MALDIVES CIVIL AVIATION AUTHORITY
Republic of Maldives

AIR SAFETY CIRCULAR
ASC 139-8

Assessment of Runway Surface Friction Characteristics

Initial Issue, 05 June 2014

1. REGULATORY COMPLIANCE

1.1 Compliance with this Circular is mandatory for all paved runways 1,100 metres or greater in length and used for public transport operations by aeroplanes with a maximum take-off weight (MTOW) in excess of 2730 kg. It is not applicable to grass runways and helicopter landing sites.

1.2 This document describes the minimum level of assessment that should be employed for the group of ICAO recommended Continuous Friction Measuring Equipments (CFME) as recommended in Annex 14 (Aerodromes) Attachment A. Other types of CFME may be used if their performance can be demonstrated, to the satisfaction of MCAA, to provide comparable results with currently recommended CFME.

1.3 The procedures in this Circular are only to be used for the acquisition of friction levels of a runway surface for understanding existing macrotexture of the pavement that may lead to the surface rejuvenation.

1.4 Aerodrome operators should carry out additional friction testing as an integral part of their Safety Management System (SMS) to establish macrotexture friction condition during adverse weather conditions and to identify areas of the runway where rubber build up may have occurred over a given period of time. These tests should be conducted using any of the ICAO recommended list of CFME self-wetting devices. In addition, accumulated rubber deposits should be assessed by employing an ICAO observation approach described in Airport Services Manual: Part 2

2. RELATED REGULATIONS

Chapter 10 of ASC 139 – 5 (Aerodrome Standards Manual) outlines the requirement, as set out in ICAO Annex 14 Chapter 10, to undertake regular assessments of runway surface friction characteristics by using the self wetting continuous friction measuring equipment (CFME) and to ensure that the friction level does not fall below an acceptable level.

3. PURPOSE

3.1 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 or NOTAM action by aerodrome operators following any such assessment.

3.2 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.

3.3 Aerodrome Licence Holders are reminded that taxiways and aprons should also provide an acceptable level of friction for aeroplanes using them.

4. DEFINITIONS

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

Aquaplaning	The condition when a layer of water separates an aircraft's tyres from the runway surface.
Check Runs	Runs intended to confirm that the operation of the CFME remains constant. These are normally 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 friction level to be achieved or exceeded on a new or resurfaced runway within one year
Friction Level by Portion	The lowest average friction value calculated from a minimum of 10 average friction values, of applicable Standard Runs, obtained over a rolling distance of 100 metres within a portion of the pavement.
Maintenance Planning Level(MPL)	The 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 Assessment	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
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.

5. RUNWAY SURFACE FRICTION ASSESSMENT

5.1 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 DOL or above.

5.2 By adopting a systematic approach to the assessment of runway surface friction characteristics, overtime, knowledge concerning the degradation of runway surface friction as a result of traffic can be acquired. By utilizing the data, aerodrome operators should be in a position to target maintenance as required in order to help ensure aircraft braking performance is optimized.

6. ASSESSMENT PERIODICITY

6.1 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 MFL.

6.2 ICAO Airport services manual: Part 2 should be used for determination of the frequency and timing of friction measurements by employing a self – wetting CFME device. The frequency has been designated in regard to operating condition of turbo-jet aircraft at a respective airport.

Table 1 – Recommended friction testing frequency in accordance with the Airport services manual Doc 9137, Part 2

Daily Turbo-jet aircraft arrivals for runway end	Annual aircraft weight for runway end(million kg)	Minimum Friction Survey Frequency
Less than 15	less than 447	Once per year
16 to 30	448 to 838	Once every 6 months
31 to 90	838 to 2404	Once every 3 months
91 to 150	2405 to 3969	Once every month
151 to 210	3970 to 5535	Once every 2 month
Greater than 210	Greater than 5535	Once every week

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

6.3 The Aerodrome Operator is required to observe the testing frequency depicted above as a mandatory requirement for safe operation of aircraft.

7. TREND ANALYSIS

7.1 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.

7.2 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.

