

NATIONAL TRANSPORTATION SAFETY BOARD

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



March 17, 2008

MATERIALS LABORATORY FACTUAL REPORT

Report No. 08-022

A. ACCIDENT

Place : King Salmon, Alaska
Date : September 30, 2007
Vehicle : Helio H-295
NTSB No. : ANC07FA109
Investigator : Clint Crookshanks, AS-40

B. COMPONENTS EXAMINED

Carry-through structure and inboard portions of wing forward spars and fractured left wing upper bolt.

C. DETAILS OF THE EXAMINATION

An overall view of the as received carry-through structure and adjacent portions of the left and right wing forward spars are shown in figure 1. The structure was separated at the left wing forward spar attachment to the carry-through structure as indicated in figure 1. The corresponding area of the right wing forward spar remained attached to the carry-through structure.

At the lower spar caps, the wings are attached to the carry-through structure by wing fittings mounted on the forward and aft sides of the spars that form clevises. The carry-through has single lug fittings inserted into each wing clevis and connected with longitudinal shear pins. Initial examinations found both fittings of the left wing fractured through the holes for the pins. The inboard portions of the clevis remained trapped within the carry-through structure. The upper caps of the wing spars are joined to the carry-through by transverse bolts threaded into barrel nuts contained within the wing structure. The left wing bolt was fractured through the shank adjacent to the barrel nut. The threaded outboard end of the bolt remaining in the barrel nut, and the shank and head portion of the bolt was received separate. Figure 2 shows an overall view of the inboard end of the left wing forward spar with the lower clevis fractures and upper bolt separation indicated.

Examination of the fractured bolt from the upper attachment position revealed rough surface features with overall and local deformation patterns consistent with overstress fracturing from bending loads. The orientation of the outboard fracture trapped within the barrel nut was consistent with upward bending of the left wing relative to the carry-through

structure. Further, the mating faces of the left wing spar upper cap and carry-through were damaged consistent with compression contact during excessive bending.

The left wing lower spar cap attachment was partially disassembled, and the inboard portions of the fractured fittings were removed. The fracture faces of the removed pieces were covered by both red and black corrosion products, and exterior areas had remnants of primer and top coat paint. Acetone cleaning with ultrasonic agitation removed most of the loose corrosion products, all of the top coat paint and most of the primer.

Although heavily corroded and darkened, magnified examinations of the fractured left wing fittings revealed generally smooth, flat fracture regions with crack arrest markings typical of fatigue cracking on the fitting fractures below the bolt holes. The fractures above the bolt holes showed large shear lip formations, adjacent bulk yielding and fracture features indicative of overstress separations. The wing side faces of the fitting fractures are displayed in figure 4 with the fatigue regions denoted. Figure 5 shows a higher magnification view looking outboard at the fatigue fractures below the bolt holes. Both fatigue fracture areas contained several ratchet marks¹ adjacent to bore surface of the pin hole, indicating multiple initiation sites on the bore surface. Extensive corrosion of the fracture and adjacent surfaces prevented establishing the exact locations and number of fatigue origins. Some of the origin locations are indicated by arrows in figures 5 and 6. Fatigue features extended downward from the origin areas through approximately 70% (about 0.41 inch) of the aft fitting fracture and about 80% (about 0.49 inch) of the forward fitting fracture. Approximate fatigue termini are indicated by the dashed lines in figure 6. The fracture regions below the fatigue were on slant planes with rougher features, typical of overstress separations.

Both fitting bore surfaces showed extensive surface corrosion with little original surface remaining, as shown in figure 7. The original surface that was present was also severely corroded. The corrosion appeared as general surface wasting with only a few shallow pits formed. A transverse metallographic section through the aft fitting revealed that the bore surface contained a relatively uniform layer of corrosion products and widely spaced shallow (0.001 inch) corrosion filled pits as displayed in figure 8 (a). In addition, an oxide filled crack was uncovered adjacent to the fracture surface as shown in figure 8 (b) and (c). The crack measured approximately 0.016 inch deep.

Hardness measurements performed on the inboard pieces of both left wing fittings averaged 40.8 HRC for the forward fitting and 40.7 HRC for the aft fitting. The engineering drawing, p/n 391-010-462, for the fitting specified 40-43 HRC (180,000 to 200,000 psi).

The faces of the fitting pieces also displayed corrosion to various extents. On the exposed faces (forward face of forward fitting and aft face of the aft fitting) of the fittings, shown in figure 9 (a), the corrosion had removed local areas of the cadmium plating and discolored the surfaces of the fittings but only a few surface penetrating pits were found. The hidden faces of the fittings (against the carry-through fitting) were more heavily

¹ Ratchet marks are vertical steps in the fracture that separate fatigue origin areas on slightly offset planes.

damaged with almost all of the plating removed and extensive pitting of the surface, as shown in figure 9 (b). In areas not previously cleaned, the top coat and primer were easily removed with acetone and light brushing. As shown in figure 10, much of the corrosion on the exposed faces had been covered by the primer and top coat paints.

The assembled right wing attachment area is displayed in figure 11. The lower spar cap fitting and the upper bolt were intact. The adjacent wing spar area had a pronounced wing tip aft bend, and the upper wing fitting was compression damaged on the aft side, consistent with the spar deformation.

A label on the carry-through structure indicated that the wing center section had been modified from original in accordance with STC SA1728CE by Brentwing Engineering. The label indicated part number B-401-1 but only a partial serial number of B-5?? was legible.

