NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

September 1, 2009

MATERIALS LABORATORY FACTUAL REPORT Report No. 09-055

A. ACCIDENT

Place	:	Denver, Colorado
Date	:	December 20, 2008
Vehicle	:	Boeing 737-500
NTSB No.	:	DCA09MA021
Investigator	:	Mark George

B. COMPONENTS EXAMINED

Captain's chair
First officer's chair
Forward flight attendants' jump seat
Seat belts

C. DETAILS OF THE EXAMINATION

The captain's chair, first officer's chair and flight attendants' jump seat were received by the NTSB Materials Laboratory in the condition shown in figures 1 and 2. The harness anchor points on the front of the captain's chair seat bottom and first officer's chair seat bottom were fractured as shown for the captain's chair in figure 3. The fracture surface was consistent with an overstress fracture. The jump seat had been partially disassembled. The seat back of the flight attendants' jump seat had been removed from the seat assembly. Rods on the seat back retraction mechanism on either side of the seat back had fractured near the threaded ends. The seat belts showed no signs of excessive wear or tearing and were not examined further.

C.1. EXAMINATION OF THE FLIGHT DECK CHAIRS

The seat bottom and seat back for each chair were removed in order to more closely examine the base of each chair. The base of the captain's chair is shown in figure 4 after removal of the seat. The linkage tubes and arm lifts were disassembled as shown in figure 5. The frames of both chairs were slightly deformed inward at the top. The linkage tubes on the captain's chair had fractured near the forward end as shown in figure 6a. The fracture surface was rough and at a 45° angle to the longitudinal axis as shown in figure 6b, consistent with an overstress fracture. The linkage tubes on the first officer's chair were intact. The outward facing flats on the pin guides of the rear arm lifts were scratched and deformed on both chairs as shown in figures 6a and 7, for the captain's chair and first officer's chair, respectively.

The left and right height adjustment lock plates for the captain's chair and first officer's chair are shown in figures 8 and 9, respectively. The lock plates on the captain's chair were covered with grease and dirt. The lock plates on the first officer's chair were clean to the unaided eye. Deformation was observed on the captain's chair lock plates. The web between the fifth and sixth hole on the left side lock plate was deformed in the aft direction as shown in figure 8a. By comparison, the webs on the right side lock plate were deformed or completely torn between the fourth and tenth holes. The deformation to the webs caused a raised edge to form along lines tangent to the tops and bottoms of the holes. The lock plates on the first officer's chair were also deformed. The webs on the left and right plates were torn and deformed between the eighth and tenth holes as shown in figures 9a and 9b, respectively. The deformation to the webs caused a raised edge to form along lines tangent to the tops and bottoms of the holes.

The seat height pins from the first officer's chair were removed from the arm lifts as shown in figure 10. Each pin had a slight bend along the outermost 0.5 inch of the pin.

C.2. EXAMINATION OF THE FLIGHT ATTENDANTS' JUMP SEAT

The left and right side seat back tracking mechanisms inside the jump seat shroud were deformed as shown in figure 11a and 11b. Both arms were deformed to the left side of the seat. The right side mechanism sustained tearing damage where a pin had been forced past the end of its track.

The seat bottom and seat back tracking mechanisms were removed from the jump seat in order to examine the pivot plate that houses the pivot bolt about which the seat bottom rotates. Cracks were observed at the base where the boss meets the landing on the left and right sides. The right side pivot plate is shown in figure 12a and a macrophotograph of the crack at the base of the boss is shown in figure 12b. The crack spanned approximately from the 4 o'clock position counterclockwise across the top of the boss to the 10 o'clock position. From there it deviated from the base of the boss and propagated through the landing to the forward end of the pivot plate. The left side pivot plate is shown in figure 13a and a macrophotograph of the crack (after sectioning) is shown in figure 13b. The crack followed the base of the boss approximately from the 12 o'clock position to the 2 o'clock position. From the 2 o'clock position the crack proceeded across the landing to the forward end of the pivot plate. From the 12 o'clock position the crack deviated from the base of the boss and propagated through the landing toward the seat stop for 0.5 inch. The crack then changed directions abruptly creating a curved crack path that terminated at a rivet hole. The seat stops on the right and left side pivot plates were deformed as shown in figures 14a and 14b, respectively. The stops were bent upward at the rearmost tip of the edge that stops the downward rotation of the seat bottom.

Features consistent with fatigue cracking were seen on both pivot plates. A scanning electron microscope (SEM) micrograph of the crack face at the 12 o'clock position of the right side boss is shown in figure 15a. Ratchet marks were observed at the base of the boss

consistent with multiple crack initiation sites. A higher magnification micrograph in this region revealed fine striations consistent with fatigue crack propagation as shown in figure 15b. The initiation sites on the right side pivot plate were located at the root of a sharp radius observed at the base of the boss as shown in figure 16a. The left side pivot plate did not have a sharp radius at the base of its boss. The mode of crack extension on the right side boss changed from fatigue crack propagation to crack propagation under monotonic loading conditions at approximately the 1 o'clock position continuing clockwise as shown in figure 16b. The fatigue crack on the left side boss extended through the landing to the forward edge of the plate and to the position indicated by the short arrows in figure 13b.

The landing of the right side pivot plate contained circumferential markings consistent with tool marks on the landing face as shown in figure 17a and 17b. The tool marks extended to the blended edge of the landing where it created a small step indicated by the arrows in figure 17a. The marks also were observed around the fillet at the base of the boss. The tool marks are shown at the 6 o'clock position as indicated by the short arrows in figures 17b and at the 12 o'clock position where the fatigue crack initiated as shown in figure 17c. No equivalent marks were observed on the left side pivot plate.

Donald Kramer
Materials Engineer

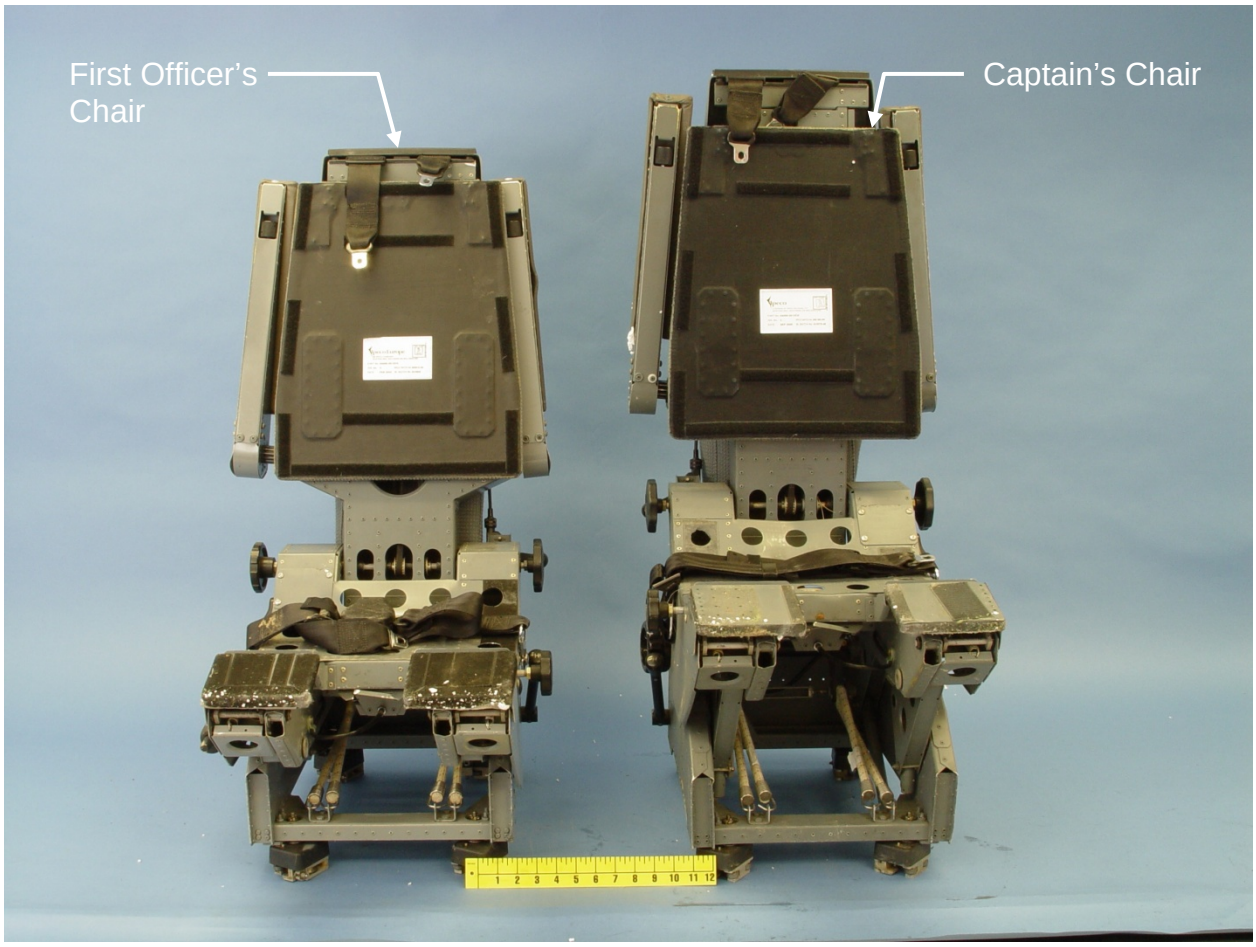
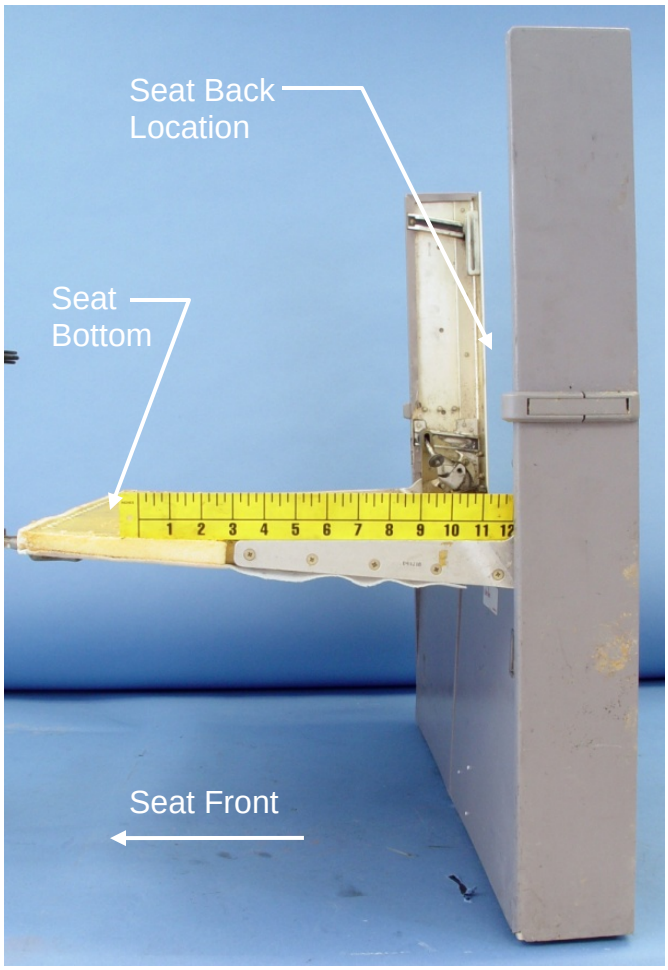


