

NATIONAL TRANSPORTATION SAFETY BOARD

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



August 10, 2016

MATERIALS LABORATORY FACTUAL REPORT

Report No. 16-054

1. ACCIDENT

Place : Prichard, Idaho
Date : July 21, 2015
Vehicle : Cessna 182Q, N759LV
NTSB No. : WPR15LA220
Investigator : Joshua Cawthra, AS-WPR

2. COMPONENTS EXAMINED

Pieces of a piston pin
Fragments of a piston
Connecting rod

3. DETAILS OF THE EXAMINATION

On July 21, 2015, about 1446 mountain daylight time, a Cessna 182Q was substantially damaged during a forced landing near Prichard, Idaho. The commercial pilot and his passenger were not injured. The pilot reported that during cruise flight, he heard a loud pop, followed by oil covering the windscreen. Despite the pilot's attempts, the engine would not restart and he initiated a forced landing to an open field. Examination of the airplane by the pilot revealed that the right wing was substantially damaged. Several components from the TCM O-470-U engine were sent to the NTSB Materials Laboratory for further examination.¹

Figure 1 shows the parts submitted to the NTSB Materials Laboratory, as received. Figure 2 illustrates the underside of the piston crown, which had fractured into smaller pieces near the piston pin position. Figure 3 shows the piston crown from the side, illustrating the fracture surface in relation to the piston pin position. The fracture surface exhibited a rough, tortuous appearance along with a dull luster. The fracture surface of the piston crown exhibited river lines and chevron marks consistent with fracture originating at the pin position. The fracture features of the piston crown underside were consistent with overstress failure. No indications of pre-existing cracking or progressive failure were observed on the piston fracture surfaces.

¹ The Continental Motors O-470-U is a carbureted six-cylinder, horizontally opposed, air-cooled aircraft engine with 230 hp (172 kW) at 2400 rpm and a dry weight of 412 lb (187 kg).

Figure 4 illustrates the two connecting rod bolts as received. The bolt in Figure 4a was received fractured in two halves, exhibiting a 45° slant fracture surface with localized necking adjacent to the fractures. The bolt fracture surface showed a dull luster and rough surface. All of these features were consistent with failure from tensile overstress.

The other bolt is illustrated in Figure 4b. Only one half of the bolt was submitted. This bolt had been bent over, with a relatively flat fracture surface along the bolt threads. This fracture surface also exhibited dull, gray, and rough features. These characteristics were consistent with failure from overstress in bending.

The connecting rod is exhibited in Figure 5. The markings on the connecting rod stated "632041F M ©" on one side and "6" on the other. The connecting rod was generally intact with no indication of cracking, fracture, twisting or gross deformation along the rod. The connecting rod cap is highlighted in Figure 6. The cap exhibited twisting and deformation consistent with batter from impacts with an adjacent object. However, there were no indications consistent with the connecting rod or cap having failed prior to the bolts fracturing.

Figure 7 illustrates the piston pin, after degreasing and cleaning. The pin exhibited some wear and impact marks along the barrel. Of note was that one of the tapered piston ends had separated and had become deformed into a spherical shape. Figure 8 through Figure 14 show the fracture surface of this side of the pin. Most of the fracture surface exhibited a shiny luster and general flat shape, consistent with post-fracture batter.

The middle of the pin fracture had a raised, flattened feature, shown in Figure 9. Around the periphery of the fracture surface, adjacent to the barrel of the pin, the fracture surface exhibited ridges consistent with ratchet marks (Figure 10). Ratchet marks are consistent with multiple smaller cracks that coalesce to form a larger crack. Figure 10 and Figure 11 show a less damaged area of the fracture surface, exhibiting crack arrest marks consistent with progressive failure.

Closer examination of the visible progressive features using a scanning electron microscope (SEM), as shown in Figure 12, revealed striations consistent with fatigue cracking (Figure 13). Examination of the fatigue crack initiation site did not reveal any material or mechanical defects, such as pits, voids, or inclusions (see Figure 14). All of the features of the pin fracture surface were consistent with fatigue cracking initiating around the outside of the pin, with the final fracture along the middle of the pin cross section (the raised, blunted portion).

Figure 15 shows the spherical deformed separated portion of the pin. The severe batter on this fragment obscured the features that would conclude fracture information. A circular impression was visible on the spherical fragment, as illustrated in Figure 16. The volume of the spherical pin remnant was consistent with a spherical impression on the underside of the piston crown, depicted by the position of the yellow arrow on Figure 2. This impression occurred after the severe deformation of the now spherical pin fragment.

The composition of the pin fracture surface was examined using energy dispersive x-ray spectroscopy (EDS). The composition was consistent with AA 2000 series aluminum alloy. Further inspection using x-ray fluorescence (XRF) found the pin material to be consistent with AA 2024 aluminum. The hardness was inspected per ASTM E18.² The hardness of the section averaged 81 HRBW. The electrical conductivity of the part was inspected per ASTM E1004.³ The conductivity averaged 39.0% IACS. These data were consistent with a T6X or T8X temper for this alloy.

