

5. Referential Matters

- 5.1 Actions and counter-measures taken up to May 31, 1987 by governmental organizations, aircraft manufacturers, and aircraft operators concerned, in reference to this accident are as follows:

5.1.1 The NTSB made the following safety recommendations to the FAA:

- a) Design change on the empennage (Safety Recommendation A-85-133, Dec. 5, 1985)

Measures should be taken so that the empennage section of Boeing 747 and 767 will be protected against catastrophic failure in the event that a significant pressure buildup occurs in the normally unpressurized empennage.

- b) Modification of the design of the hydraulic systems (Safety Recommendation A-85-134, Dec. 5, 1985)

Design modification should be made so that the integrity of all four hydraulic systems will not be impaired in the event that a significant pressure buildup occurs in the normally unpressurized empennage.

- c) Reevaluation of the fail-safe validity of the domed aft pressure bulkhead (Safety Recommendation A-85-135, Dec. 5, 1985)

Reevaluation should be made of the design of the aft pressure bulkhead of Boeing 747 and 767, and test be made to confirm their fail-safe validity.

- d) Evaluation of procedures to repair the aft pressure bulkhead (Safety Recommendation A-85-136, Dec. 5, 1985)

The current repair procedures of Boeing 747 and 767 aft pressure bulkheads should be evaluated to ensure that the repairs do not affect the fail-safe concept.

- e) Revision of the inspection program for the aft pressure bulkhead (Safety Recommendation A-85-137, Dec. 5, 1985)

In reference to the aft pressure bulkhead, an inspection program beyond the usual visual inspection should be established to detect the extent of possible multiple site fatigue cracking.

- f) Evaluation of the fail-safe criteria of the domed aft pressure bulkhead (Safety Recommendation A-85-138, Dec. 13, 1985)

Confirmation should be made on whether the fail-safe criteria have been satisfactorily evaluated for all domed aft pressure bulkheads of transport category airplanes.

- g) Evaluation of repair procedures of the domed aft pressure bulkhead (Safety Recommendation A-85-139, Dec. 13, 1985)

Procedures to repair the domed aft pressure bulkhead of all airplanes which incorporate the domed aft pressure bulkhead should be evaluated to assure that the affected repairs do not derogate the fail-safe concept of the bulkhead.

- h) Issuance of a maintenance alert bulletin to persons responsible for the engineering approval of repairs (Safety Recommendation A-85-140, Dec. 13, 1985)

A maintenance alert bulletin should be issued to persons responsible for the engineering approval of repairs to emphasize that the approval adequately consider the possibility of influence on ultimate failure modes or other fail-safe design criteria.

5.1.2 The FAA directed US operators of the Boeing 747 and the Boeing Company to make the following modifications, inspections, etc.:

- a) Vertical fin access cover installation (Airworthiness Directive AD86-08-02, April 4, 1986)

To install, within 6 months, a structural cover for the opening within the empennage which provides access to the vertical fin, to prevent destruction of the empennage structure due to a significant pressure buildup in the empennage. (A-85-133 related)

- b) Reevaluation of the fail-safe validity of the domed aft pressure bulkhead

To request the Boeing Company to conduct a reevaluation of the design and tests concerning the fail-safe validity of the aft pressure bulkheads of Boeing 747 and 767. (A-85-135 related)

- c) Evaluation of the repair procedures for the domed aft pressure bulkhead (Airworthiness Directive AD-85-22-12, Oct. 25, 1985)

To request the operators to check on whether repairs of the aft pressure bulkhead of Boeing 747 have been carried out and to report the results to the Boeing Company.

No problems were found from the FAA's review on the results of reevaluation of the repair manuals of the aft pressure bulkhead of Boeing 707, 737, 747 and 767 issued by the Boeing Company. (A-85-136 related)

- d) Review of the fail-safe criteria of the domed aft pressure bulkhead

FAA's TACD (Transport Airplane Certification Directorate) formed a team with the major aircraft manufacturers to study on NTSB's safety recommendations, and they are making a review of large aircraft exceeding 75,000 pounds taxi weight. Through the review, modifications of and additions to inspection procedures were brought into SID(AC91-51)

