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 (08/08) Advice on the design, construction and maintenance of bituminous roads is given in the Design Manual for Roads and Bridges (DMRB), Volume 7.

NG 901 (08/08) Bituminous Pavement Mixtures

General

1 (08/08) 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. Bituminous mixture specifications are given in the relevant parts of BS EN 13108 with guidance on the requirements to be selected in the UK in BSI PD6691.

2 (08/08) Requirements included in Appendix 7/1 may include penetration reference of binder and aggregate properties such as polished stone value, aggregate abrasion value, resistance to fragmentation, resistance to freezing and thawing, and water absorption as specified in BS EN 13043.

3 (08/08) Sub-Clause 2 details the Sector Schemes which are mandatory for production and laying of bituminous mixtures. The requirement to CE mark bituminous mixtures means that documentation validating the properties of those mixtures and containing information on their composition will be available. This should be made available before the start of paving works and when any source or mix changes are made.

(08/08) Aggregates for Bituminous Mixtures

4 (08/08) 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.

5 (08/08) Guidance on the use of BS EN 13043 can be found in PD 6682-2.

(08/08) Resistance to Fragmentation (Hardness)

6 (08/08) Regional knowledge may indicate that particular aggregates with higher levels of Los Angeles coefficient can be accepted, where these aggregates have given satisfactory service. It is expected that aggregates with a higher coefficient than that specified could be acceptable, provided the cleanness and durability criteria are satisfactory.

(08/08) Resistance to Freezing and Thawing (Durability)

7 (08/08) 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.

8 (08/08) 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 $WA_{24}2$, magnesium sulfate soundness tests should be carried out for compliance purposes. BS EN 13043 indicates that the water absorption test is not applicable for blast furnace slag aggregates. Blast furnace slag aggregates with absorption values up to 8% have been shown to have acceptable soundness. Therefore, the durability of blast furnace slag aggregates should be determined by periodic measurement of soundness.

(08/08) Cleanness

9 (08/08) There is no current test procedure for cleanness other than the requirement for aggregates to meet the specified BS EN 13108 requirements for the fraction passing the 0.063 mm sieve. Provided the aggregates meet requirements for particle size distribution, based on the washing and sieving techniques of BS EN 933-1, 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.

(08/08) **Resistance to Polishing and Surface Abrasion**

10 (08/08) The Design Manual for Roads and Bridges 7.5.1 (HD 36) gives guidance on aggregate properties for new bituminous surfacing.

(08/08) **Bitumen**

11 (08/08) Cutback binders are specified using the now obsolete BS 3690-1 except for asphalt concrete (formerly macadams) where flux is permitted in accordance with BS EN 13108-1 when approved by the Overseeing Organisation (e.g. for hand lay work).

(08/08) **Asphalt Durability**

12 (08/08) The Saturation Ageing Tensile Stiffness Test is described in Clause 953. The test is performance-related and considers the combined effect of ageing and moisture on bituminous pavement materials in service. It assesses the durability of adhesion with particular aggregate/filler combinations. It is specified for all base and binder course mixtures designed in accordance with Clause 929. It is not currently considered appropriate for EME2 mixtures designed to Clause 930.

13 (08/08) It is expected that a considerable proportion of existing asphalt mixtures will comply with the SATS Durability Index requirement of 80%. However, as the test is performance-related, there are no restrictions on how a mixture is modified to meet the specification. Suitable additives may include proprietary "wetting agents", lime or cement.

14 (08/08) A considerable amount of research has been undertaken in the United Sates demonstrating the beneficial effects of the addition of lime to asphalt mixtures. Thus, mixtures incorporating a minimum of 2% hydrated lime filler are deemed to comply with the asphalt durability requirements and are not required to undergo SATS assessment.

NG 902 (08/08) Reclaimed Asphalt

1 (08/08) Reclaimed asphalt includes millings, planings, return loads from site and off-cuts from bituminous layer joint preparation. Return loads can include bituminous mixtures rejected from site due to temperature problems or visual defects. Waste bituminous mixtures stockpiled at the plant may also be suitable.

2 (08/08) 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%. The grading of reclaimed asphalt will generally need to be more closely controlled than that of freshly won natural aggregate, particularly when the reclaimed asphalt is obtained from more than one source.

3 (08/08) The BS EN 13108 standards include provisions for ensuring that the properties of the combined binder are appropriate for the mixture. Limits for the minimum penetration category are included in BSI PD6691 and these should be adhered to unless there is experience of suitable alternatives. Mix design procedures are not specified, these being left to the expertise of the Contractor who will have to comply with the type testing requirements of BS EN 13108-20.

4 (08/08) Materials containing tar or tar-based binders shall not be recycled using hot processes because of health considerations; some cold processes may be suitable and safe. 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 (08/08) Placing and Compaction of Bituminous Mixtures

(08/08) **General**

1 (08/08) The purpose of this clause is to define the laying and compaction procedures that will maximise the durability of the finished pavement. It has been drafted to ensure compatibility with the general specifications for the transport, placing and compaction of asphalt mixtures given in BS 594987 and with other appropriate Clauses (929, 930, 942 and 945) and should always be read in conjunction with the above documents as they relate to the particular application.

2 (08/08) Certain key factors are important in maximising the durability of the finished pavement and should be reviewed before work commences. These are:

(i) Mechanical laying wherever practicable.

(ii) Bonding of layers.

(iii) Good compaction, particularly at joints.

(iv) Pre-planning of compaction process.

(v) Sealing of edges and joints to prevent water ingress.

3 (08/08) Clause 903 applies to the surfacing overlaying bridge decks but does not relate to laying

waterproofing systems. When laying hot paving materials on bridge deck waterproofing systems, care must be taken to follow the guidance given in IAN 96/07. Appropriate measures should be taken to ensure that the bond system is fully activated by sufficient heat but that the waterproofing system is not damaged by excessive heat.

(08/08) **Laying**

4 (08/08) Materials should be laid by paver unless there are small or inaccessible areas where hand laying is the only practicable method. Pavers should be used with the minimum of hand raking and making up. The use of automatic levelling devices should be encouraged and, where possible, greater emphasis should be given to evenness rather than levels, provided that pavement thickness and clearances at structures are achieved. This approach is particularly relevant when thick layers of base are being used to minimise the number of horizontal interfaces.

5 (08/08) As far as practicable, the paver should work continuously without stopping. Stops can adversely affect the ride quality of the finished pavement. Therefore, there should be sufficient mixed material on site when paving commences to ensure that lack of supply will not stop operations. However, an excess number of delivery vehicles should also be avoided as it can result in congestion on site and an extended time between mixing and laying for each load.

(08/08) **Compaction**

6 (08/08) It is important that an effective compaction plan appropriate to the site circumstances is in place and is understood by the paving crew. This is a requirement of sub-Clause 903.5.

7 (08/08) 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 site trials of vibratory rollers, proposed as an alternative to conventional deadweight rollers, may be beneficial. 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. Site trials are not required to prove vibrating rollers where the final density or air voids is measured as compaction is then a controlled parameter.

8 (08/08) If compaction trials have been carried out, the frequency and amplitude of vibrating rollers and travelling speed of the roller which have been found to be satisfactory should be used. The contractor can use equations [1] and [2], to select the paving and rolling rates to achieve the minimum number of roller passes required before the surfacing has cooled to the minimum temperature for compaction:

Rolling length (m) = average paving speed (m/min) x T (min) … [1]

Roller passes = (Rolling rate/Paving Rate) x No of Rollers … [2]

where:

Rolling rate (m^2/min) = Roller width (m) x Roller speed (m/min)

Paver rate (m^2/min) = Paver width (m) x Paver speed (m/min))

T = time required for compaction (usually 10 min for HRA and 8 min for mixtures without pre-coated chippings)

9 (08/08) When reliance is placed on a method specification for the control of compaction of bituminous mixtures, close attention should be paid to the temperature of the material. BS 594987 lays 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 Clauses 929, 930 and 937, 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.

(08/08) **Inter-layer Bond**

10 (08/08) Inter-layer bond is essential to prevent ingress of water and resultant deterioration of the pavement. It is also important to ensure that the pavement acts as a homogenous structure. BS 594987 and Clause 920 give explicit and comprehensive requirements that should be followed. It is difficult to overestimate the importance of bond. Generally, it is

good practice to lay bases in thicker lifts to minimise the number of layers and, hence, interfaces (giving due consideration to the maximum layer thicknesses given in BS 594987).

(08/08) **Joints**

11 (08/08) However, a joint in a bituminous layer is constructed, it will always be the weakest part of the pavement. Therefore, it is good practice, wherever possible, to minimise the number of cold joints by, for example, using wide screeds and/or paving in echelon.

12 (08/08) Joints should be located in low stressed areas of the pavement wherever practicable, as indicated in sub-Clause 903.21.

13 (08/08) Compaction at joints with unsupported edges will never be as good as in the body of the mat. This is recognised in the air void content requirements in sub-Clauses 903.24, 929.15 and 930.15.

14 (08/08) To guard against ingress of water at joints, Sub-Clause 903.22 requires binder to be applied to the vertical face prior to laying the adjacent mat in order to improve bond and Sub-Clause 903.25 requires overbanding to seal the surface of the joint.

15 (08/08) To ensure that water does not enter the pavement from the side, sub-Clause 903.26 requires sealing the edges of the finished pavement. This is always required for the high side of the elevation. Sealing of the low side is conditional on whether it necessary to let water out or stop water getting into the pavement. The selection is a design issue and should be specified in Schedule 4 of Appendix 7/1.

NG 904 (08/08) Hot Rolled Asphalt Base

1 (08/08) The mixture designation should be chosen to suit the thickness of the layer as indicated in BS 594987 Table 6B.

2 (08/08) The binder grade to be used should be stated in Appendix 7/1. The normal grade is 40/60 although 30/45 may be specified, particularly for very heavy duty use.

NG 905 (08/08) Hot Rolled Asphalt Binder Course (Recipe Mixtures)

1 (08/08) The mixture designation should be chosen to suit the thickness of the layer as indicated in BS 594987 Table 6B.

2 (08/08) The binder grade to be used should be stated in Appendix 7/1. The normal grade is 40/60 although 30/45 may be specified, particularly for very heavy duty use.

NG 906 (08/08) Dense Base and Binder Course Asphalt Concrete (Recipe Mixtures)

1 (08/08) The mixture designation should be chosen to suit the thickness of the layer as indicated in BS 594987 Table 6A.

NG 909 (08/08) 6mm Dense Asphalt Concrete Surface Course

1 (08/08) The penetration grade of binder should be stated in Appendix 7/1 as part of the mixture designation and be that which is suitable for the design traffic. Advice on the design of bituminous roads can be found in the Design Manual for Roads and Bridges (DMRB), Volume 7. Further advice is given in BSI PD6691.

NG 910 (08/08) Hot Rolled Asphalt Surface Course (Recipe Mixtures)

1 (08/08) Recipe HRA mixtures should generally only be used in relatively lightly trafficked situations and where there is some knowledge of the performance expected from local mixtures. Where more detailed knowledge exists, design mixtures to Clause 911 can be specified or for the most onerous conditions performance related mixtures to Clause 943.

2 (08/08) The mixture designation should be chosen to suit the thickness of the layer as indicated in BS 594987 Table 6B.

3 (08/08) The binder grade to be used should be stated in Appendix 7/1. The normal grade is 40/60 although 30/45 may be specified, particularly for very heavy duty use.

#NG 911 (08/08) Hot Rolled Asphalt Surface Course (Design Mixtures)

1 (08/08) The special requirements included in Appendix 7/1 may include specific mix designations, binder grade and for 30% and 35% stone content mixtures, the required properties of coated chippings in accordance with Clause 915.

2 (08/08) The method for determining the design binder content for surface course is described in BS 594987 Annex H. The target binder content in the mixture will normally be the higher of the design binder content and the minimum binder content indicated in BSI PD6691 Annex C Table C 2A or C 2C as appropriate.

3 (08/08) The contractor may usually be permitted to use either type C or type F mixtures.

