

NATIONAL TRANSPORTATION SAFETY BOARD

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



November 05, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 21-083

A. ACCIDENT INFORMATION

Place : Franklin, Arkansas
Date : 11/30/2020
Vehicle : Piper PA28-112, N9879T
NTSB No. : CEN21LA070
Investigator : John Brannen

B. COMPONENTS EXAMINED

1. Portion of a muffler and cabin heat shroud assembly

C. DETAILS OF THE EXAMINATION

Multiple views of the as-received portion of mufflers and cabin heater shroud assembly are shown in Figure 1. The muffler-shroud assembly was distorted due to the accident crash sequence. It is evident that the shroud, which is secured by two straps, encases two mufflers. The shroud straps were cut using a metal strap cutter to release the muffler assembly inside (see Figures 2 and 3). A close view of the muffler assembly is shown in Figure 3. The mufflers, which have a slender cylindrical shape, were semi-flattened along the longitudinal axis. Figure 4 shows each side of the semi-flat mufflers. The mufflers were arbitrarily numbered 1 and 2 for identification purposes. A close view of side A of muffler 2 reveals multiple branched cracks in the muffler's outer shell.

Muffler 1 exhibited a few punctures in the outer shell and a crack adjacent to one of the endplate welds. Such damage was consistent with damage incurred during the accident crash sequence as the fracture surfaces were bright and not oxidized.

The cracks in muffler 2 are identified in Figure 5. The fracture faces of the cracks were covered with oxidation product, consistent with its presence prior to the accident crash sequence. However, the distortion from the accident crash sequence enlarged the width of the cracks beyond their pre-accident crack widths. Closer views of the cracks are shown in Figures 6-8. Figures 6 and 8 show locations where metallurgical cross sections through the muffler 2 outer shell were taken. Images of the metallurgical cross sections are shown in Figures 9-12. The metallurgical cross sections reveal oxidative degradation that progressed through the thickness of the muffler 2 shell from the inside surface outwards. Some wall thickness loss due to oxidation also occurred on the outside shell surfaces. The micrographs in Figures 10 and 12 suggest that different oxidation mechanisms were in play at different locations of the muffler shell. In the location identified in Figure 6, the shell degraded from an intergranular sensitization and oxidation

wastage mechanism that occurred on both the inside and outside surfaces of the skin (although to a greater extent on the inside surface), resulting in localized thickness loss of the muffler shell. In the location identified in Figure 8, near an inlet, the formation of a semicontinuous and voluminous general oxide scale developed, reducing the wall thickness of the muffler shell over time at operating temperature.

Using a hand-held x-ray fluorescence alloy analyzer, the composition of the outer shells on mufflers 1 and 2 was determined as indicated below.

Outer shell, muffler 1: Type 321 stainless steel

Outer shell, muffler 2: Type 304 stainless steel

Michael Budinski
Chief, Materials Laboratory Division



Figure 1 Multiple views of the as-received portion of mufflers and cabin heater shroud. It is evident that the shroud encases two mufflers. The assembly distortion is associated with accident sequence damage.

