SSME . EA/CIL
REDUNDANCY SCREEN

Component Group:	Oxidizer Turbopumps	**Prepared:**	C. Abesamis
CIL Item:	B600-06	**Approved:**	T. Nguyen
Component:	Low Pressure Oxidizer Turbopump	**Approval Date:**	6/7/99
Part Number:	RS007801	**Change #:**	2
Failure Mode:	Loss of support and position control.	**Directive #:**	CCBD ME3-01-6214
		Page:	1 of 1

Phase	Failure / Effect Description	Criticality Hazard Reference
SMC .4 1	Excessive rotor movement results in potential contact between rotor and stationary components. Rubbing in oxygen environment can cause LPOTP fire or explosion. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A	1 ME-C2S,A,M,C

SSME FMEA/CIL
DESIGN

Component Group:	Oxidizer Turbopumps	Prepared:	C. Abasamis
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		Page:	1 of 3

Design / Document Reference

FAILURE CAUSE: **A: High rotor axial thrust loads.**
B: Pump end bearing failure due to wear, spalling, pitting, cage wear or failure, corrosion, loss of coolant or contamination.
E: Turbine end bearing failure due to wear, spalling, pitting, cage wear or failure, corrosion, loss of coolant or contamination.

ROTOR AXIAL THRUST IS CAUSED BY INTERNAL COMPONENT PERFORMANCE RESPONDING TO EXTERNAL ENGINE FLOW/HEAD OPERATIONAL DEMANDS. THE FLIGHT CONFIGURATION LPOTP INCORPORATES A REDUCED NET THRUST DESIGN FOR REDUCED LOADING OF THE PUMP END BEARING (1). THE NET THRUST HAS BEEN ASSESSED TO BE WITHIN THE BEARING DESIGN LOAD CAPACITY (2). THE PUMP END BEARING (3) IS A 65MM BORE ANGULAR CONTACT BALL BEARING WHICH TRANSMITS AXIAL AND RADIAL THRUST LOADS. THE BEARING RACES ARE MANUFACTURED UTILIZING 440C CRES, WHICH WAS SELECTED FOR ITS HARDNESS AND WEAR RESISTANCE CHARACTERISTICS (6). THE BALLS (15)ARE MADE FROM SINTERED AND HOT ISOSTATICALLY PRESSED SILICON NITRIDE BALL BLANKS, WHICH WAS SELECTED FOR ITS SUPERIOR HARDNESS AND REDUCED FRICTION. THERE HAS BEEN NO DEMONSTRATED BALL WEAR ON THE BLOCK IIA DESIGN (16). THE CAGE POCKETS ARE ELONGATED TO ACCOMMODATE BALL EXCURSION (13) AND THE CAGE SURFACES ARE COATED WITH MOLYBDENUM DISULFIDE FILLED FLUORINATED ETHYLENE PROPYLENE (FEP) (14). THIS MATERIAL ACTS AS A SOLID LUBRICANT AT THE CAGE OUTER DIAMETER TO RING INTERFACE AND TRANSFERS FROM THE CAGE POCKETS TO BALL SURFACES TO REDUCE FRICTION. THE TURBINE END BEARING (4) IS A 55MM BORE ANGULAR CONTACT BALL BEARING AND IS DESIGNED TO TRANSMIT ONLY RADIAL LOADS. A SPRING (5) IS UTILIZED TO PRELOAD THE TURBINE END BEARING FOR CORRECT ANGULAR CONTACT AND STIFFNESS CONTRIBUTION TO THE ROTOR. THE BEARING BALLS AND RACES ARE MANUFACTURED UTILIZING 440C CRES, WHICH WAS SELECTED FOR ITS HARDNESS AND WEAR RESISTANCE CHARACTERISTICS (6). THE ALLOY IS SINGLE VACUUM MELTED TO HELP PREVENT IMPURITY FORMATION, HARDENED, TEMPERED AND COLD STABILIZED (3) (4). THE BALLS ARE POSITIONED BY A MANDREL WRAPPED GLASS FABRIC/TFE RESIN IMPREGNATED CAGE, WHICH IS BATCH TESTED FOR LOX COMPATIBILITY (3) (4). GLASS FABRIC/TFE WAS SELECTED FOR ITS LUBRICITY AND WEAR RESISTANCE. COOLANT TO THE PUMP END BEARING IS SUPPLIED BY THE LEAKAGE FLOW OF THE LABYRINTH SEAL, WHILE TURBINE END BEARING COOLANT IS SUPPLIED BY THE HYDRAULIC TURBINE, WHICH IS DISCHARGED THROUGH THE SHAFT VENT HOLES. THE COOLANT CIRCUITS ARE HANDLED AND ASSEMBLED PER CLEANLINESS REQUIREMENTS TO PRECLUDE BLOCKAGE OF THE CIRCUITS (7). VEHICLE PROPELLANT CLEANLINESS REQUIREMENTS FILTER CONTAMINATION DURING OPERATION (8). THE CLEANING (9), PACKAGING, AND STORAGE SPECIFICATIONS (10) ENSURE CORROSION-FREE BEARINGS PRIOR TO SERVICE. ENGINE DRYING AND TRICKLE PURGES MAINTAIN A POSITIVE PRESSURE BARRIER FROM AMBIENT MOISTURE ENTRY TO THE TURBOPUMP. THE SHAFT TRAVEL SPECIFICATION LIMITS THE ALLOWABLE PUMP END BEARING WEAR TO ASSURE ADEQUATE SHAFT AXIAL CLEARANCE MARGINS PRIOR TO NEXT SERVICE (11). CONTINUED USE WITH ALLOWABLE DISCREPANCIES RESULTING FROM OPERATION IS EVALUATED AND CONTROLLED PER THE REQUIREMENTS OF THE MAINTENANCE CONTROL DOCUMENT (12).

