Road Pavements – Bituminous Bound Materials

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901 Bituminous Pavement Mixtures

General

1 This clause gives general requirements for the properties of the aggregates and bitumen used in plant-produced bituminous mixtures. These requirements apply to all plant produced bituminous mixtures unless otherwise specified in Appendix 7/1 or where other requirements are given in specific Clauses in this Series.

2 Bituminous mixtures shall be produced in plants that are registered with Transport Malta and shall be laid by contractors also registered with Transport Malta. All mixtures supplied in accordance with BS EN 13108 shall be CE marked..

Aggregates for Bituminous Mixtures

3 Natural, recycled unbound and manufactured (artificial) aggregates shall be clean, hard and durable and shall comply with BS EN 13043. Where recycled coarse aggregate or recycled concrete aggregate is used in bituminous mixtures, it shall have been tested in accordance with Clause 710 and the content of other materials (Class X) including wood, plastic and metal shall not exceed 1% by mass. Reclaimed asphalt shall comply with Clause 902.

4 Not Used

5 Not Used

Resistance to Fragmentation (Hardness)

6 The resistance to fragmentation of the coarse aggregates for bituminous mixes shall be as follows:

i. the resistance to fragmentation category of the coarse aggregate as defined in clause 4.2.2 of BS EN 13043 shall be LA_{40} or better for base, binder and base/wearing layers and LA_{20} or better for wearing layers;

ii. Natural and manufactured (artificial) aggregates recovered from a previous use in an unbound form shall comply with the requirements of this Clause.

Resistance to Freezing and Thawing (Durability)

Not Used

Cleanness

8 Unless otherwise specified in Appendix 7/1, the proportion of coarse and fine aggregates for bituminous mixtures passing the 0.063 mm test sieve (fines content) when tested in accordance with the washing and sieving method of BS EN 933-1 shall not exceed the following limits:

i. Coarse Aggregate: f_4
ii. Fine Aggregate: f_{16}

Resistance to Polishing and Surface Abrasion

9 For wearing courses the aggregate shall conform to the following PSV category in accordance with BS EN 13043 clause 4.2.3:

Construction Class[Note]	PSV
IV, V, VI	≥44
HD, I, II, III	≥50

Note: See Transport Malta Road Works (Design and Construction Standards), Volume 7(Design Charts)

10 An aggregate shall be deemed acceptable if the mean of the three most recent consecutive PSV results from tests relating to the aggregate to be supplied, carried out within the previous 6 months by testing by an appropriate organisation accredited in accordance with sub-Clauses 105.3 and 105.4 for those tests, within 6 weeks of sampling, complies with the declared categories as specified in (9) above.

11 Where required by the Overseeing Organisation the resistance to surface abrasion of coarse aggregate used in surface courses in accordance with BS EN 13043 clause 4.2.3 and BSI PD 6682-2 clause 3.3.3, shall conform to the category as specified in Appendix 7/1.

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Chemical Requirements

Dicalcium Silicate Disintegration

12 Not Used

Iron Disintegration

13 Not Used

Volume Stability

14 Not Used

Bitumen

15 Paving grade bitumen shall comply with BS EN 12591 and be supplied from locations that are registered to BS EN ISO 9001 and operate a registered quality scheme.

16 Polymer modified bitumen shall comply with BS EN 14023 and shall have British Board of Agrément HAPAS Roads and Bridges Certification or approved equivalent to demonstrate their performance. Polymer modified bitumen without British Board of Agrément HAPAS Roads and Bridges Certification or equivalent shall not be used without prior approval by the Overseeing Organisation.

Asphalt Durability

17 When required by the Overseeing Organisation the durability of adhesion in asphaltic concrete base and binder course mixtures designed in accordance with Clauses 904 and 905 shall be determined by testing in accordance with Clause 953. The SATS Durability Index of the mix components shall be above 80%.

18 Mixtures that include 2% hydrated lime filler are deemed to satisfy this requirement and SATS testing is not required. Hydrated lime filler shall be $Ca(OH)_2$ in the form of hydrated lime, type CL 90-S, complying with the requirement in BS EN 459-1.

