SERIES NG 900
ROAD PAVEMENTS - BITUMINOUS BOUND MATERIALS

Contents

NATIONAL ALTERATIONS OF THE OVERSEEING ORGANISATIONS OF SCOTLAND, WALES AND NORTHERN IRELAND

Scotland

# 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.

Volume 2 home page

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) Volume 7.

NG 901 (05/02) Bituminous Base and Surfacing Materials

General

1 (05/02) 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.

The designation of products such as DBM50 refers to the penetration reference for 40/60 grade as defined in Table 1 of BS EN 12591. The penetration reference is defined in the 'Foreword' of BS 4987 : Part 1 and for most bitumen grades is a mid-point of the permitted penetration range which is regarded as a target for that grade.

For cutback binders are specified using now obsolete BS 3690 : Part 1 except for macadams where flux is permitted in accordance with BS 4987 : Part 1 when approved by the Overseeing Organisation (eg for hand lay work).

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

DMRB, Volume 7, HD 36 gives guidance on aggregate properties for new bituminous surfacings.

Aggregates for Bituminous Materials

2 (05/01) The use of natural, recovered unbound and artificial aggregates is permitted. In this context, recovered unbound aggregates are natural aggregates recovered from a previous use in an unbound form which satisfy the requirements of Clause 901.

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 draft European Standard for aggregates for bituminous materials indicates that the water absorption test is not applicable for blastfurnace slag aggregates. Blastfurnace slag aggregates with absorption values up to 8% have been shown to have acceptable soundness. Therefore, the durability of blastfurnace slag aggregates should be determined by periodic measurement of soundness.

Volume 2 home page

Transporting, Laying and Compacting

3 (05/02) 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 surface 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 favorable 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 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 (05/02) 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 936 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. NG 945 for cold weather working gives useful advice. For hot weather, TRL Report 494 'The Behaviour of Asphalt in Adverse Hot Weather Conditions' 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 (05/01) Reclaimed Bituminous Materials

1 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 bituminous materials stockpiled at the plant may also be suitable.

2 To ensure homogeneity and consistency of the final product, all reclaimed materials should be granulated or crushed or similarly prepared before mixing with fresh aggregate and bitumen. It may be possible to add some planings and millings directly at the plant without any form of pre-treatment when the proportion added is less than 10%.

3 A check on the penetration and penetration index of the binder recovered from mixtures containing 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 trials to ensure that the materials comply with the requirements of this Clause in addition to the requirements of this Series should be sufficient to ensure the materials are suitable for use in the pavement.

4 Materials containing tar or tar-based binders should not be recycled. The environmental impact of recycling

materials containing polymer-modified binder should be assessed, together with the properties of the mixture, and reported to the Overseeing Organisation. 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, and that the aggregate quality is adequate for reuse.

NG 903 (05/02) Dense Macadam Base

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 (05/02) Rolled Asphalt Base

1 (05/02) The composition of rolled asphalt base 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 (05/02) Rolled Asphalt Binder Course

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 (05/02) Dense Macadam Binder Course

1 (05/02) These materials are intended primarily for use under high temperature surface courses, but under other surface 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.

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 (05/02) Dense Macadam Surface 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 (05/02) Rolled Asphalt Surface Course (Recipe Mix)

1 (05/02) 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 surface 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 (05/02) 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.

#NG 911 (05/02) Rolled Asphalt Surface 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 (05/02) The method of determining the design binder content for surface 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 surface course design mixtures. The target binder content is always at or

Volume 2 home page

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.

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.

NG 912 (05/02) Close Graded Macadam Surface Course

1 (05/02) The nominal size of aggregate for close graded surface course will depend upon the required layer thickness for the compacted surface 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 914 (05/02) Fine Graded Macadam Surface 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 (05/02) 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 surface 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 (05/02) Design mix rolled asphalt surface 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.

Volume 2 home page

NG 916 (05/02) Open Graded Macadam Surface 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 (05/02) The nominal size of aggregate for open textured macadam surface course will depend upon the required layer thickness for the compacted surface 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 (05/01) Slurry Surfacing Incorporating Microsurfacing

1 The permitted use of BS 434 : Part 2 slurry seals has been removed as they are no longer used by any contractor. The aggregate grading is no longer specified, but forms part of the Contractor's Design Proposal with tolerances. These changes cause the previous Clauses 918 and 927 covering slurry seals and microsurfacing to become almost identical with no obvious step change between the two so the opportunity has been taken to amalgamate them into a single Clause 918 Slurry Surfacing Incorporating Microsurfacing. Where a British Board of Agrément HAPAS Roads and Bridges Certificate for Slurry Surfacing is required Clause 942: Thin Surface Course Systems should be used.

2 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. The guarantee period is normally two years for motorways, trunk roads and heavily trafficked or highly stressed roads, and one year for other roads.

3 This specification allows considerable freedom to the Contractor in the formulation and application of the Slurry Surfacing. All Design Proposals must be supported by trials, which would normally have been carried out during routine work, but that have been fully documented using the National TAIT documentation. TAIT's are self-certified by the Contractor. The Contractor may choose any number of TAITs to cover the range of products he is prepared to install. There are likely to be several products, designs, traffic categories and site types for TAITs to be recorded. It is expected that these TAITs will eventually form the basis of CE-marking for Slurry Surfacing for each different intended use. A TAIT is suitable for all untrafficked areas such as footways, central reserves, traffic islands etc, cycle ways, tracks and paths and roads carrying less than 500 cv/lane/day with a speed limit of 60 mph or less. For all roads carrying more that 500 cv/lane/day and/or roads with speed limits greater than 60 mph Clause 942 shall be used. These are roads where the Slurry Surfacing would be in direct competition with thin hot-mixed asphalts and should meet the same requirements.

4 All coloured materials whether using bitumen emulsion or specially formulated light coloured binders should be specified using the appropriate end performance criteria. Accelerated ageing and weathering tests with colour identification tests are being developed to demonstrate colour retention by BBA/HAPAS Specialist Group 9.

5 Low tyre-noise emission Slurry Surfacings may be specified by limiting the maximum texture depth in Appendix 7/7. For Clause 942 the noise emission reduction has been demonstrated for the British Board of Agrément HAPAS Roads and Bridges Certificate measured by the Statistical Pass-by method ISO 11819-1 and certified by BBA, it is categorised by Road Surface Influence (RSI). Where the Contractor has a British Board of Agrément HAPAS Roads and Bridges Certificate (Specialist Group 3) for the Slurry Surfacing as a thin surface course system this is acceptable in place of a TAIT certificate for contracts where a TAIT is required.

6 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 Slurry Surfacing.

7 Basic details of the tendered design for each site should be completed in the Design Proposal and TAIT certificates for similar sites provided.

8 If any site is considered by the Tenderer to be unsuitable for Slurry Surfacing this should be stated in the Design Proposal. There may be sections where the existing road surface is considered not suitable for treatment or the performance requirements are too onerous to be achieved in practice.

9 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 Slurry Surfacing must nevertheless provide with their tender all the information required by Clause 918 and Appendix 7/7.

Volume 2 home page

(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 7/7 assessed as follows:

Contract Duration	All tenders will be evaluated against the lowest submitted Contract period.
Design Life	All tenders will be evaluated considering the Estimated Design Life stated in the TAIT Certificate or, if one has not been issued, the Design Proposal.
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 and Binder Data Sheet requested in Appendix 7/7 will not be considered.
Traffic Management	Any tenderer failing to submit his proposals for traffic control and aftercare as detailed in Appendix 7/7, 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 7/7 will not be considered.
Test Results	Any tenderer failing to submit the test results detailed in Appendix 7/7 will not be considered.
Previous Applications	Any tenderer failing to submit the details of previous applications, personnel, technical and managerial expertise as detailed in Appendix 7/7 will not be considered.
TAIT Certificates	Any tenderer failing to submit certificates for TAITs similar to those systems proposed for the sites in the Contract will not be considered unless no such TAIT Certificates have been issued.

10 Contractors should recognise the need for best practice as described in the Slurry Surfacing Contractors Association (SSCA) and Road Emulsion Association (REA) documents.

11 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 the time at which the surfacing should no longer be expected to provide the surface properties required at the site in question.

12 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 HD 36 and the minimum requirements for aggregate 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.

13 For the purposes of the Contract, monitoring will stop at the end of the guarantee period, or for novel, or for innovative materials, after one third of the stated Estimated 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 Slurry Surfacing. On heavily trafficked roads 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. For other roads sand patch tests or use of the mini texture meter or other device calibrated against sand patch values as Sand Patch Equivalent values, may be more convenient.

14 The Vialit pendulum test should be carried out using Clause 939 on the recovered binder used to manufacture the Slurry Surfacing. The minimum binder cohesion at peak measured using the Vialit Pendulum should be reported. The range of temperature for modified binders for a value of 1.0 J/cm^2 provides another parameter for evaluation of the modification.

15 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 may 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 set a standard the product identification test has been standardised using the results from a dynamic shear rheometer of complex shear (stiffness) modulus and phase angle as specified in Clause 928. If the supplier considers that other tests would identify his binder more precisely then he may provide the results of these additional tests in addition to the requirements of sub-Clause 918.7 and add them to the Binder Data Sheet in Appendix 7/7. Other recovery test methods may be used to provide residual binder for subsequent testing and these may be convenient for quality control purposes, however, the definitive test is Clause 923 and results for Clause 928 and Clause 939 for type approval purposes will be based on recovered binder from Clause 923.

16 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 36; over specification should be avoided in order to conserve scarce resources. Where coloured Slurry Surfacing is used on the carriageway, even in small areas like 'village gates' they should have adequate skidding resistance. As they are usually fairly 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 36, including possibly some calcined bauxite.

17 Repairs to the existing road in preparation for Slurry Surfacing (for example, patching), should be carried out well in advance of the works. They 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 maintenance period. The existing road variability and surface characteristics have a bearing on the achievable levels of performance that may be specified. If the existing surface is hot rolled asphalt then the patches will ideally be laid with hot rolled asphalt. Thin asphalt surfacings should be repaired with stone mastic asphalt of similar consistency and highly textured variable substrates should be treated with a polymer modified Bond Coat. Patches should not have a horizontal sealing strip applied as this will show through thin Slurry Surfacing reducing texture, similarly binder-rich soft materials used to seal cracks similar to stress absorbing membrane interlayers (SAMIs) should not be used, especially longitudinally in the wheel tracks.

18 The minimum and/or maximum thicknesses at which the Slurry Surfacing is to be laid should only be specified where there are specific reasons for so doing. If the Slurry Surfacing is being laid purely to restore surface characteristics such as skid resistance and texture depth, the choice of thickness should not be restricted. One reason for specifying a minimum thickness is to improve the profile. For rut filling this is often accomplished by the application of two layers, sometimes using different materials. This should be described in the Design Proposal.

19 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 0.5 m for hand laid work, or an alternative, documented, procedure producing a similar outcome.

20 General weather limitations should be covered by the Contractor's Quality Plan. Any site specific weather limitations should be specified under 'Special restrictions' in Appendix 7/7.

21 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 Surfacing has set sufficiently to enable it to take the traffic stresses that will be imposed. Too early opening will lead to damage and loss of material, which

Volume 2 home page

will require additional remedial work before the Contractor may leave 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 Surfacing until it has gained adequate strength. Strength gain will be particularly slow in conditions of high humidity and/or low temperatures, i.e. those conditions where the rate of evaporation of the water from the Slurry Surfacing is reduced. Traffickability time and mixture cohesion tests are relevant in this context.

22 As part of the normal traffic control mechanism for high-speed roads there should be a mandatory 50 mph speed limit in place for the duration of the work. Therefore, if Slurry 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 Overseeing Organisation states in Appendix 7/7 or the Slurry Surfacing contractor requires for his process should 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 of road is unusually light or the work is required to be carried late in the season, i.e. during October. The Slurry Surfacing Contractor will determine the need for a longer period from experience with the particular process that is proposed. All loose aggregate should be removed from any traffickable part of the carriageway or hard shoulder prior to removing the temporary contract speed limit from the works.

23 Care should be taken to ensure that the Slurry Surfacing bonds adequately to the underlying surface as with these relatively 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 the guarantee period and will be identified during the final visual assessment.

24 When incorrectly manufactured or laid Slurry Surfacing has poor durability. For Slurry Surfacing placed in a single layer less than about 8 mm thick the assessment of areas of total loss of material at the end of the guarantee period should be a sufficient performance measure.

25 It is important to ensure that all access covers are unmasked and if necessary reset as soon as possible after completion of laying so that their owners may find and use them if required. This is particularly important for fire hydrants, as public safety may be dependent on their visibility and accessibility. It is also easier to match the Slurry Surfacing with additional material if needed and make level adjustments while the Slurry Surfacing team is close-by.

