NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C. 20594

July 30, 2008

Powerplant Group Chairman's Engine Factual Report

NTSB ID No.: DCA-07-MA-310

A. ACCIDENT

Location:	Lambert Field – St. Louis International Airport, St. Louis, Missouri
Date:	September 28, 2007
Time:	1:16 PM Central Daylight Time
Aircraft:	American Airlines McDonnell Douglas DC-9-82 (MD-82), N454AA, Flight 1400

B. POWERPLANTS GROUP

Group Chairman:	Harald Reichel National Transportation Safety Board Washington, DC
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C. SUMMARY

On September 28, 2007, at 1:16 PM central daylight time, an American Airlines (AA) McDonnell Douglas DC-9-82 (MD-82), N454AA, flight 1400, executed an emergency landing at Lambert-St Louis International Airport (STL), St. Louis, Missouri, after the flight crew noticed a warning light indicating that the left-hand start valve was open and subsequently received a left-engine fire warning during departure climb from the airport. Upon receiving the left-engine fire warning, the flight crew performed an in-flight shutdown of the left-hand engine and discharged both aircraft engine fire bottles into the left engine. During the single engine return approach to the airport, the nose landing gear did not extend and the landing attempt was rejected. During the go-around, the flight crew was able to extend the nose landing gear using the emergency landing gear extension procedure and a successful single-engine landing was made on runway 30L where STL Airport Rescue and Fire Fighting Vehicles met the aircraft. After landing the 2 pilots, 3 flight attendants, and 138 passengers deplaned via the airstairs and no occupant injuries or fatalities were reported. The airplane was operating on an instrument flight rules flight plan under the provisions 14 Code of Federal Regulations, Part 121 from St. Louis International Airport (STL) to Chicago O'Hare International Airport (ORD), Chicago, Illinois.

The airplane sustained substantial damage. The left-hand engine nacelle cowling was destroyed due to fire. The pylon skin and engine mounts were heat affected, as was an area of fuselage skin around the pylon intersection.

The left-hand powerplant external components such as the accessory gearbox (AGB), hydraulic pump, fuel pump (FP), fuel control unit (FCU), constant speed drive (CSD), fuel-oil cooler, air turbine starter (ATS), and air turbine start valve (ATSV) were all fire damaged. The engine core was not affected. Multiple fluid leaks were found coming from the fuel and hydraulic lines.

The powerplant group convened on two occasions: The first, on September 29 to October 1, 2007 in the American Airlines hangar in Lambert Field in St. Louis, Missouri to review the damaged aircraft, pylon, nacelle and powerplant in-situ. The second, on October 29-31, 2007 in the American Airlines maintenance facilities in Tulsa, Oklahoma to perform a detailed engine and nacelle investigation. This report combines the information from both meetings.

D. <u>DETAILS OF INVESTIGATION</u>

D.1 Overview

This report contains the factual data of the nacelle and powerplant investigation only. The Air Turbine Starter, Start Valve and Start Valve air filter assembly are in a separate report.

D.2 Powerplant Information

D.2.1 <u>Nacelle Description</u>

The nacelle surrounds the engine with an aerodynamically smooth shape and among other functions serves as an inlet cowl, fairing, exhaust nozzle, and thrust reverser. It is manufactured as a combination of sheet metal and composite components.

The nacelle is comprised of six major components: the inlet duct, the upper cowl door, two lower cowl doors, pylon close-out panel, and exhaust nozzle/thrust reverser. The three cowl doors are hinged on the side adjacent to the fuselage and are latched on the opposite side.

The nacelle cavity between the engine outer bypass duct and the cowling surface is ventilated during flight utilizing airflow from around the cowling. The flow direction is from front to back.

D.2.2 Engine Description[1]

The left-hand engine installed in N454AA was a Pratt & Whitney (P&W) model JT8D-219 Serial Number 725872.

The P&W model JT8D-219 engine is a dual rotor, low-bypass, axial flow turbofan engine featuring a 1-stage fan and 6-stage low-pressure compressor (LPC) driven by a 3-stage low-pressure turbine (LPT) and a 7-stage high pressure compressor (HPC) driven by a 1-stage high pressure turbine (HPT), a can-annular combustor, and an accessory gearbox (AGB) to extract energy from the engine to operate the fuel pump (FP) and fuel control unit (FCU), hydraulic pump and constant speed drive (CSD). The air turbine starter (ATS) is also mounted to the aft side AGB and only provides engine starting power. The JT8D-219 engine has a normal thrust rating of 21,000 pounds and a maximum takeoff thrust rating of 21,700 pounds.

At the time of the event the left-hand engine had accumulated the following times and cycles:

Pratt & Whitney Engine S/N 725872	
Time Since New	43,785 hours
Cycles Since New	21,248 cycles
Time Since Last Major Shop Visit	5,340 hours
Cycles Since Last Major Shop Visit	2,805 cycles

The JT8D-219 engine established compliance with Federal Aviation Regulation Part 33.17, Amendment 6 for fire prevention via report PWA-5978 dated October 15, 1984.

[1] All orientation and directional references such as top and bottom, front and rear, right and left, and clockwise and counter clockwise are made aft looking forward unless noted otherwise. ALF indicates ‘aft looking forward’. FLA indicates ‘forward looking aft’. Clock references are as viewed from the aft end of the engine looking forward. Top Dead Center is 12 o’clock.

D.3 Preliminary Field Examination of the Left-hand Engine

D.3.1 Cowling and Pylon In-Situ Condition

The inlet cowl, including the front lip, was in-place and intact. There were no impacts noted to the nose cowl. The nacelle cowl doors were latched and in-place. The four latches on the forward door and three fasteners on the aft door remained intact and latched. No damage was noted on the cowl door hinges.

An overall view of the nacelle damage is seen on Figure 1, Figure 2 & Figure 3. The upper cowl door, which is of a composite construction was burned and delaminated. Some of the skin panel was separated from the stiffening ribs. In several areas, no resin remained. The damage was most severe over the axial center third of the cowl with the outer thirds exhibiting mostly a sooty coating. The inside of the cowl from the aft nacelle seal rearward was clean of soot and undamaged. The outer surfaces of the cowl exhibited soot streaks consistent with the direction of airflow.

The upper cowl door features two blow-out panels that limit internal nacelle pressure during sudden overpressure conditions by popping open (Figure 4). The forward blow-out door was open and still attached via the hinge to the cowl door and the hinge was bent aft. The aft blow-out door was not present; however, a section of its mating hinge was still attached to the cowl door and was melted. The outer surface of the cowl door displayed heat damage and sooting aft of each blow-out door.

The lower forward cowl door was burned (Figure 5). All of the stiffening ribs exhibited delamination, burning, and loss of resin material. The composite construction shell did not exhibit any punctures or holes. In several areas, no resin remained. The entire inside of the cowl exhibited a blackened sooty appearance. Re-solidified puddles of molten material interspersed with miscellaneous tube fittings, fasteners, and miscellaneous powerplant external ancillary hardware were found in the bottom of the cowl. The outer surfaces of the cowl exhibited soot streaks consistent with the direction of airflow. Nacelle access panels for the CSD, oil servicing, and ATSV were all liberated from the cowl door.

