

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



CEN23LA170

MATERIALS LABORATORY

Factual Report 23-102

December 29, 2023

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A. ACCIDENT INFORMATION

Location: Palmer, Texas
Date: April 30, 2023
Vehicle: Luscombe 8F, N1113B
Investigator: Andrew Finne, AS-CEN

B. COMPONENTS EXAMINED

Rudder control cable pieces and two pulleys with attachment hardware.

C. EXAMINATION PARTICIPANTS

Specialist Matthew R. Fox, Ph.D.
NTSB
Washington, DC

D. DETAILS OF THE EXAMINATION

An overall view of the submitted rudder control cable pieces and the two pulleys with attachment hardware are shown as received in figure 1. The cable was fractured approximately 12 inches from the clevis fitting attachment holes on the turnbuckle. The pulleys were intact and had a 2 inch outside diameter.

The pulley on the nut side of the pair had relatively deep cable wear marks on the bottom of the groove as shown in figure 2. The wear extended around the circumference of the pulley. The pulley on the bolt head side of the assembly had relatively shallower wear marks that were present around half the circumference of the pulley.

The cable had a 7 x 7 construction (6 outer strands around a core strand with 7 wires per strand) and a diameter that measured 0.128 inch. According to a representative for the current type certificate holder, the cable was originally specified to be a 1/8-inch diameter, 7 x 19 cable (6 outer strands around a core strand with 19 wires per strand).

A close view of the mating fractured ends of the rudder cable are shown in figure 3. The fracture locations of wires in each strand were located in close proximity to each other lengthwise. The cable surfaces were generally covered with grease. To facilitate a closer examination of the fractures and the adjacent cable surfaces, the forward side of the fracture (closer to the turnbuckle end) was selected for additional cleaning and examination.

The outer strands were carefully unwrapped from around the core strand along several inches forward of the fractured end, and the strands were splayed out

to facilitate cleaning and viewing of wire fractures and adjacent surfaces in each individual strand. The separated strands were then cleaned using a soft-bristle brush dipped in a solution of Alconox detergent and water.

Representative optical images of the fractured ends of the cleaned and separated strands are shown in figure 4. The sides of the strands had relatively deep grooves across the wires consistent with wear contact with wires on adjacent strands. The individual wires were fractured within the distance of one lay, and most showed flat fracture features in a plane perpendicular to the wire axis, features consistent with fatigue.

Next, the forward cable piece was cut just forward of the splayed end to facilitate an examination using a scanning electron microscope (SEM). The splayed end was then submerged in acetone and cleaned using an ultrasonic cleaner. A representative SEM image of an outer strand is shown in figure 5. Arrows in figure 5 point to wear grooves corresponding to wear contact with wires on adjacent strands. In some areas, the wear appeared to extend through approximately half the cross-section.

Representative SEM images of individual wire fracture features are shown in figures 6 through 9. Forty-eight of the 49 individual wires were examined. In many cases, fine fracture features were obscured by residual grease deposits, oxidation, and post-fracture rubbing damage. Direct viewing of the fracture for some wires was also limited by the orientation of the strand in the fixture. However, 83% of the wires had a flat region perpendicular to the wire axis, features consistent with fatigue, extending across 10 to 100 percent of the cross-section. Some of the flat regions had distinct curving boundaries such as the wire with one of the smaller fatigue regions shown in figure 6. Two wires showed clear evidence of reverse bending fatigue such as the wire shown in figure 7. Sixteen wires, including 3 from the core strand and 1 to 4 wires in each of the outer strands, had flat regions consistent with fatigue across the entire cross section such as the wire shown in figure 8. Eight wires, consisting of 1 to 3 wires in 4 of the outer strands, had rough features on slant planes with necking deformation features consistent with ductile overstress fracture. One of the wires with ductile overstress fracture features is shown in figure 9.

Rudder cables for the Luscombe model 8 series airplanes are subject to repetitive inspections in accordance with Federal Aviation Administration (FAA) Airworthiness Directive (AD) 51-10-02 due to reported recurring cable failures. The cable inspections are to be completed at each annual inspection with particular attention paid to areas associated with pulleys and fairleads. Cables are to be disassembled as needed to expose sections to be inspected.

