

NATIONAL TRANSPORTATION SAFETY BOARD

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



May 18, 2017

MATERIALS LABORATORY FACTUAL REPORT

Report No. 17-027

A. ACCIDENT INFORMATION

Place : Gunnison, Utah
Date : August 12, 2016
Vehicle : Robinson R-44 II
NTSB No. : WPR16LA165
Investigator : Howard Plagens, AS-WPR

B. COMPONENTS EXAMINED

1. Engine air intake filter.
2. Pump discharge fitting pieces comprising:
 - o Street elbow, 90°, FNPT x MNPT, 2"—78311-YE0-003 Honda coupling, hose (from Honda¹ WMP20 pump kit).
 - o Pieces from a close nipple, 2" MNPT—78104-YE0-003 Honda outlet (from Honda WMP20 pump kit).
 - o Banjo 200A polypropylene adapter, Coupling Type A (camlock style), male adapter x FNPT, 2".

C. DETAILS OF THE EXAMINATION

The as-received engine air intake filter and the pump discharge fitting pieces are shown in Figure 1. Further details of the pump discharge pieces are shown in Figure 5. The arrangement of the pump discharge fittings as installed on the Simplex R44III spray system are shown in Figures 2-4². The purpose of this report is to determine the failure mode of the close nipple fractures and to inspect the engine air intake filter for cake deposits.

Specific details regarding the components and pieces in the submitted discharge fitting assembly are outlined in Figure 5. In the figure, the two primary close nipple pieces are arranged close to their pre-accident configuration (without fracture surface contact). The arrangement of the fitting components relative to the Honda illustrated parts diagram is shown in Figure 6. According to Figure 6 and a representative from Simplex, the close nipple was threaded directly to the pump housing discharge outlet. However, the parts diagram shows the male side of the elbow fitting to be threaded directly to the pump housing discharge outlet.

¹ American Honda Motor Company, Torrance, CA.

² Simplex Aerospace, Portland, OR.

Images of the mating fracture surfaces of the close nipple pieces are shown in Figure 7. The forward and aft orientation of the fittings relative to the helicopter are annotated on the fracture surfaces. The portion of the close nipple threaded into the 90° elbow was removed by cutting the elbow fitting with an abrasive saw and extracting the piece. The two primary recovered close nipple pieces are shown in Figure 8 with the orientation relative to the pump housing and the 90° elbow indicated.

Close views of the lower close nipple piece fracture surface are shown in Figures 9–11. As indicated in the figures, the region along the aft side of the close nipple fracture surface revealed fractographic features consistent with slow crack growth, a progressive fracture mode in polymers. In Figure 11, the slow crack growth region is identified with tangerine shading. The balance of the fracture surface in Figure 11 exhibits fractographic features consistent with overstress fracture and a region of final fracture is identified in the figure. A higher magnification image of the initiation region within the slow crack growth region is shown in Figure 12. Just adjacent to the thread root, the initiation region exhibits mechanical damage. Several rib marks are revealed in this initiation region. Figure 13 shows another region with well-developed craze cracks consistent with slow crack growth.

The fracture surface on the lower close nipple piece removed from the pump outlet (see Figures 5 and 8) was examined using a field emission scanning electron microscope (SEM). An overall SEM fractograph of the slow crack growth region is shown in Figure 14 with the initiation region and a representative area of crazing identified. Higher magnification fractographs of the initiation region are shown in Figures 15-17. The fractographs generally reveal mechanical damage in the fracture surface immediately adjacent to the thread root. Additionally, the thread root exhibits features (e.g. wavy, undulated melt front) consistent with mold under-fill. SEM fractographs of a representative area of crazing are shown in Figures 18 and 19. As observed in Figure 18, the thread root exhibits features (e.g. wavy, undulated melt front) consistent with mold under-fill. Also evident in Figure 18, are step features consistent with multiple crack initiation sites typically found in craze cracking in rigid thermoplastics. The SEM fractograph in Figure 19 reveals smooth fracture interfaces typical of craze cracks associated with slow crack growth.

Upon receipt, the fracture surface of the upper close nipple piece connected to the 90° elbow was covered in soil deposits. The piece was removed from the 90° elbow by cutting the threaded region of the elbow with an abrasive saw, allowing the close nipple piece to be extracted. Before microscopic examination, the soil deposits were removed from the close nipple piece using Alconox nonionic detergent and a soft bristle brush. A digital microscope macrograph of the fracture surface on the close nipple piece removed from the 90° elbow (see Figures 5 and 8) is shown in Figure 20. In Figure 21, the slow crack growth region is identified with tangerine shading. The balance of the fracture surface in Figure 21 exhibits fractographic features consistent with overstress fracture and a region of final fracture is identified in the figure. A higher magnification image of the initiation region within the slow crack growth region is shown in Figure 22. Just adjacent to the thread root, the initiation region exhibits mechanical damage. Several rib

marks are present in this initiation region. Figure 23 shows a region with well-developed craze cracks consistent with slow crack growth.

A digital microscope macrograph in Figure 24 shows the inside surface of the close nipple piece removed from the pump outlet revealing a secondary crack. Secondary cracks were also observed in the roots of the aft-facing thread roots. Digital microscope macrographs of example secondary thread-root cracks are shown in Figures 25 and 26. An SEM fractograph of the initiation region, as viewed from the direction of the thread root, reveals features (e.g. wavy, undulating melt front) consistent with mold under-fill. Higher magnification SEM micrographs of the thread roots shows evidence of under-fill and incipient secondary cracks (Figures 28 and 29). For comparative purposes, the thread roots on the forward side of the close nipple exhibited an under-fill condition but did not exhibit any incipient cracks as illustrated in Figure 30.

Other molding artifacts in the close nipple pieces such as the injection gate marks, wrinkles around the injection gate, and a knit line are identified in Figures 31-33. Although present and visible, none of these molding artifacts directly influenced the fracture of the close nipple.

Fourier transform infrared spectroscopy indicated that the close nipple was molded from polyvinyl chloride (rigid PVC).

No cake deposits were noted on the internal and external surfaces of the engine air intake filter as documented in Figure 34.

Michael Budinski
Chief, Materials Laboratory Division



Figure 1 As-received pump discharge fitting pieces and engine air intake filter. View (a) is a profile image and view (b) is an axial image.

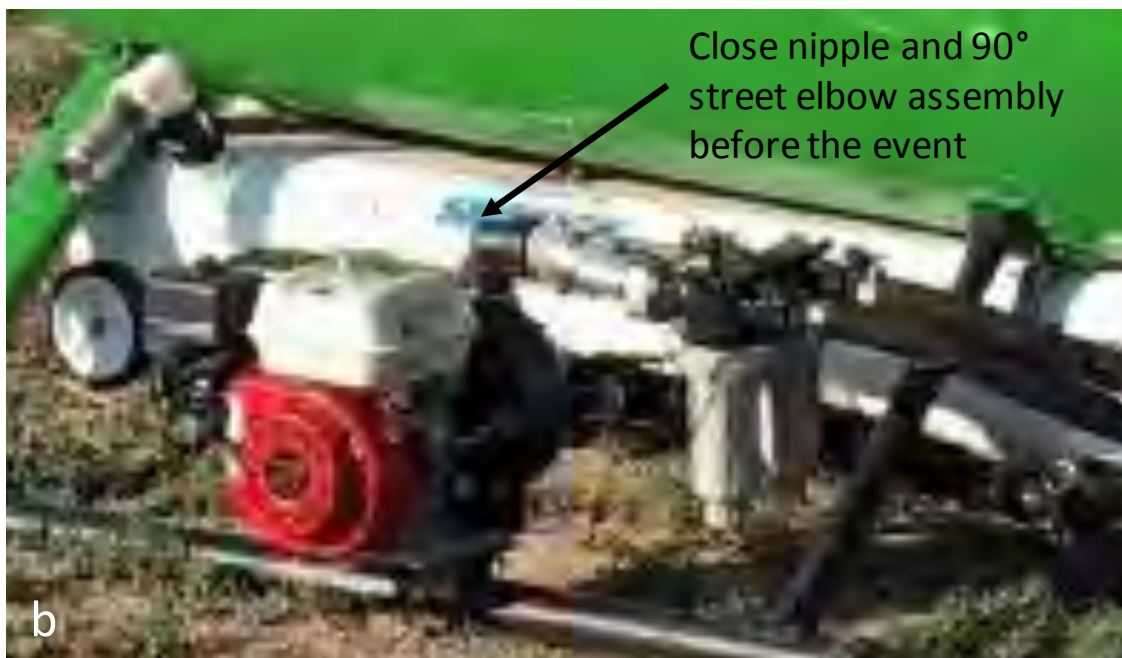


Figure 2 View of the close nipple and 90° street elbow as installed on the pump discharge portion of the Simplex R44III spray system (before the incident). Images provided by the operator.

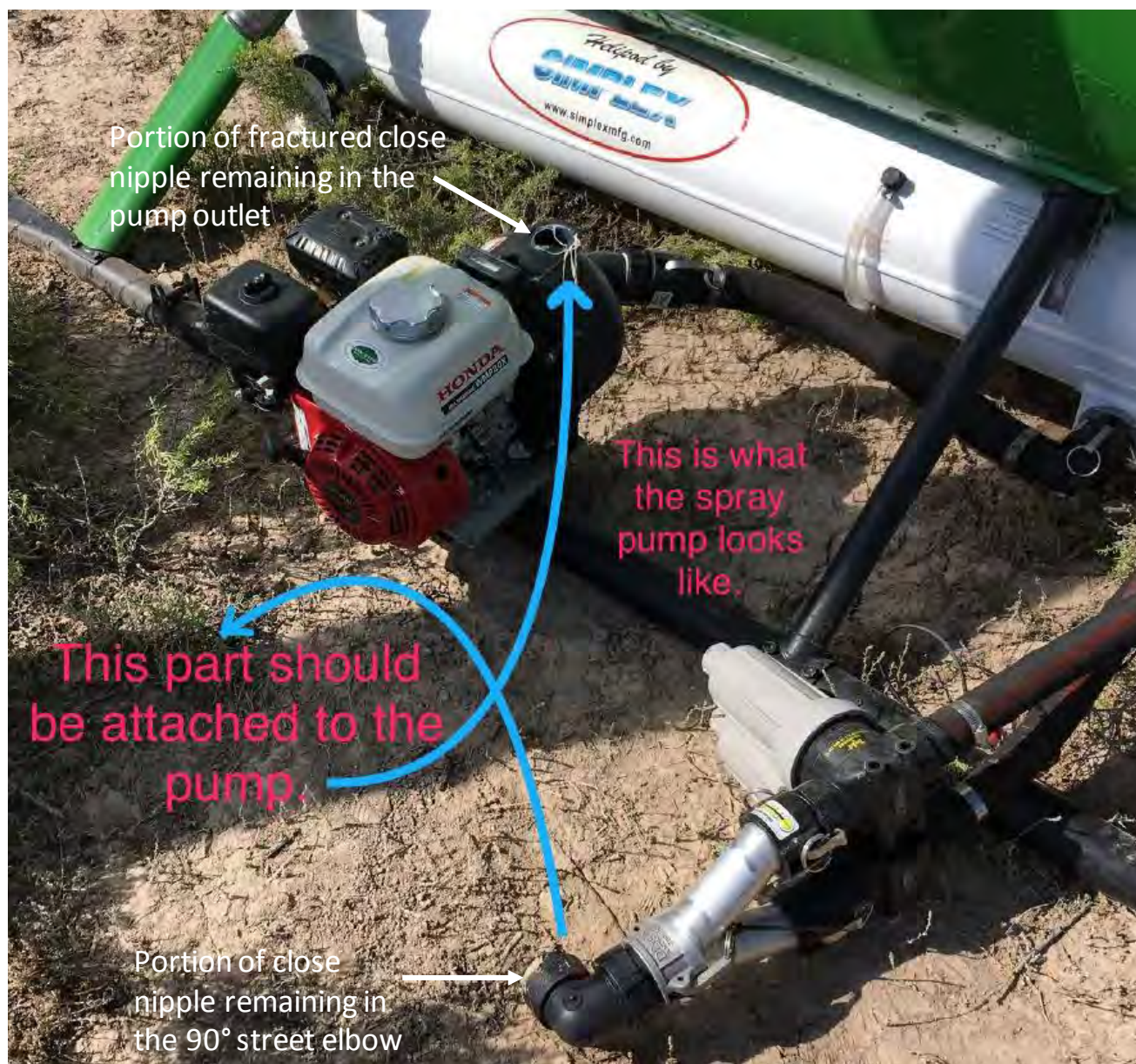


Figure 3 View of the close nipple pieces and the 90° street elbow on the Simplex R44III spray system (after the incident). Image provided by the operator.

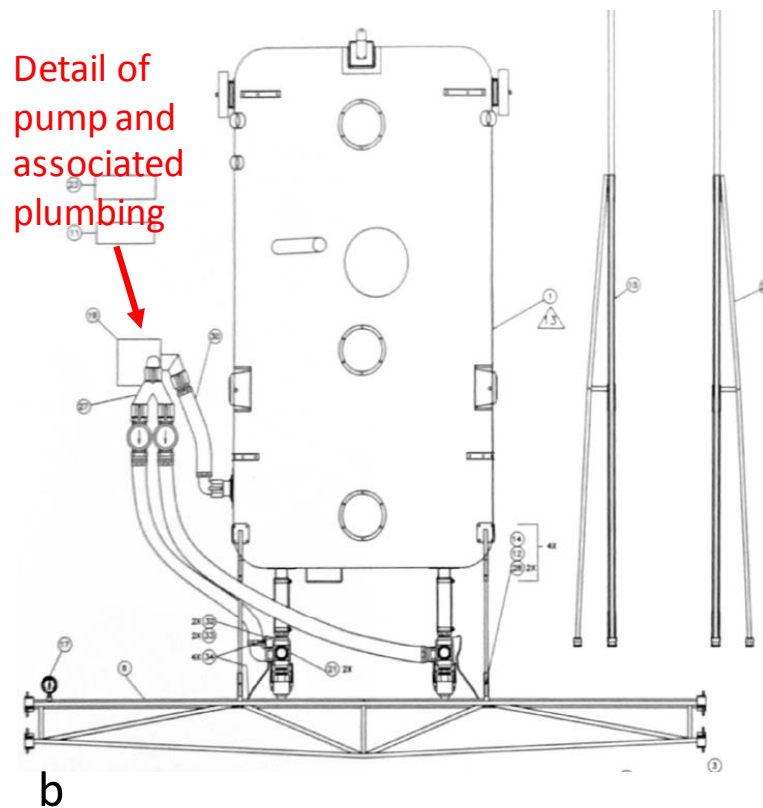


Figure 4 Images of the pump installation on the helicopter as depicted in the Simplex R44III spray system manual. View (a) shows the pump portion of the system as installed. View (b) is a top-down engineering schematic showing the relative location of the pump and its associated plumbing.

