Boeing 737-436, G-DOCG

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Aircraft Type and Registration:	Boeing 737-436, G-DOCG
No & Type of Engines:	2 CFM56-3C1 turbofan engines
Year of Manufacture:	1991
Date & Time (UTC):	21 October 1997, 0745 hrs
Location:	Stand B8, London Heathrow Airport
Type of Flight:	Scheduled Passenger
Persons on Board:	Crew - 7 - Passengers - 105 (on arrival)
Injuries:	Crew -Nil - Passengers - Nil
Nature of Damage:	Damage to forward passenger door and mechanism
Commander's Licence:	Not relevant
Commander's Age:	Not relevant
Commander's Flying Experience:	
	Last 90 days - Not relevant
	Last 28 days - Not relevant
Information Source:	AAIB Field Investigation

The aircraft taxied to Stand B8 at the end of its flight. The dispatcher positioned the airbridge against the aircraft with no reported difficulty before most of the passengers de-planed in the usual way. A single passenger required a wheel-chair and therefore waited with two colleagues in the aircraft until all other passengers had left. In the meantime the wheel-chair operator (passenger mobility assistant) had positioned himself, with the wheel-chair, at the end of the airbridge, adjacent to the aircraft door.

As he was preparing to board the aircraft, the airbridge suddenly began to lower and to retract, catching its canopy on the open passenger door and creating a widening gap between the airbridge

floor and the door sill. The lowering of the aircraft end of the airbridge was sufficient to create a slope and was clearly becoming dangerous. None of the airbridge movement warnings were heard to sound and there is no evidence that anybody was near the airbridge controls at the time. The passenger mobility assistant warned one of the passengers still on the airbridge to vacate it without delay. A cabin crew member estimated that the jetty finally came to rest approximately 5 metres away and 2 to 3 metres below its correct position against the aircraft.

Airbridge operating principles.

The airbridge is a piece of airport equipment, provided and maintained by the airport operator. The B8 airbridge at Heathrow is available to a number of nominated airline companies. Each unit is normally operated by a dispatcher or member of movements staff from the airline company whose aircraft it is servicing or a corresponding person from that company's handling agents. Such operators are normally qualified to operate individual types of airbridge.

The airbridge in question consisted of a telescopic tunnel, the outer end of which was carried on a 'Mover'; a steerable, supporting, power-driven single axle vehicle. This could be moved, steered and the upper part elevated, to enable the outer end of the tunnel to telescope and to move both vertically and laterally, under the control of the operator, to accommodate aircraft types with differing door sill heights. The outer end of the tunnel was connected to a Bridgehead, which consisted of a rotating vestibule and a flexible adjustable hood providing a weatherproof passenger connection to the aircraft. The controls of the unit were positioned in the vestibule area.

The unit at B8 was of a type which could be selected to MANUAL, AUTOMATIC or OFF. Selection of MANUAL enabled the operator to manoeuvre the vestibule into position against the door aperture of the aircraft to allow passengers, crew, maintenance personnel and other staff involved in aircraft preparation and turn-round to gain access during most of the period the aircraft is on the stand. Once in position against an aircraft, the outer end of the airbridge was required to rise and lower to accommodate changing aircraft door sill height, as weight and load distribution within the aircraft altered during refuelling and as persons boarded and disembarked.

In order to achieve such movement the airbridge controls needed to be set to AUTOMATIC. The system would then remain 'live' and in the control of an automatic levelling system until it was re-selected to MANUAL by the dispatcher or other operator in preparation for being retracted, usually to allow aircraft departure. The bulk of the system was electro-hydraulic in operation, an electric motor driving a hydraulic pump providing pressurised flow to a motor which rotated the wheels, to achieve telescopic movement of the passageway, and to jacks which moved the vestibule vertically. Direct electric drives were used to steer the wheels of the mover and to operate the canopy. The hydraulic pump would continue to run whilst the unit was selected to either Manual or Automatic.

Automatic vertical movement of the bridge-head was achieved by the jack system in response to up or down signals provided by a position detector designed to rest against the aircraft fuselage.

