Engine Investigation Report

Rolls-Royce Model 250-C30P
Engine CAE 896108

Bell 206L-4
Registration: N405MR

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New York Helicopters
New York City, NY

Incident date: June 30, 2013
On-Site Examination Date: July 2, 2013
Examination at Keystone Date: July 11, 2013
Examination at Rolls-Royce Date: Sep 25-26, 2013
Report date: 18 March, 2014

Background

On June 30, 2013, approximately 1155 local time, a Bell Helicopter 206L-4, registration number N405MR, operated by New York City Helicopter Charter, Inc., incurred minor damage after a forced landing into the Hudson River in New York due to a reported engine failure. The flight was a local sightseeing flight with a commercial pilot and four passengers on board. The pilot and passengers were uninjured in the incident. Visual meteorological conditions prevailed for the flight, which departed Downtown Manhattan/Wall Street Heliport (JRB), New York, New York, about 10 minutes prior to the incident.

According to the pilot, he had flown seven previous segments that day in the incident helicopter, with most of those under 20 minutes and the last segment being a trip to JRB after obtaining fuel in New Jersey. After landing at JRB the aircraft picked up the passengers and took off and headed northbound along a standard company tour route. Approaching the 79th Street Boat Basin, at 1,500 feet, the pilot heard a “bang” and a passenger asked if the helicopter had hit a bird. The pilot answered no, then heard the “Engine Out” warning and saw that the N2 (power turbine) indication was dropping. The pilot decided to perform an autorotation, and just prior to lowering the collective and rolling the throttle to flight idle, he saw the “Engine Chip” light illuminate.

The pilot advised the passengers that they were “going down” and transmitted a Mayday call to LaGuardia Tower. During the flare, the pilot deployed the skid-mounted floats and bled off all forward airspeed. Following impact, the chin bubbles broke and water rushed into the cabin.

Once the helicopter came to rest, the pilot verified that all of the passengers were safe, confirmed same with LaGuardia Tower, secured all switches and circuit breakers, and helped the passengers to board a boat before boarding another one himself for the trip to shore.

Examination at Recovery

The Helicopter was transported to the operators maintenance facility located at JRB for initial examination. The exam took place on 2 July 2013 with oversight from the FAA. Present were Rolls-Royce ASI, the Director of Maintenance, the owner/operator of NY Helicopters, and a representative from Keystone Engine Services.

According to the maintenance records, the turbine module had been recently overhauled by Keystone Engine Services. After the overhaul the turbine had further work done due to smoking on shutdown. The engine was returned to service with approximately 2 hours of operation prior to the incident.

The engine remained securely mounted in the helicopter engine compartment. The engine was intact and did not display any signs of external damage. There was no visible damage to the compressor. The 4th stage turbine wheel, as viewed through the exhaust collector, was normal in appearance. All engine mounts remained attached to both the engine and helicopter. The gearbox, all components, and external oil, fuel, and electrical lines were undamaged and secure.
Fig 1:

With battery power applied to the aircraft the engine chip light was illuminated. The lower chip detector was disconnected and the chip light remained illuminated. The lower chip detector was reconnected and the upper chip detector was disconnected and the light remained illuminated, indicating that metallic debris was located on both chip detectors. Both chip detectors were removed for inspection. The upper chip detector contained small amounts of metallic debris and metallic paste. The lower chip detector also contained metallic paste, metallic debris, along with a several metallic flakes. The aircraft scavenge oil filter bypass indicator was not extended. The filter bowl was removed and contained metallic particulate. The filter was clean other than a small amount of metal particles.

Attempts to motor the engine were unsuccessful with no N1 rotation as the starter/generator was turning. The compressor was attempted to turn by hand, but was rough and would bind after about a quarter turn.

