NATIONAL TRANSPORTATION SAFETY BOARD

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

July 1, 2003

MATERIALS LABORATORY FACTUAL REPORT Report No. 03-018

A. ACCIDENT

Place	:	Belle Harbor, New York
Date	:	November 12, 2001
Vehicle	:	Airbus A300-600, N14053
NTSB No.	:	DCA02MA001
Investigator	:	Brian Murphy, AS-40

B. COMPONENTS EXAMINED

Vertical stabilizer left forward longitudinal attachment lug.

C. DETAILS OF THE EXAMINATION

Two sizes of porosity were noted in the matrix material during the fractographic examination of the vertical stabilizer longitudinal attach lugs, as described in Materials Laboratory Factual Report 02-083. Matrix porosity with submicron pore sizes was observed only on the translaminar and interlaminar fracture surfaces of the left forward longitudinal attach lug. Larger scale porosity, which will be referred to as "microscopic porosity" in this report, was observed on all the interlaminar fracture surfaces examined. The microscopic porosity had a range of pore sizes on the order of several micrometers in diameter and was typically oblong in shape with cornered edges. The sizes and shapes of the microscopic porosity were consistent with the curing agent, dicyandiamide. The submicron porosity was more equiaxed in shape and more constant in size, which is consistent with entrapped air.

Porosity on both size scales was observed on the left forward lug, as shown in figure 1. Often, submicron porosity was observed associated with a granular appearance in the matrix, as shown in figure 2. This report provides a more detailed description of this submicron porosity.

The longitudinal attachment lugs are a solid carbon-fiber reinforced polymer (CFRP) laminate composed of T300 carbon fibers in a Hexcel 913[1] epoxy matrix. The laminate

[1] At the time the accident airplane was manufactured, the epoxy used in the vertical stabilizer was CIBA 913C, made by Ciba-Geigy Ltd., of Switzerland. Ciba-Geigy sold their composites business to Hexcel Corporation in 1996.

includes both unidirectional tape and eight-harness satin woven fabric layers in the construction. Each lug contains two separate pieces that are cured separately before the final assembly, referenced as the precured halves. In the final assembly of the vertical stabilizer skin panels, the outer precured half is laid down, followed by the skin layers, the inner precured half, and additional skin panel and stringer module layers. For more details regarding the materials and construction of the vertical stabilizer, see Materials Laboratory Factual Report 02-083. On the forward lugs near the attachment hole, the skin layers were located approximately 1.00 to 1.08 inch from the inboard surface at the aft side of the attachment hole and 0.71 to 0.79 inch from the inboard surface at the forward side of the attachment hole.

During the fractographic examination, the left forward lug was cut at the locations shown in figure 3. After cutting, specimen LF3b (from the aft leg of the lug) fell into three pieces, and specimen LF3c (from the forward leg of the lug) split into four pieces. The thickness of each piece was measured adjacent to the cut near the bore (outside of the tapered region and where the hat bushing was located). The inboard, center, and outboard pieces of specimen LF3b measured 1.37 inches, 0.16 inch, and 0.13 inch, respectively. The inboard, inboard center, outboard center, and outboard pieces of specimen LF3c measured 0.75 inch, 0.16 inch, 0.44 inch, and 0.24 inch, respectively.

An overall view of the translaminar fracture surface of the aft leg of the lug is shown in figure 4 before cutting specimen LF3b and LF3c. Fractographic features were evaluated at the approximate locations denoted by the yellow boxes and red diamonds on the fracture in this figure, with the red diamonds indicating locations where submicron porosity was observed at the translaminar fracture surface, and the yellow boxes indicating locations where submicron porosity was not observed. Three of the five areas where porosity was not observed corresponded to the skin layers between the precured halves.

Submicron porosity was observed at the translaminar fracture surfaces for most of the forward leg of the lug. This porosity was not observed at the outboard center side of the fracture surface on the inboard center piece of LF3b. Also, this porosity was not observed on the portions of the inboard piece that fractured parallel to the nearly-horizontal 45-degree fiber direction. (The translaminar fracture of the inboard piece of LF3b was generally fractured in a plane parallel to the zero-degree direction. However, interspersed portions of the inboard piece of LF3b were fractured parallel to the nearly-horizontal 45-degree fiber direction.)

Submicron porosity was also observed at the interlaminar fracture surfaces for the forward leg of the lug. The interlaminar fracture surfaces were examined using SEM in a grid pattern at four-millimeter intervals. Areas where porosity and granularity were observed are shown in figures 5 and 6.

At the outboard interlaminar fracture surface of the outboard center piece, submicron porosity was generally observed within approximately 0.5 inch above the translaminar fracture surface near the hole to two inches above the fracture surface near the forward end. Submicron porosity was also observed within one inch aft of the forward edge.