Both wing attachment areas of the carry-through structure were disassembled as displayed in figure 12. On the left side the lower through pin was frozen in the carry-through fitting and would not move even after several heavy hammer blows. Corrosion products were visible in the space between the pin and the fitting. The circumference of the pin was also heavily corroded in two bands corresponding to the locations of the wing fittings, see figure 13 (a). The cadmium plating was nearly intact on the carry through fitting and only light localized corrosion was visible on the faces.

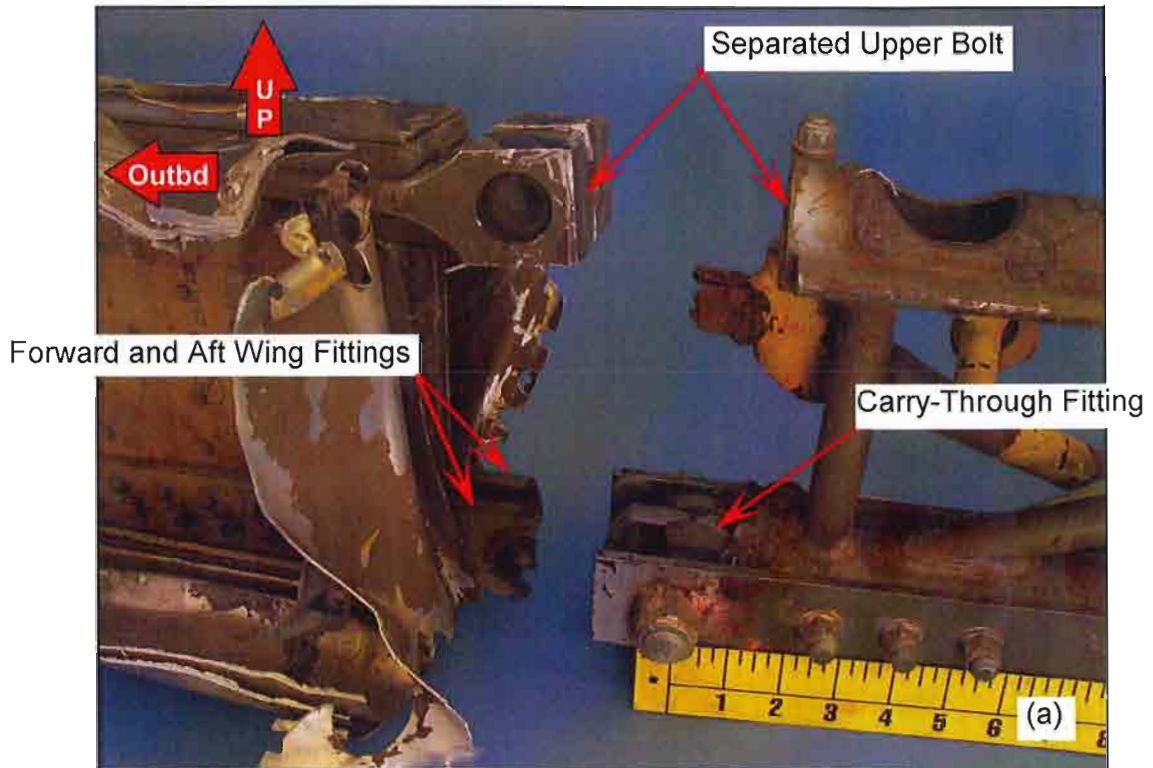
The right wing attachment was also disassembled with the through pin easily extracted from the fittings. The pin had some areas of corrosion corresponding to the locations of the wing fittings and carry-through fitting as shown in figure 13 (b). Most of the cadmium plating was intact on the fittings and only light corrosion was present. The pin bores on the wing fittings showed some corrosion but most of the original surfaces with machining marks were present and undamaged. The lower spar cap fittings from the right wing were visually examined for evidence of cracking in the areas corresponding to the fatigue cracks in the left wing, and no evidence of cracking was noted. The upper spar cap bolt was in place but found to be bent when removed. The bend direction was consistent with the rearward bend of the adjacent spar.

Joe Epperson
Senior Metallurgist



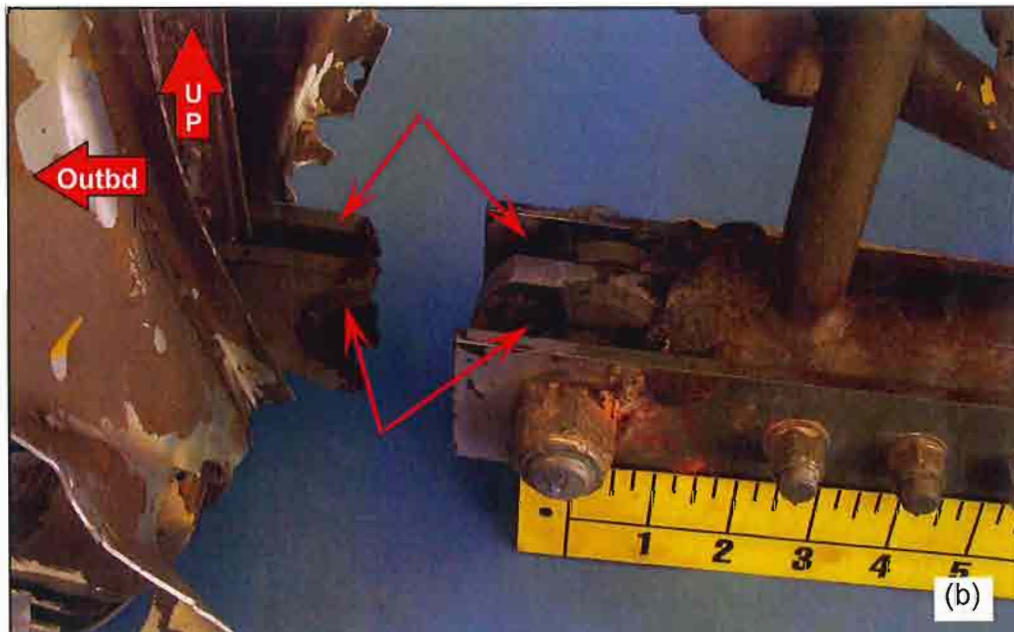
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Figure 1--The as-received structure with separated left wing and attached right wing.



