

No. 17

Yemen Arab Airlines, Douglas DC-3, 4W-AAS, accident 4 km west of Taiz runway,  
Yemen Arab Republic, on 19 March 1969. Report not dated released by the  
Director General of Civil Aviation, Yemen Arab Republic

1.- Investigation1.1 History of the flight

While the aircraft was being taxied into the hangar on 9 March 1969 for a Check III Inspection the port elevator was damaged by contact with a set of passenger stairs. It was decided therefore to change the elevator during the inspection.

The aircraft was test flown by the pilot-in-command after the inspection at 0600 hours on 18 March 1969. During the flight it was discovered that the elevator trim was ineffective. Subsequent examination revealed that the elevator trim tabs had been rigged in opposition, one up and one down. The aircraft was therefore returned to the hangar for rectification.

A further test flight was scheduled at 0600 hours on the following day, i.e. 19 March. After completing the ground run and pre-flight check the aircraft was again returned to the hangar for further work on the elevator trim mechanism. One of the engineers reported that the elevator trim was "very stiff". The work was carried out by the pilot-in-command and an engineer, who were observed to carry out a functional check of trim operation after the work was completed.

At 0730 hours the aircraft was lined up on the runway for take-off. The take-off and climb out were observed by two experienced witnesses and appeared to be quite normal. After a period of about two minutes and at an estimated height of 700 ft the aircraft made a turn to port through approximately 160° at an estimated 30° bank angle. The aircraft was then seen to recover from the turn and immediately enter a dive which became progressively steeper until the aircraft struck the ground and burst into flames.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	4		
Non-fatal			
None			

### 1.3 Damage to aircraft

The aircraft was destroyed by impact and fire.

### 1.4 Other damage

None.

### 1.5 Crew information

The pilot-in-command, aged approximately 36, was first issued an Italian licence in 1957 and on 1 September 1962 he was issued a Yemeni licence which had been renewed every six months since that time. His licence was endorsed with DC-3 and Aero Commander type ratings and also with an instrument rating issued by the United Arab Republic on 10 February 1964. He passed his last medical check on 30 November 1968. This was valid until 30 May 1969. His navigation bag containing his licence, log book and other personal data was thought to have been destroyed with the aircraft. The Airline records show that he had been undergoing DC-6B conversion training and operations from 14 January 1969 until 15 March 1969 and that he had last flown on a DC-3 on 13 January 1969. Recording of the flight crew flying hours had commenced only six months before the accident. It was estimated that he had flown a total of more than 6 000 hours, including more than 5 000 hours on DC-3 aircraft and that he had been pilot-in-command for about eight years.

The co-pilot, age unknown, held a licence issued by the FAA on 15 February 1969 and a Yemeni licence valid until 15 August 1969 and endorsed with a DC-3 type rating. He passed his last medical examination on 15 February 1969. This was valid until 15 August 1969. For the same reasons as those mentioned for the pilot-in-command no details on his flying experience were available, except that he had flown 128:30 hours as co-pilot on DC-3 for the last five months prior to the accident.

Another pilot and an engineer were also on board as observers.

### 1.6 Aircraft information

The aircraft had a certificate of airworthiness issued by Yugoslavia on 20 February 1968 which was valid for a period of two years and one issued by Yemen on 23 February 1968 which was valid until 22 February 1969. The maintenance of the aircraft was carried out as follows:

- a) The aircraft was maintained on a calendar month basis and completed a Check I every month irrespective of the amount of hours flown.
- b) A Check II was carried out at six month intervals and a Check III at twelve month intervals.
- c) The Yugoslavian State Airline JAT carried out for Yemen Airlines all major inspections (Check IV) as well as any repairs and welding that may be required. Following any such Check IV the aircraft was returned to Yemen with a Yugoslavian Certificate of Airworthiness valid for two years. The Yemen DCA then issued a C of A for twelve months and a further C of A for twelve months was issued after a Check III and test flight had been carried out.

(N.B. Every two years the aircraft was returned to Yugoslavia for a major check.

