

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



November 8, 2016

MATERIALS LABORATORY FACTUAL REPORT

Report No. 16-080

A. INCIDENT INFORMATION

Place : San Carlos, California
Date : April 29, 2016
Vehicle : Piper PA-28R-200
NTSB No. : WPR16IA100
Investigator : Thomas Little, AS-WPR

B. COMPONENTS EXAMINED

Throttle cable (McFarlane Aviation part number MC455-322).

C. DETAILS OF THE EXAMINATION

An overall view of the throttle cable assembly is shown in figure 1. The cable was fractured near the input end as shown in figures 1 through 3. The cable was an FAA-PMA part and had 1,653 hours time in service since installation about 12 calendar years before the accident.

Damage to the conduit was also observed as shown in figure 1. Two areas of wear contact are shown in the lower left image in figure 1. The smaller of the two areas in the lower left image had a flat wear pattern corresponding to contact with a smooth surface. The larger of the two areas had a ridged pattern consistent with contact with another cable. The damaged area shown in the lower right image in figure 1 had sharper edges with displaced conduit material at the edges consistent with contact with a sharp edge.

Overall views of the input end of the cable assembly are shown in figure 2. The cable was fractured 8.55 inches from the end face of the input rod, and the swivel tube was separated from the sleeve at the swivel joint. The overall length of the cable assembly between the end faces of the input and output rods was 70.229 inches. According to a representative of the cable manufacturer, for reference, the cable assembly should be approximately 70.33 inches long. The diameter of the cable adjacent to the fracture measured 0.0875 inch.

In figure 2, the input rod is shown positioned approximately in the full open throttle position (upper image) and in the closed position (lower image). The positions of the rod were determined using measurements from a drawing of the throttle cable installation provided by a representative from Piper Aircraft. The drawing did not show

the position of the input rod end face, but showed positions with an end fitting and jam nut installed to an unknown depth on the input rod threads. The end fitting and jam nut were not included in the submitted components, and no photographs of the incident assembly as installed were available. However, grease was present on the 7 threads adjacent to the smooth shank of the input rod, and the remaining 0.66 inches of threads at the input end of the input rod were free of grease. In estimating the input rod position relative to the conduit at various throttle settings, it was assumed that the end fitting and jam nut were installed up to 0.66 inches of the threaded end of the input rod based on the observed grease pattern.

Views of the cable fracture are shown in figure 3. Individual wires of the cable were fractured at locations within approximately $\frac{1}{2}$ of a lay length.¹ Portions of the fracture surface on each of the outer wires had relatively smooth fracture features oriented perpendicular to the outer surface with curving boundaries, features consistent with fatigue. In the lower image in figure 3, dashed lines indicate the fatigue boundaries, and arrows indicate the locations of the fatigue origins. The origin for each individual wire was located at the same side relative to the overall cable, and the fatigue region extended across approximately half the diameter in each wire. The core wire fracture features appeared rubbed, and the fracture mechanism for the core wire was not determined.

An end view of the sleeve at the separated swivel joint is shown in figure 4. The wall of the sleeve was deformed into an oblong shape with varying inner radius values. Arrows in figure 4 indicate areas where the inner radius was the smallest. The wall was deformed outward at the side opposite the chord marked by the arrows. The overall features of the swivel joint were consistent with bending deformation. In figure 5, a curving deformation mark (indicated with a bracket) was observed on one side of the swivel tube corresponding to contact with the wall of the sleeve under bending loads on the joint. According to the mechanic that worked on the airplane after the incident, the mechanic “snapped the sleeve from the swivel tube” with force applied by a screwdriver while removing the cable assembly from the control quadrant.

Close views of the conduit where it intersected the sleeve are shown in figure 6. As shown in the lower image in figure 6, the axis of the conduit was angled (bent) relative to the axis of the sleeve. Adjacent to the sleeve, the blue outer sheath of the conduit was depressed inward at the outside of the bend as indicated in figure 6. The depression in the outer sheath of the conduit was also visible in a radiograph of the part (see figure 7). At the location of the depression, the diameter of the double-helix coil structure of the conduit was reduced, and a gap was present in the spacing between the coils.

Another radiograph of the conduit and sleeve is shown in figure 8, where the brightness is increased to reveal more of the coil features within the sleeve. The sleeve is crimped onto the conduit, and the radiograph showed the inner diameter of the coil

¹ A lay length is the length of the cable along which a wire rotates 360 degrees about the core.

and the spacing between coils varied along the length of the sleeve. The minimum diameter measured within the sleeve was 0.131 inch at the location indicated in figure 8.

As assembled, an elastomeric boot covers the swivel joints at each end of the cable assembly. As received, the boot at the input end swivel joint was displaced onto the swivel tube (see figure 2). In comparison, the boot at the output end was received covering the joint, and a hose clamp was in place on the boot. No hose clamp was observed at the input end. During the course of the examination, the hose clamp was removed from the boot at the output end swivel joint, and the boot was displaced onto the output swivel tube as shown in figure 9. The portion of the boot that had been covering the swivel joint was flared outward relative to the other end of the boot, and an impression was observed where the hose clamp had been installed. More than two months after the hose clamp was removed, the hose-clamp impression remained visible on the surface, and a slight flare was present at the end that had been covering the swivel joint (see figure 10). By contrast, the boot for the input swivel joint had a uniform outer diameter with no evidence of a flared end or hose clamp impression (see figure 11). In addition, a photograph of the input swivel tube with a date stamp 6 days after the accident showed similar features for the boot with no evidence of a hose-clamp impression or flared end.

