

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



CEN25LA043

MATERIALS LABORATORY

Factual Report 25-018

March 31, 2025

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A. ACCIDENT INFORMATION

Location: Seguin, Texas
Date: November 17, 2024
Vehicle: Pitts S1E (N52B)
Investigator: Andrew Finne

B. COMPONENTS EXAMINED

Two rudder cables and associated attachment hardware.

C. EXAMINATION PARTICIPANTS

Specialist Brian Fuchs
National Transportation Safety Board
Washington, D.C.

D. DETAILS OF THE EXAMINATION

Two lengths of rudder cable were submitted for examination at the NTSB Materials Laboratory. One cable (labeled 'right') was cut at one end, and a linkage bar was attached to the end loop at the other end (Figure 1). The other cable (labeled 'left') was also cut at one end but had fractured at the opposite end loop, allowing the linkage bar to separate from the cable (Figure 2). Both cables were submitted from the accident aircraft.

The right cable was examined as an exemplar set of components. The linkage, cable, and ferrule were intact, with no significant damage noted. The end loop (where the linkage was attached) contained a teardrop-shaped thimble lining the inside of the loop. A section of the thimble near the top of the loop was missing (Figure 3). The fracture surfaces on the thimble at this missing section were smeared, consistent with repeated impact or rubbing. The cable showed accumulated brown rust on and between strands in this section, especially on the inside of the loop. When the cable and linkage were pulled in tension, the linkage fit into this missing section of thimble. The attachment hole through the linkage had 90° edges with no chamfer or fillet.

The overall condition of the left cable, ferrule, and linkage were similar to that of the right cable assembly, with no significant damage to the cable away from the broken loop. The thimble was not recovered and therefore was not examined. The cable had fractured near the apex of the end loop. The cable strands near the fracture were largely twisted together, with little splaying or fraying at the broken ends. The fractured loop was cleaned in an Alconox® solution in an ultrasonic bath and examined with optical microscopy (Figure 4). Surface wear consistent with

contact or rubbing was noted on strands towards the inside of the loop. The fractured ends of the strands were also examined. These fracture surfaces could generally be separated into two categories. The first set was strands that showed an angle (relative to the axis of the strand) or a knife edge fracture surface. These surfaces were more numerous on the outside of the loop. The other category of strands had broken with a flat fracture surface and no necking, more consistent with progressive cracking under applied stress. Examination of the surfaces with optical microscopy revealed thumbnail-shaped regions consistent with fatigue (Figure 5). These flat fracture surfaces were more numerous towards the inside of the loop, especially near the apex of the loop where the linkage would have been in contact while the assembly was in tension. Some of these cables were deformed and misshapen consistent with contact damage. Optical microscopy also showed that cable strands had fractured away from the final failure surface (Figure 6). These other fracture surfaces also appeared flat with no indication of necking, consistent with fatigue failure.

The linkage from the left rudder cable had a similar configuration to the right linkage, with 90° corners on the attachment through hole. These edges showed rubbing damage around the attachment hole (Figure 7). The damage resembled a series of grooves adjacent to one another, localized to the end of the hole that would have been in contact with the cable loop while the cable was under tension. These grooves were visible on both the front and back edges of the hole. The width of the grooves was measured with using Keyence VHX-7000 measurement software and found to have an average width of approximately 0.006 inch. The width of the strands that made up the cable were measured with calipers and found to be 0.008 inch in diameter.

Submitted by:

Brian Fuchs, Ph.D.
Materials Engineer

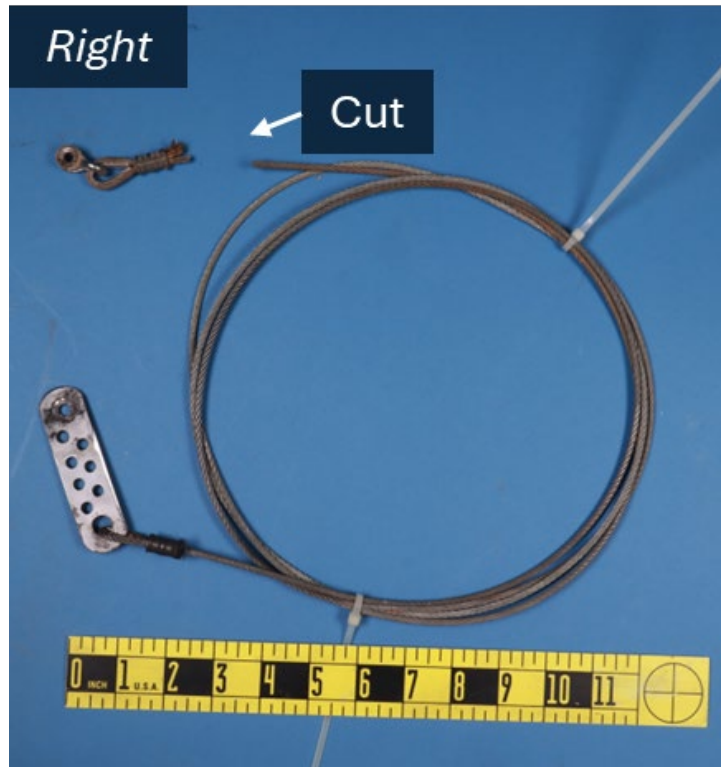


Figure 1. The exemplar right rudder cable. The cable was cut during recovery.