26 Texture is measured in the nearside (inside) wheel track where the lane width and traffic are sufficient for this to be identified; for low traffic category sites the track carrying the most traffic (wear) is tested, this may be the outside wheel track for narrow lanes where tyre paths in both directions overlap. High-speed sensor measurements should be used for measuring texture depth on high-speed and heavily trafficked roads because of the amount of texture depth measurement to be undertaken. This form of measurement avoids the need for additional lane closures, which use of sand patch testing or the mini texture meter would require. Other methods may be used, but the results should be reported as Sand Patch Equivalent values. 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 Slurry Surfacing on high-speed heavily trafficked 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 7/7 for lower speed roads.

TABLE NG 9/1: (05/01) **Minimum Sand Patch Texture Depth Requirements (or Sand Patch Equivalent) in the Nearside Wheel Track at the End of the Guarantee Period**

Traffic cv/lane/day	**Speed limit 50 mph or 60 mph Sand Patch Texture (mm)**	**Speed limit 40 mph or lower Sand Patch Texture (mm)**
50 to 500	1.0	0.8
10 to 50	1.0	0.7
Below 10	1.0	No requirement
More than 500 (or speed limit greater than 60 mph)	Not Applicable to this Clause, see Clause 942: Thin Surface Course Systems	

Volume 2 home page

27 Visual assessment of defects should be carried out in accordance with BS EN 12274-8. It is anticipated that because Slurry Surfacing defects are usually obvious the need for a full assessment procedure will be rare. The visual assessment of area defects is classified in Table NG 9/2. The class appropriate to the site should be specified in Appendix 7/7.

TABLE NG 9/2: (05/01) **Defect Classification: Area**

Site	Area of Defects % of surface losing material	Class
Dual and stressed Single Carriageways	1	3
Single Carriageways	2	2
Lightly Trafficked Single Carriageways	4	1

The visual assessment of linear defects is classified in Table NG 9/3. The class appropriate to the site should be specified in Appendix 7/7.

TABLE NG 9/3: (05/01) **Defect Classification: Linear Defects**

Site	Total Length of Defects in metres per 100 m	Class
Dual and stressed Single Carriageways	2	3
Single Carriageways	5	2
Lightly Trafficked Single Carriageways	10	1

28 If the bond between layers is to be assessed then the torque bond test used by the BBA/HAPAS scheme for thin surface course systems should be used. Alternatively, if a bond coat is proposed in the Design Proposal then the binder should have a British Board of Agrément HAPAS Roads and Bridges Certificate.

29 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 the 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.

30 Surface irregularity is measured in two ways as described in Clause 702, but as Slurry Surfacing is laid in a different manner to the method assumed in that Clause, Slurry Surfacing should meet the appropriate class given in Table NG 9/4 for transverse regularity and Table NG 9/7 for longitudinal irregularity. The class limits are given in Table NG 9/5 for the former and in Table NG 9/7 for the latter.

TABLE NG 9/4: (05/01) **Transverse Regularity - Requirements**

Site	Class
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/l/d and roads carrying less traffic where the cross fall is less that 2%.	2
All other roads	1
Roads where only sealing and improvement to surface characteristics are required (ie Regulating is not a requirement)	0

TABLE NG 9/5: (05/01) **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 9/6: (05/01) **Longitudinal Regularity - Requirements**

Site	Class
Dual carriageways and single carriageways with a speed limit greater than 40 mph	2
Single carriageways with a 40 mph or lower speed limit, carrying more than 100 cv/l/d or more than 1000 total vehicles.	1
All other roads	0

Volume 2 home page

TABLE NG 9/7: (05/01) **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

31 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 (05/01) 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 7/21 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 should state the source and type of binder he proposes to use together with the data required by Appendix 7/21.

5 The Contractor's attention should be drawn to the need for best practice as set out in Road Note 39, Highway Authorities Product Approval Scheme (HAPAS), the Road Surface Dressing Association (RSDA) and Road Emulsion Association (REA) documents.

6 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 9/8. Guidance as to the choice of binder is given in the Road Note 39.

TABLE NG 9/8: (05/01) **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 919.3.

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 7/21, should be selected from Table NG 9/9.

TABLE NG 9/9: (05/01) **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 HD 36; 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 7/21 should be selected from Table NG 9/10. 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 9/10: (05/01) **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.

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 7/21. 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 9/11. The class or classes appropriate to the site should be specified in Appendix 7/21.

TABLE NG 9/11: (05/01) **Tolerance on Design Rate of Spread of Binder**

Site	Tolerance	Class
Highly Stressed Sites, Motorways and Dual Carriageways	±5%	2
Single Carriageways	±10%	1

19 The allowable tolerance on the design rate of spread of chippings is dependant on the site and is classified in Table NG 9/12. The class or classes appropriate to the site should be specified in Appendix 7/21.

TABLE NG 9/12: (05/01) **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 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 (05/01) Bond Coats, Tack Coats and Other Bituminous Sprays

Bond Coats and Tack Coats

1 This Clause specifies tack coats and bond coats for coated macadam, hot rolled asphalt, porous asphalt, microsurfacing, and stone mastic asphalt binder course and regulating course. Bond coats and tack coats are applied prior to overlay to promote the development of a homogenous pavement structure. Bond is particularly important in highly stressed areas. Useful advice is provided in the Design Manual for Roads and Bridges (DMRB), Volume 7, HD37. All proprietary thin surface course systems are required by Clause 942 to have a British Board of Agrément HAPAS Roads and Bridges

Certificate. These provide details of the bond or tack coat required for each system and in consequence Clause 920 is not applicable to thin surface course systems.

2 Bond coats and tack coats promote adhesion between layers of material. Bond coats or tack coats should always be used on an old surface except in the rare cases where a Contractor can demonstrate that full bond between the new material and underlying old road will be developed. This is likely to occur only when the existing surface is uniform in texture, has free binder and is clean and free of all extraneous matter. Traditionally a tack coat using K1-40 emulsion has been used to add a little extra binder to an existing surface and is often adequate to initiate adhesion between layers. Bond coats generally have a higher binder content often containing modifiers and are usually used at a higher rate of spread thus promoting improved adhesion with some waterproofing capability, important to prevent water ingress below porous or permeable materials. Additional information is provided in DMRB, Volume 7, HD37.

3 Bond or tack coats may sometimes need to be blinded with fine aggregate or sand, to prevent them from being picked up when being walked on or driven over, especially during periods of hot weather. Alternatively, 'non-tack' bond coats, which are available from some suppliers, may be used. When these emulsions break, sometimes accelerated using proprietary breaking agents, the residual binder is not as tacky or sticky, only becoming so at the high temperatures associated with the asphalt overlay when they melt at the interface, thereby achieving a bond. These materials are useful for work in urban areas where foot traffic is sometimes unavoidable.

4 Rates of spread of binder should follow the recommendations of the BBA/HAPAS Certificates or British Standards as appropriate. Rates of spread may need to be altered for varying texture and porosity of the existing road and an increased rate at the kerb or road edge is beneficial to minimise water ingress where compaction by traffic is least. General guidance is given in Technical Data Sheets issued by the Road Emulsion Association.

5 Particular care is required when applying a bituminous surfacing to an existing concrete road as not all emulsions adhere well to concrete. It is likely that one specially formulated for this application will be needed. The adhesion of a bituminous surfacing to newly laid concrete is a special case and evidence of a satisfactory bond should be provided if no appropriate British Board of Agrément HAPAS Roads and Bridges Certificates have been issued.

6 Intermediate grade bond coats or bituminous sprays have a Vialit Pendulum Peak Cohesion value greater than 1.0 J/cm^2 on the recovered binder prepared using Clause 923 when measured using Clause 939. Premium grade bond coats or bituminous sprays have a Vialit Pendulum Peak Cohesion value greater than 1.2 J/cm^2. Intermediate or premium bond coats are recommended when overlaying highly variable surfaces or those of high porosity. Premium grade bond coats are recommended for sealing under porous asphalt or for improved bond in highly stressed areas.

Bituminous Sprays

7 Bituminous sprays may be used to seal and protect earthworks, drainage media, recycled material and cementitious materials including cement-stabilised soil. The primary purpose is not necessarily to promote bond with an overlay, but to limit the evaporation or ingress of water and in cementitious materials, to facilitate proper curing. Cementitious surfaces are alkaline and in warm summer conditions anionic emulsions may be more suitable than cationic emulsions. Anionic emulsions have an alkaline water phase and can penetrate the surface before breaking. Bituminous emulsions to BS 434 should be selected by the Contractor with advice from the manufacturer and by reference to Technical Data Sheets published by the Road Emulsion Association. It is important that the coverage of residual binder is uniform. Even small areas that remain unsealed will increase evaporation of water and in cementitious materials, cause premature drying that will inhibit curing. The surface of the sprayed area should normally be covered with light coloured aggregate to reduce the absorption of heat from the sun's rays and reduce water loss.

General

8 To enable the Overseeing Organisation to identify each product, the data required on the binder data sheet (Appendix 7/4) is to be provided by the Contractor. The Extended Recovery Test stated in Clause 923 may be used as an alternative to the high-pressure ageing test (HiPAT) for those binders containing volatile oils.

Volume 2 home page

NG 921 (05/02) Surface Texture of Bituminous Surface 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 (05/02) 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 surface 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 (05/02) 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 surface course.

6 (05/02) 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.

7 (05/02) 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.

8 (05/02) 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.

9 (05/02) Calibrations carried out on site are only applicable to that site and that surfacing.

10 (05/02) 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 (05/01) Surface Dressing: Design, Application and End Product Performance

1 This specification is not of the conventional recipe/method type. 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 a recipe specification 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 guarantee period specified in the Contract. The guarantee period is normally two years for motorways, trunk roads and heavily trafficked or highly stressed roads, and one year for other roads.

2 This specification allows considerable freedom for the Contractor in the design of the Surface Dressing. Where the binder has a British Board of Agrément HAPAS Roads and Bridges Certificate (Specialist Group 4) then the Surface Dressing may be specified on any category of road. All proposals must be supported by trials, which would normally have been carried out during routine work, but that have been fully documented using the National TAIT documentation. TAITs are self-certified by the Contractor under the Sector Scheme for the Production of Surface Dressing described in Appendix A. The Contractor may choose any number of TAITs to cover the range of products he is prepared to install. For example a heavily trafficked motorway site using a double dressing consisting of 14 mm chippings followed by 6 mm chippings using two applications of a premium grade modified emulsion binder would provide a suitable TAIT for all similar heavily trafficked sites, but would not necessarily be applicable to stressed sites nor lightly trafficked country lanes. There are likely to be several products, designs, traffic categories and site types for TAITs to be recorded. It is expected that these TAITs will eventually form the basis of CE-marking for Surface Dressing for each different intended use.

3 Low noise emission Surface Dressings may be specified by limiting the designs to double or multi-layered dressings and/or the maximum texture depth in Appendix 7/3. Where a British Board of Agrément HAPAS Roads and Bridges Certificate (Specialist Group 3) is required for Thin Surface Course Systems using double or multi-layered surface dressings as alternatives to thin asphalt surfacings, Specification Clause 942 should be used. For Clause 942 the noise emission reduction has been demonstrated for the BBA/HAPAS Certificate measured by the Statistical Pass-by method ISO 11819-1 and certified by BBA, it is categorised by Road Surface Influence (RSI). Where the Contractor has a British Board of Agrément HAPAS

Volume 2 home page

Roads and Bridges Certificate (Specialist Group 3) for the Surface Dressing as a thin surface course system, this is acceptable in place of a TAIT certificate for contracts where a TAIT is required.

4 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.

5 Basic details of the tendered design for each site should be completed in the Design Proposal and TAIT certificates for similar sites provided.

6 If any site is considered by the Tenderer to be unsuitable for surface dressing this should be stated in the Design Proposal. There may be sections where the existing road surface is considered not suitable for treatment or the performance requirements are too onerous to be achieved in practice, see HD 37.

7 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 considering the Estimated Design Life stated in the TAIT Certificate or, if one has not been issued, the Design Proposal.
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 and Binder Data Sheet requested in Appendix 7/3 will not be considered.
Traffic Management	Any tenderer failing to submit his proposals for traffic control and aftercare 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 multiple layer dressing expertise as detailed in Appendix 7/3 will not be considered.
TAIT Certificates	Any tenderer failing to submit certificates for TAITs similar to those systems proposed for the sites in the Contract will not be considered unless no such TAIT Certificates have been issued.

Volume 2 home page

8 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 (REA) documents. 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.

9 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 HD 36, 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 hardness and traffic category and bring any obvious anomalies about the site to the attention of the Overseeing Organisation.

