Critical Item List

Subsystem\Item No.\Part No.: HPFTP/AT\B300\4700000	**Prepared by:** D.F. Clark	**Page:** 71
Functional Assy: Structural Section 03	**Approved by:** A.J. Slone	**Issue Date:** October 28, 1986
	CIL Item: 0301	**Rev. Date:** April 16, 2001

CIL Item Code:	0301	Analyst:	D.F. Clark
FMEA Item Code:	0301	Approved by:	A.J. Slone
Function:	Contain liquid fuel	Rev. No.:	
Subsystem\Item No.\Part No:	HPFTP/AT\B300\4700000	Rev. Date:	April 16, 2001
		Effectivity:	
		Hazard Ref.:	See Listings Below

Operating Phase	Failure Mode, Description and Effect	Criticality
Operating Phase: p,s,m,c,d	**Failure Mode:** Loss of liquid hydrogen or hot gas containment, and external leak.	**Criticality:** 1
	Failure Cause(s)	**Hazard Ref:**
	A. f/n 015 & 116 Fracture or distortion of the Bearing Cover or Instrumentation Boss Cover due to vibration, overpressure, thermals, material/mfg. defect, or external corrosion.	A) D1S/A/M/C (AT): 3A1.1, 3A1.2, 3A2, 3A3, 3A7.2 D3P/D(AT): 1B4.2.1
	B. f/n 091 Fracture or distortion of the Inlet Housing due to external corrosion, vibration, over pressure, thermals, plumbing loads, or material/mfg. defect.	B) D1S/A/M/C (AT): 3A1.1, 3A1.2, 3A2, 3A3, 3A7.2, 3A8 D3P/D (AT): 1B4.2.1
	C. f/n 106 Fracture or distortion of the Discharge Housing due to vibration, over pressure, thermals, plumbing loads, material/mfg. defect, or external corrosion.	C) D1S/A/M/C (AT): 3A1.1, 3A1.2, 3A2, 3A3, 3A7.2, 3A8 D3P/D (AT): 1B4.2.1
	D. f/n 023, 024,122,123,124, 125, 127, 316, 369, 370 Fracture or distortion of any of the joint seals due to vibration, over pressure, thermals, or material/mfg. defect.	D) D1S/A/M/C (AT): 3A5.1, 3A5.2, 3A6 D3P/D (AT): 1B4.2.2.1, 1B4.2.2.2
	E. f/n 025 Fracture or distortion of the transducer housing flange due to vibration, thermals, or material/mfg. defect.	E) D3P/D (AT): 1B4.2.3
	F. f/n 118 Fracture or distortion of the turbine housing due to vibration, thermal growth, excessive loads, or material/mfg. defect.	F) D1S/A/M/C (AT): 3A1.1, 3A1.2, 3A3, 3A7.2, 3A8 D3P/D (AT): 1B4.2.1
	G. f/n 106-02 Fracture or distortion of the main pump housing stud due to thermal stress, excessive loads, material defect, or manufacturing defect.	G) D1S/A/M/C (AT): 3A5.3, 3A8 D3P/D (AT): 1B4.2.2.3
	Failure Effect: Aft engine compartment over pressure with fire due to leakage.	
	System: External fire	
	Mission/Vehicle: Loss of vehicle	
	Redundancy Screens: Does not apply since it is a single point failure	

