Rolls Wood Group (Repair & Overhauls) Ltd

TECHNICAL REPORT

OPERATOR bp			LOCATION MILLER PLATFORM	
ENGINE TYPE RB211	MK -24C		SERIAL NO 1750 - 205	
TSN 41,623	TSO N/A	TSR 34,134	DATE REMOVED 06/03/01	DATE EXAMINED 29/05/01

Report Number	Issue	Date	Prepared By	Approved By	Agreed Commercial
TR8867	1	30/01/02	G Cowperthwaite		

RB211 Engine S/No 1750 - 205

1.0 Reason for Removal

The engine was removed from service and consigned to Rolls Wood Group for a mid-life overhaul after completing 34,134 running hours since repair.

2.0 Summary of Work Carried Out

2.1 01 Module S/No: 1701 - 129

The 01 module was stripped to detail, cleaned and inspected.

The 34 off variable inlet guide vanes (VIGV's) and thrust washers were subjected to an NDT Crack Test and dimensional inspection. This operation revealed that 2 off VIGV's exhibited wear to their inner and outer journal diameters. This defect was repaired by reclaiming the journals in accordance with RWG TI30,052. Additionally, 2 off VIGV's exhibited cracks to their aerofoil surfaces. These were repaired by welding the affected areas in accordance with RWG TI30,006.

The IP compressor roller bearing was removed, cleaned and inspected in accordance with Rolls-Royce Repair Note 5019. This process revealed the rollers exhibited scoring to their load bearing surfaces that was considered outwith acceptable limits. The bearing was consequently overhauled by replacing the bearing rollers in accordance with FRS3454 and then refitted to the module.

Visual/dimensional inspection revealed that 28 off VIGV actuating ring trunnions exhibited frettage that was outwith acceptable limits. New items were fitted to the module.

Due to deterioration of the protective coating and to prevent the onset of corrosion, the 01 module air intake casing was reprotected.

TI 30,049 was introduced to prevent corrosion occurring at the journal locations, which could compress the VIGV bushes onto the VIGVs, thus causing stiction.

All 37 off VIGV/Ram actuating arms exhibited surface corrosion. They were consequently cleaned and reprotected in accordance with reprocess RP138.

The 1 off master and 2 off slave VIGV hydraulic operating rams were overhauled and tested in accordance with FSTS114 and FSTS115 respectively.

Due to exhibiting deterioration/break-up of the IP compressor rear seal Metco abradable lining, the lining was replaced in accordance with S405001.

During the module rebuild process, it became apparent that a single VIGV top location bush exhibited wear that was outwith acceptable limits. A new bush was fitted to the module.

No further defects to the module were apparent.

2.2 02 Module S/No: 1702 - 130

2.2.1 IP Compressor Stator Vanes and Casings

The casing assemblies were dismantled to detail, cleaned and inspected.

The Stages 1 to 4 stator vanes had their protective coatings removed and were then subjected to an NDT Crack Test that revealed all components to be crack free. The vanes were reprotected with a dense pack coating in accordance with TI 30,023.

The Stage 5 & 6 stator vanes were reworked and modified to Mod 1205 and Mod 1159 respectively. These modifications introduce a wear resistant coating to the vane inner platform edges and inner shrouds in order to reduce the amount of wear if degradation of the damping medium occurs. Following modification, the vanes were reprotected in accordance with RWG TI 30,023.

The IP Casings were stripped of their protective coating and NDT Crack Tested. No cracks were apparent, however Stages 1 & 5 rotor path abradable linings exhibited break-up to the Metco material. These linings were replaced in accordance with RWG TI30063 and the external casing surfaces were reprotected in accordance with RWG TI30,071.

During rebuild and to achieve the required casing split line clearance, 5 off Stage 1, 5 off Stage 2, 2 off Stage 3 and 2 off Stage 4 stator vanes were reworked in accordance with RWG TI30, 060.

Finally, following rebuild the Stage 1 - 6 inner shroud cavities were injected with a damping medium material (MSRR 9403) to the principles of Mod 1036 standard.

