

4 . C O N C L U S I O N

4. 1 Summary of Analysis

4.1.1 General Matters

4.1.1.1 The flight crew were properly qualified and had passed the established medical examination.

4.1.1.2 It is acknowledged that the then existent meteorological conditions were not directly relevant to the occurrence of the abnormal situation.

4.1.1.3 Functions and operational conditions of aids to navigation and ATC unit are acknowledged to have been normal.

4.1.1.4 The aircraft was certificated and maintained according to approved procedures.

4.1.2 Flight of the Accident Aircraft up to the Occurrence of the Abnormal Situation

4.1.2.1 On August 12, 1985, the accident aircraft took off Tokyo International Airport 1812 hours as Flight 123, subsequent to preceding four scheduled flights on the day. There were neither reports of abnormality nor flight discrepancies regarded as relevant to this accident in the preceding four flights as well as in the inspection and maintenance conducted between them (including the pre-flight check as flight 123).

4.1.2.2 At 1824:35 hours, about 12 minutes after take-off, an abnormal situation occurred so as to exert serious influence on continuation of the flight, up to which time the flight is considered to have been normal.

4.1.3 Repairs for Damage caused by the Accident at Osaka International Airport

4.1.3.1 It is acknowledged to have been proper that the repair work related to structures of the aircraft was accomplished by the Boeing Company for JAL by the contract, because the aircraft was manufactured by the company, etc.

4.1.3.2 The repair plan of the aircraft agreed on between JAL and the Boeing Company is considered to have been proper in general.

4.1.3.3 When the lower half of the aft pressure bulkhead deformed by the accident was removed and was being replaced by the new one in accordance with the repair plan, it was found that there were locations where the edge margin around the rivet holes at the splice (L18 splice) of the upper and the lower webs of the aft pressure bulkhead was less than drawing requirements. This is considered to have been caused by somewhat insufficient concern against deformation of the aft fuselage in the repair work of the aft pressure bulkhead.

4.1.3.4 For the above, the corrective measure to make a splice joint by inserting a splice plate between webs of the upper half and the lower half of the aft pressure bulkhead, which is considered as proper, was planned. But, during the

repair, improper work was conducted in which different from the intended corrective measure, one splice plate narrower than drawing requirements, and one filler were applied instead of one splice plate.

4.1.3.5 In inspections during and after the repair work, the afore-mentioned improper part of the work could not be found.

4.1.3.6 It is considered that the method of management for the work including the inspection of working process was in part insufficient in pertinency.

4.1.3.7 It is estimated that during this rework, part of L18 splice which should have been spliced by two-row rivets became spliced by one-row rivets, with the result that the strength of this part decreased to about 70% of the strength to be obtained by the original splice method. From this, it is estimated that these portions was brought under a condition susceptible of occurrence of fatigue cracks.

From the above, it is conceivable that the aft pressure bulkhead of the accident aircraft was lacking at this time in fail-safe capability.

4.1.4 Fail-safe Capability of Boeing 747 Aircraft

The fail-safe design of Boeing 747 is in accordance with standards on airworthiness of transport aircraft of the FAA, which was in effect at that time.

Provisions on airworthiness set forth minimum requirements for capability which aircraft should provide, but they would not guarantee the airworthiness under conditions caused in a very rare case, nor caused by improper repair work.

It is conceivable that the reason why ruptures propagated as a chain reaction in this accident is that prior concern had not reached as far as to the prevention of such situation from occurring, although the fail-safe design of the aircraft in the development stage, and inspection and maintenance methods which incorporated service experience were proper to meet the provisions concerned.

4.1.5 Operation and Maintenance of the Accident Aircraft after the Osaka Accident

4.1.5.1 The flight hours and the number of flights (number of landings) of the aircraft after the repairs for the accident at Osaka International Airport in June, 1978 up to this accident were 16,196 hours and 12,319, respectively.

4.1.5.2 During this period, in L18 splice of the aft pressure bulkhead, a number of fatigue cracks were caused and propagating mainly at one-row rivet connection portions.

4.1.5.3 It is considered that there were neither abnormalities nor flight discrepancies deemed to be related to this accident in flights during this period.

4.1.5.4 During this period C maintenance (a maintenance every 3,000 hours) was conducted 6 times, at which time visual inspection was made, but fatigue cracks

which had been existent at the rivet connected portions of L18 splice were not found.

The inspection method of the aft pressure bulkhead in the time of C maintenance might have been a proper method, because it was unconceivable at the time the said C maintenance was conducted that a number of fatigue cracks came into existence in this portion, provided the bulkhead was manufactured normally and repair work was done properly.

