Subsystem: HPOTP B500 - 4750000-700	**Critical Item List**	Page: 26	
Functional Assy: Pump Section B50001	Prepared by: M.T. Spencer	Issue Date: December 23, 1993	
	Approved by: R.L. Pugh	Rev. Date: December 08, 1995	
	CIL Item: 0105		

CIL Item Code: 0105		Analyst: M.T. Spencer	
FMEA Item Code: 0105		Approved by: R.L. Pugh	
Function: Direct LOX Coolant		Rev. No.:	
System/Subsystem: HPOTP B500 - 4750000-700		Rev. Date: December 08, 1995	
		Effectivity:	
		Hazard Ref.: See Listings Below	

Operating Phase	Failure Mode, Description and Effect	Criticality
p,s,m,c	Failure Mode: Loss of coolant flow control.	1

Failure Cause(s):

A. f/n 93 A80 Fracture or plugging of center tube due to vibration, thermal growth, contamination, or material/mfg defect.

B. f/n 244 Fracture or wear of the pre-burner impeller damper due to vibration, rub, thermal growth, erosion, contamination, or material/mfg defect.

C. f/n 29 Plugging of the pre-burner impeller cooling passages due to contamination, or FOD.

Hazard Ref:

A) C1S/A/M/C (AT) 1A1.1.8.2.1.1.2.6

B) C1S/A/M/C (AT) 1A1.1.8.2.1.1.2.6

C) C1S/A/M/C (AT) 1A1.1.8.2.1.1.2.6

Failure Effect:

Loss or contamination of cooling flow could result in brg failure with rotor shift/rub leading to fire.

System:

Uncontained engine damage

Mission/Vehicle:

Loss of vehicle

Redundancy Screens:

Does not apply since it is a single point failure

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Part Name/No.	Design Considerations	Document Ref
f/n 93 Center tube	FAILURE CAUSE A. The bore tube assy serves as a transfer tube to direct cooling flow to the turbine end prior to start for roller brg inner race control to prevent coning. LOX enters the center of the bore tube through holes in the shaft inboard of the turbine side inducer. The turbine side end face of this inducer is slotted to allow flow to enter the shaft. The LOX flows down the center of the bore tube to the turbine end, reverses direction, and then flows along the outside of the bore tube and the inside of the shaft. The coolant is then routed back into the bore tube end exits to the LOX drain The bore tube is threaded into the shaft at the pump end and retained with a lock. Two equally spaced lugs on the lock fit into both shaft and bore tube slots preventing relative rotation. This spring lock allows ball bearing coolant to flow with minimal restriction. MP35N material was used for the spring lock for it's high strength to modulus ratio. Once start is accomplished, most of the tube flow will cease. All brazed joints are gold-nickel (PWA-SP 19) alloy, and tube fittings are Haynes 214 (PWA-SP 1130) nickel alloy for high resistance to ignition. Use of this alloy should significantly reduce the concern for flammable metal being introduced into the LOX environment. Rub rings of KEL-F 81 are used as compliant seals which also provide damping to prevent any high frequency fretting. Mission life for the tube is greater than 1000 cycles. Vibration analysis is documented in FR-20730-2 & 4. This part meets CEI requirements.	
f/n 244-02 Preburner damper	FAILURE CAUSE B. The hydrodynamic damper provides stable rotor dynamics. Flow control is enhanced by the use of a roughened stator. The damper surface is machined to have a convergent taper between the damper and rotor land. The seal is mated to the bearing support with 6 bolts and tight fitting dowel pins and a radial snap fit which all combine to stiffen both parts and reduce deflections. The pins (f/n 246) are AMS 5844 material for it's high strength. Seal material used is Nickel 200 (PWA-SP 6000) with silver plate (AMS 2410) for LOX compatibility. The mission life is greater than 1000 cycles.	
f/n 29 Preburner impeller	FAILURE CAUSE C. The Preburner impeller is splined to the shaft,and provides the mating surfaces for the various seals, damper, and mounting of the pump end ball bearing (PEBB). Machined passages in the impeller hub provide cooling flow to the cavity formed between the impeller and tie rod (f/n 35), and from here is transferred to the pump end ball bearing inner race. Cooling flow is enhanced by the downstream 2 tooth K.E. seal (f/n 20), and the abradable seal land brazed to the support f/n 244-03. Material is Inconel 718, which is PWA-SP 1146, and has a proven history in a LOX environment (LOX testing of this material appears in Appendix 52 of the P&W MCL Manual). The heat treatment, microstructure and chemistry all enhance operation at cryogenic temperatures. Mission life for the P/B impeller is greater than 1000 cycles. This part meets CEI requirements. This part is manufactured using chemical milling (PWA-SP 108), and finishing ECMR (87-5) processes.	