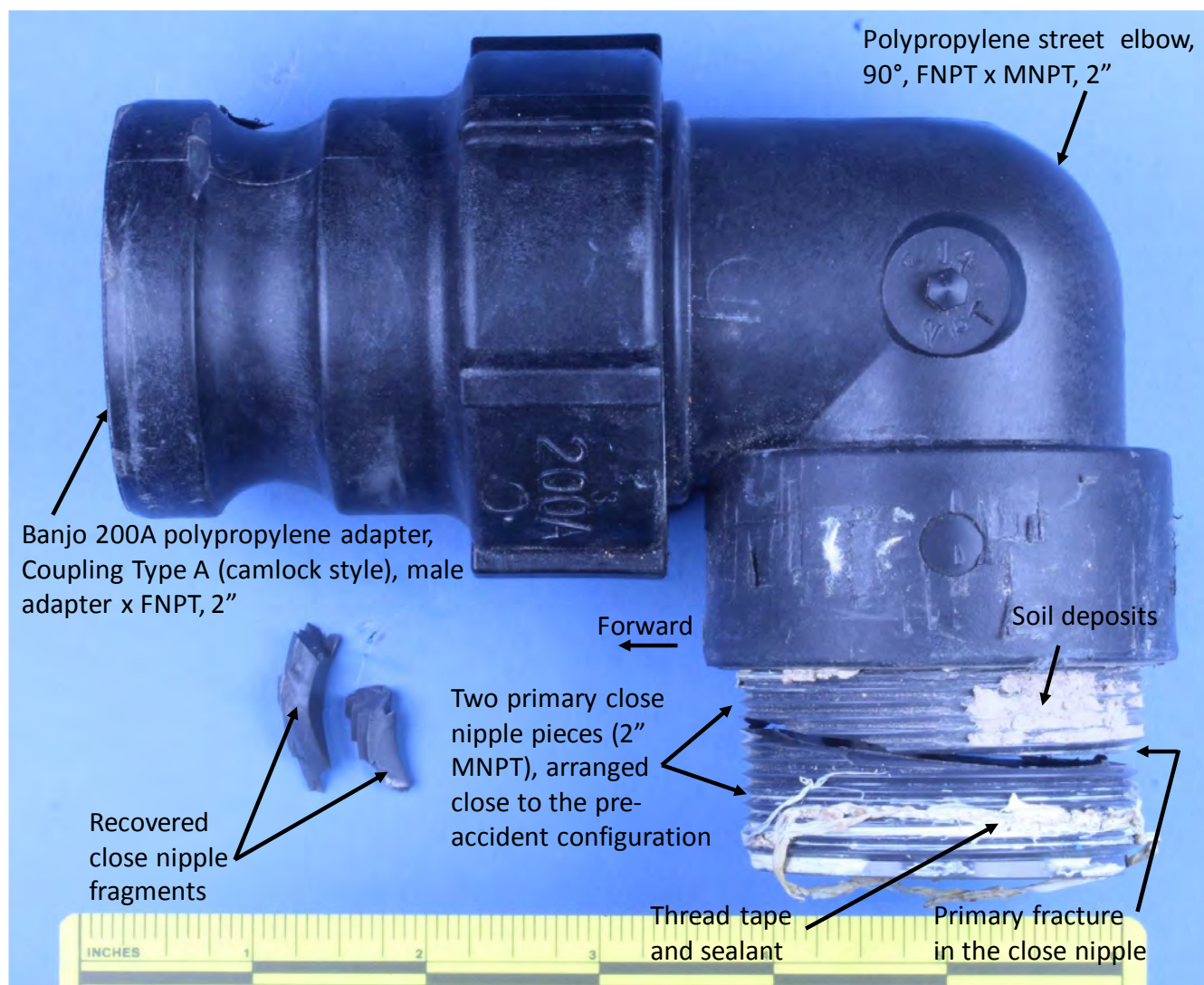


Figure 5 Close view of the 90° street elbow, the cam lock fitting and pieces of the close nipple removed from the discharge side of the spray system pump.

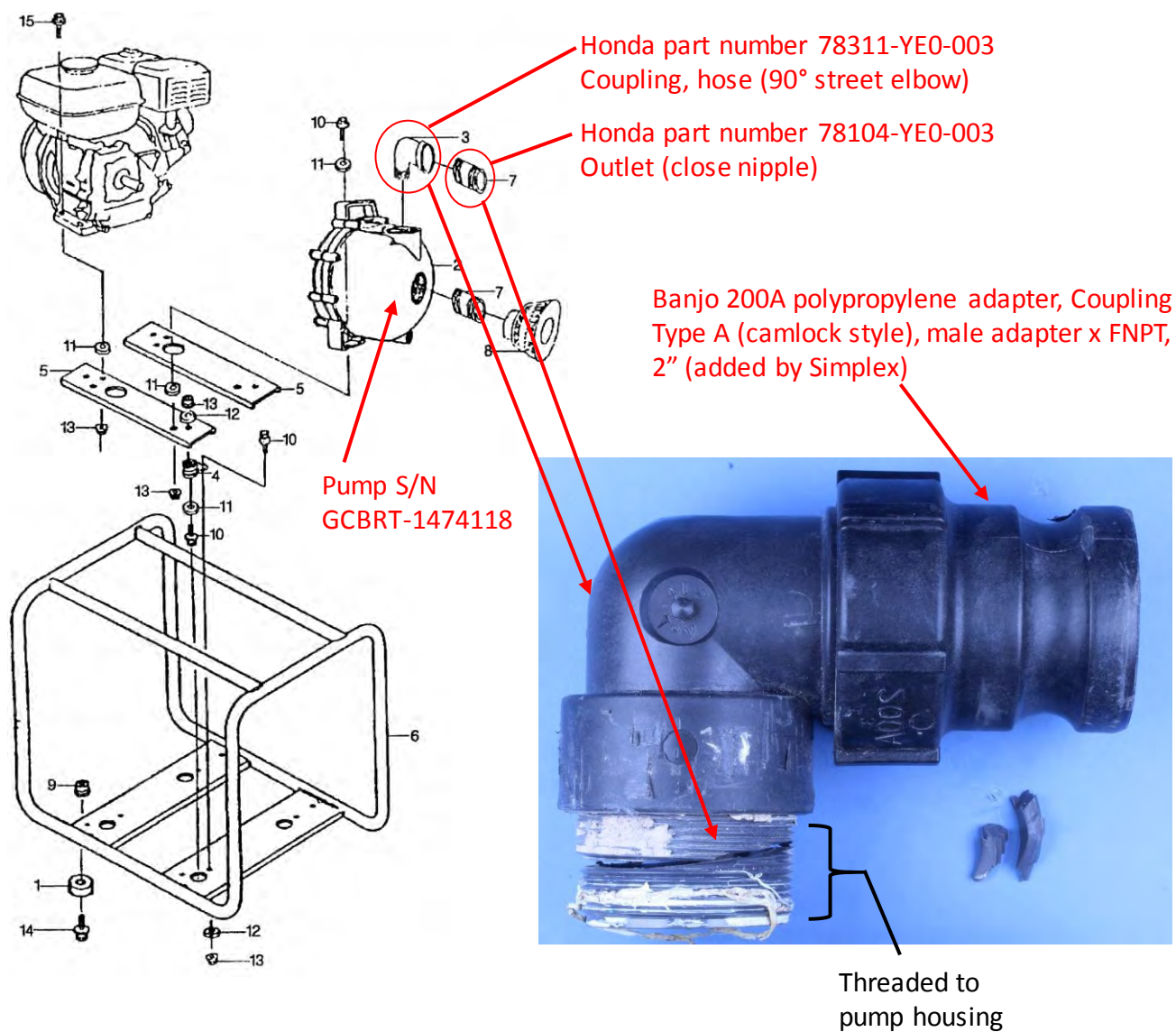


Figure 6 Illustrated parts diagram of the Honda WMP20 pump kit showing the manufacturer's arrangement of the 90° street elbow and the close nipple. Inset is an image of the same parts as installed on the R44III spray system by Simplex.

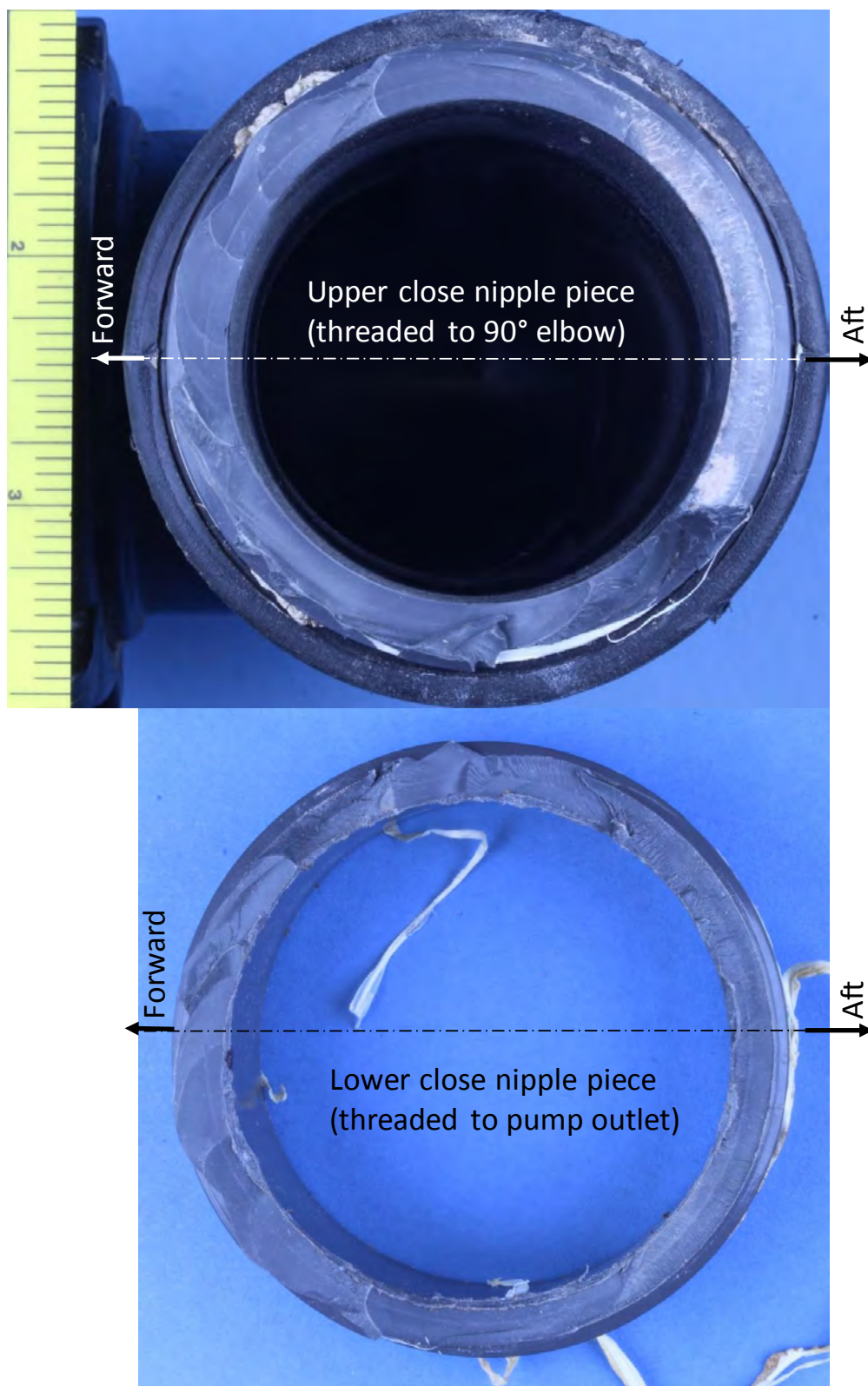


Figure 7 Top down views of both halves of the fracture surfaces from the primary close nipple pieces. The fracture features are oriented relative to the forward and aft directions of the helicopter.

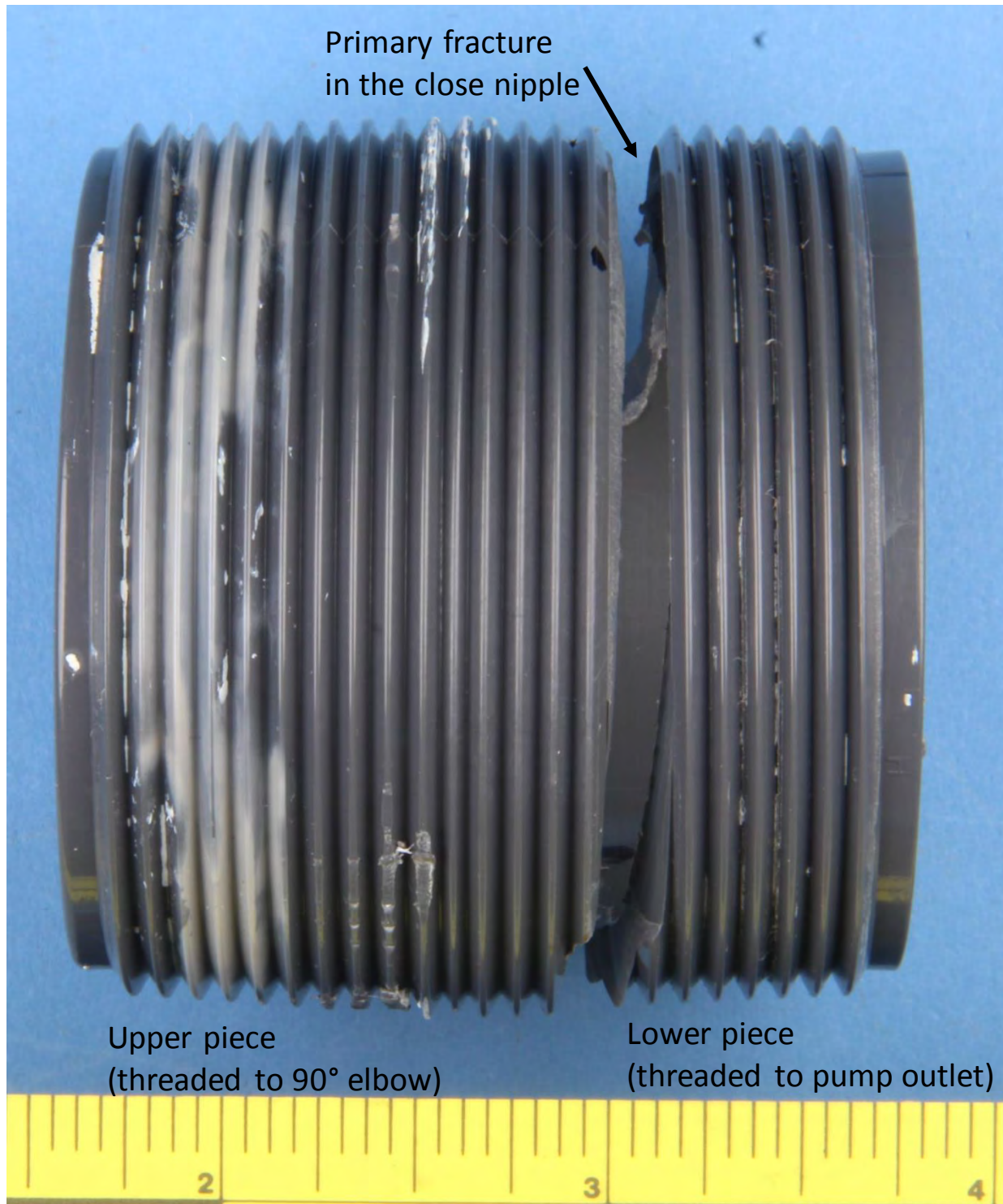


Figure 8 Image of the two primary close nipple pieces arranged close to their pre-accident configuration (without fracture surface contact).

