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Subsystem: <u>HPOTP B500 - 4750000-700</u>	Prepared by: <u>M.T. Spencer</u>	Issue Date: <u>December 23, 1993</u>
Functional Assy: <u>Structural Section B50004</u>	Approved by: <u>R.L. Pugh</u>	Rev. Date: <u>December 08, 1995</u>
CIL Item: <u>0401</u>		
CIL Item Code: <u>0401</u> FMEA Item Code: <u>0401</u> Function: <u>Containment of Liquid Oxygen/Hydrogen</u> System/Subsystem: <u>HPOTP B500 - 4750000-700</u>		Analyst: <u>M.T. Spencer</u> Approved by: <u>R.L. Pugh</u> Rev. No.: _____ Rev. Date: <u>December 08, 1995</u> Effectivity: _____ Hazard Ref.: <u>See Listings Below</u>
Operating Phase	Failure Mode, Description and Effect	Criticality

Operating Phase:
p,s,m,c,d

Failure Mode:

Loss of containment of the LOX or H2.

Failure Cause(s):

- A. In 232 ASO, Fracture of the preburner hsg due to vibration, over pressure, thermal, plumbing loads, or material/mfg defect.
- B. In 22 ASO, Fracture of the main pump hsg due to vibration, over pressure, thermal, plumbing loads, or material/weld/mfg defect.
- C. Fracture of any of the following gaskets due to vibration, over pressure, thermal, plumbing loads, or material/mfg defect.
 - Gasket In 180
 - Gasket In 179
 - Gasket In 77
 - Gasket In 125
 - Gasket In 31
 - Gasket In 147
 - Gasket In 108
- D. In 173, 174, & 175 Fracture of Manifold pipes due to vibration, over pressure, thermal, external loads, or material/weld/mfg defect.

Failure Effect:

Leakage outside the case results in an aft compartment over pressurization, and fire.

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/AM/C (AT) 4A1.1, 4A1.2, 4A3, 4A4
- B) C1S/AM/C (AT) 4A1.1, 4A1.2, 4A3, 4A4
- C) C1S/AM/C (AT) 4A8.1
- D) C1S/AM/C (AT) 4A5

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Part Name/No.	Design Considerations	Document Ref
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t/n 232
Preburner hsg

FAILURE CAUSE A. The Preburner pump hsg is forged INCO 718 (PWA-SP 1148) which was selected for its high cryogenic strength, ductility and experience in a LOX environment. This housing also provides the inlet area to the impeller, the collector and exit area to the preburner pump, support for the various seals, and maintains the required clearance for the impeller.

The cast discharge volute inner housing which is utilized as a flow guide only is Micro-Cast PWA-SP 1480, and is supported by a bolted tight fit to the main impeller housing.

This assembly is made up of the outer housing which has an access cover plate, and a cast discharge volute inner housing which is utilized as a flow guide only and is retained at the ID by 12 bolts, and at the OD by a spanner nut, and lock. The inner housing is PWA-SP 1480 (micro-cast Inco 718).

The inner hsg provides the collector volute, and leakage is prevented by gaskets.

The mission life is 350 cycles.

This part meets CEI requirements.

DVB 4.1.2.8 Structural design analysis can be found in FR-20723-02, & 52, and FR-20730-16 & 33.

t/n 22
Main pump hsg

FAILURE CAUSE B. The main hsg is made up of a welded assembly which includes the center, left, and right castings of PWA-SP 1480 (micro-cast Inco 718), and the turbine side housing which is A286.

These materials were selected for their cryogenic strength and experience in a LOX environment. LOX testing of this material (PWA-SP 1480) appears in Appendix 52 of the P&W MCL Manual. The A-286 material was selected for its high temperature strength.

The four main pump welds are fully inspectable, as well as any core support repair welds.

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.

This part on the pump side sees LOX, and on the turbine side H2.

The housing provides the LOX flowpath geometry for the inlet independently for the inducers and main impeller, and discharge volute.

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 bearing, TEBB 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.

The preburner hsg and the damper/PEBB support are bolted to this housing, as well as the turbine discharge duct.

This part was manufactured using a process which is fusion welding (PWA 16).

This part does not meet CEI LCF life, but does meet Fracture Mechanics life, so no life or inspection limits have been

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Imposed (DAR 0189).

DVS 4.1.2.9 Structural design analysis can be found in FR-20729-01 & 09, and FR-20730-21.

#/n 77 Typical
Gaskets

FAILURE CAUSE C. Static seal cavity definition can be found on detail drawings.

Specific seal vendor recommendations for seal cavity definition were used to obtain optimum sealing capability for spring-assist C seals or Belleville spring seals.

A pressure assisted seal (#n 125) is provided between the preburner and main pump hags. to prevent overboard leakage. This is a C-type seal of AMS 5598 Ni Alloy (#nco 718) and coated with Teflon AMS 2515. This material was selected for its strength and demonstrated success in a LOX environment.

Where required some seals have AMS 2424 nickel plating, and the seal designs range from 'C' type to OMEGA type . Static seal leakage has been determined to be within acceptable limits per FFI-19487-1 1-D compressible flow analysis.

DVS 4.1.2.13.1 Leakage analysis of threaded connections or flange/bolts, has been completed, and can be found documented in FR 20729-22.

DVS 4.1.4.2.8.1 Leakage test of external housings has been re-assigned to SSC testing, and is documented in SSC procedures CS-0-B1-714-R8, and -711-R3.

DVS 4.1.4.3.2.1 Leakage test of external housings is the same as above.