It is considered that the inspection method was not proper in part, in view of the fact that such fatigue cracks as to cause the aft pressure bulkhead to rupture were not found, although they resulted from the improper repair work.

4.1.6 Outlines of the Abnormal Situation

The conditions of the abnormal situation in which the accident aircraft was brought are considered as follows:

4.1.6.1 At about 1824:35, when the aircraft climbed to an altitude of about 24,000 feet, the pressure differential between the pressurized passenger cabin and outside atmosphere became about 8.66 psi, it is estimated that bay 2 whose residue strength had reduced remarkably by propagating fatigue cracks was fractured, being unable to bear the pressure differential, and taking this opportunity, L18 splice went into a total fracture at a stroke.

It is considered that the fracture propagated thereafter upward in the central portion of the bulkhead along the collector ring, and furthermore progressed upward along R6 and L2 stiffeners, and meanwhile in the outer edge portion of the bulkhead, the fracture propagated upward along Y chord.

4.1.6.2 As a result of such progress of the fracture, part of the web of the upper half of the aft pressure bulkhead was blown up aft by the air pressure of the passenger cabin to make an opening. The area of the opening is estimated as of an order of 2-3 square meters.

4.1.6.3 It is estimated that the inner pressure of the empennage increased by the pressurized air of the cabin flowed in through the opening of the aft pressure bulkhead, thereby the APU firewall was broken, and part of the empennage structure including the APU proper located aft of the wall was destroyed and separated.

4.1.6.4 It is estimated that part of the pressurized air of the passenger cabin which flowed into the empennage rushed into the vertical fin through the opening in the lower portion of the aft torque box of the vertical fin, thereby increasing the inner pressure of the vertical fin, and the fixture between the stringer and the rib chord in the upper half of the aft torque box was destroyed at first. It is estimated that thereafter destruction of the internal structures of the aft torque box and peel-off of the skin were caused, followed by separation of the upper half of the forward torque box, most of the aft torque box, the wing tip cover, etc.

4.1.6.5 It is estimated that the damage to the aft torque box of the vertical fin caused separation of the rudder, and four systems of hydraulic pressure line for the rudder control system were all fractured.

4.1.6.6 It is estimated that such destruction of the aircraft progressed within a period as short as a few seconds.

4.1.6.7 It is estimated that the pressure in the cabin including the cockpit reduced to the atmospheric pressure within a few seconds due to the opening of the aft pressure bulkhead.

4.1.6.8 It is estimated that by the afore-mentioned destruction of the airframe, control functions of the rudder and elevator and the trim function of the horizontal stabilizer were lost immediately after the abnormal situation occurred. It is also estimated that control functions of the aileron and the spoiler, and operational functions of the flaps and the gear by hydraulic pressure were lost within 1.0-1.5 minutes after the abnormal situation occurred.

4.1.6.9 It is estimated that due to loss of most of control functions and extreme deterioration of the lateral and directional stability, the maintenance of attitude and heading, and control of climb, descent, turn, and so forth became extremely difficult.

4.1.6.10 It is estimated that severe phugoid motion and dutch roll motion, of which control were difficult, were caused to the aircraft.

4.1.6.11 It is considered that the aircraft was not able to continue a stable flight and any flight as intended by the captain was difficult, and that a safe landing or landing on the water was next to impossible.

4.1.7 Flight of the Accident Aircraft after the Occurrence of the Abnormal Situation and Responsive Actions Taken by the Flight Crew

4.1.7.1 It is estimated that the flight crew immediately became aware of occurrence of some kind of abnormality, but they remained ever since unaware of details of the damage such as rupture of the vertical fin and separation of the rudder.

4.1.7.2 It is estimated that soon after the occurrence of the abnormal situation, the flight crew became cognizant of depressurization of the airframe, and nonetheless the flight crew did not put the oxygen mask up to the last. The reason, however, could not be clarified.

4.1.7.3 After the occurrence of the abnormal situation, the aircraft, without making an emergency descent, continued flight for about 18 minutes at an altitude of more than 20,000 feet, making phugoid motion and dutch roll motion. It is conceivable that the reason the emergency descent was not made during this period regardless of the intention expressed by the flight crew to make an emergency descent was that they were devoted to the control action to stabilize the

attitude. However, the definite reason could not be determined.

It is conceivable also that the flight crew suffered from hypoxic hypoxia during this period, whereby their capability of dealing with intelligent work as well as their behavior were deteriorated to some extent.

