

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ERA22LA054

MATERIALS LABORATORY

Factual Report 22-088

November 18, 2022

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A. ACCIDENT INFORMATION

Location: Sarasota, Florida
Date: November 9, 2021
Vehicle: Piper PA-28-151, N40831, S/N: 28-7415092
Investigator: Robert Gretz, ASI-ERA

B. COMPONENTS EXAMINED

Throttle cable assembly.

C. EXAMINATION PARTICIPANTS

Specialist Donald Kramer
NTSB
Washington, DC

D. DETAILS OF THE EXAMINATION

A throttle cable assembly was submitted to the NTSB Materials Laboratory for examination as shown in figure 1. The cable had seized and no longer moved in the longitudinal direction. The two ends of the assembly are shown in figure 2 and a cross section through the cable is shown in figure 3. By design, one end of the cable was connected to an arm on the throttle assembly, used to control a butterfly valve, by means of a spherical bearing rod end, as shown in figure 2a. The opposite end was connected to the throttle control lever in the cabin by means of a clevis fitting, shown in figure 2b. Each end fitting was attached to a solid guide rod that travelled inside a sleeve. The end of each guide rod was connected to an inner cable (described below) that travelled inside a cable housing. A ferrule at each end of the housing joined the sleeves to the housing. Polymeric boots covered both ends of the sleeves: one where the guide rod entered the sleeve and the other at the sleeve/ferrule transition. As seen in figure 3, the cable assembly consisted of the 7-wire inner cable, an inner lining, a flexible helical winding, and an outer protective layer of helical wires.

The cable was sectioned through the midpoint and the two inner wire sections were pulled free of the housing, as shown in figure 4. The cables were covered with oil and grease and were subsequently cleaned with organic solvents. A close-up image of the two ends after cleaning is shown in figure 5. Near the throttle attachment end, six of the seven wires had separated, with only the central wire still intact. Four of the wires, anchored by the guide rod, were separated approximately 2-3/4 inch from the rod end. The wire ends tapered to a knife's edge, consistent with separation due to wear. Closer to the end of the guide rod, two additional wires (5th and 6th wires) were separated, as shown in the top image of figure 6. One separation, indicated by the yellow square, was located approximately 0.35 inch from the rod

end and the other separation, indicated by the yellow circle, was located approximately 0.63 inch from the rod end. The wires were flattened on one side, consistent with wear, but were also fractured in the transverse direction.

The opposing separated wire ends, on the side leading to the throttle control lever, were also examined. As indicated in figure 5, approximately 1-3/4 inch from the end of the guide rod there were 5 separated wire ends that exhibited knife edge separation, similar to the four knife edge separations previously described. As seen in the image, the opposing knife edge separations overlapped one another by approximately 1 inch. A sixth wire end, indicated by the yellow square in the lower image of figure 6, overlapped the end of the guide rod by approximately 0.10 inch. The section profile of this separated wire most closely matched the fractured end indicated by the yellow square in the top image (0.35 inch from the rod end). A length of one wire, from the fractured end indicated by the yellow circle in figure 6 to one of the five knife edge separations, was unaccounted for.

An image of the inner cable at the opposite end (near the throttle control lever), is shown in the lower part of figure 5. Some wires were buckled and the cable had partially unfurled (ballooned).

The ferrule at the end of the cable leading the throttle arm was sectioned and removed to examine the inside of the guide rod sleeve and the cable housing. An image of the ferrule with the polymer boot removed is shown in figure 7. Yellow-dashed lines indicate the location of the cuts. A circumferential cut was made adjacent to a crimp along the outer diameter used to capture the guide rod sleeve and two longitudinal cuts were made along the crimp used to capture the cable housing. The ferrule was pried open and the cable housing was removed. Figure 8 shows the guide rod sleeve and cable housing after sectioning and removing the ferrule. As shown in figure 9a, the flared end of the guide rod contained pieces of a black plastic material and a wire fragment. As shown in figure 9b and compared with the cross section in figure 3, the inner lining was missing at the end of the housing.

The cable housing was then disassembled. The outer wires were unwound from the helical winding and cut back with an abrasive disk approximately 3-3/4 inch from the end. The helical winding was sectioned with the abrasive disk near the location of the wire cuts. The winding was then pulled off the inner liner. The disassembled housing is shown in figure 10a.¹ As shown in figure 10b, the inner surface of the helical winding exhibited wear marks. The inner liner no longer extended to the end of the housing but rather ended approximately 0.32 inch before the end (estimated on a calibrated image). As seen in figure 11, the liner was split

¹ The helical winding was expanded in torsion near the end in order to observe the condition of its inner diameter surface. This caused the deformation to and fracture of the winding seen in the image.

along a helical path extending approximately 1.36 inch from the end of the remnant liner end.

E. ATTACHMENTS

Materials Laboratory Attachment 1 - PA-151 AMM Excerpts.

