

FLIGHT OPERATIONS LETTER

FOL PHE505-018/14

REVISION 02

June 06th, 2016

SUBJECT: LANDING PROCEDURE BEST PRACTICES AND RECOMMENDATIONS

APPLICABILITY: Phenom 300 fleet

DESCRIPTION

Recently, the FAA has released the AC91-79A – Mitigating the risk of a runway overrun upon landing - containing good practices to address the risks involved during landing. In this Flight Operations Letter, Embraer highlights some key aspects from the FAA document adding information pertinent to the Phenom characteristics.

This FOL will cover the following topics:

- **AFM certified performance numbers** – How the published landing distance is calculated?
- **Brake system** – What are the features and behaviors expected by the braking system during the landing?
- **Landing on a wet/contaminated runway** – What are the challenges landing on this particular condition?
- **Factors that affect the landing success** – What are the main factors to be evaluated during the landing and the impact that deviations can cause on the landing distance?

AFM certified performance numbers

When assessing the landing performance in the manuals or on performance software, it is important to understand the basis for generating those numbers. Deviations from the established procedure may lead to bigger landing distances, as described further in this document.

The AFM landing numbers are based on the following landing profile:

- Threshold crossing at 50ft and at Vref,
- Bring thrust levers to idle upon threshold crossing,
- Touchdown near 1000ft mark,
- Immediate full brake application after the main landing gear touchdown, until complete aircraft stop.

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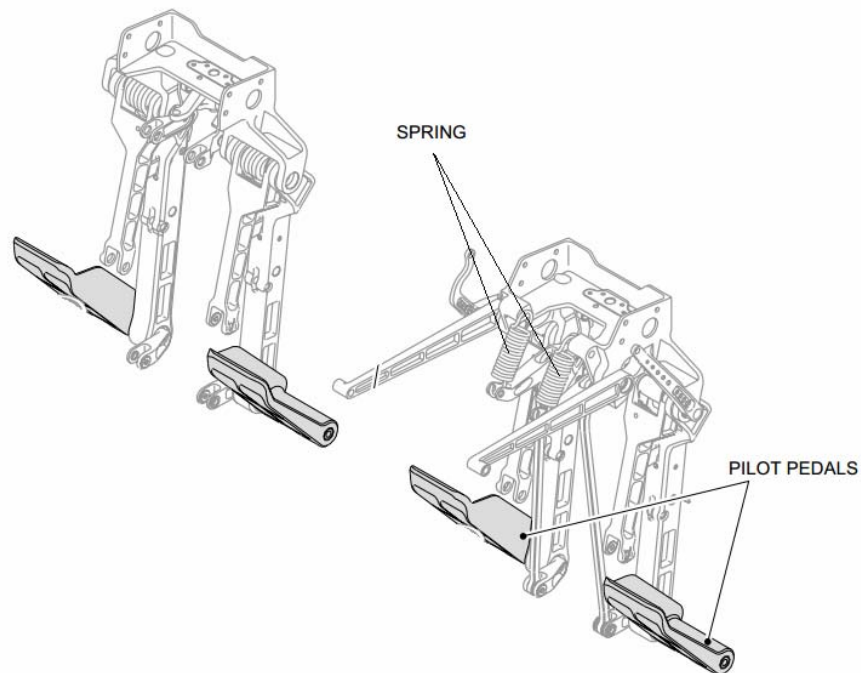
NOTE 1: The V_{ref} is the speed at the threshold crossing. Touchdown speed is expected to be below the V_{ref} .

NOTE 2: The unfactored landing distance published in the AFM is the total horizontal distance traveled from the point at which the airplane is 50 ft above the ground at V_{ref} , to the point at which the airplane is fully stopped. Therefore, the landing distance is composed of two main segments, the first one with the airplane in the air (from the 50 ft height point to touchdown) and second segment in which the airplane is on the ground (from touchdown to full stop).

