

NATIONAL TRANSPORTATION SAFETY BOARD

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



January 28, 2019

MATERIALS LABORATORY FACTUAL REPORT

Report No. 18-093

1. ACCIDENT INFORMATION

Place : Sweetwater, Texas
Date : August 18, 2017
Vehicle : Piper PA-18-150, N82912
NTSB No. : CEN17LA324
Investigator : Andrew Todd Fox, AS-CEN

2. COMPONENTS EXAMINED

Right Hydrasorb shock unit
Right main landing gear brace
Left Hydrasorb shock unit
Left main landing gear brace

3. DETAILS OF THE EXAMINATION

On August 18, 2017, about 1145 central daylight time, a Piper PA-18-150 airplane was substantially damaged while landing at Avenger Field Airport, Sweetwater, TX. The commercial pilot and his passenger were not injured. The airplane was registered to and operated by the United States Department of Agriculture (USDA) as a public aircraft. The pilot reported that the right main landing gear collapsed during landing. The airplane then swerved left, departed the left side of the runway, and encountered soft terrain where the right main landing gear collapsed. The airplane sustained substantial damage to the right wing, main wing spars, and right elevator. Components from the airplane landing gear were sent to the NTSB Materials Laboratory for further examination.

Figure 1 shows the landing gear components from the accident airplane, as received. This included components from two shock units, with the left and the right main landing gear (MLG) braces.

The left side shock unit and brace are shown in Figure 2. The shock unit was received intact, wrapped with blue masking tape for identification purposes. The unit included external shock cord rings, wrapped around the fitting tee flanges. The adjacent brace is shown in Figure 2 in the position it would attach to the shock unit. Approximately 2.75 inches from the fitting side, the brace tube on the left side had fractured (see Figure 3).

One of the mating fracture surfaces of the is shown in Figures 4 and 5. The fracture surface exhibited a generally dull luster, with a rough surface texture. Adjacent to the fracture surface, the tube had exhibited local thinning, or necking (see Figure 5). The fracture surface exhibited either a cup-shaped morphology, or a flat orientation, angled at approximately 45° relative to the tube direction. These features were all consistent with fracture from tensile overstress. No indications or features consistent with pre-existing cracks or damage were observed on the tube fracture surface.

Figure 6 shows the right side shock unit and brace. The shock unit on this side did not include the external shock cord rings, as had the left side unit. The shock unit had fractured at the internal piston shaft. The landing gear brace had buckled and partially fractured approximately 5.75 inches from the fitting hole (see Figure 7). The partial fracture surface exhibited a generally rough texture, with a dull luster, consistent with tensile overstress fracture. The opposite side of the tube 180° from the partial fracture surface had buckled inward toward the fracture side. These features were consistent with failure from bending overstress. However, the amount of stress was not high enough to completely break through the tube.

The fractured shock absorber unit is shown in Figure 8. As mentioned previously, the shock unit had fractured at the piston shaft that actuates inside the unit. The marking sticker on the unit barrel had been damaged, such that some of the lettering was obscured. What could be discerned stated, "HYDRASORB SHOCK...T", "P/N...58-1 FAA/PMA", "PA-...19, 20, 22, 25 SEE LIST". The unit barrel sticker also stated the part was made by Univair Aircraft Corporation, Aurora, CO.

The mating fracture surfaces of the piston shaft are shown in Figures 9a and 9b from the outboard and inboard faces, respectively. The outboard side of the fractured shaft extended outside the unit housing, whereas the inboard side of the fractured shaft was located inside the bottom fitting bore (Figure 9b). Figure 10 shows the outboard fracture from the side. This figure was annotated to show various dimensions of the shaft protrusion from the unit face to the fracture surface. As shown in Figure 10, the shaft had bent downward adjacent to the fracture surface.

Figure 11 shows a closer view of the fracture surface. One side of the fracture exhibited a generally flat surface on one half (left side), which transitioned to a 45° lip (right side). The fracture surface exhibited river patterns and other features consistent with the shaft having fractured from left to right in Figure 11. For reference, this fracture direction is oriented top to bottom in Figure 10 (toward the shaft bending direction). The shaft fracture surface was examined using a scanning electron microscope (SEM). The fracture surface exhibited dimple rupture in a slanted orientation. These features were consistent with fracture in bending overstress of the shock unit piston shaft.