#/n 173, 174, & 175
Manifold

FAILURE CAUSE D. The piping connections on the flange O.D. have been located in approximately the same radial position as on the Rocketdyne part. Flanged connections have been provided for all piping connections to the housing. As required, safety wired bolts and seals have been provided at the connections.

Material used is AMS 5731, and 5571 which are A286. This material was selected for its high temperature strength.

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Inspection and Test			
Possible Causes	Significant Characteristics	Inspection and Test	Document Ref
Failure Cause A In 232 P/B Housing	Material Integrity	Material integrity is verified per specification requirements. Contamination control verified per specification.	PWA-SP 1148 PWA-SP 38180-4
	INSPECTION		
	Raw Material	Sonic per QAD	
	Finished Material	FPI per QAD ECI per QAD	SP-FPM Master SP-ECM Master
	Assembly Integrity	Torques are verified per assembly drawing. Leak check is verified with GHe. Cleanliness of components will be verified per specification.	REI 013 PWA-SP 80
	In-Process Testing	Proof pressure and leak test per specification.	REI 005
Failure Cause B In 022 Main hsg and volute	Material Integrity	Material integrity is verified per specification requirements for 22-28-02, 03, and 04. Material integrity is verified per specification requirements for 22-28-08. Material integrity is verified per specification requirements for 22-28-18, 20, 21. Contamination control is verified per specification for item 22-28-12, -16, 8-22, and 22-29-11. EDMR verified per drawing requirements for In 22-28-08, and -21	PWA-SP 1490 PWA-SP 1052 AMS 5895 PWA-SP 38180-4 PWA-SP 97-5
	Heat Treat	Heat treat of parts 22-28-02, 03, and 04 is verified per specification. Heat treat for item 22 is verified per specification and drawing requirements.	PWA-SP 11-31 PWA-SP 11, and notes
	Weld Integrity	Weld integrity is verified per specification requirements for In 22-28-02, 03, and 04.	PWA-SP 16-22, PWA-SP 16-33, PWA-SP 16-2233, PWA-SP 36158
	INSPECTION		
	Raw Material	Sonic - housing - 22-28-08 per QAD X-ray - housing - 22-28-02, 03, and 04 per QAD	SP-XRM Master
	Finished Material	X-ray item 22 per QAD ECI - Item 22-28-02, 03, 04 per QAD ECI - Item 22-28-08 after proof test per QAD FPI - Cast material item nos. 22-28-02, -03, and 04 per QAD FPI - Wrought material item no 22-28-09 per QAD	SP-XRM Master SP-ECM Master SP-ECM Master SP-FPM Master SP-FPM Master

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Failure Cause C
 l/n 31, 77, 108, 125, 147,
 178, 180, 182
 Gaskets

Failure Cause D
 l/n 173, 174, & 175
 Manifold

	FPI - Unmachined welds item no 22 per QAD FPI - Machined welds item no. 22 per QAD Coolant passage min wall thickness is verified per drawing requirements.	SP-FPM Master SP-FPM Master
Assembly Integrity	Cleanliness of components is verified per specification.	REI 013 FWA-SP 80
In-Process Testing	Proof pressure test to reflect the proof factors and conditions specified in the reference documents.	REI 005
HIP	HIP is verified per specification for items 22-2B-02, 03, and 04.	PWA-SP 4, PWA-SP 1480
Material Integrity	Material integrity is verified per specification requirements. 1. Find nos. 31, 178, 180, 182 2. Find no. 77 3. Find no. 108 4. Find no. 125 5. Find no 147	1. MSD 1046 Type 3/M8D 1000 coating 3. PWA-SP 1143 4. PWA-SP 5596/AMS 2515 coat 5. AMS 5662/MSD 1000 coating.
Heat Treat	Heat treat l/n 147 is verified per specification Heat treat l/n 125 is verified per specification Heat treat l/n 108 is verified per specification.	PWA-SP 11-17 PWA-SP 11-32 PWA-SP 11-3
Plating Integrity	Plating integrity will be verified per specification for l/n 108	AMS 2424
INSPECTION		
Finished Material	FPI - l/ns 108, 125 per QAD	SP-FPM Master
Assembly Integrity	Beefing surface condition is verified per the Interface drawing requirements. Leak check requirements for l/n 125 is verified per specification REI 013	REI 013
Material Controls	Contamination control for l/n 147, and 178 is verified per specification. High pressure LOX compatibility for l/ns 125, 178, and 147 is verified per specification.	PWA-SP 30180-4 PWA-SP 82-72 BCX
Material Integrity	Material integrity is verified per specification requirements.	AMS 5731, & 5571
Heat Treat	Heat treat is verified per drawing and specification, 1 - l/ns 173 & 174, 2 - l/n 175.	1. PWA-SP 11-32

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2. PWA-SP 11-15 & 17

Braze Integrity Braze integrity is verified per specification

PWA-SP 19

INSPECTION

Raw Material Scribe - lms 173, 174, & 175 per QAD

Finished Material FPI - assembly level lms 173, 174, & 175 per QAD

SP-FPM Master

X-ray - assembly level lms 173 & 174 per QAD
 X-ray - assembly level lms 175 per QAD

SP-XRM Master
 SP-XRM Master

Leak Test Leak test as specified on drawing

Supporting hardware
 0401d
 lms 181
 Bolt

Material Integrity Material integrity is verified per specification.

AMS 5731 - per MS 8565

INSPECTION

Finished Material FPI per QAD

SP-FPM Master

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

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

PWA-SP 80

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All Cause
1/n 022
Main housing

Waivers

The Main Housing does not meet CEI LCF requirements, but does meet Fracture Mechanics life, so no limits have been imposed (DAR 0188).

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