
**VOLUME 7 PAVEMENT DESIGN AND
SECTION 3 MAINTENANCE
 PAVEMENT
 MAINTENANCE
 ASSESSMENT**

PART 1

HD 28/04

SKID RESISTANCE

SUMMARY

This Standard describes how the provision of appropriate levels of skid resistance for trunk roads will be managed. It details how measurements of skid resistance are to be made and interpreted and is complemented by HD 36 (DMRB 7.5.1), which sets out advice on surfacing material characteristics. This latest revision has changed requirements for setting investigatory levels, for annual SCRIM surveys, for determining the characteristic SCRIM coefficient and has further updates in line with current policy.

INSTRUCTIONS FOR USE

This revised Standard is to be incorporated in the Manual.

1. This document supersedes HD 28/94, which is now withdrawn.
2. Remove existing Contents page for Volume 7 and insert new Contents page for Volume 7 dated August 2004.
3. Remove HD 28/94, which is superseded by HD 28/04, and archive as appropriate
4. Insert HD 28/04 in Volume 7, Section 3, Part 1.
5. Please archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.



THE HIGHWAYS AGENCY



SCOTTISH EXECUTIVE



Llywodraeth Cynulliad Cymru
Welsh Assembly Government

WELSH ASSEMBLY GOVERNMENT
LLYWODRAETH CYNULLIAD CYMRU



THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

Skid Resistance

Summary: This Standard describes how the provision of appropriate levels of skid resistance for trunk roads will be managed. It details how measurements of skid resistance are to be made and interpreted and is complemented by HD 36 (DMRB 7.5.1), which sets out advice on surfacing material characteristics. This latest revision has changed requirements for setting investigatory levels, for annual SCRIM surveys, for determining the characteristic SCRIM coefficient and has further updates in line with current policy.

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

**VOLUME 7 PAVEMENT DESIGN AND
SECTION 3 MAINTENANCE
 PAVEMENT
 MAINTENANCE
 ASSESSMENT**

PART 1

HD 28/04

SKID RESISTANCE

Contents

Chapter

1. Introduction
2. Operation
3. Measurement of Skid Resistance
4. Setting the Investigatory Level
5. Site Investigation
6. Prioritisation of Treatment
7. Use of Warning Signs
8. References
9. Enquiries

- | | |
|---------|---|
| Annex 1 | Background Information on the Measurement and Interpretation of Skid Resistance |
| Annex 2 | SCRIM Survey of Operational Procedures |
| Annex 3 | Processing and Computation of Characteristic SCRIM Coefficient |
| Annex 4 | Site Investigation |
| Annex 5 | Assessment of Accident Data |
| Annex 6 | Use of Different Types of Test in Accident Investigation |

1. INTRODUCTION

General

1.1 The purpose of this document is to describe how the provision of appropriate levels of skid resistance on in-service UK Trunk Roads, i.e. motorways and all-purpose trunk roads, will be managed. This document describes how measurements of skid resistance are to be made and interpreted and is complemented by HD 36 (DMRB 7.5.1), which sets out advice on surfacing material characteristics necessary to deliver the required skid resistance properties.

1.2 In this document, the term “skid resistance” refers to the frictional properties of the road surface measured using a specified device under standardised conditions. The term always refers to measurements made on wet roads, unless specifically stated otherwise. **These measurements are used to characterise the road surface and assess the need for maintenance, but cannot be related directly to the friction available to a road user making a particular manoeuvre at a particular time.**

1.3 The skid resistance of a wet or damp road surface can be substantially lower than the same surface when dry, and is more dependent on the condition of the surfacing material. The objective of this Standard is to manage the risk of skidding accidents in wet conditions so that this risk is broadly equalised across the trunk road network. This is achieved by providing a level of skid resistance that is appropriate to the nature of the road environment at each location on the network. The appropriate level of skid resistance is determined from a network accident analysis plus local judgement of site-specific factors.

1.4 In this Standard, the provision of appropriate levels of skid resistance is treated primarily as an asset management issue rather than one of road safety engineering, although the accident risk is assessed in order to determine an appropriate level of skid resistance for each site. Specifically, this Standard does not address the identification of locations or routes where road safety engineering measures could be beneficial to reduce accidents.

1.5 This Standard provides advice and guidance to assist the engineer in determining an appropriate level of skid resistance for each site. It lays down the procedure to be used for measuring the skid resistance

and, for cases where the measured skid resistance is at or below a predetermined level, it provides a methodology to assist the engineer in assessing the requirement and priority for remedial works. Remedial works will be subject to an economic assessment of the costs and benefits before proceeding, to promote the best use of maintenance budgets.

Structure

1.6 Chapter 2 summarises the operation of the skid resistance Standard. Chapters 3 to 7 describe key components of the Standard: the measurement of skid resistance, the process of setting Investigatory Levels, site investigation, the prioritisation of treatments and use of warning signs. These chapters are supported by a number of Annexes that give more detailed instructions or advice.

1.7 Annex 1 provides background information relevant to the measurement and interpretation of skid resistance. Annex 2 gives operational details for measuring skid resistance and Annex 3 gives the methods for processing the raw survey data to derive values that characterise the skid resistance.

1.8 Annex 4 and Annex 5 describe methodologies for site investigation and for assessing accident data respectively.

1.9 Annex 6 discusses the different test methods used in accident investigation. Police collision investigators use physical evidence (e.g. marks on the road surface) and skid tests at accident sites to estimate the approach speed of vehicle(s) involved and its relevance to road surface condition. In giving evidence in court, police officers have, on occasion, used the results of skid tests, often made in dry conditions, to comment on the adequacy or otherwise of the skid resistance of the road surface. This has, on occasion, led to claimants using police evidence to try to demonstrate that a road surface was unsatisfactory, even though the purpose of their tests are quite separate from skid resistance tests to assess the surface condition, as explained in Annex 6.

Implementation

1.10 This Standard shall be used forthwith on all schemes for the construction, improvement and

maintenance of trunk roads including motorways, currently being prepared provided that, in the opinion of the Overseeing Organisation this would not result in significant additional expense or delay. Design organisations should confirm its application to particular schemes with the Overseeing Organisation.

Mutual Recognition

1.11 The construction and maintenance of highway pavements will normally be carried out under contracts incorporating the Overseeing Organisation's Specification for Highway Works (MCHW1). In such cases products conforming to equivalent standards and specifications of other member states of the European Union and tests undertaken in other member states will be acceptable in accordance with the terms of the 104 and 105 Series of Clauses of that Specification. Any contract not containing these Clauses must contain suitable clauses of mutual recognition having the same effect regarding which advice should be sought.

WITHDRAWN

2. OPERATION

2.1 This Chapter summarises the procedures for making and interpreting skid resistance measurements on UK trunk roads.

2.2 Routine measurements of skid resistance shall be made and processed to derive Characteristic SCRIM Coefficient (CSC) values in accordance with Chapter 3, supplemented by specific instructions issued by the Overseeing Organisation.

2.3 The CSC is an estimate of the underlying skid resistance once the effect of seasonal variation has been taken into account. This value will be taken to represent the state of polish of the road surface. These terms are explained in Annex 1.

2.4 On receipt of processed survey data, the CSC values shall be compared with the predetermined Investigatory Levels, to identify lengths of road where the skid resistance is at or below the Investigatory Level.

2.5 Investigatory Levels represent a limit, above which the skid resistance is assumed to be satisfactory but at or below which the road is subject to a more detailed investigation of the skid resistance requirements. Investigatory Levels are assigned based on broad features of the road type and geometry (the site category) plus specific features of the individual site. Investigatory Levels will be reviewed on a rolling programme, to ensure that changes in the network are identified, local experience is applied and consistency is achieved. The process for setting Investigatory Levels and the normal range of Investigatory Levels for each site category is described in Chapter 4.

2.6 Wherever the CSC is at or below the assigned Investigatory Level a site investigation shall be carried out, to determine whether treatment to improve the skid resistance is required or whether some other action is required.

2.7 A site investigation shall also be carried out if, in the normal course of accident investigation processes separate from this Standard, sites are identified where increased wet or skidding accident levels have been observed.

2.8 The process of site investigation is described in Chapter 5. The decision of whether treatment is necessary is unlikely to be clear-cut, but requires professional engineering judgement taking into account local experience, the nature of the site, the condition of the road surfacing and the recent accident history. If successive site investigations show that treatment is not warranted at the current level of skid resistance then consideration should be given to lowering the Investigatory Level.

2.9 The processes of setting Investigatory Levels and undertaking site investigations are complementary, since local knowledge and experience gained through conducting detailed site investigations can be used to refine the criteria for setting Investigatory Levels for similar types of site.

2.10 The process of site investigation will result in a number of lengths being recommended as needing treatment to improve the skid resistance. The priority for treatment will be established taking into account the observed accident history, the need for other maintenance works in the vicinity, the cost and the budget available for the works. This process is described in Chapter 6.

2.11 Signs warning road users that the road could be slippery shall be erected, as described in Chapter 7.

2.12 The decision-making process leading to the identification and prioritisation of sites for treatment is summarised in Figure 2.1.

