

NATIONAL TRANSPORTATION SAFETY BOARD

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



December 17, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 21-072

1. ACCIDENT INFORMATION

Place : Attalla, Alabama
Date : December 12, 2020
Vehicle : Beech V35A, N5470U
NTSB No. : ERA21LA068
Investigator : Timothy Monville, AS-ERA

2. COMPONENTS EXAMINED

Remnants of right aileron direct cable assembly with fractured portions of a turnbuckle assembly

3. DETAILS OF THE EXAMINATION

On December 12, 2020, about 1249 central standard time, a Beech V35A was destroyed when it was involved in an accident near Attalla, AL. The pilot was fatally injured. The pilot had established contact with Birmingham Air Traffic Control Tower prior to impacting an open field, creating a heavily fragmented debris field. Both stabilizers and ruddervator trim tabs, and pieces of both ruddervators, were found near the main wreckage. The wreckage was recovered and retained for further examination, and remnants of the right aileron direct wire rope were sent to the NTSB Materials Laboratory.

Figure 1 shows the right aileron direct cable (or wire rope) remnants, as received by the Materials Laboratory. The fractured ends of a turnbuckle fitting had been wrapped with notebook paper and taped prior to receipt. One of the sides was labeled "Cockpit End," and the other was labeled, "WMS" indicating the end towards the wing.

Figure 2 shows the WMS or wing side, as received. This section of the cable or wire rope measured 95.0 inches from the fitting to the outboard fixture (in the upper left of the figure) and 99.25 inches total length. Figure 3 shows the swaged portion of a wire rope turnbuckle terminal stud with a fracture that occurred at the terminus of the wire rope. This swaged portion of the terminal stud measured about 2.94 inches in length.

Figure 4 shows the as-received fracture surface of the swage portion of the terminal stud. This fracture surface contained enough caked dirt to obscure most of the strand ends.

Figure 5 shows the section of the wire rope labeled “Cockpit End.” This section of wire rope was attached to a chain on the forward end, shown in the top of Figure 5. From the fractured fitting to the chain, the wire rope measured about 97.25 inches, with the entire remnant of the wire rope assembly measured about 107.5 inches total.

Figure 6 shows the “Cockpit End” of the fractured turnbuckle assembly, after removing the covering. The fractured turnbuckle assembly exhibited several strands of safety wire wrapped around the part and through the holes in three locations. As shown in the left of Figure 6, the intact turnbuckle terminal stud was bent about 45°. The fracture surface of the turnbuckle terminal stud is shown in Figure 7. This end exhibited a general cup-shape, and as such was filled with caked dirt, consistent with contact with the ground after fracture.

The fractured ends of the fitting were cleaned in an ultrasonic bath, first with acetone and then with an aqueous chelating cleaning solution.¹ Figures 8 and 9 show close view of the mating faces of the fracture facing each other, after cleaning. These figures illustrate the generally tortuous shape of the fracture surfaces, along with the rough surface texture. Particularly on the wing side, the terminal stud fracture exhibited localized deformation, consistent with necking, adjacent to the fracture surface. The wing side fracture surfaces in the terminal stud exhibited a cup-shape, with a general 45° slant.

Also of note, as illustrated in contrasting Figure 8 and Figure 9, were the wire strands being present on only the swaged or wing side of the fracture. This is demonstrated on the cockpit side of the fitting fracture, shown in Figure 10 after acetone cleaning, which was absent any wire rope strands. Rather, as shown in Figure 11, this fitting side consisted of a hollow bore which held the ends of the wires shown in Figure 8. The fracture surface of this part of the fitting exhibited a dull gray luster, with a rough tortuous surface. The fracture surface of the swaged end of the terminal stud fitting (wing end) is shown in Figure 12

The fractured ends of the terminal stud were examined using a scanning electron microscope (SEM). The fracture surfaces exhibited consistent features, as typified in Figure 13—the fracture surface contained dimpled rupture, consistent with overstress fracture. There were some more visually reflective areas of the fracture surface, which were found to exhibit smearing, consistent with post-fracture damage to the surface. There were no indications of cracks, voids, or inclusions that would suggest pre-existing damage to the structure.

¹ Evapo-Rust – a commercially-available chelating rust stripper manufactured by Harris International Laboratories, headquartered in Springdale, AR.

The chemical composition of the fractured terminal stud was examined using energy dispersive x-ray spectroscopy (EDS). The fitting composition was consistent with a type 304 austenitic stainless steel. The hardness was inspected per ASTM E18.² The hardness averaged 59 HRA (consistent with 96 HRB per ASTM E140).^{3,4,5} These hardness data were typical of this material composition.

