NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Washington, D.C. 20594

April 7, 1998

MATERIALS LABORATORY FACTUAL REPORT Report No. 98-078

A. ACCIDENT

Place : Monterey, California
Date : October 13, 1997
Vehicle : Experimental Long EZ
NTSB No. : LAX98-F-A008
Investigator : George Petterson(LAX)

B. COMPONENTS EXAMINED

1) Imperial Fuel Valve from Accident Aircraft
2) Exemplar Valve for Reference

C. DETAILS OF THE EXAMINATION

General

An overall view of the accident components submitted for examination is shown in figure 1. The exemplar valve is not shown and was to demonstrate (by manipulation) how the valve operates and to show the original configuration of the valve stem.

The valve (item "A", figure 1 and shown at higher magnification in figure 2) and selector handle (item "C") were originally connected by two tubes (arrowed "1" and "2") with a universal joint in the middle (arrow "U"). The tubes are fastened to the fittings with sleeves having either rivets, bolts or in the case of the handle a screw aligned transverse to the tube. One of the two separations in the assembly occurred in the valve stem (arrowed "A", figures 1 and 2) where it attaches to the sleeve (at the position arrowed "A1" in figure 1). The other separation was on tube "1" at the position arrowed "B" in figure 1 where it connects to the universal joint at the location depicted by arrow "B1". Tube 1 appeared to be made of an aluminum alloy and tube 2 appeared to be steel.

Valve Position When Received

The valve contained markings indicating engine (E), left (L) and right (R) ports. The ports contained fittings when received (as shown in figure 1) but these fittings were subsequently removed (as shown in figure 2) to view the internal portion of the valve.

Figures 3 and 4 show the internal portion of the valve viewed looking into the ports from the outside.

The engine port displayed two portions of circular holes as shown in the top view of figure 3. The larger circular portion (approximately 1/3 exposed) was oriented on the left port side of the valve and the very small portion of the circular opening (estimated to be less than 5% of the circular opening) was oriented on the right port side.

The right port opening (middle photograph figure 3) displayed only a single portion of a circular opening (also about 1/3 exposed) oriented toward the engine port side of the valve.

The left port (bottom photograph, figure 3) showed only a very small portion of the circular opening exposed (estimated to be 2-4%) in the area of arrow "L". This opening is detailed in a higher magnification view in figure 4. In viewing the right port opening from the outside, the inside exposed hole for the left port can be seen (arrowed "IL", figure 3). Both openings "L" and "IL" are the same only viewed from opposite directions.

Valve Stem

Exemplar Valve Stem

The valve stem on the exemplar valve is displayed in figure 5. The round stem (approximately 0.315 inches in diameter) contains 3 machined flats on the last ¼ inch of the shaft. At the end, a threaded hole is tapped in the center of the shaft. The flat to flat dimension measured approximately 0.25 inch and the threaded hole measured approximately 0.17 inch on the thread root diameter.

Accident Aircraft Valve Stem Connection

The valve stem was connected to the cylindrical tube "1" through a dual sleeve both of which overlapped the valve stem. Sleeves and stem were secured together with two transversely positioned rivets oriented 90 degrees to each other.

Accident Aircraft Valve Stem Separation

Details of the valve stem separation on the valve side are shown in the two views of figure 6. The mating separation of the stem was located within the sleeve as shown in figure 7. For reference purposes the rivets securing the sleeve to the valve stem were arbitrarily identified as "a" (closest to the valve) and "b" (furthest from the valve). In figure 6 the remnants of the hole for the "a" rivet are indicated by brackets "ha". Unmarked arrows in this figure locate the machined flat areas previously mentioned for the exemplar valve stem. Rivet hole remnant for the "b" rivet is located by bracket "hb" in figure 6. A deformation mark (arrowed "D", figure 6) was found over about ½ of the circumference of

the circular valve stem shaft This deformation was located approximately ¼ inch from the base of rivet hole remnant "ha".

Magnified examination of the valve stem separations showed what appeared to be a relatively undamaged fracture on one side of the stem extending between opposing sides of rivet hole "ha". This fracture corresponded (mated) to a relatively undamaged fracture retained within the sleeve. The mating areas of this fracture are indicated by "x" in figures 6 and 7. On the other side of the stem the separation surface was heavily smeared and oriented in general on an angled plane between rivet holes "ha" and "hb" (indicated by bracket "y" figure 6 and arrow "y" figure 7). A small portion of the separation (bracket and arrow "z") was noted on the other side of the rivet "b" location.

Valve Stem Remnant Removal from Sleeve

In order to view the valve stem interior separations within the sleeve an attempt was made to remove rivet "b". Both the head and tail of the "b" rivet were removed by drilling and a punch was used to try to excise the rivet. This attempt did not remove the rivet and it was thought that other means would be better to get at the internal portions with minimal damage. The sleeve containing the valve stem remnant was then sectioned longitudinally in half with a slow speed diamond saw along the approximate plane indicated by the dashed line in figure 7. This plane was approximately through the longitudinal center of rivet "a".