- d) The aircraft was withdrawn from service on 9 March 1969 twelve months and fourteen days after issue of the C of A. The 14 days excess was covered by an extension of 100 hours granted by the DCA. Since the issue of the latest C of A, 1 062 hours 20 minutes had been flown by the aircraft and since the 100 hours extension had been granted, 50 hours 40 minutes had been used. Hours since last inspection (Check I) 102 hours 40 minutes. The Check III had been completed on 16 March 1969 but no maintenance schedules had been filled in:
- i) The ground engineers responsible for the electrical, instrument and radio sections of the inspection certified to the completion of their work on an internal Yemen Airlines certificate, but no inspection schedules detailing the actual work carried out had been signed. The electrical, instrument and radio engineers are Yugoslavian and are attached to Yemen Airlines on short-term (3 - 6 months) assignments. They held Yugoslavian licences appropriate to their respective specialities, not endorsed by Yemen. They do not certify the detailed inspection schedules as they cannot read English, the language used in the schedules.
  - ii) The airframe and engine inspections were carried out by Yemeni mechanics under the supervision of the Chief of Maintenance who held a Yemeni airframe and engine licence valid until 25 December 1970. No schedules or certificates were signed.

The aircraft carried only four persons all of whom were in the front section. The two pilots in their respective seats, the engineer observer standing between them and the pilot observer probably in the forward entrance door area. Discussions with Yemen Airlines engineering staff support this supposition. According to the refuelling agent who dipped the tanks prior to departure, the amount of fuel carried was: port main tank 140 gallons, starboard main tank 160 gallons, port and starboard auxiliary tanks empty. No ballast was carried. The aircraft being scheduled to fly on a passenger service immediately after the test flight it can be assumed that the removable equipment was all in place. In view of the above, the weight and balance of the aircraft was computed as follows:

	<u>Weight in lbs</u>		
Weight of empty aircraft			18 004
300 gallons fuel			2 160
48 gallons oil			431
4 crew at 170 lb each			<u>680</u>
			21 275 lb
	<u>Weight</u>	<u>Arm</u>	<u>Moment</u>
	<u>in lbs</u>	<u>inches</u>	
Basic weight	18 004	247	4 450 000
2 crew	340	70	24 500
2 supernumerary	340	110	37 400
oil	431	184.5	72 200
fuel	<u>2 160</u>	240.5	<u>520 000</u>
	21 275		5 104 000

Centre of gravity at take-off:  $\frac{5\ 104\ 100}{21\ 275} = 240$  in

The limits for the centre of gravity with landing gear extended are: forward limit 240 in, aft limit 263 in.

When the landing gear is being retracted on a DC-3 aircraft the centre of gravity shifts forward, which means that in the present case the centre of gravity was forward of the forward limit with landing gear retracted.

#### 1.7 Meteorological information

The first meteorological observation for the day was made for another DC-3 flight which arrived from Aden at about 0800 hours and was as follows:

surface wind: 110°/12 kt; visibility: 10 km; weather: fair;  
QNH: 1013.5 mb (760.2 mm, 29.93 in Hg); temperature: not available.

#### 1.8 Aids to navigation

Not relevant.

#### 1.9 Communications

The tower was not manned at the time.

#### 1.10 Aerodrome and ground facilities

No fire and rescue services were available.

#### 1.11 Flight recorders

No flight recorder was installed and such installation was not mandatory.

#### 1.12 Wreckage

Investigators arrived at the scene of the accident at 0850 hours. The under-carriage and both engines were still alight and six magnesium fires were also burning throughout the crash site. The investigation was hampered throughout by crowds of villagers milling about the wreckage. Twice the police and army cleared the site but eventually the villagers came back and the police and army were unable to control the crowd.

Under the circumstances it was decided to photograph as much of the wreckage as possible immediately. About sixty photographs were taken as well as necessary measurements and bearings to prepare appropriate sketches.

The site was a narrow rocky area 81 metres in length by approximately 40 metres in width. It was flanked on the west by rocky hillocks and on the east by ploughed fields bordered by a ditch. There was a road to the south with a small stream flowing through a culvert and running away to the east. A small stone building only 3 x 3 x 2 metres stands to the north, 4 metres from the initial impact marks.

