



Rolls-Royce

Engine Investigation

Allison
M250-C20B
Engine CAE 835942

MD 369D
Registration : N103SU



Model 250-C20B/J

**Signature Utilities
Tuckers Crossing, MS.**

David Riser

**David Riser
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**Accident date: December 29, 2020
Investigation date Arkansas: February 10, 2021
Disassembly Arrow Aviation: July 21, 2021
Report date: May 5, 2022**

Report Enclosures:

Report Narrative

Appendix A, Photographs at Recovery Location Clinton, Arkansas

Appendix B, Disassembly Photographs Arrow Aviation

Background Information:

On December 29, 2020, an MD 369D helicopter, operated by Signature Utilities and powered by an Allison M250-C20B gas turbine engine was involved in an accident near Tuckers Crossing, MS.

The MD 369 helicopter was conducting aerial tree trimming operations when it impacted wooded terrain under unknown circumstances and caught fire. Prior to the accident the pilot reported to a ground crewmember that he was making an emergency landing. The helicopter was heavily consumed in the post-crash fire and the pilot was fatally injured. The wreckage was recovered to a facility located in Clinton, Arkansas.

The NTSB requested technical assistance from the engine manufacturer for the investigation. Rolls-Royce provided a representative Air Safety Investigator for an examination of the wreckage which occurred at the recovery location in Clinton, Arkansas on February 10, 2021.

Engine Observations at Recovery:

The engine was removed from the recovered wreckage where it exhibited overall thermal damage resultant from the post-crash fire. The accessory gear box had been completely consumed by post-crash fire leaving the compressor attached to the engine by the left and right compressor air discharge tubes and the spur adapter gear shaft. Several drive gears including the power take off gear and torque meter gear normally resident within the accessory gear box were located. Other than thermal damage no other anomalies were noted.

The compressor displayed overall thermal damage with the bleed valve having been consumed by the fire. The scroll displayed heavy burn damage with an approximate 6-inch section burned through on the top of the scroll. Visual examination of the compressor inlet and visible blades and vanes revealed no evidence of FOD type damage. Both compressor air discharge tubes remained in position. The right tube displayed areas of burn through on the forward end. The left side air tube remained intact however the snap ring on the aft end at the outer combustion case was dislodged. The spur adapter gear shaft remained in position and other than thermal damage was visually normal.

The turbine module and exhaust collector support remained in position. The turbine displayed overall thermal damage but was otherwise normal in appearance. Both left and right-side exhaust stacks displayed impact damage and minor tearing but were otherwise normal. The stage four turbine wheel as viewed through the exhaust collector revealed it to be in position with no evidence of damage.

The outer combustion case remained in position and other than thermal damage and minor scraping was otherwise normal. The fuel nozzle and igniter were both in position. Four gears from

the oil pump and the oil pump main drive shaft were recovered and other than thermal damage revealed no anomalies.

The main drive shafts of both the fuel control unit and power turbine governor were located however the cases of both units as well as internal components were consumed by fire. Neither the upper nor lower engine chip detectors were located. (Fig 1)

At the conclusion of the recovery site engine examination and with IIC concurrence the decision was made to ship balance of the engine to a Rolls-Royce authorized facility for disassembly and further investigation.

Engine Information:

An Allison M250-C20B gas turbine engine, S/N CAE 835942, powered the helicopter.

Manufacturer	Allison
Engine Model	250-C20B
Rating:	420 Shaft Horsepower
Serial Number	CAE 835942
Engine Total Hours	3368.9
Last 150-Hour Inspection	3332.3
Last 300-Hour inspection	3332.3

Component	Serial Number	Part Number	TSO	Total Time
Engine	CAE 835942	6887190	New	3368.9
Gearbox	CAG 22613	6894171	403.4	3368.9
Compressor	CAC 41102	6890550	528.9	3368.9
Turbine	CAT 24587	23069745	403.4	3368.9
Fuel Control	318089	23070606	78.2	Unknown
Governor	26138	M250-10847	403.9	Unknown
Fuel Pump	T1399	6899253	2969.6	Unknown
Fuel Nozzle	2839	23077068	503.6	Unknown
Bleed Valve	FF44694	23053176	403.4	Unknown

❖ All component times and serial numbers taken from logbook entries and believed accurate.

