SERIES NG 900
ROAD PAVEMENTS - BITUMINOUS BOUND MATERIALS

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# denotes a Clause or Sample Appendix which has a substitute National Clause or Sample Appendix for one or more of the Overseeing Organisations of Scotland, Wales or Northern Ireland.

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ROAD PAVEMENTS - BITUMINOUS BOUND MATERIALS

NG 900 General

1 Advice on the design, construction and maintenance of bituminous roads is published in The Design Manual for Roads and Bridges (DMRB) Vol. 7.

NG 901 Bituminous Roadbase and Surfacing Materials

General

1 Current pavement design methods may give the Contractor a choice of construction materials. The extent of this choice should be stated in Appendix 7/1 and the alternative materials identified by reference to the Specification Clause numbers.

Requirements included in Appendix 7/1 may include grade of binder and binder modifier and aggregate properties such as polished stone value, aggregate abrasion value, aggregate impact value, soundness value and water absorption.

HD 28 gives guidance on aggregate properties for new bituminous surfacings.

Aggregates for Bituminous Materials

2 Regional knowledge may indicate aggregates with lower levels of ten per cent fines value can be accepted, where these aggregates have given satisfactory service. The levels specified are based on research by TRL with aggregates of known satisfactory and unsatisfactory service. It is expected that aggregates with a lower value than that specified could be acceptable, provided the cleanness and durability criteria are satisfactory. The same view can be extended to aggregate impact values, where regional experience indicates higher values can be acceptable.

There is no current test procedure for cleanness other than the requirement for aggregates to meet the specified BS 594 and BS 4987 requirements for the fraction passing the 75 micron sieve. Provided the aggregates meet requirements for particle size distribution, based on the washing and sieving techniques of BS 812, it is considered the cleanness aspect of the aggregates will be acceptable.

However, the coarse aggregates should be checked to ensure they are not coated with clay or silt after having gone through the drying plant and before being coated with bitumen.

The soundness value test should initially be used for source approval of aggregates, and thereafter only in cases where their durability is suspect. Where local experience indicates that an aggregate with a lower soundness value than that specified may be suitable, details of the aggregate and the appropriate soundness value should be inserted in Appendix 7/1. The soundness value test is not intended as a mandatory test for known durable aggregates. The water absorption test can be used as a routine check test of such aggregates. When required, details of the tests should be scheduled in Appendix 1/5.

A water absorption value of 2% or less for coarse aggregates is considered to indicate a satisfactory aggregate source. (This value may be exceeded by fine aggregates.) When absorption values of coarse aggregates exceed the recommended 2%, soundness tests should be carried out for compliance purposes. The appropriate value for blastfurnace slag is 4%.

Transporting, Laying and Compacting

3 The purpose of Clause 901 is to place reliance on mechanisation of operations to facilitate compliance with the thickness and surface regularity requirements, particularly of wearing courses, and to ensure operation of the paver is such that hand raking and making up of wearing course material is virtually eliminated, except at edges and joints. Hand-laying is also limited to places where operation of a paver is impracticable. Insulated trucks may not be required when weather conditions are favourable and where there is a short haul from mixing plant to laying site.

4 Clause 901 does not relate to laying waterproofing systems on bridge decks. The laying of hot paving materials on bridge deck waterproofing systems should be adequately supervised to ensure the waterproofing system is not damaged by excessive heat. Stock piling of hot materials should take place off the structure or on suitably protected areas.

5 There is no conclusive evidence to show all vibratory rollers provide consistently greater compaction than that achieved with conventional deadweight rollers. It is desirable that compaction should be maximised so a requirement for site trials of vibratory rollers, proposed as an alternative to conventional deadweight rollers, is

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included. The trial should not only determine the required number of passes of the vibratory roller, but also the frequency and amplitude of the vibrating rolls and roller speed. Additional advice is included in TRRL Report LR 1102. Where evidence is provided by the Contractor to indicate a proposed vibratory roller will achieve adequate compaction, the evidence should be representative of the conditions likely to be encountered in the Works. Factors which are relevant include types of compacted material and source of aggregate, the thickness and temperature of layers and the condition of the proposed roller compared with that previously used.

6 The frequency and amplitude of vibrating roll and travelling speed of the roller which have been found to be satisfactory in the trials should be used for compaction.

7 Appendix 7/1 should state which areas of dense macadam are to have a method compaction requirement. Remaining areas will have end result compaction testing in accordance with Clause 929. The primary consideration when making the decision will be the total volume of macadam to be laid, in order that the quantity provides justification for setting up air content test procedures.

8 When reliance is placed on a method specification for the control of compaction of bituminous materials, close attention should be paid to the temperature of the material. BS 594: Part 2, BS 4987: Part 2 and Clauses 930, 932 to 934 lay down minimum temperatures at which compaction should be substantially complete. It will therefore be necessary to commence rolling at temperatures exceeding the minimum, making due allowance for weather conditions which may affect the rate of cooling of the laid material. TRRL Report RR4 “Cooling of Bituminous Layers and Time Available for their Compaction” gives useful advice on the subject. For all practical purposes where material is tested for adequacy of compaction in accordance with Clause 929, the requirements should have been achieved above the minimum rolling temperature. Any subsequent rolling at temperatures below the minimum should only be necessary to remove roller marks and regulate the surface.

9 Compliance with sub-Clause 901.7 may not be possible when materials are used as regulating layers. Variable thicknesses will result which could be below the minimum specified in the British Standard.

NG 902 Reclaimed Bituminous Materials

1 Advice on the types of reclaimed bituminous materials permitted can be obtained from the Overseeing Organisation. Reclaimed bituminous materials include millings, planings, return loads from site and offcuts from bituminous layer joint preparation. Return loads can include bituminous materials rejected from site due to temperature problems or visual defects. Waste materials stockpiled at the plant may also be suitable.

2 All reclaimed materials should be granulated or crushed or similarly prepared before mixing with fresh aggregate and bitumen to ensure homogeneity and consistency of the final product. It may be possible to add some planings and millings directly at the plant without any form of pre-treatment.

3 Trials and a check on the recovered penetration value of the binder in the reclaimed bituminous materials must be performed when the amount of reclaimed bituminous materials to be added to the mix exceeds 10%. Mix design procedures are not specified, these being left to the expertise of the Contractor. The requirement for a trial to ensure the mixed materials have been mixed adequately and comply with the compositional and compaction requirements of this Clause is sufficient to ensure the materials are suitable for use in the pavement.

4 The material produced must meet the requirements of the Specification. Materials containing tar or tar-based binders should not be recycled. There is no requirement to check the quality of the aggregate in the recycled materials, it being presumed that as these come from existing pavements, or from material that was intended for new works, that the aggregate quality is adequate for reuse.

NG 903 Dense Macadam Roadbase

1 The penetration grade of binder should be stated in Appendix 7/1 and be that which is suitable for the design traffic. 100 penetration grade bitumen is required when the design traffic load exceeds 2.5 million standard axles (msa).

NG 904 Rolled Asphalt Roadbase

1 The composition of rolled asphalt roadbase should be chosen from one of those in Table 2 of BS 594: Part 1 to suit the thickness of the layer.

2 The penetration grade of binder should be stated in Appendix 7/1 and be that which is suitable for the design traffic. 50 penetration grade bitumen is required when design traffic load exceeds 2.5 million standard axles (msa).

NG 905 Rolled Asphalt Basecourse

1 Special requirements included in Appendix 7/1 may include grade of binder, type of coarse aggregate and permitted alternative mixtures. Advice is included in BS 594.

NG 906 Dense Macadam Basecourse

1 These materials are intended primarily for use under high temperature wearing courses, but under other wearing courses, when any extra cost can be justified, they are to be preferred to the open textured material in Clause 908.

2 Special requirements included in Appendix 7/1 may include grade of binder and type of coarse aggregate. Advice is included in BS 4987.

3 Hydrated lime should not be used as a filler in dense tarmacadam because there is some evidence to suggest it can cause hardening and brittleness.

NG 908 Single Course Macadam

1 The traffic category defined in BS 4987: Part 1 should be specified in Appendix 7/1. BS 4987: Part 1 Category A traffic may be taken as being equivalent to 2.5 million standard axles (msa), or more, for a 20 year design life.

2 Special requirements included in Appendix 7/1 may include grade of binder and type of aggregate. Advice is included in BS 4987.

NG 909 Dense Macadam Wearing Course

1 The traffic category defined in BS 4987: Part 1 should be specified in Appendix 7/1. BS 4987: Part 1 Category A traffic may be taken as being equivalent to 2.5 million standard axles (msa), or more, for a 20 year design life.

2 Special requirements included in Appendix 7/1 may include grade of binder and type of aggregate. Advice is included in BS 4987.

NG 910 Rolled Asphalt Wearing Course (Recipe Mix)

1 The appropriate table, schedule and column numbers of permitted mixtures from BS 594: Part 1 should be described in Appendix 7/1. Appendix A of BS 594: Part 1 contains recommendations on the grade of binder and the schedules to be used for specifying wearing course compositions in differing climatic and traffic conditions.

2 The Contractor may usually be permitted to select either Type F or Type C recipes. However, once that selection has been tested and proved satisfactory, no change should be made until proposals for a new mixture have been tested and proved satisfactory. Supply should always be in accordance with the selected recipe mixture.

3 Other special requirements included in Appendix 7/1 may include grade of binder, type of coarse aggregate and properties of coated chippings such as PSV and AAV. Advice is included in Departmental Standards and British Standards.

Note 1 of Table 1 of BS 594: Part 1 urges caution in the use of 40 penetration grade HD bitumen complying with BS 3690. Some mixtures incorporating this binder have been difficult to compact and have rapidly lost matrix and chippings. This bitumen is infrequently specified on trunk roads.

#NG 911 Rolled Asphalt Wearing Course (Design Mix)

1 The special requirements included in Appendix 7/1 may include the appropriate table and column numbers of permitted mixtures from BS 594: Part 1. Additionally the required Marshall stability and flow and the required properties for coated chippings, such as PSV and AAV, should be included.

2 The method of determining the design binder content for wearing course mixtures is described in BS 598: Part 107. Determination of the target binder content, by adjustment of the design binder content, is described in BS 594: Part 1 for wearing course design mixtures. The target binder content is always at or above the design binder content. The design binder content is the quantity of bitumen required for the mix in order to achieve the required stability. There are occasions when this design binder content would be too low for long term durability. Therefore a minimum target binder content is required by the British Standard and this may be above the design binder content.

3 The required Marshall stability and flow values, when tested on laboratory specimens made in accordance with BS 598: Part 107, should comply with the requirements of BS 594: Part 1, Annex B. Verification of the design should be carried out in accordance with that Annex. Samples prepared from plant-produced material, and tested in accordance with the procedures of BS 598: Part 107, are not directly comparable with those obtained on laboratory prepared specimens. The range of values of Marshall stability given in BS 594: Part 1, Annex B permit a number of mixtures using locally available materials; however the specified stability should be the mid-point of the range.

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4 The Contractor may usually be permitted to submit design proposals based on Type F or Type C composition in accordance with Tables 3 or 4 of BS 594: Part 1. However, once that submission has been tested and proved satisfactory no change in composition or the properties of the constituent materials should be made until proposals for a new design have been tested and proved satisfactory.

5 Checks on production material should normally be by analysis, in accordance with BS 598: Part 102 and comparison with the composition of the design, together with checks on the properties of the constituent materials. Advice on the possible use of Marshall tests on specimens produced from production material is given above.

6 Note 1 of Table 1 of BS 594: Part 1 urges caution in the use of 40 penetration grade HD bitumen complying with BS 3690. Some mixtures incorporating this binder have been difficult to compact and have rapidly lost matrix and chippings. This bitumen is infrequently specified on trunk roads.

NG 912 Close Graded Macadam Wearing Course

1 The nominal size of aggregate for close graded wearing course will depend upon the required layer thickness for the compacted wearing course and should be selected from BS 4987: Part 2 Table 1 and stated in Appendix 7/1.

2 The traffic category in relation to the tables of BS 4987: Part 1 should be specified in Appendix 7/1. BS 4987: Part 1 Category A traffic may be taken as being equivalent to 2.5 million standard axles (msa), or more, for a 20 year design life.

3 Special requirements included in Appendix 7/1 may include grade of binder and type of aggregate. Advice is given in BS 4987.

NG 913 Dense Tar Surfacing Wearing Course

1 To cater for a high proportion of standing vehicles the coarse aggregate content should be 50%. The nominal size of aggregate should be 14 mm for commercial vehicle hardstandings and 10 mm for car parks. These requirements should be stated in Appendix 7/1.

NG 914 Fine Graded Macadam Wearing Course

1 The traffic category in relation to the tables of BS 4987: Part 1 and the size, PSV and AAV requirements for any chippings should be specified in Appendix 7/1. BS 4987: Part 1 Category A traffic may be taken as being equivalent to 2.5 million standard axles (msa), or more, for a 20 year design life.

2 Special requirements included in Appendix 7/1 may include grade of binder and type of aggregate. Advice is given in BS 4987.

