Critical Item List

Subsystem\Item No.\Part No.: HPFTP/AT\B300\4700000
Functional Assy: Structural Section 03
Prepared by: D.F. Clark
Approved by: A.J. Slone
CIL Item: 0303
Page: 94
Issue Date: October 28, 1986
Rev. Date: April 16, 2001

CIL Item Code: 0303
FMEA Item Code: 0303
Function: Maintain rotor position
Subsystem\Item No.\Part No: HPFTP/AT\B300\4700000

Analyst: D.F. Clark
Approved by: A.J. Slone
Rev. No.:
Rev. Date: April 16, 2001
Effectivity:
Hazard Ref.: See Listings Below

Operating Phase	Failure Mode, Description and Effect	Criticality

Operating Phase:
s,m,c

Failure Mode:
Loss of rotor support and positioning.

Criticality:
1

Failure Cause(s)

	Hazard Ref:
A. f/n 012 & 019 Ball bearing or spring washer failure due to loss of preload, cooling, contamination, vibration, excessive load, or material/mfg. defect.	A) D1S/A/M/C (AT): 1A1.8.2.1.2.1, 1A1.8.2.1.2.3, 1A1.8.2.1.2.4, 1A1.8.2.1.2.6, 1A1.8.2.2.2.1
B. f/n 167 & 168 Fracture or wear of the thrust balance seals due to vibration, contamination, rub, or material/mfg. defect.	B) D1S/A/M/C (AT): 1A1.8.2.2.1
C. f/n 147 & 186 Roller Bearing or Outer Race failure due to loss of preload, cooling, contamination, vibration, excessive load, or material/mfg. defect.	C) D1S/A/M/C (AT): 1A1.8.2.1.2.1, 1A1.8.2.1.2.3, 1A1.8.2.1.2.4, 1A1.8.2.1.2.5
D. f/n 045 Fracture of the axial stacking nut due to vibration, thermals, or material/mfg. defect.	D) D1S/A/M/C (AT): 1A1.8.2.3, 1A1.8.2.5
E. f/n 046 Wear or fracture of the Bearing Sealing Ring due to excessive load, material defect or manufacturing defect.	E) D1S/A/M/C (AT): 1A1.8.2.2.2.2
F. f/n 166 Fracture of the Turbine Cover due to material defect or manufacturing defect.	F) D1S/A/M/C (AT): 1A1.8.2.3, 1A1.8.2.4, 1A1.8.2.5
G. f/n 017 Fracture of the ball bearing nut due to excessive load, material defect or manufacturing defect.	G) D1S/A/M/C (AT): 1A1.8.2.3, 1A1.8.2.1.2.4, 1A1.8.2.5
H. f/n 100 Failure of the diffuser retention nut due to vibration, excessive loads, material or manufacturing defect.	H) D1S/A/M/C (AT): 1A1.8.2.3, 1A1.8.2.5

Failure Effect:
Rotor shift with rub in the pump or turbine stages with possible uncontained failure.

System:
Uncontained failure

Mission/Vehicle:
Loss of vehicle

Redundancy Screens:
Does not apply since it is a single point failure

Find Number Find Name	Design Considerations

f/n 012, 019

PEBB, Spring Washer

FAILURE CAUSE A: Ball bearing or spring washer failure due to loss of preload, cooling, contamination, vibration, excessive load, or material/mfg. defect.

The Pump End Ball Bearing (PEBB FN 012) is cooled with liquid hydrogen. Inner and outer race material is PWA-SP 1134 stainless steel chosen for its stress corrosion resistance, strength, hardness and toughness, and the balls are PWA-SP 1145 Silicon Nitride for its' strength, modulus and friction coefficient properties. Under race venting of entrapped moisture is incorporated to preclude corrosive attack.

An interference fit between the outer race and the ball bearing Sleeve (FN 016) is used to anti-rotate the race relative to the sleeve. A lug that mates with the pump housing (FN 091) anti-rotates the sleeve. The Pump Inlet Housing (PIH) (FN 091) provides the volute and guide vanes for directing fuel flow to the 1st Stage impeller. The PIH is an inseparable assembly of two castings and a pinned-in labyrinth seal holder. One casting consists of the volute and housing section (FN 091-01) and the second casting is a ring-strut-ring (FN 091-02) that contains the guide vanes. The castings are made of INCO 718 (PWA-SP 1490) for its cryogenic strength, toughness and weldability and are brazed in two locations. The PIH (091) carries the labyrinth seals that meter coolant flow to the PEBB. The PIH also reacts the PEBB radial loads to the PIH journal surfaces. An operating clearance, or deadband, exists between the ball bearing sleeve O.D. and the pump housing I.D. To reduce the possibility of fretting, the sleeve is surface nitrided to increase hardness and a sputtered application Molydisulfide coating is used on the O.D. of the sleeve. The radial load is applied through the turbine end of the sleeve which increases effective radial stiffness.

