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The Measurement and Assessment of Runway Surface Friction Characteristics

Guidance Material

Foreword

As an integral part of an Aerodrome Operator's Safety Management System (SMS), effective monitoring of the surface friction characteristics of runways should be clearly set out together with a methodology for documenting and dealing with the results of such monitoring.

The objective of this document is to offer guidance to Aerodrome Operators undertaking runway surface friction assessments by describing the key elements of the procedure. It also sets out target values, as produced by CFME, for surface friction levels that should prompt maintenance and/or NOTAM action by aerodrome operators following any such assessment.

This document provides guidance to aerodrome operators on how they may vary the frequency of runway surface friction level assessments in order to adjust maintenance schedules to meet the objective of adequate runway conditions for safe aircraft operations.

This document also provides guidance to aerodrome operators for an operational need for reliable and uniform information concerning the friction characteristics of snow- and/or ice-covered paved runways.

The criteria, which are given in this Technical Publication, reflect the CAA's interpretation of Standards and Recommended Practices of Annex 14 to the Convention on International Civil Aviation.

CAA requires that all involved parties are familiar with the contents and procedures described herein.

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Glossary

ATC	Air Traffic Control
ASTM	ASTM International - American Society for Testing and Materials Standards Organisation ¹
ASFT	Airport Surface Friction Tester
CAA	Civil Aviation Authority
CFME	Continuous Friction Measuring Equipment
DOL	Design Objective Level
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LVP	Low Visibility Procedures
MPL	Maintenance Planning Level
MFL	Minimum Friction Level
MOR	Mandatory Occurrence Report
SMS	Safety Management System
SOP	Standard Operating Procedure

¹ Committee ASTM E17 has produced standards for test tires to be used by all CFMEs recognized by ICAO

Terms and Definitions

In this manual, the terms used conform to those in Law No. 03/L-051 on Civil Aviation, Regulation No. 17/2017 on Requirements and Administrative Procedures Related to Aerodromes, and Annex 14 Volume I, to the Convention on International Civil Aviation.

For the purpose of a runway surface friction assessment the following definitions apply:

Term	Definition
Aerodrome	Aerodrome means a defined area (including any buildings, installations and equipment) on land or water or on a fixed, fixed offshore or floating structure intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.
Aerodrome Operator	Any person or legal entity authorized by the Authority to manage and operate an aerodrome by means of issuance of an aerodrome certificate.
Air Traffic Service	Air traffic service includes (a) aerodrome control service; (b) approach control service; (c) area control service; (d) flight information service; (e) alerting service and (f) any other air traffic service considered by the Authority to be necessary or desirable for the safe and efficient operation of the civil aviation system.
ASTM	ASTM International is a standards organisation: committee ASTM E17 has produced standards for test tires to be used by all CFMEs recognised by ICAO.
Authority	In this manual, the Authority means the Civil Aviation Authority of the Republic of Kosovo.
Check Runs	Runs intended to confirm that the operation of the CFME remains constant. These are performed before and after Standard Runs.
Continuous Friction Measuring Equipment	A device designed to produce continuous measurement of runway friction values.

(CFME)	
Design Objective Level (DOL)	The State-set friction level to be achieved or exceeded on a new or resurfaced runway within one year.
Friction Level	The lowest average friction value calculated from a minimum of 10 averaged friction values, of applicable Standard Runs, obtained over a rolling distance of 100 metres within a portion of the pavement.
Hydroplaning	The condition when a layer of water separates an aircraft's tires from the runway surface.
Maintenance Planning Level (MPL)	The State-set friction level below which a runway maintenance programme should be undertaken.
Manoeuvring Area	That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons.
Movement Area	That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft consisting of the manoeuvring area and the apron(s).
Portions of the Pavement	A rectangular area of the runway width running the declared length, referred to as the 'central' trafficked portion and two 'outer' portions.
Runway	A defined rectangular area on a land aerodrome prepared for landing and take-off of aircraft.
Runway Surface Friction Assessment	The assessment of friction carried out under conditions of self-wetting using a CFME.
Safety Management System	Safety management system means a systematic approach to managing safety including the necessary organisational structure, accountabilities, policies and procedures;
Standard Runs	A series of runs to a prescribed pattern within an assessment.
Standing water	Standing water is considered to exist when water on the runway surface is deeper than 3 mm.

Taxiway	A defined path on a land aerodrome established for the taxiing of aircraft and intended to provide a link between one part of the aerodrome and another including aircraft stand, taxi-lane, apron, taxiway, and rapid exit taxiway.
Test Water Depth	Test water depth (also known as nominal test water thickness). The water flow rate produced by the CFME's self-wetting equipment divided by the test speed multiplied by the width of application.
Wet Runway Surface	A runway that is soaked but no significant patches of standing water are visible.
Unserviceable Area	A part of the movement area that is unfit and unavailable for use by aircraft.

1. Introduction

1.1 General

Effective monitoring of the surface friction characteristics of runways should be clearly set out together with a methodology for documenting and dealing with the results of such monitoring.

ICAO Annex 14 Chapter 10 outlines the requirement, as set out in; to undertake regular assessments of runway surface friction characteristics and to ensure that friction is maintained at an acceptable level, but in any case does not fall below the Minimum Friction Level (MFL). Should the runway friction characteristics fall below MFL a NOTAM must be issued stating the surface "may be slippery when wet" and promulgated until remedial action has restored friction values to at least Maintenance Planning Level (MPL). Further, the Annex calls for the pavement surface to be kept clear of snow slush or other contaminants that might impair the operation of aircrafts. There is a requirement to assess the condition of the pavement whenever it has not been possible to fully clear the contaminants and to make this information available to the appropriate units at the airport.

This document describes the way the assessment should be carried out using the several types of Continuous Friction Measuring Equipment (CFME) currently accepted for use worldwide: Mu-Meters, Grip Testers, Airport Surface Friction Testers (ASFT) and BV-11 Skidometer.

This document also provides guidance to aerodrome operators for an operational need for reliable and uniform information concerning the friction characteristics of snow- and/or ice-covered paved runways.

1.2 Scope

- 1.2.1 The criteria in this document apply to all paved runways with an Accelerate Stop Distance Available (ASDA) 1,200 meters or greater in length and used for air transport operations by aeroplanes with a maximum take-off weight (MTOW) in excess of 2730 kg. It is not applicable to grass runways, helicopter landing sites or waterdromes.
- 1.2.2 On paved runways where prescribed air transport operations are not carried out, the application of the procedures is at the discretion of the aerodrome operator.
- 1.2.3 With the exception of Paragraph 1.3 below, the procedures in this document should only to be used for the acquisition of friction levels of a runway surface for maintenance purposes. Data gathered concerning friction

characteristics should be made available to aerodrome users on application, but should not be communicated to the crews of aircraft intending to use the runway during periods of surface contamination.

