Critical Item List

Subsystem\Item No.\Part No.: HPFTP/AT\B300\4700000
Functional Assy: Structural Section 03
Prepared by: D.F. Clark
Approved by: A.J. Slone
CIL Item: 0302
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Issue Date: October 28, 1986
Rev. Date: April 16, 2001

CIL Item Code: 0302
FMEA Item Code: 0302
Function: Prevent H2 in turbine
Subsystem\Item No.\Part No: HPFTP/AT\B300\4700000

Analyst: D.F. Clark
Approved by: A.J. Slone
Rev. No.:
Rev. Date: April 16, 2001
Effectivity:
Hazard Ref.: See Listings Below

Operating Phase	Failure Mode, Description and Effect	Criticality

Operating Phase:
p,c

Failure Mode:
Loss of containment in the pump with leakage into the turbine.

Failure Cause(s)
A. f/n 040, 050 & 126 Fracture or blockage of the Lift-off Seal or gaskets due to vibration, flow instability, contamination, material/mating surface defect, or ice blockage.
B. f/n 047 Fracture of the lift-off sealing ring, due to vibration, rub, material defect or manufacturing defect.

Failure Effect:
Fuel flow into the turbine and through the MCC and nozzle. Possible open air fire or detonation while vehicle is on launch pad.