The fractured piston shaft was sectioned near the fracture surface, mounted and polished. The chemical composition of the shaft was inspected using energy dispersive x-ray spectroscopy (EDS) and x-ray fluorescence (XRF). The composition was consistent

with a martensitic precipitation-hardened stainless steel, such as 17-4 PH.¹ Figure 13 and Figure 14 show a typical area of the microstructure after etching. The microstructure exhibited tempered martensite (darker, browner areas) with ferrite stringers (blocky and lighter colored) distributed throughout. These constituents were typical of those in martensitic precipitation-hardened stainless steel.

The shaft hardness was inspected per ASTM E384 respectively.² The hardness averaged 38 HRC (369 HV₅₀₀). These data were consistent with those typically reported for this alloy in a solutioned and aged condition.

Erik M Mueller
Materials Research Engineer

¹ Martensitic precipitation-hardened (PH) stainless steels are a class of stainless steels hardened by the precipitation of a constituent from a supersaturated solid solution using heat treatments. The microstructure of this class of PH stainless steels is not designed to contain any retained austenite.

² ASTM E384 – *Standard Test Method for Knoop and Vickers Hardness of Materials*. ASTM International, West Conshohocken, PA



Figure 1 – The left and right main landing gear braces and the shock units, as received.



Figure 2 – The left side shock unit and main landing gear brace, as received.



Figure 3 – The fractured left brace tube fragments, as received.



Figure 4 – The inboard fracture surface of the left landing gear brace.