2.2.2 IP Compressor Rotor Assembly

The compressor was dismantled sufficient to NDT Crack Test the Stage 1 and Stage 6/7 disc to the relevant Rolls-Royce Repair Notes. This was completed satisfactorily and the discs reprotected.

The IP compressor front stubshaft was cleaned and inspected in accordance with RN5019. No defects were apparent therefore the stubshaft was accepted for further service following being reprotected.

The remainder of the assembly was cleaned and inspected. All relaxed Stage 2-5 blade lockplates were replaced where necessary.

When refitting the Stage 1 disc, the retaining bolts were replaced with bolts to Mod 976 standard.

The IP Curvic Coupling Bolts were replaced in accordance with Mod 1315. The original bolts (BLT 3662 – Jethete material) were prone to stress corrosion and therefore are replaced with (BLT 5605 – INCO 718) a material which is more resistant to stress corrosion.

On completion of rebuild the complete assembly was dynamically balanced in accordance with the manufacturers procedures.

2.3 03 Module S/No: 1753 - 204

This module was dismantled to detail, cleaned and inspected. The following components were successfully subjected to an NDT crack test: -

starter drive ratchet
bevel gear (driver)

bevel gear (driven)
IP inner sleeve
IP coupling
HP coupling sleeve
pawl carrier
pawls
pawl stops
pawl pins
bearing carrier

This process highlighted that the Starter Pawl Carrier and Pawls exhibited wear to their pin location bores. Following consultation with the Customer and Rolls-Royce, the pawl carrier was accepted for further service. The wear to the pawls however was considered outwith acceptable limits and therefore all 10 off pawls were replaced with new components.

All single life 10 off springs were replaced on rebuild of the starter pawl assembly. On completion the unit was calibrated to ensure the pawls functioned in accordance with the OEM's specifications.

Due to the possibility of damage in the dismantling process, the HP and IP thrust bearings were replaced with new components (HP–Mod 1183 and IP–Mod 899).

Due to deterioration of the protective coating and to prevent any onset of corrosion, the 03 module casing was reprotected.

The Mod 1117 7th Stage OGV ring was stripped of its protective coating, cleaned, visually/dimensionally inspected and NDT Crack Tested. These operations revealed that severe frettage was evident to the vane inner feet and upper/lower shroud rings. A new replacement Customer ‘Free Issue’ Mod 1249 OGV Assembly was fitted to the module.

The module was rebuilt using replacement 'O' ring seals in Kalrez material as specified in Mods 1017 and 1161.

No further defects to the module were apparent.

2.4 04 Module S/No: 1754 - 205

The 04 Module was dismantled to mini-modules to enable an accurate condition assessment to be carried out.

2.4.1 HP Compressor Rotor Assembly

The Compressor Rotor was dismantled to detail.

The Stage 1/2 disc was subjected to an NDT Crack Test. No cracks were apparent therefore it was accepted for further service.

The Stage 3 disc was subjected to an NDT crack test. No cracks were apparent therefore it was accepted for further service following reprotection with a Sermetel 'W' coating in accordance with S405129.

All Stage 1 - 6 blades were visually inspected and subjected to an NDT crack test. This process revealed that 2 off Stage 6 blade exhibited cracked aerofoils. These were submitted for a Laboratory Investigation to determine the mode of failure (See RWG Laboratory Report L1538). The conclusion of this was that the blades had failed due to High Cycle Fatigue and therefore in accordance with Rolls-Royce Repair Note RN5033 they were replaced as a complete stage. Additionally, a single Stage 1 blade was replaced due to impact damage outwith acceptable limits. No further defects were apparent to the remaining stages of blades which were accepted for further service following the Stage 4 blades being reprotected with a Sermetel 'W' type 'B' coating to prevent corrosion.

Following these operations, the HP compressor rotor was rebuilt and subjected to a dynamic balance in accordance with the procedures stated in the manufacturers overhaul manual.