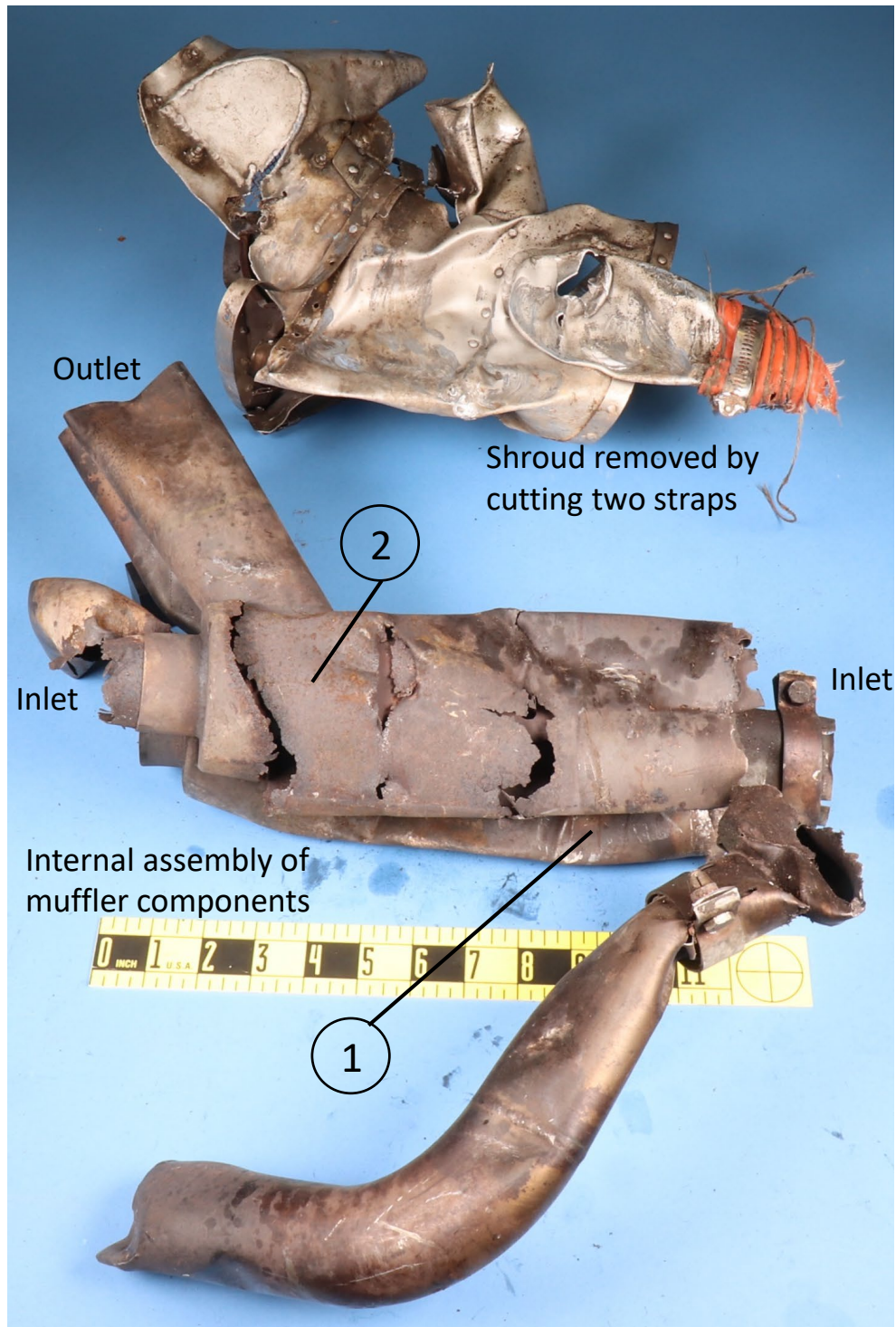


Figure 2 Image showing the muffler assembly removed from the shroud by cutting two straps holding the shroud together. Two mufflers, numbered 1 and 2, are encased within the shroud.



Figure 3 Closer image of the assembly of mufflers encased in the shroud.



Figure 4 Images of the two mufflers (arbitrarily numbered 1 and 2) showing two sides (arbitrarily labelled sides A and B).

