

No. 29

Ethiopian Air Lines, Inc., Lockheed Constellation L 749A, ETT 35, made an emergency landing, due to fire in flight, in Northern Gezira, 22 nautical miles from Khartoum, Republic of the Sudan on 10 July 1957. Report released by the Department of Civil Aviation, Ministry of Communications, The Republic of the Sudan.

Circumstances

The aircraft departed Athens, Greece, on flight No. ET 3 at 2236 hours Greenwich Mean Time on 9 July for Addis Ababa, Ethiopia, via Khartoum, Republic of the Sudan. It left Khartoum International Aerodrome at 0555 hours GMT on 10 July carrying a crew of 6 and 14 passengers and was cleared to cruise at 17 500 feet. At 0610 hours, at about 10 500 feet altitude, the number two engine fire warning light for zones 2 and 3 came on and the warning bell rang. The engine was feathered. The CO₂ bottle was released and concurrently an explosion followed by a violent fire, made it necessary (at approximately 0620) to land the aircraft with gear up on a large flat cultivated area. There were no injuries to passengers or crew, but the aircraft was almost totally destroyed by fire which continued burning on the ground.

Investigation and Evidence

The gross weight at time of take-off at Khartoum was 81 101 pounds. Maximum gross weight authorized by the company for this aircraft on a flight from Khartoum to Addis Ababa was 91 800 pounds. This was reduced from the normal maximum gross weight at 107 000 pounds for take-off for this type aircraft because of limitations on landing weight at Addis Ababa.

The centre of gravity of the aircraft was determined to be within prescribed limits by reference to the Load Manifest prepared at Khartoum. Proper location of centre of gravity was secured by placing 926 pounds of baggage and company material in the rear cargo compartment.

The aircraft was refuelled at Khartoum where approximately 500 gallons of fuel were added to the aircraft's tanks. The tanks contained a total of 1 650 US gallons at time of take-off. Refuelling and amount of fuel and oil were checked by the flight engineer. The amount of fuel on board was sufficient for the requirements of the scheduled flight to Addis Ababa.

Weather conditions as reported and forecast were favourable for the flight and had no bearing on the accident.

Communication and navigation equipment and facilities used by the flight and available to the flight were operating in a satisfactory manner.

The aircraft made a gear up landing in the desert on flat sandy soil. The initial touchdown point was approximately 1 000 feet before final touchdown on a heading of 265°. At the end of a 1 020-foot slide the aircraft made a pivoting turn to the right and came to rest on a heading of 018°.

The major sections of the aircraft remained approximately in the same position as it came to rest. The major portions of the fuselage centre section, inner wings and nacelles were consumed by fire. The fuselage aft of the pressure bulkhead was intact. The horizontal stabilizer, elevators, vertical fins and rudders were intact and suffered only negligible damage by heat and smoke. The outer wing panels including ailerons were intact with some damage to the inboard leading edge of both wings adjacent to, and outboard of, the outer wing attach joint. Engines No. 1 and 4 were located

in their normal position with respect to the rest of the aircraft and were very extensively damaged by fire. No. 3 engine was located forward and outboard of No. 4 engine position. No. 3 engine suffered only impact damage since it was torn off and rolled clear of the fire. No. 2 engine was located 3-1/10 miles from the aircraft and suffered considerable damage when it hit the ground. There was no indication of fire damage forward of the fire wall.

Indication from crew testimony is that there was no failure of the primary control cable system at the time of landing. Wing flaps were found in the "up" or retracted position although extensive fire damage had taken place to the wing flap assemblies aft of No. 2 engine nacelle. Examination of the control surface boost cylinders' by-pass levers indicated that all levers were in the "boost on" position.

Because of destruction of the aircraft by fire, it was not possible to determine the condition of the electrical system. Examination of No. 2 engine's electrical system and wiring showed no damage to the electrical wiring that would indicate that a short circuit or overload condition had existed.

All plumbing, hydraulic units and reservoirs in the fuselage forward areas and in the inner wings and nacelles were seriously damaged or destroyed by fire. Elevator and rudder emergency boost systems in the tail of the aircraft were complete and intact as was the aileron boost control valve and cylinders.

The nose gear and main gears were found to be engaged in their respective up locks indicating that all landing gears were in their "up" and locked position at the time of ground contact.

All support mechanisms for the landing gear installations were in their relative positions and, except for fire damage, were intact.

Fire Extinguishing System -

All six CO₂ bottles were accounted for. The actuating heads were damaged by fire. However, the position of the cutter in each of the six actuating heads indicated that both banks of the CO₂ bottles had been discharged.

Oxygen System -

All six low pressure oxygen tanks of the normal oxygen system were found intact with the outlet fitting destroyed by fire. The tanks did not explode. All five walk around oxygen bottles were accounted for. The pressure regulators were destroyed by fire. The bottles did not explode.

