No. 18

Línea Aérea Nacional Boeing 727-116, CC-CAQ, accident near Pudahuel Airport, Santiago, Chile, on 28 April 1969. Report released by the Directorate of Aviation, Chile

1.- Investigation

1.1 History of the flight

Flight 160 was a scheduled international flight from Buenos Aires, Argentina to Santiago, Chile. The aircraft took off at 2356 hours GMT from Ezeiza Airport, with an IFR flight plan for airways AJG 82 and UG-14, and left the Buenos Aires terminal area via the Mariana intersection, its route taking it over Junín, Villa Reynolds, El Pencal, Mendoza, Juncal and Tabón. The flight level was 310 (31 000 ft).

Before flying over Juncal, the aircraft was cleared by the Mendoza Control Centre to descend and maintain flight level 260 (26 000 ft) and after passing Juncal, it was cleared by the Santiago Control Centre to descend and maintain level 250 (25 000 ft) and to pass the Tabón NDB at flight level 150. It was also given the Santiago weather report, announcing 4/8 nimbostratus at 450 m and 8/8 altostratus at 2 400 m.

At 0135 hours, the aircraft passed over Juncal at flight level 260 and then left this level for FL 150; it gave 0142 hours at its estimated time of passage over Tabón NDB and subsequently reported that it was passing through FL 180 (18 000 ft). At 0141 hours, the aircraft passed Tabón NDB and left FL 150 for FL 70 (7 000 ft) and gave 0142 hours as its estimated time of arrival over Colina NDB.

Prior to that, Santiago Centre had cleared the aircraft to FL 70 at the Pudahuel Airport ILS outer marker.

The aircraft subsequently reported to the Control Centre that it was passing through FL 70; the Centre acknowledged receipt of the message and cleared the flight to make an ILS approach and to change to frequency 118.1 for communication with the Pudahuel Control Tower.

The aircraft passed over Colina NDB at about 5 500 ft and continued to descend intercepting the ILS (glide slope) beam at about 4 500 ft, one min 20 sec after passing FL 70. It continued its descent at a rate of about 1 500/2 000 ft/min and descended below the minimum height of 2 829 ft at the outer marker without either the pilot or the co-pilot noting this and on apparently correct indications from the Flight Director.

The aircraft continued descending and passed below the minimum height of 1 749 ft published for Pudahuel Airport when suddenly the warning light on the radio altimeter lit up. At this very moment the aircraft levelled off, but its wheels touched the ground and it landed in a field 2 kms north of the ILS outer marker, suffering heavy damage, but without serious injuries to passengers or crew. The accident occurred at about 0144 hours.

1.2 Injuries to persons

Some of the passengers and the cabin attendants suffered slight injuries. After the accident, all these persons returned home and consequently no exact record was kept of the number of persons injured and of the injuries sustained by them. To date, none of these injuries is known to have caused any serious disturbance to any of the injured persons.

1.3 Damage to aircraft

The aircraft sustained substantial damage.

1.4 Other damage

As the aircraft moved over the ground, the following damage was caused:

- Death of a horse;
- Destruction of a barbed wire fence over a distance of about 100 m.

1.5 Crew information

The crew consisted of a pilot-in-command, a co-pilot, an operator of the non-piloting systems, two stewards and two air hostesses.

The pilot-in-command, aged 46, joined Línea Aérea Nacional on 18 March 1953 with 1 795:35 flying hours to his credit. He held a valid airline pilot licence with the following ratings: aircraft, multi-engined land planes, DC-6's, Caravelle SE 210's and Boeing 727's. He was awarded his rating to act as pilot-in-command of Boeing 727 on 4 March 1968. His last inspection was on route SCL/MIA/SCL on 12 March 1969, when his work in the air, knowledge of terminals areas and instrument flight check were found to be satisfactory. His last medical examination was valid until 6 September 1969. He had flown a total of 13 591:11 hours, including 826:26 hours in Boeing 727 aircraft.

The co-pilot, aged 25, held a first class commercial pilot licence, with a multi-engined land plane rating, up to a limit of 5 700 kg. He qualified as a Boeing 727 co-pilot on 9 January 1969, and his last instrument check was on 19 December 1968, on which date he completed the theoretical and practical course given by the LAN airline for Boeing 727 co-pilots. His last medical examination was valid until 8 May 1969. He had flown a total of 3 284 flying hours including 211 hours as an operator of Boeing 727 systems and 229 hours as a co-pilot on Boeing 727 aircraft.

The other crew members held valid licences and were physically fit and technically competent to carry out the duties assigned to them.

1.6 Aircraft information

The Certificate of Airworthiness of the aircraft, issued on 28 August 1968 by the Directorate of Aviation, was valid until 30 August 1969.

