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RISKS AND FACTORS ASSOCIATED WITH OPERATIONS ON RUNWAYS AFFECTED BY SNOW, SLUSH OR WATER

1 Introduction

1.1 Operations from contaminated runways, by all classes of aeroplane, should be avoided whenever possible.

1.2 This Circular has been laid out in a conventional manner, with take-off information preceding landing information. It should not be assumed that this indicates that take-offs are considered to be more critical and equal attention should be paid to the later paragraphs dealing with landings on runways affected by snow, slush or water.

1.3 Major UK licensed aerodromes make every effort, within the limits of manpower and equipment available, to keep runways clear of snow, slush and its associated water, but circumstances arise when complete clearance cannot be sustained. In such circumstances, continued operation involves a significant element of risk and the wisest course of action is to delay the departure until conditions improve or, if airborne, divert to another aerodrome.

2 Operational Factors and Reporting Phraseology

2.1 The method used for runway surface condition reporting at UK aerodromes is described in the UK AIP Section AD 1.1.1. The presence of slush, snow and ice on runways is reported by the following method, which is described in the UK AIP Section AD 1.2.2, United Kingdom Snow Plan. The depth of snow or slush is measured by a standard depth gauge at approximately 300 metre intervals, between 5 and 10 metres from the runway centre line and clear of the effects of rutting. The depth of contamination is reported in millimetres for each third of the runway length.

For information on the assessment of wet runway surface conditions, see UK AIP AD 1.1.1.

2.1.1 A subjective assessment is also made of the nature of the surface condition, on the following scale:

(a) Dry Snow (less than 0.35 Specific Gravity);
(b) Wet Snow (0.35 to 0.50 Specific Gravity);
(c) Compacted Snow (over 0.50 Specific Gravity);
(d) Slush (0.50 to 0.80 Specific Gravity);
(e) Standing Water (1.00 Specific Gravity). **Note:** Where only water is present the reporting scheme of 2.2 will be used.

Note: Specific Gravity values are stated here to assist in the correlation of conditions with aircraft data, and not necessarily to assist in the determination of conditions as found.

2.2 The presence of water on a runway will be reported to the pilot using the following description:

Reporting Term	**Surface Condition**
DRY	The surface is not affected by water, slush, snow or ice. NOTE: Reports that the runway is dry are not normally passed to pilots. If no runway surface report is passed, the runway can be assumed to be dry.
DAMP	The surface shows a change of colour due to moisture. NOTE: If there is sufficient moisture to produce a surface film or the surface appears reflective, the runway will be reported as WET.
WET	The surface is soaked but no significant patches of standing water are visible. NOTE: Standing water is considered to exist when water on the runway surface is deeper than 3 mm. Patches of standing water covering more than 25% of the assessed area will be reported as WATER PATCHES and should be considered as CONTAMINATED.

For JAR-OPS performance, runways reported as DRY, DAMP or WET should be considered as NOT CONTAMINATED	
WATER PATCHES	Significant patches of standing water are visible. NOTE: Water patches will be reported when more than 25% of the assessed area is covered by water more than 3 mm deep.
FLOODED	Extensive patches of standing water are visible. NOTE: Flooded will be reported when more than 50% of the assessed area is covered by water more than 3 mm deep.
For JAR-OPS performance purposes, runways reported as WATER PATCHES or FLOODED should be considered as CONTAMINATED	

2.2.1 When reported, the presence or otherwise of surface contaminants on a runway will be assessed over the most significant portion of the runway (ie the area most likely to be used by aircraft taking off and landing). This area may differ slightly from one runway to another but will be approximate to the central third of the width of the runway extending longitudinally from a point 100 m before the aiming point to 100 m beyond the aiming point of the reciprocal runway.

2.2.2 Reports will be given sequentially for each third of the runway to be used, for example, 'Runway surface is wet, water patches, wet'. Where an aircraft will not make use of the entire runway, the third most likely to be used at high speed is the most critical.

2.3 Depths greater than 3 mm of water, slush or wet snow, or 10 mm of dry snow, are likely to have a significant effect on the performance of aeroplanes. The main effects are:

(a) Additional drag - retardation effects on the wheels, spray impingement and increased skin friction;

(b) possibility of power loss or system malfunction due to spray ingestion or impingement;

(c) reduced wheel-braking performance - reduced wheel to runway friction and aquaplaning. Aquaplaning significantly increases stopping distances and reduces directional control;

(d) directional control problems;

(e) possibility of structural damage.

