

NATIONAL TRANSPORTATION SAFETY BOARD

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



February 8, 2022

MATERIALS LABORATORY FACTUAL REPORT

Report No. 22-004

A. ACCIDENT INFORMATION

Place : Fort Collins, Colorado
Date : May 28, 2021
Vehicle : Pipistrel Alpha Trainer, N119JP
NTSB No. : CEN21LA241
Investigator : Samantha Link, ASI-CEN

B. COMPONENTS EXAMINED

Throttle and choke cable splitter assembly with separated throttle input cable.

C. DETAILS OF THE EXAMINATION

A throttle and choke cable-splitting assembly and a separated throttle input cable were submitted to the NTSB Materials Laboratory for examination, as shown in figures 1a and 1b. The cable splitting assembly is part of the throttle and choke (carburetor) control system (see Appendix A). By design, individual Bowden cables from the cabin throttle and choke controls run forward, attaching to the aft end of the splitter assembly's metal bracket. The inner cables extend forward into cable splitters, shown in figures 2a and 2b for the throttle and choke, respectively. Two cables are joined to each of the splitters at their forward ends. Bowden cables attached to the forward end of the assembly bracket then continue the cable runs toward the left and right bank throttle and choke controls (four cables in total). As seen in figure 1b, the throttle input cable had separated from its splitter assembly, thereby disabling throttle control.

The splitters are assembled using a soldering procedure (see figure 2b). The splitter fitting has a hole in its forward end into which two splitter cables are inserted. The cables are coated with a flux paste, inserted into the fitting, and clamped with a set screw. The cables are then joined to the fitting by introducing solder into a solder cup, located on the top side of the fitting, and connected to the cable hole. At the input end, the input cable is coated with a flux paste, inserted into a terminal fitting, clamped with a set screw, and joined to the terminal by solder introduced through a hole at the forward end of the terminal (see below). The terminal is then inserted into a through-hole on the side of the splitter fitting, with slots machined to accommodate insertion and rotation of the input cable.

The throttle control splitter fitting exhibited features consistent with a lack of filling and wetting of the solder joints. Examination of the choke control splitter fitting (figure 3a)

indicated that the cable hole was filled with solder and the solder extended forward, wetting the cables. Examination of the throttle control splitter fitting (figure 3b) revealed a void within the fitting where the solder had not filled the joint and had not wet the cables. Similarly, the choke control input cable's terminal fitting (figures 4a and 4b) exhibited solder filling the joint at the inlet and outlet of the terminal and solder wetting the cable at its inlet. By contrast, the throttle control cable's input terminal fitting (figures 5a and 5b) exhibited a void within the joint where the cable entered the terminal, while the forward end, where solder was fed into the joint, was filled.

The composition of the cable and the solder was examined using an electron microscope (SEM) equipped with an energy dispersive x-ray spectrometer (EDS). A piece of the throttle input cable was sectioned and cleaned in accordance with standard laboratory procedures. The throttle and choke input terminal fittings were ground at their forward end (where solder was added to the joint) on silicon carbide paper until the solder joint's surface layer was removed. The resulting EDS spectra for the cable surface and solder from the throttle terminal fitting are shown in figures 6a and 6b, respectively. The cable spectrum consisted primarily of iron (Fe) and zinc (Zn), consistent with a zinc-coated steel cable. The solder spectrum consisted primarily of tin (Sn) and copper (Cu). The EDS spectrum for the solder from the choke input terminal fitting (not shown) was nearly identical to the spectrum from the throttle fitting.

The throttle control input cable exhibited fractures and wear of multiple strand wires at its connection with the terminal fitting. The cable was composed of 19 wires, each wire approximately 0.25 mm in diameter, and the cable diameter was approximately 1.25 mm (as measured on a calibrated optical image). Examination of the fitting's inlet hole with the aid of a stereomicroscope revealed fractured wire ends still attached to the terminal fitting, as shown in figure 7, as did examination of the cable end itself (figures 8a – 8d). In total, 11 wires appeared fractured and 8 appeared intact. Some of the outer strand wires exhibited wear on their outward-facing surfaces, creating flat spots, such as the one indicated in figure 8d.

The cable end was cleaned using an alkaline detergent and a nylon bristle brush followed by immersion in an acetone-filled beaker placed in a sonicating bath. Dirt/debris was still adhered to the fractured wire ends. The debris on five of the strands was removed using acetate film that was softened with acetone, applied to the fracture, allowed to harden, and then removed from the fractured wire ends.

The wire fractures exhibited features consistent with a progressive fracture. The five wires shown in figure 9a were fractured in the transverse plane with no apparent necking or cup/cone-type fractures (one wire, not shown, appeared to exhibit necking and a second wire was indeterminate). As oriented in figure 9a, the fractures exhibited a progressive tint, with the darkest tint near the 10 to 11 o'clock position. Examination using a scanning electron microscope (SEM) revealed ratchet marks and curvilinear crack arrest marks, such as those shown in figure 9b, emanating from the same regions. At higher magnification, the fracture surfaces exhibited a smeared appearance that had destroyed the original fracture features. Taken as a whole, the features were consistent

with progressive fractures originating approximately between the 10 and 11 o'clock positions (indicated by yellow arrows), as oriented in figure 9a.