The aircraft and its engines had been properly maintained, in conformity with the Boeing periodical maintenance plan, duly applied by LAN, and the last 125-hour overhaul had been effected on 14 April 1969. The aircraft had flown a total of 2354:51 hours, including

114:08 hours since the last overhaul. The aircraft had flown regularly until the date of the accident and no imperfection that had not been duly corrected had been entered on the maintenance reports.

The total weight of the aircraft at the time of the accident was calculated as being 119 241 lbs. Its weight on take-off from Buenos Aires was 135 264 lbs and the centre of gravity was within the authorized limits.

The type of fuel used was Esso Turbo fuel A-1.

1.7 Meteorological information

At 0133 hours, the meteorological conditions at Pudahuel Airport were transmitted to the crew as being: wind calm, 4 km visibility, reduced on account of rain; overcast with 4/8 nimbostratus at 450 m and 8/8 altostratus at 2 400 m. Temperature 16° and dew point 10°. The visibility and ceiling were well above the minima laid down for Pudahuel Airport for ILS approaches.

1.8 Aids to navigation

The radio aids system at Pudahuel Airport consisted of an ILS localizer (near the north end, the glide slope equipment being 280 m from the threshold of runway 17), five VHF markers (named Sur, Intermedia, Exterior, Colina and Huechón) and 5 LF radio beacons housed with the VHF beacons.

All the radio aids had main and standby equipment, as well as automatic failure-detection, switching and alarm devices. All these elements were commissioned as from 0000 GMT on 16 May 1968 in their definitive form, by NOTAM No. 39/68 of 13 May 1968, after a testing period of 170 days. From that date on, the radio aids operated without interruption, except for preventive maintenance such as checking of tubes, measurement of power, etc. On all those occasions, the airport control tower was duly notified beforehand.

At about the middle of April, unofficial information was received that some pilots-in-command had reported oscillations in the glide path between the outer and middle markers. This was caused by an increase, introduced some weeks before, in the output induced in the sideband antenna, which resulted in increased signal sensitivity along the glide path. For the same reason there was an increased number of irregularities evident on all the glide paths, resulting from the signals being reflected back from objects such as small buildings, fences, runway lights, trees, etc. The oscillations occurred in rapid sequence as the aircraft approached the runway, but if the pilot was able to follow them sufficiently rapidly, they did not cause the aircraft to swerve from the true path by more than a few metres.

Immediately after this situation became known through informal conversations with third persons, the output of the sidebands was reduced, within acceptable limits. To ensure that these new conditions were fully satisfactory for pilots, the supervisor of the ATS service was requested to instruct the controllers at the centre to consult pilots on the functioning of the ILS; they all declared themselves to be satisfied. The last time the glide path equipment setting was changed was on 23 April and, from that date until the time of the accident, only one report of oscillations of the glide slope indications below 500 ft was received. The day after the accident, the radio aids test aircraft of the Directorate of Aviation made a test flight, which confirmed that the entire radio aids system was functioning normally, and that the oscillations of the glide path were within normal tolerance.

1.9 Communications

There were no communication difficulties. Frequency 128.1 mc/s was not operating at the time of the accident but this had been duly notified by NOTAM.

1.10 Aerodrome and ground facilities

Ground facilities, such as the electrical system and the runway lighting system were operating properly, however, the runway approach lighting was not switched on at the time of the accident.

1.11 Flight recorders

A United Data Control, FA 542, flight data recorder had been installed on the aircraft on 3 May 1968. It was removed from the aircraft after the accident, but unfortunately it was not possible to obtain any useful data from it, because the tape had been broken before the flight during which the accident occurred.

A special inspection of the recorder had been made on 25 April 1969 at Pudahuel Airport because a failure had been reported in the Maintenance Report and the metal tape was found to be twisted and broken. As the duty technician did not have the necessary spare parts, he removed the damaged part of the tape, rearranged the remaining part and after carrying out the appropriate tests passed the equipment as being in working order.

During the flight from Santiago to Buenos Aires, in the morning of 28 April 1969, failure of this equipment was entered in the Maintenance Report, because the warning lamp lit up, but when it was operated again, the lamp did not light up, giving a misleading indication that it was functioning properly.

When the equipment was overhauled at the LAN Chile workshops, after the accident, it was operated for half an hour for testing purposes and there was no indication of failure. However, when the failure warning system was checked, it was found to be out of order as it erroneously indicated that the flight recorder was working properly. This was due to the fact that the thermal relay (Part No. 100398) in the failure warning system was in poor condition. It was found that the flight number and date recording head (Part No. 100448) had broken and fallen between the gearwheels, jamming the mechanism and causing breaking of the tape through excessive tension.