Figure 1: Photograph of the first officer's chair and captain's chair as-received.

a)



b)

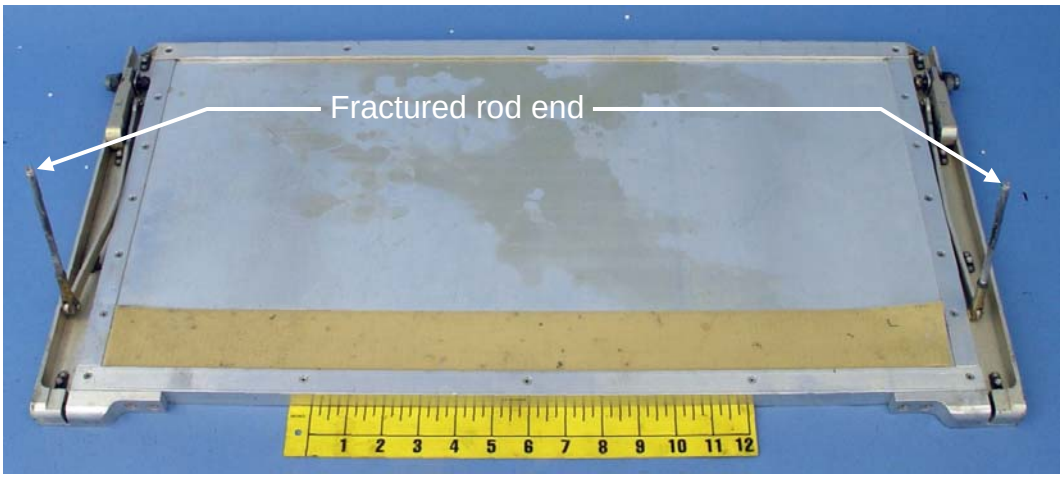


Figure 2: Photographs of the flight attendants' jump seat as-received; a) the seat bottom and shroud assembly; b) seat back viewed from the (hidden) backside.

Figure 3: Fractured harness anchor point on the captain's chair.

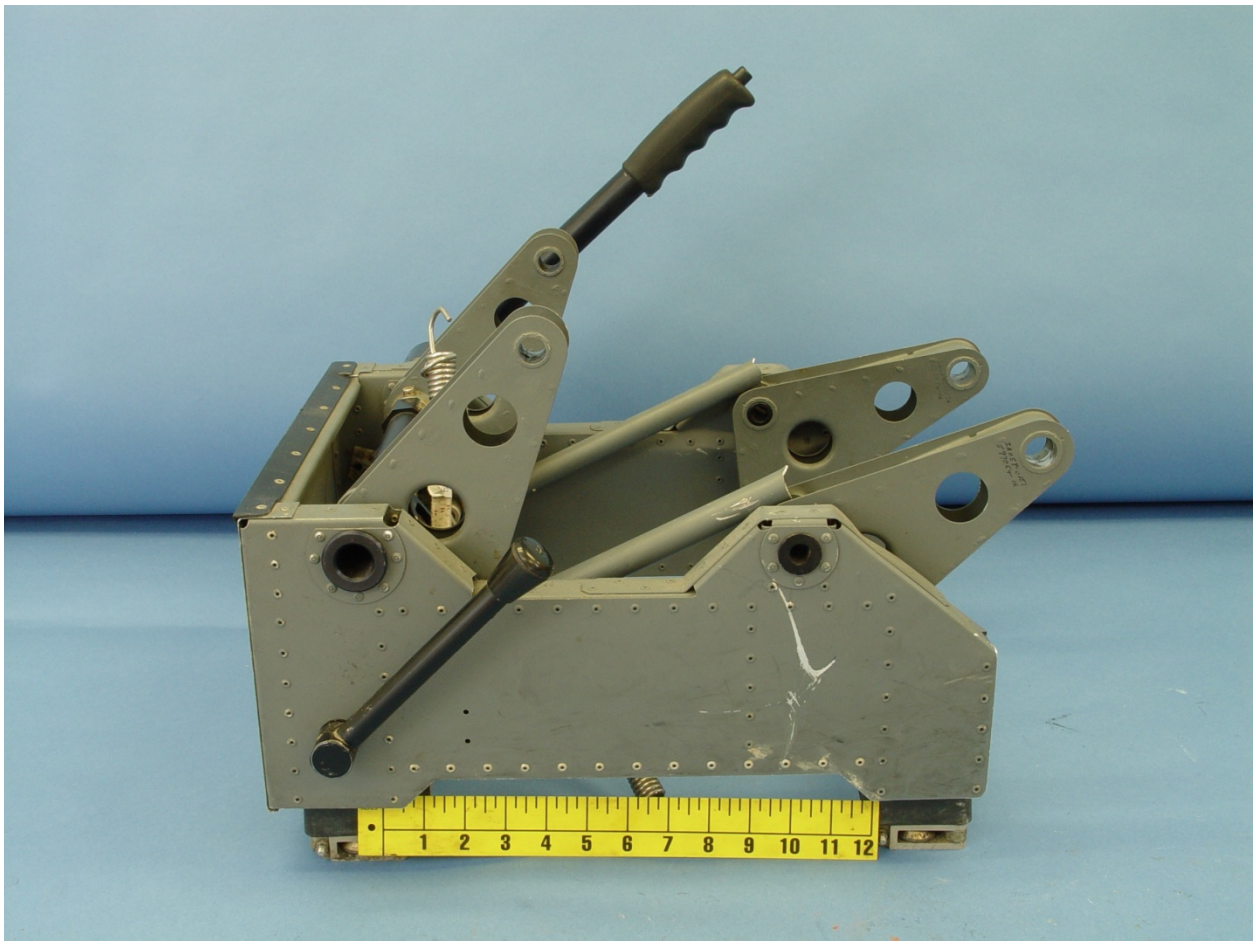
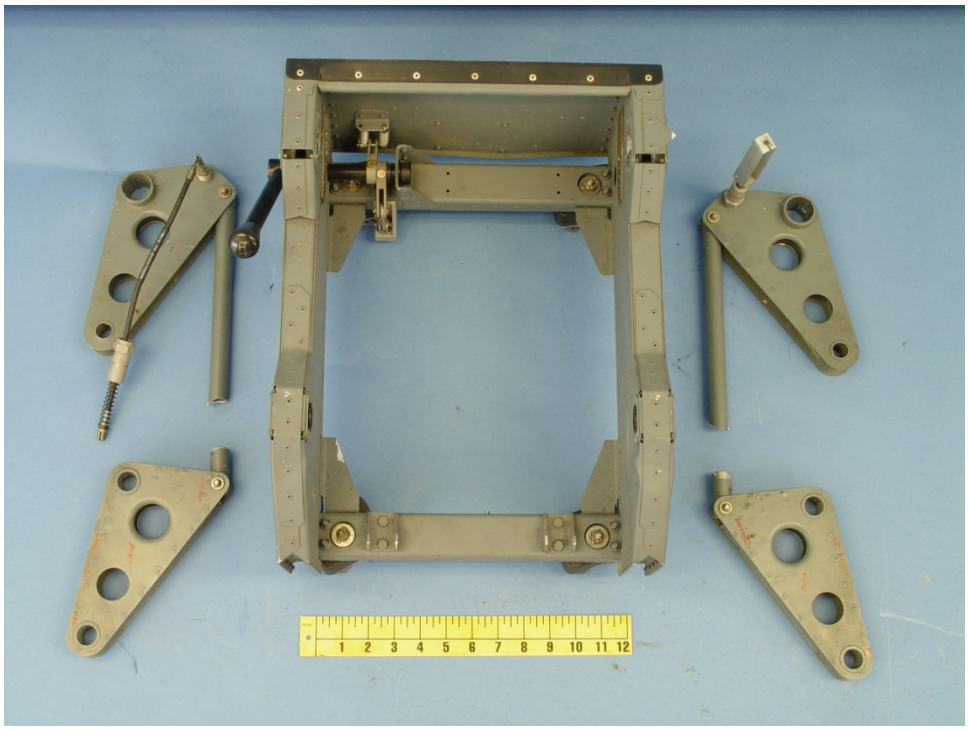


Figure 4: Photograph of the captain's chair after removal of the seat bottom and seat back.

a)



b)