2.4.2 HP Stator Vanes/Casings

Initial inspection had revealed that stages 2, 3 & 4 HP compressor adradable rotor path linings exhibited severe break-up of the lining material. The Stages 1 through 6 HP casing rotor path linings were replaced in accordance with RWG TI 30,005 which included the Modifications 1115, 1189 and 1304 (lining in Metco 601 material Stage 1/2, Metco 307 Stage 3 and Metco 314 Stage 5/6). These new material linings are more durable and should increase service life.

All the casings exhibited deterioration of their protective coating and were therefore reprotected with a Sermetel 'W' type 'B' coating in accordance with RWG TI 30,029.

The Stages 1 - 5 HP stator vanes were stripped of their protective coating then NDT Crack Tested. A single Stage 1 vane was replaced due to impact damage outwith acceptable limits and 2 off Stage 5 vanes were replaced due to missing anti-rotation stops.

During rebuild and to achieve the required casing split line clearance, 3 off Stage 1, 1 off Stage 2, 2 off Stage 4 and 4 off Stage 5 stator vanes were replaced.

No further defects were apparent therefore the HP compressor rotor assembly was rebuilt with bolts in Jethete material in accordance with Repair Note 5009.

2.4.3 Front Combustion Liner (FCL)

The FCL was overhauled to its original Mod 1128/1168 standard (improved heatshields and introduction of RODN slots).

2.4.4 HP Nozzle Box Assembly

The 18 off HP nozzle guide vanes (NGVs) were stripped of their protective coating and NDT Crack Tested.

These operations revealed that 7 off NGVs exhibited corrosion/erosion to their aerofoil surfaces. This defect was repaired by welding erosion/cracks on their gas washed surfaces in accordance with FRS4470 then the full set was reprotected with a SermaLoy 1515 coating.

The 18 off HP turbine rotor path seal segments exhibited wear to their honeycomb rotor path linings and erosion to the gas washed surfaces. Further investigation revealed that 17 off segments exhibited erosion/cracks to their IP NGV location slot that was considered outwith acceptable/repairable limits. These 17 off segments were replaced with new components. The remaining 1 off segment was repaired and relined in accordance with S405093 and RWG TI30, 061.

Visual inspection had revealed that the HP turbine seal segment locating ring exhibited frettage. This damage was repaired by welding the ring then machining it to its original profile in accordance with RWG TI30,111.

The rear combustion liner exhibited deterioration to its external thermal barrier coating. It was consequently reprotected in accordance with FRS4368.

The bolts holding the HP OGV to the Combustor Rear Inner Case (CRIC) were replaced in accordance with Mod 1315. The original bolts (AS22125 – Nimonic 80A material) were prone to stress corrosion and therefore are replaced with (AS48625 – INCO 718) a material which is more resistant to stress corrosion.

2.4.5 HP Turbine Rotor Assembly

The HP turbine assembly was dismantled to detail.

The HP turbine blades were stripped of their protective coating and subjected to a visual/NDT Crack Test.
This process revealed that the blades exhibited erosion to the outer shroud abutment/non-abutment faces.

This damage was successfully repaired by welding/machining to original profile the faces in accordance with RWG TI30,070 that included reprotection with a SermaLoy 1515 coating.

The HP turbine disc, conical shaft and panel support were successfully subjected to an NDT Crack Test.

The HP turbine bearing stubshaft was cleaned and inspected in accordance with RN5019. No defects were apparent therefore it was accepted for further service following being reprotected.

Finally the assembly was rebuilt and subjected to a dynamic balance in accordance with the procedures stated in the manufacturers overhaul manual.

2.4.6 Outer Casing

Due to deterioration of the protective coating and to prevent corrosion, the outer casing was reprotected with a Sermetel 'W' type 'B' coating in accordance with RWG TI 30,029.

On full module rebuild, the FCL securing bolts were replaced with bolts manufactured in INCO 718 material in accordance with Mod 1167.

2.5 05 Module S/No: 1755 - 205

2.5.1 Turbine Rotor Assembly

Repair Note 5021 was carried out on the Turbine assembly to assess the wear / untwist to the blades. This operation revealed that the turbine blades had consumed 80 % of their untwist life.

The IP rotor was dismantled to detail, cleaned and inspected.