Inspection and maintenance

It is understood that mechanical, non vehicular equipment carrying employees or members of the public, such as passenger lifts, escalators etc, as well as devices presenting a potential hazard, such as cranes, are required to be inspected at 6 monthly intervals. Legislation does not specify the precise nature of such inspections.

The airbridge is a device which does not fall specifically into either of these categories. It is not, however, a fixed structure and does not therefore fall under regulations governing structures carrying employees or the public. Maintenance and operation of such equipment must therefore be carried out in a manner which constitutes a programme to ensure an overall safe method of working.

This encompasses provision of suitable equipment for the task and a system of maintenance and operation which ensures that the equipment remains safe at all times. The design of equipment for use in public places is now the subject of a considerable body of requirements and standards aimed at ensuring that single point defects do not cause dangerous conditions in the whole system. This fail-safe design concept is confirmed by application of a process, known variously as fault-tree analysis and failure modes effects analysis. It is now widely used in safety critical industries, but does not appear to have been applied extensively in the early days of airbridge design. Instead, safety depended on high component reliability and in turn required a high maintenance input. In the case of this design, a degree of safety protection is provided by the fact that simultaneous operation of two hydraulic valves is required before any movement of the airbridge can take place.

The airbridge in question was supplied by the manufacturer approximately 20 years ago. New electrical controls and wiring to a revised design were supplied by a different contractor approximately 12 years ago but the hydraulic configuration appears to have remained unchanged. The moving canopy was also added at the time of the wiring revision.

Investigation

The airbridge was taken out of service immediately after the incident and a full functional check carried out by the airport operator. No operating problems were identified. Shortly afterwards the airbridge was observed to be moving although it was neither being re-positioned by an operator nor was it responding to vertical movement of an aircraft. It was also established that the same Airbridge had caused concern two days earlier.

On that occasion, a member of staff from the same airline was tasked with moving an aircraft away from Stand B8. He retracted the airbridge first but the unit continued to retract after he had released the operating knob, overshooting his intended parking position by approximately three feet. He reported this event in detail to his supervisor, recommending that the unit should be checked before a further aircraft was positioned on the stand.

The supervisor relayed this information by telephone to the airport operator's fault reporting number. No record of this conversation or fault reference was kept by the airline, or the airport operator and there is no evidence that any action was taken by the airport operator.

The airline reported that a number of airbridges had unique anomalies which operators using them frequently had come to be familiar with and of which they were wary.

The airport operator thereafter kept the airbridge out of service and requested both the original manufacturer and the makers of the revised electronic control system to carry out tests on the unit. During tests carried out by the latter, no evidence of any electrical defect was found, although during functional testing the airbridge was found to raise when the raise valve was operated manually. This was an incorrect function since a return valve must also operate to allow a fluid flow permitting the function to take place.

It was then found that operation of other valves in the system, without corresponding operation of the return valve, resulted in the relevant functions also incorrectly taking place. The wiring to the return valve was disconnected, but the inappropriate motions described above continued to take place when the relevant operating valves were selected manually. Whilst attempting to move the bridge forward it suddenly began to retract and was only brought to a halt by operating the emergency stop, thereby shutting down the hydraulic pump. It was presumed by the electrical specialists that the return valve was jammed open, creating a 'dormant fault' condition, allowing any spurious operation of other valves to create undemanded motion.

Examination of the unit revealed that the hydraulic system fluid of the B8 airbridge was heavily contaminated and the filter partially blocked. In addition the cover on the valve assemblies was missing and the exposed valves were badly corroded.

It was concluded that the level of fluid contamination would readily lead to valves failing to seat correctly, leading in turn to possible uncommanded movement when hydraulic pressure was available to the system. It appeared that the return valve was stuck in the open position allowing a flow to take place when any other valve was open.

The airbridge remained out of service until overhaul of the hydraulic system was completed by the manufacturer, Aviobridge BV. This work included flushing out of the hydraulic system and replacement of all the valves, the filter and the hydraulic fluid.

Maintenance procedures

The airport operator utilised a six monthly inspection cycle on this equipment. According to documentation received from that operator, this was last carried out on 24.3.97, somewhat over six months before the incident. The list of inspection actions called for in the cycle did not include any condition assessment or other action likely to highlight the type of incorrect functioning which occurred during the incident. Although a series of functional checks were included, none could be expected to identify the type of dormant fault which was clearly present by the time the incident occurred.