The lower aft cowl door (Figure 5 & Figure 6) was burned forward of the aft nacelle seal. The cowl skins and stiffeners were not present over an estimated 80% of the door forward of the aft nacelle seal. The remaining material consisted mostly of frayed and delaminated composite fabric with some limited remnants of the stiffening ribs on the axial door split line located near the nacelle fasteners. The inside of the cowl from the aft nacelle seal rearward was clean of soot and undamaged.

The lower forward cowl door (Figure 7) features three access panels: an oil service access panel, a CSD service access panel and an ATSV access panel. The oil service access panel was not present; however, a section of its mating hinge was still attached to the cowl door and was melted. The CSD service panel access and the ATSV access panels were not present; however, a section of their melted hinges were still attached to the cowl door.

The nacelle-to-pylon close-out island exhibited delamination, burning, and loss of resin material. The island panel was deformed, leaving a 1-inch wide gap between the pylon and the island panel (Figure 8).

Soot was found on the inner surfaces of the left-hand pylon, which is beyond the nacelle firewall. Streaked soot patterns consistent with the direction of airflow were noted emanating from the panel joints along the lower surface of the pylon (Figure 9). The inside painted surface of the fuselage skin, normally a yellow colored zinc-chromate primer, was discolored to a light brown shade (Figure 10).

A general black sooty deposit over the entire 360^o circumference of the external surfaces of the fan ducts from and including the aft bulkhead of the inlet cowl to the aft nacelle-sealing surface was observed. The sooty deposit could be removed by rubbing with finger pressure.

D.3.2 Engine In-Situ Condition

The engine was in-place on its pylon (Figure 11). There were no indications of case rupture or uncontainment. The thrust reverser was in-place and intact on the engine. The reverser was in the stowed position.

The fan ducts exhibited distress to the outer face sheet of their honeycomb construction. The face sheet appeared to be melted and delaminated (Figure 12). No distress was noted in the underlying honeycomb cells. In areas where the outer face sheet was still in place there was a wavy appearance consistent with the face sheet being debonded from the honeycomb.

The nose bullet was in-place and intact on the engine with no noted distress. The inlet guide vanes were all in-place and intact with no noted distress (Figure 13). The fan blades were all in-place and intact. There were no indications of soft body[2] Foreign Object Damage (FOD) to the fan blades. The low pressure (LP) rotor rotated freely and smoothly by hand when turning the rotor by the fan blades.

The 4th stage turbine blades were all in-place and intact with no noted distress as viewed up the tailpipe of the engine (Figure 14). As viewed through the tailpipe there were no indications of heat distress or fire within the engine fan ducts. The tailplug was in-place and intact with no noted distress. The lobed mixer was in-place and intact with no noted distress or signs of sooting.

[2] Soft body FOD is characterized by gently cusping of the fan blade leading edges or tip bending/curling. Soft body FOD is associated of ingestion of objects such as birds or ice.

The isolators for the ignitor box were heat distressed and damaged and the ignitor box was found loose from its support bracket but was retained in position by the starter line. The housing of the ignitor box was distorted and fractured exposing the internal contents. The high-tension leads out of the ignitor box were burned away.

The Pressurization and Dump (P&D) valve (Figure 15) was in-place and intact on the engine. The aluminum B-nut and adapter associated with the fuel line from the FP5 port were melted and the fuel line was separated from the P&D valve. The supply line and output line from the FP4 port were both in-place and secured to the P&D valve.

The 8th stage anti-ice air line on the left-hand side of the engine exhibited about a 4-inch long by about 1-inch wide breach in line with E-flange. The 8th stage anti-ice air line on the right-hand side exhibited about a 3-inch long by about 2-inch wide breach just after the elbow where the pipe exits the fan duct at its source end. The right-hand side line also exhibited an approximately 13-inch long discontinuity in the pipe in the area of D & E-flange characterized by pipe material remnants that appeared wrinkled/melted.

The outer sheath attachment bracket of the throttle push-pull cable was melted (Figure 16) and thus disconnected from the engine fuel control cable bracket.

The main engine fuel line exhibited a complete separation of its four-bolt flange in the solid elbow section of the line between the flange and the flexible portion of the hose (Figure 17). An estimated 2-inch long 45-degree section of the elbow had been melted away.

A fuel vapor vent line was separated at the 3 o'clock location on the engine in the axial plane of G-flange (Figure 18). The exposed end of the tube exhibited damage consistent with thermal distress. The flexible hose end of this tube assembly had separated and was found resting on a tube below.

The oil level in the engine oil tank was to the bottom of the strainer element, which is consistent with the oil quantity being about 1 to 2 quarts low. A sample of oil was removed from the tank and it appeared to be clear and did not exhibit an acrid odor.

The flanged fuel line joint of the fuel bridle on the left-hand side of the engine exhibited a gap of about 0.05-inches (Figure 19). This flange would be used on a No. 2 position engine to connect the main fuel line flex hose coming down from the pylon.

The fuel-oil cooler and thermostat were intact. The external surfaces were coated with soot (Figure 20). The aft flange displayed a wetted appearance as well as the forward oil connection.

The housing of the alternating current (AC) generator exhibited a hole approximately 9-inches circumferential by about 2-inches axial on the left-hand side of the engine (Figure 21). The edges of the hole were melted and heat distressed. The coils of wire inside the generator were visible. The CSD was in-place and intact on the gearbox and contained oil.

The boss on the AGB and associated tube coupling for the No. 4-5 bearing compartment oil breather line were melted away leaving the end of the breather line free in space at the gearbox end (Figure 22).

D.3.3 Electrical Harness and Wiring

D.3.3.1 General

All the wiring harness beneath the nacelle showed various signs of heat damage. All the wires that were on the external surface of the wiring bundles leaving the pylon connector plugs were missing their insulation sheaths along the first 18-inches exposing the bare wire. The wires within the bundles were charred; however, most were still covered with insulation (Figure 23). The wire bundle beyond the area where the insulation was missing was wrapped in a fabric sleeve that was fire damaged and covered in soot.

From the pylon connectors, the wiring harness routs vertically upwards until it reaches the top of the engine where it is fastened to a bracket. One wire bundle from the upper bracket attachment point then routes directly downward along the right side of the engine and at the 4 o'clock position it then turns forward and becomes distributed to the lower junction box and the Line Replaceable Units (LRUs) on the forward lower right engine area. All these lower wires were missing their insulation sleeves and were bare. A second wire bundle from the upper attachment point runs forward along the top of the engine. Near the front of the engine this bundle then becomes distributed into smaller bundles, which are then routed towards the bottom of the engine on the left side. There the smaller bundles are further distributed until single wires are visible and connect to their various plugs and connectors. Those bundles, which contained fewer than 20 wires near the bottom of the engine exhibited the most heat distress and were missing their insulation sheaths (Figure 24). Several connectors were missing, leaving loose bare wire ends.

The silicon rubber cushions within the P-clamps on the externals and wire harness clamps exhibited charring, burning, and disintegration to the point where the wires routed through the clamps were observed to be loose within the remaining metal of the clamps (Figure 25).