Brake system

Some aspects of the brake system design should be considered to better understand the expected behavior of the aircraft during the landing:

- Brake by wire: Electrical transducers will transmit pedal deflection signals to the brake control unit (BCU). While no hydraulic components are installed on the pedal assembly, the only force feedback expected to the pilots is from the force spring. That means, regardless of the runway condition and pressure being applied to the brakes, the pedal resistance force, felt by the pilot, will be the same.



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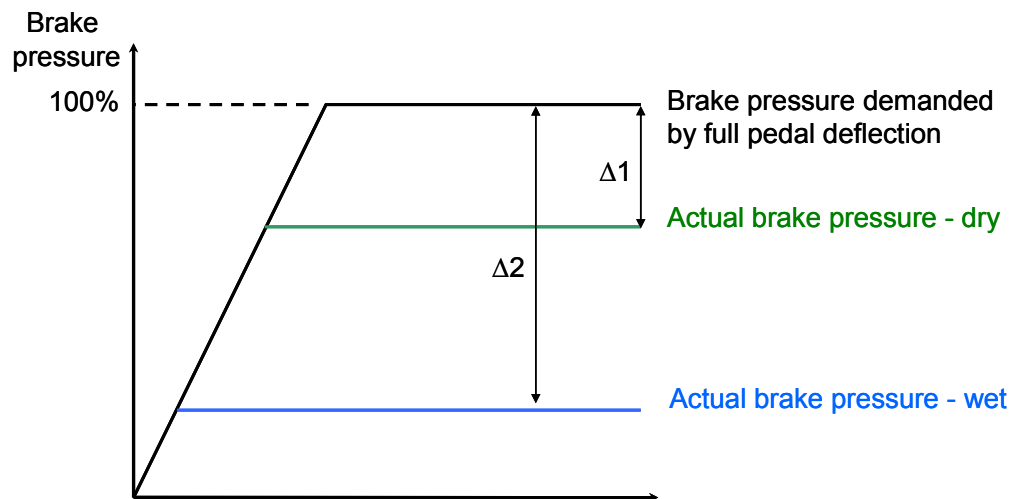
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- Anti skid logic: This feature provides optimum brake performance avoiding a wheel to lock or skid. It will deliver the best brake pressure possible to the runway conditions. The BCU receives inputs from the pedal transducers, understanding the amount of brake pressure demanded by the pilot, and wheel speed signal, to monitor the wheel deceleration and make the adjustments on the pressure as necessary.

BCU, due to the anti-skid function, will automatically calculate the maximum pressure that can be delivered to the brakes, based on the pavement conditions. As a result, pilots must be aware that for a same pedal deflection, in different pavement conditions, different amounts of hydraulic pressure will applied to the brakes.

For example, on a full brakes application the pressure that is actually being applied to the brakes, by the BCU, will be higher at a dry runway and lower on a contaminated runway. As a result, pilots will notice lower deceleration on a contaminated runway, compared with a dry runway. The graph below shows a comparison between the braking pressure on a contaminated runway and on a dry runway.



$\Delta 1$ = Anti skid pressure control to avoid a tire lock on a dry runway
 $\Delta 2$ = Anti skid pressure control to avoid a tire lock on a wet runway

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- Emergency parking brake (EPB): A dedicated hydraulic line is used for the emergency parking brake providing a redundant brake capability in case of failure of the normal brakes. However, the EPB actuation is commanded by a valve that will deliver pressure to the system without anti skid control. This can generate a performance penalty and crews must exercise caution when using this device; otherwise a tire lock may occur.

CAUTION: The emergency parking brake will always deliver worse performance when compared to the normal brakes with anti-skid protection. Its use is only recommended on abnormal conditions, when the BRK FAIL CAS message is annunciated. In these conditions, applying the landing correction factors, determinate by the QRH, are mandatory.

For additional information on the EPB use, refer to the operational video OV-500006, available at the FlyEmbraer.

