



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Western Pacific Region

DATE January 24, 2022

AIRFRAME AND ENGINE EXAMINATION

WPR20LA007

This document contains 30 embedded photos.

A. ACCIDENT

Location: Susanville, California
Date: October 13, 2019
Aircraft: N131HA / Hiller UH-12E
NTSB IIC: Fabian Salazar

B. EXAMINATION PARTICIPANTS:

Name: Fabian Salazar
Duty Position: ASI
National Transportation Safety Board
Federal Way, WA 98003

Name: Dave Riser
Sr. ASI
Rolls-Royce
Indianapolis, Indiana

C. SUMMARY

Examination of the airframe and engine was conducted at the Operator's shop in Newberg, Oregon. The engine was then shipped to a Rolls-Royce authorized service facility for further examination. Following the engine examination, components were shipped to the Rolls-Royce Corporation's Materials Laboratory for further examination. Examination of the engine revealed evidence of thermal damage to the internal components.

No mechanical malfunctions or failures were observed with the airframe that would have precluded normal operation.

Airframe Examination Summary.

The helicopter was in the bay of the operator's shop. The fuselage rested on a trailer. The engine remained secured in the fuselage. The main rotor blades were cut about 18 inches and 30 inches from the roots during recovery. The landing skids were removed for recovery, but the cross tubes remained secured to the underside of the fuselage. The acrylic plexiglass was absent and the last two feet of the tailboom was absent, to include the tail rotor assembly. The separated tailboom and tail rotor assembly were secured in a second location on the operator's property.

Cockpit Documentation. The cockpit retained its structural shape. The instrument panel remained secured in the cockpit. All instruments remained secured in the instrument panel.

Dual Tachometer: Rotor:45% RPM; Turbine: 58% RPM

Gas Producer indicator: 0.0% RPM

Torque gauge: 5% Torque

Airspeed indicator: 0 MPH

Turbine outlet temperature: 10°C

Fuel Quantity: 0 gallons

Oil Temp: less than 0°C;

Oil Pressure: 0 PSI

Fuel Pressure: 0 PSI

Amps: 0

Volts: 15

Altimeter: 9530 feet mean sea level

Second oil pressure gauge: 0 PSI

Lower-center console:

Anti-Ice control: full aft

Fuel pump: On

Circuit breakers: all in

Upper-center console: Fan: On

Heater: Off

Auto-relight: On

Generator: Off

Flight controls. Two sets of flight controls were present in the cockpit, left seat and center seat. The left seat cyclic control stick exhibited a partial separation of the control grip. The metal of the control stick exhibited a fracture, and the wires kept the cyclic control grip attached to the control stick. The center-seat cyclic appeared normal. The left and center collective remained attached to the linkages and appeared normal. The left and center anti-torque pedals remained attached to their linkages.

Flight control continuity for the cyclic control was confirmed from the cyclic controls to the swashplate. Flight control continuity for the collective controls were established from the collective controls to the swashplate, and to the power turbine governor. Flight control continuity for the anti-torque pedals was confirmed from the pedals to the cuts in the control cables near the break in the tail boom, and from the break in the tail boom to the tail rotor gearbox. Throttle control continuity was established from the collective mounted throttle to the fuel control.

Fuselage. Examination of the fuselage started from the right side and worked around to the left side. The right-side door was removed during recovery. The right underside just aft of the rear cross tube exhibited a large dent. The right skid was removed for recovery, and the fore and aft cross tubes remained attached. The cross tubes exhibited normal appearance. The tailboom exhibited upward bending beginning near the driveshaft intermediate gearbox. The tailboom separated near the intermediate gearbox. The separated section of the tailboom was about 72 inches in length. The left side of the tailboom exhibited similar damage as the right side. The left side of the fuselage exhibited damage to the underside. The fore cross tube was bent rearward,

and the aft cross tube exhibited damage to the tip, with upward bending. The left side of the cockpit framework was bent inward and upward.

Transmission. The transmission remained attached at all but the forward left mount, which was fractured.

Main rotor system. The main rotor system remained attached to the mast and the transmission. One blade had yellow tape to identify its components and the other blade had blue tape to identify its components. The root, outboard to about 30 inches of the blue blade remained attached to the yoke and the blade grip. The blue rotor-matic paddle remained attached to the rotor assembly and exhibited no damage. The root, outboard to about 18 inches of the yellow blade remained attached to the yoke at the blade grip. The yellow rotor-matic paddle exhibited damage at its tip. The remaining sections of the main rotor blades were examined. Neither could be identified with a yellow or blue color, hence they were referred to as the A blade and the B blade. Both A and B blades exhibited damage throughout their spans. Both blades exhibited chord wise, aft, and upward bending and wrinkling of the skin.