4 (08/08) In the past, Marshall properties, such as stability and flow, were used as indicators of resistance to permanent deformation, but this is no longer included as an option in the BS EN 13108 standards. In very heavily trafficked situations, where resistance to permanent deformation is of high importance, it is recommended that performance related Hot Rolled Asphalt to Clause 943 is used.

NG 912 (08/08) Close Graded Asphalt Concrete Surface Course

1 (08/08) The size of the mixture should be chosen to suit the thickness of the layer as indicated in BS 594987 Table 6A.

NG 915 (08/08) Coated Chippings for Application to Hot Rolled Asphalt Surfacings

1 (08/08) Generally, 14/20mm chippings are required to achieve an initial texture depth of 1.5mm and maintain a suitable texture under traffic. For low speed applications, particularly high stress areas such as roundabouts, lower rates of application and 8/14mm chippings combined with lower requirements for texture depth are appropriate.

2 (08/08) The condition of the binder film at the time of application is critical in achieving good adhesion to the asphalt. The hot sand test in BS EN 12697-37 and the requirement in BS EN 13108-4 and BSI PD6691 C.2.8.4 provide a means for establishing their suitability.

3 (08/08) The binder film can be adversely affected in the following ways:

- excessive mixing temperature leading to hardening;
- storage of hot or warm chippings in large stockpiles resulting in 'coking' (to prevent this, chippings should be cooled as quickly as possible after mixing and should be stored in stockpiles no more than one metre in height);
- contamination with dirt and dust.

4 (08/08) It is good practice to sheet chipping stockpiles on site in the winter to stop them becoming too cold, particularly in frosty conditions as this can make achieving adhesion more difficult.

NG 916 (08/08) Open Graded Asphalt Concrete Surface Course

1 (08/08) The size of the mixture should be chosen to suit the thickness of the layer as indicated in BS 594987 Table 6A.

NG 918 (08/08) Slurry Surfacing Incorporating Microsurfacing

1 (08/08) Slurry surfacing should be produced in accordance with BS EN 12273 (due to be published in 2008). Where a British Board of Agrément HAPAS Roads and Bridges Certificate for Slurry Surfacing is required reference should be made to Clause 942.

2 (08/08) 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 trunk roads including motorways, heavily trafficked or highly stressed roads, and one year for other roads.

3 (08/08) 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 have been fully documented as a Type Approval Installation Trial (TAIT) in accordance with BS EN 12273. The Contractor may choose any number of TAITs to cover the range of products he is prepared to install. 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 250 cv/lane/day with a speed limit of 60 mph or less. For all roads carrying more than 250 cv/lane/day and/or roads with speed limits greater than 60 mph. Clause 942 should 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. [Note: a TAIT produced in accordance with previous editions of this Clause is acceptable].

4 (08/08) All coloured materials whether using bituminous 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 have been developed to demonstrate colour retention by BBA/HAPAS.

5 (08/08) Low tyre-noise emission Slurry Surfacings may be specified by limiting the maximum macrotexture 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 (08/08) 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 (08/08) Basic details of the tendered design for each site should be completed in the Design Proposal and TAIT certificates for similar sites provided.

8 (08/08) 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 (08/08) 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.

(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.

Any tender not complying with the submission of the following information in accordance with the contract will not be considered:

- QA registrations.
- Method Statement.
- Design Proposal.
- Material Data Sheets.
- Traffic Management.
- Contingency Plans.
- Test Results.
- Previous Applications.
- TAIT Certificates.

10 (08/08) Contractors should recognise the need for best practice as described in the Slurry Surfacing Contractors Association (SSCA).

11 (08/08) 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. (This is a separate consideration from the guarantee period and does not imply a guarantee that the life will always be attained).

12 (08/08) 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 (DMRB 7.5.1) 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 (08/08) For the purposes of the Contract, monitoring will stop at the end of the guarantee period, or for novel or 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 TRACS (TRAffic-speed Condition Survey) surveys, which are currently carried out on all trunk

roads every 2 years and SCRIM surveys, which are carried out annually. For other roads volumetric patch technique or use of the mini texture meter or other device calibrated against glass spheres values as Glass Spheres Patch Equivalent values, may be more convenient

14 (08/08) The Vialit pendulum test should be carried out using Clause 957 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 (08/08) 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 956. 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 955 and results for Clause 956 and Clause 957 for type approval purposes will be based on recovered binder from Clause 955.

16 (08/08) 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 (DMRB 7.5.1); 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 macrotexture.

17 (08/08) 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 macrotexture 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 macrotexture, 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 (08/08) 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 macrotexture 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 (08/08) 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 may be used.

20 (08/08) 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 (08/08) 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 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 (08/08) As part of the normal traffic control mechanism for high-speed roads there should be a mandatory temporary 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 traffic travelling at the temporary speed limit 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 (08/08) 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. Bond coats should normally be used.

24 (08/08) 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 (08/08) 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 (08/08) Macrotexture 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 macrotexture depth on high-speed and heavily trafficked roads because of the amount of macrotexture depth measurement to be undertaken. This form of measurement avoids the need for additional lane closures, which use of volumetric patch technique or the mini texture meter would require. Other methods may be used, but the results should be reported as 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 TRACS surveys. The macrotexture depth for Slurry Surfacing on high-speed heavily trafficked roads (Clause 942 would normally be used to specify slurry surfacing on these roads) at the end of the guarantee period would normally be specified at 1.5 mm measured by the volumetric patch technique. Depending on traffic levels, lower macrotextures at the end of the guarantee period may be specified in Appendix 7/7 for lower speed roads.

TABLE NG 9/1: (08/08) **Minimum Patch Macrotexture Depth Requirements (or Volumetric 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 Patch Macrotexture (mm)	Speed limit 40 mph or lower Patch Macrotexture (mm)
50 to 250	1.0	0.8
10 to 50	1.0	0.7
Below 10	1.0	No requirement
More than 250 (or speed limit greater than 60 mph)	Not Applicable to this Clause, see Clause 942: Thin Surface Course Systems	

27 (08/08) 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 category appropriate to the site should be specified in Appendix 7/7.

TABLE NG 9/2: (08/08) **Defect Classification: Area**

Defect Classification	P_1 Bleeding Fatting up and Tracking	P_2, Delamination, Loss of Aggregate, Wearing, Lane Joint Gaps Rutting and Slippage	P_3, Corrugation, Bumps and Ridges	P_4, Groups of Small Defects or Repetitive Defects	Category
Site	Maximum % of Area Affected				
Motorways and Dual carriageways	0.2	0.2	0.2	0.2 in not more than 1 rectangle	4
Stressed single carriageways	0.5	0.5	0.5	1.0 in not more than 2 rectangles	3
Single carriageways	2.0	2.0	2.0	5 in not more than 6 rectangles	2
Lightly trafficked single carriageways	8.0	8.0	8.0	20 in not more than 20 rectangles	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: (08/08) **Defect Classification: Linear Defects**

Site	Total Length of Defects in metres per 100 m	Class
Motorway Carriageways and Dual	1	4
Stressed Single Carriageways	10	2
Single Carriageways	5	3
Lightly Trafficked Single Carriageways	10	2

28 (08/08) 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. Where 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 (08/08) Materials failing to set or setting too rapidly are caused by defects in workmanship or laying in inappropriate weather conditions. Work should stop 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 (08/08) 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: (08/08) **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 veh/l/d and roads carrying less traffic where the cross fall is less than 2%.	2
All other roads	1
Roads where only sealing and improvement to surface characteristics are required (i.e. Regulating is not a requirement)	0

TABLE NG 9/5: (08/08) **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: (08/08) **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 veh l/d	1
All other roads	0

TABLE NG 9/7: (08/08) **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 (08/08) 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 (08/08) Surface Dressing: Recipe Specification

1 (08/08) Clause 922 should normally be used for surface dressing except in the following circumstances:

(i) Where the Overseeing Organisation has the expertise to design surface dressing, the resources to supervise the works and the desire to accept the additional risks associated with designing the product. No performance criteria can be specified such as visual assessment, macro-texture etc.

(ii) Where the Overseeing Organisation wishes to carry out trial or experimental surface dressing.

(iii) Where the Overseeing Organisation wishes to carry out surface dressing in circumstances that are outside the Road Note 39 parameters such as on extremely variable substrate or out of season work.

(iv) Temporary works such as where skid resistance is needed for a short period.

Note: Knowledge of the network is required whichever Clause is used as the Overseeing Organisation either needs traffic levels and road hardness to design the surface dressing or needs to provide the Contractor with the same data so that the Contractor can carry out the design as in Clause 922.

2 (08/08) The surface dressing should be designed in accordance with Road Note 39. Additional advice is given in HD 37 (DMRB 7.5.2). 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 (08/08) 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 (08/08) The Contractor should state the source and type of binder he proposes to use together with the data required by Appendix 7/21.

5 (08/08) The Contractor's attention should be drawn to the need for best practice as set out in HD 37 (DMRB 7.5.2), Road Note 39, Highway Authorities Product Approval Scheme (HAPAS) and the Road Surface Treatment Association (RSTA) documents.

6 (08/08) The Vialit pendulum test should be carried out in accordance with Clause 957. 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 Road Note 39 and British Standards Published Document PD 6689.

TABLE NG 9/8: (08/08) **Vialit Pendulum Test**

Binder Grade	Minimum Peak Binder Cohesion Joules/cm²	Class in BS EN 13808
Super-premium	1.4	6
Premium	1.2	5
Intermediate	1.0	4
Conventional	0.7*	3

(08/08) Note: The reproducibility has been allowed for when setting these minimum levels and the average value of the peak cohesion for polymer modified binders is likely to be at least 0.3 J/cm² above the minima given in Table NG 9/8.

(08/08) * For conventional binders where 0.7 is not consistently achieved, 0.5 over a minimum temperature range of 15°C has been found to provide satisfactory performance.

7 (08/08) 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 956). 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 (08/08) 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 (C_v) for the regularity of transverse distribution. The category required for the sprayer, to be specified in Appendix 7/21, should be selected from Table NG 9/9.

TABLE NG 9/9: (08/08) **Accuracy of Binder Sprayer**

Site	Coefficient of Variation (C_v)	Category
Motorways and Dual Carriageways	< 10%*	2*
Single Carriageways	< 10%	2
Lightly Trafficked Single Carriageways	< 15%	1

(08/08) * this C_v and category is appropriate when carpet tiles 100 mm wide and at least 200 mm long are used for the test, where the surface is very even, on dual carriageways and motorways there is a case for specifying category 3. Where 50 mm wide trays are used each two adjacent trays should be averaged before calculating the Coefficient of variation (C_v).

9 (08/08) 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 (DMRB 7.5.1); over specification should be avoided in order to conserve scarce resources.

10 (08/08) 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 (C_v) for the regularity of transverse distribution. The category 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 are often satisfactory.

TABLE NG 9/10: (08/08) **Accuracy of Chipping Spreader**

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

11 (08/08) 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 macrotexture of the remedial work is sufficiently similar to the rest of the road to avoid problems of variable appearance and behaviour in the completed surface 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 macrotexture will be lost.

12 (08/08) 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 (08/08) 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 (08/08) 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 (DMRB 7.5.2).

15 (08/08) 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 (08/08) 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 (08/08) 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 (08/08) 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 category or categories appropriate to the site should be specified in Appendix 7/21.

TABLE NG 9/11: (08/08) **Tolerance on Design Rate of Spread of Binder**

Site	Tolerance	Category
Highly Stressed Sites, Motorways and Dual Carriageways	±5%	3
Single Carriageways	±10%	2

19 (08/08) 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 category or categories appropriate to the site should be specified in Appendix 7/21.

