Critical Item List

Subsystem:	HPOTP B500 - 4750000-700	Prepared by:	M.T. Spencer
Functional Assy:	Pump Section B50001	Approved by:	R.L. Pugh
		CIL Item:	0101
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Issue Date:	December 23, 1993		
Rev. Date:	December 08, 1995		

CIL Item Code:	0101	Analyst:	M.T. Spencer
FMEA Item Code:	01D1	Approved by:	R.L. Pugh
Function:	Increase Energy of Main Flowstream	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

Operating Phase:
s

Failure Mode:
Loss of inducer, impeller head rise.

Failure Cause(s):
A. I/n 18, & 19 Erosion or damage of the left or right inducer blades, due to vibration, rub, thermal growth, material/mfg defect, cavitation, or contamination/FOD

B. I/n 17 Erosion or damage of the main impeller blades, due to vibration, rub, thermal growth, material/mfg defect, cavitation, or contamination/FOD

C. I/n 23-02 or 24-02 Leakage from erosion or damage of the thrust balance corner seals, due to vibration, rub, thermal growth, material/mfg defect, or contamination

Criticality:
1R

Hazard Ref:
A) C1S/A/M/C (AT) 1A1.1.7.1.2.2 to 1A1.1.7.1.2.2.4
C1S/M (AT) 1B2.1.3.1.1, 1B2.1.3.1.3

B) C1S/A/M/C (AT) 1A1.1.7.1.2.2 to 1A1.1.7.1.2.2.4
C1S/M (AT) 1B2.1.3.1.1, 1B2.1.3.1.3

C) C1S/M (AT) 1B2.1.3.1.2, 1B2.1.3.1.3

Failure Effect:
Energy loss reduces main pump discharge pressure and flow, resulting in reduced engine thrust. This is sensed by the controller which increases oxidizer preburner flow. Excess turbine discharge temp will cause redline shutdown.

System:
Engine Shutdown

Mission/Vehicle:
Mission scrub.

Loss of vehicle due to HPOTP turbine failure may result if not detected.

Redundancy Screens:
A: Pass. Redundant hardware items are capable of checkout during normal ground turnaround.
B: Pass. Loss of a redundant hardware item is detectable during flight
C: Pass. Loss of redundant hardware items could not result from a single credible event.

Operating Phase:
m

Failure Mode:
Loss of inducer, impeller head rise.

Failure Cause(s):
A. I/n 18, & 19 Erosion or damage of the left or right inducer blades, due to vibration, rub, thermal growth, material/mfg defect, cavitation, or contamination/FOD

Criticality:
1R

Hazard Ref:
A) C1S/A/M/C (AT) 1A1.1.7.1.2.2 to 1A1.1.7.1.2.2.4
C1S/M (AT) 1B2.1.3.1.1, 1B2.1.3.1.3

B. I/n 17 Erosion or damage of the main impeller blades, due to vibration, rub, thermal growth, material/mfg defect, cavitation, or contamination/FOD

C. I/n 23-02 or 24-02 Leakage from erosion or damage of the thrust balance corner seals, due to vibration, rub, thermal growth, material/mfg defect, or contamination

B) C1S/A/M/C (AT) 1A1.1.7.1.2.2 to 1A1.1.7.1.2.2.4
C1S/M (AT) 1B2.1.3.1.1, 1B2.1.3.1.3

C) C1S/M (AT) 1B2.1.3.1.2, 1B2.1.3.1.3

Failure Effect:

Energy loss reduces main pump discharge pressure and flow, resulting in reduced engine thrust. This is sensed by the controller which increases oxidizer preburner flow. Excess turbine discharge temp will cause redline shutdown.

System:

Engine Shutdown

Mission/Vehicle:

Mission abort.

Loss of vehicle due to HPOTP turbine failure may result if not detected.

Redundancy Screens:

A: Pass. Redundant hardware items are capable of checkout during normal ground turnaround.

B: Pass. Loss of a redundant hardware item is detectable during flight

C: Pass. Loss of redundant hardware items could not result from a single credible event.

