NATIONAL TRANSPORTATION SAFETY BOARD

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

February 17, 2009

MATERIALS LABORATORY FACTUAL REPORT Report No. 09-006

A. ACCIDENT

Place	:	Denver, Colorado
Date	:	December 20, 2009
Vehicle	:	Boeing 737-500
NTSB No.	:	DCA09MA021
Investigator	:	Adam Huray (AS-40)

B. COMPONENTS EXAMINED

Nose gear steering cable in two pieces.
Exemplar nose gear steering cable from another aircraft.

C. DETAILS OF THE EXAMINATION

The received portions of the nose gear steering cable assembly are displayed in figure 1 (a). The pieces consisted of a shorter, 34 inch long section and a longer 75 inch section containing a ball stop fitting. The pieces were cut at one end and mated at the separation identified in figure 1. The separation was located approximately 20 inches from the ball fitting on the longer piece. In addition to the separation the cable was kinked at several locations with a single strand fracture at the most severe kink. The cable was nominally 3/32 (0.9375) inch in diameter and had 7 by 7 construction[1]. Measurements found the maximum outer diameter of the cable to be between 0.101 and 0.102 inch.

Portions of the cable, particularly near the separation, were partially covered with what appeared to be cable lubricant. Ultrasonic cleaning in acetone removed the adherent material. Magnified optical inspections in the immediate area of the separation revealed wear damage to the internal surfaces of the wires and strands as shown in figure 2. The amount of wear varied depending on location, with the most severe damage to the wires of the central strand. The location and geometry of the wear was typical of internal wear at a pulley location. Little or no wear was noted on the exposed surfaces of the cable adjacent to the separation. Manual unwinding of the cable revealed internal wear for a length of approximately 2 inches on either side of the separation.

[1] 7 x 7 construction: wire rope comprised of 6 strands with 7 wires in each strand, laid around a core of 7 wires.

A piece of the cable including the separation was cut from the long cable length and examined with the aid of a scanning electron microscope (SEM), as shown in figure 3. SEM viewing revealed ductile dimple overstress fracture features on all separated wires. Individual wires also displayed various amounts of wear at the fracture locations, see figure 3 (a). Some wires showed no wear (b) while other wires were worn to chisel points before fracturing (c).

Energy dispersive x-ray spectra of individual wires during SEM examination were consistent with type 300 stainless steel (corrosion resistant steel) containing iron with chromium and nickel.

As a measure of wear, the remaining thickness at the fracture of 21 of the 49 cable wires was estimated, not including yielding from fracture. In the sampled wires, approximately 45% of the original thickness remained while about 55% of the original thickness appeared to have been removed by wear. Military specification MIL-DTL-83420[2] specifies a minimum breaking strength of 920 pounds for 3/32 inch, 7 X 7 construction, composition B (corrosion resistant steel).