TABLE NG 9/12: (08/08) **Tolerance on Design Rate of Spread of Chippings**

Site	Tolerance	Category
Highly Stressed sites, Motorways and Dual Carriageways	±5%	3
All other sites	±10%	2
Lightly trafficked Single Carriageways (up to 100 cv/l/d)	±15%	1

20 (08/08) 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 (08/08) 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 (08/08) 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 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 (08/08) Bond Coats, Tack Coats and Other Bituminous Sprays

(08/08) Bond Coats and Tack Coats

1 (08/08) This Clause specifies tack coats and bond coats for asphalt concrete, hot rolled asphalt and stone mastic asphalt binder course and regulating course. Bond coats and tack coats are applied prior to laying of bituminous mixtures in order to promote the development of a homogeneous pavement structure and to prevent ingress of water. The structural design of pavements assumes that the bond between layers is complete. Bond is particularly important in highly stressed areas. The use of tack or bond coat is a universal requirement when placing bituminous material on any new or existing bound substrate, under Clause 903.4. Further information can be found in BS 594987. The use of tack and bond coats under Thin Surface Course Systems is covered by Clause 942.

2 (08/08) BS 594987 gives recommended application rates of tack and bond coats. Clause 903 converts these recommendations into requirements. A bond coat is more appropriate where greater bond strength or better sealing is required. An example is where materials are to be laid less than 30 mm thick, or where a particular site has a binder lean substrate and permeability is considered a problem. Advice on the choice of tack coat or bond coat is provided in BS 594987. Traditionally a tack coat using K1-40 or K1-60 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 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 HD 37 (DMRB 7.5.2).

3 (08/08) Bond coats may sometimes need to be partially covered with aggregate, to prevent them from being picked up when being walked on or driven over, especially during periods of hot weather. A typical rate of application of chippings is approximately 3 to 5 kg/m^2. 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 (08/08) Rates of spread of binder should follow the recommendations of BS 594987 or the BBA/HAPAS Certificates, as appropriate. Rates of spread may need to be altered for varying macrotexture 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.

5 (08/08) 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 (08/08) Pendulum Class 4 (previously known as "Intermediate grade") bond coats or bituminous sprays have a Vialit Pendulum Peak Cohesion minimum value of 1.0 J/cm^2 on the recovered binder prepared using Clause 955 when measured using BS EN 13808. Pendulum Class 5 (previously known as "Premium grade") bond coats or bituminous sprays have a Vialit Pendulum Peak Cohesion minimum value of 1.2 J/cm^2. Pendulum Class 4 or 5 bond coats are recommended when overlaying highly variable surfaces or those of high porosity. Pendulum Class 5 bond coats are recommended for sealing under porous asphalt or for improved bond in highly stressed areas.

7 (08/08) The spread rates for tack and bond coats on hydraulically bound substrates may need to be higher than those required for bituminous substrates.

Bituminous Sprays

8 (08/08) 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. 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

9 (08/08) 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.

NG 921 (08/08) Surface Macrotexture of Bituminous Surface Courses

1 (08/08) The depth of surface macrotexture is important in the dispersal of surface water from the tyre road contact area in order to maintain skid resistance in the wet at speed. It is most important on high speed roads and different criteria apply to high speed and low speed roads. For the purposes of Clause 921, a low speed road is defined one with a posted speed limit of 40 miles/hour (65 km/h) or less.

2 (08/08) The long established high speed road requirement of a minimum initial texture depth of 1.5 mm applies only to Hot Rolled Asphalt surface course. This is achieved by the application of coated chippings, as described in Clause 915 and BS 594987.

3 (08/08) A minimum initial texture depth of 1.3 mm has been found to be sufficient for high speed roads surfaced using Thin Surface Course Systems to Clause 942.

4 (08/08) Very high surface texture on high stress areas, particularly roundabouts, compromises toughness and durability and renders the surface prone to fretting, chipping loss and deterioration. Since these are rarely high speed roads by definition, it is good practice to

adopt lower texture requirements in such situations and a value of 1.2mm is considered appropriate for the trunk road network.

5 (08/08) On low speed roads, good skid resistance is achieved by maximising the area of contact between tyre and aggregate, rather than by achieving high texture. This often means adopting smaller aggregate sizes. In these circumstances, an initial texture depth of 1.0 mm is considered suitable, including roundabouts on low speed non-trunk roads.

6 (08/08) Requirements for retained texture depth for Thin Surface Course Systems specified to Clause 942 are given in that Clause.

7 (11/09) Clause 921 permits the use of the sand patch method in BS 598-105 (now withdrawn) for routine monitoring of initial surface macrotexture. If the sand patch method is used, the sand should be washed and dried silica sand with a rounded particle shape. The grading of the sand should be 100% (by mass) passing the 0.600 mm test sieve; 90 to 100% (by mass) passing the 0.300 mm test sieve; and not more than 15% (by mass) passing the 0.150 mm test sieve.

NG 922 (08/08) Surface Dressing: Design, Application and End Product Performance

1 (08/08) 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 and reference should be made to: BS EN 12271, HD 37 (DMRB 7.5.2), Road Note 39 and British Standards Published Document PD 6689. 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 (08/08) This specification allows considerable freedom for the Contractor in the design of the Surface Dressing provided it complies with BS EN 12271. 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 Type Approval Installation Trial (TAIT) documentation as described in PD 6689. 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 (08/08) Low noise emission Surface Dressings may be specified by limiting the designs to double or multi-layered dressings and/or the maximum macrotexture 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 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 (08/08) 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 (08/08) Basic details of the tendered design for each site should be completed in the Design Proposal and TAIT certificates for similar sites provided.

6 (08/08) 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 (DMRB 7.5.2).

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.

8 (08/08) 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, BSI PD 6689 and in Road Surface Treatment Association (RSTA) 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 (08/08) 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 (DMRB 7.5.1), 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 (08/08) 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 Macrotexture output from TRACS 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 volumetric patch tests or use of the Mini Texture Meter or other device calibrated against volumetric patch values as Volumetric Patch Equivalent values, may be more convenient.

11 (08/08) The Vialit pendulum test should be carried out using Clause 957. The minimum binder cohesion at peak measured using the Vialit Pendulum for four grades of binder are given in Table NG 9/13. Guidance as to the choice of binder is given in HD 37 (DMRB 7.5.2). 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 (DMRB 7.5.2).

TABLE NG 9/13: (08/08) **Vialit Pendulum Test**

Binder Grade	Minimum Peak Binder Cohesion J/cm^2	Class in BS EN 13808
Super-premium	1.4	6
Premium	1.2	5
Intermediate	1.0	4
Conventional	0.7*	3*

(08/08) Note: The cohesion test has a significant reproducibility. This has been allowed for when setting these minimum levels and the average value of the peak cohesion for polymer modified binders is likely to be at least 0.3 J/cm^2 above the minima given in the Table.

(08/08) * For conventional binders where 0.7 is not consistently achieved, 0.5 over a minimum temperature range of 15°C has been found to provide satisfactory performance.

12 (08/08) 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 956. 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 955 and results for Clause 956 and Clause 957 for type approval purposes will be based on recovered binder from Clause 955.

13 (08/08) The binder sprayer should be checked for accuracy of transverse distribution using BS EN 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 (C_v) for the regularity of transverse distribution. The category required for the sprayer, to be specified in Appendix 7/3, should be selected from Table NG 9/14.

TABLE NG 9/14: (08/08) **Accuracy of Binder Sprayer**

Site	Coefficient of Variation Cv	Category
Motorways and Dual Carriageways	< 10%	2*
Single Carriageways	< 10%	2
Lightly Trafficked Single Carriageways	< 15%	1

(08/08) * The C_v and category is appropriate when carpet tiles 100 mm wide and at least 200 mm long are used for the test, where the surface is very even, on dual carriageways and motorways there is a case for specifying category 3. Where 50 mm wide trays are used each two adjacent trays should be averaged before calculating the Coefficient of variation (C_v).

14 (08/08) 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 (DMRB 7.5.1); over specification should be avoided in order to conserve scarce resources.

15 (08/08) 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 (C_v) for the regularity of transverse distribution. The category 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: (08/08) **Accuracy of Chipping Spreader**

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

16 (08/08) 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 macrotexture 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 (DMRB 7.5.2). 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 (08/08) 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 (08/08) 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 (08/08) 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 (DMRB 7.5.2).

20 (08/08) 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 (08/08) 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 (08/08) 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 (08/08) The permitted tolerance on the design rate of spread of binder is dependent on the site and is classified in Table NG 9/16. The category or categories appropriate to the site should be specified in Appendix 7/3. These categories have been taken from BS EN 12272-1 for surface dressing.

TABLE NG 9/16: (08/08) **Tolerance on Design Rate of Spread of Binder**

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

24 (08/08) The permitted tolerance on the design rate of spread of chippings is dependent on the site and is classified in Table NG 9/17. The category appropriate to the site should be specified in Appendix 7/3. These levels have been taken from BS EN 12272-1 for surface dressing.

TABLE NG 9/17: (11/04) **Tolerance on Design Rate of Spread of Chippings**

Site	Tolerance	Category
Highly Stressed Sites, Motorways and Dual Carriageways	±5%	3
All Other Sites	±10%	2
Lightly Trafficked Single Carriageways (up to 100 cv/l/d)	±15%	1

25 (08/08) 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 (08/08) 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, is 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 (08/08) 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 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 (08/08) 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 (08/08) Macrotexture 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 macrotexture depth on trunk roads and motorways because of the amount of macrotexture depth measurement to be undertaken. This form of measurement avoids the need for additional lane closures, which the use of volumetric patch technique or the Mini Texture Meter would require. Other methods may be used, but the results should be reported as Glass Spheres 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 TRACS surveys. The macrotexture depth for high speed roads at the end of the guarantee period would normally be specified at 1.5 mm measured by the volumetric patch technique. Depending on traffic levels, lower macrotextures 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 macrotexture 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 macrotexture with time) is lower. These dressings have lower initial macrotexture 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. Macrotexture 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 (DMRB 7.5.2).

TABLE NG 9/18: (08/08) **Minimum Glass Spheres Patch Macrotexture Depth Requirements (or Glass 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 Glass Spheres Patch Macrotexture (mm)	Speed limit 40 mph or lower Glass Spheres Patch Macrotexture (mm)
More than 2000	1.5	1.5
250 to 2000	1.5	1.2
50 to 250	1.2	1.0
Less than 50	1.0	0.8

TABLE NG 9/19: (08/08) **Minimum Glass Spheres Patch Macrotexture Depth Requirements (or Glass Spheres 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 Glass Spheres Patch Macrotexture (mm)
Over 3250	1.2
250 to 3250	1.0
Less than 250	0.8

The decrease in macrotexture 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 macrotexture of 40% should be specified in Appendix 7/3. Double and multiple-layered dressings using modified binders normally show reduced loss of macrotexture with time. An increase in macrotexture depth over time indicates that the surface is losing chippings.

30 (08/08) It is anticipated that because Surface Dressing defects are usually obvious the need for a formal assessment procedure using the quantitative method in BS EN 12272-2 will be rare. All defects are measured in 100 m sections. The visual assessment of fatting up, tracking and bleeding P_1, expressed as a percentage of area, is categorised in Table NG 9/20. The category 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 (DMRB 7.5.2).

TABLE NG 9/20: (08/08) **Defect Category: Fatting Up, Tracking and Bleeding**

Site	Fatting Up, Tracking and Bleeding : % Area P_1	Category
Motorways	≤ 0.5	3
Dual and stressed Single Carriageways	≤ 0.5	3
Single Carriageways	≤ 1.0	2
Lightly Trafficked Single Carriageways	≤ 2.5	1

The visual assessment of scabbing and tearing, (P_2), expressed as a percentage of area using BS EN 12272-2, is categorised in Table NG 9/21. The category appropriate to the site should be specified in Appendix 7/3.

TABLE NG 9/21: (08/08) **Defect Category: Scabbing and Tearing**

Site	% Area Affected P_2	Category
Motorways	≤ 0.2	3
Dual and stressed Single Carriageways	≤ 0.5	2
Single Carriageways	≤ 0.5	2
Lightly Trafficked Single Carriageways	≤ 1.0	1

The visual assessment of fretting, (P_3), expressed as a percentage chipping loss using BS EN 12272-2, is categorised in Table NG 9/22. The category appropriate to the site should be specified in Appendix 7/3.

