPLIED BY THE NUT, THE INTERFERENCE FIT BETWEEN THE STATOR/NOZZLE AND NUT/HOUSING, THE DIFFERENTIAL HARDNESS AND MATERIALS AT THE INTERFACES, AND THE USE OF DRY-FILM LUBRICATION WILL MINIMIZE FRETTING. THE STATOR VANES ARE HIGH CYCLE FATIGUE LIFE LIMITED BY MAJOR WAIVER (7).

(1) RS007808; (2) RS007810; (3) RS007818; (4) RS007819; (5) RS007802; (6) RS007801; (7) DAR 2545

FAILURE CAUSE: H: Relative motion of: Vane, Housing, Bolts, Lockwashers.

- (1) VANE
- (2) HOUSING
- (3) BOLTS
- (4) LOCKWASHERS

THE VANE (1) IS PILOTED BY THE HOUSING (2) AND IS SECURED BY 8 BOLTS (3) AND LOCKWASHERS (4). THE VANE IS A-356 ALUMINUM. THE HOUSING IS TENS-50 ALUMINUM. THE BOLTS ARE A-286 CRES. THE LOCKWASHERS ARE 301 CRES. THE HOUSING (2) AND VANE (1) ARE ANODIZED. THE BOLTS ARE DRY-FILM LUBRICATED (3). BOLT FINAL TORQUE IS SPECIFIED (5). THE COMPRESSION SUPPLIED BY MULTIPLE BOLTS, THE DIFFERENTIAL HARDNESS AND MATERIALS AT THE INTERFACES, AND THE USE OF DRY-FILM LUBRICATION WILL MINIMIZE FRETTING.

(1) RS007811; (2) RS007802; (3) RD111-1012-3310; (4) RS007815; (5) RS007801

FAILURE CAUSE: I: Relative motion of: Turbine End Bearing, Spacer Sleeve, Housing, Preload Spring, Shim, Pin.

- (1) TURBINE END BEARING
- (2) SPACER SLEEVE
- (3) HOUSING
- (4) PRELOAD SPRING
- (5) SHIM
- (6) PIN

THE TURBINE END BEARING (1) OUTER RACE IS PILOTED BY THE SPACER SLEEVE (2), WHICH IN TURN IS PILOTED BY THE HOUSING (3). THE BEARING PRELOAD SPRING (4) PROVIDES AXIAL COMPRESSION TO THE BEARING, SPACER, AND SHIM (5). A ANTI-ROTATION PIN (6) PREVENTS ROTATION OF THE SPACER. THE BEARING RACE IS 440C CRES. THE SPRING IS INCONEL 718. THE SPACER IS 347 CRES. THE SHIM IS NICKEL 200. THE HOUSING IS TENS-50 ALUMINUM. THE PIN IS 420 CRES. THE BEARING JOURNAL ON THE SPACER IS CHROME PLATED FOR HARDNESS (2). DRY-FILM LUBRICATION IS UTILIZED ON THE SPACER (2). THE HOUSING SURFACES ARE CHROMIC ACID ANODIZED (3). THE DIFFERENTIAL HARDNESS AND MATERIALS AT THE INTERFACES, AND THE USE OF DRY-FILM LUBRICATION WILL MINIMIZE FRETTING.

(1) RS007857; (2) RS007821; (2) RS007802; (4) RS007822; (5) RS007832; (6) MS171625

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Page: 4 of 4

Design / Document Reference

FAILURE CAUSE: J: Relative motion of: Turbine End Bearing, Rotor, Nut, Lockwashers.