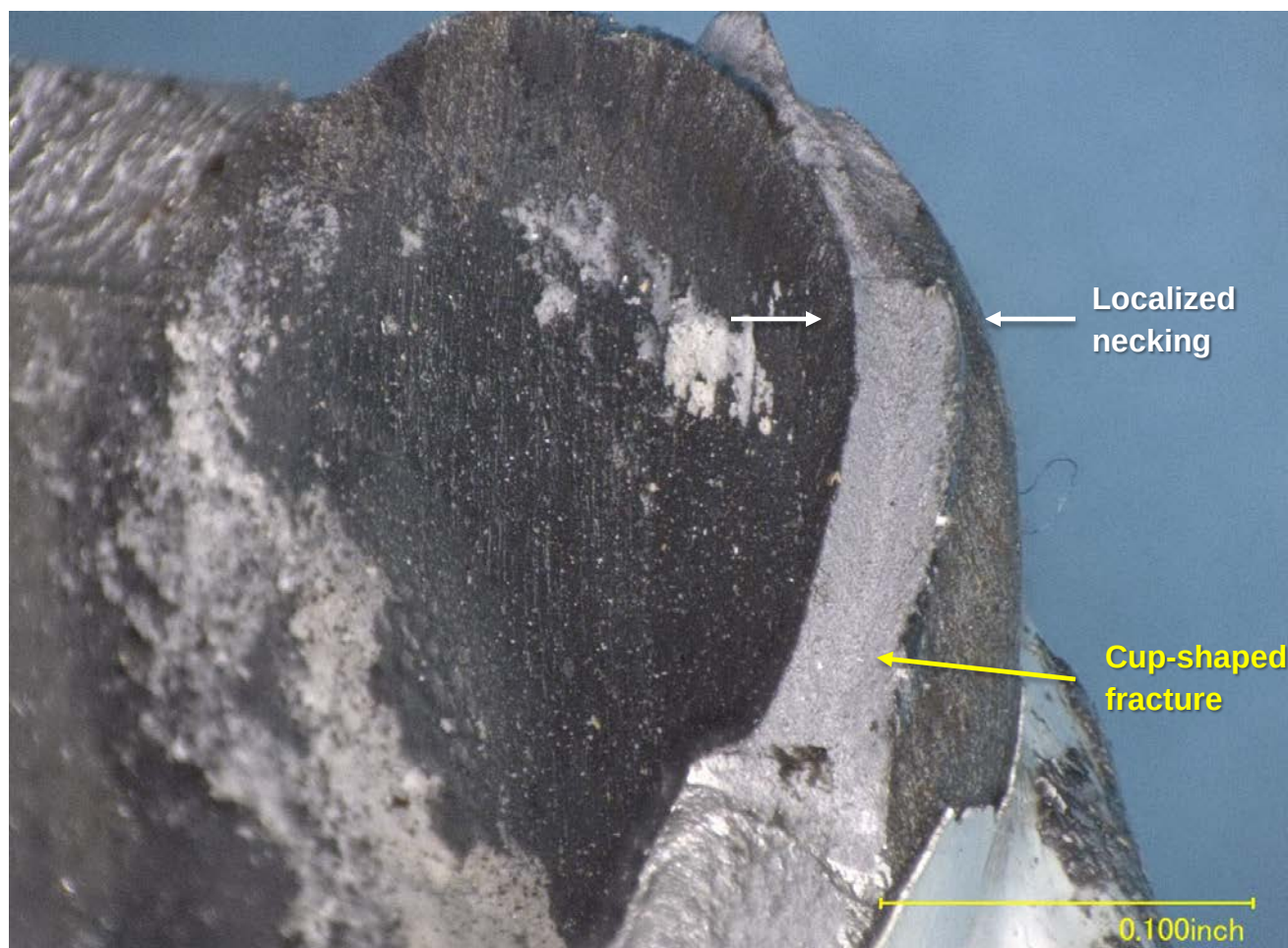


Figure 5 – Closer view of the left MLG brace fracture surface, with fracture features annotated.

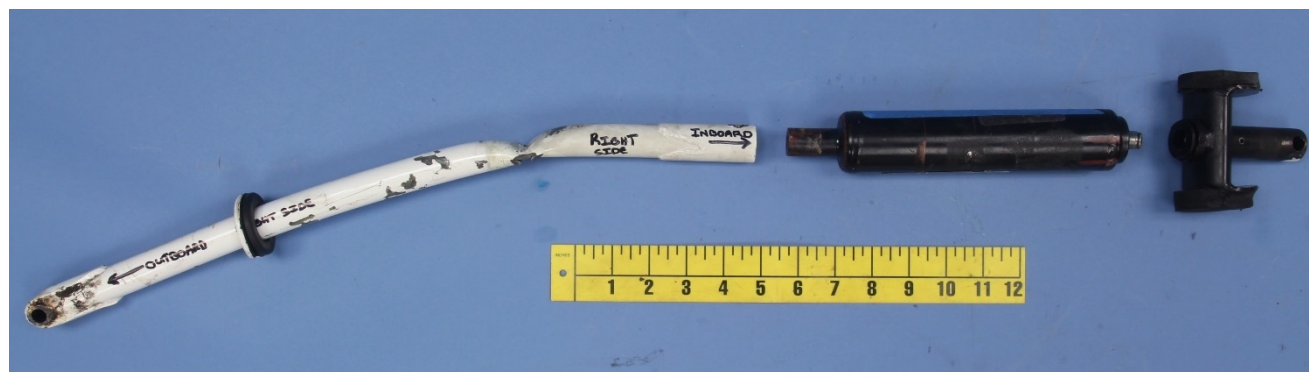


Figure 6 – The right main landing gear brace and shock unit pieces, as received.