- 1.2.4 The procedures for the measurement and assessment of compacted snow- or ice-covered paved surface friction characteristics are given in Chapter 4.

1.3 Limitations to Operational Use of CFME

- 1.3.1 Deployment of CFME on contaminated runways for the purpose of obtaining friction value readings is not permitted because contaminant drag on the equipment's measuring wheel, amongst other factors, will cause readings obtained in these conditions to be unreliable. A runway is termed contaminated when water deeper than 3 mm, or wet snow or slush is present over 25% or more of the assessed area.
- 1.3.2 For the assessments of compacted snow- or ice-covered paved surface friction characteristics, it should be borne in mind that, in the time taken to pass assessments to pilots, conditions may have changed. With the exception of compacted snow and ice tables, (paragraph 2.4.4) friction value readings must not be passed to aircrew as pilots do not have the means to interpret the readings for the purpose of calculating take-off or landing performance.

2. Runway Surface Friction Assessments

2.1 Introduction

- 2.1.1 A runway surface friction assessment is conducted under controlled dry conditions, using the self-wetting function of CFME, to establish the friction characteristics of a runway and to identify those areas of a runway surface that may require maintenance in order to restore surface friction values to the MPL or above.
- 2.1.2 To reduce potential problems caused by reduced runway surface friction, two approaches are possible: provision of reliable aircraft performance data for take-off and landing related to available runway surface friction/aircraft braking performance, and provision of adequate runway surface friction at all times and under all environmental conditions.
- 2.1.3 The first approach has proved difficult, mainly because of the problem of determining runway friction characteristics in operationally meaningful terms in all conditions, and the problem of correlation between CFME used on the ground and aircraft braking performance. This applies in particular to the wet runway case.
- 2.1.4 The second approach addresses specifically the wet runway. It consists of specifying the minimum levels of friction characteristics for pavement design and maintenance. Runways which have been constructed according to appropriate standards and are adequately maintained thereafter, provide optimum operational conditions and meet this objective. Accordingly, aerodrome operators should concentrate on developing and implementing appropriate procedures for runway design, construction and continuing maintenance.
- 2.1.5 By adopting a systematic approach to the measurement of runway surface friction characteristics, the degradation of runway surface friction can be determined by the comparison and assessment of data over time. By utilising this data, aerodrome operators should be in a position to target maintenance as required in order to help ensure aircraft braking performance does not fall below internationally accepted levels.

2.2 Assessment Periodicity

- 2.2.1 The aerodrome operator should determine the frequency of the assessments that will enable any significant change in runway surface friction characteristics to be identified and, if appropriate, for remedial maintenance

to be conducted before the friction level falls below the Minimum Friction Level (MFL).

- 2.2.2 The recommended maximum intervals between runway surface friction assessments is outlined in Table 1.

Table 1 - Recommended Maximum Interval between Runway Surface Friction Assessments

Average number of movements on the Runway per day	Maximum interval between Assessments
Less than 400	11 months
400 or more	5 months

NOTE: The total number of movements, on both runway directions, determines the average number of movements on a runway.

2.3 Trend Analysis

- 2.3.1 The friction characteristics of a runway will vary over time as the runway is subject to wear and tear (polishing), accumulation of rubber deposits and to the effects of weather and other environmental conditions. Aerodrome operators should monitor the results of assessments and should alter the interval between assessments depending on the results. If historical data indicate that the surface is deteriorating relatively quickly, more frequent monitoring may be required in order to ensure that maintenance is arranged before the friction characteristics deteriorate to MFL. The aerodrome operator should record the justification for any variation from the recommended periodicity for assessments.
- 2.3.2 The friction characteristics of a runway can also alter significantly following maintenance activities, even if the activity was not intended to affect the friction characteristics. Therefore, a runway surface friction assessment should be conducted following any significant maintenance activity conducted on the runway and before the runway is returned to service. Runway surface friction assessments should also be conducted following pilot reports of perceived poor braking action, if there are visible signs of a build-up of rubber deposits, runway surface wear, or for any other relevant reason.

2.4 Additional Assessments

Any data gathering conducted on a wet runway with the self-wetting system turned off cannot be used for the purpose of friction monitoring assessment.

- 2.4.1 Especially on new surfaces, or resurfaced runways, an aerodrome operator should carry out additional friction testing to establish friction readings during adverse weather conditions and to identify those areas of the runway where contamination (i.e. water) may build up over a short period of time. This is of particular importance where re-profiling of the runway's lateral, longitudinal or sloping planes has been accomplished as part of any rehabilitation project. These assessments should be conducted under natural conditions with the CFME self-wetting system switched off. Under these circumstances, the values given in Table 3 do not apply and it is up to the Aerodrome Operator to assess the data if necessary with the help of experts.
- 2.4.2 When there are indications that the friction characteristics of a runway may be reduced because of poor drainage, an additional assessment should be conducted, but this time under natural conditions typical of local rain. This assessment differs in that water depths in the poorly drained areas are normally greater in local rain conditions. The results are thus more appropriate to identify problem areas having low friction values that could induce hydroplaning than the standard assessment method. If circumstances do not permit assessments to be conducted during natural conditions representative of rain, then dousing the runway surface with water may simulate this condition.²
- 2.4.3 When conducting assessments on wet runways, it is important to note that, unlike compacted snow and ice conditions, in which there is very limited variation of the friction reading with speed, a wet runway produces a drop in friction with an increase in speed. However, as the speed increases, the rate at which the friction is reduced becomes less. Among the factors affecting friction between the tire and the runway surface, texture is particularly important. If the runway has a good macro-texture (roughness) allowing the water to escape beneath the tire, then the friction value will be less affected by speed. Conversely, a low macro-texture (smooth) surface will produce a larger drop in friction as speed increases.
- 2.4.4 Accordingly, when assessing runways to determine their friction characteristics, and whether maintenance action is necessary to improve it, a speed high enough to reveal these friction/speed variations should be used. *Figure 1* below shows a typical graph to illustrate the variation in friction between textures.³

² See FAA AC 150/5320-12C for additional information.

³ Further material is available in ICAO Doc 9137 Aerodrome Services manual Part 2.