10 For the purposes of the Contract, monitoring will stop at the end of the guarantee period, or for novel materials, after one third of the stated Estimated 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. On heavily trafficked roads 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. For other roads sand patch tests or use of the Mini Texture Meter or other device calibrated against sand patch values as Sand Patch Equivalent values, may be more convenient.

11 The Vialit pendulum test should be carried out using Clause 939. The minimum binder cohesion at peak measured using the Vialit Pendulum for three grades of binder are given in Table NG 9/13. Guidance as to the choice of binder is given in HD 37. The range of temperature for premium and intermediate binders for a value of 1.0 J/cm^2 for heavily trafficked roads or highly stressed sites, provides another parameter for evaluation of the modification together with peak value (see HD 37).

TABLE NG 9/13: (05/01) **Vialit Pendulum Test**

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

12 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 may 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 set a standard, the product identification test has been standardised using the results from a dynamic shear rheometer of complex shear (stiffness) modulus and phase angle as specified in Clause 928. If the supplier considers that other tests would identify his binder more precisely then he may provide the results of these additional tests in addition to the requirements of sub-Clause 922.5 and 922.6 and add them to the Binder Data Sheet in Appendix 7/3. Other recovery test methods may be used to provide residual binder for subsequent testing and these may be convenient for quality control purposes, however, the definitive test is Clause 923 and results for Clause 928 and Clause 939 for type approval purposes will be based on recovered binder from Clause 923.

13 The binder sprayer should be checked for accuracy of transverse distribution using prEN 12272-1. 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 over 60 seconds in a static condition and therefore does not simulate site conditions caused by varying spraybar height, wind effects and 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 9/14.

Volume 2 home page

TABLE NG 9/14: (05/01) **Accuracy of Binder Sprayer**

Site	Coefficient of Variation Cv	Class
Motorways and Dual Carriageways	< 5%	3
Single Carriageways	< 10%	2
Lightly Trafficked Single Carriageways	< 15%	1

14 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 36; over specification should be avoided in order to conserve scarce resources.

15 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 9/15. The rate of spread for secondary chippings is less important and an excess is usually beneficial so that spreading with two tail-board gritters in echelon is acceptable.

TABLE NG 9/15: (05/01) **Accuracy of Chipping Spreader**

Chipping Type	Coefficient of Variation Cv	Class
Primary chippings in multi-layer Surface Dressing	< 10%	2
All other chippings	< 15%	1

16 Repairs to the existing road, in preparation for Surface Dressing, (for example, patching) should be carried out well in advance of the Works. They 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 may absorb bitumen into the voids and chipping loss may ensue. The existing road variability and surface characteristics have a bearing on the achievable levels of performance that may be specified; further information is available in HD 37. 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 and fatting may occur. Thin surface course systems should be repaired with stone mastic asphalt of similar consistency and highly textured variable substrata should be sealed with a pad coat. 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. Binder-rich soft materials to seal cracks similar to stress absorbing membrane interlayers (SAMIs) should not be used especially longitudinally in the wheel tracks, as the Surface Dressing will fat up.

17 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 this is mud or dust then the Surface Dressing will fail rapidly, 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 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.

18 Traffic safety and management. The mode of operation of Surface Dressing contracts can necessitate the adoption of techniques requiring additional equipment over and above that normally required by static works. For example, where traffic lights are required as part of the traffic management scheme, some sites may require the provision of additional sets of traffic lights over and above the minimum necessary in order to permit work to progress with a minimum of interruption and disruption to road users.

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

20 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.

21 Longitudinal joints should have slightly overlapped binder films obtained by leaving at least a 100 mm wide wet edge. 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, sufficient overlap (up to 300 mm) should be implemented in order to ensure at a minimum the full rate of spread of binder at all points.

22 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 may be employed; a minimum rate of 1 test per day on motorways and trunk roads might be attained if the contract is large enough. The Overseeing Organisation will carry out testing at audit frequency, typically at about 10% of the specified frequency for the Contractor. If the results from 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. For roads other than trunk roads or motorways the frequency of testing detailed in the Quality Plan and the Sector Scheme for the Production of Surface Dressing should be used.

23 The allowable tolerance on the design rate of spread of binder is dependent on the site and is classified in Table NG 9/16. The class or classes appropriate to the site should be specified in Appendix 7/3. These levels may eventually be established in the Sector Scheme for the Production of Surface Dressing and are part of the Quality Plan and Design Proposal.

TABLE NG 9/16: (05/01) **Tolerance on Design Rate of Spread of Binder**

Site	Tolerance	Class
Highly Stressed Sites, Motorways and Dual Carriageways	± 5%	2
Single Carriageways	± 10%	1

24 The allowable tolerance on the design rate of spread of chippings is dependent on the site and is classified in Table NG 9/17. The class appropriate to the site should be specified in Appendix 7/3. These levels may eventually be established in the Sector Scheme for the Production of Surface Dressing and are part of the Quality Plan and Design Proposal.

TABLE NG 9/17: (05/01) **Tolerance on Design Rate of Spread of Chippings**

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

25 The aim of rolling should be to orientate the chippings and place them in contact with the binder rather than provide compaction. There is some consensus that vibration using a rubber coated vibratory steel-tyred roller 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 (12 tonnes) tend to crush chippings and their use should not be permitted.

26 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 or 20 mph signs, when permitted, are extremely useful and warn 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 that would otherwise become part of the mosaic. With multi-layered surface dressing it may not be necessary to sweep initially 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.

27 On motorways and heavily trafficked dual carriageways it is not normally possible to convoy traffic through the Works at a speed of 20 mph which would normally be done on other roads to consolidate the Surface Dressing prior to final sweeping and opening to unrestricted traffic. As part of the normal

Volume 2 home page

traffic management for motorway work there is generally a mandatory 50 mph speed restriction in place for the duration of the work. Therefore, instead of the normal slow speed trafficking and convoying as part of the aftercare, the Surface Dressing should be designed to be opened to 50 mph traffic after completion of initial suction sweeping. Suitable designs include double and multi-layered dressings using polymer modified emulsion binders and racked-in dressings using polymer modified cutback binders with lightly coated chippings for the primary layer. There should follow a number of days of trafficking at the restricted speed limit (generally 50 mph) with traffic management being organised in such a manner that all lanes have at least 48 hours of speed limited trafficking. A minimum of 72 hours of restricted speed limit control after opening the whole carriageway to traffic should be included in the works programme. This period may be extended as stated by the Overseeing Organisation in Appendix 7/3 or as detailed by the Surface Dressing Contractor in his Design Proposal. The period will not normally be extended except when the traffic on the section of motorway is unusually light or the work is to be carried out late season, for example in August. The Surface Dressing Contractor will determine the need for a longer period based on his experience with a particular process that is proposed. All loose chippings should be removed from any traffickable part of the carriageway or hard shoulder prior to removal of the speed restriction.

28 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. When using emulsions, humid or cool weather, results in a similar problem as the binder takes longer to gain cohesion. These conditions result in lower initial resistance to traffic forces and the mosaic may be destroyed. The Contractor should be prepared for these eventualities and have on site, ready to use, a suitable ‘dust’, if this is required, and be prepared to re-impose traffic control. 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.

29 Texture is measured in the nearside (inside) wheel track where the lane width and traffic are sufficient for this to be identified; for low traffic category sites the track carrying the most traffic (wear) is tested, this may be the outside wheel track for narrow lanes where tyre paths in both directions overlap. High-speed sensor measurements should be used for measuring texture depth on trunk roads and motorways because of the amount of texture depth measurement to be undertaken. This form of measurement avoids the need for additional lane closures, which the use of sand patch testing or the Mini Texture Meter would require. Other methods may be used, but the results should be reported as Sand Patch Equivalent values. 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 lower speed roads and for certain Surface Dressing product types as shown in Tables NG 9/18 and NG 9/19. The texture requirements are reduced for double and multiple-layered surface dressings, which are more durable especially when the binder is modified, as the rate of embedment (loss of texture with time) is lower. These dressings have lower initial texture and a greater number of points of contact to tyres and they are used to reduce tyre noise emission in areas where this is important such as urban roads or trunk roads and motorways close to a conurbation. Texture levels specified should be achievable depending on the variability and surface characteristics of the existing road and traffic category; guidance is available in HD 37.

TABLE NG 9/18: (05/01) **Minimum Sand Patch Test Texture Depth Requirements (or Sand Patch Equivalent) in the Nearside Wheel Track for Single and Racked-in Surface Dressings at the End of the Guarantee Period**

Traffic cv/lane/day	Speed limit 50 mph or higher Sand Patch Texture (mm)	Speed limit 40 mph or lower Sand Patch Texture (mm)
More than 2000	1.5	1.5
250 to 2000	1.5	1.2
50 to 250	1.5	1.0
Less than 50	1.0	0.8

Volume 2 home page

TABLE NG 9/19: (05/01) **Minimum Sand Patch Test Texture Depth Requirements (or Sand Patch Equivalent) in the Nearside and Offside Wheel Tracks for Double and Multiple-layered Surface Dressings at the End of the Guarantee Period**

Traffic cv/lane/day	Any Speed Limit Sand Patch Texture (mm)
Over 3250	1.2
250 to 3250	1.0
Less than 250	0.8

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. Double and multiple-layered dressings using modified binders normally show reduced loss of texture with time. An increase in texture depth over time indicates that the surface is losing chippings.

30 It is anticipated that because Surface Dressing defects are usually obvious the need for a formal assessment procedure using the quantitative method in prEN 12272-2 will be rare. The visual assessment of fretting P1, expressed as a percentage of chipping loss, is classified in Table NG 9/20. The class appropriate to the site should be specified in Appendix 7/3 provided that the levels are achievable depending on the traffic category and existing road surface characteristics, see HD 37.

TABLE NG 9/20: (05/01) **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 using prEN 12272-2, is classified in Table NG 9/21. The class appropriate to the site should be specified in Appendix 7/3.

TABLE NG 9/21: (05/01) **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

31 The guarantee period stated in the specification should be clearly stated as applying to the Surface Dressing. For trunk roads and motorways this period should normally be two years, for other roads such as lightly trafficked single carriageways the guarantee period may be one year. An appropriate Special Requirement should be included in the Conditions of Contract drawing particular attention to the guarantee period.

NG 923 (05/01) Binder Recovery using the Rapid Recovery Test (RRT): Preparation of Recovered Binder from Modified Bituminous Emulsions and Cutback Bituminous Binders

1 The RRT is able to drive off water from polymer modified emulsions rapidly at a comparatively low temperature of 85ºC because the stainless steel screws continually disturb the binder and there is a controlled gas flow over the binder surface encouraging a homogenous break without skinning. This is important as higher temperatures would drive off the volatile oils and/or destroy or change the microstructure of the binder, which would not therefore simulate the residual binder on the road. Some polymer microstructures are more sensitive to temperature than others and this should be considered when heating samples for subsequent testing.

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

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. However, the microwave procedure has been found to provide consistent results and eliminate the remaining moisture that may be damaging to other test methods, such as a rheometer water bath. The RRT is also suitable for

Volume 2 home page

conventional unmodified emulsions and cutbacks although prEN 13074 may be preferred for unmodified bitumen emulsions, as it does not require RTFOT apparatus, however the test takes 48 hours.

4 PTFE screws are used when the two bottles are used to set the cycle time for the microwave oven because stainless steel should not be placed in the oven. The total weight of binder is needed to check against binder content of the emulsion. 'Recovered Binder' from these two bottles may be used for further testing. When the cycle time has been established together with the number of cycles (normally one or two) the test may be carried out without repeating this check for the same emulsion sample. The other bottles will not need any microwave treatment if only one cycle demonstrates that constant weight has been achieved. Although when the 'Recovered Binder' is to be used in a rheometer water bath, one cycle in a microwave might be prudent to reduce the likelihood of leaching.

5 The 'Recovered Binder' from the bottles may be conveniently scraped onto a non-adhesive sheet or dish (eg. PTFE or silicone) in order to collect enough material for a test. Care should be taken to minimise volatile oil loss and opportunity for oxidation by ensuring a quick transfer to the storage penetration test pot or other test apparatus.

6 The percentage loss of weight should be recorded as an indicator of water and/or volatile oil losses and compared to the binder content of an emulsion or the percentage volatile flux oil of a cutback if known.

7 The period required for the RTFOT oven temperature to stabilise may be much shorter than that prescribed in ASTM D2872-88, as modern ovens with micro-processor controls stabilise very quickly, normally within 1 hour.

8 Recording sample history is important as the method of sampling whether from spraybar or storage tank or just after manufacture may affect the properties of the binder. The sample size and its subsequent treatment in terms of re-heating, exposure to frost, regular stirring etc. may make considerable difference to the result for water or volatile oil loss.