At the inboard interlaminar fracture surface of the outboard center piece, an area of porosity was observed near the fracture surface approximately midway between the forward edge and the attach hole bore. Other areas of the fracture surface near the translaminar fracture surface had a granular appearance with some submicron porosity.

At the outboard interlaminar fracture surface of the inboard center piece, submicron porosity was observed near the translaminar fracture surface near the forward and aft sides of the interlaminar fracture surface. Matrix granularity was observed near the center, between the areas of submicron porosity.

At the inboard interlaminar fracture surface of the inboard center piece, submicron porosity was observed near the translaminar fracture at the forward side. Toward the center and aft, the interlaminar fracture surface had a granular appearance adjacent to the translaminar fracture surface.

At the outboard interlaminar fracture surface of the inboard piece of LF3b, submicron porosity was observed within approximately 0.1 inch above the translaminar fracture surface near the hole to one inch above the fracture surface near the forward end. Also, porosity was observed on the fracture surface within approximately 0.5 inch aft of the forward edge.

Two concessions applied to the precured halves for the left forward lug. Concession number TS-8789 indicated that the outboard precured half had a lack of pressure at the upper edge, and porosity was observed at the upper left area. Repair instructions included grinding the low pressure area and filling the gap with additional layers when bonded with the skin. Concession number TS-8773 indicated that the thickness of the inboard precured half measured 0.4 millimeters below tolerance. The repair instruction was to add an additional layer when bonded with the skin.

Matthew R. Fox
Materials Engineer

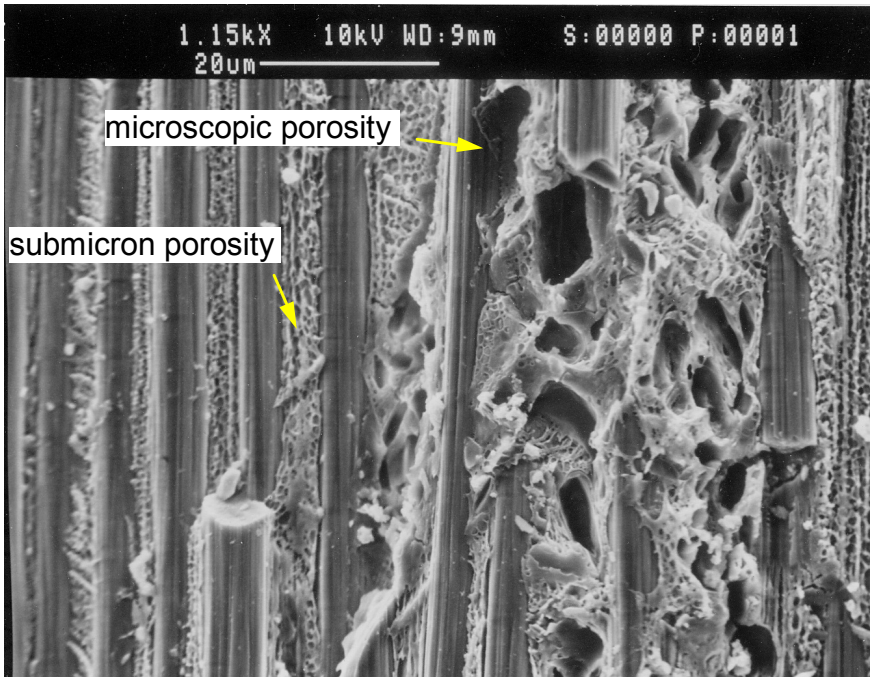

Figure 1. View of an interlaminar fracture surface on the left forward lug. Two different pore sizes were observed at the fracture surfaces as indicated in the figure.