TABLE NG 9/22: (08/08) **Defect Category: Fretting**

Site	% Chipping Loss P_3	Category
Motorways	≤ 3.0	3
Dual and stressed Single Carriageways	≤ 3.0	3
Single Carriageways	≤ 6.0	2
Lightly Trafficked Single Carriageways and footways	≤ 10.0	1

The visual assessment of streaking, (P_4), expressed as length of streaking using BS EN 12272-2, is categorised in Table NG 9/23. The category appropriate to the site should be specified in Appendix 7/3.

TABLE NG 9/23: (08/08) **Defect Category: Streaking**

Site	Length of Streaking m P_4	Category
Motorways	≤ 10	3
Dual and stressed Single Carriageways	≤ 10	3
Single Carriageways	≤ 30	2
Lightly Trafficked Single Carriageways and footways	≤ 90	1

31 (08/08) 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 924 (08/08) High Friction Surfaces

1 (08/08) 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 (08/08) 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 (08/08) 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 9/24. 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 (08/08) Each Type classification has an expected service life of between 5 to 10 years at the maximum traffic levels shown in Table NG 9/24. A Type 1 system used on a moderately or lightly trafficked site can offer a much extended life, twenty years is not unknown. Conversely a Type 3 system used on a heavily trafficked site will have a much reduced working life. Site constraints and the time of year can favour the use of less robust systems for convenience. This should not be permitted unless safety or other reasons mean there is no alternative. In such circumstances replacement may be necessary within two to three years.

5 (08/08) 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 (08/08) 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 surface course can be induced by the application of high friction surfacing. The risk of this occurring is much greater when the surface 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 (08/08) The minimum polished stone value of the aggregate used in high friction surfacing systems, determined in accordance with BS EN 1097-8, to be specified in Appendix 7/1 can be obtained from HD 36 (DMRB 7.5.1).

TABLE NG 9/24: (08/08) **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

(08/08) *Each type classification has an expected service life of between 5 and 10 years at the maximum traffic levels shown.

NG 925 (08/08) Sampling and Testing of Bituminous Mixtures

1 (08/08) The BS EN 13108 standards for bituminous mixtures include detailed requirements for mixture validation testing and consistency and conformity testing in Part 20: Type Testing and Part 21: Factory Production Control. This includes both tests for performance properties and compositional analysis at stated frequencies. The regulations governing CE marking make this testing a legal obligation of producers. The requirements for routine testing are further reinforced by Sector Scheme 14. The results of such testing should be readily available and will form the basis of the demonstration of material conformity.

2 (08/08) In special circumstances, such as very large or critical contracts, it may be appropriate to require some or all of the type testing to be repeated at the start of the contract as a demonstration or approval trial. If this is the case then this should be clearly indicated in Appendix 7/1 and Appendix 1/5.

3 (08/08) There may be certain circumstances where it would be appropriate for the Overseeing Organisation to undertake audit testing of bituminous mixtures. Any such testing and the associated sampling should be carried out in accordance with the requirements of the relevant parts of BS EN 13108, BS EN 12697 and BS 594987, using laboratories with the appropriate UKAS accreditation. Provision to require such testing, on a contract by contract basis, is given in Table NG1/1.

NG 926 (08/08) In Situ Recycling: The Repave Process

1 (08/08) Guidance to the requirements specified in Clause 926 is contained in HD 31 (DMRB 7.4.1).

2 (08/08) The Repave process is an acceptable alternative to conventional resurfacing and can be used when weather conditions might prevent the use of conventional plant.

3 (08/08) Where the suitability of resurfacing works for the 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 929 (08/08) Dense Base and Binder Course Asphalt Concrete (Design Mixtures)

1 (08/08) The requirements in Clause 929 are now based on the European Asphalt Standard BS EN 13108-1 as detailed in BSI PD6691 and BS 594987. This has implications for the verification and validation of mixtures as described below.

2 (08/08) Clause 929 requires that designed dense base and binder course asphalt concrete mixtures meet the detailed requirements of BSI PD6691 Annex B. It is the responsibility of the asphalt producer to provide verification of these properties for each mixture in the form of a Type Test Report, in accordance with BS EN 13108-20. This verification will have been carried out in accordance with a protocol given in BS 594987 Annex C. The protocol is based on the job mixture approval trial procedure specified previously in earlier editions of the Specification for Highway Works Clause 929, is technically equivalent and provides the same information.

3 (08/08) For most contracts, the information from the Type Test Report, supported by CE Marking, should be sufficient to demonstrate that the mixture complies with the requirements of Clause 929. Under these circumstances, there is no need for an additional job mixture approval trial. On particularly large or critical projects, there may be a benefit in undertaking validation trials as part of the contract. Where required, these should be carried out in accordance with BS 594987 Annex C and the requirement clearly indicated in Appendix 7/1. It should be noted that this

additional testing should only be specified where there is reasonable justification to do so.

4 (08/08) If required, mix volumetrics can be monitored in the Permanent Works by determining void contents of cores compacted to refusal. This can provide an indication of deformation resistance. It should be noted however, that resistance to permanent deformation assessed by wheeltracking forms part of the Type Test Report. Monitoring void content at refusal will generally only be practicable only on larger contracts. If void content at refusal is to be monitored in the permanent works, this should be clearly indicated in Schedule 5 of Appendix 7/1.

5 (08/08) Verification of wheel tracking properties for each mixture will be provided in the form of a Type Test Report in accordance with BS EN 13108-20. This verification will have been carried out in accordance with a protocol given in BS 594987 Annex D. Requirements appropriate to traffic and stress condition should be selected from Table NG 9/25.

6 (08/08) On particularly large or critical projects it may be appropriate to monitor resistance to permanent deformation in the permanent works. If required, this should be clearly indicated in Schedule 5 of Appendix 7/1 along with the site classification.

7 (08/08) When specifying resistance to permanent deformation, it will be necessary to take into account the transitional problems brought about by the change in the wheel tracking test method from BS 598 part 110 to BS EN 12697-22, which uses similar equipment but different duration and loading. Further information is given in the note to BSI PD6691 Table B4. Work is in hand to establish criteria for the new method, but in the interim, requirements should be based on the BS 598 test but with data provided to show the values for the same mix tested to the BS EN 12697 method.

8 (08/08) Sub-clause 6 requires a minimum stiffness category of 1800 MPa for mixtures containing 40/60 grade binder and 2800 MPa for mixtures containing 30/45 grade binder. This is a minimum default value for these mixtures and should not be confused with the design stiffness. Further information on design stiffness can be found in HD 26 (DMRB 7.2.3). There is no protocol covering stiffness determination for dense base and binder asphalt concrete mixtures in BS 594987. Therefore, the following Type Testing protocol should be adopted:

'Following the general protocol in BS 594987 Annex C, take an additional, three adjacent core pairs as described in C.3.2. Cut test specimens from these cores and determine stiffness in accordance with BS EN 12697-26 (ITSM method 20°C). The mean of the set of six values shall not be less than 1800 MPa for mixtures containing 40/60 grade binder and 2800 MPa for mixtures containing 30/45 grade binder.'

9 (08/08) Indirect density gauges, including nuclear density gauges, are specified for compaction control. It is important that these are calibrated across an appropriate range of densities as required by BS 594987. Such gauges have a penetration depth of approximately 80 mm and where layer thicknesses exceed this it is especially important that cores are visually inspected to ensure that they are uniformly compacted.

10 (08/08) A new requirement for density control close to joints has been introduced. Experience has shown that in-situ void content requirements in the wheeltracks are generally achieved. Therefore, the frequency of testing in this position has been reduced. Compaction at joints is considered to be a primary factor in affecting the durability of asphalt pavements and testing at this location has therefore been introduced. Contractors may need to adopt special measures of joint compaction in order to comply with this requirement.

11 (08/08) Where dense asphalt concrete base and binder course mixtures are to run on directly by normal highway traffic (due to traffic management requirements) it is recommended that they be surface dressed to prevent water ingress and to provide adequate skid resistance.

TABLE NG 9/25: (08/08) **Classification of Sites by Traffic and Stress Condition for Resistance to Permanent Deformation of Dense Macadams to Clause 929**

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	Motorway (main line)	BSI PD6691 Table B4, Classification 1 (45°C)				
	B	Dual carriageway (all purpose) non-event sections					
	C	Dual carriageway (all purpose) minor junctions					
	D	Single carriageway non-event sections					
	E	Single carriageway minor junctions					
IA & IIA	As I and II, above, but with contraflow anticipated during summer months				BSI PD6691 Table B4 Classification 2 (60°C)		
III	F	Approaches to and across major junctions (all limbs)					
	G1	Gradient 3% to 10%, longer than 50 m					
	L	Roundabout					
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

NG 930 (08/08) EME2 Base and Binder Course Asphalt Concrete

1 (08/08) EME2 is a durable, deformation resistant, high performance base and binder course mixture, based on established French technology. The designation EME is from the French name Enrobé à Module Élevé ("High Modulus Coated"), and this acronym is being retained to differentiate these mixtures from the traditional UK High Modulus Base (HMB) materials which have significantly lower binder contents. Further information on the background to the material and the reasons for its introduction are explained in TRL report TRL 636.

2 (08/08) Two BS EN 13924 binder grades are permitted for use in EME2. However, it is recommended that the target penetration is limited to between 15 and 20, as there is no positive UK experience outside this range. In addition, the requirements of the UK National Foreword to BS EN 13924 in combination with additional specific binder properties, as supplied and after ageing, are applied to ensure that unsuitable hard grade binders are not used.

3 (08/08) The requirements in Clause 930 are based on BS EN 13108-1 as detailed in BSI PD6691 and BS 594987. This has implications for the verification and validation of mixtures as described below.

4 (08/08) Clause 930 requires that EME 2 base and binder course mixtures meet the detailed requirements of BSI PD6691 Annex B, in terms of constituents, composition, void content, water sensitivity, deformation resistance, stiffness modulus and fatigue properties. It is the responsibility of the asphalt producer to provide verification of these properties for each mixture in the form of a Type Test Report, in accordance with BS EN 13108-20. This verification will have been carried out by laboratory testing of some properties and validation of others by means of a site trial in accordance with a protocol given in BS 594987 Annex E. The protocol is based on the French 'planche de vérification' procedure and the job mixture approval trial procedure specified previously in earlier editions of the Specification for Highway Works Clause 929.

5 (08/08) Generally, the information from the Type Test Report, supported by CE Marking, should be sufficient to demonstrate mixture compliance. As EME2 mixtures are still relatively new in the UK, it is considered appropriate to have site validation trials of volumetrics and stiffness carried out on each contract. These should be carried out in accordance with BS 594987 Annex E and the requirement to do so clearly indicated in Schedule 5 of Appendix 7/1. On particularly large or critical projects, there may be a benefit in undertaking full validation trials as part of the contract. It should be noted that this additional testing should only be specified where there is reasonable justification to do so.

5 (08/08) Binder content is a critical feature of EME2 mixtures. Therefore, a separate assessment of soluble binder content is included as a safeguard to ensure that binder contents are targeted close to the intended value and do not fall. In order to conform to this requirement, producers will need to maintain production close to mid point.

6 (08/08) EME2 is a binder rich material and should be more readily compacted to a low void content than traditional DBM, HDM and HMB materials. It is recommended that the trial strips constructed for the Type Test Report are used to evaluate and develop the contractor's method statement for compaction required by Clause 903.5.

7 (08/08) A new requirement for density control close to joints has been introduced. Contractors may need to adopt special measures of joint compaction in order to comply.

8 (08/08) EME2 is designed to be laid in thick lifts with small nominal size aggregate. Generally, it is good practice to lay bases in thicker lifts to minimise the number of layers and, hence, interfaces (giving due consideration to the maximum layer thicknesses given in BS 594987).

NG 937 (08/08) Stone Mastic Asphalt (SMA) Binder Course and Regulating Course

1 (08/08) The requirements in Clause 937 are based on BS EN 13108-5 as detailed in BSI PD6691 and BS 594987. This has implications for the verification and validation of mixtures as described below.

