

on matters of operational significance or affecting aircraft performance given, particularly in respect of the following:

- a) construction or maintenance work;
- b) rough or broken surfaces on a runway, a taxiway or an apron;
- c) snow, slush or ice on a runway, a taxiway or an apron;
- d) water on a runway, a taxiway or an apron;
- e) snow banks or drifts adjacent to a runway, a taxiway or an apron;
- f) anti-icing or de-icing liquid chemicals on a runway or a taxiway;
- g) other temporary hazards, including parked aircraft;
- h) failure or irregular operation of part or all of the aerodrome visual aids; and
- i) failure of the normal or secondary power supply.

2.9.3 Recommendation.— *To facilitate compliance with 2.9.1 and 2.9.2 inspections of the movement area should be carried out each day at least once where the code number is 1 or 2 and at least twice where the code number is 3 or 4.*

Note.— *Guidance on carrying out daily inspections of the movement area is given in the Airport Services Manual, Part 8 and in the Manual of Surface Movement Guidance and Control Systems (SMGCS).*

Water on a runway

2.9.4 Recommendation.— *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.*

WATER PATCHES — *significant patches of standing water are visible.*

FLOODED — *extensive standing water is visible.*

2.9.5 Information that a runway or portion thereof may be slippery when wet shall be made available.

2.9.6 A runway or portion thereof shall be determined as being slippery when wet when the measurements specified in 10.2.3 show that the runway surface friction characteristics as measured by a continuous friction measuring device are below the minimum friction level specified by the State.

Note.— *Guidance on determining and expressing the minimum friction level is provided in Attachment A, Section 7.*

2.9.7 Information on the minimum friction level specified by the State for reporting slippery runway conditions and the type of friction measuring device used shall be made available.

2.9.8 Recommendation.— *When it is suspected that a runway may become slippery under unusual conditions, then additional measurements should be made when such conditions occur, and information on the runway surface friction characteristics made available when these additional measurements show that the runway or a portion thereof has become slippery.*

Snow, slush or ice on a runway

Note 1.— *The intent of these specifications is to satisfy the SNOWTAM and NOTAM promulgation requirements contained in Annex 15.*

Note 2.— *Runway surface condition sensors may be used to detect and continuously display current or predicted information on surface conditions such as the presence of moisture, or imminent formation of ice on pavements.*

2.9.9 Recommendation.— *Whenever a runway is affected by snow, slush or ice, and it has not been possible to clear the precipitant fully, the condition of the runway should be assessed, and the friction coefficient measured.*

Note.— *Guidance on determining and expressing the friction characteristics of snow- and ice-covered paved surfaces is provided in Attachment A, Section 6.*

2.9.10 Recommendation.— *The readings of the friction measuring device on snow-, slush-, or ice-covered surfaces should adequately correlate with the readings of one other such device.*

Note.— *The principal aim is to measure surface friction in a manner that is relevant to the friction experienced by an aircraft tire, thereby providing correlation between the friction measuring device and aircraft braking performance.*

2.9.11 Recommendation.— *Whenever dry snow, wet snow or slush is present on a runway, an assessment of the mean depth over each third of the 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.*

2.10 Disabled aircraft removal

Note.— *See 9.3 for information on disabled aircraft removal services.*

- 30 000 m where the code number is 4;
 - 15 000 m where the code number is 3; and
 - 5 000 m where the code number is 1 or 2; or
- b) 45 m;

whichever is greater.

Note.— Guidance on implementing this specification is given in Attachment A, Section 4.

3.1.19 Transverse slopes

Recommendation.— To promote the most rapid drainage of water, the runway surface should, if practicable, be cambered except where a single crossfall from high to low in the direction of the wind most frequently associated with rain would ensure rapid drainage. The transverse slope should ideally be:

- 1.5 per cent where the code letter is C, D, E or F; and
- 2 per cent where the code letter is A or B;

but in any event should not exceed 1.5 per cent or 2 per cent, as applicable, nor be less than 1 per cent except at runway or taxiway intersections where flatter slopes may be necessary.

For a cambered surface the transverse slope on each side of the centre line should be symmetrical.

