

NATIONAL TRANSPORTATION SAFETY BOARD

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



December 22, 2017

MATERIALS LABORATORY FACTUAL REPORT

Report No. 17-092

A. ACCIDENT INFORMATION

Place : Big Lake, Minnesota
Date : July 6, 2017
Vehicle : Bell 47D1, N153B
NTSB No. : CEN17LA264
Investigator : Edward Malinowski, AS-CEN

B. COMPONENTS EXAMINED

Sections of main rotor blade structure.

C. DETAILS OF THE EXAMINATION

Two sections of the core assembly (spar) were received. Initially the outboard section was received and examined. The inboard section was received at a later date. The core assembly, p/n 91-110-122-1, was a welded steel structure consisting of a tapered -2 lug welded to the trailing edge of a longer -3 bar. Engineering drawing specified the core material as AISI¹ 1025 plain carbon steel per QQ-S-633 with an ultimate tensile strength between 55,000 and 100,000 psi.

The core assembly was fractured through the bar at the outboard edge of the lug as indicated by the red arrows in figure 1. Visual examinations of the fracture faces revealed a corroded region at the trailing edge of the bar with fracture markings and arrest lines indicative of fatigue progression from the trailing edge. Ratchet marking also indicated multiple origins in the area indicated by the red brackets in figure 2. The fatigue had propagated toward the leading edge about 0.25 inch. The fatigue terminus is indicated by the dashed red line. The initial portion of the fatigue was heavily corroded and the fracture surface obscured while the later areas were not. The remaining fracture was consistent with brittle overstress propagation with small shear lips around the periphery of the bar.

X-ray fluorescence spectrograph² found the bar material consistent with an unalloyed carbon steel such as the specified AISI 1025 material. A chordwise cross section was cut through the bar outboard of the fracture as shown in figure 1. Direct

¹ AISI American Iron and Steel Institute

² Using a Thermo Scientific Niton XL3t-980 hand held x-ray fluorescence analyzer.

hardness measurements on the cut cross section averaged 93.4 HRB³ consistent with a carbon steel having an ultimate tensile strength of approximately 98,000 psi⁴. Mounting, polishing and etching (2% Nital) the cross section revealed a ferrite and pearlite microstructure consistent with the specified AISI 1025 material.

The upper surface of the core assembly displayed significant surface corrosion with almost all the yellow green primer missing or discolored. The lower surface had less attack but had corrosion removing and undercutting the primer in many places particularly in the fracture area.

Figure 3 displays the trailing edge of the bar as-received and after ultrasonic cleaning in acetone. The fatigue origin area had some surface corrosion, but no large pits were noted and remnants of the primer remained. Large pits and material removal were seen in the adjacent areas of the upper surface of the bar, denoted by yellow bracket in figure 3.

Joe Epperson, FASM
Senior Metallurgist

³ Hardness, Rockwell, B scale

⁴ ASTM E-18 - 03. Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials. ASTM International, West Conshohocken, PA, 2004.