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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 ASTM E1004 – *Standard Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method*. ASTM International, West Conshohocken, PA.

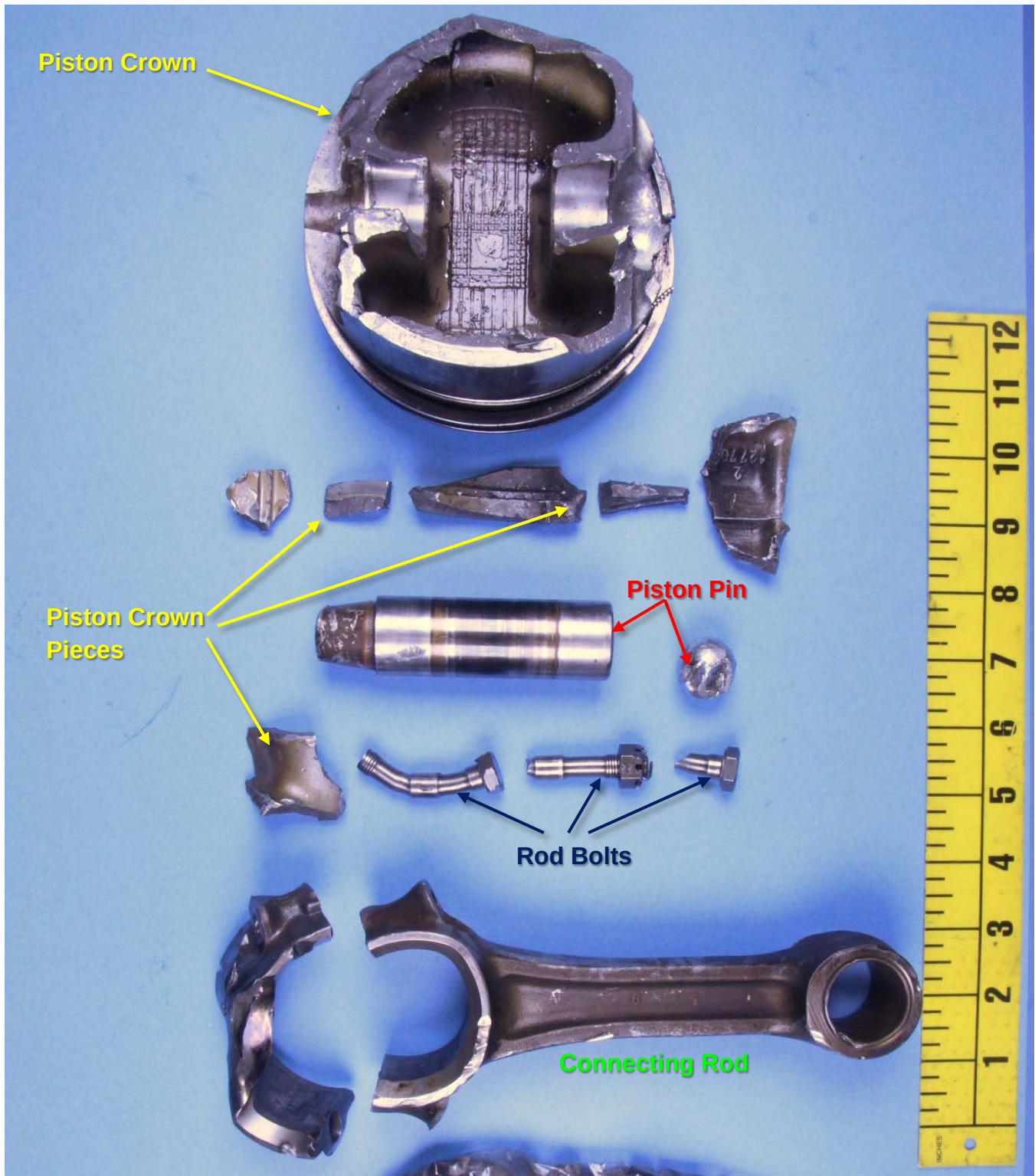


Figure 1 – The items from the accident engine, as received (a bag of small broken miscellaneous parts is not shown).