- (1) TURBINE END BEARING
- (2) ROTOR
- (3) NUT
- (4) LOCKWASHER

THE TURBINE END BEARING (1) INNER RACE IS PILOTED BY THE ROTOR (2) AND IS SECURED BY A NUT (3) AND LOCKWASHER (4). THE BEARING RACE IS 440C CRES. THE ROTOR AND NUT ARE K-MONEL. THE LOCKWASHER IS 302 CRES. THE BEARING JOURNAL ON THE ROTOR IS CHROME PLATED FOR HARDNESS AND DRY-FILM LUBRICATED (2). THE NUT THREADS ARE SILVER PLATED (3). NUT FINAL TORQUE IS SPECIFIED (5). THE COMPRESSION SUPPLIED BY THE NUT, THE INTERFERENCE FIT BETWEEN THE BEARING RACE AND ROTOR, THE DIFFERENTIAL HARDNESS AND MATERIALS AT THE INTERFACES, AND THE USE OF DRY-FILM LUBRICATION WILL MINIMIZE FRETTING.

(1) RS007857; (2) RS007805; (3) RS007823; (4) RS007824; (5) RS007801

FAILURE CAUSE: ALL CAUSES

TENS-50 ALUMINUM, A-356 ALUMINUM, INCONEL 718, INCONEL X-750, A-286 CRES, 301 CRES, 302 CRES, 321 CRES, 347 CRES, 420 CRES, 440 CRES, NICKEL 203, K-MONEL, TEFLON, SILVER, CHROME PLATING, AND DRY-FILM LUBRICATION MEET LOX COMPATIBILITY REQUIREMENTS (1). ASSEMBLY PROCEDURES FOR LOCKING DEVICES ENSURE DEFECT-FREE INSTALLATION (2). REUSE OF PARTS DURING OVERHAUL ARE CONTROLLED BY THE REQUIREMENTS OF THE OVERHAUL SPECIFICATION (3).

(1) RSS-8579-9, (2) RL01323; (3) RL01218

**SSME FM CIL
INSPECTION AND TEST**

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 Page: 1 of 7

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference	
A	HOUSING SLEEVE		RS007802 RS007802	
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-099 RB0170-051	
		HOUSING HOT ISOSTATIC PRESS IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007802 RL00372	
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0511-020	
	SURFACE FINISH	HOUSING ANODIZING IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007802 RA1609-003	
	ASSEMBLY INTEGRITY	HOUSING AND SLEEVE INTERFERENCE FIT IS VERIFIED PER DRAWING REQUIREMENTS.	RS007802	
B	INDUCER/SPLINE ROTOR/SPLINE NUT LOCKWASHER		RS007812 RS007805 RS007829 RS007830	
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RB0170-051 RS007829 RS007830	
	HEAT TREAT	INDUCER, ROTOR, AND NUT HEAT TREAT ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS. LOCKWASHER ANNEALING IS VERIFIED PER DRAWING REQUIREMENTS.	RS007829 RA0611-020 RS007830	
	SURFACE FINISH	ROTOR CHROME PLATING IS VERIFIED PER SPECIFICATION REQUIREMENTS. ROTOR THREAD AND NUT DRY-FILM LUBRICATION AND BURNISH ARE VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1609-002 RA0112-003 RA0112-007	
	ASSEMBLY INTEGRITY	INDUCER/ROTOR INTERFERENCE FIT IS VERIFIED PER DRAWING REQUIREMENTS. ROTOR AND INDUCER BALANCE ARE VERIFIED PER DRAWING REQUIREMENTS.	RS007812 RS007805 RS007805 RS007812	
		NUT INSTALLATION AND TORQUE ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS. NUT LOCK DEFORMATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS	RS007801 RL01323	
	C	PUMP END BEARING ROTOR RETAINER NUT LOCKWASHER		RS007831 RS007805 RS007827 RS007828