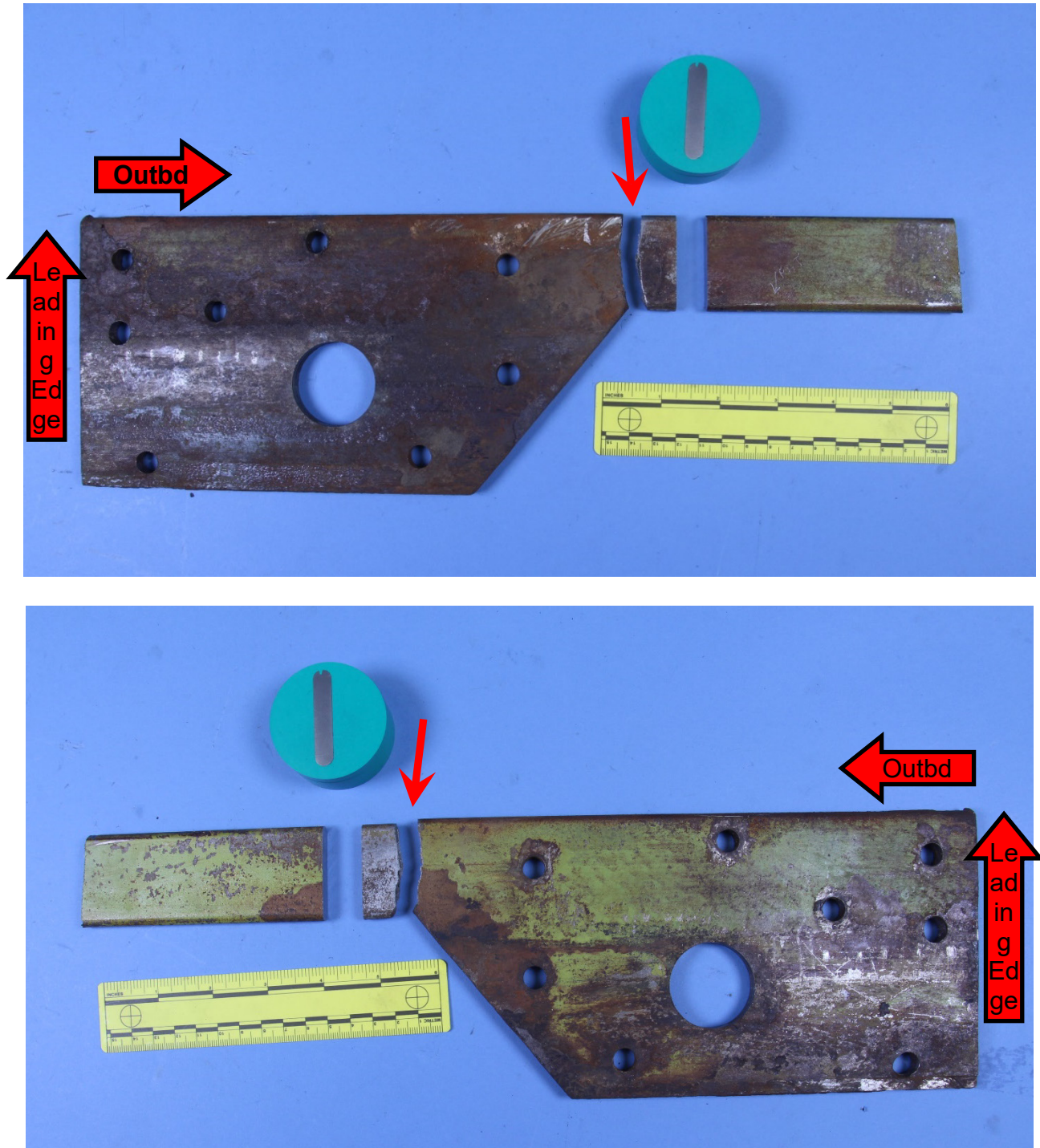


Figure 1. Upper (top) and lower (bottom) surfaces of the core pieces with separation at red arrows. Polished cross section shown above the bar at removal location. Green primer most visible on lower surface.