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Figure 2--The separated left wing forward spar attachment area to the carry-through structure.



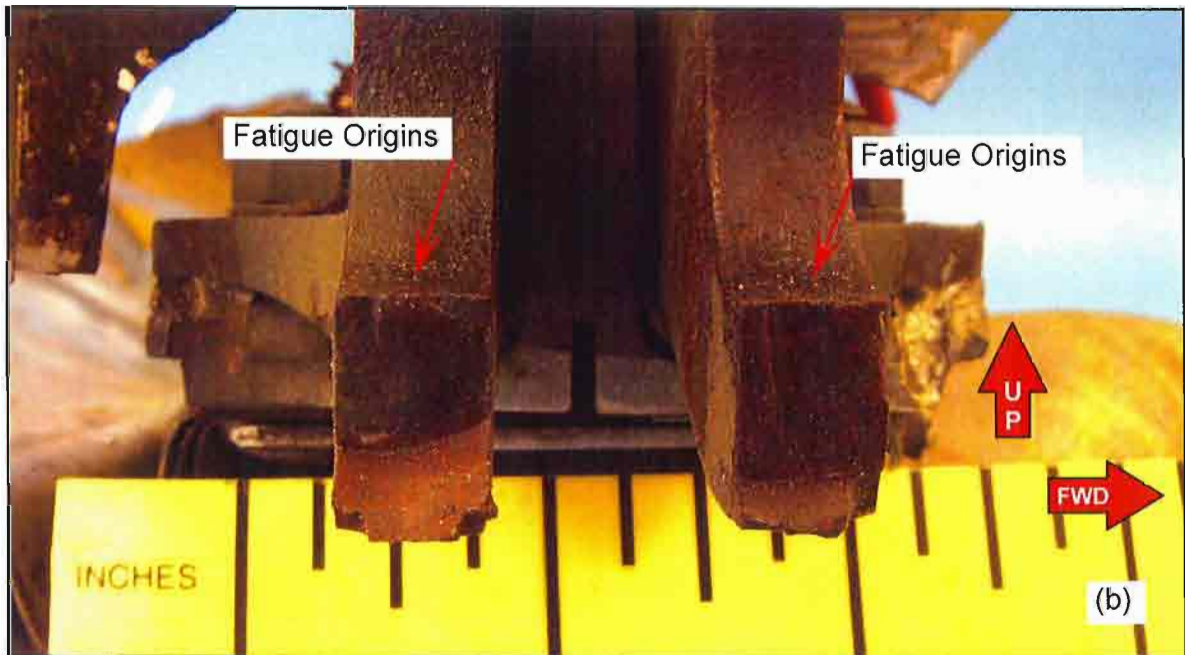
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Figure 3--The fractured lower wing fittings with arrows indicating mating fractures.



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Figure 4--The outboard fractures faces of the lower wing fittings. Looking outboard.



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Figure 5--Closer view of the fatigue fracture areas below the bolt holes on the wing fittings with approximate fatigue origin locations denoted. Looking outboard.