B - 638

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Page: 2 of 7

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C	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RB0160-064 RS007805 RS007827 RS007828 RS007831
	HEAT TREAT	RACE HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1611-005
		ROTOR HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
		NUT HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS.	RS007825
	SURFACE FINISH	NUT AND ROTOR THREADS DRY-FILM LUBRICATION AND BURNISH ARE VERIFIED PER SPECIFICATION REQUIREMENTS.	RS007828
ROTOR CHROME PLATING IS VERIFIED PER SPECIFICATION REQUIREMENTS.		RA0112-003 RA0112-007 RA1609-002	
ASSEMBLY INTEGRITY	BEARING INNER AND OUTER RINGS ARE VERIFIED TO BE COPLANAR PER DRAWING REQUIREMENTS.	RS007831	
	NUT INSTALLATION AND TORQUE ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007801 RL01323	
	NUT LOCK DEFORMATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.		
D	PUMP END BEARING SHIM SUPPORT DEFLECTOR SPRING		RS007831 R033576 R033573 R033574 R033575
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RB0160-064 RB0170-153 RB0170-196 RS007831
	HEAT TREAT	RACE HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1611-005
		SUPPORT, SHIM, SPRING, AND DEFLECTOR HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0811-020
	SURFACE FINISH	SUPPORT CHROME PLATING IS VERIFIED PER SPECIFICATION REQUIREMENTS	RA1609-002
		SUPPORT AND DEFLECTOR DRY-FILM LUBRICATION AND BURNISH ARE VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0112-003 RA0112-007
	ASSEMBLY INTEGRITY	BEARING RINGS ARE VERIFIED TO BE COPLANAR PER DRAWING REQUIREMENTS.	RS007831
THE SPRING IS CALIBRATED AND THE PRELOAD CHARACTERISTICS ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS		R033575 RS007801	
	THE SHIM THICKNESS IS VERIFIED PER THE DRAWING AND SPECIFICATION REQUIREMENT	RS007801	

B - 639

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 Page: 3 of 7

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
E	HOUSING SUPPORT NOZZLE FORWARD PRESSURE- ASSISTED SEAL BOLT LOCKWASHER DEFLECTOR		RS007802 R033573 RS007810 R035534 R007833 MS9880 R033574
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RB0170-153 RB0170-155 R035534 RB0170-099 RS007833 MS9880
		SUPPORT, DEFLECTOR, AND NOZZLE FORGINGS ARE PENETRANT AND ULTRASONIC INSPECTED PER SPECIFICATION REQUIREMENTS. NOZZLE IS ALSO PENETRANT INSPECTED PER DAR.	RA0115-116 RA0115-012 DAR 2956
		NOZZLE CASTING IS PENETRANT, AND RADIOGRAPHIC INSPECTED PER SPECIFICATION REQUIREMENTS.	RB0170-155
		SEAL AND BOLTS ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
	HEAT TREAT	SUPPORT, DEFLECTOR, SEAL, AND NOZZLE FORGING HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
		NOZZLE CASTING HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-155
		BOLT HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS.	RS007833
		LOCKWASHER ANNEALING IS VERIFIED PER DRAWING REQUIREMENTS.	MS9880
	SURFACE FINISH	SUPPORT CHROME PLATING IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1809-002
		SEAL TEFLON COATING IS VERIFIED PER SPECIFICATION REQUIREMENTS	RA1808-001
		SEALING SURFACE REQUIREMENTS ARE VERIFIED PER SPECIFICATION REQUIREMENTS	RF0004-027
		SUPPORT, DEFLECTOR, AND BOLT DRY-FILM LUBRICATION AND BURNISH ARE VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0112-003 RA0112-007
	ASSEMBLY INTEGRITY	BOLT INSTALLATION AND TORQUE ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS	RS007801 RL01323
	NUT LOCK DEFORMATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS		
F	NOZZLE HOUSING AFT PRESSURE-ASSISTED SEAL BACKING RING		RS007810 RS007802 RES1275 RS007820