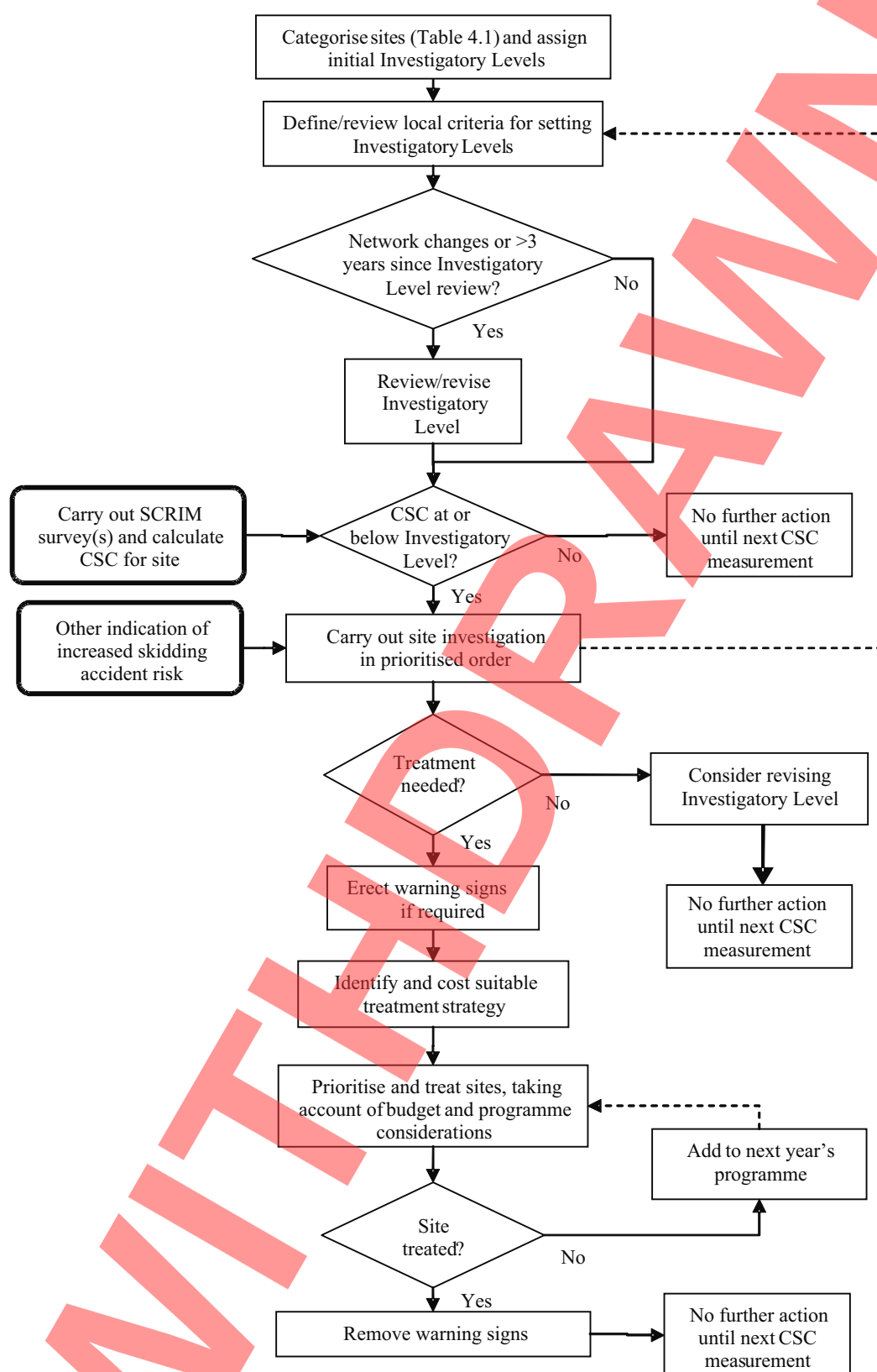


Figure 2.1: Procedure for Identification and Prioritisation of Sites

3. MEASUREMENT OF SKID RESISTANCE

Measurement equipment

3.1 Various types of equipment are available for measuring skid resistance. In different ways, all measure the force developed on a rubber tyre or slider passing over a wetted road surface and derive a value that is related to the coefficient of friction and the state of polish of the road surface.

3.2 However, the results from the different devices are not directly interchangeable. For this reason only one device is to be used for monitoring the in-service skid resistance of UK trunk roads for the purposes of this Standard.

3.3 Measurements for monitoring the in-service skid resistance of UK Trunk Roads, in line with this Standard, shall be made with a Sideway-force Coefficient Routine Investigation Machine (SCRIM).

3.4 SCRIM (see Figure 3.1) was introduced in the 1970s to provide a method for routinely measuring the skid resistance of the road network. This machine uses the sideway force principle to measure skid resistance. A freely rotating wheel fitted with a smooth rubber tyre, mounted mid-machine in line with the nearside wheel track and angled at 20° to the direction of travel of the vehicle, is applied to the road surface under a known vertical load. A controlled flow of water wets the road surface immediately in front of the test wheel so that, when the vehicle moves forward, the test wheel slides in the forward direction along the surface.

3.5 The force generated by the resistance to sliding is related to the wet road skid resistance of the road surface. Measurement of this sideways component allows the Sideway-Force Coefficient (SFC) to be calculated. SFC is the sideway force divided by the vertical load.

3.6 Depending on the machine, the vertical load is either assumed to be constant or it is measured dynamically. It has been shown that more reliable results are obtained when calculating the SFC using the measured vertical load than when a fixed constant load is assumed.

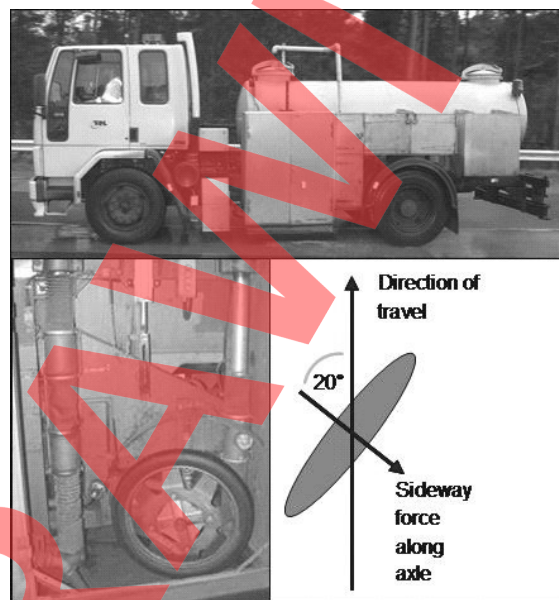


Figure 3.1 SCRIM, test wheel and principle

3.7 Equipment with a vertical load measurement capability shall be used if specified by the Overseeing Organisation.

3.8 Measurements are recorded as SCRIM Readings (SR). A SCRIM Reading is the average SFC multiplied by 100 for a pre-determined length of road, normally 10m, recorded as an integer.

3.9 Each SCRIM used on Trunk Roads shall have been accepted by the Overseeing Organisation. Acceptance will be based upon satisfactory performance at group correlation exercises arranged through the Overseeing Organisation.

3.10 A national correlation exercise will usually be held annually before the start of the testing season, with additional trials as necessary. Machines that do not perform satisfactorily at the main exercise will be required to attend and achieve acceptance at an additional exercise(s). Machines that are unable to attend the main trial will also be required to attend a supplementary correlation exercise.

Use of SCRIM

3.11 Skid resistance is not a constant, but is influenced by various factors, including temperature, test speed and weather conditions, plus longer-term effects such as seasonal variation and changes in traffic flow. Further information is given in Annex 2. For the purpose of this Standard, SCRIM measurements will be made under standardised conditions to control these effects as far as possible, including:

- limiting the testing season to a specific time of year;
- specifying a standard test speed;
- specifying the test line to be followed;
- specifying the ambient conditions under which acceptable measurements may be made.

Further details are given in Annex 2.

3.12 SCRIM operators providing measurements under this Standard must develop appropriate procedures to ensure that measurements are carried out safely and to a standard of quality agreed with the Overseeing Organisation. This must include adhering to the procedures given in British Standard BS7941-1 (1999) for making skid resistance measurements with a SCRIM and for calibrating and making regular checks on the equipment, and the further instructions given in this Chapter and in Annex 2.

Survey Strategy

3.13 The surveying strategy is planned so that the effects of seasonal variation, both within a single season and/or between successive years, can be taken into account in the determination of the CSC for any particular length of road.

3.14 Because of the different nature of traffic patterns and road networks in the different UK regions, the way in which surveys are planned and seasonal variation is accounted for may be different for the individual Overseeing Organisations. The alternative monitoring strategies to be followed are explained as part of Annex 3.

3.15 The whole trunk road network will normally be tested once during each testing season. However, the rate at which skid resistance changes may be slow on some roads, particularly where traffic volumes are low. In such circumstances it may not be necessary to monitor annually.

3.16 The Overseeing Organisation will specify the network to be surveyed, the test lane, the survey strategy and the method and/or the accuracy of location referencing required.

Processing of survey data

3.17 After collection, survey data will be validated and subject to processing to determine the CSC values that will be used for further analysis. Validation and processing will be carried out as specified by the Overseeing Organisation.

3.18 Typically, processing will include:

- application of correction factors, e.g. in circumstances where it was not possible to maintain the specified standard test speed;
- multiplication by the Index of SFC applicable to the SCRIM at the time it was making the measurement;
- calculation of the CSC;
- aggregation of raw data to longer averaging lengths, typically 100m or 50m, for further analysis (see paragraph 4.8).

3.19 Further details of the processing are set out in Annex 3.

3.20 On receipt of processed survey data, the Overseeing Organisation (through its maintaining organisation) shall check that the whole of the specified network has been surveyed. Appropriate action must be taken to ensure that, as far as possible, valid data is obtained in the following planned survey for locations where there is missing or invalid data in the current survey.

4. SETTING THE INVESTIGATORY LEVEL

Objective

4.1 The objective of setting the Investigatory Level is to assess the nature of the site and assign an appropriate level of skid resistance, at or below which a more detailed site investigation must be undertaken. It is important that the Investigatory Level is not set too low. If, during the site investigation, the Investigatory Level is found to be too high then it can be lowered. However, if the Investigatory Level is initially set at too low a level then the need to improve the skid resistance may not be detected until it has already fallen further than is desirable.

4.2 The Overseeing Organisation (through its maintaining organisation) shall assign a Site Category and Investigatory Level to each part of the network, so that the Investigatory Level can be compared with the CSC. This information must be recorded in a format agreed with the Overseeing Organisation, together with the date of assessment.

Procedure

4.3 Site categories and associated Investigatory Levels are defined in Table 4.1. These categories and ranges have been developed for trunk roads and may not be applicable to local authority roads, which are more diverse in nature.

4.4 The site category most appropriate to the layout of the site will be selected from the list in Table 4.1. If more than one site category is appropriate then the site category with the higher Investigatory Level will be selected or where the highest Investigatory Levels are the same then the category highest up the Table will be selected.