Submitted by:

Donald Kramer, Ph.D.
Senior Materials Engineer

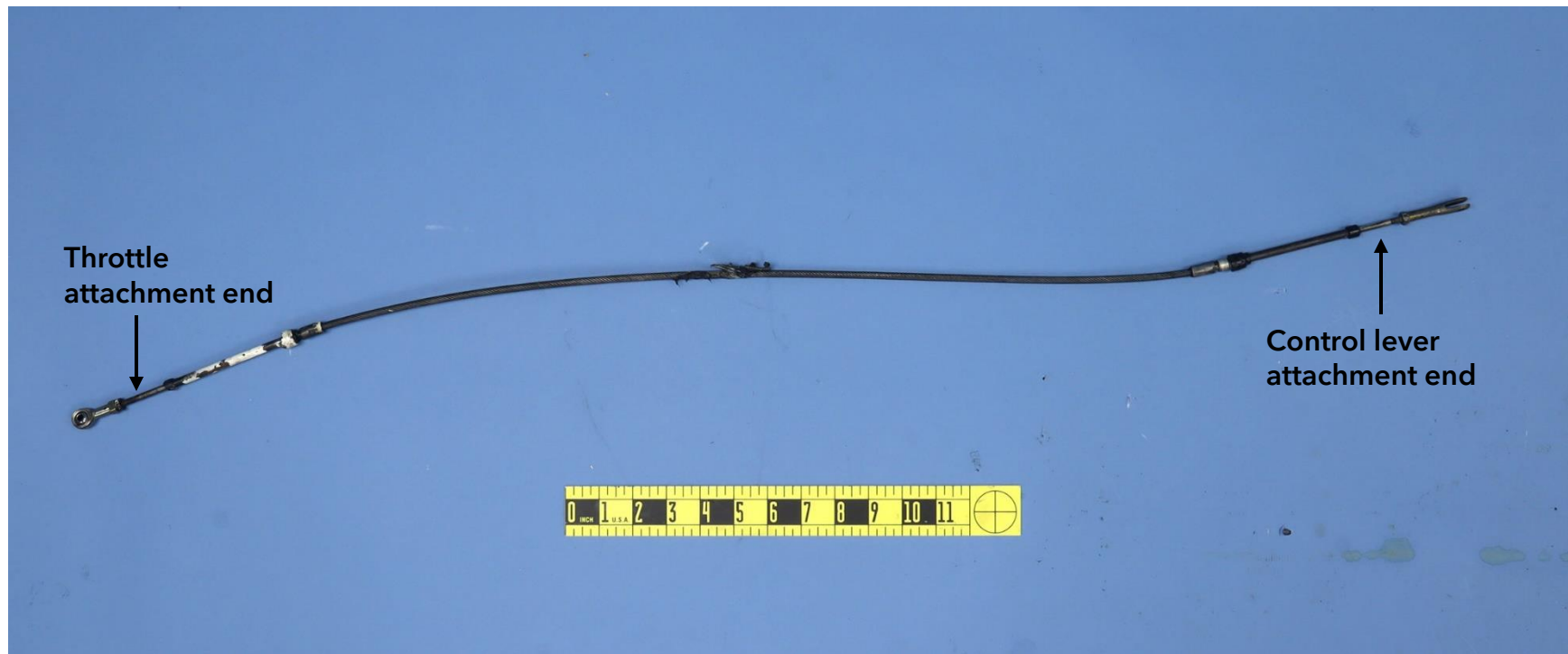


Figure 1. Image of the as received throttle cable assembly.