Donald Kramer, Ph.D.
Sr. Materials Engineer

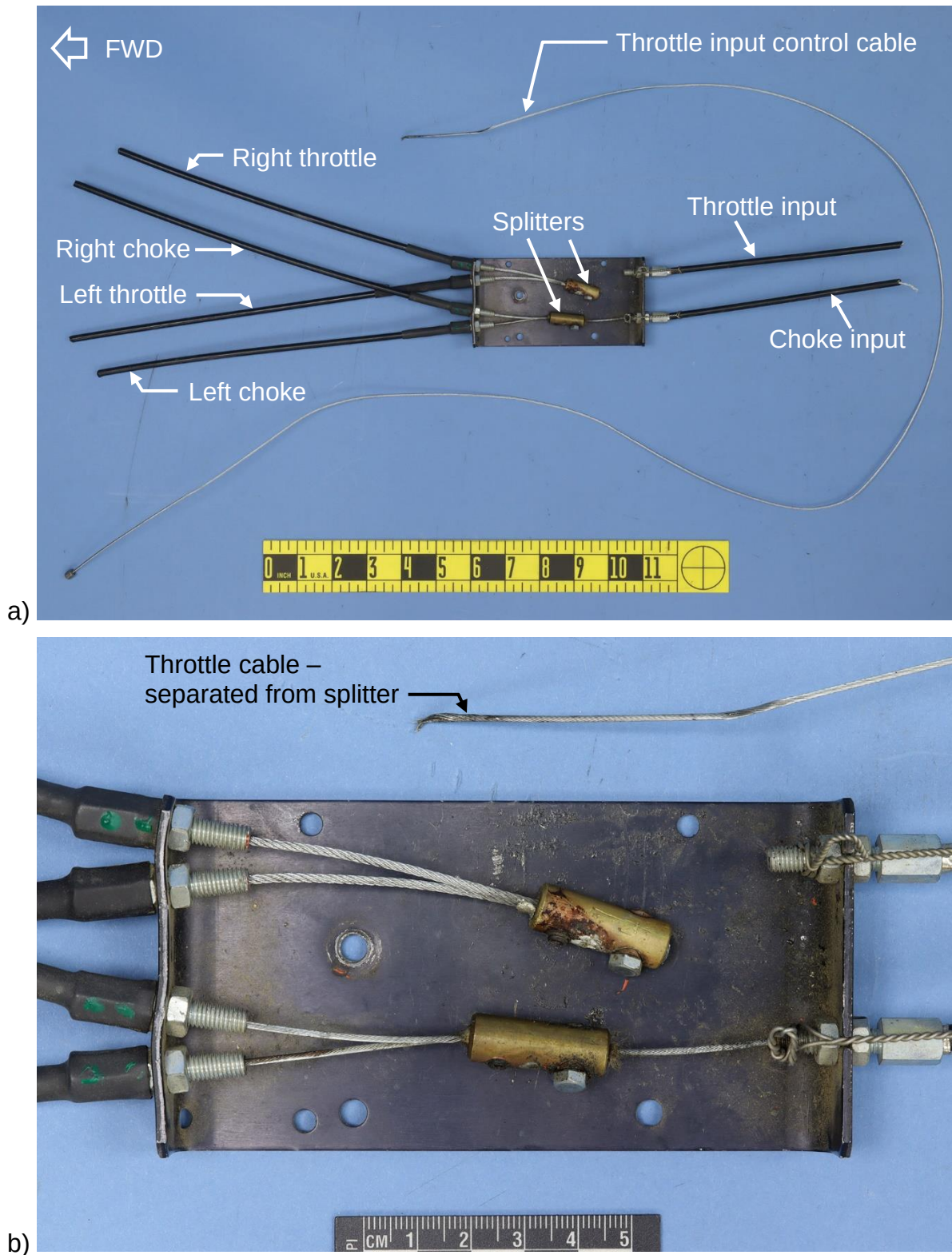


Figure 1: a) Splitter assembly and throttle input cable as received and b) higher magnification image of the splitter assembly.

