

NATIONAL TRANSPORTATION SAFETY BOARD

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



March 17, 2015

MATERIALS LABORATORY FACTUAL REPORT

Report No. 15-029

A. ACCIDENT INFORMATION

Place : The Woodlands, Texas
Date : January 16, 2015
Vehicle : Baker Bobby J Safari, N416JB
NTSB No. : CEN15LA104
Investigator : Courtney Liedler, AS-CEN

B. COMPONENTS EXAMINED

Horizontal Stabilizer
Tail Rotor Cross and Sleeve Assembly

C. DETAILS OF THE EXAMINATION

The as-received components are displayed in figure 1. With the horizontal stabilizer at top and the tail rotor cross below. The spar tube of the stabilizer was fractured just outboard of the locating flange and adjacent to the inboard edge of the airfoil section. The forward side of the end plate was bent slightly outboard but no impact damage was apparent on either the end plate or the airfoil skin of the stabilizer. The airfoil section and the mounting tube portions were received separately. The phenolic sleeve on the tail rotor cross was fractured at the end flange. Examination of the flange fracture revealed a brittle overstress separation with no indications of discontinuities.

As manufactured, the locating flange of the spar is welded (on the outboard side) to the spar tube and positioned immediately adjacent to the inboard edge of the airfoil skin as shown in the upper view of figure 2. As assembled, the fracture location and weld are partially hidden by the airfoil skin and not directly visible. The airfoil skin and the spar were saw-cut and the four inboard rivets (two top two bottom) were removed to separate the outboard spar fracture face as shown in the lower view of figure 2.

The majority of the fracture followed the outboard edge of the locating flange weld. As initially received, large areas of both fracture faces were obscured by red and brown corrosion products. Cleaning with Evapo-Rust¹ followed by ultrasonic cleaning in

¹ Evapo-Rust. A commercially available deoxidizer manufactured by Harris International Laboratories.

acetone removed the majority of the corrosion deposits and the paint from the fracture and flange as shown in figure 3.

Magnified optical examinations of the fracture surfaces identified features consistent with fatigue cracking. Three fatigue origins were found on the outer surface of the spar tube at the outboard toe (edge) of the assembly weld, denoted fatigue origins "A", "B" and "C" in figure 3 and shown in greater detail in figure 4. The fatigue propagated generally radially through the wall thickness with some circumferential spreading. The fatigue cracking progressed through about half of the total spar cross section, indicated by the dashed yellow lines. The fatigue origins and propagation were all on the aft portion of the spar. No corrosion or other obvious damage was apparent at any of the origins.

Examinations also uncovered a rust-covered crack slightly inboard of and undercutting the main fracture plain, as shown in figure 5. The undercutting crack intersected the outboard fatigue and formed part of the overall fracture. This portion of the fracture is indicated in figure 3 by the orange bracket and extended the total extent of the fatigue content of the fracture to about 2/3 of the total spar cross section. Magnified examinations of the crack faces without opening revealed fatigue features with at least one fatigue origin on the outer surface of the spar, fatigue origin "D" in figure 3. The crack morphology visible in figure 5 was consistent with additional fatigue origins in the unopened portion of the crack.

The remaining fracture displayed separation features and deformation patterns consistent with overstress separation. The deformation pattern was consistent with forces associated with the stabilizer tip moving forward and outboard.

Visually, the weld exhibited good workmanship with no apparent undercutting, weld cracking or surface discontinuities. A small pore and a single area of lack of fusion were uncovered by the weld fracturing in the overstress regions.

The inboard fracture face was viewed using a scanning electron microscope (SEM) after it was cleaned and the corrosion removed. The fracture area near fatigue origin "A" displayed a corrosion-damaged surface as shown in the upper view of figure 6. Fracture surfaces near fatigue origins "B" and "C" were much less damaged by corrosion and displayed features consistent with fatigue cracking in alloy steels as shown in the lower view of figure 6.

Energy dispersive x-ray spectra (EDS) of the spar material acquired during SEM examinations were typical of an AISI² 4100 series alloy steel as indicated on the stabilizer engineering drawing.

² AISI American Iron and Steel Institute

Joe Epperson
Senior Metallurgist



Figure 1. Overall views looking down onto the horizontal stabilizer at top with separated spar (insert) and the tail rotor cross at left with fractured phenolic slider.