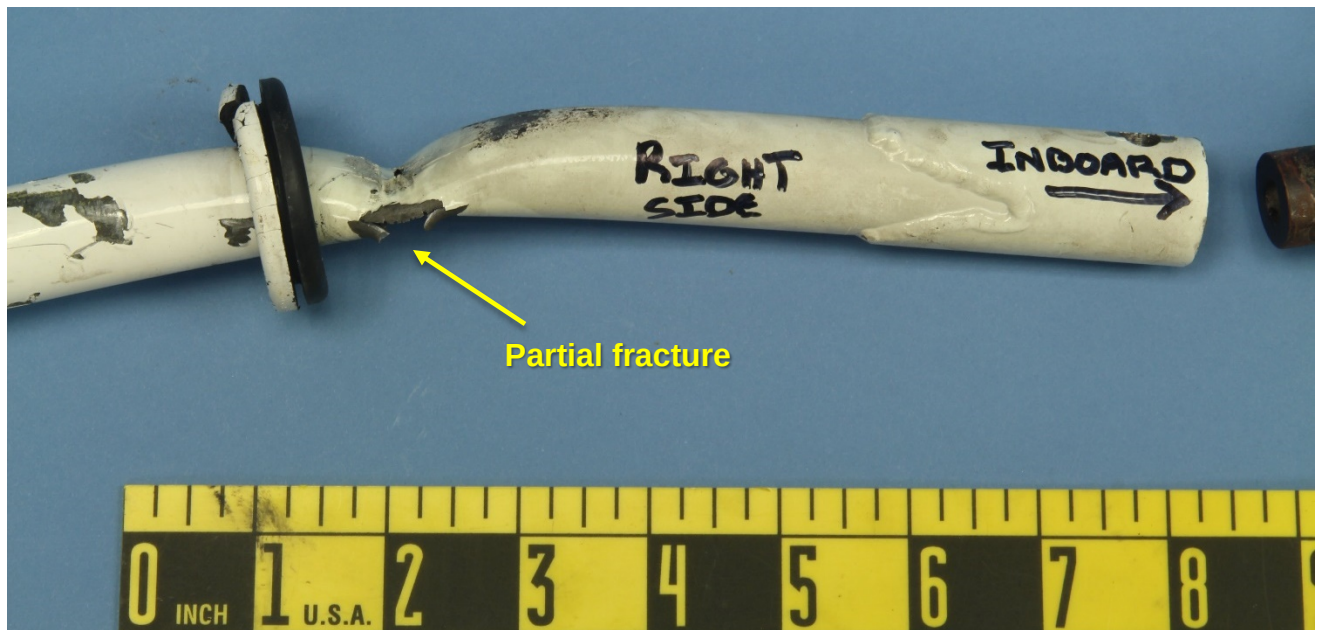


Figure 7 – The inboard side of the right brace tube, showing buckling and partial fracture on the downward side.

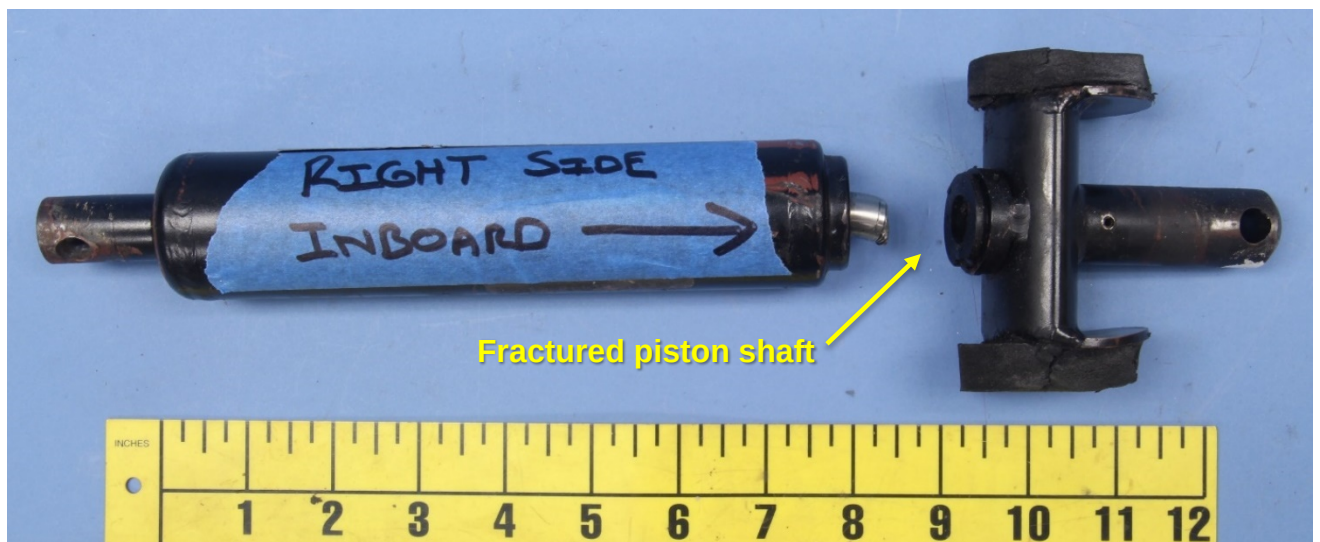


Figure 8 – The right side shock unit fragments, as received. The piston shaft of the shock unit had fractured (right side).

