Despite wet snow on the runway, the A321 crew expected normal winter landing conditions.

SLIDING AWAY

BY DAVID THOMAS

On the evening of March 26, 2006, an Airbus A321 operated by My Travel Scandinavia was involved in a serious landing incident at Sandefjord Airport Torp in southern Norway. Although damage was minimal, the aircraft stopped about 65 degrees off the runway heading with the nosewheel against the concrete base of an antenna and the right main wheel approximately 2 m (7 ft) from the end of the runway (*ASW*, 4/10, p. 56).

This crew's experience illustrates the problem of detecting and describing braking action on contaminated runways that has become the subject of significant discussion.

During the preflight preparation for the midday departure from Tenerife, Canary Islands, Spain, crewmembers had received a company briefing pack containing a snow notice to airmen (SNOWTAM) indicating that the runway at Torp was wet with good braking action, and a terminal area forecast calling for snow with deteriorating visibility as the afternoon progressed.

Just before descent, the automatic terminal information service indicated that the runway was dry with good braking action and visibility was 2.5 km (1.6 mi) in light snow. There was broken cloud at 500 ft, the temperature was minus 2 degrees C (28 degrees F), and the dew point was minus 3 degrees C (27 degrees F). Although the wind, from 030 degrees at 6 kt, marginally favored the nonprecision approach to

Runway 36, the instrument landing system approach to Runway 18 was in use. On descending through Flight Level 100 (approximately 10,000 ft), an additional 5 kt was added to the approach speed based on a formula that took into account the icing conditions.

As the aircraft descended, snow began to settle on the runway. Three minutes before landing, the air traffic control tower informed the crew that the runway was contaminated with 8.0 mm (0.3 in) of wet snow and the friction coefficients indicated medium braking. A glance at the actual landing distance (ALD) figures in the quick reference handbook indicated that the 72-tonne (158,733-lb) aircraft would require an ALD of 1,812 m (5,945 ft), with maximum manual braking after touchdown. The landing distance available (LDA) was 2,569 m (8,429 ft).

The aircraft touched down softly 357 m (1,171 ft) beyond the touchdown point, and both the reversers and spoilers were promptly deployed. The captain thought that the autobrake had disarmed because of the lack of braking action. Eight seconds later, the first officer applied full manual braking and shortly afterward, when they still were unable to feel any braking action, the captain took control and applied the parking brake. The aircraft was still decelerating as it approached the end of the runway. The first officer indicated that the terrain looked more even to the left of the runway, and the captain responded by turning the nosewheel steering toward the left.

The first assumption one might make after reading this brief account is, considering that the crew touched down 357 m down the runway, the incident must have been the result of a mishandled approach and landing. Case closed or not?

The aircraft had been slightly above the glideslope below 250 ft, crossing the runway threshold 10 ft high and carrying an extra 5 kt for icing; the extra speed might not have been necessary. These deviations can be easily understood considering the short notice to the crew about the change in runway condition and the crew's mindset of medium braking action. In normal line operations on a dry runway, both the extra height and the extra speed would have been insignificant.

The flight data recorder indicates that the autobrake was armed but may have been disengaged accidentally. Aerodynamic braking and engine reverse produced a deceleration of 0.16 g, increasing to 0.20 g when manual braking was applied at 110 kt.

In calculating landing performance using Airbus tables, 8 mm of wet snow was considered equivalent to ¼ in of slush. Airbus takes into account contaminant drag and uses varying effective Mu[1] (friction) values that are groundspeed-dependent for fluid contaminants. It is, therefore, difficult to establish an equivalent average aircraft braking coefficient (ABC) value.

After landing on a snow-covered runway in Torp, Norway, the A321 stopped with its nosewheel against an antenna's concrete base.

Accident Investigation Board Norway

In contrast, Boeing does not consider contaminant drag and uses an average (groundspeed-independent) ABC value for each contaminant.

Below 110 kt, the ABC was approximately 0.05; this reduced to 0.04 after the parking brake was set at 70 kt and the wheels locked. If Airbus used the same methodology as Boeing, the crew would have been aware before touchdown that 8 mm of wet snow corresponds to an average (groundspeed-independent) ABC value of 0.05 — associated with poor braking action. Why did such a recently completed runway friction test suggest the braking action was medium?

