Boeing 757-28A, G-FCLI

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Aircraft Type and Registration:	Boeing 757-28A, G-FCLI
No & Type of Engines:	2 Rolls-Royce RB211-535E4, turbofan engines
Year of Manufacture:	1995
Date & Time (UTC):	4 December 1999 at 2102 hrs
Location:	Manchester Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 9 - Passengers - 230
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Internal failure of right main landing gear leg and damage to bay tertiary structure
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	N/A
Commander's Flying Experience:	N/A
Information Source:	AAIB Field Investigation

Background

The aircraft departed from Runway 24R at Manchester for a flight to Las Palmas (Canary Islands). On landing gear retraction, the Engine Indication and Crew Alerting System (EICAS) displayed two caution messages, indicating 'Gear Disagree' and 'Gear Doors'. These were accompanied by an abnormal ambient airflow noise. The indications implied that the landing gear had not properly retracted, so the flight crew kept the aircraft's speed below 270 kt, in accordance with the Quick Reference Handbook procedure. After consultation with company operations and engineering, the flight crew recycled the landing gear as the aircraft was climbing through FL90 at a speed of 250 kt. The recycling had no apparent effect on the landing gear status and the EICAS caution messages remained.

The aircraft speed was limited to 270 kt/0.82 Mach in this configuration, so the commander elected to divert the aircraft for a landing at London Gatwick Airport, where engineering inspection facilities were available. ATC were informed of the nature of the problem and the aircraft made an uneventful overweight landing at Gatwick, some 4 tonnes above the normal maximum landing weight. Normal landing gear down and locked indications were obtained during the approach.

Description of landing gear

Each main landing gear unit consists of a four wheel truck, pivoted on a fork, mounted on the lower end of the inner cylinder of the main leg. The main leg consists of a hollow forging (the outer cylinder) within which the inner cylinder slides vertically. The angle of the truck is controlled relative to the inner cylinder by a tilt actuator, which rotates the truck to a 'nose up' angle when the aircraft weight is removed from the truck.

The volume between the inner and outer cylinders of the leg contains pressurised nitrogen gas at its upper end. This acts as the springing medium. A tapered metering pin mounted on the upper end of the inner cylinder passes through an orifice plate fixed in the outer cylinder. Hydraulic fluid occupies the lower part of the volume between cylinders up to a level above the orifice plate. Rapid flow of fluid through the restricted space between the pin and the orifice plate performs the damping function as the leg is compressed during landing.

During take off, as the aircraft weight comes off the leg, the inner cylinder and the truck travel to the fully down position under the influence of the truck weight and the nitrogen pressure; the truck is also tilted by its actuator. Retraction is effected by the leg pivoting inboard about a longitudinal pivot axis at its upper end, after the landing gear doors have opened. Once retracted, each main leg lies at approximately 90 degrees to the longitudinal axis of the aircraft whilst each truck lies on its side orientated approximately fore and aft. The outer boundaries of the landing gear bays take the form of composite panels.

Post incident examination

Examination of the aircraft revealed that there was damage to the composite panelling forming the outboard boundary of the starboard main landing gear bay. It was also noted that the starboard landing-gear truck was fully retracted into the main leg, ie the fescalised portion of the inner cylinder was not visible. Pressurising the leg was found to have no effect on the extension of the inner cylinder. The aircraft was jacked but the inner cylinder remained fully retracted within the leg. All efforts to extend it proved fruitless.

Phase 1 of the high-weight landing/hard landing examination of the aircraft structure was carried out. No damage/defects were found. The inspection schedule only calls for the later inspection phases to be carried out if damage is identified during the phase 1 inspection.

The complete leg was removed from the aircraft and forwarded to a landing-gear overhaul agency. A borescope inspection of the inside of the inner cylinder revealed extensive deformation of the cross-section, together with major cracking, near its upper end. The inner and outer cylinders were eventually separated by jacking them apart. This action resulted in complete failure of the inner cylinder in the region of the cracking and extraction of only the lower end. A severely deformed section at the upper end remaining firmly lodged in the outer cylinder. It was eventually extracted by drilling and tapping and pulling out by means of a specially made threaded extractor.