System:
External fire

Mission/Vehicle:
Loss of vehicle

Redundancy Screens:
Does not apply since it is a single point failure

Criticality:
1

Hazard Ref:
A) D1S/A/M/C(AT); 1A1.7.2.2 A1P/A (AT); 1B4.1
B) A1P/A (AT); 1B4.1

Find Number Find Name	Design Considerations
f/n 040, 050, 126 LOS, Gasket LOS, Stud	FAILURE CAUSE A: Fracture or blockage of the lift-off seal assembly, due to vibration, flow instability, contamination, material/mating surface defect, or ice blockage. The Lift-Off Seal (LOS FN 040) is a machined bellows - type carbon face seal assy of consisting of a spring made of MP 35N PWA-SP 1171 for its' stiffness strength, a seal made of Carbon P5N PWA-SP 1148 for its' wear resistance and friction coefficient and a ring made of A286 AMS 5732 or 5737 for its' strength and thermal expansion. Its function is to contain hydrogen in the pump prior to engine start and after shutdown while opening during engine operation to provide hydrogen flow to cool the turbine. This seal is a diaphragm supported seal which lifts off the shaft seat as the pump internal pressure increases at start-up. This seal moves toward the turbine as the pump pressure increases until it contacts a stop. The lift-off seal opens during the engine start transient as the differential pressure across its bellows reaches a certain level. This opening of the seal occurs midway through the engine start transient. During shutdown the reverse occurs with the seal closing as the differential pressure across its bellows decays to the actuation level. Closing of the seal occurs approximately half way between the shutdown command and the end of turbopump rotation. Blueprint spring rate and leak check requirements ensure that the seal operates at desired pressure levels. After contacting the stop, a plenum is created by an integral labyrinth seal and a seal land on the shaft seal face. Since the turbine disk does not have a hole through the bore, a means must be provided to supply coolant flow to the turbine and front disk face. There are 16 holes through the liftoff seal face seal just rear of the face. When the pressure causes the face seal to liftoff the shaft seal, the flow goes through these holes and into passages and tubes that conduct the coolant to the turbine disk front face. Part of the flow leaks past the integral lab seal and cools the turbine disk rear face and turnaround duct. The LOS Retainer (FN 117) is made of A286 (AMS 5732) for its strength and thermal expansion. It serves three functions: 1) retention of the LOS and heatshield to the Turbine Housing; 2) backstop for LOS I. D.; and 3) metering of coolant flow up to the disk. The retainer threads on the housing using left-hand threads, tightening in the direction of pump rotation. The I. D. of the retainer limits the travel of the LOS when the seal swings open. This limits the stress in the bellows and forces the flow split between the disk flow and coolant tube flow. A set screw (FN 251) is threaded into one of 7 holes in the heatshield which aligns with one of 24 slots in the retainer. Installation of the Turnaround Duct then traps the lock. The Turbine Housing Assembly (FN 118) consists of the housing detail (made of forged IN100 PWA-SP 1074 for its strength and low cycle fatigue), key locked self locking inserts to retain the impeller rub stop, and six interference fit tapered plugs which seal the various machined flow passages within the housing. The turbine housing includes gold plating on the barrel to diaphragm radius and diaphragm to reduce the possibility of life reduction due to hydrogen rich environment effects and to increase LCF life. The Lift-off Seal Gasket (FN 050) is made of PWA-SP 1146 nickel alloy with a teflon coating. The Turbine to Discharge Housing I.D. Gasket (FN 126) uses a single convolution teflon coated metal omega seal with an additional internal metal "V" shaped Damper (FN 205). The damper wedges into the internal groove of the omega seal and presses against the legs of the seal. This and all other main pump static axial seals operate in only cryogenic conditions which allow for the use of teflon coated seals and the use of Inco 718. Soft (low modulus) teflon easily conforms to the seal gland surfaces providing an excellent leakproof seal. Inco 718 provides nearly the highest strength material which is commonly used for a metal seal but it's use is limited to cryogenic applications in a hydrogen environment (due to embrittlement concerns). The use of this higher strength material allows for a seal which is capable of a larger range of deflection without causing yielding of the material resulting in increased margin for the seal. The lift-off seal is a fracture critical part and meets all the requirements of the SSME ATD fracture control plan FR-19793-5. On the Turbine Housing (F/N 118) a life limit has been imposed per DAR PW0267. On the Lift-Off Seal Retainer (F/N 117) a life limit and inspection limit has been imposed per DAR PW0316. DVS 4.1.4.1.4.2 Vibration tests for the current liftoff seal configuration are in works. The results will be documented in FR-20715-108 DVS 4.1.4.3.1.5 Monitoring of the LOS cooling passage pressures can not be accomplished at the component level. This DVS item is covered in VCR FR-20904-352.
f/n 047 Lift-off Seal Ring	FAILURE CAUSE B: Fracture of the lift-off seal ring, due to vibration, rub, material defect or manufacturing defect. The Lift-off Seal Ring or runner (FN 047) made from PWA-SP 1074 (IN100) provides the mating seal surface for the LOS. It is shot peened and Chrome Carbide provides the hard wear surface. Four vents are incorporated to prevent pressure buildup behind the disk coverplate. The lift-off seal ring is a fracture critical part and meets all the requirements of the SSME ATD fracture control plan FR-19793-5.

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Failure Mode: Loss of containment in the pump with leakage into the turbine. | **CIL Item:** 0302 | **Rev. Date:** April 16, 2001

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
Failure Cause A f/n 040 Seal Asyo,Lift-Off	Material Integrity	Material integrity of spring (f/n 040-01-1) is verified per specification requirements	PWA-SP 1171
		Material integrity of rivet (f/n 040-04) is verified per specification requirements	AS 7233 per MS9318B
		Material integrity of seal (f/n 040-02) is verified per specification requirements	PWA-SP 1148
		Material integrity of ring (f/n 040-03) is verified per specification requirements	AMS 5732 or AMS 5737
	Raw Material	Sonic- per- QAD (spring) (f/n 040-01)	SP-SIM 1
	Finished Material	Sonic- per- QAD (semi-finished spring) (f/n 040-01)	SP-SIM 1
		FPI- per- QAD (spring) (f/n 040-01)	SP-FPM Master
		FPI- per- QAD (ring) (f/n 040-03)	SP-FPM Master
	Assembly Integrity	Flow Check of lift-off seal is verified per REI and TOL	REI 012
Failure Cause A f/n 050 Gasket,Lift-Off Seal	Material Integrity	Teflon Coating is verified per drawing and specification requirements	HPS-655
		Material integrity is verified per specification requirements	PWA-SP 1146
	Finished Material	FPI- per- QAD	SP-FPM Master
Failure Cause A f/n 126 Gasket,Discharge	Material Integrity	Teflon coating is verified per drawing and specification requirements	HPS 655
		Material integrity is verified per drawing and specification requirements	AMS 5662
	Assembly Integrity	Leak Check after assembly of discharge hsg to turbine hsg O.D. seal is verified per REI	REI 012
Failure Cause a f/n 117 Retainr,Lft-Off Seal	Material Integrity	Material integrity is verified per specification requirements	PWA-SP 1103

