

Main Rotor Transmission Tear-down Inspection

Enstrom Model 280FX S/N 2099 N280MM, NTSB Investigation: WPR20LA191

Accident Date: 23 June 2020

Inspection Date: 29 March 2021

Report Date: 17 May 2022

Participants: Jesse Vos (Enstrom), William Taylor (Enstrom) Ronald Zeismer (Enstrom), Robyn Heidbrier (Enstrom), Albert Nixon (NTSB)

The inspection started at 6:30 am (CDT) on March 29th 2021. Mr. Nixon witnessed the inspection live via a video conference. The entire examination was recorded.

The transmission was received by Enstrom on 17 December 2020 and was secured in a locked cage to prevent contamination. The transmission was removed from the cage and transferred to the work area just prior to the inspection. The transmission was un-opened and in the original received state at the start of the inspection (Figure 1). Once the video conference was started the packaging was removed.



Figure 1. Un-Opened Transmission.

The main rotor mast and two of the three control tubes had been cut off 2 – 3 inches above the transmission housing. The third control tube was not present. The transmission was bolted to a section of the pylon; the pylon tubes had been cut 6 – 12 inches below the transmission. The upper pulley, tail rotor drive shaft coupling, and swashplate were still attached. The whole assembly exhibited damage consistent with a significant fire.

Teardown procedure – the procedure used to open the transmission is outlined below. Detailed findings on specific components are included in their own section of this report.

The tapered pin and tail rotor drive shaft (TRDS) coupling were removed. The tapered pin and tapered hole were not “oblanged” or worn.

The overrunning clutch is located inside the pulley between the pulley and the pinion shaft. Part of the pulley was melted onto the transmission housing and was cut away to see if the pulley would turn. The pulley was able to turn in the correct direction and “locked up” in the correct direction. Motion was smooth with no “notching” in the rotation.

The nut on the aft end of the pinion was removed, the nut was tight on the pulley. The P/N ECD014 upper jackstrut bearing was removed, and the pulley was pulled off the transmission. There was burnt grease and oil in the upper jackstrut bearing.

The pylon’s transmission basket was removed next. To facilitate the removal of the swashplate and collective walking beam (which were severally melted) the lug on the bottom of the transmission cover was cut off using a reciprocating saw.

It was noted that several of the nuts on the bottom of the transmission cover (for the bolts the secure the lower casing to the upper casing) were missing. We were unable to determine if this was a result of the fire or some other cause.

The seals and bearing retainer on the aft end of the transmission were removed and the pinion shaft was pulled from the transmission.

The upper cover was removed to gain access to the ring gear. The swashplate and control rod guide assembly was removed from the bottom of the transmission.

The bearing retainer on the bottom of the transmission was removed and the main rotor mast nut was removed, the nut was tight on the transmission.

The main rotor shaft was then removed from the ring gear carrier using a press. All the bearings were removed from the transmission. A heat gun and press were used to remove the bearings.

Overrunning Sprag Clutch

The overrunning clutch able to turn freely in the correct direction and lock-up in the correct direction. The clutch had burnt grease still packed around the ball bearings. The clutch was not removed from the pulley. There was no indication of any pre-impact problem with the overrunning sprag clutch.



Figure 2. Overrunning Sprag Clutch - Forward Side

Ring Gear and Pinion

No gear teeth were missing and none of the gear teeth looked to be damaged. The teeth were coated in a brittle layer of soot and corrosion. The corrosion was assumed to have formed after the post-crash fire. The shaft of the pinion did not show any evidence of spalling or wear under the bearings. The ring gear and pinion are shown in Figure 3.



(a) Ring Gear



(b) Pinion Gear Teeth



(c) Pinion Shaft

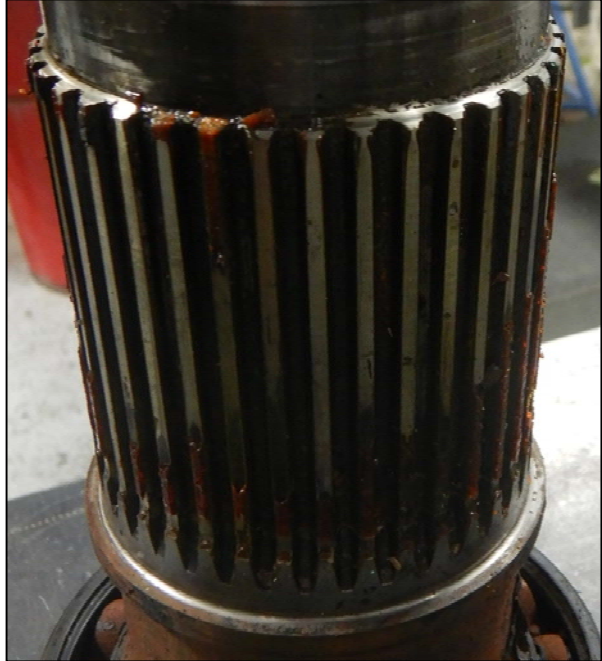
Figure 3. Ring Gear and Pinion

Main Rotor Shaft Splines

The splines on the ring gear carrier and main rotor shaft (Figure 4) were not missing any teeth and did not show any evidence of damage.