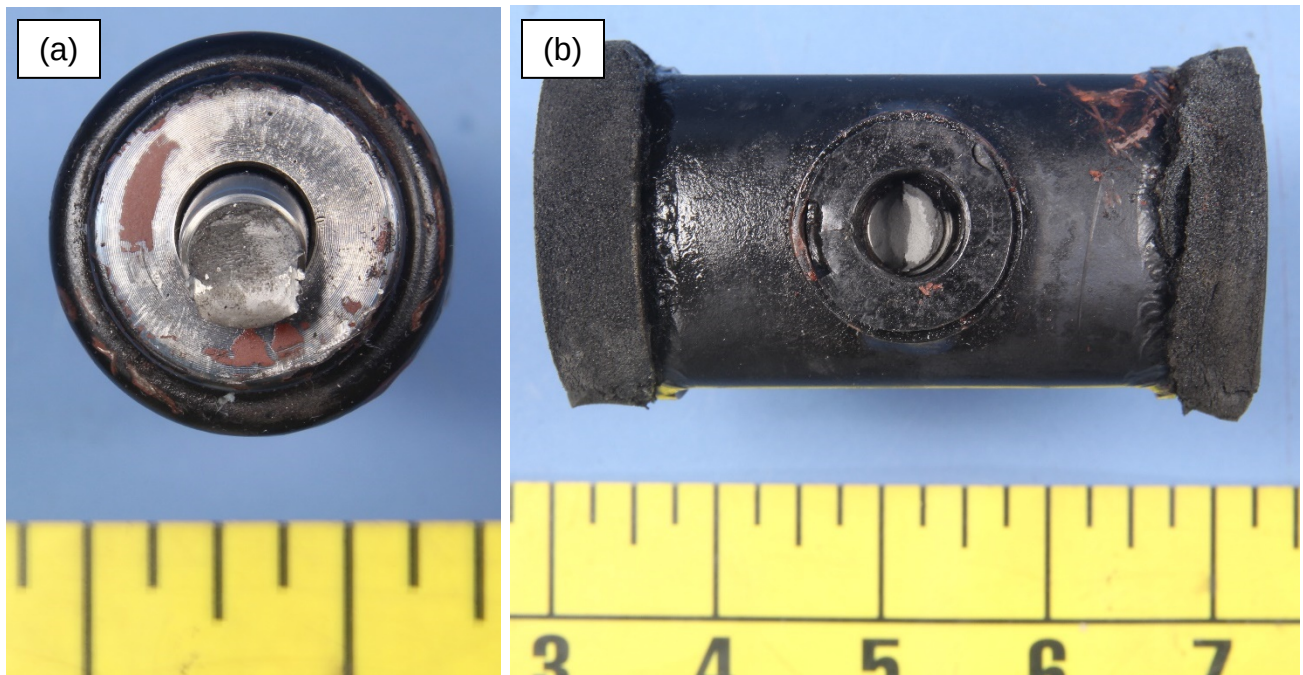


Figure 9 – The mating fracture surfaces of the fractured piston shaft from the (a) the outboard cylinder side and (b) the inboard side inside the housing of the top fitting.

