Vereniging van Nederlandse Verkeersvliegers

Dutch Air Line Pilots Association

Position Paper 07 / 1

EHRD Dispatch Dry/Wet

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This position paper represents the opinion of the Dutch Air Line Pilots Association based on IFALPA / ECA policy, legislation, scientific research and manufacturer guidelines and recommendations.

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Issue

This position paper discusses whether the porous runway surface structure of EHRD produces an effectively dry braking action with moderate rainfall and whether EHRD can be considered dry for dispatch purposes, except when heavy rain (+RA) if forecasted.

Certification

With JAR 25 Orange Paper 25/88/1 national variants of JAR 25 were removed and JAR 25X1591 Supplementary Performance Information was introduced requiring supplementary performance information to be furnished by the manufacturer for operations on wet and contaminated runways.

The following definitions of dry, wet and contaminated runways were introduced:

Dry runway: A runway which is neither wet nor contaminated, including those runways which have been specially prepared with grooves or a porous pavement and maintained to retain effectively dry braking action even when moisture is present.

Wet runway: A runway which is well-soaked but without significant areas of standing water. A runway is considered well soaked when there is sufficient moisture on the runway surface to cause it to appear reflective**.**

In the course of a few certifications some discrepancies were noted between the theoretical methods of the AMJ 25X1591 introduced at Change 13 and measured results. As a result Temporary Guidance Material (TGM/25/04) "Performance Information for Take-Off from Wet Runways; Information on Precipitation Drag", which calls for limited test substantiation, was published.

As a result of various runway overruns following high speed rejected takeoffs the National Transportation Safety Board (NTSB) published a Special Investigation Report 90/2 which has among others resulted in the review of certification requirements. The proposals were contained in the comparable FAA NPRM 93-8 and JAA NPA 25BDG-244 and introduced in FAR 25 Amendment 92 and JAR 25 Change 15. The original proposal of NPRM 93-8 addressed wet runway performance by assuming a maximum tire-to-ground braking coefficient equal to one half of that for a dry runway. Public comments however, based on ESDU Data Item 71026, resulted in a more elaborate approach to address wet runway performance. From these data, it is readily apparent that wet runway stopping performance is significantly affected by many more variables than dry runway stopping performance, such as ground speed, tire pressure, tire tread depth, runway surface texture, water depth, brake wear and maximum brake torque capability and anti-skid efficiency. The new certification requirements provide a maximum tire-to-ground friction coefficient as a function of tire pressure and groundspeed to be used in determining the wet runway accelerate-stop distances. In addition to these values the anti-skid efficiency has to be taken into account. For a properly tuned anti-skid system the following efficiencies may be used: on-off 30%, quasi-modulating 50% and fully-modulating 80%. At the option of the manufacturer other values may be used as a result from flight testing.

The FAA and JAA agreed that grooved and Porous Friction Course (PFC) runways can offer substantial safety benefits in wet conditions and it was agreed that 70% of the dry runway braking coefficient conservatively represents the stopping performance on properly designed, constructed, and maintained grooved or PFC runways. At the option of the manufacturer stopping performance must be based on either 70% dry or according to another set of maximum tire-to-ground friction coefficients as a function of tire pressure and groundspeed in combination with an anti-skid efficiency. The ESDU data used represented runways with grooved or open macro-texture/PFC runways with texture depths between 0.5 and 2.5 mm. An evaluation of the ESDU data for these runways shows that for a texture depth midway between the above limits in combination with typical anti-skid efficiencies, stopping performance is approximately the same as using 70% of the dry runway braking capability.

The previous definitions of a dry runway and wet runway (see above) were clearly not applicable anymore and where removed from ACJ 25X1591. Additionally performance information for grooved/PFC runways derived according to JAR 25 Change 15 / FAR 25 Amendment 92 must be accompanied by a note limiting its use to grooved/PFC runways that have been constructed and maintained to meet the friction level qualifications in FAA-AC 150/5320-12C or its equivalent.