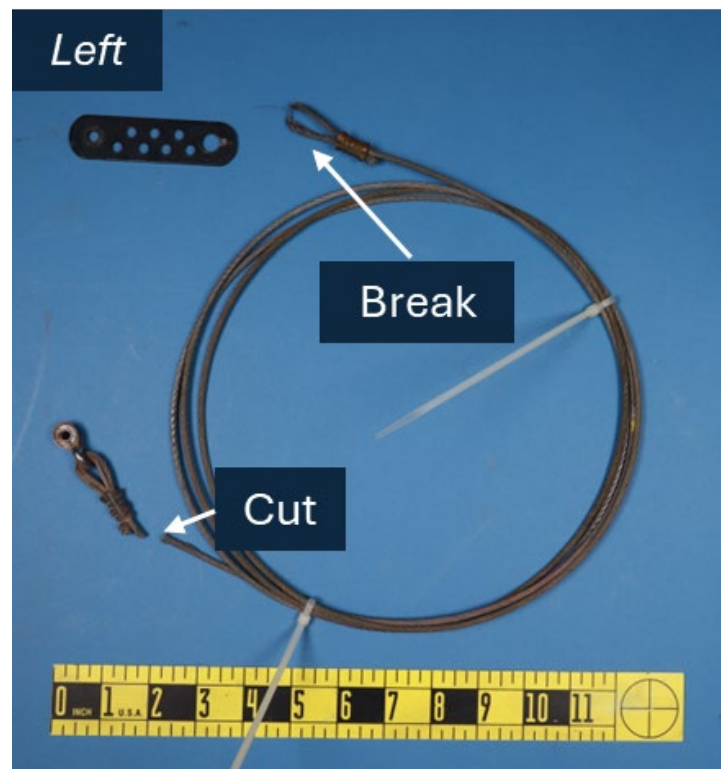


Figure 2. The fractured left rudder cable. The cable was cut during recovery.

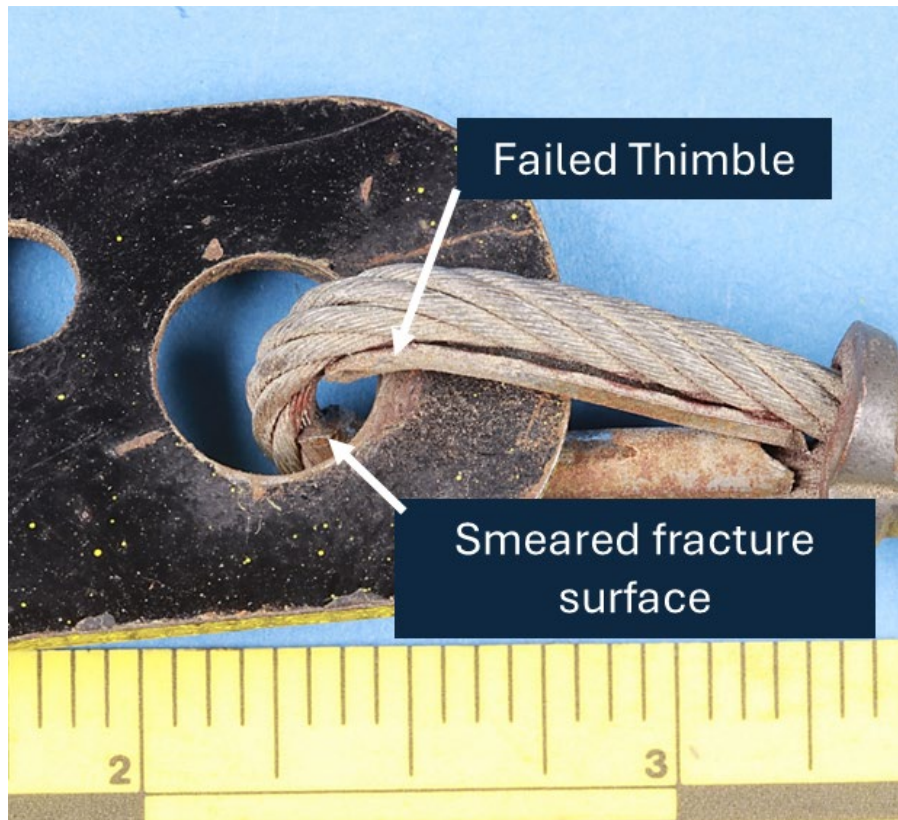


Figure 3. Close-up image of the right rudder cable showing the broken thimble in the loop attaching the cable to the linkage.