NG 915 Coated Chippings for Application to Pre-mixed Surfacings

1 It has been suggested that the use of cold pre-coated chippings from site stockpiles can cause rapid cooling of the surface of hot rolled asphalt wearing courses, potentially contributing to premature chipping loss. During periods of low ambient air temperature, it may be prudent for Contractors to consider the use of covered stockpiles.

2 When the Specification calls for high surface texture it is best to use 20 mm nominal size chippings rather than 14 mm, because deeper texture is obtained and maintained under traffic.

3 Design mix rolled asphalt wearing course materials are often stiffer than recipe mix compositions. They are less workable and, to obtain effective compaction and retention of chippings rolled into the surfacing, constraints on laying conditions may have to be considered.

4 Coking of chippings can occur during prolonged storage at high temperature. BS 594: Part 1 covers action to be taken, including cooling of the chippings and limiting the height of stacking to reduce the possibility of coking occurring.

5 The hot sand test described in BS 598: Part 108 provides a means of identifying and rejecting chippings which are unlikely to be retained in the surfacing under traffic due to coking or contamination.

NG 916 Open Graded Macadam Wearing Course

1 The traffic category in relation to the tables of BS 4987: Part 1 should be specified in Appendix 7/1. BS 4987: Part 1 Category A traffic may be taken as being equivalent to 2.5 million standard axles (msa), or more, for a 20 year design life.

2 The nominal size of aggregate for open textured macadam wearing course will depend upon the required layer thickness for the compacted wearing course and should be selected from BS 4987: Part 1 and stated in Appendix 7/1.

3 Special requirements included in Appendix 7/1 may include grade of binder and type of aggregate. Advice is given in BS 4987.

NG 918 Slurry Surfacing

General

1 This specification is a hybrid, containing elements of performance-related testing of materials, quality control of the process and end product performance. The responsibility for the design of the surfacing belongs to the Contractor and there is performance measurement of the surfacing, measured at the end of the guarantee period.

2 Four limiting gradings are provided to cover a range of situations two of which are in BS 434. The maximum thickness that these materials can be laid is about 8 mm and they should only be laid in one layer although on footways the largest nominal size material could be used for localised shaping. Except in very specific situations slurry surfacing should only be used in areas that do not normally carry any significant traffic. These specific locations would include very lightly trafficked areas such as cul-de-sacs, and for traffic delineation. If a more robust and thicker material is required then a micro-surfacing to Clause 927 could be used.

3 All coloured materials whether using bitumen emulsion or specially formulated light coloured binders should be specified using the appropriate end performance criteria.

4 When preparing the Instructions for Tendering it is essential that the compiler includes the following instructions:

(i) Tenderers' attention is drawn to the requirements for the provision of information from the Contractor, which should be provided in the tender to enable the Overseeing Organisation to assess the suitability of the Design Proposal; the Estimated Design Life; the Quality Plan; and the mixture, binder and equipment test data.

(ii) Tenderers are expected to visit all the sites, to assess the parameters required, and confirm those given in the appendices, and to design a suitable slurry surfacing.

(iii) Basic details of the tendered design for each site should be completed in the Design Proposal.

(iv) If any section of a site is considered by the Tenderer to be unsuitable for slurry surfacing this should be stated in the Design Proposal.

5 The estimated design life is required in order to assist in the assessment of tenders on a value for money basis; it is often the case that more expensive designs last longer but this should be confirmed by reference to the longevity of past contracts. The end of the design life is the time after which the surfacing should no longer be expected to provide the surface properties required at the site in question.

6 The responsibility for the provision of information upon which to base the design should be set out in the Contract, but it is expected that the Overseeing Organisation would provide the traffic data, the classification of the site in accordance with HD28 and the minimum requirements for aggregate and binder properties. The Overseeing Organisation should set out any limitations on the availability of a site in Appendix 1/13. These limitations could include requirements to avoid the site at rush hours, on market days or for particular events already planned at the time of writing the Contract. When the Contractor makes his site visit for the purposes of tendering he should make a visual assessment of the road surface and traffic category and bring any anomalies about the site to the attention of the Overseeing Organisation.

7 For the purposes of the Contract, monitoring will stop at the end of 2 years, or for innovative materials, after one third of the stated Design Life, if longer.

8 The compiler should specify the minimum PSV required for a particular site together with the maximum AAV. Guidance on the levels to specify is given in HD28; over specification should be avoided in order to conserve scarce resources. Where thin coloured slurry surfacing is used on the carriageway, even in small areas like 'village gates' they should have adequate skidding resistance. As they are thin it is not possible to provide deep texture and consideration should be given to incorporating all, or a proportion of an aggregate with a PSV higher than that indicated by HD 28, including possibly some calcined bauxite. In these circumstances it is unlikely that a conventional material to BS 434 would meet the requirements.

9 Remedial work to the existing road, for example, patching, should be carried out prior to slurry surfacing. It should be carried out in such a manner that the hardness and texture of the remedial work is sufficiently similar to the rest of the road to avoid problems of variable appearance and behaviour in the completed slurry surfacing for at least the duration of the guarantee period.

10 Cleanliness of the existing surface is extremely important. The slurry surfacing will adhere only to the top layer of the material on which it is placed and if this is mud or dust then the surfacing will fail, lacking bond with the underlying structure. It may be found necessary

in some circumstances to use high pressure washing to remove strongly adherent material. The masking of street furniture should be carried out very carefully as any cover must not be rendered immovable. In order to give a clean straight joint at the beginning and end of the work all start and finish points should be masked with a suitable material about 1 m wide for machine laid work and 0.1 m for hand laid work.

11 General weather limitations should be covered by the Contractor's Quality Plan which should include reference to any limitations set out in the British Board of Agrément HAPAS Roads and Bridges Certificate. Any site specific weather limitations should be specified under 'Special restrictions' in Appendix 7/7

12 The Overseeing Organisation may carry out audit checks on the overall rate of spread. If the results from audit checks are significantly different from those recorded by the Contractor, then the Overseeing Organisation and the Contractor should work together to determine the source of difference.

13 Traffic control immediately after slurry surfacing is critical to the production of a good quality surface. The surface should not be trafficked at all until the slurry has set sufficiently to enable it to take the traffic stresses that will be imposed. Too early opening will lead to rutting and loss of material which will require additional remedial work before the Contractor leaves the site. The surface should be monitored closely during early trafficking and if there are signs of distress due to inadequate curing the traffic control regime should be altered to keep the traffic off the slurry until it has gained adequate strength. Strength gain will be particularly slow in conditions of high humidity and/or low temperatures, ie those conditions where the rate of evaporation of the water from the emulsion is reduced. Traffickability time and cohesion tests are relevant in this context.

14 Care should be taken to ensure that the slurry surfacing bonds adequately to the underlying surface as with these very thin materials it is absolutely essential for there to be a good bond if early failure is to be avoided. Although bond may be checked using a suitable test, any unbonded areas are likely to fail within a 2 year guarantee period and will be picked up as part of the final visual assessment.

15 When incorrectly manufactured or laid slurry surfacing has poor durability and the assessment of areas of total loss of material or where specified, colour at the end of the guarantee period should be a sufficient performance measure.

16 Failure of the material to set or too rapid setting are caused by defects in workmanship or laying in inappropriate weather conditions. Work should stop until the material starts to set and should not recommence until any application faults have been rectified and the weather conditions are suitable. If the material has not been manufactured in accordance with the Design Proposal it may not set either adequately or at all and will need removal and replacement.

17 The guarantee period stated in the specification should be clearly stated as applying to the slurry surfacing. An appropriate Special Requirement should be included in the Conditions of Contract drawing particular attention to the guarantee period.

NG 919 Surface Dressing: Recipe Specification

1 This specification is of the conventional Recipe/ Method type.

2 The surface dressing should be designed in accordance with Road Note 39. Additional advice is given in HD 37. The stage 1 design binder rate of spread and its minimum grade should be set out in Appendix 7/3 for each section of the site together with the surface dressing system required and the size or sizes of chippings.

3 The Contractor should state with his tender submission the source of his aggregates and the grading and flakiness index for each source and nominal size. This enables the stage 2 rate of spread of binder to be calculated.

4 The Contractor shall state the source and type of binder he proposes to use together with the data required by Appendix 7/3.

5 The Contractor's attention should be drawn to the need for best practice as set out in RN39, Highway Authorities Product Approval Scheme (HAPAS), the Road Surface Dressing Association (RSDA) and Road Emulsion Association (REAL) documents.

6 The Vialit pendulum test should be carried out in accordance with Cl 939. The minimum binder cohesion at peak measured using the Vialit Pendulum for three grades of binder are given in Table NG 9/1. Guidance as to the choice of binder is given in the Road Note 39.

TABLE NG 9/1 Vialit Pendulum Test

Binder Grade	Minimum Peak Binder Cohesion Joules/cm^2
Premium	1.2
Intermediate	1.0
Conventional	0.5 over a minimum temperature range of 15°C

7 Product Identification Test: Penetration, softening point, Fraass Brittle point, toughness, tenacity, and other viscosity measurements are not in themselves sufficient as product identification tests, although they can be useful as quick or low cost Quality Assurance tests to check consistency from load to load of the binder. The Contractor should provide a Binder Data Sheet giving at least the information specified. In order to standardise, the product identification test has been based on the results from a dynamic shear rheometer of complex modulus and phase angle (see Clause 928). If the supplier considers that other tests would better characterise his binder then he may provide the results of these tests in addition to the requirements of sub-Clause 919.4.

8 The binder sprayer should be checked for accuracy of transverse distribution using the test method stated. This assesses the ability of the spraybar in real working conditions and may be carried out quickly using the correct binder. The Depot Tray test to BS 1707 averages the rate of spray over 60 seconds in a static condition and therefore does not simulate site conditions such as the influence of varying spraybar height above the road, or any tendency to pump or pressure surging. The performance of the binder sprayer is classified in accordance with the value of the coefficient of variation (cv) for the regularity of transverse distribution. The class required for the sprayer, to be specified in Appendix 7/3, should be selected from Table NG 9/2.

TABLE NG 9/2 Accuracy of Binder Sprayer

Site	Coefficient of Variation cv	Class
Motorways and Dual Carriageways	< 10%	3
Single Carriageways	< 12%	2
Lightly Trafficked Single Carriageways	< 15%	1

9 The compiler should specify the minimum PSV required for a particular site together with the maximum AAV. Guidance on the levels to specify is given in HD28; over specification should be avoided in order to conserve scarce resources.

10 The chipping spreader should be checked for accuracy of transverse distribution using the stated method. With multi-layered surface dressings it is very important to obtain the correct rate of spread of the larger chipping as under or over chipping will reduce the quality of the dressing and may result in it failing to perform as a multi-layered system. Particular attention should be paid to the rate of spread in the vicinity of the overlaps in the chipping spreader mechanism as the performance, particularly of worn spreaders, can be significantly different in these areas from the rest of the spreader. The performance of the chipping spreader is classified in accordance with the value of the coefficient of variation (cv) for the regularity of transverse distribution. The class required for the spreader to be specified in Appendix 7/3 should be selected from Table NG 9/3. The rate of spread for secondary chippings is less important and an excess is usually beneficial so that spreading with, for example, two tail board gritters in echelon is satisfactory.

TABLE NG 9/3 Accuracy of Chipping Spreader

Chipping Type	Coefficient of Variation cv	Class
Primary chippings in multiple layer dressings	< 10%	2
All other chippings	< 15%	1

11 Remedial work to the existing road, for example, patching, should be carried out prior to surface dressing. It should be carried out in such a manner that the hardness and texture of the remedial work is sufficiently similar to the rest of the road to avoid problems of variable appearance and behaviour in the completed dressing for at least the duration of the maintenance period; for example, patching using close textured bitumen macadam should be carried out in the previous summer otherwise it will absorb bitumen into the voids and chip loss may ensue. If the existing surface is hot rolled asphalt then the patches will have to be laid with hot rolled asphalt and preferably sufficiently far in advance of the Works for the binder to wear off the surface otherwise there will be excess binder in that area. Patches should not have a horizontal sealing strip applied as this will show through the dressing very rapidly and has been known to initiate fatting failure. The use of binder rich materials should not be used to pre-seal areas especially longitudinally in the wheel tracks as the dressing will fat up and texture will be lost.

12 Cleanliness of the existing road surface is extremely important. The binder will adhere only to the top layer of the material on which it is sprayed and if there is mud or dust then the surface dressing will fail rapidly, through the lack of bond with the underlying structure. It may be necessary in some circumstances to use high pressure washing to remove strongly adherent material. The masking of street furniture should be carried out with care as the interface between the furniture and the surrounding surface should be sprayed in order to exclude water from the road structure, but any cover must not be rendered immovable.

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13 The mode of operation of surface dressing contracts can necessitate the adoption of techniques requiring equipment for traffic management and safety over and above that normally required by static works. For example, where traffic lights are required as part of the traffic management scheme, in order to facilitate the relocation of the lights, some sites may require the provision of additional sets over and above the minimum necessary, so that the work progresses with a minimum of interruption and disruption to road users.