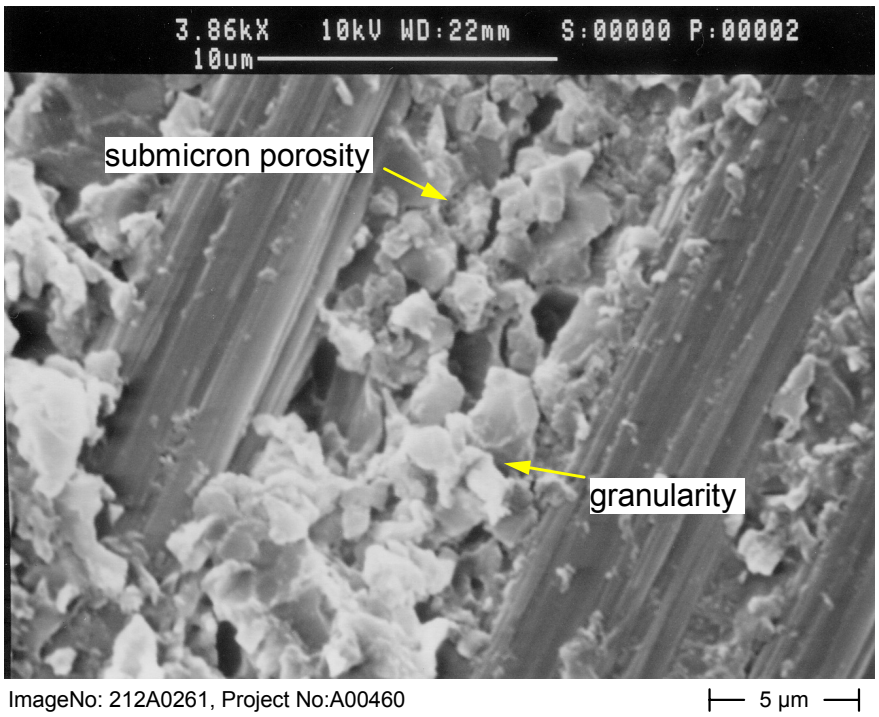

Figure 2. Submicron porosity was often observed with a granular appearance as shown in the figure.

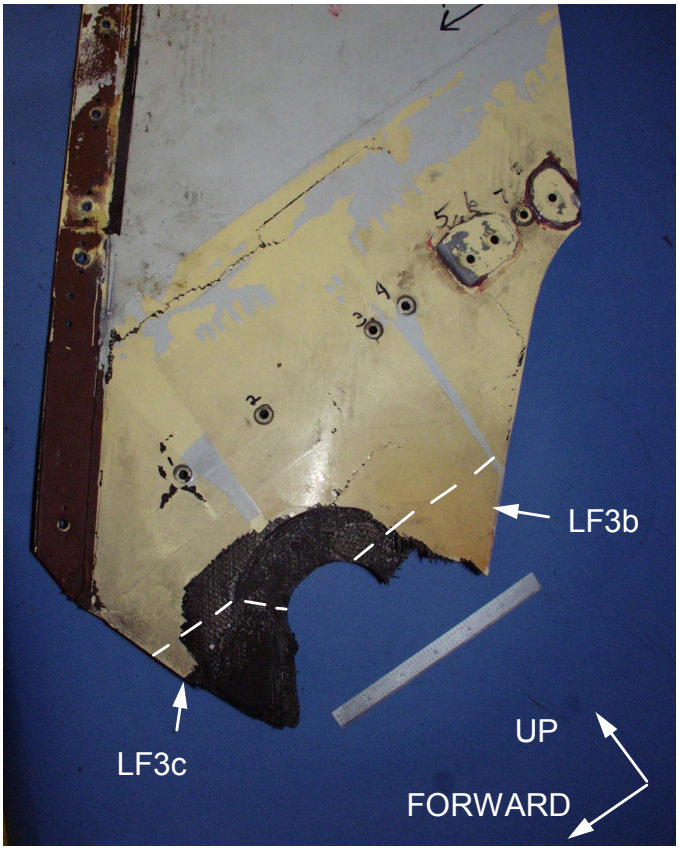

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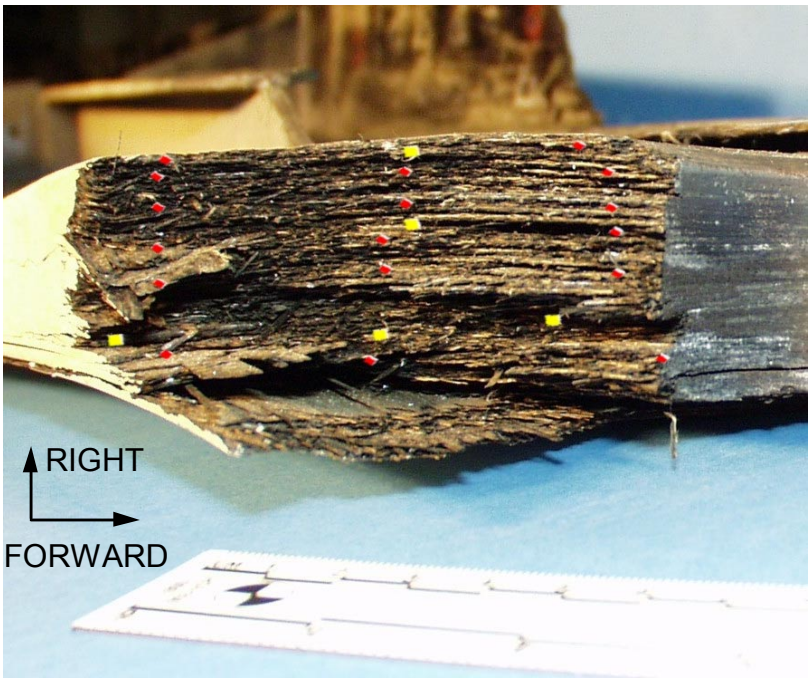
Figure 3. Overall view of the fractured left forward lug. Dashed lines indicate where samples were cut from the remainder of the lug.