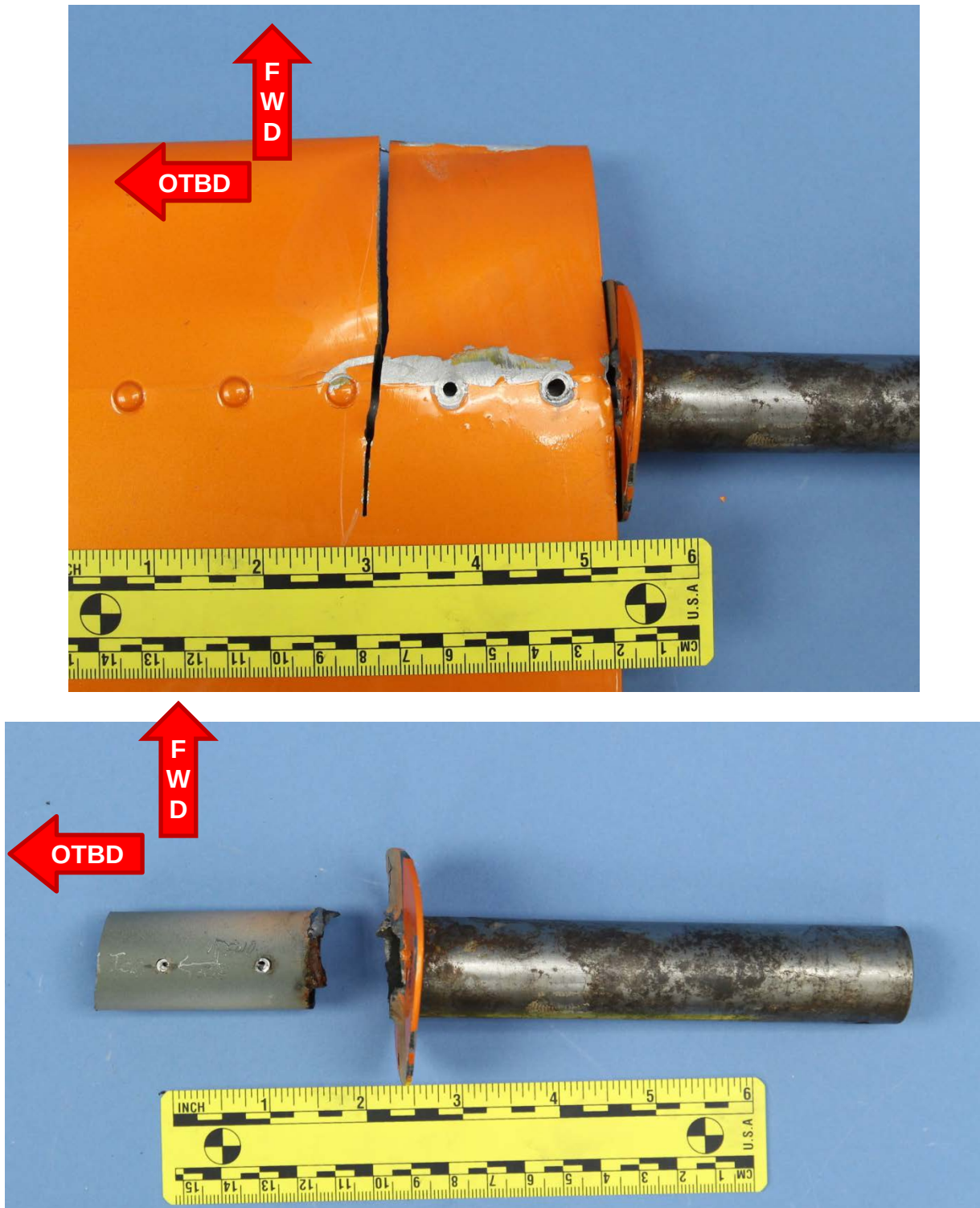


Figure 2. Upper view shows the separated inboard portion of the spar with the locating flange positioned against the airfoil skin as normally assembled (mating spar piece has been removed). Lower view displays the removed section of spar (left) with mating fracture on inboard piece.

