

Critical Item List

Subsystem: HPOTP B500 - 4750000-700
 Functional Assy: Drive Turbine Section B50002

Prepared by: M.T. Spencer
 Approved by: R.L. Pugh
 CIL Item: 0204

Page: 53
 Issue Date: December 23, 1993
 Rev. Date: December 08, 1995

CIL Item Code: 0204
 FMEA Item Code: 0204
 Function: Drive Pump
 System/Subsystem: HPOTP B500 - 4750000-700

Analyst: M.T. Spencer
 Approved by: R.L. Pugh
 Rev. No.: _____
 Rev. Date: December 08, 1995
 Effectivity: _____
 Hazard Ref.: See Listings Below

Operating Phase	Failure Mode, Description and Effect	Criticality
-----------------	--------------------------------------	-------------

Operating Phase:
a,m,c

Failure Mode:

Loss of torque carrying capability.

Failure Cause(s):

- A. In 90 Fracture of disk/shaft thru the splines, cooling holes, blade attachment, or loaded shoulder, due to vibration, thermal growth, material/mfg defect, overspeed, rub, or loss of cooling.
- B. In 18, & 19 Fracture of the splines of the left or right inducers blades, due to vibration, rub, thermal growth, FOD, material/mfg defect, or contamination
- C. In 17 Fracture of the splines of the main impeller blades, due to vibration, rub, thermal growth, FOD, material/mfg defect, or contamination
- D. In 28 Fracture of the splines of the pre-burner impeller due to vibration, rub, thermal growth, material/mfg defect, or contamination.

Failure Effect:

Loss of disk load causing over speed, burst, and case penetration with fire, and explosion.

System:

Uncontained engine damage

Mission/Vehicle:

Loss of vehicle

Redundancy Screens:

Does not apply since it is a single point failure

Criticality:

1

Hazard Ref:

- A) C1S/A/M/C (AT) 1A1.1.7.2.1.1, 1A1.1.7.2.3, 1A1.2.1, 1A1.2.4, 1A1.2.5, 1A1.2.6, 1A1.2.7.1, 1A1.2.7.2
- B) C1S/A/M/C (AT) 1A1.1.7.2.1.1, 1A1.1.7.2.3
- C) C1S/A/M/C (AT) 1A1.1.7.2.1.1, 1A1.1.7.2.3
- D) C1S/A/M/C (AT) 1A1.1.7.2.1.1, 1A1.1.7.2.3

B - 487

Subsystem: HPOTP B500 - 4750000-700
Functional Assy: Drive Turbine Section B50002

Critical Item List

Prepared by: M.T. Spencer
Approved by: R.L. Pugh
CIL Item: 0204

Page: 54
Issue Date: December 23, 1993
Rev. Date: December 08, 1995

Part Name/No.	Design Considerations	Document Ref
In 90 Disk/shaft	<p>FAILURE CAUSE A. The design features an integral disk and shaft with slots for blade retention. Torque is transmitted through four sets of standard ANSI splines that have been sized to limit bearing stresses. Axial retention for the impeller and inducer stack is provided by a nut threaded to the shaft. The pre burner impeller is retained by a bolt threaded to the I.D. of the shaft, and located axially with a classified spacer In 228. Bearing and stack locating shoulders on the shaft are provided with undercuts and generous fillets to minimize stress concentrations. The blade attachment zero-broach-angle reduces disk attachment stress concentrations, and with the common 3-blade slot, reduces manufacturing complexity.</p> <p>The shaft includes the roller bearing bore diameter, piloting diameters for all the rotating parts, the splines which drive the Inducers and Impeller, and the supply and return holes for the bare tube coolant.</p> <p>During operation, the main stack is subjected to speed, temperature, and pressure effects which result in increased compression of the stack elements and reduced tension in the shaft.</p> <p>The shaft is made of PWA-SP 1074 (GATORIZED IN 100), a high-elastic-modulus material which reduces radial disk deflections caused by blade loads, provides critical speed margin by resisting bending due to unbalanced loads, and offers superior strength and low cycle fatigue life while being reasonably resistant to hydrogen embrittlement.</p> <p>The disk is balanced by material removal. Two large diameter rings are provided on the disk, and multiple O.D. surfaces on the shaft for material removal.</p> <p>This part meets CEI requirements.</p> <p>DVS 4.1.2.9 which requires structural design analysis of the shaft was completed in 5/90, and can be found in FR-20729-08, and FR-20730-10.</p> <p>DVS 4.1.4.1.7.1 Strain gaged load test of the tie bolt had been completed in 1/91, and can be found in FR-20729-35.</p> <p>DVS 4.1.4.1.7.2 Turbine spin test evaluation had been completed in 12/90, and can be found in FR-20729-08 & 38.</p> <p>DVS 4.1.4.1.7.3 Turbine disk burst test to 122% of design rotor speed had been completed in 1/91, and can be found in FR-20729-38.</p> <p>DVS 4.1.4.1.7.4 Turbine disk vibration test to verify margin greater than 10% had been completed 12/89, and can be found in FR-20730-24.</p>	
In 18 & 19 Inducers	<p>FAILURE CAUSE B. The Inducers boost inlet pressure to the impeller. Four bladed pump stages receive flow from the low pressure pump, and raise the pressure for delivery to the main impeller.</p> <p>Standard ANSI splines mate with the shaft for torque transfer. Piloting is provided by dual concentric snaps.</p> <p>Development testing had resulted in several design changes to the inducers which include increasing the radial clearances to reduce dynamic forcing functions, change of the blade incidence angle to reduce cavitation, and change of blade shape to increase static and dynamic structural margin.</p> <p>Material is PWA-SP 1146 (Inconel 710) which was selected for its strength and LOX compatibility</p> <p>DVS testing number 4.1.4.1.4.1 thru .3 require spin (FR-20729-29), burst (FR-20729-43), and resonance testing (FR-20730-</p>	