Find Number Find Name	Design Considerations
f/n 015, 116	
Cover Brg, Instrmtn Boss	FAILURE CAUSE A: Fracture or distortion of the Bearing Cover or Instrumentation Boss Cover due to vibration, overpressure, thermals, material/mfg. defect, or external corrosion. The ball bearing Cover (FN 015) closes out the pump pressure vessel and provides access to the pump end ball bearing (PEBB) compartment. The cover provides the attachment for the speed transducer and is fitted with a removable Borescope Plug (FN 030) which is made of Inco 718 for its' cryogenic strength and thermal compatability with the titanium bearing cover housing. A small removable cover on the pump centerline can be removed and several diagnostic checks can be performed. The rotor breakaway and running torques can be measured as well as the rotor axial travel. The Bolts (FN 145) are made of MP35N (Cobalt alloy) which is the strongest material in the HPFTP needed to meet structural and flange separation margins of safety. The bolts (FN 145) and washers (FN 324) retain the pump bearing cover to the pump inlet housing. The function of the Instrumentation Boss Cover (FN 116) is to allow access to perform torque and travel checks on the HPFTP Rotor. The cover is held in place by six Bolts (FN 137). The bolts are INCO 718 for its high strength and to match the thermal properties of the cover plate. The instrumentation cover is made from INCO 718 bar stock per AMS 5663 for its good LCF characteristics and thermal expansion compatibility with the bearing cover.
f/n 091	
Inlet Housing	FAILURE CAUSE B: Fracture or distortion of the Inlet Housing due to external corrosion, vibration, over pressure, thermals, plumbing loads, or material/mfg. defect. The Pump Inlet Housing (PIH, FN 091) provides the volute and guide vanes for directing fuel flow to the 1st Stage Impeller. The PIH is an inseparable assembly of two castings and a pinned-in labyrinth seal holder. One casting consists of the volute and housing section (FN 091-01), and the second casting is a ring-strut-ring (FN 091-02) that contains the guide vanes. The castings are made of INCO 718 PWA-SP 1490 for its' cryogenic strength, toughness and weldability and are brazed in two locations: The pump end braze of the Vane Ring serves as a structural joint, and carries in shear the axial loads through the Vane Ring. The turbine-end braze at the Retention Hook feature of the castings is a manufacturing braze. It insures that the Retention Hook seat is maintained throughout all post-braze turning and drilling processes. The seal holder (FN 091-06) is installed and loaded with a work nut axially prior to pinning (FN 091-06) and serves as a redundant axial constraint for the Vane Ring. The Main Pump Radial Seals consist of three large diameter two piece piston ring seals, a small diameter one piece piston ring seal and a teflon jacketed seal. One of the large diameter piston ring seals is used in two locations (FN's 235 & 064) located near the impeller discharges for each stage in the pump to reduce leakage past each stage. Since the pump is configured with an annular cavity surrounding the diffuser housings which feeds back to the first stage inlet, some small leakage can be tolerated allowing for the use of piston ring seals. These piston ring seals are made from an aluminum bronze alloy that provides a hydrogen resistant, moderate strength/low modulus material which gives a good range of seal deflection for assembly. This material has a good match of coefficient of expansion with the aluminum alloy diffusers. This results in less change of end gap from room temperature to operational temperatures. The Studs (FN 091-03) are threaded into the pump inlet housing and locked in place with A-286 keys. The Studs (FN 091-03), Nuts (FN 135) and Washers (FN 092) retain the inlet housing (FN 091) to the main pump (discharge) housing (FN 106). The housing is a fracture critical part and meets all the requirements of the SSME ATD fracture control plan FR-19793-5. DVS 4.1.2.3 Pump hydrodynamics analysis to verify pump performance is complete. The results are documented in FR-20709-01 and -02 with the VCR in FR-20712-27 and FR-23231-107.
f/n 106	
Main Pump Hsg.	FAILURE CAUSE C: Fracture or distortion of the Discharge Housing due to vibration, over pressure, thermals, plumbing loads, material/mfg. defect, or external corrosion. The Discharge Housing (FN 106) is a hot isostatically pressed INCO 718 investment casting. This material is used for its' cryogenic strength, toughness and weldability. It contains the flow path geometry for the exiting fuel, and provides a primary structural support for the overall assembly. It is one of the three primary structural elements and is fastened between the inlet housing at the pump end and the turbine housing at the turbine end. The discharge housing also referred to as the main housing provides the exit flow path from the third and final impeller to the collecting duct on the main engine. Internally, the housing supports the third impeller pump side tip seal and the 2-3 diffuser and provides anti-rotation for the latter. The flow path itself contains ten short airfoil shaped vanes and two flow splitters directing flow from the third impeller into the collecting volute. The splitters cover a much longer circumferential arc than do the vanes, and exist as structural ribs preventing excessive load through the smaller vanes. All vanes and the leading part of the flow splitters receive a shot peen and the housing receives a proof pressure test. Eight coolant holes extend from the collection volute to the mating turbine housing providing coolant flow for distribution to the necessary hot section components. A pressure actuated static piston seal (FN 065) is used to minimize leakage between the discharge housing and the rear diffuser. The housing contains a threaded region on the ID side of the main flange to retain the main inverted nut and a ribbed transition between the ID of the barrel portion and the volute. Externally, the housing is jacketed by a molded elastometric (fabric composite and molded semi-rigid foam) insulation system designed to prevent the formation of liquid air on the exterior surface of the pump. The housing is a fracture critical part and meets all the requirements of the SSME ATD fracture control plan FR-19793-5. DVS 4.1.2.9 Structural design analysis to verify that the main pump housing has adequate margin is complete. The results are documented in FR-20715-02 and -06 and

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Functional Assy:	Structural Section 03	**Approved by:**	A.J. Slone	**Issue Date:**	October 28, 1986
Failure Mode:	Loss of liquid hydrogen or hot gas containment, and external leak.	**CIL Item:**	0301	**Rev. Date:**	April 16, 2001