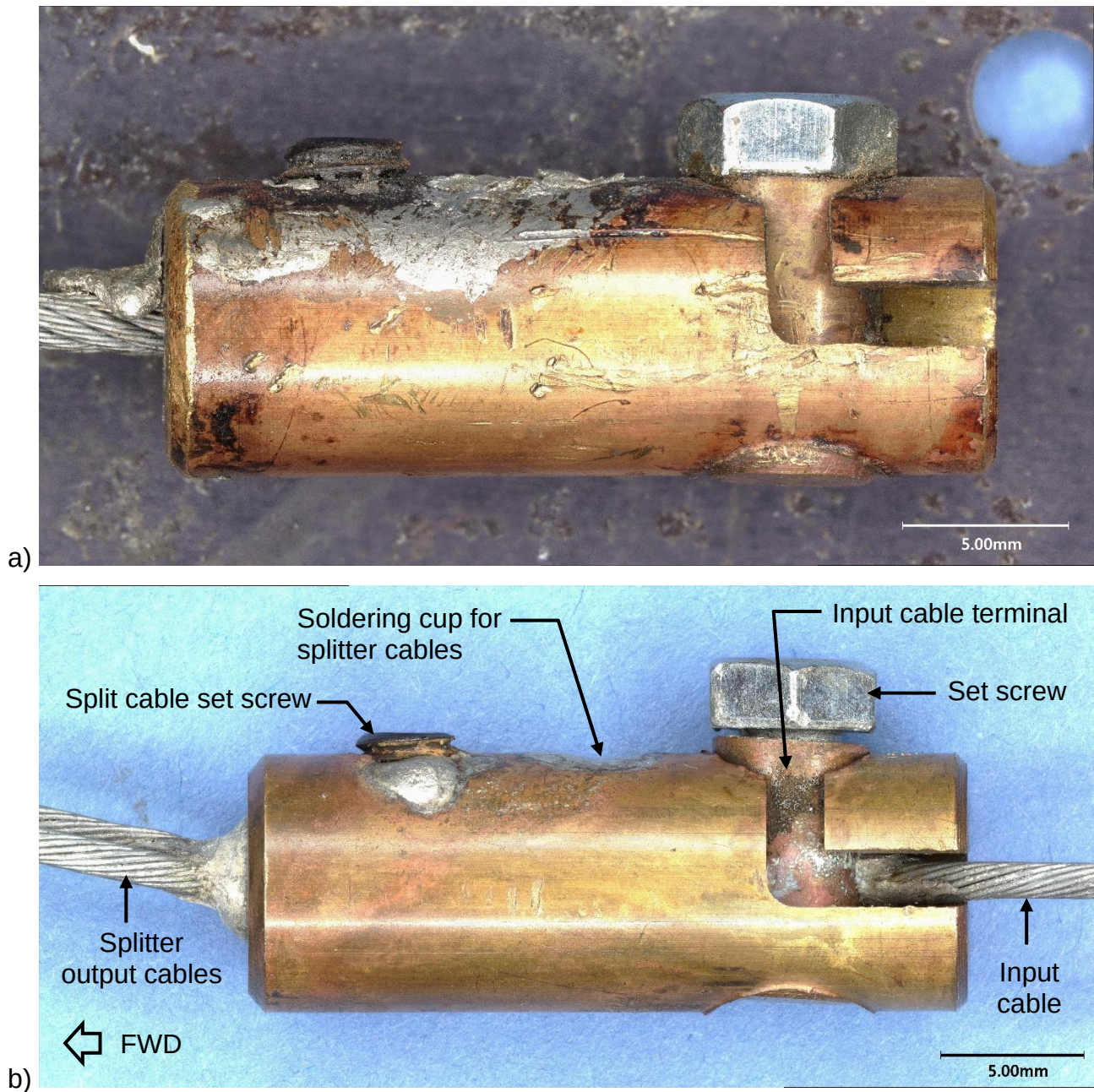


Figure 2: a) Throttle control cable splitter, as received and b) choke control cable splitter after cleaning in toluene to remove grease and dirt.

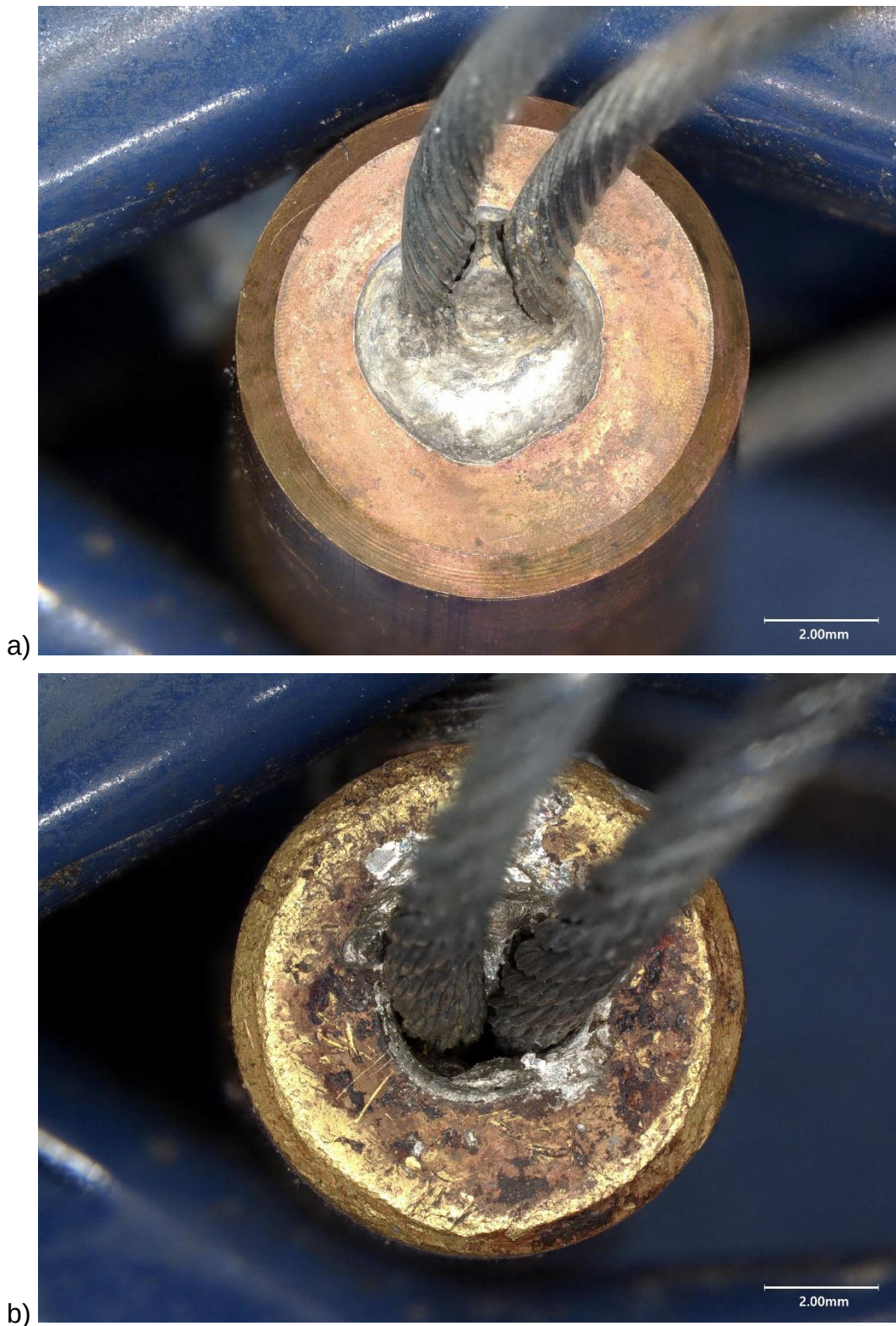


Figure 3: a) Output end of the choke control splitter fitting showing filling and wetting of the solder and b) output end of the throttle control fitting showing lack of filling and wetting of the splitter cables within the fitting.