The voice recorder was also recovered after the accident and although the tape was partly unwound (apparently as a result of the impact), it was possible to obtain from it part of the conversation in the cockpit. The voices in the cockpit and the telecommunication messages received by the aircraft could be heard very well, but it was not possible to obtain complete information on what the crew members said to each other, since the microphone picks up the noises made by the aircraft more clearly than the human voice.

1.12 Wreckage

The aircraft wreckage was in a field some 3 km in length, located 2 km to the north of the outer marker and on the line of approach to runway 17; the terrain was relatively level and had no obstacles of any size.

The aircraft first contacted the ground with its undercarriage, 2.03 km to the north of the ILS outer marker. Owing to the high forward speed and the low vertical speed, the undercarriage failed about 75 m after the point of first impact and from thereon the aircraft dragged along the ground for about 600 m until it came to a halt on a heading of 185° (magnetic).

1.13 Fire

There was no fire.

1.14 Survival aspects

Immediately after the aircraft came to a halt, the crew proceeded to open the doors and to evacuate the aircraft; this was done in a rapid and orderly manner. The crew then guided the passengers to a public road which was approximately 1 km from the location of the aircraft and the passengers were taken by bus to Pudahuel Airport.

As a result of the shaking caused when the aircraft was dragging along over the ground, some boxes containing oxygen masks came loose but did not cause any injuries to persons.

1.15 Tests and research

The timing of the recordings on the magnetic tapes of the Pudahuel Airport Control Centre was checked against the recordings made during the flight on the tape-recording equipment of the aircraft. From the information supplied by these tapes, it was possible to establish, approximately, the actual path of the aircraft from the TBN position to the site of the impact, 2 050 m to the north of the ILS outer marker of Pudahuel Airport.

A flight test of the airport ILS system was carried out the day after the accident with the Directorate of Aviation's test aircraft. Tests of the ILS transmitting equipment were also conducted on the ground.

After a detailed study of the aircraft manuals and the airline operations manual, two flights were made on a Boeing 727, executing the same manoeuvres and also carrying out the same procedures as were applied by the crew during the accident.

The Boeing 727 Flight Manual, chapter "Normal Procedures" chapter "Instrument Systems" Section 3, page 13 (A-1) indicates that:

i) It is only possible to intercept the glide path beam with the mode selector on "GS AUTO", when the deviation of the glide beam is nil.

ii) It is not possible to effect an interception from above the glide path beam with the mode selector on "GS AUTO".

iii) It is only possible to intercept the glide path with the mode selector on "GS AUTO" during level flight.

2.- Analysis and Conclusions

2.1 Analysis

Flight 160, proceeding from Buenos Aires to Santiago on an IFR flight plan, was cleared by Santiago Control Centre from the TBN NDB at FL 150 direct to the ILS outer marker (LOM) at FL 70.

The co-pilot replied: "Flight 160 to report over outer marker, cleared for ILS, level 70, will report over TBN and on leaving FL 150 for FL 70".

Santiago Centre confirmed the above readback by the co-pilot. This reply clearly indicated that the co-pilot understood that he was cleared to make a direct ILS approach from that position (TBN). Furthermore, the Santiago Centre operator did not correct the reply given by the co-pilot to his clearance, which did not authorize flight 160 to make an ILS approach, but only to proceed directly to LOM at FL 70.

Next, the pilot-in-command asked the co-pilot if they had already been cleared for an ILS approach. The co-pilot replied in the affirmative and started to read the approach check-list. On receiving notification that the aircraft was crossing FL 70, the Control Centre cleared it to make an ILS approach, instructing it to transfer to the Santiago Control Tower frequency 118.1 mc/s.

Up to that time, the mode selectors of both Flight Directors were set in the VOR/LOC position, the VHF-NAV equipment was on the Pudahuel Airport ILS frequency and the ADF equipment on the outer and middle markers frequencies.

The GS needle of the Flight Director (FDI) began to rise to the centre from the low position, which indicated that it was intercepting the glide path beam from above. When the GS needle indicated "ON COURSE", both Flight Directors were set to the "GS AUTO" mode, which showed on the flight director indicators (FDI) that the control bar was centred and on the glide beam, although the light indicating that the aircraft was on the glide path was still coloured amber. The configuration of the aircraft at that moment was landing gear extended and flaps at 15°. This situation was checked during the test flights made with a Boeing 727.

The aircraft continued to fly in a descent altitude, at about 1500/2000 rpm on the path of the runway localizer and with the GS needles on the Flight Director and the course indicator moving upwards rapidly.