9 The PTFE bottles manufactured to the dimensions stated and with screw caps to facilitate sample removal together with PTFE screws may be obtained from Tefloturn Limited in Hertford UK - web site www.tefloturn.co.uk.

10 The Extended Recovery Test is an alternative to the high pressure ageing test (HiPAT) and does not require a SHRP PAV apparatus, which is considered to be a greater safety hazard when using emulsions or cutbacks containing highly volatile oil. The binder may lose volatile oil, but increase in weight due to oxidation so care should be taken when analysing weight changes. Using nitrogen gas for 24 hours could assist in this assessment if required.

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 (05/01) 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 9/22. 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 (05/01) Each Type classification has an expected service life of between 5 to 10 years at the maximum traffic levels shown in Table NG 9/22. 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 favor 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 (05/01) 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 incorporating microsurfacing, 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 Certificate.

6 (05/02) High friction surfacing systems are best applied to surface 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 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 (05/01) 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 36.

8 If no British Board of Agrément HAPAS Roads and Bridges 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.

TABLE NG 9/22: (05/01) **High Friction Surfaces: Area of Application by Type Classification***

Site Category (As defined in HD 36)	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.

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

Volume 2 home page

NG 926 In Situ Recycling: The Remix and Repave Processes

1 Guidance to the requirements specified in Clause 926 is contained in HD 31.

2 (05/02) 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 surface courses and can 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 928 (05/01) Determination of the Complex Shear (Stiffness) Modulus (G*) and Phase Angle (δ) of Bituminous Binders using a Dynamic Shear Rheometer (DSR)

1 The IP equilibrated temperature test method provides a fundamental set of data for type testing purposes. However, as this test is time consuming the temperature sweep test method has been found to be more convenient to check the properties of a binder against the former test and is accepted for this purpose. Where there are differences and/or there is doubt the determining test is the IP test method.

2 The method of sample preparation for bituminous emulsions limits the maximum temperature for the sample to 100°C to prevent changes to the microstructure of the material that would not be experienced in practice and for cutback binders to minimise loss of volatile oils, which would only take place after many months on the road. The results for these samples may be more variable as homogeneity is not ensured, but this may be more representative of the condition immediately after application.

3 Fine mineral or organic matter in modified binders containing more than 20% by weight and/or where particles or fibres exceed dimensions greater than 40% of the plate gap may not provide true values. However, repeatable results have been achieved for Lake Asphalt (36% fine filler) and polymer modified binder/filler mixtures used in the manufacture of asphalt of up to 50% by weight of filler. The behaviour of binder/filler mixtures is critical in predicting the performance of asphalt.

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

5 A rheometer should be used that is capable of controlling the temperature of the sample to prevent temperature gradients within the sample for the equilibrated temperature test method and minimise any temperature gradients for the temperature sweep method.

6 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).

7 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 should 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.

8 Gap settings within the range 0.5 mm to 2 mm and strain settings within the range 0.005 and 0.02, have been found to be suitable for typical proprietary bituminous binders over the temperature range -5°C to +60°C at 0.4 Hz for parallel plate geometries. The gap set will change with temperature and appropriate steps will need to be taken to 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.

9 Depending on the rheometer used and the sample being tested, it may be possible to measure all the results using a single plate geometry (diameter and gap). The amplitude of the oscillation of the moving plate of the DSR should be such that the sample deformation is within the linear region of the material being tested. The rheometer operator should know the limitations of the instrument and use more than one plate and/or gap if necessary to cover the range for G* at 0.4 Hz of at least 20 MPa to 2 kPa.

10 The check that the test is being carried out within the linear range is most conveniently made by carrying out a strain sweep at both the highest and lowest temperature to be used for the rheological characterisation.

11 It has been found convenient to test at (approximately) the following temperatures as the minimum number needed to generate curves required: -5°C, 5°C, 15°C, 25°C, 35°C, 45°C and 60°C. In order to provide the temperature value within the range of results for the High Equi-stiffness Temperature some binders may require testing at temperatures above 60°C so a further frequency sweep at 70°C or higher may be necessary. The accuracy of ± 0.5°C is a maximum, the target temperature range should be nearer ± 0.1 C. Eleven equally spaced logarithmic frequencies including 0.1, 0.4, 1.6 and 10 Hz have been found to be acceptable. Where the DSR used has pre-set frequencies as close an approximation to even logarithmic spacing should be used as is possible.

12 Errors may be introduced by machine limitations, which should be checked with the rheometer manufacturer, for example:

(i) At low sample stiffness, the minimum torque that the instrument can generate and measure accurately may be too high to keep the sample in its linear region.

(ii) At 25°C and at a frequency of 0.4 Hz the strain should be typically maintained in the range 0.005 to 0.02.

(iii) At high sample stiffness, the maximum torque that the instrument can generate may be insufficient to deform the sample by the minimum amount that can be measured accurately.

(iv) At high sample stiffness, the spindle of the moving plate may deform due to spindle compliance, causing an error in the measurement of strain.

(v) At short loading times the rotational inertia of the spindle may cause errors in measurement of torque. This type of error is most obvious when the sample stiffness is low.

Values of G* above 10^7 Pa tend to be less reliable and the difference in values between different bituminous binders becomes less, so effort to improve precision at low temperatures is of little benefit. Also at this limiting stiffness non-linear effects begin and machine compliance becomes a problem.

13 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 this 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.

14 Some polymer modified binders exhibit unusual structuring or crystallisation that result in different curves for the temperature sweep when heating and cooling. It is therefore important to record the direction of sweep, cooling is difficult to control so heating is the normal procedure.

15 (05/02) The data at frequencies other than 0.4 Hz are recorded for future analysis if required. The production of a Master Curve referenced to 25°C would be a useful addition, but is optional. Zero-Shear-Viscosity is required as it may prove to be useful as a performance-related parameter for deformation in asphalt or binder flow in surface treatments. Temperatures of 45°C and 60°C have been chosen to relate to the wheel-tracking test. There are several analysis packages available to carry out this calculation.

The notes and guidance supplied in the IP Test Method IP PM CM/02 should be studied, for completeness some of the notes are duplicated or amplified in this clause.

NG 929 (05/02) Design, Compaction Assessment and Compliance of Base and Binder Course Macadams

1 (05/02) The Specification for Highway Works (SHW) requires compaction trials to be carried out when bitumen macadam, DBM50 or heavy duty macadam are used for base or binder course, 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

Volume 2 home page

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 (05/02) 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. Furthermore, compliance limits have now been set for the Stiffness Modulus for materials specified to comply with Clauses 902 or 944; and for Deformation Resistance for materials specified to comply with Clause 952.

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 (05/02) Problems have sometimes been experienced in achieving complete coating of coarse aggregates in base and binder course macadams and this is often related to the use of a particular aggregate source. The use of a design approach should assist Contractors to 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, NG 932, NG 933 and NG 934 (05/02) Heavy Duty Macadam (HDM50) and Dense Bitumen Macadam (DBM50) with Bitumen Penetration Reference 50 Base and Binder Course

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 (05/02) For binder course, 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 935 (05/02) High Modulus Base (HMB35) Base

1 HMB is a stiffer material than DBM, DBM50 or HDM. Consequently, provided a particular pavement design would otherwise be of greater thickness than the minimum thickness required in the design standard, designs which include HMB will provide a thinner pavement for the same traffic loading. Alternatively, for the same pavement thickness as with other materials, HMB increases the structural capacity of the pavement. The latter aspect can prove useful in situations where pavement thickness is constrained but it is necessary to increase the design capacity of the pavement.

2 (05/02) The specified nominal layer thickness and the minimum layer thickness for a given nominal size of aggregate in Appendix 7/1 should comply with the requirements for “Dense base” in Table 1 of BS 4987 : Part 2.

3 It is fundamentally important that sub-Clause 935.3 is complied with.

4 Potential users of this Clause should first refer to Volume 7 of the Design Manual for Roads and Bridges (DMRB).

5 If it is likely that traffic management cannot avoid highway traffic running directly on this material, in order to minimise risk of it breaking up the surface should first be sealed and then gritted to provide adequate skid resistance.

NG 936 (05/02) High Modulus Base (HMB35) BinderCourse

1 HMB is a stiffer material than DBM, DBM50 or HDM. Consequently, provided a particular pavement design would otherwise be of greater thickness than the minimum thickness required in the design standard, designs which include HMB will provide a thinner pavement for the same traffic loading. Alternatively, for the same pavement thickness as with other materials, HMB increases the structural capacity of the pavement. The latter aspect can prove useful in situations where pavement thickness is constrained but it is necessary to increase the design capacity of the pavement.

2 (05/02) The specified nominal layer thickness and the minimum layer thickness for a given nominal size of aggregate in Appendix 7/1 should comply with the requirements for “Dense binder course” in Table 1 of BS 4987 : Part 2.

3 It is fundamentally important that sub-Clause 3 is complied with.

4 (05/02) Potential users of this Clause should first refer to DMRB, Volume 7, HD 26.

5 If it is likely that traffic management cannot avoid highway traffic running directly on this material, in order to minimise risk of it breaking up the surface should first be sealed and then gritted to provide adequate skid resistance.

NG 937 (05/02) Stone Mastic Asphalt (SMA) Binder Course and Regulating Course

1 (05/02) The temperature for wheel-track testing in accordance with sub-Clause 937.31 should be specified in Appendix 7/1 as either 60°C or 45°C. The lower temperature will be appropriate for less heavily trafficked roads where the surface course overlay is 30 mm or greater in thickness.

2 (05/02) The limits for deformation using either the wheel tracking test or vacuum RLAT test are specified in Clause 952.

TABLE NG 9/23: (05/02) **Not used**

3 (05/02) The agreed mixture in sub-Clauses 937.17 and 937.18 is that obtained after the Contractor has proposed a mixture, with evidence to demonstrate that it complies with sub-Clauses 937.17 and 937.18, to the Overseeing Organisation for agreement.

4 (05/02) In sub-Clause 937.37, one cause of production variations may be due to binder drainage.

NG 938 Porous Asphalt Surface Course

1 (05/02) Guidance to the requirements specified in Clause 938 is contained in DMRB, Volume 7, 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.

Volume 2 home page

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 (05/01) 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). 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 (05/01) With reference to sub-Clause 939.11, it is important that the measured parameters in the equation for the individual pendulum are used and not the mean or mid-point value.

8 (05/01) Table NG 9/24 would be a suitable basis for pre-recording the relationship between the angle α and energy (Joules) for each pendulum tester.
Table NG 9/25 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 9/24 is used to convert the mean angle to energy (Joules) for each pendulum test.

9 (05/01) This Clause uses some non-SI metric units.

TABLE NG 9/24: (05/01) **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 α)

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.

Volume 2 home page

TABLE NG 9/25: (05/01) **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 (05/01) Thin Surface Course Systems

1 Thin surface course systems are proprietary bituminous products with suitable properties to provide a surface course that is laid at a nominal depth of less than 40 mm. As such, this classification can include hot-mixed asphalts, slurry surfacings incorporating microsurfacing and (multiple) surface dressings without any explicit exclusion.

2 This Specification for thin surface 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.

Test Certificates

3 The initial assessment as to the suitability of thin surface course systems relies on the systems having gained a British Board of Agrément HAPAS Roads and Bridges Certificate, in the course of which its in-situ properties will have been monitored for at least two years. However, because of the diversity of both systems and roads on which they can be applied, the possession of a Certificate does not automatically mean that the particular system is suitable for every situation where a thin surface course system is required. The appropriate properties need to be checked against the properties of the system as recorded on the Certificate.

4 Although a British Board of Agrément HAPAS Roads and Bridges Certificate is a mandatory requirement under this Clause, there must be an opportunity for new materials to gain a certificate. Therefore, systems that do not have a certificate can be permitted provided the works are monitored as a trial, overseen by the British Board of Agrément or their agent, for not less than two years, and with the guarantee period being extended to three years.

5 A clear distinction should be drawn between limitations set for the properties of thin surface course systems recorded on the British Board of Agrément HAPAS Roads and Bridges Certificate and

Volume 2 home page

requirements placed on the work being carried out. The former are based on results from past works and identify what the system has achieved whilst the latter identify what the system is required to achieve in this case.

6 The assessment by the British Board of Agrément as to the acceptable traffic flows that a system has been proved to be capable of carrying without excessive wear is based on the site stress level and commercial traffic on specific trial sites. The acceptable commercial traffic flows are separated by site stress levels, as given in Table NG 9/26.

7 The compiler of Appendix 7/1 should state the site stress levels for each section of road and the anticipated commercial traffic flows expected at the site over the guarantee period and should also require the Contractor to inspect the Site where the material will be laid.