Tail Rotor assembly. The tail rotor assembly remained attached to the gearbox, which remained attached to the end of the tailboom. Both blades separated from the tail rotor assembly near the root at chord-wise fractures. Both separated blade sections departed the rotor system and exhibited wrinkles and dents of the skin. The tips of both blades retained their shape and exhibited only minor damage. The crosshead and pitch change links remained attached at both ends. The right -side tail rotor control cable exhibited a broom straw break just forward of the 1st hanger bearing. The large diameter drive shaft from the transmission to the intermediate gearbox remained secured at both ends with no damage noted. The small diameter tail rotor driveshaft located from the intermediate gearbox to the 90° gearbox was fractured and separated about 1 inch aft of the splines. A second break occurred about 14 inches aft of the splines. There was a disconnect of the driveshaft at the second hanger bearing.

The right skid exhibited an upward bend about 36 inches from the aft end. The left skid exhibited no damage.

An examination of the turbine outlet temperature gauge from N131HA was conducted at a maintenance facility in West Jordan, Utah. The turbine outlet temperature gauge was connected to a Barfield TT1200A turbine temperature test set. Testing of the gauge resulted in the following values:

Test Set Value	TOT Gauge Value
50	70
100	125
150	185
200	250
250	300
300	360
350	420
400	465

450	520
500	580
550	640
600	700
650	750
700	810
750	880
800	940
850	1000

On March 30, 2022, the IIC delivered the thermocouple from the accident engine to Classic Helicopters, Woods Cross, Utah. In the presence of the IIC, a maintenance technician tested the thermocouple with a Barfield digital turbine temperature test set. The test set calibration date was: 3/2/2022, with the next calibration date of: 3/1/2023.

The thermocouple's internal resistance, at room temperature was .57 ohms. According to the Rolls-Royce M250-C20 series Operation and Maintenance Manual, for harness part number 23034926, the acceptable internal resistance is 0.50 to 0.60 ohms at room temperature.

Engine examination. The engine was initially examined at the recovery site by the IIC and the party member from Rolls-Royce Corporation. Afterwards the engine was shipped to a Rolls-Royce authorized service facility, where it was disassembled and examined by the NTSB aerospace engineer-powerplants lead. After that examination, components of the engine were shipped to the Rolls-Royce Corporation materials laboratory and examined by their metallurgist. Summaries of these exams are detailed below.

The engine was an Allison 250-C20B, Serial number: CAE821065, rated at 420 SHP. Total time: 11946.8. Examination of the helicopter maintenance logbooks revealed that the most recent 100-hour inspection was performed on September 26, 2019, at 68.2 tachometer time, 12078.4 aircraft total time. No defects were noted within the logbook entry. Additional maintenance documents revealed the turbine section had been repaired on September 9, 2014, due to low power and high operating temperatures.

Recovery Site Examination Summary

The engine was examined while at the recovery site in Newberg, Oregon. The engine remained attached to the airframe at its mounts. The engine exhibited no outward damage. Examination revealed that all B-nuts were at least finger tight. All oil and fuel line connections were at least finger tight, with no evidence of leaks. No damage to the compressor section was observed. The compressor bleed valve was in the correct open position, and the poppet valve could be moved with light resistance. Dirt and debris were observed in the outlet of the exhaust and the stage 4 turbine wheel would not rotate with moderate force.

Fuel was present in the fuel line to the fuel pump. There was no fuel present at the fuel nozzle.

Once removed from the airframe, the N1 section turned freely from the starter generator pad to the compressor rotor. The N2 drivetrain would not move with moderate force.

No contaminants were observed on the upper and lower chip detectors. The engine oil was void of contaminants. Examination of the aft end of the combustor section revealed dirt and contaminants.

The engine was then shipped to Arrow Aviation, Broussard, Louisiana for disassembly and examination, which occurred on January 16-17, 2020. During the examination the following observations were made:

Ferrous and non-ferrous material were at the base of the exhaust plenum. The engine had a reddish colored dirt over most of the exterior. Pneumatic test was performed using 75 – 80 PSI then dropped down to 20 PSI. No leaks were found. All air line connections were at least finger tight. No metal was found on the bottom chip detector. The N2 power turbine section would not turn.

The combustion chamber was removed allowing the 1st and 2nd turbine wheels to be examined. The N2 turned with difficulty and a sound of metal on metal was heard. The accessory gear box was turned at the power turbine to pinion gear coupler. The accessory gear box turned freely. The oil filter was clean and free of debris.

The engine was opened at the gas producer turbine section, exposing stage 2 and 3 turbine wheels. The stage 2 turbine wheel (gas producer second stage) exhibited damage at the tips of all turbine blades.

The gas producer turbine support and outer case were opened, exposing the stage 1 stator vanes, and stage 1 and 2 turbine wheels (1st and 2nd gas producer turbine wheels). The stage 1 stator vanes appeared to have debris on the vanes. The number 8 bearing was removed.