2.3.1 A water depth of less than 3 mm does not require corrections to take-off performance to be made other than the allowance, where applicable, for the effect of a wet surface. However, on such a runway where the water depth is less than 3 mm and where the performance effect 2.3 (a) is insignificant, isolated patches of standing water or slush of depth in excess of 15 mm located in the latter part of the take-off run may still lead to ingestion and temporary power fluctuations which could impair safety. Some aircraft types are susceptible to power fluctuations at depths greater than 9 mm and AFM limitations should be checked. For depths greater than 9 mm, specific mention will be made in the surface condition report as to the location, extent and depth of water patches.

2.4 A continuous depth of water greater than 3 mm on a well constructed runway can occur if very heavy rain combines with a lack of runway camber/crossfall or a crosswind to reduce the rate of water drainage from the runway. In such conditions the water depth is unlikely to persist for more than about 15 minutes after the rain has ceased, and take-off should be delayed accordingly.

2.5 In assessing the performance effect of increased drag (for reasons outlined in paragraph 2.3 (a)), the condition of the up-wind two thirds of the take-off runway is most important, (ie the area where the aeroplane is travelling at high speed). Small isolated patches of standing water will have a negligible effect on performance, but if extensive areas of standing water, slush or wet snow are present and there is doubt about the depth, take-off should not be attempted.

2.6 It is difficult to measure, or predict, the actual coefficient of friction or value of displacement and impingement drag associated with a contaminated runway. Therefore, it follows that aeroplane performance relative to a particular contaminated runway cannot be scheduled with a high degree of accuracy and hence any 'contaminated runway' data contained in the Flight Manual should be regarded as the best data available.

2.7 When a runway is contaminated by water (ie more than 3 mm deep), wet snow or slush, a braking action report will not be available due to the limitations of existing friction measuring equipment. However, a runway surface condition report will normally be available, stating the type of contaminant and its respective depth. In addition, reports of pilot reported braking action may be broadcast and these will include the aircraft type and the time of the observation. However, these are unofficial, subjective reports and should be interpreted accordingly. For runways contaminated with compacted snow or ice, reports of braking action are passed to pilots via the RTF for each third of the runway to be used, for example, 'Estimated braking action for Runway 23 is: poor; medium poor; poor'.

2.8 The provision of performance information for contaminated runways should not be taken as implying that ground handling characteristics on these surfaces will be as good as can be achieved on dry or wet runways, in particular, in crosswinds and when using reverse thrust. Remember, the use of a contaminated runway should be avoided if at all possible. A short delay in take-off or a short hold before landing can sometimes be sufficient to remove the contaminated runway risk. If necessary a longer delay or diversion to an aerodrome with a more suitable runway should be considered.

3 Runways that may be slippery when wet

3.1 ICAO Annex 14 (Aerodromes) requires airports to conduct periodic surveys of runway surface friction. If a survey indicates that the runway surface friction characteristics have deteriorated below a specified Minimum Friction Level, that runway will be notified via NOTAM as ‘may be slippery when wet’. The term slippery should not be confused with the term icy.

3.2 The Minimum Friction Level only needs to be recorded over a continuous strip of 100 m for a runway to be notified as 'may be slippery when wet'. When a runway is notified as such, aircraft operators may request additional information relating to that notification from the aerodrome operator. However, any performance calculations or adjustment made as a result of this information is the responsibility of the aircraft operator.

4 General Limitations for Take-off

4.1 When operations from contaminated runways are unavoidable the following procedures may assist:

(a) Take-offs should not be attempted in depths of dry snow greater than 60 mm or depths of water, slush or wet snow greater than 15 mm. If the snow is very dry, the depth limit may be increased to 80 mm. In all cases the AFM limits, if more severe should be observed;

(b) ensure that all retardation and anti-skid devices are fully serviceable and check that tyres are in good condition;

(c) consider all aspects when selecting the flap/slat configuration from the range permitted in the Flight Manual. Generally greater increments of flaps/slats will reduce the unstick speed but could, for example, increase the effect of impingement drag for a low wing aircraft. Appropriate field length performance corrections should be made (see paragraph 6);

(d) fuel planning should include a review of all aspects of the operation; including whether the carriage of excess fuel is justified;