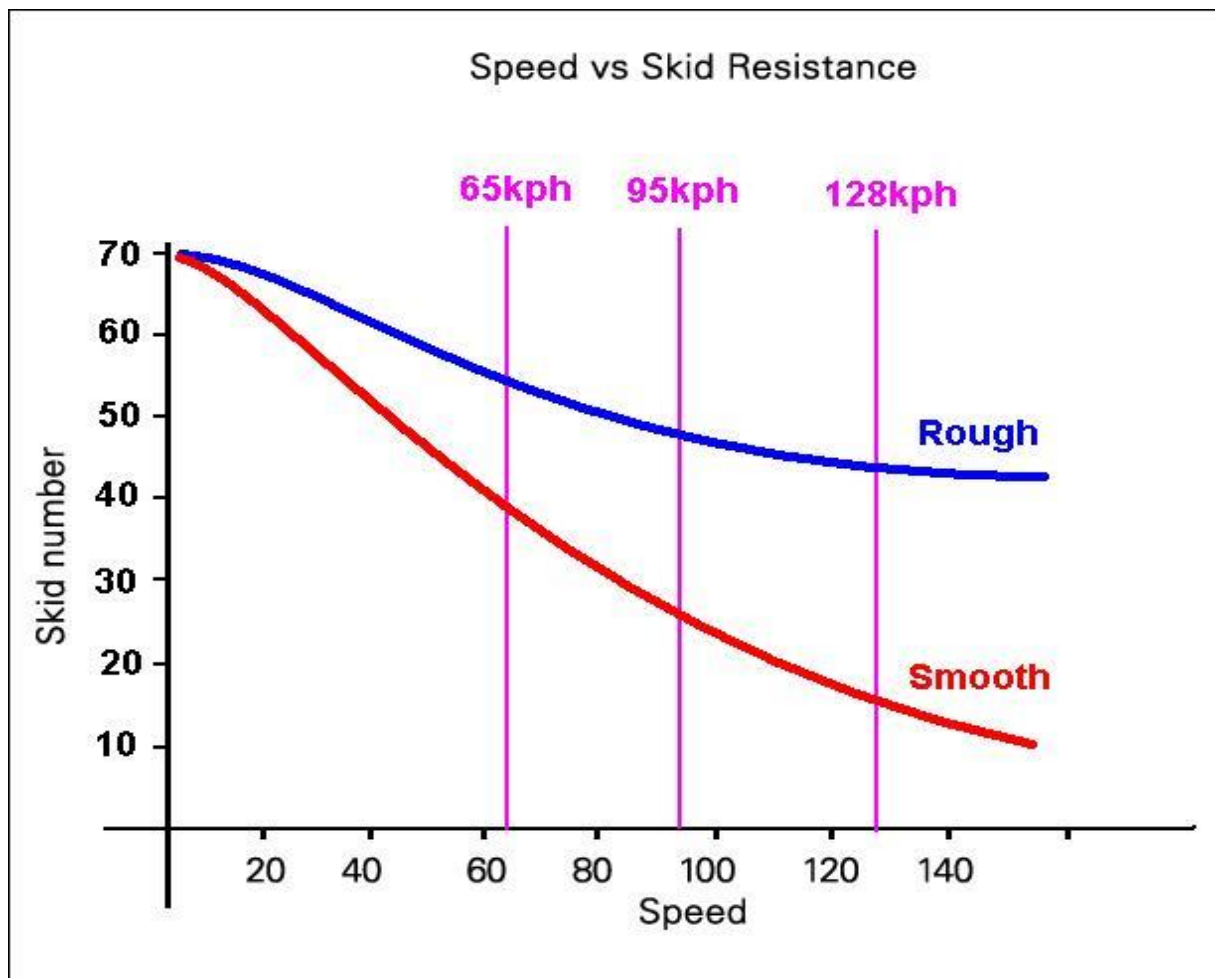


Figure 1 - Variation in friction between textures

2.4.5 CFME manufacturers should be consulted concerning any special operating procedures involved in testing at higher speeds. Operational safety assessments relating to specific aerodrome procedures may need to be reviewed to take into account testing at higher speeds.

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3. Runway Surface Friction Assessment Procedures

3.1 Equipment Checks

The CFME operator should ensure that the equipment is in full working order and calibrated in accordance with the manufacturers' operating instructions. Those with responsibility for the provision of CFME should ensure that the equipment is serviced regularly and that the measuring tire is of the correct specification and remains within manufacturers' tolerance. General guidance on test speeds, nominal test water film thickness, test tire type, test tire pressure and test tire condition should be required from the CFME manufacturer, but the operator must be aware that if the parameters specified in Table 3 are not adhered to, the values therein will not apply.

3.2 Operators Training and Competence

3.2.1 The success of friction measurement in delivering reliable friction data depends greatly on the personnel who are responsible for operating the CFME. All operators should be trained and competent in the equipment's operation and maintenance and be aware of the critical factors affecting the accuracy of friction measurements. Training may be conducted during normal assessment runs provided that suitable measures are in place to ensure that the results of the runs are valid. If additional runs are conducted for the purpose of training or maintenance of competence, the results may be included in the assessment system if they are known to be valid.

3.2.2 Where a contractor carries out an assessment, it is the responsibility of the aerodrome operator to satisfy himself as to the competence and experience of the CFME operator.

3.3 Assessment Conditions

3.3.1 During assessment operations the runway surface should be free from precipitation with no wet patches. Runs should be completed in a timely manner, with coordination from ATC, so that during the period of assessment check runs and standard runs are completed under the same conditions.

3.3.2 The assessment should be conducted at an ambient air temperature above 2°C.

3.3.3 Dampness, fog and mist conditions might also affect the outcome of the assessment and aerodrome operators should be aware that crosswinds might affect assessments utilising self-wetting. Aerodrome operators should seek

advice on these issues from the CFME manufacturer.

3.4 Assessment Procedure

3.4.1 A runway surface friction assessment consists of at least two check runs in addition to a series of standard runs.

3.4.2 Check Runs

- a) A check run is designed to confirm that the operation of the CFME is consistent throughout the full runway surface friction assessment; one should be conducted before and the other after completion of the standard runs, under the same conditions. Reference to manufacturers' guidelines should be made to determine the maximum variation between the two runs permissible.
- b) Check runs should be performed over the entire pavement length at a constant speed on a part of the runway that does not traverse any other runs.

