McDonnell Douglas DC-8-71, N8091U, 5 January 1996

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Aircraft Type and Registration: McDonnell Douglas DC-8-71,N8091U

No & Type of Engines: 4 CFM56D-2 turbofan engines

Year of Manufacture: Modified in 1983 from DC-8-61 to DC-8-71

Date & Time (UTC): 5 January 1996 at 0010 hrs

Location: East Midlands Airport

Type of Flight: Cargo

Persons on Board: Crew - 3 Passengers - None

Injuries: Crew - None Passengers - N/A

Nature of Damage: Minor damage to 2 tyres

Commander's Licence: Airline Transport Pilot's Licence

Commander's Age: 49 years

Commander's Flying Experience: 5,900 hours (of which 3,000were on type)

Last 90 days - 228 hours

Last 28 days - 91 hours

Information Source: AAIB Field Investigation

History of flight

The crew were operating return flights between Stockholm and EastMidlands via Copenhagen; they had completed the same rotationon the previous night. The flight from Stockholm to Copenhagenwas uneventful and, after downloading and loading new cargo, N8091U,operating as BCS 912, took-off from Copenhagen at 2225 hrs. Therewere no unserviceabilities noted in the technical log and thecrew considered the aircraft fully serviceable on the flight toEast Midlands.

With the first officer as the handling pilot, the aircraft wasradar positioned for an ILS to Runway 09. Prior to the approach,the 2350 hrs METAR was passed to the crew; this detailed a surfacewind of 160/ 08 kt, visibility of 10 km or more, cloud brokenat 800 feet agl and overcast at 1,200 feet agl, surface temperatureof 6°C and QNH of 1000 Hpa with the runway surface wet. The crew considered that the approach was normal and that N8091Utouched down slightly past the PAPIs at the calculated speed of145 kt with Flap 50 selected; the PAPIs are located 348 metresfrom the threshold. After lowering the nosewheel, the crew statedthat full reverse was selected on all engines; the flight engineerconfirmed that the reversers activated and that the spoilers deployed. Initially, the retardation seemed normal to the crew but, atan estimated 3,000 feet to go to the end of the runway and withthe speed still indicating 100 kt, the commander became concernedand instructed the first officer to apply foot braking. As thebrakes were applied, the crew felt increased retardation for ashort period but this did not continue and, at approximately 80kt, the commander took control. He applied full foot brakingand maintained reverse thrust on all engines, somewhere in therange from idle to full reverse.

Thereafter, even though both pilots considered that they maintainedmaximum foot pressure, the aircraft was not slowing as much asthey expected. They described it as a constant retardation withno indication of the anti-skid cycling. As the end of the runwayapproached, the commander attempted to turn N8091U right, through90° to the taxiway, but the aircraft was still at an estimated30 kt as it left the hardstanding; the commander could feel thenosewheel "scuffing" on the final turn but was not awareof any skidding from the mainwheels. The crew informed ATC thatthey had gone off the runway and ATC alerted the RFFS who werequickly on the scene; on arrival, they confirmed that there wereno signs of fire or excessive heat in the vicinity of the mainwheelsbut remained in attendance as a precaution. The crew had alreadyclosed the engines down and were then helped by the RFFS to disembarkthrough the front left door of the aircraft.

Following the incident, a runway inspection was carried out at0025 hrs; no debris was found. Within 45 minutes, the RFFS useda Grip-Tester to take friction measurements on various areas ofthe runway; readings of between 0.60 and 0.75 were obtained. Approximately one hour later, with the weather unchanged, a subsequentinspection resulted in similar readings. Figures of 0.40 andabove reflect a braking action of good.

Aircraft information

The aircraft was originally built as a DC-8-61 with JT3 enginesand was modified in 1983 as a DC-8-71 with CFM56-2 turbofans. The design includes thrust reversers which are deployable inflight and are thus not dependent on 'weight-on-wheels' logic. There is an 'anti-skid' system (Mark II, manufactured by Hydro-Aire)but no Autobrake system. In the event of brake hydraulic supplyfailure, an emergency air brake system can be used to operatethe aircraft brakes; the control lever for this system is mountedon the instrument panel in front of the commander.