(1) RS007801; (2) R/H 6173-4953; (3) RS007831; (4) RS007857; (5) RS007822; (6) RSS-8579-9; (7) RL10001; (8) ICD 13M15000; (9) RA1810-051; (10) RL00916; (11) RL00812; (12) RSS-8793; (13) R055041; (14) RA1608-011; (15) R055038 (16) VRS 0553

FAILURE CAUSE: **C: Loss of support bolt preload.**

THE SUPPORT BOLTS (1) ARE PRELOADED AT INSTALLATION TO SECURE THE NOZZLE ASSEMBLY AND PUMP END BEARING SUPPORT PACKAGE TO THE HOUSING. THE THREADS ARE DRY-FILM LUBRICATED (1) TO RELIEVE FRICTION AND ALLOW EQUAL LOAD APPLICATION TO THE THREADED SURFACES. LOCKWASHERS (2) ARE SECURED TO PREVENT BOLT DISENGAGEMENT DURING OPERATION. THE BOLTS ARE MANUFACTURED UTILIZING A-286 CRES, WHICH WAS SELECTED FOR ITS STRENGTH AND RETENTION OF TOUGHNESS AND DUCTILITY AT CRYOGENIC TEMPERATURES (3). THE ALLOY IS RESISTANT TO CORROSION AND STRESS CORROSION CRACKING (3). THE ALLOY IS SOLUTION HEAT TREATED, COLD-WORKED, AGED, AND COLD-WORKED AGAIN (1). THE LOCKWASHERS ARE MANUFACTURED UTILIZING 321 CRES, WHICH WAS SELECTED FOR ITS EASE OF FABRICATION, COMPRESSIVE STRENGTH, CORROSION RESISTANCE, AND RESISTANCE TO STRESS CORROSION CRACKING (3). THE ALLOY IS ANNEALED (2). ASSEMBLY PROCEDURES FOR LOCKING DEVICES ENSURE DEFECT-FREE INSTALLATION (4). BOLTS ARE ASSESSED TO HAVE INFINITE LIFE (5) AND ARE NOT TRACKED BY SERIALIZATION.

(1) RSD07833; (2) MS9680; (3) RSS-8579-9; (4) RL01323; (5) RL00532, CP320R0003B

Design / Document Reference

FAILURE CAUSE: D: Loss of pump end bearing inner and outer race retaining nut preload due to nut failure, lock failure, or vibration.