Reevaluation of the damage tolerance design is also under way. (A-85-138 related)

e) Evaluation of the repair procedures of the domed aft pressure bulkhead

FAA requested the large transport airplane manufacturers to review the repair criteria for the domed aft pressure bulkhead by a letter dated Dec. 12, 1985. (A-85-139 related)

f) Issuance of a memorandum to the engineering staff

A memorandum concerning repairs of important major structures of the aircraft was issued to the engineering staff belonging to each ACO (Aircraft Certification Office) (A-85-140 related)

g) Modification of the hydraulic systems

FAA initiated, with the Boeing Company in September 1985, a study on modifications necessary to prevent loss of functions of the hydraulic systems following major structural failure of Boeing 747. This work is still under progress, but indications are that functions of the elevator, ailerons, and spoilers could be secured by installing a fuse before No. 4 hydraulic system where the hydraulic lines enter the vertical stabilizer. The Boeing Company has issued a service bulletin which provides for installation of the fuse on No. 4 hydraulic system, and the SB is planned to become an FAA directive. (A-85-134 related)

5.1.3 The Boeing Company issued the following SB's and at the same time conducted design modifications, tests, etc. on new production airplanes:

a) Vertical fin access cover installation (SB747-53A-2264, Nov. 25, 1985)

The Boeing requested installation on airplanes in current use of the cover for the opening which provides access to the vertical fin. The installation on new airplanes was made from line number 626 (delivered Dec. 11, 1985). (A-85-133 related)

b) Modification of the hydraulic systems (SB747-29-2063, Dec. 23, 1986)

The Boeing requested installation on airplanes in current use of the fuse in No. 4 hydraulic systems upstream of the vertical stabilizer. The installation of the fuse on No. 4 hydraulic system of new production airplanes was initiated at line number 663 (delivered Dec. 23, 1986).

The rerouting of the hydraulic line between BS1480 and 2460 will be incorporated in production starting with line number 696, which will roll out of the factory in January, 1988. A SB which provides for rerouting of the hydraulic line will not be issued due to technical complexity unless requested by an operator through the Master Change process. (A-85-134 related)

- c) Reevaluation of fail-safe validity of the aft pressure bulkhead of Boeing 747 and 767

The fatigue test and damage tolerance test of the aft pressure bulkhead on the current design model as well as on the improved model were completed in March 1986 and in July 1986, respectively. (A-85-135 and -138 related)

- d) Evaluation of repair procedures of the aft pressure bulkhead

Boeing sent a telegram to the operators requesting them to check whether repairs have been carried out, and to report details of the repairs conducted. (A-85-136 and AD85-22-12 related)

- e) Development of the reinforced aft pressure bulkhead

The reinforced aft pressure bulkhead was installed from line number 672 delivered in February, 1987. The modification added two tear straps, a cover plate to the center of the bulkhead, and doublers to the both sides of the bulkhead around the APU cutout. (A-85-135 related)

- f) Revision on the inspection program of the aft pressure bulkhead
(SB747-53-2275, March 26, 1987)

Boeing requested the visual inspection from the aft side at 1,000 flight-cycle intervals (freighters) or at 2,000 flight-cycle intervals (passenger airplanes); and after 20,000 flight-cycles, the detailed inspection by high-precision eddy current, ultrasonic wave and X rays at 2,000 flight-cycle intervals (freighters) or at 4,000 flight-cycle intervals (passenger airplanes).

As to 747SR, Boeing requested the visual inspection at 2,400 flight-cycle intervals; and after 24,000 flight-cycles, the detailed inspection by eddy current, etc. at 4,800 flight-cycle intervals. (A-85-137 related)

- 5.1.4 The Civil Aviation Bureau of the Ministry of Transport in Japan took the following actions for the safety operation of Boeing 747 and for the improvement of the search and rescue system for aircraft:

- a) Instructions to conduct overall inspection of the vertical stabilizer and the rudder (Airworthiness Directive TCD-2483-85, August 15, 1985)

- b) Instructions to conduct overall inspection of the aft part structure of the pressurized cabin (Airworthiness Directive TCD-2483-1-85, August 17, 1985)

- c) Request was made to the airlines operating Boeing 747 in Japan to report results of repair of the aft pressure bulkhead to both the Boeing Company and Japanese Civil Aviation Bureau to reevaluate the repair procedure. (JCAB Document Ku-Ken 747, September 4, 1985)