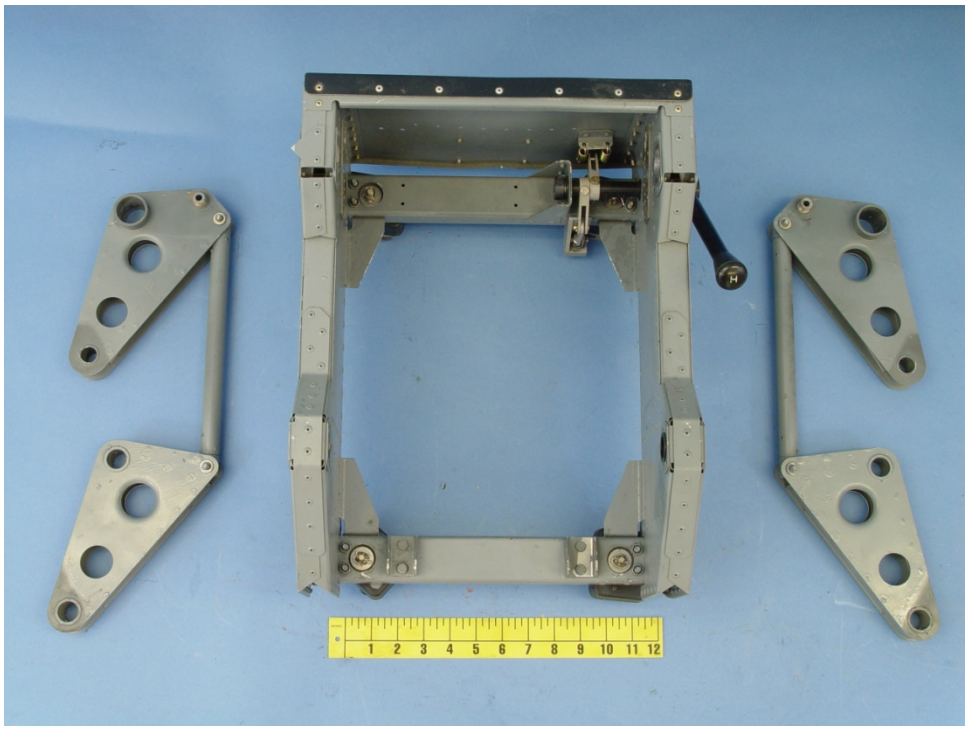
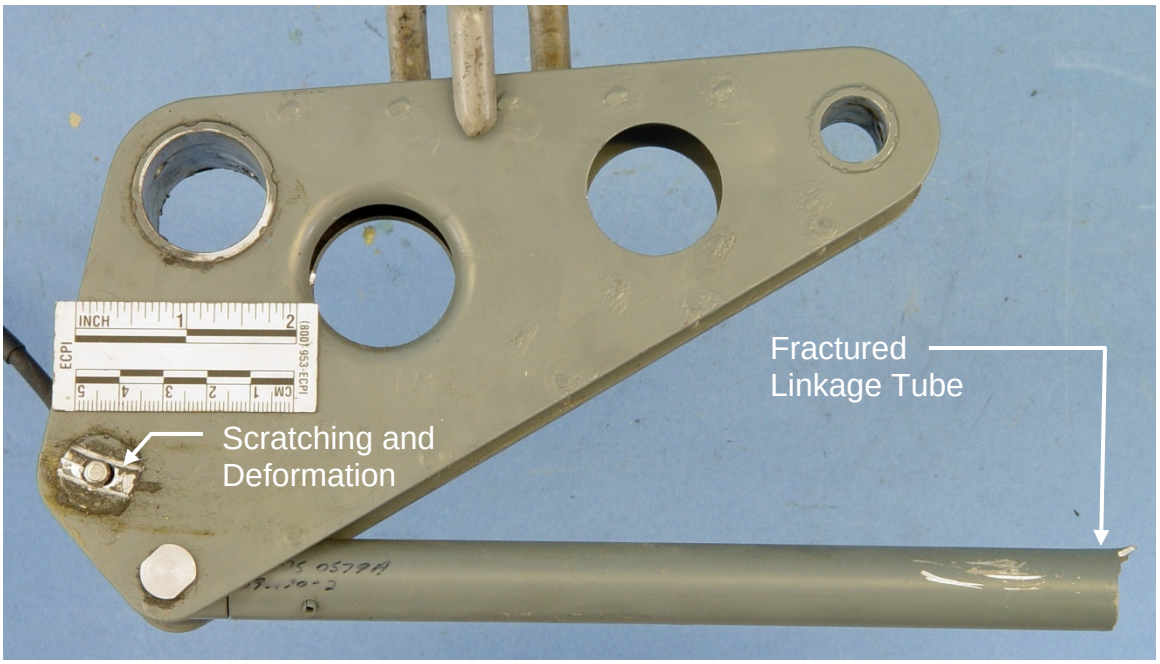


Figure 5: Photographs of flight deck chairs after disassembly of the chair lift mechanisms; a) captain's chair; b) first officer's chair.

a)



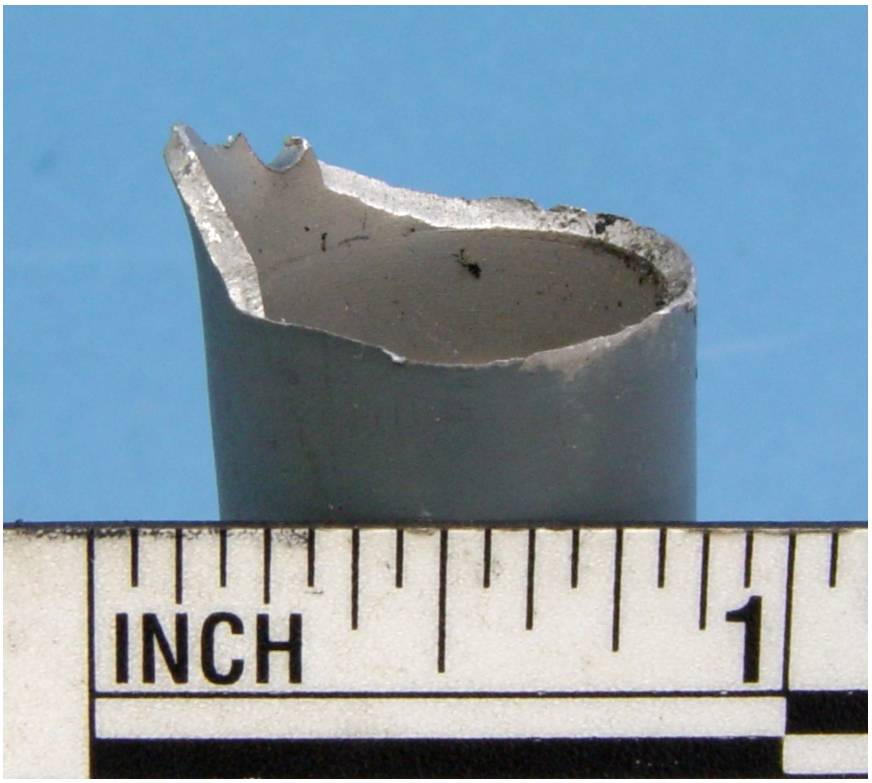


Figure 6: a) Photograph of an arm lift and fractured linkage tube from the captain's chair; b) Higher magnification image of the linkage tube fracture surface, consistent with overstress fracture.