TABLE NG 9/26: (05/01) **Site Stress Level Classification**

Site Category	Site Definition	Stress Level
A	Motorway (main line)	1
B	Dual carriageway (all purpose) non-event sections	1
C	Single carriageway non-event sections	1
D	Dual carriageway (all purpose) minor junctions	1
E	Single carriageway minor junctions	1
F	Approaches to and across major junctions (all limbs)	2
G	Gradient >5%, longer than 50 m (Dual downhill; single uphill and downhill)	2
H1	Bend (not subject to 40 mph or lower speed limit) radius 100 – 250 m	2
H2	Bend (not subject to 40 mph or lower speed limit) radius <100 m	3
L	Roundabout	3
J	Approach to roundabout	4
K	Approach to traffic signals, pedestrian crossing, railway level crossing and similar	4

8 The minimum polished stone value of the coarse aggregate should be selected from Table 3.1 and the maximum aggregate abrasion value from Table 3.2 in HD 36. Separate values of AAV should be given for thin surface course systems based on surface dressing or slurry surfacing techniques, taken from row 2 of Table 3.2, and other thin surface course systems, taken from row 3.

Performance Levels

9 The deformation resistance of thin surface course systems can be set in terms of wheel tracking level stated on the British Board of British Board of Agrément HAPAS Roads and Bridges Certificate. In deciding on the level, and hence the limiting wheel-tracking rate, the limiting wheel-tracking rut depth and the temperature of the test need to be given in Appendix 7/1, the limits given in Table NG 9/27 for site classifications defined in Table NG 9/28 should be considered. Deformation resistance should not be specified if the thin asphalt surface course system is only being laid at thicknesses less than 20 mm, where that depth is the sum of the nominal installation depth and the maximum depth of regulation required.

Volume 2 home page

TABLE NG 9/27: (05/01) **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 - 4000	over 4001
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		3
IA & IIA	As I and II, above, but with contraflow anticipated during summer months		0		1		2		3	
III	F G1 L	Approaches to and across major junctions (all limbs) Gradient 3% to 10%, longer than 50 m Roundabout	0		1		2		3	
IIIA	As III, above, but with contraflow anticipated during summer months or in a south-facing cutting uphill		0	1		2	3			
IV	G2	Gradient steeper than 10%, longer than 50 m	0	1		2	3			
IVA	As IV, above, but with contraflow anticipated during summer months or in a south-facing cutting uphill		0	2		3				
V	J/K	Approach to roundabout, traffic signals, pedestrian crossings, railway level crossings and similar	0	2		3				

Volume 2 home page

TABLE NG 9/28: (05/01) **Wheel-Tracking Levels**

Level	Test temperature (°C)	Specimen thickness (mm)	Criteria	Maximum wheel tracking rate (mm/h)	Maximum rut depth (mm)
3	60	≥ 30	Mean *	5.0	7.0
			Maximum †	7.5	10.5
		< 30	Mean *	1/6 x thickness #	7/30 x thickness #
			Maximum †	1/4 x thickness #	7/20 x thickness #
2	45	≥ 30	Mean *	2.0	4.0
			Maximum †	3.0	6.0
		< 30	Mean *	1/15 x thickness #	2/15 x thickness #
			Maximum †	1/10 x thickness #	1/5 x thickness #
1	45	≥ 30	Mean *	5.0	7.0
			Maximum †	7.5	10.5
		< 30	Mean *	1/6 x thickness #	7/30 x thickness #
			Maximum †	1/4 x thickness #	7/20 x thickness #
0	–	–	–	No requirement	No requirement

* mean = mean result of 6 consecutive determinations on individual specimens
† maximum = maximum result from 6 consecutive determinations on individual specimens
# thickness = thickness of specimens tested = nominal depth + thickness of regulating ability

10 Specified road/tyre noise Levels are only necessary in noise-sensitive areas. The Levels of noise, in terms of reduction relative to hot rolled asphalt, that can be used are given in Table NG 9/29, where the reduction is demonstrated by the optional value stated on British Board of Agrément HAPAS Roads and Bridges Certificates.

TABLE NG 9/29: (05/01) **Road/Tyre Noise Levels**

Level	Equivalence to HRA surfacing materials	Road Surface Influence RSI
2	Quieter than HRA surfacing materials	- 2.5 dB(A)
1	Equivalent to HRA surfacing materials	- 0.5 dB(A)
0	No requirement	No requirement

Layer Thickness

11 The minimum and/or maximum thicknesses at which the thin surface course system is to be laid should only be specified where there are specific reasons for doing so. If the thin surface course system is being laid purely to restore the surface characteristics such as skid resistance and texture depth, the choice of thickness should not be restricted. Possible reasons for specifying a minimum thickness are to maintain continuity with the material to be planed out, to avoid premature cooling in adverse cold weather conditions and to provide a contribution to the structural strength of the pavement. Possible reasons for specifying a maximum thickness are to maintain continuity with the material to be planed out, to retain sufficient headroom under low over-bridges, to avoid overloading weak under-bridges and to minimise the need to raise kerbs, safety barriers and/or ironwork. Premature cooling in adverse cold weather could be overcome either by use of thicker surfacing or by pre-heating. The nominal thickness at which to lay the material has to be selected by the Contractor with due allowance for the constructional tolerance. If both a minimum and a

Volume 2 home page

maximum thickness are specified, the difference between the maximum and minimum thicknesses should be at least 20% of their average.

12 The range of nominal installation depth at which a thin surface course system can be laid are given on the British Board of Agrément HAPAS Roads and Bridges Certificate. If systems are laid at nominal depths other than those quoted, then the Certificate will not be valid. The installation depths are classified into three categories, as given in Table NG 9/30.

TABLE NG 9/30: (05/01) **Nominal Installation Depth Classifications**

Type	Type A	Type B	Type C
Nominal installation depth (mm)	<18	18 to 25	>25 to ≤40

13 If thin surface course systems are required to be laid at installation depths of 40 mm or greater, no system will have a valid British Board of Agrément HAPAS Roads and Bridges Certificate because of the definition of thin surface course systems. Systems to be used in such situations must have a certificate with the appropriate properties covering installation depths up to 40 mm and the guarantee period should be extended to three years. Thin surface course systems should not be installed at nominal depths greater than 50 mm.

Surface Texture

14 The minimum texture depth required from hot rolled asphalt surfacing on high-speed trunk roads is generally 1.5 mm. There are no surface texture requirements for low speed roads (a road where the 85 percentile traffic speed is less than 90 km/h) surfaced with hot rolled asphalt, reliance being placed on the texture produced by the minimum rate of chippings required by BS 594 : Part 2. However, the surface texture obtained with a thin surface course system cannot necessarily be compared to that of a conventional single surface dressing or hot rolled asphalt. With thin surface course systems, the choice of aggregate grading is the Contractor's provided that the specified minimum surface texture is achieved. To ensure that a texture is provided and maintained on all roads, an initial texture depth is specified and a minimum requirement after two years has been included as part of the Contractor's guarantee.

15 The performance levels of texture depth used for the British Board of Agrément HAPAS scheme, given in Table NG 9/31, should be used as the basis for setting the texture depth requirements. Level 3 is the default value for motorways, trunk roads and high speed and high stressed roads. A lower level may be required where there is limited traffic and restricted speeds, but generally not where low road/tyre noise is required. (For thin surface course materials with "negative" texture, the noise tends to decrease with higher texture because there are more paths for the trapped air to escape from, which is contrary to the experience with conventional surfacings having "positive" texture.) For urban roads with speed restrictions of 40 mph or less, Level 1 should generally be adequate.

TABLE NG 9/31: (05/01) **Sand-Patch Texture Levels**

Level	Minimum Texture Depth (mm)	
	Untrafficked	After Two Years Trafficking
3	1.5	1.0
2	1.2	0.8
1	1.0	0.7
0	No requirement	No requirement

16 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 (Sensor Measured Texture Depth (SMTD)), may be used as a screening procedure, as recommended by BS 598 : Part 105.

17 Calibration trials and checks should be undertaken at the start and during the course of work to derive and confirm a relationship between the sand patch method and the SMTD.

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

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

20 SMTD is numerically different from texture measured by the sand patch method. Sand patch texture depth is a measurement of the average depth of hollows in the surface below general level of peaks. SMTD is the standard deviation of the sample height measurements.

21 In a similar way to measuring texture prior to opening to traffic, assessment of texture in the wheel tracks at the end of the guarantee period can be carried out by SMTD methods whether it be a high speed texture meter or mini texture meter, subject to them being calibrated against the sand patch method prior to carrying out a survey.

Volume 2 home page

Surface Preparation, Transportation, Placement and Compaction

22 The design, manufacture, transportation, placement and compaction of the materials is the Contractor's responsibility, within the constraints of the British Board of Agrément HAPAS Roads and Bridges Certificate for the system, as is a decision as to whether the weather conditions are suitable for placement and compaction. This transfer of responsibility provides scope for the Contractor to design and place the materials to suit the Contractor's system.

Road Markings

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

24 Problems have also been reported with pre-formed marking tapes on negatively textured surfaces coming unstuck in wet weather. Trials should be performed to select the best material.

Guarantee Period

25 The guarantee period should be clearly stated as relating only to the surface course. An appropriate Special Requirement should be included in the Conditions of Contract which draws particular attention to sub-Clause 942.14.

26 The situation with thin surface course systems is continually changing and there are likely to be an increasing number of systems coming onto the market. For advice on the latest situation, the British Board of Agrément should be consulted.

NG 943 (05/02) Hot Rolled Asphalt Surface Course (Performance-Related Design Mix)

1 (05/02) Wheel-track rutting in the surface course may result from deformation not only in the surface course itself but also in lower pavement layers, particularly in the binder course and, to a lesser extent, in the base. The designer should not consider using these materials unless he is satisfied that the binder course and base will provide the necessary support without undue deformation. To provide adequate resistance to deformation, it may be prudent to specify binder course and base macadams that are designed in accordance with Clause 929 using bitumen with penetration reference 50 for classification 2 sites and a bitumen with penetration reference 125 for the other sites in Table NG 9/32.

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 (05/02) When preparing the Instructions for Tendering it is essential that the compiler includes a requirement that approval of modified binders, 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.

Volume 2 home page

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 20 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 21 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 23 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 23 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 (05/02) 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 surface course, however, the material may be retained as part of the permanent binder course.

Testing

22 Although it is preferable to take cores prior to the surfacing being open to traffic, this may not be possible

Volume 2 home page

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 (05/02) For the reinstatement of core-holes the use of cold-lay 20 mm nominal size dense bitumen macadam binder course for layers more than 50 mm below the surface and cold-lay 6 mm size dense bitumen macadam surface course for the surface 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 (05/01) 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; 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 (05/01) 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 9/32 for site classifications defined in Table NG 9/33 should be considered.

Combinations of Factors which Promote Wheel-Track Rutting

31 (05/02) 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 9/33 has special categories IA, IIA, IIIA and IVA to cater for schemes where such conditions can be anticipated in the early life of the surface course to be laid. Special categories IA, IIA, IIIA and IVA 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 should 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 9/32: (05/01) **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 (Should 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 9/33: (05/01) 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							

Volume 2 home page

NG 944 (05/02) Design, Testing and Compliance of Performance-Specified Base

General

1 (05/02) The performance of a base material in the road structure is best measured by its stiffness modulus. Mix parameters such as aggregate grading, binder content, air voids and degree of compaction all contribute to stiffness and form part of conventional specifications. However, even with complete details of these parameters, it is not possible to say with certainty what the stiffness will be. The development of the indirect tensile stiffness modulus test (BS DD 213) now provides a straightforward method of measuring the stiffness of cores extracted from the pavement and offers a much more direct way of specifying the essential base properties.

It is envisaged that testing of conventional base parameters will continue, but less frequently.

Four grades of asphalt base have been defined, based on conventional dense bitumen macadam (DBM), heavy duty macadam (HDM) and high modulus base (HMB) made with different grades of binder:

TABLE NG 9/34: (05/02) **Characteristic Stiffness Modulus Values**

Grade	Stiffness (ITSM) (GPa)		
	Characteristic value (5^{th} percentile)	Minimum moving mean of 6 values	Minimum individual value (mean of pair of cores)
1	1.0	1.1	0.7
3	3.0	3.5	2.5
4.5	4.5	5.2	3.7

The characteristic stiffness value is the value below which only 5 per cent of all measurements are expected to lie.

Grading

2 The choice of grading will be affected by several factors including course thickness and placement circumstances. In difficult situations where there is an increased risk of segregation a grading with a smaller maximum size than usual may be beneficial. However, a finer grading will usually reduce the mix stiffness.