THE BEARING OUTER RACE IS SECURED BY A TWO PIECE BEARING SUPPORT. THE SUPPORT (1) FEATURES A STIFF INTEGRAL THRUST SHOULDER DESIGNED TO REACT TO BEARING THRUST LOADS. A BEAM SPRING (2) MAINTAINS BEARING OUTER RACE TIGHT AGAINST THE SHOULDER UNDER ALL PREDICTED AXIAL AND RADIAL LOAD CONDITIONS. THE DEFLECTOR (3) IS SECURED TO THE SUPPORT BY 6 FLUSH HEAD SCREWS (4). THE DEFLECTOR PILOTS THE BEARING SUPPORT PACKAGE IN PLACE. THE INNER RACE NUT (5) CLAMPS THE TWO HALVES OF THE PUMP END BEARING INNER RACE AGAINST AN AXIAL SHOULDER ON THE ROTOR ASSEMBLY. THE RETAINING NUT IS DRY-FILM LUBRICATED TO RELIEVE FRICTION AND ALLOW EQUAL LOAD APPLICATION TO THE THREADED SURFACES (5). THE NUT UTILIZES A LOCKWASHER (6), WHICH IS SECURED DURING ASSEMBLY TO PREVENT NUT DISENGAGEMENT DURING OPERATION. THE NUT IS MANUFACTURED UTILIZING A-286 CRES, WHICH WAS SELECTED FOR ITS STRENGTH AND RETENTION OF TOUGHNESS AND DUCTILITY AT CRYOGENIC TEMPERATURE (7). THE ALLOY IS SOLUTION HEAT TREATED, AGE-HARDENED (5), AND IS CORROSION AND STRESS CORROSION CRACKING RESISTANT (7). THE LOCKWASHER IS MANUFACTURED UTILIZING 302 CRES, WHICH IS ANNEALED TO ACHIEVE DUCTILITY FOR THIS BENDING APPLICATION (6). THE ALLOY IS RESISTANT TO CORROSION AND STRESS CORROSION CRACKING (7). ASSEMBLY PROCEDURES FOR LOCKING DEVICES ENSURE DEFECT-FREE INSTALLATION (8). THE NUT AND LOCK ARE ASSESSED TO HAVE INFINITE LIFE (9) AND ARE NOT TRACKED BY SERIALIZATION.

(1) R033573; (2) R033575; (3) R033574; (4) R033581; (5) RS007827; (6) RS007826; (7) RSS-8579-9; (8) RL01323; (9) RL00532, CP32R0003B

FAILURE CAUSE: F: Turbine end bearing pre- load spring wear or failure.

THE SPRING (1) PROVIDES A PRELOAD TO THE TURBINE END BEARING FOR ANGULAR RACE CONTACT AND STIFFNESS CONTRIBUTION TO THE ROTOR. THE SPRING IS A BELLEVILLE DESIGN MANUFACTURED UTILIZING INCONEL 718. THE ALLOY IS SOLUTION HEAT TREATED, COLD WORKED, AND AGE-HARDENED (1) INCONEL 718 WAS SELECTED FOR ITS REQUIRED STRENGTH AND RESISTANCE TO CORROSION AND STRESS CORROSION CRACKING (2). THE SPRING IS ASSESSED TO HAVE INFINITE LIFE (3) AND IS NOT TRACKED BY SERIALIZATION.

(1) RS007822; (2) RSS-8579-9; (3) RL00532, CP320R0003B

FAILURE CAUSE: G: Loss of turbine end bearing retaining nut preload due to nut failure, lock failure, or vibration.

THE INNER RACE OF THE TURBINE END BEARING IS SECURED TO THE ROTOR BY A RETENTION NUT (1). THE NUT IS MANUFACTURED UTILIZING K-MONEL, WHICH WAS SELECTED FOR ITS TENSILE STRENGTH, DUCTILITY, AND TOUGHNESS AT CRYOGENIC TEMPERATURES (2). THE ALLOY IS RESISTANT TO CORROSION AND IS MAGNETIC AT CRYOGENIC TEMPERATURES, WHICH IS A REQUIREMENT FOR EXCITATION OF THE SPEED TRANSDUCER (2). THE THREADED PORTION OF THE NUT IS FLASH SILVER-PLATED (1) FOR LUBRICITY DURING TORQUE APPLICATION. THE ALLOY IS SOLUTION HEAT TREATED AND AGE-HARDENED (1). A LOCKWASHER (3) IS SECURED AT ASSEMBLY TO PREVENT THE NUT FROM DISENGAGING DURING OPERATION. THE LOCKWASHER IS MANUFACTURED UTILIZING 302 CRES, WHICH IS ANNEALED (3) TO ACHIEVE DUCTILITY FOR THIS BENDING APPLICATION THE ALLOY IS RESISTANT TO CORROSION AND STRESS CORROSION CRACKING (2). ASSEMBLY PROCEDURES FOR LOCKING DEVICES ENSURE DEFECT-FREE INSTALLATION (4). THE NUT AND LOCK ARE ASSESSED TO HAVE INFINITE LIFE (5) AND ARE NOT TRACKED BY SERIALIZATION.