D.3.3.2 Air Turbine Start Valve Electrical Harness

The ATSV electrical wiring harness, which is a segment of the main engine wiring harness, connects the ATSV actuation solenoid and the ATSV position indicator microswitch to the pylon electrical interface connector. The entire wire run was damaged due to heat to various extents. Some lengths were only charred while others had the insulation melted, exposing the bare wire. The pylon connector plug was present and in its correct secured location. All the pins and wires within the pylon connector plug were present but damaged due to heat.

The two ATSV connector plugs were separated from the wiring harness and were found loose within the debris in the lower cowl door still connected to the 4 bare wires that were about 1-foot long. A fractured portion of the ATSV control housing was still attached to the connectors. An electrical continuity test was performed and continuity between the 4 pylon connector pins and the respective bare wires near the ATSV was confirmed.

D.3.3.3 Fire Warning Loop

The wiring harness and fire loop could not be tested for functionality because they were burned.

D.3.3.4 Engine Generator Power Feeder Cables

The cables were inspected for evidence of arcing from phase-to-phase, phase-to-neutral and phase-to-ground of the nacelle harness from the terminal lugs on the generator to the pylon J-Box connector. No evidence of arcing was found. Two cables were melted and severed adjacent to the pylon apron approximately 24-inches from the pylon connector.

D.4 Detailed Engine Teardown Examination

On October 29-31, 2007 the powerplant group convened in the American Airlines maintenance facilities in Tulsa, Oklahoma to perform a detailed engine and nacelle investigation.

D.4.1 <u>Engine High Pressure Rotor Condition</u>

When the engine was examined in Tulsa, it was not possible to rotate the high-pressure rotor through the gearbox. As accessories were removed from the gearbox in the following order: hydraulic pump, CSD, FCU, and FP, rotation of the engine became possible. After the removal of the FP, the high-pressure rotor turned normally.

A borescope inspection of the inside annulus of the fan duct from the 6 o'clock to 9 o'clock location confirmed that there was no evidence of burn through from the core of the engine. A visual inspection from the rear of the engine showed no evidence of distress on the perforated liners inside the fan duct.

D.4.2 Accessory Gearbox (AGB)

The accessory gearbox housing was coated with sooty deposits (Figure 26 & Figure 27). The accessory gearbox is supported in 3 locations by a forward and a left-hand and right-hand aft mount lug. The two aft mount lugs were visually intact. The forward mount lug was still in-place and attached to the gearbox but exhibited a crack that ran about ¾ of the perimeter of the lug at a location 1.6-inches aft of the forward face of the lug. The upper right-hand side of the gearbox housing exhibited multiple cracks and indications of insipient melting starting roughly in line with the bottom of the engine data plate and extending to the top of the gearbox right-hand side. The integral boss of the gearbox for the No. 4-5 bearing breather line and the aft area of the gearbox housing where the throttle linkage cross-over shaft exits the left-hand side was melted (Figure 22). The bolted-on aluminum elbow and the B-nut for the No. 4-5 bearing breather line were also melted away. The oil tank mount pad on the gearbox was melted from the 7:30-10:30 o'clock location including the mounting stud boss. The mounting areas for the oil tank and starter exhibited sooty deposits in the areas protected by those components. The soot deposit in the oil tank mounting area was a lighter shade compared to that of the starter location. The mounting areas for the CSD, FP, and hydraulic pump were clean in the areas protected by the in-position components.

The tower shaft was intact and oil wetted when removed from the engine. This part appeared to be undamaged.

D.4.3 Oil Tank

The oil tank had maintained its integrity and was still attached to the gearbox (Figure 28). Ten (10) quarts of oil were removed from the oil tank and an additional 4 quarts were removed from the gearbox and CSD wet spline. The capacity of the total engine oil system is 20 quarts.

D.4.4 Fuel System

D.4.4.1 General

No fuel was present in any of the fuel lines or fuel system components disassembled in this investigation.

A gap was observed on the four-bolt flange of the left-hand side fuel bridle between the bridle and the close-out plate (Figure 19). All 4 bolts and nuts were present but the washers under the nuts on the bottom side of the joint were not. Circular witness marks that were a larger diameter than the nuts were found on the underside of the flange. The washers are made of aluminum. The gap width between the fuel bridle and close-out plate was consistent with the thickness of a washer. Before the flange was split, the run-on torque of the four clamping nuts was taken. The run-on torque was less than 5 in-lb for each nut. After disassembly, the nuts were run back onto the bolts by hand and resistance to hand torque was felt consistent with the presence of the anti-rotation feature of the nut. A metal gasket with a rubber sealing o-ring on either side is sandwiched between the fuel bridle and the close-out plate. The metal portion of the gasket was present; however, the rubber o-ring on both sides was missing but black rubber-like material was noted in the recess grooves where the o-ring would normally have been.

The pylon vapor vent line was found with the flex tube liberated (Figure 29). The 90-degree elbow remained attached to the engine side plumbing. The nut retaining the elbow was loose and could be removed by hand. Three fragments of the B-nut retaining the opposite end of the vapor vent flex line were identified among the debris in the lower forward cowl. A unique geometry and part number identified the nut. Each piece showed a distinctly varying degree of heat discoloration.

A pressurization test of the fuel system was done to identify possible fuel leak sources. Before the test was performed, a new left-hand fuel bridle gasket was installed. Airflow was confirmed to exit from the free end of the pylon vapor vent line before it was capped. Air pressure was then introduced into the inlet of the right-hand fuel bridle inlet at 50 pounds per square inch (psi).

The initial attempt at pressurizing the fuel system identified a leak in the fuel filter bowl cover. The cover was removed and the o-ring was found to be hard and brittle. The fuel filter inside was a uniform black color and no fuel was present in the filter bowl. The o-ring was replaced with a new one, reassembled, and the pressurization test continued.

Further fuel system leaks were identified at the following locations: FP-to-FCU joint; the cover of Delta-P switch across the fuel filter; and the ambient pressure vent plug on the top right-hand side of the FCU just forward of the two solenoids.

The outlet pipe from the FCU was removed and no airflow was sensed at the control outlet regardless of the position of the throttle control and shutoff levers. The FCU was removed and the leak check process was continued down stream of the control.

An air source was applied to the outlet line from the FCU to leak test the components and plumbing down stream of the FCU. Fifty (50) psi air was again applied to the system.

The following air leaks were identified during this test:

- The B-nut joint going into the fan duct on the primary fuel manifold at both the 5:00 and 7:00 o'clock locations.
- P&D valve housing cover on the aft side of the valve body opposite the inlet.
- The interface between the housing and coupling adapter at the P&D valve FP4 outlet.
- The coupling adapter for the inlet supply line to the P&D valve.
- The forward cover over the fuel drain on the P&D valve.
- The inlet to the fuel flow transmitter.
- The outlet of the fuel flow transmitter.
- The outlet of the fuel-oil cooler.