3.4.3 Standard Runs

- a) A standard run should be carried out along the entire pavement length at a constant run speed, allowing for acceleration and safe deceleration (see paragraph 3.4.3 e) also). Consideration should be given to means of ensuring the target speed is maintained during the run. If cruise control is fitted to the vehicle it should be checked to ensure its accuracy. During assessment runs, any over/under speed warnings given by the CFME should take precedence over the vehicle speedometer or cruise control. Table 2 defines the recommended location of each run for nominal width runways.

NOTE: On heavily trafficked runways with a prevailing direction of use, CFME operators may detect a difference in results when collecting data on reciprocal runs. Should this be the case, the aerodrome operator may wish to seek expert opinion on the implications of any differences recorded.

- b) The track(s) of the measuring wheel(s) should not run along the line of the pavement joints or longitudinal cracks. Aerodrome operators should ensure that CFME drivers have sufficient means of track keeping whilst engaged in standard runs. This is especially important at night and when conducting runs away from the centreline or edge markings.

Table 2 Recommended Format for Runway Surface Friction Assessment Standard Runs Based on Nominal Runway Width

Runway Width	Recommended lateral displacement of standard runs each side of the centreline (metres)					
	Central portion			Outer portion		
18 m	1.5	3.5	6			
23 m	1.5	3	6	9		
30 m	1.5	4	7	12		
45 m	1.5	4	7	11	17	
60 m	1.5	4	7	11	17	23

- c) The run pattern for a runway with Touchdown Zone (TDZ) markings should be planned so as to include one run either side of the centreline to pass through the centre of the painted TDZ markings.
- d) If there is any reason to doubt the accuracy of the runway surface friction assessment, it should be repeated.
- e) On runways without displaced thresholds or paved areas before the start, or beyond the end, of LDA and especially runways near to 1200 m ASDA, operators should ensure that drivers of CFME are equipped with a suitable vehicle that can attain a steady target speed as soon as practicable. A safe method of delineating the braking zone at the end of the run should also be available to the driver to allow safe braking at the end of the run.

3.5 Records

As with all elements of the aerodrome operator's SMS, procedures should ensure all appropriate records of all runway surface friction assessments are kept for a period of at least 24 months from the date of assessment.

The following items should be recorded for each assessment, and made available upon request to the CAA:

- Date and time of assessment, including operative's name;
- Runway assessed;
- Run number and runway direction;

- Distance from the centreline and on which side of centreline the run was performed;
- Constant run speed (km/h) for each run;
- Run length;
- Test water depth;
- Test tire type;
- Measure of tire wear;
- Surface condition and air temperature;
- Average friction level per run; and
- Friction levels indicating 100 m rolling average by Portion.

Furthermore, should maintenance intervention be indicated, the location, extent, methods employed and results should be recorded.

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4. Evaluation of Runway Surface Friction Assessment Results

4.1 Introduction

4.1.1 Aerodrome operators should make effective use of the assessment data produced by CFME. Regular reviews together with planned maintenance activities driven by trend analysis will ensure that surface friction characteristics are consistently acceptable. Certified Aerodromes are recommended to use either CFME manufacturers' software based reporting or to export raw data into an appropriate spreadsheet format. If provided, a 'quick view' 100 m rolling average by Portion table is a convenient way of summarising the assessments. However, detailed examination of the data for each 10 m reading should be carried out after each assessment to identify areas of the runway, which may require maintenance or closer monitoring.

Failure to follow this guidance could lead to a runway that "may be slippery when wet" or even require taking out of service under certain weather conditions.

4.1.2 The friction readings obtained should be compared with the following friction levels:

- The Design Objective Level (DOL)
- The Maintenance Planning Level (MPL)
- The Minimum Friction Level (MFL)

4.1.3 For any given runway surface, the friction readings produced by different CFME are liable to differ from each other. Also, for any given runway surface the readings given by a particular CFME are liable to alter if the test speed, test water depth or test tire type are altered. Table 3 sets out the test speed, test water depth and test tire type required for the assessment, and gives DOL, MPL and MFL in terms of the friction readings provided, when these requirements are met, by each of the above mentioned CFME devices.

Table 3 Friction Level Values

	Test speed	Test water depth	Test tire type	DOL	MPL	MFL
Mu-Meter	65 kph	0.50 mm	ASTM E670-09 ¹	0.72 or greater	0.57	0.50
Grip Tester	65 kph	0.25 mm	ASTM E1844-08 ²	0.80 or greater	0.63	0.55
ASFT	65 kph	1.00 mm	ASTM E1551-08 ³	0.82 or greater	0.60	0.50
BV-11 Skidometer	65 kph	1.00 mm	ASTM E1551	0.82	0.60	0.50

1. This is the Standard Test Method for Side Force Friction on Paved Surfaces Using the Mu-Meter, which includes the specification for the Mu-Meter test tire.
2. This is the Standard Specification for A Size 10 × 4-5 Smooth-Tread Friction Test Tire, which is the tire used by the Grip Tester.
3. This is the Standard Specification for Special Purpose, Smooth-Tread Tire, Operated on Fixed Braking Slip Continuous Friction Measuring Equipment, which is the tire used by the CFMEs like the ASFT.
4. The BV-11 Skidometer is a trailer equipped with a friction-measuring wheel with a tire, made to ASTM E1551 specification, designed to operate at a fixed slip ratio between 15 and 17 per cent, depending on test tire configuration.

Other friction measuring devices can be used, provided they have been correlated with, at least, one test equipment mentioned in the table above.

For a definition of test water depth and further details of the ASTM specifications for the test tires, refer to the Glossary.

4.2 100 m Rolling Averages

- 4.2.1 The concept of the 100 m rolling average presented below is based on guidance from the ICAO Annex 14 Chapter 10 Aerodrome Maintenance paragraph 10.2.4.

Note - A portion (area) of the runway in the order of 100 m long may be considered significant for maintenance or reporting action.