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² ASTM E18 – *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*. ASTM International, West Conshohocken, PA.

³ HRA – Hardness, Rockwell A scale. An indentation method of determining the hardness of metal alloys with an intermediate hardness between the B and C scales, using a conical diamond indenter and 60 kg major load.

⁴ HRB – Hardness, Rockwell B scale. An indentation method of determining the hardness of softer metals using a 1/16-inch diameter ball indenter and 100 kg major load.

⁵ ASTM E140 – *Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope Hardness*. ASTM International, West Conshohocken, PA



Figure 1 – View of the control wire rope remnants, as received.

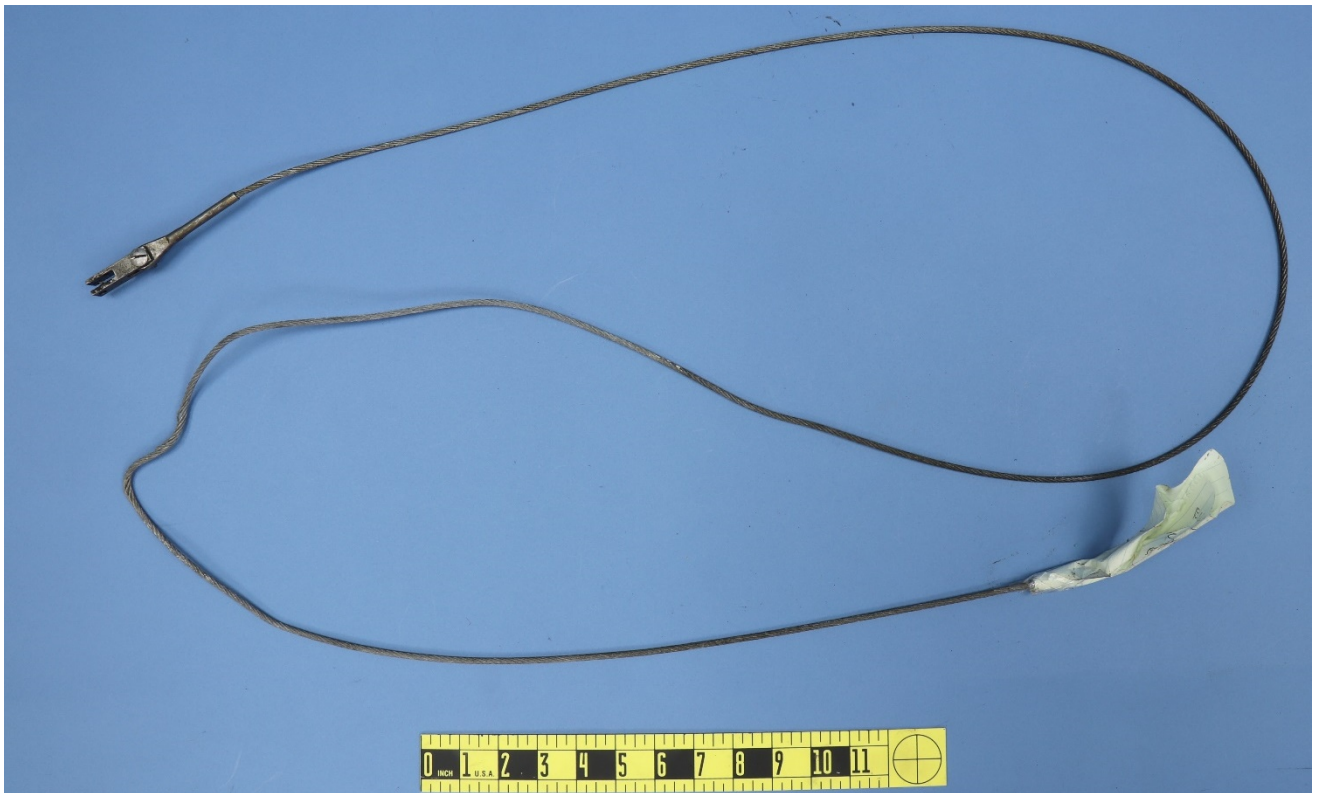


Figure 2 – View of the wire rope remnant side with the end labeled 'WMS End.'



Figure 3 – View of the swaged end of the fractured terminal stud fitting end of the WMS end, viewed from the side.



Figure 4 – View of the swaged end of the terminal stud fracture surface from Figure 3, showing caked dirt and debris in the wire strands.



Figure 5 – View of the control wire rope remnant labeled 'Cockpit End', as received.



