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UAE General Civil Aviation Authority

ANS Regulations Department

CAAP 32

The Assessment of Runway Surface Friction Characteristics

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Glossary

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

ASTM	ASTM International is a standards organisation: committee ASTM E17 has produced standards for test tyres to be used by all CFME’s recognised by ICAO.
Air Service	An airservice operation open to the public and performed by an aircraft for the public transport of passengers, mail or cargo for remuneration or hire.
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 (CFME)	A device designed to produce continuous measurement of runway friction values
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 tyres from the runway surface.
Maintenance Planning Level (MPL)	The State-set friction level below which a runway maintenance programme should be undertaken.
Minimum Friction Level (MFL)	The State-set friction level below which a runway shall be notified as 'may be slippery when wet'.
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 Surface Friction Assesment	The assessment of friction carried out under conditions of selfwetting using a CFME.
Standard Runs	A series of runs to a prescribed pattern within an assessment.
Test Water Depth	Test water depth (also known as nominal test water thickness). The water flow rate produced by the CFME’s selfwetting 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. **NOTE:** Standing water is considered to exist when water on the runway surface is deeper than 3 mm.

Chapter 1 Introduction

1 General

1.1 As an integral part of an Aerodrome Certificate Holder'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.

1.2 Chapter 4 of CAR PART IX outlines the requirement, as set out in ICAO Annex 14 Chapter 10, to undertake regular assessments of runway surface friction characteristics and to ensure that friction is maintained at an acceptable level, and does not fall below the State-set 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).

1.3 This document describes the way the assessment should be carried out using the three types of Continuous Friction Measuring Equipment (CFME) currently in use in the UAE: Mu-Meters, Grip Testers and Airport Surface Friction Testers (ASFT). Manufacturers of CFME seeking to introduce their equipment into the UAE should contact the Air Navigation Services (ANS) Regulations Section at the GCAA to discuss acceptance procedures.

1.4 The criteria, which are given in this CAAP, reflect the GCAA's interpretation of Standards and Recommended Practices of Annex 14 to the Convention on International Civil Aviation, in so far as these have been adopted by the United Arab Emirates in respect of runway surface friction testing.

2 Purpose

2.1 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.

2.2 This document also 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.

3 Scope

3.1 The criteria in this document apply to all paved runways with an Accelerate Stop Distance Available (ASDA) 1,200 metres or greater in length and used for air service operations by aeroplanes. It is not applicable to shorter runways or helicopter landing sites.

3.2 On any other paved runway not prescribed in 3.1, where prescribed air service operations are not carried out, the application of the procedures is at the discretion of the aerodrome operator.

3.3 **The procedures in this document should only 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.**

4 Limitations to Operational Use of CFME

4.1 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 is present over 25% or more of the assessed area.

4.2 Contaminated runways should be assessed and the surface conditions reported in accordance with CAR PART IX Chapter 4, Paragraph 4.10.

4.3 Additionally, it should be borne in mind that, in the time taken to pass assessments to pilots, conditions may have changed. 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.

Chapter 2 Runway Surface Friction Assessments

1 Introduction

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.

1.2 To lessen potential problems caused by reduced runway surface friction, two approaches are possible: (1) provision of reliable aircraft performance data for take-off and landing related to available runway surface friction/aircraft braking performance, and (2) provision of adequate runway surface friction at all times and under all environmental conditions.

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.

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.

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 Assessment Periodicity

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 The recommended maximum intervals between runway surface friction assessments are 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 250	4 months
250 or more	1 month

NOTE 1: The total number of movements, on both runway directions, determines the average number of movements on a runway. Either a take-off or a landing constitutes a movement.

3 Trend Analysis

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.

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 (e.g. surface enrichment course, large scale repairs) 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.

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.

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 Certificate Holder to assess the data if necessary with the help of experts.

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 representative 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. See note 2 below;

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

4.3 When conducting assessments on wet runways, it is important to note that 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 tyre and the runway surface, texture is particularly important. If the runway has a good macro-texture (roughness) allowing the water to escape beneath the tyre, 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.