For further information on the subject, AD 51-10-02 refers the reader to Luscombe Aircraft Corporation Service Bulletin (SB) 1-51. As described in SB 1-51, "fraying" of the cables was attributed to fatigue, and the failures occurred most

frequently in the rudder control cables. Further, SB 1-51 notes that control locks should be used on control surfaces of Luscombe model 8 series airplanes tied down in the open to prevent rapid wear of control cables from gusty wind conditions.

Submitted by:

Matthew R. Fox, Ph.D.
Chief Technical Advisor - Materials

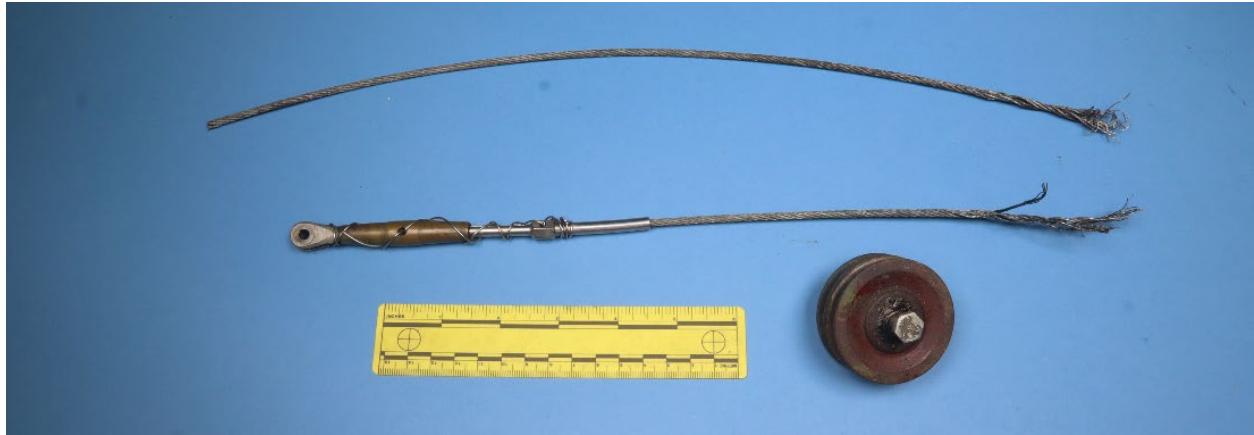


Figure 1. Overall view of the submitted cable pieces and pulleys.

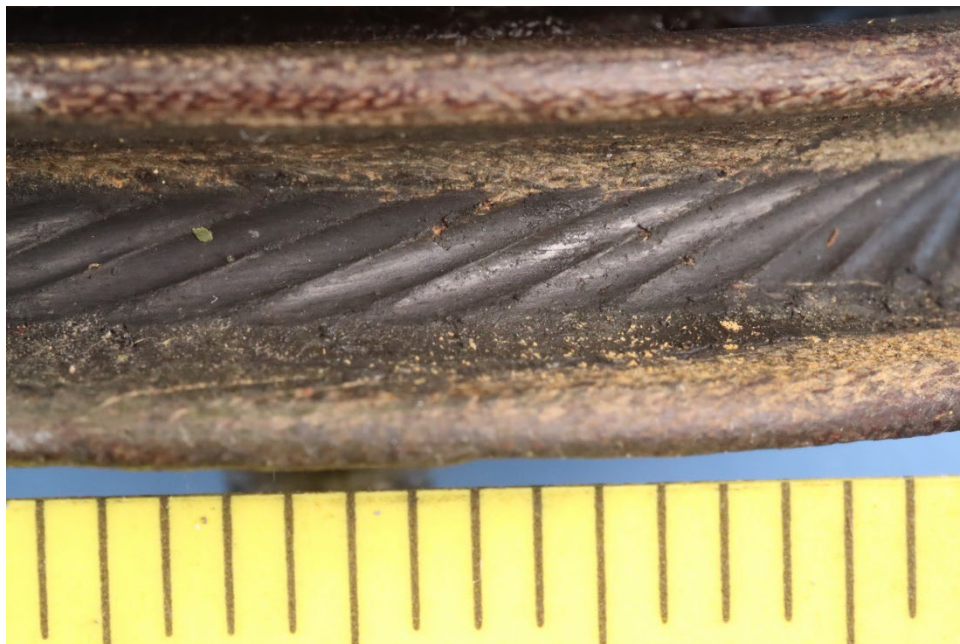


Figure 2. View of the pulley grooves (upper image) with a closer look at cable wear impressions in the bottom of the groove in the pulley closer to the nut (lower image).