Auxiliary Boost System -

Electrical wiring for the auxiliary boost system was intact although some fire and smoke damage was evident immediately aft of the pressure bulkhead.

Discussion

The evidence disclosed that the fire warning first noticed by the crew was located in zone 3 of the wheel well area from rear of No. 2 engine fire wall as evidenced by:

1. The flight engineer's statement to the aircraft commander as being in zone 2 and 3 immediately after the fire warning light became visible and the fire bell heard.
2. Smoke and flames coming from underneath, over and then the wing area in and around zone 3 area or behind No. 2 engine.

The smoke first seen came from zone 3 area and was described by witnesses as being grayish white in colour; such smoke could be produced by magnesium or hydraulic fluid striking hot metal and the resultant blaze.

An explosion was heard or felt, by crew members and passengers, that could not be identified except as a dull explosion or sound and with varying degrees of vibration and intensity.

The commander of the aircraft lost his boost control following the explosion as a result of losing primary hydraulic system pressure. This, combined with loss of power and damage to the left wing, necessitated assistance from the co-pilot in attempting to lift the left wing to a level or horizontal position. The secondary hydraulic system actuated by No. 3 or 4 engine was proved to be normal when the co-pilot partially actuated the landing gear control handle. This included a full cycle of the nose gear and only partial acting of the main gear. The use of the auxiliary boost hydraulic system resulted in actuation of the rudder and elevator.

Reconstruction of the flight up to the accident

Between 0610 and 0611 when the fire warning light came on and the bell rang, the engineer located the fire in zone 2 and 3 left main landing gear nacelle wheel well or accessory section. The pilot then instructed the engineer to feather No. 2 engine, depressurize the cabin, pull the fire bottles and to hand him his smoke mask.

No. 2 engine was feathered and at this time the engineer advised the captain to wait until he made a visual check before he pulled the handle for the fire extinguisher. The flight engineer then proceeded to the cabin and seeing no evidence of fire returned to his station in the cockpit. Just prior to the engineer's arrival in the cabin, a few puffs of grayish white smoke were seen by a passenger coming from underneath the left wing, in line with No. 2 engine. This smoke rapidly increased in intensity and was followed by the explosion. Immediately after the flight engineer returned to his station, he pulled the handle of the fire extinguisher

system, setting off a bank of 3 bottles of CO₂ into No. 2 engine nacelle. Immediately after pulling the handle and before he could sit down in his seat, the explosion was heard and/or felt. After the fire warning light came on and the fire bell started ringing, the captain immediately started a right turn to return to Khartoum. The radio operator was transmitting on carrier wave to Addis Ababa giving the departure time from Khartoum and estimated time of arrival at Addis Ababa, and at the same time the co-pilot was advising Khartoum Control Tower on VHF of the aircraft's return to Khartoum due to fire warning signals on No. 2. During the aircraft's turn and while transmitting on carrier wave to Addis Ababa, the radio operator noticed the aircraft's turn and advised Addis Ababa the aircraft was returning to Khartoum. The flight engineer, after the explosion, placed the smoke mask on the central pedestal and upon being notified by the captain that the aircraft was returning to Khartoum and descending, commenced depressurization.

Some passengers and the hostesses stated they saw black smoke following the explosion and then flames. The flames appeared level with the cabin windows and extended above, below and around the inboard side of the left wing and through the apertures in the skin of the wing between the rear of No. 2 engine and the fuselage. The passengers also stated that they smelled and saw a whitish smoke, like fog, in the cabin. This smoke was determined to be only fog, the result of depressurization and refrigeration. Some stated that the explosion sounded like thunder or a dull explosion.

The captain, during the completion of the turn and initial descent and following the explosion, lost his control boost and the aircraft went into a sharp left bank. This condition resulted in both the pilot and the co-pilot having to operate the flight controls. It is to be noted that when hydraulic boost pressure is lost,

increased forces are required to operate the controls unless the boost control levers are placed in the "Boost Off" (Manual) position. There followed, during descent, a series of explosions of varying intensity numbering anywhere from two to six as reported by the crew and passengers.

The evidence disclosed that at least three explosions occurred. The first occurred shortly after the return of the flight engineer from his visual inspection of No. 2 engine. The second occurred after flames were seen coming from the inboard side of the wing between No. 2 engine and the fuselage, and the third explosion occurred during the last final period of descent and prior to levelling off the aircraft for landing. It was believed that the first two explosions were from the right inboard tire on the left main landing gear, followed by the left tire on the left main landing gear, with the third possibly resulting from internal combustion of fumes collected as a result of broken gasoline and hydraulic lines located in and around the left main gear wheel well. Also, during the descent, the hydraulic pressure instruments and tachometers were fluctuating on No. 1, indicating that the electric and fuel lines had been affected by the explosion or fire. At approximately 1 000 ft above the ground, No. 2 left wing inboard engine dropped clear of the aircraft, followed by severe buffeting and sharp lowering of the left wing. The pilot, looking out of the window at this time, saw fire extending along the leading edge of the left wing, as far out as the left outboard engine. The auxiliary boost to the controls was actuated by the co-pilot during intervals when he was assisting the pilot in attempting to lift the left wing. The auxiliary boost was effective. During the final approach for landing, and while a few hundred feet above the ground, the pilot ordered the landing gear to the "down" position and the landing gear handle was actuated by the co-pilot; however, before the landing gear had completed its down cycle, the co-pilot asked the pilot if this was what he wanted, and the pilot said "No." It was decided to land

