Subsystem:	HPOTP B500 - 4750000-700	Page:	76
Functional Assy:	Interpropellant Seal B50003	Issue Date:	December 23, 1993
Prepared by:	M.T. Spencer	Rev. Date:	December 08, 1995
Approved by:	R.L. Pugh		
CIL Item:	0304		

CIL Item Code:	0304	Analyst:	M.T. Spencer
FMEA Item Code:	0304	Approved by:	R.L. Pugh
Function:	Retain Assembly	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 axial retention.

Failure Cause(s):
A. f/n 22-29-10 Fracture of housing due to vibration, thermal growth, excessive mechanical loads, or material/mfg defect.
B. f/n 073 Loss of flow guide nut preload due to vibration, thermal growth, excessive mechanical loads, or material/mfg defect.
C. f/n 062 Loss of nut preload due to vibration, thermal growth, excessive mechanical loads, or material/mfg defect.

Criticality:
1R

Hazard Ref:
A) C1S/M (AT) 3B8.2.2, C1S/A/M/C (AT) 3C1.1, 3C3, 3C5, 3D7
B) C1S/A/M/C (AT) 3C1.1, 3C3, 3C5
C) C1S/A/M/C (AT) 3C1.1, 3C3, 3C5

Failure Effect:
Low He source pressure redline exceeded initiating engine shutdown.

System:
Engine shutdown

Mission/Vehicle:
Mission scrub. Loss of vehicle due to propellant crossover 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 axial retention.

Failure Cause(s):
A. f/n 22-29-10 Fracture of housing due to vibration, thermal growth, excessive mechanical loads, or material/mfg defect.
B. f/n 073 Loss of flow guide nut preload due to vibration, thermal growth, excessive mechanical loads, or material/mfg defect.
C. f/n 062 Loss of nut preload due to vibration, thermal growth, excessive mechanical loads, or material/mfg defect.

Criticality:
1R

Hazard Ref:
A) C1S/M (AT) 3B8.2.2, C1S/A/M/C (AT) 3C1.1, 3C3, 3C5, 3D7
B) C1S/A/M/C (AT) 3C1.1, 3C3, 3C5
C) C1S/A/M/C (AT) 3C1.1, 3C3, 3C5

Failure Effect:

Low He source pressure redline exceeded initiating engine shutdown.

System:

Engine shutdown.

Mission/Vehicle:

Mission abort. Loss of vehicle due to propellant crossover 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.

Critical Item List

Subsystem: HPOTP B500 - 4750030-700	Prepared by: M.T. Spencer	Page:	77
Functional Assy: Interpropellant Seal B50003	Approved by: R.L. Pugh	Issue Date:	December 23, 1993
	CIL Item: 0304	Rev. Date:	December 08, 1995

Part Name/No.	Design Considerations	Document Ref

f/n 22-29-10 Housing

FAILURE CAUSE A. Provides support for the static components of the seal assembly, and the turbine and bearings.

Passages machined into the forged housing allow flow to the Oxidizer and Hydrogen drains, flow from the Helium supply and Roller Bearing and Bumper Ball Bearing coolant supply. In most locations the primary sealing system is the tight fit between the sleeve and housing, with the Teflon seals as a back-up, such as the spring assisted Teflon seal located in a seal gland between the borescope hole and hydrogen seal drain preventing leakage flow through the Borescope hole and into the primary drain. Another spring assisted Teflon seal (f/n 215) located in a seal gland in the IPS Housing on the pump end side of the Oxidizer serves as the primary seal to prevent leakage directly into that drain.

To maintain the tight Sleeve-to-Housing fits, cooling slots, a redesigned Heatshield, and a tight fit between the flow guide f/n 282, and the seal f/n 011 have been incorporated along with the Teflon seal between the sleeve and housing.

The IPS Seal package is assembled into the sleeve prior to installation of the sleeve into the Main Housing Assembly. Bearing deadband diameters are machined with the sleeve installed to eliminate the assembly load's effect on the deadbands.

On the LOX side of the IPS package, a K.E. seal package is utilized between the converter and the helium buffer seal. This seal set made up of f/ns 22-05 and -24 consists of five knife edges and five lands. Analysis has shown that continued safe operation can be achieved with greater than three times the maximum K.E. clearance for the LOX K.E. seal set, the secondary hydrogen seal sets, or the primary hydrogen seal sets.

The knife edge seal configuration on the hydrogen side of the IPS package follows the same design philosophy as the LOX side differing only in that the seal sets are made up of a primary and a secondary seal set. The primary seal is the set adjacent to the TEBB, and the secondary seal is located adjacent to the helium buffer seal.

Material selection criteria are the same as the LOX seals.

Material is PWA-SP 1146 (Inco 718) to reduce the tight assembly fit, and its demonstrated experience in a LOX environment.