902 Reclaimed Asphalt

1 The requirements of this clause apply to all bituminous mixtures containing reclaimed asphalt.

2 Reclaimed asphalt may be used in the production of bituminous surface course, binder course, regulating course and base. Unless otherwise specified in Appendix 7/1, the use of reclaimed asphalt shall be in accordance with:

i. the relevant British Board of Agrément HAPAS Road and Bridges Certificate or equivalent for surface course mixtures specified in Clause 942;

ii. BSI PD 6691, B.2.4.4 for Asphalt Concrete mixtures;

iii. Not Used;

iv. Not Used.

Other recycled materials shall only be used in bituminous mixtures with the approval of the Overseeing Organisation. The mixed material shall comply with the requirements of all the relevant clauses in this Series.

Reclaimed Feedstock

3 All reclaimed material shall be pre-treated before use such that it is homogeneously mixed and the maximum particle size does not exceed 32 mm.

Properties of Binder

4 The fresh bitumen added to the mixture shall not be more than two grades softer than the nominal grade for the mixture given in Table 12 of BSI PD 6691. Checks on the penetration of the binder recovered from the reclaimed asphalt, together with a calculation of the properties of the combined binder, shall be carried out in accordance with the relevant parts of BS EN 13108. When more than 10% of reclaimed asphalt is incorporated in a mixture, tests on binder recovered from the mixture shall be carried

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Comment [JBr5]: Air-cooled bf slag

Comment [JBr6]: Steel slag

Comment [JBr7]: HRA

Comment [JBr8]: SMA

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out in accordance with BSI PD 6691 13.3.6.2. The results shall be within the limits set out in BSI PD 6691 13.3.6.2.

Mixed materials containing more than 25% reclaimed asphalt

5 When more than 25% of reclaimed asphalt is incorporated in a designed base or binder course mixture, cores taken to assess compliance with Clause 929.12 shall also be tested for stiffness in accordance with BS EN 12697-26 (ITSM method 20°C). The frequency of testing shall be agreed with the Overseeing Organisation prior to the commencement of works.

6 The stiffness of the mixture shall comply with the appropriate category from Table 9/1.

Table 9/1: Stiffness Categories for Designed Base and Binder Course Mixtures incorporating greater than 25% Reclaimed Asphalt

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Nominal Binder Grade of Mixture	Stiffness Category (S_{min})
10/20	5500
15/25	5500
30/45	2800
40/60	1800
50/70	1500

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903 Placing and Compaction of Bituminous Mixtures

General

1 This clause gives general requirements for the placing and compaction of bituminous mixtures, which are complementary and additional to the requirements of BS 594987. These requirements and the requirements of BS 594987 apply to all bituminous mixtures, unless otherwise specified in the other Clauses in this Series or in Appendix 7/1.

2 Bituminous pavements shall be constructed using the materials specified in Appendix 7/1 and shall be laid by contractors registered with Transport Malta.

3 In order to exclude moisture from interfaces and ensure full interlayer bonding, the surface of all bituminous material shall be kept clean and uncontaminated. Unless agreed with the Overseeing Organisation, the only traffic permitted to run on the surface of bituminous material to be overlaid shall be that engaged in laying and compacting the next course. If any surface becomes contaminated, it shall be made good by cleaning and, if this proves impracticable, by rectification in compliance with Clause 702.

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4 Prior to placing bituminous material on any new or existing bound substrate, a bond coat or tack coat shall be applied in accordance with Clauses 920 or 942, as appropriate.

5 Before work commences, the contractor shall submit a method statement to the Overseeing Organisation that includes:

i. Proposed laying and compaction procedures for each layer – including paving speed and paved width; size, type and number of rollers; and number of roller passes.

ii. The proposed joint formation procedures for each layer – including the location of longitudinal and transverse joints; and the method(s) of treating upstanding edges.

Transporting

6 Hot bituminous mixtures shall be transported in accordance with the requirements of BS 594987 and shall remain covered whilst awaiting tipping.

Laying

7 Hot bituminous mixtures, other than those specified under Clause 942, shall be laid in accordance with the requirements of BS 594987 and sub-Clauses 8 to 14 of this Clause. Surfacings specified under Clause 942 shall be laid in accordance with the requirements of that Clause and sub-Clauses 8 to 14 of this Clause.

8 Wherever practicable, hot bituminous mixtures shall be spread, levelled and tamped by a self-propelled paving machine. The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously.

9 Hand placing of hot bituminous mixtures shall be restricted to the following circumstances:

i. For laying regulating courses of irregular shape and varying thickness.
ii. In confined spaces where it is impracticable for a paver to operate.
iii. For footways.
iv. At the approaches to expansion joints at bridges, viaducts or other structures.
v. For laying mastic asphalt.