The Ball Bearing Cage (FN 232) is O.D. piloted and is comprised of an PWA-SP 1156 (Armalon Glass Filled Teflon) ring used for its' lubricity, density and strength with PWA-SP 1157 (Salox) inserts. To prelubricate the ball bearing, Salox is applied to the loaded side of the inner race and to both sides of the outer race by a rub deposition process. To reduce the possibility of galling during dissassembly, the ball bearing inner race fit is coated with Molydisulfide per Spec PWA-SP 1150.

The pump end ball bearing (PEBB) radial stiffness is maintained by the application of an axial load from the PEBB Preload Springs (FN 019). The springs are made of PWA-SP 1146 nickel alloy. Sufficient radial stiffness is required in order to provide rotor dynamic stability and prevent skidding of the balls. The springs are of the footed wave washer variety, similar to the HPOTP/AT ball bearing preload spring. Proper clocking of the springs is facilitated through the use of splines in the feet. Consistent bearing preload is achieved for all operating conditions by minimizing the springrate of the preload springs.

Proper bearing preload is assured by the use of a classed Spacer (FN 313). The spacer class is determined by seating the assembled (stretched) rotor assembly on the turbine stop with a load applied to the PEBB outer race which simulates the bearing preload. The spacer controls the compressed height of the springs by setting the proper amount of thread advance on the PEBB nut (FN 017). When the nut is seated and torqued against the spacer, a predetermined compressed spring height is achieved. The nut is anti-rotated to the pump inlet housing by a Key Washer (FN 018).

The axial travel of the rotor assembly during the start and stop transients is limited in the pump direction by a bumper on the PEBB Sleeve (FN 016). During the start and stop transients, thrust piston capability briefly drops below the turbine load causing the rotor to move in the pump direction. The gap between the sleeve bumper and classed spacer is set to prevent the thrust piston turbine side tip seal from rubbing on the 3rd impeller during the transients. At mainstage, the rotor travel is controlled by the thrust piston and the bumper moves well away from the spacer due to axial expansion of the pump housings.

During a portion of the start and shutdown transients, the thrust piston does not produce sufficient restoring force to balance the turbine load and keep the rotor centered. Under these conditions, a bumper on the pump end ball bearing limits rotor travel in the pump direction. The bumper gap is sized to prevent a rub on the thrust piston turbine side OD face seal during transients.

FN 014, 022 and 204 are the Washer Key, PEBB ID race retaining Nut and pump end Balance Ring, respectively. These three details form a portion of the Shaft-Rotor axial stack by loading against the PEBB I.D. race and into the 1st impeller, in parallel with the main shaft nut (FN 045). The three details are mounted on the PEBB inverted nut support, which is an integral part of the Shaft/Disk assembly (FN 043). The PEBB race retaining Nut preloads the Washer Key and Balance Ring against the PEBB ID race by threading into the PEBB inverted nut support. The Washer Key provides mechanical retention of the Nut by engaging with O.D. slots on the Nut during assembly, and by engaging slots in the PEBB inverted nut support. This anti-rotates the Nut relative to the PEBB support. The balance ring is anti-rotated with respect to the shaft assembly by engaging a slot in the PEBB inverted nut support. The balance ring serves as sacrificial material for the pump end balancing of the rotor assembly. The Washer Key (FN 014) is made of AMS 5512 SST. This detail is a cuplock washer with a tab on its I.D. to engage with the PEBB inverted nut support. The O.D. cup portion of the washer is deformed into O.D. slots on the adjacent PEBB race retaining nut to provide mechanical locking.

The PEBB I.D. race retaining Nut (FN 022) is made out of PWA-SP 1146 nickel alloy. This detail is threaded onto the PEBB inverted nut support which is a non-removable detail in the Shaft/Disk assembly. The assembly torque on this nut provides preload into the PEBB I.D. race and into the rotor stack via the 1st impeller. This preload works in addition to the main preload applied by the main shaft nut (FN 045), and is intended to seat the PEBB I.D. race. The Balance Ring (FN 204) is made out of AMS 5737 SST (rotor grade). The ring serves as sacrificial material for the proper balance of the rotor assembly at the PEBB plane. After preassembly and balance spinning of the rotor stack, the balance ring is disassembled and scallop machined on its O.D. lip to provide proper rotor balance.

The bearing is a fracture critical part and meets all requirements of the SSME ATD fracture control plan FR-19793-5.

DVS 4.1.2.7 Bearing system analysis to verify goals for the pump end ball bearing is complete. The results are documented in FR-19848-01, FR-20712-01, FR-20713-01, -13, -15 and -16 and FR-20716-10 and -24. The VCR is in FR-20712-11A and -11B, FR-20715-120 and -121 and FR-23126-126.

DVS 4.1.4.1.2.2 Environmental rig tests on the pump end ball bearing to demonstrate 2X life have been completed. The results are documented in FR-20713-10 with the VCR in FR-23126-126.