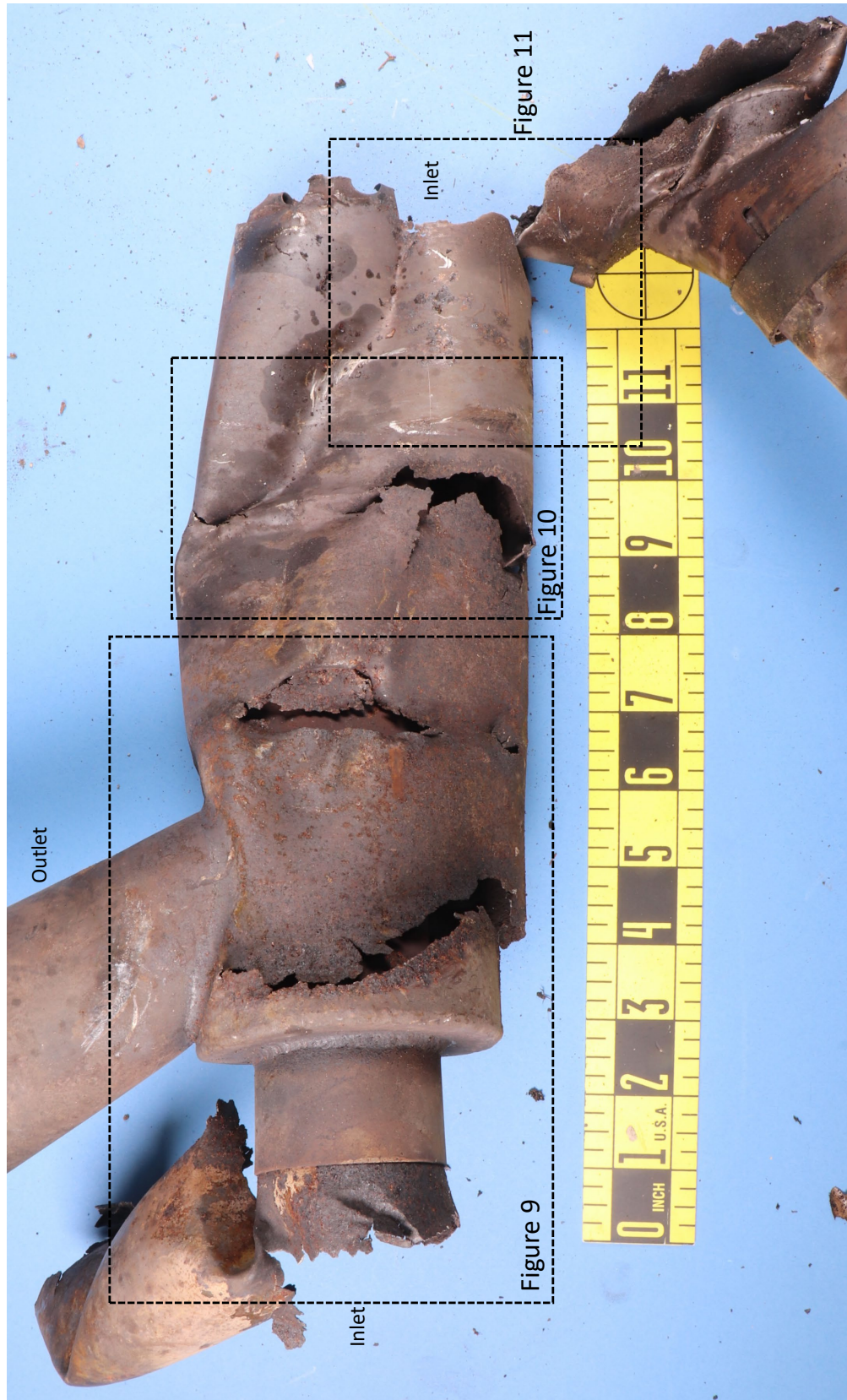


Figure 5 View of side A of muffler 2 showing areas of cracks (see Figure 4a). Closer views of the cracks are showing in Figures 6-8.



Figure 6 Cracks in the outer shell in muffler 2 near the outlet tube and adjacent to an inlet. A metallurgical cross section was excised and prepared from the tip of a crack as shown in the image.



Figure 7 Cracks in muffler 2 in the main body of the outer shell.