10 Hand-raking of surface course material or the addition of such material by hand-spreading to the paved area, for adjustment of level, shall be restricted to the following circumstances:

i. At the edges of the layers of material and at gullies, manholes and other ironwork.
ii. At the approaches to expansion joints at bridges, viaducts or other structures.

11 The method of laying shall be such that the finished mat is free from dragging, tearing and segregation of the material.

12 When laying mixtures from more than one source, the mixtures shall have equivalent laying and compaction characteristics so that surface evenness is not compromised.

13 When paving adjacent to an expansion joint of a structure, the joint or joint cavity shall be kept clear of material. When laying binder course or surface course, the paver shall be taken out of use whilst laying the remainder of the pavement up to the joint and the corresponding area beyond it. This requirement has been based on practices commonly used in ashphalt construction for airfields. It may warrant future review if this requirement proves to be excessively onerous for highway contracts.

14 When paving directly onto bridge deck waterproofing systems, any special requirements which apply to that system shall be complied with.

Compaction

15 The compaction of hot bituminous mixtures shall be in accordance with BS 594987 and the requirements for specific mixtures in:

i. Clauses 904, and 905 for base and binder course asphalt concrete (design mixtures);
ii. Clauses 906 and 908 for wearing and base-wearing course asphalt concrete (design mixtures);
iii. Clause 942 for thin surface course systems.

16 Except where otherwise specified, rollers shall comply with the general requirements of BS 594987 except that the minimum mass of deadweight smooth wheeled rollers shall be 8 tonnes. Multi-wheeled pneumatic-tyred rollers and vibratory rollers may be used if they are capable of achieving at least the standard of compaction of an 8-tonnes deadweight roller.

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17 Not Used

18 Vibratory rollers shall not be used in vibrating mode on bridge decks.

Chippings

Not Used

Joints

21 Where practicable two or more pavers shall be operated in echelon and the joints compacted by rolling. Unless otherwise specified in Appendix 7/1, longitudinal joints in all layers shall be situated outside wheel-track zones. For the purposes of this Clause, the wheel-track zones shall be taken to be between 0.5 m and 1.1 m and between 2.55 m and 3.15 m from the centre of the nearside lane markings for each traffic lane (or, in the absence of lane markings, lane edges). All joints shall be offset at least 300 mm from parallel joints in the layer beneath. Joints in the surface course shall coincide with either the lane edge or the lane marking, whichever is appropriate.

22 Unless otherwise specified in Appendix 7/1, the faces of all cold upstanding edges, including previously laid asphalt, against which hot bituminous mixtures are to be laid to form joints shall be treated with one of the following:

i. hot bituminous binder with a penetration of not less than 40 pen;

ii. hot elastomeric polymer-modified bituminous binder complying with BS EN 14023 with a penetration of not less than 40 pen;

iii. cold applied thixotropic bituminous compound of similar bitumen or polymer-modified bitumen grade;

iv. polymer-modified adhesive bitumen strip with a minimum thickness of 2 mm.

This operation shall be done so that the binder adheres to both the cold and the warm upstanding edges when the asphalt is placed.

23 Unless otherwise specified in Appendix 7/1, joints in binder courses and bases shall be compacted such that the air voids content measured from core pairs whose centres are not more than 100 mm from the final joint is not greater than 2% above the maximum permitted limit for core pairs in the body of the mat. The air voids content shall be calculated in accordance with BS EN 12697-8 using the relevant bulk and maximum densities defined in Appendix B of BS EN 13108-20 for the relevant mixture type.

24 Within 24 hours of the joint being formed, a sealant shall be applied to the top surface of all base and binder course joints such that there is not less than 0.50 kg/m² of residual bitumen 75 mm either side of the joint, unless otherwise specified in Appendix 7/1. The sealant, which may contain mineral filler to
BS EN 13043, shall be one of the following:

i. hot elastomeric polymer-modified bituminous binder complying with BS EN 14023 with a penetration of not less than 40 pen;

ii. bitumen emulsion with a cohesion by pendulum of Class 4 or above in accordance with BS EN 13808;

iii. slurry surfacing complying with Clause 918.

25 Unless otherwise specified in Appendix 7/1, a sealant, as specified in sub-Clause 24 of this Clause, shall be applied to the whole of any freestanding edge on the outside of the finished pavement on the high side of the camber and, when specified in Appendix 7/1, on the low side.

