

Material & Process Engineering Report

Report Title: Examination of a Broken Spring Pin, P/N A-3150-18, McCauley Governor Assembly, Model 421C, NTSB Investigation CEN24LA061

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Part Information

P/N	A-3150-18	Aircraft Model	421C
Part Description	Spring Pin	Aircraft S/N	Unknown
Part Serial Number	-	Hours of Flight	Unknown
Part Model Number	-	# of Landings	Unknown

Summary

This examination is to support NTSB Investigation CEN24LA061. Components of McCauley Governor Assy DCFS290D9 F/16, S/N 03-0213 were received by M&P for examination. The flight hours and number of landings were unknown. The purpose of this examination was to determine the mode of failure.

Based on the examination results, the following conclusions were drawn:

1. A-3150-18 Spring Pin was broken into multiple fragments. Representative fracture surfaces exhibited elongated dimples with no fatigue features. Thus, the mode of failure was determined to be shear overload.
2. Microstructure of the fractured spring pin appeared to be tempered martensite typical for plain carbon and low-alloy steels in the quenched + tempered condition.
3. A Pb + Br deposit was observed on both OD and ID surface of the Gear – Drive (P/N D-20594) at its gear teeth end.
4. The gear teeth end of the gear – drive is not in contact with the Spool – Pilot (P/N B-20595) during operation. Thus, the deposit did not contribute to the fracture of the spring pin.
5. Approximate dimensions of the spool – pilot were measured to be consistent with the engineering drawing requirements.
6. The inside diameter of the gear – drive was measured to be approximately [REDACTED] at its gear teeth end, which was slightly smaller than the required range ([REDACTED]) per the engineering drawing. This was attributed to the presence of the deposit on the ID surface.

Background

This examination is to support NTSB Investigation CEN24LA061. Components of McCauley Governor Assy DCFS290D9 F/16, S/N 03-0213 were received by M&P for examination. Among the components, A-3150-18 Spring Pin was broken into multiple fragments. The spring pin is used to pin B-20595 Spool – Pilot to B-20573 Spool – End Fitting. The spool – pilot is a non-rotating component that is housed inside the rotating D-20594 Gear – Drive. The flight hours and number of landings were unknown.

An excerpt from the engineering drawing of the D-20741 Governor Assembly-DCFS, B-20595 Spool – Pilot, and D-20594 Gear – Drive is presented in Figures 1-3, respectively. According to the engineering drawing, the B-20595 Spool – Pilot is required to be machined from [REDACTED] steel and carburized [REDACTED] deep at a hardness of [REDACTED]. The D-20594 Gear – Drive, however, is required to be machined from [REDACTED] steel and carburized per AMS2759/7, [REDACTED]. Moreover, the case depth is required to be [REDACTED] after final machine.

M&P was authorized to conduct limited destructive testing on the parts.

Examination Results

A-3150-18 Spring Pin, B-20595 Spool – Pilot, and B-20573 Spool – End Fitting

Figure 4 depicts images of the components from the Governor Assembly-DCFS (P/N D-20741) in the condition in which they were received by M&P. The A-3150-18 Spring Pin was broken into multiple fragments. The spring pin is used to pin B-20595 Spool – Pilot to B-20573 Spool – End Fitting. Optical and SEM images from the OD surface of the spool – pilot are shown in Figure 5. Shallow indentations and a gold-colored residue were observed near the hole for the spring pin insertion. EDS examination revealed that the gold-colored residue contained C, O, Pb, and Br (see Figure 6).

Figure 7 illustrates optical images from the two races in Figure 4. During operation, the ID surface of both the races was in contact with the OD surface of the spool – pilot. Metal dislodged from the OD surface of the spool – pilot (shallow indentations in Figure 5) was observed on the ID surface of both the races (Figure 7). Optical images from the OD surface of the B-20573 Spool – End Fitting are depicted in Figure 8. No foreign material was observed.

Figure 9 illustrates SEM micrographs from the OD surface of the large fragment from the broken Spring Pin (P/N A-3150-18). Elongated dimples on Fracture Surface C suggested a shear overload failure mode. A crack with an approximate length of 0.03" was observed on the OD surface. Elongated dimples indicative of the shear overload were also observed on Fracture Surfaces A and B, as shown in Figures 10 and 11, respectively.

D-20594 Gear – Drive

Figure 12 depicts images of the as-received Gear – Drive (P/N D-20594) from the Governor Assembly-DCFS (P/N D-20741) before and after sectioning. During operation, the non-rotating B-20595 Spool – Pilot in Figure 4 is housed inside the rotating D-20594 Gear – Drive. A dark deposit was observed on both OD and ID surface of the gear – drive at its gear teeth end. SEM micrographs from the dark deposit are shown in Figure 13. From EDS examination, the deposit was determined to mainly contain Pb and Br (see Figure 14).

Optical images from cross-section of the gear – drive (Section X-X in Figure 12) after etching with 2 % Nital reagent are illustrated in Figure 15. The typical depth of the dark deposit on the OD and ID surface was measured to be approximately 0.0002” and 0.0007”, respectively.

Material Characterization

Approximate dimensions of the Spool – Pilot (P/N B-20595) were measured to be consistent with the engineering drawing requirements (see Figure 2). The inside diameter of the Gear – Drive (P/N D-20594) was measured to be approximately [REDACTED] at the gear teeth end and [REDACTED] at the other end (see Figure 3). The former was slightly smaller than the required range ([REDACTED]) per the engineering drawing. This was attributed to presence of Pb + Br deposit on the ID surface at the gear teeth end, as shown in Figures 12 and 15. It should be noted that the gear teeth end of the D-20594 gear – drive is not in contact with the B-20595 spool – pilot during operation. Thus, the deposit did not contribute to the fracture of the A-3150-18 Spring Pin.

The typical depth of the carburized layer (case) was measured to be approximately [REDACTED] for the gear – drive (see Figure 15), which was within [REDACTED] range specified in the engineering drawing. Microstructure of the case and core regions appeared to be tempered martensite and ferrite + pearlite, respectively, as shown in Figure 16. Both the microstructures are typical for the case and core regions of carburized low-alloy steels.

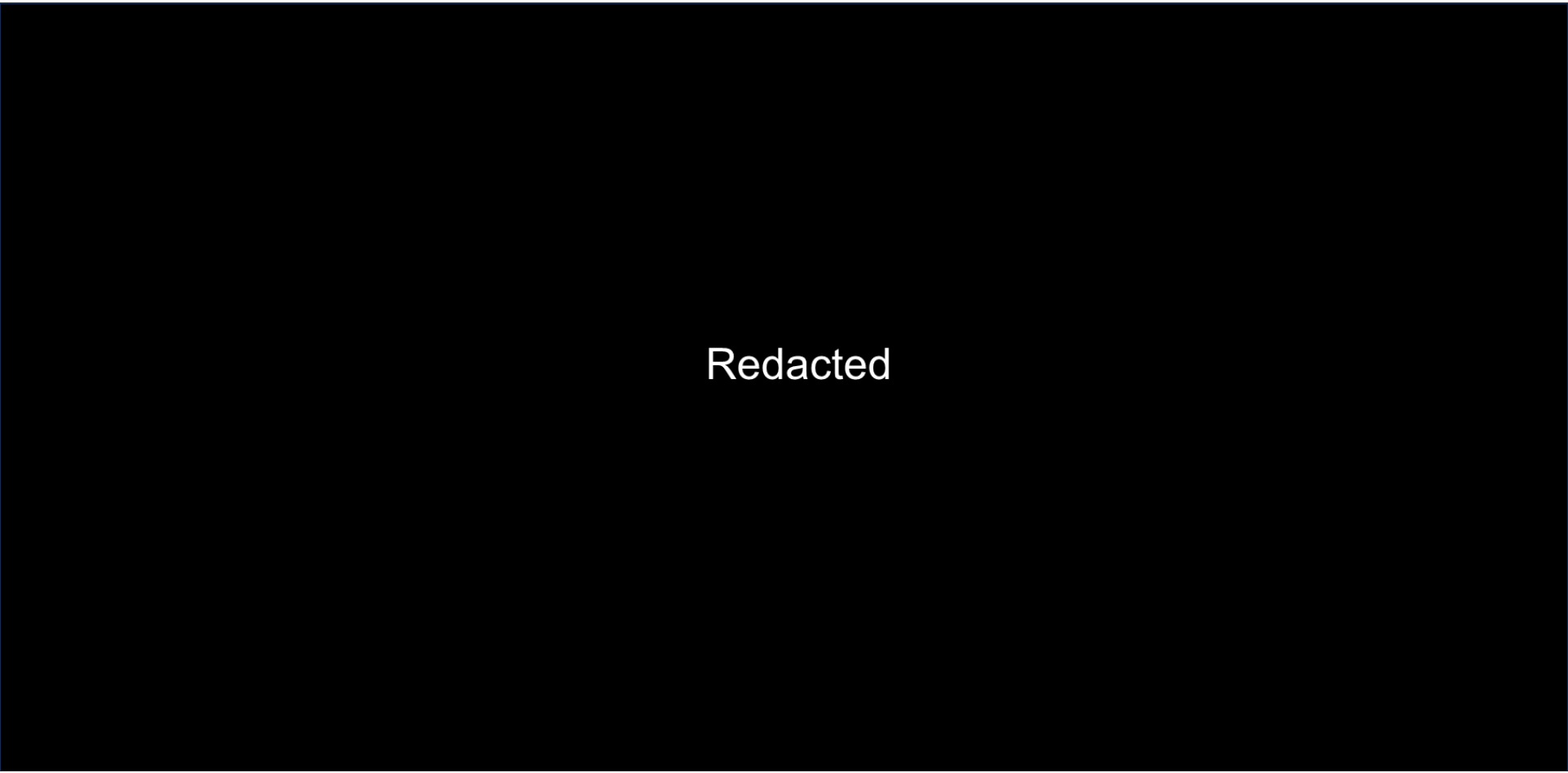
Micro-hardness of the fractured spring pin (P/N A-3150-18) was measured to be 550-581 HK, which approximately corresponds to 50-52 HRC per ASTM E140. Figure 17 shows typical EDS spectrum and optical image from microstructure of the fractured spring pin. The EDS pattern is typical for plain carbon and low-alloy steels. Moreover, the observed microstructure appeared to be tempered martensite typical for plain carbon and low-alloy steels in the quenched + tempered condition. The required material and hardness for the spring pin were not provided.

