An area of the fuselage that didn't meet Boeing's thickness specifications is blamed for a 757's rapid decompression.

BY LINDA WERFELMAN

THIN SKINNED

An error at the factory was responsible for an area of thin fuselage skin that allowed the fuselage of an American Airlines Boeing 757 to rupture, tearing an 18-in by 7-in (46-cm by 18-cm) hole over the forward left passenger door and causing a rapid decompression, the U.S. National Transportation Safety Board (NTSB) says.[1]

The Oct. 26, 2010, decompression prompted an emergency landing at Miami International Airport. None of the 160 people in the airplane was injured.

The accident was one of several recent instances in which an airplane fuselage ruptured, causing a rapid decompression. The events prompted the NTSB to convene a public forum in late September to examine issues associated with aircraft fuselage structural integrity — the first of several sessions designed to provide a closer look at situations associated with recent accidents.

In its final report on the Miami accident, the NTSB noted fatigue cracking in the fuselage crown skin, where the rupture occurred, "along the lower longitudinal step of the chemically milled pocket just above the stringer S-4L (left) lap joint." The fatigue cracks began at multiple locations on the

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Milling Process

The crown skin panel that ruptured on the accident airplane is unique among the skin panels on Boeing 757s in that it is manufactured in a single-step chemical milling process that forms waffle-like pockets.[1]

The U.S. National Transportation Safety Board said in its final report on the accident that, at the time the panel was manufactured, standard procedures called for the skin panels to be "stretch-formed for contour before being masked, hand scribed, peeled and placed on a rack."

The rack then was dipped vertically into a chemical bath several times "and measurements of select pocket thicknesses [were] taken each time it was removed and rinsed," the report said.

"Once the specified amount of material was removed, the panel would have been final-rinsed and inspected. During the final inspection, all pocket thicknesses would be checked. The typical chem-mill rate achieved is about 0.001 in [0.025 mm] per minute," the report said.

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Note

1. The other fuselage skin panels are manufactured in a multi-step process in which additional chemical milling smooths the edges of the pockets.

interior surface of the skin and spread through the skin to the exterior surface.

Although Boeing specified that the skin in that area of the fuselage must be 0.039 in (0.99 mm) thick, investigators measured the thickness at 0.035 in (0.89 mm) to 0.037 in (0.94 mm), the report said (see "Milling Process").

The report added that "calculations from an NTSB study of the fatigue striation density and propagation in the fatigue region indicate that it would take an average of 3,709 total cycles for a crack to grow through skin with 0.035-in thickness and an average of 917 cycles for a crack to grow from a minimally detectable size and penetrate a 0.035-in skin thickness."

The accident airplane was manufactured and delivered to American Airlines in 1990, and, when the accident occurred, it had been flown about 63,010 hours and had accumulated 22,450 cycles. Specific manufacturing records were not available for the panel, but the NTSB said that, "based on the airplane delivery date and estimated manufacturing flow," it probably was manufactured early in 1990.

This 757 is one of several airplanes to experience a fuselage rupture above a forward passenger door, accompanied by a rapid decompression.

The decompression occurred about 16 minutes after departure from Miami, as the 757 climbed through 32,000 ft en route to Boston Logan International Airport. The crew conducted an emergency descent and returned to land at Miami, where a preliminary inspection revealed the rupture in the fuselage crown skin. Most of the ruptured skin — the forward 13-in by 7-in (33-cm by 18-cm) section — was still attached to the airplane, but the aft 5-in (13-cm) by 7-in section had separated from the airplane and was not recovered.

Inspections

At the time of the accident, the area of the airplane where the fatigue cracking and skin rupture occurred was not subject to specific inspections, service bulletins or airworthiness directives, the NTSB said.

