STAR 016 V1 – March 2013	**Wet runway – hydroplaning**

Introduction

In 2005 an Embraer 145 overshot runway 27L at Hanover Airport. According to the German Federal Bureau of Aircraft Accident Investigation Report EX006-0/05, which can be read in full on their web site (http://www.bfuweb.de), the weather forecast indicated thunderstorms and heavy rain showers. The initial ATIS indicated a wind of 150/5 kt and a visibility of 8 km in light rain. The weather deteriorated during the approach, and at the time of landing the wind was 100/5 kt (a 3 kt tailwind) with a visibility of 2000 m in heavy rain. The runway was wet and showed patches of standing water.

A Boeing 737 that landed prior to the Embraer subsequently reported to the Investigation that the braking action was medium – but this was not reported at the time to ATC. According to crew statements the aircraft crossed the threshold at 140 kt (Vref 131 kt) and touched down in the touchdown zone. The FDR showed a threshold crossing height of 62 ft as opposed to the correct 50 ft. The crew did not experience any significant deceleration of the aircraft even though the ground spoilers had automatically deployed after touchdown. Both pilots attempted to brake, and shortly before the aircraft overshot the runway the pilot in command activated the parking brake which is also the emergency brake. This resulted in deactivation of the anti-skid system, the wheels locked up and the ground spoilers retracted (because the wheels had locked). The aircraft came to rest about 160 m beyond the end of the runway suffering only minor damage.

Eyewitnesses stated that the aircraft touched down about 1000 m after the threshold, this was later refined from FDR data to 849 m. All four tyres showed traces of rubber reversion hydroplaning (Figure 1), and had left about 400 m long bright traces on the runway which were definitely caused by rubber reversion hydroplaning (runway marks left following rubber reversion hydroplaning look like they might originate from steam blasting (Figure 2). Furthermore, melted rubber was found on the runway (Figure 3).

Above: figure 1 - marks of rubber reversion hydroplaning on the tyre

Above: figure - marks of hydroplaning on the runway

Above: figure 3 - rubber dumped from tyre

The Investigation concluded that based on the slow deceleration after touchdown it was highly likely that dynamic aquaplaning occurred in the middle portion of the runway followed by rubber reversion hydroplaning which occurred when the emergency brake was activated, the anti-skid deactivated and

Park House, 127 Guildford Road, LIGHTWATER, Surrey, GU18 5RA UK
Telephone: +44 (0)1276 856495 Fax: +44 (0)1276 857038 info@eraa.org www.eraa.org

the tyres locked.

The aircraft technical log did not show any irregularities regarding the brakes or tyres and the tyres were inflated correctly.

The worst case RLW calculation, which the investigation thought most likely to apply to this landing, gave a stopping distance with 150 m runway remaining – there was a longer runway available but the crew chose 27L because of construction work on a taxiway and the shorter distance to the terminal.

Lessons to be learned
There are two lessons to be learned from this incident, one being the factors leading to the overrun and the second hydroplaning.

Lesson 1 – The overrun

Overruns normally have more than one contributory factor. In this overrun there were several factors as listed below:

1. **Landed slightly long.** The ideal touchdown point is 300 m from the threshold - in this instance the touchdown was at 849 m. This shortened the LDA.
2. **Landed slightly fast** - but only by a few knots.
3. **Runway condition.** The runway was wet, or even flooded, but it is not clear whether the crew were aware of this. The crew were not informed of the runway condition by ATC.
4. **Wind.** There was a slight tailwind.
5. **Incorrect braking technique.** The Aircraft Operation Manual Part B included: When hydroplaning occurs, it causes a substantial loss of tire friction and wheel spin-up may not occur.

Lesson 2 – Hydroplaning

The other lesson from this accident has to do with hydroplaning. Control of your aircraft on the ground depends on the contact between the tyres and the surface and on the friction provided by that surface. Whilst the above accident highlighted the braking problems caused by hydroplaning, directional control can be equally affected, especially in strong crosswinds before the rudder becomes fully effective. As a tyre rolls along the runway it is constantly squeezing water from the tread. This squeezing action generates pressure within the water that can lift part of the tyre off the runway and reduce the amount of friction that the tyre can develop. This squeezing action is called hydroplaning. Please note that icy runways are a totally separate issue.

Three basic modes of hydroplaning have been identified: dynamic, viscous and reverted rubber.

Dynamic hydroplaning, which is also called aquaplaning, is related to speed and tyre pressure. High speed and low tyre pressure are the worst combination, giving the lowest aquaplaning speeds. During total dynamic hydroplaning the tyre lifts off the surface and rides on a wedge of water like a water ski. You have probably experienced this when driving through large puddles on the road, and felt the steering lighten. Dynamic hydroplaning will occur at speeds above 9 times the square root of your tyre pressure (in pounds per square inch).

When dynamic hydroplaning occurs it may lift the wheel off the runway and prevent spin up or, if anti-skid is not being used, cause the wheel to stop spinning. Once started the hydroplaning could continue to much lower speeds.

Viscous hydroplaning occurs on all wet runways and describes the normal slipperiness or lubricating action of the water. Viscous hydroplaning reduces the friction, but not to such an extent the spin up on touch down is prevented. The most positive way to prevent viscous hydroplaning is to provide texture to the surface – hence grooved runways.

Reverted rubber hydroplaning is similar to viscous hydroplaning in that it occurs with a thin film of water and a smooth runway surface. It often follows dynamic or viscous hydroplaning where the wheels are locked. The locked wheel creates enough heat to vaporise the underlying water film thus forming a cushion of steam that eliminates tyre to surface contact, and begins to revert the rubber, on a portion of the tyre, back to its uncured state. Once started, reverted rubber hydroplaning will persist down to very low speeds – virtually until the aircraft comes to a stop. During the skid there is no steering ability. Indications of reverted rubber hydroplaning are distinctive white marks on the runway, and a patch of reverted rubber similar to the uncured state on the tyre. It is also likely that melted away rubber will be found on the runway.

The increase in stopping distance as a result of hydroplaning is impossible to predict accurately, but it has been estimated to increase it by as much as 700%. The reduced braking action on a wet runway may prevent the aircraft from decelerating normally with the anti-skid system operational. But the anti-skid system will provide optimum braking – switching it off will most likely lead to wheel lock up and burst tyres.

Recommendations

- The approach must be flown with the target of minimising the landing distance.
- A good landing starts with a good approach.
- Think before accepting a downwind component.
- The approach must be stabilised, and landing on centre line in the touchdown zone.
- If in doubt go around.
- The touchdown should be firm to penetrate the contaminating fluid film and ensure wheel spin-up and spoiler activation.
- Immediately after touchdown, check the ground spoiler automatic deployment when thrust levers are reduced to IDLE.
- Lower the nose wheel positively, with forward pressure to assist traction and directional stability.
- Apply brakes with moderate-to-firm pressure, smoothly and symmetrically, and let the anti-skid do its job.
- If no braking action is felt, hydroplaning is probably occurring. Do not apply Emergency/Parking brake, as it will cause the spoilers to close and cut the anti-skid protection.
- Maintain runway centre line and keep braking until airplane is decelerated.
- Trust the systems and brake for effect, not comfort.
- Add an FDM event to monitoring braking pressure.