Honeywell

TEARDOWN REPORT
OF A MODEL TPE331-10T-515K TURBOPROP ENGINE
SERIAL NUMBER P-79214C AND P-79289C

March 21, 2022

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Approved By: _____

Jay Eller,
Product Integrity

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1. INTRODUCTION AND SUMMARY

1.1 PURPOSE

This report, prepared by Honeywell Aerospace, presents the findings of a tear down and examination conducted on two Honeywell Model TPE331-10T-515K turboprop engines, Serial Numbers P-79214C (left) and P-79289C (right). The inspection took place at the Honeywell Investigation Laboratory in Phoenix, Arizona, on January 10 and January 11, 2022.

The inspection was conducted at the request of the National Transportation Safety Board (NTSB) with oversight provided by an FAA representative from the Scottsdale, Arizona FSDO.

1.2 BACKGROUND

On September 28, 2021, about 0900 central daylight time, a Rockwell International 690B airplane, N690LS, was destroyed when it was involved in an accident near Hiles, Wisconsin. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 aerial imagery survey flight. According to the operator, the flight mission was to obtain aerial imagery of the forest vegetation for the Wisconsin Department of Natural Resources.

The airplane wreckage was located during an aerial and ground search in wetlands and wooded terrain about 10 miles east of Eagle River, Wisconsin, and 1 mile west of Butternut Lake, in the Chequamegon-Nicolet National Forest. The wreckage was distributed in a diameter of about 50 yards. A majority of the main wreckage was found beneath the water surface with some debris located in the trees.

1.3 SUMMARY

The teardown and examination of the left engine, S/N P-79214C, revealed that the type and degree of damage was indicative of an engine that was rotating and operating at the time of impact. No pre-existing condition was found that would have prevented normal operation.

The teardown and examination of the right engine, S/N P-79289C, revealed that the type and degree of damage was indicative of an engine that was rotating and operating at the time of impact. No pre-existing condition was found that would have prevented normal operation.

4. ANALYSIS AND CONCLUSIONS

4.1 ANALYSIS OF TPE331-10T-515K, TURBOPROP ENGINE, SERIAL NUMBER P-79214C

Engine rotation at the time of impact was evidenced by:

- The propeller shaft displayed rotational scoring through 360 degrees immediately aft of the propeller shaft nut (Figure 25 – white arrows) with corresponding rotational score marks on the sun gear forward inner bore (Figure 33).
- The propeller shaft displayed rotational scoring through approximately 360 degrees on the aft taper, with corresponding rotational score marks on the sun gear aft inner bore. (Figure 26)
- The ring gear support (bumper plate) displayed rotational scoring to the forward face. (Figure 31) associated with contact of the aft face of the planet gears.
- The sun gear displayed rotational scoring on the forward, inner bore leading edge (Figure 33) with corresponding score marks on the propeller shaft immediately behind the nut (Figure 25).
- The aft splines associated with the HSP-to-power section coupling shaft were damaged indicative of rotational damage during separation from the power section.
- All of the first-stage compressor impeller vanes were heavily bent back opposite to the direction of rotation. (Figure 40)
- The first-stage compressor impeller vanes displayed rotational scoring on the shroud line edge (Figure 41) associated with contact of the first-stage compressor impeller shroud.
- The first-stage compressor impeller aft flange edge displayed rotational scoring through 360 degrees (Figure 42).
- The first-stage compressor impeller vanes had the leading-edges bent opposite to the direction of rotation on all of the vanes. (Figure 40 and Figure 41)
- One of the first-stage compressor impeller vanes was partially missing. (Figure 41)
- The first-stage compressor impeller displayed rotational scoring through 360 degrees on the forward hub (Figure 43).
- The first-stage compressor impeller displayed rotational scoring through approximately 360 degrees on the aft hub (Figure 45) with corresponding scoring on the inner diameter of the crossover duct housing seal area.
- The first-stage compressor impeller aft curvic teeth were smeared. (Figure 45)
- The first-stage compressor impeller aft face was rotationally scored through approximately 180 degrees ((Figure 42 and Figure 44) associated to contact with the forward housing face of the first stage compressor diffuser (crossover duct).
- The first-stage compressor diffuser displayed rotational scoring on the inner diameter of the crossover duct housing seal area (Figure 50) with corresponding rotational scoring on the aft hub of the first stage compressor impeller.
- The first-stage compressor diffuser displayed rotational scoring on the inner diameter of the crossover duct housing seal area (Figure 50) with corresponding rotational scoring on the forward hub of the second-stage compressor impeller.
- The second-stage compressor housing displayed a shroud rub through 360 degrees (Figure 51 and Figure 54) with corresponding rotational scoring on the second-stage compressor impeller vanes.
- The shroud line edge of all second-stage compressor impeller vanes displayed rotational scoring (Figure 58) with corresponding rotational scoring to the second-stage impeller shroud.
- The leading edge of 14 second-stage compressor impeller vanes were damaged (rough / pitted) due to foreign object damage. (Figure 61)
- The second-stage compressor impeller forward curvic coupling teeth were heavily smeared. (Figure 56 and Figure 59)
- The second-stage compressor impeller displayed rotational scoring on the forward hub of the second-stage compressor impeller (Figure 59) with corresponding rotational scoring on the inner diameter of the crossover duct housing seal area.