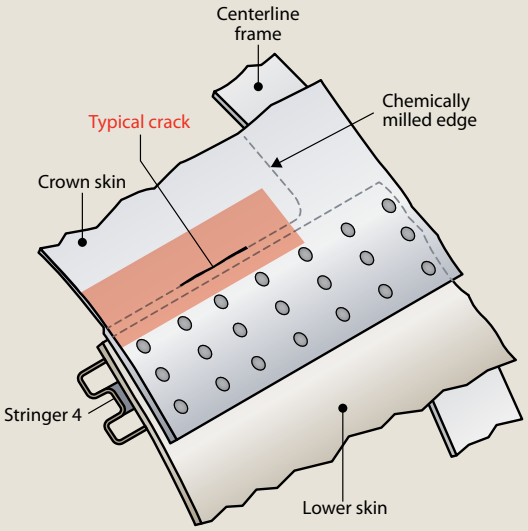
After the accident, however, Boeing and the U.S. Federal Aviation Administration (FAA) took separate actions calling for new inspections:

- On Nov. 22, 2010, Boeing issued Service Bulletin (SB) 757-53-0097, calling for repetitive external inspections, about every 300 flight hours, for cracks in the fuselage skin in the area of the fuselage rupture in the accident airplane.
- On Jan. 10, 2011, with the issuance of Airworthiness Directive (AD) 2011-01-15, the FAA mandated the inspections recommended in the service bulletin.

The NTSB's investigation revealed two incidents of fatigue cracking in the fuselage skin in patterns similar to those in the accident airplane. Both incidents involved 757s — one operated by American Airlines and the second by United Airlines. In each incident, the NTSB said, the airplane had "nonconforming thickness at the base of the chemically milled step at the stringer location specified in the SB."

In all three cases, manufacturing records were not available, so the NTSB was unable to identify a cause of the "less-than-manufacturer-specified" fuselage skin thickness. There were no requirements that the records be retained, the NTSB said.

Area of Cracking in Boeing 757 Fuselage



Note: Cracks were found above the left forward passenger door.

Source: U.S. National Transportation Safety Board

Figure 1

In addition to these instances of fuselage crown cracking, about six weeks before the Miami decompression, United Airlines personnel found a 10.75 in (27.31 cm) crack in the upper crown skin of a 757, "after reports of a whistling noise," the NTSB said. About six weeks after the decompression, American Airlines personnel — in the process of conducting an inspection to comply with the Boeing SB — found indications of cracking in the crown skin of another airplane, the NTSB added.

Gaps and Fatigue Cracks

Another similar decompression occurred several months later. On April 1, 2011, a Southwest Airlines 737-300 experienced a rapid decompression at 34,000 ft, while en route to Sacramento, California, U.S., after takeoff from Phoenix. After an emergency descent, the crew diverted to Yuma, Arizona, where a preliminary inspection revealed a 5-ft by 1-ft (1.5-m by 0.3-m) hole in the fuselage crown aft of the overwing exit at the stringer 4L lap joint. One of the 122 people in the airplane received minor injuries; the others were not hurt.[2]

The NTSB is still investigating, but preliminary reports said that a laboratory examination of the part of the fuselage surrounding the rupture showed fatigue cracks "emanating from at least 42 of the 58 rivet holes connected by the fracture." The fuselage skin was the required thickness.

X-rays showed gaps "between the shank portions of several rivets and the corresponding rivet holes for many rivets associated with S-4L," the NTSB said.

The airplane had 48,740 operating hours and had completed 39,781 cycles at the time of the accident.

After the accident, Southwest inspected several other 737s and found that three of the airplanes had "crack indications in the lap joints," the NTSB said.

As a result of the accident and the subsequent 737 inspections, Boeing issued SB 737 53A1319-00, calling on owners of some 737-300s, 400s and 500s to inspect fasteners at stringers S-4R and S-4L in the area of the crown fuselage failure, to check for cracks in the lower skin of the lap joint. FAA Emergency AD 2011-08-51 mandated the inspections.

In late April, the NTSB said that, of 136 airplanes inspected worldwide, four — all with between 40,000 and 45,000 cycles — had crack indications at a single rivet and one had crack indications at two rivets.

New Regulations

About six months after the Miami accident, on April 16, 2011, U.S. Federal Aviation Regulations Part 21.137(k) took effect, requiring that records associated with the manufacturing of aircraft critical components be retained for at least 10 years.

Because so much time elapsed between the manufacture date of the crown skin panel and the accident, however, even if the regulatory requirement had been in place at the time of the accident, it would not have applied to manufacturing records for the accident airplane, the NTSB said.

Notes

1. NTSB. Accident Report no. DCA11FA004. Oct. 26, 2010.
2. NTSB. Accident report no. DCA11MA039, and related news releases.