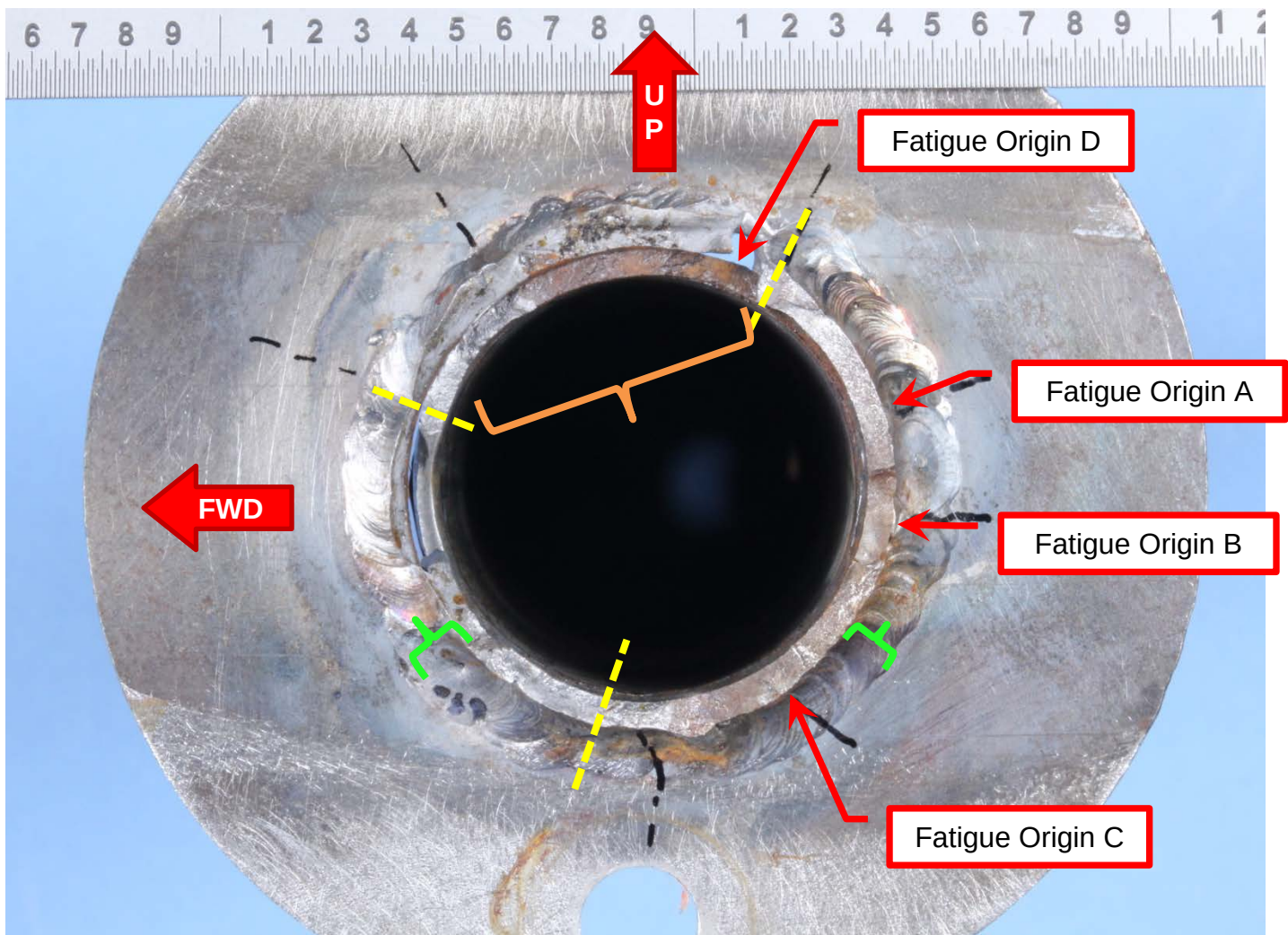


Figure 3. A view of the inboard fracture face of the spar with weld (green brackets) and locating flange. Fatigue origins A, B, C and D are denoted. From the origins the fatigue extends to the dashed yellow lines. Orange bracket indicates the exposed portion of the inboard crack.