DVS 4.1.4.1.2.4 Service life tests on the pump end ball bearing to demonstrate 2X life have been completed. The results are documented in FR-20713-10 with the VCR

Find Number Find Name	Design Considerations
	in FR-23126-126. DVS 4.1.4.3.1.4 The requirement to monitor outer race temperatures on the pump end ball bearing at the component level has been deleted. It will be verified during engine level testing at SSC. See FR-23231-126. DVS 4.1.4.4.1.6 Results of the bearing verification tests for the pump end ball bearing are included in VCR document FR-23131-126.
f/n 167, 168 Thrst Balance Seals 1, 2	FAILURE CAUSE B: Fracture or wear of the thrust balance seals due to vibration, contamination, rub, or material/mfg. defect. The pump side thrust piston Seal (FN 168) is a classed part made from PWA-SP 1143 and serves as the thrust piston pump side cavity supply flow control orifice. The seal is snapped on the OD and threaded into the pump discharge housing. The turbine side OD Face Seal (FN 167) is a classed part made of PWA-SP 1146 and functions as the thrust piston turbine side cavity supply flow control orifice. The seal is threaded onto the turbine housing. The clearances between the rotor and seals are optimized for maximum thrust piston capability at mainstage while minimizing leakage and precluding a rub. The key lock (FN 385) provides a positive mechanical locking device to anti-rotate the pump side tip seal (FN 168) from loosening or tightening. The pump side ID Corner Seal (FN 069) functions as the thrust piston pump side cavity discharge flow control orifice. The seal (FN 069) is snapped on the O.D. and bolted to the 2-3 diffuser with 13 self-locking AS7477 SST bolts (FN 245). DVS 4.1.3.3.7 Thrust balance capacity and stability testing has been completed. The results are documented in FR-20712-10,-11,-11A, -13 and -15 and FR-21351-01 with the VCR in FR-20712-01A, -28 and -31. DVS 4.1.4.4.1.5 Impeller seal flow erosion and the resulting thrust balance deterioration will be verified during duty cycle/LCF life engine testing at SSC. The results will be included in the engine testing VCR FR-20904-500 and -501
f/n 147, 186 Roller Bearing, Race	FAILURE CAUSE C: Roller Bearing or Outer Race failure due to loss of preload, cooling, contamination, vibration, excessive load, or material/mfg. defect. The Roller Bearing (FN 147) is located at the turbine end of the shaft and supports the radial load of the rotor. The bearing inner race (FN 147-01) is retained by the axial rotor stack from the disk shoulder to the rotor stacking nut. The outer race (FN 186) is retained by the stack from the bolted bumper thru the load spring (FN 048). An interference fit at running condition prevents rotation of the roller bearing Outer Race (FN 186) relative to the Sleeve (FN 191). Outer race anti-rotation is accomplished with a tang on the roller bearing sleeve (FN 191) which mates with the roller bearing knife edge seal (FN 054). The A286 sleeve has a higher alpha than the Cronidur 30 roller bearing outer race and is intended to reduce the bearing IRC at operating condition and allow a positive IRC at room temperature. The roller bearing outer race I.D. is classified and the IRC of the bearing is set by a selection criteria based on the actual dimensions of the bearing components and the shaft. The roller bearing cage (FN 147-03) is O.D. piloted and is made from PWA-SP 1156 (Armalon Glass Filled Teflon used for its' lubricity, density and strength. A deadband exists between the sleeve O.D., when mounted on the roller bearing assembly, and the turbine housing I.D. The sleeve outer diameter is classified to allow a consistent operating deadband clearance. To reduce the possibility of fretting between the roller bearing sleeve and the turbine housing, a sputtered application Molydisulfide coating is on the O.D. of the sleeve. The Monel K500 AMS 4676 Roller Bearing Lab Seal (FN 054) serves several functions. It meters recirculation flow from the bearing cavity back to the impeller bore, provides axial support for the rub load, provides anti-rotation to the Roller Bearing Outer Race Sleeve and axial retention of the outer race. The seal itself is anti-rotated in the Turbine Housing(f/n 118) by use of a tab. The rotating Bearing Seal Ring (FN 046), made from forged IN 100 PWA-SP 1074 for its' strength and low cycle fatigue serves two functions. It provides the lands for the Roller Bearing Lab Seal (FN 054) as well as the mating hard face for the Thrust Piston Face Seal. It is anti-rotated to the 3rd impeller by two tangs positioned in slots in the impeller balance area. Bolt (FN 151) retains the rub stop plate (FN 152) and roller bearing knife edge seal (FN 054) to the main Turbine Housing (FN 118). The bolts are made from A-286 which is a very ductile material with good cryogenic strength. They are threaded into INCO 718 self-locking inserts. These inserts are threaded into the main turbine housing and locked in place with 302 CRES keys. The inserts provide the locking for the bolts via beams which are deformed radially inward thus causing an interference with the bolt. The beam lock design provides high reuse capability. FN 234 is a large diameter metal piston ring which is employed near the 3rd stage impeller discharge to minimize leakage between the discharge and turbine housings. The ring is made of an aluminum-bronze alloy which provides a hydrogen resistant, moderate strength, low modulus material which gives a good range of seal deflection (for assembly without yielding). Also, this material has a relatively good match of coefficient of expansion with the aluminum alloy diffusers (compared to most commonly used high strength alloys). This results in less change of end gap from room temperature to operational temperatures. The Turbine to Discharge Housing I. D. Gasket (FN 126) uses a single convolution teflon coated annealed metal omega seal with an additional internal metal "V" shaped Damper (FN 205). The damper wedges into the internal groove of the omega seal and presses against the legs of the seal. A Torsion Spring (FN 048) is used in the roller bearing inner race axial stack to provide preload. The axial dimension of the spring is classified and a selection criteria based on the actual dimensions of the shaft, inner race, seal runner, and cover plate is used to provide a consistent preload. To reduce the possibility of galling during disassembly, the roller bearing inner race fit is coated with Molydisulfide per Spec PWA-SP 1150. The roller bearing is a fracture critical part and meets all requirements of the SSME ATD fracture control plan FR-19793-5.