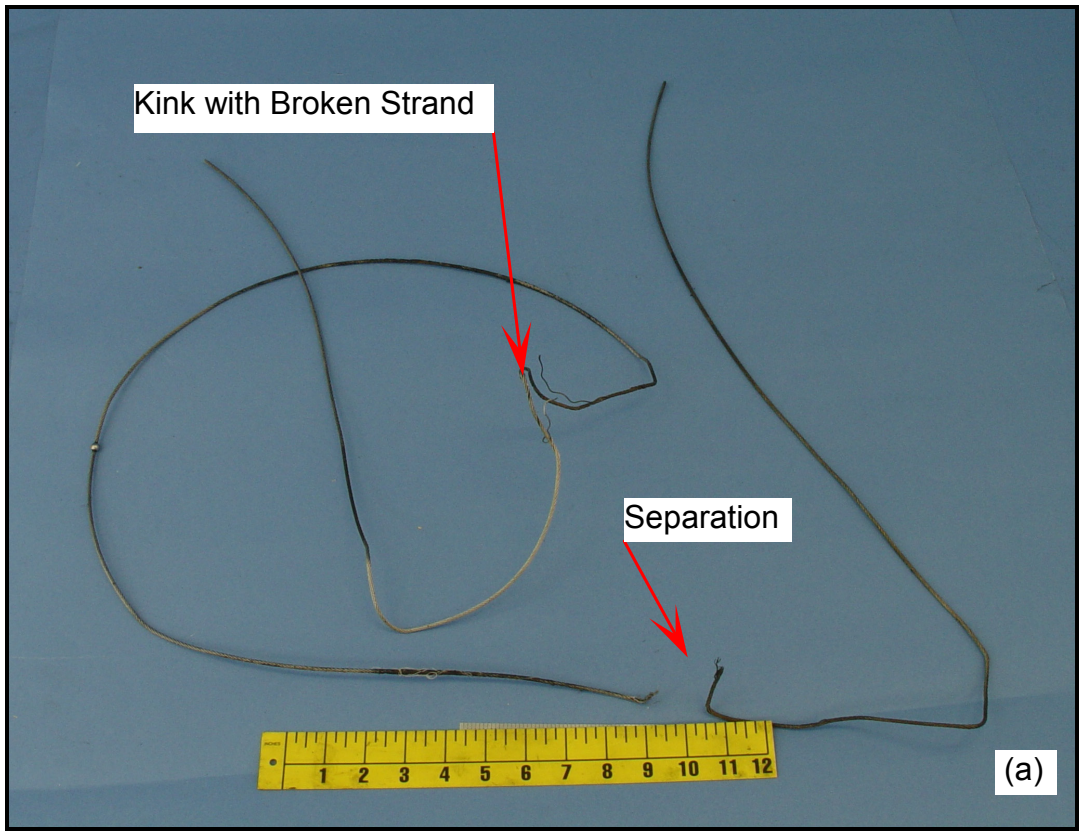
Visual inspection of the remaining cable lengths uncovered heavy external wear damage in two areas on the longer piece. One 2 inch long wear region was located about 12 to 14 inches from the fracture and another 2 inch long region about 26 to 28 inches from the fracture. Both wear regions had similar features as shown in figure 4. The external surfaces were worn nearly flat with a few wires nearly worn through their diameters. The cable diameter in these areas was about 0.09 inch. Both wear regions also had an unusual ridge feature near the middle of the wear area as shown in figure 4 (c). The ridge appears to be nearly unworn and approximately full diameter. The relative locations of the wear areas are denoted in the illustration contained in figure 5.

An exemplar cable was received from another similar airplane. The cable was reported to have been intact on the aircraft but cut during its removal. The cable was about 219 inches long with a turnbuckle fitting swaged onto the end. One fitting was marked with what appeared to be a date “11/20/00” and a part number “923230”.

The cable was tagged “reason for removal” at a visible wear location 89 inches from the numbered fitting. Magnified visual inspections of this area revealed significant external wear to the strands and several separated wires, as shown in figure 6. Closer inspection found that the separated wires had been worn completely through their diameters. A wear ridge, similar to that seen on the accident cable, was noted near the broken wires. Further inspections of the cable uncovered four additional areas of external wear on the cable, one of which also contained the ridge feature. An illustration of the locations of the wear areas is shown in the upper portion of figure 5.

Joe Epperson
Senior Metallurgist

[2] MIL-DTL-83420M,1 April 2005, General Specification For Wire Rope, Flexible, For Aircraft Control



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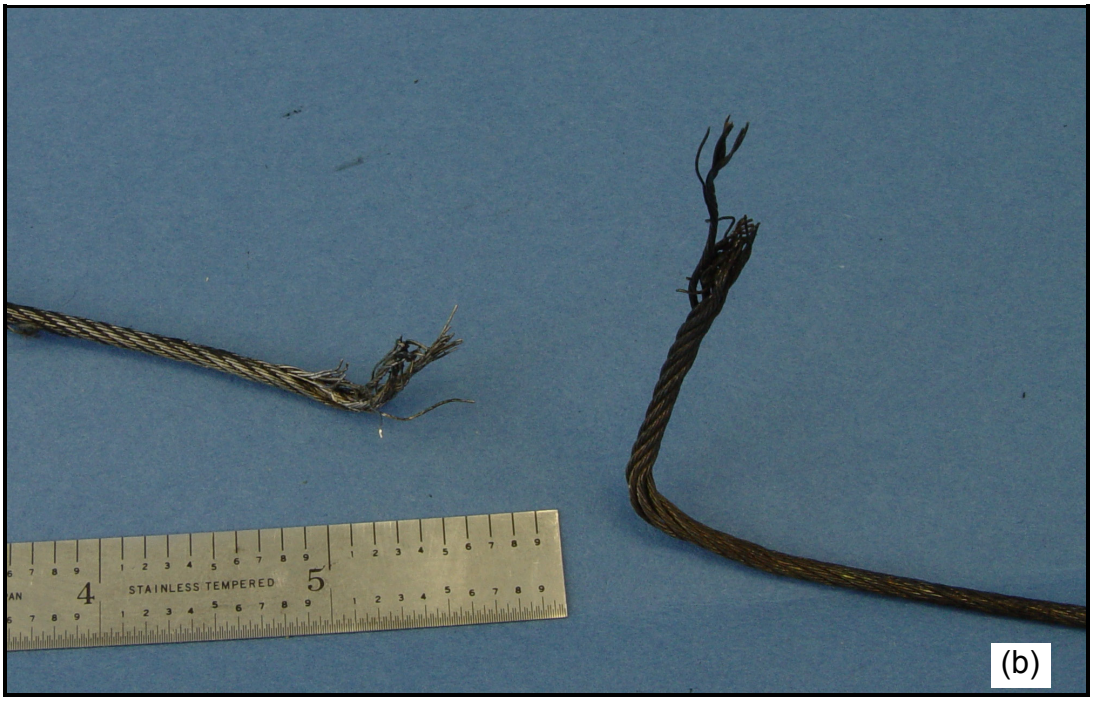