Note.— On wet runways with cross-wind conditions the problem of aquaplaning from poor drainage is apt to be accentuated. In Attachment A, Section 7, information is given concerning this problem and other relevant factors.

3.1.20 Recommendation.— The transverse slope should be substantially the same throughout the length of a runway except at an intersection with another runway or a taxiway where an even transition should be provided taking account of the need for adequate drainage.

Note.— Guidance on transverse slope is given in the Aerodrome Design Manual, Part 3.

Strength of runways

3.1.21 Recommendation.— A runway should be capable of withstanding the traffic of aeroplanes the runway is intended to serve.

Surface of runways

3.1.22 The surface of a runway shall be constructed without irregularities that would result in loss in friction

characteristics or otherwise adversely affect the take-off or landing of an aeroplane.

Note 1.— Surface irregularities may adversely affect the take-off or landing of an aeroplane by causing excessive bouncing, pitching, vibration, or other difficulties in the control of an aeroplane.

Note 2.— Guidance on design tolerances and other information is given in Attachment A, Section 5. Additional guidance is included in the Aerodrome Design Manual, Part 3.

3.1.23 The surface of a paved runway shall be so constructed as to provide good friction characteristics when the runway is wet.

3.1.24 Recommendation.— Measurements of the friction characteristics of a new or resurfaced runway should be made with a continuous friction measuring device using self-wetting features in order to assure that the design objectives with respect to its friction characteristics have been achieved.

Note.— Guidance on friction characteristics of new runway surfaces is given in Attachment A, Section 7. Additional guidance is included in the Airport Services Manual, Part 2.

3.1.25 Recommendation.— The average surface texture depth of a new surface should be not less than 1.0 mm.

Note 1.— This normally requires some form of special surface treatment.

Note 2.— Guidance on methods used to measure surface texture is given in the Airport Services Manual, Part 2.

3.1.26 Recommendation.— When the surface is grooved or scored, the grooves or scorings should be either perpendicular to the runway centre line or parallel to non-perpendicular transverse joints, where applicable.

Note.— Guidance on methods for improving the runway surface texture is given in the Aerodrome Design Manual, Part 3.

3.2 Runway shoulders

General

Note.— Guidance on characteristics and treatment of runway shoulders is given in Attachment A, Section 8, and in the Aerodrome Design Manual, Part 1.

3.2.1 Recommendation.— Runway shoulders should be provided for a runway where the code letter is D or E, and the runway width is less than 60 m.

CHAPTER 10. AERODROME MAINTENANCE

10.1 General

10.1.1 **Recommendation.**— *A maintenance programme, including preventive maintenance where appropriate, should be established at an aerodrome to maintain facilities in a condition which does not impair the safety, regularity or efficiency of air navigation.*

Note 1.— Preventive maintenance is programmed maintenance work done in order to prevent a failure or degradation of facilities.

Note 2.— “Facilities” are intended to include such items as pavements, visual aids, fencing, drainage systems and buildings.

10.1.2 **Recommendation.** — *The design and application of the maintenance programme should observe Human Factors principles.*

Note.— Guidance material on Human Factors principles can be found in the Human Factors Training Manual.

10.2 Pavements

10.2.1 The surface of pavements (runways, taxiways, aprons and adjacent areas) shall be kept clear of any loose stones or other objects that might cause damage to aircraft structures or engines, or impair the operation of aircraft systems.

Note.— Guidance on precautions to be taken in regard to the surface of shoulders is given in Attachment A, Section 8, and the Aerodrome Design Manual, Part 2.

10.2.2 The surface of a runway shall be maintained in a condition such as to prevent formation of harmful irregularities.

Note.— See Attachment A, Section 5.

10.2.3 Measurements of the friction characteristics of a runway surface shall be made periodically with a continuous friction measuring device using self-wetting features.

Note.— Guidance on evaluating the friction characteristics of a runway is provided in Attachment A, Section 7. Additional guidance is included in the Airport Services Manual, Part 2.

10.2.4 Corrective maintenance action shall be taken when the friction characteristics for either the entire runway or a portion thereof are below a minimum friction level specified by the State.