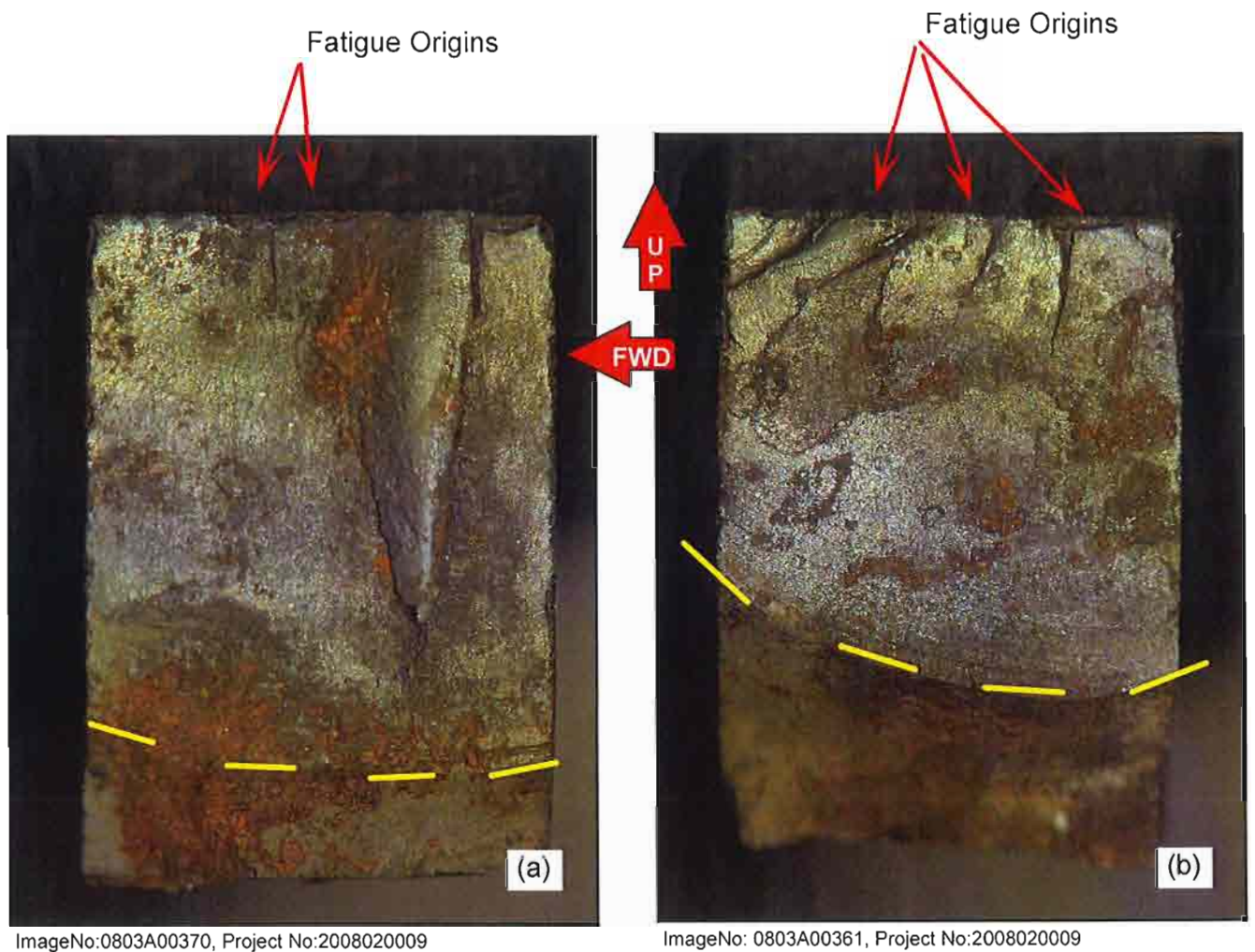


Figure 6--Closer views of the cleaned inboard faces of the forward (a) and aft (b) fatigue fractures in the left wing lower fittings. Fatigue termini are denoted by dashed yellow lines. The bore surface is at top with some of the fatigue origins denoted. Viewed looking outboard.

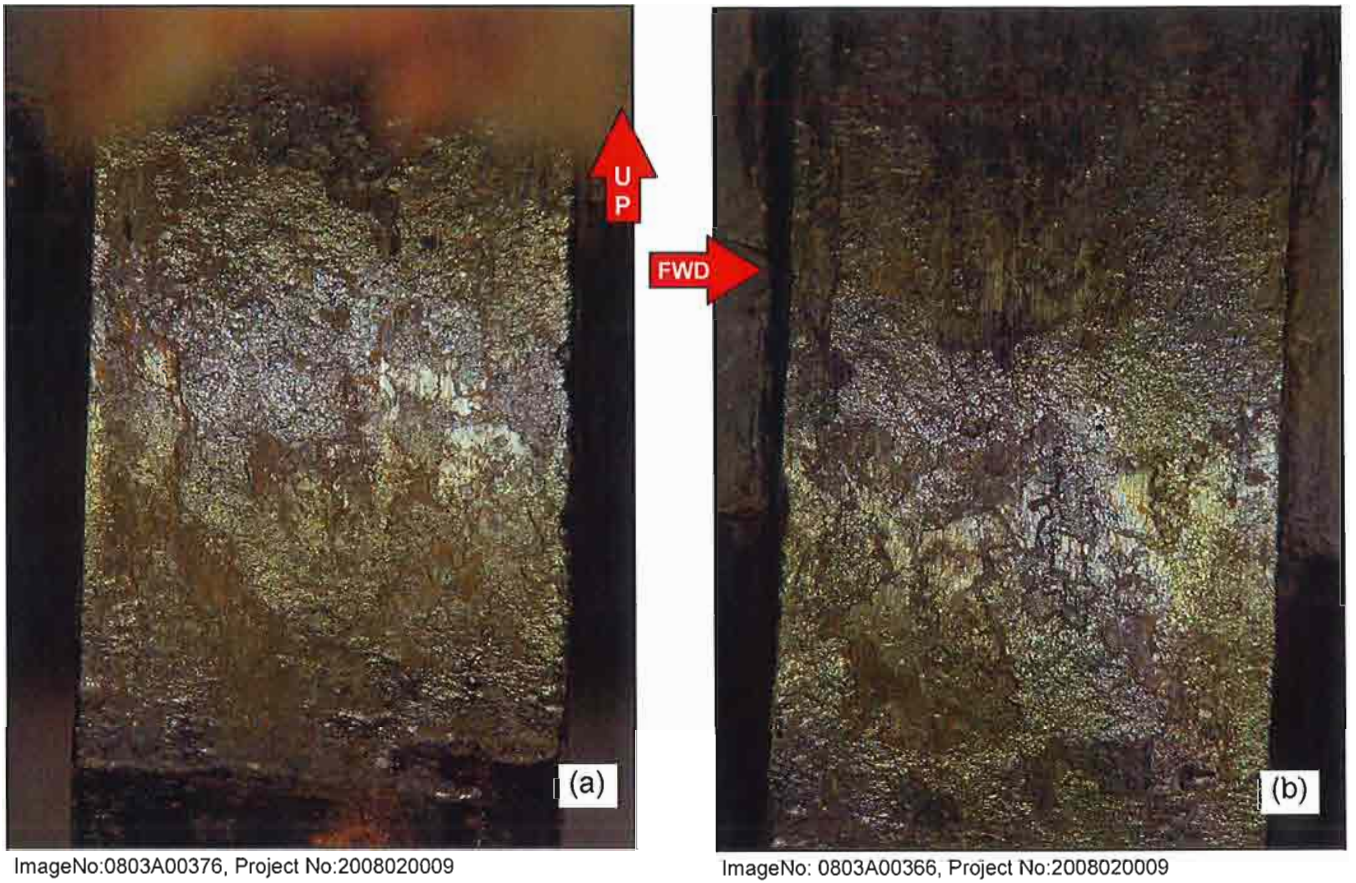


Figure 7--The bore surfaces of the forward (a) and aft fittings showing extensive surface corrosion with little original surface remaining.

