

NATIONAL TRANSPORTATION SAFETY BOARD

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



January 3, 2020

MATERIALS LABORATORY FACTUAL REPORT

Report No. 19-066

A. ACCIDENT INFORMATION

Place : Grass Valley, California
Date : April 19, 2019
Vehicle : Nanchang CJ6, N621JM
NTSB No. : WPR19LA117
Investigator : Joshua Cawthra, AS-WPR

B. COMPONENTS EXAMINED

Portion of a fractured wire rope brake cable
Thimble with retained bushing, clevis pin with hole, split pin

C. DETAILS OF THE EXAMINATION

A portion of fractured wire rope brake cable was submitted to the NTSB Materials Laboratory for examination to determine the failure mode. Additional components received included a thimble with a retained bushing, a clevis pin with a single hole near the end of the shank, a washer, and a split pin (cotter pin). Components examined are shown in figure 1 for reference.

The portion of brake cable measured approximately 8 $\frac{3}{4}$ inches in length and was constructed of seven strands of seven metal wires (7x7) with a right regular lay. The nominal outside diameters of the cable and strands were measured using a digital caliper to be approximately 0.07 inches and 0.024 inches, respectively. One free end of the cable was fractured through all the strands. The fractured strands and wires were raveled approximately $\frac{3}{8}$ inches away from the fracture location with a single wire approximately $\frac{3}{8}$ inches longer than the other fractured strands and wires. A second fracture location was observed approximately 2 $\frac{1}{8}$ inches further along the cable at a feature consistent with a tapered and concealed hand-tucked splice joint for an eye termination. When comparing the thimble with the cable contour between these fracture locations, the fit was consistent with a thimble-eye termination created by a hand-tucked splice joint. This indicated that the two fracture locations observed were mating fracture surfaces.

The other free end of the brake cable exhibited wire and strand terminations at approximately the same location and same knife-edge orientation with no evidence of raveling, consistent with having been mechanically cut. A permanent bend in the cable, approximately 120° with approximately a 0.3 – 0.4 inch radius of curvature was observed approximately $\frac{1}{2}$ inch from the end of the hand-tucked splice joint towards the cut end of the cable. A localized area of external cable wear approximately one inch long and up to 40% of the individual wire diameter was observed on one side of the cable approximately 2 $\frac{1}{2}$ inches from the cut end as shown in figures 1 and 2.

A dark brown-black, greasy, lubricating substance was present in between the strands and wires of the as-received cable. No visual signs of corrosion were observed. To facilitate closer observation of the fracture surface, the cable was cleaned ultrasonically in a solution of Alconox detergent and water followed by acetone.¹

The fracture surface of the cleaned cable was examined using a scanning electron microscope (SEM). To facilitate examination, the cable was cut within the eye adjacent to the hand-tucked splice approximately 0.25 inches from the start of the splice. Six of the seven strands of wires exhibited evidence of relatively flat fracture surfaces oriented normal to the wire axis as shown in figures 3 and 4, consistent with a progressive fracture mechanism, such as fatigue fracture. Only one strand and a few of the remaining individual wires showed evidence of minor elongation at the fracture location. Energy dispersive spectroscopy (EDS) examination of the fatigue fracture location returned peaks of iron, nickel, and zinc consistent with galvanized steel. In addition, EDS found lead and tin, consistent with typical solder alloys. Strands and wires at the fracture location and within the hand-tucked eye splice were surrounded with solidified metal consistent with a lead-tin solder alloy. This material was visible on the external surfaces of wires, as shown in figures 3 and 4. Figure 5 presents a photograph of the hand-tucked eye splice with solder present. There were visible cracks in the solder network oriented along the general direction of the cable strands and wires.

Michael Meadows
Materials Engineer

¹ Alconox is a powdered cleaning detergent, containing primarily sodium bicarbonate and sodium alkylbenzene sulfonate, manufactured by Alconox, Inc., White Plains, NY.