Figures 8 and 9 show both sides of the sectioned sleeve compared to the original side views of the sleeve in the same orientation (before attempting to remove rivet "b"). The section exposed showed that rivets "a" and "b" were notably bent along their longitudinal axis and were actually in contact with each other where they crossed. Figure 10 displays the section after rivet "a" was removed allowing for better viewing of the fracture and rivet hole. Remnants indicated by arrows "x", "y" and "z" in figures 9 and 10 contained the fractures similarly indicated in figure 7. The small piece arrowed "z" in figure 10 is shown at higher magnification on the right. Brackets "f" and "h" denote the fracture and hole wall surfaces, respectively. It was clear that the saw cut did not go through any fracture or separation in the valve stem.

Examination of Valve Stem Remnants

The valve stem remnants arrowed "x", "y" and "z" in figure 10 were carefully removed with tweezers from the sectioned pieces, ultrasonic cleaned in acetone and examined with the aid of a scanning electron microscope (SEM). Figure 11 shows a low magnification SEM view of fracture "x". Most of the fracture contained ductile dimples typical of a ductile overstress separation. Energy dispersive x-ray analysis (EDXA) of this fractured area indicated the material was a copper (54%) zinc (36%) alloy containing small amounts of lead (5%), iron (2%) and oxygen (3%). The % indicated is by weight and suggests this alloy is a leaded brass.

One corner of the fracture within the dashed line area arrowed "X1" in figure 11 contained heavy deposits such as those shown in figure 13. EDXA indicated these deposits were rich in iron, oxygen, sodium and chlorine with significant amounts of magnesium.

Another isolated area of fracture (in the area of arrow "X2" in figure 11) displayed a striated surface morphology as shown in figure 14. Spot EDXA analysis indicated a notable difference in iron concentration within highly localized portions the area.

The fracture on piece "y" displayed only ductile dimples and SEM examination of piece "z" disclosed no discernable fracture features (heavily smeared).

Putting Valve Stem Pieces Together

Figure 15 shows the valve stem with the extricated pieces placed relative to the shaft by fracture matching. This assembly showed that the hole containing rivet "a" was misshaped on the tail side of the rivet. Also, there appeared to be damage to the valve stem surface in the area of the bracket suggestive of rotational contact with another object such as the mating sleeve.

Tube "1" Separation

Figure 16 displays the fracture of the tube in the area of arrow "B" in figure 1. The outside diameter surface within about ½ inch adjacent to the fracture appeared to have been ground (see bracket, figure 16) to reduce the overall diameter. The fracture appeared typical of an overstress separation with the plane of fracture indicating a compressive buckle.

Michael L. Marx
Chief Technical Advisor: Metallurgy & FA

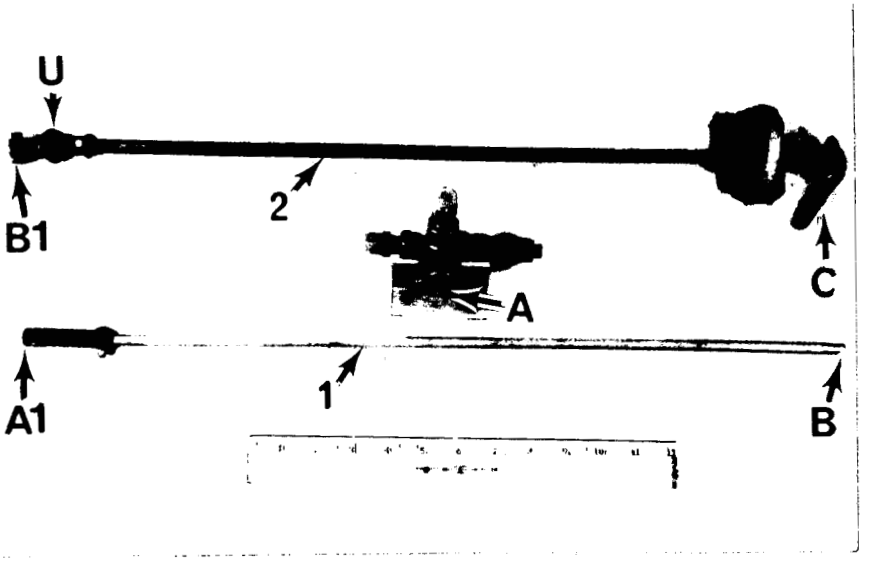


Figure 1. Overall view of the accident aircraft components as received for examination.