Find Number Find Name	Design Considerations
	FR-20716-02 and -07. The VCR is in FR-20715-105, -106, -107 and -115. DVS 4.1.4.1.1.1 Strain gage pressure testing on the main pump housing to define high stress concentration locations is complete. The results are included in VCR documents FR-20715-105, -106, -107 and -115. DVS 4.1.4.1.1.2 Vibration tests to define mode shapes and frequencies for the main pump housing are complete. The results are included in VCR documents FR-20715-105, -106, -107 and -115.
f/n 023,024,122,123, 124,125,127,316, 369,370 Static Gaskets/Seals	FAILURE CAUSE D: Fracture or distortion of any of the joint seals due to vibration, over pressure, thermals, or material/mfg. defect. The Main Pump Static Axial Seals consist of a two "E" configuration metal seals and two metal omega configuration seals which are teflon coated. All of these 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 Bearing Cover Gasket (FN 124) uses a metal double convolution "E" configuration to seal between the bearing cover and the main pump inlet housing. The advantage of using an E seal in this location is that it's radial height is low, allowing it to fit well away from the corner of the pump inlet housing while still providing a very effective seal. The Main Inlet Housing to Discharge Housing Gasket (FN 125) uses a single convolution gold plated metal omega seal. In this location, it is not as important to have a lower radial height so an omega seal configuration is used. The Turbine to Discharge Housing I.D. Gasket (FN 126) minimizes leakage of high pressure hydrogen into the turbine stud/shank area. The seal uses a single convolution teflon coated annealed 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. Turbine Section Static Axial Seals provide a reduction or elimination of leakage of hot gaseous hydrogen steam between static components associated with the fuel pump turbine section and internal chambers formed by these components. Also, the Turbine to Discharge Housing Gasket (FN 127) provides a positive seal against overboard leakage of this hot gaseous hydrogen at the interface between the main turbine and pump housings. A gold coating is used on the sealing surfaces of this gasket in order to provide a soft compliant surface which is not subject to hydrogen embrittlement which is necessary since leakage cannot be tolerated at this location. It uses a single convolution omega seal which has a high axial load that, when coupled with a soft plating, provides essentially a leakproof seal. The Pump Section External Seals consist of two very small diameter teflon coated Inco 718 metal seals and a small diameter teflon jacketed seal. These seals are located on ports on the front ball bearing cover. They all experience only cryogenic conditions during operation which allows for the use of teflon jacketed or coated seals and the use of Inco 718. Soft low modulus teflon easily conforms to the seal gland surfaces providing an excellent leakproof seal. All of these seals function as axial seals. The Ball Bearing Boroscope Gasket (FN 023) uses a metal double convolution "E" configuration to seal between the bearing cover and a threaded lug which closes off this port. The advantage to using an E seal in this location is that its' radial height is low, allowing it to fit well under the head of the plug. The Speed Transducer Gasket (FN 122) uses a single convolution metal omegea seal. In this location it is not as important to reduce radial height so an omega seal configuration is used. Both of these metal seals are coated with a thin teflon layer on the sealing surfaces. The Ball Bearing Cover Gasket (FN 024) consists of a teflon jacketed seal with an internal metal spring. Using a soft teflon jacket with a helical or serrated internal metal spring offers the optimum means of conforming to gland surfaces and achieving a leakproof seal. Since this seal is a relatively small diameter seal, radial contractions of the jacket in the seal gland are small and have no impact on the function of the seal. The Turbine Section External Seals consist of two small diameter, gold coated, Waspalloy metal omega seals (FN 123 & 370) and two small diameter, 347 SST boss seals (FN 316 and 369). These seals are located in ports on the turbine housing. They all experience relatively high temperature gaseous hydrogen during operation which prohibits the use of teflon seals. A gold coating is used on the sealng surfaces of these seals in order to provide a soft compliant surface since leakage can not be tolerated at these locations. One of the omega seals (FN 123) is used at two locations on the turbine housing (the balance cavity port gasket and the roller bearing borescope port gasket). These seals all function as axial seals. The metal omega seal configuration is pressure activated by pressure internal to the seal's single covolution cantilevered legs. A different type of seal is used for the Drying Purge Gasket (FN 316) and the Adapter Plug Gasket (FN 369). These two seals are designed to be installed into a standard MS boss and seal against a threaded plug. This seal functions quite differently and is designed to yield during installation. The seal has a nose extending from a washer face which installs into a conical surface in the boss. When the plug is tightened, this nose is wedged into this conical surface causing it to collapse radially inward. Since the seal is intentionally made from a relatively low strength alloy, the highly loaded section of seal face yields providing a very good seal where it contacts the plug face. Since the axial clamping of this boss seal in the gland collapses the cylindrical seal nose, considerably more spring back is achieved than in a flat gasket. All seals are fracture critical parts and meet all the requirements of the SSME ATD fracture control plan FR-19793-5. DVS 4.1.2.13.1 Leakage analysis to verify leakage limits for the main pump is complete. The results are documented in FR-20715-16 with the VCR in FR-20904-352. DVS 4.1.4.2.6.2 Static seal and threaded connector leakages for the main pump have been verified to be below limits on engine HPFTP's at SSC using SSC leakage test procedures. The leakage test results are included in the VCR (FR-20712-61).