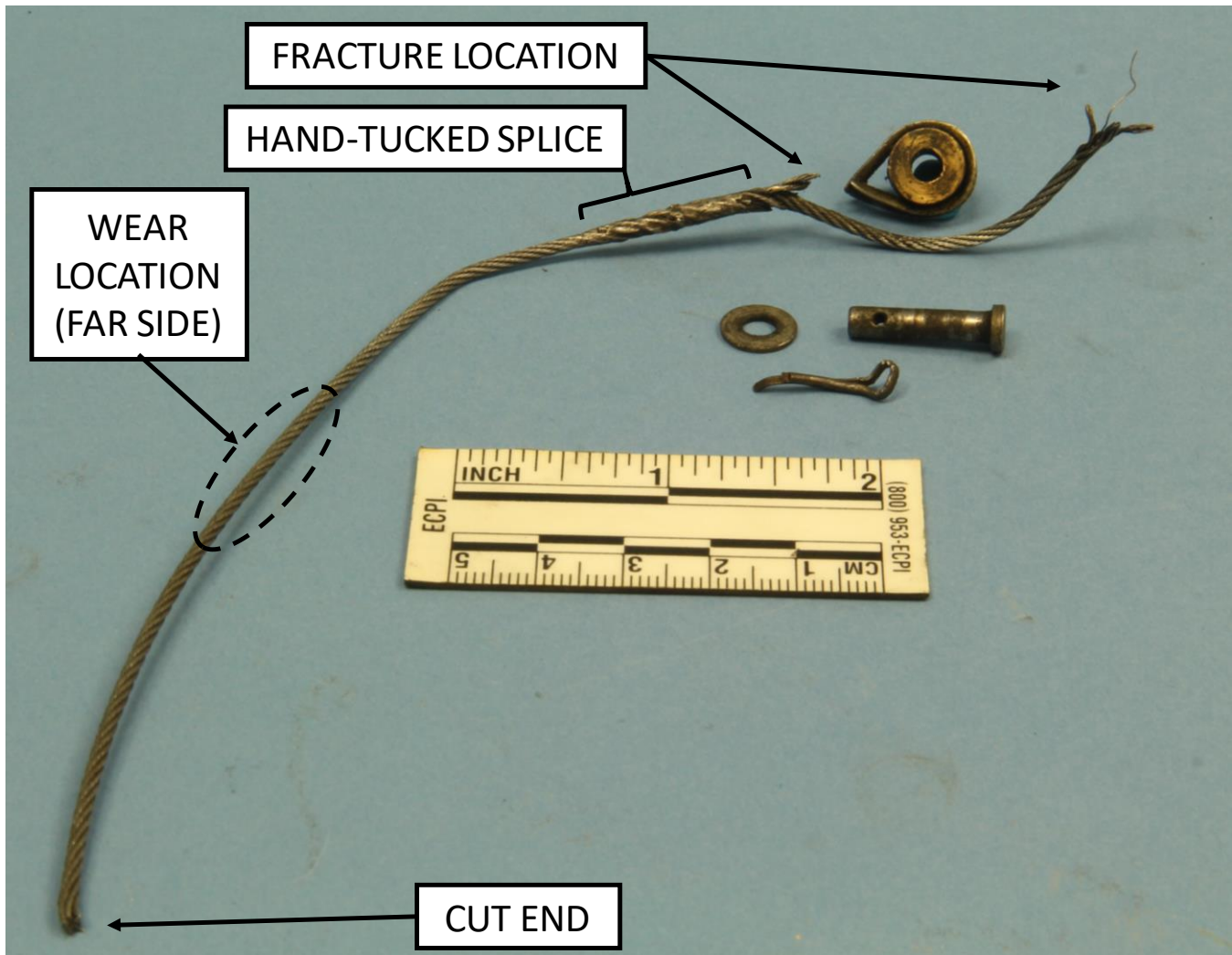


Figure 1: As-received components with cable fracture location identified with arrows. Location of the thimble with retained bushing intended to show a pseudo-reconstructed view of the eye termination. Mating fracture surfaces were within the eye and adjacent to the start of the hand-tucked splice joint when the cable was wrapped around the thimble.



Figure 2: Magnified view showing external wear to the individual wires from the section of cable identified in figure 1. Arrows indicating several locations of features consistent with wear.