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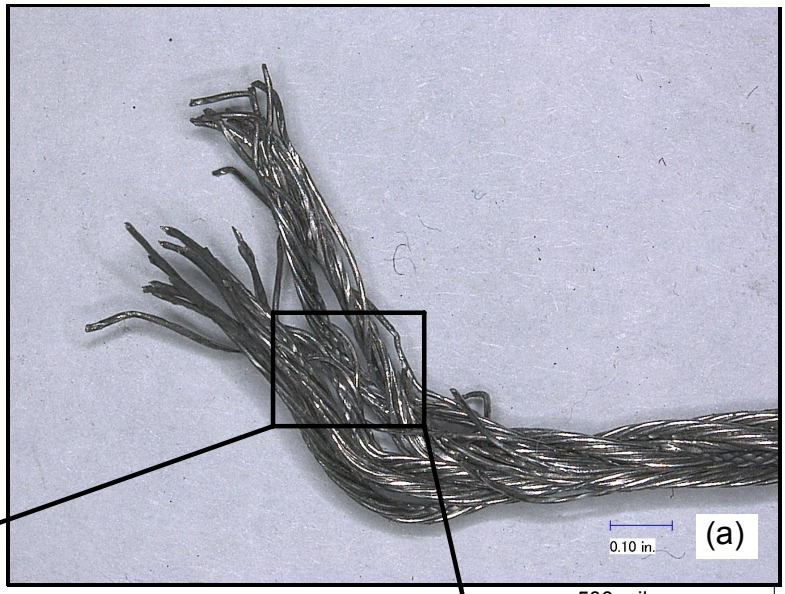
Figure 1--Overall view (a) of as-received wires. Closer view (b) of separation area.



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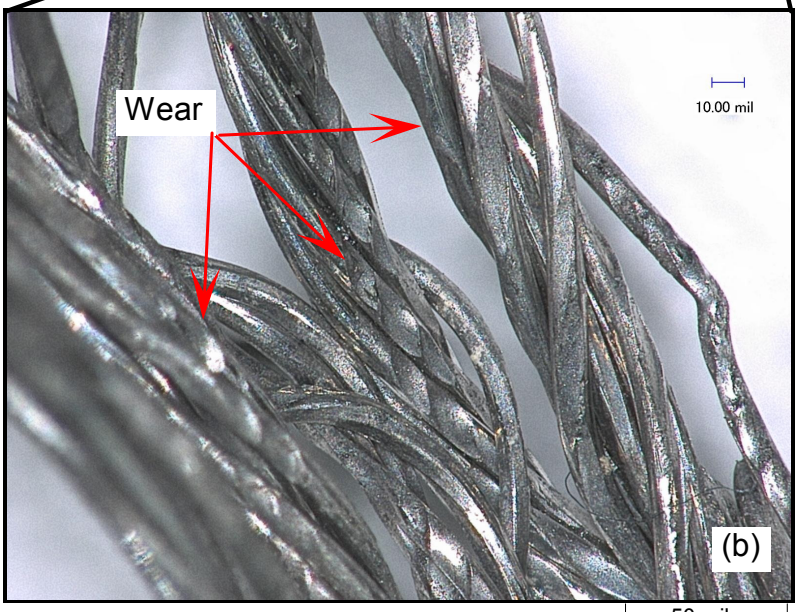