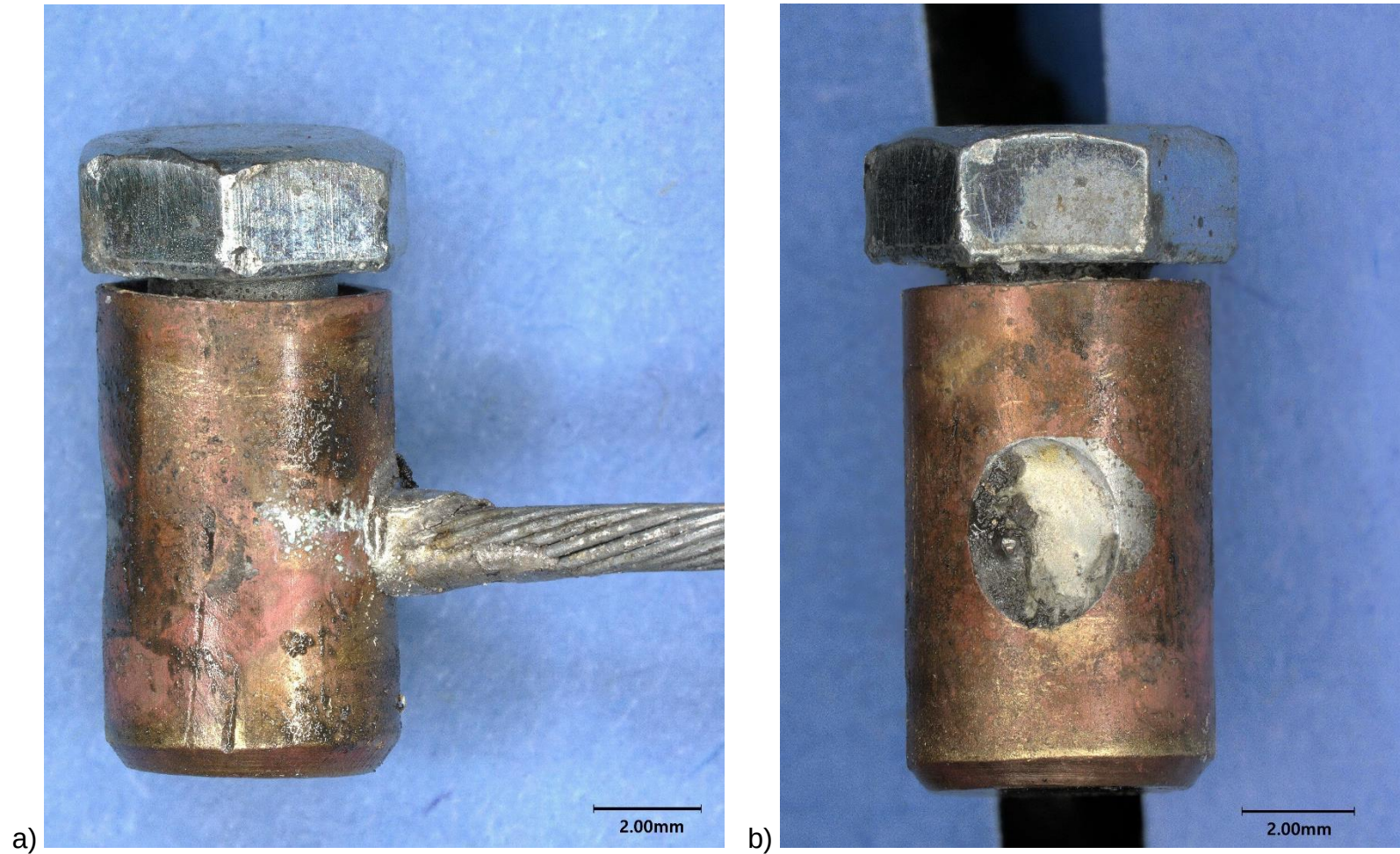
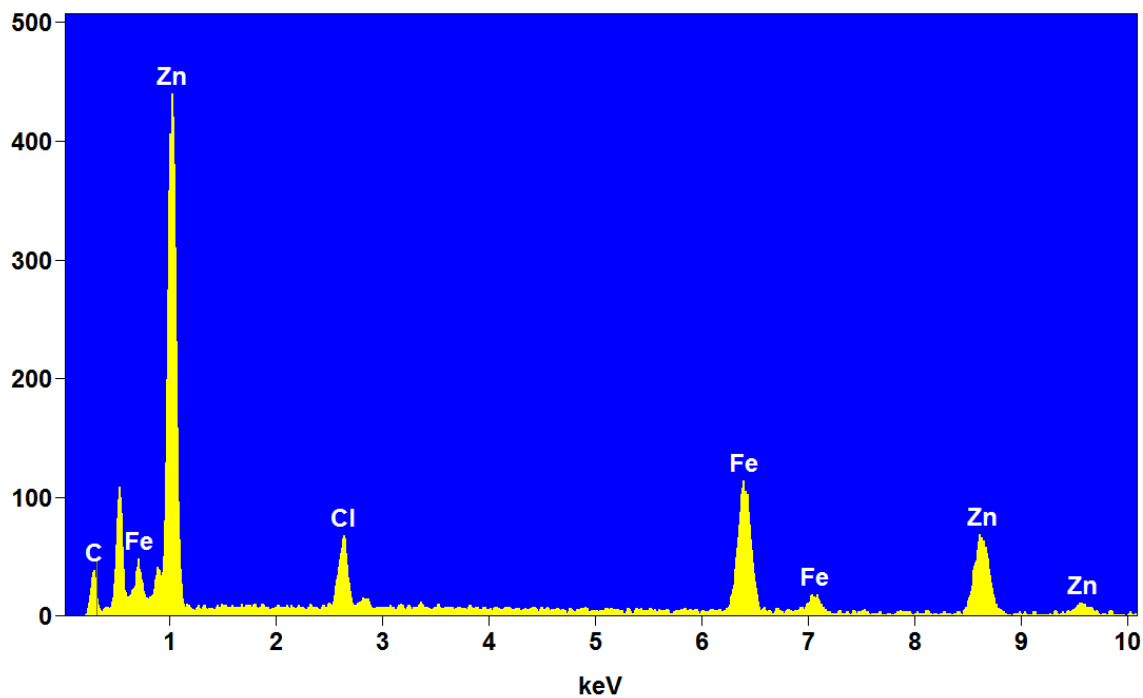