Regulating Course

26 Regulating course material shall be made and laid in accordance with the requirements of Clause 907.

Use of Surfaces by Traffic

27 Where a bituminous layer other than the surface course is to be opened to highway traffic as a temporary running surface it shall contain a coarse aggregate of category of not less than PSV_{50}, unless otherwise specified in Appendix 7/1.

Deleted: Where compaction is to be determined in accordance with Clause 929, the requirements to prove the performance of rollers do not apply. In such cases, the Contractor may use any plant to achieve the specified level of compaction and shall finish compaction at temperatures above the minimum specified rolling temperature.

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28 Construction plant and traffic used on pavements under construction shall be suitable in relation to the material, condition and thickness of the courses it traverses so that damage is not caused to the subgrade or the pavement courses already constructed. The wheels or tracks of plant moving over the various pavement courses shall be kept free from deleterious materials.

904 Asphalt Concrete Base Course (Designed)

Mix Designation

1 The mix designation shall be as follows:

AC 32 Base 50/70 Des

Aggregate

2 Coarse aggregate shall be material substantially retained on a 2mm test sieve, conforming to all appropriate requirements of BS EN 13043 and consisting of crushed rock of the limestone group or another declared group as approved by the Overseeing Organisation.

3 The flakiness category shall be FL35.

4 The fines content for coarse aggregate shall be f_{NR}.

5 Fine aggreagte shall substantially pass a 2mm test sieve and and consisting of fines produced from the crushing of the limestone group rock or another declared group as approved by the Overseeing Organisation.

6 The fines content for fine aggregate shall be f_{NR}.

7 If added filler is used in the mix it shall consist of crushed rock filler, hydrated lime or cement.

8 The grading of the added filler shall comply with BS EN 13043, clause 5.2.1.

9 The loose bulk density in kerosene of the added filler (except for hydrated lime) shall be in accordance with BS EN 13043, clause 5.5.5.

Bitumen

10 The penetration grade of the bitumen shall be 50/70.

Reclaimed Asphalt

11 Where used reclaimed asphalt shall be classified in accordance with BS EN 13108-8.

12 It shall conform to the following categories:
Foreign matter - Category F5
Binder properties, for additions > 20% of the mixture – Category P_{15}.

13 In accordance with BS En 13108-1, clause 4.4, unless otherwise indicated in appendix 7/1, the amount of reclaimed asphalt added to the mixture shall not exceed 50%.

Additives

14 Additives permitted for inclusion following approval by the Overseeing Organisation shall have theie suitability determined in accordance with BS EN 13108-1.

Laboratory Validation Testing

15 The Laboratory Mix shall be manufactured in accordance with TM Document "Laboratory Mix Design Procedure (Marshall Asphalt)".

The following test methods shall apply:

i. Specimen Mixing: BS EN 12697-35;
ii. Specimen Preparation: Impact compactor to BS EN 12697-30; Sliding mass fall height – 457+/-5mm; Number of blows – 50 blows each side;
iii. Specimen Bulk Density: BS EN 12697-6, Procedure B (SSD);
iv. Specimen Voids: BS EN 12697-8 (The maximum density shall be determined using BS EN 12697-8, Procedure A);

Laboratory Mix Validation Test Parameters

16 The following test parameters shall apply:

i. Grading: TM Document "Asphalt Concrete Mixes – Combined Target Grading Limits";
ii. Binder Content: *B_{min}4.8 (Uncorrected); The correction factor in BS EN 13108-1, clause 5.3.1.3 shall be applied;*
iii. Air Voids in Mix (V_m): $V_{min4.0}$ - V_{max7}
iv. Air Voids in Mineral Aggregate (VMA): VMA_{NR}
v. Air Voids filled with Bitumen: (VFB): $VFB_{min}65$ – $VFB_{max}78$
vi. Stability: $S_{min7.5}$ - S_{maxNR}

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vii. Flow: F_{min2} (F_2) - F_{max4} (F_4)
viii. Marshall Quotient: Q_{minNR}

Production Mix (Plant Mix) Validation

17 The Production Mix shall be the approved Laboratory Mix, modified if necessary, in accordance with TM Document "Plant Mix Trial Procedure". It shall be the standard for the routine production of Asphalt Concrete – Base Course for the works subject to the plant tolerances permitted in clause 910.