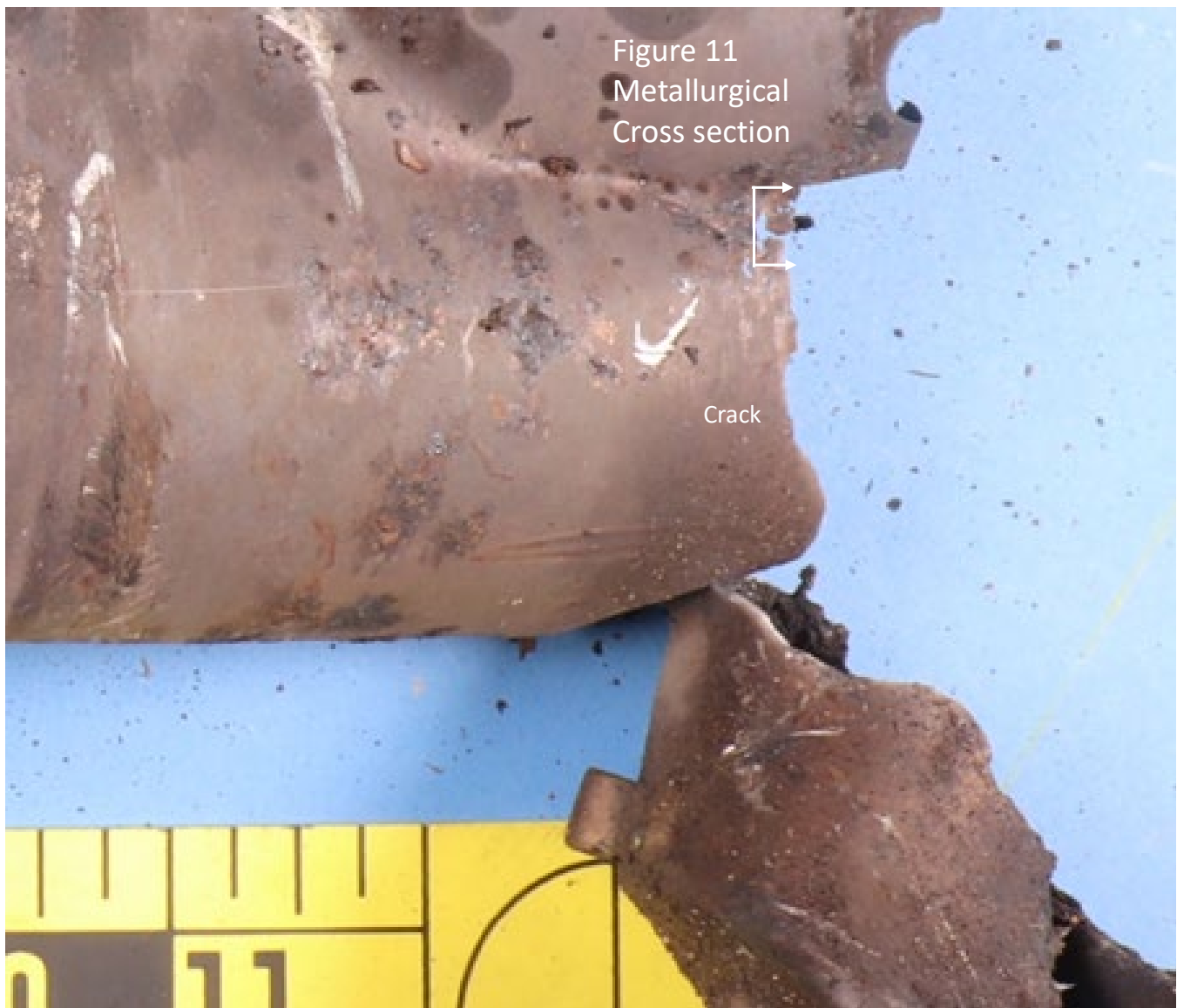


Figure 8 Cracks in the outer shell in muffler 2 near an inlet. A metallurgical cross section was excised and prepared from a cracked area as shown in the image.

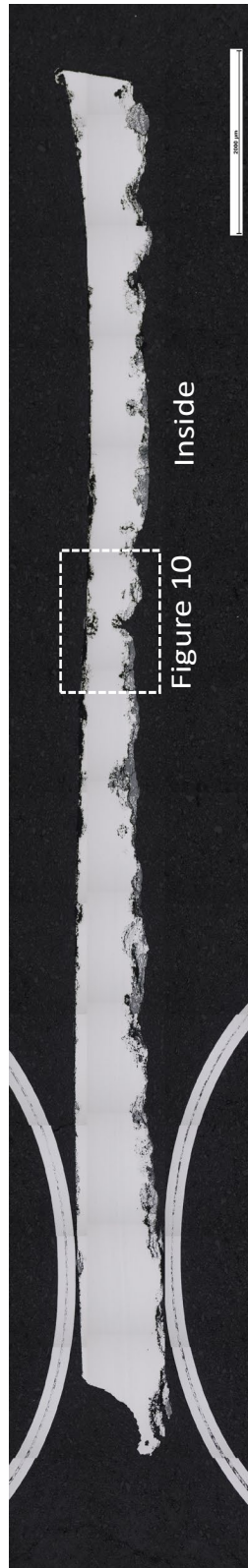


Figure 9 Optical micrograph of a metallurgical cross section adjacent to a muffer 2 crack tip as indicated in Figure 6. The inside side of the muffer is indicated in the image. (Brightfield, unetched, 100X original magnification.)