The INCO 792 IP turbine blades were NDT crack tested, inspected in accordance with Rolls-Royce Repair Note RN5037 and the following defects observed (Total 10 off blades): -

1 off exhibited cracks to the Outer Shroud non-abutment faces
1 off exhibited cracks to the trailing edge aerofoil at the outer shroud radii
2 off exhibited pitting to the concave aerofoil
4 off exhibited cracks to the concave aerofoil root fillet radius
2 off exhibited cracks to the concave aerofoil root pocket

These defects were considered outwith acceptable/repairable limits and therefore the blades were replaced with overhauled items to Mod 1222 standard.

The remaining 138 off blades were successfully repaired by reclaiming their outer shroud inter interlocks and seal fins followed by reprotection with a SermaLoy Mod 1515 coating in accordance with S405247.

The IP turbine shaft, inner race and sleeve were subjected to a crack test in accordance with Rolls-Royce Repair Notes 5025 and 5030. No defects were noted and prior to being reprotected with a Sermetel 'W' type 'B' coating to Mod 937 standard they were accepted for further service.

The IP turbine disc was successfully subjected to an NDT Crack Test with no defects apparent.

Following these operations, the turbine assembly was rebuilt then subjected to a dynamic balance in accordance with the procedures stated in the overhaul manual.

2.5.2 IP Casing Assembly

The casing was dismantled to detail, cleaned and inspected.

An internal borescope inspection of the HP/IP bearing housing support (spider assembly) was carried out to ensure the integrity of the internal components. This operation revealed a single fractured pipe securing bracket, which was repaired in accordance with S405158. To commonise with aero standard assemblies and to prevent premature failure, Mod 1125 was embodied which deletes the secondary vent/drain pipe. Following this repair the assembly was reprotected with a Sermetel 'W' coating in accordance with RWG TI 30,029.
All 34 off IP turbine rotor path seal segments exhibited break-up/wear to their honeycomb rotor path linings. 17 off segments were replaced with new/overhauled components (Mod 1141) due to exhibiting severe erosion to the gas washed surface/seal location groove that was outwith acceptable/repairable limits. The remaining 17 segments were relined to Mod 1141 standard.

Mod 1141 introduces a seal segment with a change of honeycomb abradable material (Haynes 214) to help reduce erosion. It also amends the depth of material, which will reduce the wear to the seal fins of the IP turbine blades. Additionally, to extend their life, all 34 off IP turbine rotor

path seal segment gas washed surfaces were protected with a SermaLoy ‘J’ coating.

Finally, to extend their service life, all 34 off IP turbine rotor path seal segment gas washed surfaces were protected with a SermaLoy ‘J’ coating.

The 26 off IP nozzle guide vanes (NGVs) were stripped of their protective coating, cleaned and NDT Crack Tested. 2 off NGV’s that exhibited erosion to the aerofoil surfaces outwith repairable limits were replaced with new components. The remaining 24 off NGVs exhibited cracks to the internal cooling channel and 11 off exhibited corrosion on the aerofoil gas washed surfaces. This defect was repaired by welding the affected areas and replacing the cooling tubes in accordance with RWG TI 30,038 and S405087. Finally, the NGVs were protected with a SermaLoy coating.

The HP/IP roller bearings were cleaned and inspected in accordance with Rolls-Royce Repair Note 5019. This process revealed both bearing rollers exhibited scoring to their load bearing surfaces that was considered outwith acceptable limits. The bearings were consequently overhauled by replacing the bearing rollers in accordance with FRS3454 and then refitted to the module casing.

The IP and HP bearing retainers exhibited deterioration to their abradable seal linings. The IP was relined to Mod 1214 standard and the HP to it’s original standard. (Mod 1214 introduces an improved abradable material with revised clearance to reduce galling on initial start-up).

Before refitting the bearing assemblies, the HP/IP bearing support thread inserts were replaced in accordance with Rolls-Royce Repair Note 5029.

During rebuild, Mod 1129 was embodied in the bearing housing assembly. This modification introduces longer HP turbine bearing retainer bolts.