Matthew R. Fox
Senior Materials Engineer

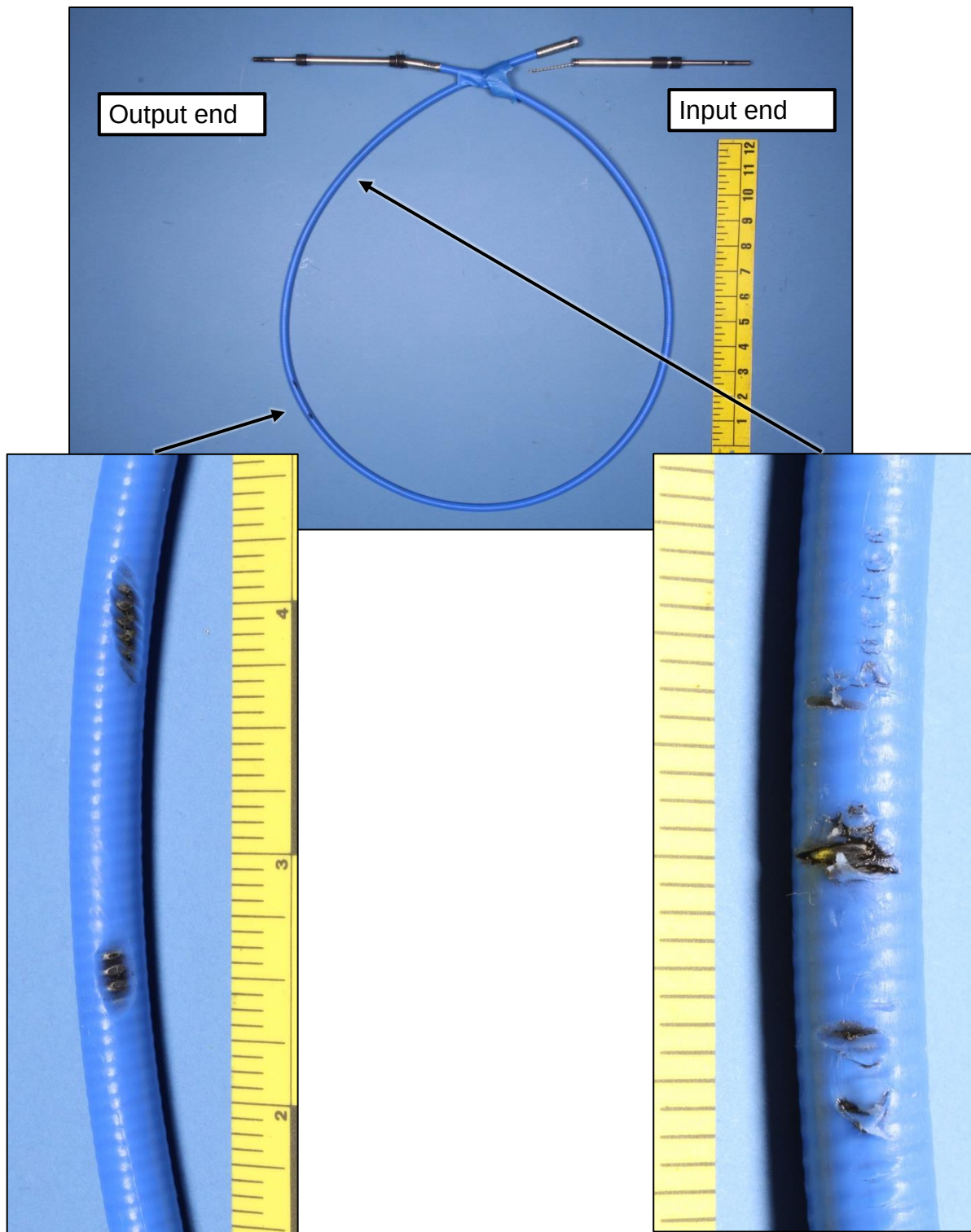


Figure 1. Overall view of the submitted throttle cable with closer views of damaged areas on the conduit.