B - 640

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 Page: 4 of 7

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F	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RB0170-153 RB0170-155 RB0170-099 RB0170-154 RES1275		
		NOZZLE FORGING IS PENETRANT AND ULTRASONIC INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116 RA0115-012		
		NOZZLE CASTING IS PENETRANT, AND RADIOGRAPHIC INSPECTED PER SPECIFICATION REQUIREMENTS	RB0170-155		
		HOUSING IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116		
		HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020	
			NOZZLE CASTING HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-155	
		SURFACE FINISH	HOUSING ANODIZING IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1609-003	
			SEAL SILVER PLATING IS VERIFIED PER SPECIFICATION REQUIREMENTS	RA1609-001	
		G	NOZZLE STATOR HOUSING STATOR NUT LOCKWASHER	MATERIAL INTEGRITY	RSC07810 RSC07808 RS007802 RS007818 RS007819
				MATERIAL INTEGRITY	RB0170-153 RB0170-091 RB0170-099 RS007818 RS007919
	STATOR AND HOUSING ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.			RA0115-116	
	NOZZLE AND NUT ARE PENETRANT AND ULTRASONIC INSPECTED PER SPECIFICATION REQUIREMENTS.			RB0170-155 RA0115-116 RA0115-012	
HEAT TREAT	HOUSING HOT ISOSTATIC PRESS IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.			RS007802 RL00372	
	NOZZLE, STATOR, AND HOUSING HEAT TREAT ARE VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.			RA0611-020 RB0170-155 RS007810	
	NUT HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS.			RS007818	
	LOCKWASHER ANNEALING IS VERIFIED PER DRAWING REQUIREMENTS.			RS007819	
SURFACE FINISH	HOUSING ANODIZING IS VERIFIED PER SPECIFICATION REQUIREMENTS.			RA1609-003	

B - 641

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 Page: 5 of 7

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
G	ASSEMBLY INTEGRITY	NUT INSTALLATION AND TORQUE ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS. LOCKWASHER DEFORMATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007801 RL01323
H	VANE HOUSING BOLT LOCKWASHER MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS. HOUSING HOT ISOSTATIC PRESS IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS. HOUSING IS PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS. VANE IS PENETRANT AND RADIOGRAPHIC INSPECTED PER SPECIFICATION REQUIREMENTS.	RS007811 RS007802 RD111-1012-3310 RS007815 RB0170-099 RS007811 RD111-1012-3310 RS007815 RS007802 RL00372 RA0115-116 RA0115-116 RL10009
	HEAT TREAT	HOUSING HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS. VANE HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS. BOLT HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS.	RA0611-020 RS007811 RD111-1012-3310
	SURFACE FINISH	VANE ANODIZING IS VERIFIED PER SPECIFICATION REQUIREMENTS. HOUSING ANODIZING IS VERIFIED PER SPECIFICATION REQUIREMENTS BOLT DRY FILM LUBE IS VERIFIED PER DRAWING REQUIREMENTS.	RA1509-003 RD111-1012-3310
	ASSEMBLY INTEGRITY	NUT INSTALLATION AND TORQUE ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS. LOCKWASHER DEFORMATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS	RS007801 RL01323
I	TURBINE END BEARING PRELOAD SPRING SPACER SLEEVE SHIM HOUSING PIN		RS007857 RS007822 RS007821 RS007832 RS007802 MS171525

B - 642

Component Group: Oxidizer Turbopumps
 CIL Item: 8800-09
 Component: Low Pressure Oxidizer Turbopump
 Part Number: RS007801
 Failure Mode: Fretting of internal parts.

Prepared: C. Abbasakis
 Approved: T. Nguyen
 Approval Date: 8/7/99
 Change #: 2
 Directive #: CCBD ME3-01-5214
 Page: 8 of 7