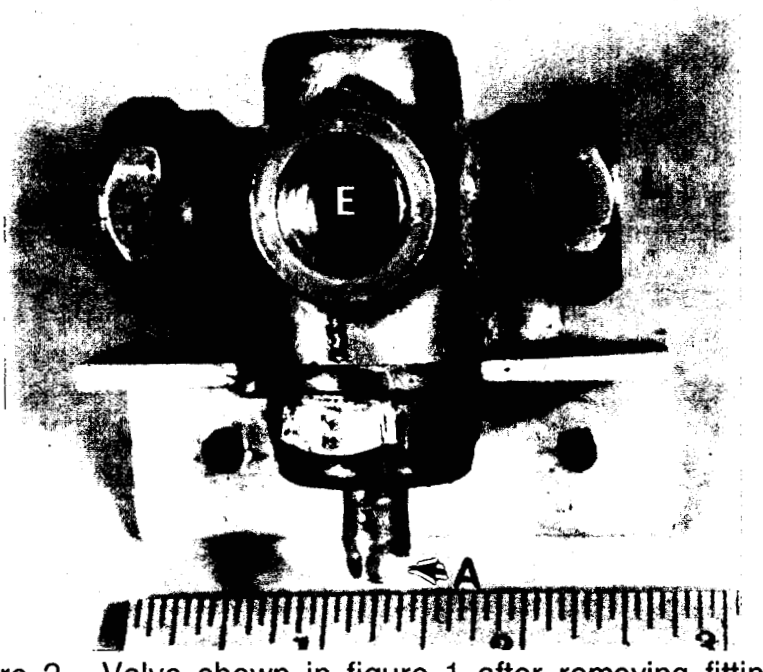


Figure 2. Valve shown in figure 1 after removing fittings protecting the ports. Arrow "A" denoted fracture on the valve stem. Letters "E", "R", and "L" locate the ports identified as engine, right and left, respectively. Approximately X1.

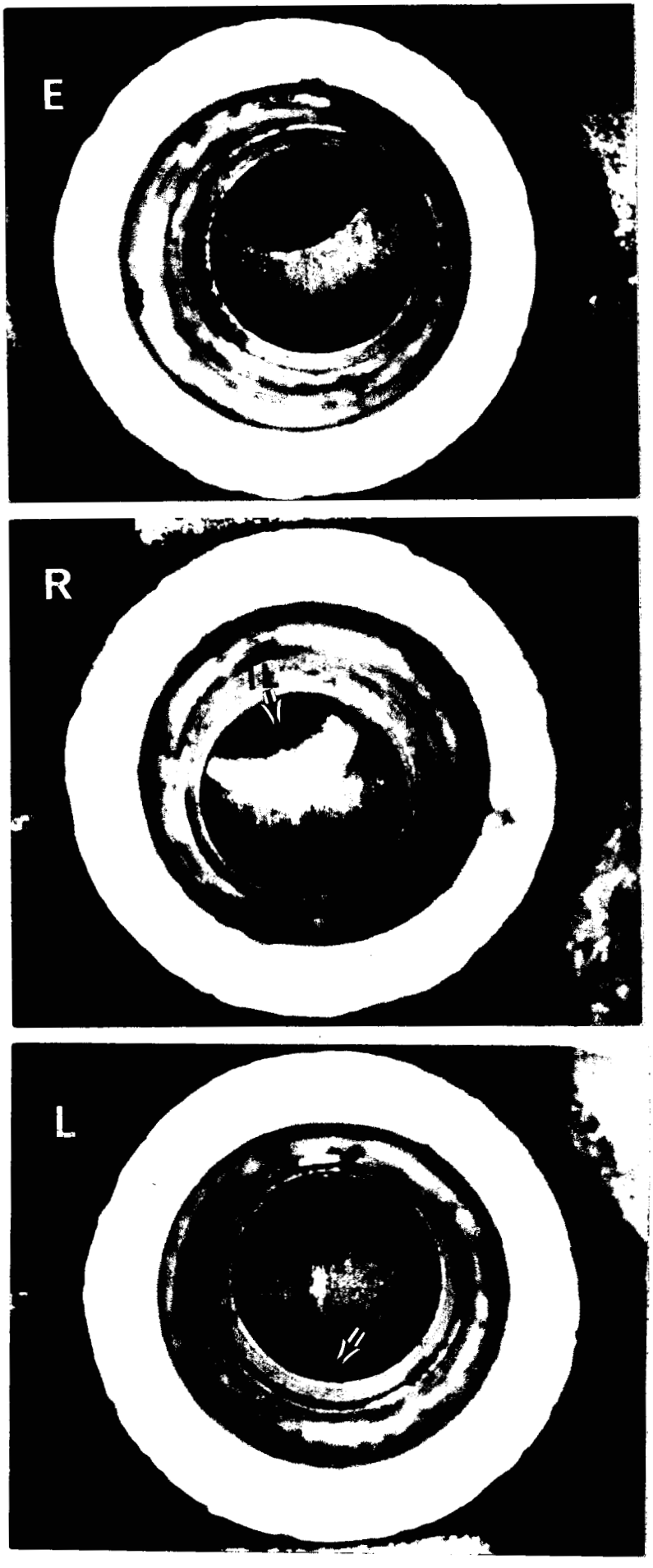


Figure 3. Views looking from the outside into the valve ports (see figure 2 for orientation). Valve stem location in all views is to the right and all photographs are approximately X 3.75

Figure 4. Detail of the lower photograph in figure 3 at arrow "L" to show the small opening in the left port. In this view a light was directed in from the right port side. X12.5