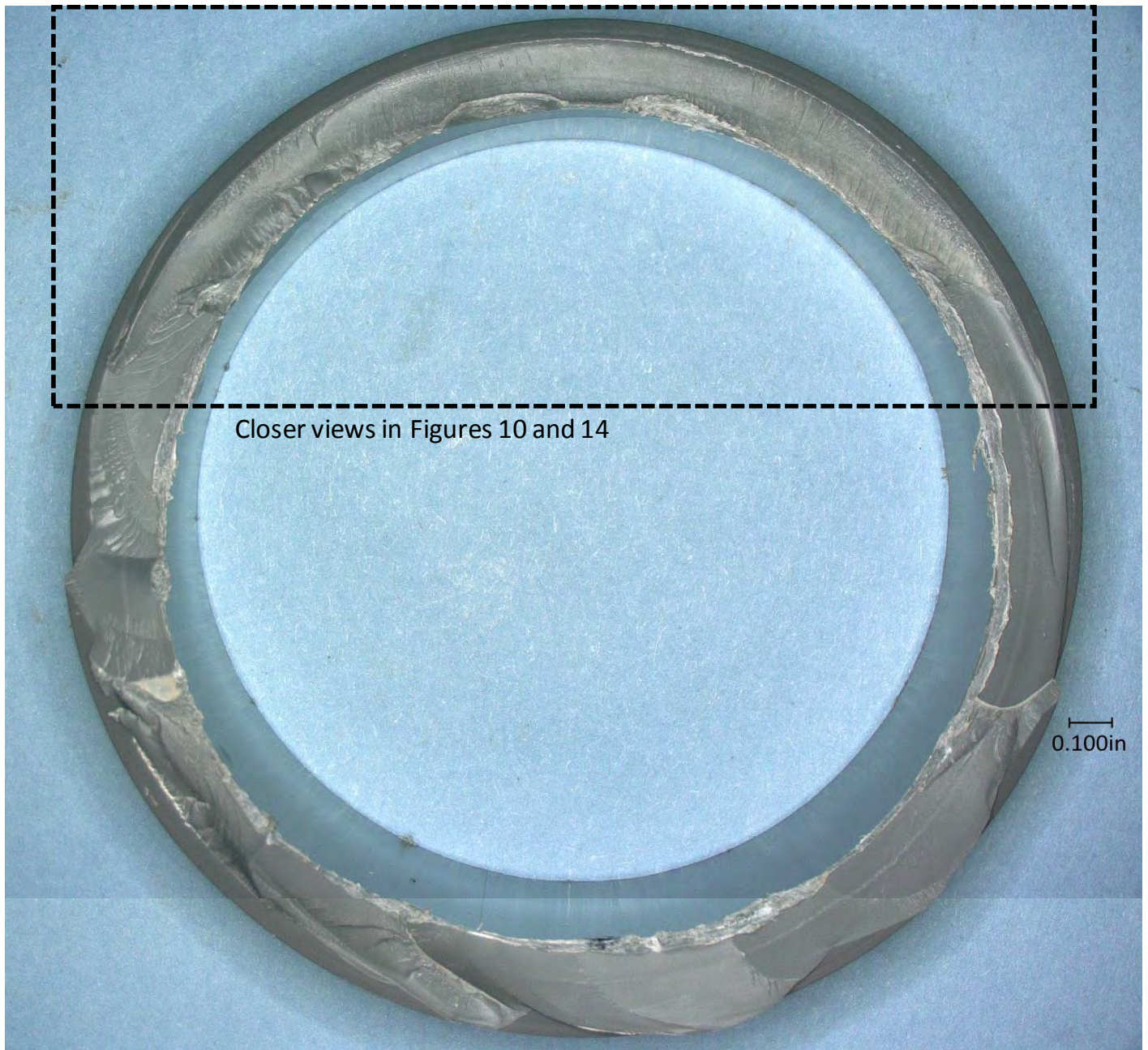


Figure 9 Overall view of the lower close nipple piece fracture surface. An annotated version of this image is shown in Figure 11.

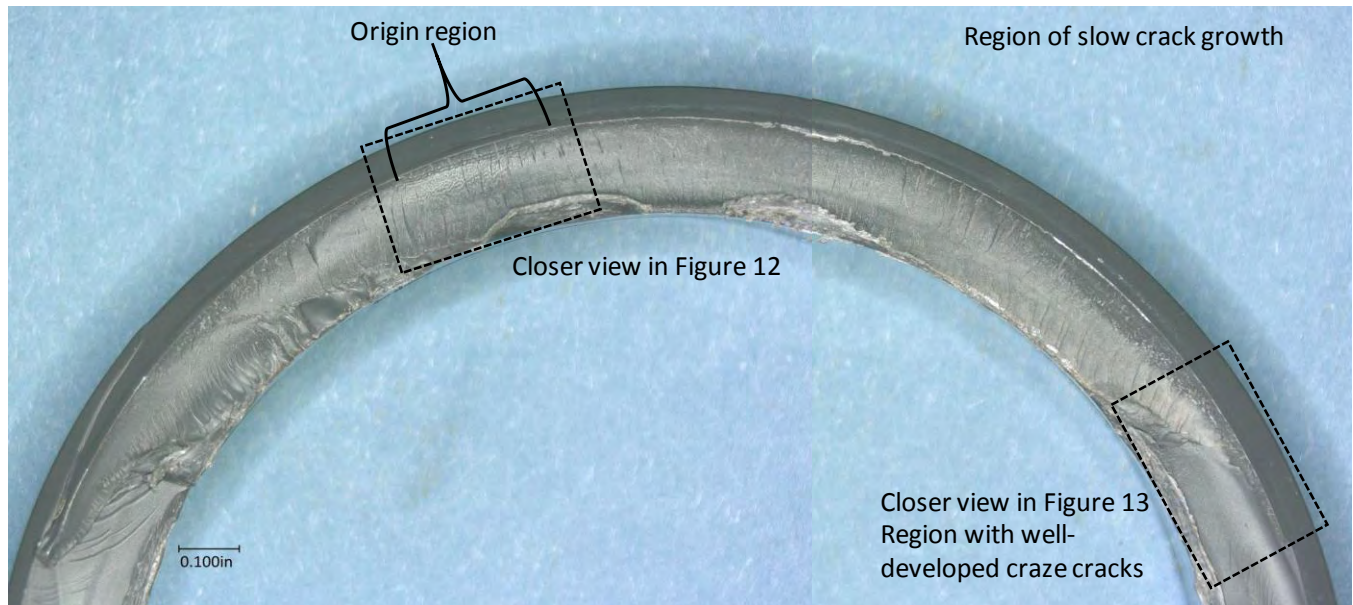


Figure 10 Close view of the lower close nipple piece fracture surface in a region dominated by fracture surface features. An origin region is identified.

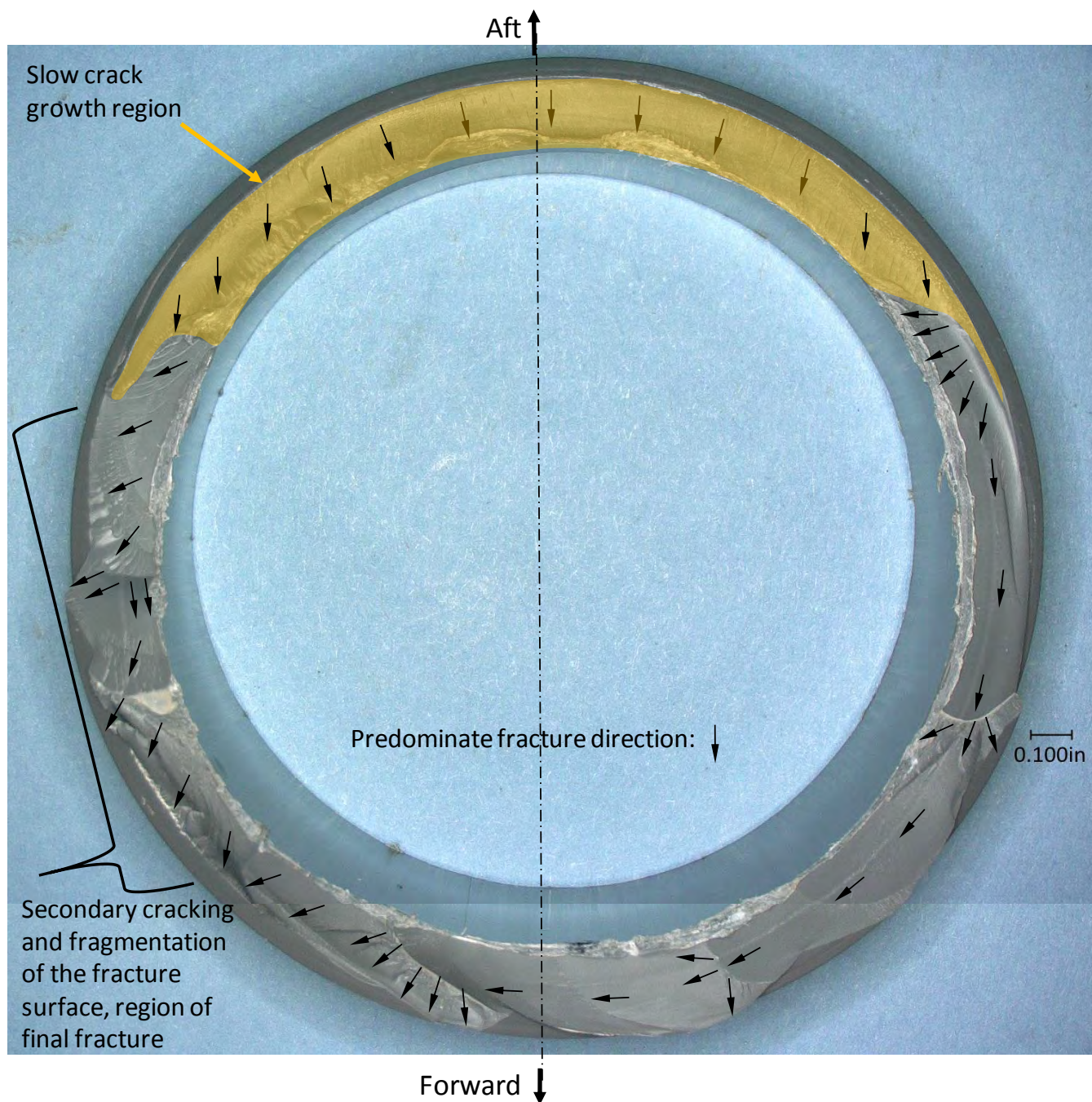


Figure 11 Same view as Figure 9 with the fracture surface annotated with arrows indicating the direction of predominate crack propagation.



Figure 12 Digital microscope image of the origin region as identified in Figure 10.



Figure 13 Digital microscope image of a region with incipient craze fracture features as identified in Figure 10

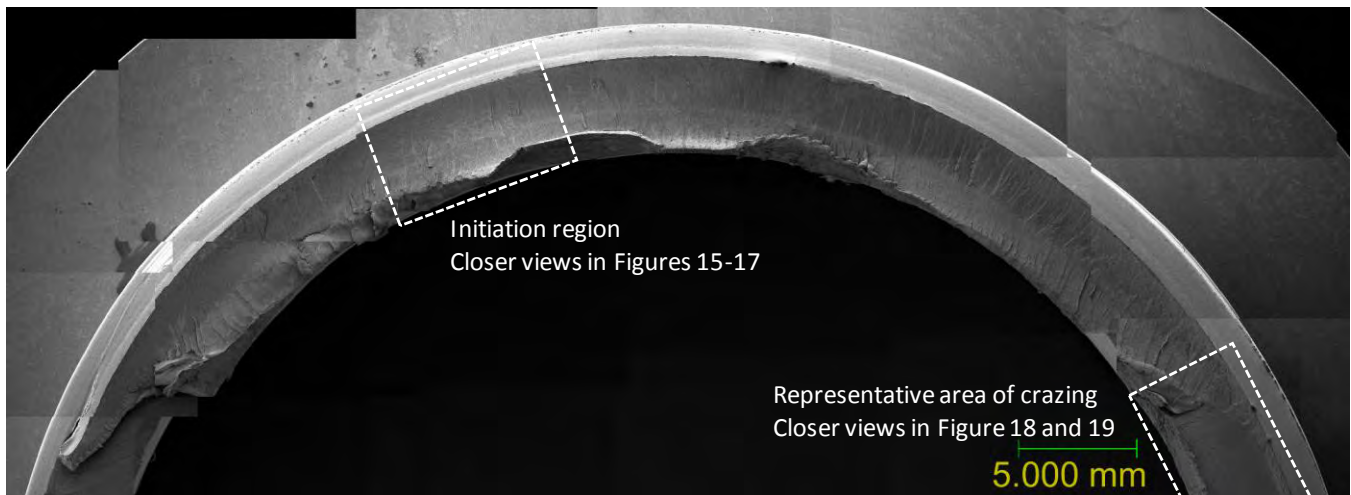


Figure 14 Scanning electron fractograph of the fracture surface on the lower close nipple fracture surface in the slow crack growth region.