D.4.4.2 Fuel Manifolds

The fuel manifolds (Figure 30) could be moved by hand at the B-nut connections where the manifold passes through the outer fan duct. The amount of play was approximately 0.1-inch radial relative to the engine. This motion was found after removal of the P&D valve and present at all four fan duct penetration points (5 o'clock and 7 o'clock location for both the primary and secondary fuel manifolds). A pressure test of these manifolds detected a leaking condition at all four points. Dust consistent with degraded packing material was found after removal of all four of the B-nuts at the fuel manifold fan duct pass-through locations.

D.4.4.3 Fuel Pump (FP)

The FP housing was intact and exhibited a uniform sooty deposit. The FP was removed from the gearbox and examination of its gearbox-mounting pad revealed a purple-blue discoloration consistent with heat tint. The two o-rings that sealed between the FP and gearbox were intact but flat and brittle.

The FP was placed on a fuel test stand and checked for leaks. Leaks were found in the following locations:

- The mating flange between fuel heater and FP.
- From the o-rings on the two transfer tubes.
- The main drive shaft rotating seal.
- The two o-ring locations on the fuel filter Delta-P switch.
- The o-ring on the fuel filter drain plug.
- The o-ring between the boost pump cover and pump housing.

- The main fuel line input seal.

D.4.4.4 Fuel Control Unit (FCU)

The FCU housing was intact and exhibited a uniform sooty deposit. The FCU mounts and mount links were intact.

The N2 sense shaft was fractured with 0.1-inches length of spline left on the FP side of the shaft. The fractured surface was clean and shiny. The remaining length of the spline teeth were intact and appeared to be full height but exhibited a twist in the counter clockwise direction as viewed from the FP looking towards the FCU.

The FCU was placed on a fuel test stand and checked for leaks. Leaks were found at the following locations:

- The ambient pressure vent leaked fuel, consistent with an internal leak.
- The idle and part-power trims adjustment block seal.
- Cannon plug for automatic reserve thrust reset switch.
- The seal on the speed sensing servo cap.
- The plug on the deceleration bleed valve lever.
- The minimum pressure shut off valve supply line leaked at both ends.
- The minimum fuel flow adjustments cover seal.
- The main filter cover seal.
- The split line seal.
- The P (ambient) large access cap consistent with an internal leak.
- The P (ambient) rate adjustment bellows consistent with an internal leak.
- The seal between compressor inlet temperature and rack gear plates.
- Several other minor leaks that were hard to pinpoint.

No leaks were noted at the fuel shut off valve during a low-pressure test with the shut off valve in either the ON of OFF position consistent with normal operation.

D.4.4.5 Pressurization and Dump Valve (P&D)

The P&D valve (Figure 30), P/N 766342, S/N 6155740, was in its correct location on the outer fan duct. The fan duct mount boss for the P&D Valve aft side lower mount lug was fractured. The fractured surface was flat.

The P&D valve housing was visually intact with no breaches noted. After removal of the valve from the engine, black powdery debris was noted on the inlet adapter and FP4 B-nut consistent with heat degraded packing material. The forward end of the FP5 coupler and associated B-nut were melted. The lower half centered at the 8 o'clock position of the nut and the fitting was thermally distorted and sagged. The upper portion of the nut and fitting were drooping, thus partially covering the FP5 orifice.

The P&D valve was placed on a test stand and checked for leaks. Leaks were found at the following locations:

- Discharge port.
- Pressurizing valve cap.
- Primary and secondary tap plugs.
- Fuel screen filter cap.

D.4.4.6 Fuel Flow Transmitter

The inlet line to the fuel flow transmitter exhibited a clean gold colored appearance. The surface was free of soot. The B-nut securing the line to the transmitter inlet was loose, and could be rotated by hand in either direction until limited by the lockwire.

The fuel flow transmitter was intact and on the inlet side of the transmitter remnants of all of the packing material and seals were found in the form of black colored dust. On the outlet side of the transmitter, the o-ring was intact but was hard and lacked compliance.

D.4.4.7 Fuel-oil Cooler

The fuel-oil cooler was full of oil when removed from the engine. The fuel-oil cooler was intact and black dust consistent with remnants of an o-ring was present when the outlet fuel tube was removed. All of the packing material on the oil lines associated with the fuel-oil cooler were present and had a tactile feel of elastic compliance.

D.4.4.8 Deceleration Bleed Control Valve

The fuel lines on the forward side of the deceleration bleed control valve were noted to be loose at the coupling adapters when the lockwire was removed from the B-nuts. When the adapters were removed from the housing a white-gray colored dust was found consistent with packing material remains. The housing of the bleed itself was intact but exhibited distress that had the appearance of surface cracking in the area of the fuel carrying line ports.

D.4.5 <u>Ignition System</u>

D.4.5.1 Ignitor Box

The igniter box housing was distorted and melted exposing and freeing the internal components of the box. The damage was more extensive on the forward side. The mount brackets and the vibration dampers were no longer attached to the box and the box had fallen and wedged into a space between the engine bypass duct and bleed air duct.

D.4.5.2 Ignition Leads

Both igniter leads were separated at the solder joint at the end terminals yet no fracture on either part was noted. This is consistent with a high temperature condition that weakened the solder joint connecting the two parts.

D.4.6 Hydraulic Pump and Hoses

D.4.6.1 Hydraulic Pump

The engine-driven hydraulic pump (Figure 31) is a dual-range electrically depressurized variable displacement hydraulic pump. Outlet flow is 8.6 gallons per minute (GPM) at 3000 psi. The hydraulic pump was removed from the engine and examined in the American Airlines Hydraulic Shop. After cleaning, the following damage was noted:

The rectangular shaped rear cover was distorted or bulged outward (Figure 32). The maximum deformation was at the lower half of the cover and near the centerline of the bottom edge. There were two major cracks and multiple thin “spider cracks” originating from this area of distortion. The two major cracks continued past the parting line and joined at one corner of the housing. A second fracture was also located in this area. A “coked” deposit consistent with overheated hydraulic fluid was on the interior of the rear cover as well as on the bottom interior of the housing. No internal mechanical damage was noted. No external fasteners were missing. The coupling shaft bolt was found loose. Two seals were found to be brittle, consistent with heat damage.

A source of hydraulic pressure was connected to the pump case drain connection. With approximately 20 psi applied, the housing emitted streams of fluid through the two fracture locations.

D.4.6.2 Hydraulic Hoses

The three hydraulic hoses that connect to the hydraulic pump were present. The fire sleeves that surround these hoses were present and were severely heat damaged but remained intact. The fire sleeve on the pressure hose near a P-clamp was broken.

The hydraulic pump and hose assembly contained a small amount of burned hydraulic fluid. A hydraulic test unit was connected to the case-drain and pressure hoses and fluid was introduced to the system. Three leaks were identified at a very low-pressure setting (Figure 33). One leak was found on the pressure hose 3-inches below the bridle.

The second leak was found on the case drain hose at mid-length near a clamp that holds the fire sleeve onto the line. The third leak was found on the return hose and seepage was noted along the entire length.

The history of these hoses were as follows:

- The case drain hose was manufactured in October 1982.
- The pressure hose was manufactured in September 1984.
- The return hose was manufactured in March 1983.