Figure 5. View of the exemplar valve stem to show shape before assembly. X 3.75

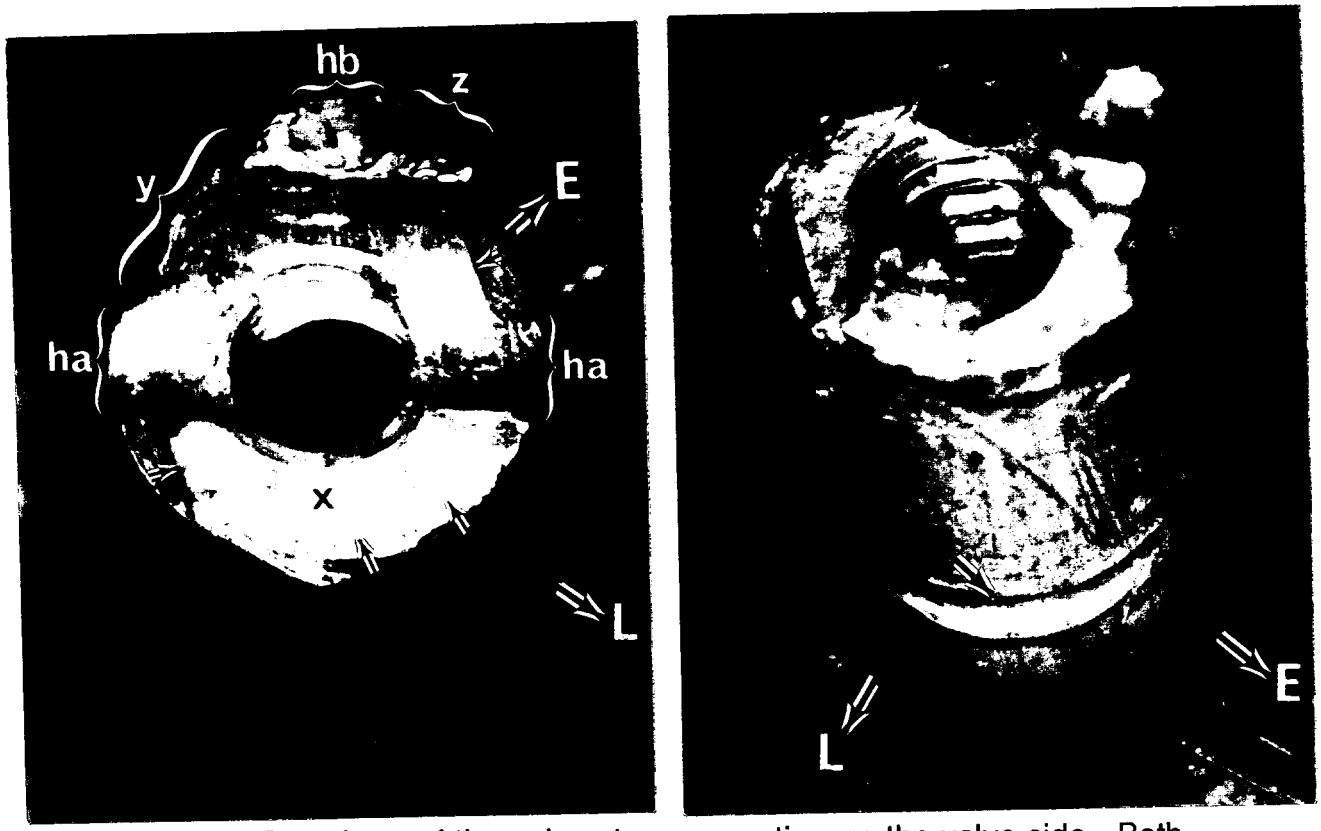


Figure 6. Two views of the valve stem separation on the valve side. Both photographs approximately X7.5

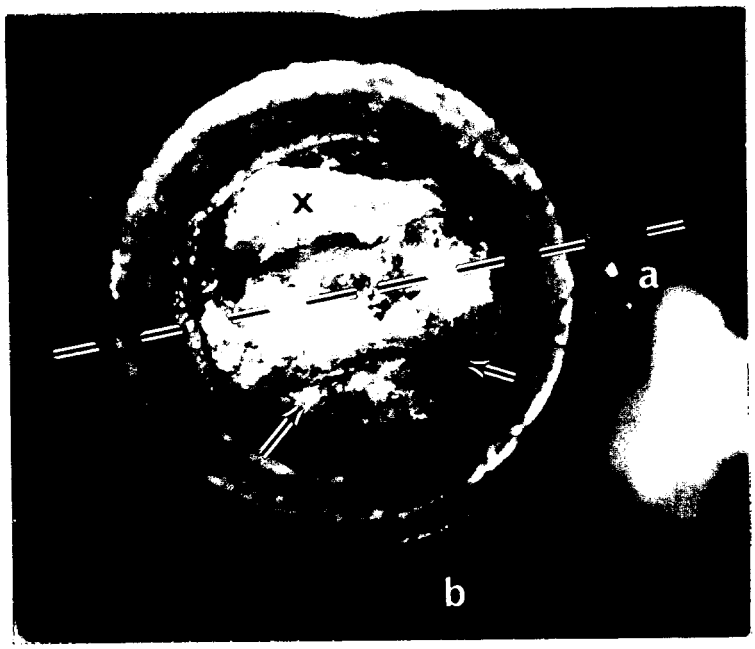


Figure 7. View looking into the sleeve (at area arrowed "A1", figure 1) showing the separation of the valve stem still retained in the sleeve. X 3.75