14 General weather limitations should be covered by the Contractor's Quality Plan. Any site specific weather limitations should be stated in Appendix 7/3. Further guidance may be obtained from HD 37.

15 In order to ensure that only the binder is overlapped on transverse joints the chipping application should stop short of the end of the binder film wherever possible. When spraying from a completed section some hand canning and masking of the end is necessary in order to abut the joint without forming a ridge.

16 Longitudinal joints should have slightly overlapped binder films obtained by leaving a wet edge approximately 100 mm wide. Care should be taken to ensure that double chipping does not take place as this will form a ridge. As the binder overlap is generally in a lightly trafficked location the additional thickness of binder film is unlikely to be a problem. Quartering (spraying of a part bar) should be avoided wherever possible, but may be necessary at tapers and other similar locations. An overlap (up to 300 mm) should be provided to ensure full rate of spread of binder at all points.

17 The frequency of testing for rates and accuracy of spread of binder and chippings should be stated in Appendix 1/5. The rate of testing should be reduced once the Contractor has demonstrated his ability to consistently meet the requirements. The more consistent a Contractor is in his work the lower the rate of testing that can be employed, a minimum rate of 1 test per day could be reached if the Contract is large enough. The Overseeing Organisation may carry out testing at audit frequency, typically at about 10% of the specified frequency for the Contractor. If the results from this audit testing are significantly different from those of the Contractor, for example, by more than the reproducibility of the test, then the Overseeing Organisation and the Contractor should work together to determine the source of difference. With this type of specification it is important that all the required testing is carried out, preferably under supervision, as it is not possible to assess the rate of spread of either binder or aggregate subsequent to the spreading of those materials.

18 The allowable tolerance on the design rate of spread of binder is dependent on the site and is classified in Table NG 9/4. The class or classes appropriate to the site should be specified in Appendix 7/3.

TABLE NG 9/4 Tolerance on Design Rate of Spread of Binder

Site	Tolerance	Class
Highly stressed sites	±6 %	4
Motorways and dual carriageways	±8 %	3
Single carriageways	±10 %	2
Lightly trafficked single carriageways	±12 %	1

19 The allowable tolerance on the design rate of spread of chippings is dependant on the site and is classified in Table NG 9/5. The class or classes appropriate to the site should be specified in Appendix 7/3.

TABLE NG 9/5 Tolerance on Design Rate of Spread of Chippings

Site	Tolerance	Class
Lightly trafficked single carriageways	±10 %	1
All other sites	±5 %	2

20 Both types of rollers specified are suitable for rolling surface dressing. The aim should be to orientate the chippings and place them in contact with the binder rather than provide compaction. There is some consensus that vibration assists in the break of emulsion binders and a re-roll can help where the 'cheesy' stage of an emulsion is prolonged. The ability of the rollers to spray water on to the drums or tyres should be checked before commencement of any work. Although water may not be needed all the time, when it is, it is needed urgently. Heavy steel wheeled rollers tend to crush chippings and their use should not be permitted.

21 Traffic control immediately after surface dressing is most crucial in the production of good quality surface dressing. On high speed roads the best way of doing this is to introduce convoy vehicles into the traffic stream in order to keep speeds low. The deployment of 10 mph signs, when permitted, is an extremely useful method of inducing caution in the road user. If possible cones should be used to vary the lane position so that as much of the dressing as possible is subjected to slow speed traffic. The lane should be suction swept prior to removal of the convoying vehicles from the traffic stream, care being taken not to remove chippings which would otherwise become part of the mosaic. With multi-layered surface dressing it may not be necessary to

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sweep, unless there are windrows which should be removed. If the work has been carried out correctly there will be no loose large chippings. Provided there are no loose large sized chippings it may be useful to gradually increase the speed of the convoying vehicles to disperse excess small chippings to the side of the lane for subsequent removal.

22 It is essential that the dressing is monitored for some time after opening to traffic, particularly in hot weather when using cutback binders, as at high temperatures the binder cohesion is low and when using emulsions in humid or cool weather, the binder takes longer to gain cohesion. Both conditions result in lower initial resistance to traffic forces and the mosaic may be destroyed. Should this happen the Contractor should be prepared to re-impose traffic control and have on site a suitable "dust" ready to use. The ideal "dust" is light coloured, absorbent and about 4 mm to 1 mm in size. Oolitic limestone and blastfurnace slag are particularly good although other materials available locally may have to be used.

NG 920 Bond or Tack Coats and Other Bituminous Sprays

1 Bond or tack coats prior to overlay are used to promote the development of a full bond. This is particularly important where thin surface courses are used. All proprietary surfacings should have a British Board of Agrément HAPAS Roads and Bridges Certificate and this will give details of the bond coat necessary on the various types of substrate on which the material can be laid.

2 Apart from bond or tack coats under thin surfacings and surface dressing, sprayed membranes of cut-back bitumen or bitumen emulsion may be required as a surface coating for formations or pavements courses for the following purposes:

(a) As a bond coat promoting adhesion between layers of material - particularly when the underlying layer is the running surface of an existing road. A bond coat should always be used on an old surface except in the rare cases where a Contractor can demonstrate that full bonding between the new material and underlying old road will be developed (this is most likely when the existing surface has free binder on the surface and is clean and free of all extraneous matter).

(b) To protect subgrades and sub-bases - careful consideration should be given to this method of protection as it can induce water to collect at formation level and cause softening of the subgrade or sub-base. It can also soften unbound substrates due to a build up of vapour pressure in warm conditions.

3 The preferred emulsion for sealing large areas, particularly in conditions of high humidity and low temperature is Class K1 - 70 but Classes K1 - 60 and A1 - 60 are also suitable in normal conditions. The emulsion manufacturer should be consulted. Where polymer modified binders are used all the data required by Clause 922 for polymer modified surface dressing binders should be provided by the Contractor in order that the Overseeing Organisation may check that the binder is the one that was intended to be used. All the data required on the binder data sheet in Appendix 7/4 should be provided.

4 Membranes may sometimes need to be blinded with fine aggregate or sand, to prevent the membrane from being picked up when being walked on or driven over.

5 Rates of spread of binder should follow the recommendations of the appropriate British Standards and Road Note 39. The rate of spread of bond or tack coats required for proprietary surfacings should be in accordance with the British Board of Agrément HAPAS Roads and Bridges Certificate for the surfacing.

NG 921 Surface Texture of Bituminous Wearing Courses on High Speed Roads

1 The depth of surface texture is more important on high speed roads than on low speed roads. A high speed road is one with an 85 percentile speed of traffic exceeding 55 miles/hour (90 km/h).

2 BS 594: Part 2 gives a rate of spread of chippings which will provide a surface of adequate skidding resistance on low speed roads when chippings with suitable polished stone value and aggregate abrasion value are used.

3 Embedment of chippings, resulting in loss of surface texture and reduced resistance to skidding at high speeds, accompanies deformation. This problem occurs most frequently in the slow lane of roads carrying a high volume of heavy commercial traffic.

4 The level of surface texture on high speed roads required for 1000 metre sections of carriageways with bituminous surfacings is an average of 1.5 mm or more. This is easily achieved with surface dressings. Experience with rolled asphalt wearing course indicates that the required texture can be consistently achieved if proper attention is paid to all the relevant factors at time of laying and applying the chippings.

5 To achieve high rates of spread, chippings must be of good shape and free flowing. The chipping machine

must be capable of spreading coated chippings at a uniform and consistently high rate. Regular checking of the rate of spread, together with any necessary adjustments to the machine, should be carried out throughout the laying of the wearing course.

6 In addition to ensuring the provision of a stable wearing course careful control over the surfacing temperature during rolling is necessary. Experience appears to show that, when 50 penetration grade bitumens are used in the manufacture of rolled asphalt wearing course, the best results are obtained where an upper limit for rolling temperature of 130°C is observed. For the 35 penetration grade and 40 penetration grade permitted alternative binders the upper rolling temperature limit should be 15°C higher.

7 Whilst measurement of texture depth for compliance purposes is to be by the sand patch method specified in BS 598: Part 105 only, the TRRL Mini Texture Meter, may be used as a screening procedure, as recommended by BS 598: Part 105.

8 Calibration trials should be undertaken at the start of work to derive a relationship between the sand patch method and the TRRL Mini Texture Meter.

9 In the event of dispute, or discrepancy between the two methods, only results obtained using the sand patch method will be considered for compliance purposes.

10 Calibrations carried out on site are only applicable to that site and that surfacing.

11 Sensor Measured Texture Depth (SMTD) is numerically different from texture depth measured by the sand patch method. Sand patch texture depth is a measurement of the average depth of the hollows in the surface below the general level of the peaks. SMTD is the standard deviation of the sample height measurements.

NG 922 Surface Dressing: Performance Specification

1 This specification is not of the conventional recipe/method type, which is covered by Clause 919. It is a hybrid, containing elements of performance-related testing of materials, quality control of the process and end product performance. The principal differences from Clause 919 are that responsibility for the design of the dressing is transferred from the Overseeing Organisation to the Contractor and that there is performance measurement of the surface dressing, measured at intervals throughout a period specified in the Contract.

2 Tenderers are expected to visit all the sites, to assess the parameters required, and in conjunction with those given in the appendices, to design a suitable surface dressing.

3 Basic details of the tendered design for each site should be completed in the Design Proposal.

4 If any site is considered by the Tenderer to be unsuitable for surface dressing this should be stated in the Design Proposal.

5 When preparing the Instructions for Tendering it is essential that the compiler includes the following information and instructions:

(i) Tenderers' attention is drawn to the requirement that Tenderers intending to sub-contract surface dressing must nevertheless provide with their tender all the information required by Clause 922 and Appendix 7/3.

(ii) In determining the award of the Contract, regard will be had not only to the price tendered but also to the following criteria:

(a) the Contract time period entered in the Form of Tender by the Tenderer.

(b) the requirements of Appendix 7/3 assessed as follows:

Contract Time Period	All tenders will be evaluated against the lowest submitted Contract period.
Design Life	All tenders will be evaluated against a theoretical 5 year design life.
QA Certification	Any tender submitting QA registrations which are not valid in the context of this scheme will not be considered.
Method Statement	All tenders will be evaluated in respect of the submitted method statement and any that do not fully comply with all the constraints contained in the Contract documents will not be considered.
Design Proposal	Any Tenderer submitting design proposals which do not fully comply with the constraints contained in the Contract Documents will not be considered.
Material Data Sheets	Any Tenderer failing to submit the materials details requested in Appendix 7/3 will not be considered.

Traffic Management	Any Tenderer failing to submit his proposals for traffic control and after care as detailed in Appendix 7/3, or not fully complying with all the constraints contained in the Contract Documents, will not be considered.
Contingency Plans	Any Tenderer failing to submit his details of contingency plans as detailed in Appendix 7/3 will not be considered.
Test Results	Any Tenderer failing to submit the test results detailed in Appendix 7/3 will not be considered.
Previous Applications	Any Tenderer failing to submit the details of previous applications, personnel, technical and managerial expertise etc as detailed in Appendix 7/3 will not be considered.

6 It is expected that the design would normally be carried out based on Road Note 39 although alternative, documented, design procedures may be used provided they take into account the particular requirements of the site. Contractors should recognise the need for best practice as set out in Road Note 39, in Road Surface Dressing Association (RSDA) and Road Emulsion Association (REAL) documents and in HD 37. An estimated design life is required in order to assist in the assessment of tenders on a value for money basis; it is often the case that more expensive designs last longer. The end of the design life is when the dressing no longer provides the surface properties required at the site in question.

7 The responsibility for the provision of information upon which to base the design should be set out in the Contract, but it is expected that the Overseeing Organisation would provide the traffic data, the classification of the site in accordance with HD28, the minimum requirements for aggregate and binder properties, and records of road surface hardness measurements carried out in accordance with Road Note 39. The compiler should set out any limitations on the availability of a site in Appendix 1/13. These limitations could include requirements to avoid the site at rush hours, on market days or for particular events already planned at the time of writing the Contract. There are problems with hardness measurements in that they need a lane closure and are best carried out when the road temperature is above 20°C, therefore it may be necessary for the Overseeing Organisation to carry out measurements during the preceding summer. When the Contractor makes his site visit for the purposes of tendering he should make a visual assessment of the road and traffic category and bring any obvious anomalies to the attention of the Overseeing Organisation.

8 For the purposes of the Contract, monitoring by the Overseeing Organisation will stop at the end of 2 years, or for novel materials, after one third of the stated Design Life, but in order to check the proposed Design Life against the actual achieved life, monitoring should continue for the whole life of the dressing. This can most conveniently be done by means of the Texture output from HRM surveys, which are currently carried out on all trunk roads every 2 years and SCRIM surveys, which are currently carried out every 3 years.

9 The Vialit pendulum test should be carried out in accordance with Clause 939. The minimum binder cohesion at peak measured using the Vialit Pendulum for three grades of binder are given in Table NG 9/6. Guidance as to the choice of binder is given in the Road Note 39.