Find Number Find Name	Design Considerations
f/n 025 Speed Transducer	FAILURE CAUSE E: Fracture or distortion of the transducer housing flange due to vibration, thermals, or material/mfg. defect. The Speed Transducer (FN 025) is used to monitor the rotor speed of the HPFTP and interface with the controller. The transducer is made of 304 stainless steel, selected for its superior cryogenic properties and corrosion resistance. The transducer is the same as the Rocketdyne SSME fuel pump speed transducer, with the exception of a few geometry differences to facilitate usage in the HPFTP/AT. The Bolts (FN 107) and Washers (FN131) retain the speed transducer to the bearing cover housing. The bolts are MP35N and the washers are INCO 718 for there high strength. DVS 4.1.4.4.1.5 Duty cycle and LCF life capabilities of the speed transducer are being verified during engine testing at SSC. The results will be included in the engine testing VCR FR-20904-500 and -501
f/n 118 Turbine housing	FAILURE CAUSE F: Fracture or distortion of the turbine housing due to vibration, thermal growth, excessive loads, or material/mfg. defect. The Turbine Housing Assembly (FN 118) consists of the housing detail made of IN100 PWA SP 1074 for its' strength and LCF properties, 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 Turbine Housing (FN 118-05) outer barrel section serves as the primary turbine pressure vessel, containing high hot gas pressure levels during mainstage operation, as well as carrying high axial loads generated by diaphragm loads throughout the turbopump which are introduced by the 32 studs joining the turbine and pump discharge housings, and the turbine exit diffuser support. The load is ultimately transferred to the SSME hot gas manifold at the G-6 flange. The radial diaphragm portion of the housing serves as the turbine end roller bearing radial support structure. The radial diaphragm also serves as a pressure bulkhead separating the pump 3rd impeller backface region from the turbine hot gas environment. The diaphragm is also a key component in the turbopump thrust balance system providing attachment of the 3rd impeller's turbine side tip seal and ID axial rub stop and lab seals. In addition, flow straightening vanes on the pump side of the diaphragm serve to maximize the pressure available on the impeller backface for thrust balance. The Turbine to Discharge Housing I. D. Gasket (FN 126) minimizes leakage of high pressure hydrogen into the turbine stud/shank area. The seal uses a single convolution gold 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. The housing G6 flange provides the primary turbopump mount to the engine, and utilizes a cantilevered flange to prevent flange separation and minimize bending in the engine G6 studs. The turbine housing has an axial step between the flange ID (heel) and the OD (toe). The use of a shim permits minor adjustments to be made to compensate for flange or HGM warping rather than producing the final cantilever gap with the housing step only. The axial load from the turbine static structure is transferred to the turbine housing from the turbine exit diffuser support (spool piece) at a full circumference load shelf directly inboard from the G6 flange. To accommodate the large relative radial deflections without inducing large radial loads or applying significant radial deflection limitations on the TED, the spool piece is radially splined through eight lugs on the ID of the barrel which mate with the slots in the eight axial load arms on the spool piece. The radial spline maintains concentricity control while permitting relative radial motion, and also serves to react the turbine static structure torque, originating primarily from the turbine vanes, into the turbine housing. The eight spline lugs were also sized to permit the entire axial load from the spool piece to be reacted into the turbine side end of the lugs in the event of a failure of the spool piece axial load carrying arms. Eight structural ribs span between the barrel and the diaphragm to limit bending induced by the axial load couple between the discharge housing studs and the barrel. These ribs control the stress in the barrel to diaphragm fillet, outboard of the studs, as well as control axial deflections of the diaphragm due to the Delta P from the 3rd impeller backface. Shallow, round bottomed, axial clearance scallops align with the cooled ribs to provide clearance with the turbine coolant tubes attached to the turbine exit diffuser. Four of the eight turbine housing ribs contain integral coolant passages which provide hydrogen coolant to the tubes assembled on the turbine exit diffuser which ultimately route the coolant to chambers 2 and 48. To close the flow circuit inboard of the cross drill intersection in the radial passage, plugs are used at each of four passage locations. To verify integrity of the plug installation, the plugs are leak checked after assembly as well as being pressure tested during the housing proof test. Hydrogen enters the annulus formed by a groove in the turbine housing and the LOS OD flange through 68 holes in the LOS flange. Three holes transfer the coolant from the annulus to each radial passage and on to the awaiting coolant tube. Eight cross drilled passages deliver roller bearing coolant from a supply annulus fed by eight holes in the discharge housing. The roller bearing receives approx. 35% of the total flow delivered from the annulus through holes in the rub stop lab seal, with the remaining flow bypassing the bearing through the axial hole or recirculating back to the pump through the rub stop lab seals. The function of the third impeller back face pressure Access Cover (FN 055, F20 Inspection Interface) is to cover and seal the port used by a ground test pressure probe (monitors the 3rd impeller back face pressure during Green Run testing). The cover is used only in flight and is fastened to the Turbine Housing by four bolts and washers (FN 133 & 142). The material used for the cover, A-286, was chosen to match the coefficient of thermal expansion (alpha) of the fasteners. The turn around duct to spool piece Gasket (FN 231) uses a double convolution "W" shaped seal because of relatively large gland movements. This formed sheet metal