No other examinations were conducted.



Redacted

Figure 1. An excerpt from the engineering drawing of the Governor Assembly-DCFS (P/N D-20741). B-20596 assembly (highlighted in yellow) and D-20594 Gear-Drive were examined in this report. The B-20596 assembly includes B-20595 Spool – Pilot, B-20573 Spool – End Fitting, and A-3150-18 Spring Pin.



Redacted

Figure 2. An excerpt from the engineering drawing of the Spool – Pilot (P/N B-20595). The measured approximate dimensions (blue font color) were consistent with the required ranges per engineering drawing (black font color).



Redacted

Figure 3. An excerpt from the engineering drawing of the Gear – Drive (P/N B-20594). The inside diameter was measured to be approximately 0.3748” at the gear teeth end and 0.3750” at the other end. The former was slightly smaller than the required range () per the engineering drawing.

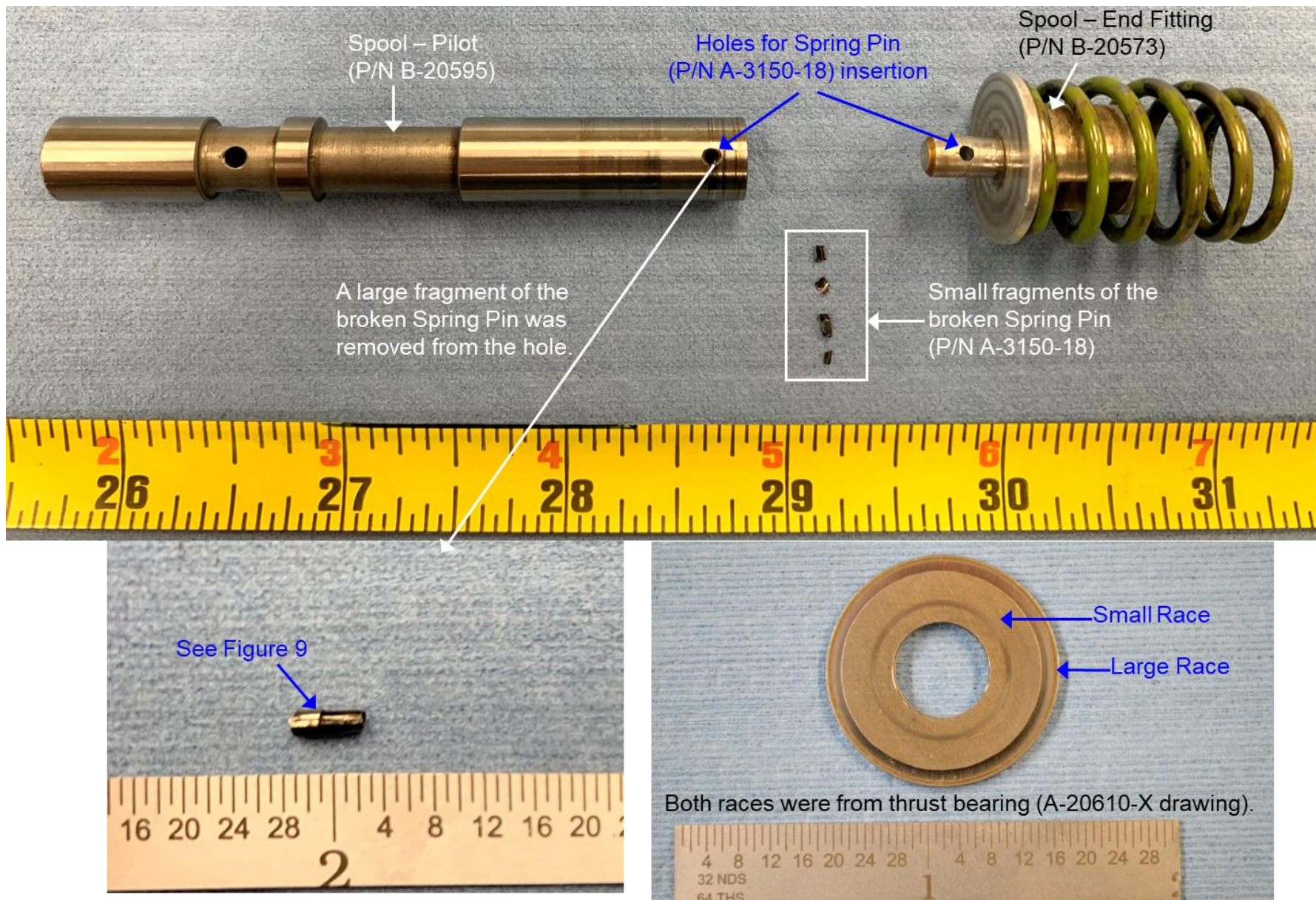


Figure 4. Images of the components from the Governor Assembly-DCFS (P/N D-20741) in the condition in which they were received by M&P. B-20595 Spool - Pilot and B-20573 Spool - End Fitting are cross-pinned with an A-3150-18 Spring Pin. Two races from the A-20610-X Thrust