Additionally, Mod 1236 was embodied which introduces a longer securing bolt for the elbow outlet vent assembly.

6 off casing liner segments were replaced with new components due to exhibited distortion that was considered outwith acceptable limits. 11 off segments that exhibited distortion were successfully repaired in accordance with RWG TI30,018.

New insulation blankets were fitted when rebuilding the module.

No further defects to the casing were apparent.

2.6 06 Module S/No: 1756 - 205

The 06 module consists of all external engine accessories e.g. pipework, electrical harness, T6 thermocouples, bleed valves and burners as fitted to the engine.

The gas manifold and pigtail pipes were subjected to a pressure test as detailed in TI 30,035, which proved the integrity of the components. 2 off gas pipes failed this test and were therefore replaced with new components.

The liquid fuel manifold (Pre-Mod 1151 standard) was cleaned and inspected. This operation revealed that valve seats exhibited wear. Both halves were overhauled and calibrated in accordance with CTS1169 to Mod 1151 standard.

Mod 1151 introduced an aero standard of weight type fuel distributor (WTD) and a new blanking ferrule that will allow external adjustment of the WTD thus saving time during calibration of the industrial liquid fuel manifold. Additional

advantages also include commonised aero parts and calibration procedures for both aero and industrial liquid manifolds.

The 18 off dual fuel burners were overhauled to their original Mod 1114 standard.

Note: Mod 1114 introduces a dual fuel burner incorporating a swirler and restrictor in place of a pintle. This configuration should increase the service life of the burner.

All 3 off 01 Module IP speed probes exhibited break-up to the cable housing sty-cast potting compound. The probes were successfully repaired by re-potting the cable housings in accordance with RWG TI30,073.

The 2 off IP handling and 1 off HP handling BOV's were overhauled in accordance with CTS 1159 & 1160 respectively.

The 3 off HP starting bleed valves were overhauled to Mod 1203 standard.

This modification deletes the BOV Controller such that HP3 air directly operates the HP starting bleed valves. In addition the valves are modified by introducing a double spring and stronger piston to delay the BOV operating point.

All 3 off IP compressor thrust piston components (cover, diaphragm and cylinder) exhibited corrosion/break-up to their abradable seal linings. The linings were replaced in accordance with RWG TI 30,011, 013 & 014 respectively.

Initial visual inspection revealed that the Front Nose Bullet exhibited frettage/elongation to the bolt hole locations. This defect was repaired by reclaiming the holes in accordance with RWG TI30,020.

As a precautionary measure to prevent frettage, the nose bullet retaining nut was replaced.

The HP3 Transducer and Vent Valve were successfully function tested in accordance with CTS 1158 and TL 1108 respectively.

To comply with current safety requirements regarding electrical equipment operating in a hazardous area, a new starter speed probe harness to Mod 1108 standard was fitted.

6 off external oil/air pipe that exhibited frettage damage were successfully repaired in accordance with RWG TI30,076. A single pipe unit was replaced due to a stripped end fitting thread.

The Hydraulic Starter Gearbox was dismantled sufficient to remove the internal major assemblies. No defects were apparent to the internal components therefore the gearbox was rebuilt and accepted for further service following a replacement MPCD being fitted.

The Hydraulic Starter Motor was overhauled and refitted to the gearbox assembly.

The anti-icing system was deleted in accordance with RWG TI 30,083.

During rebuild, the following modifications were embodied: -

1149 deletion of P2 momentum separator

1257 increased bolt length to secureT6 thermocouples

1277 introduction of 03 module centre bearing oil feed gasket

1278 starter-engine interface‘O’ seal upgraded to Kalrez material

Prior to despatch, all relevant blanks and clamping devices were fitted to ensure the continued integrity of the engine.

No further defects were apparent.

2.7 Engine Test

Following full rebuild the engine was subjected to 'seal break' and 'full performance runs' at Rolls-Royce Ansty in accordance with Rolls-Royce CTS 5017 in the presence of Mr Geoff Brassington and Mr George Rae. These runs proved the integrity of the engine and that the performance was within the manufacturers pass-off limits.