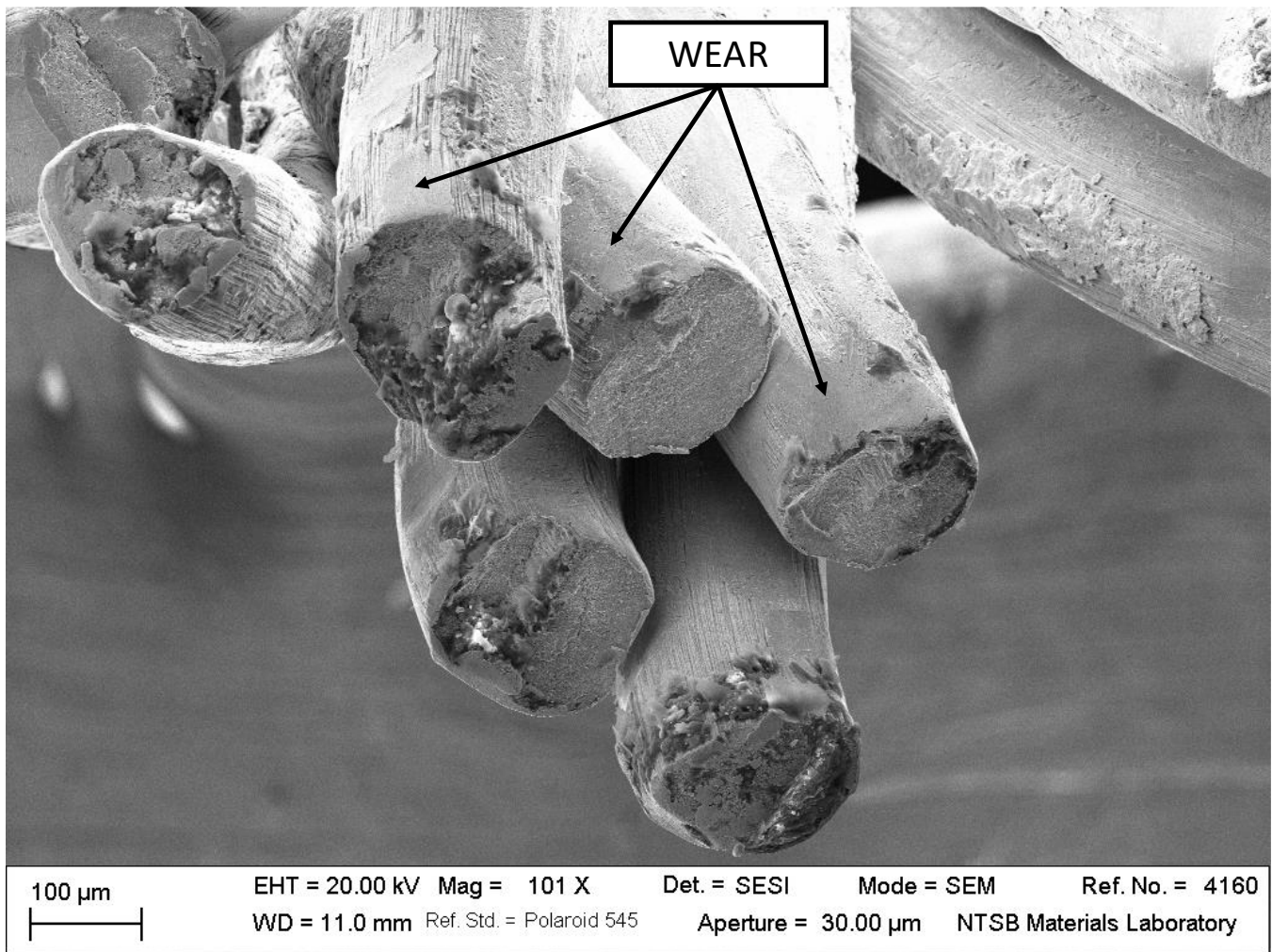


Figure 3: SEM micrograph of fractured wires exhibiting relatively flat fracture surfaces consistent with fatigue cracking and evidence of wear on the outer surface of individual wires.