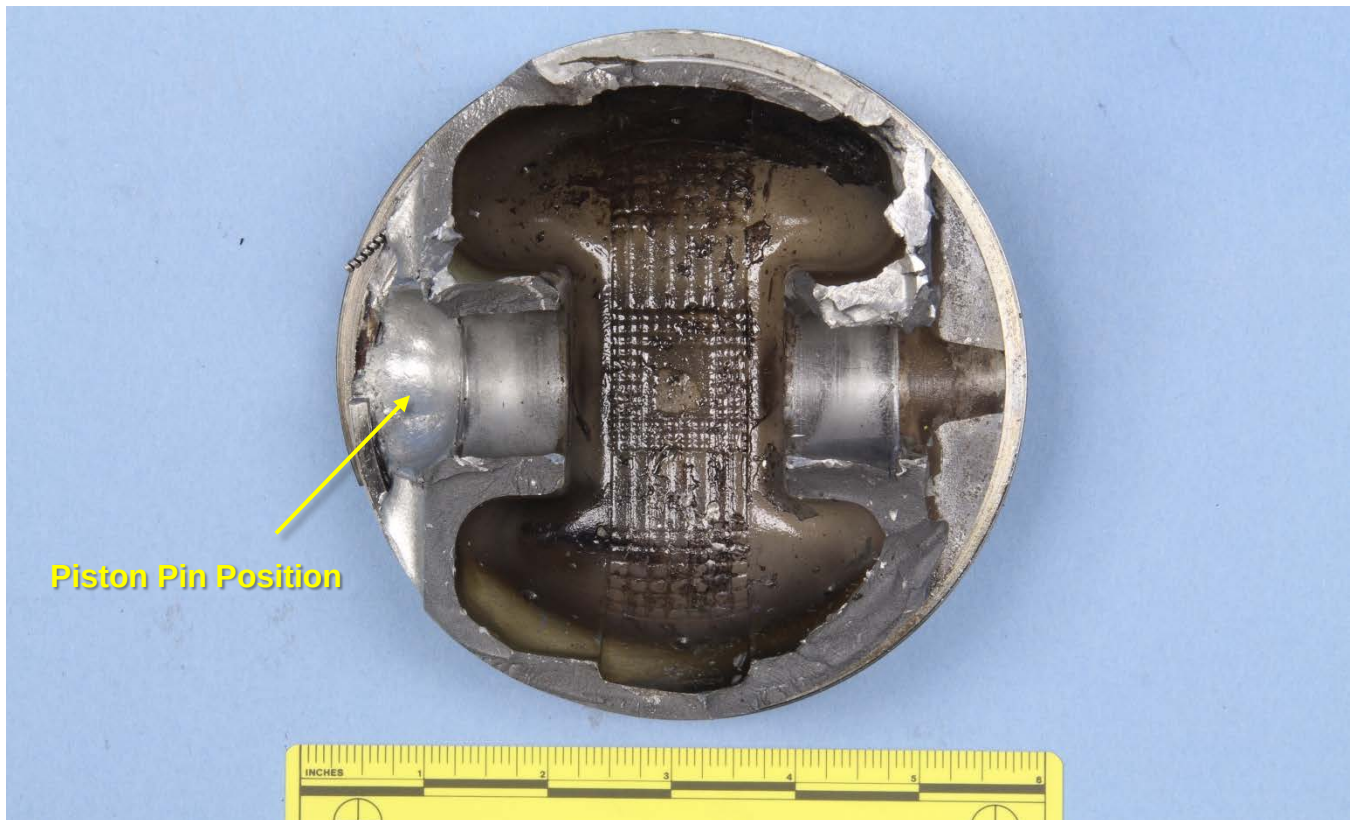


Figure 2 – The underside of the piston crown, as received, showing the fracture surface.



Figure 3 – The piston crown, as viewed from the side along the piston position, as received.

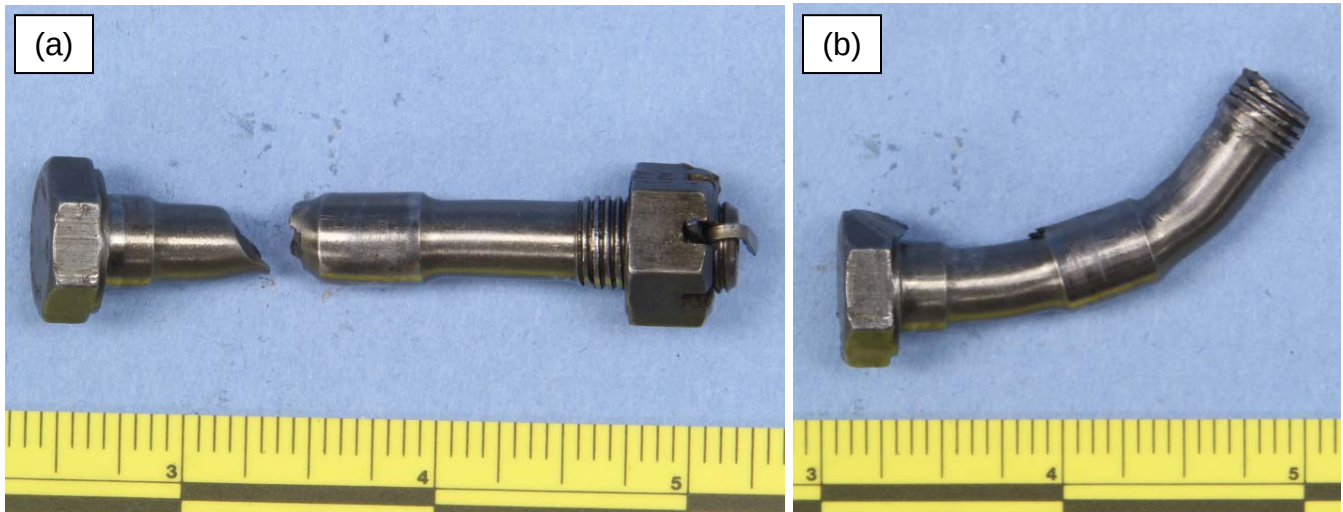


Figure 4 – The two connecting rod bolts, as received. The figures show (a) both halves one bolt and (b) the one half of the other bolt.