The compressor section was removed from the accessory gearbox. The compressor section was then opened exposing the six-stage centrifugal, single-stage axial compressor. The 6-stage compressor section. And the axial compressor section appeared normal with no apparent damage to the blades. Slight contact was made from the 1st stage guide vanes to the compressor assembly. A thickness check was performed on the 1st, 2nd and 3rd stage blades. All passed with sufficient thickness. The gap between the impeller and the number 2 bearing was checked and found at .012 inch, within acceptable tolerance (.010 to .012 inch).

The stage 1 turbine wheel (1st stage gas producer) exhibited damage to all blades. All blade tips were eroded to about 40 to 50%. There was a crack running from the base of the turbine blades towards the center of rotation.

The stage 2 turbine wheel (2nd stage gas producer) exhibited damage to all blades. All blade tips were eroded away, about 15-20% of the blade. Both the first and second stage nozzles exhibited thermal damage with noted metal spatter and dirt throughout the gas path including the stage three and four nozzles and wheels.

The stage 3 turbine wheel (1ST stage power turbine wheel) exhibited a crack at the outer diameter. No damage was observed at the stage 3 or stage 4 nozzles. The stage 4 power turbine wheel (2nd stage power turbine wheel). exhibited normal appearance.

Rolls-Royce Corporation Materials laboratory examination summary

The stage 1 and stage 2 turbine wheels and the stage 1 and 2 nozzles were shipped to the Rolls-Royce Materials Laboratory in Indianapolis, Indiana, for further examination. Examination of the damaged components revealed:

The stage 1 turbine wheel exhibited a crack extending radially inboard approximately 1.12 inches from the rim into the web. The crack initiated in the rim in thermal fatigue and transitioned to interdendritic fracture consistent with cracking expected after over-temperature operation. The interdendritic fracture exhibited two distinct regions consistent with it having formed from two separate over-temperature events.

The T1 [stage 1] and T2 [stage 2] wheels and nozzles exhibited evidence of thermal distress including burned airfoil tips, voiding, and plastic flow.

The stage 1 wheel exhibited 31 visually apparent rim cracks on the trailing edge side of the wheel and rim cracks in between every airfoil on the leading-edge side of the wheel. According to Rolls-Royce excessive rim cracking is indicative of the occurrence of an over temperature start.

The T1 and T2 wheels and nozzles exhibited layers of deposited material on the gas flow path surfaces which were consistent with deposits of T1 and T2 wheel material due to melting of the airfoils.

PHOTO EXHIBIT



Figure 1. N131HA at the accident site. Photo courtesy of the operator.



Figure 2. Right-underside view. Photo courtesy of the operator.



Figure 3. Front view of N131HA inside the operator's hangar. Photo NTSB.



Figure 4. Right-side view. Photo NTSB.



Figure 5. Right-side view showing damage to the tailboom. Photo NTSB.



Figure 6. Rear view. Photo NTSB.



Figure 7. Left-side view. Photo NTSB.



Figure 8. Left-side view of the cockpit. Photo NTSB.