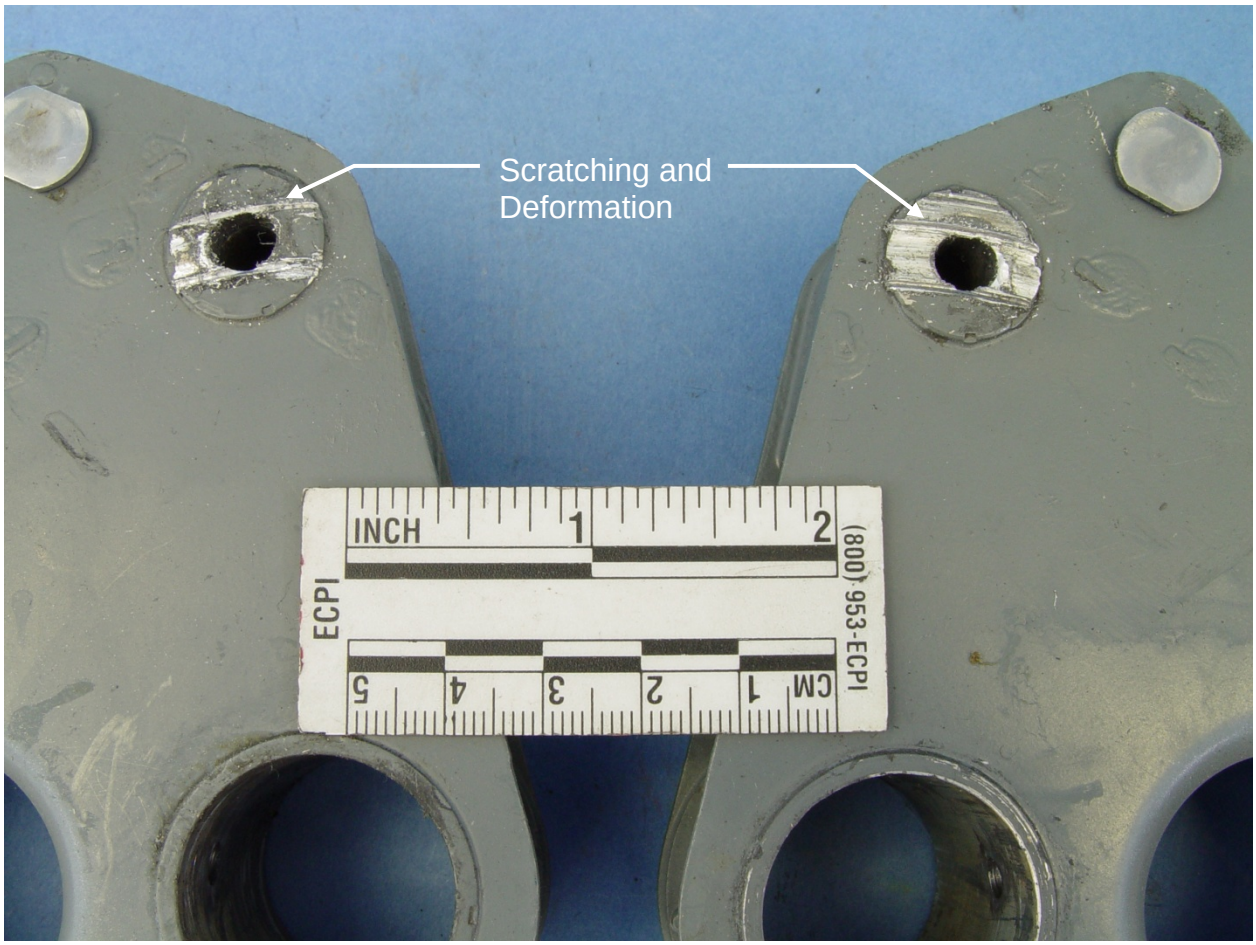
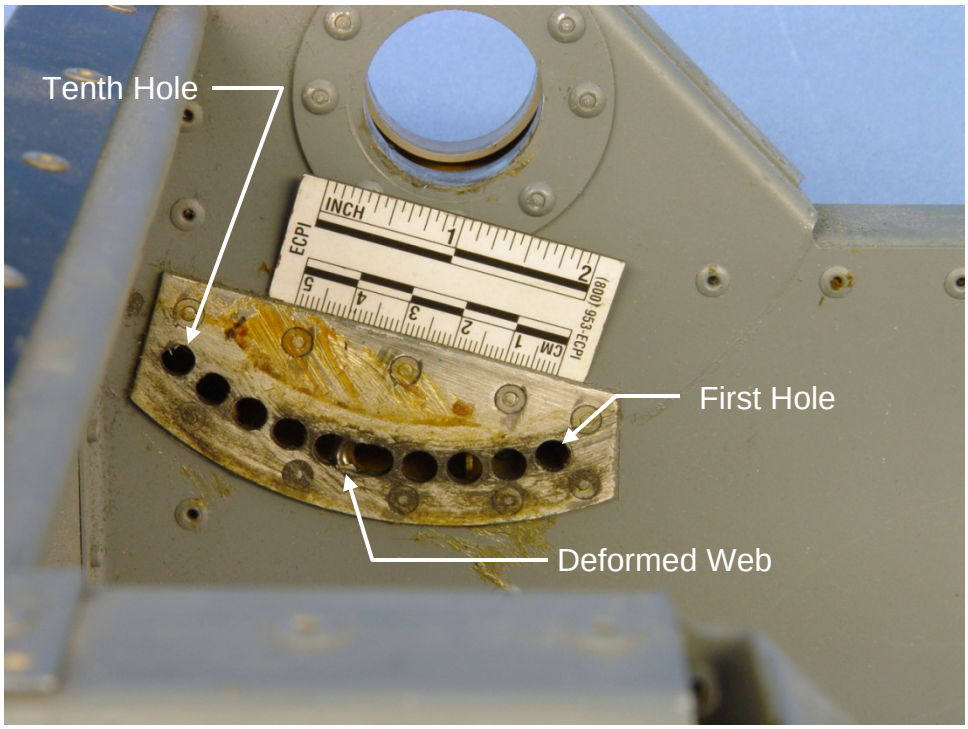
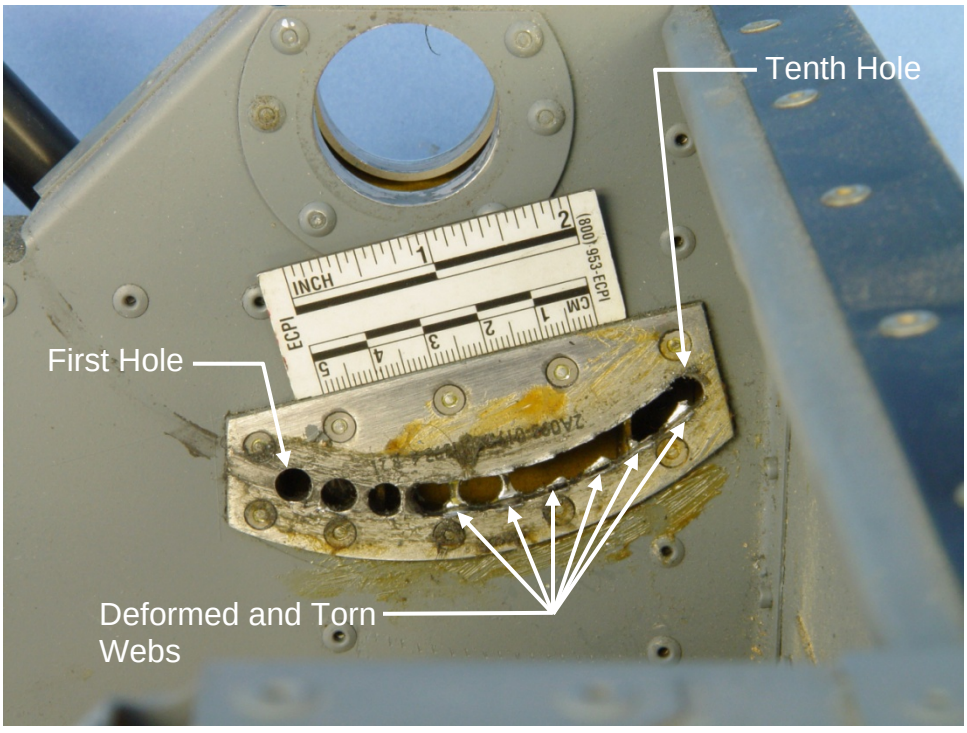


Figure 7: Photograph of the first officer's chair arm lifts. The flat faces on the pin guides are scratched and deformed.



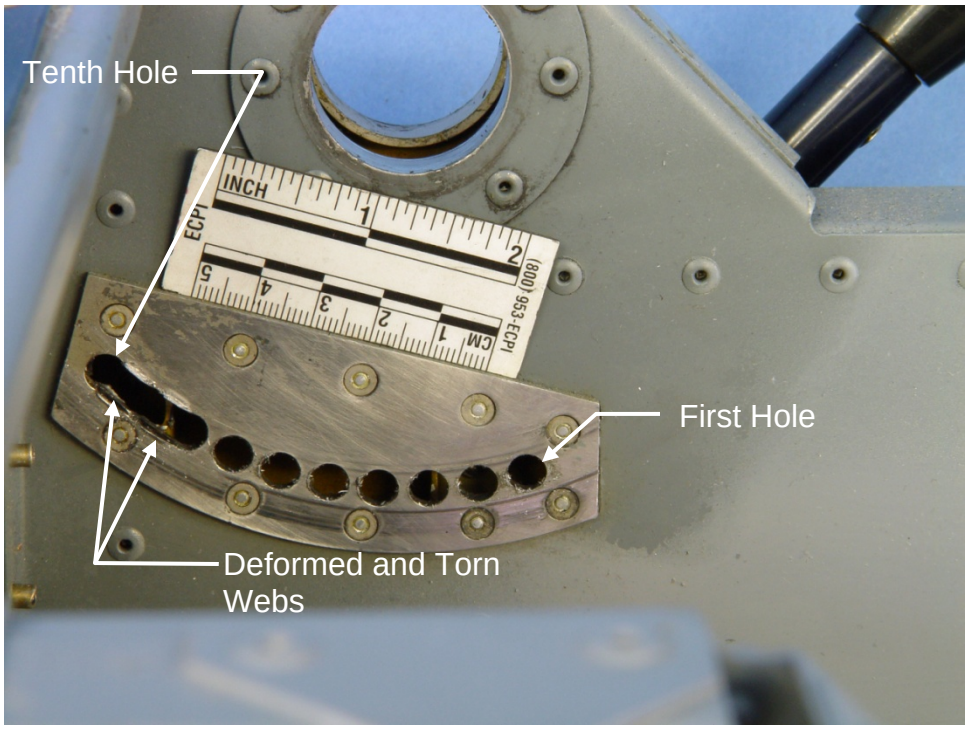
a)



b)

Figure 8: Seat height adjustment lock plates on the captain's chair. The faces of both plates were coated with dirt and grease; a) The left side lock plate had a deformed web between the fifth and sixth hole; b) The right side lock plate had deformed and torn webs between the fourth and tenth holes.

a)



b)

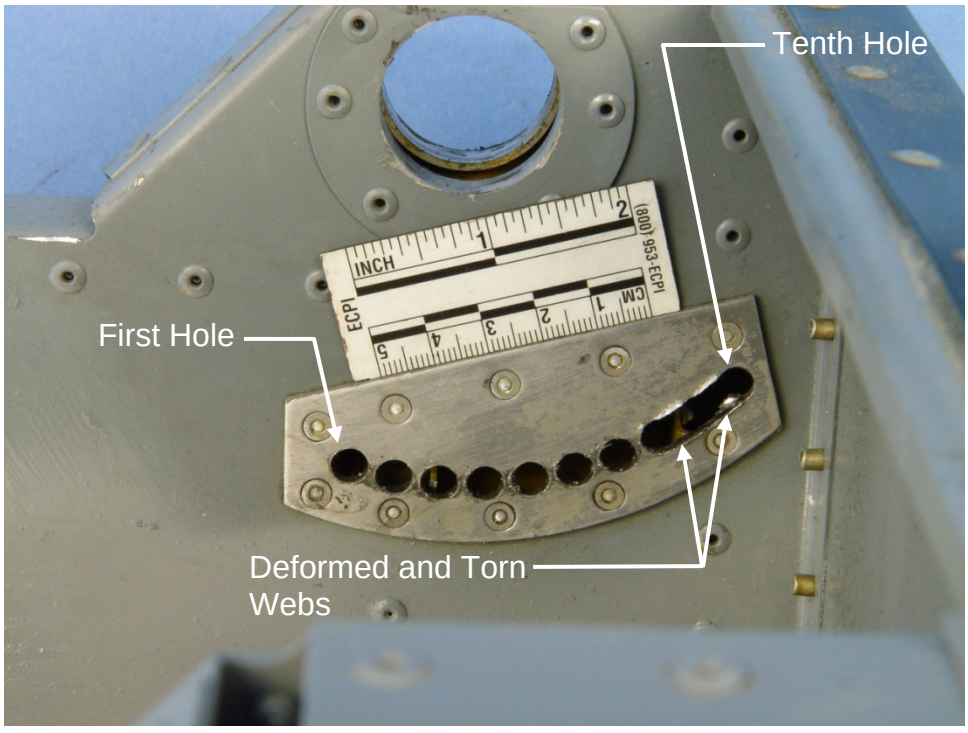


Figure 9: Seat height adjustment lock plates on the first officer's chair. Both sides had deformed and torn webs between the eighth and tenth holes; a) Left side lock plate; b) Right side lock plate.