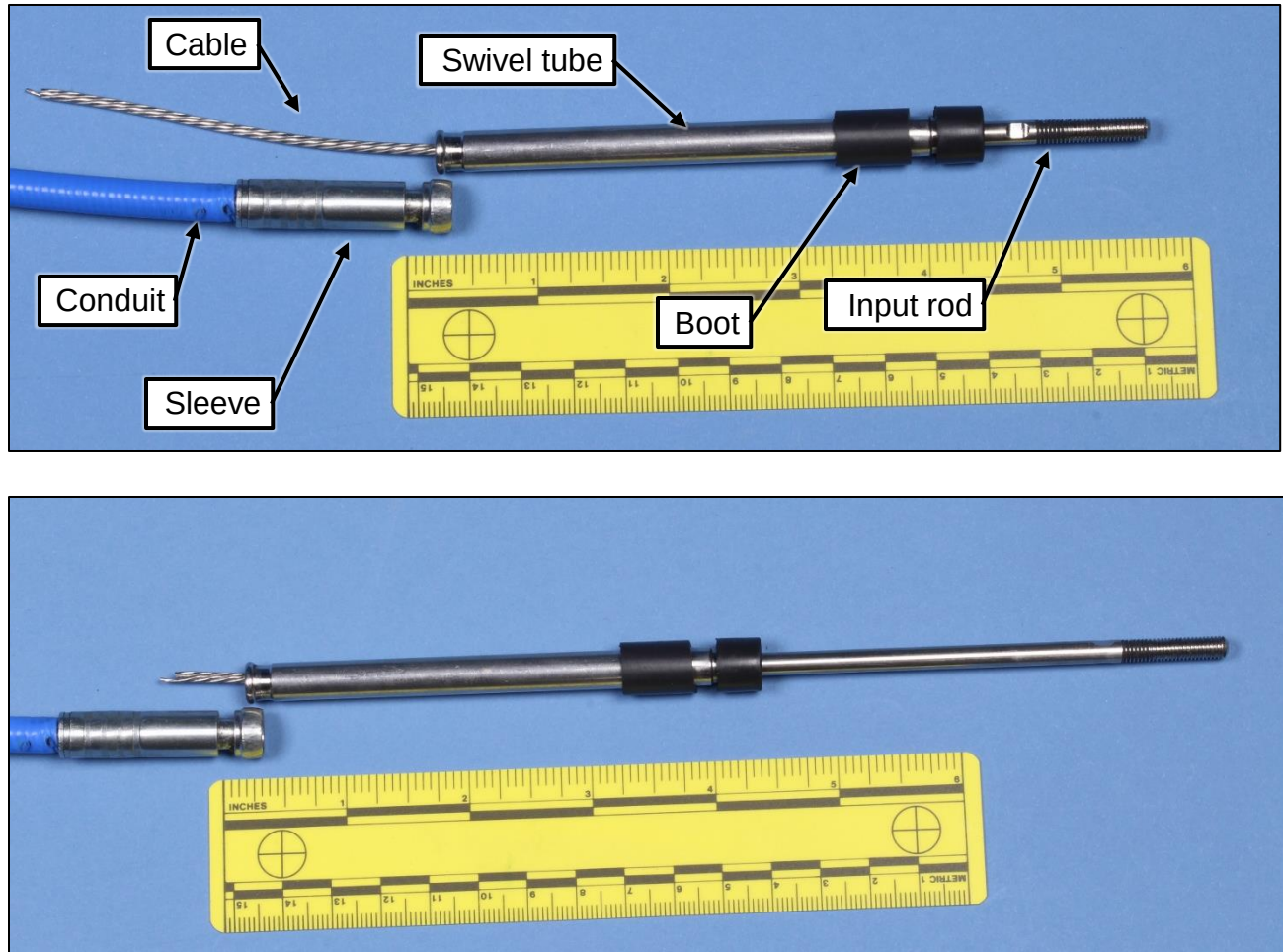


Figure 2. Input end of the control cable assembly shown positioned in the full open (upper image) and closed positions (lower image).