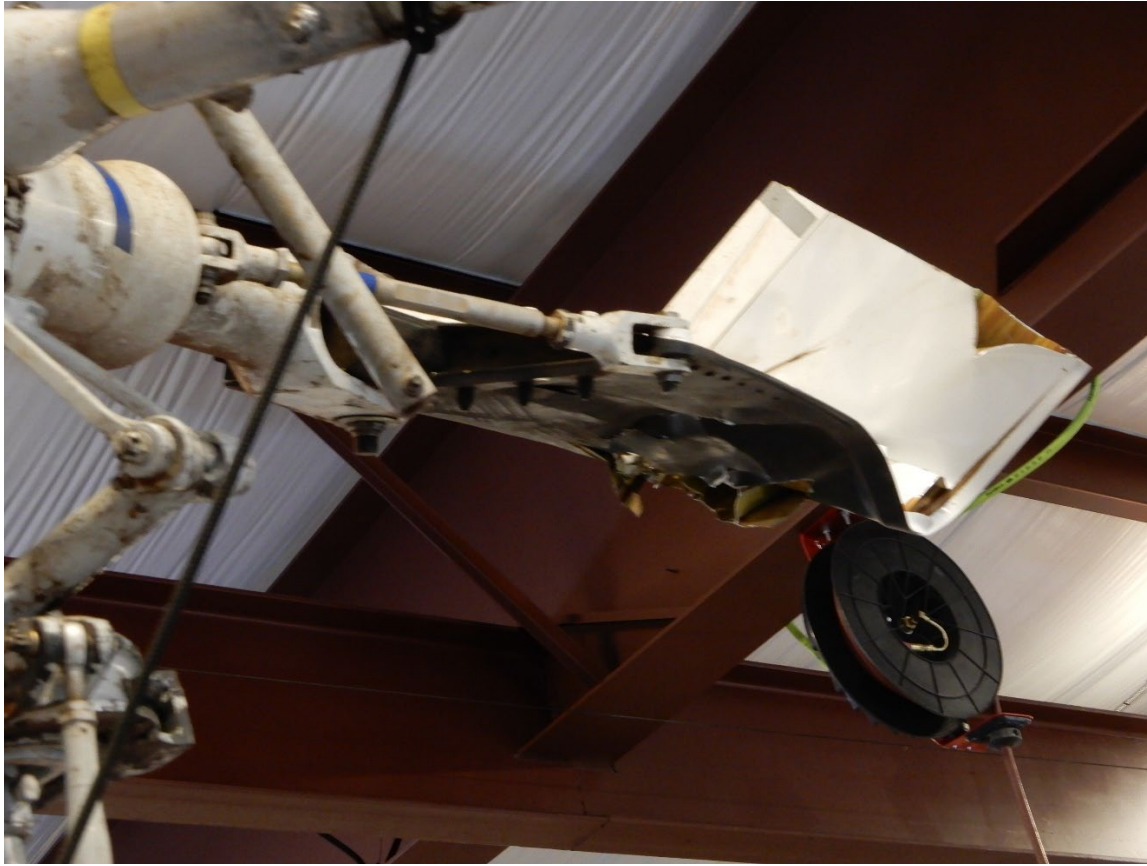


Figure 9. View of the blue main rotor blade root. Photo NTSB.



Figure 10. View of the yellow main rotor blade root. Photo NTSB.



Figure 11. View of the main rotor blades, top side, with blade tops in the foreground. Photo NTSB.



Figure 12. View of the separated tailboom and tail rotor assembly. Photo NTSB.



Figure 13. View of the tail rotor assembly and the 90° gearbox. Photo NTSB.



Figure 14. Left-side view of the 250-C20B turbine engine. Photo NTSB.

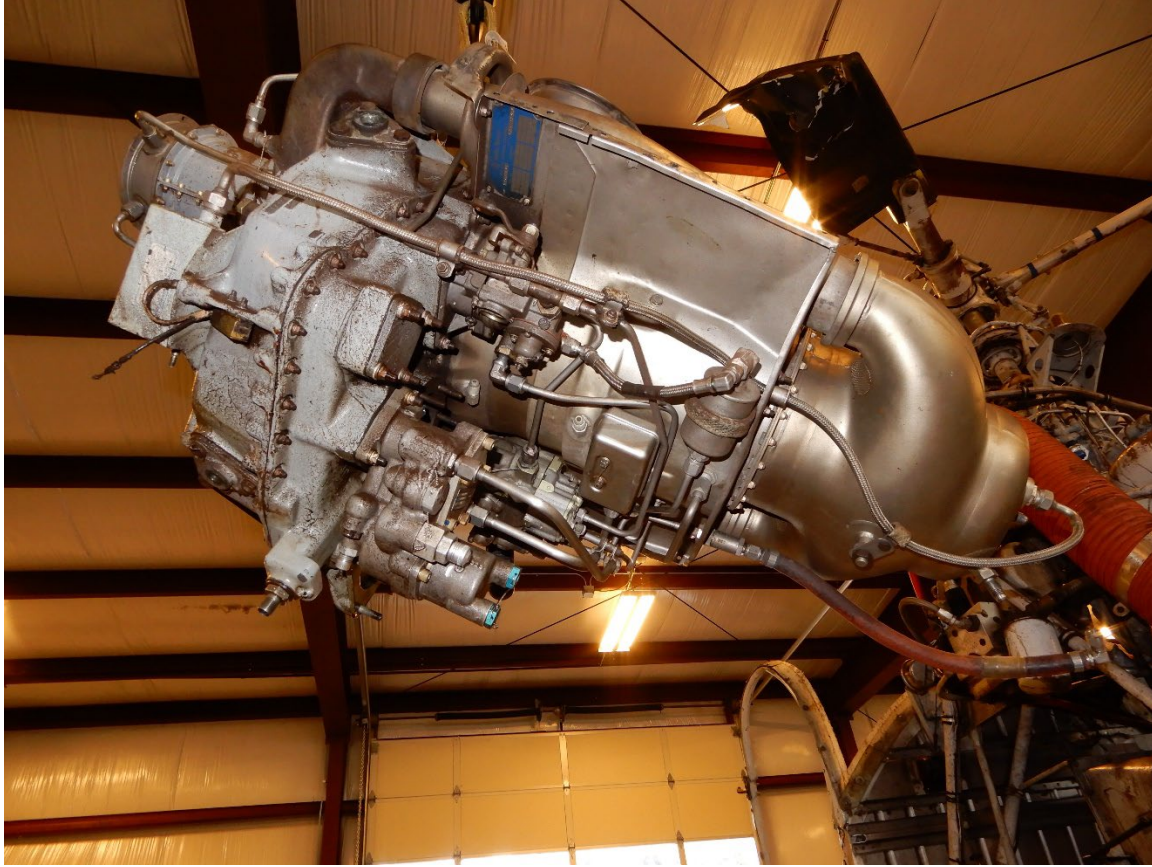


Figure 15. Underside view of the 250-C20B turbine engine. Photo NTSB.