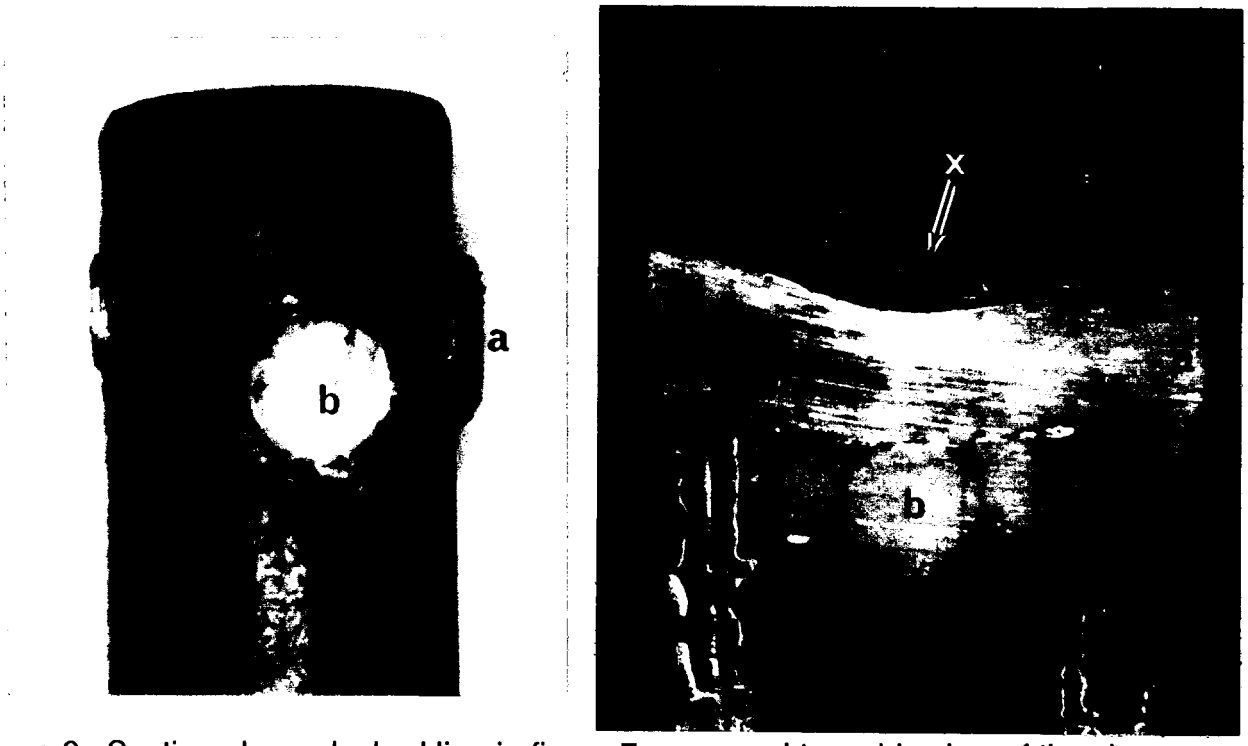


Figure 8. Section above dashed line in figure 7 compared to a side view of the sleeve as received in the same orientation. Left photo X 3.75 right photo approximately X5