(e) ensure that de-icing of the airframe and engine intakes, if appropriate, has been properly carried out and that the aircraft is aerodynamically clean at the time of take-off. Necessary de-icing fluids on the aerodynamic surfaces are permitted;

(f) pay meticulous attention to engine and airframe anti-ice drills including during ground operation;

(g) do not attempt a take-off with a tail wind or, if there is any doubt about runway conditions, with a crosswind in excess of the slippery runway crosswind limit. In the absence of a specified limit take-off should not be attempted in crosswinds exceeding 10 kt;

(h) taxi slowly and adopt other taxiing techniques which will avoid snow/slush adherence to the airframe or accumulation around the flap/slat or landing gear areas. Particularly avoid the use of reverse thrust, other than necessary serviceability checks which should be carried out away from contaminated runway areas. Avoid taxiing too closely behind other aircraft and be cautious of making sharp turns on a slippery surface;

(i) use the maximum runway distance available and keep to a minimum the amount of runway used to line up. Any loss should be deducted from the declared distances for the purpose of calculating the RTOW;

(j) power setting procedures appropriate to the runway condition as specified in the AFM should be used. Rapid throttle movements should be avoided and allowances made for take-off distance increases;

(k) normal rotation and take-off safety speeds should be used, (eg where the Flight Manual permits the use of data for overspeed procedures to give improved climb performance, these procedures should not be used). Rotation should be made at the correct speed using normal rate to the normal attitude;

(l) maximum take-off power should be used.

5 The Safety Regulation Group of the Civil Aviation Authority will advise on the safety of any proposed change to the above procedures.

6 Aircraft Commanders should also take the following factors into account when deciding whether to attempt a take-off:

(a) The dimensions and nature of any overrun area that is available, and the consequences of an overrun off that particular runway;

(b) weather changes since the last runway surface condition report, particularly precipitation and temperature, the possible effect on stopping or acceleration performance and whether subsequent contaminant depths exceed Flight Manual limits.

7 Take-off Performance

7.1 Aeroplanes in JAR-OPS 1 Performance Classes A and C:

(a) JAR-OPS 1 specifically requires account to be taken of the conditions of the surface of the runway from which the take-off will be made. Consequently, in the absence of approved contaminated runway performance data, operations from contaminated runways are not permitted. The CAA should be consulted about the data that is required to be obtained;

(b) operators present the limitations and performance corrections in their Operations Manuals in terms of reported precipitation depths. The limiting depth recommended in paragraph 4.1(a) should be used and the Specific Gravities given in the scale in paragraph 2.1 should be assumed;

(c) the take-off weight from a contaminated runway should not exceed the maximum permitted for normal operation when the runway is dry. If a normal take-off weight analysis for the runway results in a weight which is limited by obstacle clearance in the Net Flight Path, it is necessary to assume, for the contaminated runway take-off, that the Take-off Distance Available is equal to the Take-off Distance Required at the dry runway obstacle limited weight.

7.2 Aeroplanes in Performance Class B of MTWA not exceeding 5700 kg:

(a) JAR-OPS 1 requires specific reference to the conditions of the surface of the runway from which the take-off will be made. The ability to give take-off performance information with any confidence depends on knowledge of the slush drag characteristics. For small aeroplanes this knowledge is limited;

(b) in all instances manufacturer's information for operations on a contaminated runway should be sought. In its absence the best information available using conservative assumptions is given in paragraphs 7.2(d) to (e). Before using it to show compliance with JAR-OPS 1, approval should be sought from the appropriate operational authority. In all cases any limitations in the AFM must be strictly adhered to: those associated with flight in icing conditions are particularly relevant when considering operations from runways contaminated with ice, snow or slush;

(c) before using this guidance material to determine weather a take-off can be carried out, operators of Class B aeroplanes should also anticipate the possibility of having to re-land soon after take-off. Clearly, the runway surface condition under consideration will determine whether this can be safely carried out. Paragraph 8 below describes the factors that should be taken into account when determining if the landing distance available at the departure aerodrome (or the nearby take-off alternate aerodrome) allows for a safe landing in the expected conditions.

