

No. 8

Arab Wings, Lear Jet 36A, JY-AFC, accident at Amman, Jordan, on 23 September 1977. Report dated 1 April 1978, released by Director General of Civil Aviation, Jordan.

1.- Investigation1.1 Synopsis

The referenced aircraft was seen after take-off from runway 24 to suddenly drop the left wing while in climb attitude, make a recovery to wings level and then continue in a slow roll to the right beginning descent. During this descending roll the nose of the aircraft was observed to oscillate once or twice as if forward stick pressure was being exerted. Recovery was not effected and the aircraft impacted on the cockpit area in an inverted position on hard ground approximately 8 ft north of the parallel taxiway.

Disintegration began at this point with the aircraft separating into three major sections; cockpit and cabin, aft fuselage from fuel tank bulkhead to vertical and horizontal stabilizer, and wings with gear extended. Fuel ignition was generated at ground impact of the right wing tip tank and fire contributed to damage to the aft fuselage as well as to wing leading edges.

The cockpit and cargo floor came to rest approximately 350 ft along the ground path with the aft fuselage section being stopped by a tree 375 ft along the ground path. The wings landed inverted at a distance of 573 ft with leading edge facing towards the main wreckage.

The accident was not survivable owing to the impact forces experienced.

1.2 History of the flight

On 22 September this aircraft, with the same crew and passengers, arrived on a charter flight Beirut/Amman at 1515 GMT. Although originally scheduled for departure at 0900 GMT on the 23rd, further planning advanced the departure to 0700 GMT and this crew volunteered to make the flight as the scheduled crew could not be notified of the change in timing. The aircraft was topped off with 260 U.S. gal of fuel at 1830 GMT, making the fuel load equivalent to 4 500 lb. There was approximately 200 lb of fuel in the fuselage tank. The fuelling top-off on the 22nd and morning departure were supervised by a licensed Arab Wing mechanic. The first officer undertook an outside pre-flight inspection and then called the tower for take-off data. The right-hand engine was started at approximately 0700. Start-up clearance was requested and at 0703 the crew were notified that start-up clearance would be at 0715. When the tower advised the crew they could start up, the captain requested taxi clearance, and during taxi-out was advised to slow down. Owing to co-ordination of traffic beyond the borders of Jordan, the crew were informed that take-off clearance would be 0729 or later. At 0724 request for take-off was again made and the tower advised that clearance was 0729.

At 0729 the aircraft was cleared by the tower for take-off and after this was acknowledged, no further voice communication was carried out from the aircraft.

The time lapse from acknowledgement of clearance to "Mayday" call from a taxiing Academy aircraft was 55 seconds.

1.3 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2	2	0
Non-fatal	0	0	0
None	0	0	

1.4 Damage to aircraft

The aircraft was demolished through impact and fire.

1.5 Other damage

The aircraft broke two reinforced concrete postings and cut a swath through a corn field planted at the airport sewage farm.

1.6 Personnel information

a) Pilot-in-command

Age: 28 years
 Licence: Jordanian Airline Transport Pilot
 Ratings: Aeroplane multi-engined land Lear-Jet
 Medical: Valid Class I issued 1 August 1977
 Experience: Total time 2 289 hours
 Total pilot-in-command 970 "
 Pilot-in-command/Lear Jet 92 "
 Instrument 115 "
 Night 242 "
 Hours flown last 6 months 250 "

b) Second-in-command

Age: 27 years
 Licence: Jordanian Commercial Pilot
 Ratings: Single and multi-engined
 Instrument Rating Lear-Jet 35/36
 Medical: Valid Class I issued 22 June 1977
 Experience: Total time 974 hours
 Total pilot-in-command 536 "
 Instrument 50 "
 Hours flown last 6 months 200 "