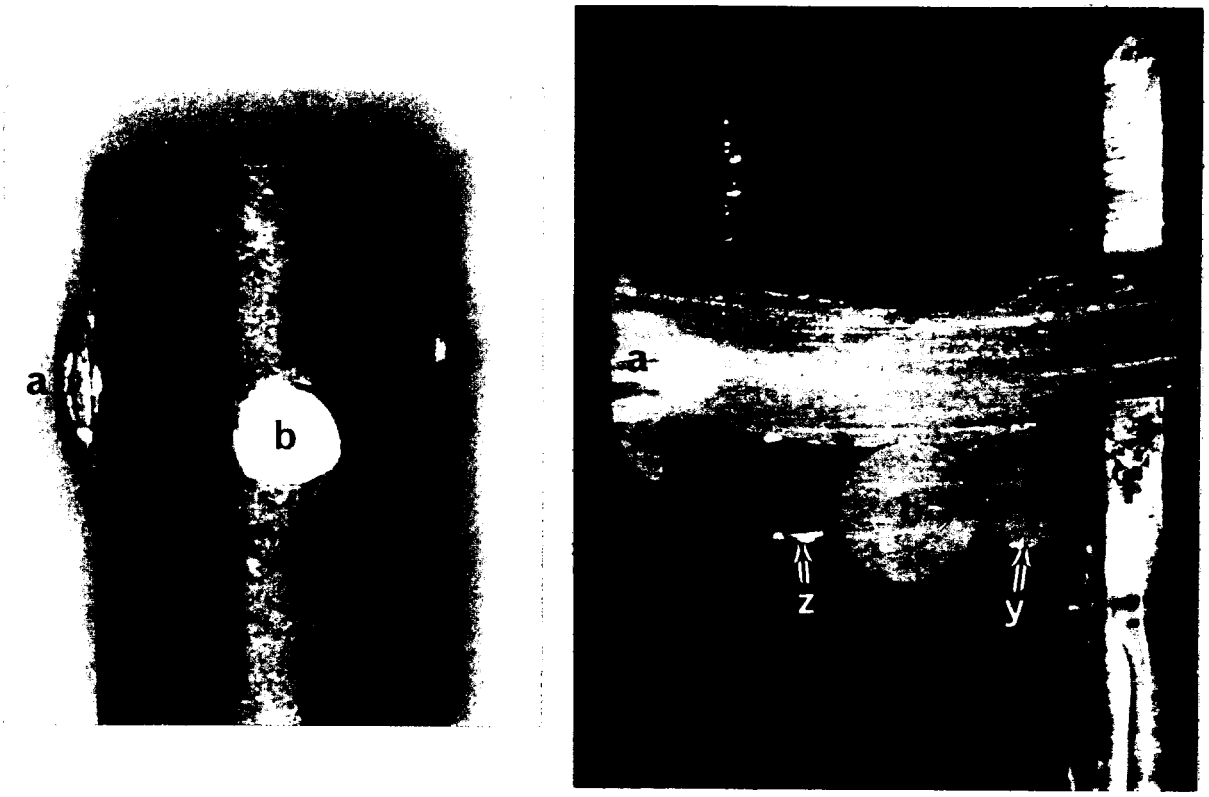


Figure 9. Section below dashed line in figure 7 compared to a side view of the sleeve as received in the same orientation. Left photo X 3.75 right photo approximately X5

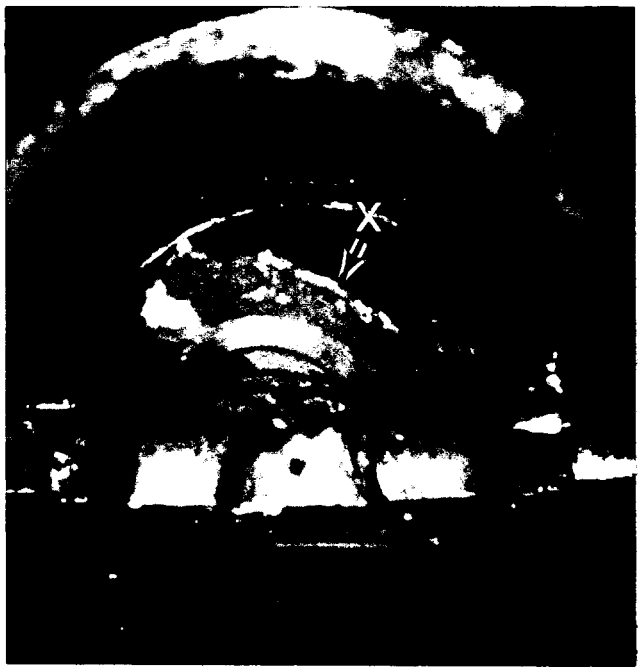
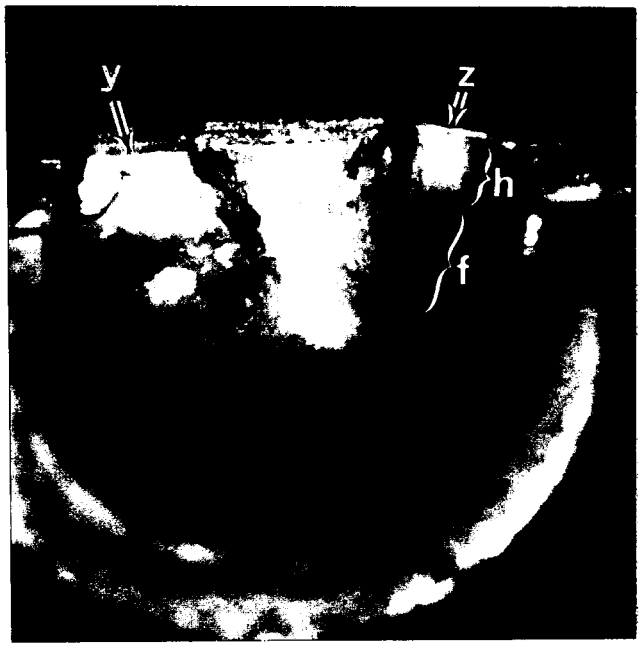


Figure 10. Section halves shown in figures 8 and 9 after removing rivet "a". Sections placed relative to each other in the left views (X7.5). Right photograph shows detail (X20) of area by arrow "z" in left photograph.