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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 20729-40) have been completed.

DVS item 4.1.2.9 for structural design analysis has been completed, and can be found in FR-20729-5, and FR-20730-2, and 10.

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Functional Assy: Pump Section B50001

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Inspection and Test

Possible Causes	Significant Characteristics	Inspection and Test	Document Ref
Failure Cause A f/n 83 Center tube	Material Integrity	Material integrity is verified per specification requirements. Contamination control is verified per specification.	AMS 5561, PWA-SP 1130 PWA-SP 36160-4
	Plating Integrity	Plating integrity is verified per specification.	AMS 2403
	Braze Integrity	Braze integrity is verified per specification and drawing requirements. Filler material per AMS 4787 anywhere except turbine end (heat exchanger) Filler material per AMS 4788 anywhere	PWA-SP 19 AMS 4787 AMS 4788
	INSPECTION		
	Finished Material	FPI - Items 04, 07, & 08 per QAD FPI - Items 03, 05, & 06 per QAD	SP-FPM Master SP-FPM Master
		X-ray per QAD Leak test is verified per print requirements.	SP-XRM Master
	Assembly Integrity	Cleanliness of components verified per specification.	PWA-SP 80
Failure Cause B f/n 244-02 P/B damper	Material Integrity	Material integrity is verified per specification Contamination control is verified per specification.	PWA-SP 6000,PWA-SP 1105 PWA-SP 36160-4
	Heat Treat	Heat treating is verified per specification, -02, and -03.	PWA-SP 11-32, PWA-SP 1146
	Plating Integrity	Silver plating is verified per specification, Items -02, and -03 Chrome plating is verified per specification, item -03. Plating of f/n 244 is verified per specification	AMS 2410 AMS 2406 PWA-SP 11
	Braze Integrity	Braze integrity is verified per specification, Items -02, and -03.	PWA-SP 19
	INSPECTION	I.D. of the pump end ball brg seal land is verified per drawing. The surface profile of the damper and support set (244) and support assembly (-03) is verified per drawing requirements. The I.D. and O.D. of the -03 support is verified per drawing requirements.	

	Raw Material	Sonic - Support -02, and -03 per QAD	
	Finished Material	FPI - Support assembly item -03, and 244, per QAD	SP-FPM Master
		FPI - Support -02, and 03 per QAD	SP-FPM Master
		Sonic - Ring and support assembly-02 only per QAD	
		X-ray - Support assembly item -03 per QAD	SP-XRM Master
		FPI - Damper & support set, 244, ring & support assy, 244-02, per QAD	SP-FPM Master
	Assembly Integrity	Cleanliness of components is verified per specification.	PWA-SP 80
Failure Cause C I/n 29 P/B Impeller	Material Integrity	Material integrity is verified per specification.	PWA-SP 1146
		Chem milling	PWA-SP108
		ECMR	PWA-SP 97-5
		Contamination control	PWA-SP 36160-4
	INSPECTION		
	Raw Material	Sonic - at the detail level per QAD	
	Finished Material	FPI - Detail level per QAD	SP-FPM Master
		FPI - Assembly level per QAD	SP-FPM Master
		ECI - Detail level per QAD	SP-ECM Master
		Blade thickness is verified per drawing requirements.	
		Impeller O.D. PEBB sealing diameter is verified per drawing requirements.	
		Spline requirements are verified per drawing requirements.	
	Assembly Integrity	Vacuum dry, check axial travel, and GN2 purge.	REI 013
		Cleanliness of components is verified per specification.	PWA-SP 80
		Vibration controlled by assembly balance.	REI 013
		Balance weights are staked per specification.	PWA-SP 361
		Tiebolt installed, torqued, and locked to the limits specified in the Table of Limits to ensure joint integrity.	REI 013
Supporting hardware 0105c I/n 020 Seal	Material Integrity	Material integrity is verified per specification.	PWA-SP 1146
	INSPECTION		
	Raw Material	Sonic per QAD	

	Final Inspection	Seal diameter is verified per drawing requirements.	
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. 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.	PWA-SP 300
	Acceptance	Acceptance test will be conducted as required by contract, to demonstrate specified performance.	DR SE-13
	Waivers	This section would contain a description of any limiting features of CIL hardware Not applicable at this time	DAR Numbers