Figure 5 – The submitted connecting rod, as received.



Figure 6 – The connecting rod cap, showing batter and impact damage.



Figure 7 – The piston pin, as received. The left side of the pin exhibited batter on the plug, while the right side plug fragment had separated and been deformed into a spherical shape.

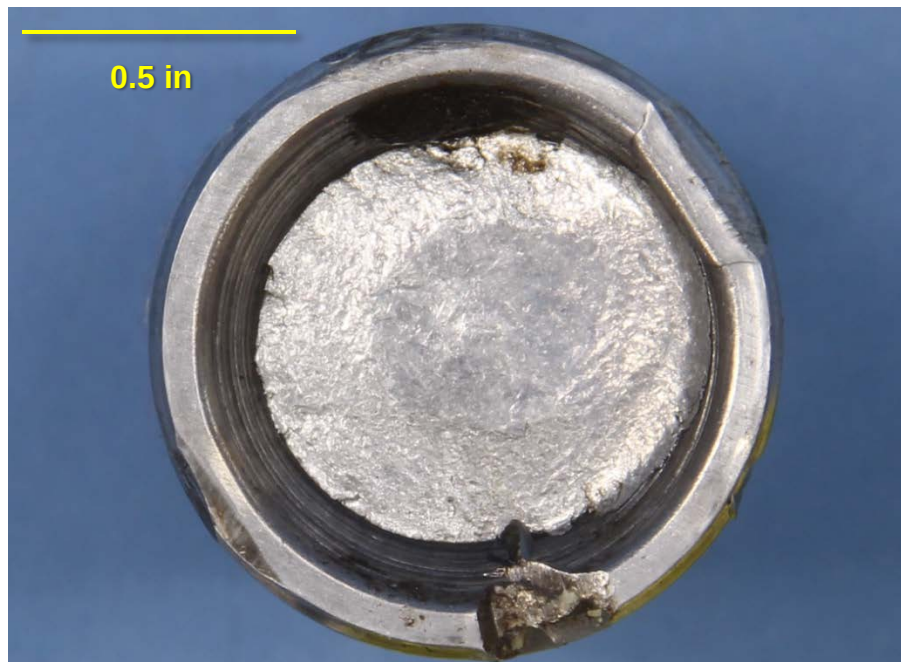


Figure 8 – The right side of the piston pin in Figure 7, showing the fracture surface at the separated plug.



Figure 9 – Closer view of the pin fracture surface from Figure 8.