D.4.7 Generator

The external generator housing was dry and coated with a white deposit on the left-hand side (Figure 34). The remainder of the housing was coated with a sooty deposit. The 2-inches portion of the housing surrounding the field wires was melted from approximately 7 o'clock position to the 11 o'clock position. This axial location corresponded to the plane of the starter exhaust deflector. The exposed internal copper colored field wires appeared to be undamaged.

D.4.8 Constant Speed Drive (CSD)

The CSD appeared to be undamaged and covered with soot. The oil tank level of the CSD could be seen through the sight glass and was observed to be approximately three quarters full. Approximately 3-1/2 to 4 quarts of oil were drained from the CSD. The oil appeared normal.

Harald Reichel
Aerospace Engineer - Powerplants

Figure 1 – Side view of nacelle

Photo No: P9280002.tif

Figure 2 – Front view of nacelle

Photo No: P9280003.tif

Figure 3 – Aft view of nacelle

Photo No: P9280004.tif

Figure 4 – Blow-out doors

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Figure 5 – Forward and aft lower cowl doors

Photo No: P9290005.tif

Figure 6 – Lower aft cowl door - detail

Photo No: P9290036.tif

Figure 7 – Lower forward cowl door - detail

Photo No: P9290012.tif

Figure 8 – Pylon close-out island – view looking up

Photo No: P9290023.tif

Figure 9 – Lower pylon surface – streaked soot pattern

Photo No: P9290024.tif

Figure 10 – Inner surface of fuselage skin at pylon interface

Brown discoloration

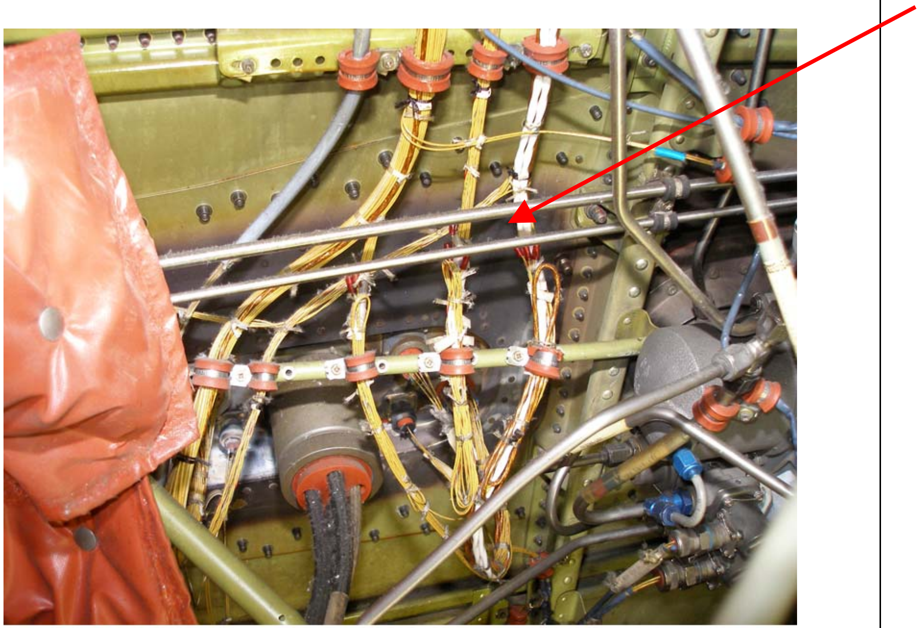

Photo No: PA010181.tif

Figure 11 – Engine in-situ

Photo No: P9290077.tif

Figure 12 – Outer fan duct

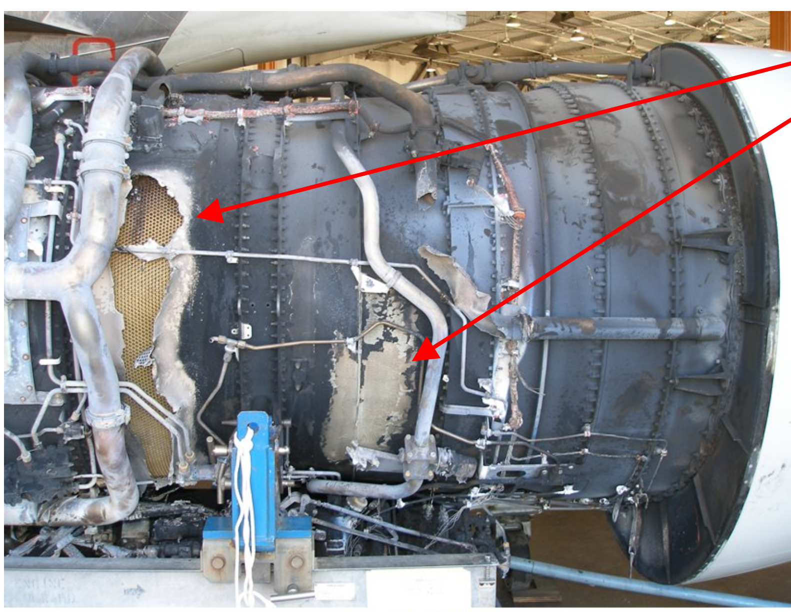

Photo No: PA010159.tif

Figure 13 – Engine view from front

Photo No: P9290041.tif