2 (08/08) Clause 937 requires the volumetric properties of SMA binder course and regulating mixtures to comply with BSI PD6691 Annex D. It is the responsibility of the asphalt producer to provide verification of these properties for each mixture in the form of a Type Test Report, in accordance with BS EN 13108-20. This verification will have been carried out in accordance with a protocol given in BS 594987 Annex G. The protocol is based on the job mixture approval trial procedure specified previously in earlier editions of the Specification for Highway Works, is technically equivalent and provides the same information.

3 (08/08) The means to specify resistance to permanent deformation for SMA binder courses, previously given in Clause 952, are now contained within this Clause. Requirements appropriate to traffic and stress condition

should be selected from Table NG 9/26. Verification of wheel tracking properties for each mixture will be provided in the form of a Type Test Report in accordance with BS EN 13108-20. This verification will have been carried out in accordance with a protocol given in BS 594987 Annex G.

4 (08/08) On particularly large or critical projects it may be appropriate to monitor resistance to permanent deformation in the permanent works. If required, this should be clearly indicated in Schedule 5 of Appendix 7/1 along with the site classification.

5 (08/08) When specifying resistance to permanent deformation, it will be necessary to take into account the transitional problems brought about by the change in the wheel tracking test method from BS 598 part 110 to BS EN 12697-22, which uses similar equipment but different duration and loading. Further information is given in the note to BSI PD6691 Table B4. Work is in hand to establish criteria for the new method, but in the interim, requirements should be based on the BS 598 test but with data provided to show the values for the same mix tested to the BS EN 12697 method.

NG 938 (08/08) Porous Asphalt Surface Course

1 (08/08) There has been little recent experience with Porous Asphalt in the UK and consequently no detailed requirements are given. Where porous asphalt is to be used, the specific mix details and performance requirements should be agreed with the Overseeing Organisation and established in terms of BS EN 13108-7

NG 942 (08/08) Thin Surface Course Systems

1 (08/08) 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 50 mm. As such, this classification can include hot-mixed asphalts, slurry surfacings incorporating microsurfacing and (multiple) surface dressings without any explicit exclusion.

2 (08/08) 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 (08/08) 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 (08/08) 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 (08/08) 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 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 (08/08) 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 9/27.

7 (08/08) 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: (08/08) **Classification of Sites by Traffic and Stress Condition for Resistance to Permanent Deformation of SMA to Clause 937**

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	Motorway (main line)	BSI PD6691 Table D.7, Classification 1 (45°C)				
	B	Dual carriageway (all purpose) non-event sections					
	C	Dual carriageway (all purpose) minor junctions					
	D	Single carriageway non-event sections					
	E	Single carriageway minor junctions					
IA & IIA	As I and II, above, but with contraflow anticipated during summer months				BSI PD6691 Table D.7 Classification 2 (60°C)		
III	F	Approaches to and across major junctions (all limbs)					
	G1	Gradient 3% to 10%, longer than 50 m					
	L	Roundabout					
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

TABLE NG 9/27: (08/08) **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 (08/08) 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 (DMRB 7.5.1). 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 (08/08) 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 9/28 for site classifications defined in Table NG 9/29 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.

TABLE NG 9/28: (08/08) **Classification of Sites by Traffic and Stress Condition for Resistance to Permanent Deformation of Thin Surface Course Systems**

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 9/29: (08/08) **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 (08/08) 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, which can be used are given in Table NG 9/30, where the reduction is demonstrated by the optional value stated on British Board of Agrément HAPAS Roads and Bridges Certificates. In the interest of sustainability Level 3 should only be specified in very noise sensitive areas.

TABLE NG 9/30: (08/08) **Road/Tyre Noise Levels**

Level	Equivalence to Traditional Surfacing Materials	Road Surface Influence RSI
3	Very quiet surfacing material	- 3.5 dB(A)
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 (08/08) 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 macrotexture 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 maximum thickness are specified, the difference between the maximum and minimum thicknesses should be at least 20% of their average.

12 (08/08) 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 9/31 but the majority of products overlap these categories so the certificates should be consulted carefully.

TABLE NG 9/31: (08/08) **Nominal Installation Depth Classifications**

Type	Type A	Type B	Type C
Nominal installation depth (mm)	<18	18 to 25	>25 to ≤50

(08/08) **Surface Macrotexture**

13 (08/08) The minimum macrotexture depth required from hot rolled asphalt surfacing on high-speed trunk roads is generally 1.5 mm. With thin surface course systems, the choice of aggregate grading is the Contractor's provided that the specified minimum surface macrotexture is achieved. To ensure that suitable macrotexture is provided and maintained on all roads, an initial macrotexture depth is specified in Clause 921 and a minimum requirement after two years has been included as part of the Contractor's guarantee.

14 (08/08) The performance levels of macrotexture depth used for the British Board of Agrément HAPAS scheme, given in Table NG 9/32, should be used as the basis for setting the macrotexture depth requirements. Level 3 is the default value for trunk roads including motorways and other high speed roads. A lower level may be suitable where there is limited traffic and/or restricted speeds. For urban roads with speed restrictions of 40 mph or less, Level 1 should generally be adequate.

TABLE NG 9/32: (08/08) **Glass Spheres Patch Macrotexture Levels**

Level	Minimum Macrotexture 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

15 (08/08) Whilst measurement of macrotexture depth for compliance purposes is to be by the volumetric patch technique specified in BS EN 13036-1 only, the TRL Mini Texture Meter (Sensor Measured Texture Depth) may be used as a screening procedure.

16 (08/08) 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 Measured Texture Depth (SMTD).

17 (08/08) In the event of a dispute, or discrepancy between the two methods, only results obtained using the volumetric patch method will be considered for compliance purposes.

18 (08/08) Calibrations carried out on site are only applicable to that site and that surfacing.

19 (08/08) SMTD is numerically different from macrotexture measured by the volumetric patch technique. Glass spheres patch macrotexture 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.

20 (08/08) In a similar way to measuring macrotexture prior to opening to traffic, assessment of macrotexture in the wheel tracks at the end of the guarantee period can be carried out by SMTD methods whether it be TRACS or mini texture meter, subject to them being calibrated against the volumetric patch technique prior to carrying out a survey.

Surface Preparation, Transportation, Placement and Compaction

21 (08/08) 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

22 (08/08) 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.

23 (08/08) Problems have also been reported with pre-formed marking tapes on negatively macrotextured surfaces coming unstuck in wet weather. Trials should be performed to select the best material.

Performance Guarantee

24 (08/08) The guarantee periods should be clearly stated as only relating to the surface course. An appropriate Special Requirement should be included in the Conditions of Contract, which draws particular attention to sub-Clauses 942.14, 942.15 and 942.16. At the end of the five-year guarantee period, the surfacing should be in at least a "Moderate/Acceptable" condition, or a better condition after discounting any faults caused by the substrate. Surface conditions are as defined in Appendix R of TRL Report 176.

25 (08/08) Sensor Measured Texture Depth (SMTD) is routinely measured on the Highways Agency's trunk road network. To comply with sub-Clause 942.16, macrotexture need only be measured in accordance with BS EN 13036-1 in cases of dispute, when the measured SMTD or another routine assessment method indicates compliance may not have been achieved.

26 (08/08) There are many thin surface course systems on the market. The British Board of Agrément can advise on systems with HAPAS certification. Most certificates can be downloaded from www.bbacerts.co.uk where the current status of all certificates is given.

NG 943 (08/08) Hot Rolled Asphalt Surface Course and Binder Course (Performance-Related Design Mixtures)

1 (08/08) This clause is for the specification of hot rolled asphalt mixtures that have been designed to achieve controlled levels of resistance to permanent deformation (rutting) measured by the wheel tracking test. These mixtures are used as both surface course and binder course. They are particularly suitable as a regulating binder course under thin surfacings and as a binder course over bridge deck waterproofing. When used as surface course they must be chipped to provide a skid resistant surface.

2 (08/08) Using hot rolled asphalt surface course to this clause will ensure a good level of resistance to permanent deformation within the surface course itself. Designers should be aware that significant rutting often occurs in the lower layers of the pavement and use of a performance designed surface course on an inadequate substrate will not protect against this. To provide adequate resistance to deformation, binder course and base designed in accordance with Clauses 929, 930 or 937 should be used, particularly in the top 100 mm of the pavement.

3 (08/08) In almost all cases, the use of a modified binder or binder modifier will be required in order to achieve the more onerous (Class 2) performance level. Since these are generally proprietary products, sub-Clause 5 requires the submission of information to the Overseeing Organisation for approval. If there is evidence of successful use of a modified binder/ modifier in similar conditions, the presumption should be of approval.

4 (08/08) Verification of wheel tracking properties for each mixture will be provided in the form of a Type Test Report in accordance with BS EN 13108-20. This verification will have been carried out in accordance with a protocol given in BS 594987 Annex F. This protocol is based on the job mixture approval trial procedure specified previously in earlier editions of Clause 943, is technically equivalent and provides the same information. Requirements appropriate to traffic and stress condition should be selected from Table NG 9/33 and included in Appendix 7/1.

5 (08/08) On particularly large or critical projects it may be appropriate to monitor resistance to permanent deformation in the permanent works. If required, this should be clearly indicated in Schedule 5 of Appendix 7/1 along with the site classification.

6 (08/08) When specifying resistance to permanent deformation, it will be necessary to take into account the transitional problems brought about by the change in the wheel tracking test method from BS 598 Part 110 to BS EN 12697-22, which uses similar equipment but different duration and loading. Further information is given in the note to BSI PD6691 Table B4. Work is in hand to establish criteria for the new method, but in the interim, requirements should be based on the BS 598 test but with data provided to show the values for the same mix tested to the BS EN 12697 method.

TABLE NG 9/33: (08/08) **Classification of Sites by Traffic and Stress Condition for Resistance to Permanent Deformation of Performance Related HRA Surface Course and Binder Course to Clause 943**

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	Motorway (main line)	BSI PD6691 Table C.3, Classification 1 (45°C)				
	B	Dual carriageway (all purpose) non-event sections					
	C	Dual carriageway (all purpose) minor junctions					
	D	Single carriageway non-event sections					
	E	Single carriageway minor junctions					
IA & IIA	As I and II, above, but with contraflow anticipated during summer months					BSI PD6691 Table C.3 Classification 2 (60°C)	
III	F	Approaches to and across major junctions (all limbs)					
	G1	Gradient 3% to 10%, longer than 50 m					
	L	Roundabout					
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

NG 945 (08/08) Weather Conditions for Laying of Bituminous Mixtures

1 (08/08) This Clause considers the laying conditions for bituminous mixtures in four separate categories:

(i) General, applying to all bituminous mixtures.

(ii) Hot bituminous materials laid less than 50 mm thick.

(iii) Thin surface course systems.

(iv) Hot rolled asphalt with pre-coated chippings.

2 (08/08) The layer thickness has a major effect on the time available for compaction before the temperature drops below that at which the compaction is effective. Materials laid 50 mm or more thick, other than hot rolled asphalt with chippings, are likely to be tolerant of all but the most extreme conditions encountered in the UK.

3 (08/08) For materials at nominal thicknesses below 50 mm, air temperatures and, more particularly, wind speeds have a significant effect. For this situation, Sub-Clause 945.2 calls up Figure 9/8 which gives limiting conditions based on a minimum available compaction time of 8 min. Contractors will need to take account of this requirement in their compaction plans drawn up under sub-Clause 903.5.

4 (08/08) The weather conditions for the laying of thin surface course systems are covered by the relevant BBA/HAPAS Roads and Bridges Agrément Certificate.

5 (08/08) Experience with hot rolled asphalt with pre-coated chippings led to the conclusion that the most appropriate combination for laying in UK weather conditions was a 35 % stone content mixture laid at a nominal 50 mm thickness. Sub-Clause 945.4 gives specific limiting delivery, air temperature and wind speeds for this mixture and thickness only. These requirements for hot rolled asphalt with pre-coated chippings are based on a minimum available compaction time of 10 min from the time the material emerges from the paver. The use of modified binders in the hot rolled asphalt can change the relevant conditions.

6 (08/08) The additional constraints that can apply in during winter and/or night-time laying that can affect the suitability of the weather conditions include:

(i) The temperature of bituminous mixtures drops rapidly during winter and night time laying operations. Extra care needs to be taken to ensure bituminous mixtures are adequately protected during transportation, off loading, laying and rolling.