4.1.7.4 Thereafter, a gear-down operation was conducted, the aircraft entered into a descent and the phugoid motion subsided. When the aircraft descended to an altitude of about 7,000 feet, the flight crew noticed the aircraft was approaching mountains. As soon as they raised engine power immediately, the aircraft would have been brought into an unstable flight condition again, being accompanied by phugoid motion and dutch roll motion.

4.1.7.5 After the occurrence of the abnormal situation, the flight crew not only fell into an abnormal situation which was out of the scope of the education and training they received or the knowledge and experience they had, but also was unable to comprehend fully the substance of the abnormal situation, and furthermore they were brought into a severe environment of being subjected to severe motion and depressurization of the aircraft. For these reasons, it is conceivable that they were concentrated on the operation to stabilize the flight while not able to make a pertinent judgement on how to cope with the situation.

4.1.8 Crash of the Accident Aircraft

4.1.8.1 It is estimated that the aircraft which was in the unstable flight condition hit "the single larch tree" and "the U-shaped ditch" both short of the crash point, with the result that the remaining portion of the vertical fin and the horizontal fin as well as the engines, etc., were separated from the airframe at this time.

4.1.8.2 It is estimated that thereafter the aircraft collided against the crash point with an attitude of the nose and the right wing both down. The time of crash is estimated as approximately 1856:30 hours based on records of the DFDR and seismometer, etc.

4.1.8.3 By the severe shock at the time of crash the fore fuselage and the right wing were broken into small fragments and dispersed. The aft fuselage is estimated to have been separated by the shock at the time of crash, and fallen into the 3rd branch of Sugeno Dale passing over the ridge line. The other parts were dispersed in a wide area involving the crash point.

4.1.8.4 Fuel supposed to have been dispersed from the fuel tank flamed up, and the wreckage dispersed in the vicinity of the heliport which had been constructed after the accident for rescue purpose was burnt down.

4.1.9 Injuries to Passengers and Crew

4.1.9.1 It is considered that passengers and crewmembers in the fore and mid fuselage were all instantaneously killed by the shock estimated as much as hundreds of G as well as the total destruction of structures of the fore and mid fuselage at the time of crash.

4.1.9.2 Out of passengers and cabin attendants who were in the aft fuselage, those seated on forward seating are considered to have been killed almost instantaneously due to a possible strong shock in excess of 100 G's at the time of crash.

The shock persons on the aft seating were subjected to was also of an order of tens of G, and by this shock most of them are considered to have undergone fatal injuries. Moreover, the possibility would be considered high that since the flooring, seating, galley, etc were all destroyed and dispersed by the shock at the time of crash, they were killed enlarging the extent of injuries by bruise and oppression resulting from collision with such broken pieces.

4.1.9.3 Four persons survived this accident, but they were all seriously injured. All of them were seated at the aft portion of the aft fuselage and are considered to have been subjected to tens of G, but they were able to escape death miraculously. The conceivable reason would be that their seating attitude, way to fasten the belt, status of damage to the seat, status of substances surrounding their body, etc., at the time of collision chanced to help buffer the impact, and that they were less subjected to collision with dispersed internal substances of the fuselage.

4.1.10 Support to Flight of the Accident Aircraft from the Ground

It is considered that provision of information to the accident aircraft and actions respondent to requests of the aircraft by ATC/Communications were conducted adequately on the whole.

4.1.11 Search and Rescue Activities

4.1.11.1 Since the crash point was located in a remote area among a rolled mountainous district and the search was conducted in the night, considerable time was required to discover the aircraft and to confirm the crash point, which could, however, be justifiable under such conditions.

4.1.11.2 It is acknowledged that rescue activities were carried out to the best with close coordination of organizations concerned which participated in the activities, although they were confronted with extreme difficulties.

4. 2 Cause

It is estimated that this accident was caused by deterioration of flying quality and loss of primary flight control functions due to rupture of the aft pressure bulkhead of the aircraft, and the subsequent ruptures of a part of the fuselage tail, vertical fin and hydraulical flight control systems.

The reason why the aft pressure bulkhead was ruptured in flight is estimated to be that the strength of the said bulkhead was reduced due to fatigue cracks propagating at the spliced portion of the bulkhead's webs to the extent that it became unable to endure the cabin pressure in flight at that time.

The initiation and propagation of the fatigue cracks are attributable to the improper repairs of the said bulkhead conducted in 1978, and it is estimated that the fatigue cracks having not be found in the later maintenance inspection is contributive to their propagation leading to the rupture of the said bulkhead.