(1) RS007823; (2) RSS-8579-9; (3) RS007824; (4) RL01323; (5) RL00532, CP320R0003B

Design / Document Reference

FAILURE CAUSE: H: Excessive fretting at bearing journals.

THE ROTOR (1) IS DESIGNED WITH BEARING JOURNALS TO ACCOMMODATE BOTH THE PUMP END BEARING (2) AND TURBINE END BEARING (3) INNER RACES. THE ROTOR IS MANUFACTURED UTILIZING K-MONEL FORGINGS, WHICH WAS SELECTED FOR ITS TENSILE STRENGTH, DUCTILITY, AND TOUGHNESS AT CRYOGENIC TEMPERATURES (4). THE ALLOY IS SOLUTION HEAT TREATED AND AGE-HARDENED (1) AND IS RESISTANT TO IGNITION AND CORROSION (4). THE JOURNALS ARE CHROME PLATED (1) AND DRY-FILM LUBRICATED (1) TO MINIMIZE GALLING AND FRETTING. THE INNER RACES ARE PRELOADED TO THE ROTOR BY INNER RACE NUTS (5) (6), WHICH PREVENT RELATIVE AXIAL MOTION DURING OPERATION. RADIAL MOTION IS MINIMIZED BY THE INTERFERENCE FIT DESIGNED INTO THE INNER RACE JOURNALS (1). THE OUTER RACE OF THE PUMP END BEARING IS PILOTED IN PLACE AND SECURED BY THE BEARING SUPPORT (7). THE SUPPORT (7) FEATURES A STIFF INTEGRAL THRUST SHOULDER DESIGNED TO REACT TO BEARING THRUST LOADS. A BEAM SPRING (8) MAINTAINS BEARING OUTER RACE TIGHT AGAINST THE SHOULDER UNDER ALL PREDICTED AXIAL AND RADIAL LOAD CONDITIONS. THE DEFLECTOR (9) IS SECURED TO THE SUPPORT BY 6 FLUSH HEAD SCREWS (10). THE DEFLECTOR PILOTS THE BEARING SUPPORT PACKAGE IN PLACE. THE SUPPORT AND DEFLECTOR ARE MANUFACTURED UTILIZING AN INCONEL 718 FORGING, WHICH WAS SELECTED FOR ITS REQUIRED STRENGTH, RESISTANCE TO CORROSION, AND STRESS CORROSION CRACKING (4). THE ALLOY IS SOLUTION HEAT TREATED AND AGE-HARDENED (7) (9). THE SUPPORT JOURNAL IS CHROME PLATED (7) AND DRY-FILM LUBRICATED (7). THE DEFLECTOR PILOT DIAMETERS ARE DRY FILM LUBRICATED (9) ACCURATE POSITIONING SUPPLIED BY THE SPRING (8) AND DEFLECTOR (9) TO THE RACE, REDUCES THE POTENTIAL FOR GALLING OR FRETTING. THE SPRING IS MANUFACTURED UTILIZING INCOLOY 903, WHICH WAS SELECTED FOR ITS CRYOGENIC MECHANICAL PROPERTIES, THERMAL EXPANSION COEFFICIENT, THERMAL CONDUCTIVITY, ELASTIC MODULUS, AND STRESS CORROSION CRACKING RESISTANCE (12). THE PART IS SOLUTION HEAT TREATED AND AGE-HARDENED. THE TURBINE END BEARING OUTER RACE IS PRELOADED BY AN OUTER RACE SPRING (11) AND IS DESIGNED TO FREELY SLIDE IN THE BEARING SPACER SLEEVE JOURNAL (13). THE SLEEVE IS MANUFACTURED UTILIZING ANNEALED (13) 347 CRES, WHICH WAS SELECTED FOR ITS STRENGTH, AND RESISTANCE TO CORROSION AND STRESS CORROSION CRACKING (4). THE SLEEVE JOURNAL IS CHROME PLATED (13) AND DRY-FILM LUBRICATED (13). COMPONENT DYNAMIC BALANCE REQUIREMENTS FOR THE ROTOR (1) AND INDUCER (14) MINIMIZE SYNCHRONOUS UNBALANCE POTENTIALS WHICH REDUCE THE RELATIVE MOTION BETWEEN THE BEARING RACES AND JOURNALS. THE SPACER IS ASSESSED TO HAVE INFINITE LIFE (15) AND IS NOT TRACKED BY SERIALIZATION.