(ii) Cooling of bituminous layers, factors affecting cooling (wind chill, temperature) and time available for compaction (particularly during short night time lane possessions) needs to be borne in mind whilst planning for laying operations.

(iii) Human factors and health, welfare and safety implications should be given extra consideration for winter and night time working.

7 (08/08) The requirements of Clause 903 still apply, unless specifically amended by this Clause.

NG 948 (08/08) Ex Situ Cold Recycled Bound Material

1 (08/08) Materials to this Clause should be specified in Appendix 7/1. Either a specific material or materials should be stated or the contractor permitted to choose a suitable material to meet the design thickness required. For roads designed for more than 20msa only QVE or QH materials should be used.

Examples of the types of materials that satisfy the material classifications QH, SH, QVE and SVE are provided below. It is realised that the combinations listed in Table NG 9/34 for each family are not exhaustive and alternatives to those shown can be considered (as indicated by 'other' in the table).

Table NG 9/34: (08/08) **Examples of Material Families**

Quick Hydraulic (QH)	Slow Hydraulic (SH)	Quick Visco-elastic/hydraulic (QVE)	Slow Visco-elastic/hydraulic (SVE)
• PC/PFA • PC/GGBS • PC/PFA/GGBS • PC/'other'	• Lime/PFA • Lime/GGBS • Lime/PFA/GGBS • Lime/GGBS • Lime/PFA/GGBS • Lime/'other'	• Foam/PC • Foam/PC/PFA • Foam/PC/GGBS • Foam/PC/GGBS • Foam/PC/'other' • Emulsion/PC • Emulsion/PC/PFA • Emulsion/PC/GGBS • Emulsion/PC/GBS • Emulsion/PC/'other'	• Foam/Lime/PFA or • Foam/Lime/GGBS • Foam/Lime or • Foam/GBS or • Foam/'other' • Emulsion/GBS or • Emulsion/Lime/PFA or • Emulsion/Lime/'other' • Emulsion/'other'

2 (08/08) The aggregate component should be of a quality generally suitable for use in cement bound material or asphalt. However, given the nature of the operation, which involves processing arisings from existing road pavements, some discretion should be applied. The emphasis should be on ensuring that deleterious materials, such as clay lumps and badly weathered aggregate are excluded from the recycled material.

3 (08/08) When determining the grading of materials containing asphalt planings, samples should be dried to constant mass at 40°C and care should be taken not to break down the aggregated particles of asphalt unnecessarily.

4 (08/08) It is good practice to undertake mix design evaluation in advance of works on site, but it must be recognised that this is not always practicable, particularly for small projects. Additionally, there will not always be time for the full design procedure and, in particular, the curing stage to be carried out in advance of the works. Where this is the case, information from earlier works with the same process or accelerated curing regimes should be taken into consideration.

The components used in the mix design stage should represent the materials available in the permanent works. Where a representative component is unavailable, the contractor should use a replacement component of similar properties in the mix design stage.

The laboratory prepared aggregate should be thoroughly mixed with measured proportions of the bitumen binder, cementing binder and adhesion agent(s). The type and grade of the bitumen and adhesion agent(s) used in the trial mixtures shall be the same as those used in the finished works.

For QVE, the contractor should declare the Indirect Tensile Stiffness Modulus in accordance with BS DD 213.

For SVE it is recommended that an accelerated curing regime is used involving curing at 60°C for 72 hours and then determining Indirect Tensile Stiffness Modulus. However, the values obtained in this way should not be expected to reflect in situ performance in the same way as for the other material types.

For QH and SH materials the contractor should declare the minimum performance class achieved according to the direct measurement of Dynamic Modulus and Flexural Strength after conditioning; where these values are not directly measurable, suitable alternative apparatus and transfer functions may be utilised as described below.

If information is required on the moisture sensitivity of the mixtures, additional sets of specimens can be made up and tested after 24 hours soaking in water. The soaked specimen should not show any signs of cracking or swelling and the modulus or strength values should be at least 75% of the un-soaked values.

Declaration using alternative test methods for hydraulic mixtures should be dealt with as follows:

Using compressive strength tests in accordance with prEN13286 Part 41 and using relationships from Croney (1991):

$$E_{dyn} = \frac{\log f_f + 0.773}{0.0301}$$

$$f_f = 0.11 f_c$$

Using the indirect tensile strength and stiffness in accordance with prEN13286 Part 42

$$E_{dyn} = 11 + 0.84E_{ITSM}$$

$$f_f = 1.33\, f_{it}$$

Where E_{dyn} is elastic dynamic stiffness in GPa, E_{ITSM} is the ISTM in GPa, f_f is the flexural strength in MPa, f_c is the compressive strength in MPa, f_{it} is the indirect tensile strength in MPa.

This declaration shall include the direct value from laboratory tests and also a predicted 360 day value. Factors can be used to relate the laboratory test values with 360 day test values. Based on current knowledge, the following factors are suggested; other factors may be used supporting evidence. These factors should be applied to the test results prior to any transfer functions.

Table NG 9/35: (08/08) **Factors to Link Laboratory Test Values and 360 Day Values**

Material Type	Factor
QH	1.2
QVE	1.0
SH	1.0
SVE	N/A

The Contractor should also justify this design with appropriate references to design charts or if requested by the Overseeing Organisation, carrying out analytical pavement design.

5 (08/08) It is recommended that a trafficking trial be performed as part of the mixture approval trial and is a best-practice approach to ensure that excessive deformation will not occur in the Permanent Works. It should be noted that a trafficking trial cannot guarantee deformation resistance in the Permanent Works and it can be a time-consuming method of approving a foundation.

As a general rule, the 'Quick' mixtures, which include cement, are less likely to be susceptible to rutting, as are those with a stable, angular, granular aggregate content. Particular care should be taken if there is a high proportion of rounded gravel.

A trafficking trial may not be necessary if:

- evidence is available to show that the proposed construction (materials, construction and thicknesses) has performed well at other sites under the same moisture conditions; or
- the type of construction is of a type that is unlikely to be susceptible to deformation.

The experience of the contractor with this type of work and evidence of satisfactory application of the same techniques on similar sites in the past should be taken into consideration.

Deformation may also result from weak underlying foundations which may be exposed during recycling operations. This should be taken into account by those responsible for the design of the works. Whether a trafficking trial is performed or not, it is important to ensure that the foundation meets the specified requirements in the Permanent Works.

If the construction is to be trafficked by special, very heavy vehicles, additional consideration should be given to the proven performance of the material approval trial under trafficking in relation to these vehicles.

6 (08/08) The plant used for ex situ stabilisation should be capable of achieving controlled batching by weight or volume. The plant should have hoppers and tanks appropriate for the component materials to be mixed. The mixing plant shall be located close enough to the site to enable placing of the material within the appropriate setting time.

7 (08/08) It is important to establish a testing regime for end performance properties (stiffness, tensile strength) appropriate to the nature of the works. It is recommended, given the precision of the testing the results are assessed for conformity in sets of six. This does not, however, mean that a full set of six specimens needs to be made up at one time.

For works of a reasonable size, it is recommended that specimens are prepared at an overall frequency of three per 1000 tonnes, with a minimum of three per working day. Conformity should be assessed on a rolling basis.

It may be possible to relax this requirement for small and intermittent jobs.

40kg of material is required for each sample to have sufficient material for the three test samples (PRD, Cylindrical and Moisture Content) to be produced. PRD samples require a minimum of 5kg of material; Cylindrical samples, 4kg; Moisture Content samples, 3kg; as well as three PSD tests from a bulk sample of six individual samples.

8 (08/08) A PRD or other other suitable mould may be used. Where long-term storage of materials is required, the use of an inexpensive mould such as plastic soil pipe is advised.

9 (08/08) The criteria in this sub-Clause represent the minimum permitted end-product compliance criteria; however, they can be supplemented by other laboratory and non-destructive in situ test methods as agreed with the Overseeing Organisation. For VE materials, particularly those containing asphalt planings, analysing for bitumen content is unlikely to be of value. This aspect of process control is better controlled through tank reconciliation. A description of the supplementary test methods and expected outcomes of the testing can be including in the Material Quality Plan declaration. Supplementary testing can be of value to both the Contractor and the Overseeing Organisation and should be viewed as good practice. For example, a non-destructive falling weight test device can in certain circumstances be used to show the in situ performance of the layer and also show that curing is occurring. It is advised that any agreed supplementary testing is used as a tool for 'acceptance' (as opposed to 'rejection') so that along with practical evidence at other sites these may be used to resolve non-compliance issues should they occur.

NG 953 (08/08) Durability of Bituminous Materials - Saturation Ageing Tensile Stiffness (SATS) Test

1 (08/08) This test method assesses the combined effect of ageing and moisture on bituminous pavement materials in service. It assesses the durability of adhesion with particular aggregate/filler combinations. It is specified for all base and binder course mixtures and is carried out on samples produced with a nominal (water accessible) air void content of 8%, a nominal binder content of 4% (mixtures may be tested at the actual designed target binder content, within a typical range of 3.5 to 5.5%) but substituting a 10/20 penetration grade binder complying with TRL Report TRL 636 Annex A for the binder to be used in the mixture.

2 (08/08) Evidence from an early demonstration trial of High Modulus Base (HMB) materials in the UK showed an unexpected drop in material stiffness modulus (up to 60%) only a few years after construction. Similar reductions in stiffness modulus have since been measured on other sites using convention dense bitumen macadams with softer binders. The main purpose of the SATS test is to reproduce in the laboratory the decrease in stiffness modulus that is likely to occur with a mixture, so that unsuitable aggregate/filler combinations are screened out at mixture design stage.

3 (08/08) Deterioration in asphalts due to a gradual loss of adhesion resulting in falling stiffness is the aspect of durability combated by this test. Nevertheless although very important, this is not the only aspect of durability, deterioration may be induced, for example, by a lack of bond between layers or an inadequate foundation resulting in excessive stress, movement and cracking, or scouring by entrapped water under pressure where segregation has occurred when the mixture was laid.

4 (08/08) With reference to sub-Clause 953.4(ii), 100 mm wide 'Foil-faced self-adhesive tape' supplied by IDENT, has been found to be suitable. The tape can be obtained from WR Thermal Contracts, 1 Ludlam Avenue, Giltbrook, Nottingham, NG16 2UL (Tel: 0115 9386078 or 07775 646 526, Fax: 0115 9383788).

5 (08/08) With reference to sub-Clause 953.5(v), a 100 mm diameter, 5mm thick rigid porous disc for use with a standard soils triaxial cell as described in clause 3.2 (g) of BS 1377-8, has been found to be suitable.

6 (08/08) The form and dimensions of the pressure vessel and specimen tray shown in Figures 9/9 and 9/10 have been found to yield repeatable results in the SATS test when used with different aggregate types. Other forms of pressure vessel and specimen tray may also be suitable, but have not been specifically investigated. However, early work carried out in a standard binder pressure ageing vessel to BS EN 14769 yielded similar results to those generated using the apparatus described in Clause 953.

7 (08/08) The standard SATS test involves specimens cored from a slab manufactured using a laboratory roller compactor. Specimens for test may also be cored from an in-service pavement in accordance with BS 598-100, but research data on the performance of such specimens in the SATS test are not currently available.

8 (08/08) The measurement of density on sealed specimens is considered essential for material with an air void content of 8%. Wax is not suitable as a sealing material since it is practically impossible to remove from specimens that will be subjected to subsequent mechanical testing. The self-adhesive aluminium foil described in sub-Clause NG 953.4 above has been successfully used in a number of laboratories in the UK for over 10 years, and is easy to remove. For laboratory prepared specimens with a rough surface texture, the foil may cause observation of texture voids as internal specimen voids, which may cause an under-estimation of the specimen density and an over-estimation of the

air voids level of the specimen. However, the risk of this is considered to be relatively small in the SATS test specimens, which are normally cored from a laboratory manufactured slab and then trimmed (sawn) to the specified thickness.