* By the Sudanese authorities

with gear up and the co-pilot immediately retracted his gear. During this operation the nose wheel green light indicated that the nose wheel did complete its full cycle and lock down. No green light was seen for either main gear to indicate they were locked down, however, the single red warning light stayed on showing at least one of the other gears was in motion. This red warning light went off when the gear handle was put to the "up" position indicating that all 3 gears were up and locked in the "up" position. A gear up landing was made on a large flat ground area into the wind, with Nos. 1, 3 and 4 propeller blades showing marks on the ground of having rotated, with No. 3 then No. 4 followed by No. 1 contacting the ground in this order. Fortunately, just prior to the end of the roll, the aircraft turned to the right approximately 113°, which resulted in the fairly strong wind blowing the fire away from the exits thus permitting all persons on board to evacuate the aircraft without danger of encountering the flames.

Probable Cause

This accident was due to the overheating of one of the brakes of the main landing gear during the aircraft's taxiing and take-off run. It was caused by a dragging brake and a leakage of hydraulic oil with resultant fire and tire blow out. The tire blow out resulted in damage to hydraulic oil and fuel lines within the confined area of No. 2 engine nacelle, between the rear of the engine fire wall and rear spar, and between the fuselage and left side of the landing gear wheel well doors.

Note: It is interesting to note at this time that information received* during this investigation showed some apparent parallel to other similar aircraft accidents and occurrences. The following information was received by cable:

"A tire blow out caused by heated brakes when in gear up position

has been known to occur and result in damage to wing structure and fire. One such case involved a Constellation which crash landed and burned at Argentia, Newfoundland, on 17 April 1957, after taking-off with a dragging left brake. Other known cases have involved KC-97's. The Civil Aeronautics Board has no record of any tire blow out on civil aircraft with gear in the "up" position. There have been numerous cases of wheel failures due to fatigue cracking accompanied by tire blow out during ground operation. Several of these ruptured brake lines can cause other minor damage to aircraft. Several fires occurred due to the excessive use of brakes in ground operation and several due to wheel bearing failures. During one brake fire, application of fire extinguishing agent by ground crew caused wheel failure and tire blow out with a large segment of wheel being hurled a considerable distance with high energy. Such fires could conceivably result in wheel failure and/or tire blow out after gear retraction."

South African Airways states "two incidents experienced DC-7B airplane due excessive brake force. Firstly, during landing, small fire around left brake assembly, damage negligible. Secondly, left brake outboard wheel overheated during take-off causing inner tube to deflate while retracted. Wheel well area NOT damaged."

Recommendations

The investigation of the accident disclosed

- a) the need for an adequate fire wall or shield so located around this landing and nose wheel gear well that would protect the fuel,

hydraulic and alcohol lines and other parts of the aircraft vital to its operation from wheel tire blow outs and/or wheel fire;

- b) the need for a heat indicating device to indicate to the operating crew when the brakes have reached a temperature of sufficient heat that would result in fire when in contact with combustible materials, and permit preventative fire action on the ground and airborne;
- c) the need for eliminating magnesium wheels and brake assemblies due to its being subject to burning, with intense heat, and the improbability of extinguishing such type of fire;
- d) the need for investigation to determine some means of extinguishing wheel and tire fires and eliminating the resultant possibility of simultaneous explosion when CO₂ or other fire extinguishing agents are applied against it;
- e) that government authorities responsible for the provision of Air Traffic Control Services should ensure that the latest and most comprehensive voice recording system with built in Time Injection designed to fulfil the recommendations of ICAO is installed. Failing the installation of such equipment, authorities should ensure that adequate records are kept of all transmissions including the time of all transmissions both from the ground and aircraft.
- f) It is recommended that in view of the fact that no unpremeditated crash will ever exactly duplicate another, an immediate form of personnel training program be considered for

implementation covering all aspects of aircraft fire fighting, both on the airport and within the operational limits of the equipment and that liaison with the Municipal Fire Services be maintained on a continuous basis.

- g) In view of the fire and the many brake fires of similar nature brought to light during this investigation, it is recommended

that a more detailed brake inspection be carried out at more frequent intervals.

- h) That a study be made into the possibilities of developing a brake system designed so as to permit the use of a Fire Resistant Hydraulic fluid "MIL 5606" in the aircraft's main 'Hydraulic System'.

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