NATIONAL TRANSPORTATION SAFETY BOARD

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

May 2, 1997

METALLURGIST'S FACTUAL REPORT

Report No. 97-85

A. ACCIDENT

Place	: East Moriches, New York
Date	: July 17, 1996
Vehicle	: Boeing 747
NTSB No.	: DCA96-M-A070
Investigator	: Al Dickinson, AS-10

B. COMPONENTS EXAMINED

Samples of "spike tooth" fracture from

1. Piece CW601 of spanwise beam #3 (located just inboard of RBL 91.1 and 4 inches from the lower chord),
2. Piece CW704 of spanwise beam #2 (located about 1 foot from the lower chord and 25 to 30 inches outboard of RBL25),
3. The left inboard landing light surround structure.

Samples cut from the rear spar of the wing center section

1. Sooted and corroded sample from piece CW1004,
2. Sample with no thermal damage from piece CW1006.

C. DETAILS OF THE EXAMINATION

SPIKE TOOTH FRACTURES

An overall view of the samples containing "spike tooth" fractures is shown in figure 1. The numbers adjacent to the samples in this figure correspond to the sample list in section B, above. The Structures Group identified these fracture areas, based on a series of closely spaced, usually sharp teeth associated with a separation. See the Structures Group documentation for a complete listing of all the "spike tooth" fracture areas found on the airplane.

Landing Light Surround Structure

The landing light surround structure (item "3" in figure 1) contained no soot and appeared unaffected by fire. The spike tooth fracture area on this piece was in a portion of a 0.050 inch thick aluminum sheet that was sandwiched between two other aluminum sheets. The outer sheet was separated approximately at the same location as the middle sheet with the spike tooth fracture. The inner sheet was not separated and did not contain significant rubbing or mechanical damage in the area corresponding to the spike tooth fracture.

The two sides of the spike tooth fracture in the middle sheet were cut from adjacent structure, ultrasonically cleaned in acetone and visually examined with a bench binocular microscope. Figure 2 shows magnified views of the exterior and interior[1] surfaces of the aluminum sheet in the vicinity of the two sides of the spike tooth fracture. The spikes consisted of pointed fingers of metal oriented nearly perpendicular to the overall separation. Most of the spikes were twisted and were generally pointing slightly toward the center of the landing light structure (upward in figure 2). The average spacing of the individual spikes was approximately 0.035 inch. The two sides of the separation in the spike tooth area are labeled "A" and "B" in figure 2. On side "A" the outside surface of the sheet contained rub marks on and adjacent to the spike tooth area, consistent with damage from a striking object (see brackets in figure 2b). The inside surface on side "A" did not contain rubbing damage or evidence of contact from a striking object. The rubbing pattern on side "B" was opposite from the rubbing pattern on side "A", with rubbing damage on the inside surface but not on the outside surface. Brackets in figure 2a indicate the rubbing damage area in the vicinity of the spike teeth on side B. As can be seen in figure 2a, the rubbing pattern on the interior surface extended to the edge of the landing light surround structure piece.

Examination of side B of the spike tooth fracture on the landing light surround structure with a scanning electron microscope (SEM) showed smeared (sheared) surfaces between the spikes, as shown in figure 3. Higher magnification SEM examinations showed that the surfaces between the spikes were mostly covered by a heavy mud-cracked oxide layer, as shown in figure 4. Extensive ultrasonic cleaning in acetone failed to remove much of this mud-cracked layer. In areas where the mud-cracked layer was removed, original fracture features were not discernible.

The microstructure on side B of the spike tooth area on the landing light surround structure was examined on two sections, one oriented parallel to the plane of the sheet and one oriented transverse (perpendicular) to the plane of the sheet. A low magnification metallographic photograph of the transverse section is shown in figure 5 with arrow "s" denoting the separation between the spike tooth (at the top of the photograph) and sheet material (at the bottom of the photograph). The microstructure directly adjacent to the fracture was severely deformed. Slightly further away from severely deformed areas, the microstructure contained deformation bands (figure 6).