Figure 16. Right-side view of the 250-C20B turbine engine. Photo NTSB.



Figure 17. The six-stage axial compressor. Photo Courtesy of Rolls-Royce.



Figure 18. Stage 1 turbine wheel, showing crack extending into the web. Photo courtesy of Rolls-Royce.

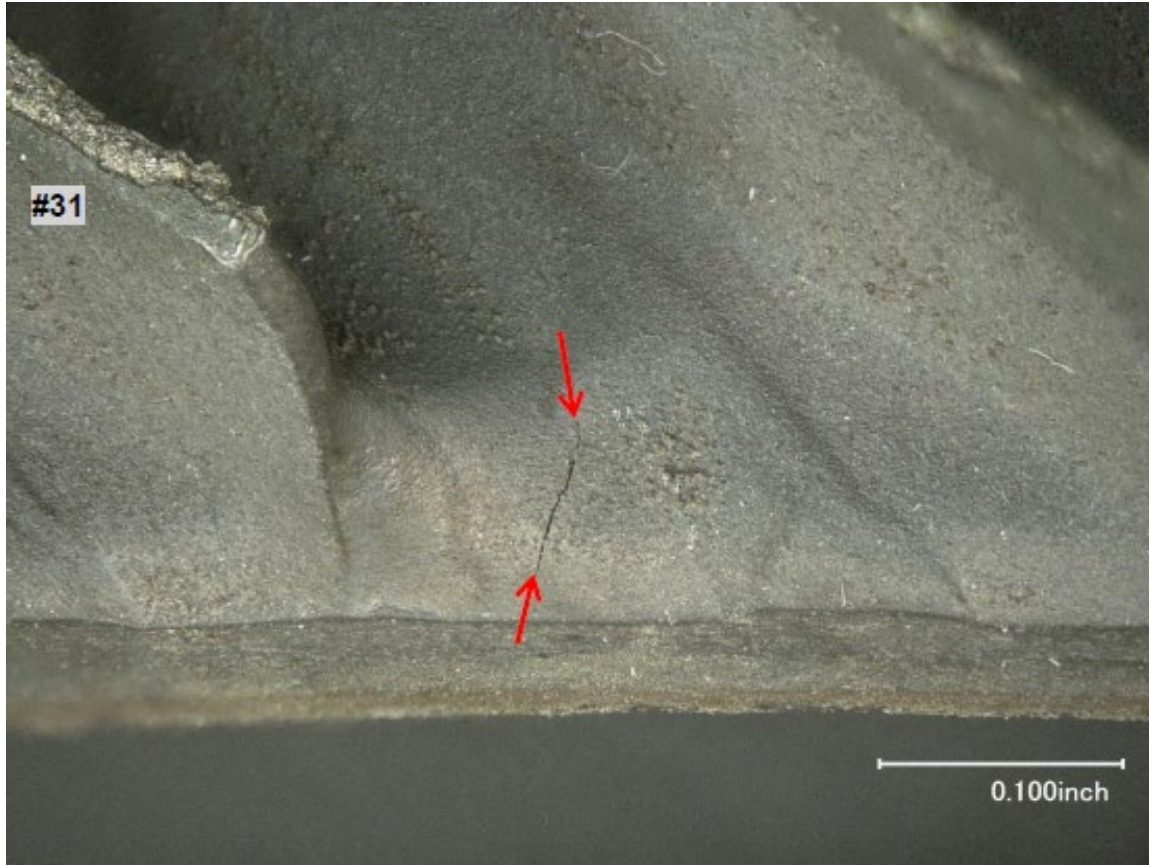


Figure 19, Example of a rim crack on the first stage wheel. The red arrows point to the stark and stop of the crack. Photo courtesy of Rolls-Royce.



Figure 20. Stage 1 nozzle. Photo courtesy of Rolls-Royce. Photo courtesy of Rolls-Royce.



Figure 21. Stage 2 turbine wheel. Photo courtesy of Rolls-Royce.



Figure 22. Stage 2 nozzle. Photo courtesy of Rolls-Royce.



Figure 23. Stage 3 nozzle. Photo courtesy of Rolls-Royce.