8. ADDITIONAL ASSESSMENTS

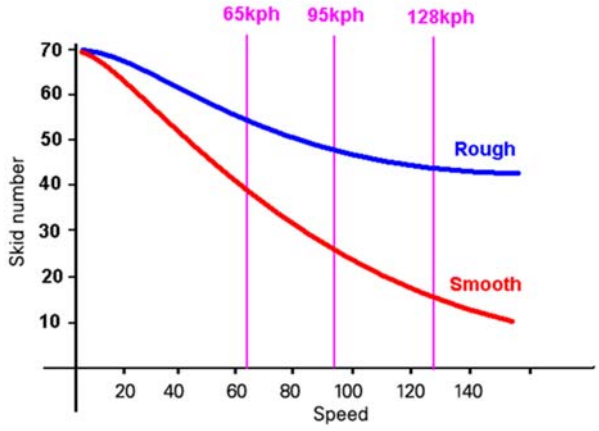
8.1 Especially on new surfaces, or resurfaced runways, an aerodrome operator should carry out additional friction testing to establish friction readings during adverse weather conditions and to identify those areas of the runway where contamination may build up over a short period of time. These assessments 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.

8.2 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 depth 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.

8.3 When conducting assessments on wet runways, it is important to note that, 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 co-efficient 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, 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.

8.4 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. (Note: Further material is available in ICAO Doc 9137 Aerodrome Services Manual Part 2.)

Figure 1– Typical graph to illustrate the variation in friction between textures.



8.5 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.

9. RUNWAY SURFACE FRICTION ASSESSMENT PROCEDURES

Equipment Checks

9.1 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 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.

Operators Training and Competence

9.2 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 its 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.

9.3 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.

Assessment Conditions

9.4 During assessment operations the runway surface should be free from precipitation with no wet patches.

9.5 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.

9.6 Dampness, fog and mist conditions might also affect the outcome of the assessment and aerodrome operators should be aware that crosswinds might affect assessments utilizing self-wetting. Aerodrome operators should seek advice on these issues from the CFME manufacturer.

Assessment Procedure

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

Check Runs

9.8 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.

9.9 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.

Standard Runs

9.10 A standard run should be carried out along the entire pavement length at a constant run speed, allowing for acceleration and safe deceleration. 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.

9.11 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 centerline or edge markings.

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

Runway Width	Recommended lateral displacement of standard runs each side of the centerline (meters)					
	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

9.12 Where a runway is not a standard width as depicted in ASC 139-5, 3.1.10, 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.

9.13 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.

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

9.15 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.

Records

9.16 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 MCAA:

- Date and time of assessment;
- 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 for each portion of the pavement.

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

9.17 Attachment A - Sample forms depict typical assessment report sheets that can be used and retained as a record for each runway surface friction assessment.

10. EVALUATION OF RUNWAY SURFACE FRICTION ASSESSMENT RESULTS

10.1 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 Licence Holders 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.

10.2 The friction level values obtained should be compared with the following criteria:

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

10.3 The friction level values produced by different CFME vary slightly for any given runway surface friction characteristics. Table 3 indicates the correlation between the assessment criteria of CFME devices and ICAO recommended target friction levels.

Table 3: ICAO list of CFME and their recommended target friction levels (extract from Airport Service Manual Doc 9137, Part 2, Table 3-1)

Test Equipment	Test Tyre		Test speed km/hr	Test water depth (mm)	Design Objective Level (DOL)	Maintenance planning level (MPL)	Minimum friction level (MFL)
	Type	Pressure (kPa)					
Mu-meter trailer	A	70 70	65 95	1.00 1.00	0.72 0.66	0.52 0.38	0.42 0.26
Skiddometer Trailer	B	210 210	65 95	1.00 1.00	0.82 0.74	0.60 0.47	0.50 0.34
Surface Friction	B	210	65	1.00	0.82	0.60	0.50
Tester Vehicle	B	210	95	1.00	0.74	0.47	0.34
Runway Friction	B	210	65	1.00	0.82	0.60	0.50
Tester Vehicle	B	210	95	1.00	0.74	0.54	0.41
TATRA Friction	B	210	65	1.00	0.76	0.57	0.48
Tester Vehicle	B	210	95	1.00	0.67	0.52	0.42
Griptester	C	140	65	1.00	0.74	0.53	0.43
Trailer	C	140	95	1.00	0.64	0.36	0.24

Note: List of CFME is progressively updated by ICAO to account for new and emerging technologies and out of manufacture devices.