- The second-stage compressor impeller displayed rotational scoring inside of the inner bore (Figure 63).
- The leading edge of several second-stage compressor diffuser vanes exhibited damage (nicks) consistent with foreign object damage. (Figure 67)
- The de-swirl vane assembly had earthen and shredded wood debris adhering to the flow surfaces. (Figure 72)
- The combustion chamber contained earthen debris and shredded wood debris in and around various cooling holes, fuel nozzle swirlers, inner diameter seams and skirts of the combustor. (Figure 73)
- The first-stage turbine blade tip shroud displayed rotational scoring on all segments (Figure 86 and Figure 87) with corresponding rotational scoring to the shroud line edges of all first-stage turbine blades.
- The first-stage turbine rotor displayed rotational scoring on the shroud line edge of all blade tips (Figure 91) with corresponding rotational scoring on the first-stage turbine blade tip shroud.
- The first-stage turbine rotor displayed rotational scoring on the aft blade platforms (Figure 89 and Figure 90) with corresponding scoring to the forward inner vane support for the second-stage stator.
- The second-stage turbine stator displayed rotational score marks through 360 degrees on the forward face of the inner vane support (Figure 99, Figure 100, and Figure 104) with corresponding score marks on the aft face of the first-stage turbine wheel blade platforms.
- The second-stage turbine stator displayed rotational scoring through 360 degrees of the shroud surface (Figure 105) with corresponding scoring to the shroud line edge of all second-stage turbine blades.
- The second-stage turbine rotor displayed rotational scoring on the shroud line edge of all blade tips (Figure 108) with corresponding rotational scoring on the second-stage turbine blade tip shroud.
- The second-stage turbine rotor displayed rotational scoring on the aft blade platforms (Figure 109 and Figure 113) with corresponding scoring to the forward inner vane support for the third-stage stator.
- The second-stage turbine rotor displayed rotational scoring to the aft balance ring (Figure 109 and Figure 113) with corresponding rotational scoring to the inner seal support of the third-stage stator.
- The third-stage turbine stator displayed rotational score marks on the forward inner vane support (Figure 120) with corresponding rotational scoring to the aft blade platforms of the second-stage turbine wheel.
- The third-stage turbine blade tip shroud displayed rotational scoring through 180 degrees (Figure 121) with corresponding scoring on the shroud line edge of all third-stage turbine rotor blades.
- The third-stage turbine stator displayed rotational scoring to the forward inner seal support (Figure 120) with corresponding rotational scoring to the aft balance ring of the second-stage turbine wheel.
- The third-stage turbine rotor displayed rotational scoring on the shroud line edge of all blade tips (Figure 124) with corresponding rotational scoring on the third-stage turbine blade tip shroud.
- The third-stage turbine rotor displayed rotational scoring on the aft blade platforms (Figure 125) with corresponding scoring to the forward face on the inner housing of the rear bearing support.
- The turbine bearing support housing displayed rotational scoring to the forward face on the inner housing of the rear bearing support with corresponding rotational scoring on the aft blade platforms of the third-stage turbine wheel.
- The forward face of the turbine oil-scavenge pump drive gear was rotationally scored. (Figure 137)
- The aft (turbine) main-shaft nut displayed rotational score marks on the interface between the flats of the turbine nut (Figure 144 – blue circles) with corresponding rotational score marks to the inside of the pump housing.