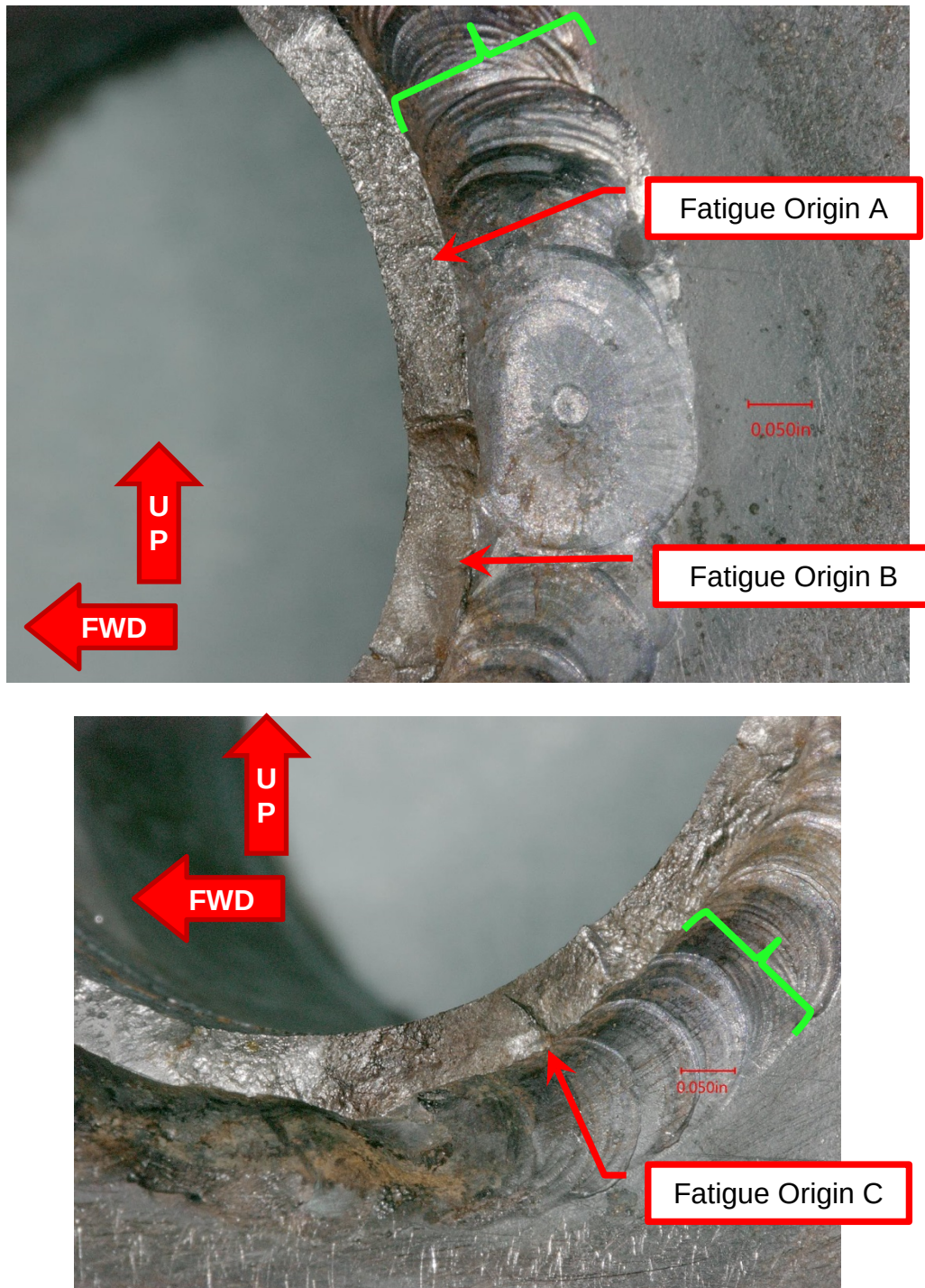


Figure 4. Closer views of fatigue origins A, B (top) and C (lower). The weld bead is denoted by the green brackets.