Find Number Find Name	Design Considerations
	seal is capable of relatively high percentages of axial compression without permanent yielding of the seal. This type of seal allows a small amount of leakage since its axial loading and sealing surface contact stresses are relatively low. The Bolts (FN 133) retain the third impeller back face pressure port cover plate, retain the turbine end roller bearing borescope cover plate, retain a support bracket for the OBB purge line, retain a support adapter for the D16 interface and retain the N11 drying port cover plate. Two ports provide access to the turbine for drying. Plugs (FN 315) and gaskets (FN 316).seal these ports when they are not being used for drying. Adapter (FN 362) provides an interface for attaching a helium purge used during prestart cooldown to keep nitrogen ice from forming in the turbine coolant passages. It also has a port for attaching a purge for drying the turbine post flight. The adapter is held in place with a loop clamp that is secured to the clamp block (FN 361). The block is held in place by bolts (FN 363 and FN 366) and washer (FN 367). The adapter (FN 362) and clamp block (FN 361) are made from AMS 5732 or 5737 (A286) material. The adapter is designed to withstand N11 coolant cavity pressure levels. The port on the adapter used for the post flight drying purge is plugged for flight with plug (FN 368). The plug is sealed with gasket (FN 369). The housing is a fracture critical part and meets all the requirements of the SSME ATD fracture control plan FR-19793-5. DVS 4.1.2.9 Structural design analysis to verify that the turbine housing has adequate margin is complete. The results can be found in FR-20715-02 and -06 and FR-20716-02 and -07. The VCR is in FR-20715-105, -106, -107 and -115. On the Turbine Housing (F/N 118) a life limit has been imposed per DAR PW0267. DVS 4.1.4.1.1.1 Strain gage pressure testing on the turbine housings to define high stress concentration locations is complete. The results are included in VCR documents FR-20715-105, -106, -107 and -115. DVS 4.1.4.1.1.2 Vibration tests to define mode shapes and frequencies for the turbine housings are complete. The results are included in VCR documents FR-20715-105, -106, -107 and -115.
f/n 106-02 Main Pump Housing Stud	FAILURE CAUSE G: Fracture or distortion of the main pump housing stud due to thermal stress, excessive loads, material defect, or manufacturing defect. Studs (FN 106-02) and self-locking Nuts (FN 049) retain the main pump (discharge) housing to the main turbine housing. The studs are threaded into the discharge housing and are locked in place with A-286 keys. The self-locking nuts have a spline wrenching configuration to provide high assembly torque capability. The nut and nut end of the stud is exposed to the hot hydrogen rich turbine environment at the hot circumferential side of the turbine. The stud and nut are made of MP35N (cobalt nickel alloy) which is the highest strength material in the HPFTP. The Fastener Heatshields (FN's 258, 259, 260 & 319) provide temperature margin in the studs and nuts joining the Turbine Housing to the Pump Discharge Housing by reducing hot gas 'scrubbing' and convection coefficients as well as radiant heat. Eight heatshields fit in the pockets created by the eight housing ribs, covering eight gangs of fasteners. Sixteen A286 Bolts (FN 262) and Cupwashers (FN 263) retain the shields to the housing. The shields are machined from Incoloy 909 forgings. The low thermal expansion and modulus allow for large variations in temperature / growth of the shield and bolt. Shield thickness and rib location were chosen for a low shield / bolt springrate as well. The internal cover ribs, between fasteners, reduce cover internal flow and convection. The covers also incorporate vents in the endwall adjacent to the housing ribs to prevent pressure build-up and aid drying. The stud is a fracture critical part and meets all the requirements of the SSME ATD fracture control plan FR-19793-5.