Operation at the time of impact was evidenced by:

- There were compressor-shroud metal spray deposits on the leading edge of the first-stage turbine stator vanes. (Figure 85)
- There were compressor-shroud metal spray deposits on the suction side of the first-stage turbine stator vanes. (Figure 81 and Figure 83)
- There were compressor-shroud metal spray deposits on the pressure side of the first-stage turbine stator vanes. (Figure 84 and Figure 85)
- There were compressor-shroud metal spray deposits on the suction side of the first-stage turbine rotor blades. (Figure 92)
- There were compressor-shroud metal spray deposits on the leading edge of the first-stage turbine rotor blades. (Figure 93)
- There were compressor-shroud metal spray deposits on the inner blade platforms of the first-stage turbine rotor blades. (Figure 94)
- There were compressor-shroud metal spray deposits on the flow surfaces of the blade platforms of the first-stage turbine rotor blades. (Figure 95)
- There were compressor-shroud metal spray deposits on the leading edge of the second-stage turbine stator vanes. (Figure 101)
- There were compressor-shroud metal spray deposits on the pressure side of the second-stage turbine stator vanes. (Figure 102)
- There were compressor-shroud metal spray deposits on the suction side of the second-stage turbine stator vanes. (Figure 103)
- There were compressor-shroud metal spray deposits on the suction side of the second-stage turbine rotor blades. (Figure 110)
- There were compressor-shroud metal spray deposits on the pressure side of the second-stage turbine rotor blades. (Figure 111)
- There were compressor-shroud metal spray deposits on the leading edge of the second-stage turbine rotor blades. (Figure 112)
- There were compressor-shroud metal spray deposits on the suction side of the third-stage turbine stator vanes. (Figure 117)
- There were compressor-shroud metal spray deposits on the leading edge of the third-stage turbine stator vanes. (Figure 118 and Figure 119)
- There were compressor-shroud metal spray deposits on the pressure side of the third-stage turbine stator vanes. (Figure 119)
- The third-stage turbine rotor had compressor-shroud metal spray deposits on the suction side of the blades. (Figure 126)
- The third-stage turbine rotor had compressor-shroud metal spray deposits on the pressure side of the blades. (Figure 127)
- The third-stage turbine rotor had compressor-shroud metal spray deposits on the leading edge of the blades. (Figure 128)

4.2 ANALYSIS OF TPE331-10T-515K, TURBOPROP ENGINE, SERIAL NUMBER P-79289C

Engine rotation at the time of impact was evidenced by:

- The propeller shaft displayed rotational scoring through 360 degrees immediately aft of the propeller shaft nut (Figure 188 – white arrows) with corresponding rotational score marks on the sun gear forward inner bore.
- The propeller shaft displayed rotational scoring through approximately 90 degrees in the middle of the shaft (Figure 189), with corresponding rotational score marks on the sun gear inner bore.
- The propeller shaft displayed rotational scoring through approximately 180 degrees on the aft taper, with corresponding rotational score marks on the sun gear aft inner bore. (Figure 190)
- The ring gear support (bumper plate) displayed rotational scoring to the forward face. (Figure 192) with corresponding score marks on the aft face of the planet gears.
- The sun gear displayed rotational scoring on the forward, inner bore leading edge (Figure 194) with corresponding score marks on the propeller shaft immediately behind the nut (Figure 188).