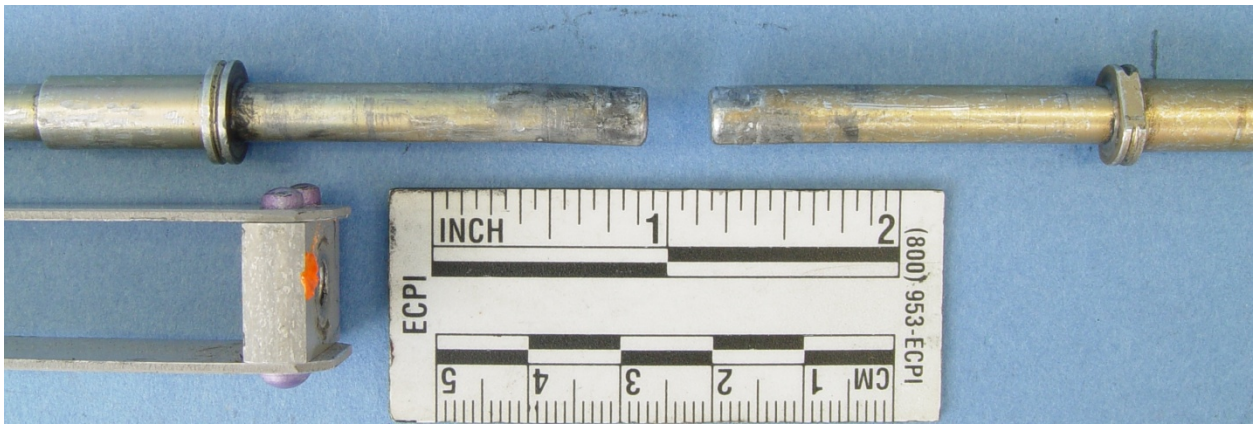
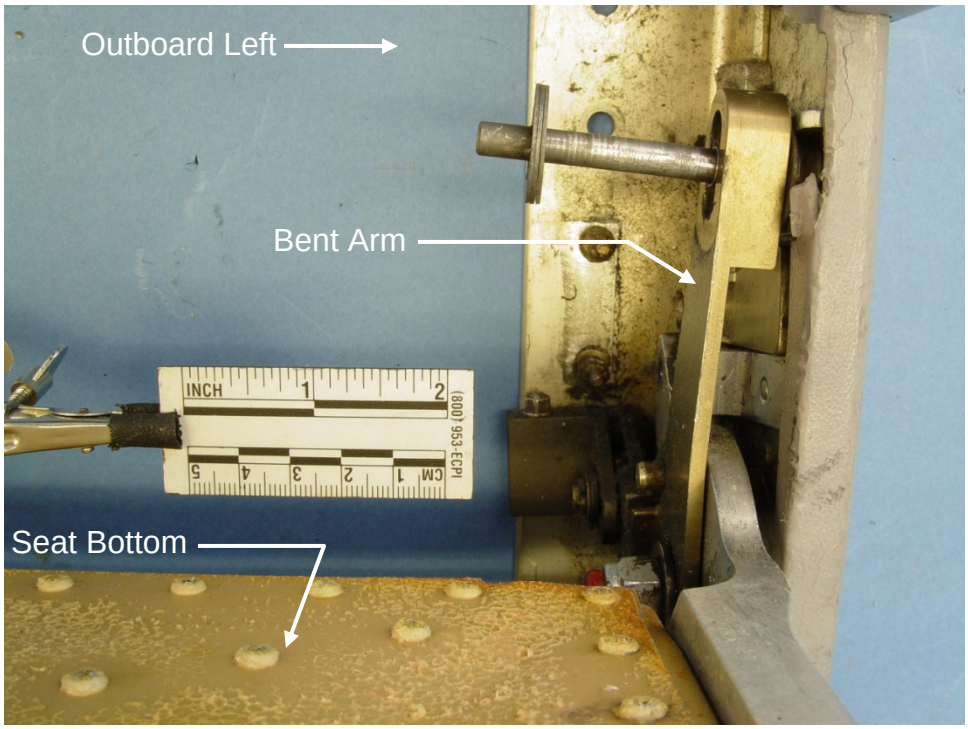


Figure 10: The seat height adjustment lock pins from the first officer's chair.

a)



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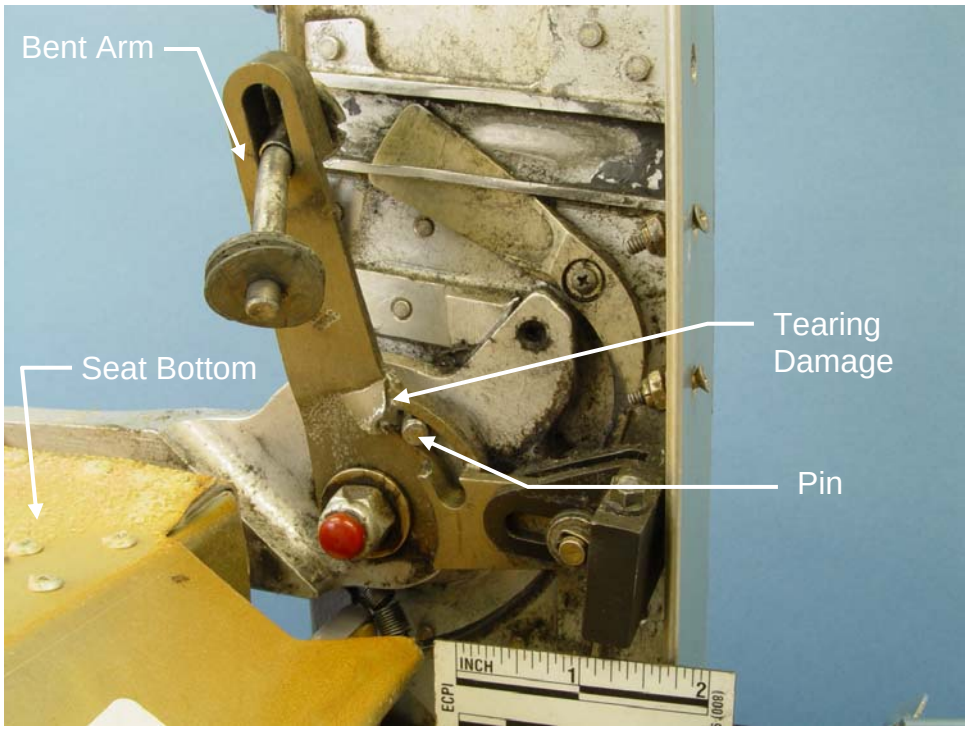


Figure 11: Photographs of the flight attendants' jump seat showing deformation to the seat back tracking mechanism; a) Left side of the seat; b) Right side of the seat.