The Turbine Module was removed from the engine and showed no signs of damage. The outer combustion case and combustion liner were removed to facilitate further inspection. Inspection of the combustion section revealed metallic spatter coating the inside of the combustor liner and both air discharge tube. There was evidence of carbon within the combustion liner and on the face of the fuel nozzle, but no excessive hot spots on the combustion liner assembly. The combustor liner was otherwise normal in appearance. The gas producer and power turbine supports were unremarkable. Both the Gas Producer Turbine and the Power Turbine turned freely by hand. Examination of the 1st stage turbine nozzle and nozzle shield revealed metallic spatter across the nozzle shield face and 1st stage nozzle surfaces. Visible portions of the 1st stage turbine wheel were normal in appearance. The power turbine to pinion gear coupling and turbine to compressor coupling were in place and undamaged. **Fig 2:**

The engine was removed at a later date by NY Helicopters maintenance technicians and transported to Keystone Engine Services for further examination.

Engine Information

Engine Model: Rolls-Royce 250-C30P
Rating: 650 HP
Serial Number: CAE896108
Engine Total Hours: 2536.4
Last 100-Hour Inspection: 2534.1
Last 300-Hour inspection: 2333.4

Engine Records

Component	Serial Number	Part Number	TSO	Total Time
Engine	CAE896108	23062065	2536.4	2536.4
Gearbox	CAG96117	23035178	2536.4	2536.4
Compressor	CAC92356	23051643	2536.4	2536.4
Turbine	CAT98741	23035128	2534.0	52.9
PTG	HR48491	23086751	401.1	2135.3
FCU	HR59441	23070613	2.4	2534.0
Fuel Pump	JG08AKW0366	23074706	2536.4	2536.4
Fuel Nozzle	VN1BAA1644	23077067	401.1	2135.3
Bleed Valve	FF326151	23073353	1075.3	1461.1

Engine/component times are from maintenance records and the operators component time sheet dated 9 July 2013.

Engine Observations at Keystone

On 11 July 2013 the engine was transported to Keystone Engine Services by the operator. It arrived separated into three modules in separate boxes. The examination took place with the oversight of the NTSB IIC. Present were representatives from Rolls-Royce, the FAA, Bell Helicopters, Keystone, and NY Helicopters.

The Compressor was removed from the shipping box for examination. The compressor impeller remained locked. The spur adapter gearshaft was in place with slight damage to the teflon seal. It was covered with a carbon substance, but was otherwise unremarkable **Fig 3.** The No. 2 bearing was dry and damaged with signs of heat distress. The bearing was removed and showed further signs of damage to the bearing and inner race. The forward side of the bearing revealed the most significant damage **Fig 4.** The compressor was further disassembled and the impeller shroud showed signs of significant rub damage from the impeller with corresponding rub indications 360 degrees around the impeller blades **Fig 5.** The No. 1 bearing was oil wetted and did not show any signs of damage.

The gearbox assembly was removed from the shipping box for examination. Visual examination of the gearbox did not reveal any damage. It was noted that the oil pressure regulator adjustment was backed out with the poppet guide observed abnormally close to the outer lip of the housing. After removal of the lock wire, and unscrewing the poppet guide outward approximately one turn, the O-ring was visible. **Fig 6** shows the regulator in the position as found during examination compared to a similar regulator adjusted in a more typical position on an engine coming in for repair.
An initial approximate adjustment is made by bottoming the valve and then backing it out 5 - 1/2 turns. Backing out (counter clockwise turning) of the regulator adjustment would decrease system oil pressure. One turn of the adjustment will change the oil pressure approximately 13 psig. Rolls-Royce maintenance manual states “Except for initial adjustments on newly installed engines, do not adjust the pressure regulating valve to correct for high oil pressure. Do not make a pressure regulating valve adjustment to correct for a sudden increase or rapid change in oil pressure. These conditions are cause to suspect other oil system problems have developed”.
Oil flow through the gearbox was tested by connecting an oil reservoir to the gearbox oil inlet and turning the oil pump by using a pneumatic ratchet and splined adaptor. Oil flowed through all visible oil passages except one oil jet located on the oil delivery tube (piccolo tube) used to lubricate the # 2 bearing. The gearbox was disassembled for further examination. The interior of the gearbox did not show signs of any abnormalities. The oil pump was disassembled and was unremarkable other than slight scaring, indicating that metallic fragments may have passed through the pump. The piccolo tube and pressure screen upstream of the piccolo tube were removed. The screen has heavily coated with an undetermined black substance. The piccolo tube did not show any signs of damage and none of the oil jets were visually blocked **Fig 7**.