Figure 7 is a low magnification photograph of the section parallel to the plane of the sheet. Metallographic features on this section were similar to the features found on the

[1] The interior surface faces the landing light and the exterior surface faces the outside of the airplane.

transverse section. The tips of the spikes were subjected to secondary damage and were bent over, as can be seen in this figure.

Piece CW704 of Spanwise Beam #2

The piece cut from spanwise beam piece #2 (SWB#2) is identified as item 2 in figure 1. Figure 8 shows a view of a portion of the forward face of piece CW704 before removal of the laboratory sample. As can be seen in figure 8, CW704 contained a portion of the lower chord of SWB#2, as well as a piece of the adjacent web. What appeared to be a length of control cable (unlabeled arrow, figure 8) was noted through the separation associated with the spike tooth area. The laboratory sample piece contained soot accumulation on both the forward and aft surfaces, with heavier accumulation on the forward side. Piece CW704 contained some areas with incipient melting, as documented in NTSB Materials Laboratory Report No. 96-141. The spike tooth fracture area was in the web of the front spar, on a crack that extended several inches beyond the spike tooth area.

Figure 9 shows a view of the front face of the web adjacent to the two sides of the spike tooth area on the piece from SWB#2. This photograph was taken after one side of the spike tooth area was cut from the remainder of the laboratory sample so that the mating spike tooth areas could be aligned close to each other. Damage associated with the spike tooth area on this sample was similar to the damage on the landing light surround structure. One side of the spike tooth area had rubbing damage on the front face of the web (bracket, figure 9), while the other side had damage on the web's aft face. The spikes in this area generally pointed toward the tip of the crack associated with the spike tooth area.

The microstructure on the spike tooth area from SWB#2 was examined on a section parallel to the plane of the web. The location of the section is indicated by the dashed lines in figure 9. The microstructure on this section was similar to the microstructure on the previous sections, with deformation adjacent to the surface of the spikes. Figure 10 shows the tip of one of the spike teeth from the section. No evidence of recrystallization of the microstructure was noted on the section.

Piece CW601 of spanwise beam #3

The spike tooth fracture area from piece CW601 is indicated as item "1" in figure 1. The side of the piece shown in figure 1 was painted with green primer, while the other side was unpainted. Soot accumulation was noted on both sides of the piece, with heavier soot on the unpainted side.

Figure 11 shows a closer view of a portion of the spike tooth area from the primed side of the piece. As can be seen in figure 11, all of the spikes on this piece were associated with significant mechanical damage. No metallographic sections through the spike tooth fracture area on this piece were taken.

REAR SPAR

Figure 12 shows the two rear spar samples examined in the laboratory. The sample cut from rear spar piece CW1006 appeared unaffected by fire and was not corroded. The sample cut from piece CW1004 had soot accumulation and heavy corrosion adjacent to the fracture surface. In some places this corrosion had substantially reduced the thickness of the plate. These samples were subjected to a metallurgical examination in order to document features associated with the different amount of corrosion.

A small fracture area on the sample from CW1006 was cut from the remainder of the sample and examined with the SEM. Although visual examination of the fracture on CW1006 revealed no apparent corrosion, the SEM examination showed that the fracture was covered by tightly adhering mud-cracked oxide deposits similar to those found on the spike teeth (see figure 4).

Metallographic sections were prepared through the most severely corroded area on the sample from CW1004 and through the fracture on the sample from CW1006. The microstructure on the sample from CW1006 appeared unaffected by heating and was typical for 7075-T651 aluminum alloy. Figure 13 shows the microstructure on the sample from CW1006.

The corrosion effects on the sample from CW1004 were readily visible on the metallographic section through this piece. Most of the corrosion appeared to penetrate preferentially along the boundaries of the elongated grains, and in many areas the corrosion had destroyed the integrity of the microstructure. Figure 14 shows a low magnification photograph of the unetched metallographic section adjacent to the fracture in this sample. Higher magnification examination of the metallographic section after etching showed that much of the microstructure in the areas affected by corrosion had recrystallized. Figure 15 shows a higher magnification view of the partially recrystallized microstructure.

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