4.5 Slip roads will be allocated to categories B, Q, G or S as appropriate to their length and layout.

4.6 A single site category can vary in length from a few tens of metres to several kilometres, depending on the nature of the site. The length of site categories Q and K will normally be the 50m approach to the feature, but this shall be extended where justified by site

characteristics, e.g. if queuing traffic creates an additional risk, to allow for traffic joining the back of the queue.

4.7 After selecting a site category, the appropriate Investigatory Level is assigned from the range available for that site category, following the process described in paragraphs 4.10 to 4.13. The range of Investigatory Levels for each site category has been developed as a result of UK research studies on trunk roads and reflects the variation in accident risk within a site category. Further details are given in Annex 1. The flexibility to set different Investigatory Levels for different sites within the same category allows for sites where the risk of skidding accidents is potentially higher to have a higher Investigatory Level and possibly be treated to maintain a higher level of skid resistance.

4.8 Investigatory Levels are applied to the mean CSC within 100m averaging lengths (50m lengths for some Overseeing Organisations), except that the Investigatory Levels for site category R are based on 10m averaging lengths. Shorter lengths will be necessary where the site category is less than 100m long or at the end of a site category longer than 100m. Residual lengths less than 50% of a complete averaging length may be appended to the penultimate length, providing the site category is the same.

Site category and definition		Investigatory Level at 50km/h						
		0.30	0.35	0.40	0.45	0.50	0.55	0.60
A	Motorway							
B	Dual carriageway non-event							
C	Single carriageway non-event							
Q	Approaches to and across minor and major junctions, approaches to roundabouts							
K	Approaches to pedestrian crossings and other high risk situations							
R	Roundabout							
G1	Gradient 5-10% longer than 50m							
G2	Gradient >10% longer than 50m							
S1	Bend radius <500m – dual carriageway							
S2	Bend radius <500m – single carriageway							

Notes:

- Investigatory Levels are for the mean skidding resistance within the appropriate averaging length
- Investigatory Levels for site categories A, B, and C are based on 100m averaging lengths (50m lengths for some Overseeing Organisations) or the length of the feature if it is shorter.
- Investigatory Levels and averaging lengths for site categories Q, K, G and S are based on the 50m approach to the feature but this shall be extended when justified by local site characteristics.
- Investigatory Levels for site category R are based on 10m lengths.
- Residual lengths less than 50% of a complete averaging length may be attached to the penultimate full averaging length, providing the site category is the same.
- As part of site investigation, individual values within each averaging length should be examined and the significance of any values which are substantially lower than the mean value assessed.

Table 4.1 Site categories and Investigatory Levels

4.9 Dark shading in Table 4.1 indicates the range of Investigatory Levels that will generally be used for trunk roads carrying significant traffic levels. Light shading indicates a lower Investigatory Level that will be appropriate in low risk situations, such as low traffic levels or where the risks present are well mitigated and a low incidence of accidents has been observed. Exceptionally, a higher or lower Investigatory Level may be assigned if justified by the observed accident record and local risk assessment.

4.10 On first implementation of this Standard, the lowest Investigatory Level with dark shading in each site category, or the middle Investigatory Level for category Q, may be assigned. On a rolling programme (see paragraph 4.17), this initial assignment shall be superseded by the more detailed risk assessment described below.

4.11 The accident risk for each individual site must be evaluated in comparison with other sites in the same site category, in order to set an appropriate Investigatory Level. Criteria for making this assessment will be developed at a local level, taking into account the features of the local network. Guidelines of the factors to consider in developing these criteria are given below.

4.12 Roads within the site category with no exceptional risk of skidding accidents will be assigned the lowest Investigatory Level. It is envisaged that this will apply to the majority of sites. The following factors could influence the choice of a higher Investigatory Level. However, a higher Investigatory Level will not be appropriate if the overall level of risk is low (e.g. because of low traffic flow or low traffic speed) or if the risk has been mitigated by other means (e.g. through clear signing of a hazard or reduced speed limit.)

- Notable potential for conflict between road users at the site, particularly where the outcome is likely to have severe consequences, e.g. a head-on or side impact at speed.
- Road geometry departing substantially from current Standards.
- Known incidence of queuing where the traffic speed is otherwise high.
- Accesses onto the main carriageway, if they are busy (e.g. for a service station) or have poor advance visibility, or if the speed of leaving or joining traffic creates conflict with other traffic on the main carriageway.

- Two or more events in proximity, e.g. a junction on a downhill gradient.
- Low texture depth (less than 0.8mm measured as Sensor Measured Texture Depth (SMTD)), except for High Friction Surfacing materials.
- Bends where the traffic speed and/or geometry is judged to give rise to added risk. This could apply to some sites in non-event categories as well as sites in the bend categories.
- Sharp left-hand bends, such as on the approach to or exit from a roundabout, where greater polishing action by traffic could lead to lower skid resistance occurring in the right-hand wheel path than is measured in the left-hand wheel path.
- For non-event categories B and C: approach to slip road leaving main carriageway or merging area downstream of slip road joining main carriageway, except if low traffic flow means that the slip road gives rise to little added conflict between road users, compared with the mainline.
- For approaches to minor junctions: poor advance visibility; high risk of head-on collisions; high approach speed, except if this is mitigated (e.g. by adequate taper length for traffic leaving and joining the main carriageway and/or a separate lane for right turning traffic).
- For pedestrian crossings: poor advance visibility; high approach speed.
- For roundabouts: high speed of circulating traffic; high incidence of cyclists or motorcyclists; absence of signalised control on roundabouts at grade separated interchanges.
- For all site categories on all-purpose roads, significant numbers of pedestrians crossing at a given location.
- Known history of accident occurrence being more frequent than normal, particularly in wet conditions or where skidding is reported.

4.13 The Overseeing Organisation (through its maintaining organisation) shall develop and document criteria for assigning Investigatory Levels within each site category. This could consist of local examples of sites assigned different Investigatory Levels. These criteria will be refined on an on-going basis to take account of local experience of detailed site

investigations.

4.14 The network evolves both through substantial changes such as the addition or improvement of junctions, or the addition of traffic calming measures and through more subtle changes such as increasing traffic levels or change of land use. The criteria by which Investigatory Levels are assigned may also evolve as experience of local conditions is gained, e.g. where treatment to improve skid resistance in some locations is found to be more effective in reducing accident rates than in others.

4.15 The Investigatory Levels throughout the network that is surveyed for skid resistance must be reviewed on a rolling programme, so that:

- changes in the network are identified and taken into account;
- local experience is applied;
- consistency is maintained.

4.16 A review of the Investigatory Level shall be carried out when a significant change to the network is made.

4.17 Notwithstanding the above, a procedure shall be put in place to ensure that the Investigatory Levels are reviewed at least every three years unless agreed otherwise with the Overseeing Organisation.

5. SITE INVESTIGATION

Objectives and outcomes

5.1 Sites where the CSC is at or below the Investigatory Level require a detailed investigation. The objective is to determine whether a surface treatment is justified to reduce the risk of accidents, specifically accidents in wet conditions or involving skidding, whether some other form of action is required, or whether the site should be kept under review. This investigation is an important part of the operation of the skid resistance Standard. In conjunction with the process of setting Investigatory Levels, the objective is to promote effective targeting of treatments.

5.2 Treatment will normally be a surface treatment to improve the skid resistance. However, if the site investigation identifies any characteristic of the site or road user behaviour that suggests other road safety engineering measures could be appropriate, then the appropriate specialist dealing with safety schemes must be consulted before deciding upon the best course of action. If it is found that there is a need for other types of routine maintenance, for example re-application of road markings or additional road sweeping, then this must also be addressed.

5.3 Some form of treatment will be justified if:

- based on an accident analysis, the number of accidents observed is higher than average for the type of site being considered;
- based on an accident analysis, the site has a higher than average proportion of accidents in wet conditions or involving skidding for the type of site being considered;
- the nature of the individual site and the demands of road users mean that a higher accident risk (compared with other sites in the same category) might be expected with the skid resistance at its current value or if it were to fall further before the next measurement. In this case, preventive treatment is justified to pre-empt a potential increase in accident risk.

5.4 If none of the above are true then there is currently no justification for treatment to increase the skid resistance. If the site remains below the Investigatory Level at the next measurement, then it

will automatically be subject to a further investigation. That is, sites with skid resistance remaining below the Investigatory Level are automatically kept under review.

5.5 Further details of making these assessments are given in Annex 4 on site investigation and Annex 5 on assessment of accident data.

5.6 If the skid resistance and accident pattern remain stable for an extended period, for example, more than 3 years, then lowering the Investigatory Level should be considered. However, it is important that stability is observed before reducing the Investigatory Level, because, unless the skid resistance falls further, regular investigation that would detect an increase in accidents would no longer be prompted by the skid resistance Standard.

Procedure

5.7 Sites requiring investigation shall be identified as soon as practicable on receipt of the CSC values.

5.8 CSC values should be used in preference to single run survey values that have not been adjusted for seasonal effects, as the latter are less reliable. However, if single run survey data indicate that the skid resistance is significantly below the Investigatory Level (e.g. at least 0.05 units SCRIM coefficient below) then it is likely that the CSC will also be found to be below the Investigatory Level. Single run data can therefore be used to give early warning of sites requiring investigation, but any decision on the need for treatment should normally be based on the CSC.

5.9 Site investigations shall be carried out in a prioritised order, by personnel experienced in pavement engineering.

5.10 Site investigations will be prioritised initially on the basis of the amount by which the skid resistance is below the Investigatory Level. This order may be refined to take into account the efficiency of conducting

investigations and as a result of other information gathered during the early part of the investigation, such as the recent accident history.

5.11 Persons with relevant local experience must be identified, and should be consulted if appropriate, during the site investigation process. These will include the person locally responsible for accident investigation and prevention.

5.12 The results of the investigation, including whether further action is required, shall be documented and retained together with the identity of the assessor and other parties consulted.

6. PRIORITISATION OF TREATMENT

6.1 Site investigation results in the identification of lengths of pavement where treatment is recommended to improve the skid resistance. This chapter addresses the prioritisation of these treatments on the assumption that budget resources are limited. If other actions are identified as a result of the site investigation then these must be prioritised as appropriate.