JAR-OPS

JAR-OPS 1.520 requires that an operator shall ensure that when the appropriate weather reports or forecasts, or a combination thereof, indicate that the runway at the estimated time of arrival may be wet, the landing distance available is at least 115% of the required landing distance, determined in accordance with JAR–OPS 1.515 (dry runways). JAR-OPS 1.520 allows a landing distance on a wet runway shorter than that required above, but not less than that required for a dry runway, provided that the Aeroplane Flight Manual includes specific additional information about landing distances on wet runways. This information will have to be derived from flight testing.

According to a CAA-UK paper on the derivation of the landing distance factor, the origin of the dispatch factors are believed to be the ‘traditional’ 1.43 factor with an allowance for runway surface variations to bring it to 1.67. As a result of testing of jet aircraft on wet surfaces, the 1.67 factor was found to be inadequate resulting in the additional 1.15 factor for operations on wet runways.

The definitions of runway state as defined in JAR-OPS 1.480 are a direct result of the original definitions defined in JAR 25 Change 13. With the advent of NPA 25BDG-244 changes in JAR 25 were not reflected in changes in JAR-OPS however. This is being addressed by the JAA Performance Subcommittee and covered in DNPA-OPS 47, which is still awaiting further progress by EASA. The accompanying Regulatory Impact Assessment (RIA) states that the current definition of a dry runway was written when the understanding of the braking characteristics of aircraft on grooved and PFC runways was in its infancy. Since then, knowledge of the subject has evolved considerably, principally following the development of NPA 25BDG-244 to the extent that it is now recognised that grooved or PFC runways do not retain effectively dry braking action when wet.

The following definitions of dry and wet runway are contained in DNPA-OPS 47:

Dry runway: A dry runway is one which is clear of contaminants and visible moisture within the required length and the width being used.

Wet runway: A runway that is neither dry nor contaminated is considered wet.

Runway Maintenance Standards

Runway maintenance standards can be found in ICAO Annex 14 and the ICAO Airport Services Manual. Attachment A of ICAO Annex 14 contains minimum friction values for different friction testing devices (self-wetting maintenance friction measurements) for three categories: The Design Objective Level (DOL) for new runways, the Maintenance Planning Level (MPL) and the Minimum Friction Level (MFL). When the measured friction level drops below the MFL a NOTAM '*slippery when wet*' has to be furnished.

According to the Airport Services Manual the term Minimum Friction Level is related to ensuring the safe operation of aeroplanes when the runway is wet. Appendix 1 to the Airport Services Manual contains a method for relating the MFL to aeroplane wet dispatch performance.

In other words runways maintained in accordance with the guidelines provided by the Airport Services Manual should ensure safe operations for aeroplanes provided wet dispatch performance is applied and provided the runway measured friction is above MFL. When the maintenance friction measurements drop below the MFL, clearly application of wet takeoff and landing performance regulations may be inappropriate for field length limited operations. Other comparable maintenance standards can be found in FAA AC 150/5320-12C and CAA-UK CAP 683.

Friction Measurements & Aircraft Performance

Maximum wet runway friction drops with increasing groundspeed and for low speeds approximates the dry value which is virtually independent of groundspeed. This is also reflected in the certification requirements introduced in FAR 25 Amendment 92 and JAR 25 Change 15.

Boeing and Airbus do currently not support correlation between friction testing devices and aircraft performance. Nevertheless a lot of research has been done for decades and is still ongoing at the moment. Examples are the Joint FAA/NASA Runway Friction Program and the Joint Winter Runway Friction Measurement Program. A literature survey by NLR on behalf of CROW concludes that correlation between friction measurement and aircraft stopping performance remains difficult, especially on wet surfaces.

The ICAO Airport Services Manual provides a method in Appendix 1, based on NASA Combined Viscous/Dynamic Hydroplaning Theory relating non-dimensional tire-to-ground friction ratios (μ-actual/μ-ultimate) for both friction testing device and aircraft tire. An aircraft effective braking coefficient is derived from the resulting aircraft tire-to-ground friction value. The μ-ultimate value must be derived from low-speed testing on a dry surface.

ESDU Data Item 99015 provides a statistical method for relating measured friction values on wet runways and aircraft braking performance. This method also assumes a groundspeed friction relation where the zero speed value on a wet runway approximates the dry friction value.

