

NATIONAL TRANSPORTATION SAFETY BOARD

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



March 20, 2019

MATERIALS LABORATORY FACTUAL REPORT

Report No. 19-004

1. ACCIDENT INFORMATION

Place : Lynchburg, Virginia
Date : January 1, 2018
Vehicle : Costruzioni Aero Tecnam P2006T, N594MA
NTSB No. : ANC18LA018
Investigator : Michael Hodges, AS-ANC

2. COMPONENTS EXAMINED

Pieces of a left main landing gear assembly
Right main landing gear assembly (exemplar)

3. DETAILS OF THE EXAMINATION

On January 1, 2018, about 1725 eastern standard time, a Costruzioni Aeronautiche Tecnam P2006T airplane sustained substantial damage following a landing gear separation while landing at the Falwell Airport, Lynchburg, VA. The certificated flight instructor and pilot sustained no injuries. The flight instructor reported that the left main landing gear assembly separated at the axle immediately after touchdown. The airplane skidded for about 100 feet, departed the runway, and came to rest on the grass. The separated main landing gear leg assembly was recovered and sent to the NTSB Materials Laboratory for further examination.

Figure 1 shows the landing gear assembly components, as received. The left main landing gear assembly had fractured along the interior circumferential weld on the attachment flange of the trailing arm. This flange is where the wheel hub axle and bushing plate affix. The right main landing gear assembly was intact and used as an exemplar reference. Figure 2 shows a side view, highlighting the location of the fracture.

Figure 3 shows the mating fracture surfaces of the fractured circumferential weld on the strut, positioned to face the reader at the same time. The inside fracture was located along the weld on the attachment flange. The flange had been affixed to the axle via four attachment bolts. The mating outside fracture was located on the circumferential weld on the trailing arm tube. Figure 4 shows a closer view of the mating fracture surfaces. All of the fracture surfaces exhibited rust, consistent with post-fracture oxidation from exposure to moist air and water.

Figure 5 and Figure 6 show the fracture surface. The inner regions of the arm side fracture surface were shinier and flatter, consistent with an area absent weld filler material. Conversely, the outer areas exhibited a slanted morphology and rougher surface texture, consistent with a fracture through the weld filler. Figure 7 and Figure 8 show a portion of the arm side fracture surface before and after cleaning with acetone in an ultrasonic bath, respectively. Figure 7 shows elongated parallel marks on the inner surface of the tube. These marks were inconsistent with crack arrest marks, but rather they were consistent with machine or lapping marks made on the surface prior to welding. This flatter, shinier area was consistent with unwelded sections of the tube face.

The flange side fracture surface was cleaned successively using acetone and then a solution with Alconox and water.¹ This fracture surface was examined using a scanning electron microscope (SEM). The majority of the fracture surface had been covered in rust-colored oxidation. When the cleaning process removed this product, the underlying fracture features had been obliterated, leaving pits and selected underlying microstructural features. While many of the microstructural features were damaged, some areas were relatively undamaged, such as illustrated in Figure 9.

Figure 9 is oriented such that the exterior of the flange faces upward (absent paint removed during cleaning). As shown in this figure, most of the area shown had not been welded. All of the area in the figure exhibited damage from the surface corrosion, consistent with exposure to the environment. The lower half of Figure 9 shows an area that had not been welded and thus had not fractured.

The upper area exhibited fracture features consistent with progressive cracking. As labeled in Figure 10, both crack arrest marks and ratchet marks were present—these were consistent with progressive crack growth and multiple crack coalescence, respectively. Figure 11 and Figure 12 shows a closer view of some of the crack arrest marks. As illustrated in these figures, fatigue striations consistent with fatigue crack propagation were present.

The crack initiation sites of these fatigue cracks were examined using a SEM. Due to the amount of oxidation, no information could be found that was consistent with material defects at the initiation sites. There were, however, pores present in the weld, as shown in the lower middle of Figure 10. In addition, other smaller voids or pores were found throughout the fracture surface, consistent with them having been present since the welding process.

Figure 13 shows an area with concentric, circular crack arrest marks emanating from small pore. These features were found to be fatigue striations (see Figure 14). These features were consistent with a fatigue crack that initiated at a small (approximately 10 μm in diameter) pore in the weld filler material.

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

The chemical composition of the attachment flange was inspected using energy dispersive x-ray spectroscopy (EDS) and x-ray fluorescence (XRF). The composition was consistent with an alloy steel. According to company marketing material, the composition of the strut was stated as 15CDV6, an alloy steel similar to Type 4130 steel. The hardness of the flange was inspected per ASTM E18.² The hardness averaged 57 HRA.³

Part of the flange was sectioned through the fracture surface. This section was vacuum mounted using slow-curing epoxy, polished, and etched with 2% Nital solution.⁴ Figure 15 shows this cross section through the fractured weld. Figure 16 shows corrosion on the fracture surface through the weld. The corrosion appears to be consistent with pitting that occurred after fracture. No branching or subsurface cracks were present in this cross section.

Figure 17 shows a typical area of the strut attachment flange microstructure. This microstructure shows horizontal grain flow lines and small, elongated grains, typical of a rolled component. The microstructural constituents were a mix of pearlite (darker colored) and ferrite (lighter color). This microstructure was consistent with the composition and mechanical properties measured above. Figure 18 shows a typical area of the weld filler material microstructure. This microstructure exhibited more martensite, typical of faster cooling in alloy steels.