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Functional Assy: Structural Section 03 **Approved by:** A.J. Slone **Issue Date:** October 28, 1986

Failure Mode: Loss of liquid hydrogen or hot gas containment, and external leak. **CIL Item:** 0301 **Rev. Date:** April 16, 2001

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
Failure Cause A f/n 015 Cover,Bearing	Material Integrity	Material integrity is verified per specification requirements	PWA-SP 1240
	Raw Material	Sonic- per- QAD	SP-SIM 1
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Inspection of F3.4.1 Ball Bearing Boroscope Access interface seal surface finish (on bearing cover and on plug) is verified per REI	REI 012
		Inspection of F3.4 Torque Check Access interface seal surface finish (on bearing cover and on plate) is verified per REI	REI 012
		Inspection of F3.1 Shaft Speed Sensor Mount interface seal surface finish (on bearing cover and on transducer mount) is verified per REI	REI 012
	Recycled Hardware	FPI-per-PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause A f/n 116 Cover,Boss,Instrmtn	Finished Material	FPI- per- QAD	SP-FPM Master
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause a f/n 030 Plug,Brg.Boroscope	Material Integrity	Material integrity is verified per specification requirements	PWA-SP 96
	Raw Material	Sonic- per- QAD	SP-SIM 314
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Torque limit is verified per TOL requirements	
		Visually inspect sealing surface of plug	
Failure Cause a f/n 137 Bolt,Access Cover	Material Integrity	Material integrity is verified per specification requirements	PWA-SP 96

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Failure Mode:	Loss of liquid hydrogen or hot gas containment, and external leak.	**CIL Item:**	0301	**Rev. Date:**	April 16, 2001

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Torque limit is verified per TOL requirements	
Failure Cause a f/n 145 Bolt,Front Cover	Material Integrity	Material integrity is verified per specification requirement	AS 7468
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Torque limit is verified per TOL requirements	
Failure Cause a f/n 324 Washer,Cover,Front	Material Integrity	Material integrity is verified per specification requirements	AMS 5663
Failure Cause B f/n 091 Housing Asyo,Pump In		Chrome plating integrity of housing A/O (f/n 091) is verified per specification requirements	AMS 2406
		Heat treatment and hardness of housing A/O (f/n 091) is verified per drawing and specification requirement	PWA-SP 11-17 & PWA-SP 1490
		Welding integrity of core supports closures on housing casting (f/n 091-01-1) are verified per drawing and specification requirements	PWA-SP 36158
		Material integrity of housing (f/n 091) is verified per specification requirements	PWA-SP 1146
		Braze integrity of housing A/O (f/n 091) is verified per drawing and specification requirements	PWA-SP 19 & AMS 4786
		Material integrity of bearing support casting (f/n 091-02-1) is verified per specification requirements	PWA-SP 1490-1
		Weld repair integrity of bearing support casting (f/n 091-02-1) is verified per specification requirement	PWA-SP 36158
		Material integrity, heat treatment and hardness of insert (f/n 091-04) is verified per drawing and specification requirements	AMS 5662 & PWA-SP 11-17

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
		Weld repair integrity of housing casting (f/n 091-01-1) is verified per specification requirements	PWA-SP 36158
		Material integrity of housing casting (f/n 091-01-1) is verified per specification requirements	PWA-SP 1490-1
		Material integrity of stud (f/n 091-03) is verified per specification requirement	PWA-SP 115
	Inspection	Ball bearing journal diameter (f/n 091) is verified per drawing requirements	
		Wall thicknesses on housing A/O (f/n 091) (2 places) are verified per drawing requirement	
	Finished Material	Proof pressure test of housing A/O (f/n 091) is verified per specification requirements	REI 017
		FPI- per- QAD (stud) (f/n 091-03)	SP-FPM Master
		Sonic- per- QAD (housing A/O) (f/n 091)	SP-SIM 309
		FPI- per- QAD (housing A/O) (f/n 091)	SP-FPM Master
		Xray- per- QAD (bearing support casting) (f/n 091-02-1)	SP-XRM Master
		Xray- per- QAD (housing casting) (f/n 091-01-1)	SP-XRM Master
		FPI- per- QAD (housing) (f/n 091-01)	SP-FPM Master
	Assembly Integrity	Inspection of F3 Pump Inlet Flange interface seal surface finish is verified per REI	REI 012
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause b f/n 064 Seal,Forwrd.Diffuser	Material Integrity	Material integrity is verified per specification requirements	ASTM B 150
Failure Cause b f/n 092 Washer,Pump Inlet		Heat treatment is verified per specification requirements	PWA-SP 11-17
		Material integrity is verified per specification requirements	AMS 5596

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Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
Failure Cause b f/n 135 Nut,Inlet Pump		Material integrity is verified per drawing and specification requirements	AMS 5844
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Torque limit is verified per TOL requirements	
Failure Cause b f/n 235 Ring,Sealing,Inlet	Material Integrity	Material integrity is verified per specification requirements	ASTM B 150
Failure Cause C f/n 106 Housing Assy,Dischrg		Weld repair integrity (to vanes and splitters on casting (f/n 106-03-1)) is verified per specification requirement	PWA-SP 36158
		Shot peen of housing (f/n 106-03) is verified per specification requirements	AMS 2430
		Material integrity of casting (f/n 106-03-1) is verified per specification requirements	PWA-SP 1490-2
	Raw Material	Xray- per- QAD (casting) (f/n 106-03-1)	SP-XRM Master
		FPI- per- QAD (casting) (f/n 106-03-1)	SP-FPM Master
	Finished Material	Proof pressure test of A/O (f/n 106) is verified per specification requirements	REI 017
		FPI- per- QAD (A/O) (f/n 106)	SP-FPM Master
	Assembly Integrity	Penetrant inspect per DAR	PW0227
		Part Seating is verified per REI	REI 012
		Inspection of F4 Pump Discharge Flange interface seal surface finish is verified per REI	REI 012
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause c f/n 065 Seal,Rear Diffuser	Material Integrity	Material integrity is verified per specification requirements	ASTM B 150