TABLE NG 9/6 Vialit Pendulum Test

Binder Grade	Minimum Peak Binder Cohesion Joules/cm^2
Premium	1.2
Intermediate	1.0
Conventional	0.5 over a minimum temperature range of 15°C

10 Product Identification Test: Penetration, softening point, Fraass Brittle point, toughness, tenacity, and other viscosity measurements are not in themselves sufficient as product identification tests, although they can be useful as quick or low cost Quality Assurance tests to check consistency from load to load of the binder. The Contractor's Design Proposal should provide a Binder Data Sheet giving at least the information specified. In order to standardise, the product identification test has been based on the results from a dynamic shear rheometer of complex modulus and phase angle. If the supplier considers that other tests would identify his binder more precisely then he may provide the results of these tests in addition to the requirements of sub-Clause 922.5.

11 The binder sprayer should be checked for accuracy of transverse distribution using the test method stated. This assesses the ability of the spraybar in real working conditions and may be carried out quickly using the

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correct binder. The Depot Tray test to BS1707 averages the rate of spray over 60 seconds in a static condition and therefore does not simulate site conditions such as the influence of varying spraybar height above the road or any tendency to pump or pressure surging. The performance of the binder sprayer is classified in accordance with the value of the coefficient of variation (cv) for the regularity of transverse distribution. The class required for the sprayer, to be specified in Appendix 7/3, should be selected from Table NG 9/7.

TABLE NG 9/7 Accuracy of Binder Sprayer

Site	Coefficient of Variation cv	Class
Motorways and Dual Carriageways	< 10%	3
Single Carriageways	< 12%	2
Lightly Trafficked Single Carriageways	< 15%	1

12 The compiler should specify the minimum PSV required for a particular site together with the maximum AAV. Guidance on the levels to specify is given in HD 28; over specification should be avoided in order to conserve scarce resources.

13 The chipping spreader should be checked for accuracy of transverse distribution using the stated method. With multi-layered surface dressings it is very important to obtain the correct rate of spread of the larger chipping as under or over chipping will reduce the quality of the dressing and may result in it failing to perform as a multi-layered system. Particular attention should be paid to the rate of spread in the vicinity of the overlaps in the chipping spreader mechanism as the performance, particularly of worn spreaders, can be significantly different in these areas from the rest of the spreader. The performance of the chipping spreader is classified in accordance with the value of the coefficient of variation (cv) for the regularity of transverse distribution. The class required for the spreader to be specified in Appendix 7/3 should be selected from Table NG 9/8. The rate of spread for secondary chippings is less important and an excess is usually beneficial so that spreading with, for example, 2 tail board gritters in echelon is satisfactory.

TABLE NG 9/8 Accuracy of Chipping Spreader

Chipping Type	Coefficient of Variation cv	Class
Primary chippings in multiple layer dressings	< 10%	2
All other chippings	< 15%	1

14 Remedial work to the existing road, (for example patching) should be carried out prior to surface dressing. It should be carried out in such a manner that the hardness and texture of the remedial work is sufficiently similar to the rest of the road to avoid problems of variable appearance and behaviour in the completed dressing for at least the duration of the maintenance period; for example, patching using close textured bitumen macadam should be carried out in the previous summer otherwise it will absorb bitumen into the voids and chip loss may ensue. If the existing surface is hot rolled asphalt then the patches will have to be laid with hot rolled asphalt and preferably sufficiently far in advance of the works for the binder to wear off the surface otherwise there will be excess binder in that area. Patches should not have a horizontal sealing strip applied as this will show through the dressing very rapidly and has been known to initiate fatting failure. The use of binder rich materials similar to stress absorbing membrane interlayers (SAMIs) should not be used as the dressing will fat up.

15 Cleanliness of the existing road surface is extremely important. The binder will adhere only to the top layer of the material on which it is sprayed and if there is mud or dust then the surface dressing will fail rapidly through the lack of bond with the underlying structure. It may be necessary in some circumstances to use high pressure washing to remove strongly adherent material. The masking of street furniture should be carried out with care as the interface between the furniture and the surrounding surface should be sprayed in order to exclude water from the road structure, but any cover must not be rendered immovable.

16 The mode of operation of surface dressing contracts can necessitate the adoption of techniques requiring equipment for traffic management and safety over and above that normally required by static works. For example, where traffic lights are required as part of the traffic management scheme, in order to facilitate the relocation of the lights, some sites may require the provision of additional sets over and above the minimum necessary, so that the work progresses with a minimum of interruption and disruption to road users.

17 General weather limitations should be covered by the Contractor's Quality Plan. Any site specific weather limitations should be stated under 'Special Restrictions' in Appendix 7/3. Further guidance may be obtained from HD 37.

18 In order to ensure that only the binder is overlapped on transverse joints the chipping application should stop short of the end of the binder film wherever possible. When spraying from a completed section some hand canning and masking of the end is necessary in order to abut the joint without forming a ridge.

19 Longitudinal joints should have slightly overlapped binder films obtained by leaving a wet edge approximately 100 mm wide. Care should be taken to ensure that double chipping does not take place as this will form a ridge. As the binder overlap is generally in a lightly trafficked location the additional thickness of binder film is unlikely to be a problem. Quartering (spraying of a part bar) should be avoided wherever possible, but may be necessary at tapers and other similar locations. An overlap up to 300 mm should be provided to ensure full rate of spread of binder at all points.

20 The frequency of testing for rates and accuracy of spread of binder and chippings should be stated in Appendix 1/5 (see Appendix NG 1/1). The rate of testing should be reduced once the Contractor has demonstrated his ability to consistently meet the requirements. The more consistent a Contractor is in his work the lower the rate of testing that can be employed. A minimum rate of 1 test per day could be reached if the Contract is large enough. The Overseeing Organisation may carry out testing at audit frequency, typically at about 10% of the specified frequency for the Contractor. If the results from this audit testing are significantly different from those of the Contractor, for example, by more than the reproducibility of the tests, then the Overseeing Organisation and the Contractor should work together to determine the source of difference.

21 The allowable tolerance on the design rate of spread of binder is dependent on the site and is classified in Table NG 9/9. The class or classes appropriate to the site should be specified in Appendix 7/3.

TABLE NG 9/9 Tolerance on Design Rate of Spread of Binder

Site	Tolerance	Class
Highly Stressed Sites	± 6%	4
Motorways and Dual Carriageways	± 8%	3
Single Carriageways	± 10%	2
Lightly Trafficked Single Carriageways	± 12%	1

22 The allowable tolerance on the design rate of spread of chippings is dependent on the site and is classified in Table NG 9/10. The class appropriate to the site should be specified in Appendix 7/3.

TABLE NG 9/10 Tolerance on Design Rate of Spread of Chippings

Site	Tolerance	Class
Lightly Trafficked Single Carriageways	±10%	1
All Other Sites	± 5%	2

23 Both types of roller specified are suitable for rolling surface dressing. The aim should be to orientate the chippings and place them in contact with the binder rather than provide compaction. There is some consensus that vibration assists in the break of emulsion binders and a re-roll can help where the 'cheesy' stage of an emulsion is prolonged. The ability of the rollers to spray water on to the drums or tyres should be checked before commencement of any work. Although water may not be needed all the time, when it is, it is needed urgently. Heavy steel wheeled rollers tend to crush chippings and their use should not be permitted.

24 Traffic control immediately after surface dressing is most crucial in the production of good quality surface dressing. On high speed roads the best way of doing this is to introduce convoy vehicles into the traffic stream in order to keep speeds low. The deployment of 10 mph signs, when permitted, is an extremely useful method of inducing caution in the road user. If possible cones should be used to vary the lane position so that as much of the dressing as possible is subjected to slow speed traffic. The lane should be suction swept prior to removal of the convoy vehicles from the traffic stream, care being taken not to remove chippings which would otherwise become part of the mosaic. With multi-layered surface dressing it may not be necessary to sweep unless there are windrows which should be removed. If the work has been carried out correctly there will be no

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loose large chippings. Provided there are no loose large sized chippings it may be useful to gradually increase the speed of the convoying vehicles to disperse excess small chippings to the side of the lane for subsequent removal.

25 It is essential that the dressing is monitored for some time after opening to traffic, particularly when using cutback binders in hot weather, as at high temperatures the binder cohesion is low. When using emulsions in humid or cool weather, the binder takes longer to gain cohesion. Both conditions result in lower initial resistance to traffic forces and the mosaic may be destroyed. Should this happen the Contractor should be prepared to re-impose traffic control and have on site a suitable 'dust', ready to use. The ideal 'dust' is light coloured, absorbent and about 4 mm to 1 mm in size. Oolitic limestone and blastfurnace slag are particularly good although other materials available locally may have to be used.

26 Because of the amount of texture depth measurement to be undertaken, high speed sensor measurements should be used. They also avoid the need for additional lane closures, which sand patch testing or the mini texture meter would require. Other methods may be used, but the results should be reported as sand patch test equivalent texture depth. Lightly trafficked roads should be assessed for cleanliness and cleaned if necessary before measurements are made. This would not normally be necessary on roads carrying heavy or fast traffic. The use of high speed measurements also enables long term monitoring as part of the routine HRM surveys. The texture depth for high speed roads at the end of the guarantee period would normally be specified at 1.5 mm measured by the sand patch test. Depending on traffic levels, lower textures at the end of the guarantee period may be specified in Appendix 7/3 for roads carrying traffic at speeds below 90 km/hr, as shown in Table NG 9/11.

TABLE NG 9/11 Minimum Sand Patch Test Texture Depth Requirements

Traffic cv/lane/day	Speed limit 50mph or higher	Speed limit 40mph or lower
Over 3250	1.5	1.5
250 - 3250	1.5	1.2
Less than 250	1.5	1.0

The decrease in texture between 12 and 24 months is a guide to the life of the dressing, the lower the value the longer the life, unless other failure mechanisms intervene. A maximum reduction in texture of 40% should be specified in Appendix 7/3. An increase in texture depth over this period indicates that the surface is losing chippings.

27 Procedures used for the visual assessment of defects should be in accordance with the test method stated. It is anticipated that because surface dressing defects are usually obvious the need for a formal assessment procedure will be rare. The visual assessment of fretting P1, expressed as a percentage of chipping loss, is classified in Table NG 9/12. The class appropriate to the site should be specified in Appendix 7/3.

28 The guarantee period stated in the specification should be clearly stated as applying to the surface dressing. An appropriate Special Requirement should be included in the Conditions of Contract drawing particular attention to the guarantee period.

TABLE NG 9/12 Defect Classification : Fretting

Site	Fretting: % Chipping Loss P1	Class
Motorways	≤ 4%	4
Dual and Stressed Single Carriageways	≤ 6%	3
Single Carriageways	≤ 8%	2
Lightly Trafficked Single Carriageways	≤ 10%	1

The visual assessment of all defects except fretting, (P2), expressed as a percentage of area, is classified in Table NG 9/13. The class appropriate to the site should be specified in Appendix 7/3.

TABLE NG 9/13 Defect Classification : All Defects except Fretting

Site	% Area Affected P2	Class
Motorways	≤ 2%	4
Dual and Stressed Single Carriageways	≤ 4%	3
Single Carriageways	≤ 6%	2
Lightly Trafficked Single Carriageways	≤ 8%	1

The visual assessment of localised chipping loss in an area of one square metre, (P3), expressed as a percentage using the method of test for fretting (P1), is

classified in Table NG 9/14. The class appropriate to the site should be specified in Appendix 7/3.

TABLE NG 9/14 Defect Classification : Localised Chipping Loss

Site	% Localised Chipping Loss: P3	Class
Lightly Trafficked Single Carriageways	≤ 20%	1
All Other Sites	≤ 10%	2

NG 923 Binder Recovery Method: Preparation of Recovered Binder from Bituminous Emulsions and Cut-back Bituminous Binders

1 The term 'recovered binder', rather than 'residual', has been used to avoid confusion with CEN test methods.

2 Nitrogen gas is used, rather than air, to minimise ageing of the binder and to increase safety.

3 This recovery method attempts to simulate the state of a binder film soon after spraying using conventional surface dressing or bond coating equipment; the method is not intended to drive off all the volatile components nor to remove every molecule of water.

4 The percentage loss of weight should be recorded as an indicator of water and/or volatile oil losses.

Note: The period required to do this may be much shorter than that prescribed in ASTM D2872-88, as modern ovens with micro-processor controls stabilise very quickly, eg. within 1 hr.

NG 924 High Friction Surfaces

1 Experience has shown these surfacings to be highly effective in reducing traffic accidents on sites with high traffic density and skidding risk. Typical sites are the approaches to signal controlled junctions, to roundabouts and pedestrian crossings subject to a heavy flow of vehicles.

2 These surfacings are expensive, particularly if productivity is affected by the geometry of a site and the number of areas to be treated. The use of cheaper alternatives should be considered, if feasible, such as improved road signs and markings, improved street lighting, or surface dressing with a high PSV natural aggregate bonded with a binder capable of withstanding the braking forces generated, etc.