The pilot paid too much attention to keeping the Delta indicator aligned with the control bars, and failed to observe the longitudinal attitude indicated by the instrument. Likewise, the indications of the performance instruments (IVSI, aneroid altimeter and radio altimeter) were not observed, nor were the indications of the low frequency navigation instruments (ADF).

The aircraft rapidly crossed the minimum LOM altitude, without the co-pilot reporting this and without any attention being paid to the rate of descent, which in no case was corresponding to the approximate rate of descent of an ILS glide path. This was all the more serious in that the ADF, which was tuned in to the LOM frequency, indicated that the aircraft had not yet passed the marker.

The co-pilot also failed to report 1 000 ft above the height of the runway, as laid down in the aircraft check-list: neither did he communicate to the pilot the indications of the Flight Director and course indicator GS needles, which clearly indicated that the aircraft was below the ILS glide path. He also failed to observe the 500 ft indication selected as the minimum decision height (MDA) on the radio altimeter.

Finally, the aircraft descended below the minimum altitude for a Category II ILS approach at Pudahuel Airport (200 ft); it is presumed that, at that moment, the pilot received the indication from his radio altimeter corresponding to the minimum decision height of 200 ft, which was set on his instrument, which made him react by changing the longitudinal altitude.

On account of the high rate of descent (1 500 - 2 000 rpm) and the effect of inertia, the aircraft continued a few seconds descending with its nose up, as a result of which it struck the ground relatively smoothly with the main wheels of the landing gear, which broke a few yards further on. Right up to the time of impact, the crew had not realized the situation. The terrain where the accident occurred is level for some 3 000 m and had been wet by rainfall during the preceeding hours, which helped to avoid fire and extensive damage.

The weather conditions at the time of the accident were: wind calm, 4 km, visibility reduced by rain, overcast with 4/8 nimbostratus at 450 m and 8/8 altostratus at 2 400 m; temperature 16°C, dewpoint 10°C.

The aircraft's altimeters had been set to the pressure given by the approach control tower (1 015.5 mb).

As soon as the aircraft was on the ground, the crew performed the necessary emergency procedures rapidly, expeditiously and in an orderly manner.

The approach lights of Pudahuel Airport were not lit up.

2.2 Conclusions

(a) Findings

At the time of the accident, the crew held valid pilot licences with the appropriate qualifications for the duties they were performing.

The Certificates of Registration, Airworthiness and airborne electronic equipment were valid.

The aircraft had been maintained in accordance with the company's maintenance plan, approved by the Directorate of Aviation.

The weight and centre of gravity of the aircraft were within the prescribed limits.

The atmospheric conditions at the time of the accident were above the minimum laid down for an ILS approach.

The radio navigation aids and the components of the ILS system of Pudahuel Airport were operating normally.

The approach lights of the airport were not lit up as they should have been, having regard to the visibility conditions. The runway lights were lit up.

(b) Cause or Probable cause(s)

The investigating commission considered the causes of the accident to be as follows:

a) excessive concentration by the crew on the indications given by the Flight Director;

b) the crew erroneously operated the Flight Director equipment on a direct ILS approach;

c) as a result of a) above, the crew did not check the instruments, which indicated:

- descending below the minimum safety altitude;
- rate of descent greater than normal for an ILS approach;
- longitudinal attitude of the aircraft greater than normal for an ILS approach;
- position of the aircraft below the ILS glide path.

3.- Recommendations

a) The Company should organize practice sessions for pilots in a flight simulator for Boeing 727 aircraft, at the Santiago terminal area.

b) The Company should revise its training procedures, so that crews may acquire the necessary knowledge for making technical judgments, and understand the use and operation of the various airborne equipment.

c) The Company should have the pilot and co-pilot of flight 160 follow a theoretical and practical refresher course competently and efficiently which will ensure that they can discharge their duties.

d) A study of air traffic procedures for direct ILS approach to runway 17 of Pudahuel Airport be made.

e) In order to achieve better understanding between crews and the personnel operating in Control Centres and towers, the latter should at given intervals fly in commercial aircraft so that they can achieve a better understanding of the work of the pilot in flight and the latter a better understanding of the work of air traffic control personnel.

f) ICAO, FAA and the respective manufacturers should be given detailed information on failures occurring in flight recorders and on poor quality of tape recording in the cockpit.

g) It should be suggested to ICAO that transport aircraft be required to carry visual and sound alarms to indicate minimum decision heights.

h) The inspection requirements of flight recording equipment and the "on condition" tape recording equipment should be amended to take place after each 1 000 hours of operation.

Scheduled international
Landing
Undershoot
Pilot - Improper IFR operation

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