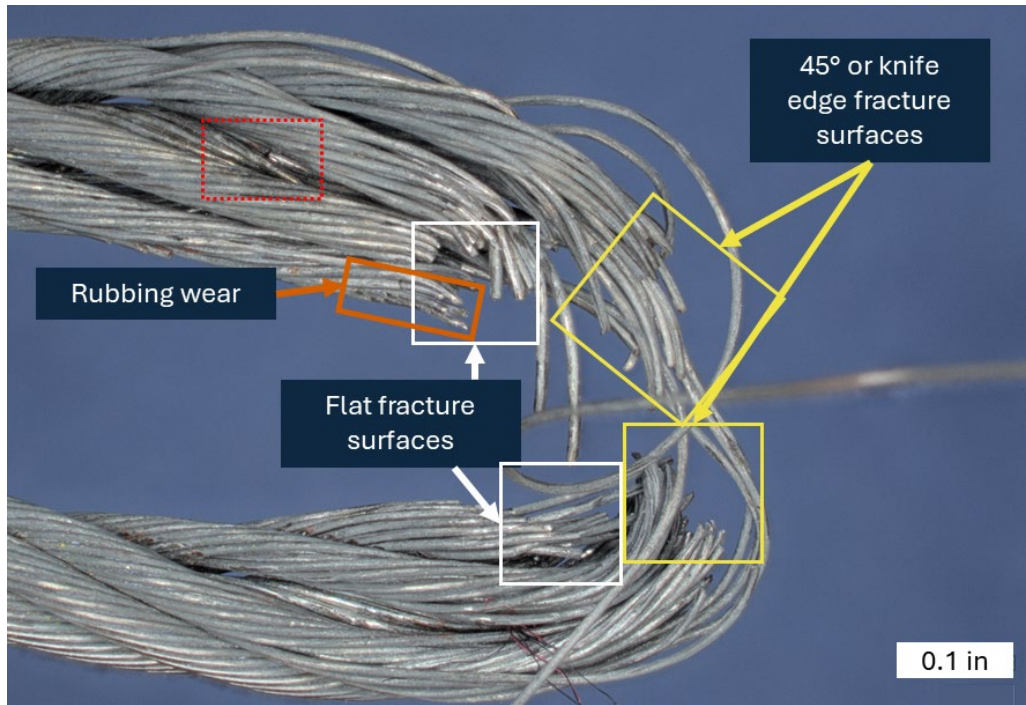


Figure 4. Fractured end of the cable loop from the left rudder cable. The area outlined in the red dashed line is highlighted in Figure 6.



Figure 5. Magnified view of a fractured cable bundle. White arrows point to thumbnail-shaped regions on several strands.