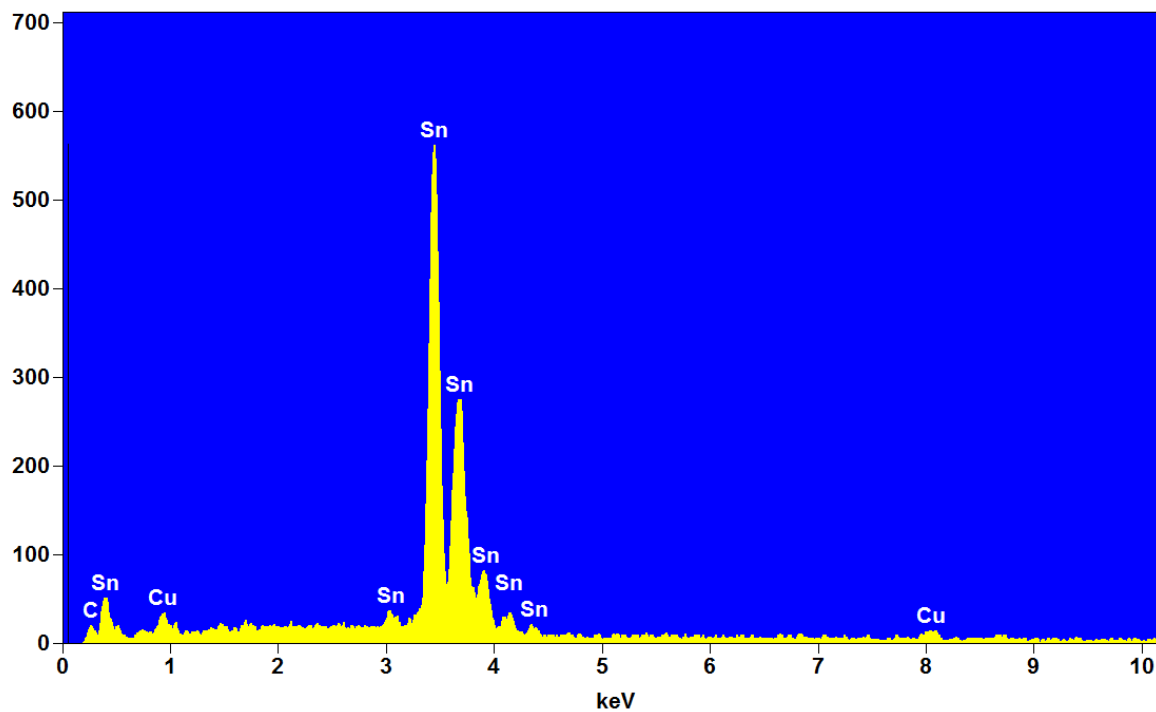
Figure 4: Images of the choke control input cable terminal: a) side view showing solder filling the joint and wetting the input cable and b) forward end view showing solder at the solder inlet.



Figure 5: Images of the throttle control input cable terminal: a) cable inlet showing a void within the terminal and b) forward end view showing solder at the solder inlet.



a)



b)

Figure 6: Energy dispersive x-ray spectra from: a) the throttle input cable surface and b) the throttle input terminal fitting solder joint.