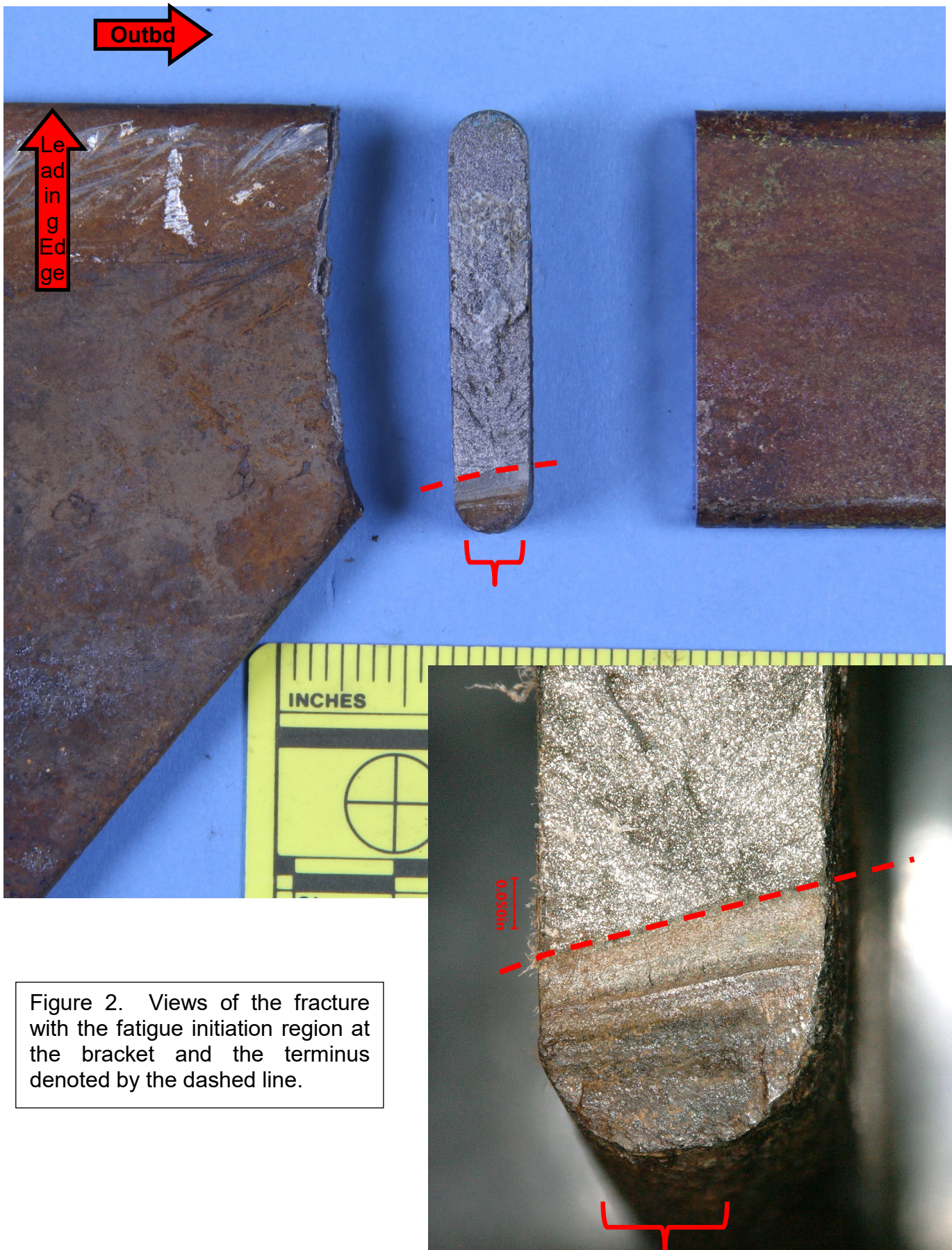


Figure 2. Views of the fracture with the fatigue initiation region at the bracket and the terminus denoted by the dashed line.

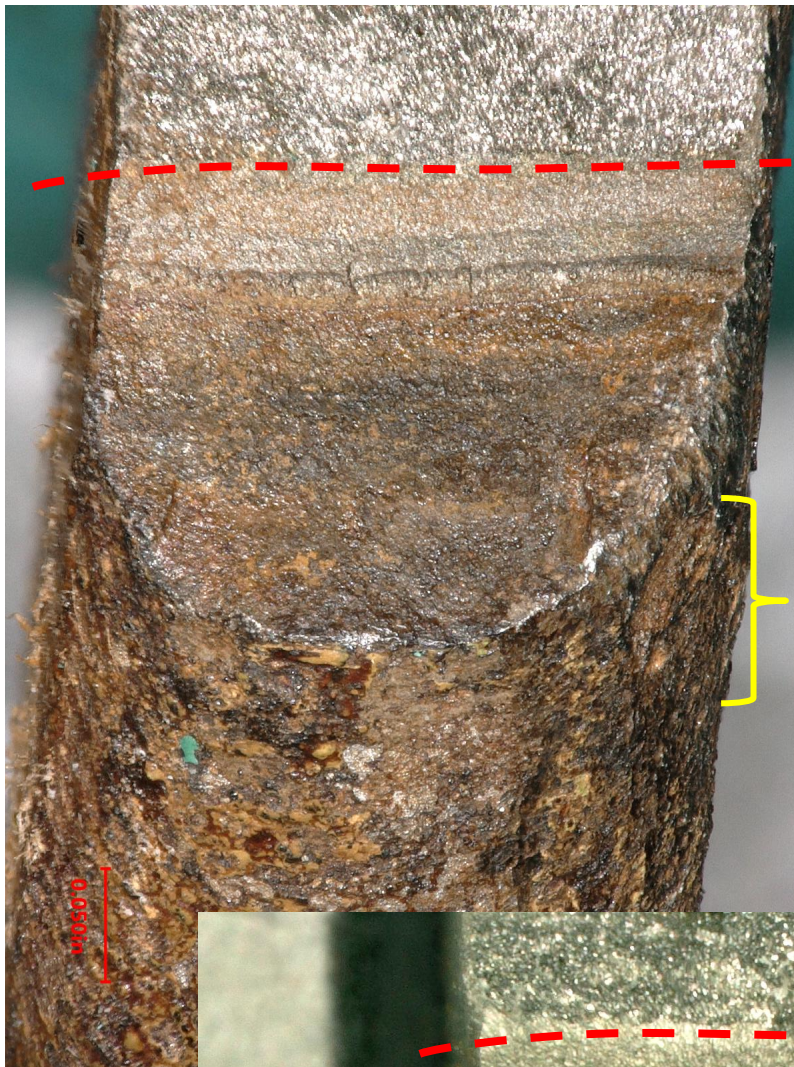


Figure 3. Views of the trailing edge fatigue initiation area showing corrosion before (left) and after cleaning. Yellow bracket shows area of heaviest corrosion on the upper surface.