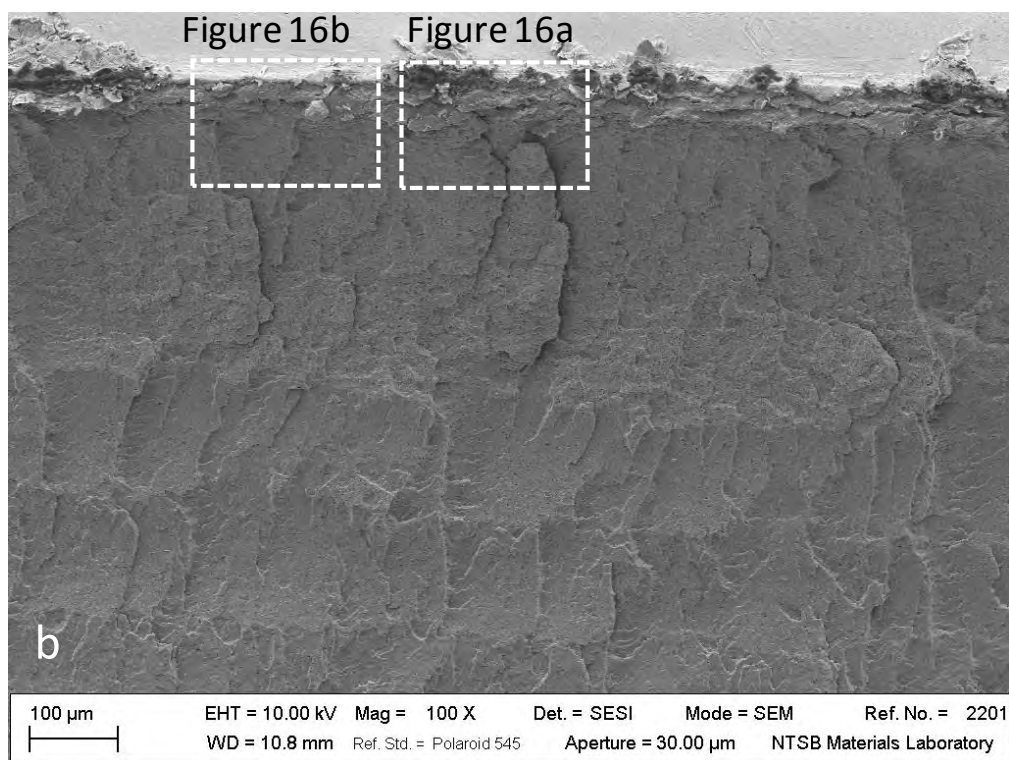
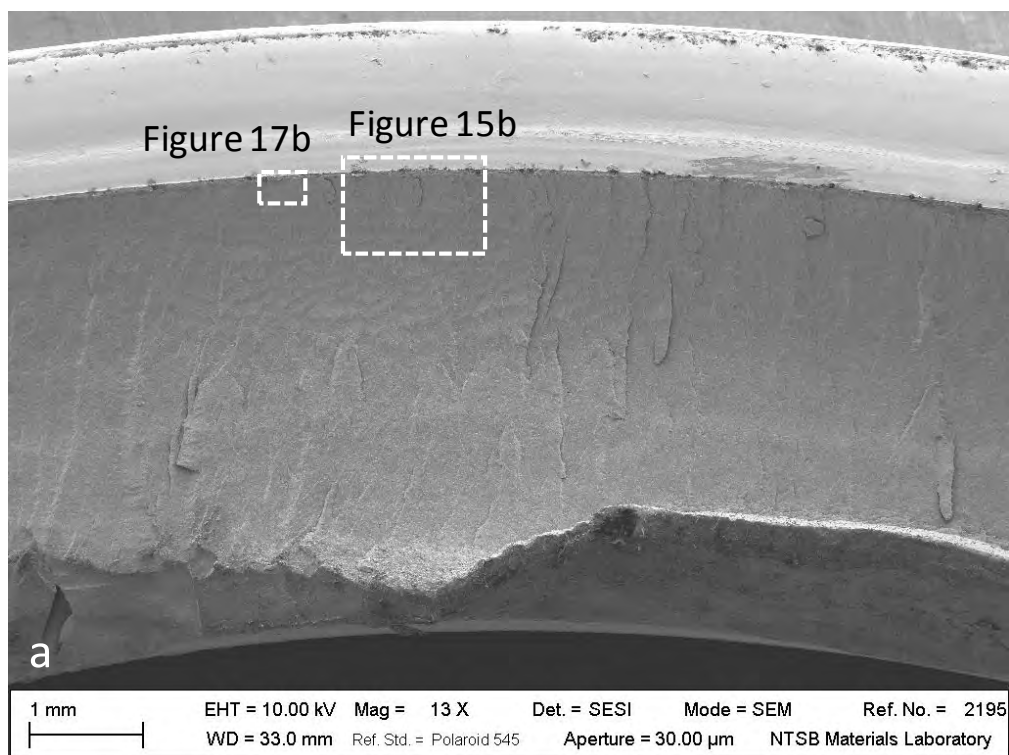


Figure 15 Scanning electron fractograph of the origin region shown in Figures 10 and 14. View (a) is an overall image and view (b) is a closer fractograph of the fracture surface just below the thread root.

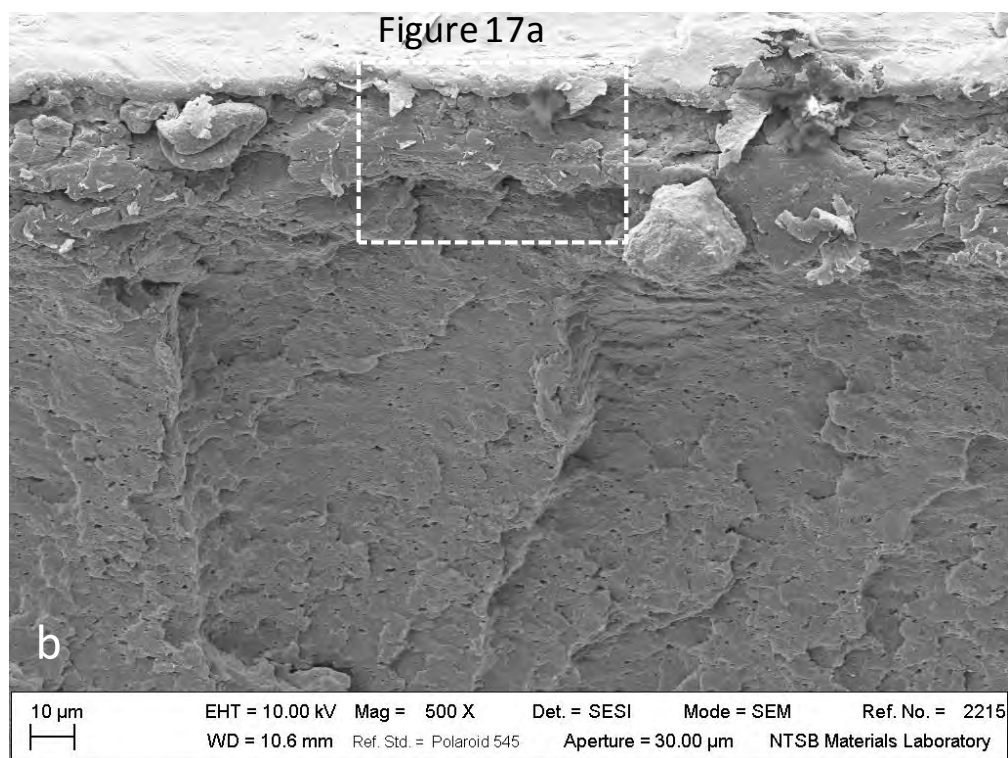
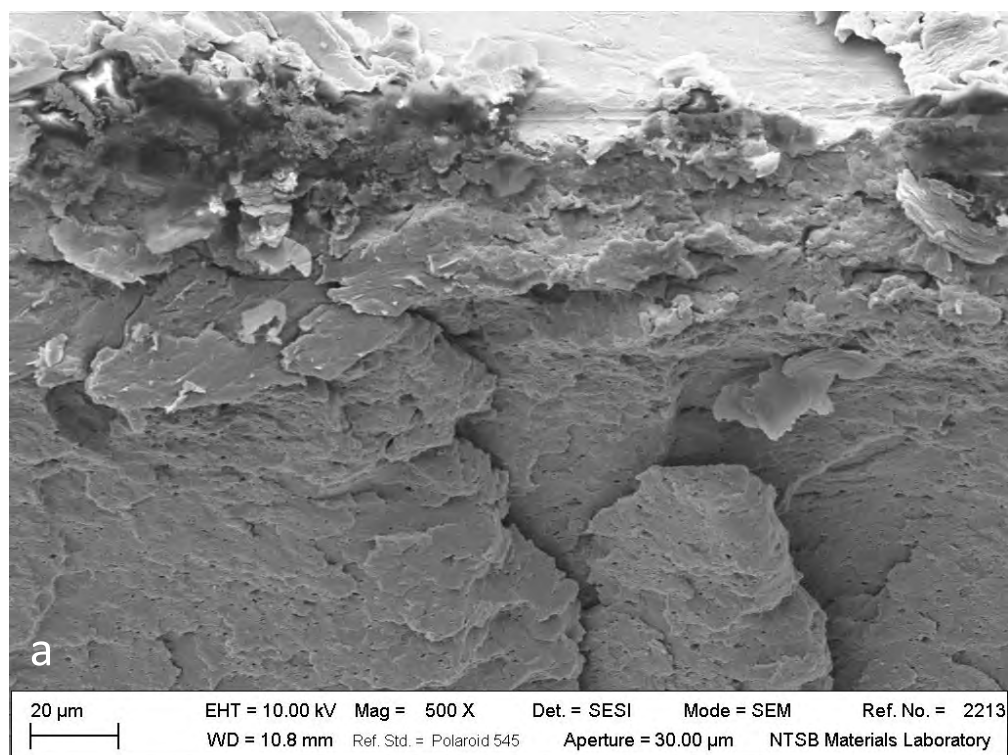


Figure 16 Scanning electron fractographs of the initiation region (just below the thread root) as identified in Figure 15b.

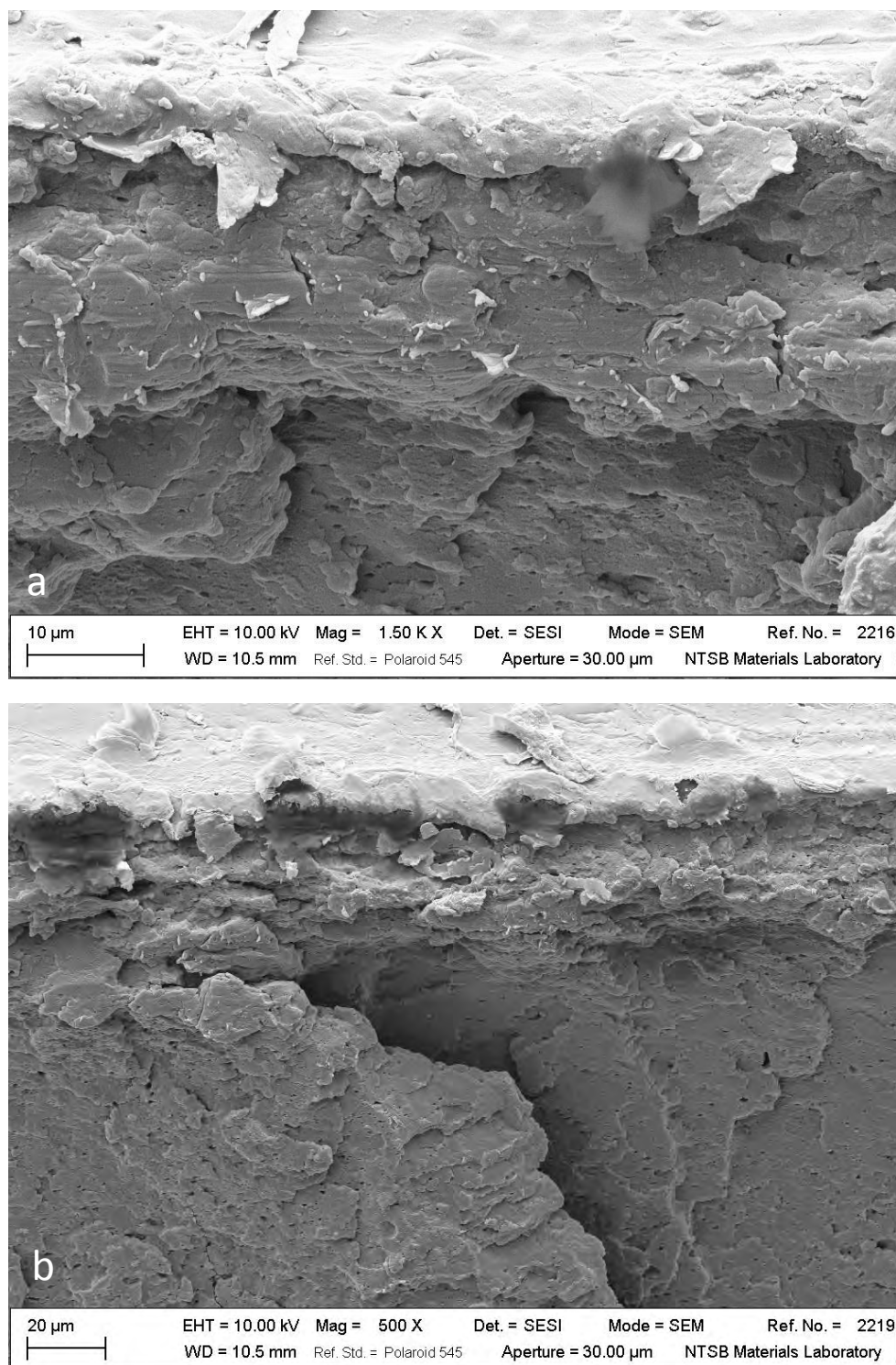


Figure 17 Scanning electron fractographs of the initiation region identified in Figures 15a and 16b. View (a) is a higher magnification fractograph revealing mechanical damage in the initiation region identified in Figure 16b. View (b) is a higher magnification fractograph of the initiation region identified in Figure 15a. This region, with less mechanical damage, shows incipient craze fracture features.

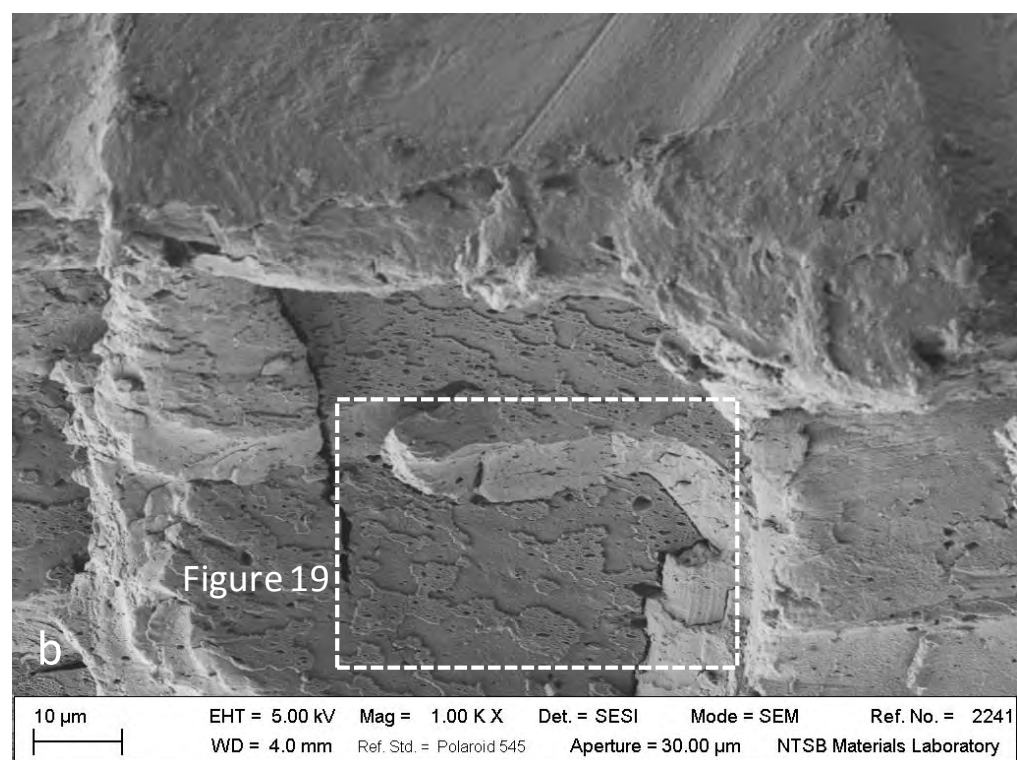
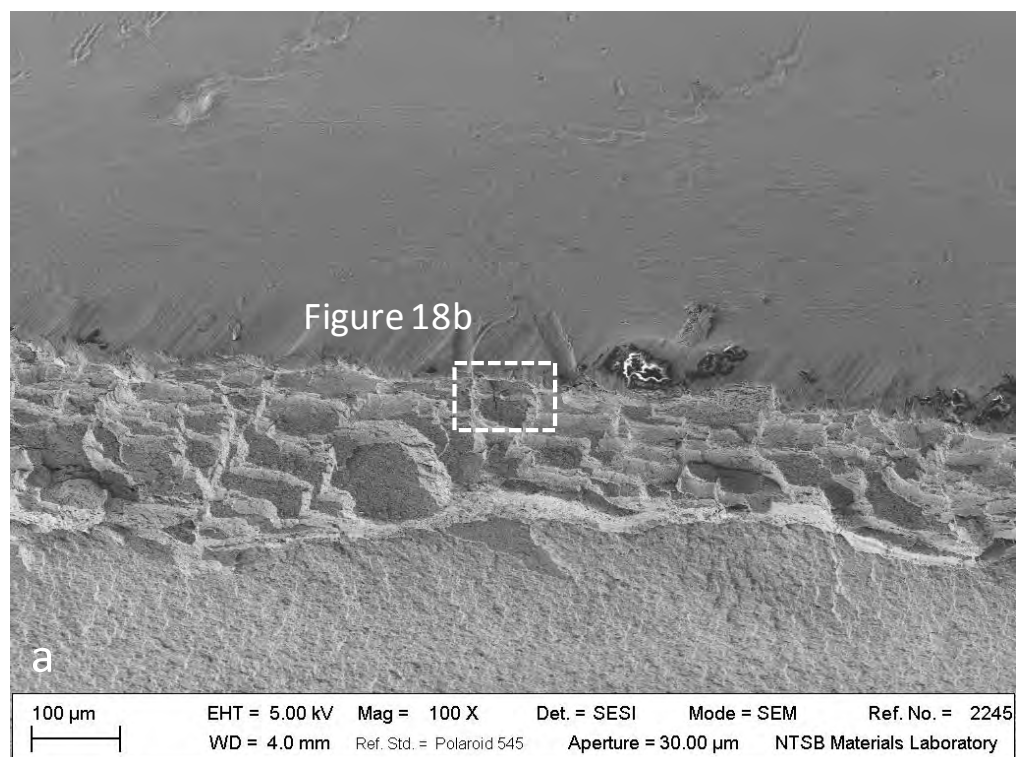


Figure 18 Scanning electron fractographs of a region identified in Figure 14. This region is largely free from mechanical damage and exhibits fracture features typical of craze crack formation.