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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 Hardness, Rockwell A scale (HRA). 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 load.

⁴ Nital is an acidic solution of 2% concentrated nitric acid in ethanol.



Figure 1 – The landing gear assembly components, as received.



Figure 2 – The halves of the left assembly, positioned such that the fracture surfaces mate.

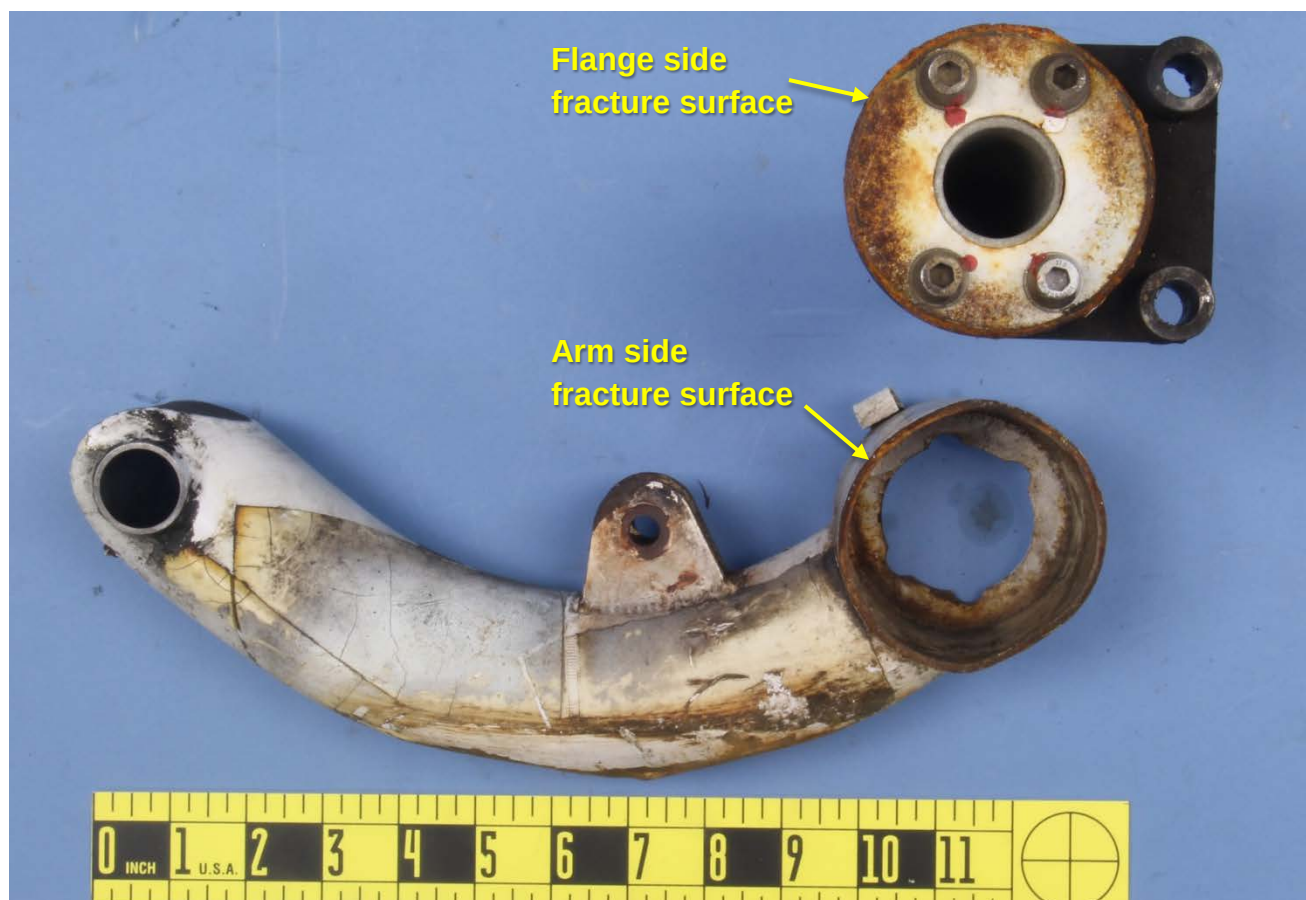


Figure 3 – The halves of the left assembly, with the fracture surfaces facing the reader.