The turbine module was removed from the shipping box. However, no further examination of the turbine took place at the time.

The NTSB took possession of the piccolo tube, the pressure screen, the No. 2 bearing, and its associated hardware. The remainder of the engine was repackaged and sent to Rolls-Royce for further examination.

Examination at Rolls-Royce

The engine was shipped to Rolls-Royce in boxes separated into modules. The NTSB IIC hand carried the piccolo tube, No. 2 bearing, and the piccolo tube screen. On 25 & 26 September, 2013 under the supervision of the NTSB IIC representatives from Rolls-Royce, Bell Helicopters, and the FAA convened at Rolls-Royce Indianapolis for examination of the below hardware. Portions of the hardware examination were not able to be completed on this date and were examined/tested at later dates under the supervision of the FAA.

No. 2 Bearing

Visual examination of the bearing revealed signs of thermal distress. The forward side of the bearing was thermally distressed more than the aft side and the separator showed plastic deformation. All ten balls were in place and generally round, however some areas were rough and exhibited loss of material. Material from the balls was transferred onto both the inner and outer races. Metallographic examination revealed thermal distress to the raceway surfaces consistent with the bearing operating with reduced oil flow. Thermal distress extended completely through the ball cross-section and localized spalling damage was evident along the ball surface. The separator showed thermal distress across approximately 75% of the cross-section extending from the forward face aft. A hardness test was not conducted due to the thermal distress of the bearing.
The microstructure and chemistry of the bearing and associated hardware conformed to the engineering drawing requirements **Fig 8**.

Oil Delivery Tube (Piccolo Tube)

Visual examination of the forward opening of the tube (oil inlet) revealed a thick-dark substance adhered to the face and chamfer. Analysis of the substance determined it was consistent with thermally degraded MIL-PRF-23699 type turbine oil. The oil jet that lubricates the No. 2 bearing did not show obvious obstruction in the orifice. The oil delivery tube was x-ray inspected for internal blockage. No restrictions were detected in any of the oil passageways. Two flow tests of the oil delivery tube were conducted. The orifice that lubricates the No. 2 bearing was below the engineering drawing total flow requirement in the as-received condition. The tube was cleaned ultrasonically while being submerged in various cleaning solutions (methanol, acetone, isopropanol, and methanol) a total of four times. The amount of debris collected decreased after subsequent cleanings. After cleaning of the internal passageway the total flow of the # 2 bearing orifice met the engineering drawing requirement during retesting **Fig 9**.

Pressure Oil Screen

Nearly the entire surface of the screen was covered in a thick-dark substance. The area that was not blocked was covered by the O-ring. A sample of the substance from the screen assembly was consistent with thermally degraded MIL-PRF-23699 type turbine oil **Fig 10**.

Pinion Bearing Oil Nozzle

The pinion bearing oil nozzle supplies lubrication to the No. 4 and No. 5 bearings. Binocular examination of the three orifices showed no obvious blockages. The oil nozzle was flow tested two times. Both tests conformed to the engineering drawing requirements **Fig 11**.

No. 2 ½ Bearing and Bearing Support Cage

Hard coked oil deposits were adhered to the surfaces of both components. The bore of the support cage had sheets of a thick-dark substance that were peeled off the surface. A sample of the substance from the bore of the support cage was consistent with thermally degraded MIL-PRF-23699 type turbine oil **Fig 12**.

Spur Adapter Gearshaft
The teflon seal just aft of the forward splines was distorted and appeared partially melted. There were coked oil deposits along the shaft in the area of the No. 2.5 bearing inner ring. The inside surface of the gearshaft (forward end) was covered with coked oil **Fig 13**.