6.2 HD 36, HD 37 and HD 38 (DMRB 7.5.1-3) give advice about the choice of surfacing materials to provide the appropriate level of skid resistance and about the use of re-texturing treatments to provide short-term improvements to skid resistance and/or texture depth. Other aspects of pavement condition must also be taken into account in selecting the most appropriate form of treatment.

6.3 The most appropriate form of treatment shall be identified for each treatment length taking account of current advice.

6.4 Priority must be given to completing treatments where the skid resistance is substantially below the Investigatory Level (e.g. at least 0.05 units CSC below), or low skid resistance is combined with a low texture depth, or the accident history shows there to be a clearly increased risk of wet or skidding accidents. In other cases, treatment will be programmed as a longer-term measure taking into consideration other maintenance requirements.

6.5 A comparison of the estimated accident saving and the cost-effectiveness of treatments can be used to assist in establishing the relative priority of treatments at different locations. The Overseeing Organisation will provide information that can be used to make this assessment. Other estimates of accident savings may be used if backed up by local experience or other information.

6.6 The cost effectiveness of treatments at different locations can be calculated by dividing the estimated accident saving by the anticipated cost of treatment.

6.7 The priority for treatment should be established for all new treatment lengths and for those lengths previously recommended for treatment to improve the skid resistance, but where treatment has not yet been carried out or definitely programmed. If more than a year has elapsed since the site investigation was carried out then the accident history and priority for treatment must be re-examined using the most recent data available. This programme should be reviewed and progress recorded at appropriate intervals.

7. USE OF WARNING SIGNS

7.1 Warning signs shall be erected at sites where the need for treatment to improve skid resistance has been identified following a site investigation. In Scotland, sites identified in this way shall be referred on an individual basis to the Overseeing Organisation for a decision on the provision of warning signs.

7.2 This strategy provides a targeted use of signs and is designed to avoid a proliferation of signs that would undermine their effectiveness and would not make best use of resources.

7.3 Since warning signs are erected (if required) after a site investigation, it is particularly important to complete site investigations in a prioritised order and within a reasonable time period, so that warning signs can be placed where they are needed without undue delay.

7.4 The slippery roads warning sign (Diagram 557) is to be used in accordance with the instructions contained in The Traffic Signs Regulations and General Directions (2002).

7.5 A visual inspection of the site shall be made after the signs are erected to confirm that they have been erected and correctly placed and a record of this observation shall be made and retained.

7.6 Depending on the nature of the surface treatment, it may be necessary to leave slippery road warning signs in place for a period after a new surface is opened to traffic. Additionally, at sites where the risk of skidding may temporarily increase after surface treatment, it may be necessary to erect warning slippery road signs if not already in place.

7.7 Warning signs shall be removed as soon as they are no longer required.

8. REFERENCES

1976

LR738; Hosking JR and Woodford GC, "Measurement of Skidding Resistance Part ii: Factors Affecting the Slipperiness of a Road Surface"; TRRL.

1999

BS7941; Part1; "Methods for Measuring the Skid Resistance of Pavement Surfaces. Side-ways Force Coefficient Routine Investigation Machine", BSI.

DMRB

HD 29 (DMRB 7.3.2) Structural Assessment Methods.

HD 36 (DMRB 7.5.1) Surfacing Materials for New and Maintenance Construction.

HD 37 (DMRB 7.5.2) Bituminous Surfacing Materials and Techniques.

HD 38 (DMRB 7.5.3) Concrete Surfacing and Materials.

9. ENQUIRIES

All technical enquiries or comments on this Standard should be sent in writing as appropriate to:

Chief Highway Engineer
The Highways Agency
123 Buckingham Palace Road
London
SW1W 9HA

G CLARKE
Chief Highway Engineer

Chief Road Engineer
Scottish Executive
Victoria Quay
Edinburgh
EH6 6QQ

J HOWISON
Chief Road Engineer

Chief Highway Engineer
Transport Directorate
Welsh Assembly Government
Llywodraeth Cynulliad Cymru
Crown Buildings
Cardiff
CF10 3NQ

M J A PARKER
Chief Highway Engineer
Transport Directorate

Director of Engineering
The Department for Regional Development
Roads Service
Clarence Court
10-18 Adelaide Street
Belfast BT2 8GB

G W ALLISTER
Director of Engineering

ANNEX 1: BACKGROUND INFORMATION ON THE MEASUREMENT AND INTERPRETATION OF SKID RESISTANCE

General

A1.1 When a vehicle travels over a road, each part of the tyre in contact with the road surface is momentarily at rest. The frictional forces generated at these stationary contact areas between the tyre and the road surface can allow vehicles to be manoeuvred. However, a vehicle will start to skid whenever the available friction between the road surface and the tyre is insufficient to meet the demands of the driver in whatever manoeuvre (including braking) they are attempting to make.

A1.2 The friction available to a driver attempting a particular manoeuvre depends on many different factors. The influence of road surface characteristics is described below. Other factors include the vehicle's tyres and braking system, the dynamic interaction of the vehicle suspension with the road geometry and environmental factors, such as the temperature and the presence of water or other contaminants. The objective of measurements carried out under the operation of this Standard is to characterise the influence of the road surface skid resistance and hence define the skid resistance available to road users.

Road Surface Properties

A1.3 The contribution of the road surface to the overall friction is known as skid resistance. In practice, it is found that the skid resistance measured on dry, in-service road surfaces is generally high, but that lower and more variable measurements are obtained when the same road surfaces are wet or damp. For this reason, measurements of skid resistance for the purpose of routine condition monitoring are made on wetted road surfaces.

A1.4 The level of (wet road) skid resistance is dependent on two key properties of the surface, the microtexture and the texture depth. The fine scale microtexture, on the surface of aggregate particles and provided by the fines in the mixture, is the main contributor to skid resistance at low speeds and the main property measured in wet skid resistance tests. Greater texture depth generates friction by physically

deforming the tyre surface and also provides rapid drainage routes between the tyre and road surface.

A1.5 The effects of microtexture and texture depth combine to influence the skid resistance at higher speeds. The standard SCRIM measurement is carried out at a slip speed less than 20km/h, much lower than the slip speed in locked-wheel braking from normal traffic speed. The typical reduction of skid resistance from the 20km/h value at higher speeds, and the influence of texture depth, is illustrated in Table A1.1. The effect of texture depth becomes apparent at speeds as low as 50 km/h, but is increasingly significant at higher speeds.

Speed	Texture depth (mm SMTD)		
	Below 0.5	0.5 – 0.8	Above 0.8
50 km/h	40%	30%	25%
120 km/h	70%	60%	50%

Table A1.1 Typical Reduction in Skid Resistance Compared with 20km/h Value

Effect of Traffic

A1.6 Under the action of traffic, the microtexture becomes "polished", leading to a reduction in skid resistance. HD 36 (DMRB 7.5.1) requires the components of the surfacing mixture to satisfy certain criteria in relation to their resistance to polishing, so that surfacing materials generally provide adequate skid resistance during their service lifetimes.

A1.7 In combination with the specification of surfacing materials, the skid resistance of roads is monitored to identify areas where the microtexture has been lost as the surface has been polished by traffic and treatment might, therefore, be needed to improve the skid resistance. This is necessary because the performance in service cannot be predicted precisely from the properties of the surfacing components and traffic levels, and the effects of manoeuvring vehicles at

the location might be greater than was anticipated at the time the surfacing was designed.

A1.8 Similarly, the texture depth of road surfacings can reduce with time under the combined influences of traffic flow, temperature and the nature of the surface and is also monitored. The measurement of texture depth is described in HD 29 (DMRB 7.3.2).

Early Life Skid Resistance of Asphalt Surfacings

A1.9 Asphalt surfacings exhibit different skid resistance properties in the initial period after laying, compared with the same surfacings that have been exposed to traffic for a period of time. **This phenomenon is not within the scope of this document, which is concerned with in-service condition rather than the properties in the initial period.**

A1.10 Sections of road that exhibit these different skid resistance properties during this the initial period, must be identified, so that they can be excluded from certain types of analyses, as described in Chapter 3 and Annex 4 of this Standard. The duration of this initial phase will depend on local conditions but, for the purpose of interpreting skid resistance measurements, it is assumed that the surface has reached an equilibrium state one year after opening to traffic on trunk roads in the UK.

Seasonal Variation of Skid Resistance

A1.11 After the initial period of wearing in, road surfaces reach an equilibrium state of polishing. For roads where the traffic level is constant, the skid resistance will then fluctuate through seasonal weathering and polishing cycles but will remain at about a constant level for many years. If the traffic level subsequently increases or decreases, the position of the equilibrium will shift so that a lower or higher overall level of skid resistance is observed, but with the same seasonal fluctuation superimposed.

A1.12 An example of long-term variation in skid resistance is shown in Figure A1.1. A suggested explanation for the annual variation is that in the winter (October to March) when the roads are wet for much of the time, the detritus is mainly gritty so that the road surface becomes harsh and the skid resistance rises. The lowest skid resistance is generally observed in the summer period, when the roads are wet for a relatively short time, the detritus on them is mainly dusty so that the road surface becomes polished and the skid

resistance falls. In practice, the minimum skid resistance varies from year to year and occurs during different periods depending on the prevailing weather conditions.

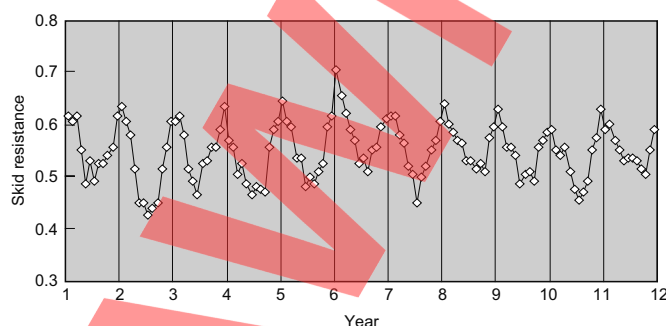


Figure A1.1 Example of Long-Term Variation in Skid Resistance (from LR 738)

A1.13 Because the skid resistance varies continuously, various strategies have been developed to provide a measurement that characterises the state of polish of the microtexture. Survey strategy and processing procedures are designed to reduce the effect of the variation within a year and/or between successive years, so the sites with low skid resistance can be identified more accurately. Typically, measurements are made during the summer period, when the lowest measured values are observed.