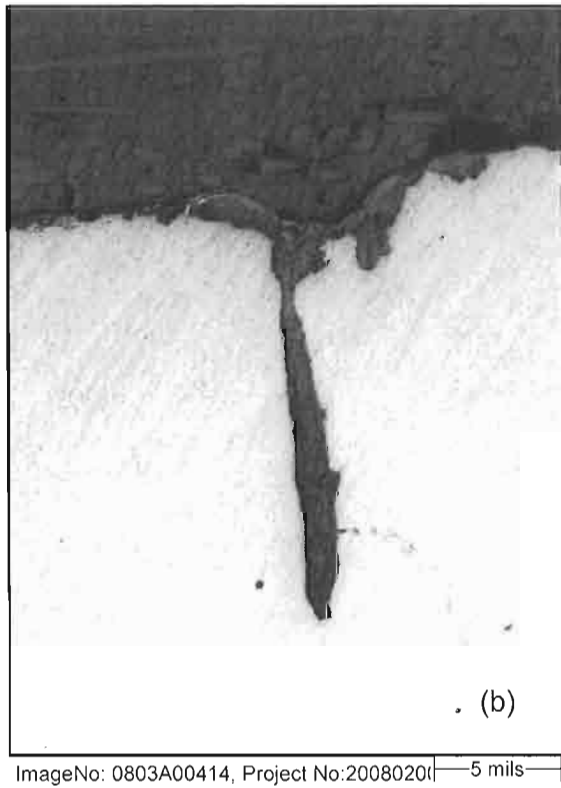
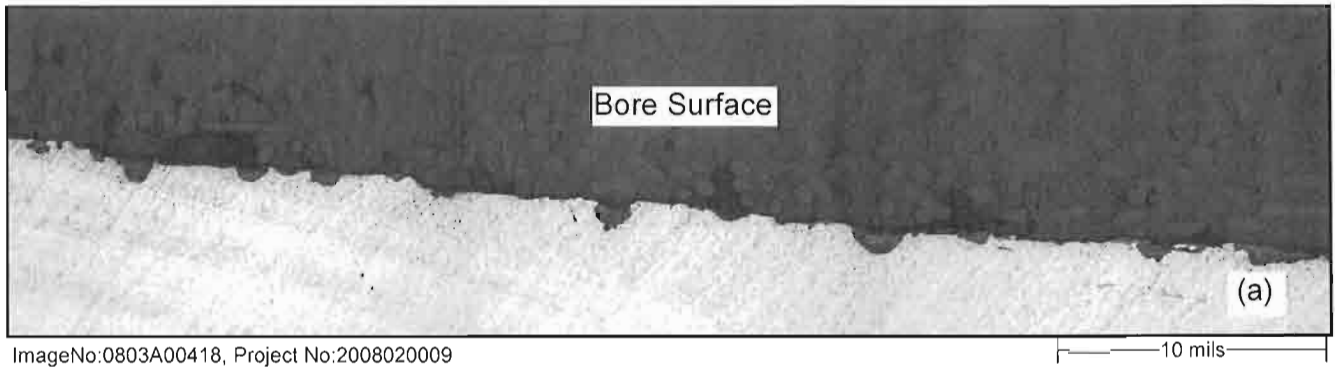
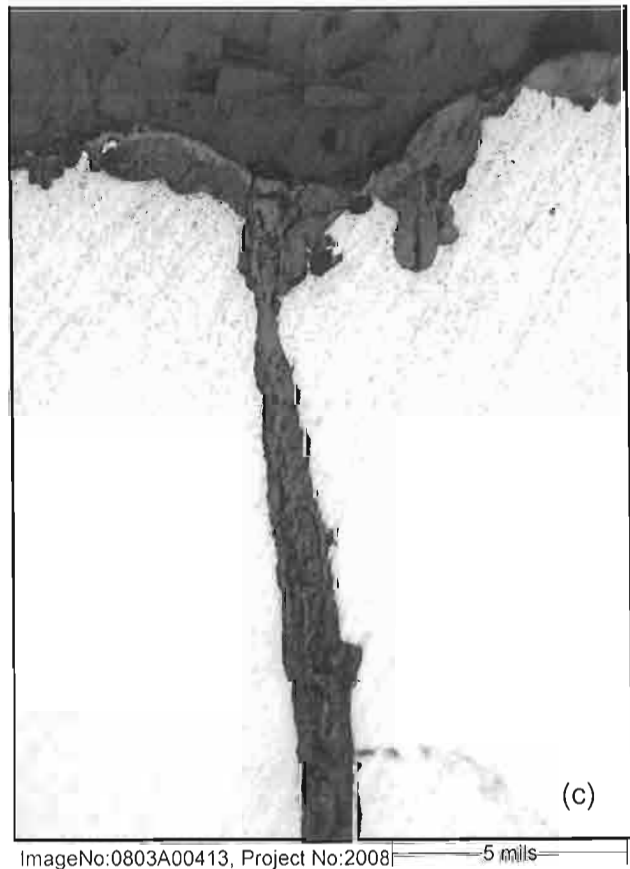


Figure 8--Metallographic section through the bore of the aft fitting showing the general surface corrosion with occasional shallow pits (a). Views (b) and (c) display an additional oxidized crack adjacent and parallel to the fracture.