- 4.2.2 The following is an explanation of how CFME collects data and derives values for 100 m rolling average per run or per Portion of the runway width and should be read in conjunction with Figure 2. During a standard run friction readings are collected by the CFME along the line of the complete run, provided the operator maintains target speed. An averaged friction value is

collected in 10 m increments along the run so that, over a distance of 100 m, an average can be calculated; this is the average of the 10 inclusive averaged values within the 100 m. To assist in understanding the process, as an example, a 1,000 m run would collect 100 hundred-metre readings in 10 m increments. The first rolling average is the sum of the first 10 readings divided by 10 (RA1). The second rolling average is the sum of readings number 2 to 11 divided by 10 (RA2) and so on to the end of the run. The last rolling average, in this example, is the sum of readings number 90 to 100 divided by ten. A rolling average is best visualised as a 100 m long cursor passing over the surface of the runway. The illustration shows the cursor has reached a position from RA12 to RA22 (e.g. from 210 m to 310 m along the run). This cursor can be moved to 10 different positions whilst still including the 10 m increment in question (i.e. RA22). By comparing the values shown against each 10 m increment on the runway against the adjacent line representing the rolling average the difference should be self-evident. After a value has been attributed to every 10 m increment of the run, the CFME's onboard software sifts these average friction values and selects the lowest of them. So, at the start of the run there will be only one to choose from (RA1). However, at 10 m there will be two values from which to select (RA1 and RA2) etc. This process is repeated throughout the run in order to locate the minimum 100 m rolling average at any 10 m segment on the run.

- 4.2.3 The runway width is divided into three areas; these areas, or Portions of the pavement, are referred to as 'central' and 'outer' trafficked Portions and bound the edges of the sliding cursor. (See Table 2).
- 4.2.4 On a 45 m wide runway each Portion is 15 m wide. On runways of lesser width, the central Portion remains 15 m wide and each outer portion has its width reduced by applying the formula: $\sim W2 - 7.5$ where W is the total width of the runway in metres.
- 4.2.5 From Table 2, it can be seen that 6 standard runs cover the 15 m central trafficked Portion and the remainder the outer Portions.
- 4.2.6 The procedure for calculating the 100 m rolling average for each run is repeated in a similar fashion for each of the three Portions across the runway. In each case, the applicable runs across the width of each Portion are first averaged before undertaking the rolling average calculation as described above.
- 4.2.7 By reference to the software's display function a representation of the runway spilt into Portions can be called up. Only when a minimum 100 m rolling average by Portion falls below the MFL, generally shown as a red shaded area, does an aerodrome operator have to issue a NOTAM declaring the runway "may be slippery when wet".

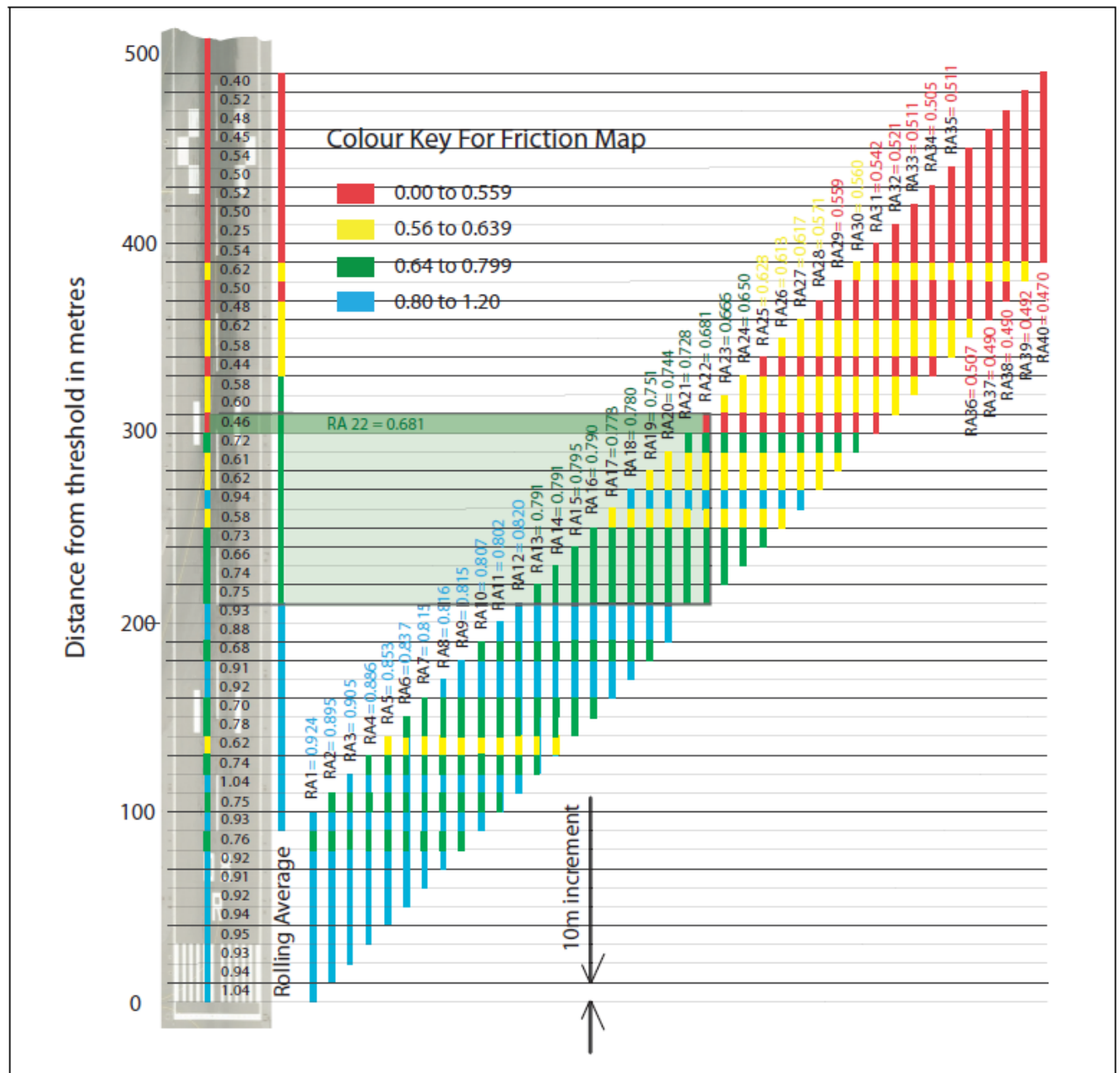


Figure 2 - Rolling average values

4.3 Action to be taken as a Result of a Runway Friction Assessment

4.3.1 The aerodrome operator should review the results of each runway friction

assessment and where appropriate take the following action:

- a) If the friction level is below the MPL, maintenance should be arranged to restore the friction level, ideally to a value equal to or greater than the MPL. Reference to each 10 m reading on the standard runs should indicate target areas.
- b) If the friction level indicates a falling trend, the aerodrome operator should increase the frequency of runway friction assessments in order to identify any further or rapid deterioration and, if appropriate, any action to be taken.
- c) i) If the friction level is below the MFL, maintenance should be arranged urgently in order to restore the friction readings to an acceptable level.

ii) In accordance with ICAO Annex 14 Volume 1, if the lowest 100 m rolling average by portion is below MFL, a NOTAM shall be issued advising that the runway 'may be slippery when wet'.