A1.14 The survey and analysis methods to be used for the purposes of this Standard are described in Chapter 3, Annex 2 and Annex 3 of this Standard.

Standardised Measurements

A1.15 To characterise the condition of the microtexture, measurements of skid resistance are made under standardised conditions that restrict the influence of other factors on the measurement as far as possible. For example, measurements are made at a specified speed, using a specified tyre and a controlled amount of water. Corrections may be applied to the measured value where the specified standard conditions were not achieved, e.g. where it was not safe to maintain the specified speed. Further details of test procedures are given in Chapter 3.

A1.16 The measurements made and interpreted according to this Standard provide a guide to the general condition of the road to assist in maintenance planning. Because they indicate the general level of skid resistance under standardised

conditions, the values do not relate directly to specific accident situations, where other factors such as the tyre condition, vehicle speed and manoeuvre attempted all influence the level of friction generated at that time.

A1.17 In contrast, skid tests carried out by the Police for the purpose of reconstructing the situation leading to an accident are intended to recreate the specific conditions of the accident. The results of these different types of test cannot be compared precisely. Further details of Police skid tests are given in Annex 6.

Relationship to Accident Risk

A1.18 Within normal ranges, low skid resistance does not cause accidents on its own although, depending on the particular circumstances, it may be a significant contributory factor. The level of skid resistance, even on a polished surface, will generally be adequate to achieve normal acceleration, deceleration and cornering manoeuvres on sound surfaces that are wet but free from other contamination. However, higher skid resistance can allow manoeuvres that demand higher friction to be completed, e.g. to stop quickly or corner sharply. Higher skid resistance can therefore reduce accidents in cases where drivers need to complete a more demanding manoeuvre in order to avoid an accident. A key part of this Standard is the judgement of locations where this is more likely to occur, so that the provision of higher levels of skid resistance can be targeted at these locations.

A1.19 Accident analyses have shown that there are relationships between measured skid resistance and accident risk. These relationships are not precise, in that differences in skid resistance may account for only a relatively small part of the difference in accident risk between individual sites because of all the other factors involved. Nevertheless, they have allowed general observations to be drawn that make it possible to provide guidance for managing the provision of skid resistance on the network.

A1.20 The influence of skid resistance on accident risk is markedly different for roads with different characteristics. For this reason, site categories have been defined to group roads with similar characteristics.

A1.21 For some site categories, no statistically significant relationship, or only a weak relationship, is observed between skid resistance and accident risk. A good example of this is motorways, where the road design has effectively reduced the potential for conflict

between road users. Although the skid resistance is still important, because of the need to provide uniform road characteristics, the level of skid resistance can be lower than other categories.

A1.22 For other site categories, progressively more accidents are observed, on average, as the skid resistance falls. For these categories, there are benefits in maintaining a higher level of skid resistance to contribute to reducing the number of accidents at these sites.

A1.23 However, not all sites within a single category are equivalent in terms of their accident risk. Figure A1.2 illustrates the range in accident risk present for individual sites within a single site category. This range is not surprising when the range of characteristics present within a single nominal site category is considered, e.g. in road design and traffic flow. It should also be noted that there is no boundary at which the skid resistance passes from being “safe” to being “dangerous”.

A1.24 Judgement of the relative accident risk and appropriate level of skid resistance for different sites within the same category forms a key part of the effective operation of this Standard.

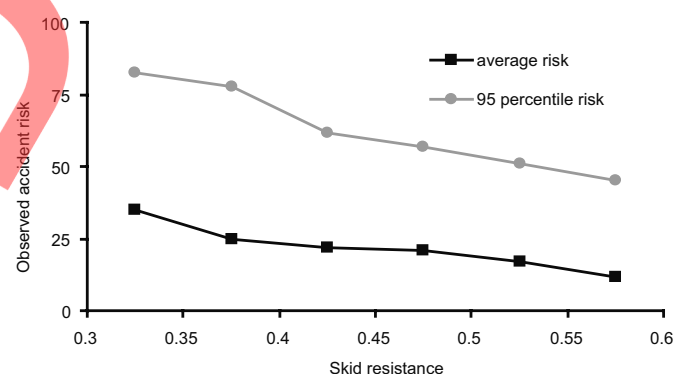


Figure A1.2 Accident Risk and Skid Resistance - Variation Within Site Category

ANNEX 2: SCRIM SURVEY OF OPERATIONAL PROCEDURES

A2.1 This Annex lists the standard testing procedures that are required to limit the variability of skid resistance measurements resulting from factors other than the road surface condition, e.g., the test speed.

Testing Season

A2.2 For standardised tests, measurements shall be made during the testing season, defined as the summer period 1 May – 30 September.

A2.3 In exceptional circumstances the testing season may be extended but only with the prior agreement of the Overseeing Organisation.

Testing Speed

A2.4 On Motorways and Dual Carriageway All Purpose Trunk Roads where the posted speed limit is greater than 50mph, the target test vehicle speed is 80km/h. On all other roads, or where a SCRIM is being used without dynamic vertical load measurement, the target test vehicle speed is 50km/h.

A2.5 The SCRIM driver shall maintain a vehicle speed as close to the target test speed as possible. This is achievable for most parts of the network.

A2.6 If it is not safe or practical to maintain the target speed then, in exceptional circumstances, a different speed may be used at the discretion of the SCRIM driver. **The safety of the SCRIM and other road users has priority at all times.**

A2.7 The Investigatory Levels for the CSC values defined in Chapter 4 have been set in terms of the 50km/h standard testing speed. The method for applying speed corrections is given in Annex 3 of this Standard.

Testing Lane and Line

A2.8 For most roads, the leftmost lane will be tested in both directions of travel. This lane usually carries the most heavy traffic and can, therefore, be expected to show the lowest skid resistance. In areas where this is not the case (for example, approaching points where routes diverge and a greater proportion of heavy vehicles uses the offside lane) then a different lane, or more than one lane will be tested.

A2.9 The test lane shall be as specified by the Overseeing Organisation.

A2.10 Measurements shall be carried out with the test wheel in the nearside (left) wheel path of the running lane unless an alternative test line has been agreed with the Overseeing Organisation.

A2.11 If it is necessary for the SCRIM to deviate from the test line (e.g. to avoid a physical obstruction or surface contamination) the data shall be marked as invalid and eliminated from the standard analysis procedure.

A2.12 On urban roads where roadside parking in unmarked positions is commonplace, there may be two pairs of wheel paths – one followed at times of day when parked cars are mostly absent and another when they are largely present. In such circumstances the line that normally carries the most commercial vehicle traffic must be followed.

A2.13 In situations where the test line is prone to physical obstruction, for example by parked cars, then an alternative test line must be agreed with the Overseeing Organisation to avoid recording invalid data for the same length of road in successive years. Testing the offside wheel path might be an appropriate alternative in these circumstances, with the aim of achieving a consistent test path, year on year.

Testing on Bends

A2.14 There are no special requirements for testing on bends. At locations where a sharp bend is combined with traffic braking or accelerating, the wheel path on the outside of the bend can become more polished than the inside wheel path. This is taken into account in setting the Investigatory Level (See Chapter 4) and during the site investigation (See Paragraph A4.15).

Testing on Roundabouts

A2.15 Roundabouts can present practical problems regarding potential traffic conflicts and testing speed. They range from small, mini-roundabouts to large grade-separated interchanges. Larger roundabouts may have free-flowing traffic or traffic light controls at certain times of day.

A2.16 Mini-roundabouts or small island roundabouts should be treated as part of the main carriageway test line and do not need to be tested separately. (This applies to the testing procedure – the roundabout section may be assigned to a different Site Category to that of the main line.)

A2.17 On most roundabouts or interchanges, a line equivalent to the outermost lane should be tested.

A2.18 On roundabouts with lane markings for specific routes, a representative line should be chosen broadly following the most polished path. Usually this will be that followed by most heavy vehicles, which, because of their size, may not be able to keep to the marked lanes.

A2.19 The test line(s) to be followed at roundabouts shall be as agreed by the SCRIM operator and the Overseeing Organisation. They will take into account the need for consistency in representative measurements in successive surveys and possible variations in Site Category through the intersection.

A2.20 On some smaller roundabouts where the distance between the arms is short, it may be appropriate to record data at a shorter interval than the standard 10m length. Changes to the recording interval will be specified by the Overseeing Organisation.

Ambient Conditions During Testing

A2.21 The ambient conditions can have an effect both on the skid resistance of the road and on the measurements. The SCRIM operator shall record the weather conditions at the time of the survey as required by BS7941-1 (1999).

A2.22 Testing in extremely strong side winds must be avoided because these can affect the measurements by creating turbulence under the vehicle that causes the water jet to be diverted from the correct line.

A2.23 Testing must be avoided in heavy rainfall or where there is standing water on the road surface. Excess water on the surface can affect the drag forces at the tyre/road interface and influence the measurements.

A2.24 Measurements shall not be undertaken where the air temperature is below 5°C.

A2.25 The maintaining organisation shall maintain a record of general conditions throughout the testing season. Both the SCRIM operator and the maintaining organisation shall endeavour to record any road conditions that could affect the results.

A2.26 Contamination of the road surface by mud, oil, grit, or other contaminants is to be noted and the affected measurements identified (in the same way as for out-of-line testing) so that results are eliminated from the standard analysis procedure. If the contamination is severe, emergency action may be required to remove the contamination. In this case the problem must be reported without delay to the Overseeing Organisation, together with the relevant results if possible. The Overseeing Organisation will then notify the managing organisation for appropriate action to be carried out.

ANNEX 3: PROCESSING AND COMPUTATION OF CHARACTERISTIC SCRIM COEFFICIENT

A3.1 This Chapter lists the processing options that may be required by the Overseeing Organisation. Options that are required must be applied in the order listed below.

A3.2 On completion of the survey, the corrected SCRIM Coefficient (SC) shall be determined for each 10m section for which a valid SCRIM Reading is available. The corrected SC shall be used to determine the CSC using one of the methods listed below.

Speed Correction

A3.3 The test speed has a significant effect on the measurements of skid resistance.