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Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
Failure Cause D f/n 023 Gasket,Brg.Boroscope		Teflon Coating integrity 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 D f/n 024 Gasket,Brg.Cover	Material Integrity	Spring material integrity is verified per specification requirements	AMS 5664
		Teflon coating is verified per specification requirements	HPS 655
	Finished Material	FPI- per- QAD	SP-FPM Master
Failure Cause D f/n 122 Gasket,Speed Trnsdcr	Material Integrity	Material integrity is verified per specification requirements	PWA-SP 1146
		Teflon Coating is verified per drawing & specification requirements	HPS-655
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Maximum temperature limit if part is subjected to heat to facilitate assembly is verified per REI	REI 012
Failure Cause D f/n 123 Gasket,Interface	Material Integrity	Heat treatment after plating is verified per drawing requirements	
		Material integrity is verified per specification requirements	AMS 5707
	Plating Integrity	Plating Integrity is verified per drawing & specification requirements	AMS 2422
	Finished Material	FPI- per- QAD	SP-FPM Master
Failure Cause D f/n 124 Gasket,Front Cover	Material Integrity	Teflon Coating is verified per drawing & specification requirements	HPS-655

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Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
		Material integrity is verified per specification requirements	PWA-SP 1146
	Finished Material	FPI- per- QAD	SP-FPM Master
Failure Cause D f/n 125 Gasket,Inlet Pump	Material Integrity	Teflon coating removal is verified per drawing and specification requiremnts.	HPS-655
		Gold plating is verified per drawing and specification requirements.	AMS 2422
		Material integrity is verified per specification requirements	PWA-SP 1146
	Finished Material	FPI- per- QAD	SP-FPM Master
Failure Cause D f/n 127 Gasket,Discharge	Material Integrity	Heat treatment after plating is verified per drawing requirements	
		Material integrity is verified per specification requirements	AMS 5707
	Plating Integrity	Plating Integrity is verified per drawing & specification requirements	AMS 2422
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Leak check after assembly of discharge housing to turbine housing O.D. seal is verified per REI	REI 012
Failure Cause D f/n 316 Gasket,Drying Plug	Material Integrity	Material integrity is verified per specification requirements	AMS 5646
	Plating Integrity	Plating Integrity is verified per drawing and specification requirements	AMS 2422
	Finished Material	FPI- per- QAD	SP-FPM Master
Failure Cause D f/n 369 Gasket,Boss	Material Integrity	Material integrity is verified per specification requirements	AMS 5646
	Plating Integrity	Plating Integrity is verified per drawing and specification requirements	AMS 2422

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Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Finished Material	FPI- per- QAD	SP-FPM Master
Failure Cause D f/n 370 Gasket,Spg,N11 Purge	Material Integrity	Material integrity is verified per specification requirements	AMS 5707
		Gold plate integrity is verified per drawing and specification requirements	AMS 2422
	Finished Material	FPI- per- QAD	SP-FPM Master
Failure Cause d f/n 126 Gasket,Discharge	Material Integrity	Material integrity is verified per drawing and specification requirements	AMS 5662
		Teflon coating is verified per drawing and specification requirements	HPS 655
	Assembly Integrity	Leak Check after assembly of discharge hsg to turbine hsg I.D. seal is verified per REI	REI 012
Failure Cause d f/n 205 Damper,Spring	Material Integrity	Material integrity is verified per specification requirements	AMS 5596
Failure Cause E f/n 025 Transducer,Speed	Raw Material	Sonic- per- QAD	SP-SIM 314
	Finished Material	Acceptance test is verified per specification requirement	ATP-D0030023
		FPI- per- QAD	SP-FPM Master
Failure Cause e f/n 107 Bolt,Front Cover	Material Integrity	Material integrity is verified per specification requirement	AS 7468
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Torque limit is verified per TOL requirements	