3 High friction surface treatments are now available based on a variety of binders, both thermosetting and thermoplastic. Depending on the type of binder, high PSV aggregates - most commonly calcined bauxite - are either broadcast over a pre-applied binder film or pre-blended with binder and the mixture applied. On heavily trafficked sites, the durability of different systems can vary greatly. To avoid discriminating against those products that are suitable only for moderately or lightly trafficked sites, and also to encourage innovation, the BBA/HAPAS certification scheme to assess high friction surfacings has been set up. High friction surfacing systems are classified during the assessment into three types, as shown in Table NG 9/15. The type or types permitted appropriate to the traffic level on a site should be specified in Appendix 7/1, - Types 1,2 & 3 for very lightly trafficked sites, Types 1 & 2 for moderately trafficked sites and Type 1 for heavily trafficked sites.

4 Each Type classification has an expected service life of between 5 to 10 years at the maximum traffic levels shown in Table NG 9/15. A Type 1 system used on a moderately or lightly trafficked site can offer a much extended life, twenty years is not unknown. Conversely a Type 3 system used on a heavily trafficked site will have a much reduced working life. Site constraints and the time of year can favour the use of less robust systems for convenience. This should not be permitted unless safety or other reasons mean there is no alternative. In such circumstances replacement may be necessary within two to three years.

5 High friction surfacing should be applied strictly in accordance with the current system method statement provided in accordance with the British Board of Agrément HAPAS Roads and Bridges Certificate. Systems should only be installed on surfaces which are dry, hard and sound, and free from dust, oil, excess bitumen or other contaminants that may cause lack of adhesion. Surfaces not suitable for treatment include slurry surfacing, micro-surfacing, fatted and multilayer surface dressings and surface dressings over soft or unsound bases. Performance on concrete may not be as good as on bituminous surfacings and the suitability of a system should be checked by reference to the British Board of Agrément HAPAS Roads and Bridges Certificate.

6 High friction surfacing systems are best applied to wearing courses that have been trafficked for some weeks prior to installation of the surfacing. For reasons that are not entirely understood, on occasion cracking which extends into the wearing course can be induced by the application of high friction surfacing. The risk of this occurring is much greater when the wearing course is newly applied and untrafficked. Provided the high friction surfacing is well bonded to the substrate and with the agreement of the Overseeing Organisation, the

TABLE NG 9/15 High Friction Surfaces : Area of Application by Type Classification*

Site Category (As defined in HD 28)	Site Definition	Maximum Traffic Levels (Commercial Vehicle per lane per day)		
		Type 1	Type 2	Type 3
F G1 H1 L	Approaches to and across major junctions (all limbs). Gradient 5 % to 10 %, longer than 50 m. Bend (not subject to 40 mph or lower speed limit) radius 100 - 250 m. Roundabout.	3500	1000	250
G2 H2	Gradient > 10 %, longer than 50 m. Bend (not subject to 40 mph or lower speed limit) radius < 100 m.	2500	750	175
J/K	Approach to roundabout, traffic signals, pedestrian crossing, railway level crossing etc.	2500	500	100

*Each type classification has an expected service life of between 5 and 10 years at the maximum traffic levels shown.

cracking may be sealed using a suitable epoxy or similar resin and the high friction surfacing made good. Any cracks in excess of 0.5 mm are the liability of the Contractor under the terms of the guarantee required in sub-Clause 924.7.

7 The minimum polished stone value of the aggregate used in high friction surfacing systems, determined in accordance with BS 812: Part 114, to be specified in Appendix 7/1 can be obtained from HD 28.

8 If no BBA/HAPAS certificates have been issued, advice on which high friction surfacing systems are nearing completion of their BBA assessment should be obtained from the British Board of Agrément.

NG 925 Testing of Bituminous Mixtures and Their Component Materials

1 Methods of sampling and testing of mixtures or materials not covered by a British Standard, eg. sampling plates behind the paver, should be specified in Substitute or Additional Clauses. Non-standard sampling procedures are not recommended.

2 Where alternative sampling procedures are given in the British Standard it is recommended that site sampling should be adopted.

3 The frequency of acceptance testing for mixed materials should be approximately one test for every 100 tonnes of material laid in straight runs, but not less than two samples of mixed material manufactured to any one specification should be taken daily. On contracts where the output of mixed materials is large, frequency of testing may be reduced if the quality of the material being supplied is consistently satisfactory.

4 The Hot Sand Test is not to be used to assess the suitability of coated chippings to be used in surface dressing.

The following provisional precision data is given for the Hot Sand Test:

Repeatability (r) - 8 g/kg
Reproducibility (R) - 12 g/kg

NG 926 In Situ Recycling - The Remix and Repave Processes

1 Guidance to the requirements specified in Clause 926 is contained in HD31.

2 The Overseeing Organisations are satisfied that provided certain criteria are met the Remix and Repave processes are an acceptable alternative to conventional resurfacing. The processes are considered suitable for restoration of hot rolled asphalt wearing courses and can

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be used when weather conditions might prevent the use of conventional plant.

3 Where the suitability of resurfacing works for the Remix or Repave process has been established it should always be included as an option in tender documents or accepted as an alternative method by suitably equipped contractors following the award of a contract.

NG 927 Micro-surfacing

General

1 This specification is a hybrid, containing elements of performance-related testing of materials, quality control of the process and end product performance. The responsibility for the design of the surfacing belongs to the Contractor and there is performance measurement of the surfacing, measured at intervals throughout a period specified in the Contract.

2 The specification allows considerable freedom to the Contractor in the formulation of the micro-surfacing. Three limiting gradings are provided to cover a range of situations; the alternative gradings are technically similar but use the 2 alternative sets of sieves used in CEN standards. Micro-surfacings can be laid to a significant thickness and can provide a regulating function, and a varying amount of macro-texture. For thinner materials used in untrafficked or very lightly trafficked areas Clause 918 Slurry Surfacing may be used.

3 When preparing the Instructions for Tendering it is essential that the compiler includes the following instructions:

(i) Tenderers' attention is drawn to the requirements for the provision of information from the Contractor, which should be provided in the tender to enable the Overseeing Organisation to assess the suitability of the Design Proposal; the Estimated Design Life; the Quality Plan; and the mixture, binder and equipment test data.

(ii) Tenderers are expected to visit all the sites, to assess the parameters required, and confirm those given in the appendices, and to design a suitable micro-surfacing.

(iii) Basic details of the tendered design for each site should be completed in the Design Proposal.

(iv) If any section of a site is considered by the Tenderer to be unsuitable for micro-surfacing this should be stated in the Design Proposal.

4 The estimated design life is required in order to assist in the assessment of tenders on a value for money basis; it is often the case that more expensive designs last longer. The end of the design life is when the surfacing no longer provides the surface properties required at the site in question.

5 The responsibility for the provision of information upon which to base the design should be set out in the Contract, but it is expected that the Overseeing Organisation would provide the traffic data, the classification of the site in accordance with HD28, the minimum requirements for aggregate and binder properties, and an estimate of the average rut depth and other irregularities that have to be removed. The Overseeing Organisation should set out any limitations on the availability of a site in Appendix 1/13. These limitations could include requirements to avoid the site at rush hours, on market days or for particular events already planned at the time of writing the Contract. When the Contractor makes his site visit for the purposes of tendering he should make a visual assessment of the road surface and traffic category and bring any anomalies about the site to the attention of the Overseeing Organisation.

6 For the purposes of the Contract, monitoring will stop at the end of 2 years, or for innovative materials, after one third of the stated Design Life. This can most conveniently be done by means of the Texture, Rutting and Short Wavelength irregularity outputs from HRM surveys, which are currently carried out on all trunk roads every 2 years.

7 The compiler should specify the minimum PSV required for a particular site together with the maximum AAV. Guidance on the levels to specify is given in HD28; over specification should be avoided in order to conserve scarce resources.

8 Remedial work to the existing road, for example, patching, should be carried out prior to micro-surfacing. It should be carried out in such a manner that the hardness and texture of the remedial work is sufficiently similar to the rest of the road to avoid problems of variable appearance and behaviour in the completed micro-surfacing for at least the duration of the guarantee period.

9 Cleanliness of the existing road surface is extremely important. The micro-surfacing will adhere only to the top layer of the material on which it is placed and if this is mud or dust then the surfacing will fail, lacking bond with the underlying structure. The masking of street furniture should be carried out very carefully as any cover must not be rendered immovable. In order to give a clean straight joint at the beginning and end of the work all start and finish points should be masked with a suitable material about 1 m wide.

10 General weather limitations should be covered by the Contractor's Quality Plan which should include reference to any limitations set out in the British Board of Agrément HAPAS Roads and Bridges Certificate. Any site specific weather limitations should be specified under 'Special Restrictions' in Appendix 7/8.

11 The Overseeing Organisation may carry out audit checks on the overall rate of spread. If the results from audit checks are significantly different from those recorded by the Contractor, then the Overseeing Organisation and the Contractor should work together to determine the source of difference.

12 Traffic control immediately after micro-surfacing is most crucial in the production of a good quality surface. The surface should not be trafficked at all until the surfacing has set sufficiently to enable it to take the traffic stresses that will be imposed. Too early opening will lead to rutting and loss of material which will require additional remedial work before the Contractor leaves the site. The surface should be monitored closely during early trafficking and if there are signs of distress due to inadequate curing the traffic control regime should be altered to keep the traffic off the surfacing until it has gained adequate strength. Strength gain will be particularly slow in conditions of high humidity and/or low temperatures, ie those conditions where the rate of evaporation of the water from the emulsion is reduced. Traffickability time and cohesion tests are relevant in this context.

13 As part of the normal traffic control on roads carrying high speed traffic there should be a mandatory 50 mph speed limit in place for the duration of the work. If micro-surfacing is being used in this situation (assuming a design is produced and approval given) it should be designed to be opened to 50 mph traffic on completion of initial sweeping. There should follow a number of days of trafficking at this speed with the traffic management being organised in such a manner that all lanes have at least 48 hours of speed limited trafficking within a minimum of 72 hours of first opening the carriageway to controlled traffic. This period, or such other, longer period, that either the compiler states in Appendix 7/8 or the micro-surfacing Contractor requires for his process shall be included within the works programme. The Overseeing Organisation will not normally require a longer period than this but may do so if the traffic on the section is unusually light or the work is required to be carried late in the season, ie during October. The micro-surfacing Contractor may determine the need for a longer period from experience with the particular process that is proposed. All loose aggregate shall be removed from any trafficable part of the carriageway or hard shoulder prior to removing the temporary contract speed limit from the works.

14 The high speed sensor measurements should be used for measuring texture depth because of the amount of measurement to be undertaken. This also avoids the need for additional lane closures, which sand patch testing or the mini texture meter would require. Other methods may be used, but the results should be reported as sand patch test equivalent texture depth. Lightly trafficked roads should be assessed for cleanliness and cleaned if necessary before measurements are made. This would not normally be necessary on roads carrying heavy or fast traffic. The use of high speed measurements also enables long term monitoring as part of the routine HRM surveys. The texture depth for high speed roads at the end of the guarantee period would normally be specified at 1.5 mm measured by the sand patch test. Depending on traffic levels, lower textures at the end of the guarantee period may be specified in Appendix 7/8 for roads carrying traffic at speeds below 90 km/hr, as shown in Table 9/16.

TABLE NG 9/16 Minimum Sand Patch Texture Depth Requirements at the End of the Guarantee Period

Traffic cv/lane/day	Speed limit 50 mph or higher	Speed limit 40 mph or lower
Over 3250	1.5	1.5
250 - 3250	1.5	1.2
Less than 250	1.5	1.0

15 The decrease in texture between 12 and 24 months is a guide to the life of the surfacing, the lower the value the longer the life, unless other failure mechanisms intervene. A reduction in texture over this period of not more than 40% should be specified in Appendix 7/8. An increase in texture depth over this period indicates that the surface is losing aggregate.

16 Procedures used for the visual assessment of defects should be in accordance with the draft test method as stated, but a later draft may be used with the agreement of the Overseeing Organisation. It is anticipated that because micro-surfacing defects are usually obvious the need for a formal assessment procedure will be rare. The visual assessment of fretting and ravelling is the area losing material expressed as a percentage of the area of the section being assessed, is classified in Table NG 9/17. The class appropriate to the site should be specified in Appendix 7/8.

TABLE NG 9/17 Defect Classification : Fretting and Ravelling

Site	Fretting and Ravelling: % of surface losing material	Class
Motorways	≤ 4%	4
Dual and stressed Single Carriageways	≤ 6%	3
Single Carriageways	≤ 8%	2
Lightly Trafficked Single Carriageways	≤ 10%	1

17 The visual assessment of all defects except fretting and ravelling, expressed as a percentage of area, is classified in Table NG 9/18. The class appropriate to the site should be specified in Appendix 7/8.

TABLE NG 9/18 Defect Classification: All Defects Except Fretting

Site	% Area Affected	Class
Motorways	≤ 2%	4
Dual and Stressed Single Carriageways	≤ 4%	3
Single Carriageways	≤ 6%	2
Lightly Trafficked Single Carriageways	≤ 8%	1

18 The visual assessment of localised defects other than potholes in an area of one square metre, expressed as a percentage, using the method of test for fretting and ravelling is classified in Table NG 9/19. The class appropriate to the site should be specified in Appendix 7/8.