18 Sampling shall comply with BS EN 12697-27.

Production Mix - Compaction Degree

19 The following shall apply:

i. Reference Density: BS EN 12697-9, clause 6.1.1, 7 (Equation 2);
ii. Compaction Degree: 2 X 50 blows, Reference Table C1;
iii. Values: ≥ 97%

905 Asphalt Concrete Binder Course (Designed)

Mix Designation

1 The mix designation shall be as follows:

AC 20 Bin 50/70 Des

Aggregate

2 Coarse aggregate shall be material substantially retained on a 2mm test sieve, conforming to all appropriate requirements of BS EN 13043 and consisting of crushed rock of the limestone group or another declared group as approved by the Overseeing Organisation.

3 The flakiness category shall be FL35.

4 The fines content for coarse aggregate shall be f_{NR}.

5 Fine aggreagte shall substantially pass a 2mm test sieve and and consisting of fines produced from the crushing of the limestone group rock or another declared group as approved by the Overseeing Organisation.

6 The fines content for fine aggregate shall be f_{NR}.

7 If added filler is used in the mix it shall consist of crushed rock filler, hydrated lime or cement.

8 The grading of the added filler shall comply with BS EN 13043, clause 5.2.1.

9 The loose bulk density in kerosene of the added filler (except for hydrated lime) shall be in accordance with BS EN 13043, clause 5.5.5.

Bitumen

10 The penetration grade of the bitumen shall be 50/70.

Reclaimed Asphalt

11 Where used reclaimed asphalt shall be classified in accordance with BS EN 13108-8.

12 It shall conform to the following categories:
Foreign matter - Category F5
Binder properties, for additions > 20% of the mixture – Category P_{15}.

13 In accordance with BS EN 13108-1, clause 4.4, unless otherwise indicated in appendix 7/1, the amount of reclaimed asphalt added to the mixture shall not exceed 50%.

Additives

14 Additives permitted for inclusion following approval by the Overseeing Organisation shall have theie suitability determined in accordance with BS EN 13108-1.

Laboratory Validation TestingInput Target Composition

15 The Laboratory Mix shall be manufactured in accordance with TM Document "Laboratory Mix Design Procedure (Marshall Asphalt)".

The following test methods shall apply:

v. Specimen Mixing: BS EN 12697-35;
vi. Specimen Preparation: Impact compactor to BS EN 12697-30; Sliding mass fall height – 457+/-5mm; Number of blows – 50 blows each side;

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vii. Specimen Bulk Density: BS EN 12697-6, Procedure B (SSD);
viii. Specimen Voids: BS EN 12697-8 (The maximum density shall be determined using BS EN 12697-8, Procedure A);

Laboratory Mix Validation Test Parameters

16 The following test parameters shall apply:

i. Grading: TM Document "Asphalt Concrete Mixes – Combined Target Grading Limits";
ii. Binder Content: $B_{min}5.0$ *(Uncorrected); The correction factor in BS EN 13108-1, clause 5.3.1.3 shall be applied;*
iii. Air Voids in Mix (V_m): $V_{min4.0}$ - V_{max6}
iv. Air Voids in Mineral Aggregate (VMA): VMA_{NR}
v. Air Voids filled with Bitumen: (VFB): $VFB_{min}65$ – $VFB_{max}78$
vi. Stability: $S_{min7.5}$ - S_{maxNR}
vii. Flow: F_{min2} (F_2) - F_{max4} (F_4)
viii. Marshall Quotient: Q_{minNR}

Production Mix (Plant Mix) ValidationOutput Target Composition

17 The Production Mix shall be the approved Laboratory Mix, modified if necessary, in accordance with TM Document "Plant Mix Trial Procedure". It shall be the standard for the routine production of Asphalt Concrete – Base Course for the works subject to the plant tolerances permitted in clause 910.

18 Sampling shall comply with BS EN 12697-27.

Production Mix - Compaction Degree

19 The following shall apply:

iv. Reference Density: BS EN 12697-9, clause 6.1.1, 7 (Equation 2);
v. Compaction Degree: 2 X 50 blows, Reference Table C1;
vi. Values: ≥ 97%

906 Asphalt Concrete Wearing Course (Designed)

Mix Designation

1 The mix designation shall be as follows:

AC 12 Surf 50/70 Des

Aggregate

2 Coarse aggregate shall be material substantially retained on a 2mm test sieve, conforming to all appropriate requirements of BS EN 13043 and consisting of crushed rock of the limestone group or another declared group as approved by the Overseeing Organisation.