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

10.2.5 **Recommendation.**— *Corrective maintenance action should be considered when the friction characteristics for either the entire runway or a portion thereof are below a maintenance planning level specified by the State.*

10.2.6 **Recommendation.**— *When there is reason to believe that the drainage characteristics of a runway, or portions thereof, are poor due to slopes or depressions, then the runway friction characteristics should be assessed under natural or simulated conditions that are representative of local rain and corrective maintenance action should be taken as necessary.*

10.2.7 **Recommendation.**— *When a taxiway is used by turbine-engined aeroplanes, the surface of the taxiway shoulders should be maintained so as to be free of any loose stones or other objects that could be ingested by the aeroplane engines.*

Note.— Guidance on this subject is given in the Aerodrome Design Manual, Part 2.

10.2.8 The surface of a paved runway shall be maintained in a condition so as to provide good friction characteristics and low rolling resistance. Snow, slush, ice, standing water, mud, dust, sand, oil, rubber deposits and other contaminants shall be removed as rapidly and completely as possible to minimize accumulation.

Note.— Guidance on determining and expressing the friction characteristics when conditions of snow or ice cannot be avoided is given in Attachment A, Section 6. The Airport Services Manual, Part 2, contains further information on this subject, on improving friction characteristics and on clearing of runways.

10.2.9 **Recommendation.**— *A taxiway should be kept clear of snow, slush, ice, etc., to the extent necessary to enable aircraft to be taxied to and from an operational runway.*

10.2.10 **Recommendation.**— *Aprons should be kept clear of snow, slush, ice, etc., to the extent necessary to enable*

A, B and C. For the purpose of reporting information to aeronautical service units, section A is always the section associated with the lower runway designation number. When giving landing information to a pilot before landing, the sections are however referred to as first, second or third part of the runway. The first part always means the first third of the runway as seen in the direction of landing. Friction measurements are made along two lines parallel to the runway, i.e. along a line on each side of the centre line approximately 3 m or that distance from the centre line at which most operations take place. The objective of the tests is to determine the mean friction value for sections A, B and C. In cases where a continuous friction measuring device is used, the mean values are obtained from the friction values recorded for each section. The distance between each test point should be 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 third of the runway should have three tests carried out on it. Test results and calculated mean friction values are entered in a special form (see *Airport Services Manual*, Part 2).

Note.— Where applicable, figures for stopway friction value should also be made available on request.

6.8 A continuous friction measuring device (e.g. Skiddometer, Surface Friction Tester, Mu-meter, Runway Friction Tester or Grip Tester), can be used for measuring the friction values for compacted snow- and ice-covered runways. A decelerometer (e.g. Tapley Meter or Brakemeter — Dynamometer) may be used on certain surface conditions, e.g. compacted snow, ice and 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, as it can give misleading friction values. Other friction measuring devices can also give misleading friction values under certain combinations of contaminants and air/pavement temperature.

6.9 The *Airport Services Manual*, Part 2 provides guidance on the uniform use of test equipment to achieve compatible test results and other information on removal of surface contamination and improvement of friction conditions.

7. Determination of friction characteristics of wet paved runways

7.1 The friction of a wet paved runway should be measured to:

- a) verify the friction characteristics of new or resurfaced paved runways when wet (Chapter 3, 3.1.24);
- b) assess periodically the slipperiness of paved runways when wet (Chapter 10, 10.2.3);

c) determine the effect on friction when drainage characteristics are poor (Chapter 10, 10.2.6); and

d) determine the friction of paved runways that become slippery under unusual conditions (Chapter 2, 2.9.8).

7.2 Runways should be evaluated when first constructed or after resurfacing to determine the wet runway surface friction characteristics. Although it is recognized that friction reduces with use, this value will represent the friction of the relatively long central portion of the runway that is uncontaminated by rubber deposits from aircraft operations and is therefore of operational value. Evaluation tests should be made on clean surfaces. If it is not possible to clean a surface before testing, then for purposes of preparing an initial report a test could be made on a portion of clean surface in the central part of the runway.