NOTE: The NOTAM should contain information to assist aircraft operators to adjust their performance calculations where possible. This should include the location and extent of where friction values are below MFL.

4.3.2 If the friction level is significantly below the MFL, the aerodrome operator should withdraw the runway from use for take-offs and/or landings when wet and inform the CAA.

4.3.3 Caution should be exercised when choosing the most appropriate method of restoring friction values. Expert advice on the types of processes best suited to both the surface and the cause of the reduced friction levels should be required to guard against causing damage to the runway.

4.4 Assessments made following Maintenance Activities

4.4.1 The friction characteristics of some runway surface materials can improve over time, commonly as a result of the dispersal of volatile oils in the surface layers following rehabilitation. However, if the runway surface friction assessment indicates that the friction characteristics of an area of the runway that has been subject to maintenance work are poorer than anticipated or fall below the MPL, additional assessments should be performed over a period of time to ascertain whether the friction characteristics remain stable, improve, or if additional work should be carried out.

4.4.2 Aerodrome operators contemplating major runway rehabilitation and/or re-profiling must contact the CAA in advance to discuss management of the overall friction characteristics of the runway during the project. Of particular

importance to the CAA in this context will be the extent and length of time areas of any base course will remain exposed and newly laid wearing course will be left un-grooved, if grooving is envisaged.

- 4.4.3 Certified aerodromes should ensure that procedures in the aerodrome SMS that manage risks associated with the work in respect of friction characteristics of the runway are effective, both throughout the period of works, if the runway is to be taken back into service at times and during any wearing-in period following completion of the project.

5. Measurement of Compacted Snow - or Ice-Covered Paved Surface Friction Characteristics

5.1 Measurement

5.1.1 The friction coefficient should be measured if a runway is covered wholly or partly by snow or ice and should be repeated as conditions change. Friction measurements and/or braking action assessments on airport surfaces other than runways should be made when an unsatisfactory friction condition can be expected on such surfaces.

5.1.2 A continuous friction-measuring device (e.g. Mu-meter, Runway Friction Tester, Skiddometer, Airport Surface Friction Tester, or Grip Tester) can be used for measuring the friction values for compacted snow- and/or ice-covered runways. A decelerometer (e.g. Brakemeter-Dynamometer or Tapley Meter) may be used only on surfaces covered by compacted snow and/or ice, with the possible additional covering of very thin layers of dry snow. Other friction-measuring devices can be used provided they have been correlated with at least one of the types mentioned above. A decelerometer should not be used in loose snow or slush or on ice covered with a water film because it can give misleading friction values. Other friction-measuring devices can also give misleading friction values under certain combinations of contaminants and when there are variations in air-to-pavement temperatures. Methods of estimating braking action when no friction-measuring devices are available at the airport are described in ICAO Doc 9137 Part 2 Appendix 2.

5.2 Reporting

5.2.1 There is a requirement to report the presence of snow, slush or ice on a runway or a taxiway. To be able to report meteorological contaminants with some degree of reliability and consistency, a uniform method for describing them must be established. Whenever dry snow, wet snow, slush ice or frost is present and reported, the description of the runway surface condition should use the following terms:

- (1) dry snow;
- (2) wet snow;
- (3) compacted snow;
- (4) wet compacted snow;
- (5) slush;
- (6) ice;
- (7) wet ice;
- (8) frost;
- (9) dry snow on ice;

- (10) wet snow on ice;
 - (11) chemically treated;
 - (12) sanded; and
- should include, where applicable, the assessment of contaminant depth.

Snow (on the ground)

- a) Dry snow. Snow which can be blown if loose or, if compacted by hand, will fall apart again upon release; specific gravity: up to but not including 0.35.
- b) Wet snow. Snow which, if compacted by hand, will stick together and tend to or form a snowball; specific gravity: 0.35 up to but not including 0.5.
- c) Compacted snow. Snow which has been compressed into a solid mass that resists further compression and will hold together or break up into lumps if picked up; Specific gravity: 0.5 and over.

Slush. Water-saturated snow which with a heel-and-toe slap-down motion against the ground will be displaced with a splatter; specific gravity: 0.5 up to 0.8.

NOTE. – Combinations of ice, snow and/or standing water may, especially when rain, rain and snow, or snow is falling, produce substances with specific gravities in excess of 0.8. These substances, due to their high water/ice content, will have a transparent rather than a cloudy appearance and, at the higher specific gravities, will be readily distinguishable from slush.

5.2.2 There is also a requirement to report the friction characteristics of a compacted snow- and/or ice covered runway. The friction conditions of a runway should be expressed as “braking action information” in terms of the measured/calculated friction coefficient μ or estimated braking action.

5.2.3 Specific numerical μ values are necessarily related to the design and construction of the friction measuring device, as well as to the surface condition being measured and, to a lesser extent, the measuring speed employed.

5.2.4 Table 4 with associated descriptive terms was developed from friction data collected only in compacted snow and ice and should not therefore be taken to be absolute μ values applicable for all contaminant conditions. If the surface is affected by snow and/or ice and the braking action is reported as “good”, pilots should expect to find conditions not as good as those for a dry, clean runway pavement surface (where the available friction may well be greater than that needed in any case). The value “good” is a comparative value and implies that aeroplanes should not experience directional control or braking difficulties when landing.

5.2.5 It has been found necessary to provide surface friction information for each third of a runway. The one third segments are called A, B and C. For the

purpose of reporting information to aeronautical service units, segment A is always the segment associated with the lower runway designation number. When giving information to a pilot before landing, the segments are referred to as the first, second or third part of the runway. The first part always means the first third of the runway where the aeroplane will land.

5.2.6 Friction measurements should be made along two tracks parallel to the runway, i.e. a track on each side of the runway centre line, approximately 3 m from the centre line or that distance from the centre line at which most aeroplane operations take place. The object of the tests is to determine the mean friction (μ) value for segments A, B and C. In cases where a continuous friction-measuring device is used, the mean μ values are obtained from the friction values recorded for each segment. If a spot friction measuring device is used, the distance between each test point should be not more than approximately 10 per cent of the usable length of the runway. If it is decided that a single test line on one side of the runway centre line gives adequate coverage of the runway, then it follows that each segment of the runway should have three tests conducted on it. The test results and calculated mean friction values can be entered in a form similar to that shown in Figure 3. Where applicable, figures for stopway friction value should also be made available on request.