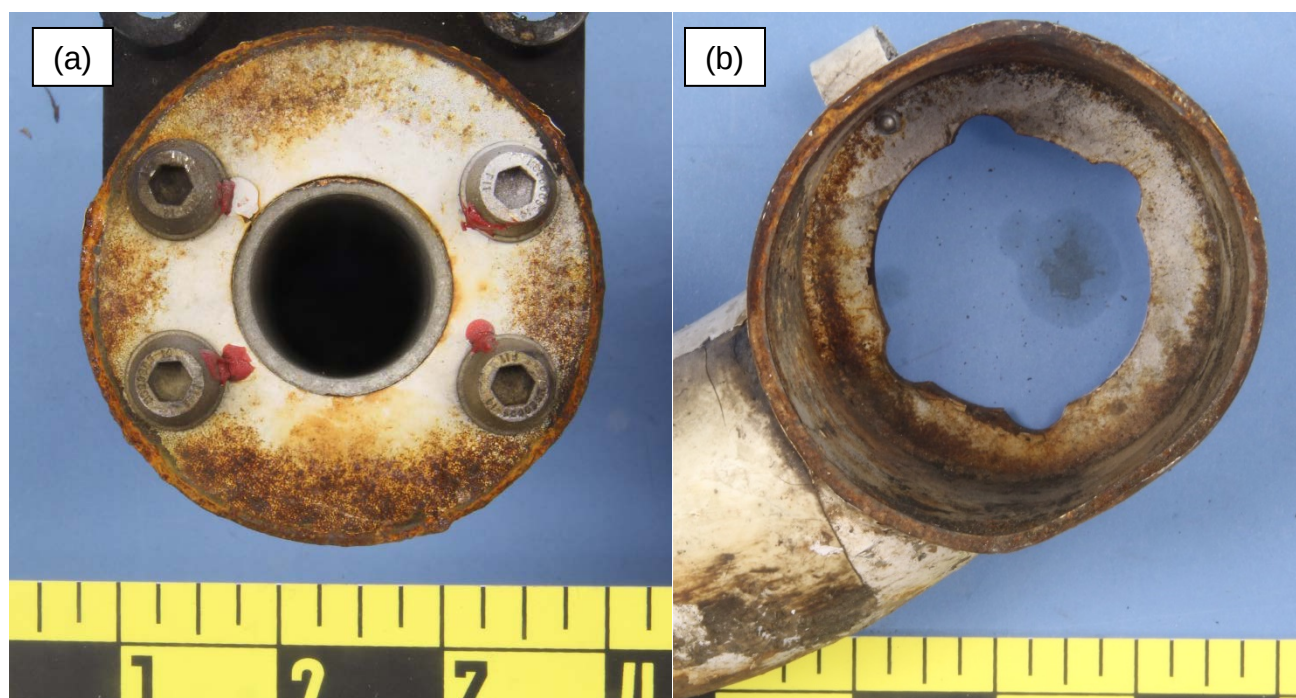


Figure 4 – The fracture surfaces from (a) the attachment flange side and (b) the arm side.



Figure 5 – Closer view of the fracture surface from the arm side.

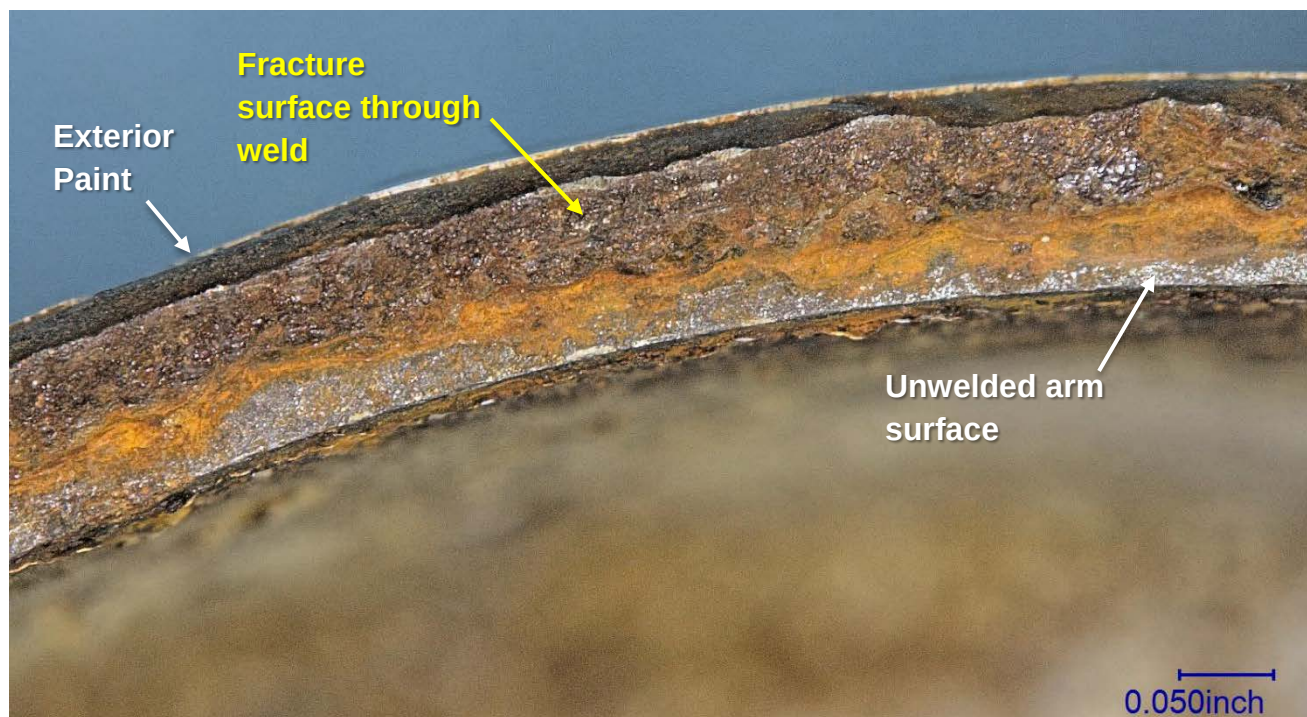


Figure 6 – View of a portion of the arm side fracture surface, showing fractured weld and unwelded surfaces.