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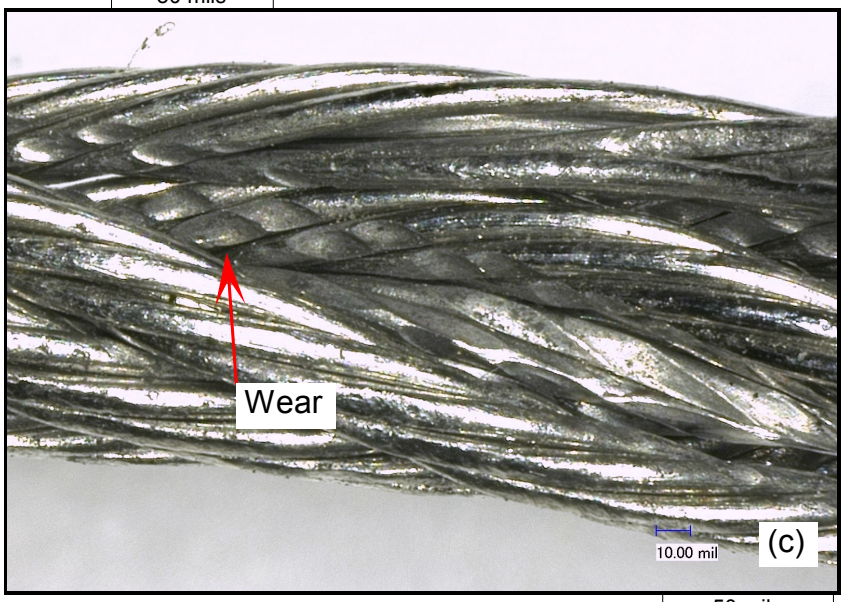
Figure 2--Views of the separated end of the long piece (a) showing the internal wear (b) and (c).



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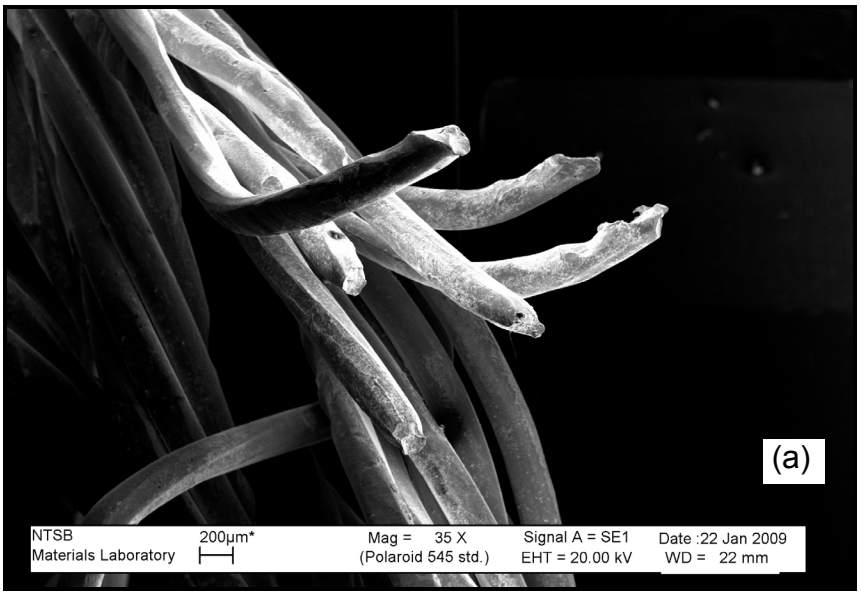

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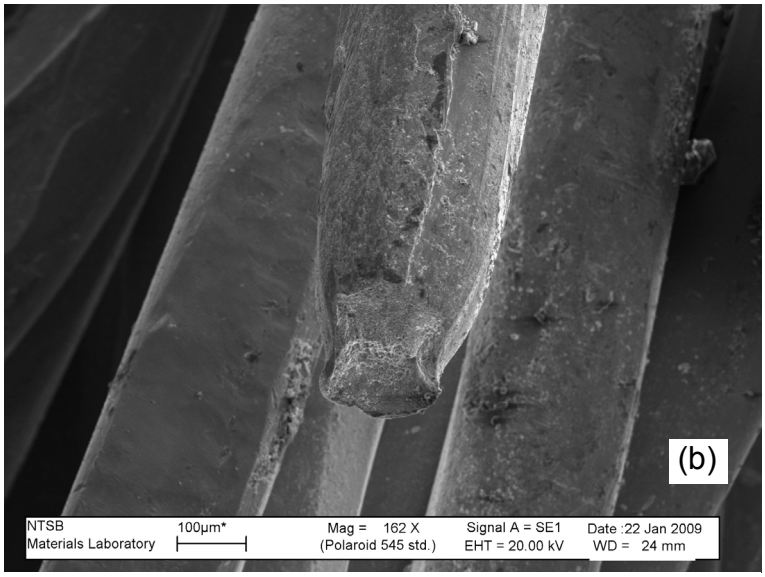