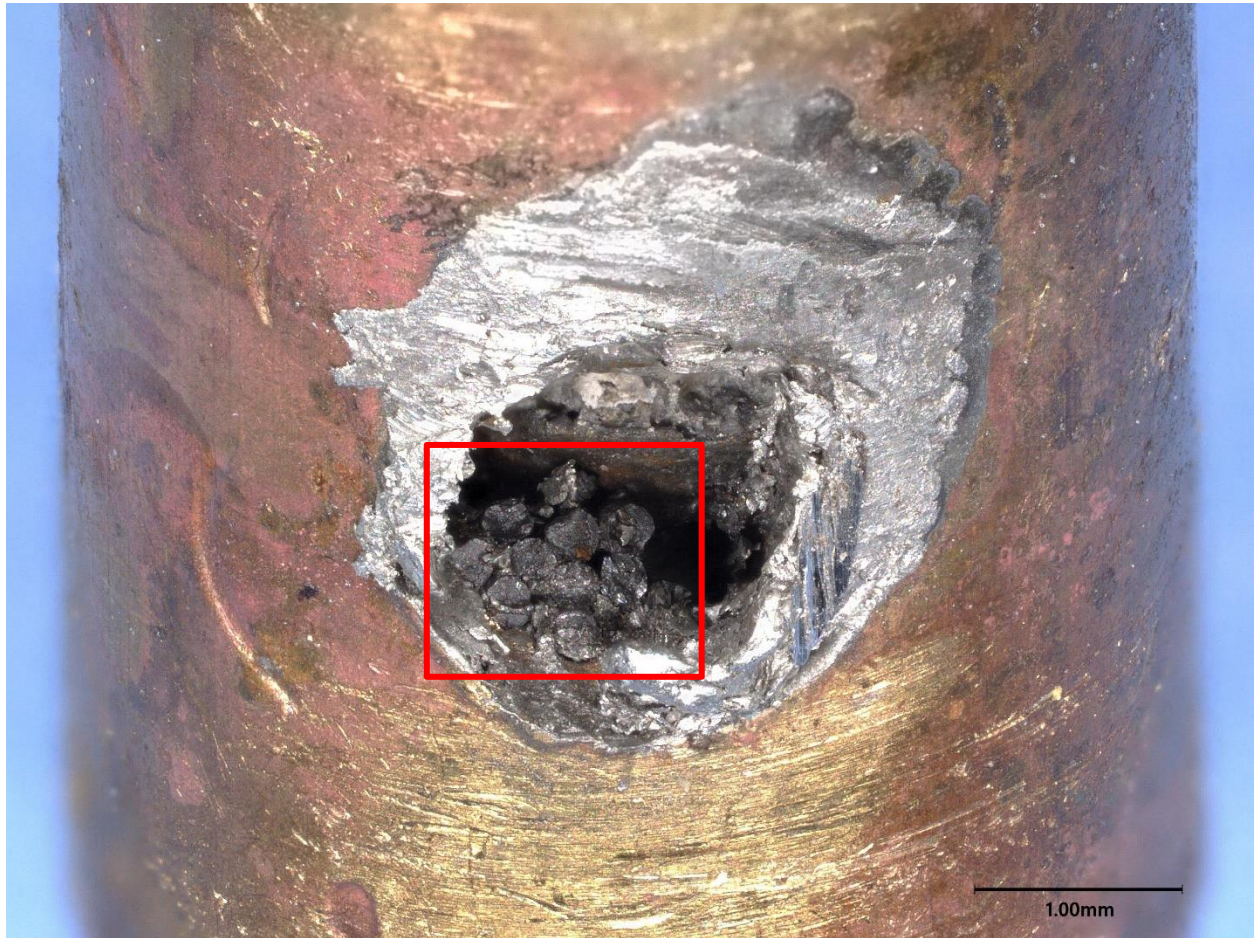


Figure 7: Higher magnification image at throttle control cable inlet showing fractured wire ends.

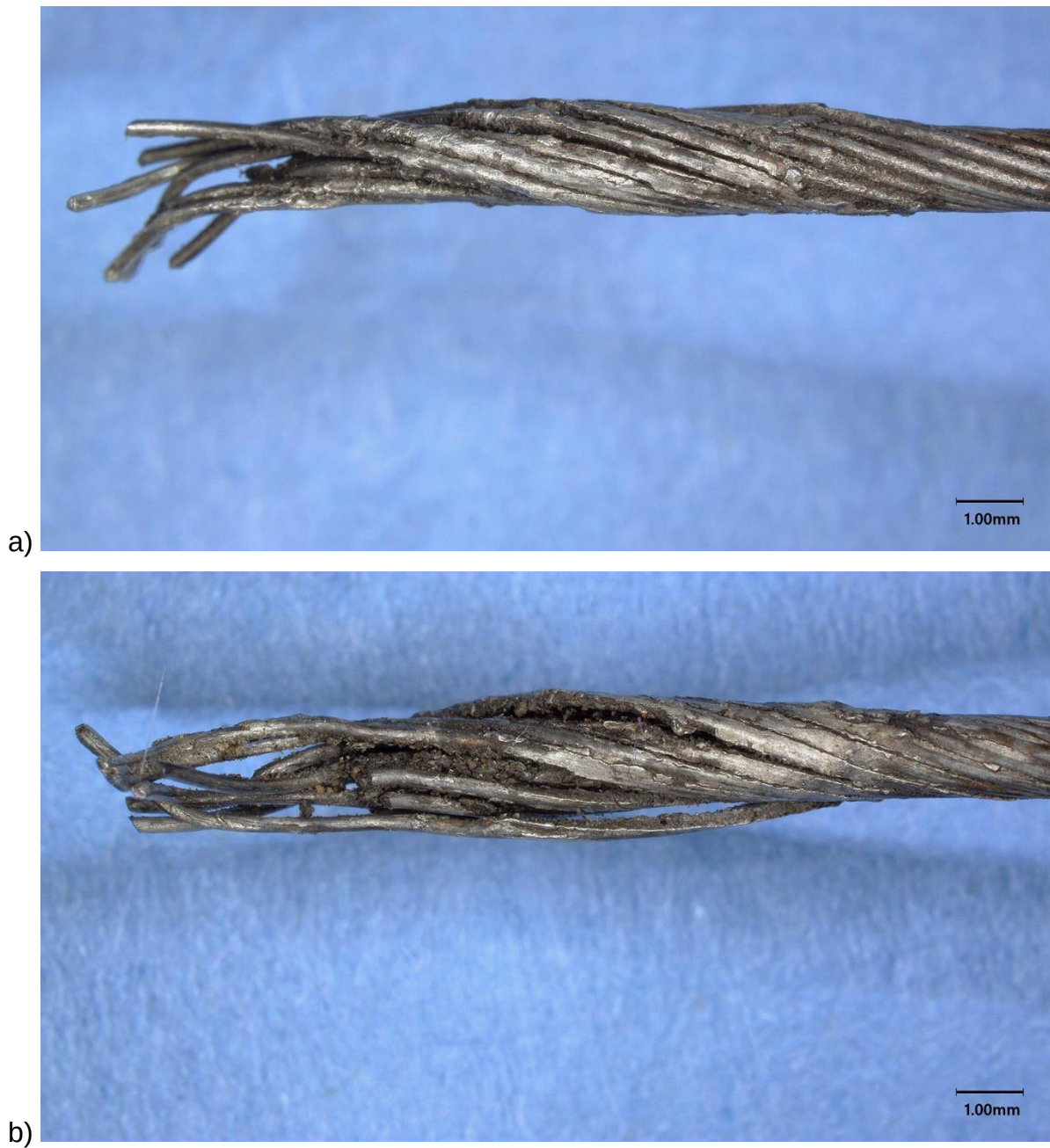


Figure 8: Images of the throttle control input cable at its insertion end into the terminal fitting:
a) side view; b) side view rotated 90°;