### Distribution of wreckage

The initial impact indicated that the two engines struck the ground simultaneously and that the angle of the aircraft at impact was about 60°. Several small bushes within two metres of the impact and a small stone building only three metres away were untouched. The crumpled L/H mainplane was three metres ahead of the L/H engine impact mark. The L/H propeller and power section were in the impact hole and although two of the blades were broken off at the hub evidence indicated that there was some power on at impact.

The R/H propeller and part of the reduction case remained in the impact mark. The propeller blades showed sand scuff marks on the face and some power on at impact.

The R/H engine was 15 metres ahead of the R/H propeller, the crumpled R/H wing and undercarriage 30 metres ahead of initial impact. The centre section and cockpit was ahead of the R/H wing and to the left of the tail section which lay with the L/H elevator vertical, the rudder horizontal and the R/H elevators some distance to the right. The remainder of the wreckage was thrown forward as far as the stream, i.e. 81 metres from the first impact. The carburettor and intake from the port engine were 60 metres ahead of the engine while the rear accessory case from the same engine was 70 metres ahead of impact. Small pieces of wreckage littered the hill on the western side of the site. The four bodies were found 55 metres from initial impact on the western side of the site.

There was no wreckage found north of the initial impact and no wreckage south of the stream.

The magnesium in the powerplants and wheel hubs had caused almost total loss of useful evidence particularly as one undercarriage was burning in the cockpit area.

The remains of the throttle pedestal showed the two throttles almost closed and the pitch levers half way between the fine and course positions. The elevator and rudder trim wheels were burnt off and the trim drums and cables crushed and broken.

The tail section although badly burned showed the elevator trim tabs in the maximum up position. Measured at the inboard end the tabs were displaced 6.35 cm (i.e. the aircraft was trimmed NOSE DOWN).

The rudder trim was displaced 11.4 cm measured at the base of the tab. The rudder was trimmed for a L/H turn.

The starboard elevator trim cables were burnt off close to the trim drum which had allowed the cable to unwind from the drum. The port elevator trim drum cable and push pull rod were intact. The rudder trim drum cable and push pull rod were intact. Inside the tail cone the cables for elevator and rudder and their respective trims were on the pulleys but had been burnt off or broken forward of the tail cone bulkhead.

In the tail section all the micarta and fibre members of pulleys and fairleads had been destroyed by fire.

### 1.13 Fire

Both main tanks containing 300 gallons of fuel were ruptured. Source of ignition was provided by the hot engines and friction.

#### 1.14 Survival aspects

This was a non-survivable accident.

#### 1.15 Tests and research

In order to formulate the sequence of events described in Analysis and Conclusions a DC-3 aircraft, partially stripped for overhaul, was examined in the Middle East Airlines hangar at Beirut, with the assistance of the Airlines engineering staff.

#### 1.16 Medical aspect

The pilot-in-command's and co-pilot's medical examinations were valid, with no waivers. It was impossible to arrange post mortem examination of the victims.

### 2.- Analysis and Conclusions

#### 2.1 Analysis

The position in which both the elevator trim tabs were found after the accident i.e. both full up was of the utmost significance as such a setting would produce a very large nose down pitch. The behaviour of the aircraft was exactly consistent with such a setting, it was also consistent with the eye witness statements, i.e. the aircraft entered a dive which became progressively steeper. The progressively steeper dive could result from progressively winding on nose down trim.

The elevators on the DC-3 are interchangeable, when the elevator is fitted to the port side the push pull rod is on the upper surface, when fitted to the starboard side the push pull rod is on the lower surface.

The cables from the port elevator trim drum are routed through the tail cone "straight" while those from the starboard are "crossed". The crossing ensures that both tabs operate in the correct sense and in unison. There is adequate clearance between the crossed cables so that no rubbing occurs.

The working space in the tail cone is confined and artificial light is essential to ascertain if the trim cables are crossed or uncrossed.

It will be recalled that during the first test flight on 18 March the elevator trim tabs were rigged in opposition (one up, one down). As the starboard elevator had not been disturbed it follows that an error must have occurred in connecting the trim cable to the port elevator. In other words they must have 'crossed' in a similar manner to the cables heading to the starboard elevator trim tab which in fact are required to be crossed.