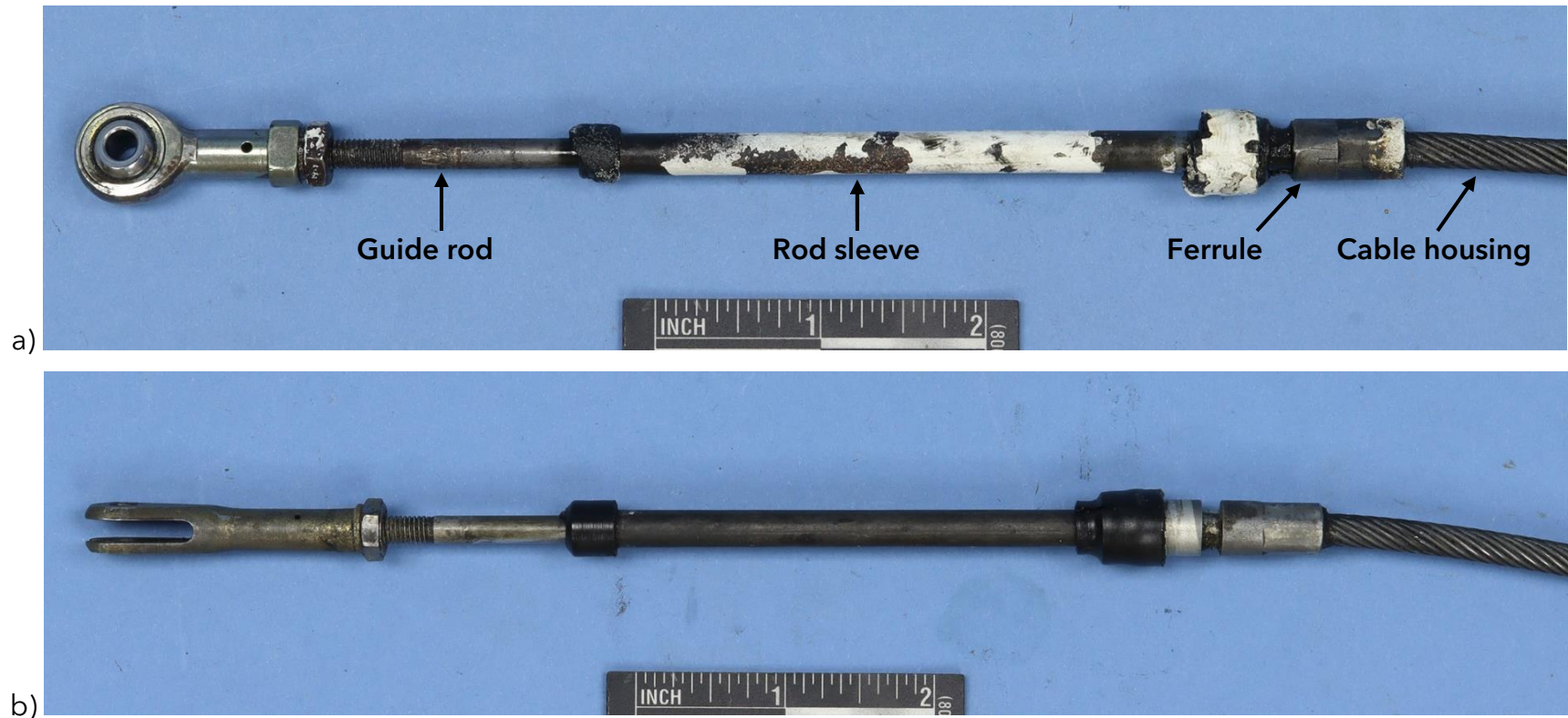


Figure 2. The ends of the throttle cable assembly; a) end attached to the throttle and b) end attached to the throttle control lever.