Examination of the remains of the inner cylinder showed that considerable plastic deformation of the cross-section had occurred near the upper end. The fracture faces were metallurgically examined and found to be free from pre-existing defects. The shape of the deformation rather suggested crippling due to excessive compressive end load. All the static and dynamic seals were examined and showed no evidence of damage or failure. Examination of the face surrounding the base of the metering pin revealed evidence of forcible contact with the orifice plate.

Other information

Within a few days of the arrival of the gear leg at the overhaul facility, another leg was returned to them from another operator of the same aircraft type. This was similarly collapsed and could not be extended. Very similar cracking and deformation of the upper end of the inner cylinder was evident on borescope examination.

Similar forces as before were required to extract the inner cylinder and failure occurred leaving the upper end of the latter jammed within the outer cylinder. A similar method as before was used to extract the upper end of the inner cylinder. All seals were found to be intact, the fracture face was free from pre-impact defects and the operator reported that no aircraft damage was noted after a hard-landing inspection was carried out.

The deformation damage was similar in extent and of corresponding orientation to that of the inner cylinder of G-FCLI although it was the left unit and the damage was handed accordingly. It was also found that the face surrounding the metering pin had struck the metering plate.

The crew report on the relevant flight of the second aircraft stated that a slight nosewheel bounce was noted during taxiing (this was attributed at the time to low aircraft mass). After take off and gear retraction the Gear Doors light remained on with the lever in the off position. The gear lever was moved to 'up' in accordance with the QRH; the light remained on. The speed was therefore limited to 250 kt. Once the gear was selected down indications were normal. The approach was made with wings level but the aircraft touched right-gear first before rolling left onto the left gear.

On examining the aircraft, it became clear that the inner cylinder of the left gear was fully compressed and that it had been at the time of gear retraction. This had resulted in damage being inflicted to the wing/body fairing forward of the landing gear door.

The manufacturer reported that, during calculations carried out in support of the design and development testing of the 757 leg, it was demonstrated that the inner cylinder could not be collapsed by excessive hydraulic or gas pressure during high alighting rates, unless these were so high that severe damage also occurred to the mounting trunion, the truck or the aircraft structure.

Experience from the aircraft manufacturer's landing-gear specialist indicated that only one previous instance of a failure having similar appearance and characteristics was known to them, the failure in question having occurred to a Boeing 737 aircraft. The cause of the previous failure was not established. The possibility of 'dieseling' was discussed. This is the effect of rapid combustion of the hydraulic fluid vapour and consequent pressure rise during compression of the leg on landing. Such a possibility would exist if the leg was inadvertently charged with compressed air rather than nitrogen. It was considered, however, that sources of compressed air of suitable pressure are not generally found in the vicinity of aircraft maintenance areas.

An assessment of the operating patterns of the two aircraft confirms they had not recently had any work carried out at a common location.

It was noted that the available stroke from the normal at rest position to the fully compressed position was short. With a leg fully compressed and the fescalised portion not visible, the aircraft did not lean noticeably to one side when at rest. The possibility existed that the leg was fully compressed during the walk round and was not spotted.

Operators of both aircraft subsequently carried out fleet checks on the remainder of their aircraft to confirm that the legs were full of fluid to the correct level and correctly charge with nitrogen. No deficiencies were found with either fleet.

Discussion

In the absence of any aircraft damage, or any damage external to the leg, it is reasonable to conclude that neither aircraft had been subjected to any excessively high descent rates during recent landings. It is most likely, from the appearance of the damage to the inner cylinder, that it was a form of compressive crippling which occurred when the surround of the metering pin on the top of the inner cylinder came forcibly into contact with the travel stop (ie the orifice plate) in the outer cylinder.

Under normal circumstances, this cannot occur without inflicting other damage that was absent on this occasion. It is possible, however, that lower forces than those associated with the design limit may have been applied to the leg during the previous landing yet still have lead to full compression of the leg. This could have occurred if the gas and fluid within the leg were not present in the correct quantities, proportions and pressure. In particular, an insufficiency of fluid, together with correct gas pressure could have lead to the fluid level being below the orifice plate throughout all or most of the compression range of the leg. Reasonably normal behaviour during smooth landings would probably have been present but lack of damping would have lead to excessive travelling during firmer arrivals.