Figure 3. Closer view of the fractured cable ends.

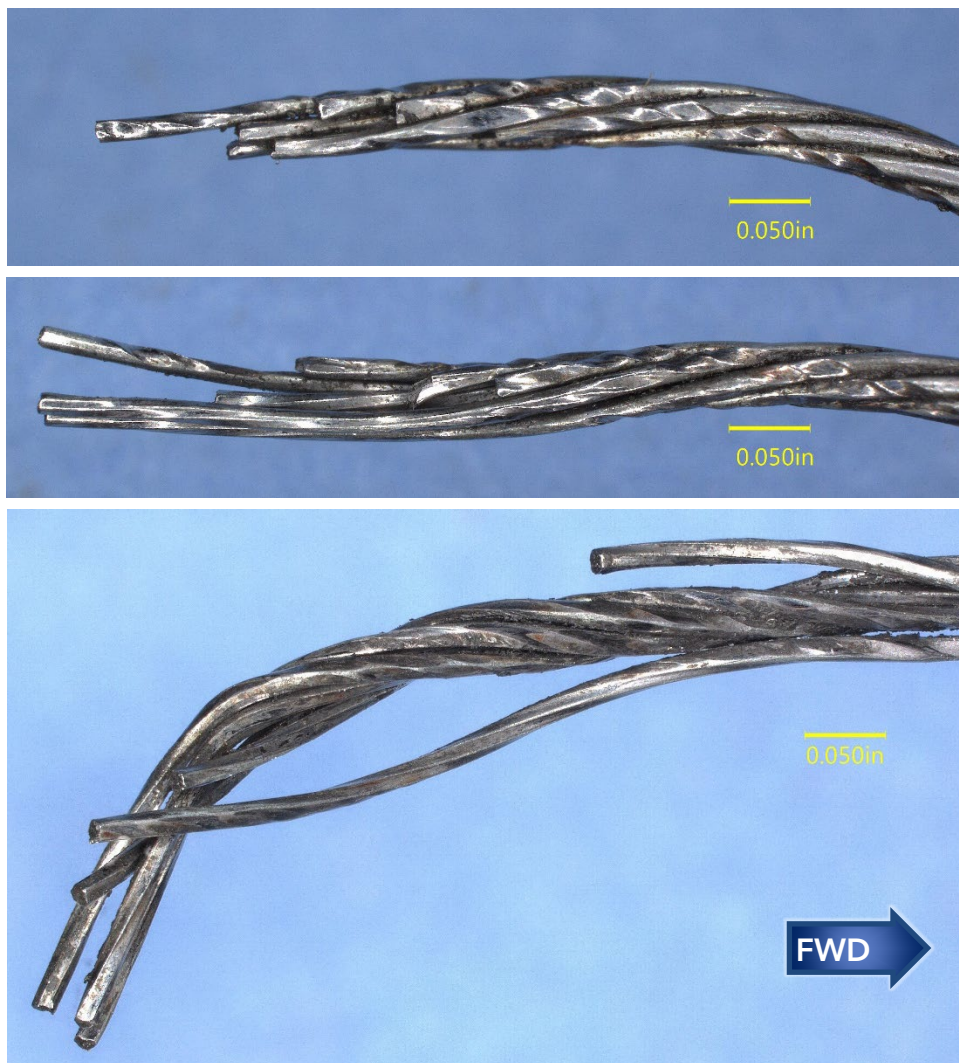


Figure 4. Images of the fractured ends of individual strands showing two representative outer strands (upper and middle images) and the core strand (lower image) obtained using a Keyence VHX-7000 optical microscope in depth mode.