(1) RS007805; (2) RS007831; (3) RS007857; (4) RSS-8579-9; (5) RS007827; (6) RS007823; (7) R033573; (8) R033575; (9) R033574; (10) R033581; (11) RS007822; (12) RSS-8578-11; (13) RS007821; (14) RS007812; (15) RL00532, CP320R0003B

FAILURE CAUSE: I: Excessive rotor radial loads.

ROTOR RADIAL LOADS ARE GENERATED BY THE INDUCER (1) AND THE ROTOR ASSEMBLY (2). FIXED RADIAL LOADS ARE MINIMIZED BY THE AXIAL FLOW DESIGN OF THE INDUCER AND ROTOR. THE OVERALL DYNAMIC RESPONSE IS MONITORED BY LPOTP RADIAL ACCELEROMETERS DURING GREEN RUN AND ACCEPTANCE TESTING, AND IS SUBJECTED TO AN ACCEPT/REJECT CRITERIA ESTABLISHED BY THE GREEN RUN SPECIFICATION (3). ASSEMBLY REQUIREMENTS ENSURE PROPER ALIGNMENT, RETENTION, AND LOCKING OF ALL ROTATING COMPONENTS (4). RADIAL LOADS FROM UNBALANCE IS MINIMIZED BY COMPONENT DYNAMIC BALANCE REQUIREMENTS FOR THE ROTOR (2) AND INDUCER (1) MEASURED RADIAL ACCELERATION FROM ENGINE TEST DATA SHOWS RADIAL LOADS ARE WITHIN THE CAPACITY OF THE TURBOPUMP BEARINGS.

(1) RS007812; (2) RS007805; (3) RL00461; (4) RL01323

FAILURE CAUSE: ALL CAUSES

440C CRES, A-286 CRES, 321 CRES, 302 CRES, INCONEL 718, INCOLOY 903, AND K-MONEL SATISFY LOX COMPATIBILITY REQUIREMENTS (1). THE HIGH CYCLE AND LOW CYCLE FATIGUE LIFE OF THE PUMP END BEARING, TURBINE END BEARING, ROTOR, SUPPORT, SUPPORT BOLTS AND LOCKS, SPACER, SPRING AND BEARING RACE NUTS AND LOCKS MEET CEI REQUIREMENTS (2). THE MINIMUM FACTORS OF SAFETY FOR THESE PARTS MEET CEI REQUIREMENTS (3). THE HARDWARE PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH SINCE THEY CONTAIN NO FRACTURE CRITICAL PARTS, EXCEPT FOR THE BEARING SUPPORT WHICH WAS CLEARED BY CRITICAL INITIAL FLAW SIZE DETECTABILITY AND THE HOUSING ASSEMBLY WHICH WAS CLEARED BY RISK ASSESSMENT (4). REUSE OF PARTS DURING OVERHAUL ARE CONTROLLED BY THE REQUIREMENTS OF THE OVERHAUL SPECIFICATION (5).

(1) RSS-8579-9; (2) RL00532, CP320R0003B; (3) RSS-8546-16, CP320R0003B; (4) NASA TASK 117; (5) RL01219

SSME FM CIL
INSPECTION AND TEST

Component Group: Oxidizer Turbopumps
CIL Item: B600-05
Component: Low Pressure Oxidizer Turbopump
Part Number: RS007801
Failure Mode: Loss of support and position control.