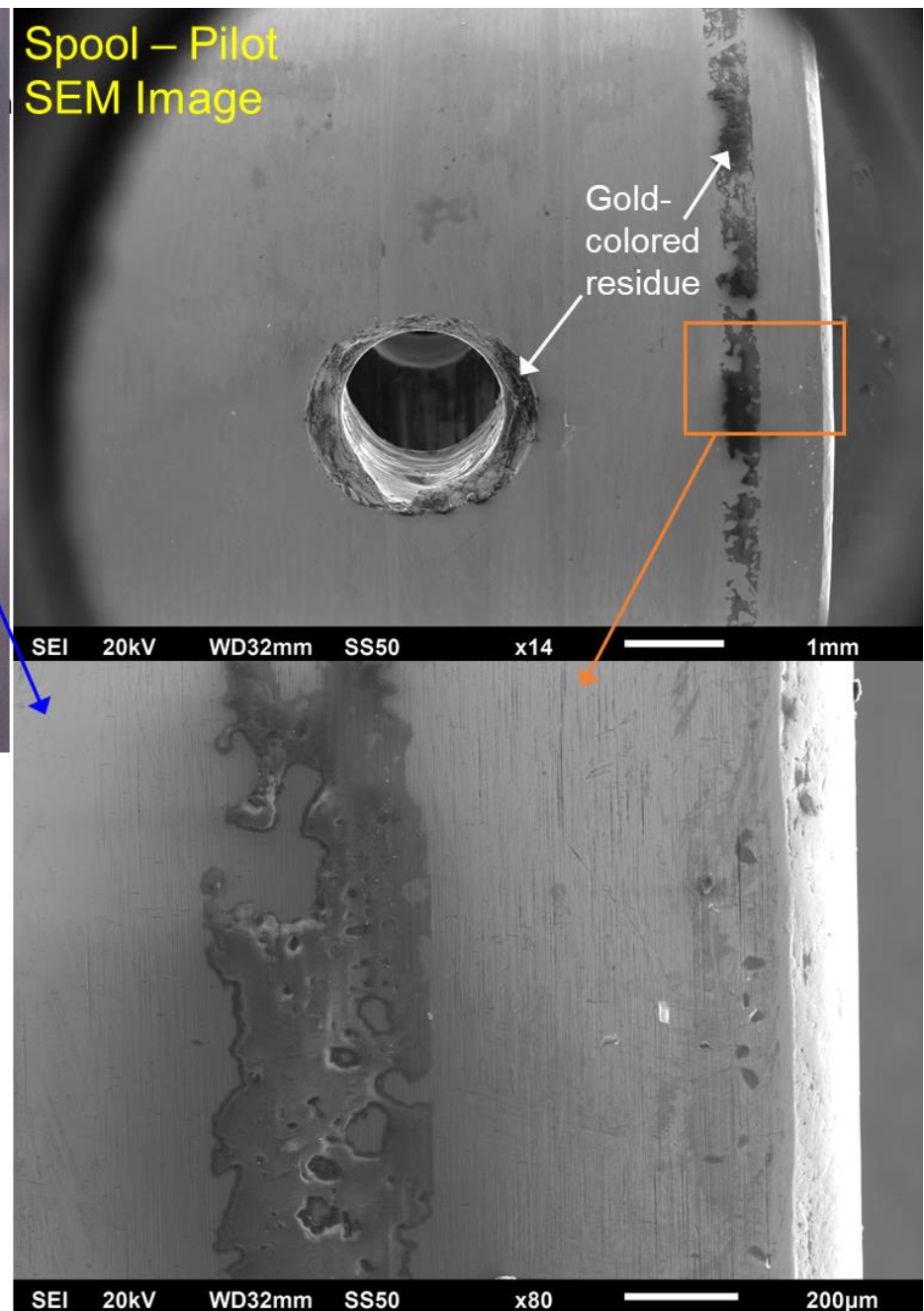
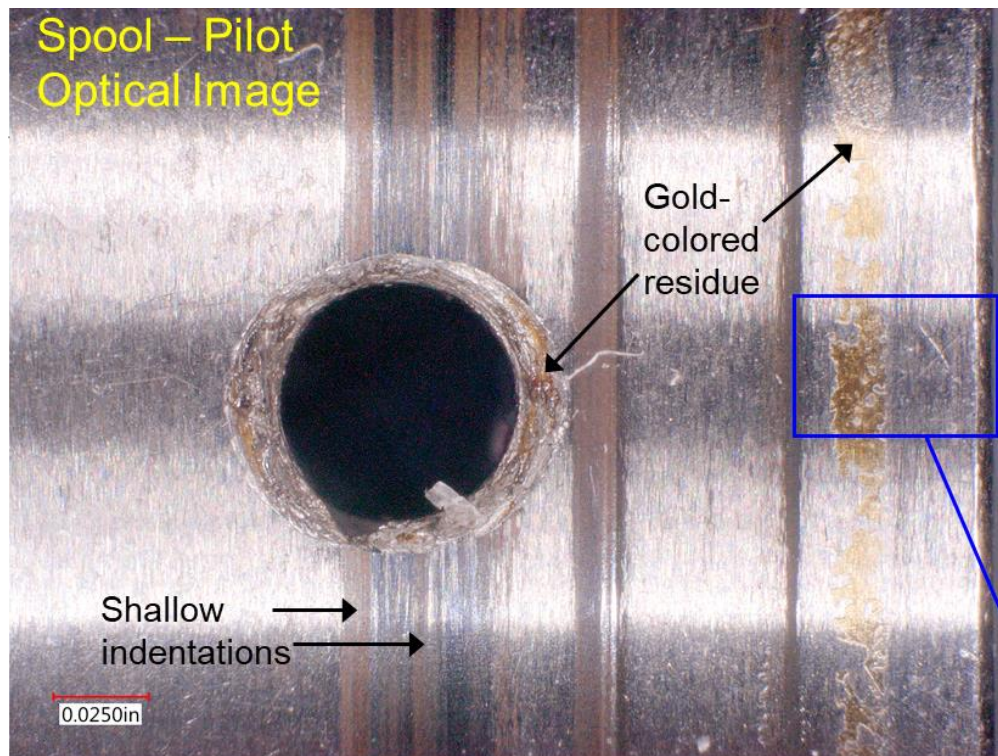


Figure 5. Optical and SEM images from the OD surface of the B-20595 Spool – Pilot. Shallow indentations and a gold-colored residue were observed near the hole for the Spring Pin insertion. Magnifications: x14, x20, and x80.

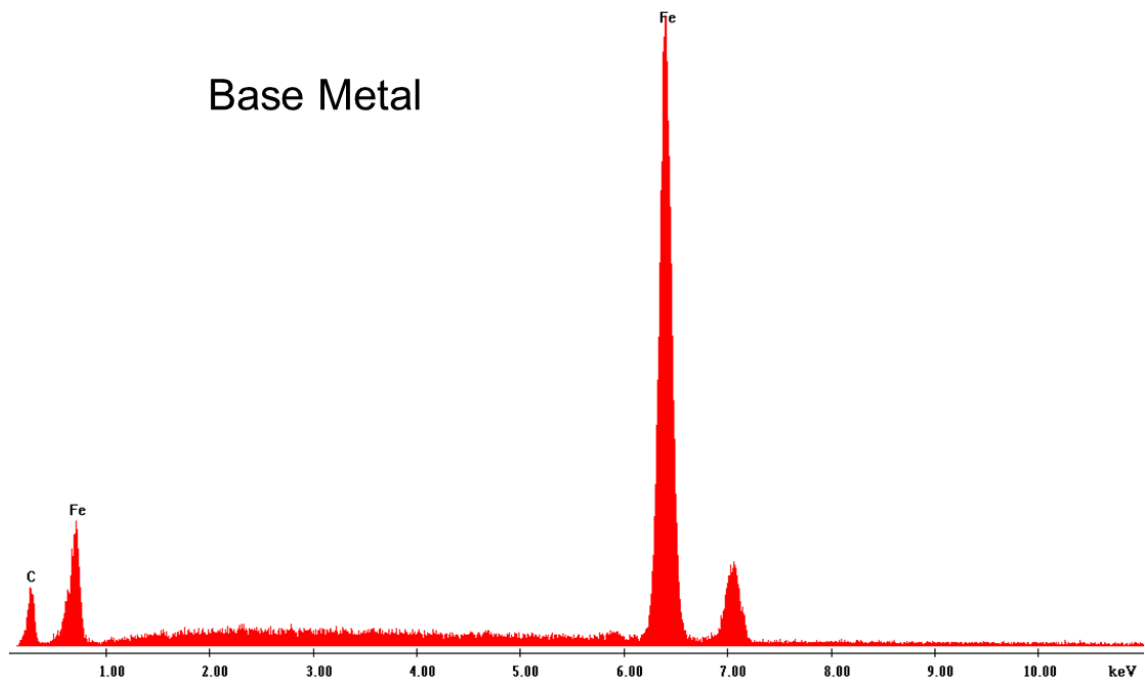
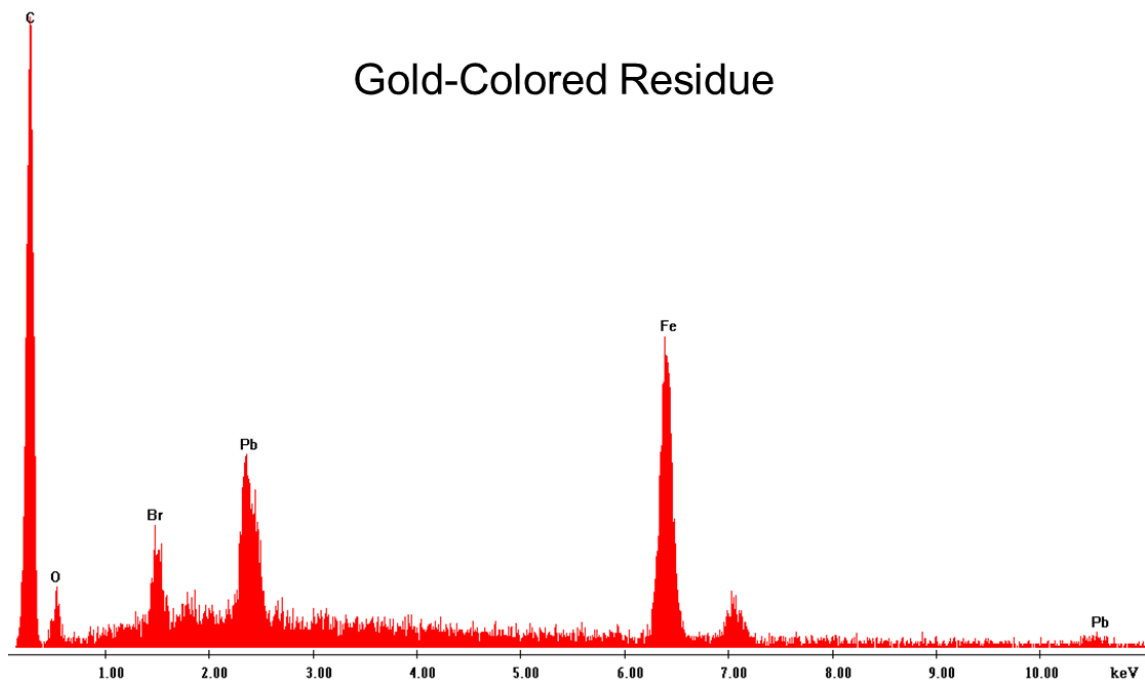


Figure 6. Typical EDS spectra from the gold-colored residue and base metal in Figure 4. The residue contained C, O, Pb, and Br.