A3.4 For the purpose of this Standard, measurements collected within the speed range 25 to 85 km/h will be corrected to a speed of 50km/h, using the following equation:

$$SC(50) = SC(s) + (s \cdot 2.18 \cdot 10^{-3} - 0.109)$$

Where:

SC(50) is the SC corrected to 50km/h

SC(s) is the SC measured at the test speed, s.

Temperature Correction

A3.5 The temperature of the air or road can have a small effect on the tyre rubber and the measurements made. It has been found that under normal UK conditions, the influence of temperature is not of practical significance in comparison with other factors affecting the measurements. Temperature correction is not necessary for surveys carried out under the conditions set out in this Standard.

Index of SFC

A3.6 The Index of SFC was originally introduced as a factor to relate the values given by SCRIM to the SFC obtained from the equipment at TRI during the period 1963-1972 used to derive information on which to base proposals for specification. From this revision of the Standard, it serves as a general correction factor that will allow the Overseeing Organisation to maintain the SC at a consistent general level as future developments are made to the equipment or monitoring techniques.

A3.7 The Index of SFC is defined by the Overseeing Organisation. The value currently in force is 78 per cent (0.78) and is applicable to all SCRIMs in current use but it may be amended in future, either for the whole fleet or for individual SCRIMs.

A3.8 The SC value shall be multiplied by the Index of SFC currently in force.

Calculation of Characteristic SCRIM Coefficient Values

A3.9 As noted in Annex 1, the skid resistance of road surfaces can fluctuate within a year and between successive years, while maintaining a similar general level over a long period of time. The basis of this Standard is that skid resistance will be assessed on the basis of the overall (summer) level of skid resistance rather than an instantaneous measurement.

A3.10 By removing the effect of seasonal variation as far as possible (both variation within a single year and between successive years) sites exhibiting a lower skid resistance can be identified more accurately.

A3.11 The following paragraphs list different methods of providing an estimate of the summer skid resistance, referred to as the CSC from the corrected SC values. The choice of which method to apply determines the survey strategy that will be necessary to obtain the required data.

Single Annual Survey Method

A3.12 This approach is based upon a single annual survey of the network. The method uses measurements from the preceding 3 years to characterise the long-term skid resistance of the network. This value is used with the mean network skid resistance in the current year, to calculate a correction factor, which is applied to the current year's data to make current values consistent with the long-term average.

A3.13 As the effect of seasonal variation will vary in different geographical areas (e.g. due to different amounts of rainfall), larger networks will be split into smaller localities and the correction factor will be determined and applied separately within each locality.

A3.14 The Single Annual Survey Method is implemented as follows:

A3.15 The whole network shall be surveyed once during the Testing Season in each year. Surveys must be planned such that in successive years each road length is tested in the early, middle and late parts of the season.

A3.16 The early middle and late parts of the season are defined, respectively, as: May to mid-June, mid-June to mid-August and mid-August to the end of September. For example, a route tested in the early part of the season in year 1 could be tested in the late part of the season in year 2 and in the middle part of the season in year 3. In year four, it must be tested in the early part of the season again, etc.

A3.17 Each site on the network shall be allocated to a locality by the Overseeing Organisation.

A3.18 A **locality** is a collection of road sections or routes for which a **Local Equilibrium** Correction Factor will be determined. A locality must be small enough so that similar weather conditions will normally be experienced within it, and large enough so that a stable value can be calculated to represent the long-term skid resistance. This approach is based on the assumption that the climatic effects leading to seasonal variation influence all the roads in a local area in a similar way.

A3.19 The **Local Equilibrium Correction Factor** (LECF) is the correction factor determined within each locality to bring the current year data to a level consistent with the long-term average.

A3.20 By surveying all road sections within a locality at the same time, this method can remove a component of the within-year seasonal variation as well as the variation between years.

A3.21 All the road sections within each locality shall be surveyed within the same part of the test season.

A3.22 The LECF is calculated in three stages:

- (i) The **Local Equilibrium SC** (LESC) is determined to represent the average skid resistance level for the locality over recent years. The LESC is the average SC, calculated for all valid 10m sub-section measurements in the defined locality over the 3 years that precede the current testing season. This must contain surveys from each of the three parts of the test season. Valid measurements are those that were made in the required part of the test season, on the required test line, on road surfaces that were at least 12 months old at the time of testing.
- (ii) The **Local Mean SC** (LMSC) is determined for the current survey. The LMSC is the average of all valid 10m sub-sections in the locality in the current year survey.
- (iii) The LECF is determined by dividing the LESC by the LMSC, i.e.:

$$\text{LECF} = \text{LESC} / \text{LMSC}$$

A3.23 The CSC for each 10m sub-section shall be determined by multiplying the corrected SC by the LECF.

Annual Survey with Benchmark Sites Method

A3.24 This alternative approach to the determination of CSC is not to be used in England but has been used in the past and may be adopted by other Overseeing Organisations.

A3.25 Historically, when the Investigatory Levels were based upon MSSC measurements, this approach allowed the survey frequency to be reduced on lightly used parts of the regional networks. It is based on monitoring all of a selected network every year and using the average of the Mean Summer SCRIM Coefficient (MSSC) for selected sites known as "Benchmark sites" spread around the area to indicate seasonal variation.

A3.26 The Annual Survey with Benchmark Sites Method is implemented as follows:

A3.27 The Overseeing Organisation will agree a number of Benchmark Sites to cover a relevant geographical area.

A3.28 The Benchmark Sites shall all be tested three times with surveys spread through each testing season to provide MSSC values for each Benchmark Site and an overall average MSSC value for the area.

A3.29 The whole of the selected network shall be tested once in each year. It is acceptable to survey different parts of the network in different parts of the testing season.

A3.30 Whenever a part of the network is surveyed, all the Benchmark Sites shall be tested at the same time.

A3.31 The LECF is the correction factor determined for the network area to bring the current year data to a level consistent with the long-term average.

A3.32 With this method it is assumed that the average behaviour of the Benchmark Sites is representative of the area and that the climatic effects leading to seasonal variation between years will have influenced all of the Benchmark Sites in an area in a similar way. By surveying the benchmark sites three times each season, some account can be taken of the within-year variation. Comparing the sites in successive years allows the effects of between-year variation to be reduced.

A3.33 The LECF is calculated in five stages:

- (i) The **Mean Summer Correction Factor (MSCF)** is determined to take account of variation in skid resistance between the time of a particular survey and the average during the testing season. The MSCF is the overall average of all of the

Benchmark Sites for the testing season, divided by the average of all of the Benchmark Sites at the time of the relevant survey.

- (ii) The MSSC for each 10m section in the survey is estimated by multiplying the SC for each valid 10m sub-section by the MSCF.
- (iii) The LESC is determined to represent the average skid resistance level in the area over recent years. The LESC is the overall average MSSC for all of the Benchmark Sites over the three years that precede the current testing season.
- (iv) The LMSC is determined to represent the average skid resistance level in the area for the current testing season. The LMSC is the average MSSC of all Benchmark Sites in the area for the current testing season.
- (v) The LECF is determined by dividing the LESC by the LMSC, i.e.:

$$LECF = LESC/LMSC$$

A3.34 The CSC for each 10m sub-section shall be determined by multiplying the MSSC for each 10m sub-section by the LECF.

A3.35 Because MSSC is used to calculate the correction factors, determination of CSC using this alternative approach will not be possible until after the end of the testing season when the final Benchmark Site survey has been completed.

Mean Summer SCRIM Coefficient Method

A3.36 This method uses the MSSC to represent the equilibrium summer level of skid resistance and this takes the place of the CSC used in the Single Annual Survey method.

A3.37 Although the MSSC method takes some account of within-season variation, it has been found from experience that the approach is potentially vulnerable to differences between particular years or, with longer repeat cycles, to changes in skid resistance in the intervening period between surveys. Particularly hot or wet summers, for example, could give rise to relatively low or high MSSCs compared with the underlying equilibrium value. In a "low-MSSC" year, small changes could give rise to significant lengths of the network requiring investigation and subsequent

treatment that may not be necessary. Conversely, in a “high-MSSC” year, sites that should be investigated may be missed and not reviewed for another three years.

A3.38 Thus, relatively small changes in MSSC between survey years have given rise to large fluctuations in the lengths of road being identified for treatment, with consequent difficulties for maintenance planning. Also, with a longer repeat cycle, on some sites important changes to the skid resistance occurring in the intervening years between tests might pass undetected, with increased accident risk for a time.

A3.39 Using the MSSC method, the network shall be surveyed three times in the same year, in the early, middle and late parts of the testing season.

A3.40 The MSSC is determined for each 10m section by taking the average of the three SC values from the three surveys. The MSSC averaged over the relevant site should be used as the CSC value for comparison with Investigatory Levels.

A3.41 In areas where the MSSC method is used, dividing the network into two or three parts and testing the parts over successive years can reduce the proportion of the network to be surveyed in any year. Thus, half the network is surveyed in alternate years or one-third of the network may be surveyed each year so that the whole network is covered over a three-year cycle.

A3.42 This method takes no account of variation between years.

Measurements Outside the Normal Testing Season

A3.43 Occasionally, SCRIM measurements may be made outside the normal testing season. Although data from such measurements can be used for comparative purposes by experienced personnel, such measurements are subject to the full uncertainty of seasonal variation and do not form part of this Standard.

A3.44 Survey planning should allow for the possibility of delays, for example, due to a machine breakdown or severe wet weather, and allow for recovery within the defined testing season. This also applies to tests made in the early or middle parts of the testing season using the main Single Annual Survey method to determine CSC.

A3.45 Exceptionally, surveys may be completed up to the end of the first week of October with the agreement of the Overseeing Organisation, provided that the general weather conditions in the area remain comparable to those experienced in September and that no frosts or treatments to the road such as gritting have occurred.

A3.46 Where the Annual Survey with Benchmark Sites approach is being used, then if measurements are to be made in early October, the relevant Benchmark Sites should also be included. The SCs obtained should then be adjusted to a late-season equivalent value by multiplying them by a factor obtained by dividing the average for the benchmark sites in the late part of the standard season by the average for the benchmark site in early October. The corrected results would then be used in the determination of MSSC as described in paragraph A3.34.