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Figure 9--The faces of the fractured left wing fittings showing various amounts of corrosion. View (a) shows exposed faces of fittings. View (b) the hidden faces adjacent to carry through structure fitting.

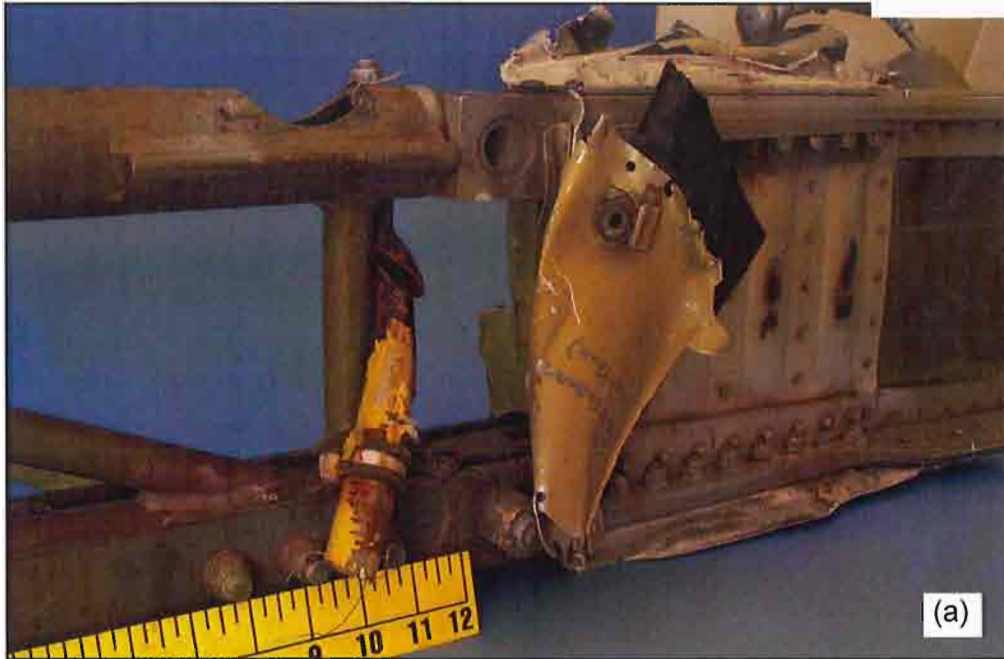


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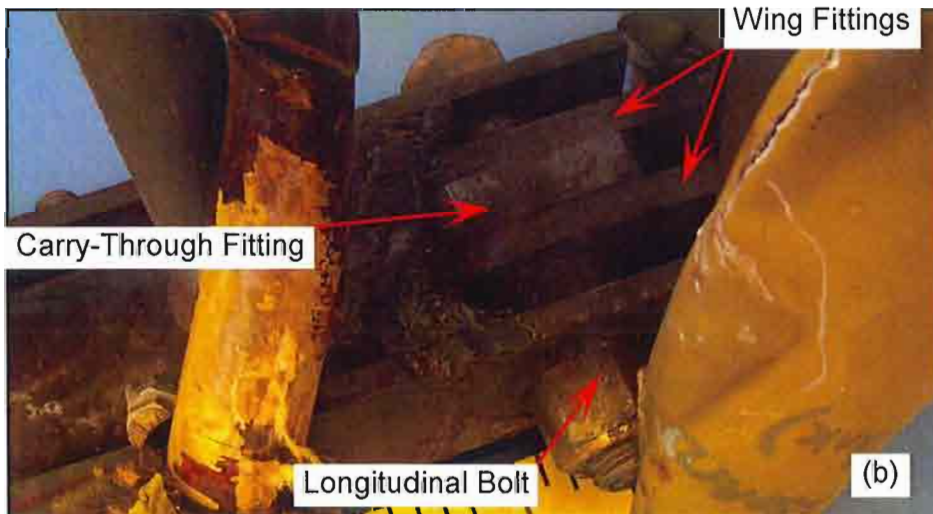


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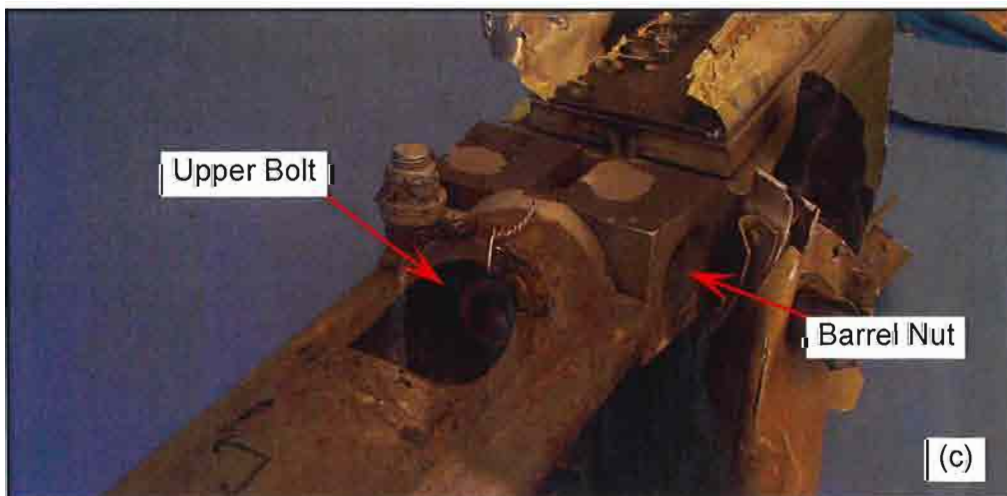
Figure 10--The aft face of the aft fitting with as received paint (a) and after paint removal (b) revealing underlying surface corrosion (dark spots).