Aircraft examination

The marks made by the landing gear showed that the aircraft hadtravelled a distance of 40 metres beyond the runway and that itsfinal heading was 40° to the right of the runway heading,the turn being continuous over approximately the last 100 metres. The wheels had sunk into the ground to a depth of 30-40 cm and,apart from mud contamination of the wheels and brakes, the onlydamage was that inflicted on tyres 2 and 5 by the runway lights.

Examination of the aircraft and its technical records after theincident revealed no apparent technical reason for the over-run. The tyre condition (apart from the damage due to the runway lights)was satisfactory, with no evidence of 'flat spots' or rubber reversiondue to brakes locking or the tyres aquaplaning. Brake wear wasaround 25% of the wear limit and brake functioning was normal. 'Spin-up' testing of the wheel speed transducers indicated thatthe anti-skid system was functional.

The intact wire-lockingon the emergency air brake control lever showed that the systemhad not been used.

Before the aircraft was returned to revenue service on 6 January,the relief flight deck crew performed a taxi test on the runway,which was still wet, accelerating to 70 kt IAS (55 kt ground speed)and then braking. The crew reported normal functioning of thebrake and anti-skid systems during this test and during the subsequentlanding at Brussels the same evening.

Crew braking procedures

The Company Aircraft Operating Manual (AOM) includes the followingprocedures for the touchdown and landing roll:

'After touchdown move the thrust reverse levers to reverse idleand gently *fly* the nose gear to the ground. NOTE: Theflight engineer will monitor the deployment of the ground spoilers. If they fail to extend on touchdown, he will call out "Nospoilers".'

'Under most circumstances apply light braking at 100 knots orless. Heat builds up in the brakes and tires very quickly athigh speeds. More brake energy is required to slow the airplanefrom 120 knots to 100 knots than from 100 knots to 80 knots.'

'After the nose gear is lowered onto the runway, you may applyreverse thrust beyond idle. At lighter weights and longer runways,power beyond idle may not be necessary. The amount of reversethrust used is a matter of pilot discretion. If reverse is used,apply it evenly on all four engines up to the reverse power stopif necessary. Alternatively, you may apply reverse thrust beyondidle on the two inboard engines. It is against EWA policy toapply reverse thrust beyond idle on just the two outboards, however. Reverse thrust is most effective at high speed. The flight engineershould monitor and ensure that the maximum allowable N1, N2 andEGT limits are not exceeded. The pilot not flying will call out"80 Knots" then "60 Knots" as the airplanedecelerates. As the airplane decelerates to 80 knots, move thereverse levers forward to the reverse idle detent. At 60 knotsmove all four reverse thrust levers forward slowly to forwardidle. Plan to be in forward idle shortly after reaching 60 knots.'

Douglas Aircraft Company were asked for information on stoppingtechnique using reverse thrust. They recommend the followingprocedure:

'Upon main gear ground contact, the thrust reversers should beimmediately moved to the REVERSE IDLE DETENT and spoiler lightchecked for automatic spoiler deployment from main gear spin up. When the nosewheels are on the runway, the inboard thrust reversersshould be moved to MCT until speed decays to approximately 80knots at which time they should be returned to the reverse idledetent. When stopping distance is critical, the maximum landingflap setting is recommended and all four reversers may be movedto MCT or as necessary to effect a safe stop. For maximum energystop, the pilot should apply and hold maximum antiskid brake pressureimmediately after nose gear touchdown.'

Airfield information

Runway 09 at East Midlands has a landing distance available (LDA)of 2,280 metres with a 0.33% down slope; the PAPIs are located348 metres from the threshold. The runway surface is of concreteblocks and was laid in 1965. The normal exit from Runway 09 isa right angle turn at the end of the runway adjacent to the thresholdmarkings; the threshold markings had been painted with frictionpaint in November 1995.

FDR information

The Flight Data Recorder, a Fairchild Model F800 was replayedsatisfactorily using AAIB facilities. The 30 minute Cockpit VoiceRecorder had overwritten the recording of the landing when groundpower was applied to the aircraft during the recovery.

Figure 1 shows the FDR data for the relevant parameters for finalapproach and landing. The aircraft was lined up with the runwayfrom 2,000 ft agl, although there were some subsequent bank anglevariations of up to ±15°, and consequent magnetic headingchanges of up to 15°. The approach speed was maintainedat approximately 160 kt. From 800 ft agl the rate of descentwas 1,200 ft/min, decreasing to 600 ft/min from 400 ft agl.