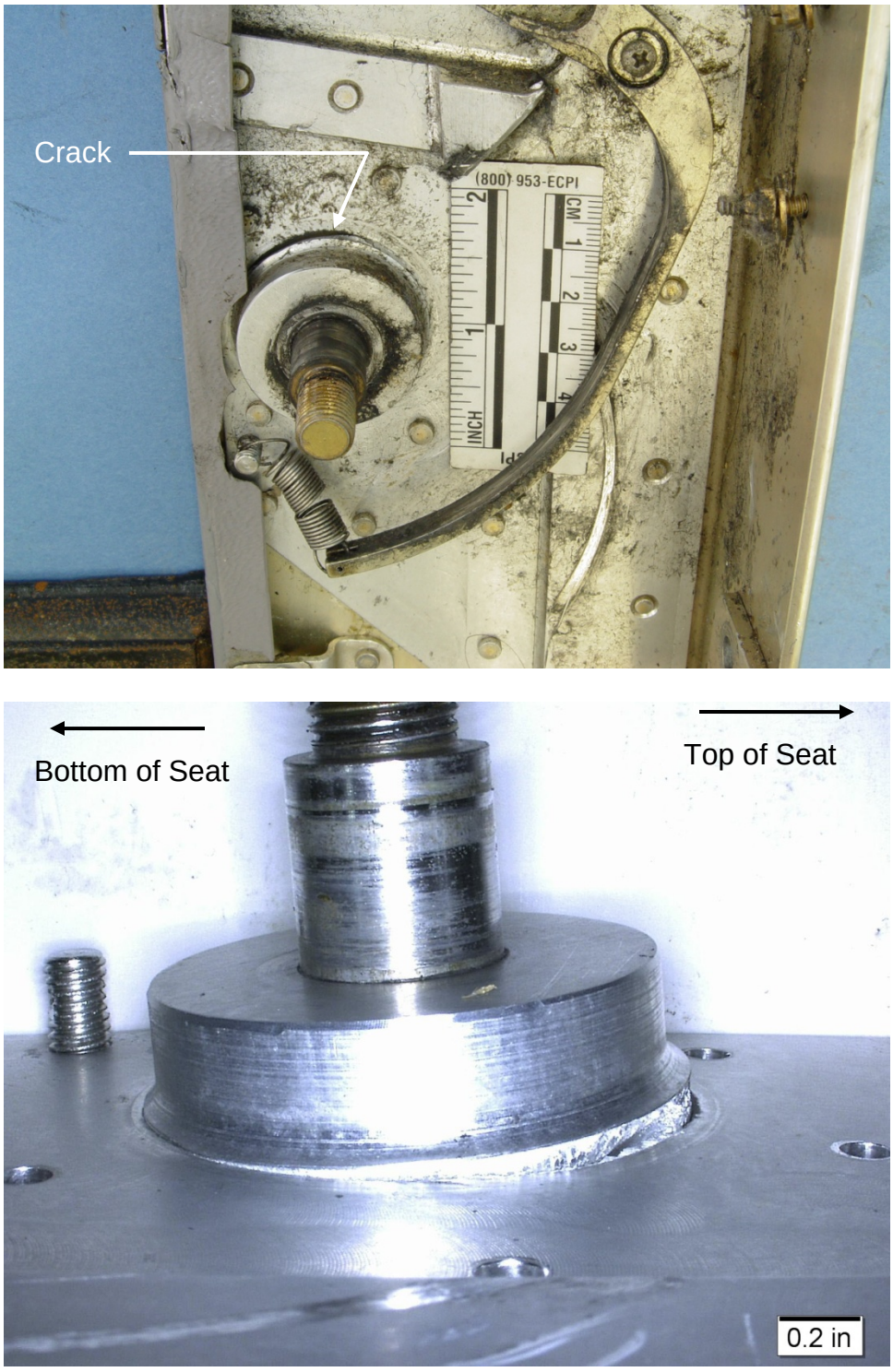
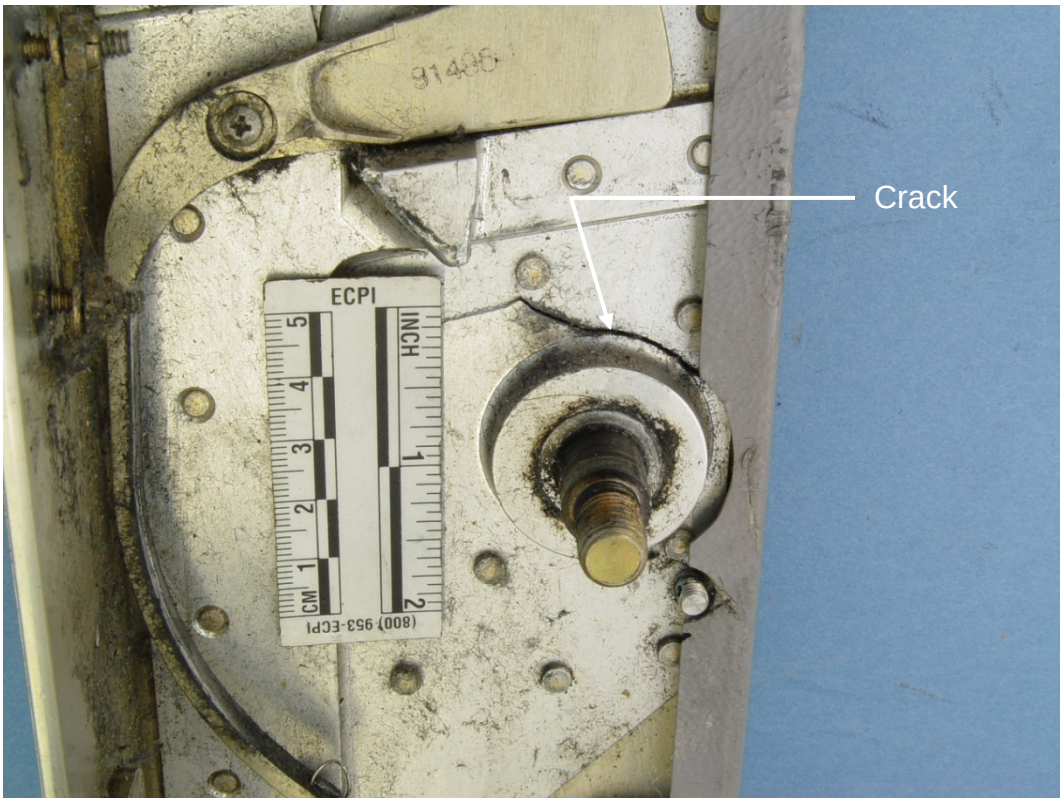


Figure 12: a) Photograph of the right side pivot plate with a crack visible at the base of the boss; b) Microphotograph of the boss viewing the 3 o'clock position.

a)



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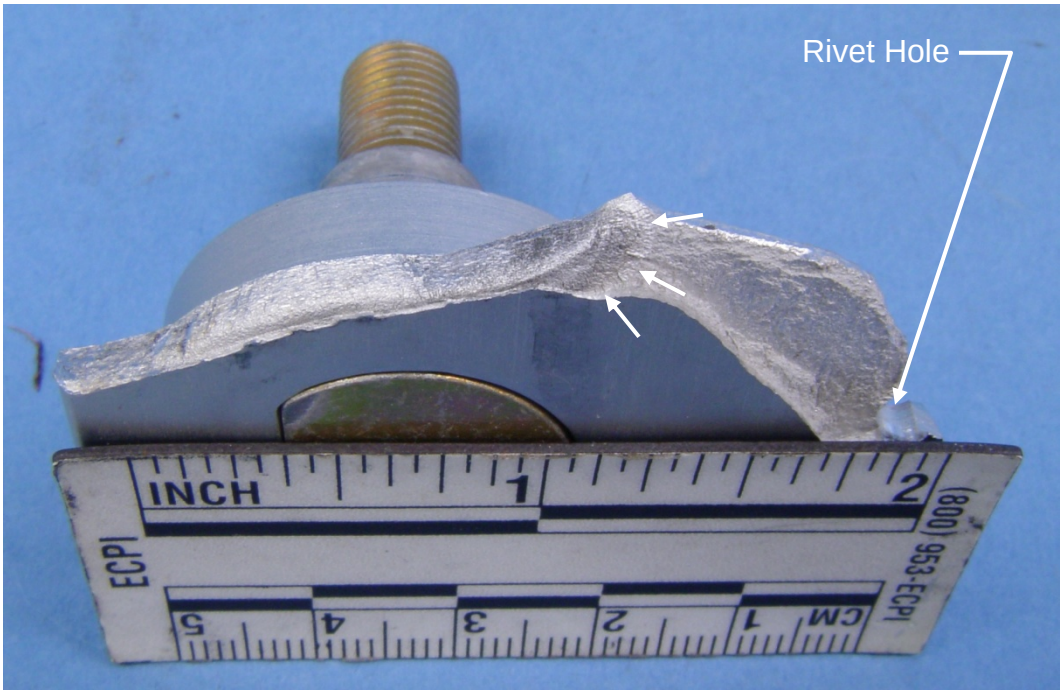
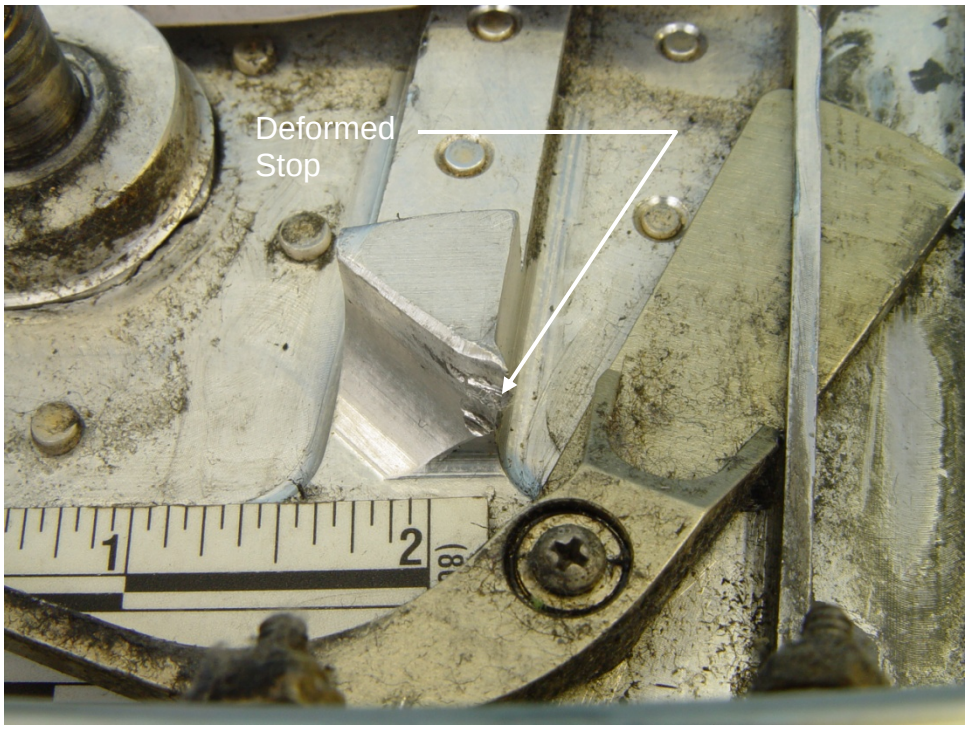


Figure 13: a) Photograph of the left side pivot plate with a crack at the base of the boss that extended into the landing; b) Photograph of the crack face viewed from the backside of the pivot plate.

a)



b)