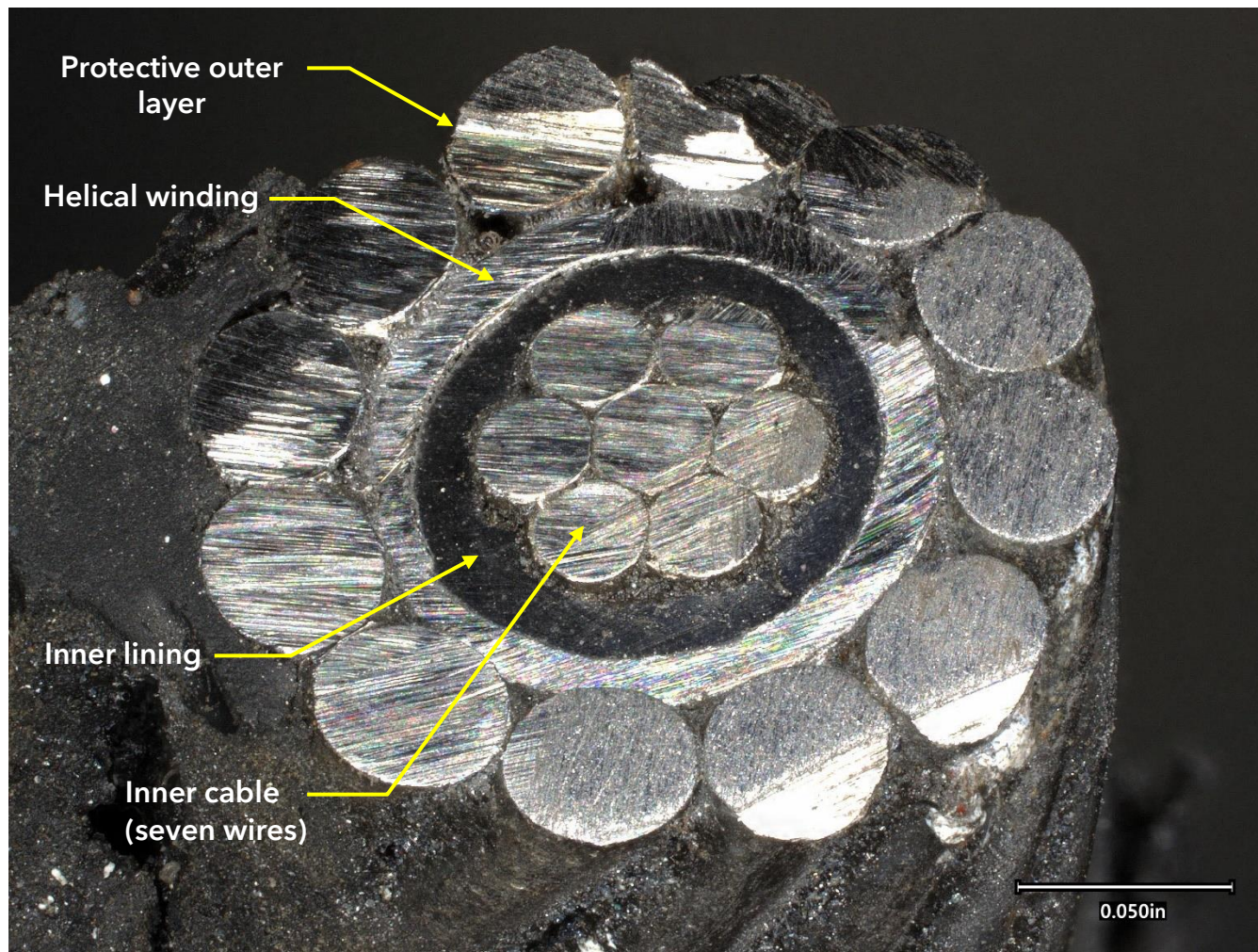


Figure 3. Cross section through the middle of the cable assembly showing the layers in the construction of the cable.

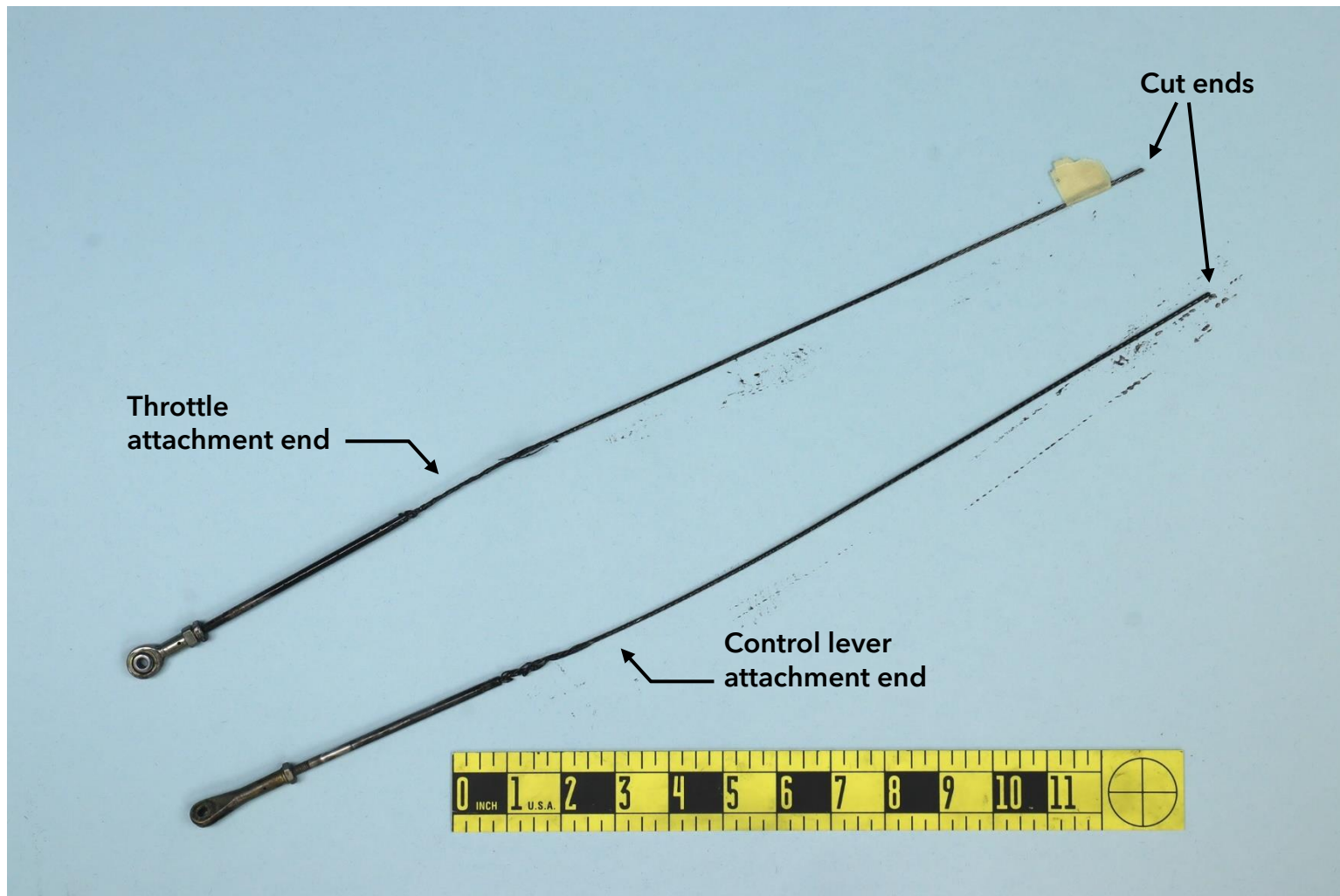


Figure 4. The inner cable and end assemblies after sectioning through the middle of the cable and removing the outer layers.