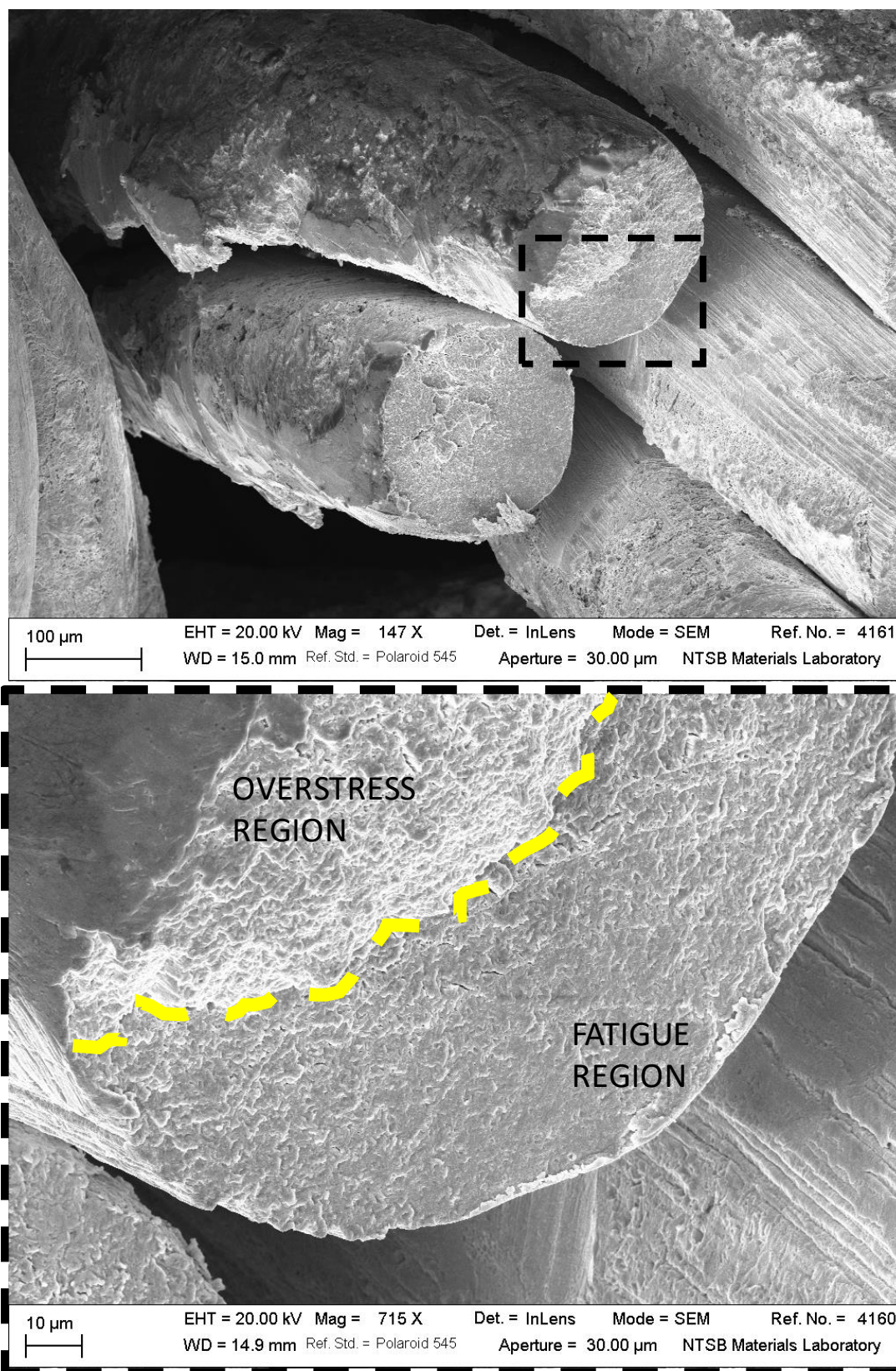


Figure 4: SEM micrographs of fractured wires showing features consistent with fatigue fracture. The right image shows higher magnification of the area indicated on the left image.