9 (08/08) The test temperature of 85°C and test duration of 65 hours are the same as those adopted for the High Pressure Ageing Test (HiPAT) developed for BBA/HAPAS (British Board of Agrément/Highway Authorities Product Approval Scheme) Specialist Group (SG)4 for Modified Binders.

10 (08/08) With reference to sub-Clause 953.16, the 24h cooling period is applied to minimise pressure related damage during the depressurising process. It has been found that the reduced target temperature (30°C) can be achieved well within 24hrs using the apparatus described in this test method. It should be noted that the pressure needs to be carefully maintained during this cooling process, as the reducing temperature will reduce the vessel pressure accordingly. This can be achieved by careful adjustment of the pressure input controlling valve to just below the target pressure (2.1 MPa); any gradual loss of pressure will then be automatically compensated for by the gradual input of pressure from the compressed air cylinder.

11 (08/08) Slow release of pressure is required at the end of the SATS conditioning procedure, to minimise damage to the specimens as a result of sudden changes.

12 (08/08) With reference to sub-Clause 953.18, 3 minutes has been found to be a practical time period to complete the surface drying and weighing of all 5 specimens after removal from the pressure vessel. Any reduction in this time period (below 3 minutes) should help to improve the precision of the test.

13 (08/08) The output from the SATS test for mixture assessment purposes is the average stiffness ratio value of the four individual specimens above the water.

14 (08/08) Figure NG 9/1 shows a suitable format for the graphical representation of the stiffness modulus versus saturation value plot detailed in sub-Clause 953.26 h). The data shown in the figure are examples only.

15 (08/08) Precision data are still being established for this test method.

Figure NG 9/1: (08/08) **Graphical Representation of Typical Retained Stiffness/Saturation Data**

Volume 2 home page

NG 954 (08/08) Method for Laboratory Determination of Interface Properties Using the Modified Leutner Shear Test

1 (08/08) The test method is intended to assess the bonding between adjacent asphalt pavement layers using cylindrical samples. It is also appropriate for asphalt applied to concrete.

2 (08/08) The peak shear stress at the interface between asphalt layers measured using the Modified Leutner Shear Test should not be less than 1MPa for an interface within the top 75 mm of the pavement structure and not less than 0.5MPa for interfaces at or below the top 75 mm.

3 (08/08) Clause 954 incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed in Appendix F. For dated references, subsequent amendments to or revisions of any of these publications apply to this Clause only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

4 (08/08) The Leutner shear test was developed in Germany in the late 1970s as a simple means of undertaking a direct shear test on a bond between two pavement layers. The test is performed on 150 mm diameter cores comprising at least two layers (with a bond between them) taken either from a pavement or produced in the laboratory. The principle of the test is to apply a shear displacement rate across the interface under investigation and monitor the resulting shear force. No normal force is applied to the specimen. The standard loading rate is 50 mm/min and the test is typically carried out at 20°C. It should be noted that a 5mm gap is introduced in this modified version of the shear test, as shown in Figure 9/12, in order to give a certain level of tolerance for interface alignment to the shear plane.

5 (08/08) With reference to sub-Clause 954.4, the shear test apparatus supplied by the apparatus manufacturer STRASSENTEST GmbH, D-63755 Alzenau, Germany, HR8 8049 (Tel: +49 (0) 60 23 / 50 56-0) has been found to be suitable. Various sizes of standard shearing rings are also available from the same manufacturer, necessary in order to incorporate some variation in specimen diameter. It should be noted that these standard shearing rings require modification to introduce a 5 mm gap over the shear plane (see sub-Clause 954.3 above); this modification is easily available from a local workshop.

6 (08/08) It is recommended to use a servo-hydraulic universal testing machine with an incorporated data logging system. However, other loading frames (such as the Marshall apparatus) can also be used, providing they fulfil the requirements of sub-Clause 954.4 (ii).

7 (08/08) The data logging system described in sub-Clause 954.4(iii) shall to be capable of collecting around 40 data points per second.

8 (08/08) The recommended material for the metal extension is aluminium.

9 (08/08) The recommended diameter of the cored specimens is 150 ± 2 mm. It is recommended to have a range of shearing rings and metal extensions to cover the range of specimen diameters.

10 (08/08) The thickness of the layer below the interface to be tested shall be sufficient to ensure a secure grip is maintained on the specimen during the test (Figure 9/12 B). 60 mm is recommended as the minimum thickness.

11 (08/08) The thickness of the layer above the interface shall be sufficient to ensure a proper contact with the upper shearing ring (Figure 9/12 C). The minimum recommended thickness of the layer above the interface is 15 mm. If the thickness of the layer above the interface is between 15 and 30 mm, a metal extension shall be glued on the top of the layer above the interface.

12 (08/08) It is recommended that the shearing rings are selected to form a loose fit around the specimen. For example, if the specimen diameter is 150.1 mm, 151 mm shearing rings shall be selected.

13 (08/08) It is recommended that the metal extension selected shall have a diameter slightly larger than the diameter of the specimen (the difference shall not be more than 2 mm). When a metal extension is used, it is recommended that the shearing rings are selected to form a loose fit around the metal extension. For example, if the metal extension diameter is 151 mm, 152 mm shear rings shall be selected.

14 (08/08) The sample support shown in Figure 9/12 B needs to be tightened using a hand spanner to give a firm grip. However, care is necessary to avoid over tightening and consequent damage to the specimen.

15 (08/08) It is necessary to carefully inspect both sections of the sheared specimen. Crushed coarse aggregate on the specimen edge could indicate misalignment of the specimen interface in the shear plane.

NG 955 (08/08) Binder Recovery Using the Rapid Recovery Test (RRT) and Accelerated Ageing Using the RRT

1 (08/08) 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 (08/08) Nitrogen gas is used, rather than air, to minimise ageing of the binder and to increase safety especially with cutback binders.

3 (08/08) This recovery method simulates the state of a binder film soon after application using conventional surface dressing and bond coat sprayers or slurry surfacing mixing 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 used for conventional unmodified emulsions and cutbacks although prEN 13074 may be preferred for unmodified bitumen emulsions, as it does not require RTFOT apparatus, however it takes a much longer time.

4 (08/08) Two bottles are used to set the cycle time for the microwave 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 minimise leaching.

5 (08/08) 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 (08/08) 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 (08/08) It has been found to be possible to leave the metal screws in the bottles in the microwave for some materials, however, the risk should be assessed bearing in mind the concentration of volatile oil and the effect of any arcing in the bottle.

8 (08/08) 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.

9 (08/08) 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.

10 (08/08) The PTFE bottles manufactured to the dimensions stated and with screw caps to facilitate sample and screw removal may be obtained from Tefloturn Limited in Hertford UK - website is **http://www.tefloturn.co.uk**.

11 (08/08) The stainless steel screws are manufactured from high quality surgical steel so that they are resistant to corrosion, which is particularly a problem with emulsions. The screws may be obtained from Newlands Engineering, Unit 13, Wren Industrial Estate, Coldred Road, Parkwood, Maidstone, Kent, ME15 9XN. The screws are to a 'fine machined finish' and a certificate of conformity is issued.

12 (08/08) The scraper may be obtained from Babtie Laboratories, St Michael's Close, Aylesford, Maidstone, ME20 7BU.

13 (08/08) 'Stabilising' using nitrogen gas at 135ºC for one hour removes most of the volatile oil left within the 'Recovered' sample after the RRT. Some binders with large quantities of volatile flux will need conditioning at 135ºC for more than one hour before the nitrogen gas supply is switched to air to begin the ageing process. If two hours are required for this conditioning the total time of test will be extended by one hour. The binder sample after loss of the majority of its volatile oil by this process results in a so-called 'Stabilised Binder' and may be used for test although the properties after the

first period of ageing at 3 hours may be more consistent and represent a few years on the road.

14 (08/08) The weight loss during 'stabilising' may be used to evaluate the proportion of volatile oil present and the length of time necessary to drive it off may indicate the volatility. Tests on the samples before and after 'stabilising' may reveal properties of solvating ability and fluxing power. The quality of nitrogen (oxygen impurity) and air in the sample may result in some ageing. It is possible to use purer nitrogen and lower temperature to investigate volatile oil loss.

15 (08/08) The procedure for RTFOT ('Short Term Ageing') for binders for Hot Mix Asphalt is faster than normal, only 45 mins. as opposed to 75 mins (both at 163ºC using air) and is due to the use of screws, which accelerate the test. The problems experienced with polymer modified binders not turning and continually exposing new surfaces as efficiently as unmodified binders in the conventional test is overcome by the use of screws which minimise phase separation and skinning. The sample is always removed by scraper, whereas the method of removal in BS EN12607-1 was designed for unmodified binders and when the binder does not flow easily from the glass bottles (sometimes the case with heavily modified binders) the option to scrape rather than pour may introduce sample heterogeneity and reproducibility problems.

16 (08/08) If only 'Aged Binder' samples are required for Emulsions then except for two bottles to provide 'Recovered Binder' the test may be run continuously and the microwave procedure ignored as the 'Stabilising' period at 135ºC will drive off any remaining water from the samples.

17 (08/08) The Modified Ageing Rolling Thin Film Oven Test (Modified Aging RTFOT) is an alternative to the high pressure ageing test (HiPAT) as specified by the British Board of Agrément HAPAS modified binder group, to evaluate 'ageing' or 'stabilising' of the binder on the road 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. In static tests such as the trays in the HiPAT or PAV the presence of polymer in the binder leads to skinning and heterogeneous ageing of the samples and depends how they are scraped. The combination of the screw continually mobilising the binder film and the rotation of the specimen in the air stream in the Modified Ageing RTFOT reduces the test time whilst maintaining a homogeneous sample. This is particularly relevant for heavily polymer-modified binders and is one reason why 135ºC was selected (otherwise the binder is not continuously disturbed). The test temperature for viscosity is at this temperature. The protocol minimises the possible phase separation of the polymer from the base binder.

18 (08/08) The binder may lose volatile oil, but may increase in weight due to the products of oxidation so care should be exercised in evaluating weight changes.

19 (08/08) Binder samples for test from other apparatus may be loaded into the bottles without carrying out the RTFOT at 163ºC. Binders that have been tested in accordance with BS EN12607-1 in a separate RTFOT apparatus do not necessarily result in identical 'Aged Binder' after the Modified Ageing RTFOT, this especially the case when the binder is heavily modified (skinning is likely to occur).

20 (08/08) The 'Recovered Binder' provides the first sample for test for bituminous emulsions, cutbacks and fluxed binders. With the Modified Ageing RTFOT a further three samples at different ages are provided. The 'Aged Binder' is deemed to be the sample after 8 hours although the HiPAT work (simulative of PAV) would indicate that equivalent samples in terms of stiffness are achieved at 22 hours. The ageing of emulsions and cutbacks on the road is likely to be less than for Hot Mixed Asphalt binders where the temperature of mixing is high. The samples may be used to provide graphical data such as complex stiffness modulus G* (see Clause 956) or Vialit Pendulum Cohesion (see Clause 957). The RTFOT used for Hot Mix binders does 'Age' the binder considerably and so the equivalent to HiPAT or PAV is approximately 8 hours in the Modified Ageing RTFOT (see schematic diagrams below).

21 (08/08) The test method produces around 10 g of material per bottle. This is sufficient for testing using rheology (see Clause 956) or Vialit Pendulum Cohesion (see Clause 957). For other tests sufficient bottles should be used and the binder combined prior to testing.

22 (08/08) Polymer modified binders may need to be heated and stirred prior to testing in other apparatus to ensure that internal stresses are not present in the test specimens.