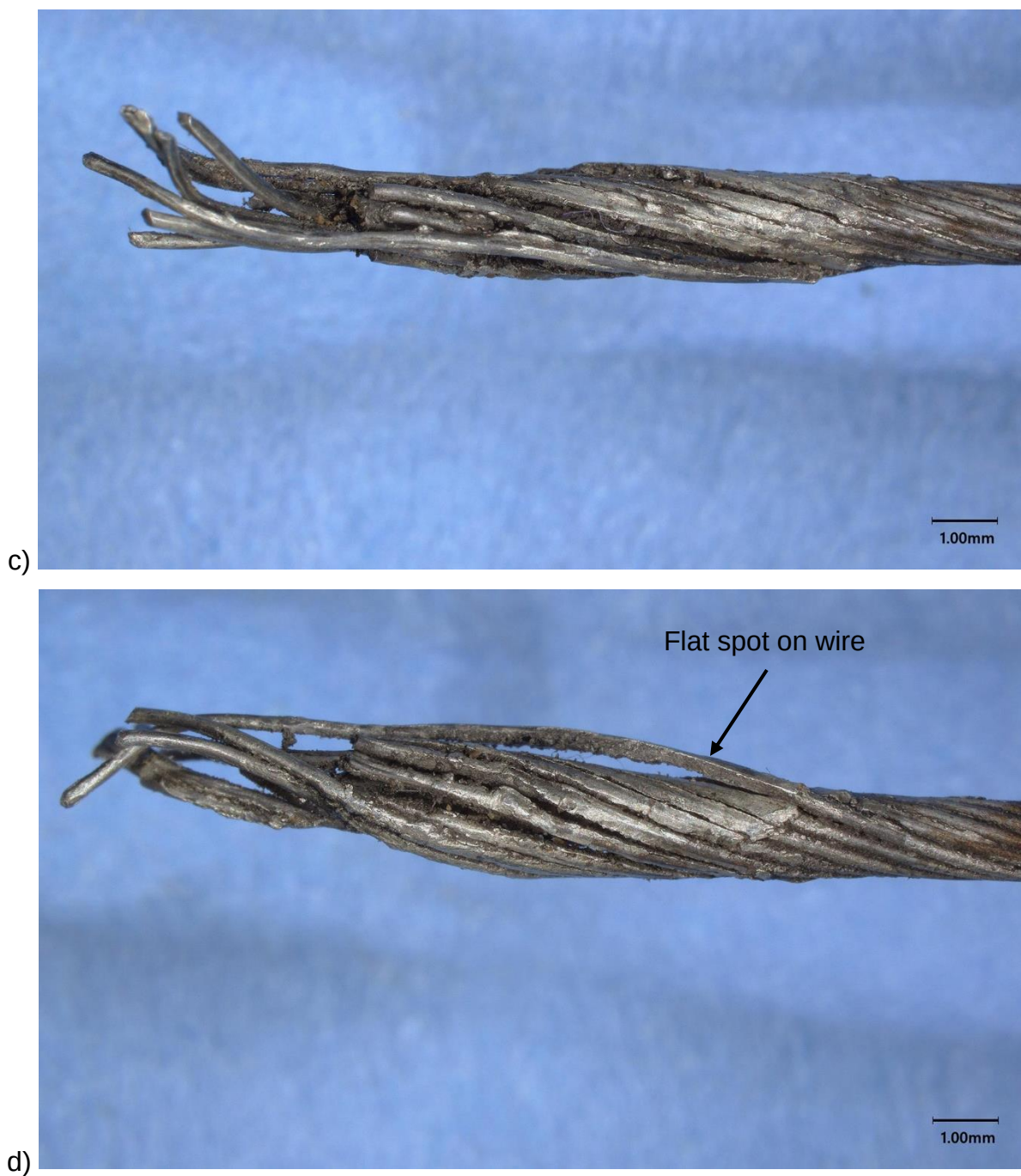


Figure 8 (cont.): c) side view rotated 180°; and d) side view rotated 270°.