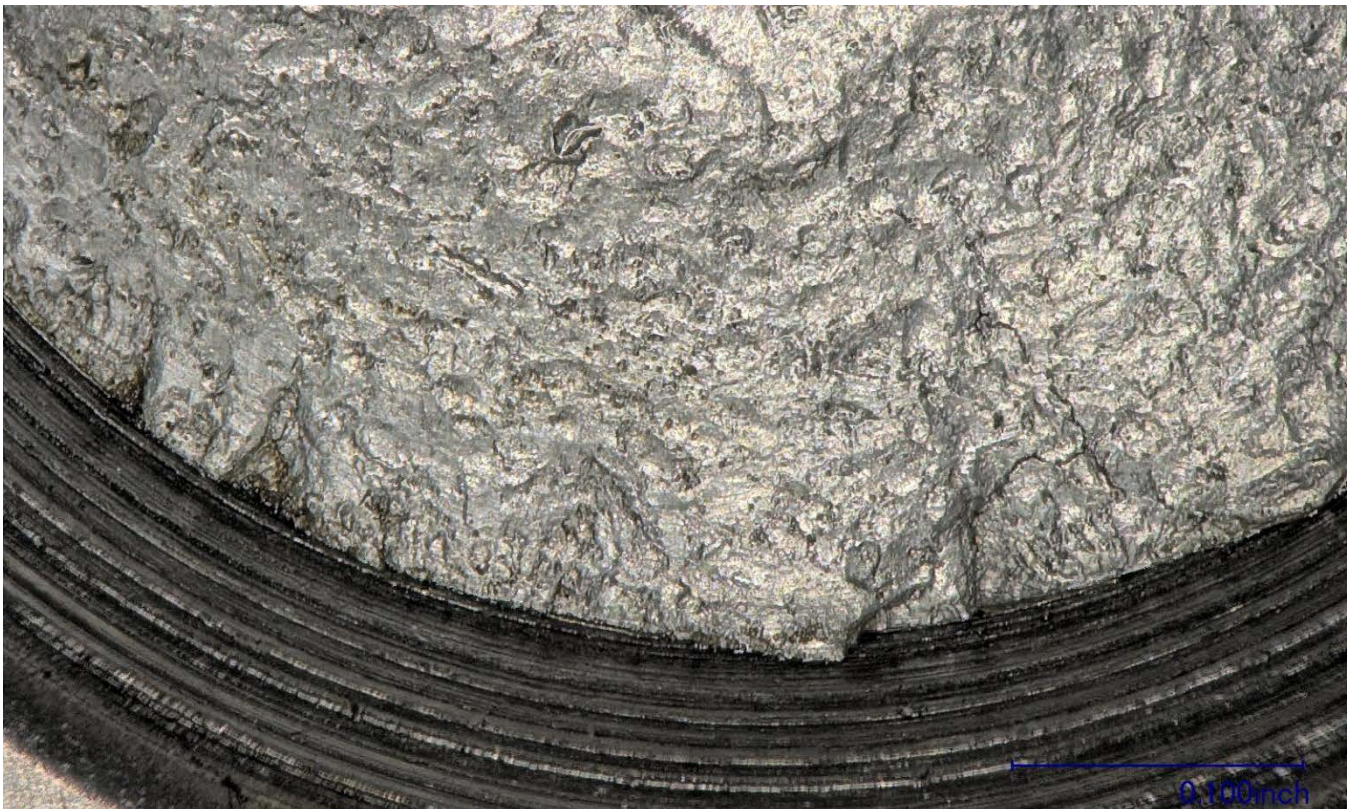


Figure 10 – The lower right side of the pin fracture from Figure 9, showing a small thumbnail crack.