100 m Rolling Averages

10.4 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 in10 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 where the last rolling average 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.

10.5 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).

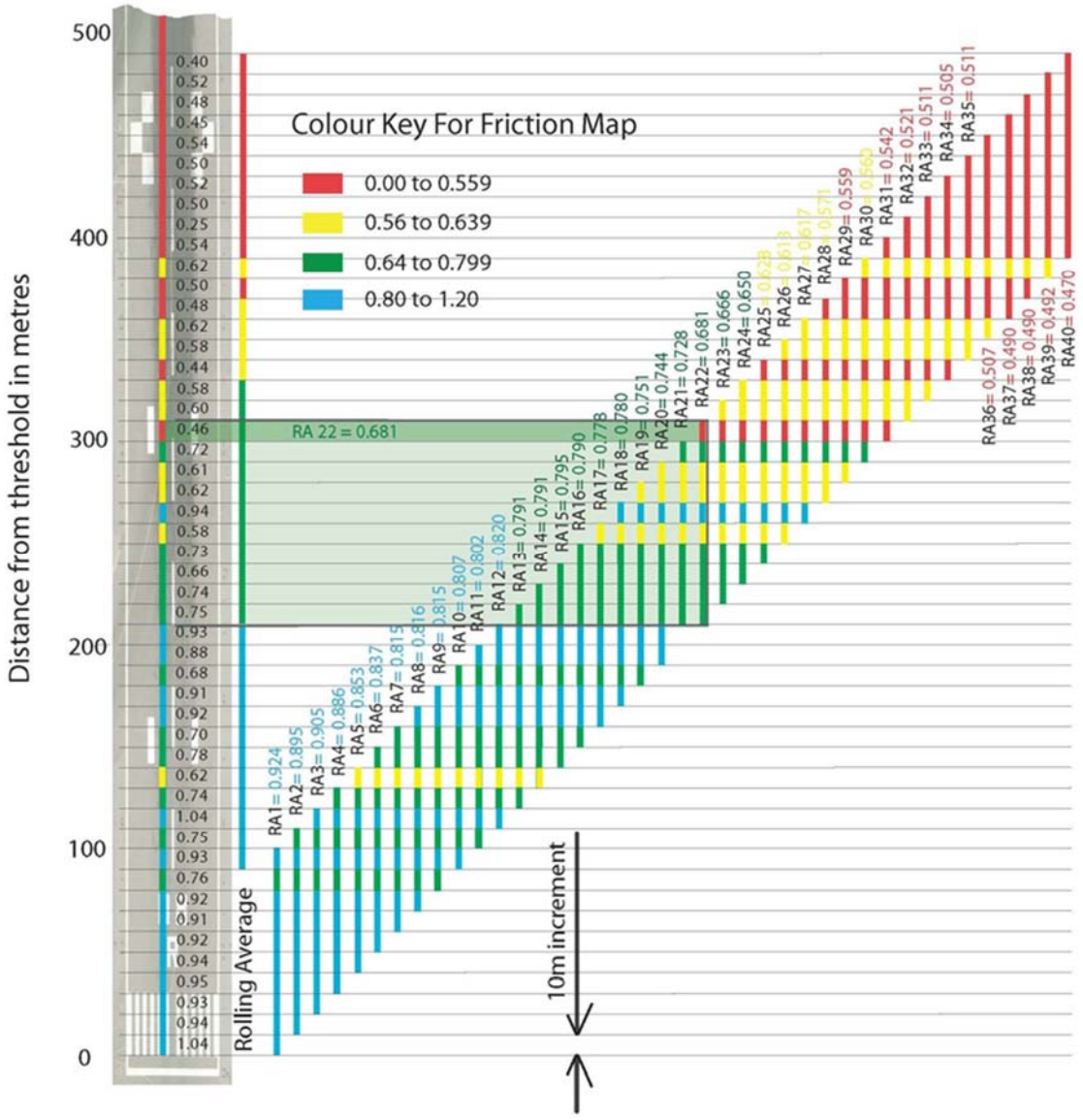


Figure 2 Selection of 100m Rolling Average

10.6 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 ~ W/2-7.5 where W is the total width of the runway in metres.