Figure 14 – Engine view from aft

Photo No: P9290045.tif

Figure 15 – Pressurization & Dump valve

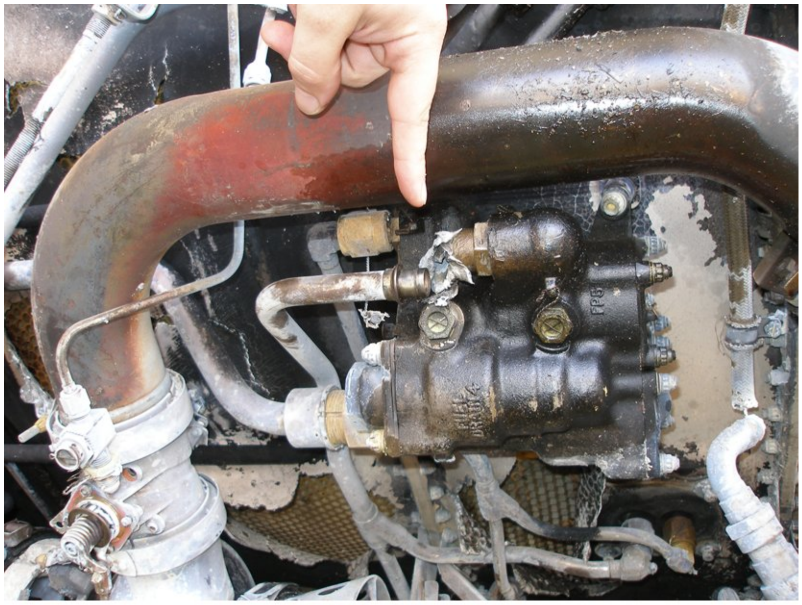

Photo No: P9300126.tif

Figure 16 – Throttle cable bracket

Throttle cable disconnected

Photo No: IMG_3649.tif

Figure 17 – Main engine fuel line – melted from flange

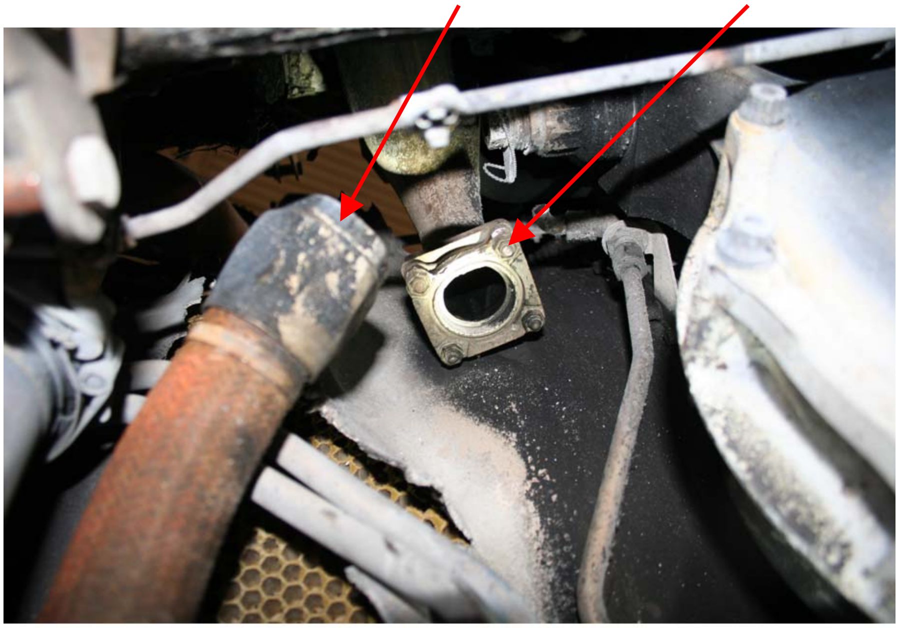

Photo No: IMG_3641.tif

Figure 18 – Fuel line separated

Photo No: IMG_3681.tif

Figure 19 – Fuel bridle flange gap

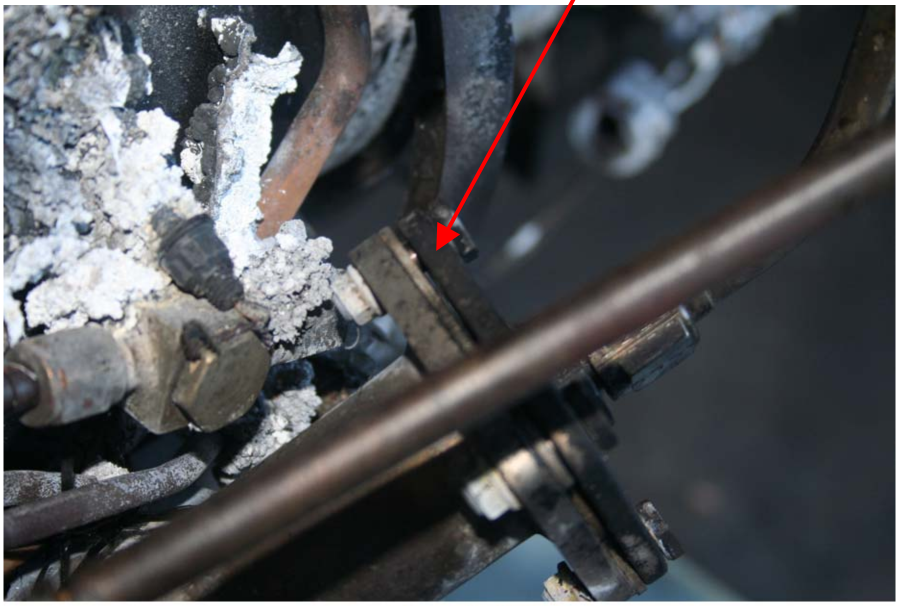

Photo No: IMG_3679.tif

Figure 20 – Fuel-oil cooler

Photo No: PA290045.tif

Figure 21 – AC generator housing breach

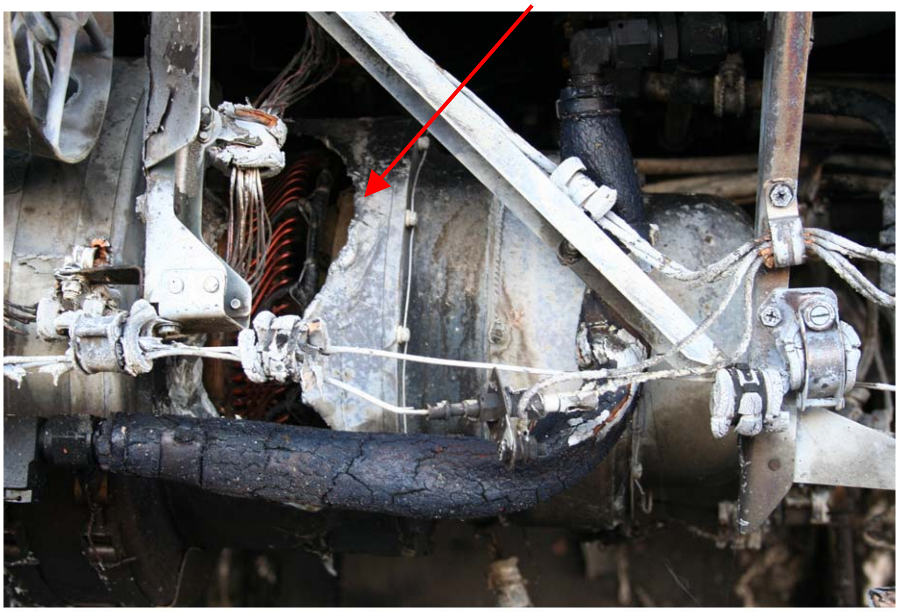

Photo No: IMG_3623.tif

Figure 22 – AGB boss melted

Photo No: PA290043.tif

Figure 23 – Main pylon electrical harness

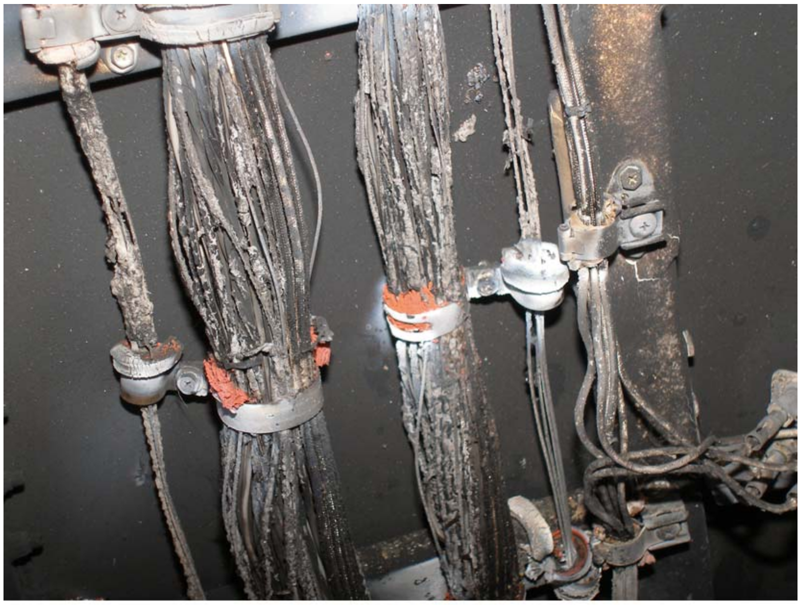

Photo No: P9300098.tif

Figure 24 – Wiring harness & connector damage details