- Rotational scoring was noted through 180 degrees on the shouldered (main) shaft just aft of the break. (Figure 205)
- There was earthen debris and wood adhering to the vane surfaces and lodge within the first-stage compressor diffuser. (Figure 211)
- The first-stage compressor diffuser displayed rotational scoring on the inner diameter of the crossover duct housing seal area (Figure 213) associated with rotational contact of the first stage compressor impeller.
- The first-stage compressor diffuser displayed rotational scoring on the inner diameter of the crossover duct housing seal area (Figure 213) with corresponding rotational scoring on the forward hub of the second-stage compressor impeller.
- The second-stage compressor housing displayed a heavy shroud rub through 360 degrees (Figure 214 and Figure 217) with corresponding rotational damage to the shroud line edge of the second-stage impeller vanes.
- The shroud line edge of all second-stage compressor impeller vanes displayed rotational scoring (Figure 224) with corresponding rotational scoring to the second-stage impeller shroud.
- 2 of the second-stage compressor impeller vanes were found bent opposite to the direction of rotation at the exducer end of the vanes. (Figure 219)
- The leading edge of 2 second-stage compressor impeller vanes were bent opposite to the direction of rotation. (Figure 221)
- 14 of the leading edges of the second-stage compressor impeller vanes were damaged (rough / pitted) due to foreign object damage. (Figure 221)
- The second-stage compressor impeller forward curvic coupling teeth were smeared. (Figure 219 and Figure 222)
- The second-stage compressor impeller displayed rotational scoring on the forward hub of the second-stage compressor impeller (Figure 222) with corresponding rotational scoring on the inner diameter of the crossover duct housing seal area.
- The second-stage compressor impeller displayed score marks on the aft face (Figure 220, Figure 223, and Figure 226) associated with contact of the inner seal support retention bolts of the outer transition liner.
- Shaved material associated with the second stage compressor impeller shroud was observed on an outer, leading edge of the second stage impeller vane. (Figure 225)
- The second-stage compressor diffuser vane assembly contained earthen debris and shredded wood debris between and adhering to the diffuser vanes. (Figure 229 and Figure 230)
- The leading edge of several second-stage compressor diffuser vanes exhibited damage (nicks) consistent with foreign object damage. (Figure 229)
- Shredded wood and earthen debris were observed in the aft portion of the combustor plenum case. (Figure 235)
- The de-swirl vane assembly had earthen and shredded wood debris adhering to the flow surfaces. (Figure 237)
- The combustion chamber contained earthen debris and shredded wood debris in and around various cooling holes, fuel nozzle swirlers, inner diameter seams and skirts of the combustor. (Figure 237 and Figure 238)
- There were score marks on the inner seal support of the outer transition liner retention bolts (Figure 241) with corresponding score marks on the aft face of the second-stage impeller.
- Rotational scoring was noted on the inner honeycomb seals of the outer transition liner inner seal (Figure 242).
- The first-stage turbine blade tip shrouds displayed rotational scoring on all segments (Figure 252 and Figure 253) with corresponding rotational scoring to the shroud line edges of all the first-stage turbine blades.
- The first-stage turbine rotor displayed rotational scoring on the shroud line edge of all blade tips (Figure 257) with corresponding rotational scoring on the first-stage turbine blade tip shroud.
- The first-stage turbine rotor displayed rotational scoring on the aft blade platforms (Figure 255 and Figure 256) with corresponding scoring to the forward inner vane support for the second-stage stator.