Passages in the housing interface with the bolted plumbing which provides the helium buffer and purge flow as well as the conduit for venting the oxygen and hydrogen which leaks thru the seals safely overboard.

These parts meet CEI requirements.

DVS 4.1.3.2.2 IPS evaluation test on a simulation has been completed, and can be found in FR-20904-1, FR-20728-03, and FR-20728-2.

f/n 22-05, and 22-24 LOX K.E. Seal

FAILURE CAUSE B. These seal assemblies reduce flow with K.E. seal members in close clearance to the static lands, and provide increased confidence by virtue of their 'graceful' failure signature (time related wear failure mode) as compared to carbon seals (instantaneous fracture failure mode).

The design configuration consists of five knife edges and five lands. Land surfaces are interrupted with steps to help obstruct carryover within the seal. Seal failure due to the loss of any single K.E is precluded by the use of redundant stages. A wedge shaped tooth design resist rub induced cracking while the silver plating of the land provides a more uniform surface if rubbed. Silver plated Nickel 201 was selected for the seal land because of it's LOX compatibility and high thermal conductivity which pulls heat away from a rub thus inhibiting self sustained combustion.

The rotating members are retained axially by the rotor stack, and the stationary members by the cartridge spanner nut (f/n

062), and cupwasher (i/n 071) which is crimped per PWA-SP 320, and anti-rotated with a tab fitting.

To prevent leakage from the pump side of the sleeve housing (i/n 22-29-10) to the LOX drain cavity in the main pump housing, a Teflon seal (i/n 215) has been incorporated as the primary seal.

Due to the extremely large propellant cross-over margins in both the oxidizer and hydrogen drains, a single Redline has been adopted using the Intermediate Seal (IMSL) pressure, since the helium buffer flowrate and carbon buffer seal clearance are the most influenced.

The seal land consist of a support of PWA-SP 5731 (A286), brazed using PWA-SP 19 (Au-Ni) to a PWA 6000-1 (Nickel 201) land which is then plated with AMS 2410 silver.

PWA-SP 5731 (A-286) was used for the land supports primarily for its high coefficient of thermal expansion. This allows the seal clearances to be built looser at assembly. The seal gap will decrease after chill down. This eases assembly and reduces the risk of damage to the seals. Land final diameters are machined as part of the overall IPS Sleeve and Housing Assembly in order to maintain tight assembly clearance tolerances.

PWA-SP 1148 (Inconel 718) was used for the rotating parts for its high strength and demonstrated success in a LOX environment.

The knife edge seal configuration on the hydrogen side of the IPS package follows the same design philosophy as the LOX side differing only in that the seal sets which consists of i/ns 22-06 & -07, and 22-25, -26, and -27 are made up of a primary and a secondary seal set. The primary seal is the set adjacent to the TEBB, and the secondary seal is located adjacent to the helium buffer seal.

Mission life for the seal is greater than 1000 cycles.

This part meets CEI requirements.

Measurements are taken to confirm seating of the seals which are retained by the Axial Stacking Nut. This nut is locked by a key washer per PWA-SP 318.

DVS 4.1.3.2.2 IPS evaluation test on a simulation has been completed, and can be found in FR-20904-1, and FR-20728-2. The test determined clearance and flow levels, demonstrated positive propellant separation and demonstrated that the interpropellant seal system will meet two times the HPOTP service life.

i/n 22-06, 07, and 22-25, -26, and -27 H2 K.E. seal sets

FAILURE CAUSE a. These seal assemblies reduce flow with K.E. seal members in close clearance to the static lands, and provide increased confidence by virtue of their 'graceful' failure signature as compared to carbon seals.

The rotating members are retained axially by the rotor stack, and the stationary members by the cartridge spanner nut and tabwasher. The assembly consists of five K.E.s on the secondary seal, eight K.E.s on the primary seal. Secondary and primary seal land surfaces are interrupted with steps to help obstruct carryover within the seal. Seal failure due to the loss of any single K.E. is precluded by the use of redundant stages. A wedge shaped tooth design resist rub induced cracking while the silver plating of the land provides a more uniform surface if rubbed. Silver plated Nickel 201 was selected for the seal land for it's high thermal conductivity which pulls heat away from a rub thus inhibiting self sustained combustion.

The seal lands consist of a support of PWA-SP 5731 (A286), brazed using PWA-SP 19 (Au-Ni) to a PWA 6000-1 (Nickel 201) land which is then plated with AMS 2410 silver.

Secondary and Primary H2 seal lands are retained in the IPS Sleeve by the IPS Retention Nut. This nut is locked using a cuplock washer per PWA-SP 320 and anti-rotated with a tab fitting.

All of the land final diameters are machined as part of the overall IPS Sleeve and Housing assembly in order to maintain tight assembly clearance tolerances.