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
I	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RB0160-064 RB0170-154 RS007821 RS007832 MS171525 RB0170-051 RB0170-099 RB0130-013
	HEAT TREAT	RACE HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS. SHIM ANNEALING IS VERIFIED PER DRAWING REQUIREMENTS. HOUSING AND SPRING HEAT TREAT ARE VERIFIED PER SPECIFICATION REQUIREMENTS. SPACER ANNEALING IS VERIFIED PER DRAWING REQUIREMENTS.	RA1611-005 RS007832 RA0611-020 RS007821
	SURFACE FINISH	SPACER SLEEVE CHROME PLATING IS VERIFIED PER SPECIFICATION REQUIREMENTS. SPACER SLEEVE DRY-FILM LUBRICATION AND BURNISH ARE VERIFIED PER SPECIFICATION REQUIREMENTS. HOUSING ANODIZING IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1609-002 RA0112-003 RA0112-007 RA1609-003
	ASSEMBLY INTEGRITY	BEARING RINGS ARE VERIFIED TO BE COPLANAR PER DRAWING REQUIREMENTS. SPRING LOAD CHARACTERISTICS ARE INSPECTED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007857 RS007822 RL01323
J	TURBINE END BEARING ROTOR NUT LOCKWASHER		RS007857 RS007805 RS007823 RS007824
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS	RB0160-064 RB0170-051 RS007823 RS007824
	HEAT TREAT	RACE HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS. ROTOR AND NUT HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS. LOCKWASHER ANNEALING IS VERIFIED PER DRAWING REQUIREMENTS	RA1611-005 RA0611-020 RS007824
	SURFACE FINISH	ROTOR THREAD DRY-FILM LUBRICATION AND BURNISH ARE VERIFIED PER SPECIFICATION REQUIREMENTS NUT SILVER PLATING IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0112-003 RA0112-007 RA1609-011
	ASSEMBLY INTEGRITY	BEARING RINGS ARE VERIFIED TO BE COPLANAR PER DRAWING REQUIREMENTS. NUT INSTALLATION AND TORQUE ARE VERIFIED PER DRAWING AND SPECIFICATION	RS007857 RS007801

B - 643

CIL Item: Oxidizer Turbopumps
 Component: B000-09
 Part Number: Low Pressure Oxidizer Turbopump
 Failure Mode: RS007801
 Fretting of internal parts.

Prepared: C. M. Espar
 Approved: T. Nguyen
 Approval Date: 6/7/99
 Change #: 2
 Directive #: CCBD ME3-01-5214
 Page: 7 of 7

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	LPOTP		RS007801
	ASSEMBLY INTEGRITY	<p>THE PUMP SUBASSEMBLIES ARE INSPECTED DURING OVERHAUL PER SPECIFICATION REQUIREMENTS.</p> <p>INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, AND REPLACEMENT OF USAGE ITEMS AS APPLICABLE, PER OVERHAUL SPECIFICATION.</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>SHAFT TRAVEL IS PERFORMED PRIOR TO EACH FLIGHT (PHASE II AND BLOCK I).</p> <p>SHAFT TRAVEL IS PERFORMED PRIOR TO AND AFTER ACCEPTANCE TESTING AND EVERY 10 STARTS THEREAFTER (BLOCK II AND IIA).</p> <p>DATA FROM THE PREVIOUS FLIGHT OR HOT FIRE IS REVIEWED FOR PROPER TURBOPUMP OPERATION/ PERFORMANCE. (LAST TEST)</p>	<p>RL01210 RA0115-116</p> <p>RL00050-04 RL00056-06 RL00056-07 RL00461</p> <p>OMRSD V41BS0.030</p> <p>OMRSD V41BS0.032</p> <p>OMRSD V41BS0.033</p> <p>MSFC PLN 1228</p>

B - 644

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
 Reference: NASA letter SA21/88/308 and Rockwell letter 86RC09761.

Operational Use: Not Applicable.

**SSME TA/CIL
WELD JOINTS**

Component Group: Oxidizer Turbopumps
 CIL Item: B800
 Component: Low Pressure Oxidizer Turbopump
 Part Number: RS007801

Prepared: C. Abesamis
 Approved: T. Nguyen
 Approval Date: 6/7/99
 Change #: 2
 Directive #: CCBD ME3-01-5214
 Page: 1 of 1

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable		Comments
						HCF	LCF	
ROTOR	RS007805	1PLC(OPT)	GTAW	I				
ROTOR	RS007805	1PLC(OPT)	EBW	I				
NOZZLE	RS007810	1PLC	EBW	I				

B - 645

**SSME FMEA/CIL
FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE**

Component Group: Oxidizer Turbopumps
Item Name: Low Pressure Oxidizer Turbopump
Item Number: B800
Part Number: RS007801

Prepared: C. Abesamis
Approved: T. Nguyen
Approval Date: 6/7/99
Change #: 1
Directive #: CCBD ME3-01-5214