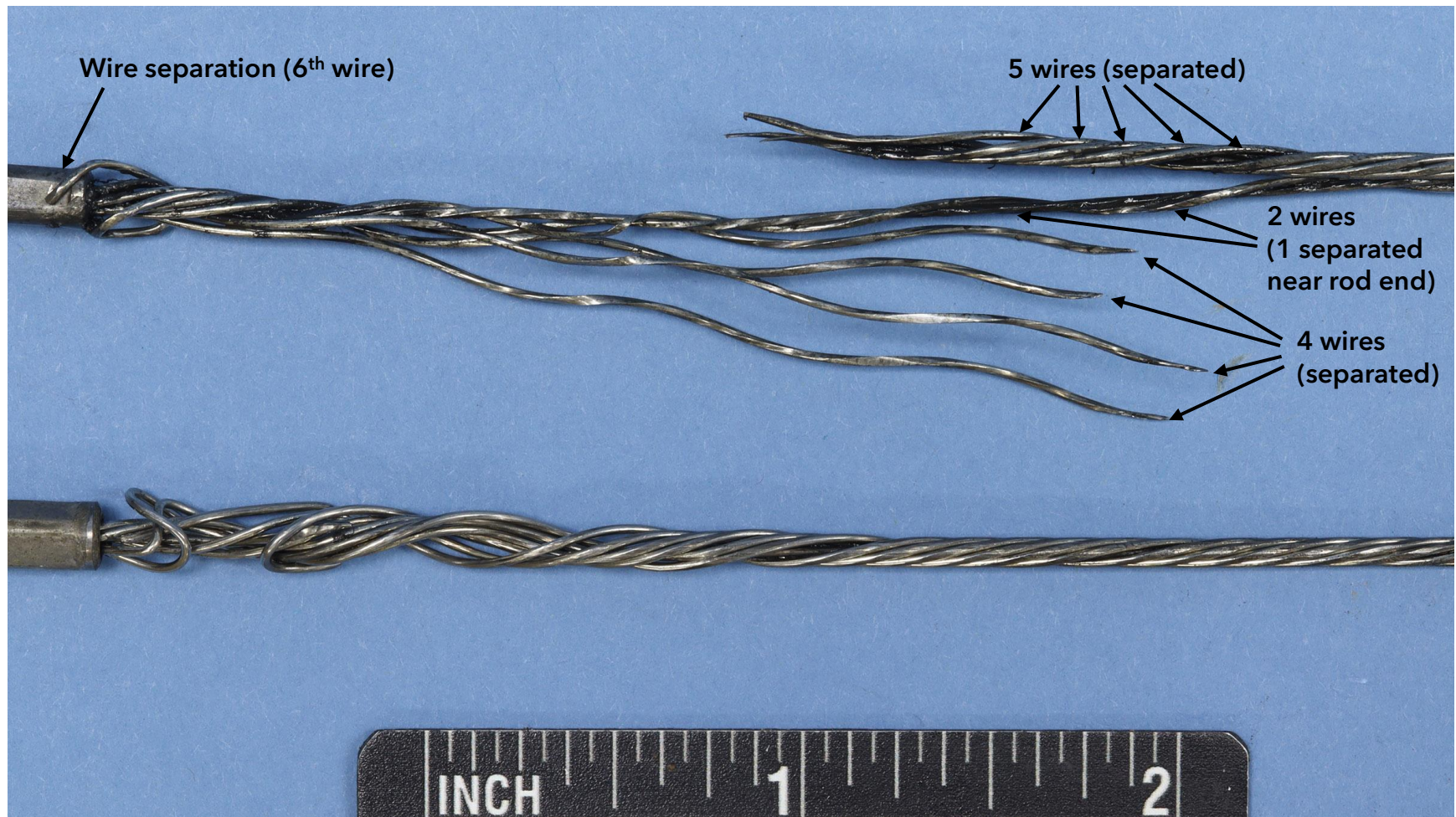


Figure 5. Top: End of cable near throttle attachment exhibiting separated and deformed wires. Bottom: End of cable near throttle control lever exhibiting unfurling and buckling of wires.