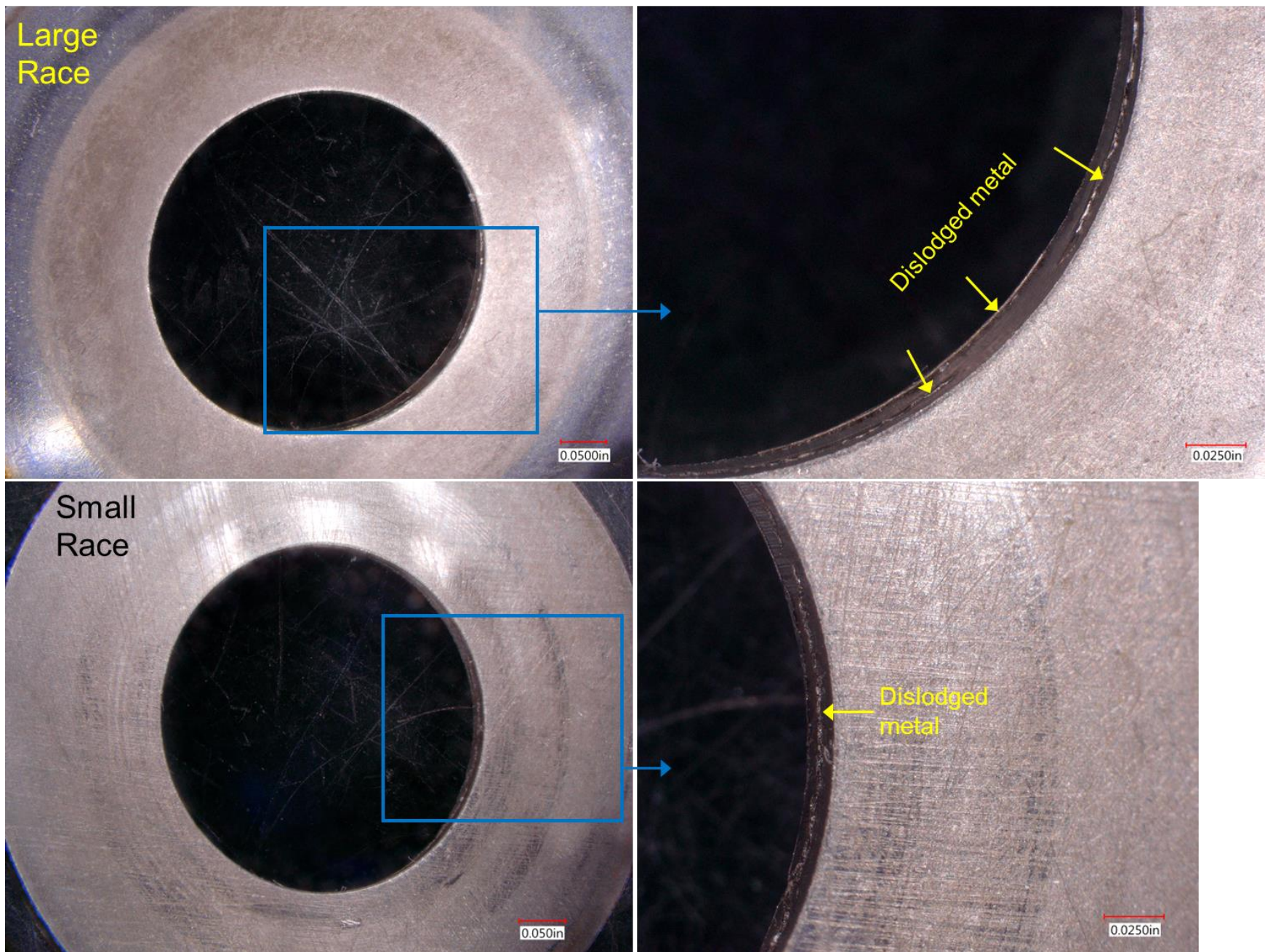


Figure 7. Optical images from the two races in Figure 5. Both the races were tilted before imaging. Metal dislodged from the OD surface of the B-20595 Spool – Pilot (shallow indentations in Figure 4) was observed on the ID surface of both the races. Magnifications: x7 and x17.

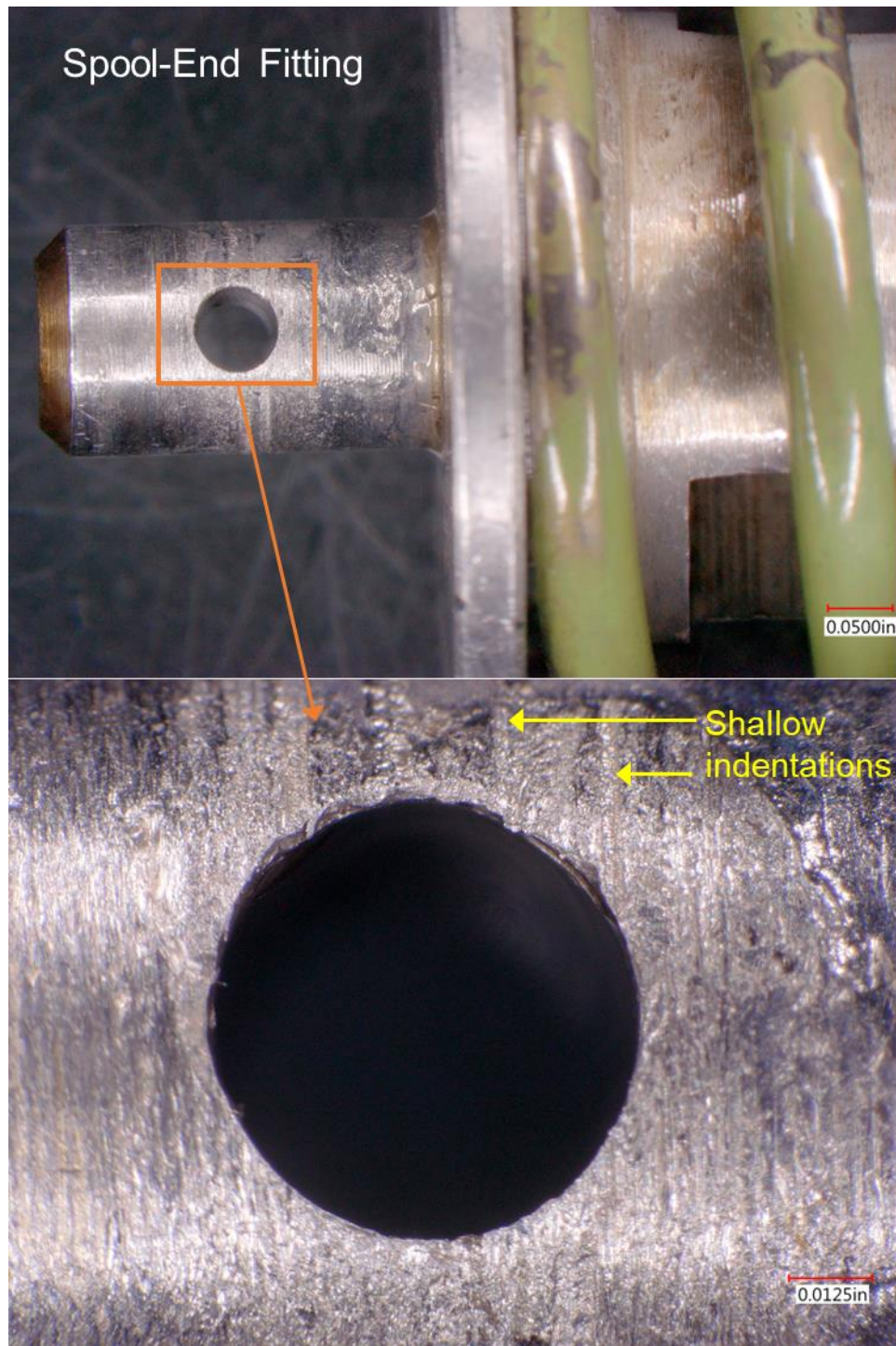


Figure 8. Optical images from the OD surface of the B-20573 Spool – End Fitting. Shallow indentations were observed near the hole for the spring pin insertion with no foreign material being present. Magnifications: x7 and x37.