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 shows a typical graph to illustrate the variation in friction between textures.

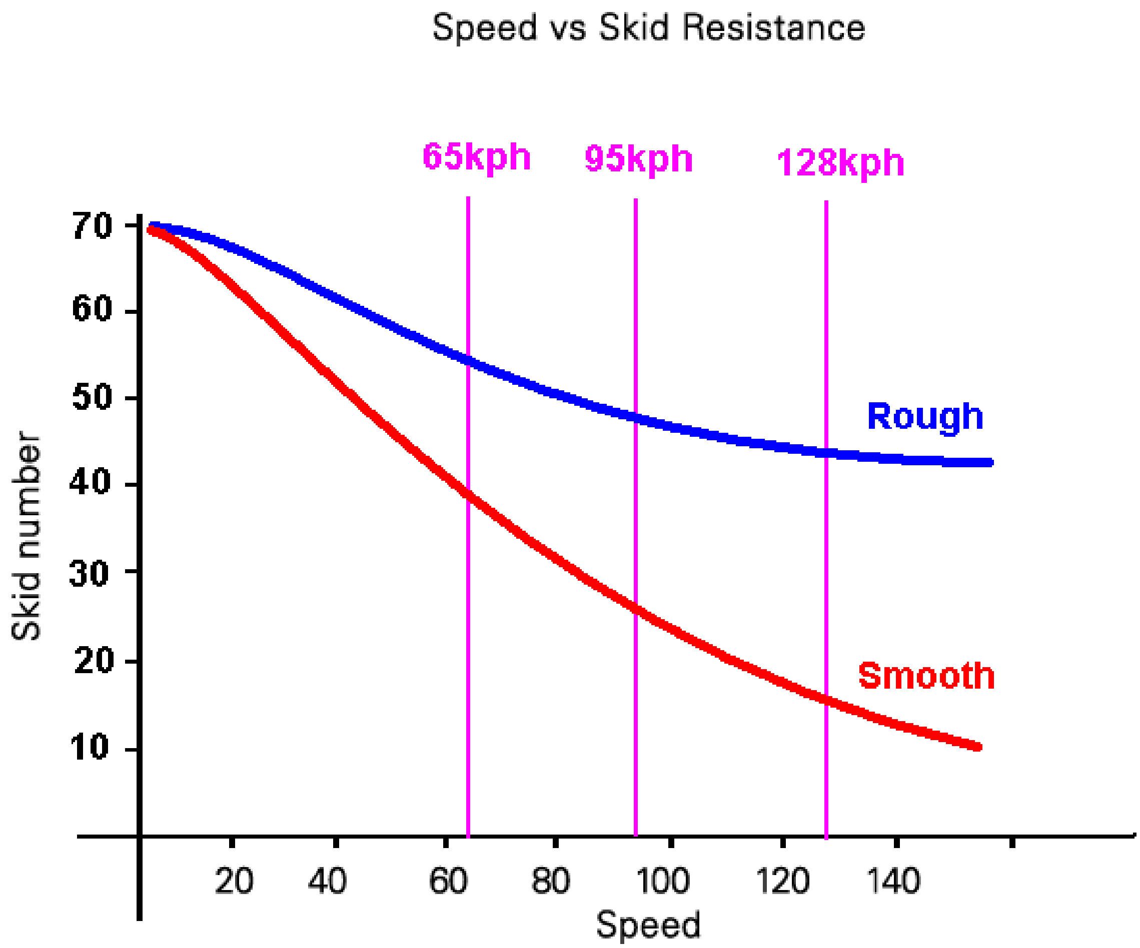

Figure 1

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.

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

Chapter 3 Runway Surface Friction Assessment Procedures

1 Equipment Checks

1.1 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 tyre is of the correct specification and remains within manufacturers' tolerance. General guidance on test speeds, nominal test water film thickness, test tyre type, test tyre pressure and test tyre condition should be sought 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.