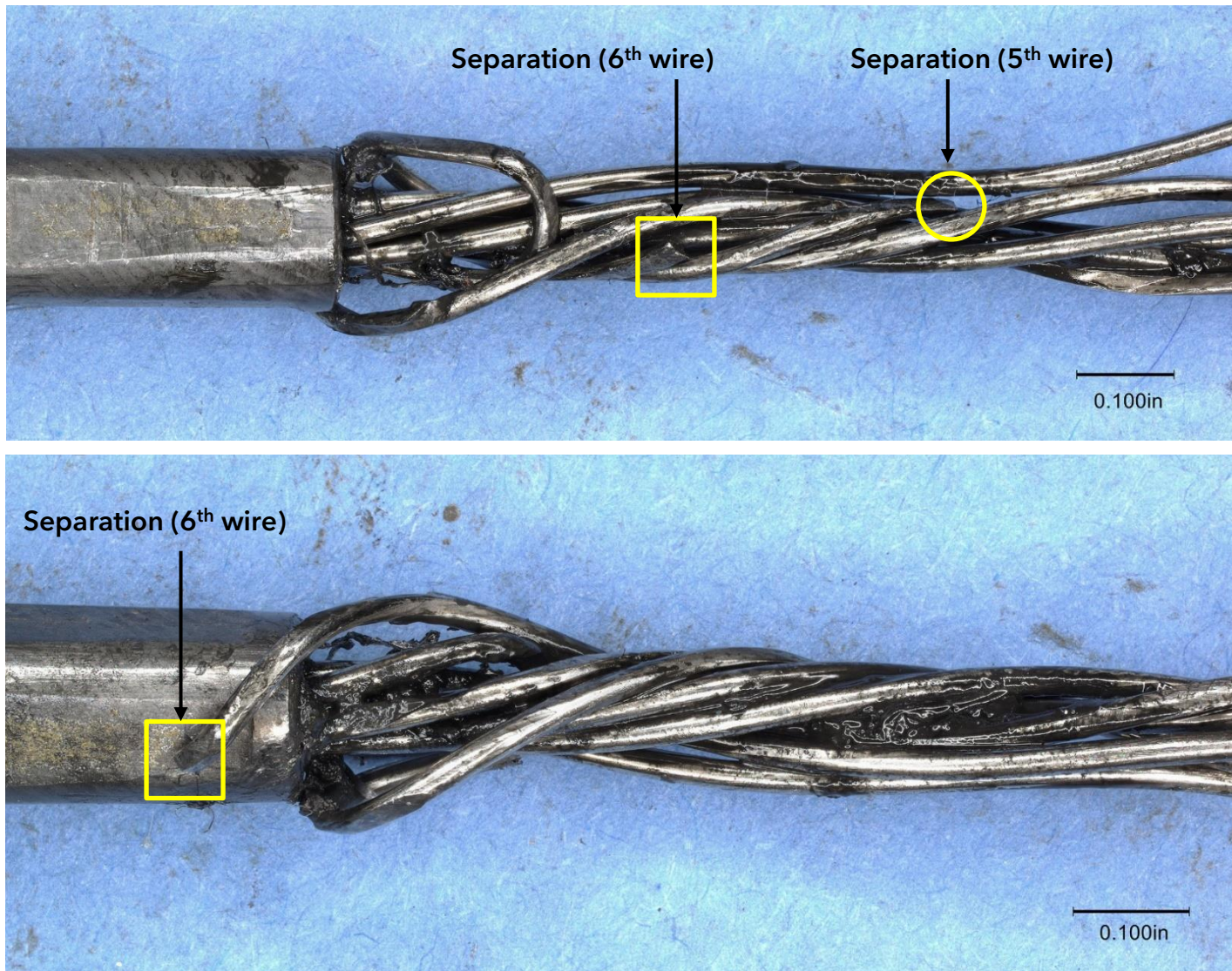


Figure 6. Wire separations near the connection to the guide rod. Top image: One side with one separation indicated by a yellow square and another separation indicated by a yellow circle. Bottom image: Opposite side of the rod, with a separated wire end indicated by a yellow square, corresponding to the separated end indicated by the yellow square in the top image.