Figure 6 – View of the as-received turnbuckle fitting with a fractured portion of a terminal stud from the 'Cockpit End' wire rope remnant, viewed from the side.

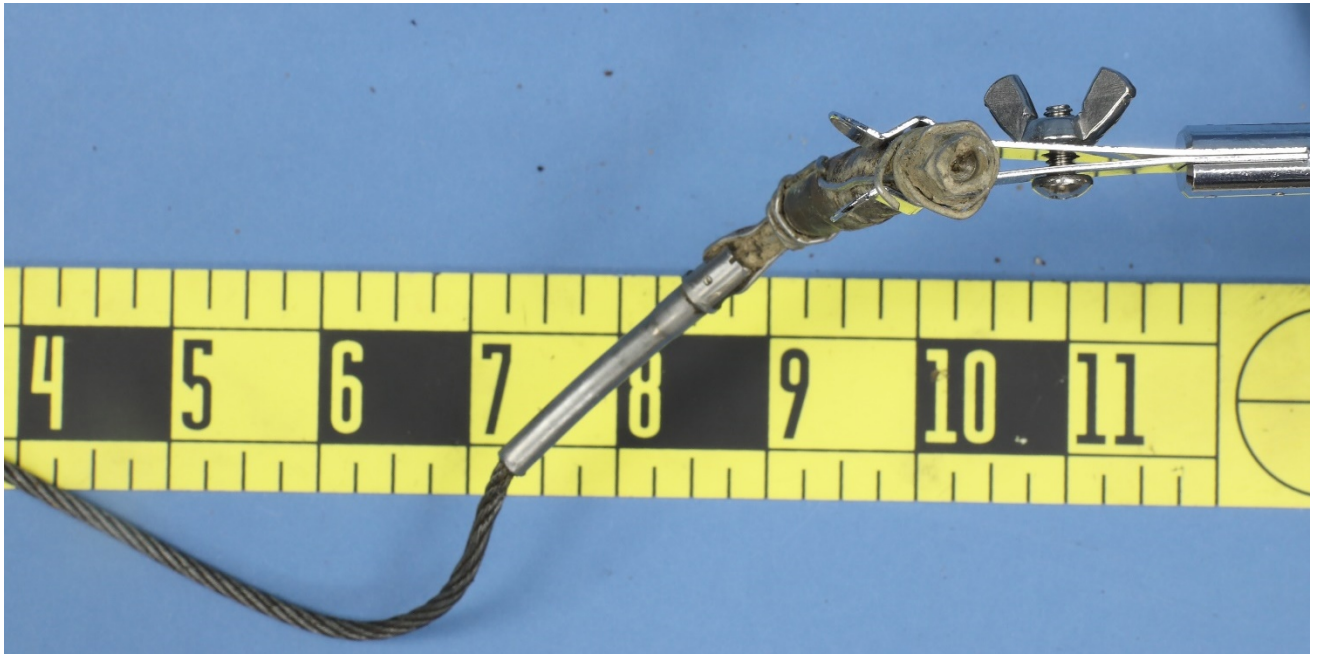


Figure 7 – View of the terminal stud fracture surface for the portion assembled to the turnbuckle fitting from cockpit end in Figure 6.