Other Types of SCRIM Survey

A3.47 Surveys with SCRIM are occasionally carried out for special purposes such as research or for local investigations and may not be following one of the monitoring methods set out above.

A3.48 Such measurements are subject to the full uncertainty of the factors affecting test procedures and require careful interpretation. The data do not form part of this Standard.

A3.49 Measurements that are made outside the testing season are subject to the full uncertainty of seasonal variation. They do not form part of this Standard. Nevertheless, a site with low resistance to skidding measured outside the testing season is likely to have a lower resistance to skidding within the testing season.

A3.50 Although non-standard testing can be of some use to experienced personnel who are fully aware of the limitations, its main use is only to test roads on a comparative basis.

ANNEX 4: SITE INVESTIGATION

A4.1 This Chapter describes the process of site investigation and should be read in conjunction with Annex 5 on the assessment of accident data.

Format of the Site Investigation

A4.2 Paragraphs A4.14 to A4.22 provide a list of headings under which a structured site investigation may be carried out. Each heading contains a number of items for consideration. Answers are not required to individual points, but a written assessment of site characteristics must be made under appropriate headings, taking into account relevant factors from the items listed plus any other relevant points. Reference to supporting documents or data should be made as appropriate.

A4.3 The site investigation must include a review of the Investigatory Level(s) assigned. If a change is required then it should be reported as required by the Overseeing Organisation.

A4.4 The review of the Investigatory Level should include a check of whether the current criteria for setting the Investigatory Level have been followed (see Chapter 4). In the event of treatment being required then the Investigatory Level will be needed to determine the appropriate specification for treatment. If, additionally, issues are identified during the site investigation that have implications for reviewing the criteria for setting the Investigatory Levels, then these must be noted so that they can be acted upon at an appropriate stage.

A4.5 The level of detail appropriate for the investigation will depend on the nature of the site and the time since a detailed investigation was last carried out. Many of the points listed are only relevant to more complex sites. If the site has been investigated recently then it will only be necessary to identify the changes that have occurred since the last investigation.

A4.6 The level of detail used should also be appropriate to the likely cost of the treatment and the amount of disruption likely to be caused to road users. A relatively cheap treatment, that has potential to reduce accident risk and where the works cause little disruption or added risk to road users, will not warrant an extensive investigation.

A4.7 Reviewing the nature of the site and condition of the surfacing is an important component of the site investigation. This can be achieved through a combination of the following methods, but it is recommended that a physical visit to the site is always made unless the site is a motorway or dual carriageway “non-event” category:

- On foot (allows the condition of the road to be observed in detail but has associated safety risks that must be controlled).
- From a parked or moving vehicle (allows pattern of traffic movement and speed to be observed during the visit).
- From recent local knowledge of the site (may provide a more general knowledge of the road usage under a wider range of traffic, weather and lighting conditions).
- From video records and maps.

Recommendation

A4.8 As a result of the investigation, a clear recommendation must be recorded of the actions to be taken (including if no immediate action is required).

A4.9 Treatment should be recommended if, taking into account the nature of the site and the observed accident history, it appears that improving the skid resistance of the surfacing, or improving the surface condition in other respects is likely to reduce the risk of skidding accidents.

A4.10 If the site investigation identified any characteristic of the site or road user behaviour that suggests other road safety engineering measures could be appropriate, then the appropriate people must be notified so that the site is considered for safety improvements.

A4.11 If the site investigation identifies requirements for additional routine highway maintenance, such as sweeping, re-application of markings etc then appropriate action must be taken.

A4.12 If there is no justification for treatment then no further action is required other than to review the site after a period of time. If the site remains below the

Investigatory Level after the next measurement of skid resistance then it will automatically become subject to a further investigation.

A4.13 If the skid resistance and accident pattern have been stable for more than 3 years then lowering the Investigatory Level should be considered (see also paragraph A4.3).

Content of Site Investigation

A4.14 Site location and use:

- *What is the location and nature of the site?*
- *Are there any features that could be expected to require road users to be able to stop or manoeuvre to avoid an accident? For example, junctions, lay-bys, other accesses, crossings, bends or steep gradients.*
- *What are the site category and the current Investigatory Level? Has there been any substantial change in the amount or type of traffic using the road that would influence the requirement for skid resistance and could require the Investigatory Level to be changed?*

A4.15 Pavement condition data:

- *What is the CSC, by how much is it below the Investigatory Level and over what length? Is the skid resistance uniform along the site or are there areas of lower skid resistance or large changes in skid resistance? Is the lowest skid resistance in locations where road users have a specific need to stop or manoeuvre? (The risk of accidents generally increases as the skid resistance falls, but the increase in risk will be greater for sites where the road user is likely to need to stop quickly or manoeuvre.)*
- *Are there any individual 10m lengths that fall significantly below the mean for an averaging length, and is the location of such lengths significant, e.g. a short length of low skid resistance within a sharp curve.*
- *Does the site contain a sharp bend to the left in combination with traffic braking or accelerating, e.g. a sharply curved roundabout approach or exit? In these circumstances the offside wheel path can become more polished than the nearside wheel path and the skid resistance in the offside wheel path can be up to 0.05 units CSC lower*

than that measured in the nearside wheel path. However, this does not mean the skid resistance is more than 0.05 units CSC below the Investigatory Level, because the Investigatory Level will have been raised in the vicinity of the curve to compensate for this effect (Chapter 4).

- *What is the texture depth and do areas of low texture depth (below 0.8mm SMTD) coincide with areas of low skid resistance?*
- *Are there any extreme values of rut depth or longitudinal profile variance that could affect vehicle handling or drainage of water from the carriageway?*

A4.16 Accident history:

- *A methodology for analysing the accident history is given in Annex 5.*

A4.17 Site inspection:

- *Has a visit to the site been carried out? If so, then what range of weather and traffic conditions has been observed and over what period? If not, then what other information has been drawn upon?*

A4.18 Visual assessment:

- *Is a visual inspection of surface condition consistent with the available survey data?*
- *Skid resistance and texture depth are generally measured in the nearside wheel track in lane one. Is the rest of the area of the maintained pavement surface visually consistent with the measured path, or are there any localised areas of polished surfacing, low texture depth, patching or areas otherwise likely to give rise to uneven skid resistance? If it is likely that the skid resistance of other lanes could be lower than the lane tested then additional surveys may need to be carried out to investigate this. This could occur, eg. If the surface in other lanes (including the hard shoulder) is different to the lane tested, and these lanes carry a similar volume of heavy traffic to the lane tested.*
- *If so, is the location such that the lack of uniformity is likely to increase the risk of accidents occurring?*

- *Is the area of the maintained pavement surface free from debris and other sources of contamination? Is water known to drain adequately from the carriageway during heavy rain? Is the pavement free of other defects such as potholes?*

A4.19 Road users:

- *What is the volume and type of traffic, including vulnerable road users? Are observed traffic speeds appropriate to the nature of the site? If there is significant variation in the speed, type or volume of traffic during the day, have observations been made in an appropriate range of traffic conditions? What types of manoeuvres are made and what are the consequences if not completed successfully, e.g. head-on or side impact at speed are likely to have severe consequences? Is there any evidence that road users consistently fail to negotiate the site successfully, such as tyre tracks into the verge?*

A4.20 Road layout:

- *Is the road design still appropriate for the speed and volume of traffic? Is the layout unusual or likely to be confusing to road users?*
- *Is the carriageway particularly narrow and is a hard shoulder or 1 metre strip provided? Is the road layout appropriate for the number and type of vulnerable road users (pedestrians, cyclists, motorcyclists, equestrians, bus and tram users)?*
- *Are junction sizes appropriate for all vehicle movements? Are right turning vehicles adequately catered for? Are priorities at junctions clearly defined? Are traffic signals operating correctly and are they clearly visible to approaching motorists?*

A4.21 Markings, signs and visibility:

- *Are all pavement markings, warning and direction signs appropriate and effective in all conditions (e.g. day, night, fog, rain, on coloured pavement surface)? Have old pavement markings been removed properly? Are there any redundant signs that could cause confusion? Are signs or other roadside objects on high-speed roads adequately protected from vehicle impact?*

- *Is visibility adequate for drivers to perceive the correct path? Do sight lines appear to be adequate at and through junctions and from minor roads or other accesses? Is the end of likely vehicle queues visible to motorists? Does landscaping, taking into account future growth of vegetation and the effects of wind and rain, reduce the visibility, including visibility of signs?*

A4.22 Additional information:

- *Are any other sources of information available, such as reports or visual evidence of damage only accidents, incidental damage to street furniture or reports from the Police? Such reports are likely to be subjective but are relevant if the reliability of the information is borne out by observations of the site.*

ANNEX 5: ASSESSMENT OF ACCIDENT DATA

A5.1 The most recent available records of personal injury accidents recorded on the STATS19 database over at least a three-year period should be used in the analysis. The location of accidents should be plotted, identifying accidents that occurred in the wet, or that involved skidding.

A5.2 The following aspects should also be considered:

- Is the location of accidents significant in relation to the observed pattern of skid resistance?
- Is there any other pattern apparent in the location or type of accidents that would warrant more detailed analysis or consultation with the person responsible for accident investigation?
- Have there been any significant changes to the site or the traffic using it in the analysis period, that could have affected the number of accidents?

A5.3 The number of accidents occurring within a particular site will be related to the length of the site and the amount of traffic as well as the length of time considered. This means it is necessary to consider both the number of accidents and the accident rates, which can be calculated given the site length and an estimate of the annual average daily two-way flow.

A5.4 The number of accidents, the average number per year and the accident rates and severity ratio should be tabulated:

$\text{Accidents/100km} = (\text{Average number of accidents per year} / \text{site length in km}) * 100\text{km}$

$\text{Accidents/10}^8\text{veh-km} = \text{Average number of accidents per year} / (\text{site length in km} * \text{vehicles per day} * 365 / 10^8)$

$\text{Accident severity ratio} = \text{Accidents where a casualty was killed or seriously injured} / \text{total injury accidents}$

A5.5 The sites most likely to benefit from treatment are those where the accident rates observed are greater than normal for the type of site. However, if the total number of accidents is rather small, then the same resource may be more effectively used at other sites.