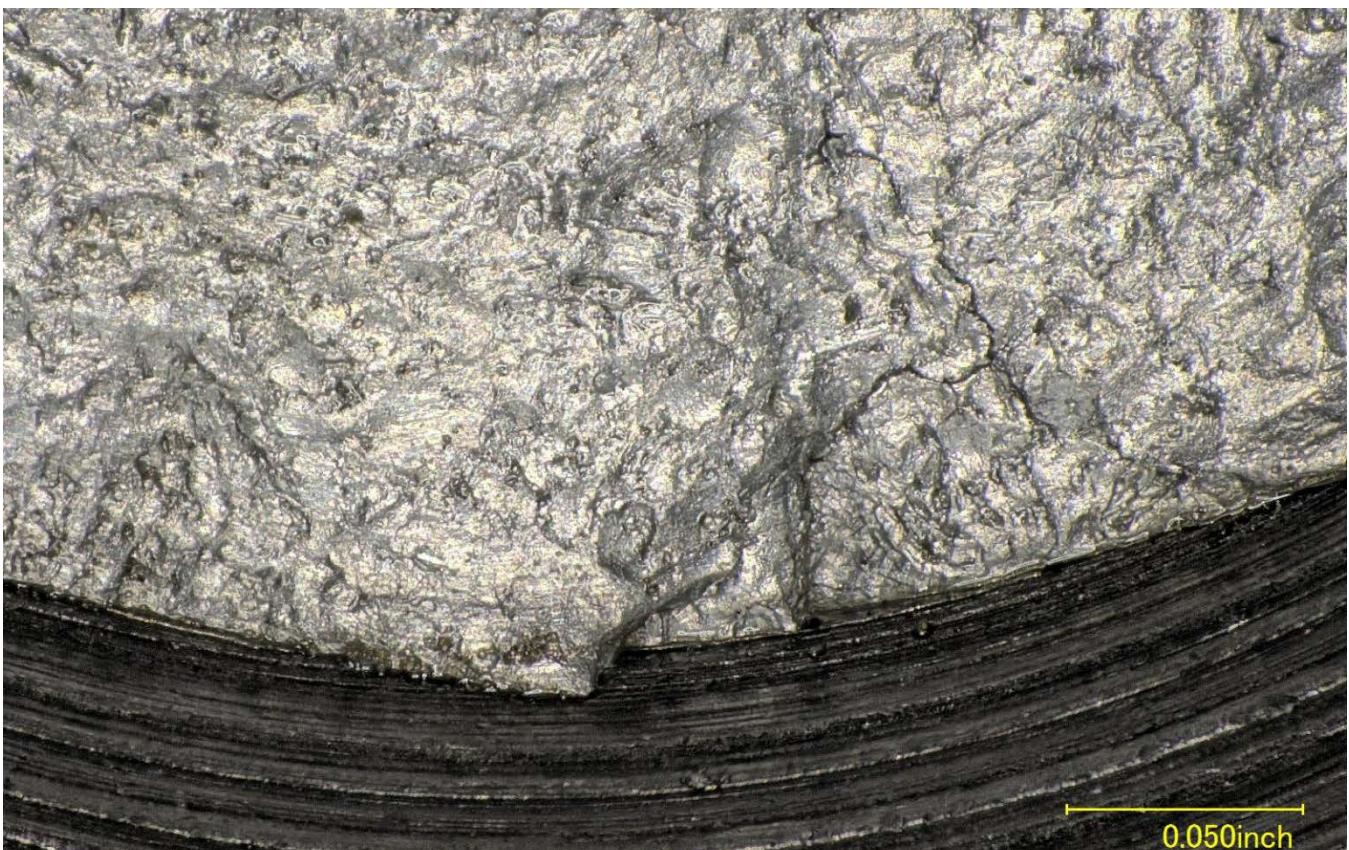


Figure 11 – The small thumbnail crack in Figure 10.

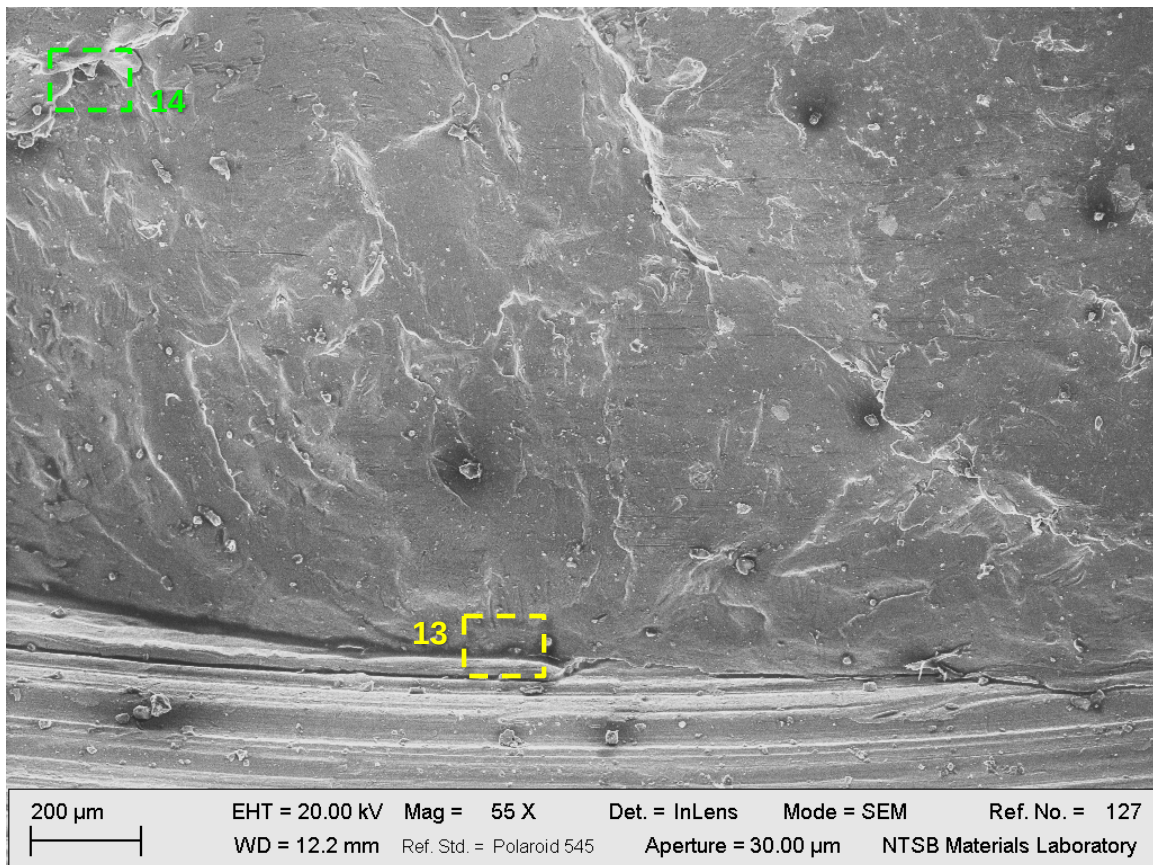


Figure 12 – Secondary electron (SE) micrograph of the thumbnail crack. The two boxed areas are highlighted in Figure 13 and Figure 14.