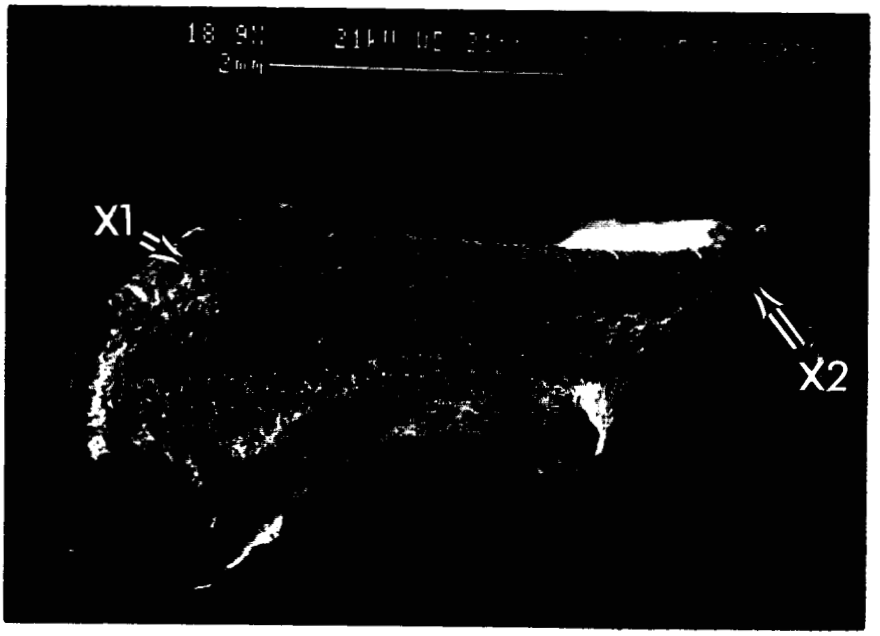


Figure 11. SEM view of the fracture identified by arrow "x" in figure 10 after removal from the section. (X18.9)

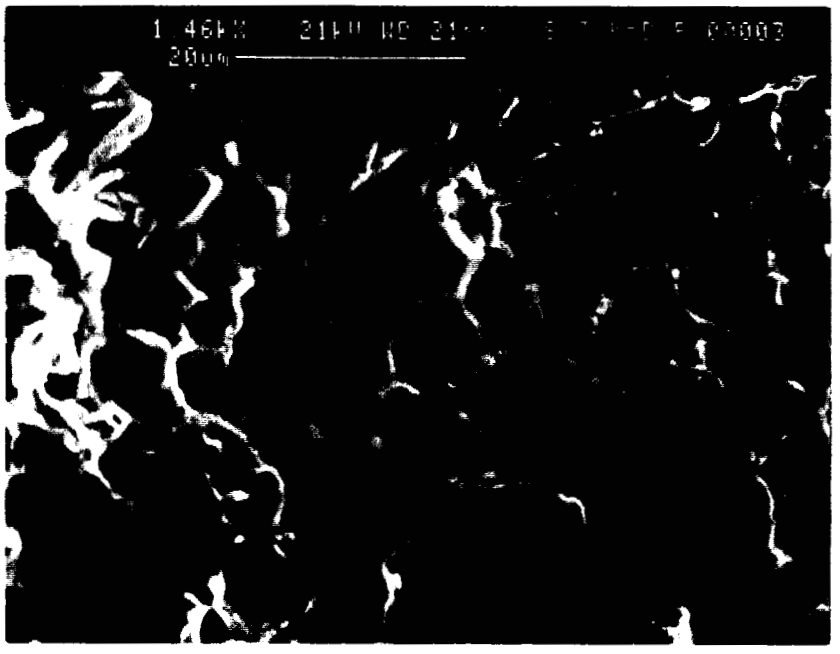


Figure 12. High magnification view of the fracture shown above in the central area just off the thread root. (X 1,460)