- d) Enforcement of an entry for inspection into JAL's Maintenance Department, and recommendation of service improvements based thereon for safety operation

(September 5, 1985)

- 1) to conduct overall inspection on Boeing 747s whose number of pressurized-flight times has reached the order of 18,000.
- 2) to review the inspection items of C maintenance and others, and at the same time to improve work cards used in the inspection of airframe structures, for the reinforcement of airframe structure inspection of Boeing 747.
- 3) to set up a long-range monitor program of airframe structures damaged by an accident or others.
- 4) to review the sampling inspection procedures of airframe structures of Boeing 747, and at the same time to improve the technical evaluation procedures of the sampling inspection results.

Furthermore, to promote to development of preventive measures against the the reoccurrence of major failures.

- 5) to ensure the thorough implementation of instructions from the maintenance department to the engineering planning department.
- 6) to reinforce the inspection and maintenance system of airframe structures as well as the all-round safety promotion system.

e) Notification to FAA of the inspection results of the pressurized cabin structures of JAL's Boeing 747SR's conducted pursuant to the service improvement recommendation, for FAA's further improvement actions to ensure the operation safety of the aircraft. (November 5/December 10, 1985)

f) Instructions to install a structural cover for the opening within the empennage which provides access to the vertical fin for the purpose of preventing the rupture of the fin structures due to flow-in of the pressurized air to the empennage aft of the pressure bulkhead. (Airworthiness Directive TCD-2611-86, May 7, 1986, A-85-133 related)

g) Instructions to incorporate SID items into the maintenance regulations as a measure to cope with the aging change of Boeing 747SR (Airworthiness Directive TCD-2636-86, October 12, 1986)

h) Up to Summer of 1986, the improvement of facilities of the Tokyo Airport Office where the Search and Rescue Center is located and the communications network among organizations concerned was completed, and the necessary staff was increased. Furthermore, on August 7, 1986, a joint training was carried out by the Civil Aviation Bureau and organizations concerned.

5.1.5 JAL has effected or is planning the following improvement actions, counter-measures, etc.:

a) Design modification of the vertical fin (Airworthiness Directive TCD2611-86, AD86-08-02 and A-85-133 related)

On all Boeing 747's in current use the cover was installed to the opening which provides access to the vertical fin up to December 31, 1985. On JA8169 and the aircraft thereafter the cover is installed in their production.

b) Modification of the Hydraulic Systems

The installation of the fuse to the hydraulic systems on 4 aircraft in current use was completed by the end of May, 1987, and on the other aircraft in current use will be completed by the end of March, 1988. On JA8178 and the aircraft thereafter its installation is made at the production time. (A-85-134 related)

c) Evaluation of repair procedures of the domed aft pressure bulkhead

Inspection on all aircraft in current use was made as to whether repairs were conducted and to what extent the work was carried out, and their results were reported to both the Boeing Company and the Japanese Civil Aviation Bureau. (A-85-136 and 139, AD85-22-12, the Boeing's Telegram, and JCAB Document Ku-Ken 747 related)

d) Revision of the inspection program of the aft pressure bulkhead

The eddy current inspections were implemented on six aircraft in the overall inspection of Boeing 747SR. (No cracks have been found) (A-85-137 Rescue related)

5. 2 Comments

5.2.1 A further improvement is desirable of the DFDR's anti-impact capability, in view of the fact that the magnetic tape of the DFDR on board the accident aircraft was broken, and near the broken spot was found damage such as many small folds and wrinkles.

5.2.2 In the CVR of the accident aircraft, voices were recorded for approximately 32 minutes and 16 seconds, but information helpful to the accident investigation may have been recorded at a portion which had been erased. There were also found portions difficult to read, although the equipment was a product meeting the specifications (TSO C-84).

It is, therefore desirable to develop a CVR covering more recording period, and to promote a study to improve the recording in terms of clarity through improvement of the total system involving the CVR.

5.2.3 Further enhancement is desirable of search and rescue capabilities through periodical enhancement of trainings etc., pursuant to agreements which have been concluded among organizations concerned to ensure prompt and effective search and rescue activities in an emergency.