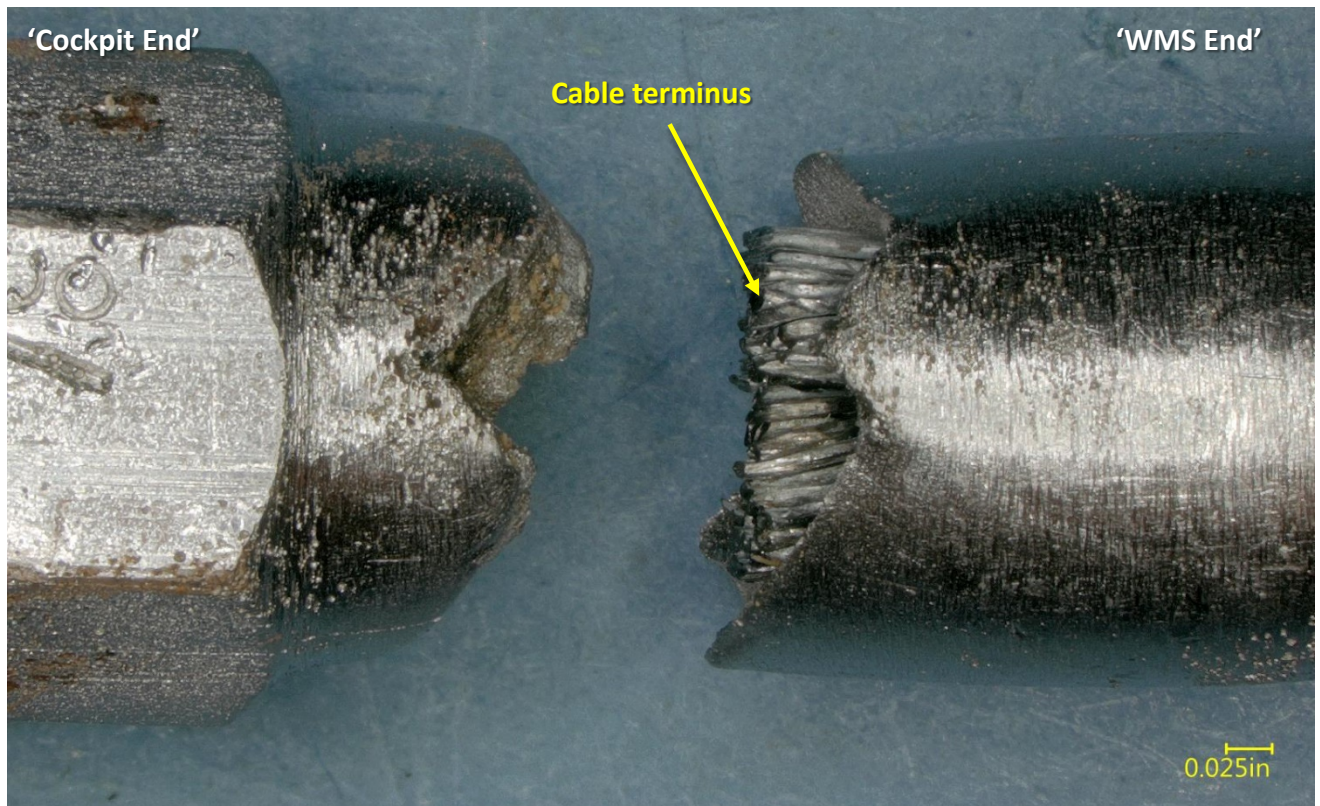


Figure 8 – View of the mating ends of the terminal stud fracture surface, viewed from the side after cleaning twice.