- The second-stage turbine stator displayed rotational score marks on the forward face of the inner vane support (Figure 262 and Figure 265) with corresponding score marks on the aft face of the first-stage turbine wheel blade platforms.
- The second-stage turbine stator displayed rotational score marks on the aft face of the inner vane support (Figure 266) with corresponding score marks on the forward face of the second-stage turbine wheel blade platforms.
- The second-stage turbine stator displayed rotational scoring through 360 degrees of the shroud surface (Figure 267) with corresponding scoring to the shroud line edge of all second-stage turbine blades.
- The second-stage turbine rotor displayed rotational scoring on the shroud line edge of all blade tips (Figure 270) with corresponding rotational scoring on the second-stage turbine blade tip shroud.
- The second-stage turbine rotor displayed rotational scoring on the aft blade platforms (Figure 271) with corresponding scoring to the forward inner vane support for the third-stage stator.
- The second-stage turbine rotor displayed rotational scoring on the aft hub face (Figure 272 – white arrows) with corresponding scoring to the forward inner vane support for the third-stage stator.
- The third-stage turbine stator displayed rotational score marks on the forward inner vane support (Figure 279) with corresponding rotational scoring to the aft blade platforms of the second-stage turbine wheel.
- The third-stage turbine blade tip shroud displayed rotational scoring through 360 degrees (Figure 280) with corresponding scoring on the shroud line edge of all third-stage turbine rotor blades.
- The third-stage turbine rotor displayed rotational scoring on the shroud line edge of all blade tips (Figure 283) with corresponding rotational scoring on the third-stage turbine blade tip shroud.
- The third-stage turbine rotor displayed rotational scoring on the aft blade platforms (Figure 285) with corresponding scoring to the forward face on the inner housing of the rear bearing support.
- The rear curvic coupling displayed rotational scoring to the aft face (Figure 288) with corresponding score marks on the turbine seal assembly bolt heads.
- The turbine bearing support housing displayed rotational scoring to the forward face on the inner housing of the rear bearing support (Figure 293) with corresponding rotational scoring on the aft blade platforms of the third-stage turbine wheel.
- The turbine air/oil carbon seal bolt heads displayed rotational scoring (Figure 299) with corresponding scoring to the rear curvic coupling aft face

Operation at the time of impact was evidenced by:

- Cleaning of the first-stage turbine stator revealed compressor-shroud metal spray deposits on the leading edge of the first-stage turbine stator vanes. (Figure 250)
- Cleaning of the first-stage turbine stator revealed compressor-shroud metal spray deposits on the suction side of the first-stage turbine stator vanes. (Figure 251)
- Cleaning of the first-stage turbine rotor wheel revealed compressor-shroud metal-spray deposits on the suction side of the blades. (Figure 258)
- Cleaning of the first-stage turbine rotor wheel revealed compressor-shroud metal spray deposits on the pressure side of the blades. (Figure 259)
- Cleaning of the wheel revealed compressor-shroud metal spray deposits on the pressure side of the second-stage turbine stator vanes. (Figure 263)
- Cleaning of the wheel revealed compressor-shroud metal spray deposits on the suction side of the second-stage turbine stator vanes. (Figure 264)
- There were compressor-shroud metal spray deposits on the suction side of the second-stage turbine rotor blades. (Figure 273)
- There were compressor-shroud metal spray deposits on the pressure side of the second-stage turbine rotor blades. (Figure 274)
- There were compressor-shroud metal spray deposits on the leading edge of the second-stage turbine rotor blades. (Figure 275)

- Cleaning of the wheel revealed compressor-shroud metal-spray deposits on the suction side of the third-stage turbine stator vanes. (Figure 278)
- Cleaning of the third-stage turbine rotor revealed compressor-shroud metal-spray deposits on the suction side of the blades. (
- Figure 286)

4.3 ANALYSIS OF FIRST-STAGE COMPRESSOR IMPELLER SHROUD, TURBOPROP ENGINE, UNKNOWN SERIAL NUMBER

Two portions of a first-stage compressor impeller shroud were returned with the right engine components, but it was unable to be determined which engine they were associated.

Engine rotation at the time of impact was evidenced by:

- The first-stage compressor impeller shroud was heavily rubbed. (Figure 207 and Figure 208)
- The first-stage compressor impeller shroud displayed a shroud rub along the exducer area (Figure 208) with corresponding rotational scoring on the impeller vane shroud line edge.
- The first-stage compressor impeller shroud displayed rotational scoring and gouging along the inducer area (Figure 208) with corresponding rotational scoring on the impeller vane shroud line edge.

4.4 CONCLUSIONS

The teardown and examination of the right engine, S/N P-79214C, revealed that the type and degree of damage was indicative of an engine that was rotating and operating at the time of impact. No pre-existing condition was found that would have prevented normal operation.

The teardown and examination of the left engine, S/N P-79289C, revealed that the type and degree of damage was indicative of an engine that was rotating and operating at the time of impact. No pre-existing condition was found that would have prevented normal operation.