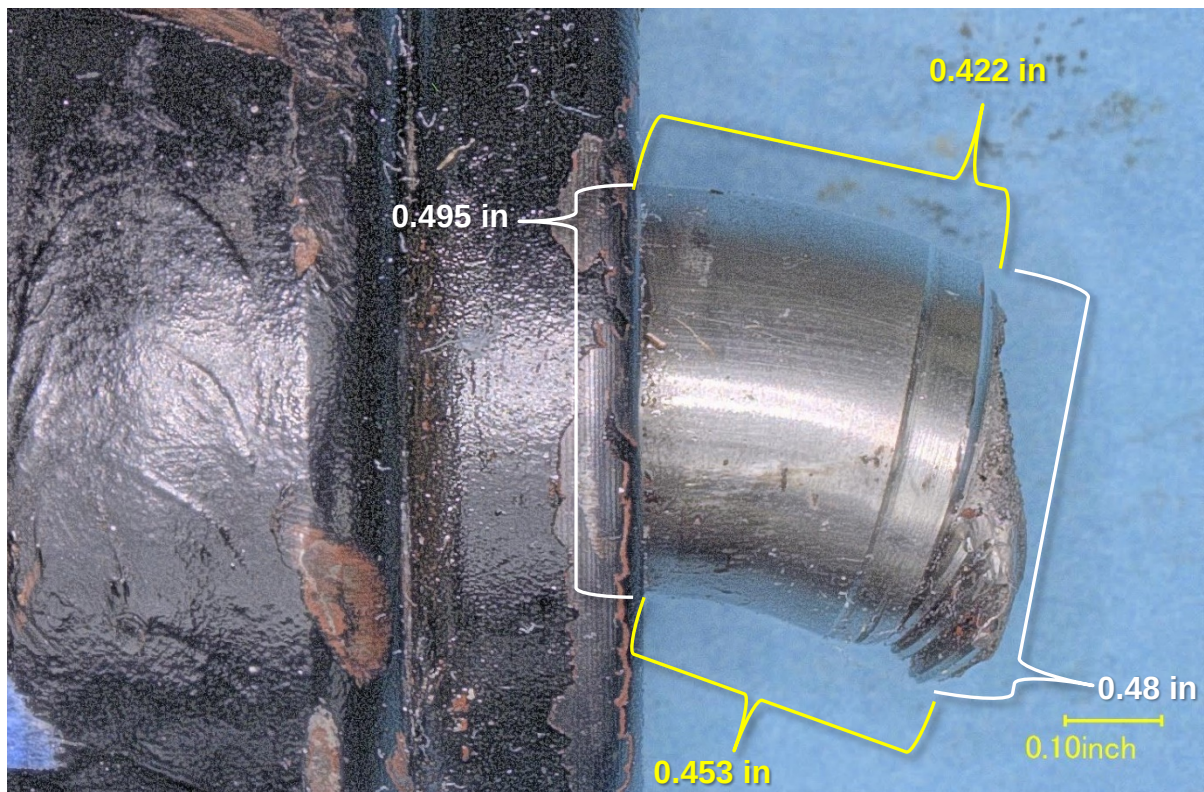


Figure 10 – The piston shaft fracture surface from Figure 8a, viewed from the side with selected measurements annotated.



Figure 11 – Closer view of the piston rod fracture surface, with arrows showing the fracture direction.

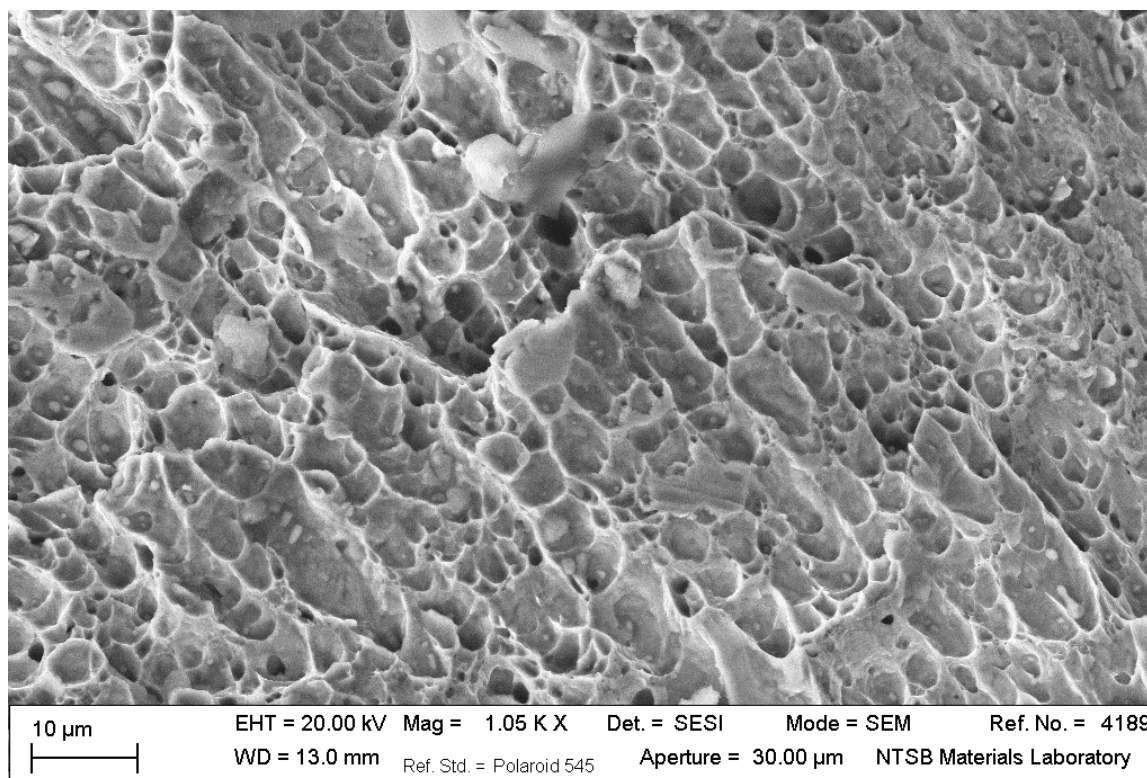


Figure 12 – Secondary electron (SE) micrograph of the shaft fracture surface, showing dimple rupture.