Page: 1 of 3

B - 646

Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. B800-06, B800-08 BEARINGS ARE PROCESSED AND INSPECTED PER SPECIFICATION REQUIREMENTS (RL00918). (ECP 909)	BEARINGS ARE PROCESSED AND INSPECTED PER SPECIFICATION REQUIREMENTS (RL00558).	LONG TERM FATIGUE LIFE OF BEARINGS IS EXTENDED BY REDUCING THE ALLOWABLE SIZE AND QUANTITY OF ALLOWABLE DEFECTS. USE AS IS RATIONALE: 1. THE HIGH CYCLE AND LOW CYCLE FATIGUE LIFE OF BEARINGS PROCESSED PER RL00558 MEET CEI REQUIREMENTS. 2. THE MINIMUM FACTORS OF SAFETY FOR BEARINGS PROCESSED PER RL00558 MEET CEI REQUIREMENTS (RSS-8546-16).	-011, -121, -051, -071, -081, -091, -101, -111, -141, -151, -161, -181
2. B800-01 - CAUSE C / B800-09 CAUSE E THE SUPPORT IS PILOTED BY THE DEFLECTOR, WHICH IN TURN IS PILOTED BY THE NOZZLE.	THE SEAL IS PILOTED BY THE SUPPORT THE SUPPORT IS PILOTED BY THE NOZZLE.	THE PHASE II SILVER SEAL IS DESIGNED TO BE PILOTED BY THE ONE PIECE BEARING SUPPORT. THE PHASE II DESIGN ADEQUATELY CONTROLS THE STACK-UP OF THE STATIONARY HARDWARE TO PREVENT MOTION BETWEEN MATING PARTS.	RS007810-021 RS007801-191, -201
3. B800-04 CAUSE A THE INDUCER IS REDESIGNED FOR USE WITH THE LARGE THROAT MCC. THE NEW DESIGN DEMONSTRATED INCREASED PUMP CAPABILITIES AT HIGHER FLOW/SPEED WITH ACCEPTABLE INCREASE IN HEAD OUTPUT.	THE INDUCER IS DESIGNED FOR PHASE IV BLOCK I OPERATING CONDITIONS	THE PHASE II INDUCER WAS DESIGNED FOR OPERATION WITH THE STANDARD THROAT ENGINE.	RS007812-005 RS007801-201 -191
4. B800-06 - CAUSE D, H THE BEARING OUTER RACE IS SECURED BY A TWO PIECE BEARING SUPPORT. THE SUPPORT FEATURES A STIFF INTEGRAL THRUST SHOULDER DESIGNED TO REACT TO BEARING THRUST LOADS.	THE OUTER RACE NUT SECURES THE PUMP END BEARING OUTER RACE TO THE SUPPORT. PRELOAD SUPPLIED BY THE OUTER RACE NUT REDUCES POTENTIAL FOR FRETTING OR GALLING	THE PHASE II DESIGN USING A NUT TO RETAIN THE OUTER RACE PROVIDES ADEQUATE CLAMPING AND ALIGNMENT	RS007814-015 RS007825-007 RS007826-003 RS007801-201 191
5. B800-06 - CAUSE B / B800-08 - CAUSE I BALLS ARE MADE FROM SILICON NITRIDE, WHICH WILL ELIMINATE WEAR.	THE BALLS AND RACES OF THE BEARINGS ARE MANUFACTURED UTILIZING 440C CRES	THE 440C BALLS IN THE PHASE II DESIGN ARE CONTROLLED FOR WEAR AND SPALLING BY OMRSD AND DAR 2880	RS007831-091, -181 RS007801-201 -191

Component: Oxidizer Turbopumps
 Item Name: Low Pressure Oxidizer Turbopump
 Item Number: B800
 Part Number: RS007801

Prepared: C. Abesa
 Approved: T. Nguyen
 Approval Date: 6/7/99
 Change #: 1
 Directive #: CCBD ME3-01-5214