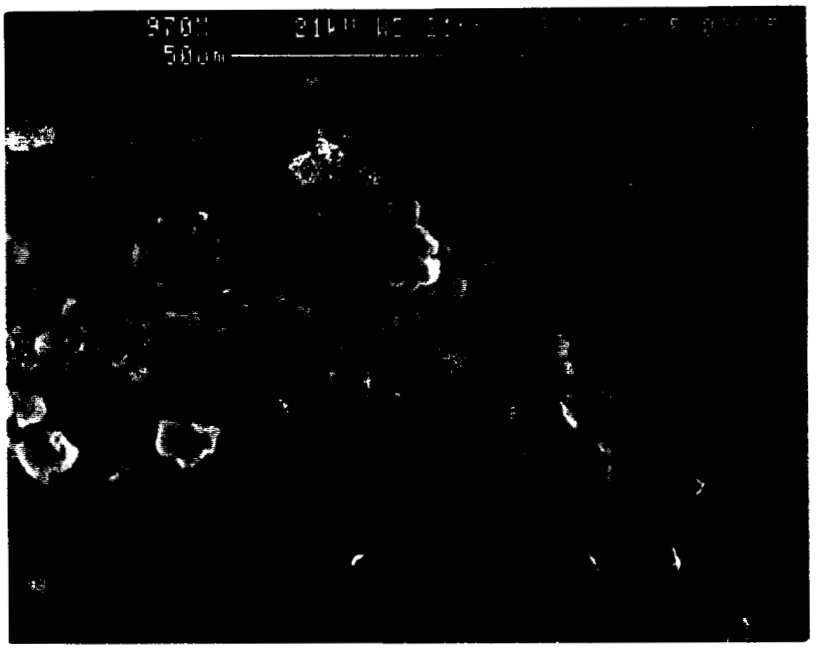


Figure 13. Example of deposits found on the separation in the area shown by arrow "X1" in figure 11. (X970)

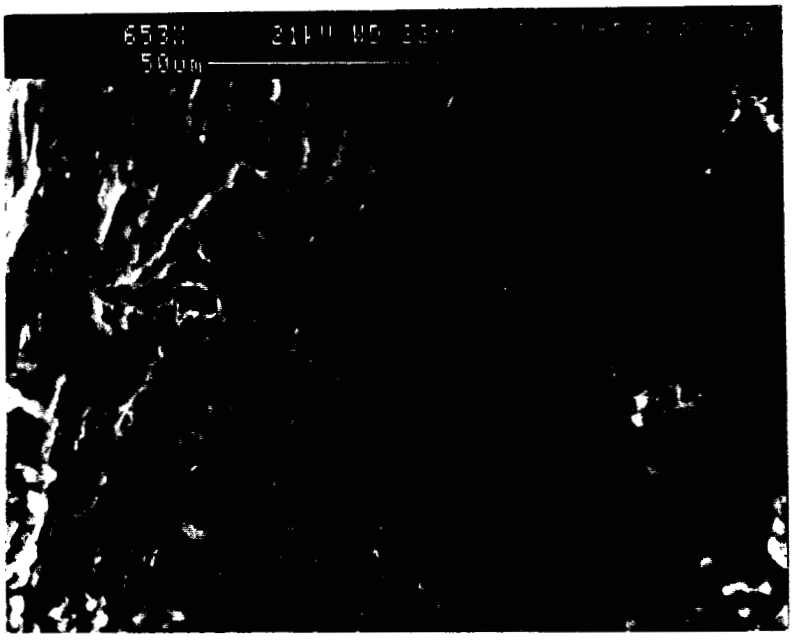


Figure 14. Typical separation features found in the area of arrow ""X2" in figure 11. (X 653)

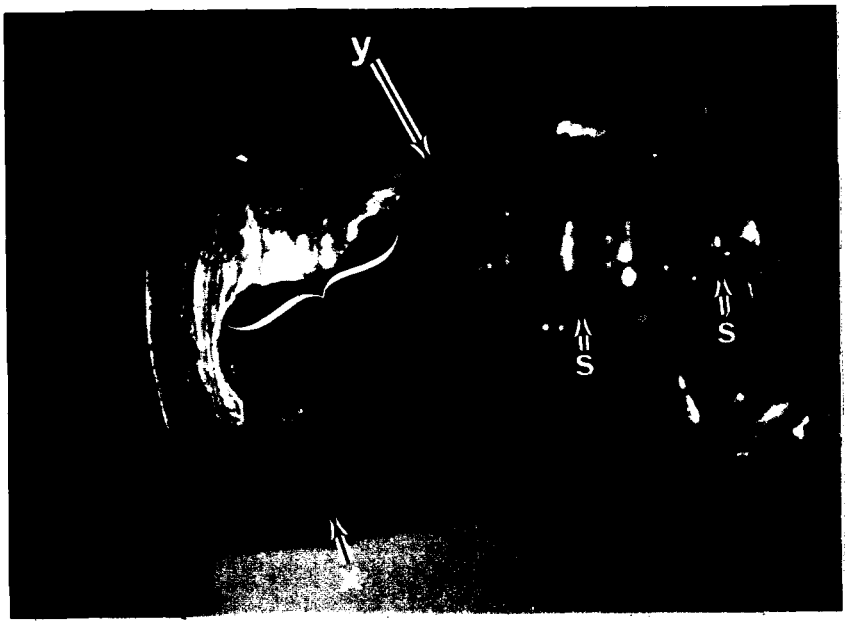


Figure 15. View of the valve stem with the pieces removed from the sleeve and situated next to the shaft (using scotch tape). Arrows "x" and "y" denote the separation areas indicated the same in figures 6 through 10 and arrows "s" denote the saw cuts made to extract the valve stem remnants from the sleeve. Note the hole for rivet "a" is misshaped (side shown corresponds to the tail side of rivet "a'). (X7.5)

Figure 16. Separation of tube '1" in the area of arrow "B" in figure 1. Note grinding marks on shaft in area of the bracket.