Engine Investigation:

On July 21, 2021 an engine disassembly was conducted under the auspices of the NTSB IIC with the following facts and findings being noted.

Compressor Section:

The compressor front support and inlet guide vanes exhibited no visible damage other than post-crash fire signatures. Separation of the compressor case halves revealed the stage 1-6 compressor blades and stage 1-6 stator vanes to exhibit no damage and other than thermal damage and rust coating from post-crash fire exposure. Areas of burn through from post-crash fire were noted in several blade tracks of the compressor case halves. The compressor scroll exhibited areas of burn through from post-crash fire but were otherwise undamaged. (Fig 2)

The compressor impeller, diffuser and aft support were all in position and other than light surface rust, were all visually normal and exhibited no damage.

Accessory Gearbox Section:

The accessory gear box was consumed in the post-crash fire and not recovered.

Combustion Section:

The outer combustion case exhibited discoloring and heavy thermal damage from post-crash fire exposure but was otherwise normal. Removal of the outer combustion case and examination of the combustor liner revealed an ash coating on the interior of the liner but was otherwise visually normal in appearance with no evidence of unusual streaking or burn patterns. The right side air tube displayed areas of burn through on the forward end. The left side air tube remained intact however the snap ring on the aft end at the outer combustion case was dislodged. (Fig 3)

Turbine Section:

The gas producer support remained in position and other than post-crash fire exposure exhibited no visible damage. The power turbine support remained in position and displayed thermal damage from post-crash fire exposure. The forward power turbine support bearing bore had fractured approximately ¼ inch from the forward end and retained the #6 bearing retaining ring. Both the # 6 and 7 bearings remained in position. (Fig 4)

The stage one nozzle and stage one nozzle shield both exhibited light spatter and ash coating over the shield and across vane surfaces with areas of oil staining and coking on the nozzle diaphragm area and several vane surfaces. The stage one turbine wheel exhibited no visible damage however light spatter and light tip rub was noted.

The stage two nozzle, other than light spatter and white ashen coating across vane surfaces was visually normal in appearance and exhibited no damage. The stage two wheel was visually normal and other than very light spatter and light tip rub, exhibited no damage. (Fig 5)

The stage three nozzle exhibited thermal discoloring from fire exposure. Two inner ring alignment tangs had fractured 180 degrees apart. Impact damage was noted to a single trailing edge vane.

The stage three wheel exhibited seven blades having fractured at or about mid span with the outer shroud above the blades absent. The stage four wheel exhibited a fracture in the outer rim with all blades present. Due to damage the power turbine rotor could not be separated at disassembly for a detailed examination of the stage three wheel and the stage four nozzle and wheel. (Fig 6)

Engine Shafting:

N1 shafting consisting of the spur adapter gear shaft, and turbine to compressor coupling were both found in proper position. The spur adapter gear shaft could not be removed from the #3/4 bearing housing due to molten gear box material however the forward end of the shaft displayed no visible damage. The spur adapter gear shaft was mechanically cut to allow of compressor for removal. The turbine to compressor coupling and was discolored with surface flaking due to post crash fire exposure but was otherwise undamaged. (Fig 7)

N2 shafting consisting of the power turbine outer shaft and the power turbine to pinion gear coupling were generally dry in appearance and thermally blackened. The power turbine to pinion gear coupling remained in position and was visually undamaged however the Teflon rings had melted away. Rotational scoring was observed on the power turbine out shaft however a detailed examination of the power turbine inner and outer shafts could not be conducted as the power turbine rotor could not be separated at disassembly. (Fig 8)

Oil System and Engine Bearings:

All remaining engine oil lines were visually and tactilely examined. During removal of the remaining engine oil lines, all "B" nuts were found to be at least hand tight with no evidence of leakage. The engine oil pump was consumed by the post-crash fire.