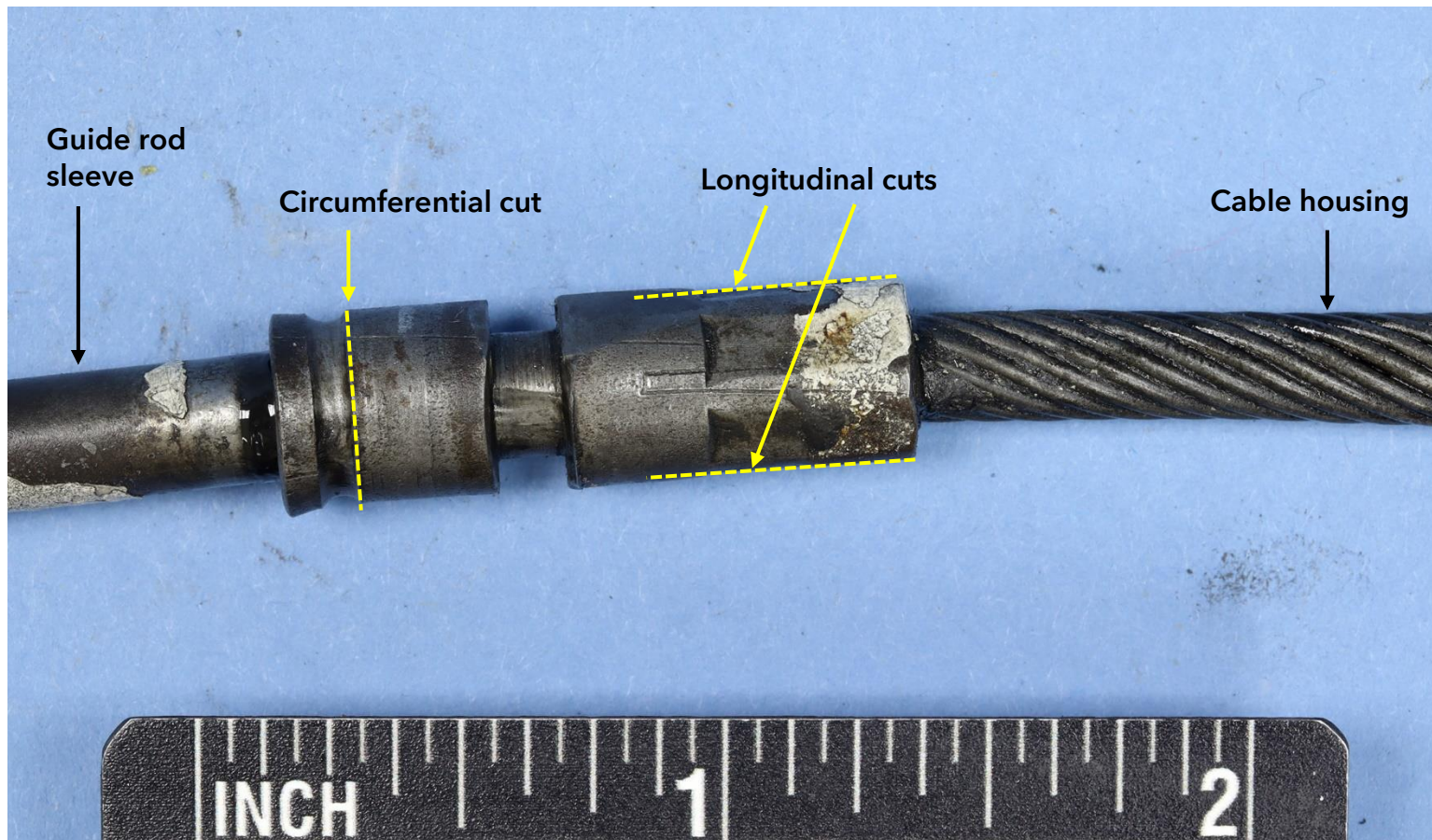


Figure 7. Image of the ferrule at the end of the cable housing (end of cable attached to the throttle). The ferrule joins the outer cable housing to the guide rod's outer sleeve. The ferrule was cut at both ends so as to examine the guide rod sleeve and cable housing.



Figure 8. Top image: Guide rod sleeve after sectioning the ferrule. Lower image: Cable housing after removing the ferrule.



Figure 9. a) Image at end of guide rod sleeve showing remnant wire fragment and black plastic material and b) image at end of cable housing showing lack of inner lining.