Figure 7 – A portion of the arm side fracture surface, prior to cleaning with acetone.



Figure 8 – A portion of the arm side fracture surface, after cleaning with acetone.

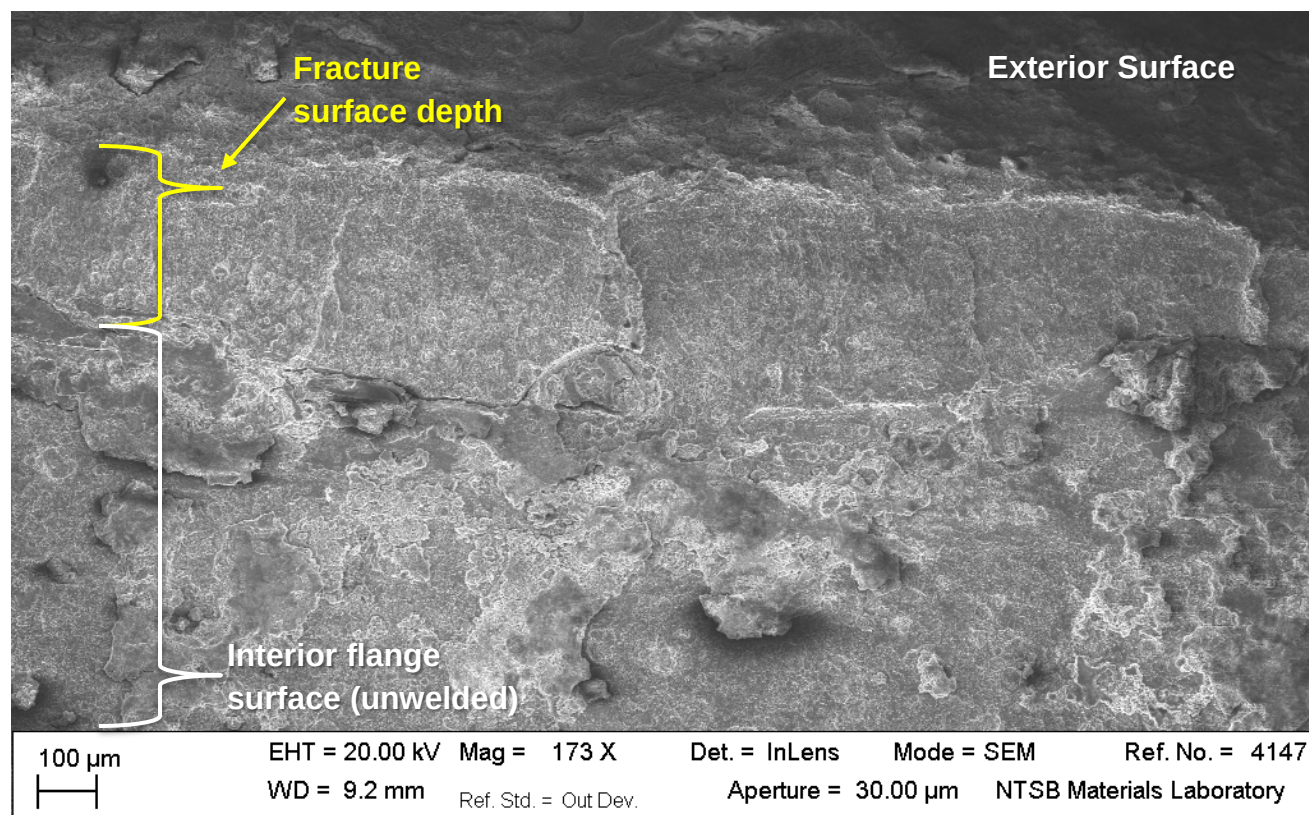


Figure 9 – Secondary electron (SE) micrograph of a section of the cleaned flange-side fracture surface.