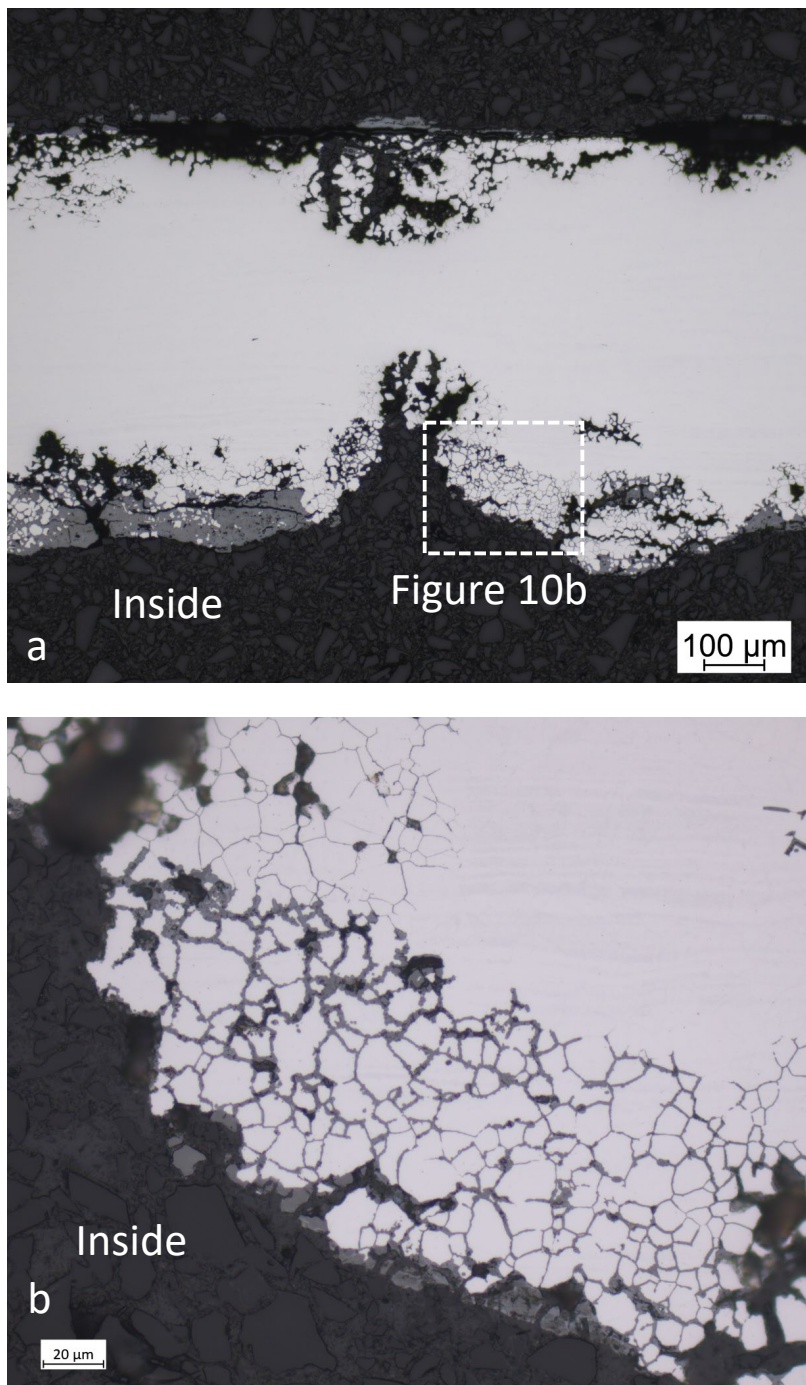


Figure 10 Optical micrograph of a metallurgical cross section adjacent to a muffler 2 crack tip as indicated in Figure 9. The inside side of the muffler is indicated in the image. The microstructure adjacent to the crack tip and in other nearby regions reveals metal wastage associated with intergranular sensitization and thermal oxidation. (Brightfield, unetched, Figure 10a is 200X and Figure 10b is 500X original magnification.)