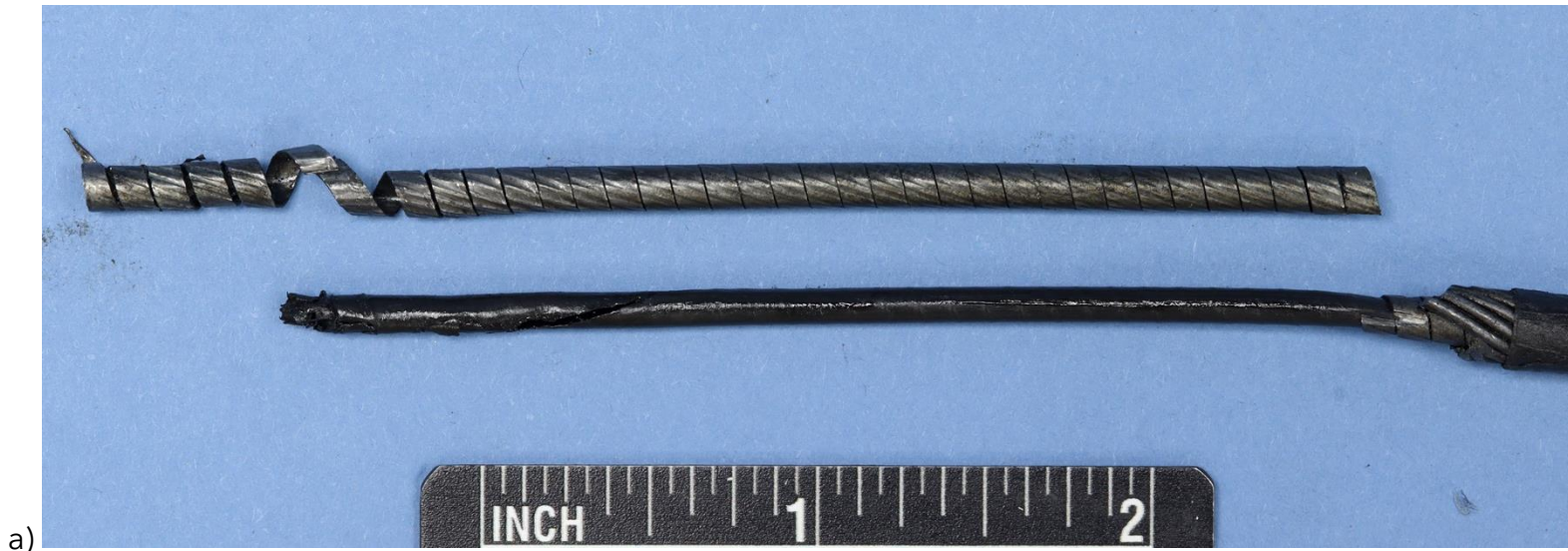


Figure 10. a) Image of disassembled cable housing (outer wires not shown). Deformation and fracture of the helical winding was caused during disassembly; b) image of the helical winding at the end of the cable housing with the windings spread apart to show the wear marks on the inner diameter surface.

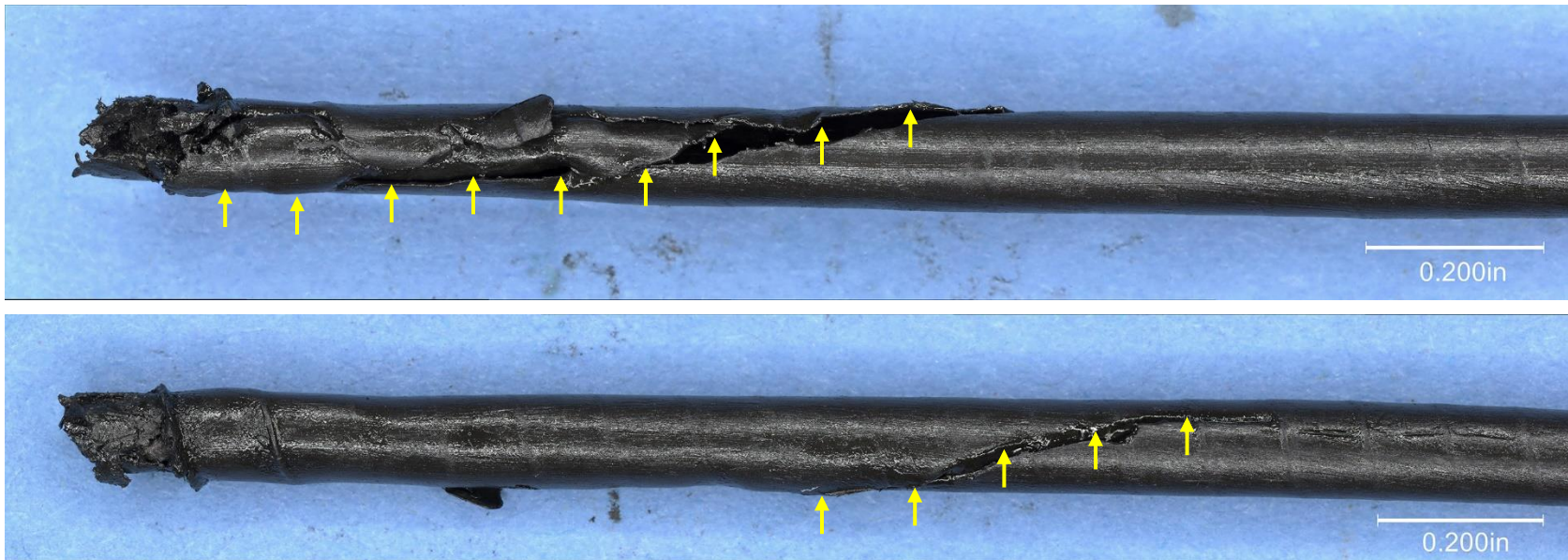


Figure 11. Two images of the inner polymeric liner rotated 180° relative to one-another with yellow arrows indicating the location of a helical split in the liner.