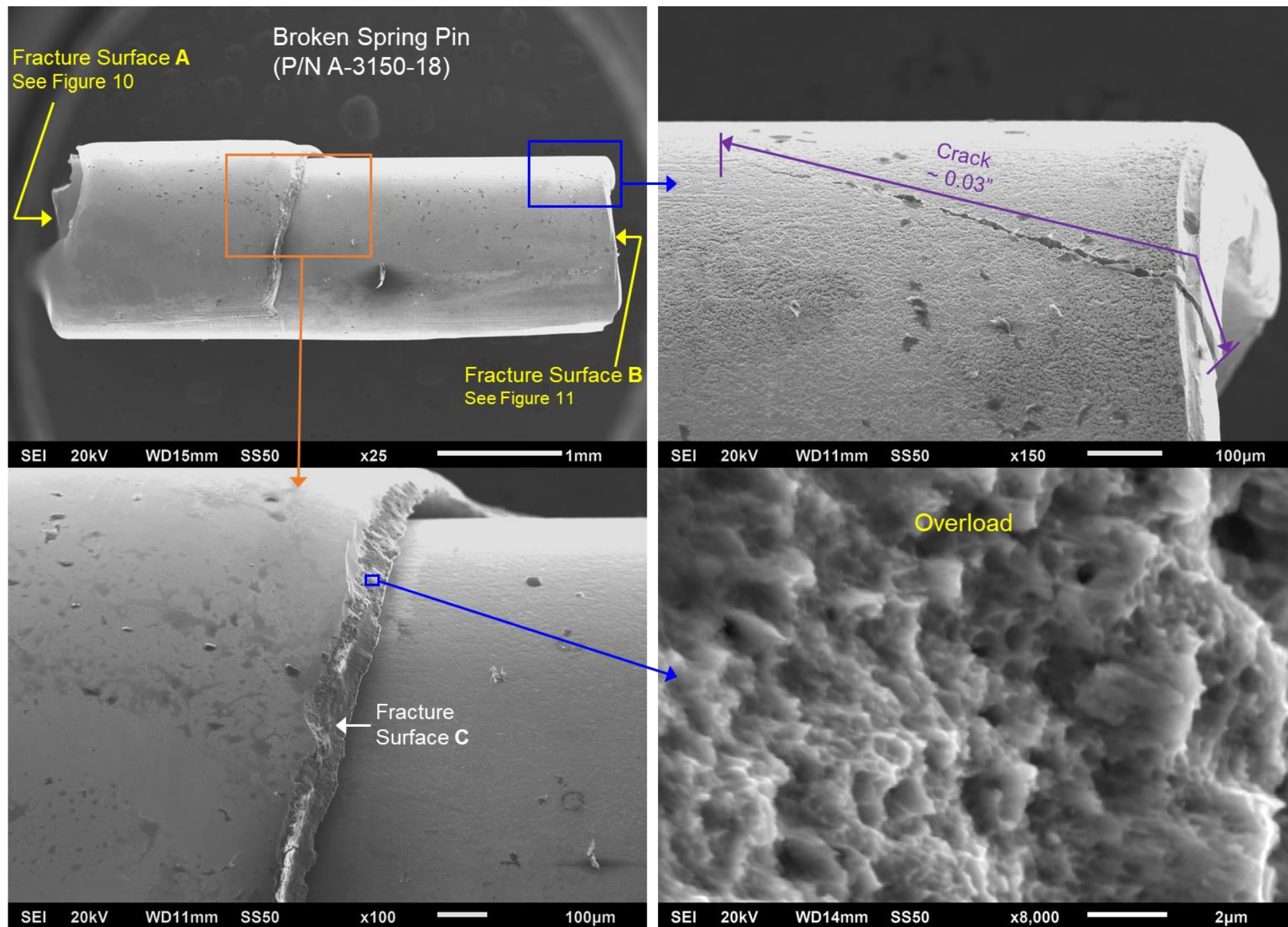


Figure 9. SEM images from the OD surface of the large fragment from the broken Spring Pin (P/N A-3150-18) in Figure 4. Elongated dimples on the Fracture Surface C suggested a shear overload failure mode. A crack with an approximate length of 0.03" was also observed.

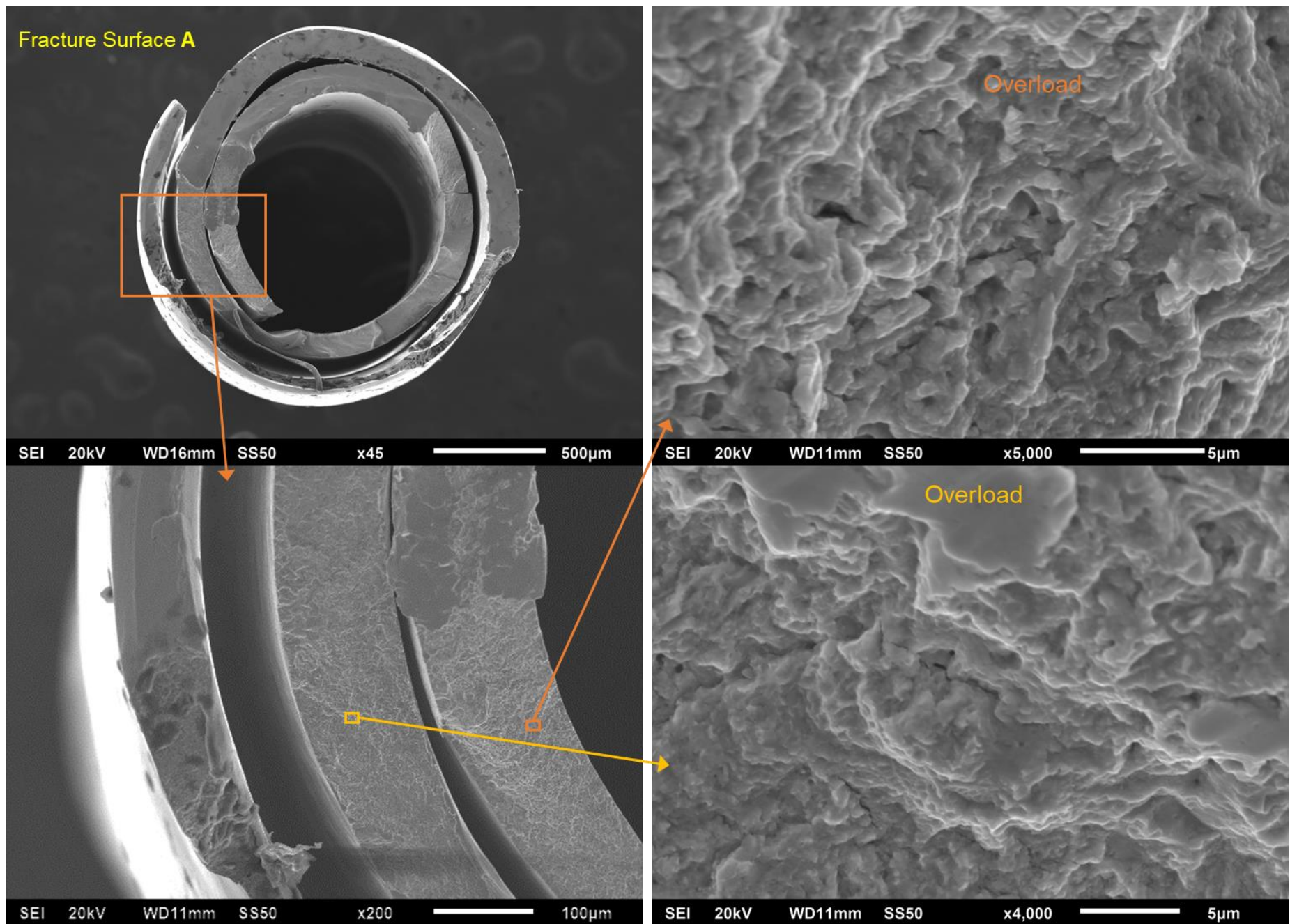


Figure 10. SEM micrographs from Fracture Surface A in Figure 9. Elongated dimples on the fracture surface suggested a shear overload failure mode.