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Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
Failure Cause e f/n 131 Washer,Speed Trnsdcr	Material Integrity	Material integrity is verified per specification requirement	AMS 5663
Failure Cause F f/n 118 Housing Asyo,Turbine		Contamination control of insert (f/n 118-06) is verified per specification requirements	PWA-SP 36180-4
		Material integrity of housing (f/n 118-05-1) is verified per specification requirements	PWA-SP 1074
		Material integrity of pin (f/n 118-04) is verified per specification requirements	QQ-N-281
		Material integrity of pin (f/n 118-02) s verified per specification requirements	QQ-N-281
		Material integrity of plug (f/n 118-01) 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 insert (f/n 118-06) is verified per drawing and specification requirements	AMS 5662 & PWA-SP 11-17
	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	ECI-per-QAD	TDM-1 per NDTM 99-1
		EDM and removal of recast are verified per specification requirements	PWA-SP 97-5 and PWA-SP 105
		Sonic- per- QAD (A/O (f/n 118) - Shearwave insp)	SP-SIM 1
		Proof pressure test of A/O (f/n 118) is verified per specification requirements	REI 017
		FPI- per- QAD (housing) (f/n 118-05)	SP-FPM Master
		FPI- per- QAD (A/O) (f/n 118)	SP-FPM Master

Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Assembly Integrity	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
		Part Seating is verified per REI	REI 012
		Inspection of G6 Pump Mounting Flange interface seal surface finish is verified per REI	REI 012
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause f f/n 055 Plate,Coolant Adptr.	Material Integrity	Material integrity is verified per specification requirements	AMS 5732 or AMS 5737
	Raw Material	Sonic- per- QAD	SP-SIM 314
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Visually inspect sealing surface of adptr.	
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause f f/n 126 Gasket,Discharge	Material Integrity	Material integrity is verified per drawing and specification requirements	AMS 5662
		Teflon coating is verified per drawing and specification requirements	HPS 655
Failure Cause f f/n 133 Bolt,Boss		Material Integrity is verified per specification requirements	AMS 5731 per MS9566
	Raw Material	Sonic- per- QAD	SP-SIM 314
	Finished Material	FPI - per- QAD	SP-FPM Master
	Assembly Integrity	Torque limit is verified per TOL requirements (-701 Only)	

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Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
Failure Cause f f/n 142 Washer	Material Integrity	Material Integrity is verified per specification requirements	AMS 5732
Failure Cause f f/n 205 Damper,Spring		Material integrity is verified per specification requirements.	AMS 5596
Failure Cause f f/n 315 Plug,Trbn.Hsg.Drain		Material integrity is verified per specification requirements	AS 7477
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Torque limit is verified per TOL requirements	
		Visually Inspect sealing surface	
Failure Cause f f/n 361 Clamp,Block	Material Integrity	Material integrity is verified per specification requirements	AMS 5737 or 5732
Failure Cause f f/n 362 Adaptor,Inlet		Material integrity is verified per specification requirements	AMS 5737 or AMS 5732
	Raw Material	Sonic-per-QAD	SP-SIM 314
	Finished Material	FPI-per QAD	SP-FPM
Failure Cause f f/n 363 Bolt	Material Integrity	Material integrity is verified per specification requirements	AMS 5731 per MS9566
	Finished Material	FPI - per- QAD (if made from MS part number)	SP-FPM Master
Failure Cause f f/n 366 Bolt	Material Integrity	Material integrity is verified per specification requirements	AMS 5731 per MS9566
	Raw Material	Sonic- per- QAD	SP-SIM 314

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Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
	Finished Material	FPI - per- QAD	SP-FPM Master
	Assembly Integrity	Torque limit is verified per TOL requirements	
Failure Cause f f/n 368 Plug	Material Integrity	Material integrity is verified per specification requirements	AS 7477
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Torque limit is verified per TOL requirements	
Failure Cause G f/n 106-02 Stud, Trbn Housing	Material Integrity	Material integrity of stud (f/n 106-02) is verified per specification requirement	PWA-SP 115
	Raw Material	Sonic- per- QAD (stud) (f/n 106-02)	SP-SIM 314
	Finished Material	FPI- per- QAD (stud) (f/n 106-02)	SP-FPM Master
		ECI- per- QAD (stud) (f/n 106-02)	SP-ECM Master
Failure Cause g f/n 049 Nut,Spline,Main Hsg	Material Integrity	Material integrity is verified per drawing and specification requirements	AMS 5844
	Finished Material	FPI- per- QAD	SP-FPM Master
	Assembly Integrity	Torque limit is verified per TOL requirements	
Failure Cause g f/n 262 Bolt,Cover	Material Integrity	Material integrity is verified per specification requirements	AMS 5731 per MS9676
	Raw Material	Sonic- per- QAD	SP-SIM 314
	Finished Material	FPI- per- QAD	SP-FPM Master

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Inspection and Test

Possible Causes	Significant Charactertistics	Inspection and Test	Document Ref
Failure Cause g f/n 263 Washer,Key,Bolt-Covr	Assembly Integrity	Locking feature inspected is verified per REI	REI 012
All Cause		Leak Check of Pump after final assembly is verified per REI	REI 012
		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