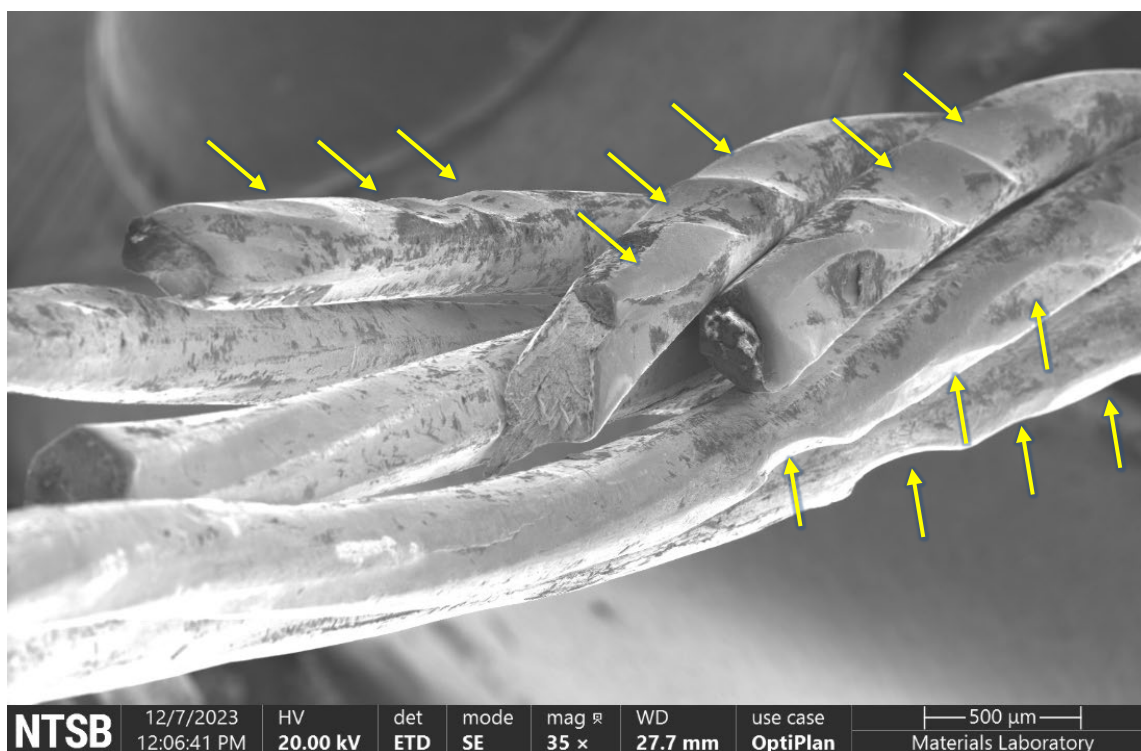


Figure 5. Representative SEM image of an outer strand showing extensive wear damage and fractured wires. Arrows point to wear grooves corresponding to contact with wires on adjacent strands.