2 Operators Training and Competence

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.

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 Assessment Conditions

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 co-ordination from ATC, so that during the period of assessment check runs and standard runs are completed under the same conditions.

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

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.

4 Assessment Procedure

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

4.2 Check Runs

4.2.1 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 permissible between the two runs.

4.2.2 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 (1.5m from the runway edge).

4.3 Standard Runs

4.3.1 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 4.3.6 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 4: 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.

4.3.2 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

4.3.3 Where a runway is not a standard width as depicted in CAR PART IX the aerodrome operator should ensure that the spacing between the standard runs is of similar dimensions to the patterns illustrated in Table 2 above, that they run parallel to the runway centreline and are laterally separated by a distance no greater than 6 metres.

4.3.4 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.

4.3.5 If there is any reason to doubt the accuracy of the runway surface friction assessment, it should be repeated.

4.3.6 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.

5 Records

5.1 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 GCAA:

- 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 tyre type;
- Measure of tyre wear;
- Surface condition and air temperature;
- Average friction level per run; and
- Friction levels indicating 100 m rolling average by Portion.

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

Chapter 4 Evaluation of Runway Surface Friction Assessment Results

1 Introduction

1.1 Aerodrome Operators should make effective use of the assessment data produced by CFME. Regular reviews coupled with planned maintenance activities driven by trend analysis will ensure that surface friction characteristics are consistently acceptable. Aerodrome Operators 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.

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)

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 tyre type are altered. Table 3 sets out the test speed, test water depth and test tyre type required for the assessment, and gives the DOL, MPL and MFL in terms of the friction readings provided, when these requirements are met, by each of the CFME devices currently accepted for use in the UAE.

Table 3 Friction Level Values

	Test speed	**Test water depth**	**Test tyre type**	**DOL**	**MPL**	**MFL**
1 Mu-Meter	65 km/h 95 km/h	1.00 mm 1.00 mm	ASTM E6701	0.72 0.66	0.52 0.38	0.42 0.26
2 Grip Tester	65 km/h 95 km/h	1.00 mm 1.00 mm	ASTM E18442	0.74 0.64	0.53 0.36	0.43 0.24
3 ASFT	65 km/h 95 km/h	1.00 mm 1.00 mm	ASTM E15513	0.82 0.74	0.60 0.47	0.50 0.34

1. This is the Standard Test Method (ASTM) for Side Force Friction on Paved Surfaces Using the Mu-Meter, which includes the specification for the Mu-Meter test tyre.

2. This is the Standard Specification for A Size 10 × 4-5 Smooth-Tread Friction Test Tire, which is the tyre used by the GripTester

3. This is the Standard Specification for Special Purpose, Smooth-Tread Tire, Operated on Fixed Braking Slip Continuous Friction Measuring Equipment, which is the tyre used by the CFME's like the ASFT.

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

2 100 m Rolling Averages

2.1.1 The GCAA has developed the concept of the 100 m rolling average based on guidance in ICAO Annex 14 Chapter 10 Aerodrome Maintenance which states in paragraph 10.2.4.

NOTE 5 - A portion (area) of the runway in the order of 100 m long may be considered significant for maintenance or reporting action.

2.1.2 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 Table 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. Table 2 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.

2.3 The runway width is divided into three areas; these areas, or portions of the pavement, are referred to as 'central' and 'two outer' trafficked Portions and bound the edges of the sliding cursor. (See Table 2)