1.7 Aircraft information

Manufacturer:	Gates Lear-Jet Corporation
Type:	Model 36A
Serial Number:	36A-020
Date of Manufacture:	9 June 1976
Nationality and Registration Marks:	JY-AFC
Registration: Certificate of Airworthiness:	Jordanian
Maintenance:	Valid until 3 July 1978 6 months and one year inspection carried out on 10 August 1977 at Amman
Engines:	Garret Corp. Airesearch TFE 731-2-2B No. 1 Serial No. P74316 T.T. 372 hours No. 2 Serial No. P74299 T.T. 728 hours
Airframe:	Aircraft maintained in accordance with a Gates/Garrett maintenance programme for the type of airframe and engine
Applicable Airworthi- ness Directives:	Accomplished

1.8 Meteorological information

Weather is not considered a factor in this accident.

Surface wind:	280/08
Visibility:	10 km
Clouds:	Nil
QNH:	1015 mb
Temperature:	24°C

1.9 Aids to navigation

Not applicable as contributing to this accident.

1.10 Communications

Communications were normal in all respects and did not contribute to the accident. (Ground control frequency 121.90 and tower 118.10.) Aircraft was in radio contact for taxi and take-off clearances.

1.11 Aerodrome information

The elevation of Amman airport is 2 548 ft amsl. The airport is served by a single runway 24/06 which is 11 515 ft in length with parallel taxiway available only to the beginning of new extension to 24.

1.12 Flight recorders

CVR and Flight Data recorder not installed.

1.13 Wreckage

Aircraft began separation at point of initial impact area.

1.14 Medical and pathological information

Post-mortem report concludes that crew were in good health and no evidence of drugs or other soporifics was found. The examination of lungs did not show penetration of gases or other noxious contaminants being inhaled.

1.15 Fire

Fire was experienced in the first second as the right wing tip tank ruptured. Although this fire contributed to aft fuselage and wing damage, the cockpit area was mostly untouched by fire.

1.16 Survival aspects

High 'G' loads were experienced and the medical report indicates no survivability factor.

1.17 Tests and research

The cockpit was compressed into a single ball and the recovered instruments were too damaged to provide factual information. The first officer's airspeed needle was observed to be near the 100 kt indication, with bug set at 117. The fuel control units were found at 120 degrees Power Lever Angle (PLA), which corresponds to take-off power. However, the throttles were at approximately 1/2 travel when the pedestals were recovered.

All control mechanisms, hydraulic and electrical, were removed, tested for function and found serviceable to the design use. The engines and wing stand-by fuel pumps (2) were dispatched to the manufacturers for investigation.

1.18 Other information

Several eyewitnesses were located and they have reported. Two of the witnesses observed the take-off; one from the moment of entering the runway to the right rolls; the other witness saw the aircraft after it was airborne and observed the final moments.

1.19 Company operational information

The loading and calculation for centre of gravity and maximum take-off weight were pre-calculated for all Lear Jets. The centre of gravity was calculated for worst cases, *i.e.* forward and aft centre of gravity and in all fuel configurations. In all normal cases the centre of gravity remains well within limits and the DGCA therefore gave Arab Wings a dispensation so that the centre of gravity need not be calculated for normal loading.

If an abnormal load is carried the procedures laid down in the Aeroplane Flight Manual for calculating weight and balance are used.

For weight purposes a normal man is taken to weight 200 lb with one suitcase or 150 lb without a suitcase. Therefore, with 4 passengers and baggage the weight is 800 lb.

2.- Analysis

2.1 The possibility of sabotage contributing to this accident was ruled out at an early stage of investigation.

Aircraft mechanical integrity is not suspect. Engine tear-down indicated power was constant at the time of impact and the power lever angle indicators were found in positions which correspond to take-off power.

Flight trim was set for take-off and spoiler actuators were found in the retracted and mechanical lock position.

Weather, communications and airport conditions are not considered contributing factors.

The flight crew were certificated for this flight.

During this investigation a query was raised concerning the cross-flow valve which was found in the open position, while normal procedures call for this valve to be in the closed position during take-off.