During a pre-flight check after rectification of the above situation the trim control was found to be stiff. Further work on the system was therefore necessary. The exact nature of this work will never be known. However on the assumption that the pilot did not deliberately trim the aircraft into the dive the known setting of the trim tab after the accident can be reconciled with the following sequence of events:

- a) On the initial test flight the port cables were crossed resulting in the trim tab operating in opposition.

- b) During rectification the port cables were crossed twice which resulted in the tab operation in unison and in the correct sense, but introducing stiffness in the system.
- c) One 'cross' was removed from the port cables, which relieved the stiffness but resulted in the tabs reverting to the situation in paragraph a) above.
- d) The 'cross' was removed from the starboard cables, which resulted in the tabs working in unison, but in the wrong sense.

Perhaps the sequence can be followed more clearly in tabulated form.

<u>Condition</u>	<u>Cause</u>	<u>Rectification</u>	<u>Result</u>
One tab up and one down	Port tab cables crossed	Port cables double crossed	1. Both tabs operation in correct sense in unison. 2. Cable system very stiff.
Tabs in unison and correct sense but stiff	Double cross in port cables	One cross removed from port tab cables	Tabs working in opposition, i.e. one up and one down
One tab up and one down	Port tab cables crossed	Starboard tab cables uncrossed	Tabs working in unison but in opposite sense

The foregoing cannot be proved conclusively because the complete trim control system was destroyed by fire. Therefore, the following other possibilities were examined:

#### Physical incapacity

It was impossible to arrange post mortem examination of the crew in the environment in which the accident occurred. However, they were all in an age group not normally associated with heart attack or other causes of sudden incapacity. The pilot-in-command and co-pilot had successfully undergone their medical examinations which were still valid. The possibility of carbon monoxide contamination can be ruled out due to the very short time of possible exposure. The country is 'dry' therefore the question of alcohol can also be ruled out. Finally one of the pilots must have operated the trim control to its fullest extent which indicated possession of faculties. Therefore it appeared unlikely that physical incapacity was a factor in the accident.

#### Control difficulty

The C of G of the aircraft was beyond the forward limit. This would have resulted in a nose heavy condition and offered the most likely explanation for the initial pitch down of the nose as the aircraft recovered from the left-hand turn. The pilot-in-command's immediate and instinctive action would almost certainly have been to wind the trim control back. The effect of the reversed elevator trim would have been to accentuate the pitch down. As a result the pitch down could well have been violent enough to throw the two observers and the crew forward introducing control difficulty and cockpit confusion at a moment when instant recognition and corrective action was vital. The observers were standing

behind the pilots' seats when the aircraft taxied out, they had remained in the position throughout the previous test flight, and it was established that this was in fact standard practice.

The C of G position and the disposition of the crew must therefore be considered a probable cause factor in the circumstances surrounding the accident.

#### Unfamiliarity with aircraft

The pilot-in-command was a very experienced DC-3 pilot; however, for a period of two months before the accident he had flown exclusively on DC-6 aircraft for licence endorsement purposes. The DC-6 is heavier on controls which may partly account for the fact that the effect of the reverse trim on the lighter DC-3 was not recognized earlier.

## 2.2 Conclusions

### (a) Findings

The pilot-in-command and co-pilot were in possession of valid licences endorsed for DC-3 aircraft.

The aircraft was flying under a valid certificate of airworthiness.

The aircraft was test flown twice following a maintenance Check III and port elevator change.

During the first test flight the elevator control trim tabs were found to be operating in opposition.

Following attempted rectification of the above the two trim tabs operated in unison but in the wrong direction in relation to the trim wheel control.

A 'double' control check was not made prior to either test flight.

After the accident the two elevator trim tabs were found in the 'full up' position.

The centre of gravity was sufficiently beyond the forward limit to cause nose heaviness but not control difficulty.

The mode of entry into the final dive could have resulted in control difficulty and cockpit confusion.

The pilot-in-command's lack of recent experience on the DC-3 may have delayed recognition of the incorrect trim situation.

Physical incapacity was not a factor in the accident.

### (b) Cause or Probable cause(s)

The accident was attributed to the incorrect assembly of the elevator trim tab mechanism. The resulting tab reversal induced an involuntary steep dive into the ground before there was time for recognition.

Test
Take-off
Loss of control
Other personnel - inadequate maintenance inspection.