Removal and visual examination of the #6/7 bearing oil delivery tube, revealed the tube to be visually open; and other than minor coking was normal in appearance. The inline oil screen at the #6/7 bearing pressure line "T" fitting was open and void of material. The #8 bearing oil delivery tube was normal in appearance and open to air flow. The #8 bearing oil nozzle was in position and visually open. The #8 bearing sump area was visually dry and exhibited oil coking. (Fig 9)

Engine bearings consisting of # 2, 3, 4, 5, 6, 7 and 8 were all visually examined. The #1 bearing residing in the compressor front support could not be removed due to fire exposure. The front support could however be rotated allowing for rotation of the bearing resulting relatively smooth bearing rotation. The #2 bearing exhibited heavy external fire damage however both the inner and outer races were in position and the balls exhibited no sign of spalling or wear. The # 3 and 4 bearings normally resident within the bearing housing and inside accessory gear box cover could not be removed from the bearing housing due to post crash fire exposure and molten gear box material, however visual examination of the bearings revealed all rollers to be in position and no visible evidence of failure. The #5 bearing was blacked due to fire exposure however all balls were in position and displayed no evidence of damage or failure. Both the #6 and #7 bearings were dry but visually normal with all rollers displaying no evidence of damage. The #8 bearing was slightly discolored but was rotationally free with no evidence of damage. (Fig 10)

Fuel System:

The fuel pump was consumed in the post-crash fire and could not be examined.

The fuel nozzle remained in position. Upon removal and disassembly, other than rust and discoloration from fire exposure the nozzle was visually normal and the fuel screen clear. (Fig 11)

Engine Accessories:

The fuel control unit and power turbine governor were both consumed by post-crash fire.

Additional Testing:

The following components were submitted to the Rolls-Royce material for further examination with the following results.

Part Name	Part Number	Serial Number
Third Stage Turbine Wheel	23065818	X637652
Fourth Stage Turbine Wheel	M250-10445	X651648
Third Stage Turbine Nozzle	23069744	X584067
Fourth Stage Turbine Nozzle	23055939	X591526
Power Turbine Labyrinth Seal	PMA	
Power Turbine Inner Shaft	23071309	GK535997
Power Turbine Outer Shaft	Illegible	
First Stage Turbine Wheel	M250-10223	X653697
Second Stage Turbine Wheel	23073854	X670623
No. 6 Bearing	PMA	
Power Turbine Support	Illegible	
No. 7 Bearing	PMA	
No. 8 Bearing	M250-10107	NWL150903
Second Stage Turbine Nozzle	PMA	

Seven airfoils comprising a single packet of third stage turbine wheel airfoils between shroud slots were fractured in overload near the shroud. The outboard portions of the airfoils and the shroud segment were not recovered. All the airfoil fractures were consistent with overload. There was no evidence of progressive fracture on any of the third stage turbine blades.

The intact portion of the shroud on the third stage turbine wheel exhibited asymmetric rub damage, with the most severe rub damage located approximately 90° in the direction of engine rotation from the center of the packet of missing airfoils.

The third stage turbine blades exhibited re-solutioned gamma prime near midspan consistent with thermal distress. The thermally distressed area spanned approximately 60% of the airfoil span, centered around midspan on a longitudinal cross-section through an unfractured blade.

The third stage turbine blades exhibited a re-crystallization layer on the airfoil surfaces in the thermally distressed area.

There was no evidence of any impact damage on the third stage turbine nozzle or the other turbine components in the gas path upstream of the third stage turbine wheel.

No evidence of stress rupture void formation was found on cross-sections through any of the turbine components.

The fourth stage turbine blades did not exhibit any impact damage. Deposited material was found on the fourth stage blades.

The fourth stage turbine blades exhibited coarsened gamma prime and rafting of the gamma prime at midspan.