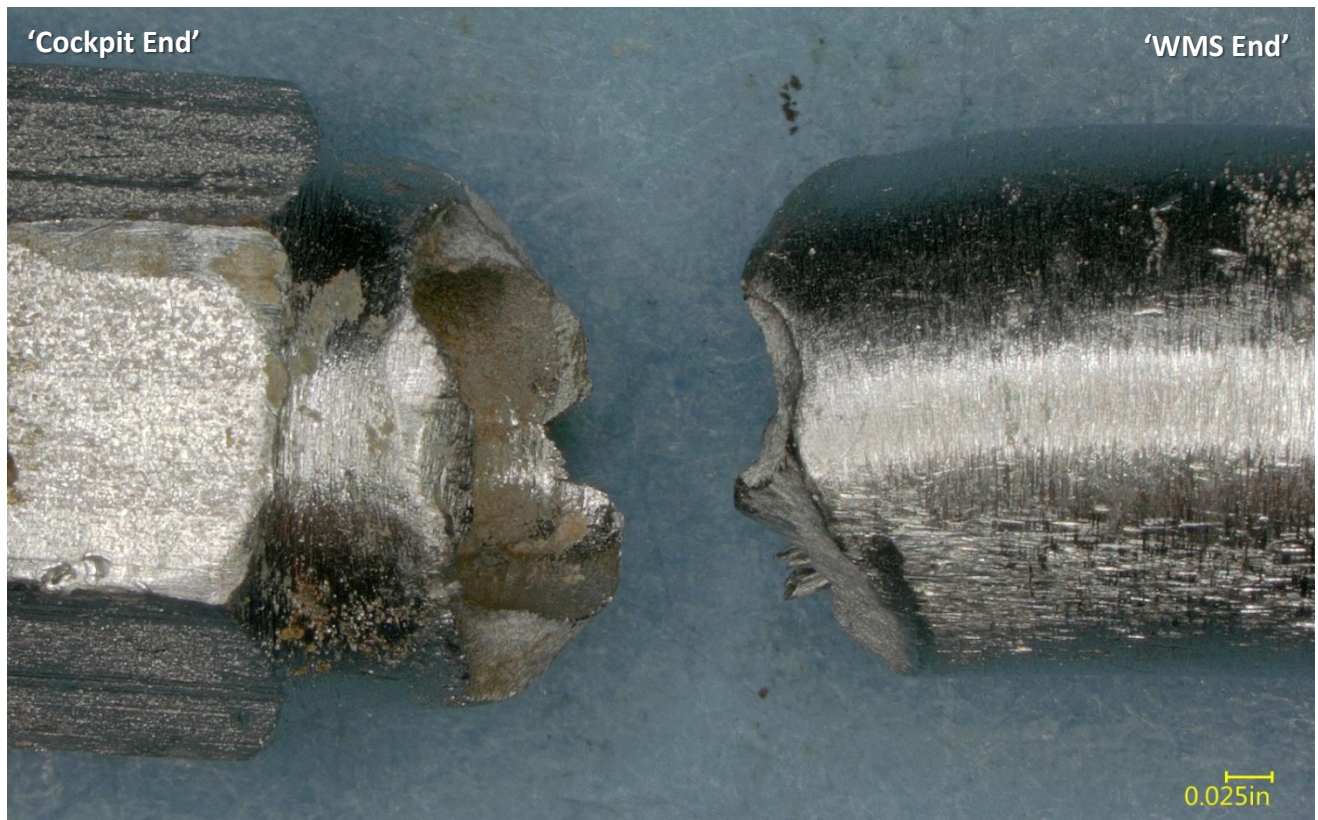


Figure 9 – View of the terminal stud fracture surfaces viewed 180° from Figure 8.



Figure 10 – View of the stud side (cockpit side) terminal stud fracture surface, post acetone cleaning.



Figure 11 – View of the stud side (cockpit side) terminal stud fracture surface after second cleaning.



Figure 12 – View of the swaged end of the fractured terminal stud (WMS end) of the fitting, showing the wire-rope ends.

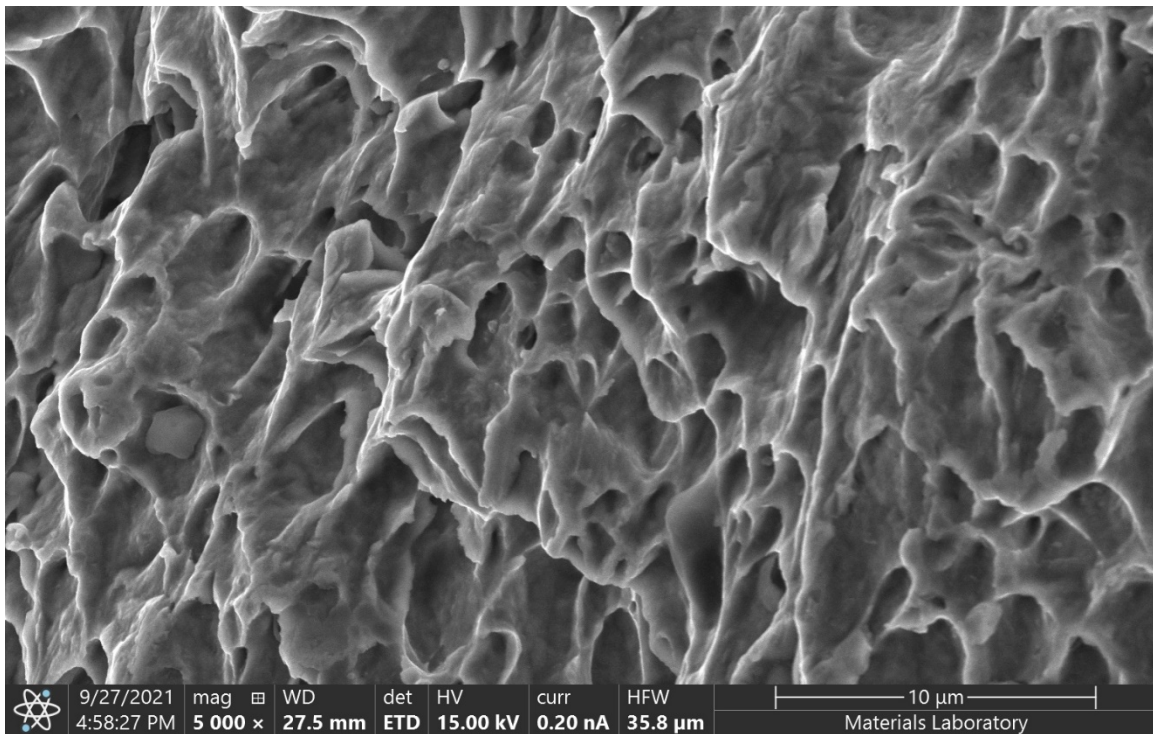


Figure 13 – Representative secondary electron (SE) micrograph of the terminal stud fracture surface, showing dimple rupture features.