5.2.7 When reporting the presence of dry snow, wet snow or slush on a runway, an assessment of the mean depth over each one-third segment of a runway should be made to an accuracy of approximately 2 cm for dry snow, 1 cm for wet snow and 0.3 cm for slush.

Table 4 - Friction coefficient for compacted snow- and/or ice-covered runways

Measured coefficient	Estimated braking action	Code
0.40 and above	Good	5
0.39 to 0.36	Medium to good	4
0.35 to 0.30	Medium	3
0.29 to 0.26	Medium to poor	2
0.25 and below	Poor	1

6. Collection and Dissemination of Pavement Surface State Information

6.1 General

6.1.1 The provisions in Annex 14, Volume I, Chapter 2, 2.9, require that the appropriate authority assess the conditions of pavements whenever it has not been possible to clear the contaminants fully, and make this information available to the appropriate units at the airport.

Further, in accordance with the provisions in Annex 15, 5.1.1.1 r), a NOTAM notifying the presence or removal of or significant changes in hazardous conditions due to snow, slush, ice or water on the movement area must be issued. This information may be promulgated by means of a SNOWTAM (Figure 3).

6.1.2 The requirements for an effective system of collecting and disseminating pavement surface state information may be set out as described in this chapter. (It is assumed that it is not always possible to achieve and maintain a clean, dry pavement surface.)

6.1.3 A standardized code is, therefore, necessary in order to streamline the communications processes, particularly when severe meteorological conditions prevail over a large area, and to allow rapid updating.

6.1.4 Transmission of the information must be quick, regular and timely; i.e., it must reach the pilot in time to be of use and yet be up to date. This aspect is especially important as much of the information is necessarily very transitory.

6.1.5 It is essential that arrangements be made for the timely provision of required information to the aeronautical information service by each of the State services associated with aeroplane operations. Before introducing changes to the air navigation system, due account shall be taken by the services responsible for such changes of the time needed by the aeronautical information service for the preparation, production and issue of relevant material for promulgation. Timely and close coordination between the services concerned, including the aeronautical information service, is therefore required to ensure timely provision of the information to the aeronautical information service.

6.4.1 A SNOWTAM is used to disseminate information relating to the accumulation of snow, slush, ice or standing water on the movement area (Figure 3).

To facilitate completion of the SNOWTAM, concise text containing explanatory notes is published in association with the SNOWTAM format in ICAO Doc 9137 Part 2 – Chapter 6.4.3.

APPENDIX 2. SNOWTAM FORMAT*(see Chapter 5, 5.2.3)*

(COM heading)	(PRIORITY INDICATOR)	(ADDRESSES)										≡≡								
(Abbreviated heading)	(DATE AND TIME OF FILING)	(ORIGINATOR'S INDICATOR)										≡≡								
(Abbreviated heading)	(SWAA* SERIAL NUMBER)	(LOCATION INDICATOR)	DATE/TIME OF OBSERVATION										(OPTIONAL GROUP)							
S	W	*	*																	≡≡ (

SNOWTAM	(Serial number)	→
(AERODROME LOCATION INDICATOR)	A)	→
(DATE/TIME OF OBSERVATION <i>(Time of completion of measurement in UTC)</i>)	B)	→
(RUNWAY DESIGNATORS)	C)	→
(CLEARED RUNWAY LENGTH, IF LESS THAN PUBLISHED LENGTH <i>(m)</i>)	D)	→
(CLEARED RUNWAY WIDTH, IF LESS THAN PUBLISHED WIDTH <i>(m; if offset left or right of centre line add "L" or "R")</i>)	E)	→
(DEPOSITS OVER TOTAL RUNWAY LENGTH <i>(Observed on each third of the runway, starting from threshold having the lower runway designation number)</i> NIL — CLEAR AND DRY 1 — DAMP 2 — WET or water patches 3 — RIME OR FROST COVERED <i>(depth normally less than 1 mm)</i> 4 — DRY SNOW 5 — WET SNOW 6 — SLUSH 7 — ICE 8 — COMPACTED OR ROLLED SNOW 9 — FROZEN RUTS OR RIDGES)	F)	→
(MEAN DEPTH <i>(mm)</i> FOR EACH THIRD OF TOTAL RUNWAY LENGTH)	G)	→
(FRICTION MEASUREMENTS ON EACH THIRD OF RUNWAY AND FRICTION MEASURING DEVICE MEASURED OR CALCULATED COEFFICIENT or ESTIMATED SURFACE FRICTION 0.40 and above GOOD — 5 0.39 to 0.36 MEDIUM/GOOD — 4 0.35 to 0.30 MEDIUM — 3 0.29 to 0.26 MEDIUM/POOR — 2 0.25 and below POOR — 1 9 — unreliable UNRELIABLE — 9 <i>(When quoting a measured coefficient, use the observed two figures, followed by the abbreviation of the friction measuring device used. When quoting an estimate, use single digit)</i>	H)	→
(CRITICAL SNOWBANKS <i>(If present, insert height (cm)/distance from the edge of runway (m) followed by "L", "R" or "LR" if applicable)</i>)	J)	→
(RUNWAY LIGHTS <i>(If obscured, insert "YES" followed by "L", "R" or both "LR" if applicable)</i>)	K)	→
(FURTHER CLEARANCE <i>(If planned, insert length (m)/width (m) to be cleared or if to full dimensions, insert "TOTAL")</i>)	L)	→
(FURTHER CLEARANCE EXPECTED TO BE COMPLETED BY . . . <i>(UTC)</i>)	M)	→
(TAXIWAY <i>(If no appropriate taxiway is available, insert "NO")</i>)	N)	→
(TAXIWAY SNOWBANKS <i>(If more than 60 cm, insert "YES" followed by distance apart, m)</i>)	P)	→
(APRON <i>(If unusable insert "NO")</i>)	R)	→
(NEXT PLANNED OBSERVATION/MEASUREMENT IS FOR) <i>(month/day/hour in UTC)</i>	S)	→
(PLAIN-LANGUAGE REMARKS <i>(Including contaminant coverage and other operationally significant information, e.g. sanding, de-icing)</i>)	T)) ≡≡

NOTES: 1. *Enter ICAO nationality letters as given in ICAO Doc 7910, Part 2.
 2. Information on other runways, repeat from C to P.
 3. Words in brackets () not to be transmitted.