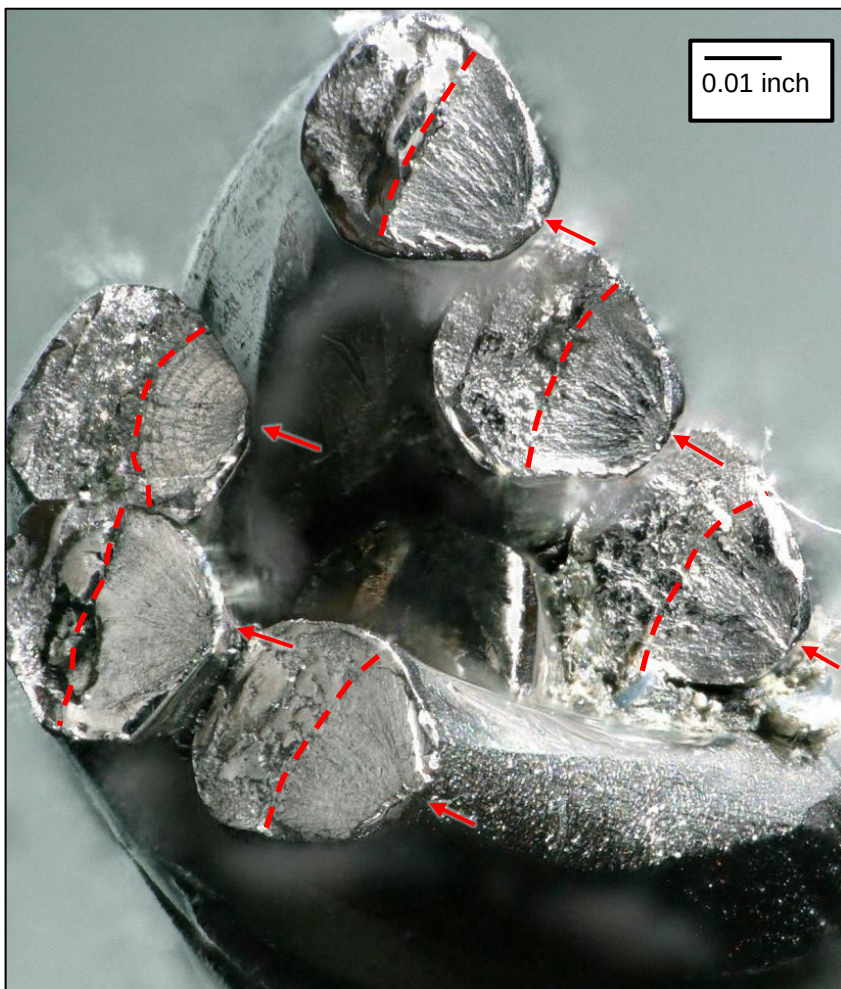


Figure 3. Magnified views of the cable fracture as imaged using the “Depth Up” feature on a Keyence VHX-5000 microscope. Unlabeled arrows indicate fatigue origins, and dashed lines indicate fatigue boundaries on individual wires of the cable.

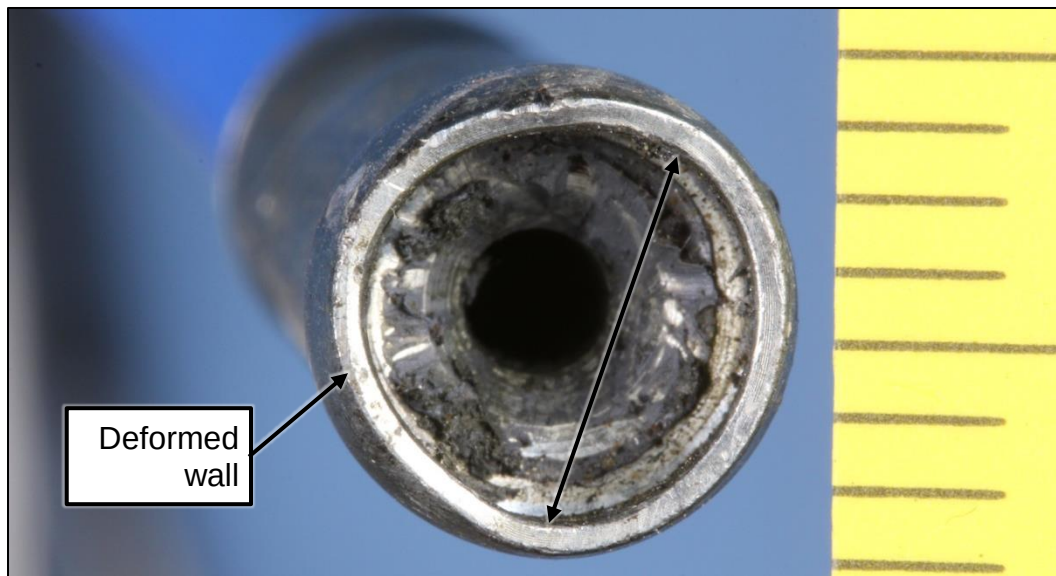


Figure 4. End view of the sleeve showing wall deformation at the input end swivel joint. Arrows point to areas with relatively smaller inner radius.

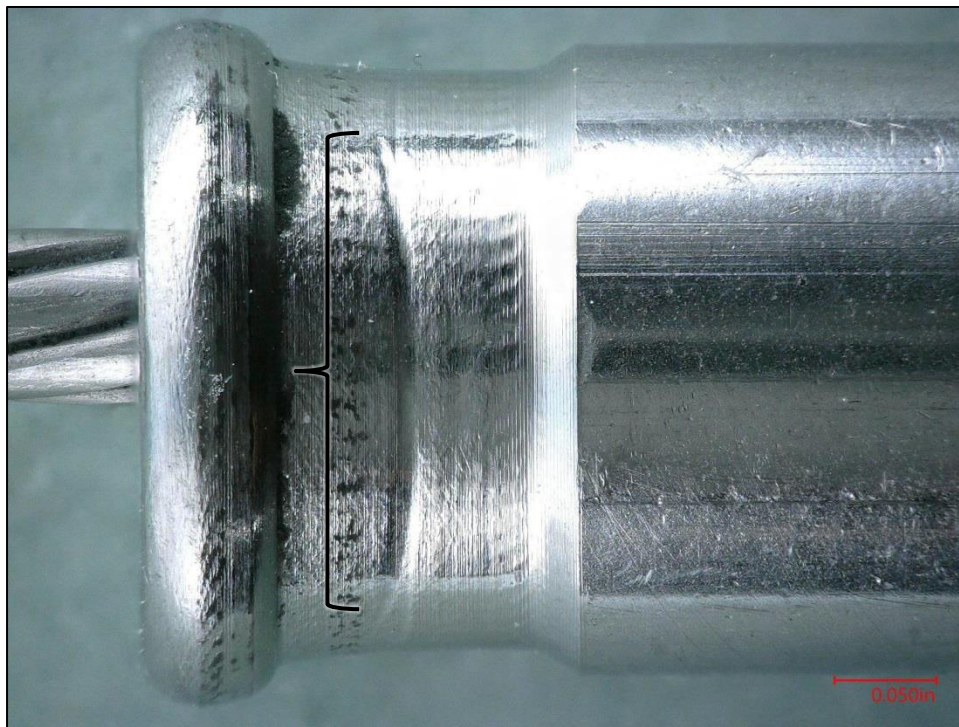


Figure 5. Close view of the sleeve end of the swivel tube. A bracket indicates a curving depression corresponding to contact with the wall of the sleeve.