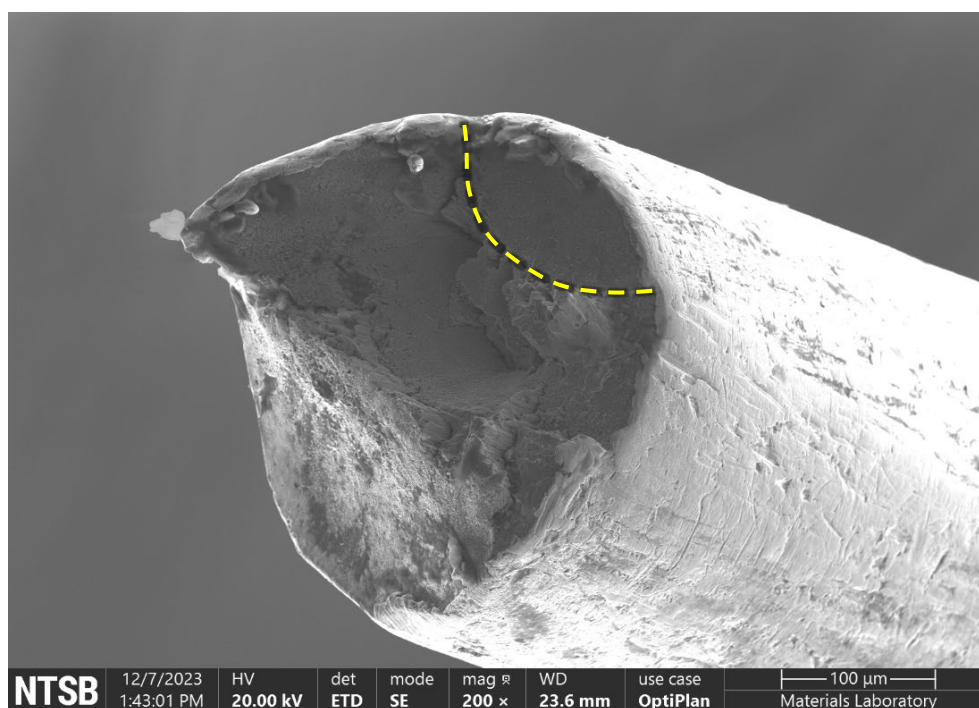


Figure 6. Representative SEM image of a wire with a fatigue region that extended across a fraction of the fracture surface. A dashed line indicates the fatigue boundary.

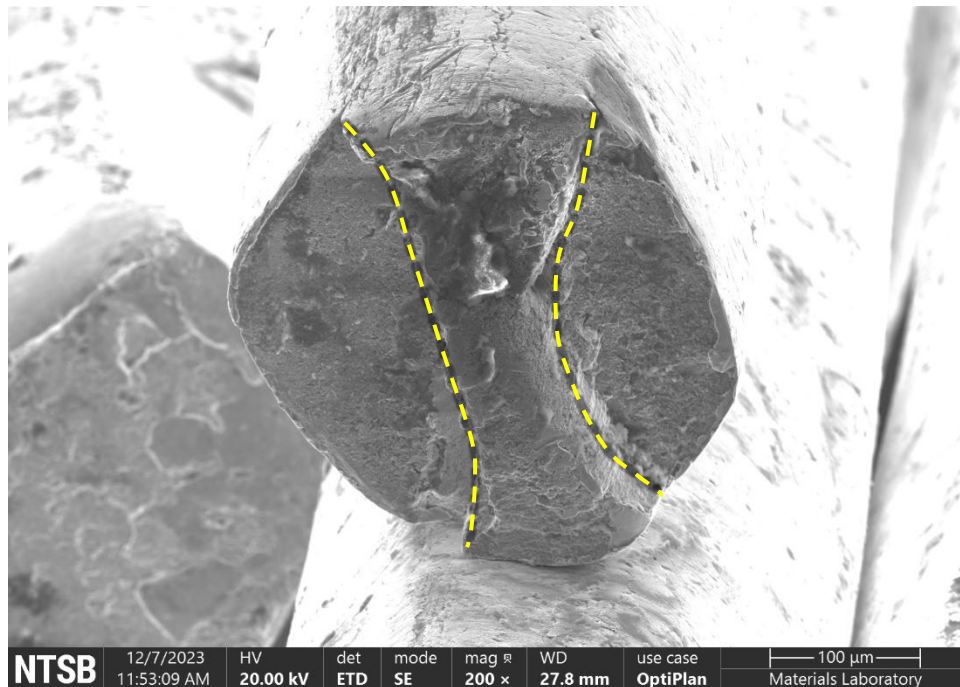


Figure 7. Representative SEM image of a wire with fatigue regions on opposite sides of the wire consistent with reverse bending fatigue. Dashed lines indicate the fatigue boundaries.