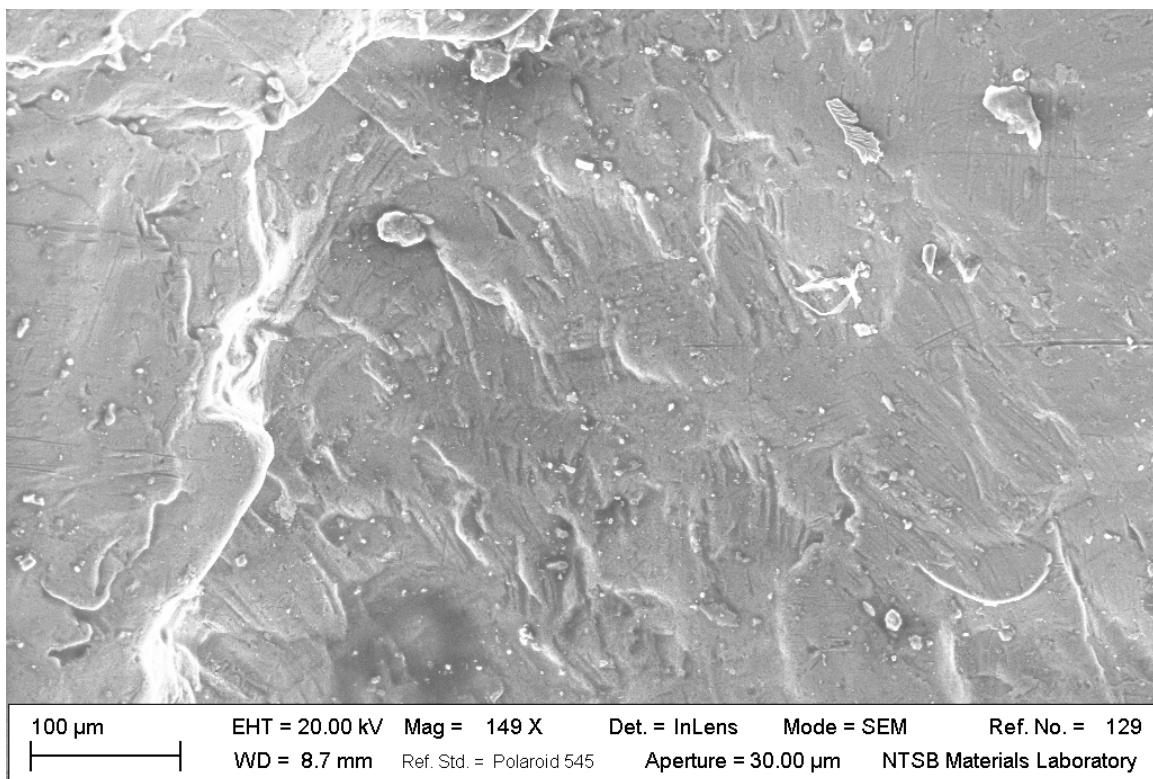


Figure 13 – SE micrograph of the end of the thumbnail crack, showing faint fatigue striations.