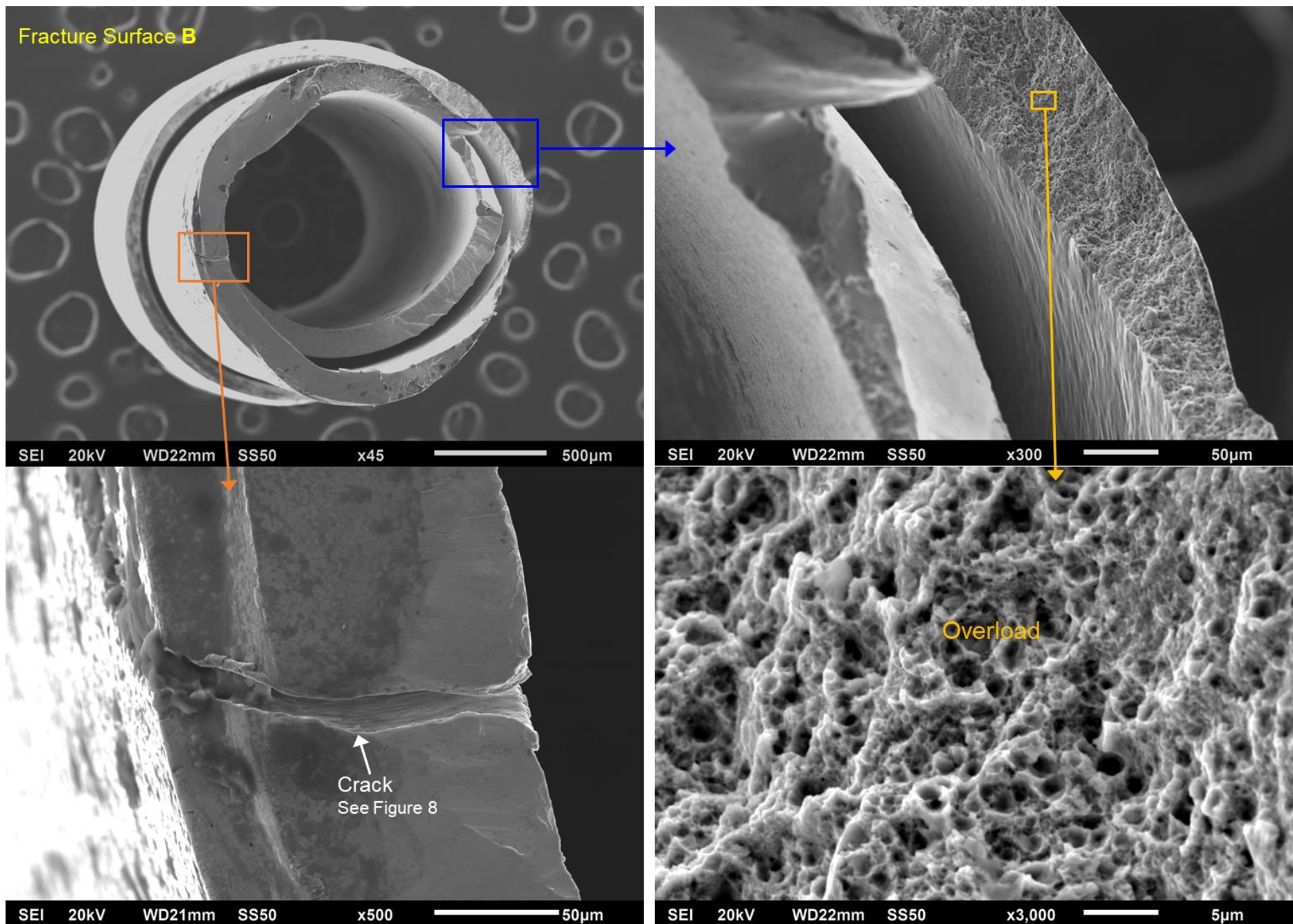


Figure 11. SEM micrographs from Fracture Surface B in Figure 9. Elongated dimples on the fracture surface suggested a shear overload failure mode.

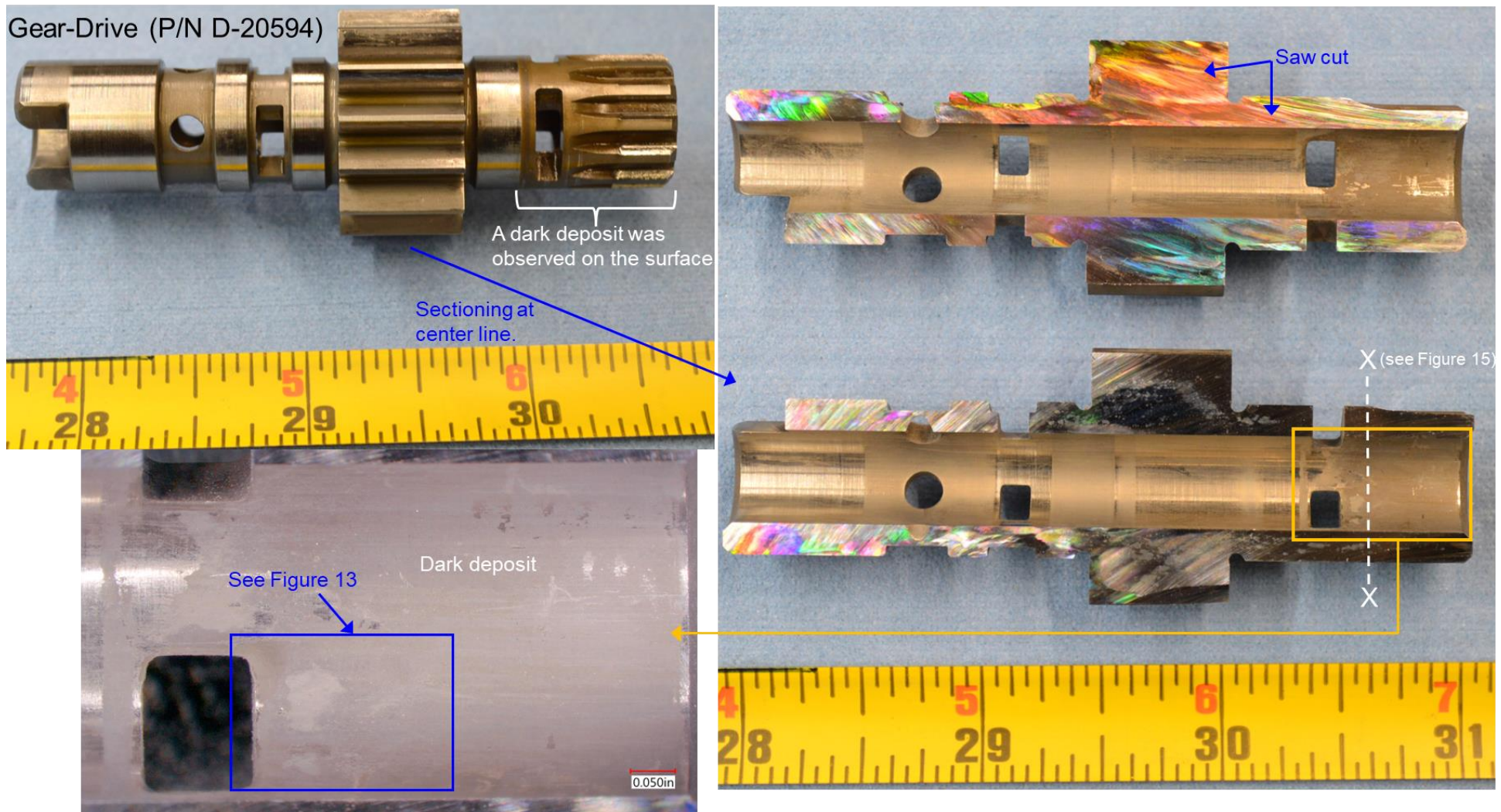


Figure 12. Images of the as-received Gear – Drive (P/N D-20594) from the Governor Assembly-DCFS (P/N D-20741) before and after sectioning. In operation, the non-rotating B-20595 Spool – Pilot in Figure 4 is housed inside the rotating D-20594 Gear – Drive. A dark deposit was observed on both OD and ID surface of the gear – drive at its gear teeth end. Magnifications: x1.5 and x6.0.

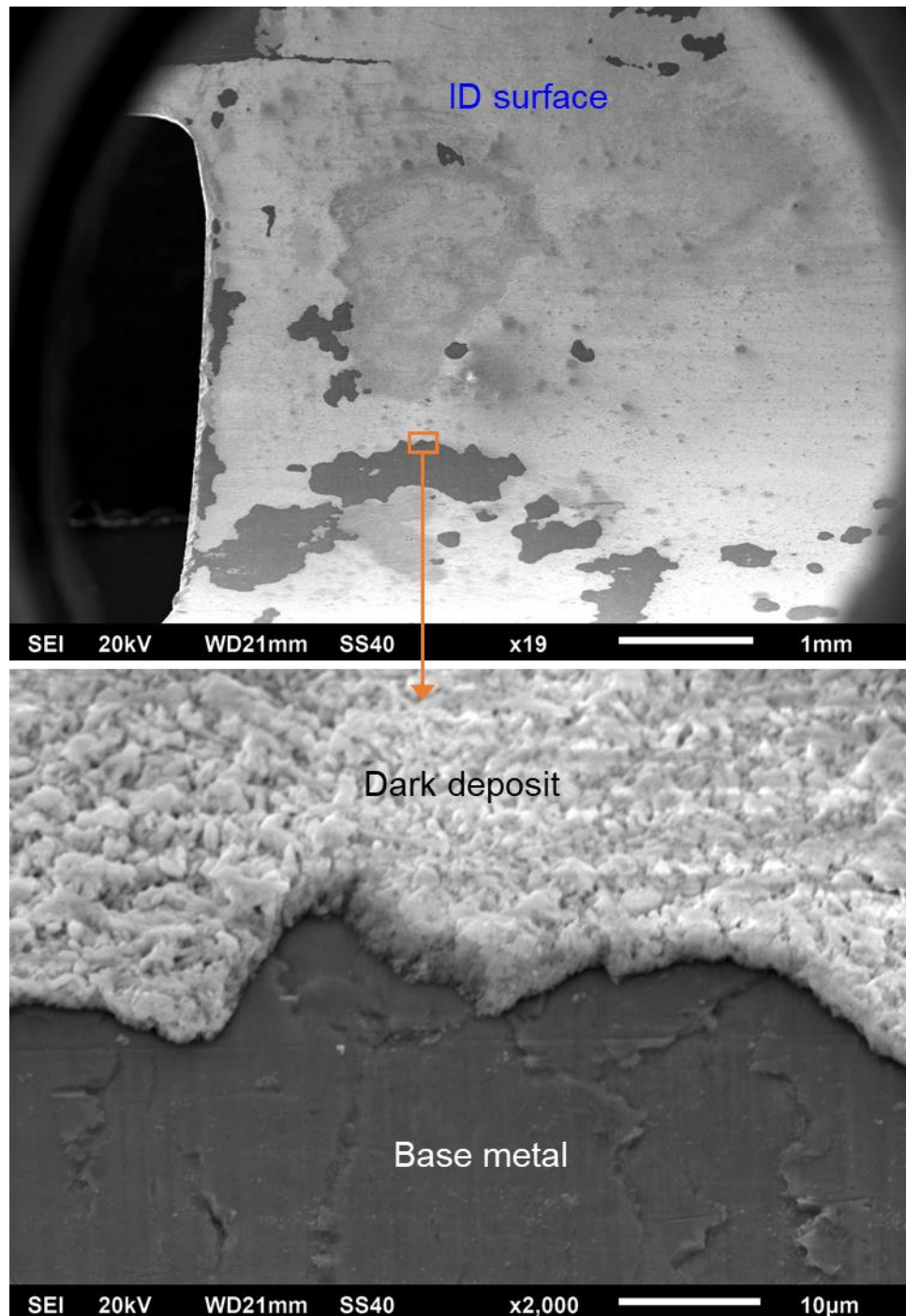


Figure 13. SEM micrographs from the ID surface of the D-20594 Gear – Drive (blue rectangle in Figure 12). Under electron microscopy, the dark deposit appeared lighter (in color) than the base metal.