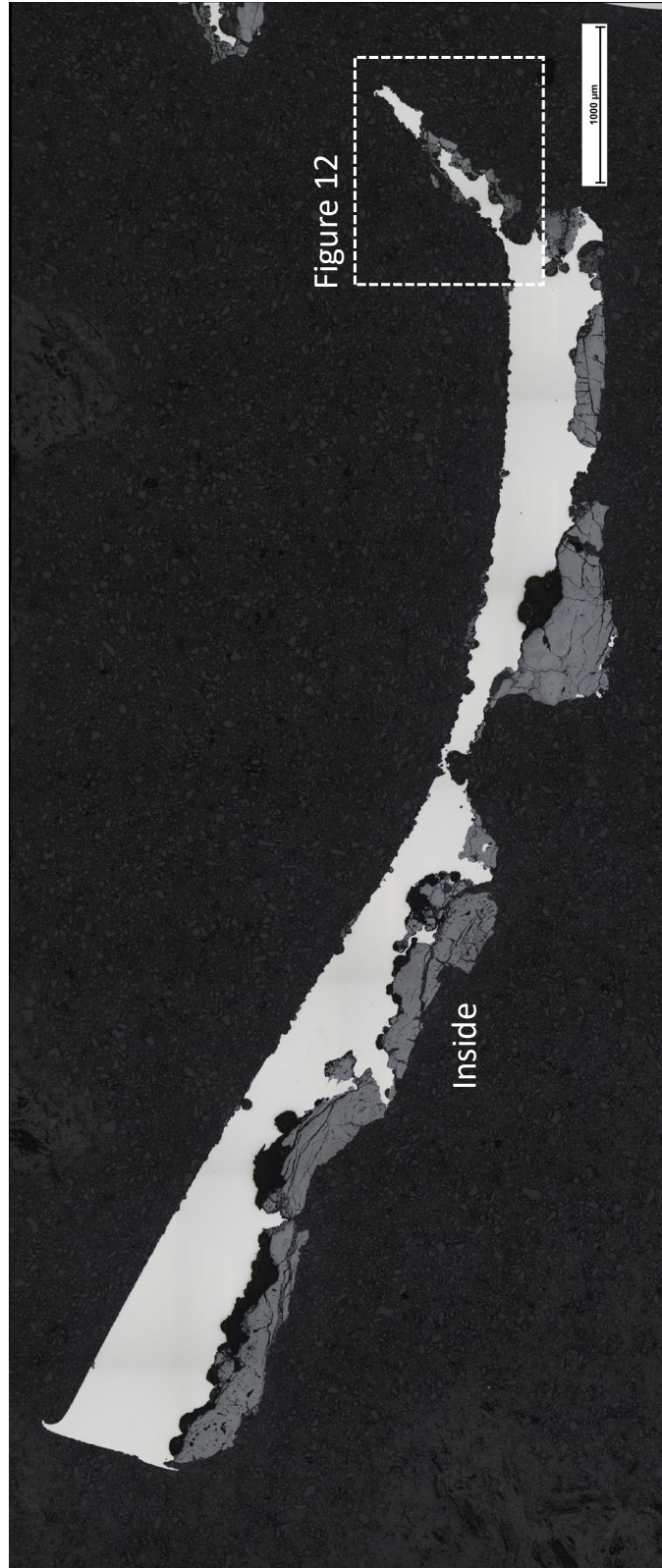


Figure 11 Optical micrograph of a metallurgical cross section adjacent to a muffler 2 crack tip as indicated in Figure 9. The inside side of the muffler is indicated in the image. The microstructure adjacent to the crack tip and in other nearby regions reveal metal wastage associated with thermal oxidation. (Brightfield, unetched, 100X original magnification.)