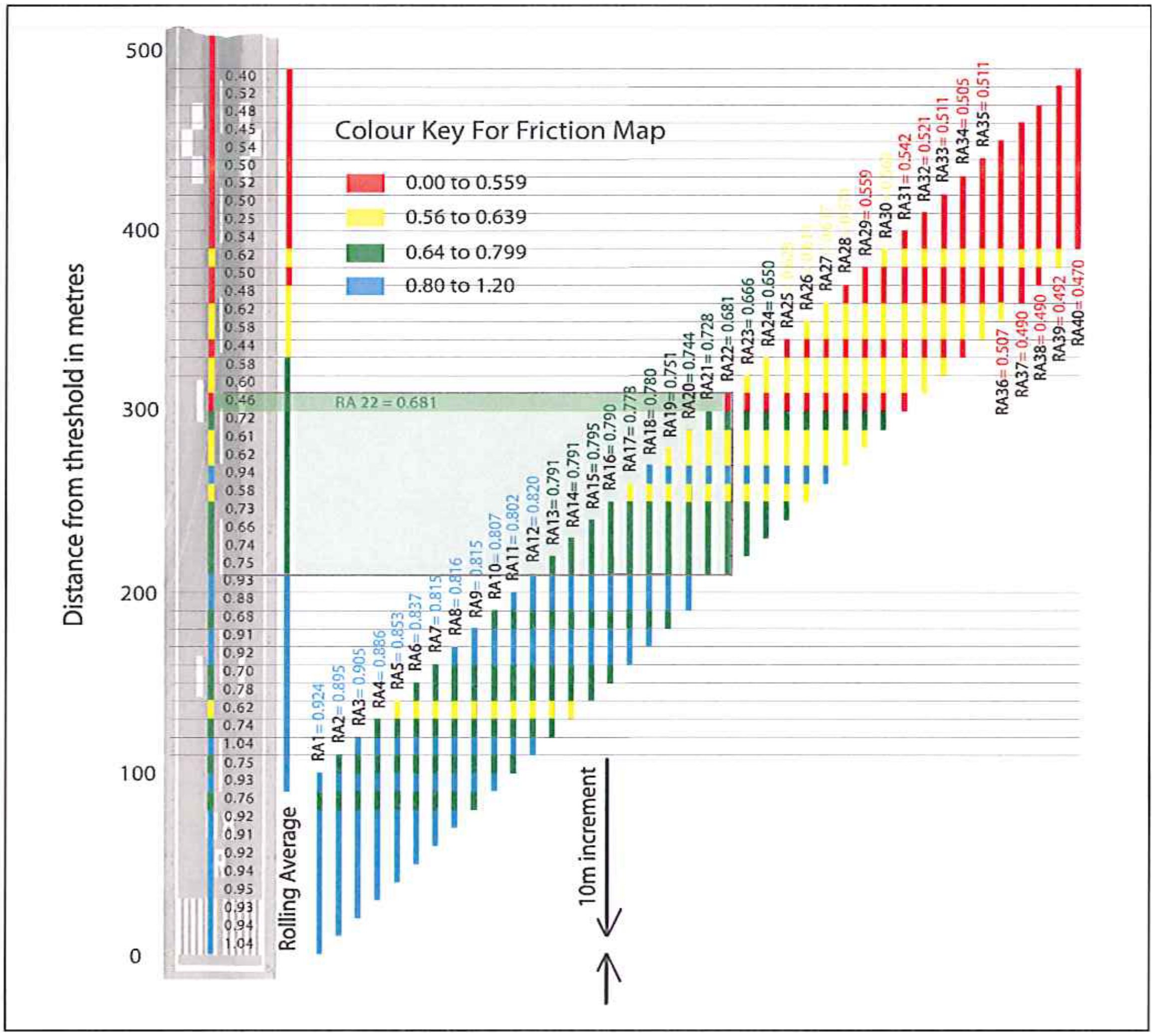

Table 2

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 appropriately.

2.5 From Table 2, 6 standard runs cover the 15 m central trafficked Portion and the remainder the outer Portions.

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.

2.7.1 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". The generic UAE AIP advice is insufficient in this regard.

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

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 by the aerodrome operator advising that the runway 'may be slippery when wet'.

NOTE 6: 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.

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 ANS Regulations at the GCAA.

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 sought to guard against causing damage to the runway.

4 Assessments made following Maintenance Activities

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.

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

4.3 Aerodrome Certificate holders 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.