Figure 4. View of the translaminar fracture on the aft leg of the left forward lug. Locations where submicron porosity was and was not observed are indicated in red and yellow, respectively.



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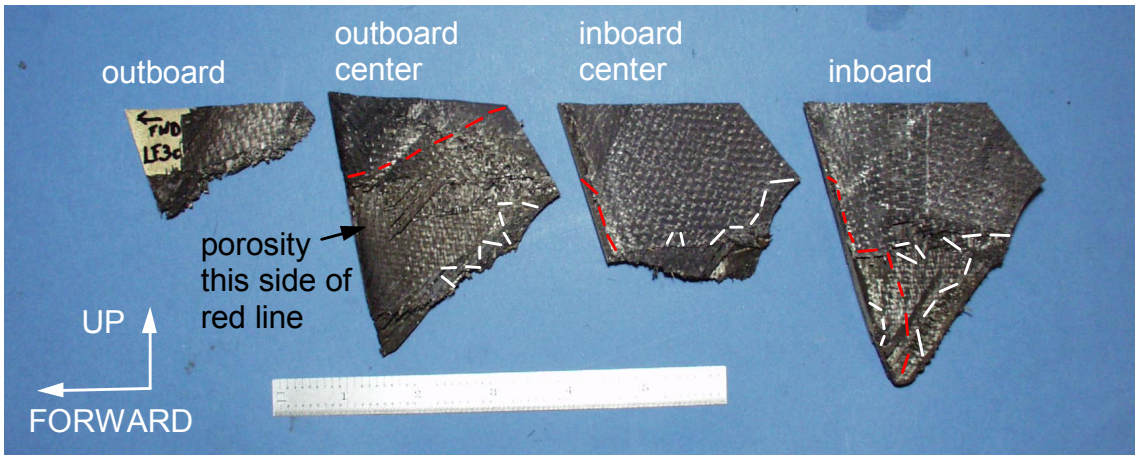

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Figure 5. Outboard surfaces of pieces of LF3c. Approximate areas of porosity and granularity are outlined in red and white, respectively.

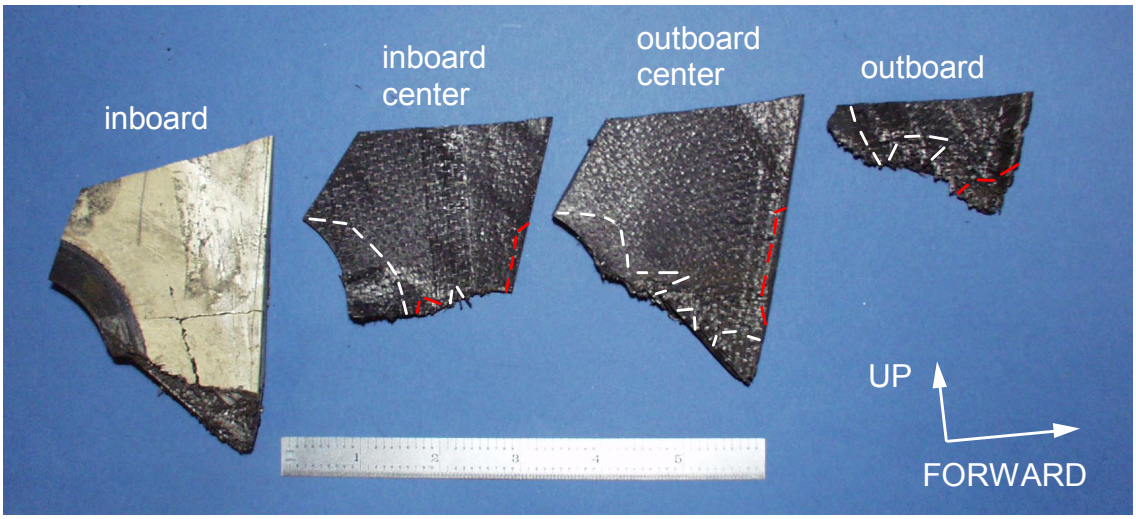

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Figure 6. Inboard surfaces of pieces of LF3c. Approximate areas of porosity and granularity are outlined in red and white, respectively.