Binder

3 (05/02) It is expected that contractors should be able to achieve the specified levels of stiffness using standard grade binders, complying with BS EN 12591 or BS 3690 : Part 3. However, contractors may propose the use of a modified binder. Until the Highways Authorities Product Approval Scheme is operational, specific binder modifiers or process bitumens will need to be approved by the Overseeing Organisation.

4 When preparing the Instructions for Tendering, the compiler should include a requirement that approval of non-standard binders should be obtained prior to the date of return of tenders.

Job Mixture Approval Trial

5 The thickness and width of the trial strip is job specific. The thickness should not be less than the thickest course proposed for the permanent works. The minimum practical thickness to allow for test specimen trimming will be approximately 90 mm.

6 (05/02) The properties of the base material will change with prolonged transportation or storage. In the case of non-job-specific trials, the material should be transported for a distance of not less than 16 kilometres.

7 ITSM specimens should be as thick as possible in the range 35 to 70 mm.

Main Works Testing

8 Where limited volumes of materials are being placed, such as tie-ins or junctions, coring of separate layers may result in unreasonable delay because of the time needed for the lower layer to cool to the coring temperature. In these circumstances it would be reasonable to allow coring of both layers. This relaxation should only be given to avoid excessive paving delay and not simply to reduce the amount of coring effort.

9 If necessary, a lever may be used in a controlled manner to break the bond between the core and the underlying layer. If the core does not easily break away from the underlying layer then the coring should continue and a core of the test material and underlying material should be extracted. The test material shall be cut from this longer core in accordance with Clause 5.1 of BS DD 226.

10 The responsibility for contractual testing (by the Contractor or by the Overseeing Organisation) should be defined. Where the Overseeing Organisation is responsible, the time interval between laying macadam and providing results should also be stated in order to enable the Contractor to allow for this delay in his programme.

11 (05/02) The Indirect Tensile Stiffness Modulus (ITSM) measurements made in accordance with sub-Clause 944.9 should be sent to Pavement Engineering Group (PEG) of the Highways Agency

within one month of completion of the relevant works. This is essential in order to obtain feedback on stiffness values which have been obtained from different contracts.

NG 945 (05/01) Weather Conditions for Laying of Bituminous Materials

1 (05/02) This Clause describes the requirements for laying hot rolled asphalt surface course and increases the layer thickness in relation to prevailing weather conditions expected on site. It also contains requirements for laying hot rolled asphalt and dense macadam binder course and base materials. It takes into account the cooling effect of wind, in addition to air temperature, on hot rolled asphalt surface course.

2 (05/02) It is the Contractor's choice at the time of tender to select the surface course thickness. This should be either 45 mm or 50 mm, with a corresponding reduction to the overall thickness of binder course, or of base when binder course is omitted, to maintain the overall designed pavement thickness. This should be included in Appendix 7/1. The Contractor's option to select one of the above thicknesses of surface course should not be removed unless there are particular operational or technical reasons.

3 (05/02) For hot rolled asphalt materials, when site conditions are such that the time available for compaction is excessively long, such as when air temperatures are high, wind speeds are low or solar radiation is high, the delivery temperature may be reduced. However, the delivery temperature for hot rolled asphalt surface course materials should not be less than 150°C for a layer thickness of 45 mm or 45°C for a layer thickness of 50 mm.

4 (05/02) For dense macadam base and binder course materials, when compaction is not determined in accordance with sub-Clause 901.19, the weather conditions at the time of laying should comply with the requirements of sub-Clauses 1, 2 and 7 of this Clause.

5 For dense macadam materials, when compaction is determined in accordance with sub-Clause 901.19 there is no requirement to state additional constraints on laying conditions other than those given in sub-Clauses 1 and 2 of this Clause.

6 (05/02) The term 'light precipitation' is considered as rainfall less than 0.5 mm or equivalent per hour. This can be verified either by a local rain gauge, or a telephone call to the nearest Environment Agency Station in England or Wales, the relevant River Purification Board in Scotland, or the Environmental Protection Branch of the Department of the Environment for Northern Ireland, Culvert House, Castle Place, Belfast BT1 1FY, where the officer responsible for liaison with the Meteorological Office will obtain a reading from the nearest available rainfall recording source. A local rain gauge, of a suitable design, could be located at the site office or in close proximity to the Works.

7 The requirements of sub-Clauses 3, 4 and 6 of this Clause are based on a minimum available compaction time of 10 minutes from the time the material emerges from the paver. The requirements of Clause 901 still apply, unless specifically amended by this Clause.

NG 946 (05/02) China Clay Sand Asphalt Base

1 Trials have demonstrated that asphalts can be mixed successfully with china clay sand, although adjustments to the grading of raw china clay sand by the addition of specific fractions of the sand has been found to be beneficial in achieving the required properties.

2 The design of china clay sand asphalt by checking the properties of specimens taken from trials is identical to that for macadams manufactured from natural aggregates.

NG 947 (05/02) Slate Macadam Base

1 Slate may be bulkier than non-flakey aggregate when uncompacted, and this should be taken into account during mixing and laying.

2 As yet, there is no information as to the properties of dense macadams manufactured with a mixture of slate and aggregate of a different geological type. In particular, the mixture of cuboidal and flakey particles is liable to produce a less dense mixture than with either purely cuboidal or purely flakey particles alone. Therefore, mixtures of the two types of aggregate should not be used and slate aggregate from a single source is preferred.

3 (05/02) Due to the general horizontal alignment of the long sides of slate aggregate particles in a slate macadam base, it is an anisotropic material. When cores are taken normally, with axis vertical, the orientation of the stresses and strains set up by the ITSM and RLAT are aligned in the correct direction with the horizontal axis of the slate; ie tensile for ITSM and compressive for RLAT. Tests for stiffness modulus should ideally load the material with the compressive force perpendicular to the long sides of the aggregate particles and measure the tensile strain parallel to them. However, as cores are tested, for certain core orientations, axes will be perpendicular to the short sides in some cases and long sides in others. This could

result in variable results. Similar problems may occur with the axes of loading and measurement in tests for other mechanical properties.

4 (05/02) The design of slate asphalt base, by checking the properties of samples taken from trials, is identical to that for macadams manufactured from natural aggregates.

5 The special requirement to confirm continuity across any joints is because there is limited data as to the suitability of an edge of macadam produced with slate to lay further material against. With the high proportion of flakey aggregate, there is a concern that excessive voids may be trapped in a joint so formed.

NG 948 (05/01) Cold Recycled Bitumen Bound Material

1 General advice for the design and construction of cold recycled materials is published in Volume 7 of The Design Manual for Roads and Bridges (DMRB).

2 These Notes relate to the associated Specification for Cold Recycled Materials and offer the Design Consultant, Overseeing Organisation and Contractor the latest best practice advice on the design, supervision and execution of cold recycling works, used for structural maintenance of highway pavements.

3 Dependent on the type of pavement and specific site conditions, the cold recycling process may be used to form the structural course for a reconstructed pavement or the structural course and foundation platform as a combined layer. Alternatively, it may be used to provide a foundation course for a new overlying pavement construction.

Site Evaluation

Identification of Sites for Structural Maintenance by Cold In-situ Recycling

4 Structural maintenance of a road pavement may be required for a variety of reasons, when the running surface of the pavement becomes unserviceable and the cost of local repairs too expensive to sustain, due to the underlying pavement structure being incapable of offering the support required.

5 In the event of the deterioration being identified as a failure of the road haunch, any remedial measures should be investigated and implemented in accordance with TRL Report 216, Road Haunches: A Guide to Re-usable Materials (Potter, 1996).

6 If the deterioration is identified as being a general structural failure of the running lanes then any remedial measures should be investigated and implemented in accordance with TRL Report 386, Design Guide and Specification for structural maintenance of highway pavements by cold in-situ recycling (Milton and Earland, 1999).

7 In keeping with the objectives of sustainable development, each site should be investigated with the prime aim of determining the suitability of the existing materials for re-use. Irrespective of the remedial strategy ultimately implemented, the limits and condition of the site should be identified, including the following details for completion of Appendix 7/18.

- location, length and width of the site;
- construction of existing pavement;
- type and severity of deterioration;
- subgrade bearing capacity and condition;
- location and condition of drainage;
- location and condition of services;
- edge detail and verge condition, and
- future traffic loading.

8 To achieve the economies of scale and energy savings offered by the in-situ recycling process, a minimum programme of works of the order of 3,000 m^2 is suggested as a general guide, which could be a combination of a number of smaller schemes in close proximity. However, in particular circumstances, where conventional methods of reconstruction are onerous or precluded, smaller scale recycling works may still offer a cost-effective solution.

9 The use of the cold recycling process may also depend on whether there is sufficient thickness of existing pavement available for recycling. Although, in certain circumstances, it may be possible to include subgrade material into the recycled structural course, provided that a non-plastic pulverised aggregate is produced naturally or by modification using lime or cement. Alternatively, it might be possible to import additional material suitable for recycling.

Investigation Framework

10 Any pre-contract site evaluation, forming the first stage of the design process, should be planned and implemented to ensure that sufficient information is obtained to demonstrate to the Overseeing Organisation whether or not the recycling option is feasible. In addition, this evaluation should offer any prospective contractor all information necessary to plan their working practices and to tender on an equitable basis to achieve the targets set by an end-product performance specification.

11 The sampling and testing proposals for cold recycling projects on medium to heavily trafficked sites are summarised in Table 4 of TRL Report 386. However, the actual scope of the investigation carried out should reflect the nature and variation of the existing pavement materials.

12 Sites known to contain a variety of materials of uncertain origin should be evaluated more fully than those that are known to contain consistent layers of standard materials. The limits of each section of works should be identified and listed separately in Appendix 7/18. Also, sufficient representative information should be collected to enable the design process to be carried out for each of these sections.

Alternative Recycling Strategies

13 The situation may arise where it is impractical to divide the site into sections that contain consistent materials, capable of being designed as cold recycled material. However, as a mixed stockpile of materials from various parts of the site, it provides suitable feedstock for processed recycled aggregates. In such cases, despite contributing less to sustainable development, in terms of transport movements and energy used, compared to the in-situ process, alternative recycling strategies could be considered using central or mobile crushing, screening and mixing plants.

14 To encourage and advance the cause of sustainable development, attention should be paid to the removal from site of surplus pulverised aggregate, which could be used to strengthen other roads in the area. Local co-operation between different highway authorities should be sought and programmes of maintenance works on different parts of the local road network co-ordinated. Locations for stockpiles of surplus materials should be included in Appendix 7/18.

Representative Test Specimens

15 For any assessment related to the design of recycling works, it is important that any sample of aggregate obtained for testing is typical of the pavement to be recycled, either as a mixed sample in representative proportions or as separate components for recombining later.

16 Ideally, the test specimens should also represent the grading and particle shape of the pulverised aggregate. Development and use of mini-planers designed for trenching works, used to excavate trial pits, may offer a means of obtaining such samples. However, to date, pulverised aggregate is not generally available during the pre-contract investigation and the design process relies on test specimens derived from samples crushed in the laboratory. A variety of laboratory crushing methods and devices are currently employed but none is specifically designed to produce the pulverised aggregate produced by a recycling machine.

17 Where it is recognised that the laboratory crushing process is not achieving sufficient fine material, which is often the case where the feedstock material contains a significant proportion of hot rolled asphalt, the finer grading should not be obtained by further excessive crushing because this would not reflect the pulverisation in the field, which tends not to break the existing aggregate component. Although not ideal, the grading of the test specimen should be contrived to satisfy the specified grading envelope by the transfer of fine material from other sub-samples of the laboratory crushed material.

18 Alternatively, the grading of the test specimens could be made to meet the specified grading envelope by the addition of crushed rock fines, pit sand or PFA, particularly if their addition is considered beneficial to the performance of the recycled material in the field. Therefore, if the design using these test specimens is accepted, the proportion of fine material added to the material pulverised in the field should, ideally, be the same as the proportion of the same fine material used in the design process.

Underground Services, Ducts and Culverts

19 Because of their potential for disrupting the recycling works, all known services, ducts and culverts within 150 mm of the underside of the recycled layer should be accurately located and included with the site details given in Appendix 7/18.

Risk Assessment

20 Before drawing up a Contract involving the use of cold in-situ recycled materials, which are inherently more variable than plant produced new materials, the additional risks should be identified, apportioned and their management pre-planned to the satisfaction of all parties concerned. For this reason, the Overseeing Organisation and Contractor should be satisfied and agree that the existing pavement materials in all sections of the works, as defined in Appendix 7/18, are capable of being recycled by pulverisation, to form the primary aggregate component of a new cold recycled mixture. Also, that the mixture designed in accordance with sub-Clauses 948.58 to 948.65 for foamed bitumen bound material, is capable of being produced to meet the end-product performance requirements.