Find Number Find Name	Design Considerations
	DVS 4.1.2.7 Bearing system analysis to verify goals for the turbine end roller bearing is complete. The results are documented in FR-20712-01, FR-20713-02, -16, and -23 and FR-20716-10 and -24. The VCR is in FR-20712-11A and -11B, FR-20715-120 and -121 and FR-23126-126. DVS 4.1.4.1.2.1 Tests to evaluate hardness of the turbine end roller bearing outer race have been completed. The results are documented in FR-20713-11 and the VCR is in FR-23126-126. DVS 4.1.4.1.2.2 Environmental rig tests on the turbine end roller bearing to demonstrate 2X life have been completed. The results are documented in FR-20713-08 and -09 with the VCR in FR-23126-126. DVS 4.1.4.1.2.4 Service life tests on the turbine end roller bearing to demonstrate 2X life have been completed. The results are documented in FR-20713-08 and -09 with the VCR in FR-23126-126. DVS 4.1.4.3.1.4 The requirement to monitor outer race temperature on the turbine end roller bearing at the component level has been deleted. It will be verified during engine level testing at SSC. See FR-23231-126. DVS 4.1.4.4.1.6 Results of the bearing verification tests for the turbine end roller bearing are included in VCR document FR-23131-126.
f/n 045 Stacking Nut	FAILURE CAUSE D: Fracture of the axial stacking nut due to vibration, thermals, or material/mfg. defect. The main pump rotor is preloaded at assembly by stretching the shaft and compressing the stack elements. The tensile load is applied to the shaft pump end through endcap threads using high strength tooling. The compressive stack load is applied to the inner race sleeve through 2.3125-16 UNJ threads. The tooling applies first a load to seat the axial stack, then a preload. The preload that is applied by the tooling is maintained by torquing the main stack nut (FN 045) which is made from PWA-SP 1146 for its' cryogenic strength and toughness. Anti-rotation of the main stack nut is provided by the Endcap/Speed Pick-up (FN 026) which is anti-rotated by a lock washer between the main stack nut and the endcap. The Lockwasher (FN 027) has 2 equally spaced extensions which fit into 2 slots in the shaft and anti-rotate the lockwasher to the shaft. The lockwasher is deformed into 4 castellations on the end cap to anti-rotate the cap. This nut is a fracture critical part and meets all the requirements of the SSME ATD fracture control plan FR-19793-5.
f/n 046 Bearing Seal Ring	FAILURE CAUSE E: Wear or fracture of the Bearing Sealing Ring due to excessive load, material defect or manufacturing defect. The Thrust Piston Turbine-side Bearing Seal Ring (FN 046) and Seal Seat (FN 252) counteract thrust inbalance loads towards the turbine. During the start and shutdown transients, the mating faces act as a rub stop, physically bearing the load unbalance. During mainstage, the axial gap between the rotating face and static face meters flow from the impeller back face to the bore. The IN-100 Bearing Seal Ring (FN 046) serves two functions. It provides the lands for the Roller Bearing Lab Seal (FN 054) as well as the mating hard face for the Thrust Piston Face Seal. It is anti-rotated to the 3rd impeller by two tangs positioned in slots in the impeller balance area. The Seal Seat (FN 252) is clamped axially and anti-rotated by an INCONEL 718 Retainer (FN 152) and 8 bolts. The load path is through the Roller Bearing Lab Seal (FN 054) and into the Turbine Housing. The classed insert is free to grow radially as it is heated during rubbing, avoiding thermal cracking of the face. Its axial thickness is determined from rotor and static hardware measurements to set LOS runner axial position for proper LOS preload. The rear bump stop is a fracture critical part and meets all the requirements of the SSME ATD fracture control plan FR-19793-5. On the 3rd Stage Impeller Seal Seat (F/N 252) a life limit and inspection limit has been imposed per DAR PW0266.
f/n 166 Disk Cover	FAILURE CAUSE F: Fracture of the Turbine Cover due to material defect or manufacturing defect. The Coverplate (FN 166) shields the disk from direct scrubbing of the lift-off seal flow and provides insulating dead space pockets between the parts. This allows the temperature from the hotter rim to soak down into the body of the disk through conduction providing a more gradual thermal gradient from bore to rim similar to what the flow mixtures accomplish on the inlet side of the disk. The coverplate, machined from a PWA-SP 1074 (IN 100) forging, is a disk/plate type structure with a hole in the center and a zigzag OD that provides piloting and support for the part. It is held in place axially by the main shaft stack with the same load split that goes through the roller bearing inner race and lift-off seal (LOS) runner controlled by an axial spring. On the disk side of the coverplate are 8 radiused vent slots that allow drying and pressure relief of the middle dead cavity. The disk cover is a fracture critical part and meets all the requirements of the SSME ATD fracture control plan FR-19793-5.
f/n 017 Ball Bearing Nut	FAILURE CAUSE G: Fracture of the ball bearing nut due to excessive load, material defect or manufacturing defect.