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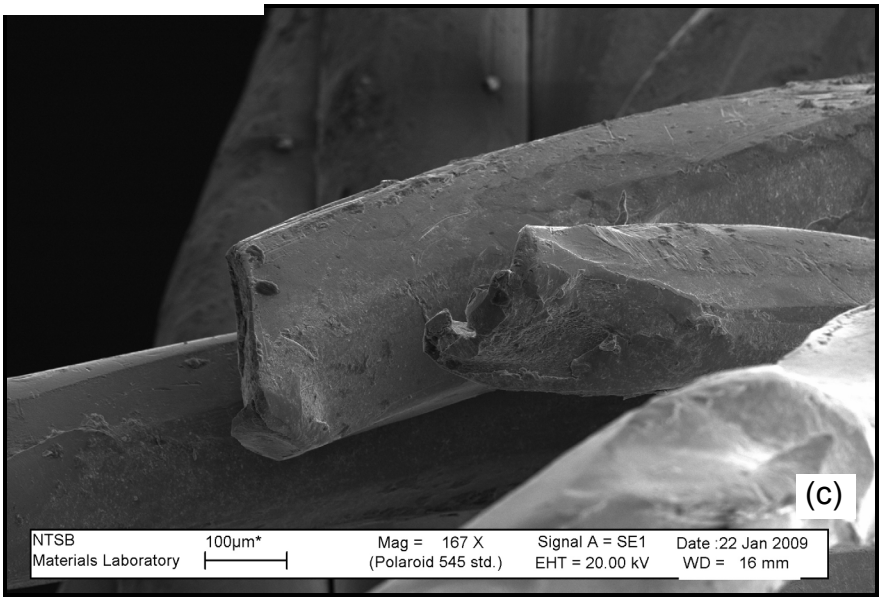
Figure 3--SEM views showing wear at several fracture wires (a) and the absence of wear at some with overstress yielding (b). Wires worn to a chisel point (c).



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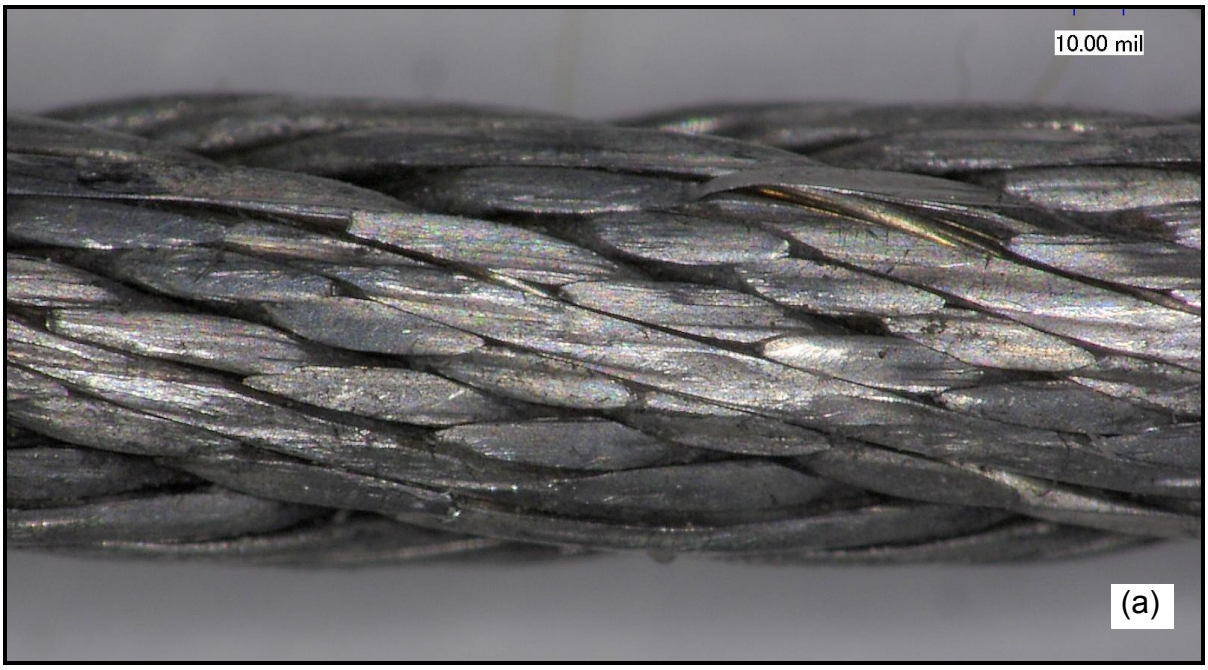