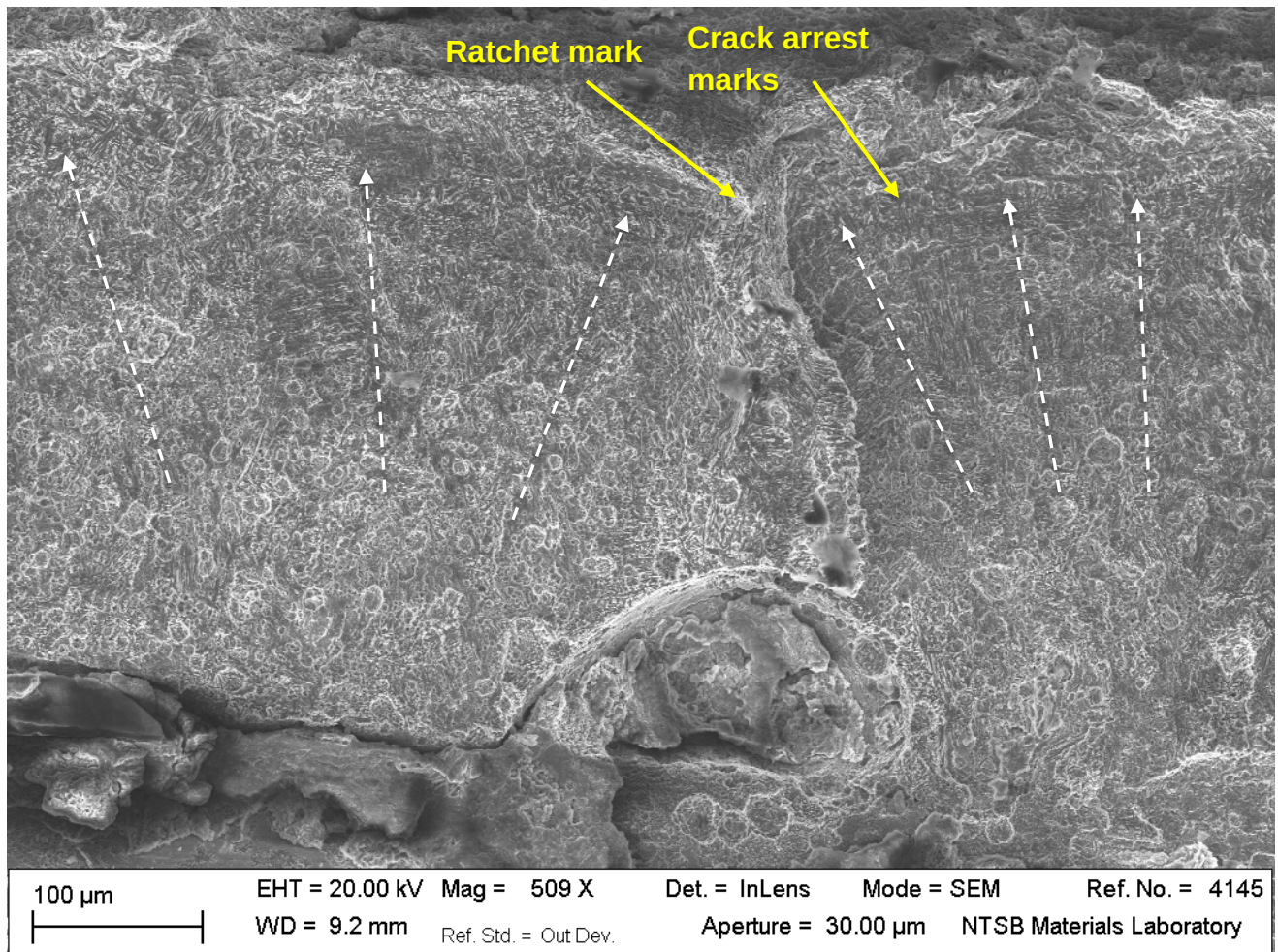


Figure 10 – SE micrograph of the fracture surface section in Figure 9, showing crack arrest marks and a central ratchet mark. The dashed white arrows show the general crack growth directions from interior to exterior.