Landing on a wet/contaminated runway

Landing on a wet/contaminated runway presents additional challenges to the pilots. Carefully evaluating the conditions and identifying the most suitable performance numbers to use are mandatory. A considerable difference can be found between wet versus standing water runways.

By definition, a wet runway is a pavement covered by less than 3mm (0.125") of water and the standing water has more than 25% of the pavement covered with more than 3mm of water.

However, it is very difficult to receive a clear report from the ATC about the runway conditions, so pilots would use other indications to properly assess the performance numbers. The amount of rain, at the moment of the landing, may be an indicator. Moderate to heavy rain increases the possibility of having greater water quantities on the runway and using standing water numbers may be more adequate than wet. Runway grooving is also a factor, but do not overestimate it. If you know that the runway drainage is good, the wet numbers may be used, but if the runway is unknown, be conservative. Also, be careful when evaluating a light rain over a non-grooved runway or a concrete polished surface. This may result in a slippery surface, which reduces braking action. In this case, the standing water numbers are more recommended than wet.

Once the runway condition is identified, pilots must be aware of the expected braking behavior of the aircraft in different surfaces. The graph below demonstrates the speed

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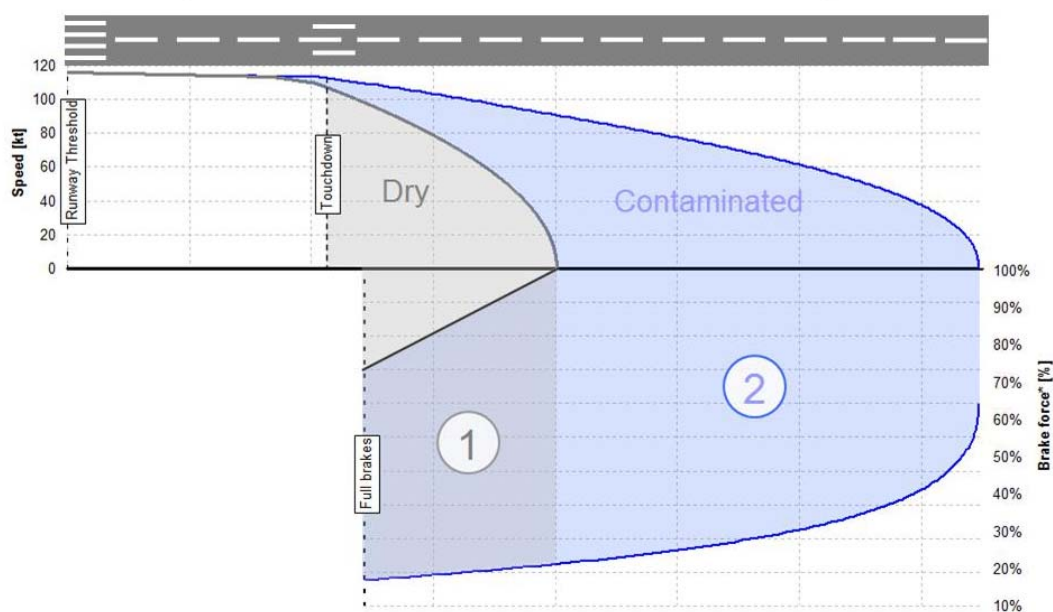
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reduction (top region) and braking force improvement (bottom region) on a dry (gray area) and standing water 3mm (blue area) runway. The landing conditions are ISA, MLW, flaps full.

Comparison between dry and contaminated runway braking action



Region 1: The braking force reference, in the graph, is the maximum force achieved during the landing on a dry runway. This is defined as 100%. The region 1 shows how degraded is the braking action on a contaminated runway compared to the dry.

Region 2: Braking force increases slowly on a contaminated runway, requiring more runway distance to stop the airplane. The braking force increases exponentially, only by the end of the landing roll, differently from a dry runway that has a linear behavior. The reason for this is the degraded braking coefficient and the hydroplaning effect.