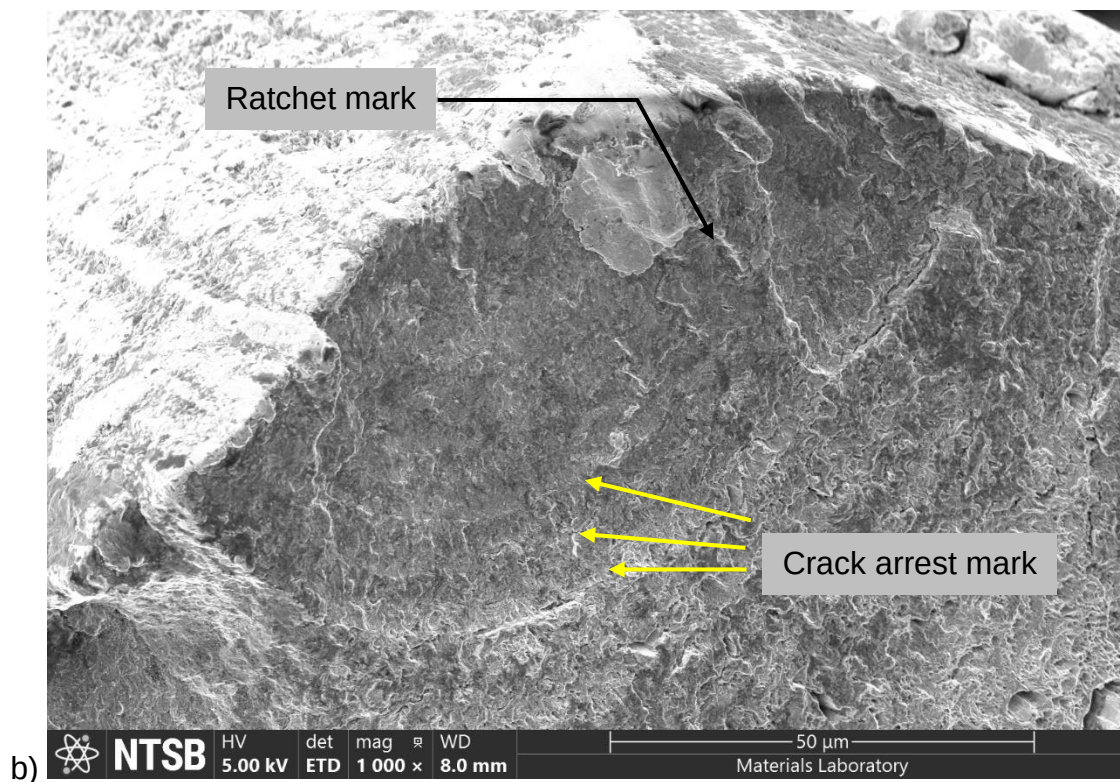
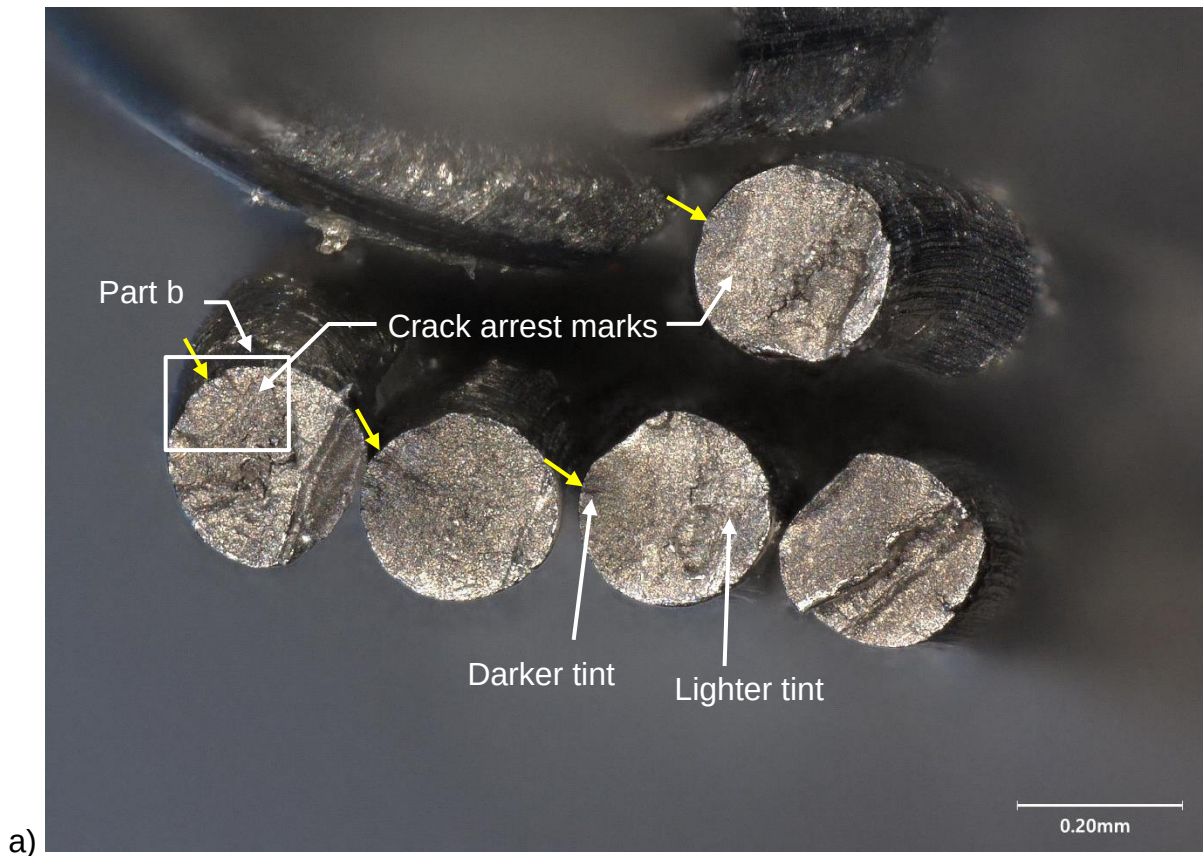


Figure 9: a) Digital optical microscope image of throttle control cable fractured strand wires; and b) SEM image at the location indicated in part a).

APPENDIX A: THROTTLE AND CHOKE CONTROL ILLUSTRATION AND PARTS LIST



111-76-10-100 Throttle and Choke Controls

Pos.	Qty	Part No.	Description	Dimension	Rev.	Remarks
1	0,5	5053023	Temp shrink tube	Ø9.4-Ø4.8		part of service kit
2	0,07	5052009	Fuel hose	Ø6.5/Ø12.5		
3	0,04	5052009	Fuel hose	Ø6.5/Ø12.5		
4	2	5081034	Hexagon Socket Set Screw	M4x6		part of service kit
5	3	5084007	Bowden end piece - standard size			part of service kit
6	2	5084008	Cable attachment pin			part of service kit
7	1	1150043	Throttle bowden cable			cylinders 2+4
8	1	1150039	Throttle and choke bowden cable			cylinders 1+3
9	1	1150039	Throttle and choke bowden cable			cylinders 2+4
10	1	1150039	Throttle and choke bowden cable			cylinders 1+3
11	2	1150048	Bowden cable solder fitting	Ø9x25	A01	part of service kit
12	1	1150041	Choke bowden cable		A02	
13	1	1150037	Throttle bowden cable		A00	
14	2	5019098	Cable seal	Ø1.5		part of service kit
15	1	1150046	Assembly kit			service kit