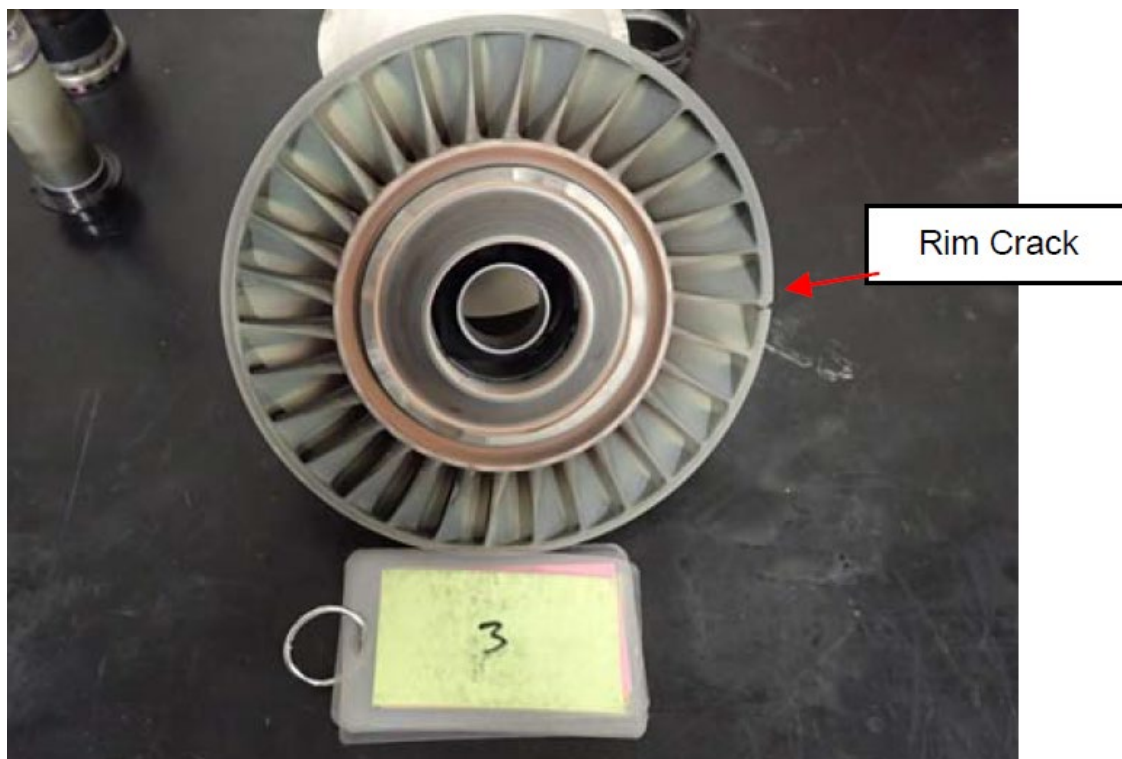


Figure 24. Stage 3 turbine. Photo courtesy of Rolls-Royce.



Figure 25. Stage 4 nozzle. Photo courtesy of Rolls-Royce.



Figure 26. Stage 4 turbine wheel. Photo courtesy of Rolls Royce.



Figure 27. Turbine outlet temperature gauge from the accident helicopter.