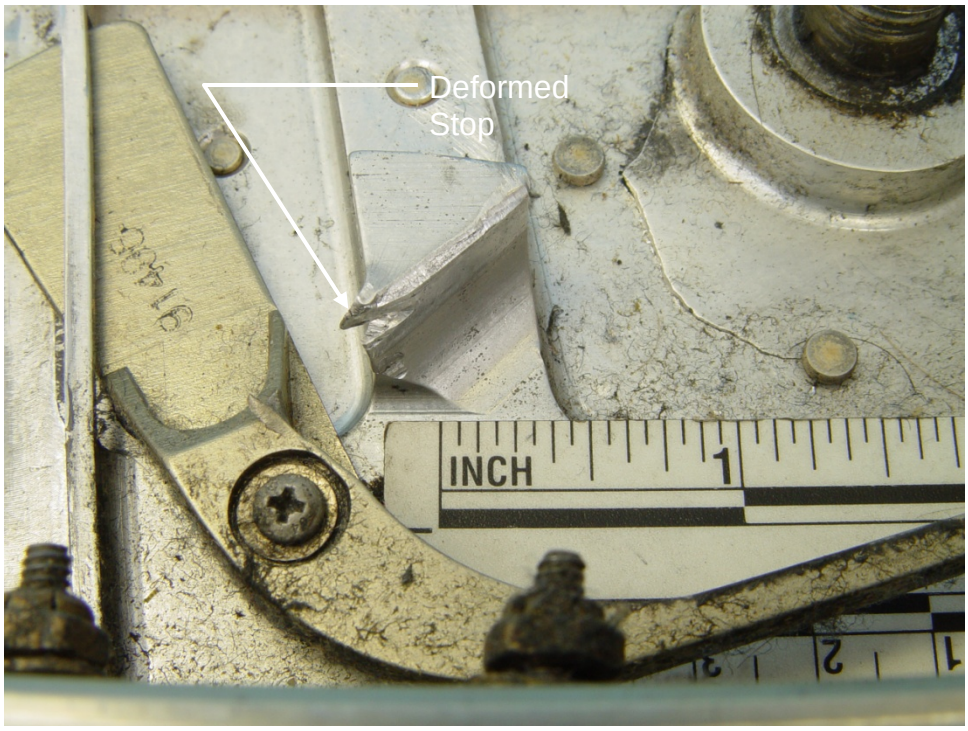
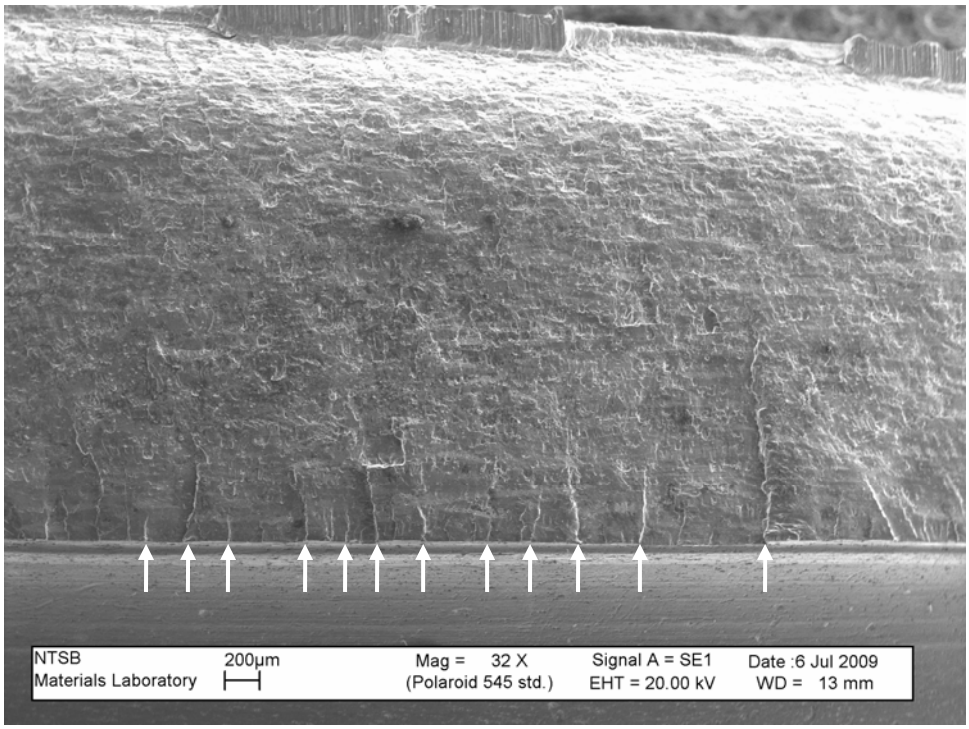


Figure 14: Photographs of the deformed seat stops; a) Right side; b) Left side.

a)



b)

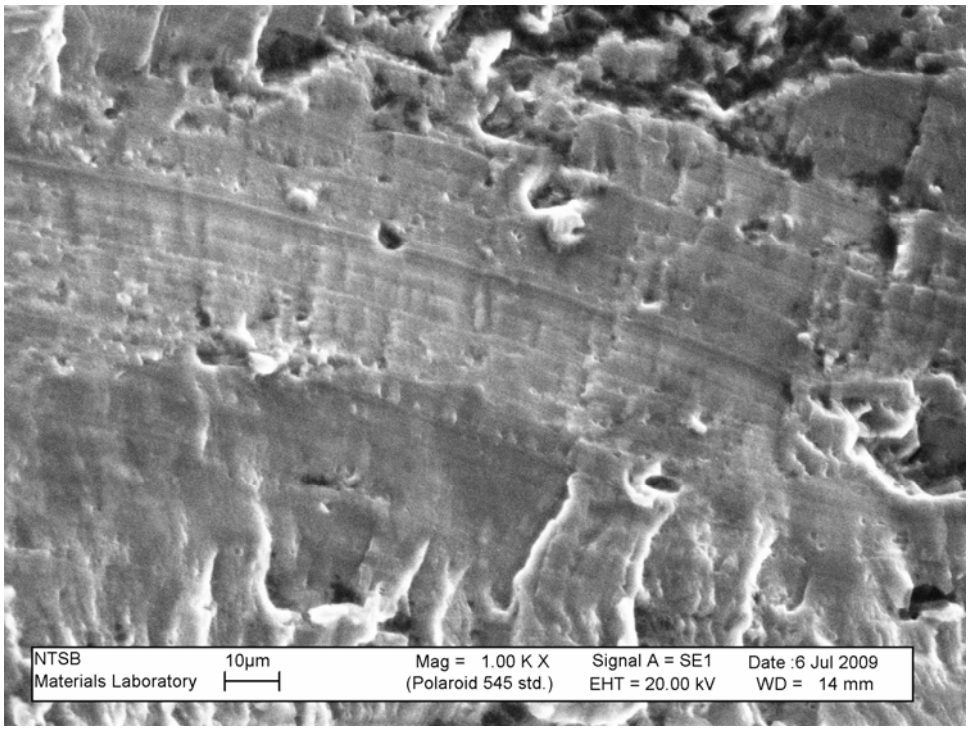
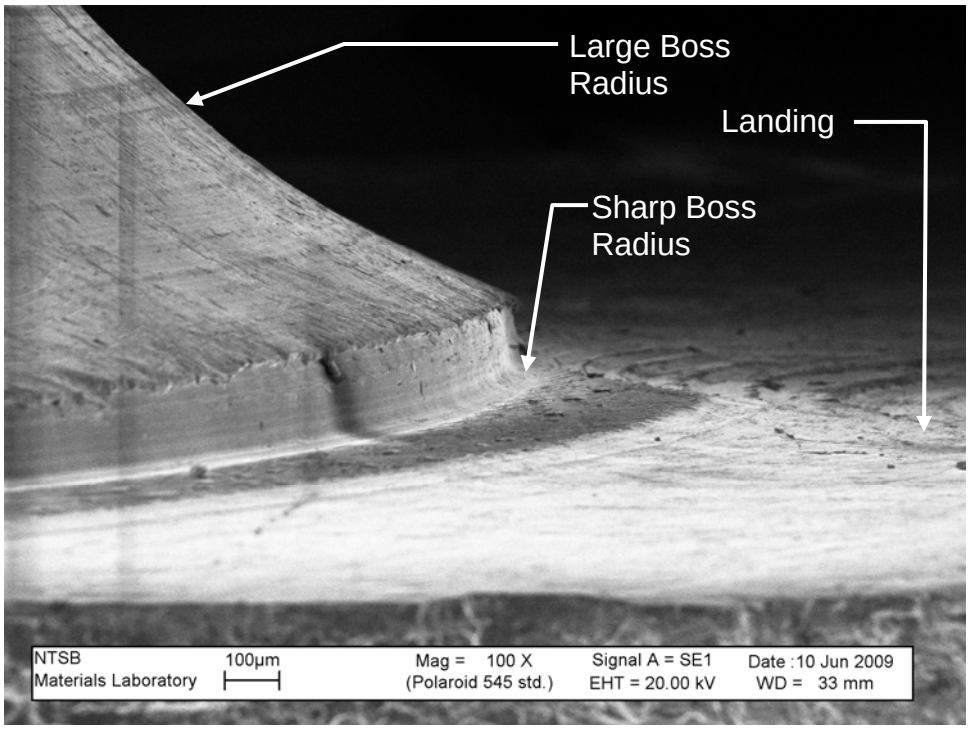


Figure 15: SEM micrographs of the fatigue crack at the 12 o'clock position of the right side pivot plate boss; a) Arrows indicate the location of some of the ratchet marks; b) Fatigue striations.

a)



b)