Find Number Find Name	Design Considerations
	The preload springs made from PWA-SP 1146 are held against the PEBB by the PEBB Nut (FN 017). The PEBB preload can be increased or decreased by adjusting the classed shim. The thread shear margin of the nut (with minimum engagement, max predicted external load and maximum seating torque) is 2.90. The nut is a fracture critical part and meets all the requirements of the SSME ATD fracture control plan FR-19793-5.
f/n 100 Diffisurer Retention nut	FAILURE CAUSE H: Fracture of nut due to vibration, material or manufacturing defect. The 2-3 Diffuser axial load is taken out through the inverted Nut (FN 100) into the Discharge Housing. This prevents the total diffuser load from having to be carried through the 1-2 Diffuser. The tall radial height and steep face of the thread was required to retain the high assembly load. The nut is axially loaded at assembly by applying hydraulic ram load to the diffuser and tightening the nut to maintain diffuser compression. Nut load becomes less during operation. The margin of safety in thread shear is +1.08. A dowel pin installed in the 1-2 diffuser serves to lock the nut.

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
Failure Cause A f/n 012 Bearing,Ball,Annular	Material Integrity	Material integrity of the retainer (f/n 012-01-01, P/N 2194355) is verified per drawing and specification requirements	PWA-SP 1157
		Hardness of the outer ring (f/n 012) is verified per drawing requirements	
		Material integrity of the inner ring (f/n 012) is verified per specification requirements	PWA-SP 1134
		Hardness of the inner ring (f/n 012) is verified per drawing requirements	
		Material integrity of the outer ring (f/n 012) is verified per specification requirements	PWA-SP 1134
		Material integrity of the balls (f/n 012) is verified per specification requirements	PWA-SP 1145-2
	Inspection	Max/Min diametral play (f/n 012) is verified per drawing requirements	
		Roughness of the raceways (f/n 012) is verified per drawing requirements	
		Roughness of the balls (f/n 012) is verified per drawing requirements	
	Raw Material	Xray- per- QAD (cage - Bronze filled PTFE) (f/n 012)	SP-XRM Master
		Sonic- per- QAD (inner and outer ring) (f/n 012)	SP-SIM 14
	Finished Material	ECI- per- QAD (inner and outer ring) (f/n 012)	SP-ECM Master
		FPI- per- QAD (balls and rings) (f/n 012)	SP-FPM Master
		Sonic- per- QAD (balls) (f/n 012)	SP-SIM 315
	Assembly Integrity	Vacuum Drying (of an assembly of parts containing a bearing that was chilled to facilitate assembly) is verified per REI	REI 012
		Maximum axial force applied thru the bearing balls to facilitate assembly is 4000 LBS verified per REI	REI 012
Failure Cause A f/n 019 Washer Set,Spring	Material Integrity	Material integrity (slotted washer (f/n 019-02-01) and tabbed washer (f/n 019-01-01)) is verified per specification requirements	PWA-SP 1146

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Raw Material	Sonic- per- QAD (tabbed washer) (f/n 019-01)	SP-SIM 1
		Sonic- per- QAD (slotted washer) (f/n 019-02)	SP-SIM 1
	Finished Material	FPI- per- QAD (slotted washer) (f/n 019-02)	SP-FPM Master
		FPI- per- QAD (tabbed washer) (f/n 019-01)	SP-FPM Master
	Recycled Hardware	FPI-per-PWA-SP 36187 (tabbed washer) (f/n 019-01)	PWA-SP 36187
		'FPI-per-PWA-SP 36187 (slotted washer) (f/n 019-02)	PWA-SP 36187
Failure Cause a f/n 014 Washer,Key,I.D.Brg.	Material Integrity	Material integrity is verified per specification requirements	AMS 5512
		Anneal process is verified per drawing and specification requirements	PWA-SP 11-3
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Locking feature inspected is verified per REI	REI 012
Failure Cause a f/n 016 Housing,Bearing	Material Integrity	Material integrity is verified per specification requirements	PWA-SP 1146
		Nitride surface treatment integrity is verified per specification requirements	PWA-SP 1144
	Inspection	Outside Diameter after coating is verified per drawing requirements	
	Finished Material	FPI- per- QAD	SP-FPM Master
	Recycled Hardware	FPI-per-PWA-SP 36187	PWA-SP 36187
Failure Cause a f/n 018 Washer,Key,O.D.Brg.	Material Integrity	Material integrity is verified per specification requirements	PWA-SP 1146
	Finished Material	FPI- per- QAD	SP-FPM Master