Pinion Gear, No. 3 Bearing, And No. 4 Bearing
The forward and aft sides of the assembly were dark black in color. The deposits could be partially wiped off with a rag indicating the oil had not completed coked. However, the internal splines did show coked oil deposits **Fig 14**.

No. 5 Bearing
The bearing was a brownish color but it appeared free of coked oil deposits. No destructive evaluations of the No. 5 bearing were conducted **Fig 15**.

No. 6 and 7 Bearing Pressure Oil Screen
The pressure oil screen assembly that is located in the tee-fitting provides lubrication to the No. 6 and No. 7 bearings. The screen was clean and unremarkable.

Power Turbine Support Pressure Oil Nozzle
The oil nozzle had a thick-dark substance adhered to the inboard surface similar to the material adhered to the surface of the pressure oil screen **Fig 16**.

External Scavenge Oil Sump Assembly
A thick-dark substance similar to the material adhered to the surface of the pressure oil screen assembly was adhered to the inboard surface of the sump. The substance was determined to be consistent with thermally degraded MIL-PRF-23699 type turbine oil. An oil sample from the sump assembly was also collected. Analysis of the oil sample determined it to be consistent to MIL-PRF-23699 type turbine oil **Fig 17**.

Gas Producer Support Pressure Oil Fitting Assembly
The gas producer support pressure oil fitting assembly displayed thick-dark substance adhered to the inboard surface. Analysis of the substance determined it to be consistent to thermally degraded MIL-PRF-23699 type turbine oil **Fig 18**.

Gas Producer Scavenge Oil Drain Fitting
A thick-dark substance similar was adhered to the inboard surface of oil drain fitting. Analysis of the substance determined it to be consistent to thermally degraded MIL-PRF-23699 type turbine oil **Fig 19**.

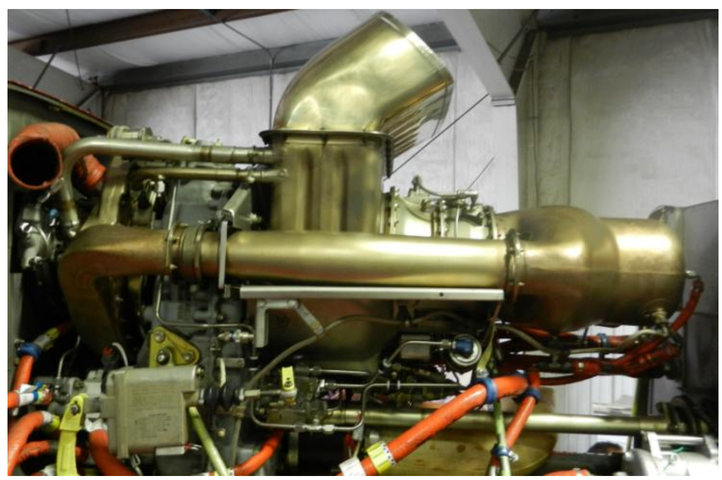
Oil Pressure Regulator Filter Housing
The oil filter was not provided for examination, however the O-ring that seats against the filter remained in the filter bowl. The O-ring showed damage to the outer surface. Visual inspection of the internal cavities of the housing showed no evidence of the thick-dark substance as observed on other engine components described earlier **Fig 20**.

Summary of Findings

The No. 2 bearing failed due to thermal distress. Findings were consistent with reduced oil flow to the bearing. Thermally degraded MIL-PRF-23699 type turbine oil was found throughout the engine oil system. The pressure oil screen located upstream of the No. 2 bearing oil delivery tube was almost completely blocked and total flow from the oil delivery tube No. 2 bearing orifice was below engineering requirements. After cleaning and retesting, the total flow of the orifice met engineering drawing requirements. The cause of the degraded oil within the system could not be determined during this investigation. The damage associated to the compressor was consistent with damage that would occur after the No. 2 bearing failure.