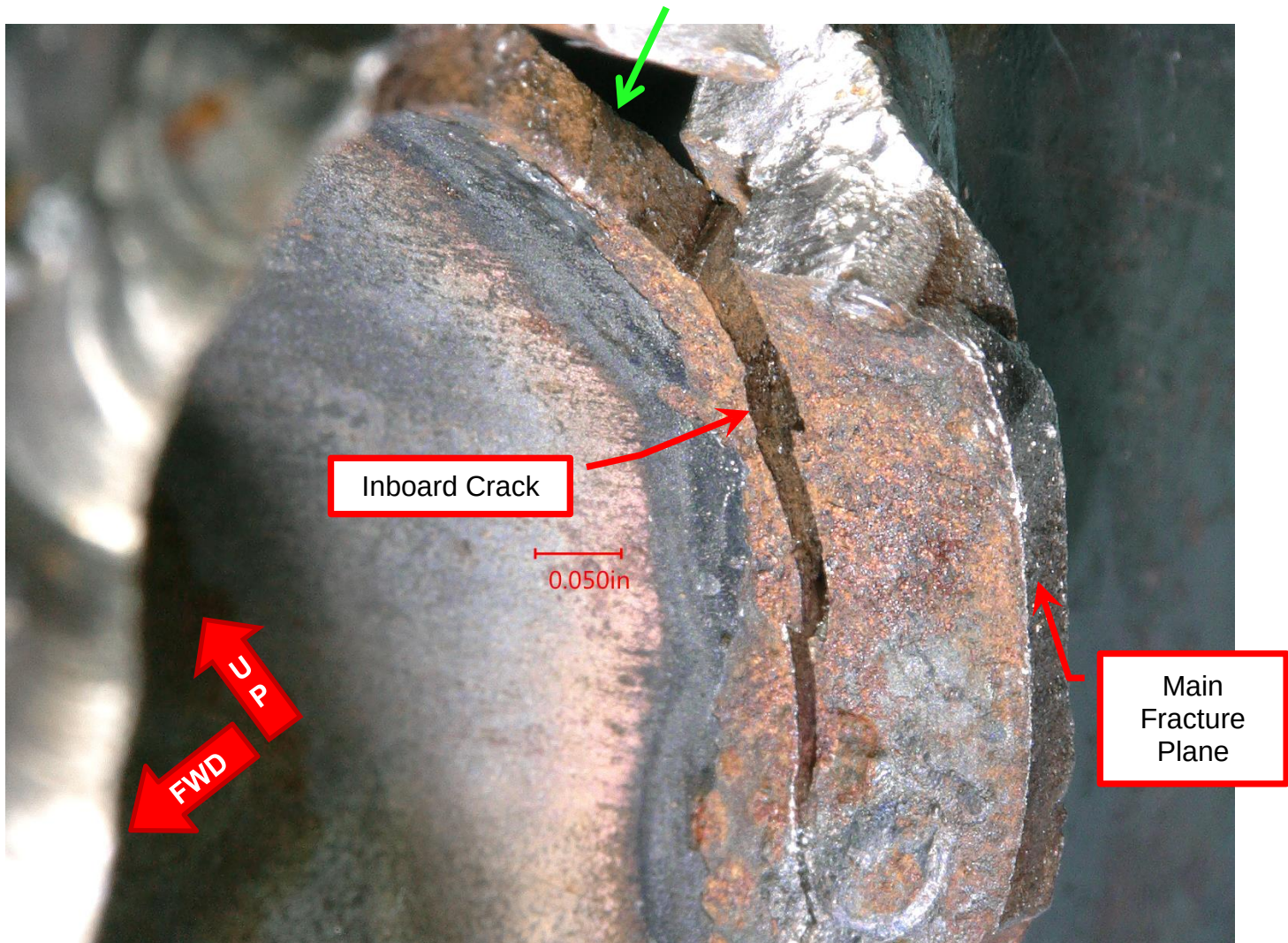


Figure 5. Oblique view looking inside the spar tube at the crack inboard of the main fracture plane. Note the corrosion. Green arrow indicates one origin on inboard crack.