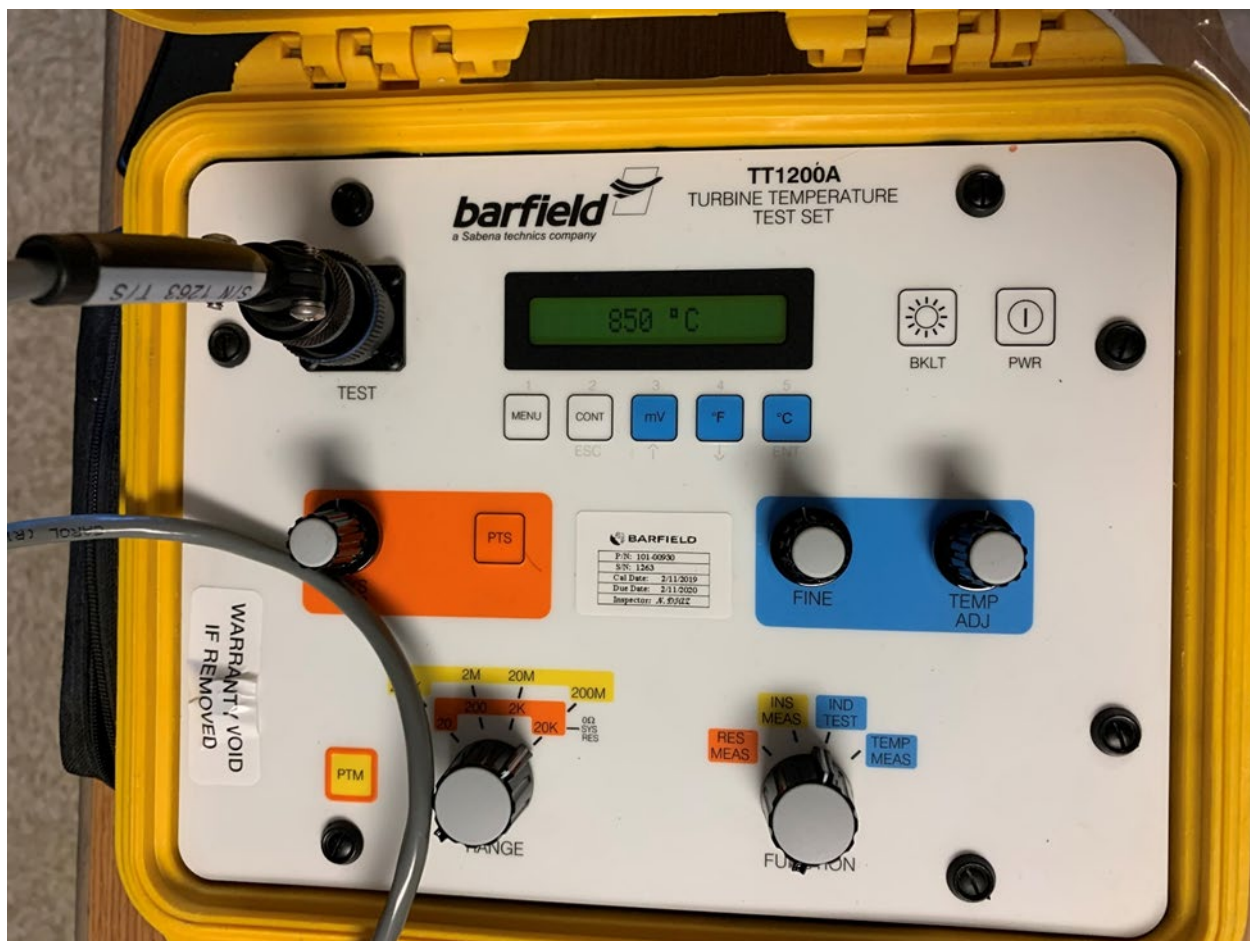


Figure 28. TT1200A turbine temperature test set.