B - 468

Subsystem: HPOTP B500 - 4760000-700
Functional Assy: Drive Turbine Section B50002

Critical Item List
Prepared by: M.T. Spencer
Approved by: R.L. Pugh
CIL Item: 0204

Page: 55
Issue Date: December 23, 1989
Rev. Date: December 08, 1995

15) have all been completed.

DVS Item 4.1.2.9 for structural design analysis has been completed, and can be found in FR-20729-3, and FR-20730-3 and 4.

These parts meet CEI requirements.

These parts were manufactured with a shot peening (AMS 2430) process.

FAILURE CAUSE C. The double inlet shrouded main impeller consists of four full blades, and four partial blades on each side of the hub. The impeller raises the fluid pressure prior to discharge to a common collector.

Standard ANSI splines mate with the shaft for torque transfer. Piloting is provided by dual concentric snaps.

Material is provided at both faces of the hub for detail balancing. Final assembly trim balance is provided at the O.D. shroud by the ϕ 024 counter weights.

Radially inside the two inlets are cylindrical surfaces which are used for radial piloting between the impeller and the two inducers. These pilots were added to increase the stiffness of the joint between the impeller and inducers in order to address rotordynamic concerns.

Material is PWA-SP 1146 (Inconel 718) which was selected for its strength and LOX compatibility.

Mission life for the main impeller is greater than 1000 cycles.

This part meets CEI requirements.

DVS 4.1.4.1.3.1 Impeller spin test evaluation is complete, and can be found in FR 20729-41.

4.1.4.3.2 Burst spin test analysis is complete, and can be found in FR 20729-42.

4.1.2.1.3.3 Vibration NASTRAN analysis is complete, and can be found in FR 20730-14.

4.1.2.10 Unbalance forced response analysis is complete, and can be found in FR 20730-27.

4.1.2.3 Bi-stable operation, analytical verification by the DTM< P&M> etc. is complete, and can be found in FR 19647-1, and FR 20723-01 & 02.

FAILURE CAUSE D. The shrouded Preburner impeller has four full, and four partial blades that raise the fluid pressure for delivery to the preburners.

Standard ANSI splines mate with the shaft for torque transfer. Piloting is provided by dual concentric snaps.

Two radial snaps keep the impeller concentric with the shaft. Two equally spaced slots in the front face allow flow to pass into the impeller bore to provide coolant flow to the pump and ball bearing.

Trim balance as required is provided by balance weights ϕ 299 which is made of AMS 5646.

Material is PWA-SP 1146 (Inconel 718) which was selected for its strength and LOX compatibility.

Mission life for the P/B impeller is greater than 1000 cycles.

This part meets CEI requirements.

ϕ 17
Main Impeller

B - 469

ϕ 29
Preburner Impeller

Critical Item List

Subsystem: HPOTP B500 - 4750000-700
Functional Assy: Drive Turbine Section B50002

Prepared by: M.T. Spencer
Approved by: R.L. Fugh
CIL Item: 0204

Page: 56
Issue Date: December 23, 1993
Rev. Date: December 08, 1995

This part is manufactured using processes which are chemical milling (PWA-SP 108), and finishing ECMR (87-5).

DVS testing number 4.1.4.1.3.1 thru .3 require spin, burst, and resonance testing. As of 04/91, resonance testing (FR 20730-16), and spin and burst tests (FR 20728-38 & 40) have been completed.

DVS Item 4.1.2.9 for structural design analysis has been completed, and can be found in FR-20728-5, and FR-20730-2, and Rotor dynamics FR-20730-27.