SIGNATURE OF ORIGINATOR *(not for transmission)*

Figure 3 – Sample of SNOWTAM Format**Instructions for the completion of the SNOWTAM format****1. General information**

- When reporting on two or three runways, repeat Items C to P inclusive.
- Items together with their indicator must be dropped completely, where no information is to be included.
- Metric units must be used and the unit of measurement not reported.

d) The maximum validity of SNOWTAM is 24 hours. New SNOWTAM must be issued whenever there is a significant change in conditions.

The following changes relating to runway conditions are considered as significant:

- 1) a change in the coefficient of friction of about 0.05;
- 2) changes in depth of deposit greater than the following: 20 mm for dry snow, 10 mm for wet snow, 3 mm for slush;
- 3) a change in the available length or width of a runway of 10 per cent or more;
- 4) any change in the type of deposit or extent of coverage which requires reclassification in Items F or T of the SNOWTAM;
- 5) when critical snow banks exist on one or both sides of the runway, any change in the height or distance from centre line;
- 6) any change in the conspicuity of runway lighting caused by obscuring of the lights;
- 7) any other conditions known to be significant according to experience or local circumstances.

e) The abbreviated heading "TTAAiiii CCCC MMYGgg (BBB)" is included to facilitate the automatic processing of SNOWTAM messages in computer data banks. The explanation of these symbols is:

TT = data designator for SNOWTAM = SW;

AA = geographical designator for States, e.g. LF = FRANCE, EG = United Kingdom (see Location Indicators (Doc 7910), Part 2, Index to Nationality Letters for Location Indicators);

iiii = SNOWTAM serial number in a four-figure group;

CCCC = four-letter location indicator of the aerodrome to which the SNOWTAM refers (see Location Indicators (Doc 7910));

MMYGgg = date/time of observation/measurement, whereby:

MM = month, e.g. January = 01, December = 12

YY = day of the month

GGgg = time in hours (GG) and minutes (gg) UTC;

(BBB) = optional group for:

Correction to SNOWTAM message previously disseminated with the same serial number = COR.

Note. Brackets in (BBB) are used to indicate that this group is optional.

Example: Abbreviated heading of SNOWTAM No. 149 from Zurich, measurement/observation of 7 November at 0620 UTC:

SWLS0149 LSZH 11070620

2. Item A — Aerodrome location indicator (four-letter location indicator).

3. Item B — Eight-figure date/time group — giving time of observation as day, month, hour and minute in UTC; this item must always be completed.

4. Item C — Lower runway designator number.

5. Item D — Cleared runway length in metres, if less than published length (see Item T on reporting on part of runway not cleared).

6. Item E — Cleared runway width in metres, if less than published width; if offset left or right of centre line, add “L” or “R”, as viewed from the threshold having the lower runway designation number.

7. Item F — Deposit over total runway length as explained in SNOWTAM Format. Suitable combinations of these numbers may be used to indicate varying conditions over runway segments. If more than one deposit is present on the same portion of the runway, they should be reported in sequence from the top to the bottom. Drifts, depths of deposit appreciably greater than the average values or other significant characteristics of the deposits may be reported under Item T in plain language.

Note. Definitions for the various types of snow are given at the end of this Appendix.

8. Item G — Mean depth in millimetres deposit for each third of total runway length, or “XX” if not measurable or operationally not significant; the assessment to be made to an accuracy of 20 mm for dry snow, 10 mm for wet snow and 3 mm for slush.

9. Item H — Friction measurements on each third of the runway and friction measuring device. Measured or calculated coefficient (two digits) or, if not available, estimated surface friction (single digit) in the order from the threshold having the lower runway designation number. Insert a code 9 when surface conditions or available friction measuring device do not permit a reliable surface friction measurement to be made. Use the following abbreviations to indicate the type of friction measuring device used:

- BRD Brakemeter - Dynamometer
- GRT Grip tester
- MUM Mu-meter
- RFT Runway friction tester
- SFH Surface friction tester (high-pressure tire)
- SFL Surface friction tester (low-pressure tire)
- SKH Skiddometer (high-pressure tire)
- SKL Skiddometer (low-pressure tire)
- TAP Tapley meter

If other equipment is used, specify in plain language.

10. Item J — Critical snowbanks. If present insert height in centimetres and distance from edge of runway in metres, followed by left (“L”) or right (“R”) side or both sides (“LR”), as viewed from the threshold having the lower runway designation number.

11. Item K — If runway lights are obscured, insert “YES” followed by “L”, “R” or both “LR”, as viewed from the threshold having the lower runway designation number.

- 12. Item L** – When further clearance will be undertaken, enter length and width of runway or “TOTAL” if runway will be cleared to full dimensions.
- 13. Item M** – Enter the anticipated time of completion in UTC.
- 14. Item N** – The code for Item F may be used to describe taxiway conditions; enter “NO” if no taxiways serving the associated runway are available.
- 15. Item P** – If applicable, enter “YES” followed by the lateral distance in metres.
- 16. Item R** – The code for Item F may be used to describe apron conditions; enter “NO” if the apron is unusable.
- 17. Item S** – Enter the anticipated time of next observation/measurement in UTC.
- 18. Item T** – Describe in plain language any operationally significant information but always report on length of uncleared runway (Item D) and extent of runway contamination (Item F) for each third of the runway (if appropriate) in accordance with the following scale:
- Runway contamination – 10% – if less than 10% of runway contaminated
 - Runway contamination – 25% – if 11–25% of runway contaminated
 - Runway contamination – 50% – if 26–50% of runway contaminated
 - Runway contamination – 100% – if 51–100% of runway contaminated.

EXAMPLE OF COMPLETED SNOWTAM FORMAT

GG EHAMZQZX EDDFZQZX EKCHZQZX 070645 LSZHNYX
SWLS0149 LSZH 11070620
(SNOWTAM 0149
A) LSZH B) 11070620
C) 02 D) ...P)
C) 09 D) ...P)
C) 12 D) ...P)
R) NO S)11070920 T) DEICING

Source: ICAO Annex 1

Bibliography

- Regulation No. 17/2017 on Requirements and Administrative Procedures Related to Aerodromes
- Regulation No 01/2013 Implementation of Safety Management Systems (SMS)
- ICAO Annex 14 Aerodromes (Volume I)
- ICAO Annex 15 Aeronautical Information Services
- ICAO Doc 9137 Part 2 Pavement Surface Conditions
- CAP 683 - The Assessment of Runway Surface Friction Characteristics (UK CAA)