The cross-flow valve is normally used as a means of controlling lateral fuel balance. Fuel cross-flow from one wing to the other is accomplished by opening the cross-flow valve and energizing the applicable standby pump and de-energizing the opposite pump. With standby pump operating the rate of flow is approximately 50 lb/min. However, although the standby pump output is 50 lb/min, it could not be established that, in fact, a standby pump was switched "ON". Nevertheless, fuel will flow through gravity with the cross-flow valve in the "OPEN" position. If a condition exists whereby a transfer of fuel is made by pump, or gravity flow, lateral stability could be affected by a larger quantity of fuel in either wing.

The fuelled condition of this aircraft would allow fuel transfer at any time up to fuel capacity of either side to a maximum differential of 600 lb between tip tanks. The aircraft flight manual, page 3-15, states that maximum demonstrated fuel imbalance was with one tip tank jet pump in a failed condition (approximately 600 lb of fuel in one tip tank). The above information concerns an in-flight condition only.

Referring to the statement of one witness, the aircraft was observed holding on the loop for some time before entering the runway. The initial roll-out through lift-off and entry to climb was also under observation until obstructed by an adjacent building.

From lift-off to an approximate height of 25 ft above the runway, the aircraft was apparently in normal climb attitude. At this point the left wing was seen to drop suddenly to a 90 degree left wing low condition.

The aircraft recovered to wings level for a short period while in climb attitude and then began a somewhat slower right climbing roll which was continuous until the aeroplane disappeared behind the obstructing trees and building.

Additional testimony from other witnesses confirms the right roll from a low altitude continuing to inverted position at the time of impact.

From inspection of impact area and other witnesses' testimony, the aircraft did not dive into the ground but hit on the cockpit area on an oscillation path. The nose of the aircraft had been seen oscillating during an attempted flight recovery before the beginning of the final descent. Inspection of the wreckage indicated that the rudder was offset for right turn at point of impact. This is confirmed by flash burn and smoke displacement on the vertical stabilizer and rudder conjunction.

3.- Conclusions

3.1 Findings

- i) The crew were properly licensed.
- ii) The aircraft had been maintained in accordance with an approved maintenance schedule.
- iii) Loading and centre of gravity were in accordance with company procedures and within prescribed limits.
- iv) The cross-flow valve was in "OPEN" position, which is not normal procedure.
- v) The flight manual check-lists do not specify checking of fuel balance by the flight crew.
- vi) The cockpit check-list does not specify checking of fuel balance by the flight crew.
- vii) There is no indication of fuel cross-flow other than monitoring the fuel quantity gauges over a considerable period of time.
- viii) Engines and components were tested by the manufacturers and found functional.
- ix) Inspection of aircraft controls indicated an operable condition.
- x) The manufacturers' maintenance manual makes no mention of checking fuel balance or cross-flow valve position after refuelling.

3.2 Probable cause

The highest probability centres around a possible fuel imbalance at the time of take-off. As the aircraft was observed dropping a left wing very rapidly with an eventual recovery still in climb attitude, the actual cause of continuing right roll cannot be explained unless gyroscopic forces were assisted by the use of right rudder.

Although not conclusive, tests were carried out by a senior flight crew member of Arab Wings in a Lear Jet simulator set up with the data applicable to the aircraft and field conditions at the time of the accident. Using maximum fuel imbalance condition the test crew experienced similar results and loss of control through right roll owing to inability to centre rudder control after wings level, as stated by the pilot of the simulated flight (Appendix 'G').

4.- Recommendations

4.1

It is recommended that:

- i) The flight manual be revised so that a check is made of fuel balance before take-off.
- ii) The manufacturers' cockpit check-list be revised so that a check is made of fuel balance before take-off.
- iii) The manufacturers' maintenance manual be revised to include, in the pre-flight check and after refuelling, a provision that fuel balance be checked and the cross-flow valve closed.
- iv) There should be a prime indication of fuel cross-flow in addition to the fuel gauges.
- v) A copy of this report be sent to the National Transportation Safety Board of the U.S.A. (NTSB).
- vi) When the proposed new Rules and Regulations for Jordan are implemented, in respect of Air Operators, that Arab Wings be classified as a Commercial Operator and not an Air Charter Company.