The aircraft touched down at 154 kt IAS; Vref was assessed bythe crew as 145 kt. Reverse thrust was applied 5 seconds aftertouchdown to a maximum of 60% N1 on No 1 and 4 engines, and 70-75% N1 on No 2 and 3 engines. Power began to reduce to idle,25 seconds after touchdown, as the airspeed decreased through65 kt IAS. The effect of the reverse thrust application can beseen on the longitudinal deceleration which, initially aftertouchdown, was around 0.05 to 0.1 G increasing after 5 secondsto an average of 0.15 G. Although brake application is not recorded,an increase in the deceleration shown by the longitudinal G around19 seconds after touchdown, at about 80 kt IAS, suggests additionalbraking was applied after this point. The subsequent level ofdeceleration was then around 0.2G, but this level was heavilymodulated; this could be due to the operation of the antiskidsystem. There is a heading change indicated on the FDR, 30 secondsafter touchdown, which corresponds to the aircraft turning atthe end of the runway. The speed was then below 40 kt IAS. Therewas a large deceleration of 0.4G as the aircraft came to restin the soft ground.

The distance from touchdown to the turn at the end of the runwaywas estimated, by integrating longitudinal deceleration, as 1,600metres (± 200 metres). Touchdown was therefore estimatedto be 680 metres from the threshold; the normal touchdown pointwould be at the PAPIs, 348 metres from the threshold. The normaltouchdown zone extends to 900 metres.

A comparison was made with the previous four landings recordedon the FDR; of these, one was also at East Midlands, one was atStockholm and two were at Copenhagen. Figure 2 shows the comparisonof IAS, and indicates that the touchdown speed was similar onall five landings. However there was a noticeably slower decreasein airspeed during the landing run for the overrun case; thiswas also noted in the case of the first landing at Copenhagen. This was confirmed in the comparison of longitudinal decelerationfor the five cases, shown in Figure 3. During the initial fiveseconds the deceleration was noticeably lower for the overrunand the first landing at Copenhagen. Subsequently, up to 25 secondsafter touchdown, the average deceleration was also lower for thesetwo cases. From around 60 kt, there were then higher levels ofdeceleration on both these cases compared to the three others;this was particularly so on the overrun case, suggesting a higherlevel of foot braking.

Comparing the levels of reverse thrust shown in Figures 4 and5, there appear to have been two techniques, the overrun and thefirst landing at Copenhagen show a slower rise in the power, anda lower maximum N1, of around 60% on the outer engines, and 70%on the inners. The other recorded cases show that N1 consistentlyrose more quickly to a maximum of 85% on all four engines. Thisdifference in the use of reverse thrust could explain the lowerlevels of initial longitudinal deceleration seen on the overruncase, and on the first landing at Copenhagen.

Performance calculations

The manufacturer of the anti-skid system, Hydro-Aire, was askedto review the overrun time history trace of longitudinal g (Figure3) during the landing deceleration. This single trace gave limitedinformation but the assessment was that the braking over the periodfrom 18 seconds to 35 seconds, ranging from 0.15g to 0.20g, "wasindicative of light braking effort by the crew and/or a contaminatedrunway environment". The manufacturer further noted thatflight tests in the 1980s using their 'Mark III anti-skid technology'had demonstrated improved stopping performance on contaminatedrunways over their Mark II system and that many DC-8-70 seriesaircraft had either been produced or retrofitted with the MarkIII option.

Douglas Aircraft Company advised that the landing speed for theDC8-71 is approximately 6 to 8 kt higher than that for the DC8-61because of the higher stalling speeds. They calculated the basiclanding speed, using full flap but without any wind correction,for N8091U as 140 kt.

Douglas Aircraft Company were also asked to provide informationon Federal Aviation Administration (FAA) DC8-71 aircraft landingdistances. Based on a landing weight of 240,000 lb, zero wind,no runway slope, wet runway, at sea level and using full flap,the landing distance required (from a height of 50 feet) is 2278metres. These figures assume that all engines are at forwardidle and that maximum anti-skid braking is applied immediatelyafter nose wheel touchdown.