Fig: 1

Aircraft at Recovery



Engine Installed at Recovery

Fig 2:

Compressor As Installed

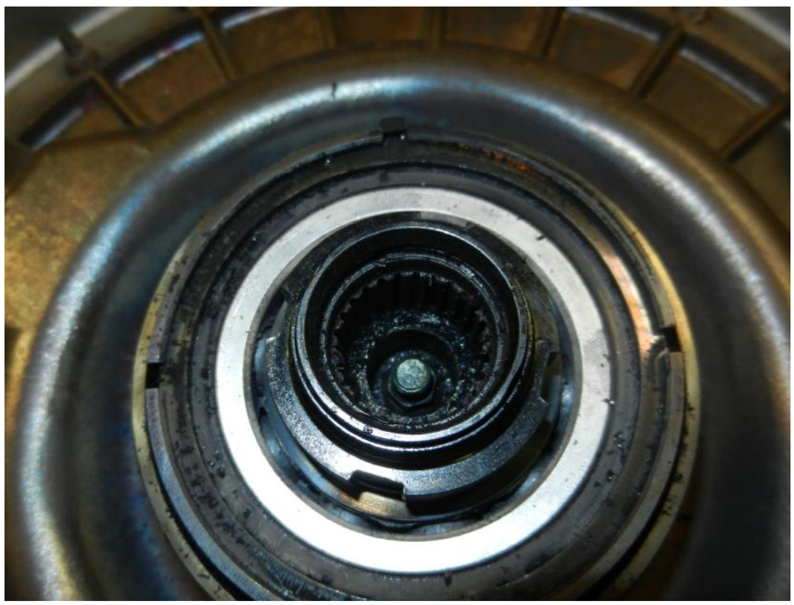
Stage Turbine After Removal

Power Turbine To Pinion Gear Coupling And Turbine To Compressor Coupling

Fig 3:

Spur Adaptor Gearshaft

Fig 4:



No. 2 Bearing While Installed In Support

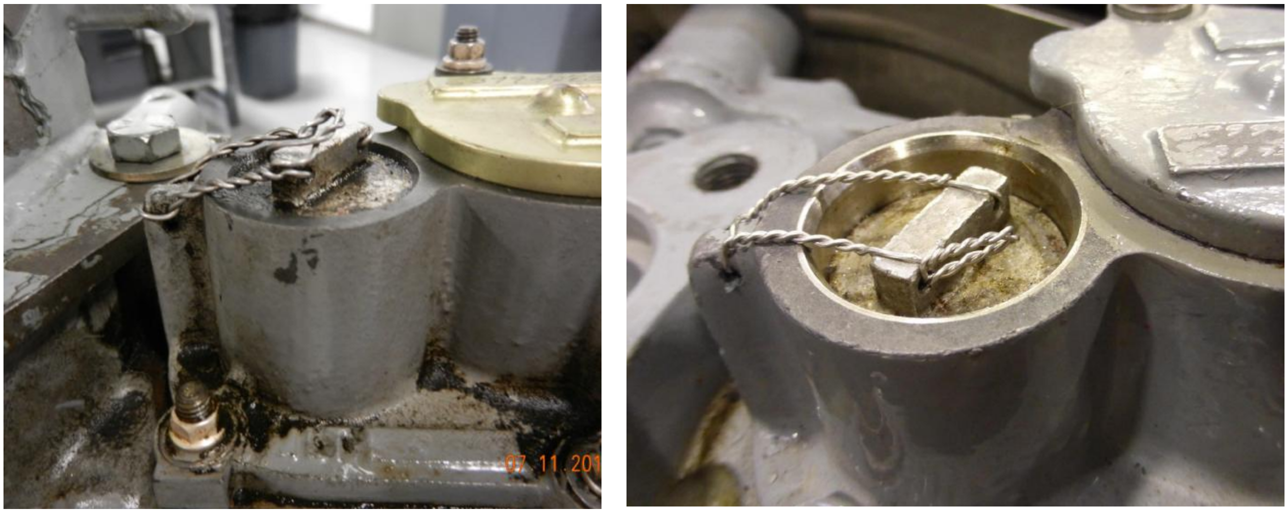
No. 2 Bearing Removed at Keystone

Fig 5:

Impeller

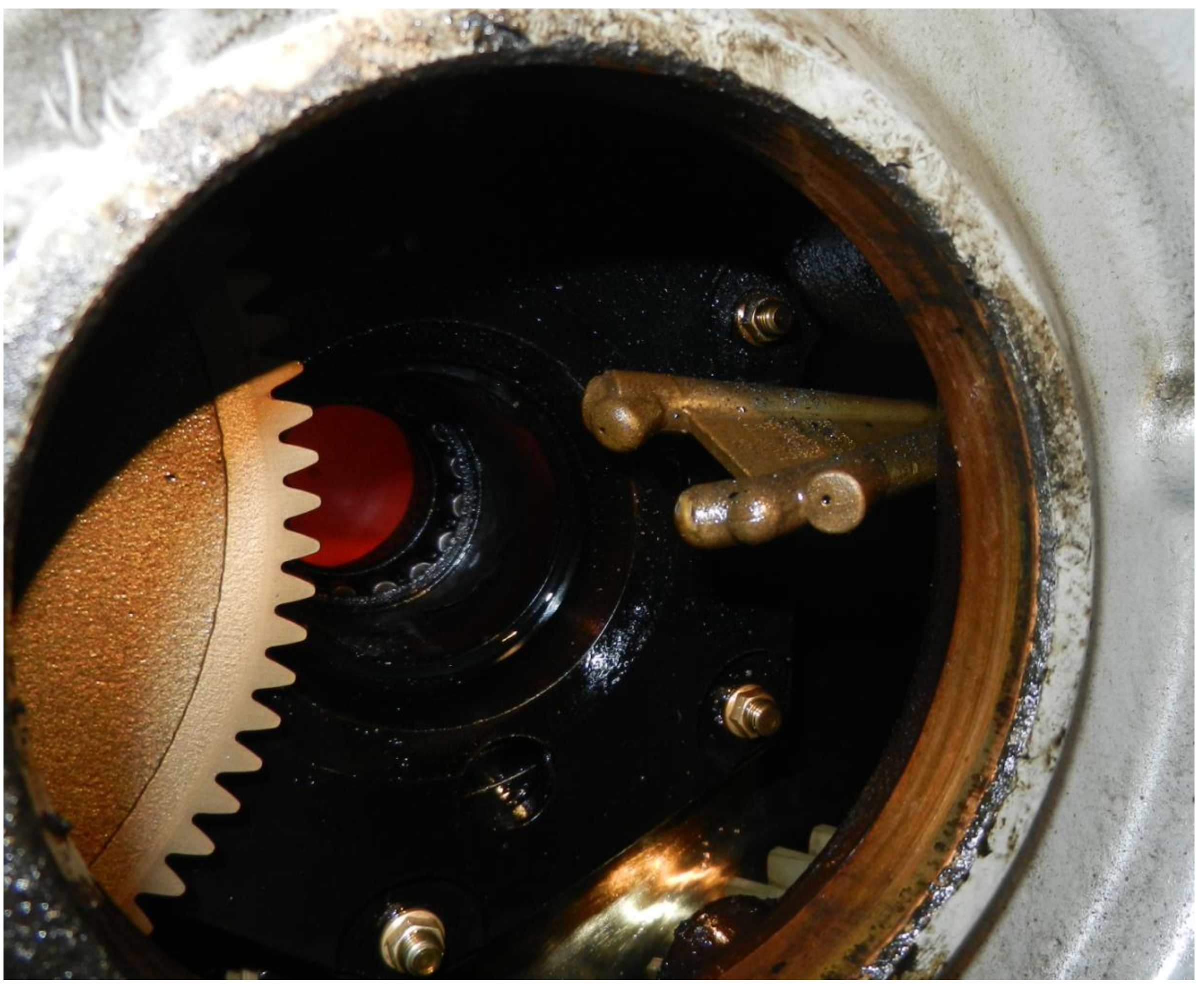
Impeller Shroud

Fig 6:



Oil Pressure Regulator As Found At Keystone (Left) Compared To An Oil Pressure Regulator Adjustment On A Similar Engine At A Repair Facility(Right)

Fig 7:



Piccolo Tube As Installed

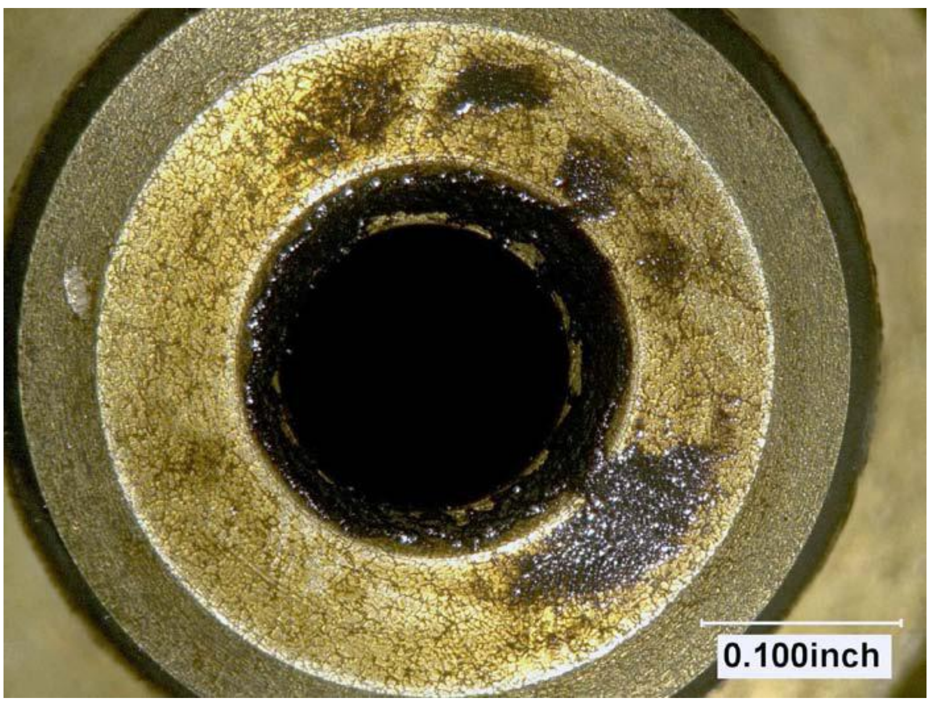
Fig 8:

Aft Side Of No. 2 Bearing At Rolls Royce

Forward Side Of No. 2 Bearing At Rolls Royce

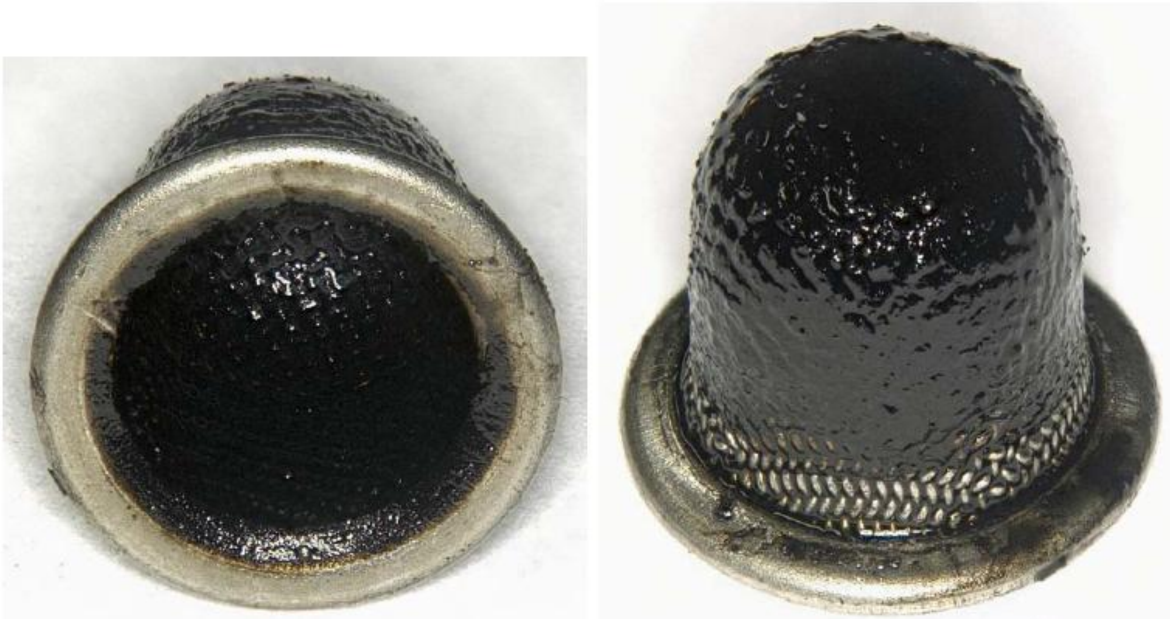
Fig 9:

Piccolo Tube At Rolls-Royce



Face And Chamfer Of The Piccolo Tube Inlet.

Fig 10:



Pressure Oil Screen Located Upstream of Piccolo Tube

Fig 11:

Pinion Bearing Oil Nozzle

Fig 12:

No. 2 ½ Bearing And Support Cage

Fig 13:

Spur Adaptor Gearshaft

Forward End Of Spur Adapter Gearshaft

Fig 14:

Bearing, Pinion Gear, And No. 4 Bearing

Forward Side Of No. 3 Bearing

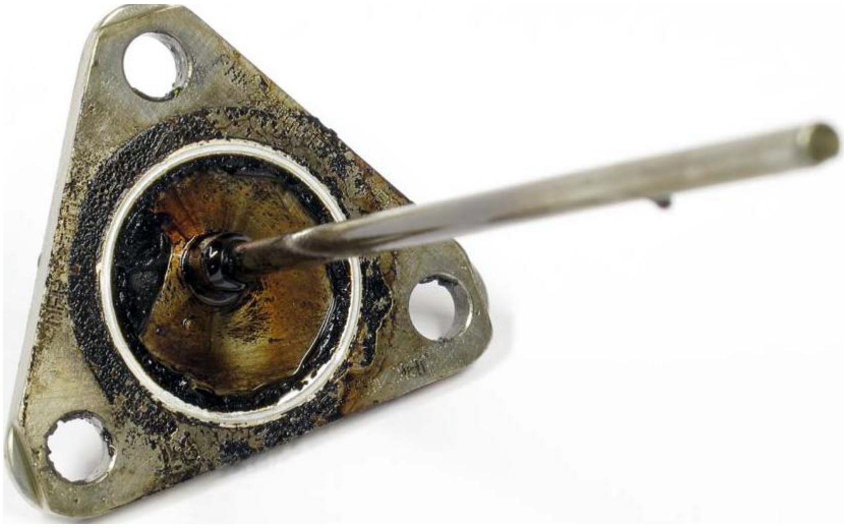
Aft Side Of No. 4 Bearing

Pinion Gear Aft Spline Surfaces

Fig 15:

No. 5 Bearing

Fig 16:



Power Turbine Support Pressure Oil Nozzle

Fig 17:

External Scavenge Oil Sump

Fig 18:

No. 8 Bearing Pressure Oil Nozzle

Fig 19:

Gas Producer Scavenge Oil Drain Fitting

Fig 20:

Oil Pressure Regulator Filter O-Ring