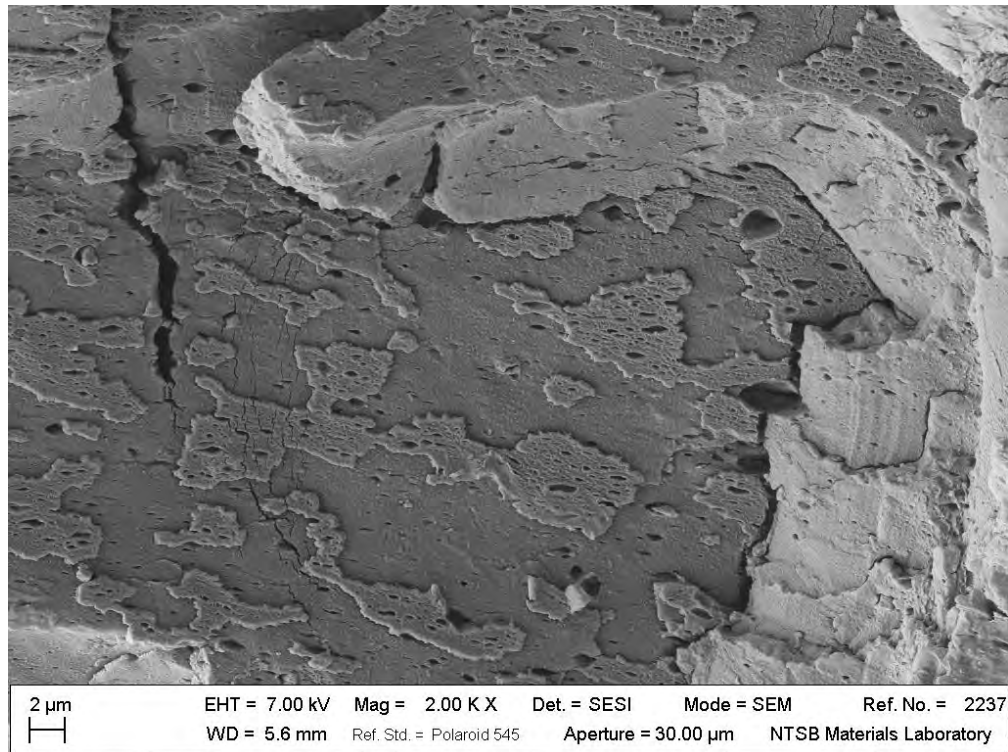


Figure 19 Scanning electron fractograph of a region identified in Figure 18b. This fractograph reveals fracture features of a craze crack.

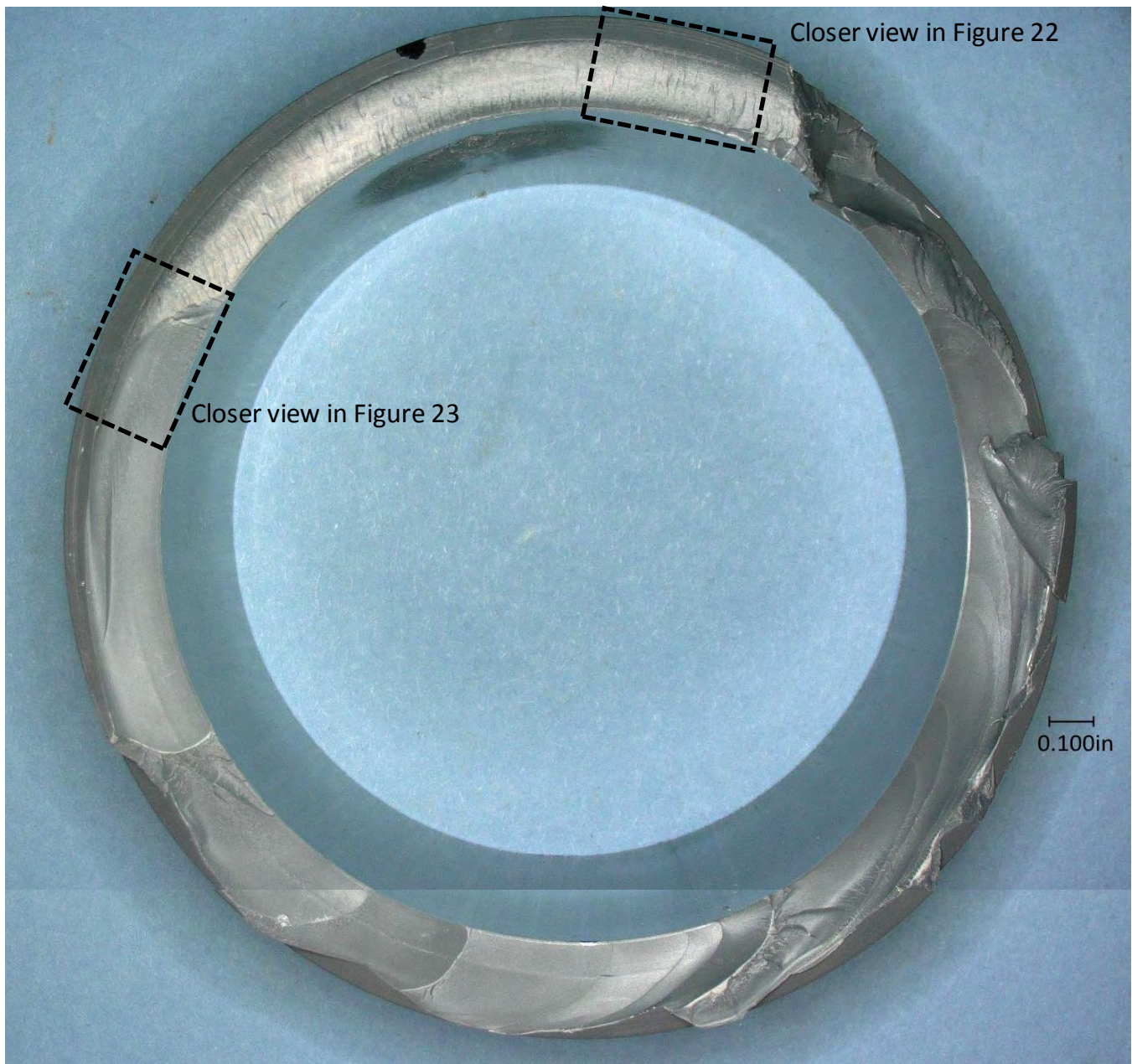


Figure 20 Overall view of the upper close nipple piece fracture surface. An annotated version of this image is shown in Figure 21.

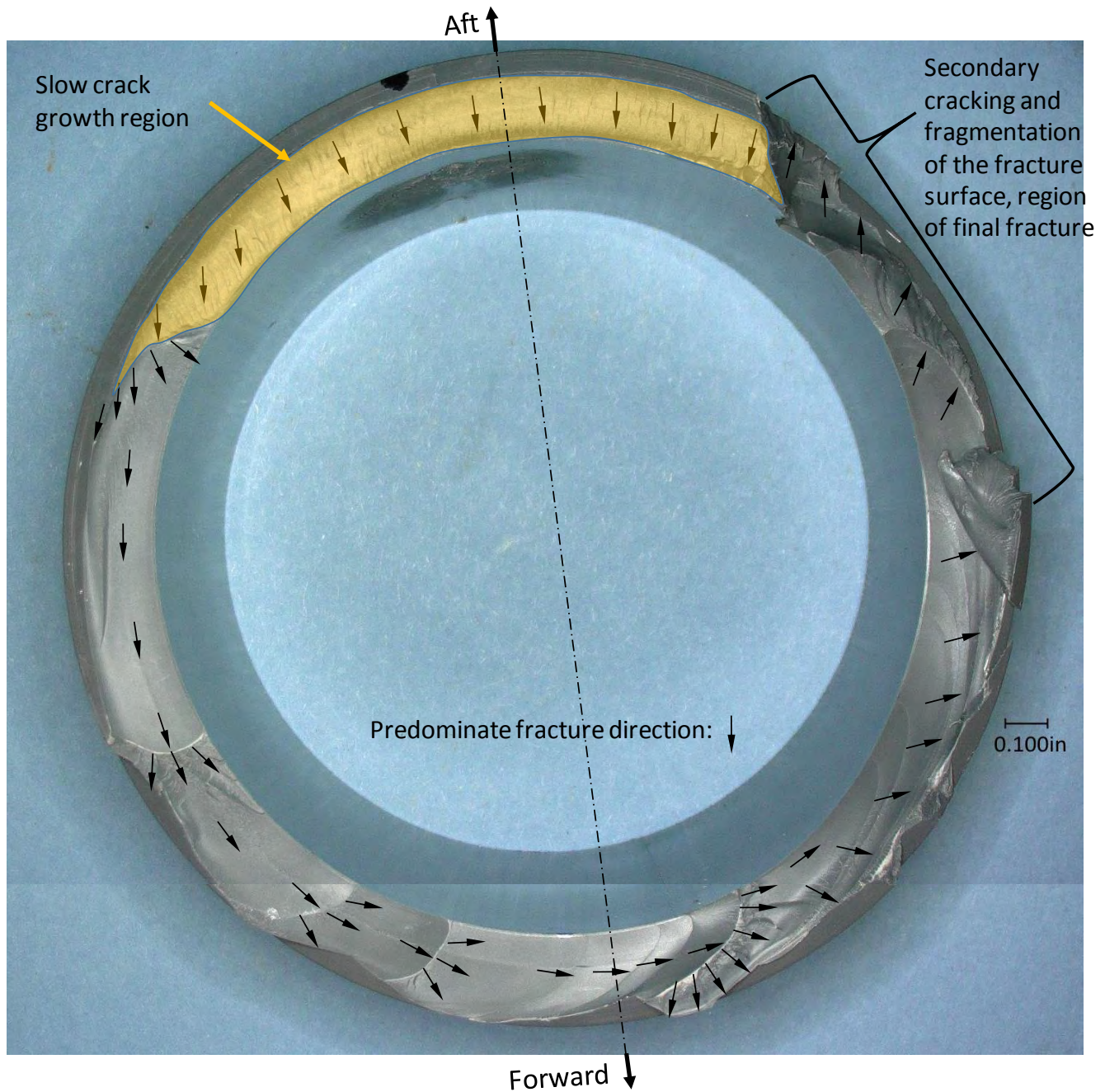


Figure 21 Same view as Figure 20 with the fracture surface annotated with arrows indicating the direction of predominate crack propagation.

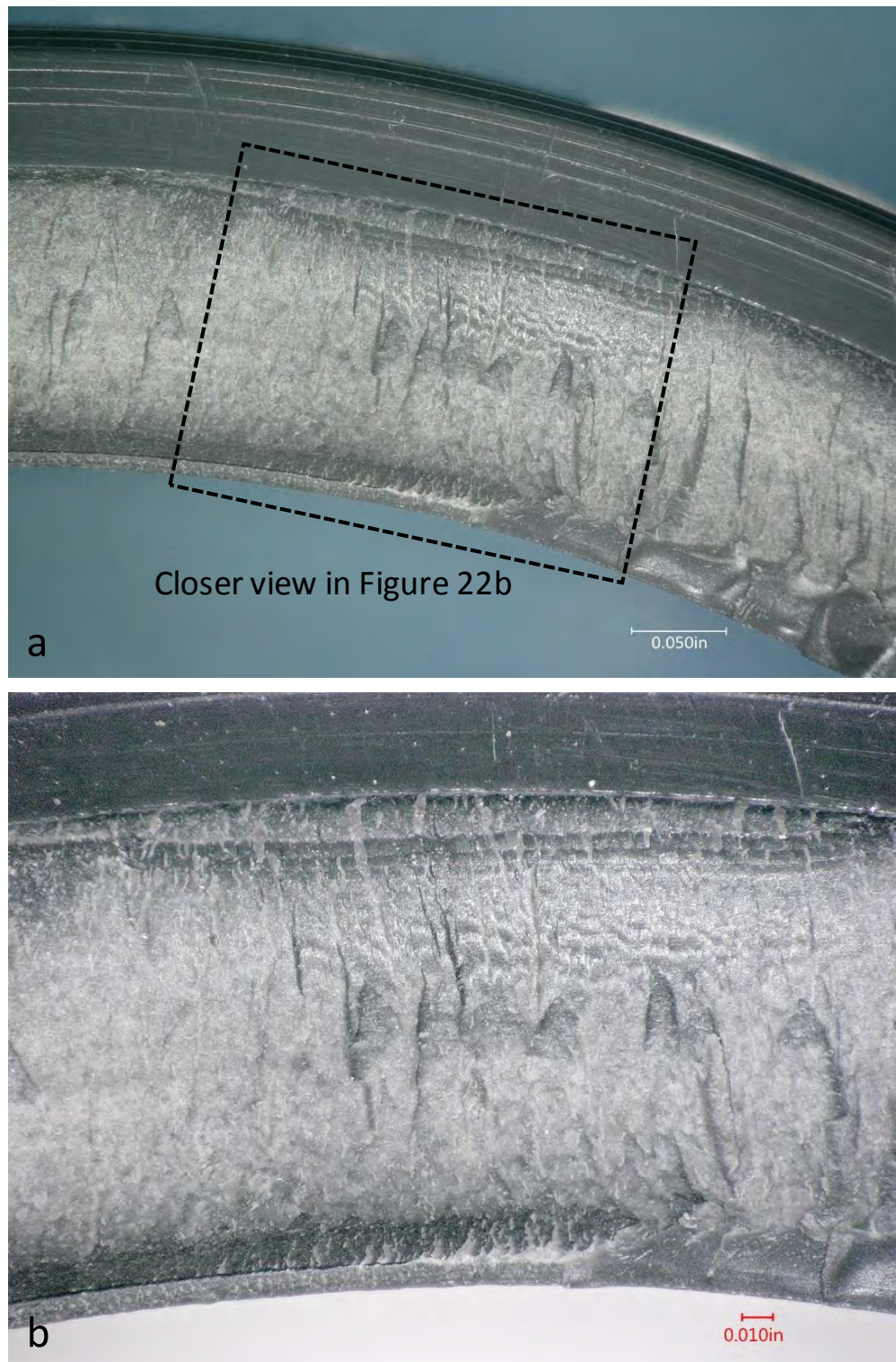


Figure 22 Digital microscope macrographs of the origin region as identified in Figure 20.