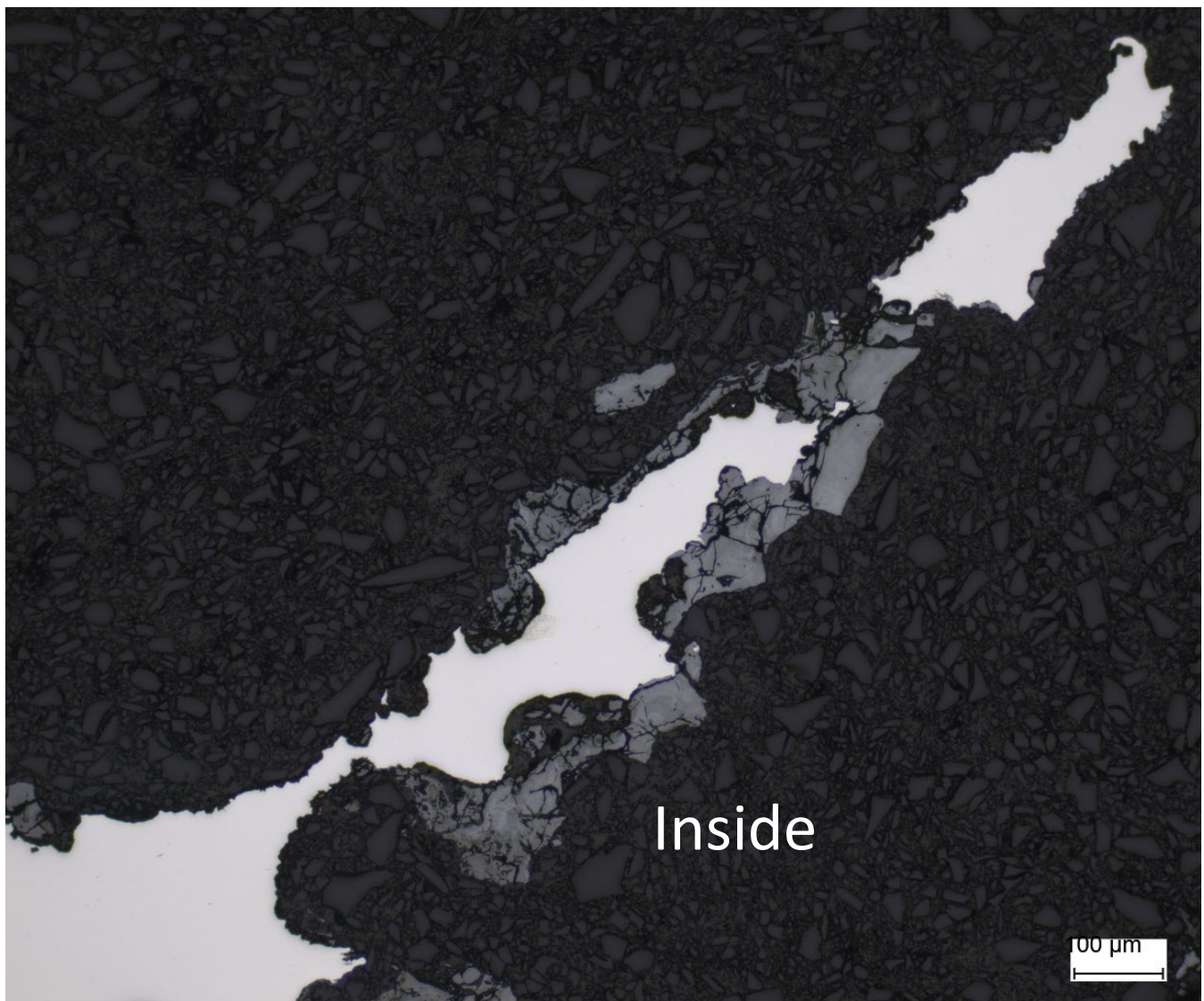


Figure 12 Optical micrograph of a metallurgical cross section adjacent to a muffler 2 crack tip as indicated in Figure 11. The inside side of the muffler is indicated in the image. The microstructure adjacent to the crack tip and in other nearby regions reveal metal wastage associated thermal oxidation. (Brightfield, unetched, 500X original magnification.)