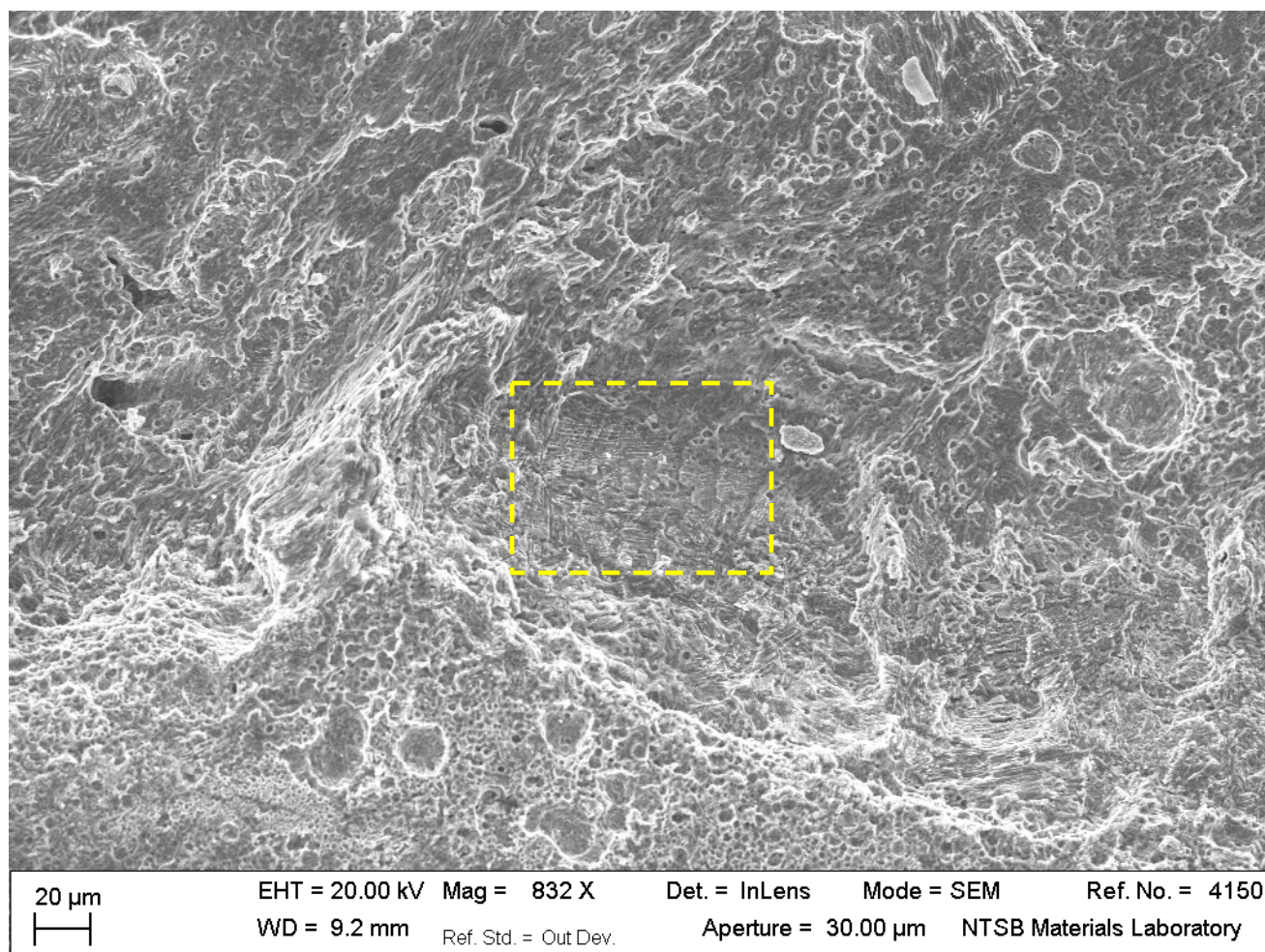


Figure 11 – SE micrograph of an area with clear crack arrest marks, showing fatigue striations, highlighted in Figure 12 (yellow-dashed box).

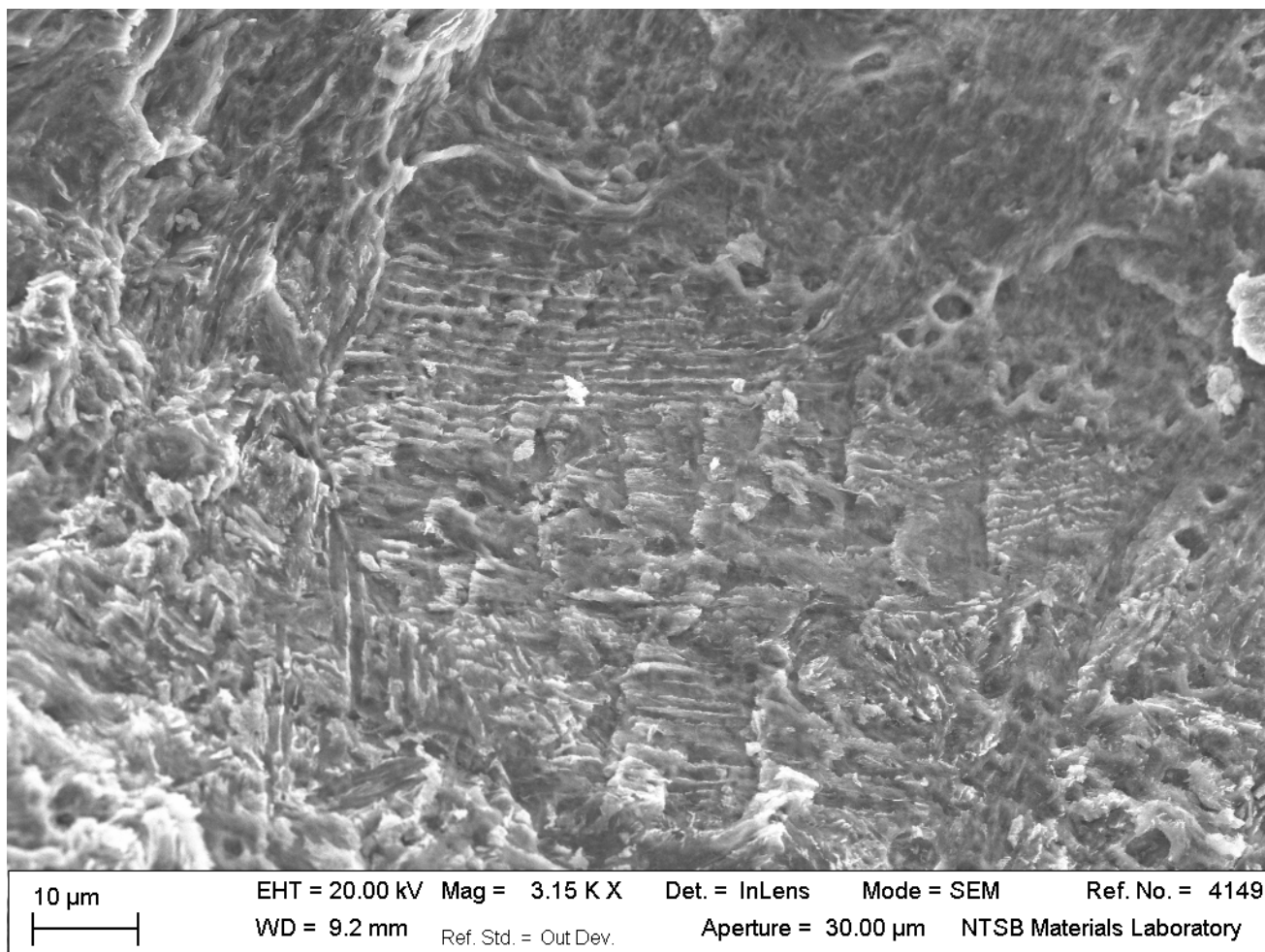


Figure 12 – SE micrograph showing the fatigue striations (after cleaning) in Figure 11.