The shroud on the fourth stage turbine wheel exhibited asymmetric rub damage and was cracked, with at least one through crack. The most severe rub damage was located approximately 90° in the direction of engine rotation from the center of the packet of missing third stage airfoils.

Two of the mounting tabs on the third stage turbine nozzle diaphragm were fractured and missing. Two fourth stage nozzle airfoils were fractured in overload. The hub castellations on the fourth stage nozzle assembly were partially fractured.

The first and second stage turbine airfoils exhibited tip rub.

The first stage turbine blades exhibited coarsened gamma prime and rafting of the gamma prime at midspan.

The power turbine labyrinth seal, second stage turbine nozzle, and Nos. 6 and 7 bearings were FAA PMA components and were not examined in detail.

Summary of Findings:

- All the third stage turbine wheel airfoil fractures were consistent with overload. There was no evidence of progressive fracture on any of the third stage turbine blades.
- All other damage was consistent with impact or accident sequence induced damage.
- Examination of the recovered engine components revealed no pre-impact anomalies which would have precluded engine operation.

**Appendix A,
Photographs at Recovery Location
Clinton, Arkansas**

Fig 1



Engine as Recovered



Engine Bottom as Recovered



Engine Top as Recovered



Turbine Module



Compressor Inlet

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**Appendix B,
Photographs at Arrow Aviation
Broussard, Louisiana**

Fig 2



Compressor



Compressor



Compressor Rotor



Compressor Case Half
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Fig 3



Outer Combustion Case



Combustor Liner

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Fig 4



Fractured Bearing Bore



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Fig 5



Stage One Nozzle



Stage 1 Wheel



Stage Two Nozzle



Stage two Wheel

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Fig 6



Stage Three Nozzle W/Fractured Positioning Tangs



Stage Three Nozzle



Stage Three Wheel



Stage Four Wheel

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Fig 7



Turbine to Compressor Coupling



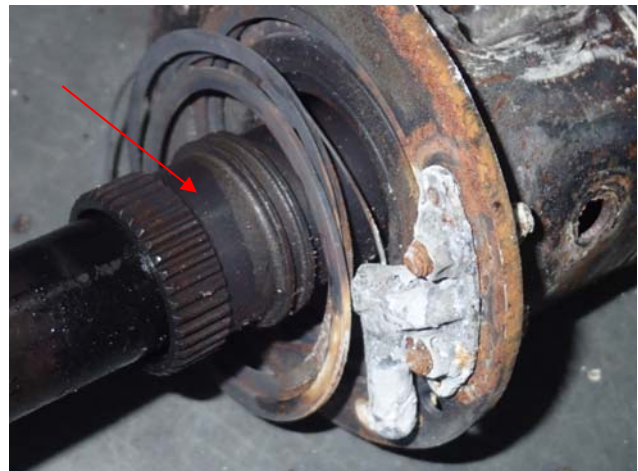
Spur Adapter Gear Shaft Mechanically Cut

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Fig 8



Power Turbine Outer Shaft



Power Turbine to Pinion Gear Coupling

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Fig 9



6/7 Bearing Oil Delivery Tube



#8 Bearing Oil Delivery Tube



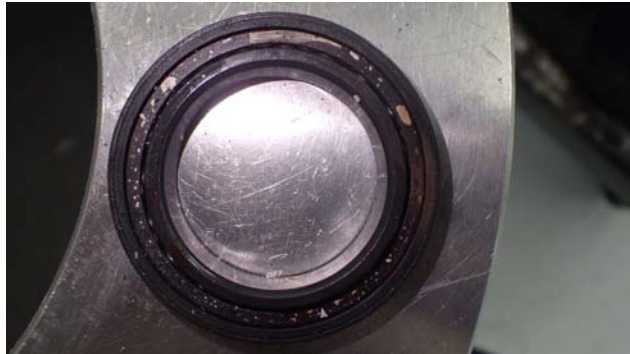
#8 Bearing Oil Nozzle

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Fig 10



#1 Bearing in Housing



5 Bearing



#6 Bearing



#8 Bearing

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Fig 11



Fuel Nozzle



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