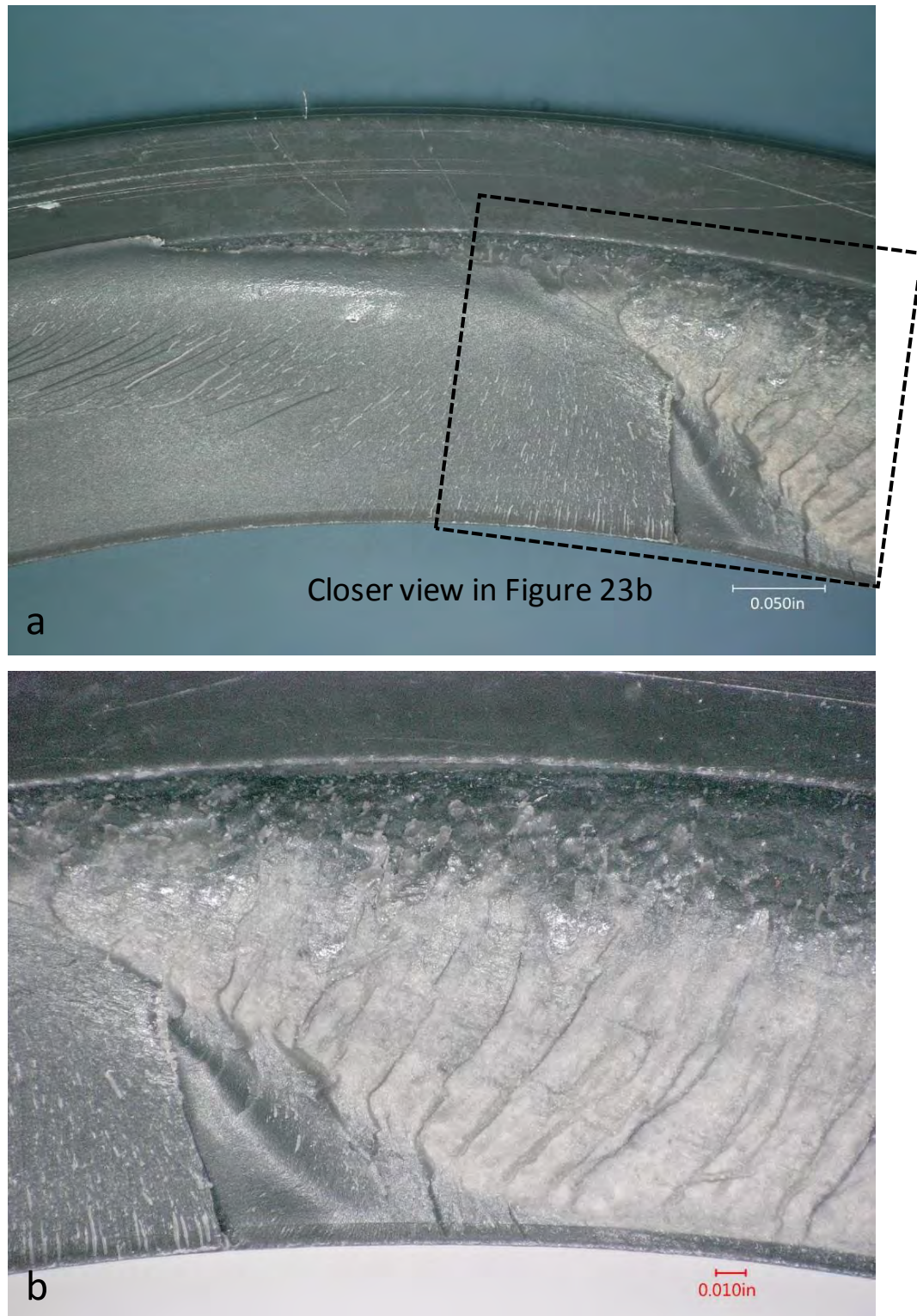


Figure 23 Digital microscope macrographs of a region with incipient craze fracture features as identified in Figure 20.

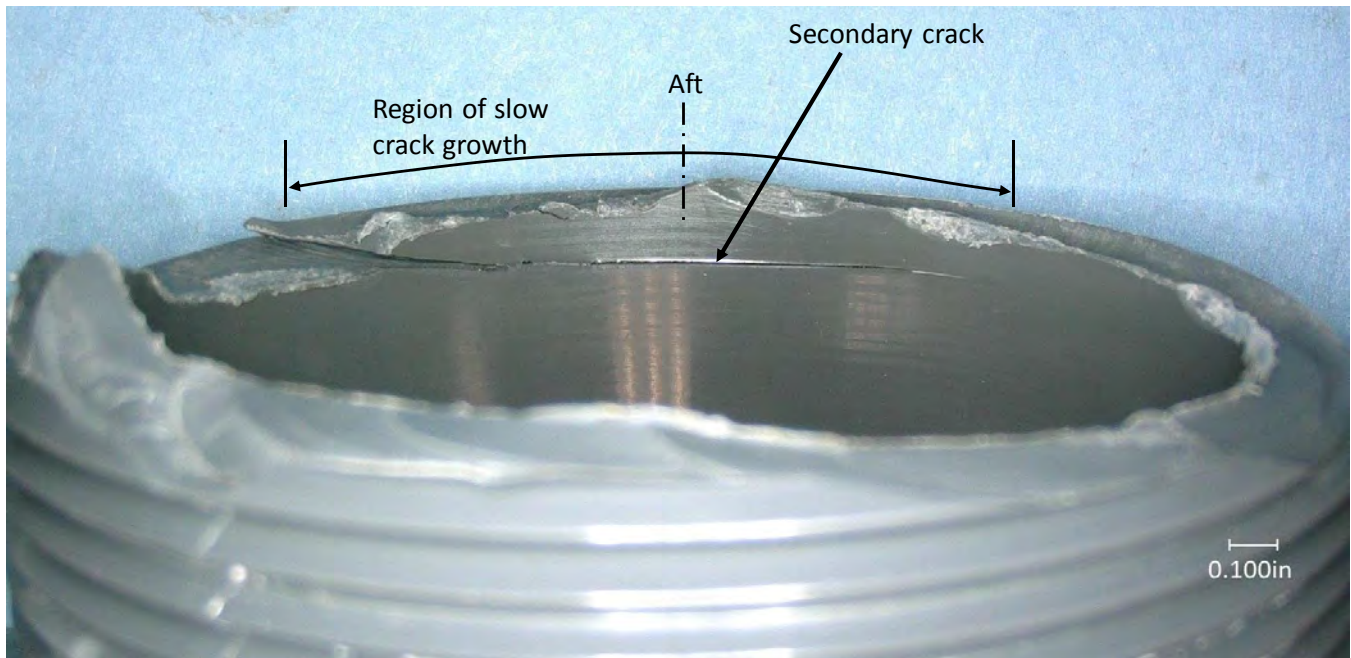


Figure 24 Digital microscope macrograph of a secondary through-crack.

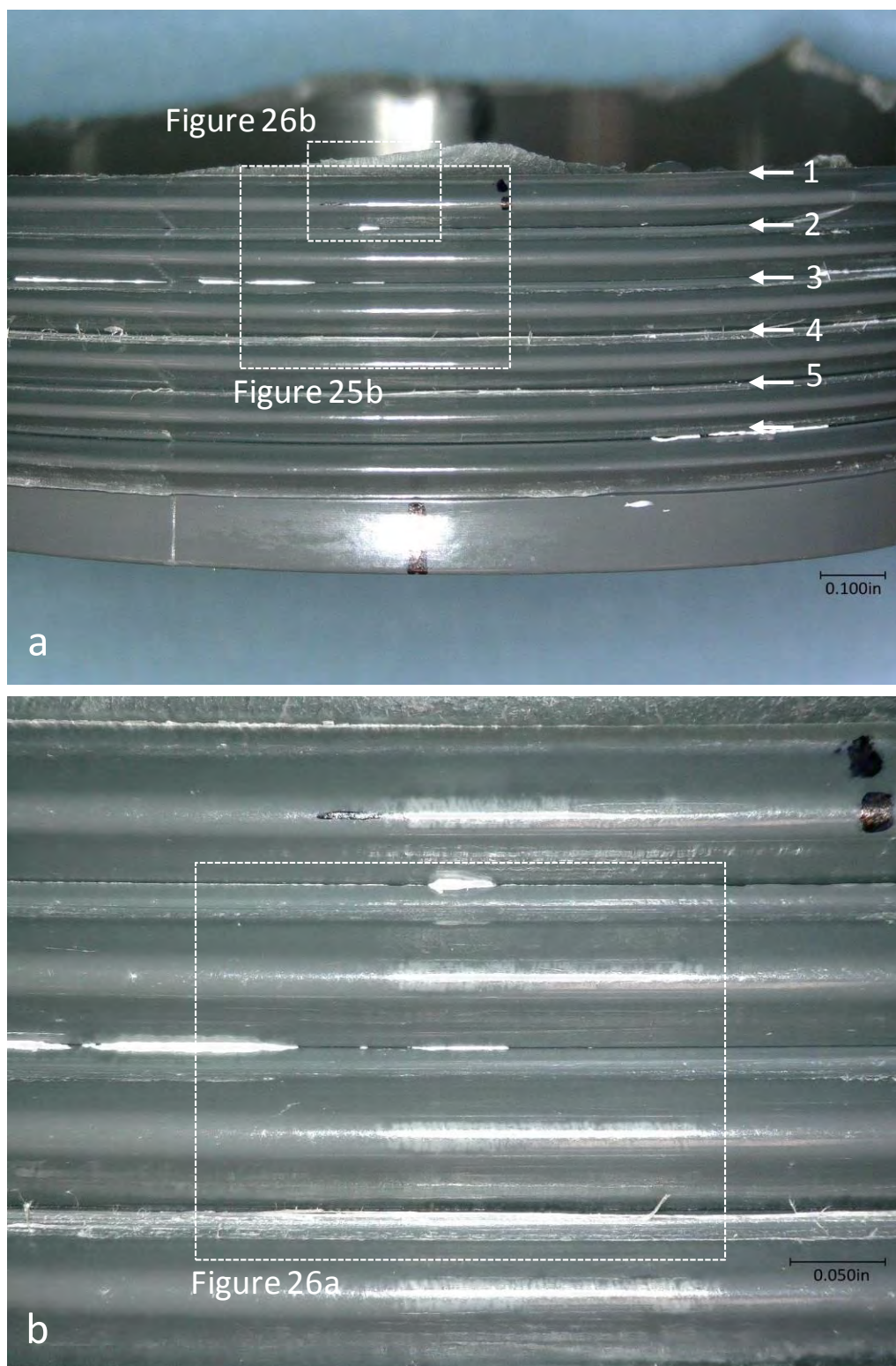


Figure 25 Digital microscope macrographs of the aft-facing threads on the lower close nipple piece threaded to the pump outlet.

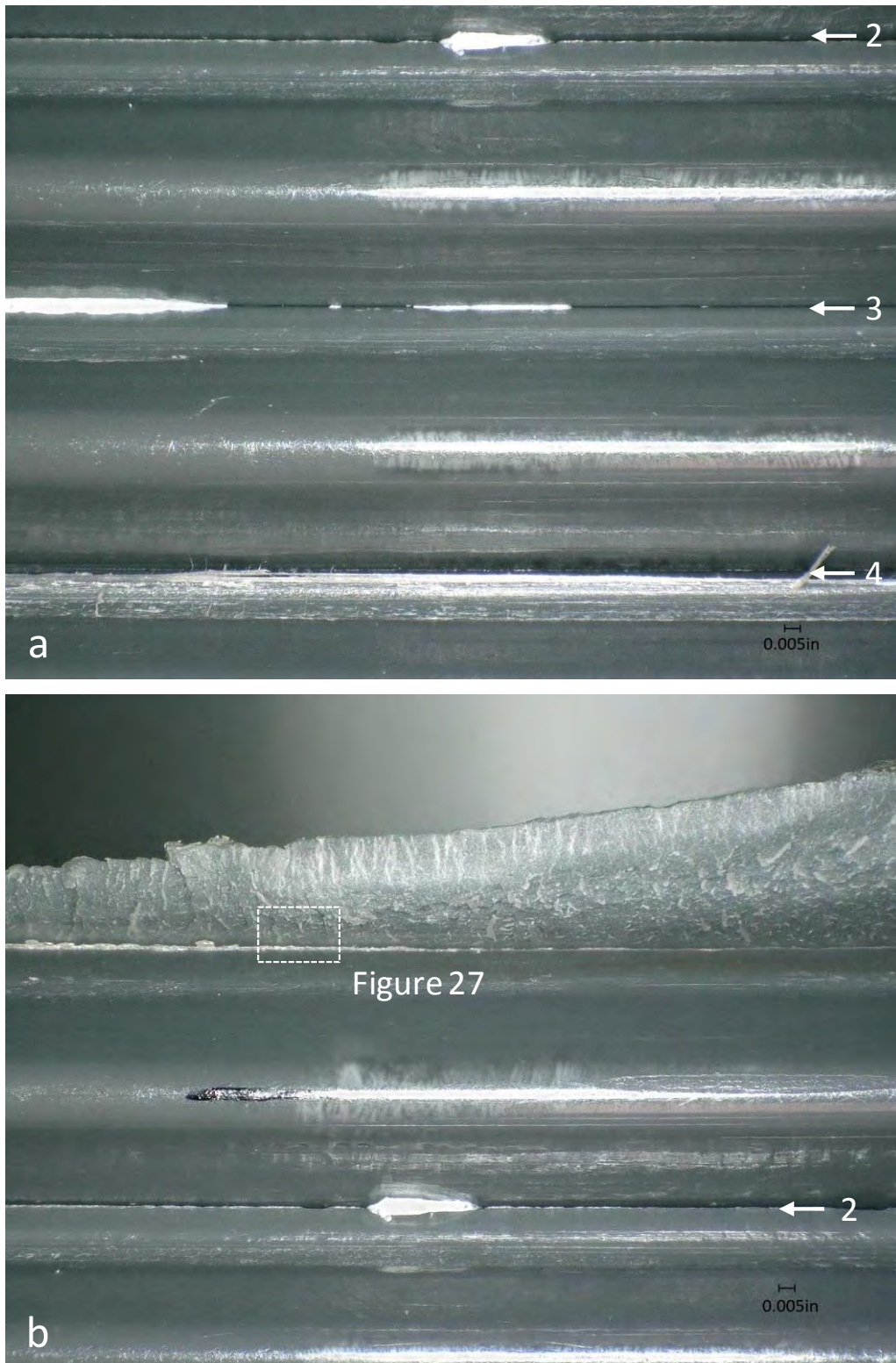


Figure 26 Higher magnification digital microscope macrographs of the aft-facing threads on the lower close nipple piece threaded to the pump outlet shown in Figure 25.