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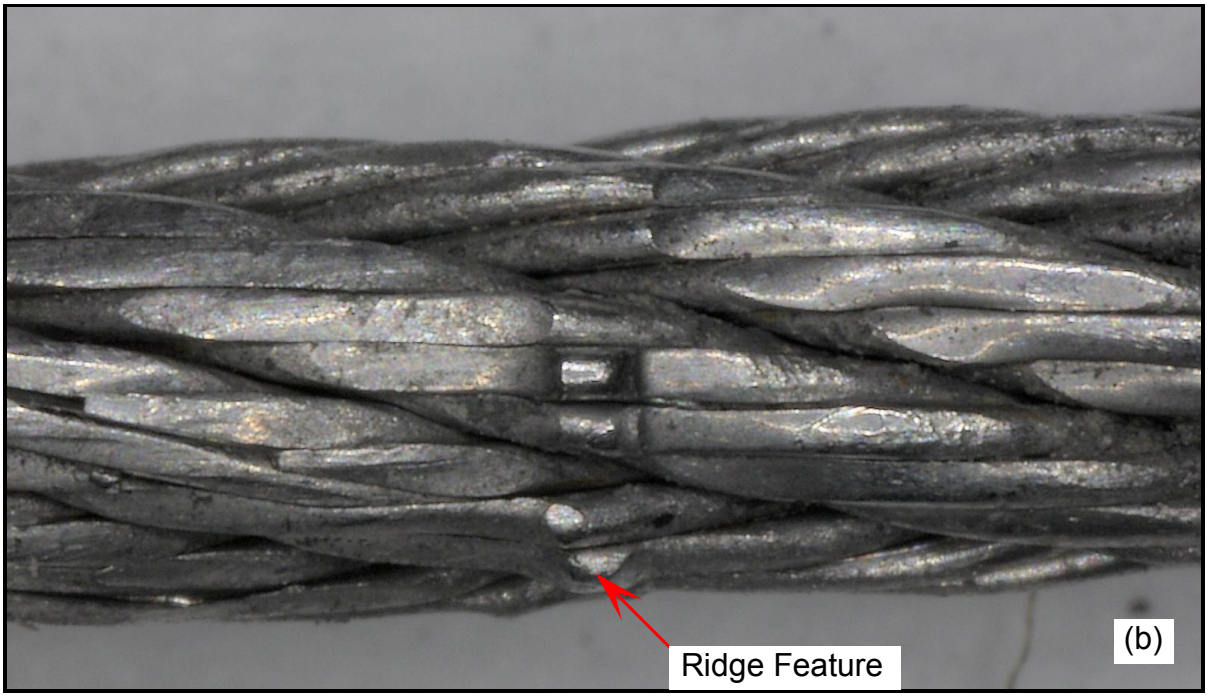

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Figure 4--External wear on the cable away from the separation (a). The wear ridge (b) noted at two external wear locations.