Component Materials

Pulverised Aggr1egate

21 The nature and grading of the aggregate produced by pulverisation will depend largely on the nature, thickness and proportions of the existing road materials. In situations where the depth of the existing pavement is insufficient to accommodate the new pavement design, it may be necessary to include subgrade material into the recycled structural layer or treat the subgrade as the only foundation, compensated by an equivalent increase in thickness of the recycled layer. Alternatively, suitable additional aggregate could be imported provided that site level changes are acceptable.

22 The foamed bitumen bound option is often very sensitive to the fines component because the foamed bitumen has a tendency to mix and agglomerate with the fines. As a result, the amount passing the 75 micron BS sieve should, ideally, be restricted to the range of not less than 5 per cent and not more than 20 per cent, none of which should be clay.

23 Finer material may be tolerated, provided any clay fraction is modified using either hydrated lime or Portland cement. This pre-treatment is normally required if the percentage of aggregate passing the 75 micron BS sieve is greater than 20 per cent and the Plasticity Index of material passing the 425 micron BS sieve is greater than 6. Conversely, any material that is too coarse may be modified by the addition of fine material to meet the specified grading. Crushed rock fines, pit sand, PFA or lime filler are examples of materials most commonly used.

Moisture

24 The moisture content of the pulverised aggregate during stabilisation and compaction is as important as the grading because it is a prime feature controlling the workability and, therefore, the degree of compaction that is achievable.

25 For compaction of granular material used in construction, the moisture content is usually targeted on the optimum moisture content determined in accordance with BS 5835. However, for in-situ recycled mixtures, the specified moisture content is dependent on the binder content, targeted slightly on the wet side of the optimum moisture content, determined in accordance with BS 1924 : Part 2. Furthermore, the constituents of the mixture to determine the optimum moisture content are dependent on the proportion of filler added in the field.

26 For foamed bitumen bound material, where the foam contributes to the fluid content of the mixture, a specified moisture content range ± 2% of the optimum moisture content is recommended. In those cases where a small amount of filler is added in the field, the optimum moisture content of the unmodified pulverised aggregate will normally suffice for control purposes because the moisture absorbed by the filler is mostly balanced by the suppression of the optimum value. However, where the addition of filler in the field accounts for more than 4 per cent by mass, the moisture content control should be based on the optimum moisture content determined for the modified aggregate.

Primary Binder Agents

27 The selection of the primary binder agent for a particular recycling contract will depend to a great extent on the site conditions, cost factors and the design requirements in terms of either a flexible or flexible composite pavement. For UK conditions the current recommended choice is restricted to Portland cement or foamed bitumen.

28 Foamed bitumen has a low apparent viscosity, high volume and low surface tension characteristics which enable moist, cold aggregate surfaces to be coated, particularly the fine aggregate portion. The process does not require the evaporation of a solvent or excess water prior to compaction and the material can be reworked if necessary, up to 48 hours after processing. In practice it is possible to use penetration grade bitumen from grade 40 to over 200 as the base bitumen for foaming. However, higher penetration grades, which tend to foam better, are likely to produce mixtures of significantly lower stiffness. Experience in the UK has shown that a base bitumen of penetration grade 100 achieves the highest possible mix stiffness consistent with an acceptable foaming and coating ability.

29 The stiffness gain of foamed bitumen bound mixtures is slower than that achieved by the cooling of hot-mix bitumen mixtures and is influenced by the ambient conditions which dictate curing rate.

30 In winter conditions, particularly in colder districts, the use of higher penetration grade bitumen may more easily achieve the specified degree of compaction. However, this is likely to produce a lower stiffness material, which should be checked as part of the design process, bearing in mind that a mix of lesser stiffness will require a thicker construction to achieve equal performance.

31 The success of foamed bitumen mixtures rely upon early life stability derived from aggregate interlock for pre-trafficking and ongoing development of stiffness. However, provided the density achieved is at least 95% refusal density, experience has shown that opening to traffic in a one day construction cycle is feasible.

Volume 2 home page

Supplementary Binder Agents

32 Portland cement is commonly used as a supplementary binder in foamed bitumen bound mixtures, added in the proportion of about 2 per cent by mass, to act as an adhesion agent between the bitumen and damp aggregate. By using this amount of cement, it is likely to contribute significantly to the development of strength and in consequence, a partially cemented bitumen bound hybrid material is formed. Lime may be added as filler or as the modifier for plastic fines within the pulverised aggregate. Despite the practical advantages of using quicklime, related to water absorption and control of spreading, the stringent safety measures required lead to hydrated lime as the preferred option for inclusion in Appendix 7/18.

Pulverisation and Stabilisation

33 Road pulverisation and stabilisation involves the use of specialised stabiliser plant that operates to the specified depth plus construction tolerances. To ensure adequate pulverisation and mixing of materials to full depth, it is recommended that the drive performance of the recycling machine is at least 260kW.

34 Stabilisers are manufactured with a height adjustable mixing box situated close to road level, incorporating a special toothed rotor designed to pulverise and mix the material within the mixing hood. The use of smaller agricultural equipment is no substitute because they are usually designed to work on cohesive soils and, therefore, are not designed to produce pulverised granular aggregate of the required grading and shape for construction purposes.

35 However, the powerful stabiliser plant can damage services, so the Overseeing Organisation should identify any services or obstructions present and include their details in Appendix 7/18. The time required to lower any services should also be taken into account within the Works programme.

36 A specialist manufactured stabiliser plant will incorporate all the features and facilities necessary to complete the works in accordance with the current recycling specification. Some will be larger and more powerful than others, whereas others may incorporate more refined control systems.

37 The systems normally employed to control the depth of pulverisation relate the position of the rotor relative to the vertical position of the wheels. Therefore, to ensure that the appropriate depth of pulverisation or stabilisation is carried out consistently, it is particularly important that a working platform of known level profile is prepared prior to the operation of the stabiliser.

Process Control

38 This section provides guidance for the Overseeing Organisation to help supervise the Works but, in addition, describes the best practice for the Contractor to follow to control the pulverisation and stabilisation processes.

Foamed Bitumen-Bound Material

39 Although this material is generally described as a bitumen bound material, it is unlike any standard hot plant mixed bitumen bound material. The foamed bitumen tends to combine more readily with the fines component of the pulverised aggregate, forming a “mortar”, which fills the voids between the partially coated coarse aggregate. In addition, where cement is used as an adhesion agent, a component of the stiffness is likely to derive from the hydration of the cement. Therefore, unlike the cement bound option, the Specification and Notes for Guidance for conventional bitumen bound plant mixes are not applicable to this cold recycled product. Compaction control using the Nuclear Density Meter is essentially the same as that for the cement bound option and, provided adequate stability of the layer is achieved, early life trafficking is not a problem. The collapse of the foam takes place shortly after mixing and stiffness develops by a curing process, which involves the stiffening of the bitumen and cement bound mortar. As an additional safeguard, the as-installed performance, measured by either the dynamic plate loading or penetrometer techniques, demonstrates that the layer has achieved a required stiffness before proceeding with the construction of the overlying pavement.

Added Water and Moisture Control

40 Although the control of moisture content is of prime importance for optimum compaction, there is currently no automated process available that can ensure the provision of moisture at a uniform and optimum level during the recycling process. It is vital, therefore, that the process is controlled by an experienced operator who has access to controls for adding water, particularly when the water is sprayed directly in the mixing box at the time of stabilisation.

41 The stabiliser should, ideally, be fitted with a separate pump and spraybar system for metering the added water, which is regulated to the ground speed of the machine. An experienced operator will normally assess the moisture content of the mix relative to the target optimum by squeezing samples of the material regularly by hand and be guided by test results at the commencement and during any job so as to “calibrate” personal judgement. The operator must assess the moisture content immediately behind the stabiliser and

be prepared to make quick adjustments as the machine may be progressing forward at a rate of 4-6 metres per minute.

Application of Cement or Hydrated Lime

42 Cement may be required either as the primary binder or as a supplementary binder to act as an adhesion agent or to help improve the short term properties of the compacted material. In comparison, hydrated lime is generally used as a plasticity modifier for cohesive fines within the pulverised aggregate.

43 Specialist spreaders are necessary for the application of these materials, which should incorporate control systems to ensure that the rate of spread is achievable to a target accuracy of ± 0.5 per cent of the specified spread rate. The particle size of cement and lime as supplied may vary and such behaviour should be noted as it may affect the accuracy of application. The use of consistent sources and standard routines for storage and loading of the spreader is recommended to minimise any variation.

Application of Foamed Bitumen

44 Because of the short life span of the fully foamed bitumen during the mixing process, usually defined in terms of its “half-life” (ie time taken in seconds for the foamed bitumen to settle to one half of the initial expanded volume), it is necessary for the foaming process to be incorporated into the spraybar of the recycling machine so that immediate distribution and mixing with the pulverised aggregate in the mixing hood can take place. The reduced viscosity and greater volume of the foamed bitumen enables it to be distributed and mixed with the damp cold aggregate.

45 To ensure adequate mixing of the foamed bitumen with the aggregate, the minimum expansion ratio of the foam should be 10, linked with a minimum half-life of 10 seconds. Also, in the interests of durability, irrespective of the results of the design tests, the absolute minimum added bitumen content should be 3.5 per cent. The uniformity of mixing should be continuously inspected visually by the Contractor and work should stop if bitumen streaks or blotches are observed.

46 A typical stabiliser has computer-controlled devices on board that calculate the application rate of the binder as the stabiliser moves along the pavement. The stabiliser should, ideally, be fitted with a separate pump and spraybar system for metering the added bitumen and one that allows variable widths of binder to be applied. The bitumen jets should be of a self cleansing design and for reasons of safety, bitumen lines should be heated.

47 The spraybar control systems incorporated into the stabiliser should ensure that the rate of spread is achievable to a target accuracy of ± 0.5 per cent of the specified spread rate in order to obtain a construction tolerance for added bitumen of ± 0.6 per cent of the target binder content. As a means of verification, dipping in the tanker before and after a stabilisation run can be used to verify the computer collected data. An inspection or test jet should, ideally, be fitted to ensure that the flow of bitumen and the required expansion and half-life qualities of the foamed bitumen are achieved.

Compaction

48 Compaction is a critical part of the stabilisation process and demands particular care. This is especially the case for thicker layers of construction, where there is the possibility of a density profile developing during compaction, such that the lower part of the layer does not achieve the same density as the upper part.

49 This effect may be minimised when applying compaction at the earliest possible time using either heavy vibratory compaction or by a compactor capable of “kneading” the material at depth, as is the case with a tamping roller. To date in the UK, heavy compaction for cold recycling works has been carried out mostly using the heavy vibratory roller option although, more recently, a heavy combined pneumatic tyre roller (PTR) and vibratory drum roller has been trialed but their field performance has yet to be verified.

50 From monitored works, it is evident that vibratory compaction did not always achieve full depth compaction of thicker layers. Therefore, where the stabilised material is assessed as having poor workability, it is recommended that consideration be given to the use of heavy tamping rollers for the initial deep-seated compaction, particularly for layers having a compacted thickness in excess of 225 mm. This should be followed by grading of the surface and final compaction using the conventional heavy vibratory compaction. This is similar to the compaction methodology commonly used in Australia for thick-lift construction.

51 When using heavy vibratory compactors, caution should be exercised where there is any danger of damage to shallow culverts, underground services or adjacent buildings.

52 The use of a pneumatic tyre roller (PTR) as a finishing roller is often advocated, particularly for the cement bound material. However, whereas the PTR may tend to assist in the compaction of the lower level material, care is required to ensure that the near surface material does not dry out or stiffen too quickly, which may result in disruption and shear displacement of the near surface material caused by the load applied under

the individual tyres, which results in an unstable surface finish and the necessity for removing loosened unacceptable material.

(05/02) **Surface Sealing**

53 (05/02) The type and rate of spread of the bituminous emulsion, as stated in Appendix 7/18, should comply with the recommendations given in BS 434.

End-Product Performance Specification

54 The process of cold recycling for the structural maintenance of highway pavements has been developed and used in a variety of countries, each with their own local requirements, often related to climate and geology. Consequently, the types of road available for recycling have been wide ranging. As a result, previous recycling specifications have been derived from a variety of component material designs and construction methods that were generally aimed at producing materials of conventional form with anticipated performance similar to the plant mixed option.

55 Whilst the recipe and methods specification has served the industry well for the lower trafficked roads, end-product performance specification is seen as a means of specifying recycled materials in their own right, using performance properties, allowing the recycled material to be considered for more heavily trafficked sites on an equitable basis to standard plant produced materials.

56 The end-product performance assessment is designed to follow a three stage procedure, to allow the construction to proceed at the same time as giving the Overseeing Organisation the opportunity to verify the acceptability of the product at the earliest possible time.