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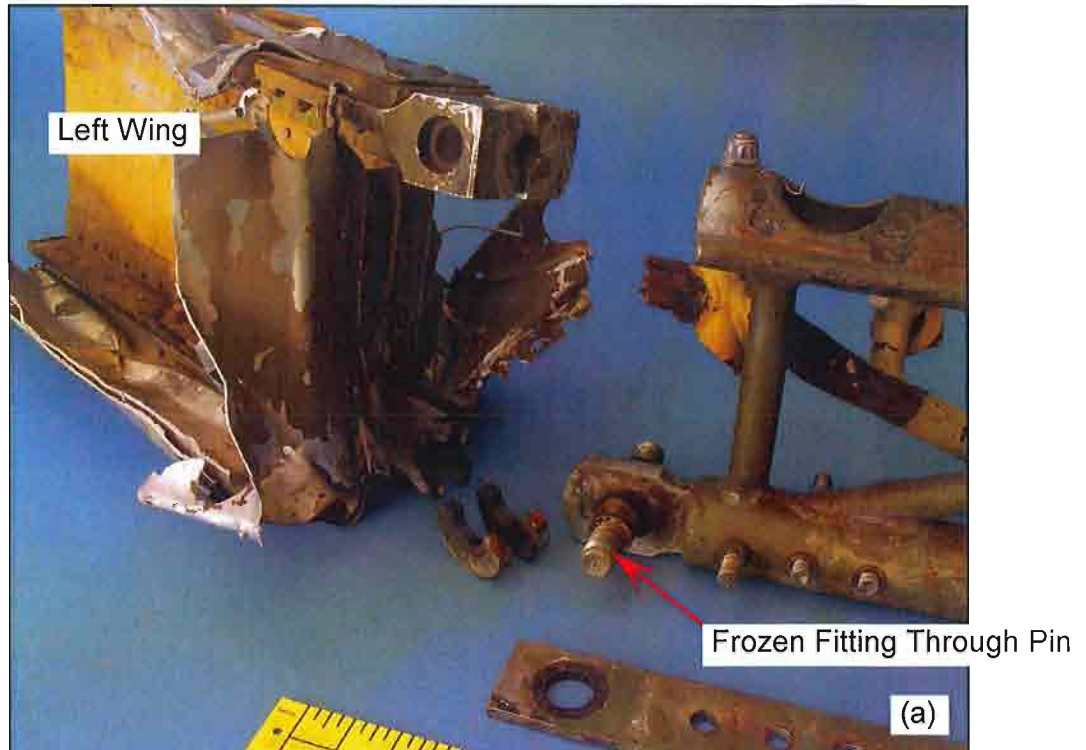


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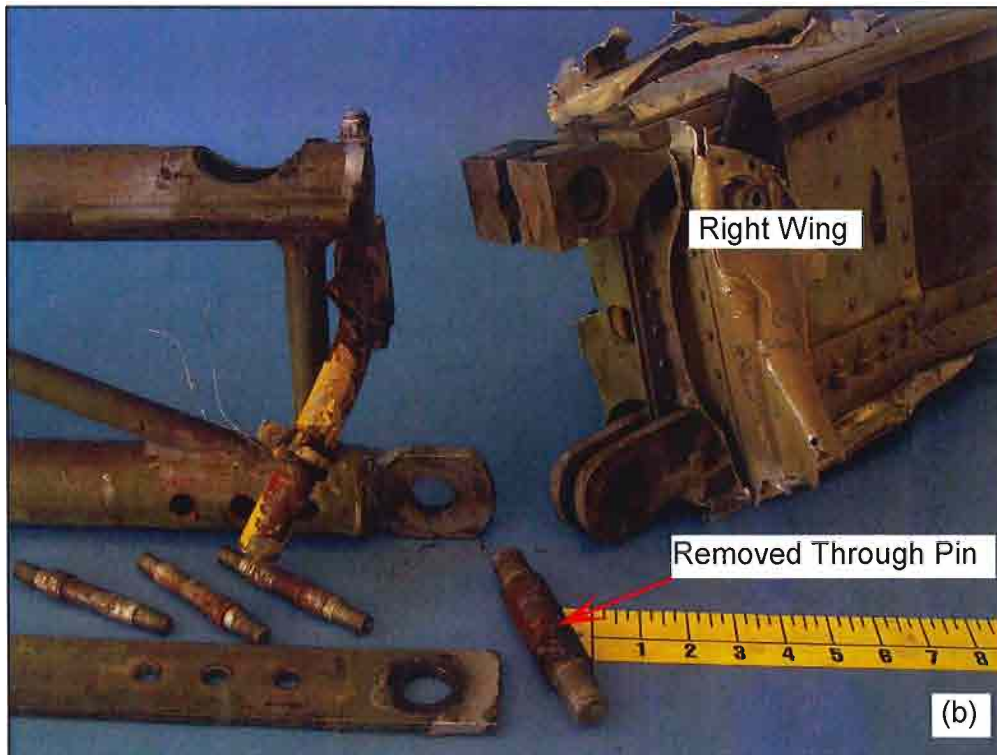


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Figure 11--The intact right wing attachment (a) with a closer view of the lower attachment fittings (b) and the upper attachment bolt (c). Viewed generally from the aft side looking outboard.