B - 470

Critical Item List

Subsystem: HPOTP B500 - 4750000-700
 Functional Assy: Drive Turbine Section B50002

Prepared by: M.T. Spencer
 Approved by: R.L. Pugh
 CIL Item: 0204

Page: 57
 Issue Date: December 23, 1983
 Rev. Date: December 08, 1985

Inspection and Test

Possible Causes	Significant Characteristics	Inspection and Test	Document Ref
Failure Cause A 1/n 080 Disk/shaft/sleeve	Material Integrity	Material Integrity is verified per specification requirements. Shot peen per specification.	PWA-SP 1074, PWA-SP 1146 AMS 2430
	INSPECTION		
	Raw Material	Sonic - disk and shaft per QAD	
	Finished Material	FPI - disk shaft set, sleeve per QAD	SP-FPM Master
		ECI - disk & shaft set, and detail, per QAD	SP-ECM Master
		Shaft journal diameters are verified per drawing requirements. Profile of broach slot center line is verified per drawing requirements. Spine data requirements are verified per drawing requirements.	
	Assembly Integrity	Part seating will be verified per the assembly drawing. Cleanliness of components will be verified per specification.	REI 013 PWA-SP 80
Failure Cause B 1/n 018 & 019 Inducers	Material Integrity	Material Integrity is verified per specification . Shot peening verified per specification.	PWA-SP 1146 AMS 2430
	INSPECTION		
	Raw Material	Sonic per QAD	
	Finished Material	FPI (before balance) per QAD FPI per QAD Spine requirements verified per drawing requirements.	SP-FPM Master SP-FPM Master
		ECI per QAD	SP-ECM Master
	Assembly Integrity	Part seating will be verified per assembly drawing. Rotor assembly tierod will be stretched, torqued, and locked per assembly drawing. Vibration controlled by assembly balance. Cleanliness of components will be verified per specification.	REI 013 PWA-SP 80
Failure Cause C 1/n 017	Material Integrity	Material Integrity is verified per specification requirements.	PWA-SP 1146

Critical Item List

Subsystem: HPOTP B500 - 4750000-700
 Functional Assy: Drive Turbine Section B50002

Prepared by: M.T. Spencer
 Approved by: R.L. Pugh
 CIL Item: 0204

Page: 58
 Issue Date: December 23, 1993
 Rev. Date: December 08, 1995

Failure Cause C In 017 Impeller	Material Integrity	Material integrity is verified per specification requirements.	PWA-SP 1148
	INSPECTION		
	Raw Material	Sonic per QAD	
	Finished Material	ECI per QAD	SP-ECM Master
		Spline requirements verified per drawing requirements.	
		FPI per QAD	SP-FPM Master
	Assembly Integrity	Part seating will be verified per assembly drawing. Cleanliness of components will be verified per specification.	REI 013 PWA-SP 80
		Vibration verified per assembly drawing. Balance weights are stated per print requirements.	REI 003 PWA-SP 381
Failure Cause D In 029 P/B Impeller	Material Integrity	Material integrity is verified per specification requirements. ECM & ECMR Contamination control	PWA-SP 1148 PWA-SP 108, & 87-5 PWA-SP 36108-4
	INSPECTION		
		Impeller O.D. PEBB seating diameter is verified per drawing requirements.	
	Raw Material	Sonic- detail level per QAD	
	Finished Material	FPI - assembly level per QAD FPI - detail level per QAD ECI - detail level per QAD	SP-FPM Master SP-FPM Master SP-ECM Master
	Assembly Integrity	Vibration verified per assembly drawing. Balance weights are stated per print requirements. FPI balance weights per QAD	REI 003 PWA-SP 381 SP-FPM Master
		Part seating will be verified per assembly drawing.	Assy Spec PWA-SP REI 013
		Tiebolt installed, torqued and locked, per the assembly drawing. Cleanliness of components will be verified per specification.	Assy Spec PWA-SP REI 013 PWA-SP 80

B - 472

Subsystem: HPOTP B500 - 4750000-700
Functional Assy: Drive Turbine Section B50002

Critical Item List

Prepared by: M.T. Spencer
Approved by: R.L. Pugh
CIL Item: 0204

Page: 5B
Issue Date: December 23, 1993
Rev. Date: December 08, 1995

All Cause	General Quality Requirements:		
		Supplier Quality Assurance requirements are included in PW-QA-6076, and include such requirements as first piece layouts. This requires the documentation of dimensions on all characteristics represented on the delivered article.	PWA-SP 300
		Inspection Methods Sheets for use in the inspection of purchased parts and assemblies contain the necessary information to insure that the requirements of the QADs, engineering drawings, and referenced documents are satisfied. For shop fabricated parts, the sheets are audited by Inspection Methods.	
		The purchase orders for vendor supplied parts must comply with PWA-SP 300, 'Control of Materials Processes and Parts', which requires the vendor to provide material, process, and dimensional information to the Quality Department.	
	Acceptance	Acceptance test will be conducted as required by contract, to demonstrate specified performance.	DR SE-13
	Maintenance	Shaft rotation torque check is performed after engine operation, or HPOTP installation/reinstallation.	OMRSD-V41BSO.050
	Cleanliness	Cleanliness of components will be assured by compliance to Contamination Control Specification.	PWA-SP 36180-1
	Welds	This section would contain a description of any limiting features of CIL hardware Not applicable at this time	DAR Numbers

B - 473