7.3 Friction tests of existing surface conditions should be taken periodically in order to identify runways with low friction when wet. A State should define what minimum friction level it considers acceptable before a runway is classified as slippery when wet and publish this value in the State's aeronautical information publication (AIP). When the friction of a runway is found to be below this reported value, then such information should be promulgated by NOTAM. The State should also establish a maintenance planning level, below which, appropriate corrective maintenance action should be initiated to improve the friction. However, when the friction characteristics for either the entire runway or a portion thereof are below the minimum friction level, corrective maintenance action must be taken without delay. Friction measurements should be taken at intervals that will ensure identification of runways in need of maintenance or special surface treatment before the condition becomes serious. The time interval between measurements will depend on factors such as: aircraft type and frequency of usage, climatic conditions, pavement type, and pavement service and maintenance requirements.

7.4 For uniformity and to permit comparison with other runways, friction tests of existing, new or resurfaced runways should be made with a continuous friction measuring device provided with a smooth tread tire. The device should have a capability of using self-wetting features to enable measurements of the friction characteristics of the surface to be made at a water depth of at least 1 mm.

7.5 When it is suspected that the friction characteristics of a runway may be reduced because of poor drainage, owing to inadequate slopes or depressions, then an additional test should be made, but this time under natural conditions representative of a local rain. This test differs from the previous one in that water depths in the poorly cleared areas are normally greater in a local rain condition. The test results are thus more apt to identify problem areas having low friction values that could induce aquaplaning than the previous test. If circumstances do not permit tests to be conducted during natural conditions representative of a rain, then this condition may be simulated.

7.6 Even when the friction has been found to be above the level set by the State to define a slippery runway, it may be known that under unusual conditions, such as after a long dry period, the runway may have become slippery. When such a condition is known to exist, then a friction measurement should be made as soon as it is suspected that the runway may have become slippery.

7.7 When the results of any of the measurements identified in 7.3 through 7.6 indicate that only a particular portion of a runway surface is slippery, then action to promulgate this information and, if appropriate, take corrective action is equally important.

7.8 When conducting friction tests 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 coefficient 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 the friction coefficient between the tire and the runway surface, texture is particularly important. If the runway has a good macro-texture allowing the water to escape beneath the tire, then the friction value will be less affected by speed. Conversely, a low macro-texture surface will produce a larger drop in friction with increase in speed. Accordingly, when testing 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.

7.9 Annex 14, Volume I requires States to specify two friction levels as follows:

a) a maintenance friction level below which corrective maintenance action should be initiated; and

b) a minimum friction level below which information that a runway may be slippery when wet should be made available.

Furthermore, States should establish criteria for the friction characteristics of new or resurfaced runway surfaces. Table A-1 provides guidance on establishing the design objective for new runway surfaces and maintenance planning and minimum friction levels for runway surfaces in use.

7.10 The friction values given above are absolute values and are intended to be applied without any tolerance. These values were developed from a research study conducted in a State. The two friction measuring tires mounted on the Mu-meter were smooth tread and had a special rubber formulation, i.e. Type A. The tires were tested at a 15 degree included angle of alignment along the longitudinal axis of the trailer. The single friction measuring tires mounted on the Skiddometer, Surface Friction Tester, Runway Friction Tester and TATRA were smooth tread and used the same rubber formulation, i.e. Type B. The GRIPTESTER was tested with a single smooth tread tire having the same rubber formulation as Type B but the size was smaller, i.e. Type C. The specifications of these tires (i.e. Types A, B and C) are contained in the *Airport Services Manual*, Part 2. Friction measuring devices using rubber formulation, tire tread/groove patterns, water depth, tire pressures, or test speeds different from those used in the programme described above, cannot be directly equated with the friction values given in the table. The values in columns (5), (6) and (7) are averaged values representative of

Table A-1.

Test equipment	Test tire		Test speed (km/h)	Test water depth (mm)	Design objective for new surface	Maintenance planning level	Minimum friction level
	Type	Pressure (kPa)					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Mu-meter Trailer	A	70	65	1.0	0.72	0.52	0.42
	A	70	95	1.0	0.66	0.38	0.26
Skiddometer Trailer	B	210	65	1.0	0.82	0.60	0.50
	B	210	95	1.0	0.74	0.47	0.34
Surface Friction Tester Vehicle	B	210	65	1.0	0.82	0.60	0.50
	B	210	95	1.0	0.74	0.47	0.34
Runway Friction Tester Vehicle	B	210	65	1.0	0.82	0.60	0.50
	B	210	95	1.0	0.74	0.54	0.41
TATRA Friction Tester Vehicle	B	210	65	1.0	0.76	0.57	0.48
	B	210	95	1.0	0.67	0.52	0.42
GRIPTESTER Trailer	C	140	65	1.0	0.74	0.53	0.43
	C	140	95	1.0	0.64	0.36	0.24

the runway or significant portion thereof. It is considered desirable to test the friction characteristics of a paved runway at more than one speed.