3 The flakiness category shall be FL35.

4 The fines content for coarse aggregate shall be f_{NR}.

5 Fine aggreagte shall substantially pass a 2mm test sieve and and consisting of fines produced from the crushing of the limestone group rock or another declared group as approved by the Overseeing Organisation.

6 The fines content for fine aggregate shall be f_{NR}.

7 If added filler is used in the mix it shall consist of crushed rock filler, hydrated lime or cement.

8 The grading of the added filler shall comply with BS EN 13043, clause 5.2.1.

9 The loose bulk density in kerosene of the added filler (except for hydrated lime) shall be in accordance with BS EN 13043, clause 5.5.5.

Bitumen

10 The penetration grade of the bitumen shall be 50/70.

Reclaimed Asphalt

11 Where used reclaimed asphalt shall be classified in accordance with BS EN 13108-8.

12 It shall conform to the following categories:
Foreign matter - Category F5
Binder properties, for additions > 20% of the mixture – Category P_{15}.

13 In accordance with BS EN 13108-1, clause 4.4, unless otherwise indicated in appendix 7/1, the amount of reclaimed asphalt added to the mixture shall not exceed 10%.

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Additives

14 Additives permitted for inclusion following approval by the Overseeing Organisation shall have theie suitability determined in accordance with BS EN 13108-1.

Laboratory Validation TestingInput Target Composition

15 The Laboratory Mix shall be manufactured in accordance with TM Document "Laboratory Mix Design Procedure (Marshall Asphalt)".

The following test methods shall apply:

i. Specimen Mixing: BS EN 12697-35;
ii. Specimen Preparation: Impact compactor to BS EN 12697-30; Sliding mass fall height – 457+/-5mm; Number of blows – 50 blows each side;
iii. Specimen Bulk Density: BS EN 12697-6, Procedure B (SSD);
iv. Specimen Voids: BS EN 12697-8 (The maximum density shall be determined using BS EN 12697-8, Procedure A);

Laboratory Mix Validation Test Parameters

16 The following test parameters shall apply:

i. Grading: TM Document "Asphalt Concrete Mixes – Combined Target Grading Limits";
ii. Binder Content: $B_{min}5.8$ *(Uncorrected); The correction factor in BS EN 13108-1, clause 5.3.1.3 shall be applied;*
iii. Air Voids in Mix (V_m): $V_{min3.0}$ - V_{max5}
iv. Air Voids in Mineral Aggregate (VMA): VMA_{NR}
v. Air Voids filled with Bitumen: (VFB): $VFB_{min}65$ – $VFB_{max}78$
vi. Stability: $S_{min7.5}$ - S_{maxNR}
vii. Flow: F_{min2} (F_2) - F_{max4} (F_4)
viii. Marshall Quotient: Q_{minNR}

Production Mix (Plant Mix) ValidationOutput Target Composition

17 The Production Mix shall be the approved Laboratory Mix, modified if necessary, in accordance with TM Document "Plant Mix Trial Procedure". It shall be the standard for the routine production of Asphalt Concrete – Base Course for the works subject to the plant tolerances permitted in clause 910.

18 Sampling shall comply with BS EN 12697-27.

Production Mix - Compaction Degree

19 The following shall apply:

vii. Reference Density: BS EN 12697-9, clause 6.1.1, 7 (Equation 2);
viii. Compaction Degree: 2 X 50 blows, Reference Table C1;
ix. Values: ≥ 97%

907 Regulating Course

1 Regulating courses, which may consist of one or more layers of a bituminous material, shall have their finished surfaces laid to achieve the appropriate tolerances for horizontal alignments, surface levels and surface regularity for pavement layers, in accordance with Clause 702.

2 Bituminous mixtures for regulating courses shall have at least the techological properties of the asphalt layer which is being adjusted by the regulating layer.

3 Where the total depth of a regulating course exceeds 150 mm then the course shall be laid so that each regulating layer has a compacted thickness of between 75 mm and 150 mm.

908 Asphalt Concrete Combined Course "Base-Wearing" (Designed)

Mix Designation

1 The mix designation shall be as follows:

AC 20 Base/Surf 50/70 Des

Aggregate

2 Coarse aggregate shall be material substantially retained on a 2mm test sieve, conforming to all appropriate requirements of BS EN 13043 and consisting of crushed rock of the limestone group or another declared group as approved by the Overseeing Organisation.