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause a f/n 022 Nut,I.D.Bearing	Material Integrity	Material integrity is verfied per specification requirements	PWA-SP 1146
	Raw Material	Sonic- per- QAD	SP-SIM 1 or SP-SIM 314
	Finished Material	FPI- per- QAD	SP-FPI Master
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause a f/n 091 Housing Asyo,Pump In	Material Integrity	Chrome plating integrity of housing A/O (f/n 091) is verified per specification requirements	AMS 2406
		Material integrity of housing casting (f/n 091-01-1) is verified per specification requirements	PWA-SP 1490-1
		Material integrity of housing (f/n 091) is verified per specification requirements	PWA-SP 1146
		Welding integrity of core supports closures on housing casting (f/n 091-01-1) are verified per drawing and specification requirements	PWA-SP 36158
		Material integrity, heat treatment and hardness of insert (f/n 091-04) are verified per drawing and specification requirements	AMS 5662 & PWA-SP 11-17
		Weld repair integrity of housing casting (f/n 091-01-1) is verified per specification requirements	PWA-SP 36158
		Material integrity of bearing support casting (f/n 091-02-1) is verified per specification requirements	PWA-SP 1490-1
		Heat treatment and hardness of housing A/O (f/n 091) is verified per specification & drawing requirements	PWA-SP 11-17, PWA-SP 1490
		Braze integrity of housing A/O (f/n 091) is verified per drawing and specification requirements	PWA-SP 19 & AMS 4786
		Weld repair integrity of bearing support casting (f/n 091-02-1) is verified per specification requirement	PWA-SP 36158

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
		Material integrity of stud (f/n 091-03) is verified per specification requirement	PWA-SP 115
	Inspection	Ball bearing journal diameter is verified per drawing requirements	
		Wall thicknesses on housing A/O (f/n 091) (2 places) are verified per drawing requirement	
	Finished Material	FPI- per- QAD (housing) (f/n 091-01)	SP-FPM Master
		FPI- per- QAD (housing A/O) (f/n 091)	SP-FPM Master
		Proof pressure test of housing A/O (f/n 091) is verified per specification requirements	REI 017
		Xray- per- QAD (housing casting) (f/n 091-01-1)	SP-XRM Master
		Sonic- per- QAD (housing A/O) (f/n 091)	SP-SIM 309 or SP-BTM 2
		FPI- per- QAD (stud) (f/n 091-03)	SP-FPM Master
		Xray- per- QAD (bearing support casting) (f/n 091-02-1)	SP-XRM Master
	Assembly Integrity	Inspection of F3 Pump Inlet Flange interface seal surface finish is verified per REI	REI 012
Failure Cause a f/n 204 Ring,Balance,Bll.Brg	Material Integrity	Material integrity is verified per specification requirements	AMS 5737
	Inspection	Snap diameter is verified per drawing requirements	
	Raw Material	Sonic- per- QAD	SP-SIM 1
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Part seating of DIM R8 is verified per REI	REI 012
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master

Critical Item List

Subsystem\Item No.\Part No.: HPFTP/AT\B300\4700000 | **Prepared by:** D.F. Clark | **Page:** 103

Functional Assy: Structural Section 03 | **Approved by:** A.J. Slone | **Issue Date:** October 28, 1986

Failure Mode: Loss of rotor support and positioning. | **CIL Item:** 0303 | **Rev. Date:** April 16, 2001

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
Failure Cause a f/n 232 Retainer Asyo, Brg.	Material Integrity	Material integrity of P/N 2194356 (F/N 232-01-01) is verified per specification requirements	PWA-SP 1156
		Material integrity of P/N 2194355 (F/N 232-01-01) is verified per drawing and specification requirements	PWA-SP 1157
	Finished Material	Xray- per- QAD (retainer in assembly) (F/N 232)	SP- XRM Master
	Raw Material	Xray- per- QAD (cage - Bronze filled PTFE) (F/N 232-01-01)	SP- XRM Master
	Recycled Hardware	Xray- per- PWA-SP 36187	PWA-SP 36187 & SP-XRM Master
Failure Cause a f/n 313 Spacer,Ball Bearing	Assembly Integrity	Selection of classification of part is verified per assembly drawing requirements	
Failure Cause B f/n 167 Ring Assy,Stg 3,Rear	Material Integrity	Material integrity is verified per specification requirements	PWA-SP 1146
	Finished Material	FPI- per- QAD (ring) (f/n 167-01)	SP-FPM Master
		FPI- per- QAD (if machined to reclass at the Assembly level) (F/N 167)	SP-FPM Master
	Assembly Integrity	Selection of classification of part is verified per assembly drawing requirements	
		Part Seating is verified per REI	REI 012
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause B f/n 168 Ring Assy,Stg 3,Fwd	Material Integrity	Material integrity is verified per specification requirements	PWA-SP 1143
	Raw Material	Sonic- per- QAD	SP-SIM 14
	Finished Material	FPI- per- QAD (ring) (f/n 168-01)	SP-FPM Master
		FPI- per- QAD (if machined to reclass at the Assembly level) (F/N 168)	SP-FPM Master