TABLE NG 9/19 Defect Classification : Localised Material Loss

Site	% Localised Aggregate Loss in a square metre	Class
Lightly Trafficked Single Carriageways	≤ 20%	1
All Other Sites	≤ 10%	2

19 Failure of the material to set or too rapid setting are caused by defects in workmanship or laying in inappropriate weather conditions. Work should stop until the material starts to set and should not recommence until any application faults have been rectified and the weather conditions are suitable.

20 Surface irregularity is measured in two ways as described in Clause 702, but as micro-surfacing is laid in a different manner to the method assumed in that Clause the micro-surfacing should meet the appropriate Class given in Table NG 9/20 for transverse regularity and Table NG 9/22 for longitudinal regularity. The class limits are given in Table NG 9/21 for the former and in Table NG 9/23 for the latter.

TABLE NG 9/20 Transverse Regularity - Requirements

Site	Class
Motorways, dual carriageways and single carriageways with a speed limit greater than 40 mph	3
Single carriageways with a 40 mph or lower speed limit, carrying more than 100 cv/l/d or more than 1000 v/l/d and roads carrying less traffic where the cross fall is less that 2%.	2
All other roads	1
Roads where sealing only is required (ie regulating is not a requirement)	0

TABLE NG 9/21 Transverse Regularity - Class Limits

Class	Maximum allowable difference between 3 m straight edge and the road, mm	
	New	At end of guarantee period
3	3	5
2	4	7
1	6	10
0	no requirement	no requirement

TABLE NG 9/22 Longitudinal Regularity - Requirements

Site	Class
Motorways, dual carriageways and single carriageways with a speed limit greater than 40 mph	3
Single carriageways with a 40 mph or lower speed limit, carrying more than 100 cv/l/d or more than 1000 v/l/d.	2
All other roads	1
Roads where sealing only is required (ie regulating is not a requirement)	0

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TABLE NG 9/23 Longitudinal Regularity - Class Limits

	Irregularity				
	4 mm		7 mm		10 mm
Length	300 m	75 m	300 m	75 m	any
Class 3	20	9	2	1	0
Class 2	40	18	4	2	0
Class 1	60	27	6	3	0
Class 0	no requirement	no requirement	no requirement	no requirement	no requirement

21 The guarantee period stated in the specification should be clearly stated as applying to the micro-surfacing. An appropriate Special Requirement should be included in the Conditions of Contract drawing particular attention to the guarantee period.

NG 928 Determination of the Complex Stiffness Modulus (G*) and Phase Angle (δ) of Bituminous Binders using a Dynamic Shear Rheometer (DSR)

1 Most rheometers operate using an air bearing; to avoid damage, the air supply to the bearing must be switched on before the instrument is switched on. When not in use the spindle should be secured. Such instruments must not be operated without air.

2 When the rheometer uses water or other liquid as the temperature control mechanism, it is advisable to use glycol or a mixture of glycol and water for low temperature work (below 5°C).

3 Caution needs to be exercised in the selection of the plate geometry in order to be assured of achieving accurate results. If not known, the operational limits of stiffness must be determined for each plate geometry in each DSR (either by the manufacturer or the operator). Measurements carried out beyond the limits will give increasingly inaccurate results. Software correction to the stiffness may be acceptable providing appropriate validation is available.

4 Gap settings within the range 0.5 mm to 2 mm have been found to be suitable for bituminous binders over the temperature range (-5°C to +60°C) for parallel plate geometries. The gap set will change with temperature and appropriate steps will need to be taken into account for these changes. If the DSR has automatic gap compensation feature then the gap may be set at any temperature within the range to be covered. If the DSR has no gap compensation feature, the gap should be set at the mid temperature of the range to be covered. A suitable means of correcting for gap changes should be used; one way is to gap at each temperature, another is to apply software corrections.

5 Normally 2 plate diameters will be required but one may suffice in some circumstances.

6 To check that the test is being carried out within the linear range is most conveniently made by carrying out a torque sweep at both the highest and lowest temperature to be used for the rheological characterisation. For the majority of binders it has been found that testing at a strain level of between 0.5% and 1.0% lies within the linear (elastic) region.

7 It has been found convenient to test at (approximately) the following temperatures as the minimum number needed to generate master curves: -5, 5, 15, 25, 35, 45 and 60°C. Eleven equally spaced logarithmic frequencies including 0.1 and 10 Hz have been found to be acceptable. Some DSRs can test a wider frequency range than the minimum, if advantage is taken of this then the number of frequencies tested should be increased appropriately. Where the DSR used has pre-set frequencies as close an approximation to the even logarithmic spacing should be used as is possible.

8 Care should be taken at the lowest temperature that the torque required to shear the sample is not introducing errors into the measurement of the angle through which the sample is being turned (this is often called machine compliance and should be checked with the rheometer manufacturer).

9 For most binders, over the range 5°C to 60°C it has been found that an 8 mm diameter plate will give sufficiently precise results (although it may be limited at the high temperature end by the precision with which torque can be measured). It may be more convenient to test over the whole range with one test geometry and then to review the results to determine whether a second or even a third geometry may be necessary.

10 Measurements of stiffness in excess of 10^8 Pa may be subject to error, even with the smallest and thickest geometry, however they may be acceptable if fully validated by an alternative test method where negligible machine compliance is involved.

11 In order to construct a good master curve it is essential that there is considerable overlap between adjacent sections of the shifted data. 50% overlap is suggested as desirable. The degree of overlap can be increased either by using more temperatures or by increasing the frequency range at each temperature. It is not necessary that the same frequencies shall be used at all temperatures.

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12 Tables NG 9/24 and NG 9/25 give informative test details.

TABLE NG 9/24 Approximate Sample Volumes for Parallel Plate Geometry (Informative)

Gap mm	8 mm plate ml	10 mm plate ml	15 mm plate ml	20 mm plate ml	25 mm plate ml	40 mm plate ml
0.5	0.03	0.04	0.09	0.16	0.25	0.66
1	0.05	0.08	0.18	0.31	0.49	1.3
2	0.1	0.16	0.35	0.63	0.98	2.6

TABLE NG 9/25 Limits of Accuracy of Complex Stiffness Modulus Measurements using one DSR and Two Parallel Plate Geometries (Informative)

(Shaded rows meet the 15% test Data Acceptability Criterion for G* in sub-Clause19)

25 mm PP geometry			
Gap mm	G* actual Pa	G* measured Pa	Accuracy %
2	1.00E+9	8.4E+6	**0.8**
2	1.00E+8	7.7E+6	**8**
2	1.00E+7	4.6E+6	**46**
2	1.00E+6	8.9E+5	**89**
2	1.00E+5	9.9E+4	**99**
1	1.00E+9	4.2E+6	**0.4**
1	1.00E+8	4.04E+6	**4**
1	1.00E+7	3.0E+6	**30**
1	1.00E+6	8.1E+5	**81**
1	1.00E+5	9.8E+4	**98**
0.5	1.00E+9	2.1E+6	**0.2**
0.5	1.00E+8	2.1E+6	**2**
0.5	1.00E+7	1.7E+6	**17**
0.5	1.00E+6	6.8E+5	**68**
0.5	1.00E+5	9.6E+4	**96**
8 mm PP geometry			
Gap mm	G* actual Pa	G* measured Pa	Accuracy %
2	1.00E+9	4.1E+8	**41**
2	1.00E+8	8.7E+7	**87**
2	1.00E+7	9.9E+6	**99**
2	1.00E+6	1.0E+6	**100**
2	1.00E+5	1.0E+5	**100**
1	1.00E+9	2.6E+8	**26**
1	1.00E+8	7.8E+7	**78**
1	1.00E+7	9.7E+6	**97**
1	1.00E+6	1.0E+6	**100**
1	1.00E+5	1.0E+5	**100**
0.5	1.00E+9	1.5E+8	**15**
0.5	1.00E+8	6.3E+7	**63**
0.5	1.00E+7	9.5E+6	**95**
0.5	1.00E+6	9.9E+5	**99**
0.5	1.00E+5	1.0E+5	**100**

NG 929 Design, Compaction Assessment and Compliance of Roadbase and Basecourse Macadams

1 The Specification for Highway Works (SHW) requires compaction trials to be carried out when bitumen macadam, DBM50 or heavy duty macadam are used for roadbase or basecourse, unless otherwise stated in Appendix 7/1.

2 Clause 929 permits Contractors to design macadams to meet an 'end product' specification and represents a major departure from the traditional 'recipe' approach previously used in the UK. BS 4987: Part 1 sets out well established recipes for macadams based on past experience but regardless of material source or type. Clause 929 requires that a Contractor's proposed target aggregate grading and target binder content lie within the fixed composition envelopes and binder contents specified in BS 4987: Part 1. However in order to allow as much freedom as possible to the Contractor in designing a mix appropriate to the materials to be used, the tolerances that may be applied to the proposed target aggregate grading and the target binder content are set out in Table 9/3. The Contractor's design trials may involve mixtures compacted in the laboratory or field laying trials, at the option of the Contractor. This note should be read in conjunction with NG 929.11

3 BS 4987 provides no guidance on the design of mixes to achieve stable mixtures resistant to deformation nor any guidance on trials to validate mix designs. The objectives of the Job Mixture Approval trial are to demonstrate that the mix will be stable and resistant to deformation and that it will be durable. This should be achieved by ensuring that there is always a minimum air void content in the mixture even at the ultimate state of compaction at the Refusal Density, as determined by the procedures set out in BS 598: Part 104, and by ensuring that the in situ void content is not excessive. It should be noted that a design procedure is not being proposed, rather a means by which a Contractor's proposals for a macadam mixture may be evaluated.

4 Nuclear density gauges in general use typically penetrate to a depth of approximately 80 mm. Where layer thicknesses exceed 80 mm it is especially important that cores are visually inspected to ensure that they are reasonably uniform. A slight increase in voidage at the base may be expected but it should not be excessive. If voidage is excessive additional cores will establish the area affected. Further information regarding the use of nuclear density gauges is given in the Transport and Road Research Laboratory Supplementary Report SR 754.

5 The average binder content by volume at each location in the trial area is determined to check that the minimum binder content of the Contractor's mix design exceeds the minimum volume specified to ensure the durability of the mixture.

6 The stiffness modulus and deformation resistance determined from cores in the trial area are required to enable both Contractors and Overseeing Organisations to gain experience of values achievable with mixtures currently in use and no compliance limits are specified. Provided consistent levels are found in practice, it is anticipated that compliance levels could be set in the future which are better focused on pavement performance thus permitting some relaxation in other requirements.

7 When assessing trials, it is necessary to ensure the materials can be laid to achieve the regularity requirement specified in the Series 700.

8 On completion of successful trials, the target aggregate grading and target binder content are established by the Contractor. This becomes the mixture (referred to as 'the job standard mix' in some specifications), about which the tolerances in Table 9/3 are applied for the purposes of assessing compliance.

9 The compaction of macadam layers should be checked for compliance as each constructed layer is completed. The maximum depth of sample permitted in the PRD test is 150 mm. This is also the maximum layer thickness permitted in BS 4987.

10 If a layer exceeds 150 mm thickness it should not do so by more than the tolerance permitted in Clause 702, which is 30 mm. The maximum layer thickness (core length) is therefore 180 mm. Should a core exceed 150 mm in this manner, then the lower excess portion should be removed by saw-cutting which will increase the core density slightly. This is not unexpected and reflects the boundary conditions known to exist.

11 Some aggregate types do not readily compact in laboratory trials and 'full' refusal density will not be obtained. It has been noted in TRL research (SR 717) that a difference in compaction level can be achieved with loose mixtures compacted to refusal in the laboratory, compared to a core of the same mixture compacted to refusal after being laid in the field, with the field mixtures giving lower air void contents. For this reason, checking of air void contents at refusal should be performed on cores from the mat. Nevertheless Contractors may use a laboratory compaction technique in order to gain an indication of the possible levels of air void content that might be achieved on site.

12 Problems have sometimes been experienced in achieving complete coating of coarse aggregates in roadbase and basecourse macadams and this is often related to the use of a particular aggregate source. The use of a design approach should assist Contractors to

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overcome this by permitting designed adjustments to the grading and binder content of the mixture, subject to meeting the requirements set out in Clause 929. This note should be read in conjunction with NG 930.

NG 930, 932, 933 and 934 Heavy Duty Macadam and Dense Bitumen Macadam With Grade 50 Penetration Binder

1 The stiffer binder in these materials requires a higher mixing temperature to achieve the required binder viscosity and coat the aggregate properly. A longer mixing time should be expected with the increased proportion of filler in heavy duty macadam in order to distribute the binder and coat the aggregate properly. It may be possible for manufacturers to avoid increased mixing times by increasing the binder content within the permitted range. Inspectors should ensure that the material is properly mixed and coated, especially with the first deliveries to the site. Laying temperatures will normally be higher to achieve the required workability with stiffer binder.

2 For basecourse, the traffic category in relation to the tables of BS 4987: Part 1 should be specified in Appendix 7/1. BS 4987: Part 1 Category A traffic may be taken as being equivalent to 2.5 million standard axles (msa), or more, for a 20 year design life.