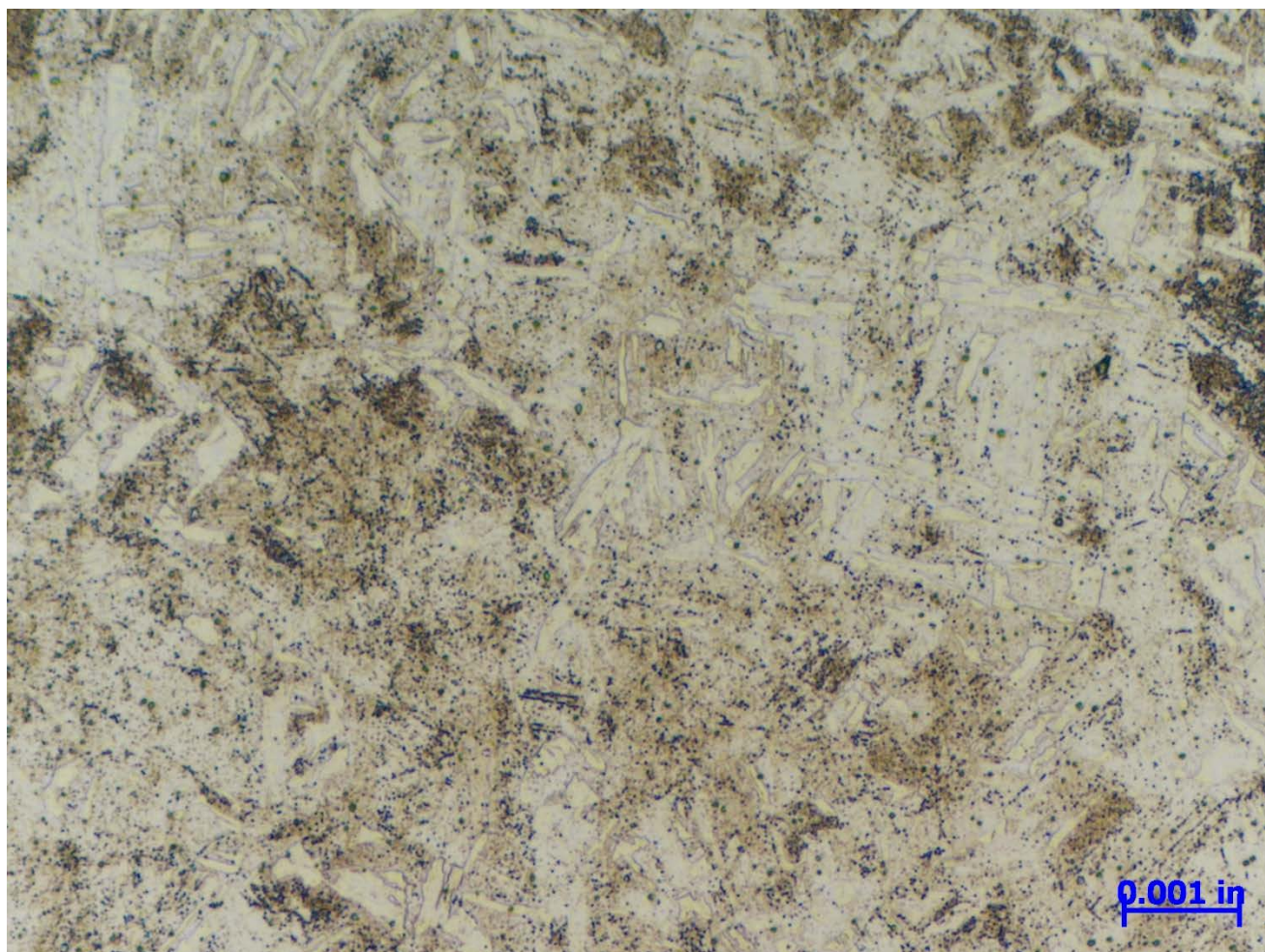


Figure 13 – Bright-field optical micrograph of a typical area of the piston microstructure (~500X, etched Ralph's Reagent).³

³ Ralph's Reagent is a solution of 50 mL each of water, ethanol, methanol, and hydrochloric acid (HCl), with 1 g cupric chloride (CuCl_2), 3.5 g ferric chloride (FeCl_3), and 2.5 mL of nitric acid (HNO_3).