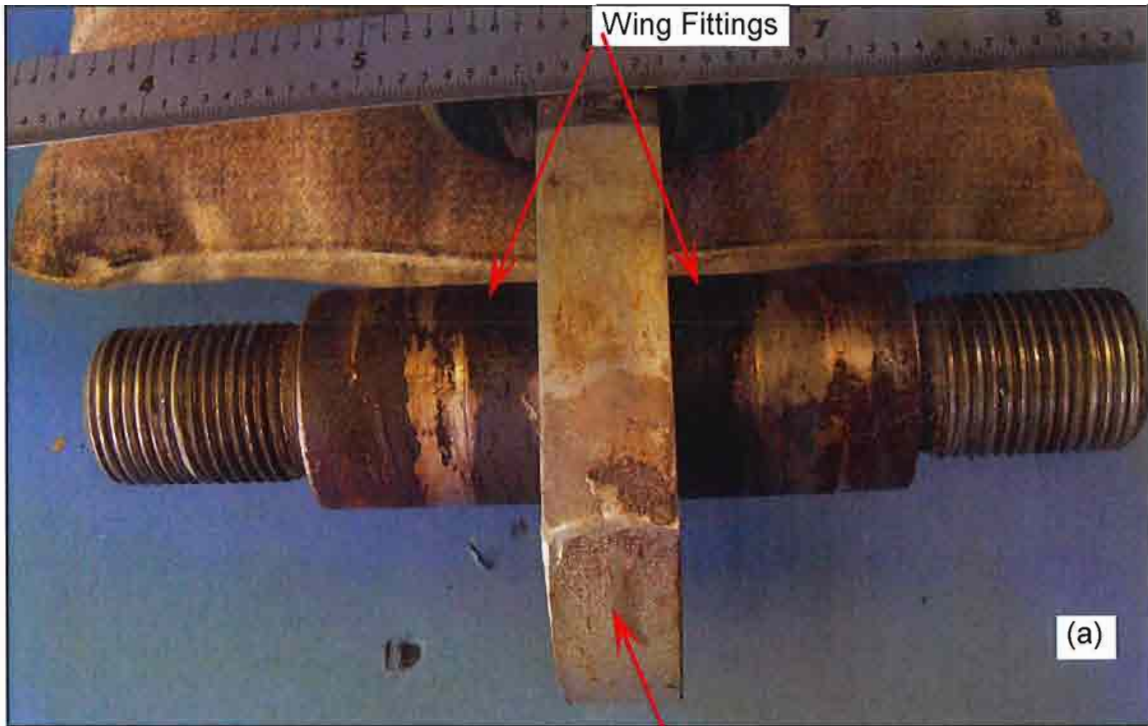


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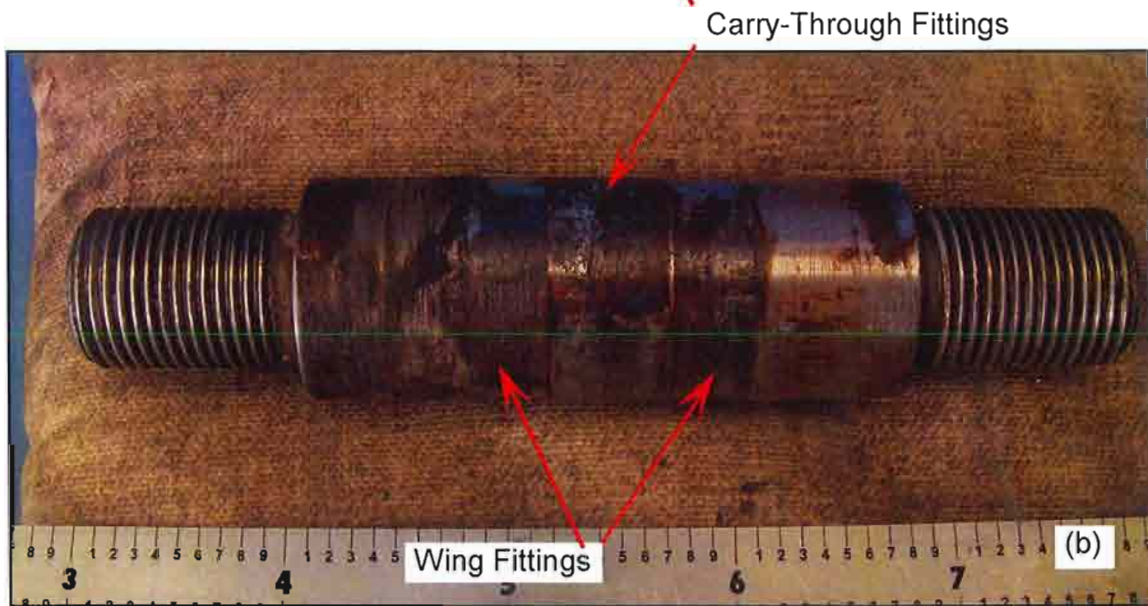


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Figure 12--The disassembled left (a) and right (b) wing attachments. Note the frozen through pin lodged in the left wing carry-through fitting.



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Figure 13--The through pins from the left wing (a) and right wing (b) showing corrosion at the interfaces with the wing and carry-through fittings.