3 Attention is drawn to the notes to Clause 4.5.1 of BS 4987: Part 1.

NG 931 Use of Rubber in Bituminous Materials

1 Appendix 7/1 should state when rubber is a required additive to bituminous materials.

NG 938 Porous Asphalt Surface Course

1 Guidance to the requirements specified in Clause 938 is contained in HD 27.

2 Clause 938 contains requirements for porous asphalt containing modified penetration grade binder. The use of modifiers, other than natural rubber, is permitted on trunk roads, including motorways, only with agreement of the Overseeing Organisation. HD 27 contains advice to be followed with respect to proposals for use of modifiers.

3 The type of binder permitted, requirements for the PSV of the coarse aggregate and the traffic category should be stated in Appendix 7/1. The specification of specific proprietary modifiers in Appendix 7/1 is not permitted.

4 Before use of a modifier or modified binder, other than natural rubber, the Contractor should provide all necessary information to enable evaluation of the modifier to be carried out and suitable specification clauses for its use to be prepared.

5 Landscaping operations should preferably be completed before laying porous asphalt surface course, to avoid contamination of the surface.

NG 939 Determination of Cohesion of Bitumen and Bituminous Binders

1 This method may be used with pure bitumens, modified bitumens, and cutback bitumens. In the case of cutback bitumens, the test may be performed on the binder containing solvent or on binder from which the solvent has been removed. The test does not give meaningful results with bitumen emulsions, although it may be used on the 'recovered binder' from an emulsion as defined in Clause 923.

2 With reference to Figures 9/5 and 9/6, although different pitches of serration are allowed, the surface of metal in contact with the binder will remain constant at 100 $\sqrt{2}$ mm^2 for each component, as stated in sub-Clause 939.4(b). It may be noted that the value of A used in sub-Clauses 939.9 to 939.13 is not the above area but is the area of binder sheared on impact of the pendulum, which is 100 mm^2. For a given test, combining eg. a cube with serrations at 1.0 mm pitch with a cube support having serrations at 2.0 mm pitch has been found not to affect the results. Such combinations may become necessary if components have been damaged by pendulum back-swing during prior tests.

3 With reference to sub-Clause 939.4(e), a ring and ball softening point thermometer is suitable and would be compliant.

4 With reference to sub-Clause 939.6(a), if the binder contains volatile solvent the cube and supports may be used at ambient temperature. If the binder has a softening point above 60°C, the cube and supports should be heated to that softening point temperature. If this is done, it should be stated in the report.

5 With reference to sub-Clauses 939.6(c), item (i), and 939.10, some modified binders show elastic behaviour which can lead to stress being retained in the binder film and to poor repeatability between tests, or in extreme cases it can cause the cube to lift from the support before testing is commenced. To overcome this problem the cube, support and sample may be pre-heated to higher temperatures than specified in sub-Clauses 939.6(a) and 939.6(b) of this Clause. If this is done, it should be stated in the report.

6 With reference to sub-Clause 939.8(viii) these zeroing test results are likely to vary with the ambient temperature of the laboratory. Their frequency should be increased if there is any significant variation in the ambient temperature (eg due to solar gain or failure of air conditioning equipment).

7 Table NG 9/26 would be a suitable basis for pre-recording the relationship between the angle α and energy (Joules) for each pendulum tester. Table NG 9/27 would be a suitable basis for recording the experimental results, giving the angle α and deducing the mean angle. Then the sheet for the specific test equipment based on Table NG 9/26 is used to convert the mean angle to energy (Joules) for each pendulum test.

8 This Clause uses some non-SI metric units. The Clause may be changed to SI units (eg. kJ/m^2) in due course.

TABLE NG 9/26 Typical Layout for Pre-calculated Sheet for a Given Test Equipment

Cohesion Meter Pendulum Test

Test Equipment No .....

Conversion table from degrees++ to Joules

Energy (Joules) = $5.8(1 + \cos \alpha)$

Pendulum swing (α) (degrees)		**Energy (E_T) (Joules)**
120	00	4.008
	30	3.964
121	00	3.921
	30	3.878
122	00	3.835
	30	3.793

... and continue to 179 degrees 30 minutes

Note 1. Angular scale may also be calibrated in grads (or gon)++, in which case the sheet heading and the Column 1 heading and detail should be amended to suit.

Note 2. Based on the sample being a cube of sides 10 mm.

++ Delete as appropriate

NB. The constant in the formula and the derived values in Column 3 should be based on the actual mass (M) of the pendulum.

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TABLE NG 9/27 Typical Results Sheet for Cohesion Test for Bitumen and Bituminous Binders (Vialit Test)

Name of Laboratory **Cohesion Meter Pendulum Test Data**

(Vialit Test)

Sample ID .... Date ..... Operator .... Project .....

Angles measure in degrees/grads (or gon)++

Temperature (°C)							
Angle 1							
Angle 2							
Angle 3							
Mean angle							
Gross energy (J)							
Correction (J)							
Cohesion value (J/cm^2)							

++ Delete as appropriate

Note: Correction = Zeroing values E_K = measured at ambient temperature of °C at hrs.

NG 942 Thin Wearing Course Systems

1 Thin wearing course systems are proprietary systems generally comprising an emulsion tack or bond coat sprayed onto an existing surface before placing a hot bituminous-bound mixture which after compaction forms a textured surfacing course that may be trafficked immediately on cooling. The tack or bond coat may be polymer-modified and sprayed hot, but this depends on the system used.

2 The nominal thicknesses of systems currently available vary between 15 to 40 mm. Proprietary systems complying with this Clause are available in nominal thickness ranges of 15 to 25 mm, 20 to 30 mm and 30 to 40 mm. These systems are not directly comparable and, in particular, the compiler should consider the need for a modified mixture and the minimum thickness required for the particular application. The systems permit minor regulation of existing surfaces and the recommendations of the system proprietor should be obtained in this respect. Nevertheless the maximum local thickness should be limited to about twice the average thickness of the proprietary system. If it is proposed to use a system above its nominal maximum thickness more generally, for example to replace by inlay an existing worn out surfacing layer, then the increase in thickness should be limited to not more than 25% of the nominal maximum thickness given above and a three year guarantee should be obtained from the proprietor of the system to replace the two year requirement in sub-Clause 26.

3 Thin wearing course systems have a skeletal structure and offer a high resistance to wheel-track rutting. It is important to remember however, that wheel-track rutting may originate from deformation not only in the wearing course itself but in lower pavement layers, particularly in the basecourse and to a lesser extent in the roadbase. To provide adequate resistance to deformation where thin surfacings are to be used over new layers, it will be prudent to to specify either high stone content hot rolled asphalt as the basecourse or basecourse or roadbase macadams designed in accordance with Clause 929.

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4 This Specification for thin wearing course systems is not intended to be an exhaustive, binding specification for the use of proprietary-type mixtures but rather to form the basis of a document for Contractors to tender for work.

5 The surfacing systems can be laid either in one pass by a single purpose-built machine or in one pass of a sprayer followed by a conventional paving machine. A number of processes are currently available, as described below. The processes, while appearing similar, use different techniques.

6 One process utilises a machine on site which applies hot modified emulsion bond coat to the surface to be treated. Pre-mixed materials using a mixture of nominal sized aggregate, fines and filler and penetration-graded bitumen, are immediately placed on the tack coat. Other processes utilise modified conventional mixing and laying plant. Pre-mixed materials, using a mixture of nominal sized aggregate, fines and filler are mixed with binder modified with polymer or fibres and laid as a thin layer onto a tack or bond coat which has been previously sprayed onto the surface to be treated.

7 All the processes provide a surface of a material which can be described as either a 'very thin or a thin bitumen macadam'. They provide a smooth riding surface which generates slightly lower noise levels under traffic, compared to conventional surface dressing or hot-rolled asphalt surfaces.

8 Due to the macro-texture created by the rugous surfacings, some reduction in spray levels may be noted, however, this is not significant. The compiler should specify the minimum PSV required for a particular site together with the maximum AAV. Guidance on the levels to specify is given in HD28; over specification should be avoided in order to conserve scarce resources. The processes offer the ability to lay a thin layer of macadam with high PSV stone, thus improving the skidding resistance of the surface while providing good regularity at the same time. The surfaces do not provide drainage through the layer and can not be compared to porous asphalt in this respect. Although the nominal thicknesses of the systems offered currently vary between 15 mm and 40 mm, the selection of the appropriate thickness depends on the condition of the road to be surfaced.

9 The design, manufacture, transportation, placement and compaction of the materials is the Contractor's responsibility, as is the decision with regard to whether the weather conditions are suitable for placement and compaction. This provides scope to the Contractor to design and place the materials to suit the Contractor's system. As a consequence, the two year guarantee period is required.

10 Skidding test values on surfaces complying with this Clause are satisfactory and are similar to those recorded for hot-rolled asphalt surfacings. A minimum texture depth of 1.5 mm is required for high speed roads, the same as for hot-rolled asphalt surfacing. The choice of aggregate grading is the Contractor's provided the specified minimum surface texture is achieved.

11 The surface texture obtained cannot be compared to that of a surface dressing or hot-rolled asphalt. There are no surface texture requirements for low speed roads surfaced with hot rolled asphalt, reliance being placed on the texture produced by the minimum rate of chippings required by BS 594: Part 2. To ensure that a texture is provided on low speed roads, a minimum requirement after two years has been included as part of the Contractor's guarantee. A low speed road is one where the 85 percentile traffic speed is less than 90 kph.

12 The amount of tack coat to be sprayed is dependent on the porosity of the underlying layer and should be sufficient to provide at least a seal to that layer.

13 The requirement to use hot spray tack coat can be waived in small areas where it is impractical to apply. In this instance, an appropriate application of cold bituminous tack coat is acceptable.

14 The object of specifying aggregate grading and binder content range is to permit audit-type testing to be carried out. The grading limits given should be regarded as indicative. Difficulties may be encountered by site staff attempting to measure the binder content of materials containing polymer-modified binders.

15 The guarantee period should be clearly indicated as relating only to the thin wearing course system. The compiler should state the anticipated traffic flows at the site over the guarantee period and should also require the Contractor to inspect the site where the material will be laid. An appropriate Special Requirement should be included in the Conditions of Contract which draws particular attention to this Clause (sub-Clause 26) in the Specification.

16 Contraflow and maintenance operations often require the application of temporary reflecting road studs. There are many proprietary types of stud available. Trials have indicated many types of stud leave a sticky deposit of bituminous adhesive which clogs and blocks the surface voids and some studs also cause pluck-out of surface aggregate. Therefore, trials may need to be performed, at the back edge of the hard shoulder or edge strip, to ensure the studs proposed for use will come free from the surface without plucking out surface aggregate or leaving an excessive deposit.

17 Similar problems have also been reported with pre-formed marking tapes. Trials should be performed to select the best material.

18 The situation with thin wearing course systems is continually changing and there is likely to be an increasing number of systems coming onto the market. For advice on the latest situation the Overseeing Organisation should be consulted.

NG 943 Hot Rolled Asphalt Wearing Course (Performance-Related Design Mix)

1 Wheel-track rutting in the wearing course may result from deformation not only in the wearing course itself but also in lower pavement layers, particularly in the basecourse and, to a lesser extent, in the roadbase. The designer should not consider using these materials unless he is satisfied that the basecourse and roadbase will provide the necessary support without undue deformation. To provide adequate resistance to deformation, it may be prudent to specify basecourse and roadbase macadams that are designed in accordance with Clause 929 using 50 Pen binder for classification 2 sites and 100 Pen binder for the other sites in Table NG 9/26.

2 The intention of this Clause is to specify 35% stone content hot rolled asphalt in terms of:

(i) the component materials (other than binder modifiers) to be as required for the materials specified in other Clauses of SHW together with Section 2, Constituent Materials, of BS 594: Part 1;

(ii) a maximum wheel-tracking rate in the laid mat to limit permanent deformation;

(iii) a maximum wheel-tracking rut depth to avoid mixtures with a tendency for significant early rutting but whose rutting subsequently stabilises;

(iv) a maximum air voids content in the laid mat to ensure durability; and

(v) the surface characteristics (such as texture depth and surface profile) to be as required for the materials specified in other Clauses.

3 Marshall stability and flow values are not specified for these mixtures, although the results may be reported to the Overseeing Organisation for information if the test has been carried out as part of the Contractor's design method. Instead, the more directly related properties of wheel-tracking rate, wheel-tracking rut depth and air voids content are used to achieve the required properties of rut-resistance and durability, respectively.

Instructions For Tendering

4 When preparing the Instructions for Tendering it is essential that the compiler includes a requirement that approval of modified binders or Grade 40 penetration HD bitumen, as specified in sub-Clause 943.5, should be obtained prior to the date for the return of tenders. Tenderers' attention should be drawn to Clause 943, clearly stating that it will be the responsibility of the Contractor to ensure the pavement material is in a suitable condition before the road is opened to traffic.

Binder Modifiers

5 Where shown to be necessary, modified binders are used to enhance the properties of the mixture over those provided by the available aggregate with unmodified bitumen. In the absence of the Highways Authorities Product Approval Scheme, which is to be run by the British Board of Agrément, specific binder modifiers or process modified bitumens will need to be approved by the Overseeing Organisation.