7.11 Other friction measuring devices can be used, provided they have been correlated with at least one test equipment mentioned above. The *Airport Services Manual*, Part 2 provides guidance on the methodology for determining the friction values corresponding to the design objective, maintenance planning level and minimum friction level for a friction tester not identified in the above table.

8. Strips

8.1 Shoulders

8.1.1 The shoulder of a runway or stopway should be prepared or constructed so as to minimize any hazard to an aeroplane running off the runway or stopway. Some guidance is given in the following paragraphs on certain special problems which may arise, and on the further question of measures to avoid the ingestion of loose stones or other objects by turbine engines.

8.1.2 In some cases, the bearing strength of the natural ground in the strip may be sufficient, without special preparation, to meet the requirements for shoulders. Where special preparation is necessary, the method used will depend on local soil conditions and the mass of the aeroplanes the runway is intended to serve. Soil tests will help in determining the best method of improvement (e.g. drainage, stabilization, surfacing, light paving).

8.1.3 Attention should also be paid when designing shoulders to prevent the ingestion of stones or other objects by turbine engines. Similar considerations apply here to those which are discussed for the margins of taxiways in the *Aerodrome Design Manual*, Part 2, both as to the special measures which may be necessary and as to the distance over which such special measures, if required, should be taken.

8.1.4 Where shoulders have been treated specially, either to provide the required bearing strength or to prevent the presence of stones or debris, difficulties may arise because of a lack of visual contrast between the runway surface and that of the adjacent strip. This difficulty can be overcome either by providing a good visual contrast in the surfacing of the runway or strip, or by providing a runway side stripe marking.

8.2 Objects on strips

Within the general area of the strip adjacent to the runway, measures should be taken to prevent an aeroplane's wheel, when sinking into the ground, from striking a hard vertical face. Special problems may arise for runway light fittings or

other objects mounted in the strip or at the intersection with a taxiway or another runway. In the case of construction, such as runways or taxiways, where the surface must also be flush with the strip surface, a vertical face can be eliminated by chamfering from the top of the construction to not less than 30 cm below the strip surface level. Other objects, the functions of which do not require them to be at surface level, should be buried to a depth of not less than 30 cm.

8.3 Grading of a strip for precision approach runways

Chapter 3, 3.4.8 recommends that the portion of a strip of an instrument runway within at least 75 m from the centre line should be graded where the code number is 3 or 4. For a precision approach runway, it may be desirable to adopt a greater width where the code number is 3 or 4. Figure A-3 shows the shape and dimensions of a wider strip that may be considered for such a runway. This strip has been designed using information on aircraft running off runways. The portion to be graded extends to a distance of 105 m from the centre line, except that the distance is gradually reduced to 75 m from the centre line at both ends of the strip, for a length of 150 m from the runway end.

9. Runway end safety areas

9.1 Where a runway end safety area is provided in accordance with Chapter 3, consideration should be given to providing an area long enough to contain overruns and undershoots resulting from a reasonably probable combination of adverse operational factors. On a precision approach runway, the ILS localizer is normally the first upstanding obstacle, and the runway end safety area should extend up to this facility. In other circumstances and on a non-precision approach or non-instrument runway, the first upstanding obstacle may be a road, a railroad or other constructed or natural feature. In such circumstances, the runway end safety area should extend as far as the obstacle.

9.2 Where provision of a runway end safety area may involve encroachment in areas where it would be particularly prohibitive to implement, and the appropriate authority considers a runway end safety area essential, consideration may have to be given to reducing some of the declared distances.

10. Location of threshold

10.1 General

10.1.1 The threshold is normally located at the extremity of a runway, if there are no obstacles penetrating above the