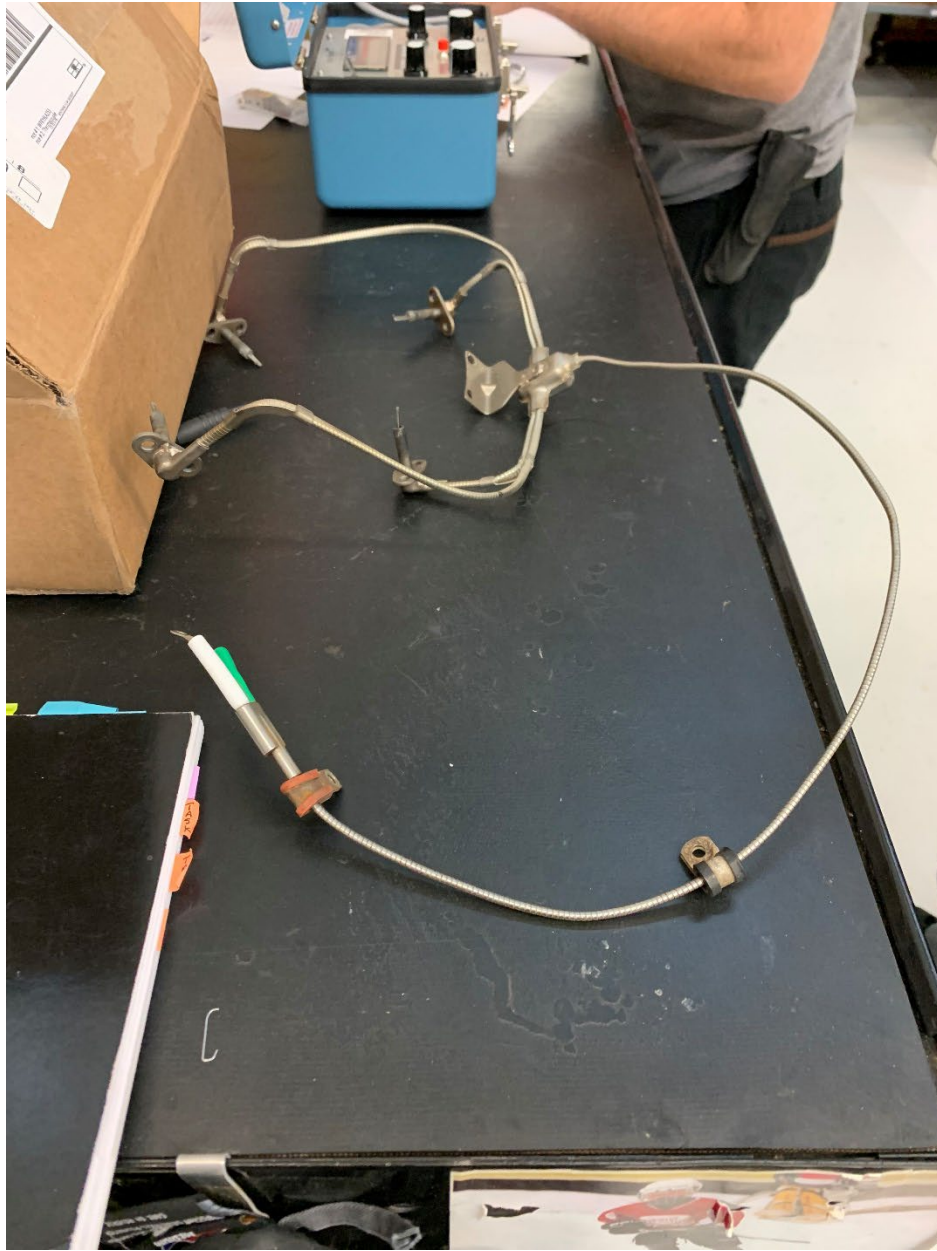


Figure 29. Thermocouple from the accident engine. Photo NTSB.

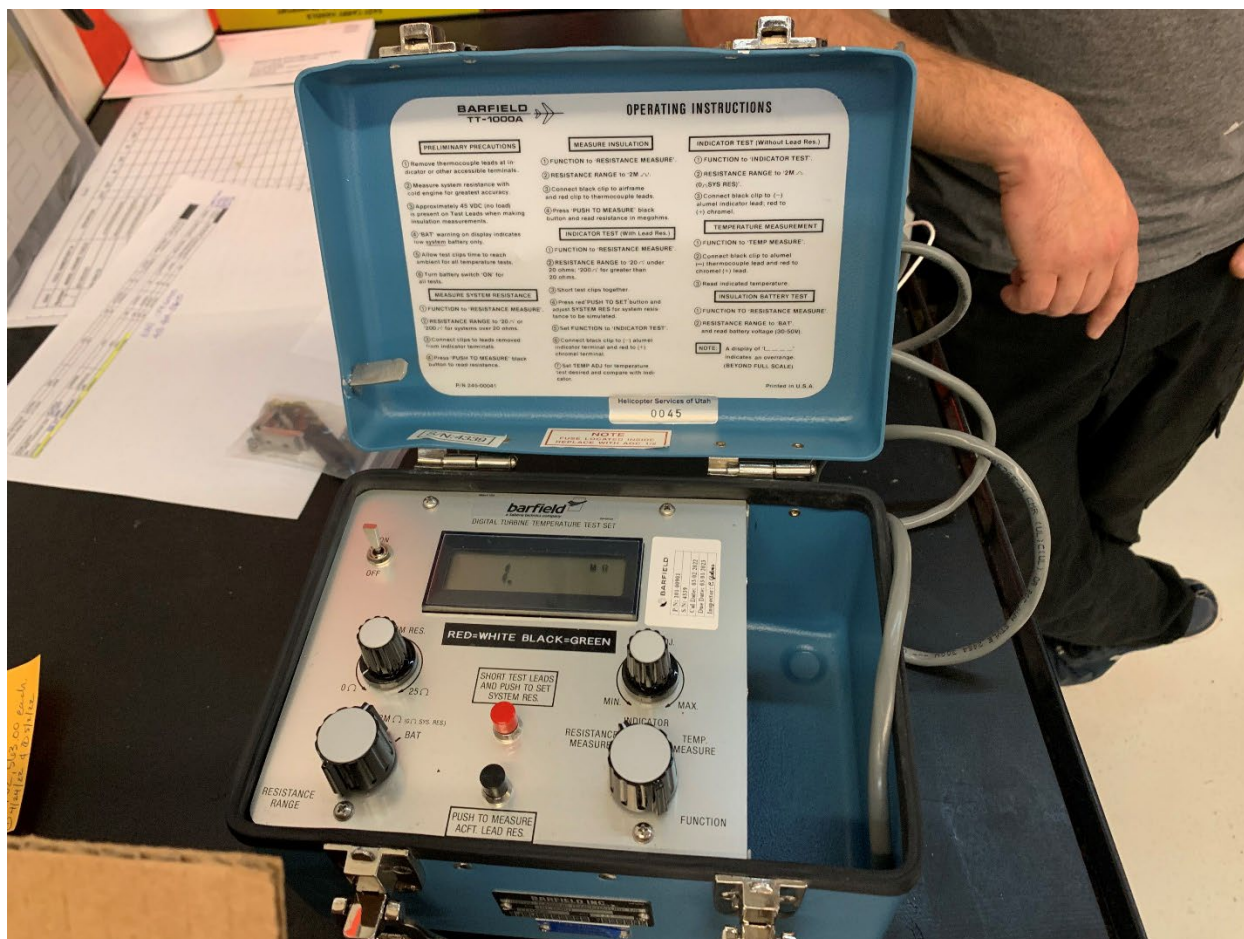


Figure 30. Test set used to test the thermocouple. Photo NTSB.