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

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B	BEARING BALL SPRING SHIM SHIM		RS007831 R055038 RS007822 RS007832 R033576
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RB0170-154 RB0130-013 RB0160-064 RB0170-196 RS007831 RS007822 RS007832 R033576
		BEARING RACES ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
		BEARING RACES ARE EDDY CURRENT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA1615-034
		BALLS ARE ULTRASONIC INSPECTED	R055038
	HEAT TREAT	RACE HEAT TREATS ARE VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1611-005
	ASSEMBLY INTEGRITY	BALLS AND RACES ARE VISUALLY INSPECTED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007831 RL00916
		THE BALL BEARINGS ARE INSPECTED TO AFBMA STANDARDS FOR SIZE AND GRADE PER DRAWING REQUIREMENTS.	RS007831
		BEARINGS ARE ASSEMBLED AND DISASSEMBLED PER SPECIFICATION REQUIREMENTS.	RL00916
		RING IS VERIFIED TO BE COPLANAR PER DRAWING REQUIREMENTS.	RS007831

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B	ASSEMBLY INTEGRITY	CAGE QUALITY IS VERIFIED PER DRAWING REQUIREMENTS.	R056041
		CAGE COATING IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENT.	RA1608-011
		AXIAL GAP IS INSPECTED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007801 RL01323
	CLEANLINESS OF COMPONENTS	BEARING RACES AND BALLS ARE VERIFIED CLEANED PER SPECIFICATION REQUIREMENTS.	RA1610-051 RL10001
		LOX COMPATIBILITY OF THE CAGE IS MAINTAINED PER DRAWING AND SPECIFICATION REQUIREMENT.	R056041 RA1103-009 RL00916
		BEARINGS ARE INSPECTED FOR CORROSION PRIOR TO PACKAGING, BEFORE ASSEMBLY, AND BEFORE INSTALLATION PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007831 RA1110-010 RS007801 RL00916 RL01323
C	HOUSING BOLT WASHER CUP/LOCK		RS007802 RS007833 MS9880
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007833 MS9880 RB0170-099
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RA0611-020 MS9880 RS007833
	SURFACE FINISH	BOLT DRY-FILM LUBRICATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS	RS007833 RA0112-003
	ASSEMBLY INTEGRITY	BOLT INSTALLATION AND TORQUE ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007801 RL01323
		BOLT LOCK DEFORMATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
D	NUT - INNER RACE LOCK - INNER RACE ROTOR SUPPORT DEFLECTOR SPRING SHIM		RS007827 RS007828 RS007805 R033573 R033574 R033575 R033576
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS007805 R033573 RS007827 RS007828 R033574 R033575 R033576
		DEFLECTOR, SPRING, SHIM, SUPPORT AND ROTOR ARE PENETRANT INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-116
		DEFLECTOR, SUPPORT AND ROTOR ARE ULTRASONIC INSPECTED PER SPECIFICATION REQUIREMENTS.	RA0115-012
	HEAT TREAT	DEFLECTOR, SPRING, SHIM, SUPPORT, AND ROTOR HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS	RA0611-020
	SURFACE FINISH	SUPPORT, DEFLECTOR, AND NUT DRY-FILM LUBRICATION AND BURNISH ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007827 R033573 R033574 RA0112-003 RA0112-007
		SUPPORT CHROME PLATING IS VERIFIED PER DRAWING AND SPEC REQUIREMENTS.	R033573 RA1609-002
	ASSEMBLY INTEGRITY	NUT INSTALLATION AND TORQUE ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007801 RL01323
		NUT LOCK DEFORMATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	
		THE SPRING CALIBRATION AND LOAD CHARACTERISTICS ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RL00410 R033575 RS007801
		SPRING PAD COPLANAR AND PARALLELISM IS VERIFIED PER DRAWING REQUIREMENT.	R033575
E	BEARING		RS007857
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION AND DRAWING REQUIREMENTS.	RB0130-013 RB0160-064 RS007857