CROW Report 03-10 and the Airport Services Manual Appendix 1 contain dry friction values in the form of μ-ultimate or μ-datum values in the range from 0.95 to 1.15. The Airport Services Manual states an ultimate friction value for the Saab Surface Friction Tester as used on EHRD of 1.10. Actual maintenance friction measurements on EHRD are some 20 – 30 % lower.

NASA TP 2917 contains the following conclusions: A lower macrotexture surface creates less friction than a rough macrotexture surface, wet grooved or PFC runways improve the wet runway friction capability, however it is not the same as a dry runway and the runway friction on a damp runway was reduced compared to a dry runway. These conclusions are reproduced in the Boeing Performance Engineer Operations Course Notes.

Conclusions

VNV does not support the conclusion that the runway surface of EHRD can be considered dry for dispatch purposes when rain is forecasted based on the following:

- This conclusion is based purely on a textual interpretation of the definition of a dry runway currently in JAR-OPS and cannot be substantiated by friction measurements, flight testing or scientific research.
- Although the definitions of runway state in JAR-OPS should be amended in line with CS/JAR/FAR 25 (see DNPA-OPS 47), the current definition of a dry runway merely includes an unattainable condition, i.e. '… maintained to retain 'effectively dry' braking action …' This applies to aircraft and not friction testing equipment.
- There is no maintenance program on EHRD comparable with FAA AC 150/5320-12C or CAA-UK CAP 683, which are industry wide accepted as being an acceptable standard for accepting performance credit on grooved/PFC runways.
- The maintenance program on EHRD is not designed to retain effective dry friction and does not consider preventive maintenance and as such does not prevent friction levels from dropping below MFL.
- The MFL assures safe operations when the runway is considered wet. The equivalent braking action associated with wet runways in Boeing terminology is GOOD. Braking action GOOD is approximately equal to half the braking action of a dry runway.
- The maintenance standard for the texture depth at EHRD is 1.3 mm. This is well within the range of tested surfaces considered in ESDU Data Item 71026 and used for CS/JAR/FAR 25 grooved/PFC performance credit. As such there is no reason to expect significant better performance than considered for certification requirements.
- There is no scientific research or flight test data available showing equivalent dry performance of jet aircraft on these surfaces and maintenance friction values measured cannot be used for operational interpretation of aircraft stopping distances.
- JAR-OPS addresses aircraft performance and not performance of friction measuring devices. As such landing distances shorter than that for a wet runway can only be used according to JAR-OPS 1.520 when specific information on landing distances on wet runway is contained in the Aircraft Flight Manual. This information will have to be derived from flight testing and such information is available from manufacturers (e.g. Airbus A320 for operations on Funchal, Madeira).
- Correlation between friction testing devices and aircraft performance is problematic, especially on wet runways and currently not supported by Boeing and Airbus. Amongst others, aircraft antiskid behaviour, the considerably higher operating speeds of aircraft and their different tire pressures and tire geometry hamper direct correlation to friction testing equipment.

- The reflective criterion is of little use for grooved/PFC runways as this merely reflects a situation where the water starts to rise above the texture depth. This situation is more representative of a flooded runway with an increasing possibility of hydroplaning and considerably reduced braking action. Long before water levels reach this height already a reduction in runway friction is present as reflected in the certification requirements.
- Although recommended/actual landing distances for aircraft types concerned may indicate a feasible landing with braking action GOOD, this could (depending on aircraft type) require a maximum effort landing, including reverse thrust credit for an aircraft dispatched according to a dry runway. Recommended/actual landing distances are not certified and for information only and do not provide the safety level intended by dispatch requirements and as such cannot be considered in the dispatch phase.
- There is no internationally agreed rain intensity level defining heavy rain (+RA).
- CAA-NL has not given approval.

VNV acknowledges the fact that the runway surface of EHRD has excellent friction characteristics and appreciates the quality of the maintenance program and the efforts of staff involved. An excellent example is the recent resurfacing of the runway. Nevertheless the fact remains that international experts from manufacturers, authorities and scientific institutes agree that an equivalent dry capability of aircraft when moisture is present on grooved/PFC runways is not a real life scenario. This is reflected in current certification requirements.

Considering grooved/PFC runways dry with forecasted rain is merely based on whether the literal interpretation of current JAR-OPS wording is possible, but has nothing to do with the actual capability of grooved/PFC runways.