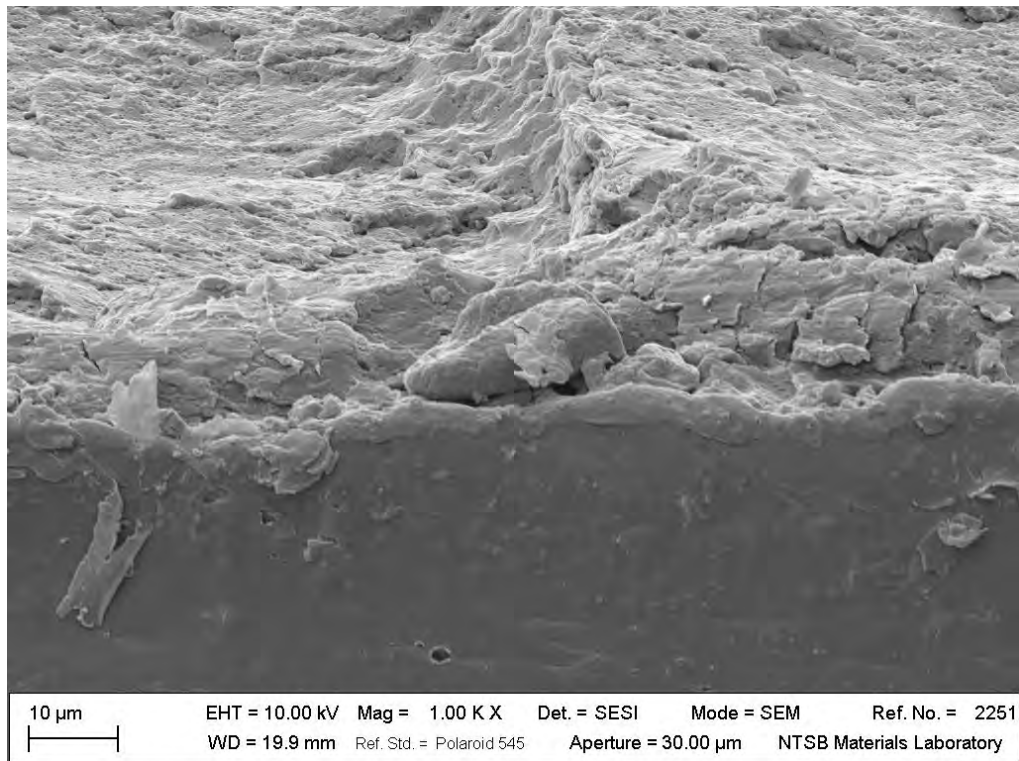


Figure 27 SEM fractograph of the slow crack growth initiation region looking from the thread root side (See Figure 26b for location).

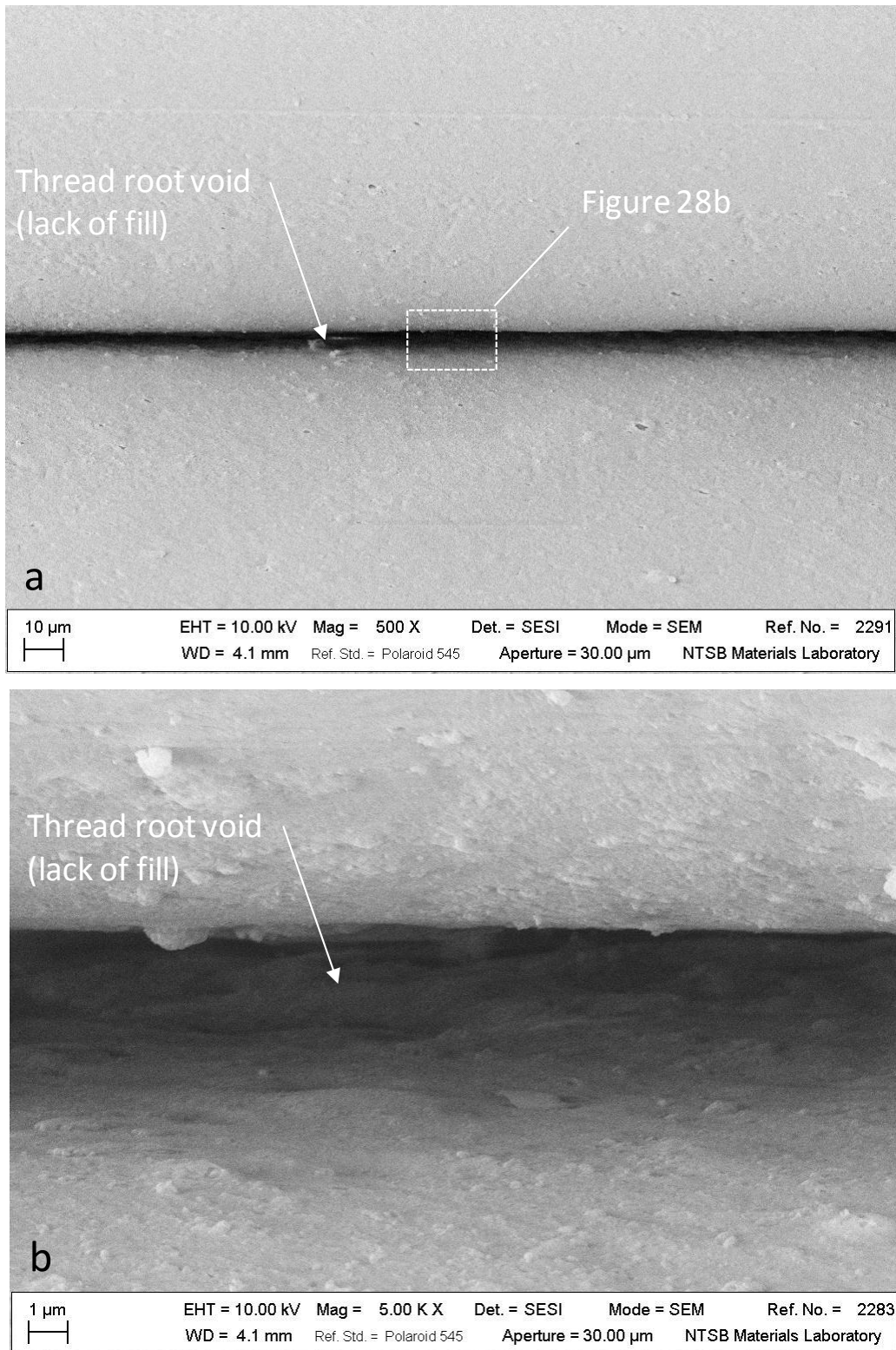


Figure 28 SEM micrographs of thread root 2 (see figures 25 and 26).

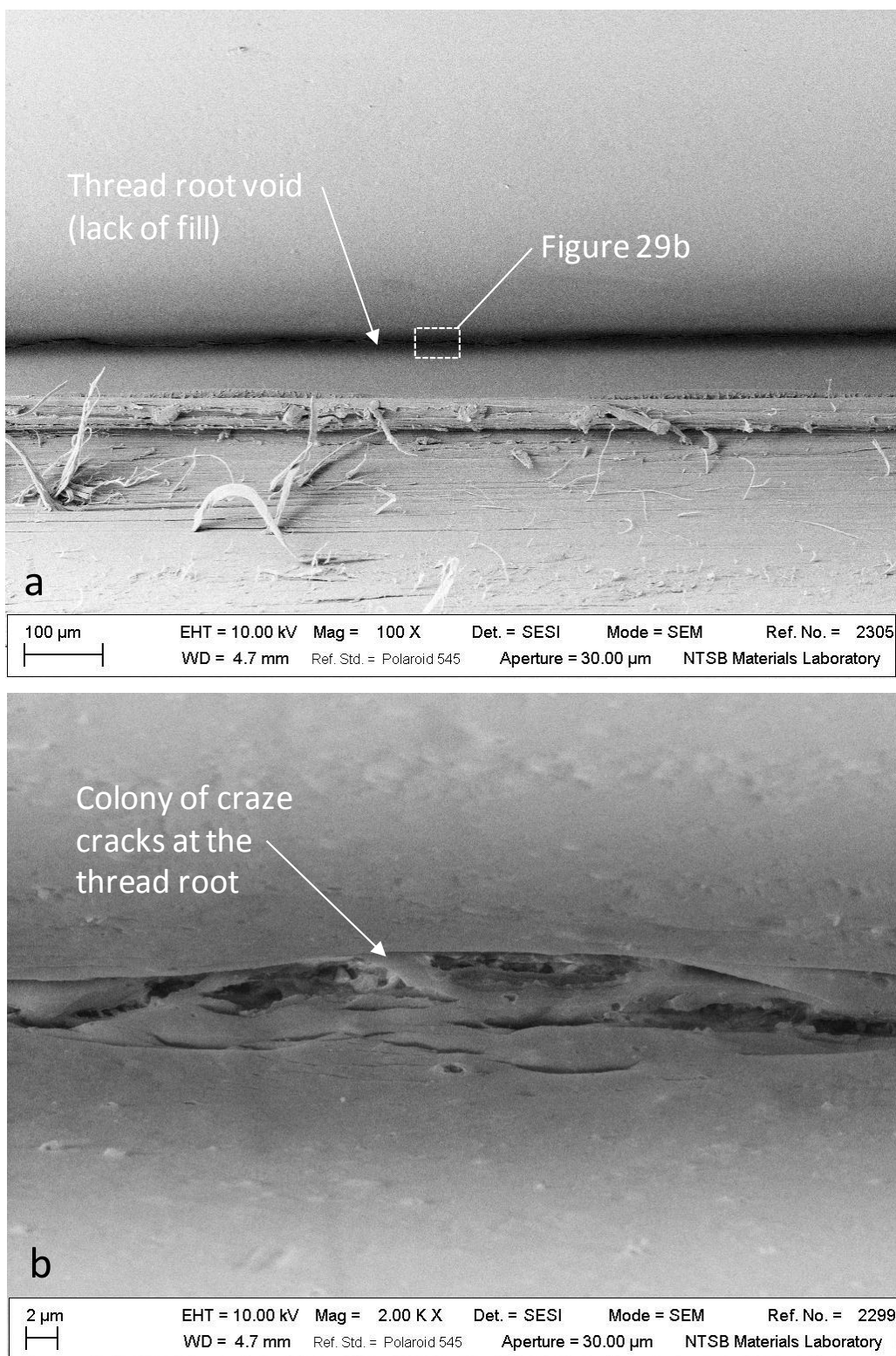


Figure 29 SEM micrographs of thread root 4 (see figures 25 and 26).

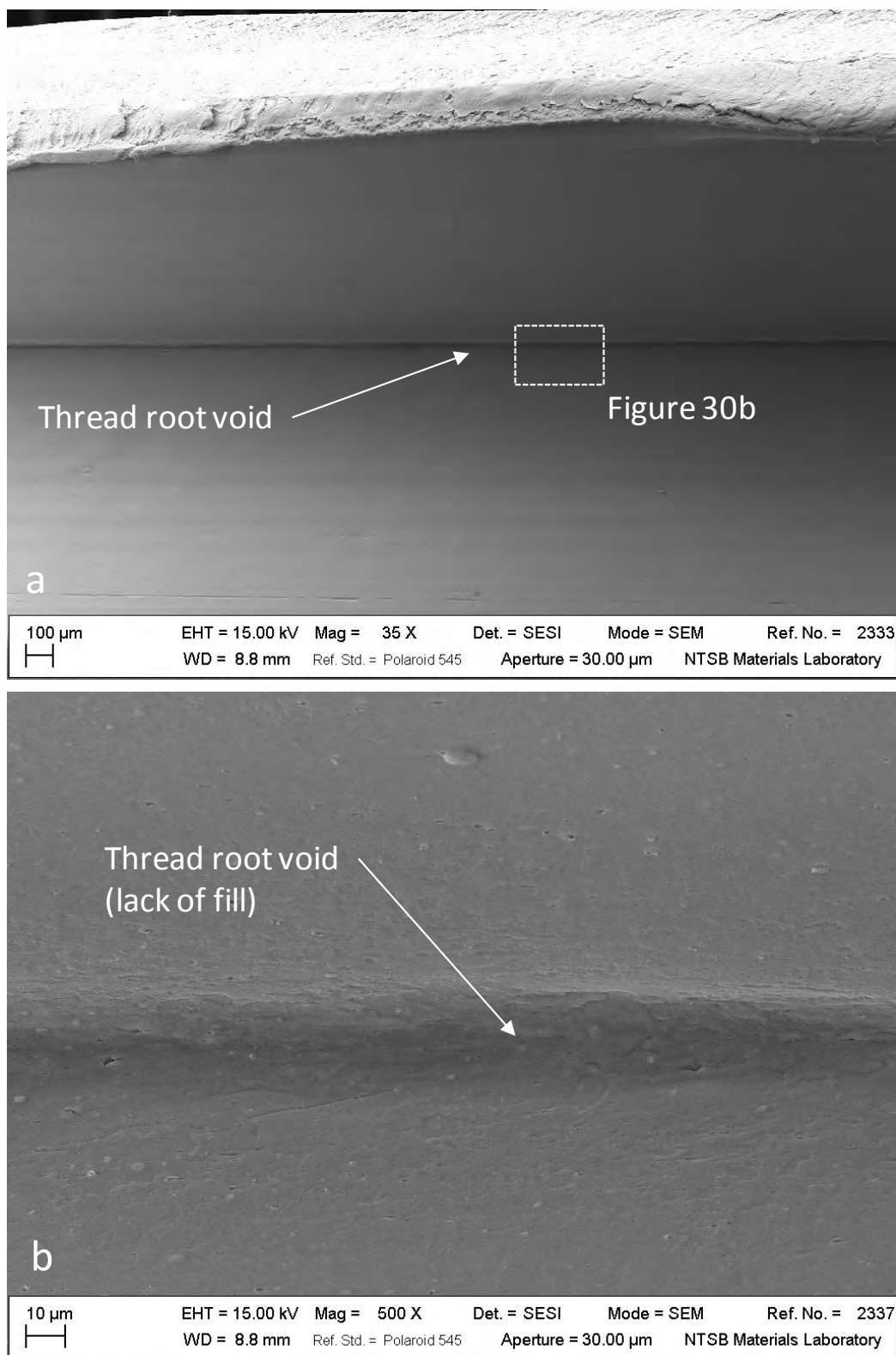


Figure 30 SEM micrographs of the thread root just below the fracture surface on the forward side of the lower close nipple piece.