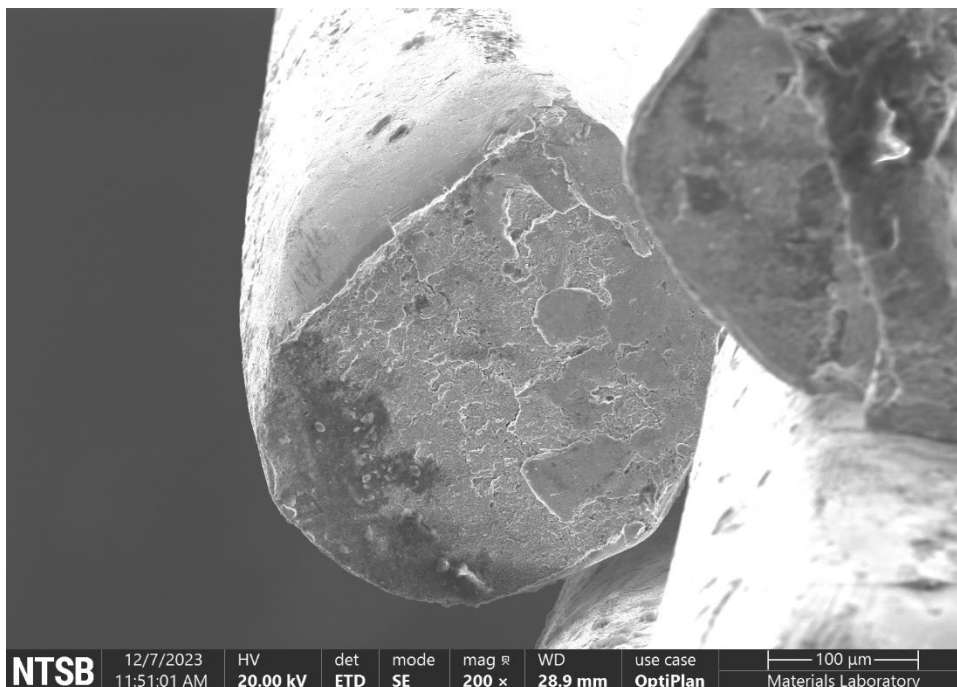


Figure 8. Example of a wire fracture with flat fracture features perpendicular to the wire axis across the fracture with no necking deformation.

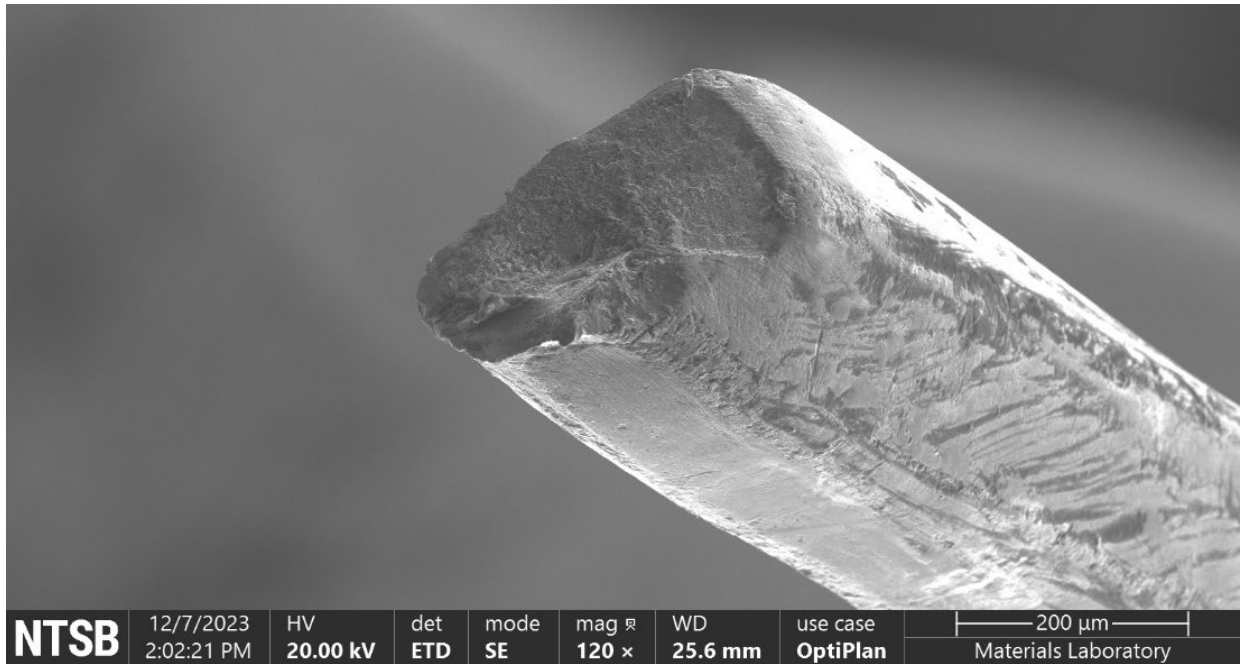


Figure 9. Representative SEM image of a wire with ductile overstress fracture features.