ICAO Note: Only Appendix G to the report is reproduced.
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Appendix G

Ref.: AWO/11-516
Date: 2nd March, 78

The Director General
Civil Aviation Dept.
Amman - Jordan

Subject: Accident to JY-AFC - Lear Jet.

While I was on course at the Gates Lear Jet Factory, I took advantage of the Lear Jet 35/36 simulator to re-simulate the conditions that I think led up to the accident on JY-AFC.

My theory is that Captain had as much as 600 lb unbalanced fuel in the left wing tip. This theory is brought about by finding the cross-feed cock open after the crash and would also explain the violent drop of the left wing after take-off that was described by one good witness.

My second theory is that Capt. caught his right heel in the floor plate and it jammed the rudder pedal fully forward. After the left wing dropped the instinctive reaction is to apply full opposite aileron and rudder. It is a fact that there are marks on the right shoe of consistent with his heel catching and also the medical evidence is that his right leg was straight at point of impact as all the bones in his right leg and tip were broken. Also it is a fact that the aircraft hit the ground with nearly full right rudder on.

Using the theories about fuel and right rudder I had the simulator set up in exactly the same conditions. I then did three take-offs with the following results.

Take-off No. 1.

Using exactly the same V_1 and V_R the left wing dropped violently after take-off at a height of about 25 ft. By quick movement of the aileron and rudder I was able to regain control and climb away. After this exercise it was found that the simulator instructor had set the wrong temperature and it was 50°F too cool.

Take-off No. 2.

With all figures correct this time we did a normal take-off and at about 25 ft the left wing dropped as violently as before and I corrected with full right aileron and right rudder. As the wings became level I applied full opposite aileron and tried to centralize the rudder and found I could not. I had caught my heel in the floor plate. Now the left wing was rotating quite fast from a position about 70° low to about 20° or 30° high and the aileron control was not sufficient to stop the inertia plus the rudder deflection which was also inducing the roll. The rate of roll decreased but could not be stopped and once past the 90° bank to the right I had the impression that the roll rate increased again.

The flight path was a climb to about 100 ft with a roll to the right and finally impacted the ground inverted in roughly the position that JY-AFC hit the ground. The total time was about four seconds.

The reality was so great that I was shocked by the speed of things and the total lack of ability to do anything positive in the short time available. Also bearing in mind that I was expecting this to happen and being forewarned I hoped I could prevent the accident. Also the reality of catching my heel finally convinced me that I was right in my theory.

Take-off No. 3.

Yet again the same conditions were set up but this time I kept my heel off the floor. After the wing dropped I was just able to stop the aircraft rolling over with violent aileron and rudder movements. As the speed increased so the aircraft became more controllable but even with foresight and practice it was very close between a crash and getting away with it.

Conclusion.

After these tests I am firmly convinced that the cause of the crash was due to a fuel imbalance of between 400 and 600 lb in the left tip tank and that whilst trying to regain control of the aircraft Captain caught his right heel in the rudder pedal and completely lost control which led to the crash.

None of the above reflects discredit on the pilot as there was no requirement in the check-list to check fuel balance before take-off (we have now put it in) and also anyone could catch their heel in the floor plate. I think that any pilot faced with the same situation would not have regained control once his heel was caught.

Remedial Action.

All pilots have been made aware and all check-lists amended to check fuel balance before take-off.

All aircraft should be checked to ensure that the floor plate is firmly fixed to the carpet and does not protrude at the front face which could lead to a heel jamming.

Vice President Operations
(Arab Wings)

ICAO Note: Pilot's name deleted by ICAO.