

**Critical Item List**

Subsystem: HPOTP B500 - 4750000-700  
 Functional Assy: Pump Section B50001

Prepared by: M.T. Spencer  
 Approved by: R.L. Pugh  
 CIL Item: 0103

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

CIL Item Code: 0103  
 FMEA Item Code: 0103  
 Function: Direct Main Pump Flow  
 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
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Operating Phase:  
s

**Failure Mode:**  
Pressure drop, or flow distortion.

**Failure Cause(s):**  
 A. In 22 ASO Fracture or distortion of the main pump hog and integral vanes, due to vibrations, contamination, or material/weld/mfg defects.  
 B. In 22 Fracture or distortion of the discharge volute hog due to vibrations, contamination, or material/weld defects.

**Failure Effect:**  
Energy loss reduces 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.

**Criticality:**  
1R  
**Hazard Ref:**  
 A) C1S/M (AT) 1B2.1.3.3.1,  
 1B2.1.3.3.3  
 B) C1S/M (AT) 1B2.1.3.3.1

Operating Phase:  
m

**Failure Mode:**  
Pressure drop, or flow distortion.

**Failure Cause(s):**  
 A. In 22 ASO Fracture or distortion of the main pump hog and integral vanes, due to vibrations, contamination, or material/weld/mfg defects.  
 B. In 22 Fracture or distortion of the discharge volute hog due to vibrations, contamination, or material/weld defects.

**Failure Effect:**  
Energy loss reduces 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

**Criticality:**  
1R  
**Hazard Ref:**  
 A) C1S/M (AT) 1B2.1.3.3.1,  
 1B2.1.3.3.3  
 B) C1S/M (AT) 1B2.1.3.3.1

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**Mission/Vehicle:**

Mission abort.

Loss of vehicle due to HOPTP 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
In 22-28 Main pump hsg	<p><b>FAILURE CAUSE A.</b> The main hsg is made up of a welded assembly which includes the left, center, and right side parts made of cast PWA-SP 1490 (Microcast Inconel 718) which was chosen for it's high strength, and experience in a LOX environment.</p> <p>This material has a proven history in a LOX environment. LOX testing of this material appears in Appendix 52 of the P&amp;W MCL Manual. The welded on turbine side housing is wrought Super A286, and was chosen for it's high strength and resistance to hydrogen embrittlement.</p> <p>The four main pump welds are all fully inspectable, as well as any core support welds.</p> <p>Materials Control Plan FR-19673-5 describes the EB Weld Development Program which will demonstrate the process to ensure the successful fabrication/assembly of this housing.</p> <p>The inlet side of the pump sees LOX, and the turbine side H2.</p> <p>The housing provides the LOX flowpath geometry for the inlet using two symmetrical volutes to supply LOX to the inducers and main impeller, and discharge volute.</p> <p>The left and right inducer tip flow paths are made up of castings, and retained by threaded fasteners. The housing also provides the backbone for the pump to transmit induced loads to the hot gas manifold. It also provides support for the various seals, roller brg, passages for the interpropellant seals, and maintains the required clearance for the inducers, main impeller, and thrust balance system thru support of the inner hsg. assembly.</p> <p>The preburner hsg and the seal support are bolted to this housing, as well as the turbine discharge duct.</p> <p>This part does not meet CEI LCF life, but does meet Fracture Mechanics Life, so no life or inspection limits have been imposed (DAR 0188).</p> <p>This part is fusion welded per PWA 16.</p> <p>DVS analysis item 4.1.2.9 for structural analysis has been completed, and can be found in FR-20729-08, 01, and FR-20730-01.</p> <p>DVS testing for pressure and vibration is documented in FR-20729-50, and 20730-78.</p> <p>DVS 4.1.4.1.1.3 weld sample test to certify the welding techniques has been completed, and establishes the ESA process.</p> <p>DVS 4.1.3.2.1.1 Water flow visualization and pressure measurement tests has been completed, and can be found in FR-19647-3, &amp; 4.</p>	DAR No. 0189
In 22-28 Discharge volute	<p><b>FAILURE CAUSE B.</b> The volute consists of a vaneless diffuser with 5 tongue volute discharge, and a single collector to minimize recirculation, mixing losses, and radial side load imposed on rotor. The collector is an integral member of the impeller housing. As with the main pump housing, the volute is made of cast PWA-SP 1490 (Microcast Inconel 718) which was chosen for it's high strength, and experience in a LOX environment.</p> <p>This material has a proven history in a LOX environment, LOX testing of this material appears in Appendix 52 of the P&amp;W MCL Manual. The welded assembly is fully inspectable.</p>	