(d) Aerodrome Requirements:

(i) Twin engined Aeroplanes in Class B:

(1) Either a paved runway having an Accelerate Stop Distance Available not less than 1.5 x Take-Off Distance Required* or 1500 ft whichever is the greater, or a grass runway having an Accelerate Stop Distance Available not less than 2.0 x Take-Off Distance Required* or 2000 ft which ever is the greater, should be available;

* As given in the Approved Flight Manual for the conditions of weight, aerodrome altitude, air temperature, runway slope and wind, appropriate to a dry hard surface runway and **including** the factors of JAR-OPS 1.530, as appropriate;

(2) so that a check can be made on acceleration, the pilot will need to be able to identify the point on the runway at a distance of 40% of the ASDA from the start of take off. Pilots should request the aerodrome authority to provide, for this purpose, a suitable marker board, flag or readily identifiable object that does not contravene the obstacle requirements for a licensed aerodrome. If the necessary acceleration is not achieved, take-off should be abandoned (see paragraph 7.2.(e).

(ii) Single engined aeroplanes in Class B.

(1) Either a paved runway having an Accelerate Stop Distance Available not less than 2.0 x Take-off Distance to 50 ft Height Point* or 1500 ft whichever is the greater, or a grass runway having an Accelerate Stop Distance Available not less than 2.66 x Take off Distance to 50 ft Height Point* or 2000 ft whichever is the greater, should be available;

* As given in the Performance Schedule or 'Owners Manual' for the conditions of weight, aerodrome altitude, air temperature, runway slope and wind, appropriate to a dry hard-surfaced runway, and including the factors of JAR OPS 1.530, as appropriate;

(2) an acceleration check should be made (as described in paragraph 7.2(e)(i)(2)) above and if the necessary acceleration is not achieved take-off should be abandoned.

(e) Flight Procedure:

(i) The aeroplane is accelerated along the runway as for a normal take-off but using a small amount of aft stick to relieve nose gear drag. If a speed of 0.85 V_2 has been achieved before reaching the distance marker, the take-off should normally be continued. Rotation should be initiated and lift-off achieved at 0.9 V_2. The aeroplane should then be accelerated and climbed away to achieve V_2 at 50 ft;

(ii) if a speed of 0.85 V_2 has not been achieved on reaching the marker boards the take off should be abandoned. The throttles should be closed and maximum retardation used, consistent with retaining directional control.

(f) Additional limitations for take-off: In addition to the procedures recommended in paragraph 4.1 (a) to (l), the following factors should also be considered when operations from contaminated runways are contemplated:

(i) Visibility should be adequate to see the distance marker (recommended in paragraph 7.2 (d)(i)(2) and 7.2(d)(ii)(2)) from the start of take-off; and

(ii) Performance credit for reported headwinds and for downhill runway slopes should not be taken when ascertaining the take-off Distance Required.

8 Landing

8.1 JAR-OPS 1 requires that at the flight planning stage the landing distance requirements at the destination and alternate aerodromes are satisfied taking into account the runway surface condition. It follows therefore that if the runways at the destination or alternate aerodromes are forecast to be contaminated then approved landing distance data, appropriate to the anticipated conditions must be available in order to satisfy this requirement at dispatch.

8.2 In all cases however, Attempts to land on heavily contaminated runways involve considerable risk and should be avoided whenever possible. If the destination aerodrome is subject to such conditions departure should be delayed until conditions improve or an alternate used. It follows that advice in the Flight Manual or Operations Manual concerning landing weights and techniques on very slippery or heavy contaminated runways is there to enable the Commander to make a decision at despatch and, when airborne, as to his best course of action.

8.3 Depths of water or slush, exceeding approximately 3 mm, over a considerable proportion of the length of the runway, can have an adverse effect on landing performance. Under such conditions aquaplaning is likely to occur with its attendant problems of negligible wheel-braking and loss of directional control. Moreover, once aquaplaning is established it may, in certain circumstances, be maintained in much lower depths of water or slush. Crews should be familiar with the characteristics of aquaplaning, as its symptoms can be confused with a brake failure. A landing should only be attempted in these conditions if there is an adequate distance margin over and above the normal Landing Distance Required and when the crosswind component is small. The effect of aquaplaning on the landing roll is comparable with that of landing on an icy surface and guidance is contained in some Flight Manuals on the effect on the basic landing distance of such very slippery conditions.

8.4 If a runway is found to be slippery during the landing roll the handling pilot should reduce speed to taxi speed before attempting to turn off the runway.

This Circular is issued for information, guidance and necessary action.

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