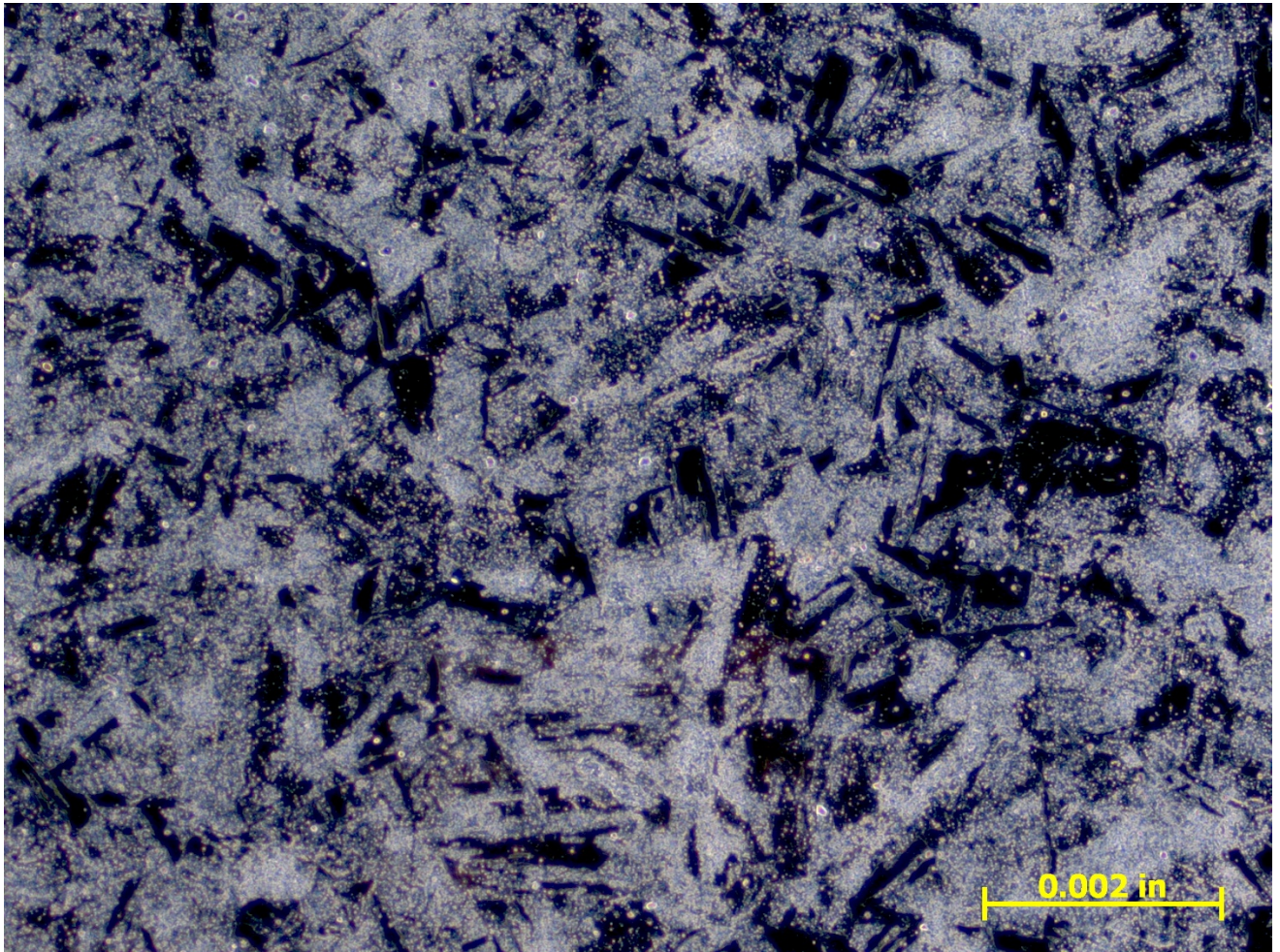


Figure 14 – Dark-field optical micrograph of a typical area of the piston microstructure (~500X, etched Ralph's Reagent).³