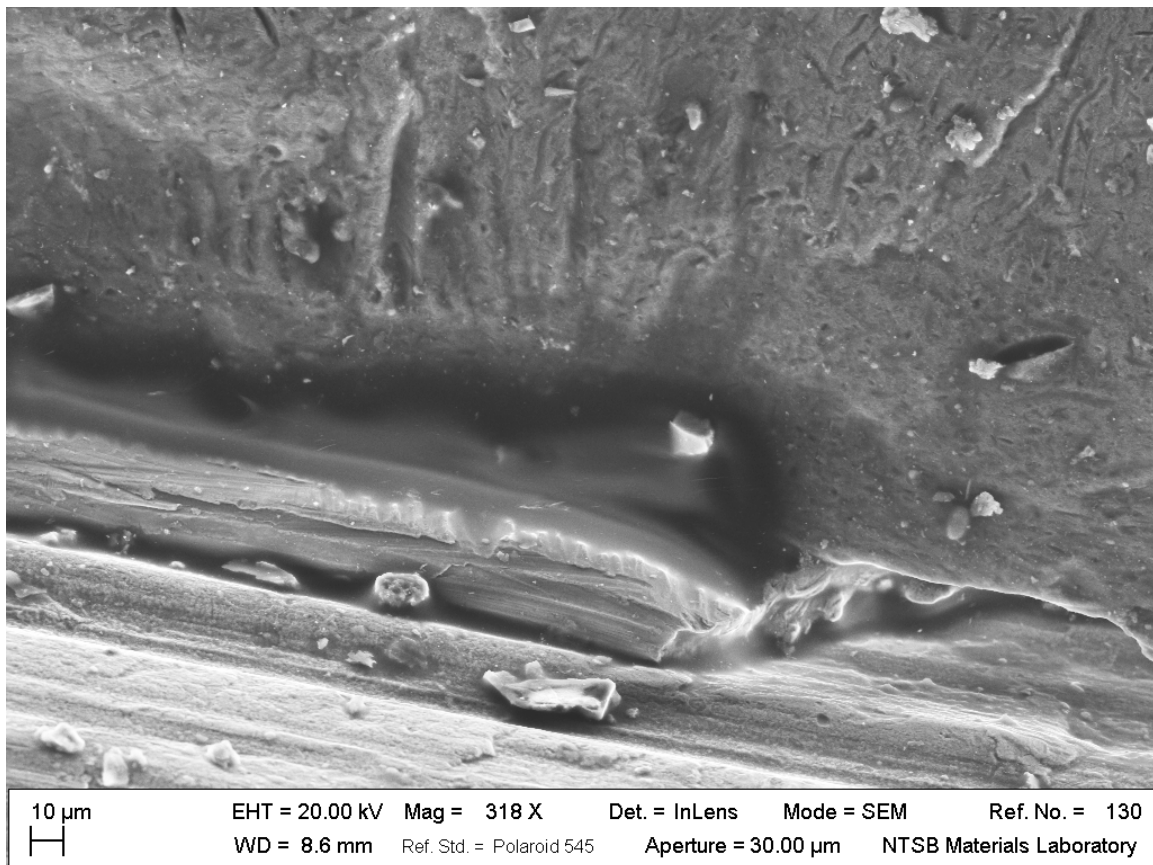


Figure 14 – SE micrograph of the fatigue crack initiation site of the pin thumbnail crack.



Figure 15 – The spherical separated pin piece, showing impressions from collisions.

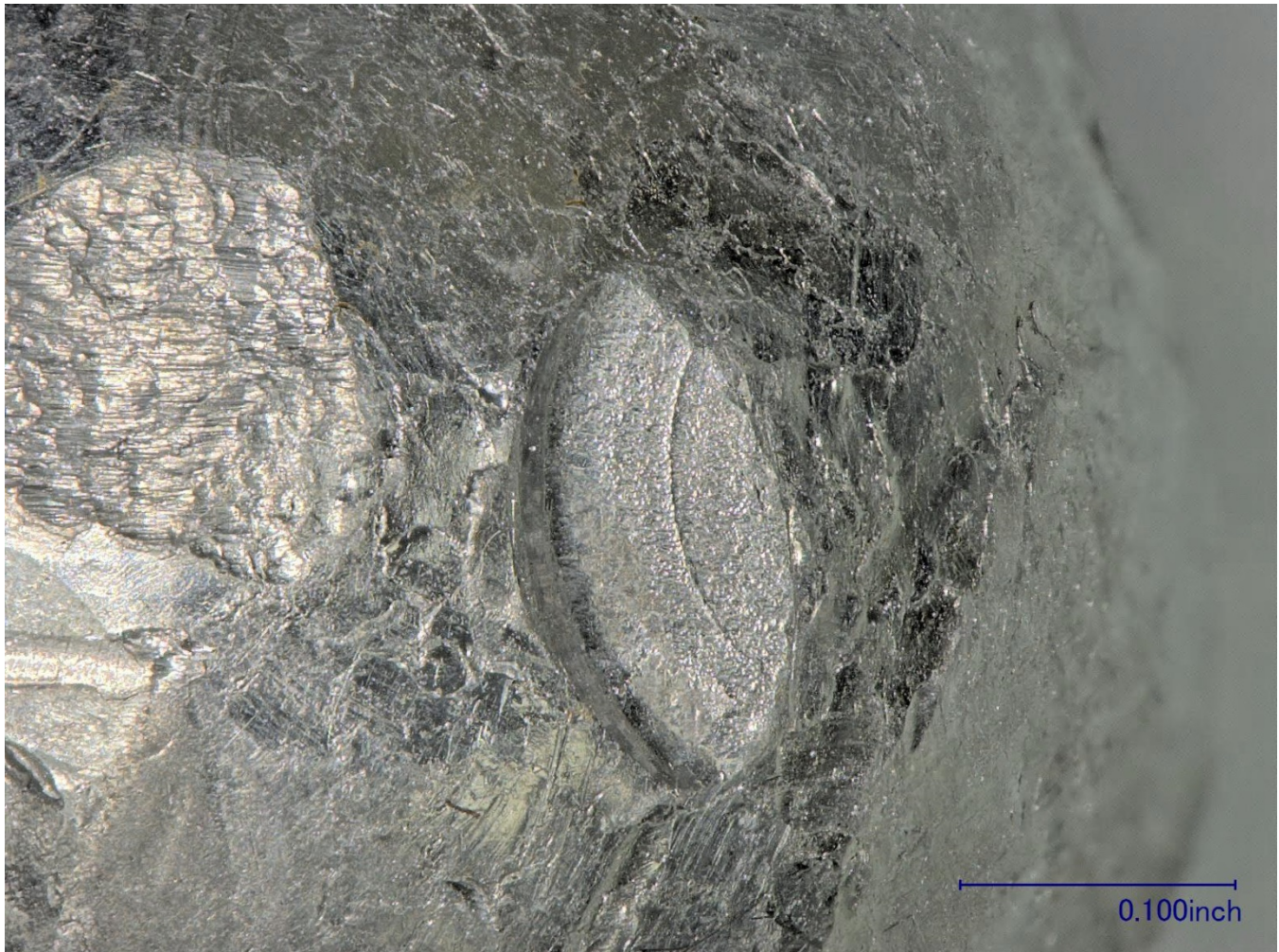


Figure 16 – Closer view of the impact mark on the separated spherical pin piece.