As-Installed Stiffness Using a Dynamic Plate or Penetrometer Tests

57 The as-installed performance of the stabilised layer, within 24 hours of completion of compaction, is evaluated using a dynamic plate loading or penetrometer techniques to determine the elastic modulus at points on a closely spaced grid pattern. Furthermore, before proceeding with the surfacing, repeated values are expected to demonstrate that the elastic modulus values have increased, as an indication that the curing/stengthening process has started. The first repeat measurements should normally be made after 24 hours and thereafter at intervals, dependent on the measured rate of increase of elastic modulus. In the trial and first section of main paving, tests should be carried out on a 2 m grid pattern. During main paving, should consistent elastic moduli be achieved, the longitudinal grid spacing can be relaxed to 5 m and 10 m should the latter spacing also produce consistent results. The single point and mean value of elastic modulus for the assessment areas, and their respective percentage increase, must comply with the minimum standards stated in Appendix 7/18.

58 Experience to date, using a dynamic (light) plate loading technique has determined that fresh, well compacted cold recycled material typically achieves a single point elastic modulus value (Evd) in the range 40 to 70 MPa. Therefore, the as-installed performance of an acceptable constructed layer, based on at least 100 point evaluations, is expected to display an initial minimum mean value of elastic modulus in excess of 50 MPa, with no single point value less than 30 MPa. Prior to surfacing, an increase of 20 per cent for single point values and 30 per cent for the mean value, would be indicative that the curing process is underway. For the as-installed condition and initial stage of curing, these values should be applied to both the cement bound and bitumen bound materials.

59 For other plate loading or penetrometer test methods, an equivalent correlation should be provided to the satisfaction of the Overseeing Organisation.

Pavement Stiffness from Falling Weight Deflectometer (FWD) Survey

60 The current status of the FWD and associated elastic stiffness evaluation does not allow the procedure to be used as a rejection method. However, if acceptably high stiffness modulus values are determined consistently, as described in Appendix 7/18, the method should provide the Overseeing Organisation with sufficient confidence and a means of acceptance for foamed bitumen bound material.

61 Experience to date using the FWD, as described in the Specification, suggests that a pavement stiffness value for the combined bound layers of the pavement (i.e. recycled layer plus surfacing) of the order of 2500 MPa for foamed bitumen bound option, below which not more than 15 per cent of the derived values should fall, offers an acceptable performance standard.

Compressive Strength/Stiffness Measurements of Core Specimens

62 The development of the end-product performance specification for the cold recycled materials has passed through various stages, in which the initial intention was to determine the performance of cored specimens in terms of the Indirect Tensile Stiffness Modulus (ITSM) of bitumen bound material.

63 The above option was set aside, however, when it was decided that coring should only be performed as a last resort. This decision was reinforced by the

experience gained on some monitored sites, where the core extraction itself was difficult, such that a suitable number of test specimens could not be obtained.

64 The rate of success for extraction of cores from cold recycled material is generally enhanced by using air flush coring in place of the more usual water flush method. Also, removal of the cored asphalt surfacing layers, before proceeding with the coring into the recycled material, was found to improve the success rate of core extraction.

65 In the event that acceptance is not achieved using the FWD survey and analysis, the current specification uses the core testing option as the last resort performance assessment. If carried out after the FWD survey, as late as possible within the Contract maintenance period, it should maximise the success rate for the extraction of cores and offers the best opportunity of obtaining specimens that are suitable for testing.

Mixture Design and Characterisation

66 The design procedures adopted to date, have been developed by various organisations for their local needs although, in general, most mixture design procedures for cold recycled materials are based on the determination of compressive strength for cement bound material or the stiffness modulus for bitumen bound material, related to a recycled layer of specified thickness, to carry a required traffic loading over a stated period of time.

67 In practice, the feedstock material to be stabilised does not usually exist until after pulverisation, so the initial mix appraisal or design process is often a matter of experience by the specialist contractors using their particular recycling plant, in order to obtain the optimum component design.

68 Also, the results of stiffness and other tests performed on laboratory prepared specimens are dependent on the curing regime of the specimens, which is unlikely to be representative of the site conditions, so these tests are only valid for comparison and assessment of the optimum mixture condition. Therefore, the values obtained do not necessarily relate to the in-situ condition of the material.

69 The details of the procedure given in sub-Clauses 948.58 to 948.65 are based on the current industry practice, which will be developed when more representative specimens and test results can be verified.

Bitumen-bound mixtures

70 The main objective of the design process for foamed bitumen bound recycled material is to check that an adequate level of stiffness is achieved using an optimum added bitumen content mixed with a pulverised aggregate, derived from the existing road construction, together with the correct proportions of any adhesion agent and/or added filler.

71 The target stiffness for all levels of traffic is generally accepted as an individual ITSM value of 2000 MPa and an average value of 2500 MPa. Experience has shown that the stiffness of recycled mixtures is generally insensitive to variations of added bitumen content, with an adequate stiffness achieved for an added bitumen content over a plateau optimum range of 3 to 6 per cent, subject to the recommended absolute minimum added bitumen content of 3.5 per cent for durability. Any existing bitumen in the pulverised aggregate is not normally activated in the stabilisation process, although the effect of the residual bitumen in the finished mixture could influence the stiffness achieved.

72 For the laboratory production of foamed bitumen, it is recommended that the anticipated bitumen supplier is consulted, in conjunction with the manufacturer of any foaming agent used, in an attempt to replicate as closely as possible, the characteristics of the foamed bitumen to be used, particularly in terms of the size and sustainability of the air bubbles during mixing.

73 The specified curing programme for the specimens prior to testing, including baking the specimens for 72 hours at 60°C, is not an attempt to represent the curing conditions in the field, but is a standardised procedure to replicate the longer term ageing process of the recycled material. The drawback of using this technique is that it does not indicate the early life stiffness of the recycled material, which is important for early life performance of the material.

NG 952 (05/02) Deformation Resistance for Binder Course and Base

General

1 Rutting is the most common form of deterioration of fully flexible pavements for heavy traffic. However, surveys have shown that with well constructed asphalt pavements, deformation was generally confined to the top 100 mm immediately below the road surface. For this reason, where the wheel-tracking or the vacuum repeated load axial tests (RLAT) are required to assess deformation resistance, it is intended that this be applied only to the top 100 mm of the pavement immediately below the road surface.

Volume 2 home page

2 With increasing traffic, shift to increased use of wide-base single tyres on commercial vehicles, slower vehicle speeds and possible trend towards warmer summers, the propensity for asphalt pavements to deform is increasing. In addition, pavements often have to withstand slow moving canalised traffic during periods of road maintenance.

3 Experience to date indicates that the minimisation of the occurrence of rutting can best be achieved by end performance specifications. Consequently, this specification has been written in end performance terms. However, it is only intended to be applied to roads, which are exposed to a reasonably high risk of surface rutting.

4 Experience, both in this country and elsewhere, has shown that for dense macadams compliance with Clause 929 will greatly reduce the risk of rutting. However, it suffers from the draw back that it is not able to rank the rut resistance of various materials; whereas, the wheel-tracking test and vacuum RLAT test can. For these reasons, for macadams, the use of Clause 929 as the means to control rutting is confined to Class 1 traffic loading and the wheel-tracking and vacuum RLAT tests to Class 2 roads. For stone mastic asphalt (SMA), either the wheel-tracking test or RLAT test will be required to be carried out for both Class 1 and 2 roads. Table NG 9/37 indicates the classification of sites and stress conditions and the test methods to be used to measure deformation.

5 TABLE NG 9/35 and TABLE NG 9/36 specify the deformation requirements to be applied for binder courses and bases.

TABLE NG 9/35: Wheel-Tracking Test (BS 598:Part 110)

Class	Temperature (degrees C)	Maximum Rut Rate (mm/hr)	Maximum Rut Depth (mm)
1	45	2.0	4.0
2	60	5.0	7.0

TABLE NG 9/36: (05/01) Vacuum Repeated Load Axial Test (RLAT) (BS DD 226 and TRL PA3287/97)

Class	Temperature (degrees C)	Maximum Strain Rate (microstrain/ 100 cycles)	Maximum Strain (%)
1	45	100	1.5
2	45	70	1

6 Clause 929 has been specified for dense macadam materials even where either the wheel-tracking or vacuum repeated-load axial tests (RLAT) have been specified. The reason for this is that information on air void content at hundred per cent PRD could give an early warning of potential rutting problems where air voids are non-existent or below the specification limit. Where this happens corrective action with mix design can be taken or the outcome of deformation tests awaited.

Modified Binders

7 Contractors may propose the use of modified binders. Until the Highways Authorities Product Approval Scheme is operational, specific binder modifiers or processed bitumens will need to be approved by the Overseeing Organisation. When preparing the Instructions for Tendering, the compiler should include a requirement that approval of non-standard binders should be obtained prior to the date of return of tenders.

Job Mixture Approval Trial

8 The thickness and width of the trial strip is job specific. The thickness should not be less than the thickest course proposed for the permanent works. The minimum practical thickness to allow for test specimen trimming will be approximately 60 mm.

Permanent Works Testing

9 Where limited volumes of material are being placed, such as tie-ins or junctions, coring of separate layers may result in unreasonable delay because of the time needed for the lower layer to cool to the coring temperature. In these circumstances it would be reasonable to allow coring of both of both layers. This relaxation should only be given to avoid excessive paving delay and not simply to reduce the amount of coring effort.

10 If necessary, a lever may be used in a controlled manner to break the bond between the core and the underlying layer. If the core does not easily break away from the underlying layer then the coring should continue and a core of the test material and underlying layer material should be extracted. The test material should be cut from this longer core in accordance with BS DD 226.

Sampling and Testing

11 The choice of whether to use the wheel-tracking test or vacuum RLAT should be that of the Contractors. Choice of test could well be influenced by the different diameter test core samples used in each of these tests.

Volume 2 home page

The sample core size for the vacuum RLAT is the same size as that used in the indirect tensile stiffness test specified in Clause 944, namely 150 mm. Consequently, once cores have been tested for stiffness, the same cores can then be subjected to the vacuum RLAT. This would reduce the overall number of cores required for testing with the consequential benefits of reduction in costs and time. For the wheel-tracking tests, 200 mm diameter cores are required, which means that these will be additional to those that may be required for indirect tensile stiffness with the disbenefit of additional costs and time.

12 The responsibility for contractual testing (by the Contractor or by the Overseeing Organisation) should be defined. Where the Overseeing Organisation is responsible, the time interval between laying material and providing results should also be stated in order to enable the Contractor to allow for this delay in his programme.

13 The deformation resistance measurements made in accordance with sub-Clauses 952.4 and 952.5 should be sent to the Highways Agency's Pavement Engineering Group (PEG) within one month of completion of the relevant works. This is essential in order to obtain feedback on deformation values which have been obtained from different contracts.

TABLE NG 9/37: (02/02) **Classification of Sites by Traffic and Stress Condition**

	Site Category	Site Definition	Traffic at Design life (Commercial vehicles per lane per day)				
			CLASS 1				CLASS 2
			Up to 250	251 - 500	501 - 1000	1001 - 1500	> 1500
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	For Macadams, Clause 929 or for SMAs Wheel Tracking Test BS 598 : Part 110, test temperature 45°C or Vacuum Repeated Load Axial Test BS DD 226 and TRL PA3287/97, test temperature 45°C				
IA & IIA	As I and II, above, but with contraflow anticipated during summer months						
III	F G1 L	Approaches to and across major junctions (all limbs) Gradient 3% to 10%, longer than 50 m: Roundabout			Wheel–Tracking Test BS 598 : Part 110, test temperature 60°C or Vacuum repeated Load Axial Test BS DD 226 and TRL PA3287/97 at test temperature 45°C		
IIIA	As III, above, but with contraflow anticipated during summer months or in a south-facing cutting uphill						
IV	G2	Gradient steeper than 10%, longer than 50 m:					
IVA	As IV, above, but with contraflow anticipated during summer months or in a south-facing cutting uphill						
V	J/K	Approach to roundabout, traffic signals, pedestrian crossings, railway level crossings and similar					

Volume 2 home page

NATIONAL ALTERATIONS OF THE OVERSEEING ORGANISATION OF SCOTLAND

NG 911SE (05/02) Rolled Asphalt Surface Course (Design Mix)

1 (05/02) The naturally occurring fine aggregates which are readily available in Scotland tend to produce rolled asphalt surface 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 B1 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 9/1SE below:

TABLE NG 9/1SE: (05/01) **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 (05/01) 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 9/1SE 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 (05/02) The method of determining the design binder content for surface 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 surface 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.

Volume 2 home page