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
E	HEAT TREAT	BALL AND RACE HEAT TREATS ARE VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1611-005
	ASSEMBLY INTEGRITY	BALLS AND RACES ARE EDDY CURRENT INSPECTED PER DRAWING REQUIREMENTS.	RS007857
		BALLS AND RACES ARE VISUALLY INSPECTED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007857 RL00916
		BALL BEARINGS ARE INSPECTED TO AFBMA STANDARDS FOR SIZE AND GRADE PER DRAWING REQUIREMENTS.	RS007857
		BEARINGS ARE ASSEMBLED AND DISASSEMBLED PER SPECIFICATION REQUIREMENTS.	RL00916
		RING IS VERIFIED TO BE COPLANAR PER DRAWING REQUIREMENTS.	RS007857
		CAGE FABRIC LAYERS ARE INSPECTED PER DRAWING REQUIREMENTS.	
	CLEANLINESS OF COMPONENTS	BEARING RACES AND BALLS ARE VERIFIED CLEANED PER SPECIFICATION REQUIREMENTS.	RA1610-051 RL10001
		BEARINGS ARE INSPECTED FOR CORROSION PRIOR TO PACKAGING, BEFORE ASSEMBLY, AND BEFORE INSTALLATION PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007857 RS007801 RL00916 RL01323
F	SPRING (TURBINE END BEARING PRELOAD)		RS007822
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-154
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
	ASSEMBLY INTEGRITY	THE SPRING PRELOAD CHARACTERISTICS ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007822 RL01323
G	NUT - INNER RACE LOCK - INNER RACE ROTOR		RS007823 RS007824 RS007805
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007805 RS007823 RS007824 RB0170-051
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020
	SURFACE FINISH	NUT SILVER PLATING IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1609-011
	ASSEMBLY INTEGRITY	NUT INSTALLATION AND TORQUE ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007801 RL01323
		NUT LOCK DEFORMATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
H	ROTOR BEARING BEARING SUPPORT SPRING SPACER		RS007805 RS007831 RS007857 R033573 R033575 RS007821
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007821 RB0170-051 RB0170-153 RB0130-013 RB0160-064 RB0170-196 RS007805 RS007831
	HEAT TREAT	HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0611-020 RA1611-005
	SURFACE FINISH	SUPPORT, ROTOR DRY-FILM LUBRICATION IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA0112-003
		JOURNAL CHROME PLATING IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA01609-002
	ASSEMBLY INTEGRITY	ROTOR, SUPPORT, SPRING, SPACER, AND BEARING JOURNAL DIAMETER DIMENSIONS ARE INSPECTED PER DRAWING REQUIREMENTS.	RS007805 R033573 R033575 RS007821 RS007831 RS007857
		NUT INSTALLATION AND TORQUE ARE VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007801 RL01323
		NUT LOCK DEFORMATION IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	
I	ROTOR INDUCER		RS007805 RS007812
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RB0170-051
	ASSEMBLY INTEGRITY	ROTOR AND INDUCER BALANCE ARE VERIFIED PER DRAWING REQUIREMENTS.	RS007805 RS007812
		INDUCER BLADE COORDINATES ARE INSPECTED PER DRAWING REQUIREMENTS.	RS007812
ALL CAUSES	LPOTP		RS007801
	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 SPECIFICATION	RL01219 RA0116-116

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	ASSEMBLY INTEGRITY	OPERATION/PERFORMANCE IS VERIFIED BY ENGINE HOT FIRE TESTING AND 2ND E & M TESTS ON INSPECTIONS.	RL00050-04 RL00056-06 RL00056-07 RL00461
		TORQUE CHECKS ARE PERFORMED PRIOR TO EACH FLIGHT.	OMRSD V41BS0.030
		SHAFT TRAVEL IS PERFORMED PRIOR TO EACH FLIGHT (PHASE II AND BLOCK I).	OMRSD V41BS0.032
		SHAFT TRAVEL IS PERFORMED PRIOR TO AND AFTER ACCEPTANCE TESTING AND EVERY 10 STARTS THEREAFTER (BLOCK II AND IIA).	OMRSD V41BS0.033
		DATA FROM THE 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 SA21/88/306 and Rocketdyne letter 88RC09761.

Operational Use: Not Applicable.

SSME FA/CIL WELD JOINTS

Component Group: Oxidizer Turbopumps
CIL Item: B8D0
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 HCF	Critical Initial Flaw Size Not Detectable LCF	Comments
ROTOR	RS007805	1PLC(OPT)	GTAW	I				
ROTOR	RS007805	1PLC(OPT)	EBW	I				
NOZZLE	RS007810	1PLC	EBW	I				

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

Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. B800-05, 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 II/ 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. B800-05 - 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 Z880	RS007831-091, -181 RS007801-201 -191

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. B800-08 - 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 PILOTED 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 PILOTED 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

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