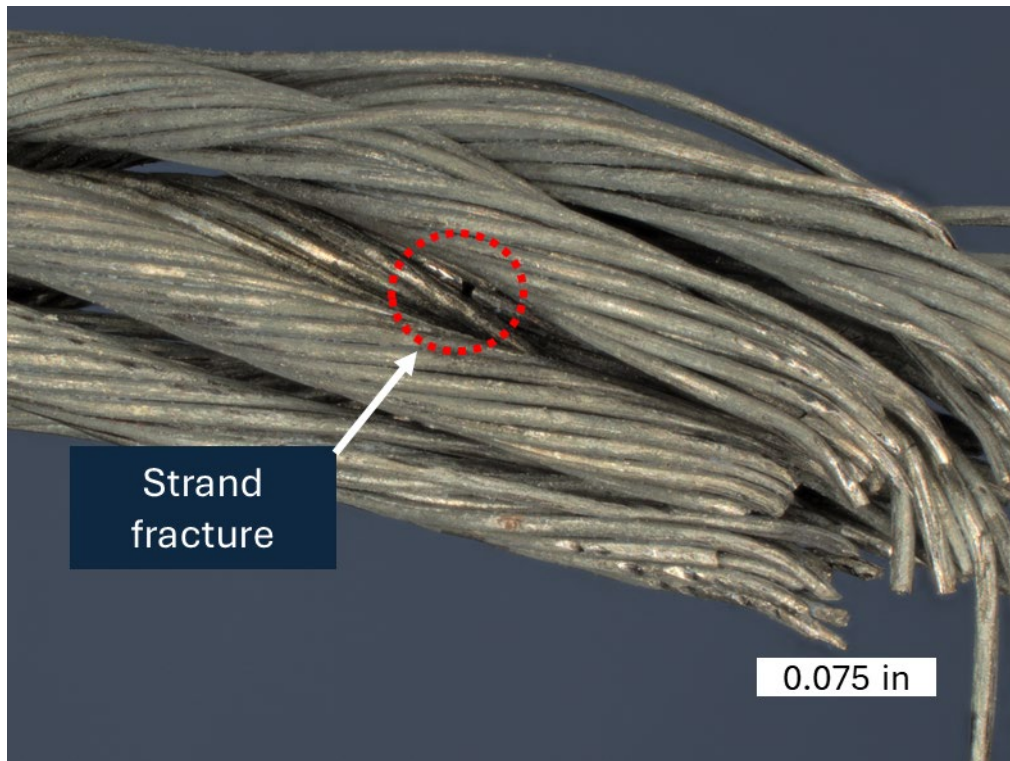


Figure 6. Fractured wire in a strand away from the cable failure.

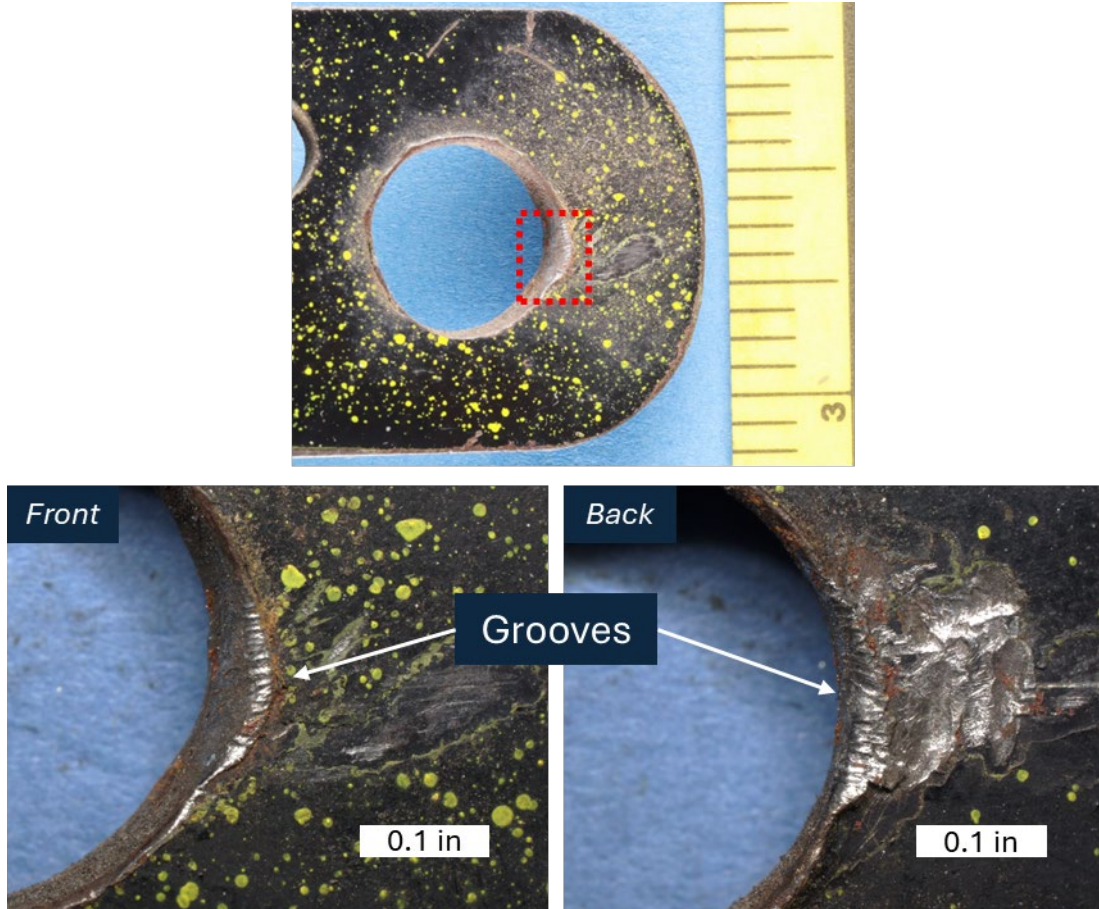


Figure 7. (Top) Left linkage. The red square shows the location of surface damage at the corner of the through hole where the cable would have been attached. (Bottom Left) Magnified view of the damage, which resembles grooves on the front side of the linkage. (Bottom Right) Magnified view of the grooves on the back of the linkage.