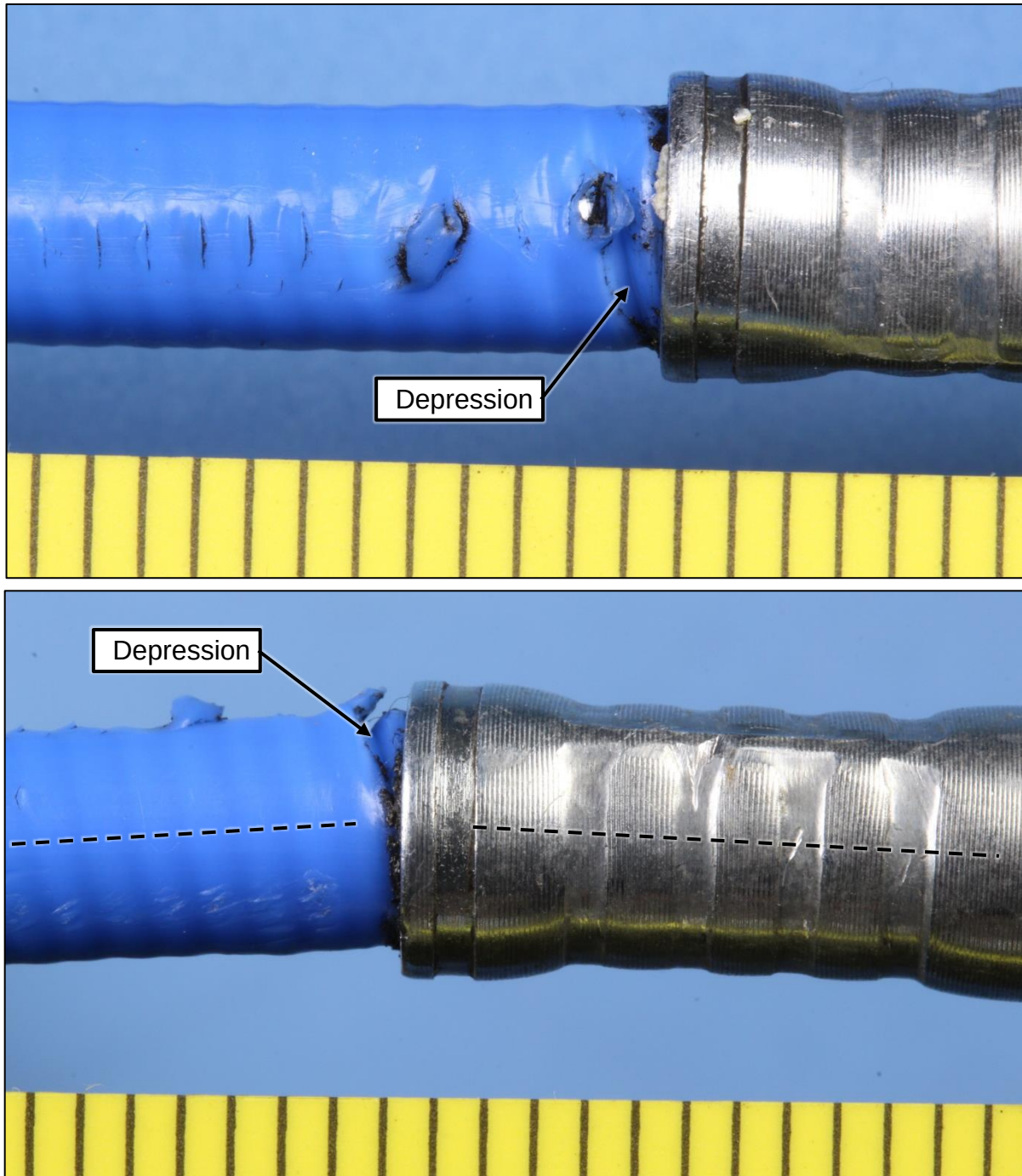


Figure 6. Close views of conduit damage and deformation adjacent to the sleeve at the input end of the cable assembly. The conduit and sleeve were rotated 90 degrees in the lower image relative to the upper image. Dashed lines in the lower images indicate axes of the conduit and sleeve.