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Part Name/No.	Design Considerations	Document Ref
f/n 18 & 19 Inducers	FAILURE CAUSE A. The primary function of the inducers is to boost inlet pressure and prevent cavitation. Double entry four bladed unshrouded pump stages splined to the shaft, receive flow from the low pressure pump, and raise the pressure for delivery to the main impeller. Both inducers are detail balanced by material removal near the ends. Material is Inconel 718 which is PWA-SP 1148. The heat treatment, microstructure and chemistry enhance operation at cryogenic temperatures. This material has a proven history in a LOX environment, LOX testing of this material appears in Appendix 52 of the P&W MCL Manual. Mission life for the inducers is greater than 1000 cycles. Structural dynamic analysis report FR-20730-4 and vibration testing documented in FR-20730-15, shows that all inducer natural frequencies have sufficient speed and frequency margin. The flutter parameter is in the stable region and is diverging as required. Coincidence Analysis show that there is no coupling between the seal and stator. DVS testing number 4.1.4.1.4.1 thru .3 require spin (FR-20729-29), burst (FR-20729-43), and resonance testing (FR-20730-14) 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.	
f/n 17 Main Impeller	FAILURE CAUSE B. The shrouded main impeller consists of four full blades, and four partial blades on each side of the hub, splined to the shaft, which drives the impeller to raise the fluid pressure level prior to discharge to a common collector. The impeller also provides the mating surfaces for the corner seals of the thrust balance system. Material is provided at both sides of the hub for detail balancing. Final assembly trim balance is provided at the O.D. shroud by the f/n 021 counter weight as required, with material which is AMS 5946. 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 rotor dynamic concerns. Material is Inconel 718, which is PWA-SP 1148. The heat treatment, microstructure and chemistry all enhance operation at cryogenic temperatures. This material has a proven history in a LOX environment, LOX testing of this material appears in Appendix 52 of the P&W MCL Manual. Mission life for the main impeller is greater than 1000 cycles. DVS 4.1.4.3.1 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 complete. (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, PBM, etc. is complete and can be found in FR 19847-1, and FR 20723-01 & 02.	

This part meets CEI requirements.

f/n 23-02 and 24-02 Corner seals	FAILURE CAUSE C. The impeller shrouds serve as the rotating elements of the pump's thrust balance system. Closely controlled surfaces near the impeller inlet, and discharge are designed to operate close to, but not contact the corner seals. The resulting orifices vary the pressure on the outside of the shrouds as a function of the axial position of the rotor, thus balancing the net thrust on the rotor. These seals are retained by 11 bolts each f/ns 127 & 128 to the left and right shroud assemblies. Leakage is prevented by the use of two f/n 25 ring seals made of MSD 1046 Teflon on each side. Mission life for the seals is greater than 1000 cycles. The bolts on the turbine side (f/n 126) are made of (AMS 7468) MP35N material to provide the highest operational bolt load since contact with the impeller could occur if the bolt backed out. The bolts used on the pump side (f/n 127) are made of A-286 (AMS 5731) which has adequate margin, and in this configuration traps the bolt head. Predicted leakage is below the level to effect thrust balance. Material used on the static seals for rub ignition resistance is Haynes 214, which is PWA-SP 1130 This part meet CEI requirements.

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Inspection and Test

Possible Causes	Significant Characteristics	Inspection and Test	Document Ref
Failure Cause A f/n 18 & 19 Inducers	Material Integrity	Material integrity is verified per specification requirements. Shotpeening.	PWA-SP 1146 AMS 2430
	INSPECTION		
	Raw Material	Sonic per QAD	
	Finished Material	FPI (before balance) per QAD.	SP-FPM Master
		ECI per QAD FPI per QAD	SP-ECM Master SP-FPM Master
		Spline requirements are verified per drawing requirements. Blade thickness is verified per drawing requirements.	
	Assembly Integrity	Part sealing will be verified per assembly specification.	REI 013
		Vibration limits verified per assembly balance. Cleanliness of components shall be verified per specification.	PWA-SP 80
Failure Cause B f/n 17 Main Impeller	Material Integrity	Material integrity is verified per specification requirements.	PWA-SP 1146
	INSPECTION		
	Raw Material	Sonic per QAD	
	Finished Material	Spline requirements are verified per drawing requirements. Blade thickness is verified per drawing requirements.	
		FPI per QAD	SP-FPM Master
		ECI per QAD	SP-ECM Master
	Assembly Integrity	Vibration limits verified per assembly balance. Balance weights are staked per print requirements.	PWA-SP 361

		Part seating will be verified per assembly specification. Cleanliness of components shall be verified per specification.	REI 013 PWA-SP 80
Failure Cause C f/n 23-02 or 24-02 Corner seals	Material Integrity	Material integrity is verified per specification requirements.	PWA-SP 1130
	Heat Treat	Heat treat is verified per specificaton.	PWA-SP 11-31
	INSPECTION		
	Finished Material	FPI at the assembly level per QAD	SP-FPM Master
	Assembly Integrity	Seals will be bolted, torqued, and locked as required on the assembly drawing. Cleanliness of components shall be verified per specification. Contamination control of insert per specification.	REI 013 PWA-SP 80 PWA-SP 36180-4
		Part seating will be verified per assembly specification.	REI 013
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.	PW-QA-6076 PWA-SP 300
	Acceptance	Acceptance test will be conducted as required by contract, to demonstrate specified performance.	OR SE-13
	Maintenance	Shaft rotation torque check is performed after engine operation, or HPOTP installation/reinstallation.	OMRSD - V41BSO.050
	Waivers	This section would contain a description of any limiting features of CIL hardware Not applicable at this time	DAR Numbers