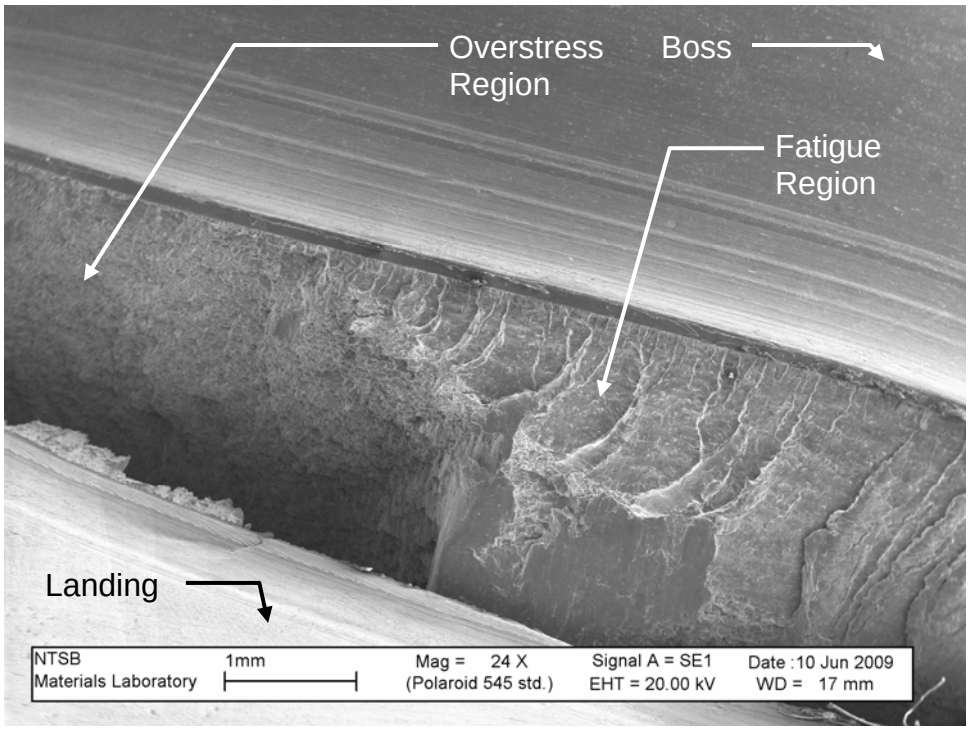
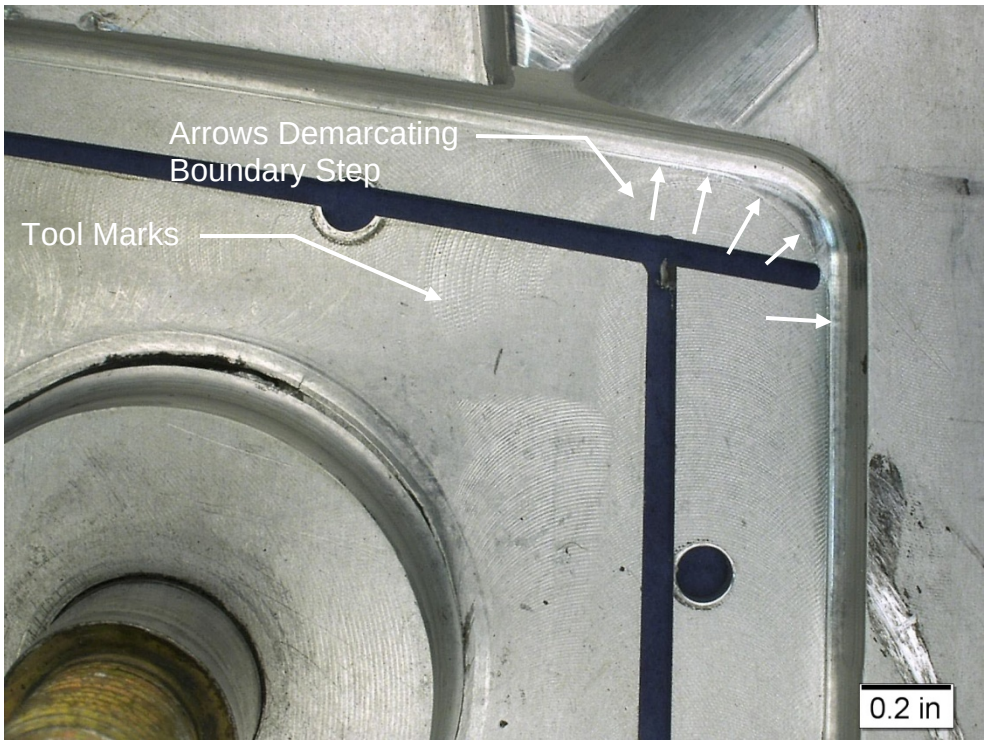


Figure 16: a) SEM micrograph of the right side pivot plate showing the profile of where the radius at the base of the boss blends with the flat landing; b) SEM micrograph at the 1 o'clock position showing the transition from fatigue to overstress crack propagation.

a)



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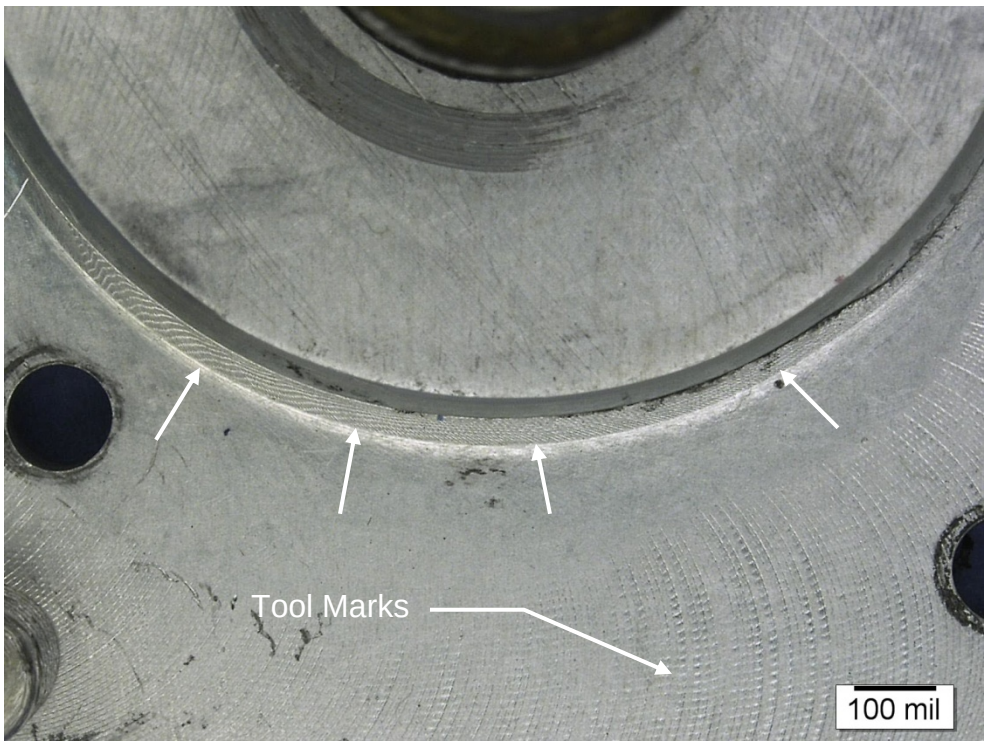


Figure 17: Microphotographs of the right side pivot plate landing; a) Tool marks were visible on the landing and a step was created at the landing edge; b) Tool marks on the landing at along the base of the boss at the 6 o'clock position.

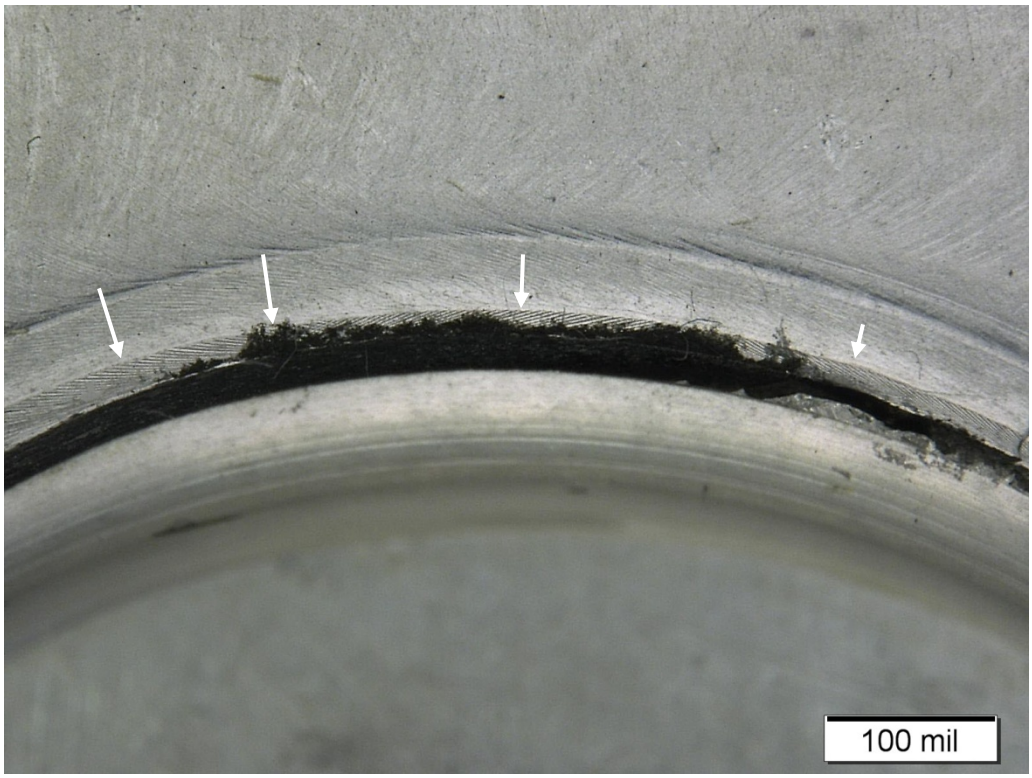
c) 

Figure 17 (cont.): c) Tool marks at the base of the boss where the fatigue crack initiated.