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Because the discharge housing was optimized for low efficiency, parts of the volute are elliptical. External ribs are integrally cast on the volute in these areas to reduce bending stresses in the volute.

This part contains fusion welding (PWA 18).

Stress analysis is documented in FR-20729-02.

This part does not meet CEI LCF life requirements, but does meet Fracture Mechanics Life, so no life or inspection limits have been imposed (DAR 0189).

DAR NO. 0189

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**Inspection and Test**

Possible Causes	Significant Characteristics	Inspection and Test	Document Ref
Failure Cause A and B In 022 Main Pump and Volute Hsg	Material Integrity	Material integrity is verified per specification requirements for 22-28-02, 03, and 04. Material integrity is verified per specification requirements for 22-28-09. Contamination control is verified per specification for items 22-28-12, 13, 18, & 22, & 22-29-11. EDMR 22-28-09	PWA-SP 1490-1 PWA-SP 1052 PWA-SP 36180-4  PWA-SP 97-5
	Heat Treat	Heat treat is verified per specification requirements for 22-28-02, 03, and 04. Heat treat is verified per specification requirements for 22. Heat treat is verified per specification and drawing requirements for 22	PWA-SP 11-31, PWA-SP 1490 PWA-SP 11-17, PWA-SP 1490 PWA-SP 11 & drawing note.
	Weld Integrity	Weld integrity is verified per specification and drawing requirements.  Weld repair is verified per specification, 22-28-02, 03, & 04	PWA-SP 16-22, PWA-SP 16-2233, PWA-SP 16-33 PWA-SP 36158
	INSPECTION		
	Raw Material	Sonic - housing item 22-28-09 per QAD X-Ray - housing item nos. 22-28-02, 03, and 04 per QAD	SP-XFM Master
	Finished Material	X-ray - item 22 per QAD	SP-XFM Master
		ECl - item 22-28-02, 03, 04 per QAD ECl - item 22-28-09 per QAD Min wall thickness of coolant passage is verified per drawing requirements.	SP-ECM Master SP-ECM Master
	Assembly Integrity	FPI - Cast material item nos. 22-28-02, 03, and 04 per QAD FPI - Wrought material item no. 22-28-09 per QAD FPI - Unmachined welds item no. 22 per QAD FPI - Machined welds item no. 22 per QAD	SP-FPM Master SP-FPM Master SP-FPM Master SP-FPM Master
		Cleanliness of components will be assured by compliance to Contamination Control Specification.	PWA-SP 80
		Interface seal surface finish is verified per the installation drawing as specified in the assembly specification.	REI 013
		HIP	HIP is verified per specification for items 22-28-02, 03, and 04.
All Cause	In-Process Testing	Proof pressure test to reflect the proof factors and conditions specified in the reference documents.	REI 005

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Subsystems: HPOTP B500 - 4750000-700

Functional Assy: Pump Section B50001

**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.

**Maintenance**

On a contingency basis perform post flight boroscope inspection of the pump inlet for contamination.

V41BUD.128

**Cleanliness**

Cleanliness of components will be assured by compliance to Contamination Control Specification.

PWA-SP 80

All Cause  
1/n 022  
Main pump hsg

**Welders**

This part does not meet CEI LCF life requirements, but does meet Fracture Mechanics life, so no limits have been imposed (DAR 0189).

DAR NO. 0189