10.7 From Table 2, it can be seen that 6 standard runs cover the 15 m central trafficked Portion and the remainder the outer Portions.

10.8 The procedure for calculating the 100m 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.

10.9 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 licence holder have to issue a NOTAM declaring the runway "may be slippery when wet"

11. ACTION TO BE TAKEN AS A RESULT OF A RUNWAY FRICTION ASSESSMENT

11.1 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, the action to be taken.

c. i) If the friction level is below the MFL including 10 m increment values, 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.

11.2 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.

11.3 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.

Assessments made following Maintenance Activities

11.4 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.

11.5 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 base course will remain exposed and newly laid wearing course be left un-grooved, if grooving is envisaged.

11.6 Aerodrome licence 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.

12. RECOMMENDED MAINTENANCE PRACTICES

Operator's Obligation for Restoration of Runway Skid Resistance

On finding that the friction levels are well below the recommended values which trigger maintenance consideration, the Aerodrome Operator should devise engineering means for restoration of microtexture and macro texture of the pavement surface.

Macrotexture and Microtexture restoration methods

12.1 For restoration of microtexture, the Aerodrome Operator should lightly grind the surface to cause sharpening of the exposed coarse aggregate by using the appropriate mechanical equipment.

12.2 For restoration of the macro texture, the Aerodrome Operator should judicially use high pressure water jetting to remove some of the matrix fines from the surface. Alternatively, pavement surface grooving using mechanical equipment should be used.

12.3 Single chip seal (surface dressing) consisting stones with adequate polishing values should be applied on top of rubberized or abraded pavement surface in case observed to be a necessary maintenance option for improving skid resistance.

12.4 Application of environmentally approved chemicals to remove accumulated rubber deposits should be used to remove built up rubber.

Note: Approval of a specific chemical reagent should be approved by relevant bodies

13. DETERMINATION AND REPORTING OF WATER COVERAGE ON RUNWAYS

13.1 Whenever water is present on a runway, a description of the runway surface conditions on the centre half of the width of the runway, including the possible assessment of water depth, where applicable, should be made available using the following terms:

DAMP — the surface shows a change of colour due to moisture.
WET — the surface is soaked but there is no standing water.
STANDING WATER — for aeroplane performance purposes, a runway where more than 25 per cent of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by water more than 3 mm deep

13.2 Normally, such an exercise is conducted by the Operations personnel (pavements) using the mapping sheet and the windscreen or walk-over visual assessment. The mapping sheet is used to indicate the coverage of water at the various locations of the runway.

13.3 A runway or portion thereof shall be determined as being slippery when wet when the measurements specified in Table 3 show that the runway surface friction characteristics as measured by a continuous friction measuring device are below the minimum friction level specified.

14. EFFECTIVITY

This regulation will come in to force on 05 June 2014

For the Civil Aviation Authority
Hussain Jaleel
Chief Executive

15. APPENDIX 1 – SAMPLE FRICTION MEASUREMENT FORMS

RUNWAY FRICTION MEASUREMENT

Aerodrome Name	
Runway	
Date of testing	

Run No.	RWY Direction	Time	Distance from CL	Side of CL	Speed km/hr	Run Length	Self-wet on/off	Surface Condition	Average Friction Value

Remarks

RUNWAY FRICTION MEASUREMENT

Aerodrome Name	
Runway	
Date of testing	

Description	**Applicable Runs**	**Friction Level**
Friction level for central portion	Run numbers:	
Friction level for outer portion (Right)	Run numbers:	
Friction level for outer portion (Left)	Run numbers:	
Overall friction level	Average value taken from all standard runs	

Is any portion of runway below MFL	YES/NO	

Remarks

Remedial measure to be undertaken

Recommended date of next friction measurements	