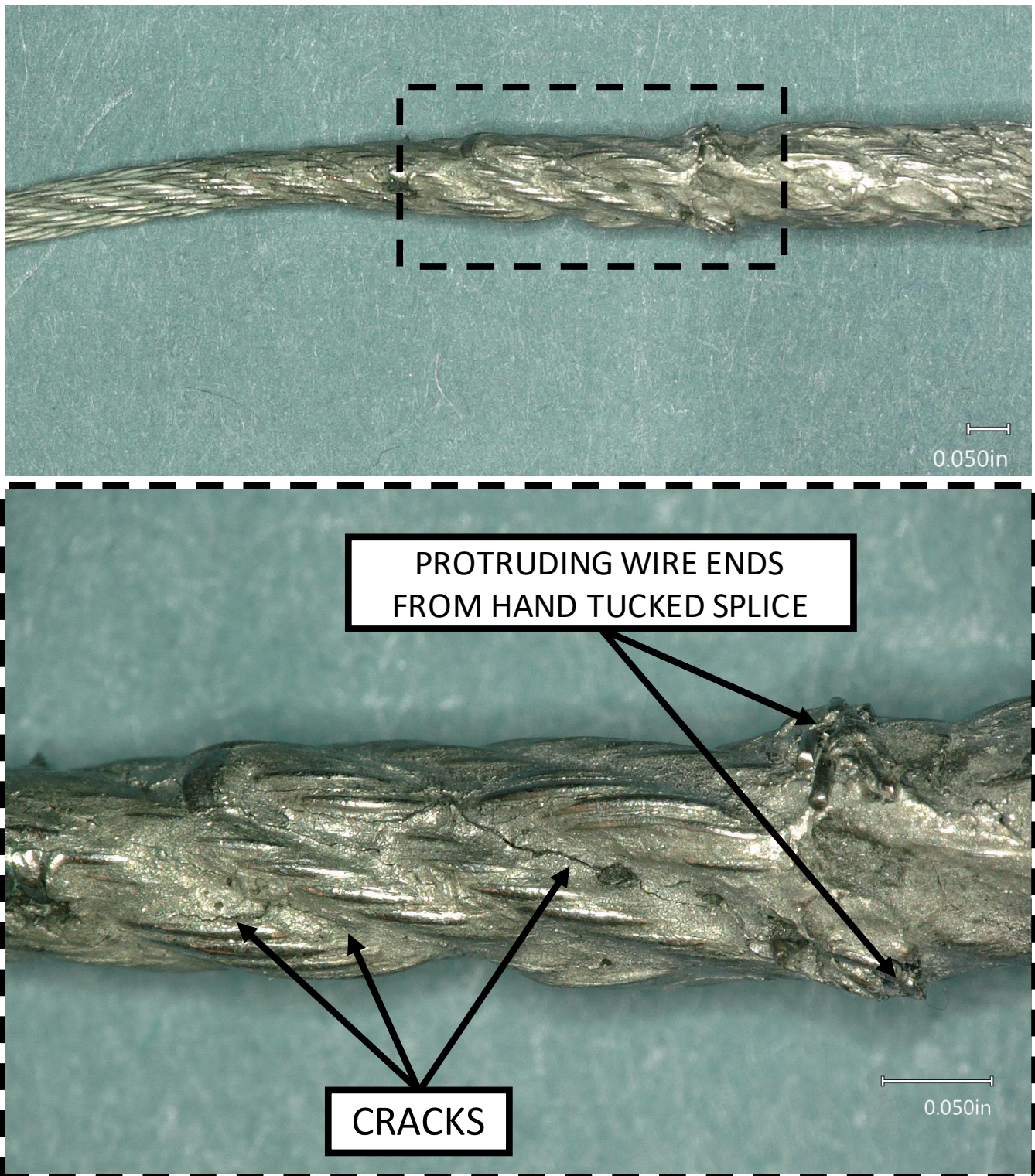


Figure 5: Cleaned cable at terminating end of hand-tucked splice joint showing a smooth metallic material surrounding cable strands and wires. The left image shows the termination of the hand-tucked splice joint transitioning to un-spliced cable as viewed from right-to-left. The right image shows a magnified view of the indicated region of the left image to highlight several cracks observed in this surrounding material.