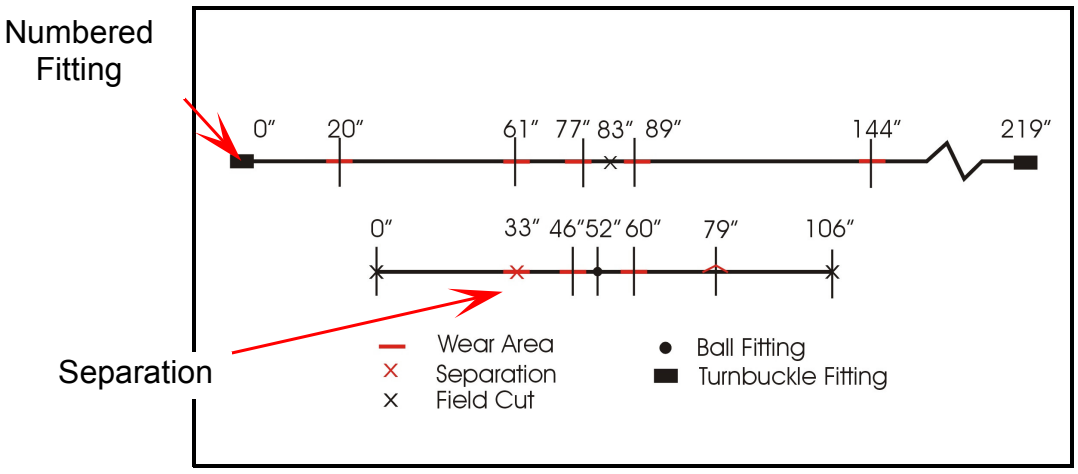

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Figure 5--A illustration of the relative wear locations and other features on the separated cable (bottom) and on the exemplar cable (top).

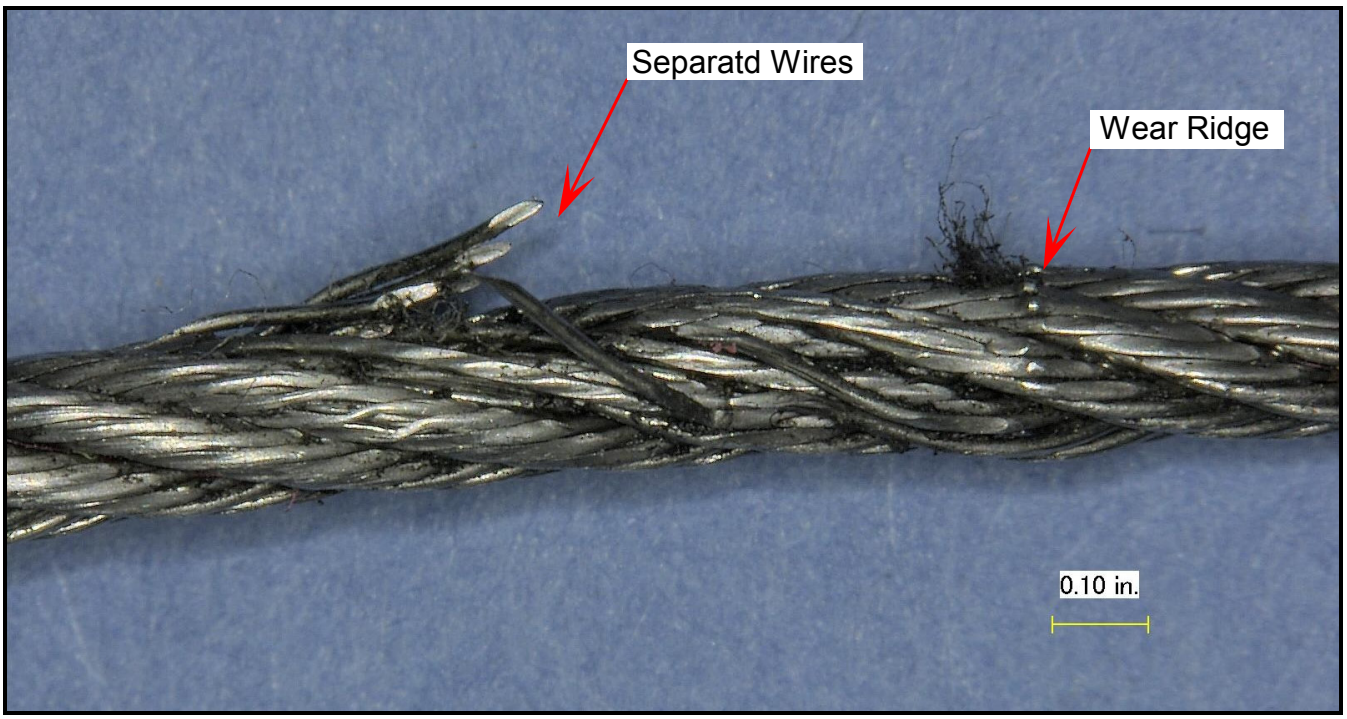

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Figure 6--Wear and fractured wires on the exemplar cable.