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Assembly Integrity	Selection of classification of part is verified per assembly drawing requirements	
		Part Seating is verified per REI	REI 012
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause b f/n 069 Seal,Corner,Stage 3	Material Integrity	Material integrity is verified per specification requirements	AMS 4127
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Part Seating is verified per REI	REI 012
		Selection of classification of part is verified per assembly drawing requirements	
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause b f/n 245 Screw,Rear Diffuser	Material Integrity	Material integrity is verified per specification requirements	AS 7477
	Raw Material	Sonic- per- QAD	SP-SIM 314
	Finished Material	FPI- per- QAD	SP-FPM Master
Failure Cause b f/n 385 Key-Mach,Thrst Balnc	Material Integrity	Material integrity is verified per specification requirements	AMS 5664
Failure Cause C f/n 147 Bearing Set,Roller		Material integrity of the retainer (f/n 147-03-01) is verified per specification requirements.	PWA-SP 1156
		Case depth and hardness of the inner race (f/n 147-01) is verified per drawing requirements	
		Material integrity of the inner race (f/n 147-01) is verified per specification requirements	PWA-SP 1134

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
		Material integrity of the rollers (f/n 147-02) is verified per specification requirements	PWA-SP 1145-2
	Inspection	Roller (f/n 147-02) diameter variation is verified per drawing requirement	
	Raw Material	Xray- per- QAD (cage-PTFE filled glass fabric) (f/n 147-03)	SP-XRM Master
		Sonic- per- QAD (inner ring) (f/n 147-01)	SP-SIM 14
	Finished Material	FPI- per- QAD (inner ring) (f/n 147-01)	SP-FPM Master
		ECI- per- QAD (inner ring) (f/n 147-01)	SP-ECM Master
	Assembly Integrity	Part seating is verified per REI	REI 012
		Vacuum Drying (of an assembly of parts containing a bearing that was chilled to facilitate assembly) is verified per REI	REI 012
	Finish Material	FPI- per- QAD (rollers) (f/n 147-02)	SP-FPM Master
		Sonic- per- QAD (rollers) (f/n 147-02)	SP-SIM 315
Failure Cause C f/n 186 Ring,Outer,Rllr.Brg.	Material Integrity	Case hardening is verified per drawing requirements	
		Material integrity is verified per specification requirements	PWA-SP 1134
	Raw Material	Sonic- per- QAD	SP-SIM 14
	Finished Material	FPI- per- QAD	SP-FPM Master
		ECI- per- QAD	SP-ECM Master
	Assembly Integrity	Selection of classification of part is verified per assembly drawing requirements	
Failure Cause c f/n 046 Ring,Sealing,Bearing	Material Integrity	Shot peen is verified per specification requirement	AMS 2430

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
		Hardface is verified per drawing and specification requirement	PWA-SP 288-1
		Material integrity is verified per drawing and specification requirements	PWA-SP 1074
	Raw Material	Sonic- per- QAD	SP-SIM 1
	Finished Material	ECI- per- QAD	SP-ECM Master
		FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Part seating is verified per REI	REI 012
Failure Cause c f/n 048 Washer,Spring,Brg.	Material Integrity	Material integrity is verified per drawing and specification requirements	PWA-SP 1074
	Raw Material	Sonic- per- QAD	SP-SIM 1
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Selection of classification of part is verified per assembly drawing requirements	
Failure Cause c f/n 054 Seal, Roller Bearing	Material Integrity	Material integrity is verified per specification requirements	AMS 4676
		Heat treatment and hardness are verified per drawing & specification requirements	PWA-SP 11-17 & AMS 4676
	Finished Material	FPI- per- QAD	SP-FPM Master
Failure Cause c f/n 126 Gasket,Discharge	Material Integrity	Material integrity is verified per drawing and specification requirements	AMS 5662
		Teflon coating is verified per drawing and specification requirements	HPS 655
Failure Cause c f/n 151 Bolt,Turbine Housing		Material integrity is verified per specification requirements	AMS 5731-85 per MS9558

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Raw Material	Sonic- per- QAD	SP-SIM 314
Failure Cause c f/n 152 Plate,Retaining,Brg.	Material Integrity	Material integrity is verified per specification requirements	PWA-SP 1146
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Part Seating of DIM S6.1 is verified per REI	REI 012
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause c f/n 191 Housing,Roller Brg.	Material Integrity	Material integrity is verified per specification requirements	PWA-SP 1103
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Selection of classification of part is verified per assembly drawing requirements	
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause c f/n 205 Damper,Spring	Material Integrity	Material integrity is verified per specification requirements.	AMS 5596
Failure Cause c f/n 234 Ring,Sealng,Trbn Hsg		Material integrity is verified per specification requirements	ASTM B 150
Failure Cause D f/n 045 Nut,Bearing		Material integrity is verified per specification requirements	PWA-SP 1146
	Inspection	Pitch diameter is verified per drawing requirement	
		Perpendicularity is verified per drawing requirement	
	Raw Material	Sonic- per- QAD	SP-SIM 1