A5.6 If a greater than normal proportion of accidents occur in wet conditions or involve skidding, this provides an indication that increasing the skid resistance may reduce the accident risk. The following percentages should be calculated and tabulated:

$\% \text{Wet} = (\text{Number of accidents that occurred in wet conditions} / \text{total accidents}) * 100$

$\% \text{Skid} = (\text{Number of accidents where skidding was reported} / \text{total accidents}) * 100$

$\% \text{Wet skid} = (\text{Number of accidents that occurred in wet conditions where skidding was reported} / \text{number of accidents that occurred in wet conditions}) * 100$

A5.7 Here, “wet” is where the road surface was recorded as wet/damp or flood in the STATS19 accident record and “skid” is where any of the skidded, jack-knifed and overturned options was recorded in the vehicle record for any of the vehicles involved in the accident.

A5.8 However, these percentages do not provide a good indication of the influence of the surfacing in cases where the total number of accidents is rather small, when a small change in the number of wet or skidding accidents results in a substantial change in the percentages calculated.

A5.9 Control data are necessary to be able to assess what the “normal” accident risk is. For trunk roads in England, control data for the whole trunk road network and for the route that the site is a part of can be obtained from the appropriate HA Route Manager. These will provide values for the parameters above, broken down into Motorways, built-up A-roads and non-built-up A-roads. Non-built-up A-roads are further divided into dual carriageways and single carriageways. The most appropriate category should be selected and both the national and the route values should be compared with the values for the site under investigation, for example, by using Table A5.1.

A5.10 The control data will help to indicate whether the accident risk at the site is greater than the route or the national average. This should only be taken as a guide because the route and, particularly, the national data will include different types of site, with different risk factors to the site being investigated. If available, accident data from other, similar sites (e.g. with the same site category as defined in Table 4.1) would also provide a useful comparison. However, there will be relatively few accidents recorded at individual sites, including the site being investigated, and this number will be subject to random fluctuation. If there have been changes during the analysis period that could have influenced the past accident history, for example, a marked change in traffic, road works or major events, these should be listed with the dates and accidents affected and taken into account in the analysis.

	Site data	Control data		
		Route	National	Similar sites
Number of accidents in analysis period				
Accidents/year				
Accidents/100km				
Accidents/10 ⁸ vehicle-km				
%Wet				
%Skid				
%Wet skid				

Table A5.1 Example Table for Comparison of Site Data and Control Data

ANNEX 6: USE OF DIFFERENT TYPES OF TEST IN ACCIDENT INVESTIGATION

General

A6.1 Road accidents usually result from a combination of several factors and these can be difficult to isolate and identify.

A6.2 When investigating accidents, the police are usually attempting to determine the causes of the accident and to obtain evidence that will assist them in accident reconstruction and any proceedings against individuals that are subsequently deemed necessary. In this regard they are particularly interested in the behaviour of the vehicles involved in the accident. The speed of a vehicle, the condition of its brakes, suspension and tyres and the driver's response will affect its ability to avoid a collision. The highway authority's objectives will be different, as they will be seeking to determine the extent to which the road layout, construction and general surface condition, including its skid resistance, are contributing to accident risk and whether some form of remedial action should be considered.

Friction and Skid Resistance

A6.3 For a vehicle to complete a particular manoeuvre safely there must be adequate friction available between the tyre and the road surface at the particular time. The level of friction required will be influenced by the nature of the manoeuvre and the site layout.

A6.4 The coefficient of friction is the ratio of the force resisting motion to the vertical force, and strictly refers to a particular tyre on a particular surface at a particular time. For most vehicles, an average coefficient of friction is normally assumed for all tyres on a vehicle unless there is particular evidence to do otherwise.

A6.5 Skid resistance is a measure of the contribution that the road provides to tyre/road friction made under standardised conditions. It provides an indication of the general condition of the road but does not relate specifically to the coefficient of friction that a road user will experience with particular tyres and the road at a particular time.

A6.6 The friction available to a manoeuvring vehicle will depend upon the underlying skid resistance of the road surface, which should be appropriate for the type of site, but it will also be affected by seasonal factors and specific conditions that apply at the material time, such as the weather e.g. dry, wet or icy, and the presence of other contaminants on the surface such as mud or oil.

The Vehicle and the Police Skid Tests

A6.7 Before attempting to reconstruct an accident, police collision investigators usually measure the tyre/road coefficient of friction in conditions that are as close as possible to those prevailing at the material time.

A6.8 When a vehicle has been involved in an accident and has left skid marks which indicate that one or more of its wheels were locked, an estimate of its likely speed can be made from the length of the skid marks and the coefficient of friction, which is directly related to the deceleration rate.

A6.9 In the police tests, the "locked wheel braking coefficient" of a vehicle at the accident site is derived by applying the brakes of a test vehicle quickly, so that the wheels lock rapidly, and measuring either the distance or the average rate of deceleration that it takes to stop from a known speed. The initial test speed is normally 50 km/h. The vehicle used in the test should ideally be the one involved in the accident (or a similar one in terms of model etc) but may often be a police vehicle.

A6.10 Stopping distances are indicated using a chalk gun that fires at the road when the brakes are first applied. Deceleration is measured using special proprietary equipment that incorporates accelerometers and is mounted in the test vehicle.

A6.11 In dry tests, the average coefficient of friction is assumed to apply at any speed (it is not normally speed dependent) and so can be used in calculating vehicles' speeds from stopping distances measured from the skid marks left at the accident site.

A6.12 In wet tests the average value recorded represents a range of values of friction which will increase as the skidding vehicle slows down. In this context the results are unsuitable for estimating speeds but the average value may be used to provide a comparison with wet roads in general to assist in interpreting other evidence obtained at an accident scene.

The Road Surface and Skid Resistance Tests

A6.13 A number of factors affect the skid resistance of the road surface and these are fully described in Annex 1. In summary, research has shown that in dry conditions all clean surfaced roads have a high skid resistance but their performance varies greatly in the wet.

A6.14 On wet surfaces 'slipperiness' is caused by the lubricating effect of the water film which becomes more effective as vehicle speeds increase, so that skid resistance generally falls as vehicle travel faster. The risk of an accident involving skidding increases significantly when roads are wet.

A6.15 On some newly laid asphalt surfaces, the bitumen layer coating the aggregate at the surface can affect both wet and dry skid resistance. More details are given in HD 36 (DMRB 7.5.1).

A6.16 The wet skid resistance of a road surface is routinely measured on trunk roads using SCRIM. SCRIM has a test wheel fitted with a smooth tyre which is mounted mid-machine in line with the nearside wheel track and angled at 20 degrees to the direction of travel. A controlled jet of water wets the road surface immediately in front of the test wheel. As the vehicle moves forward the test wheel, whilst freely rotating in its own plane, scuffs in a forward direction on the wet road surface generating a sideways-force. The ratio of this force to the vertical force between the test wheel and the road gives a measure of the skid resistance that can then be recorded continuously along the road.

A6.17 Because skid resistance varies with speed, SCRIM tests are made at standardised operating speeds, normally about 50km/h or 80km/h depending on the type of road. All test results are corrected to an equivalent standard speed of 50km/h before comparing with Investigatory Levels.

A6.18 Because the test wheel is set at an angle to the direction of travel, the effective slip speed of the test tyre is much slower than the vehicle operating speed.

The measurement is therefore one of low-speed skid resistance: at a 50km/h standard test speed, the slip speed is approximately 17km/h.

A6.19 Extensive research has established relationships between wet skid resistance as measured by SCRIM and accident risk for different types of site. Table 4.1 lists investigatory skid resistance bands for different categories of site. Roads are routinely monitored with SCRIM to detect any sections where skid resistance may have fallen to a level where skidding accident risk for that type of site may increase; such sites are investigated and if necessary remedial works are put in hand.

A6.20 Some UK Highway Authorities may use other test devices to measure wet skid resistance in particular circumstances. As with SCRIM tests, these tests are intended to investigate the general condition of the road surface and not specific friction conditions. The devices operate on different principles to SCRIM, such as using in-line locked-wheel friction for spot checks or an in-line fixed-slip technique in which the test wheel is forced to rotate at a slower speed than the vehicle speed and so skids over the surface. The different principles and slip speeds mean that different values are obtained and they cannot necessarily be compared with SCRIM Coefficient values.

A6.21 Another device used to assess skid resistance as part of an accident investigation is the pendulum tester, BS EN 13036-4:2003. Like the other tests, results from the pendulum tester do not relate directly to the actual coefficient of friction experienced by a particular tyre in a particular situation. This device measures skid resistance on a small length of road (approximately 125mm) and therefore positioning and frequency of sampling are critical. It was originally designed to simulate a patterned tyre skidding at 50km/h but with changes to tyre compounds, construction and tread patterns, this can no longer be safely assumed. SCRIM measures skidding resistance using a smooth tyre and therefore the surface texture will influence the relationship between SCRIM measurements and Pendulum Test Values (PTVs). The portable tester is not therefore recommended for use on fine textured surfaces and results on coarse textured surfaces can be misleading because of operational difficulties.

Relevance of the Tests

A6.22 When considering these two general types of test, it is important to understand that:

- Police skid tests are carried out in differing conditions and are used at accident sites to assist in accident reconstruction. They are frequently made in dry conditions. **The measurements are not suitable for assessing whether a road surface is substandard or in need of remedial treatment.** However, if a dry skid test indicates a lower than expected dry road skid resistance, this should be drawn to the attention of the highway authority so that the cause can be investigated;
- the SCRIM test is a standardised wet road test and is used for routine monitoring of the skid resistance of the nearside wheel track of the road surface to assess if maintenance is required. It is not specifically carried out after an accident. The results of SCRIM tests may be used to assess whether the road surface might have been a contributory factor where it is known that a vehicle skidded on a wet road, but even if this were considered likely, it would not necessarily imply that the road condition was sub-standard;
- results given by the SCRIM test and the police tests can appear similar. SCRIM Coefficients, which represent friction, have a typical range of 0.30 to 0.60. The Police skid test produces values that may look numerically similar but because they are from quite different measurements they are not related.

A6.23 Both groups of test are valid only for the particular purposes for which they were derived.