The airport's winter regulations in 2006 said that it was a priority to offer a runway free of snow and ice and that when runway friction decreased below poor, the affected areas were to be closed until satisfactory braking action could be re-established.

Both Airbus and Boeing support the view that friction readings from ground friction-measuring devices may not represent actual ABC. In a number of countries, friction-measuring devices can only be used on compacted snow and ice or on a bare runway. The Accident Investigation Board Norway (AIBN) has highlighted the uncertainty of friction measurements from friction-measuring devices. Their findings suggest tolerances on fluid contaminants of plus or minus 0.20; on dry contaminants, tolerances are plus or minus 0.10. The friction-measuring device used at Torp was certified for use only in up to 3.0 mm (0.1 in) of wet snow. However, considering the fluid contaminant tolerances, this was not seen as a contributory factor.

The unreliability of ground friction-measuring devices is not the sole reason for the incorrect braking action report. Other factors are the air temperature and dew point. The AIBN has investigated 30 incidents and accidents that occurred on contaminated runways over the last 10 years and has highlighted a number of coinciding factors. The most common — evident in 21 of the 30 occurrences — was a difference of 3 degrees or less between the air temperature and the dew point.

The narrow temperature–dew point split indicates that the relative humidity of the air mass will be at least 80 percent. Given these conditions, with an air temperature at or below freezing, the air mass immediately above the runway surface is close to, or at, saturation, causing freezing on contact with the runway surface.[2] This phenomenon was derived from findings by the AIBN and is referred to as the 3-Kelvin-Spread Rule. The AIBN has concluded that poor braking action often is associated with moist low-level atmospheric conditions. Although the rule is not an absolute, it is a good indicator of hazardous conditions. It is likely that at Torp, the lower layers of wet snow had frozen to form ice on the runway.

Four years after the accident, have things changed?

As a result of a Dec. 8, 2005, runway excursion accident involving a Southwest Airlines 737-700 at Chicago Midway International Airport (*ASW*, 2/08, p. 28),[3] the U.S. Federal Aviation Administration issued Safety Alert for Operators 06012 and a related advisory circular. The agency also formed the Takeoff and Landing Performance Assessment (TALPA) Aviation Rule-Making Committee. Although the committee's recommendations have not been adopted, a primary provision is the runway safety matrix, designed to produce a standardized reporting method, developed from different types of surface condition reports and aircraft data (see "Unveiling the Matrix," p. 33).

Airbus released a letter in mid-2010 advising operators to add safety margins to its ALDs, in line with the committee's proposals. As an interim solution, Airbus has settled on a plan to factor its ALDs to calculate an operation landing distance (OLD), which is designed to reflect the actual performance achieved by a line pilot.

If the TALPA matrix had been available for use on the evening of the Torp runway incident, the crew would have factored their 1,812 m ALD to obtain an OLD of 2,563 m (8,409 ft) — 6 m (20 ft) less than the LDA.

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Notes

1. Airbus uses the term *effective Mu*, while other manufacturers, including Boeing, use *ABC*, referring to the percentage of the airplane's weight on the wheels (W-L), which is converted into an effective stopping force. For example, an airplane with a W-L of 100,000 lb (45,360 kg) would create 20,000 lb (9,072 kg) of stopping force for an ABC of 0.20. ABC depends on tire pressure, tire wear, aircraft speed, aircraft weight and anti-skid system efficiency.
2. Water vapor can change to ice without becoming liquid. This is likely if the air is saturated and is cooled below the freezing point. The process is known as sublimation.
3. As it skidded off the runway, through an airport fence and onto a road, the 737 struck two cars, killing one passenger. Another occupant of a vehicle received serious injuries, and three others received minor injuries. Of 103 people in the airplane, 18 received minor injuries. The U.S. National Transportation Safety Board said the probable cause of the accident was the flight crew's failure to promptly apply reverse thrust. The pilots were distracted by the airplane autobrake system, which they had not used before, the NTSB said.