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Finished Material	FPI- per- QAD	SP-FPM Master
		ECI- per- QAD	SP-ECM Master
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause d f/n 026 Wheel,Transducer	Material Integrity	Heat treatments are verified per specification requirementrs	PWA-SP 11-17 and AMS 4676
		Material integrity is verified per specification requirements	AMS 4676
	Finished Material	FPI- per- QAD	SP-FPM Master
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause d f/n 027 Washer,Trnsdcr Wheel	Material Integrity	Stress relieve is verified per drawing and specification requirements	PWA-SP 11-15K
		Material integrity is verified per specification requirements	AMS 5599
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Locking feature inspected is verified per REI	REI 012
Failure Cause E f/n 046 Ring,Sealing,Bearing	Material Integrity	Shot peen is verified per specification requirement	AMS 2430
		Material integrity is verified per drawing and specification requirement	PWA-SP 1074
		Hardface is verified per drawing and specification requirement	PWA-SP 288-1
	Raw Material	Sonic- per- QAD	SP-SIM 1
	Finished Material	ECI- per- QAD	SP-ECM Master
		FPI- per- QAD	SP-FPM Master

Critical Item List

Subsystem\Item No.\Part No.: HPFTP/AT\B300\4700000 | **Prepared by:** D.F. Clark | **Page:** 109

Functional Assy: Structural Section 03 | **Approved by:** A.J. Slone | **Issue Date:** October 28, 1986

Failure Mode: Loss of rotor support and positioning. | **CIL Item:** 0303 | **Rev. Date:** April 16, 2001

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Assembly Integrity	Part seating is verified per REI	REI 012
Failure Cause e f/n 054 Seal, Roller Bearing	Material Integrity	Heat treatment and hardness are verified per drawing & specification requirements.	PWA-SP 11-17 & AMS 4676
		Material integrity is verified per specification requirements.	AMS 4676
	Finished Material	FPI- per- QAD	SP-FPM Master
Failure Cause e f/n 152 Plate,Retaining,Brg.	Material Integrity	Material integrity is verified per specification requirements.	PWA-SP 1146
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Part Seating of DIM S6.1 is verified per REI.	REI 012
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause e f/n 252 Seat,Sealing,Stg.3	Material Integrity	Material hardness is verified per drawing requirements	
		Material integrity is verified per specification requirements	PWA-SP 1039
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Penetrant inspect per DAR	PW0266
		Selection of classification of part is verified per assembly drawing requirements	
Failure Cause F f/n 166 Cover,Turbine	Material Integrity	Shot peen is verified per specification requirements	AMS 2430
		Material integrity is verified per drawing and specification requirements	PWA SP- 1074
	Raw Material	Sonic- per- QAD	SP-SIM 1

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Finished Material	FPI- per- QAD	SP-FPM Master
		ECI- per- QAD	SP-ECM Master
	Assembly Integrity	Part seating is verified per REI	REI 012
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause G f/n 017 Nut,O.D.Ball Brg.	Material Integrity	Material Integrity is verified per specification requirements	PWA-SP 1146
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Part seating of DIM S16 is verified per REI	REI012
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause H f/n 100 Invr Nut,Stg.2,Diffu	Material Integrity	Material integrity and heat treatment are verified per drawing and specification requirements	AMS 5664
	Finished Material	FPI- per- QAD	SP-FPM Master
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
All Cause	Assembly Integrity	Pump and Turbine Assembly final residual unbalance is verified per drawing requirement	
		Cleanliness control of all parts during final assembly are verified per specification requirement	PWA-SP 80
		Shipping container; cleanliness control of closures, desiccant material and GN2 purge are verified per specification requirements	PWA-SP 80, MIL-D-3464, MIL-P-27410C
		Turbine Assembly final residual unbalance limit is verified per drawing requirement	
		Pump and Turbine Assembly initial dynamic unbalance is verified per drawing requirement	

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
		FPI- per- QAD (if material is removed from balance rings during final turbine assembly dynamic balance)	SP-FPM Master
	Acceptance	Acceptance test will be conducted as required by contract, to demonstrate specified performance.	FR24542
	Maintenance	Post Flight borescope inspection of the Ball Bearing is verified per OMRSD.	OMRSD V41BU0.135
		Turbine area is dried per OMRSD.	OMRSD V41CB0.082
		Investigative torque is verified per OMRSD (Contingency)	OMRSD V41BS0.065
		Turbine area dryness is verified per OMRSD.	OMRSD V41CB0.083
		Shaft rotation torque check is verified per OMRSD.	OMRSD V41BS0.060