(a) Ring Gear Carrier



(b) Main Rotor Shaft

Figure 4. Main Rotor Splines

Transmission Bearings

A schematic of the transmission is shown in Figure 5 with the bearings labeled. All the bearings had a similar condition. Each bearing is discussed separately below.

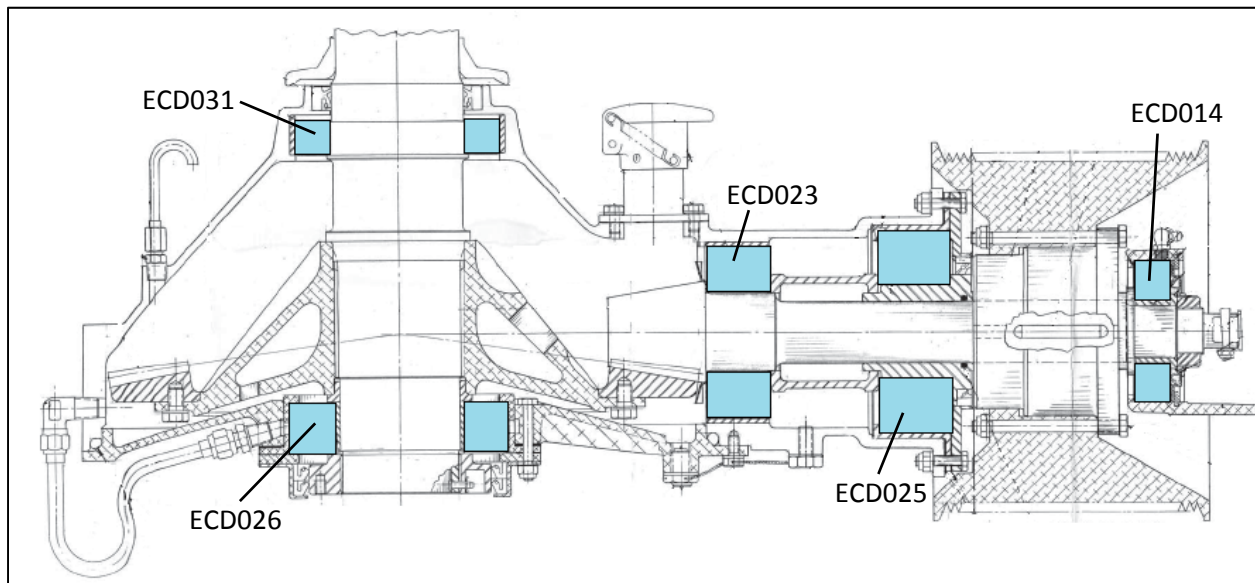


Figure 5. Transmission Bearing Locations

ECD026 Lower Main Rotor Mast Bearing

The bearing was coated burnt oil and some soot. The bearing was not able to turn which was attributed to the fire damage. There were no indications of wear or spalling on the inside of the outer race. The bearing is shown in Figure 6



(a) Un-Installed

(b) Installed

Figure 6. ECD026 Bearing

ECD031 Upper Main Rotor Mast Bearing

The top of the bearing was heavily corroded, this was attributed to the post-crash fire. The bearing was not able to turn. The bearing's cage was not broken, but it was corroded and coated in soot. There were no indications of wear or spalling on the inside of the outer race. The bearing is shown in Figure 7.