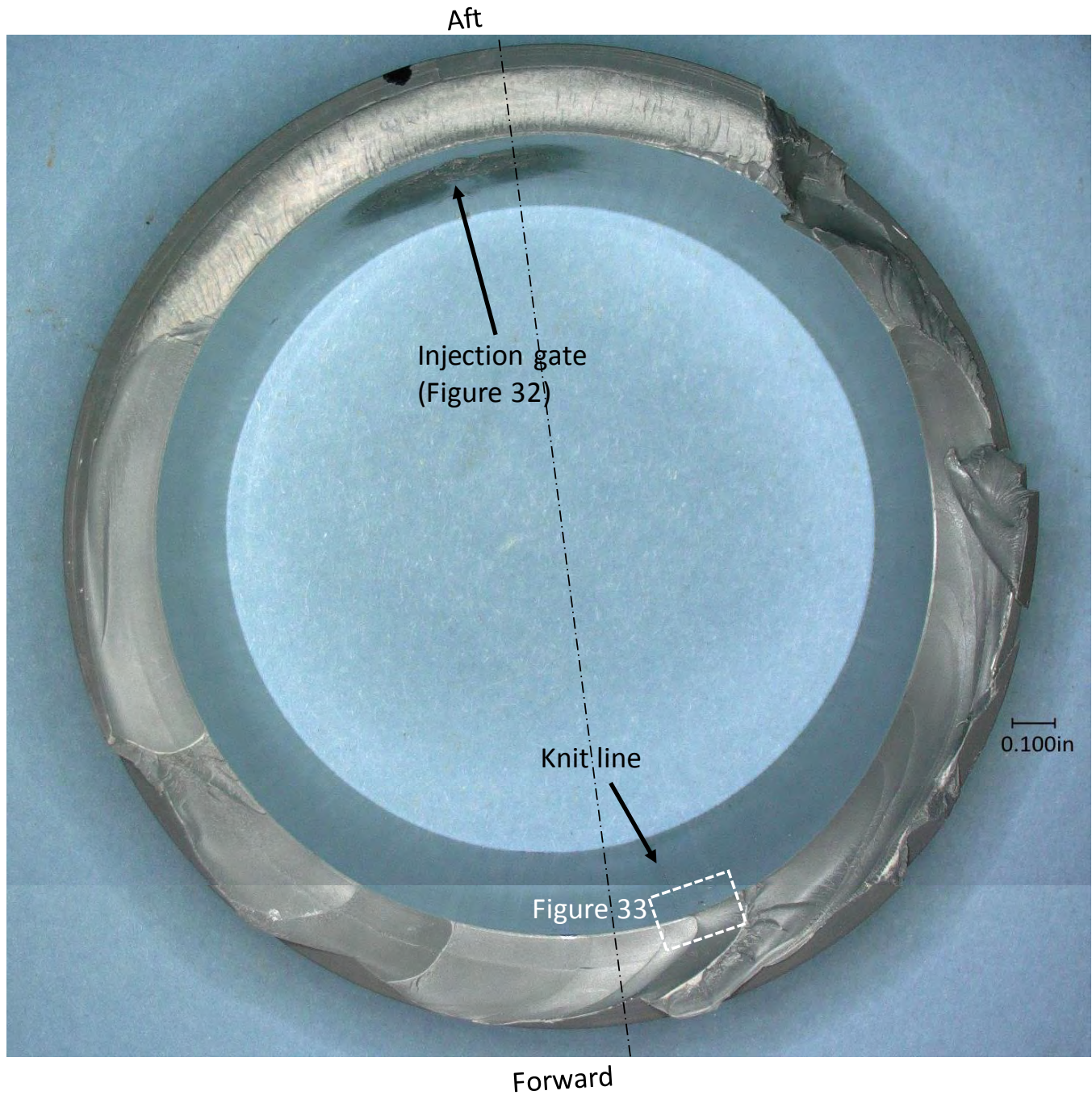


Figure 31 Macrograph of the close nipple piece removed from the 90° elbow showing the location of the injection gate and the knit line.

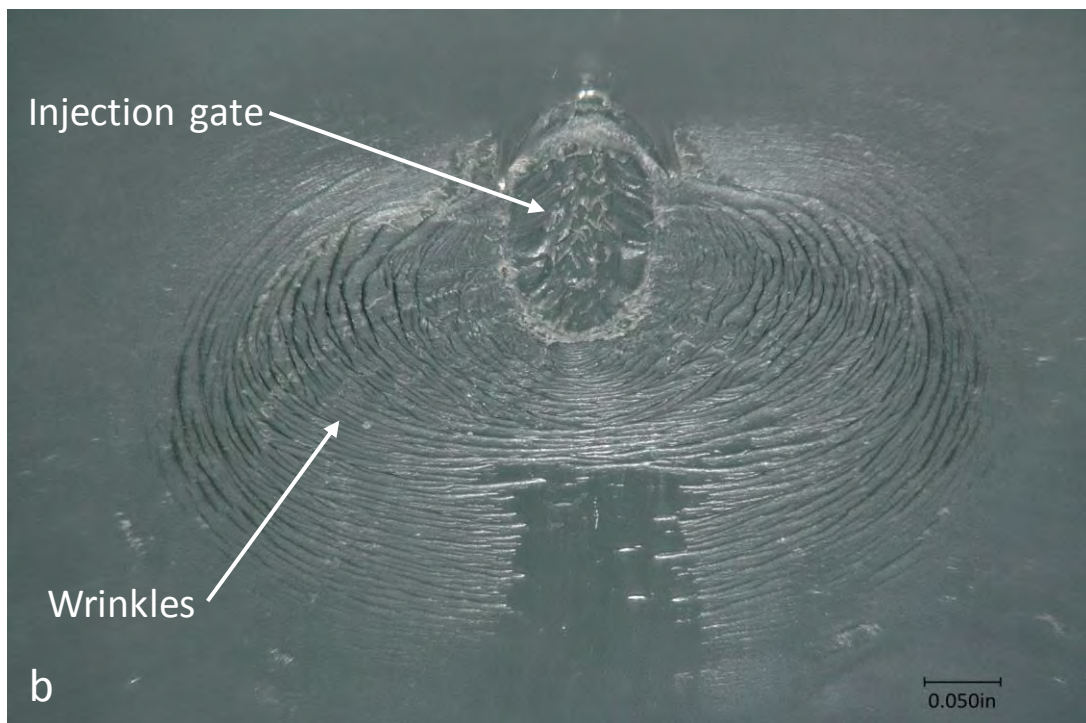
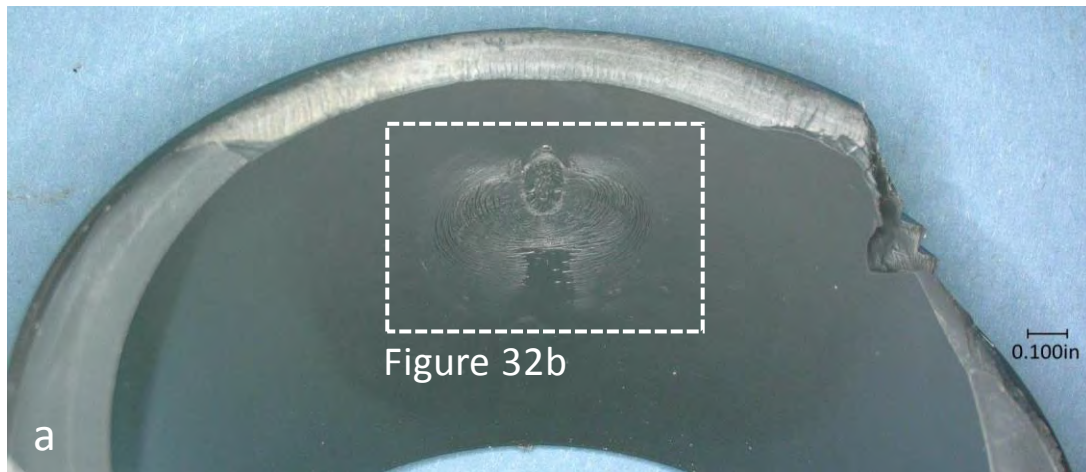


Figure 32 Digital macrographs of the inner bore of the close nipple piece removed from the 90° elbow.

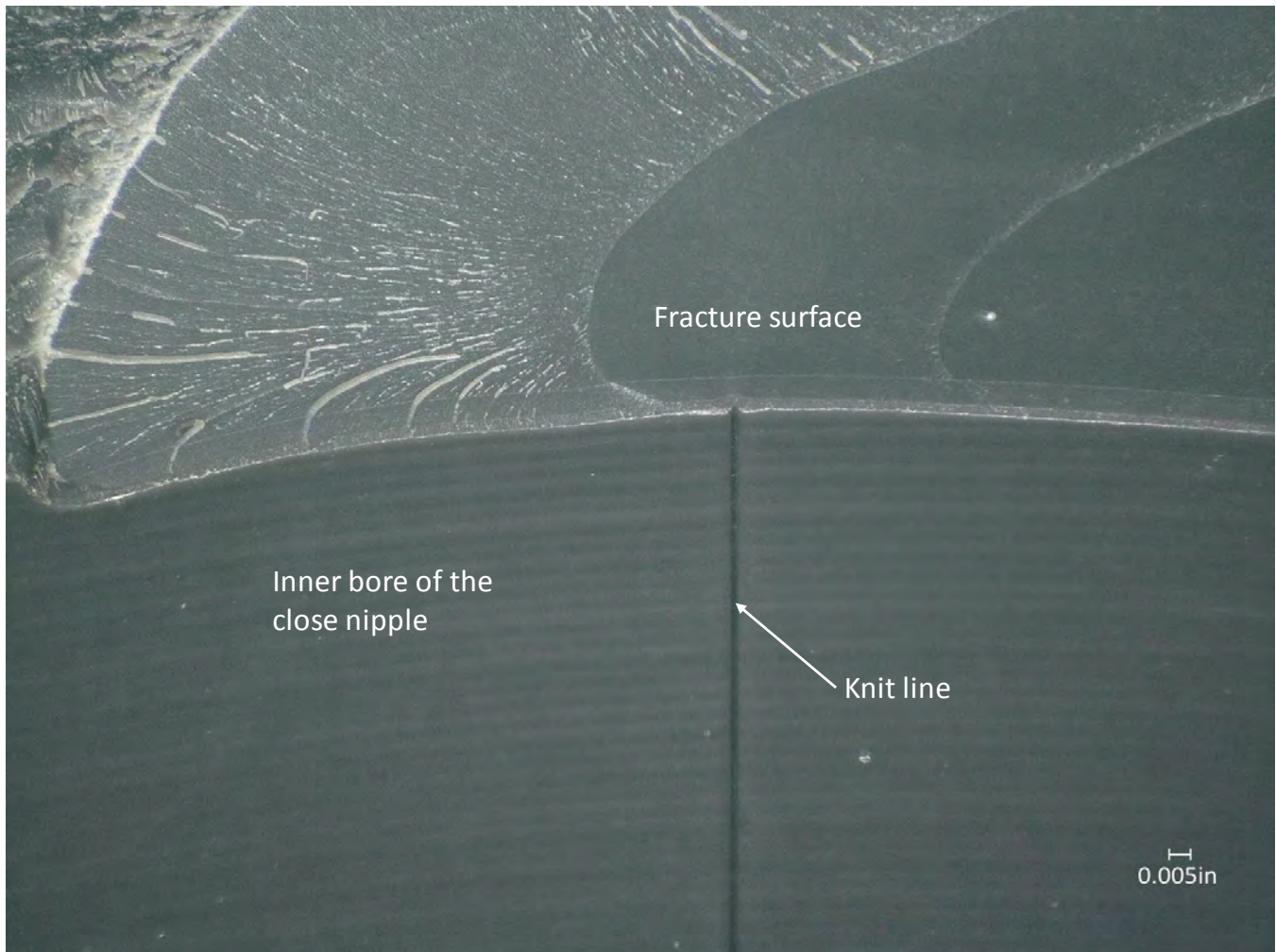
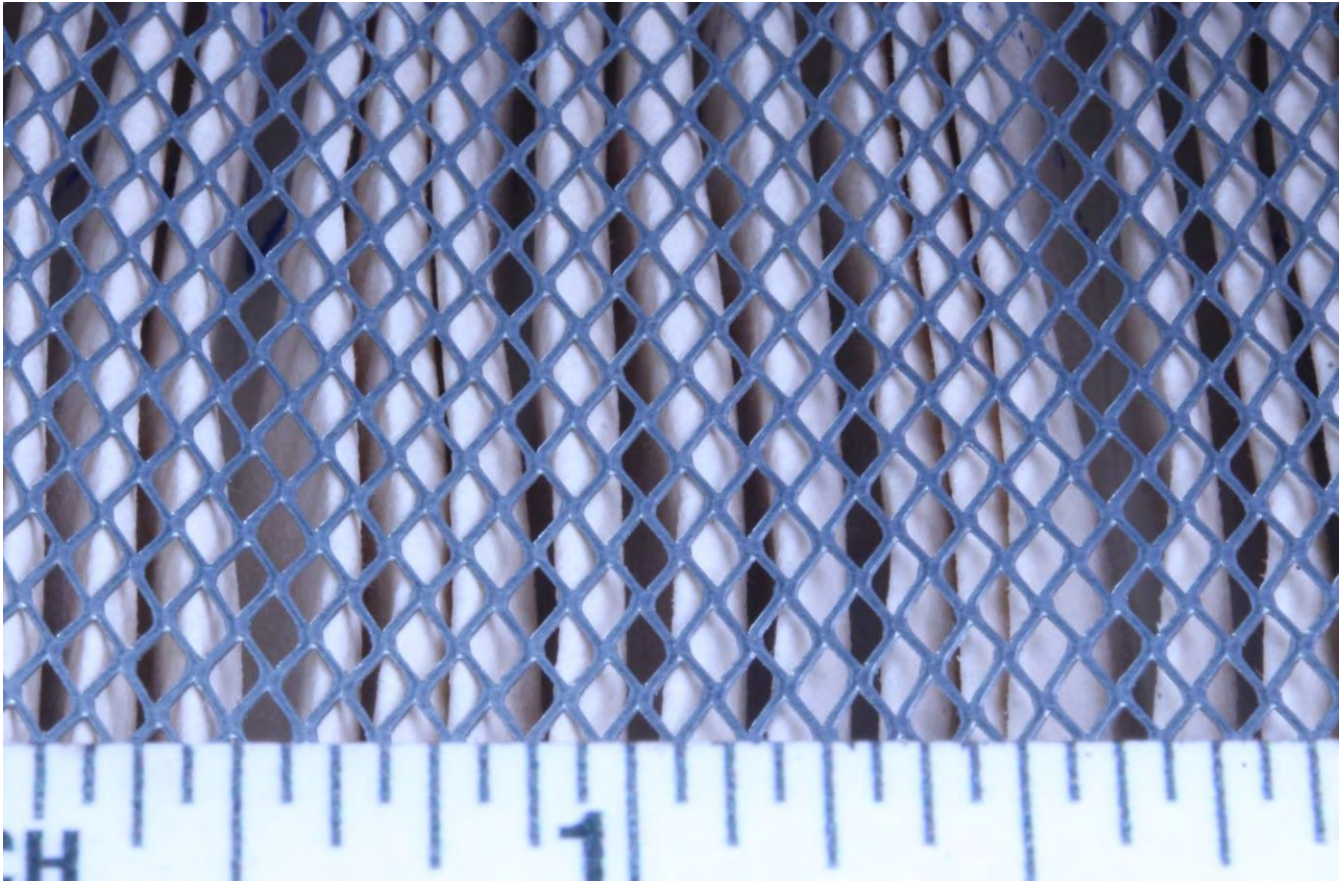


Figure 33 Higher magnification digital macrograph of the inner bore of the close nipple piece removed from the 90° elbow (see Figure 31 for location).



Inside surface of the filter

Figure 34 Image of the intake side of the air intake filter.