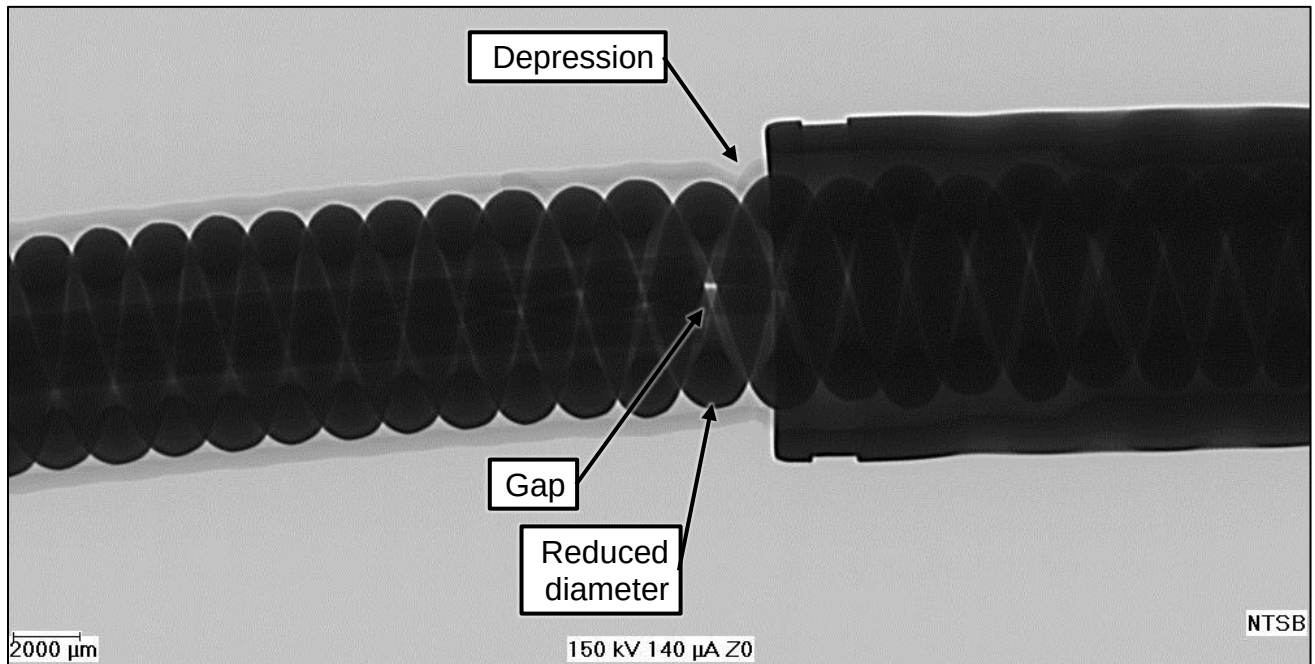


Figure 7. Radiograph of the intersection between the conduit and the sleeve at the input end of the cable assembly. The depression at the exterior of the conduit (see figure 7) is indicated. The location corresponded to a reduced diameter and gap in the spiral reinforcement, also indicated.

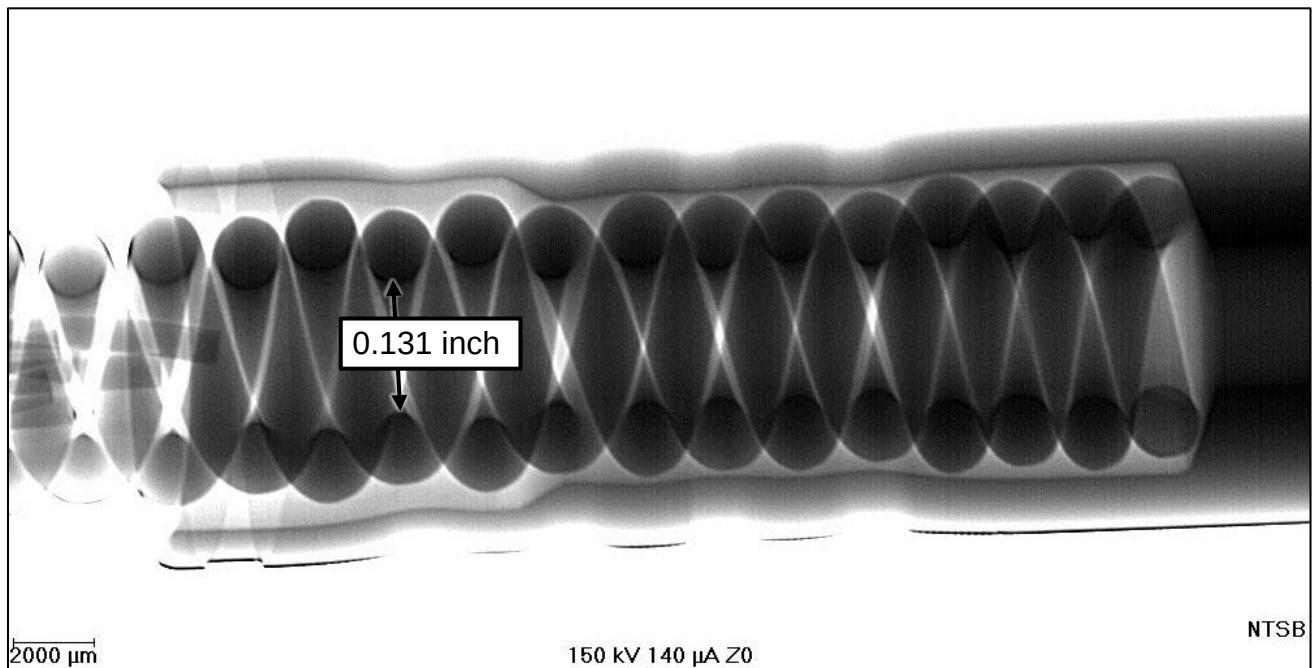


Figure 8. Radiograph of the crimped portion of the sleeve at the input end of the cable assembly.