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Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Raw Material	Sonic- per- QAD	SP-SIM 1
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Penetrant inspect per DAR	PW0316
		Part Seating is verified per REI	REI 012
		Selection of classification of part is verified per assembly drawing requirements	
Failure Cause a f/n 118 Housing Asyo,Turbine	Material Integrity	Contamination control of insert (f/n 118-06) is verified per specification requirements	PWA-SP 36180-4
		Material integrity of insert (f/n 118-06) is verified per drawing and specification requirements	AMS 5662 & PWA-SP 11-17
		Material integrity of housing (f/n 118-05-1) is verified per specification requirements	PWA-SP 1074
		Material integrity of pin (f/n 118-02) is verified per specification requirements	QQ-N-281
		Material integrity of pin (f/n 118-04) is verified per specification requirements	QQ-N-281
		Material integrity of plug (f/n 118-03) is verified per specification requirements	QQ-N-281
		Material integrity of plug (f/n 118-01) is verified per specification requirements	QQ-N-281
	Inspection	Minimum thickness of gold plating is verified per drawing requirements	
		Integrity of gold plating is verified per specification requirements	PWA-SP 36966-2
	Raw Material	Sonic- per- QAD (housing) (f/n 118-05)	SP-SIM 1
	Finished Material	FPI- per- QAD (A/O) (f/n 118)	SP-FPM Master
		Sonic- per- QAD (A/O (f/n 118) - Shearwave insp)	SP-SIM 1
		FPI- per- QAD (housing) (f/n 118-05)	SP-FPM Master

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Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
		EDM and removal of recast are verified per specification requirements	PWA-SP 97-5 and PWA-SP 105
		ECI-per-QAD	TDM-1 per NDTM 99-1
		Proof pressure test of A/O (f/n 118) is verified per specification requirements	REI 017
	Assembly Integrity	Inspection of G6 Pump Mounting Flange interface seal surface finish is verified per REI	REI 012
		Inspection of N11 Turbine Area Drying Purge interface seal surface finish (on housing, on cover & on plugs at N11.3 & N11.4) is verified per REI	REI 012
		Inspection of F20 Balance Cavity Pressure interface seal surface finish (on housing and on plate) is verified per REI	REI 012
Failure Cause a f/n 205 Damper,Spring	Material Integrity	Material integrity is verified per specification requirements.	AMS 5596
Failure Cause a f/n 251 Pin,L.O.S.Retainer		Material integrity is verified per specification requirements	AMS 5732
Failure Cause B f/n 047 Ring,Sealing,Lft-Off		Material integrity is verified per drawing and specification requirements	PWA-SP 1074
		Shot peen is verified per specification requirements	AMS 2430
		Hardface is verified per drawing and specification requirements	PWA-SP 288-2
	Inspection	Inside diameter is verified per drawing requirements	
	Raw Material	Sonic- per- QAD	SP-SIM 1
	Finished Material	ECI- per- QAD	SP-ECM Master
		FPI- per- QAD	SP-FPM Master

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Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
All Cause	Assembly Integrity	Cleanliness control of all parts during final assembly are verified per specification requirement	PWA-SP 80
		Shipping container; cleanliness control of closures, desiccant material and GN2 purge are verified per specification requirements	PWA-SP 80, MIL-D-3464, MIL-P-27410C
	Acceptance	Acceptance test will be conducted as required by contract, to demonstrate specified performance.	FR24542