A further set of programmed maintenance checks were carried out by the operator at regular monthly, 3 monthly and yearly intervals. Of the items relevant to this incident, these actions called for checking and replenishment of the hydraulic reservoir at 3 monthly intervals and replacement at those intervals of the filters if contaminated. Fluid was to be replaced if an annual oil sample indicated the need. No record of these maintenance actions having been carried out was provided.

The inspection and maintenance procedures documented and provided by the operators do not address the problem of dormant faults in the hydraulic system. The only way of ensuring that undemanded operation could not occur would require an independent check to be made of the functioning of the return valve at regular intervals. Without this, the valve may remain defective for an indefinite period without being detected. During this period, normal controlled operation could take place but nonetheless a condition would exist where simple malfunction or sticking of an operating valve would make the airbridge operate on other occasions without any control demand. The laid down maintenance procedures, even if correctly carried out, failed to take account of the design characteristics of the airbridge.

This piece of equipment carries members of the public and is 'live' at all times that it does so. Inspection and maintenance procedures carried out by the manufacturer under contract to the operator seem geared to assessing the overall condition of the equipment and structure, ensuring

that the equipment operates correctly when being actively controlled and that no overall deterioration of the structure has occurred. They pay no specific attention to the over-riding safety need for it to remain static and secure when it is not being re-positioned but passengers are walking and standing on it.

The monthly, 3 monthly and yearly maintenance checks carried out by the airport operator before the incident similarly were incapable of detecting a dormant fault in the hydraulic system unless it manifested itself by coinciding with another valve fault during functional testing.

As a result of the findings of the equipment examination, the airport operator instituted a system of checks of all similar equipment at this airport and at others in the group. In addition, those programmed maintenance checks carried out at monthly, 3 monthly and yearly intervals by airport personnel, were modified to incorporate a check of hydraulic valves at the 3 monthly intervals. No description, however, of the nature of that check was incorporated in the documentation received from the airport operator. It is not known if particular steps were taken to ascertain the likely period during which fluid could be relied upon to remain safely clear of contamination.

In the longer term the operator proposes to bring forward the planned refurbishment of the B8 and adjacent B10 airbridges to raise them to a modern standard.

Safety recommendations

It is recommended that the BAA and other airport operators, in conjunction with airbridge manufacturers should:-

Recommendation 98-42

(1) Identify those features of airbridge control and operating system designs which guard against uncommanded operation when the equipment is set in automatic mode.

Recommendation 98-43

(2) Devise a maintenance regime for airbridges which takes account of the above findings and the system design philosophy to ensure that dormant faults are eliminated during inspection/testing.

Recommendation 98-44

(3) Establish realistic maintenance intervals for the above checks and for related examinations such as hydraulic fluid contamination sampling, taking into account real time experience of the rates of system deterioration measured in both calendar time and operating cycles.

Recommendation 98-45

(4) Provide specific detailed written instructions to inspectors of airbridges within the airport authority or their contractors defining exactly how the above check requirements will be carried out.

Following discussions on the contents of a first draft of this Bulletin the BAA has indicated that they have taken the following actions:

1 The bridge that was involved in the incident has been removed and is currently with the manufacturers being refurbished under the current years programme, which involves refurbishment of eleven bridges in the year 1998/99.

2 A group is being set up to fully investigate potential failure modes on the bridge control systems and to recommend any equipment changes. (AAIB Recommendation 1)

3 The findings of the above group have been incorporated into the maintenance schedules and inspections procedures. Identified potential failures will be addressed. (AAIB Recommendation 2)

4 The maintenance routines will be revisited in view of in-house and manufacturer's experience and revised routines are currently being implemented.

The oil sampling process has been changed to an annual sample after discussion with the designers and manufacturers and the results will be closely monitored. (AAIB Recommendation 3)

5 New airbridge maintenance standards are in the process of being produced and are to be issued shortly. These standards define maintenance and checking requirements. (AAIB Recommendation 4)