Figure NG 9/2: (08/08) **Bituminous Emulsion, Cutback and Fluxed Binder - Polymer Modified and Unmodified**
(Schematic Diagram to show procedures)

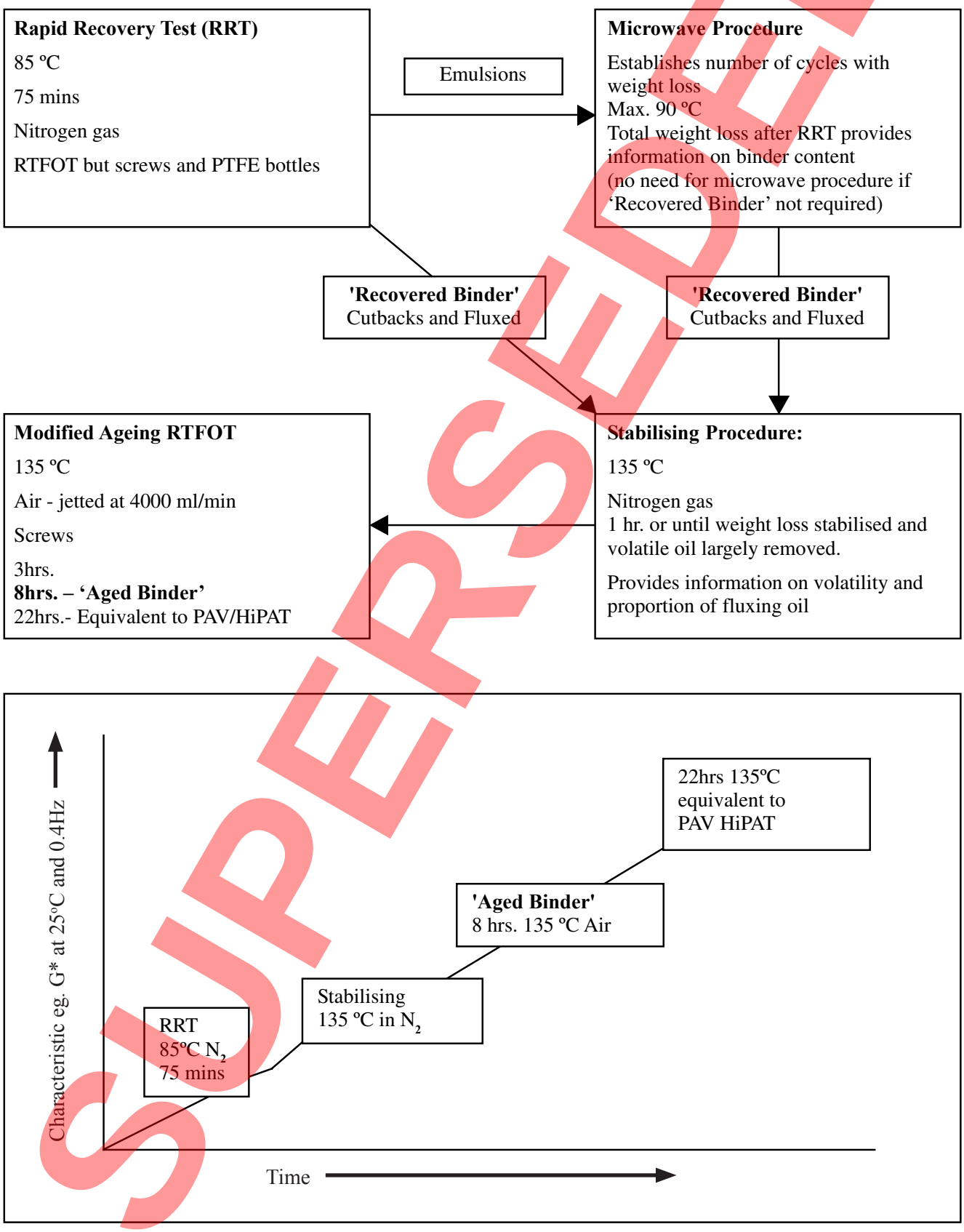
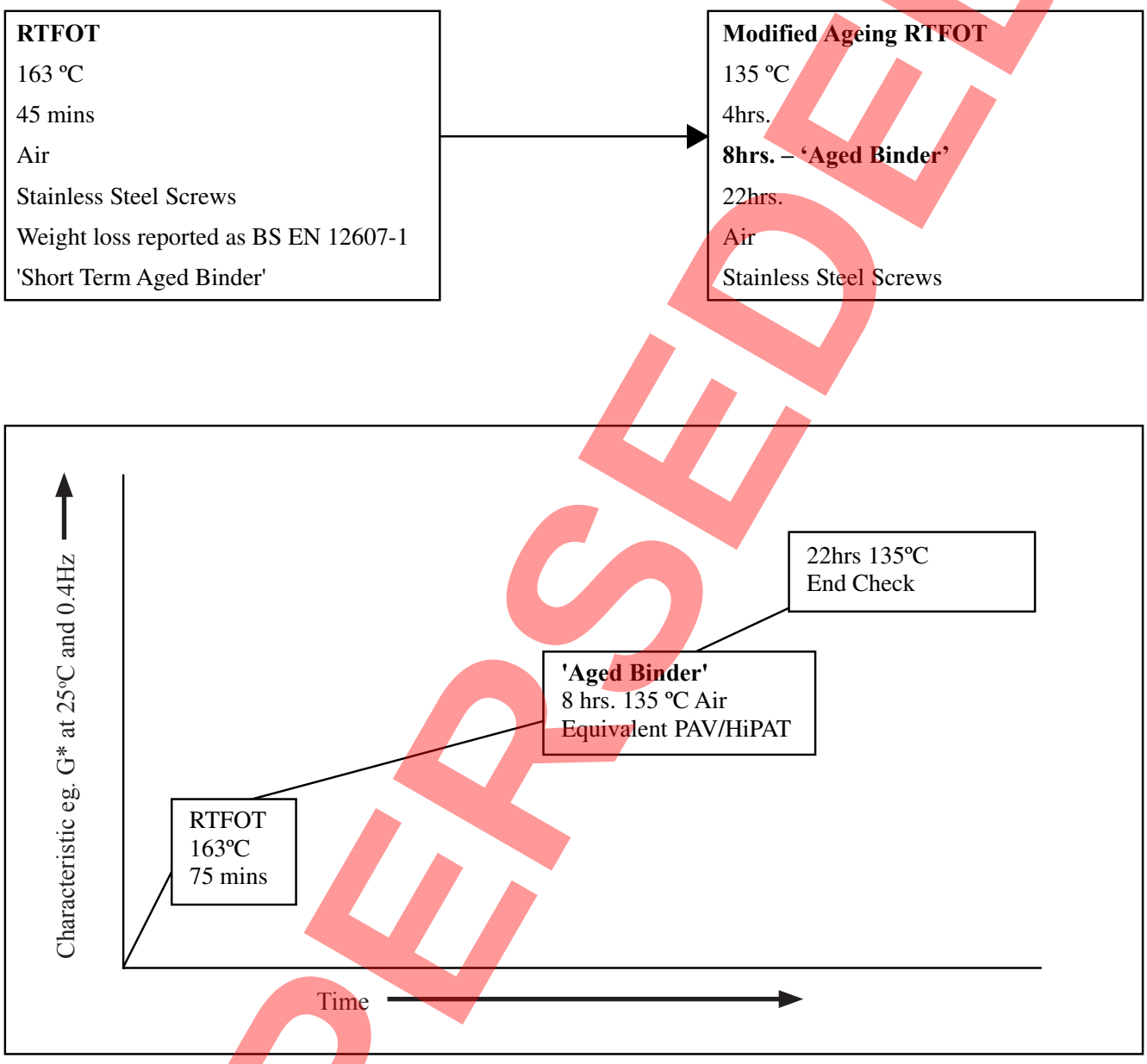


Figure NG 9/3: Bituminous Binders for Hot Mix Asphalt - Polymer Modified and Unmodified
(Schematic Diagram to show procedure)



NG 956 (08/08) Determination of the Complex Shear (Stiffness) Modulus (G*) and Phase Angle (δ) of Bituminous Binders Using a Dynamic Shear Rheometer (DSR)

1 (08/08) 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. It has been found that although the values of G* at any particular combination of frequency and temperature may be different for the two methods the slopes of the graphs of G* against frequency are in very good agreement and in particular values of T_{2kPa} - T_{2MPa} are virtually identical in the two methods.

2 (08/08) 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 (08/08) 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 (08/08) 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 (08/08) A rheometer should be used that is capable of controlling the temperature of both the top and bottom 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 (08/08) 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 (08/08) 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 (08/08) 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 (up to 80°C for some elastomeric modified binders). 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 (08/08) 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 (08/08) 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 (08/08) 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 (08/08) 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 (08/08) 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 (08/08) 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 (08/08) 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.

16 (08/08) 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 957 (08/08) Determination of Cohesion of Bitumen and Bituminous Binders

1 (08/08) This method may be used with pure bitumens, modified bitumens, cutback bitumens and binders recovered from emulsions in accordance with Clause 955. 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 is not meaningful on uncovered bitumen emulsions.

2 (08/08) 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 957.4(b). It may be noted that the value of A used in sub-Clauses 957.9 to 957.13 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 e.g. 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 (08/08) With reference to sub-Clause 957.4(e), a ring and ball softening point thermometer is suitable and would be compliant.

4 (08/08) With reference to sub-Clause 957.6(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 (08/08) With reference to sub-Clauses 957.6(c), item (i), 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

Volume 2 home page

the cube, support and sample may be pre-heated to higher temperatures than specified in sub-Clauses 957.6(a) and 957.6(b). If this is done, it should be stated in the report.

6 (08/08) With reference to sub-Clause 957.8(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 (e.g. due to solar gain or failure of air-conditioning equipment).

7 (08/08) With reference to sub-Clause 957.11, 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 (08/08) Table NG 9/36 would be a suitable basis for pre-recording the relationship between the angle α and energy (Joules) for each pendulum tester. Table NG 9/37 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 9/36 is used to convert the mean angle to energy (Joules) for each pendulum test.

9 (08/08) This Clause uses some non-SI metric units.

TABLE NG 9/36: (08/08) **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

TABLE NG 9/37: (08/08) **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 EK = measured at ambient temperature of ..... °C at ..... hrs.

NATIONAL ALTERATIONS OF THE OVERSEEING ORGANISATION OF SCOTLAND

NG 911TS (11/08) Rolled Asphalt Surface Course (Design Mixtures)

1 (11/08) The special requirements included in Appendix 7/1 may include specific mixture designations, binder grade and for 30/14 and 35/14 mixtures, the required properties of coated chippings in accordance with Clause 915.

2 (11/08) The method of determining the design binder content for surface course mixtures is described in BS 594987, Annex H. The target binder content of the mixture will normally be the higher of the design binder content and the minimum binder content indicated in BSI PD 6691, Annex C, Table C2A or Table C2C as appropriate.

3 (11/08) The Contractor may usually be permitted to use either Type F or Type C mixtures. The use of 70/100 grade bitumen will also usually be permitted, when there is experience of good performance with locally available mixtures.

(11/08) **Marshall Stability and Flow**

4 (11/08) In the past, Marshall stability and flow have been used as indicators of resistance to permanent deformation. The BS EN 13108 standards no longer require these properties to be specified because resistance to deformation is now measured directly using wheel tracking apparatus. In heavily trafficked situations, where resistance to permanent deformation is of high importance, it is recommended that performance related Hot Rolled Asphalt to Clause 943 is used.

5 (11/08) Marshall stability and flow values at different binder contents are determined as part of the procedure for establishing the design binder content for surface course mixtures. For roads that are not heavily trafficked, stability and flow values at the target binder content may also be used as an additional requirement. The selected values should comply with the requirements of Table NG 9/1TS:

TABLE NG 9/1TS: (11/08) Criteria for the Stability and Flow of Rolled Asphalt Surface Course (Design Mixtures)

Traffic (commercial vehicles per lane per day)	Stability Range, kN	Maximum Flow, mm
Less than 1500	3 to 8	5 mm
1500 to 3000	4 to 8	5 mm

NOTE 1. Experience of locally available mixtures may indicate that a maximum stability value of 10.0 kN should be specified. If the stability value is greater than 8 kN, the maximum flow value may be increased to 7 mm.

NOTE 2. Performance related Hot Rolled Asphalt to Clause 943 should be used when the traffic flow is greater than 3000 commercial vehicles per lane per day.

NOTE 3. The stability and flow values are those determined at the target binder content. These values may be different to the values determined at the design binder content.