The hydroplaning effect is a phenomenon that causes the airplane to roll on top of the contaminant layer. It will be no longer in contact with ground, but only with the fluid layer. This effect is more prone to happen when the aircraft is in contact with the fluid above the hydroplaning speed. This speed can be calculated by the expression below:

$$V_p = 9\sqrt{P}$$

where P is the tire pressure in PSI and Vp the hydroplaning speed in knots.

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The higher the tire pressure, higher will be the hydroplaning speed, thus, hydroplaning is less probable to happen. This reinforces the importance of constantly service the tires.

Taking into consideration the typical tire pressure from the Phenom 300 (174 to 184 psi) the hydroplaning speeds will be from 118kts to 122kts. As the hydroplaning is a function of the airplane groundspeed, the tailwind is an important factor to be considered when assessing the best runway to land.

During the initial portion of the landing roll, where the braking action is highly degraded and hydroplaning can take place, the biggest contributor for deceleration is the airplane drag. Thus, landing at configurations that provide higher drag, such as flaps full, are encouraged. To retract the flaps during the landing on a contaminated runway, will reduce the drag penalizing the landing distance. The expected effect of increasing the airplane braking force, reducing the lift by retracting the flaps, will be not relevant on a contaminated runway, as tire will still be over the water layer.

Factors that affect a successful landing

In order to develop risk mitigation strategies and tools, it is important to identify what are the key factors that contribute to the landing success. While some of them are related to the pilot techniques to fly the landing profile as described earlier, others are related to the interpretation of runway conditions and proper use of the aircraft performance data.

1) Stabilized approach

A stabilized approach means that the aircraft is maintaining the correct flight path, at the appropriate speed and configuration using only small inputs of thrust and pitch to adjust the aircraft slope and speed.

Flying a stabilized approach is one of the most fundamental elements to guarantee that the landing profile is followed and the stopping distance will match the AFM ones. Fail to perform a stabilized approach will result in deviations and increased landing distances.

Operators are encouraged to determine stabilized approach criteria and incorporate them to the SOP. Stabilized approach call outs are highly recommended to be performed at the Final Approach Fix (FAF) or 1000ft for an IMC approach and 500ft for a VMC approach. If the stabilized approach criteria are not meet at those altitudes, pilots should initiate a go around maneuver.

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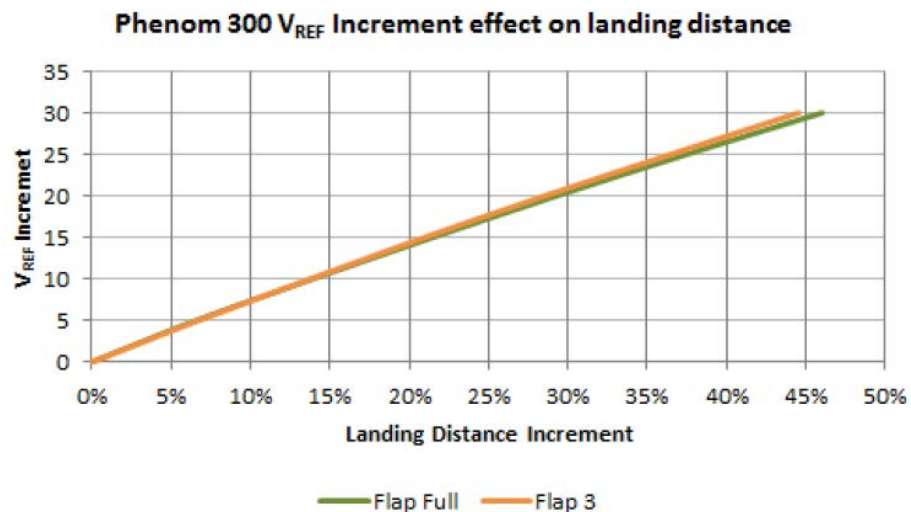
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2) Excessive speed at the runway threshold

V_{ref} is the target speed until the runway threshold crossing. Higher speeds mean more energy, thus requiring more distance to decelerate the airplane. Below is an example of the effect of V_{ref} overspeeds on a typical Phenom landing.