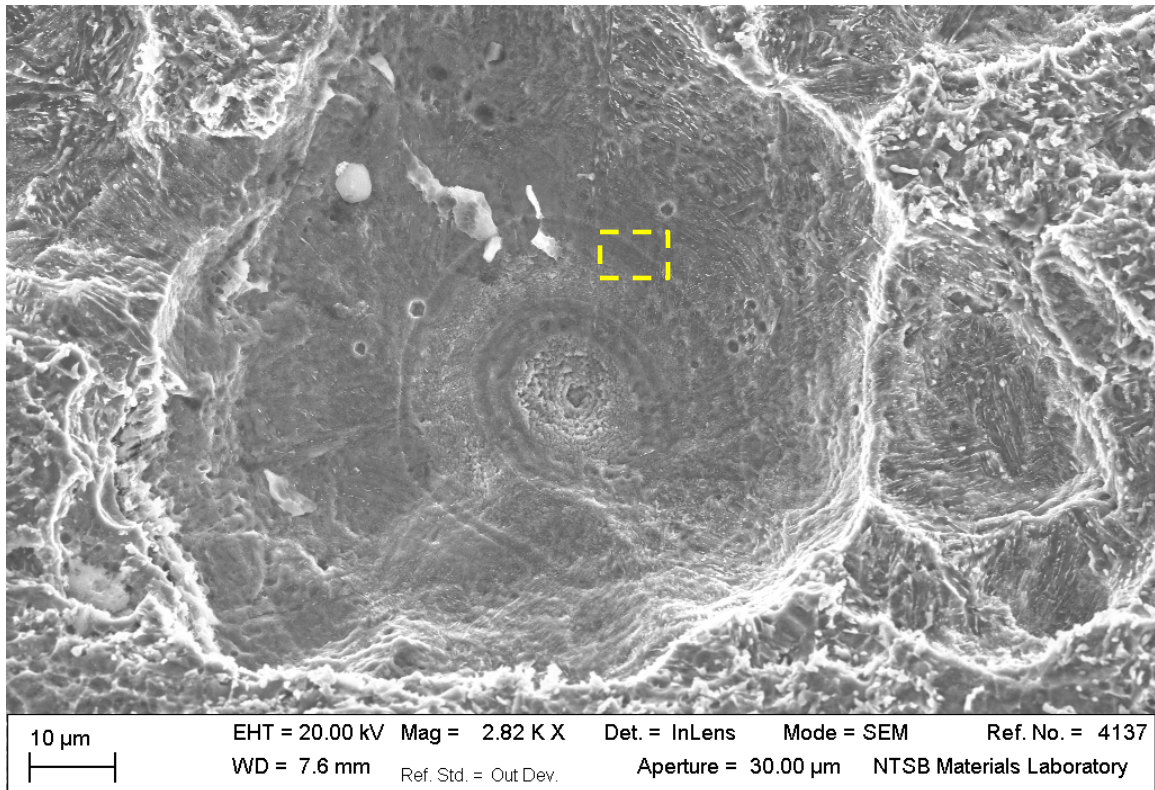


Figure 13 – SE micrograph showing an area of fatigue striations propagating radially outward from a central void; the boxed area is shown in Figure 14.



Figure 14 – SE micrograph showing a closer view of the fatigue striations in Figure 13.



Figure 15 – Bright-field (BF) micrograph of a cross section through the fracture surface on the flange side weld (upper left) (~25X, etched 2% Nital).