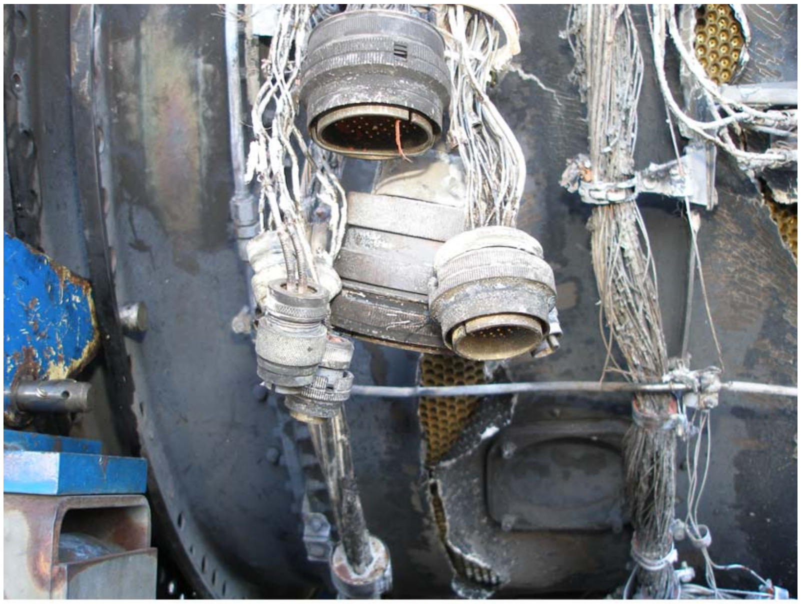

Photo No: PA010168.tif

Figure 25 – Silicon rubber cushions in P-clamps

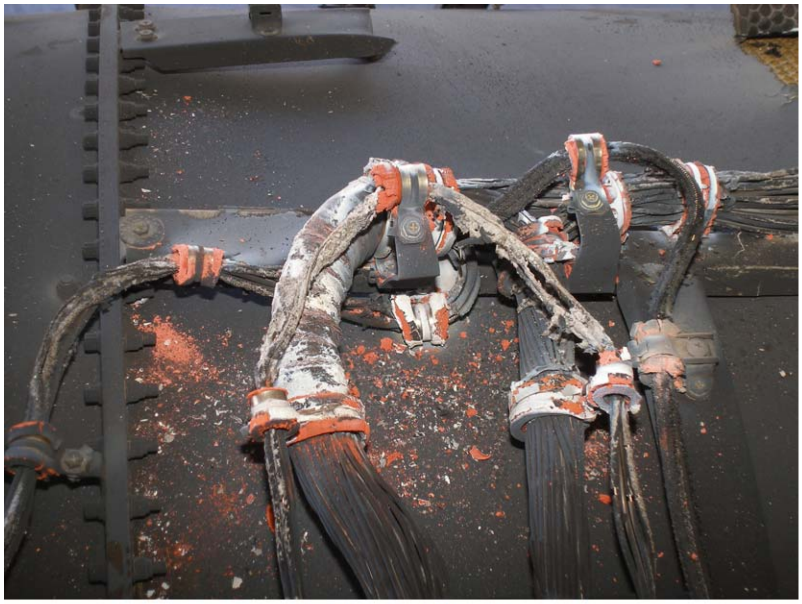

Photo No: P9300099.tif

Figure 26 – Accessory gearbox – aft view

Photo No: PA310115.tif

Figure 27 – Accessory gearbox – front view

Photo No: PA310116.tif

Figure 28 – Main oil tank

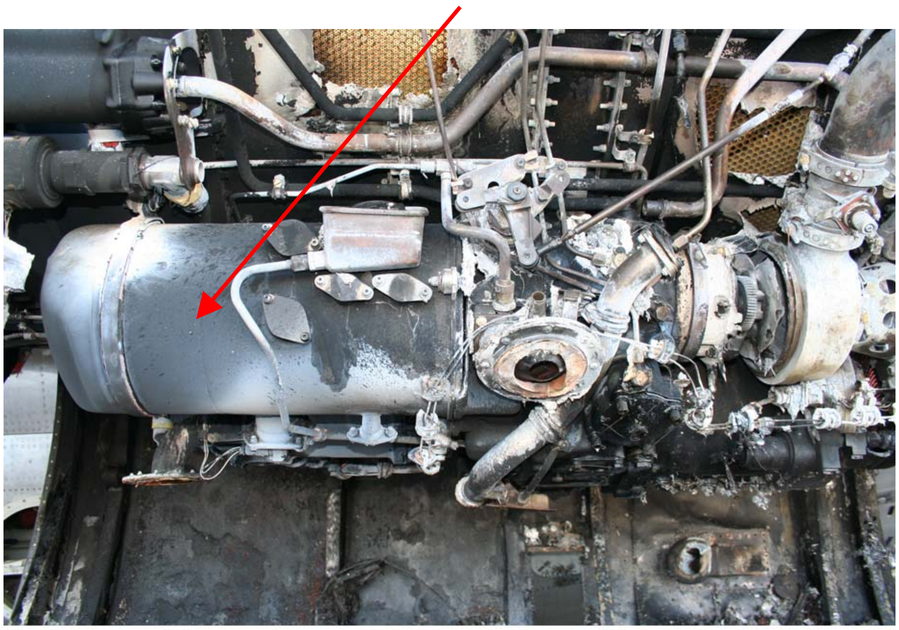

Photo No: IMG_3628.tif

Figure 29 – Fractured fuel vent line

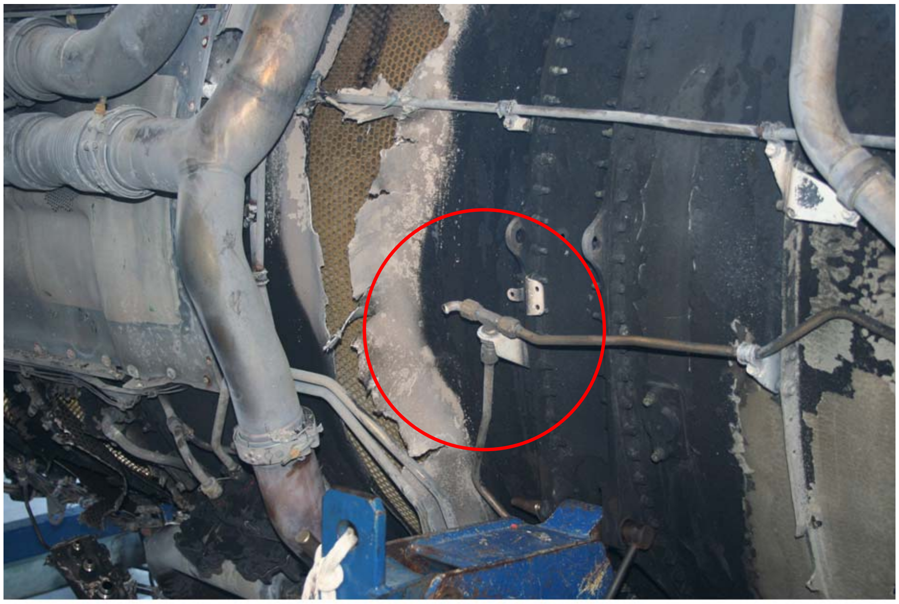

Photo No: IMG_3680.tif

Figure 30 – Fuel manifolds

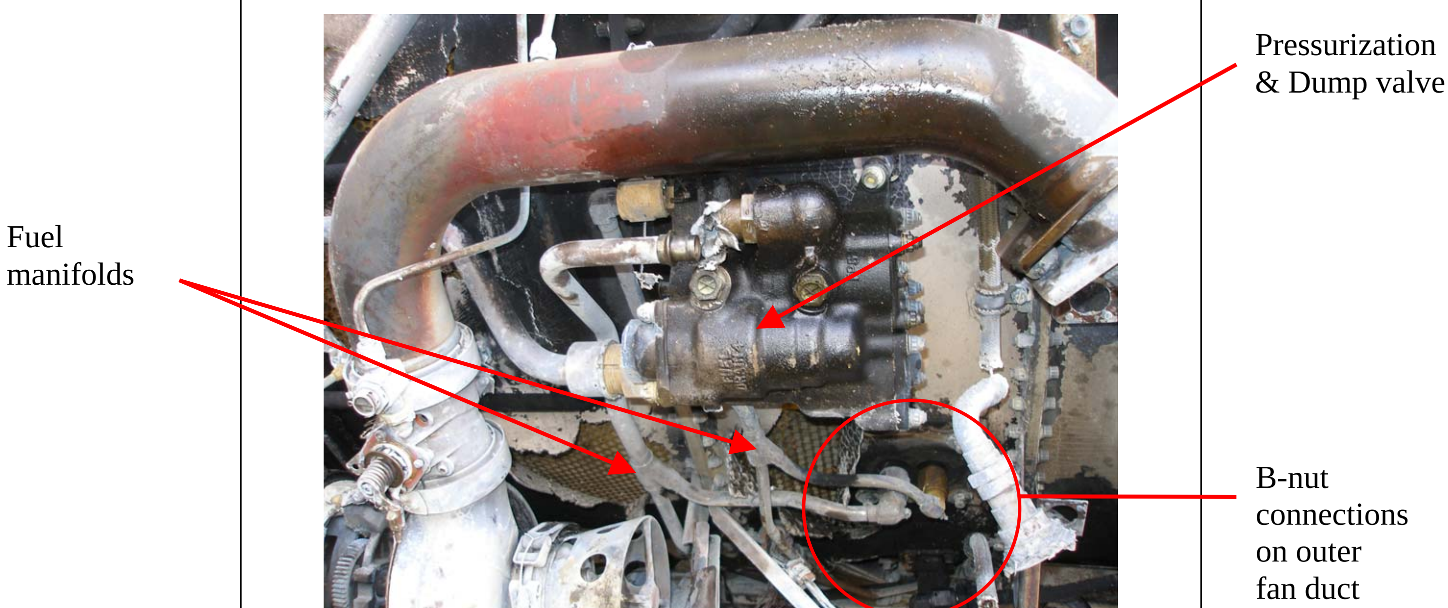

Photo No: P9300125.tif

Figure 31 – Hydraulic pump

Photo No: PA310095.tif

Figure 32 – Hydraulic pump fracture

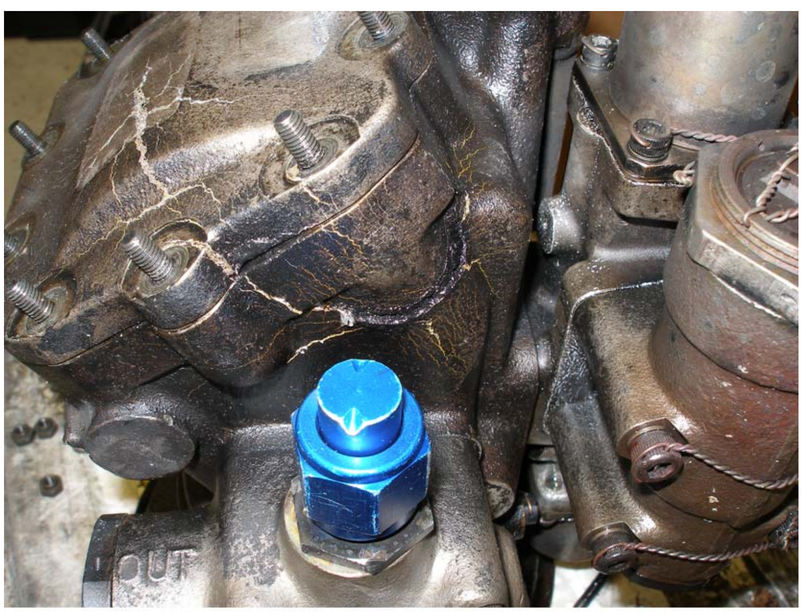

Photo No: PA310105.tif

Figure 33 – Hydraulic hose leaks

Photo No: PA290006.tif

Figure 34 – CSD and AC generator

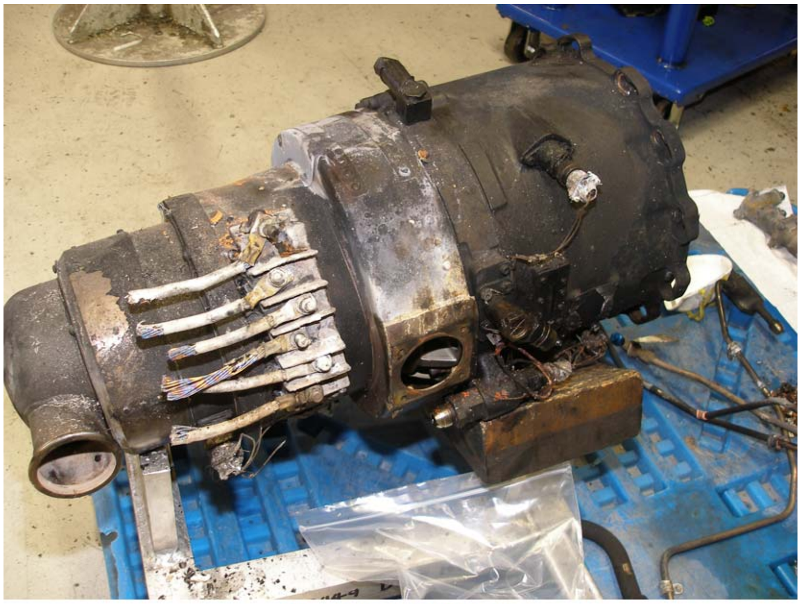

Photo No: PA310108.tif