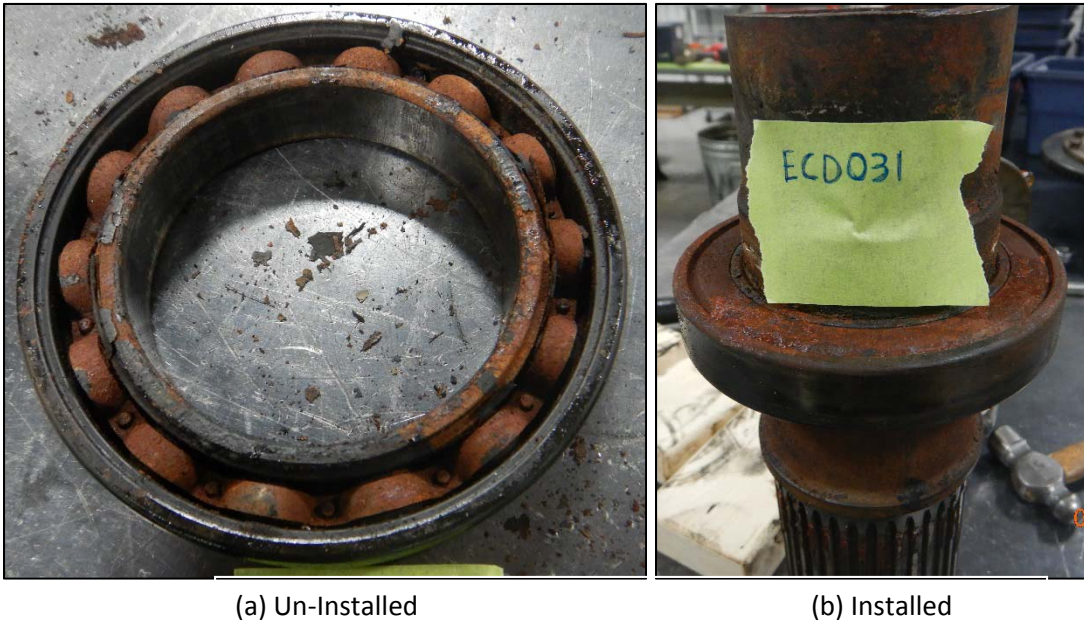


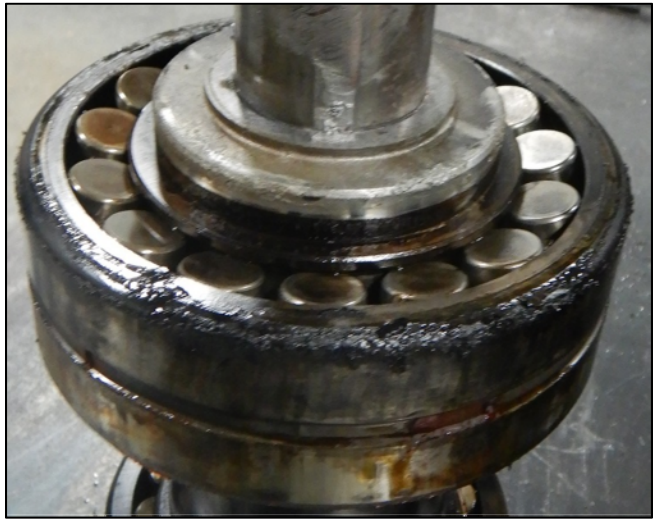
Figure 7. ECD031 Bearing

ECD025 Aft Pinion Bearing

The bearing was coated in burnt oil and some soot. The bearing was not able to turn which is attributed to the fire damage. There were no indications of wear or spalling on the inside of the outer race. The bearing is shown in Figure 8.



(a) Un-Installed



(b) Installed

Figure 8. ECD025 Bearing

ECD023 Forward Pinion Bearing

The bearing was coated in burnt oil and some soot. The bearing was not able to turn which is attributed to the fire damage. There were no indications of wear or spalling on the inside of the outer race. The bearing is shown in Figure 9.



(a) Un-Installed



(b) Installed

Figure 9. ECD023 Bearing

ECD014 Upper Jackstrut Bearing

The bearing was coated with soot and burnt grease. The bearing was not able to turn which is attributed to the fire damage and corrosion. The bearing's cage was not broken, and there were no indications of wear or spalling on the inside of the outer race. The bearing is shown in Figure 10.

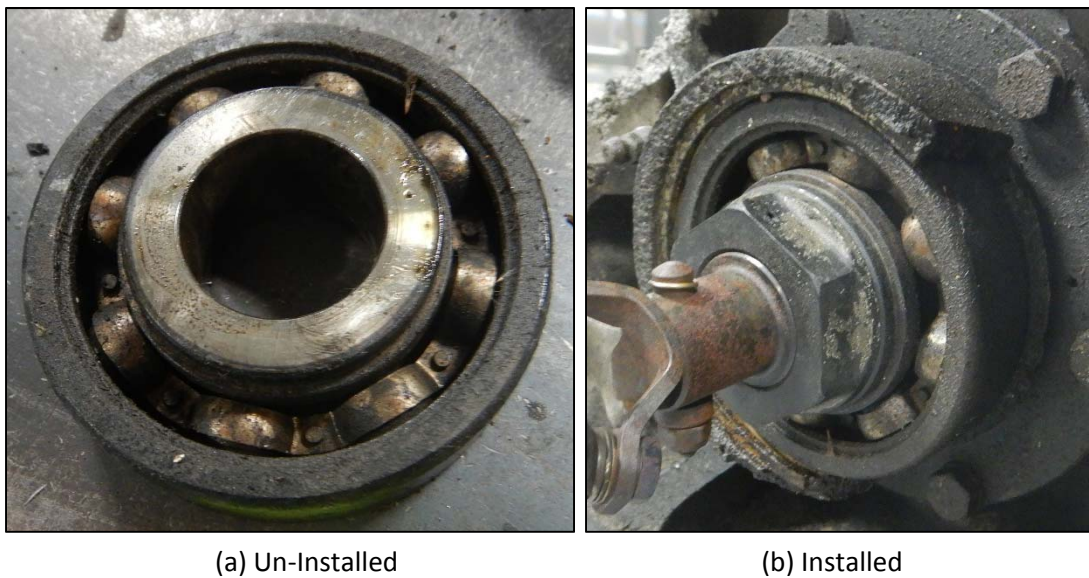


Figure 10. ECD014 Bearing

Discussion

All of the components exhibited damage consistent with a severe fire. There were no indications to suggest the transmission and overrunning clutch were not completely serviceable prior to the impact and post-crash fire.