3) High threshold crossing

Crossing the threshold above 50 ft may result touching down beyond the 1000ft mark. As a rule of thumb, each additional 10ft will increase the landing distance by 200ft or 61m (i.e. crossing the threshold at 100ft will increase the landing distance by 1000ft or 305m).

The TAWS altitude call-outs during the approach provide additional guidance on the aircraft height above ground.

4) Partial brake application or delaying the brake application

Delaying the full brake application, after the main landing gear touchdown, may increase the landing distance in up to 200ft per second delayed in reaching the full brakes.

Partial braking will also increase the landing distance, as the certified numbers are based only on the full brake application.

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5) In flight landing assessment

When the landing conditions are unusual or the runway conditions are uncertain, performing a landing assessment during approach is highly recommended. However, it is important to carefully evaluate several parameters in order to precisely identify the aircraft stopping capability and if there are safety margins if deviations occur.

Some of the most relevant parameters to be evaluated on a landing assessment are:

- Aircraft weight: Evaluating the actual landing weight is imperative to identify the correct approach speeds and landing distance required. Pilots are encouraged to closely monitor the fuel consumption during the flight in order to have an accurate estimate of the landing weight. Some avionics' features, like the weight planning page and the FOB sync are a good aid to make proper landing weight estimation.
- Tailwind: The tailwind will significantly increase the aircraft groundspeed, increasing the landing distance. Sometimes, due to traffic, ATC will not assign the best runway with headwind. When tailwind is predicted, take that into consideration.

The Garmin avionics are capable of displaying the wind direction on the PFDs, providing additional information to evaluate the landing performance.

- Runway slope: A downhill slope will increase the landing distance, while an uphill slope will be beneficial on stopping the aircraft. The runway selection should not only consider the wind but also the effect of the slope on the landing distance.
- Runway condition: As already described in the earlier sections of this document, understanding the correct runway condition is imperative to assess the correct performance number. A wet versus contaminated numbers are considerably different and the amount of rain is a good indication on which number is most applicable.

6) Smooth or Light Bounced Landing

- In order to avoid hydroplaning on wet, contaminated runways and reduce the strength of ice bond that, during flight, might have been eventually formed on brakes and wheels assembly. The positive landing technique is recommended to ensure initial wheel spin-up and initialization of firm ground contact upon touchdown. In addition to that, brake pedals application should only occur after the MLG have touched the ground in a firm and conclusive touchdown.

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NOTE: During the approach pilots should avoid inadvertently applying pressure on the brake pedals. Brake application should only occur after the MLG have touched the ground in a firm and conclusive touchdown.

For further information on landing assessment refer to the FAA document SAFO6012.

Final considerations

The certified landing numbers are based on a typical landing profile defined by aeronautical requirements. Deviations from this profile will increase stopping distance and pilots should take that into consideration when evaluating a landing on critical conditions.

The brake by wire system will provide optimum braking performance. As it is equipped by electronic transducers on the brake pedals, pilots will only receive force feedback through a force spring. This will generate a constant resistance on the pedals, regardless of the amount of brake pressure that the BCU is applying to the system.

Landing on wet/contaminated runway provides additional challenges to the pilots. Carefully evaluate the landing conditions, assessing the proper performance numbers. During the landing roll, be aware of the expected braking behaviors.

Flying a stabilized approach is key for the landing success. It will guide the aircraft to the landing profile described on the AFM, minimizing deviations and guaranteeing the landing distance numbers. After the touchdown, brake for safety and not for comfort.

Best Regards,

Executive Flight Operations Support
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