K.E. material is PWA-SP 1146 and was selected for it's experience in a hydrogen environment.

Mission life for the seal is greater than 1000 cycles.

These parts meet CEI requirements.

f/n 073
Flow Guide Nut

FAILURE CAUSE B. The IPS sleeve housing (f/n 22-29-10) is retained in the pump housing with the nut which also serves as part of the inlet flowpath wall directing flow to the turbine sid inducer. In addition, deswirl vanes are incorporated on the back side of the nut to improve the performance of the f/n 061 converter. The material for this nut was selected based on its experience in a cryogenic environment.

A cup washer is used in this location due to the concern that the converter could excite a tab, and cause it to be released into the flowstream (f/n 074). Development testing demonstrated a condition where the preload was relaxed during chilldown allowing the nut to rotate in the tighteningd direction. The redesigned nut incorporated 8 one way locking features, increased preload, and revised locking tab material from 347 stainless to Inconel 625, which doubles the strength and endurance limit.

Locking is per PWA-SP 320. Material of the nut is PWA-SP 1146 (Inco 718) which was selected for its proven experience in a LOX environment.

f/n 062
Nut

FAILURE CAUSE C. The static portions of the IPS which include the H2 seal lands, the helium buffer seal housing and cover, and the LOX seal land are all retained axially by the f/n 062 nut which is locked with the washer f/n 071. These material were selected for their proven experience in a LOX environment. Material of the nut is PWA-SP 1146 (Inco 718) which was selected for its proven experience in a LOX environment.

Critical Item List

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CIL Item:	0304
Page:	80
Issue Date:	December 23, 1993
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Inspection and Test

Possible Causes	Significant Characteristics	Inspection and Test	Document Ref
Failure Cause A f/n 22-29-10 Housing	Material integrity	Material integrity is verified per specification requirements.	PWA-SP 1146
	INSPECTION		
	Raw Material	Sonic per QAD	
	Finished Material	FPI per QAD	SP-FPM Master
	Assembly Integrity	Cleanliness of components will be verified per specification. Assembly temperature limits for Teflon seals is verified per assembly specification.	PWA-SP 80 REI 013
Failure Cause B f/n 1. 22-06, 2. 22-07 K.E. seal	Material integrity	Material integrity is verified per specification requirements.	1. & 2. PWA-SP 1146
	INSPECTION		
	Raw Material	1. & 2. Sonic per QAD	
	Finished Material	1. & 2. ECI per QAD	SP-ECM Master
Supporting hardware 0304a f/n 215 Seal	Material integrity	Material integrity is verified per specification. Contamination control is verified per specification. High pressure oxygen compatability is verified per specification.	Elgiloy, MSD 1046 Fluoroloy, MSD 1000 PWA-SP 38180-4 PWA-SP 62-72 BCGX
Supporting hardware 0304a f/n 22-05, and 22-24 1. K.E. seal 2. Seal land	Material Integrity	Material integrity is verified per specification requirements.	1. PWA-SP 1146 2. PWA-SP 5731, PWA -SP 5000-1
	Heat Treat	Heat treat is verified per specification.	2. PWA-SP 11, and 11-32
	Plating Integrity	Silver plating integrity is verified per specification.	2. AMS 2410

	Braze Integrity	Braze integrity is verified per specification. Au-Ni	2, PWA-SP 19
	INSPECTION		
	Raw Material	1. Sonic per QAD	
	Finished Material	Diametrical clearances are controlled per drawing requirements.	
		1.ECI per QAD 2. FPI - assembly and detail ring, and support per QAD 2. X-ray per QAD	SP-ECM Master SP-FPM Master SP-XRM Master
	Assembly Integrity	Part seating will be verified per assembly specification. Cleanliness of components will be verified per specification.	REI 013 PWA-SP 80
Failure Cause a f/n 22-25, 26, 27 Seal Ring	Material Integrity	Material integrity is verified per specification requirements.	PWA-SP 5731 PWA-SP 6000-1
	Heat Treat	Heat treat is verified per specification , and drawing requirements.	PWA-SP 11 PWA-SP 11-32
	Plating Integrity	Plate integrity is verified per specification requirements.	AMS 2410
	Braze Integrity	Braze integrity is verified per specification requirements.	PWA-SP 19
	Finished Material	X-ray per QAD	SP-XRM Master
		FPI - assembly and detail ring and support per QAD	SP-FPM Master
Failure Cause b f/n 073 Flow Guide Nut	Material Integrity	Material integrity is verified per specification.	PWA-SP 1146
	INSPECTION		
	Raw Material	Sonic per QAD	
	Finished Material	FPI per QAD	SP-FPM Master

Failure Cause C f/n 062 Nut	Material Integrity	Material integrity is verified per specification.	PWA-SP 1146
	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. 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