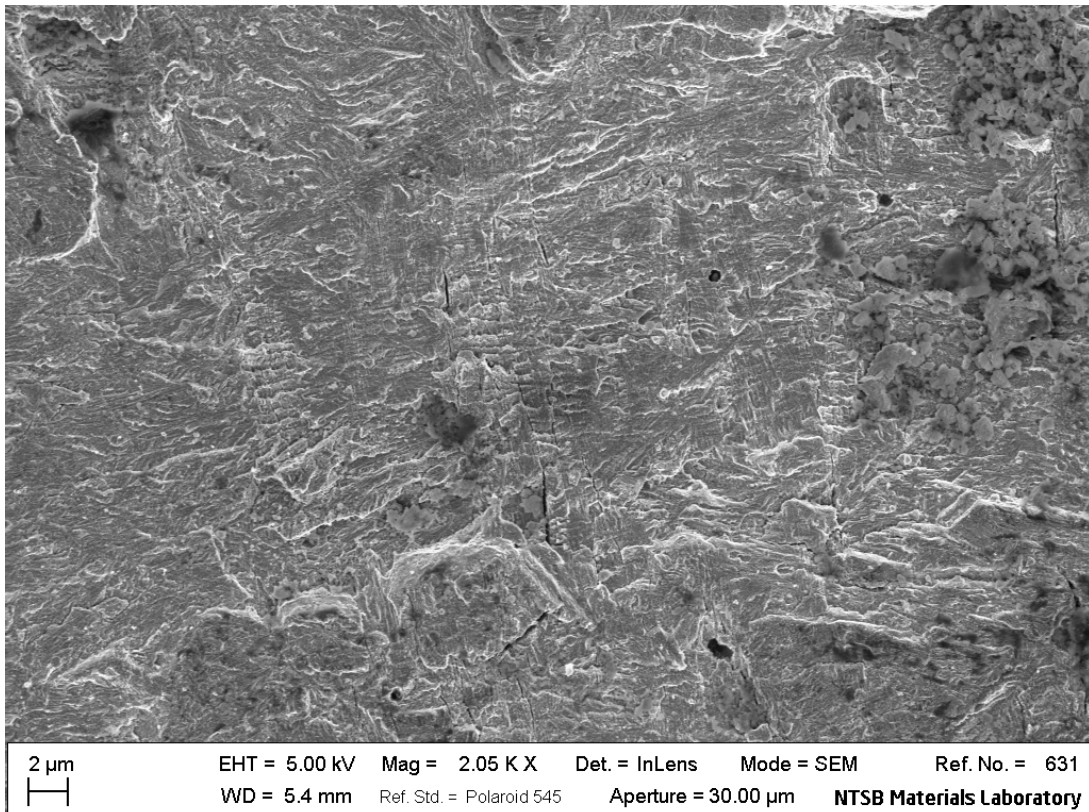
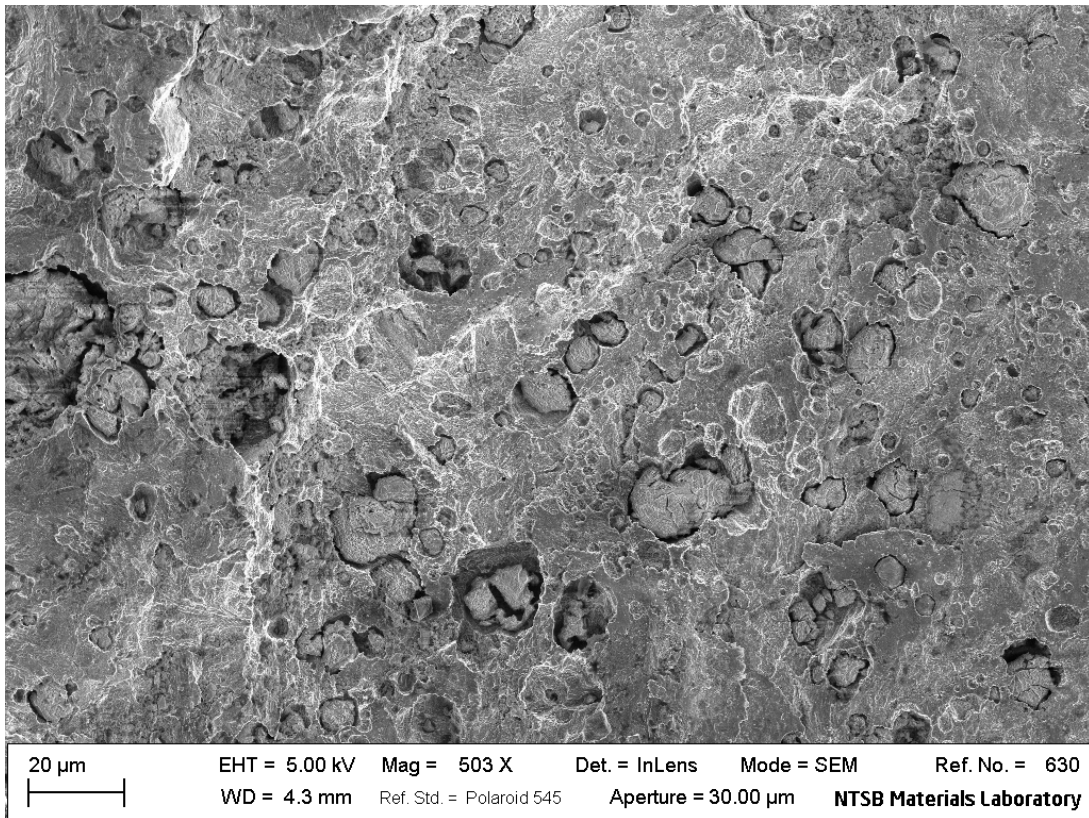


Figure 6. SEM views of corrosion damage near origin "A" at top and typical fatigue features near origin "B".