6 The need for approval of binder modifiers and modified binders is to minimise the possibility of adding anything to the mixture that may have harmful long-term effects. If there is evidence of successful use of a binder modifier/modified binder in similar conditions, the presumption should be of approval whilst, if there is knowledge of the binder modifier/modified binder having had deleterious effects on mixtures or if there is no known data available, the binder modifier/modified binder should be rejected. The actual need for the modifier and the extent of its concentration are the responsibility of the tenderer in ensuring that the mixture complies with the performance requirements.

7 It is possible that tenderers may wish to seek approval for more than one modified binder and/or binder modifiers. Arrangement should be made so that approval for specific modified binder(s) and/or binder modifier(s) can be given in due time so that those tendering can submit tenders based on approved binders; if all binders submitted by a tenderer are rejected, there should be sufficient time to allow for the tenderer to submit alternative binders for approval.

8 The data required to be submitted with the request for approval of a binder modifier or modified binder is primarily for inclusion on a database held by TRL on behalf of the Overseeing Organisations, and should be forwarded to TRL.

9 Analytical test methods for modified binders are outside the scope of BS 598: Part 102 because not all of some modified binders are recovered using the standard methods. Therefore, any modifications to the test method and/or corrections to the results need to be established before work commences with a modified binder.

Job Mixture Approval

10 The Contractor may submit the results of any tests carried out on the mixture or its component materials as part of the design that he considers relevant for the purposes of mixture approval.

11 For the Job Mixture Approval trial of a mixture from a specific mixing plant, at least 20 tonnes should be mixed, transported, laid, compacted, sampled and tested. Within the laid total area, a designated section of sufficient size to allow it to be compacted properly should be left unchipped.

Job Mixture Approval Sampling

12 Three samples of uncompacted material should be taken from the paver as near to where cores are to be taken as is practicable from the paver augers in accordance with BS 598: Part 100, Clause 6.3.

13 Not less than six 200 mm diameter cores and six 150 mm diameter cores should be cut from the trial area with pre-coated chippings; not less than six 150 mm diameter cores should be cut from the trial area without pre-coated chippings.

Job Mixture Approval Tests

14 A compositional analysis should be carried out on each sample of uncompacted material in accordance with sub-Clause 19 of Clause 943.

15 The wheel-tracking rate and the rut depth of each 200 mm diameter core should be determined in accordance with sub-Clause 20 of Clause 943 at the test temperature specified in Appendix 7/1.

16 Nuclear density gauge readings should be taken on an area where sand has been applied to fill surface depressions so as to give a smooth surface adjacent to each core hole in the trial area with pre-coated chippings. The temperature of the surface when the reading is taken should be recorded.

17 The nuclear density gauge should be calibrated for the mixture being laid. In addition, correlation analyses should be carried out between the air voids content, as measured from the cores in accordance with sub-Clause 22 of Clause 943, and the density determined using the nuclear density meter.

18 The bulk density of each 150 mm diameter core with pre-coated chippings, and the maximum density of each pair of cores, should be determined in accordance with sub-Clause 21 and the air voids content determined in accordance with sub-Clause 22 of Clause 943.

19 To calculate the binder content by volume as specified in sub-Clause 3 of Clause 943, the bulk density of the 150 mm diameter cores taken from the unchipped area should be determined in accordance with the procedure in BS 598: Part 104, Clause 4. The density of the compacted hot rolled asphalt without pre-coated chippings should be calculated as the mean bulk density of the individual cores.

20 The Overseeing Organisation can approve the results from a previous contract or a trial carried out up to eighteen months previously.

21 The material in a Job Mixture Approval trial carried out on site may have too many core holes to be suitable for retention as part of the permanent wearing course, however the material may be retained as part of the permanent basecourse.

Testing

22 Although it is preferable to take cores prior to the surfacing being open to traffic, this may not be possible when the road has to be re-opened by a specific time. If the time during which the site is available to the Contractor is not sufficient to allow:

(a) the preparation for and laying of the mat;

(b) the mat to cool sufficiently for coring;

(c) the coring operation; and

(d) the reinstatement of the core hole,

the requirement to cut cores before trafficking should be excluded in Appendix 7/1.

23 After cores have been cut, a diamond shape can be sawn around the core(s) and the material within the diamond shape removed to leave the core(s) proud and more accessible for removal to minimise damage, particularly during warm weather. Reinstatement of a larger area may also permit better compaction by roller to be achieved. Removing cores which have not cooled sufficiently can reduce their density.

24 For the reinstatement of core-holes the use of cold-lay 20 mm nominal size dense bitumen macadam basecourse for layers more than 50 mm below the surface and cold-lay 6 mm size dense bitumen macadam wearing course for the wearing course may not be suitable for high stress sites or diamond shape cut outs and can be excluded in Appendix 7/1.

Nuclear Density Gauge

25 The nuclear density gauge is used as a monitoring tool to identify if and when the mixture or its compaction changes and to indicate possible non-compliance with the specification. This method of screening is intended to keep the use of coring to a minimum.

Air Voids Content

26 The determination of air-voids content employs the concept of maximum density of compacted mixtures. The test method for determining the maximum density of a compacted mixture is given in British Standards Institution Draft for Development DD 228 Issue 2; the method is based on ASTM D 2041.

27 The limiting values for air-voids content are derived from work carried out at TRL and reported in PR 78.

Wheel-Tracking Rate

28 The test method for wheel-tracking is given in BS 598: Part 110. The option of using paraffin wax in determining the bulk density of cores should not be used in order to avoid problems with subsequent testing for maximum density.

29 The limiting wheel-tracking rut depth after 45 minutes testing is used to avoid the possibility of materials deforming significantly in their early life and then densifying so as to achieve an acceptable wheel-tracking rate in the last 15 minutes of the test.

30 In deciding on the limiting wheel-tracking rate, the limiting wheel-tracking rut depth and the temperature of the test to be given in Appendix 7/1, the limits given in Table NG 9/28 for site classifications defined in Table NG 9/29 should be considered.

Combinations of Factors which Promote Wheel-Track Rutting

31 The majority of permanent deformation occurs during the summer months when the hot rolled asphalt is at higher temperatures, particularly when there are slow heavy-goods vehicle movements, such as climbing lanes. This is especially the case when newly laid material is not yet fully stable and it is less resistant to deformation under wheel loads. This can occur on road construction sites during summer months when partially completed pavements are re-opened to highway traffic under contraflow arrangements. The added factor of concentration of traffic can provide the worst combination of factors to cause permanent deformation. For this reason, Table NG 9/29 has special categories I_A, II_A, III_A and IV_A to cater for schemes where such conditions can be anticipated in the early life of the wearing course to be laid. Special categories I_A, II_A, III_A and IV_A are also applicable to locations which can be regarded as "sun traps", in particular south facing cuttings where vehicles are travelling uphill.

32 In assessing the appropriate category, other local factors may also influence the choice, including areas which have previously demonstrated high surface temperatures and the use of aggregate with particular characteristics such as dark or light colouring. The problems of high surface temperatures can also be exacerbated on elevated structures which have less thermal capacity than where there is ground support of the pavement, and consequently higher temperatures.

Trafficking Newly Laid Hot Rolled Asphalt Surfacing

33 Curing time, as well as cooling, is an important aspect in the development of deformation resistance. In addition to the requirement of BS 594 that 'newly laid sections of asphalt shall not be open to traffic until all pavement layers have cooled to ambient temperature;' in hot weather the surfacing should, where possible not be opened to traffic until at least 24 hours after paving, especially with contra flow working. Irrespective of the ambient temperature, but particularly where the above lead time before opening is not practicable due to site specific constraints, either the surface temperature should not exceed 25°C or the temperature anywhere within the mat should have fallen below 35°C at the time of opening, or such other temperatures as the binder manufacturer may recommend. The maximum temperature within the mat may be assumed to be at mid-mat.

TABLE NG 9/28 Limiting Wheel-Tracking Requirements for Site Classifications

Classification		Test Temperature	Maximum Wheel-Tracking	
No.	Description	(°C)	Rate (mm/h)	Rut Depth (mm)
0	Lightly stressed sites not requiring specific design for deformation resistance	Not required (Shall comply with the requirements of BS 594: Part 1)		
1	Moderate to heavily stressed sites requiring high rut resistance.	45	2.0	4.0
2	Very heavily stressed sites requiring very high rut resistance	60	5.0	7.0

Table NG 9/29 Classification of Sites by Traffic and Stress Condition

Site Category		Site Definition	Traffic at Design life (Commercial vehicles per lane per day)										
			Up to 250	251 - 500	501 - 1000	1001 - 1500	1501 - 2000	2001 - 2500	2501 - 3000	3001 - 4000	4001 - 5000	5001 - 6000	over 6001
I & II	A B D C E	Motorway (main line) Dual carriageway (all purpose) non-event sections Dual carriageway (all purpose) minor junctions Single carriageway non-event sections Single carriageway minor junctions	0				1				2		
IA & IIA	As I and II, above, but with contraflow anticipated during summer months		0				1				2		
III	F G1 L	Approaches to and across major junctions (all limbs) Gradient 3% to 10%, longer than 50 m: Dual (uphill and downhill) Single (uphill and downhill) Roundabout	0				1				2		
IIIA	As III, above, but with contraflow anticipated during summer months or in a south-facing cutting uphill		0			1				2			
IV	G2	Gradient steeper than 10%, longer than 50 m: Dual (uphill and downhill) Single (uphill and downhill)	0			1		2					
IVA	As IV, above, but with contraflow anticipated during summer months or in a south-facing cutting uphill		0		1			2					
V	J/K	Approach to roundabout, traffic signals, pedestrian crossings, railway level crossings and similar	0		1			2					

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NATIONAL ALTERATIONS OF THE OVERSEEING ORGANISATION OF SCOTLAND

NG 911SO Rolled Asphalt Wearing Course (Design Mix)

1 The naturally occurring fine aggregates which are readily available in Scotland tend to produce rolled asphalt wearing courses with relatively higher Marshall stabilities than elsewhere in the UK. The stabilities generally exceed the upper limits recommended for the more lightly trafficked roads in Scotland, the majority of which fall into the lowest category in Table B.1 of BS 594: Part 1, Annex B.

2 The required Marshall stability and flow values when tested on laboratory specimens made in accordance with BS 598: Part 107 should comply with the requirements of Table NG 9/1SO below:

TABLE NG 9/1SO Criteria for the Stability of Laboratory Designed Asphalt

Traffic (in commercial vehicles per lane per day)	Stability of complete mix kN
Less than 1500	4 to 10[1)]
1500 to 6000	6 to 10
Over 6000	8 to 12

[1)] It may be necessary to restrict the upper limit where difficulties in the compaction of materials might occur. Type R enriched mixes conforming to Table 5 of BS 594: Part 1 are intended for use with this traffic category.

NOTE 1. For stabilities up to 8.0 kN the maximum flow value should be 5 mm. For stabilities in excess of 8.0 kN a maximum flow of 7 mm is permissible.

NOTE 2. The stability values referred to should be obtained on laboratory mixes.

NOTE 3. The stability and flow values are those pertaining to the target binder content.

3 Verification of the design should be carried out in accordance with Annex B of BS 594: Part 1 using laboratory prepared specimens made from "hot-bin" aggregates. Samples prepared from plant produced material and tested in accordance with the procedures of BS 598: Part 107 are not directly comparable with those obtained on laboratory prepared specimens. The range of values of Marshall stability given in Table NG 9/1SO above permit a number of mixtures using locally available materials; however the specified stability value should be the mid-point of the range.

4 The special requirements included in Appendix 7/1 may include the appropriate table and column numbers of permitted mixtures from BS 594: Part 1. Additionally the required Marshall stability and flow and the required properties for coated chippings, such as PSV and AAV, should be included.

5 The method of determining the design binder content for wearing course mixtures is described in BS 598: Part 107. Determination of the target binder content, by adjustment of the design binder content, is described in BS 594: Part 1 for wearing course design mixtures. The target binder content is always at or above the design binder content. The design binder content is the quantity of bitumen required for the mix in order to achieve the required stability. There are occasions when this design binder content would be too low for long term durability. Therefore a minimum target binder content is required by the British Standard and this may be above the design binder content.

6 The Contractor may usually be permitted to submit design proposals based on Type F or Type C composition in accordance with Tables 3 or 4 of BS 594: Part 1. However, once that submission has been tested and proved satisfactory no change in composition or the properties of the constituent materials should be made until proposals for a new design have been tested and proved satisfactory.

7 Checks on production material should normally be by analysis, in accordance with BS 598: Part 102 and comparison with the composition of the approved design, together with checks on the properties of the constituent materials. Advice on the possible use of Marshall tests on specimens produced from production material is given above.

8 Note 1 of Table 1 of BS 594: Part 1 urges caution in the use of 40 penetration grade HD bitumen complying with BS 3690. Some mixtures incorporating this binder have been difficult to compact and have rapidly lost matrix and chippings. This bitumen is infrequently specified on trunk roads.

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