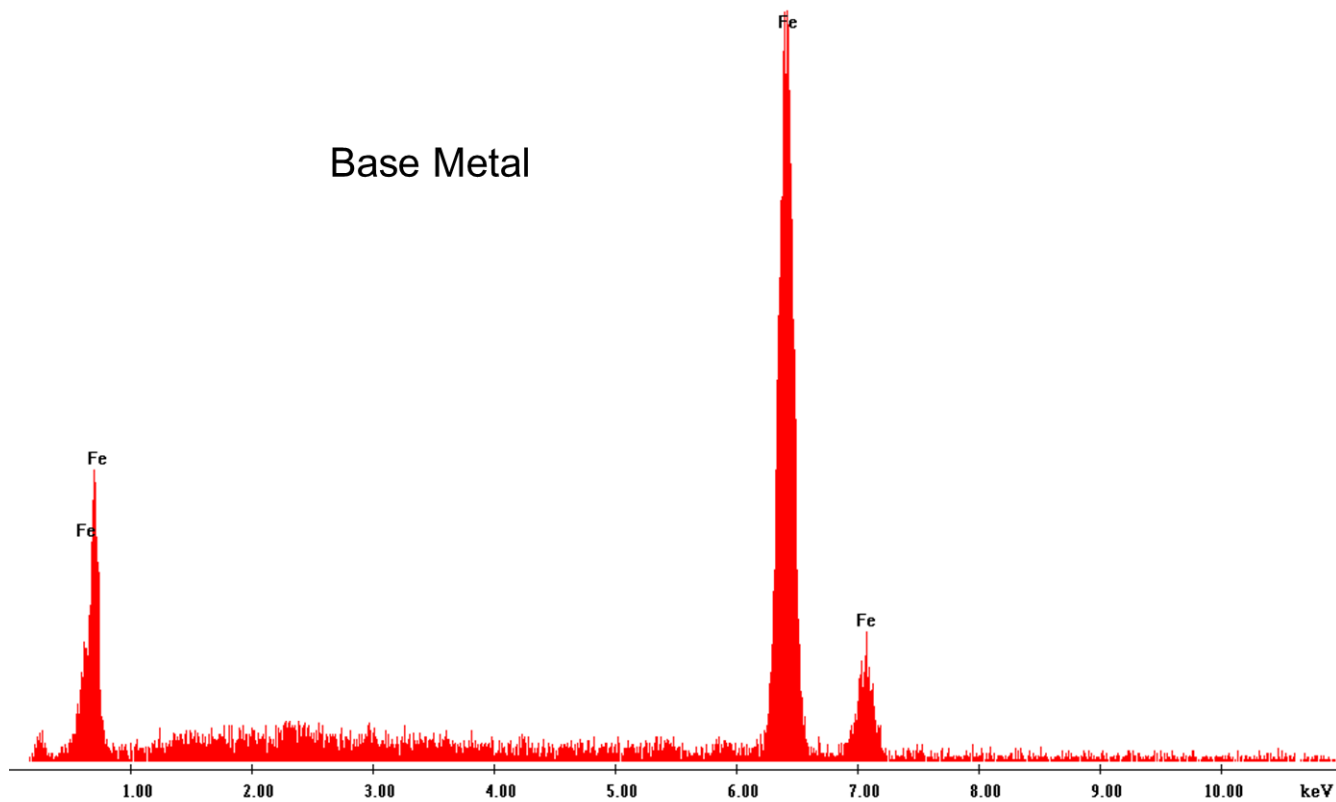
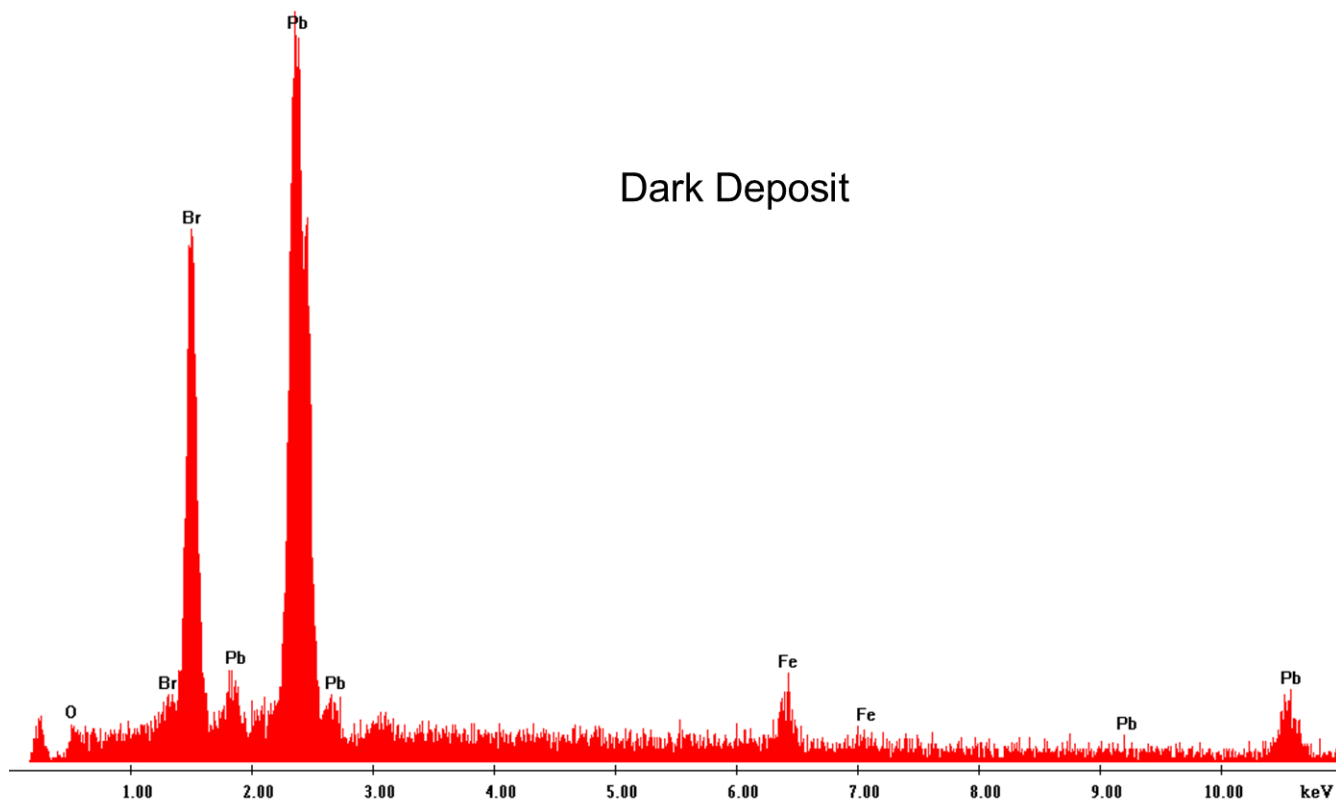


Figure 14. Typical EDS patterns from the dark deposit and base metal in Figure 13.