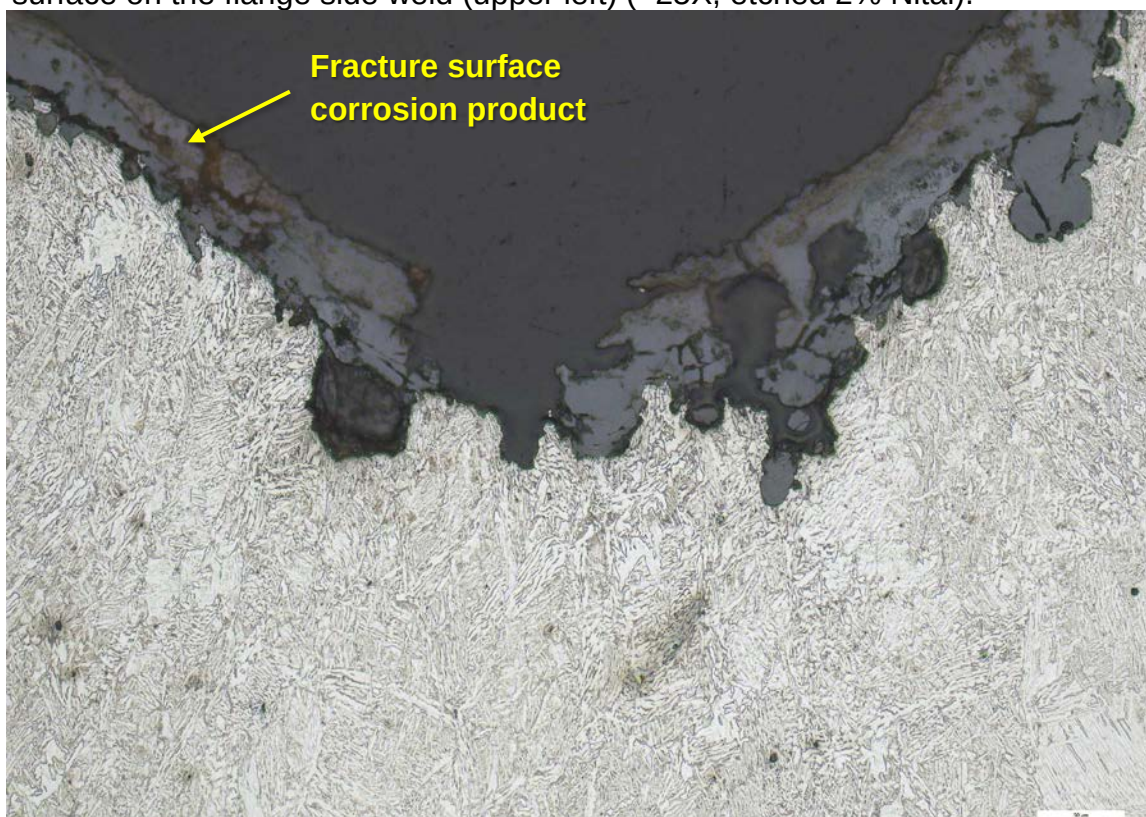


Figure 16 – BF micrograph showing the corrosion product on the fracture weld surface of the arm flange (~100X, etched 2% Nital).



Figure 17 – BF micrograph showing a typical area of the arm flange microstructure (~200X, etched 2% Nital).

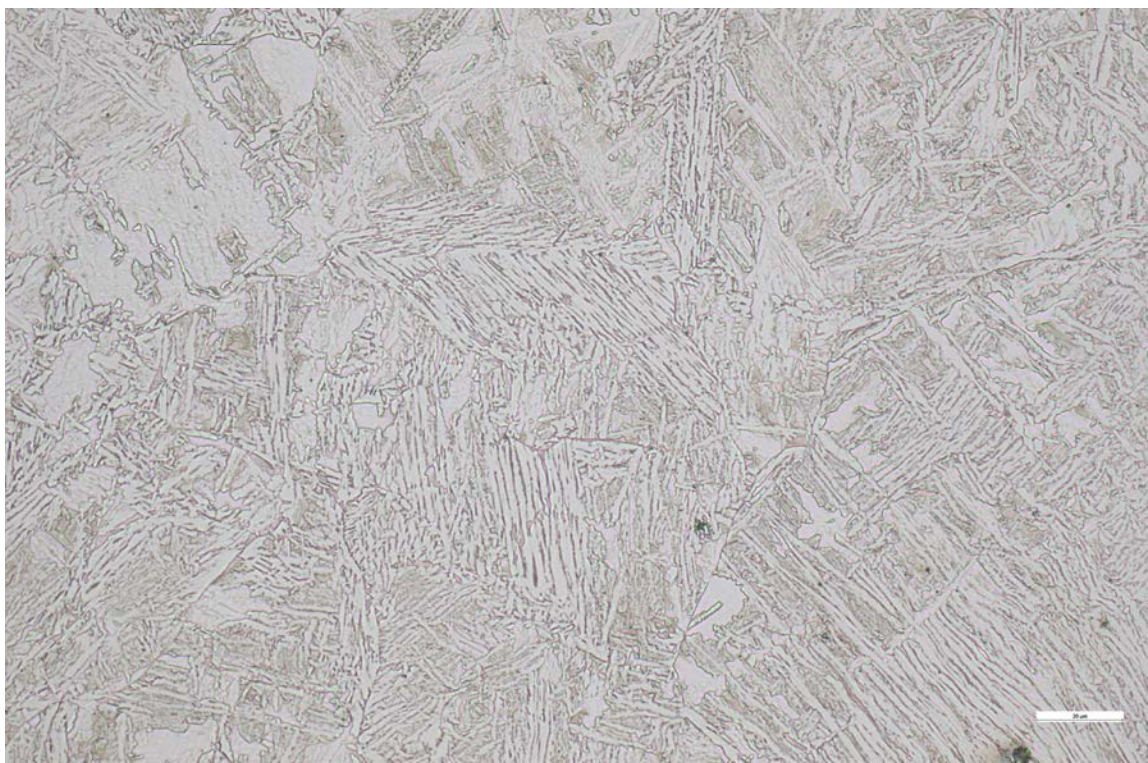


Figure 18 – BF micrograph showing a typical area of the weld filler microstructure (~500X, etched 2% Nital).