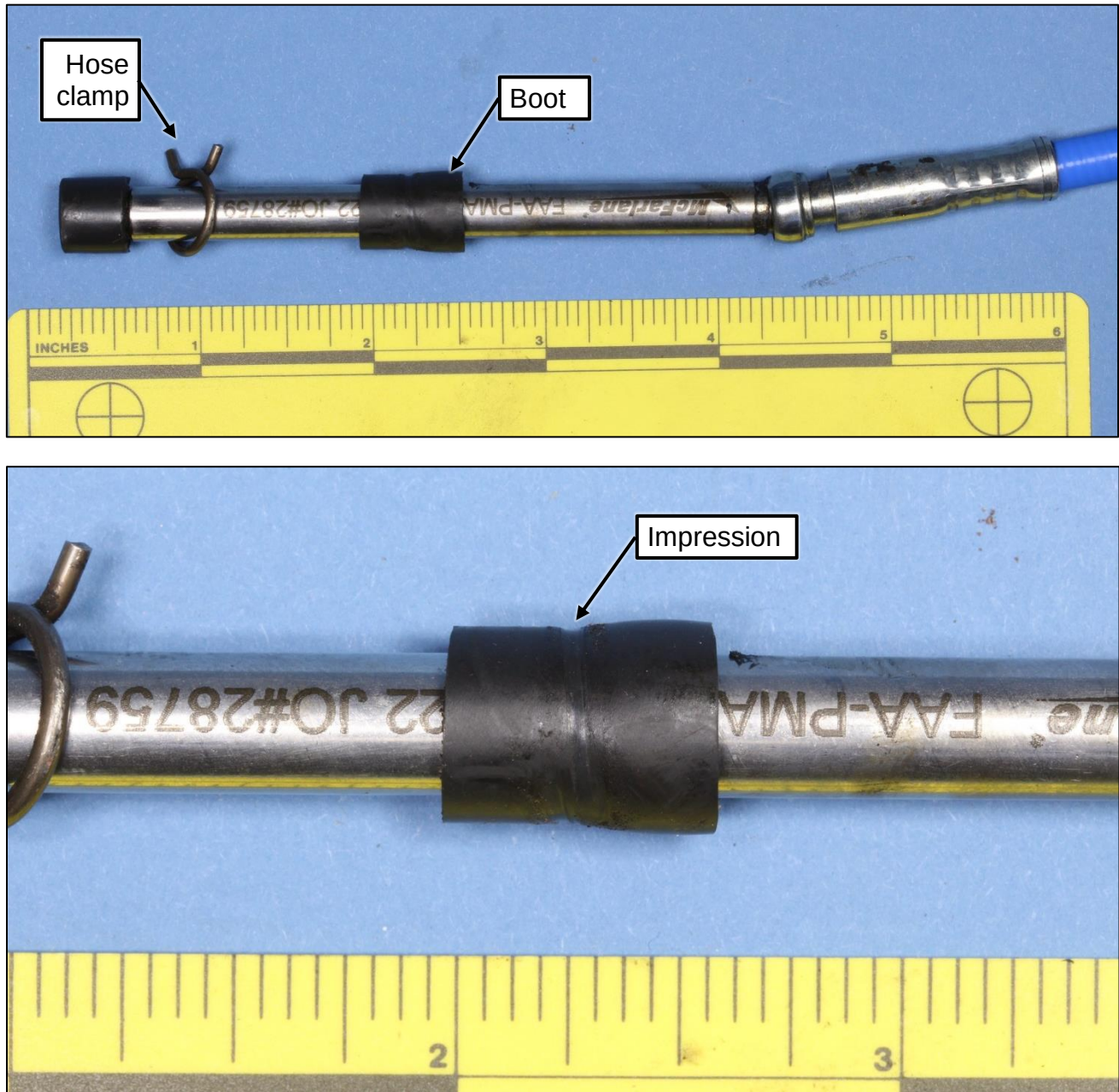


Figure 9. Output end of the control assembly after the cable was removed from the conduit and after removing the boot from the swivel joint. In the upper image, the swivel tube is shown at the maximum deflection for the joint, an angle of 8.2 degrees between the sleeve axis and the swivel tube axis.