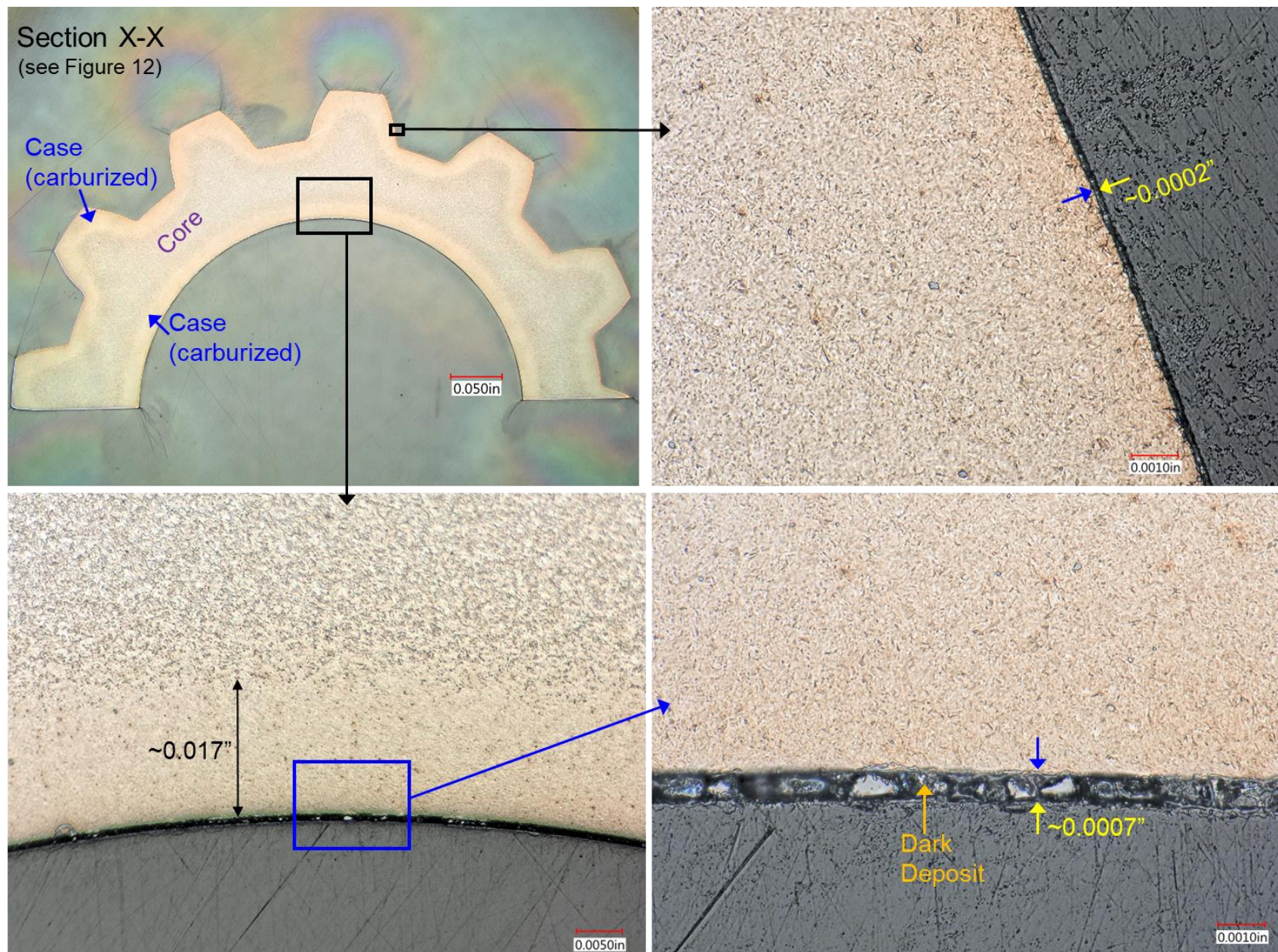


Figure 15. Optical images from the cross-section of the gear – drive (Section X-X in Figure 11) after etching with 2 % Nital reagent. The typical depth of the dark deposit on the OD and ID surface was measured to be approximately 0.0002" and 0.0007", respectively. The typical depth of the carburized layer (case) was measured to be approximately [REDACTED], which was within [REDACTED] range specified in the engineering drawing. Mount Index No. 4634. Magnifications: x7, x62, and x310.

24-359-183 Rev -

Case
(carburized)



Core

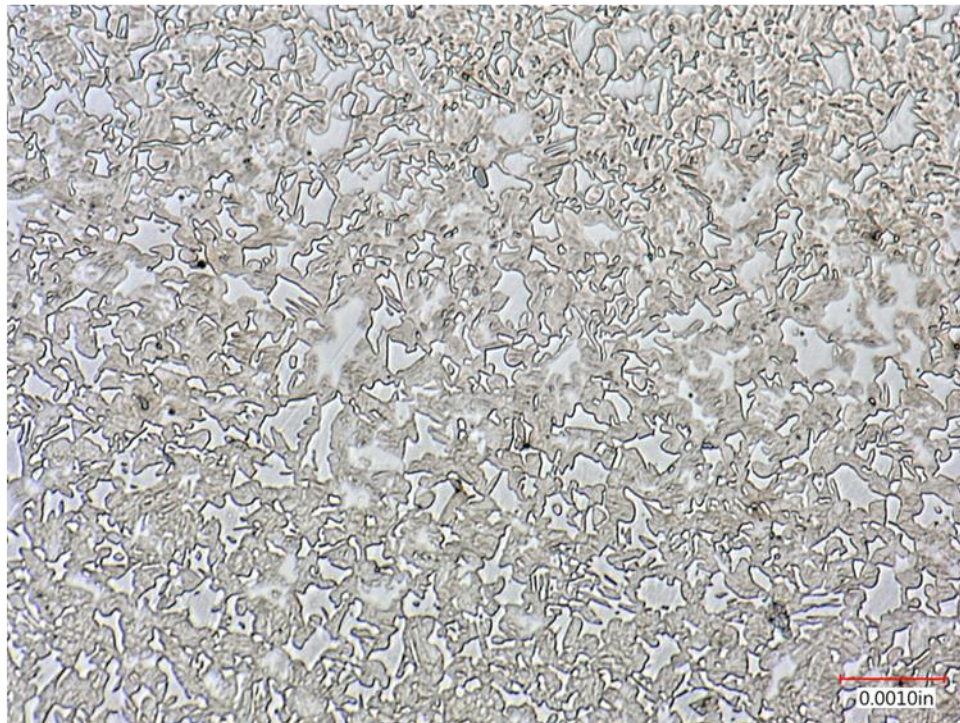
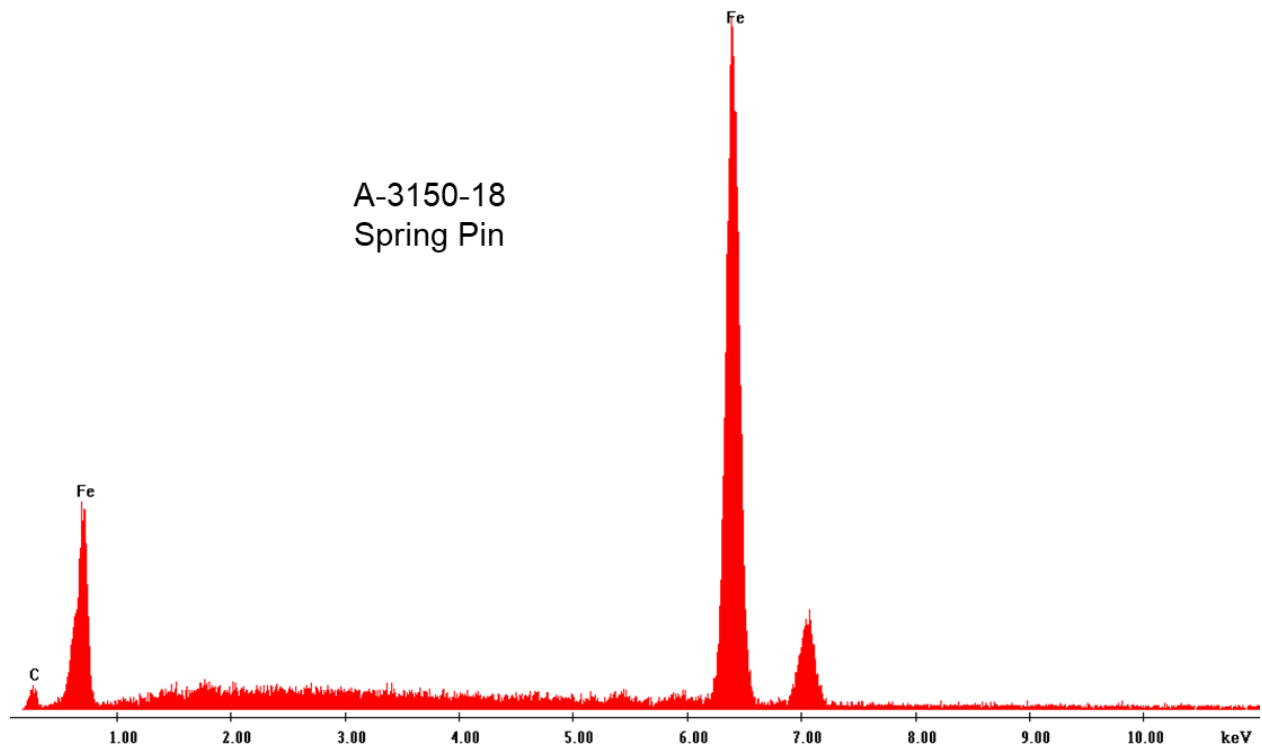


Figure 16. Typical optical images from the case and core regions in Figure 14. Microstructure of the case and core appeared to be tempered martensite and ferrite + pearlite, respectively. Both the microstructures are typical for the case and core of carburized low-alloy steels. Mount Index No. 4634. Magnifications: x700 and x540.



A-3150-18
Spring Pin



Figure 17. Typical EDS spectrum (top) and optical image from microstructure (bottom) of the fractured spring pin (P/N A-3150-18). 2 % Nital reagent as used for etching. The EDS pattern is typical for plain carbon and low-alloy steels. Microstructure appeared to be tempered martensite typical for plain carbon and low-alloy steels in the quenched + tempered condition. Mount Index No. 4637. Magnification: x720.