Nevertheless VNV supports landing performance credit comparable with the option currently available for accelerate-stop distances in the certification requirements, in order to provide further economic incentive for the building of grooved/PFC runways. However, stimulating airports in investing in high quality runway surface materials and excellent maintenance by allocating performance credits should be undertaken at the appropriate international level and with an international accepted standard.

Legislation

1. JAR-OPS 1 Subpart G Amendment 11 – 1 August 2006
   Section 1 JAR-OPS 1.480 Terminology (a)(4) Dry Runway
   Section 1 JAR-OPS 1.480 Terminology (a)(10) Wet Runway
   Section 1 JAR-OPS 1.515 Landing – Dry Runways
   Section 1 JAR-OPS 1.520 Landing – Wet and Contaminated Runways
   Section 2 IEM OPS 1.485(b) General – Wet and Contaminated Runway Data
2. DNPA-OPS 47 Revisions to JAR-OPS 1 Subparts F, G and H arising from ARAC Harmonisation discussions (JAA Performance Subcommittee)
3. Regulatory Impact Assessment for NPA-OPS 47 Proposal 1, JAR-OPS 1.475(d) (OST 04/4 WP)
4. Regulatory Impact Assessment for NPA-OPS 47 Proposal 2, JAR-OPS 1.480 (OST 04/4 WP)
5. FAR 25 Amendment 92 (Effective 20 Mar 1998)
6. NPRM 93-8 (58 FR 36738) (Published 8 Jul 1993)
7. JAR Orange Paper 25/88/1 (Effective 18 Oct 1988)
8. JAR 25 Change 13 (Effective 5 Oct 1989)
9. JAR Temporary Guidance Material 25/04 (Effective 1 Oct 1995)
10. JAR 25 Change 15 (Effective 1 Oct 2000)
11. JAA NPA 25BDG-244 Accelerate-Stop Distances and Related Performance Matters (Published Mar 1991, Revised Feb 1993)
12. ICAO Annex 14 Aerodromes Volume I, Aerodrome Design and Operations (Effective 25 Nov 2004)
13. ICAO Airport Services Manual (Doc 9137) Part 2, Pavement Surface Conditions (2002)
14. CAA-UK CAP 683 The Assessment of Runway Surface Friction for Maintenance Purposes (14 May 2004)
15. FAA AC 150/5320-12C Measurement, Construction and Maintenance of Skid-Resistant Airport Pavement Surfaces (18 Mar 1997)

Scientific Reports / Papers

1. Engineering Sciences Data Unit (ESDU) Data Item 71026, Frictional and Retarding Forces on Aircraft Tyres. Part II: Estimation of Braking Forces (Amendment D, 1 Jun 1995)
2. Engineering Sciences Data Unit (ESDU) Data Item 99015, Statistical Analysis of Wet Runway Friction for Aircraft and Ground-test Machines (Nov 1999)
3. NTSB SIR 90/2 Runway Overruns Following High Speed Rejected Takeoffs (27 Feb 1990)
4. NASA TP 2917 Evaluation of Two Transport Aircraft and Several Ground Test Vehicle Friction Measurements Obtained for Various Runway Surface Types and Conditions - A Summary of Test Results from the Joint FAA/NASA Runway Friction Program (Feb 1990)
5. CROW Report 03-06 A Literature Survey on Tire-Surface Friction on Wet Pavements, Application of Surface Friction Testers
6. CROW Report 03-10 Correlation of Self-Wetting Friction-Measurement Devices, Evaluation of the ESDU method
7. CROW Report D07-06 Literature Survey on Operational Runway Surface Friction Measurements
8. Discussion Paper on the Derivation of the FAA Landing Distance Factor (CAA-UK, G. Skillen)

Other

1. KLM cockpit bulletin 04/12 (29 Dec 2004)
2. KLM cockpit bulletin 06/02 (19 Jan 2006)
3. KLM General ROM 3.3.1 (8 Jun 2006)

4. VNV Vliegtechnisch Bulletin 2005/3 Slippery When Wet?
5. Boeing Performance Engineer Course Notes – Wet Runway, Physics, Certification, Application (Paul Giesman, 2005)
6. Boeing 777 Certified Aircraft Flight Manual
7. Boeing 737NG Certified Aircraft Flight Manual