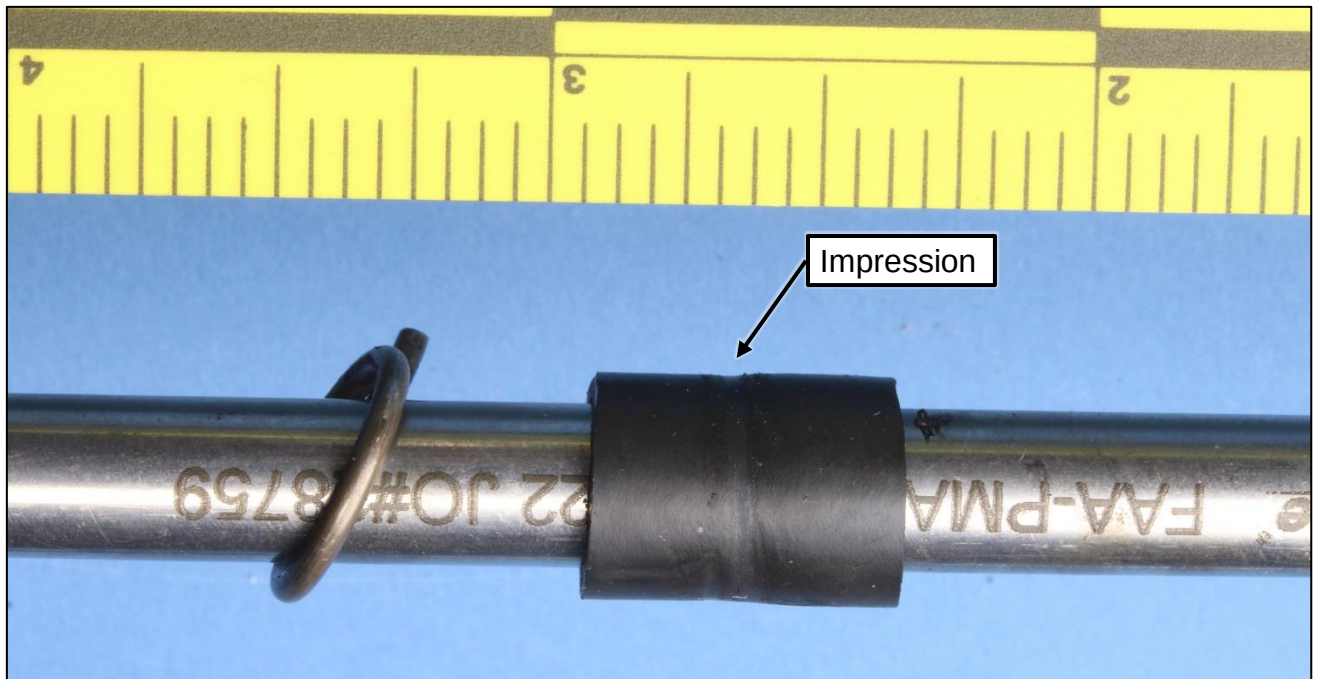


Figure 10. Close view of the boot on the output end of the cable photographed over 2 months after the hose clamp was removed. The hose clamp impression is still visible.

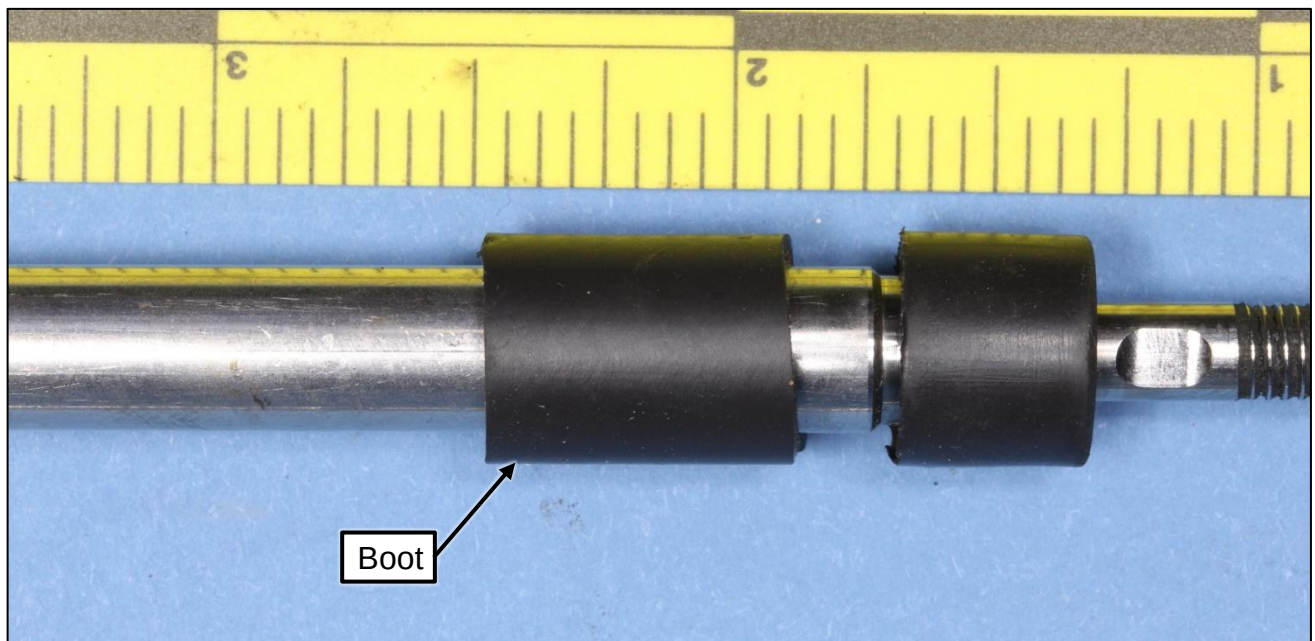


Figure 11. Close view of the boot at the input end of the swivel tube. An impression consistent with an installed hose clamp was not observed on the boot.