Page: 2 of 3

Base Line Rationale	Variance	Change Rationale	Variant Dash Number
6. B800-01 - CAUSE A&B, B800-02, CAUSE A-D, B800-08 CAUSE D LPOTP NOZZLES ARE LIFE LIMITED PER DEVIATION DAR 2956	LPOTP NOZZLES ARE LIFE LIMITED PER DEVIATION DAR 2742	PHASE II LPOTP NOZZLES ARE LIFE LIMITED PER DEVIATION DAR 2742	RS007810-021
7. B800-06 - CAUSE M THE SHIM AND SPRING ARE MANUFACTURED UTILIZING INCOLOY 903, WHICH WAS SELECTED FOR CRYOGENIC MECHANICAL PROPERTIES.	B800-08 - CAUSE K THE SHIMS WERE MANUFACTURED UTILIZING NICKEL 200.	THE PHASE II DESIGN SHIM MATERIAL, NICKEL 200, PROVIDES ADEQUATE PROPERTIES FOR ITS FUNCTION.	RS007817 RS007801-201 -191
THE PUMP END BEARING OUTER RACE IS PILOTTED BY THE SUPPORT AND IS RETAINED, TIGHT AGAINST THE SUPPORT SHOULDER ALONG WITH SHIMS AND SPRING, AND IS SECURED IN PLACE BY THE DEFLECTOR.	B800-09 - CAUSE D THE PUMP END BEARING OUTER RACE IS PILOTTED BY THE SUPPORT AND IS RETAINED, ALONG WITH A SHIM, BY THE OUTER RACE NUT.	THE PHASE II DESIGN USING A NUT TO RETAIN THE OUTER RACE PROVIDES ADEQUATE CLAMPING AND ALIGNMENT.	
8. B800-01 THROUGH B800-09 THE PUMP SUBASSEMBLIES ARE INSPECTED DURING OVERHAUL PER SPECIFICATION REQUIREMENTS RL01219	THE PUMP SUBASSEMBLIES ARE INSPECTED DURING OVERHAUL PER SPECIFICATION REQUIREMENTS RL00473	THE RL00473 WAS SPECIFICALLY WRITTEN FOR THE PHASE II DESIGN	RS007801-191,-201
9. B800-02 THROUGH B800-04 AND B800-06 THROUGH B800-09 ASSEMBLY INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS RL01323	ASSEMBLY INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS RL00006.	THE RL00006 WAS SPECIFICALLY WRITTEN FOR THE PHASE II DESIGN	RS007801-191,-201
10. B800-04 FAILURE CAUSE A AND B NET POSITIVE SUCTION PRESSURE REQUIREMENTS WERE SATISFIED OVER THE ENTIRE OPERATING RANGE BY DESIGN VERIFICATION TESTING VRS 0553	NET POSITIVE SUCTION PRESSURE REQUIREMENTS WERE SATISFIED OVER THE ENTIRE OPERATING RANGE BY DESIGN VERIFICATION TESTING DVS-SSME-401B	THE DVS SSME 401B WAS SPECIFICALLY WRITTEN FOR THE PHASE II DESIGN	RS007801-191,-201

B-647

Component Group: Oxidizer Turbopumps
 Item Name: Low Pressure Oxidizer Turbopump
 Item Number: B800
 Part Number: RS007801

Prepared: C. Abesamis
 Approved: T. Nguyen
 Approval Date: 6/7/99
 Change #: 1
 Directive #: CCBD ME3-01-5214

Page: 3 of 3

Base Line Rationale	Variance	Change Rationale	Variant Dash Number
11. B800-01 - CAUSE C VENT HOLES DESIGNED INTO THE SEAL RING STRUCTURE PREVENT PRESSURE BUILDUP AND DISTORTION OF THE SEAL RING ONTO THE LABYRINTH SEAL.	VENT HOLES DESIGNED INTO THE SUPPORT STRUCTURE PREVENT PRESSURE BUILDUP AND DISTORTION OF THE SEAL RING ONTO THE LABYRINTH SEAL.	PHASE II DESIGN ADEQUATELY PREVENTS PRESSURE BUILD UP	RS007816-009 RS007801-201 -191

B - 64B