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Output Target Composition¶

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3 The flakiness category shall be FL35.

4 The fines content for coarse aggregate shall be f_{NR}.

5 Fine aggreagte shall substantially pass a 2mm test sieve and and consisting of fines produced from the crushing of the limestone group rock or another declared group as approved by the Overseeing Organisation.

6 The fines content for fine aggregate shall be f_{NR}.

7 If added filler is used in the mix it shall consist of crushed rock filler, hydrated lime or cement.

8 The grading of the added filler shall comply with BS EN 13043, clause 5.2.1.

9 The loose bulk density in kerosene of the added filler (except for hydrated lime) shall be in accordance with BS EN 13043, clause 5.5.5.

Bitumen

10 The penetration grade of the bitumen shall be 50/70.

Reclaimed Asphalt

11 Where used reclaimed asphalt shall be classified in accordance with BS EN 13108-8.

12 It shall conform to the following categories:
Foreign matter - Category F5
Binder properties, for additions > 20% of the mixture – Category P_{15}.

13 In accordance with BS EN 13108-1, clause 4.4, unless otherwise indicated in appendix 7/1, the amount of reclaimed asphalt added to the mixture shall not exceed 10%.

Additives

14 Additives permitted for inclusion following approval by the Overseeing Organisation shall have theie suitability determined in accordance with BS EN 13108-1.

Laboratory Validation TestingInput Target Composition

15 The Laboratory Mix shall be manufactured in accordance with TM Document "Laboratory Mix Design Procedure (Marshall Asphalt)".

The following test methods shall apply:

i. Specimen Mixing: BS EN 12697-35;
ii. Specimen Preparation: Impact compactor to BS EN 12697-30; Sliding mass fall height – 457+/-5mm; Number of blows – 50 blows each side;
iii. Specimen Bulk Density: BS EN 12697-6, Procedure B (SSD);
iv. Specimen Voids: BS EN 12697-8 (The maximum density shall be determined using BS EN 12697-8, Procedure A);

Laboratory Mix Validation Test Parameters

16 The following test parameters shall apply:

i. Grading: TM Document "Asphalt Concrete Mixes – Combined Target Grading Limits";
ii. Binder Content: *B_{min}7.2 (Uncorrected); The correction factor in BS EN 13108-1, clause 5.3.1.3 shall be applied;*
iii. Air Voids in Mix (V_m): V_{minNR} - V_{max7}
iv. Air Voids in Mineral Aggregate (VMA): VMA_{NR}
v. Air Voids filled with Bitumen: (VFB): VFB_{min}78 – VFB_{max}89
vi. Stability: $S_{min7.5}$ - S_{maxNR}
vii. Flow: F_{min2} (F_2) - F_{max5} (F_5)
viii. Marshall Quotient: Q_{minNR}

Production Mix (Plant Mix) ValidationOutput Target Composition

17 The Production Mix shall be the approved Laboratory Mix, modified if necessary, in accordance with TM Document "Plant Mix Trial Procedure". It shall be the standard for the routine production of Asphalt Concrete – Base Course for the works subject to the plant tolerances permitted in clause 910.

18 Sampling shall comply with BS EN 12697-27.

Production Mix - Compaction Degree

19 The following shall apply:

i. Reference Density: BS EN 12697-9, clause 6.1.1, 7 (Equation 2);

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ii. Compaction Degree: 2 X 50 blows, Reference Table C1;
iii. Values: ≥ 96%

909 Identification on Delivery

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The following information shall be included in the bituminous plant supply delivery ticket:

i. Name of manufacturer
ii. Name of mixing plant
iii. Mix identification code and mix designation
iv. How to obtain details of mix conformity to BS EN 13108-1
v. Details of any additives
vi. CE marking requirements (See BS EN 13108-1, Annex ZA)

910 Tolerances for the Assessment of Conformity

The individual samples method of BS EN 13108-21, Table A.1 shall be used unless otherwise indicated in Appendix 7/1 as follows:

Asphalt Concrete – Base, Binder and Combined Courses

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% Passing Sieve / Binder	Individual samples Tolerance about Plant Mix Base, Binder, Base/Wearing	Wearing
40	0 / -2%	NA
31.5	-9 / +5	NA
20	-9 / +9	NA
16	NA	0 / -2%
12.5	NA	-8 / +5
6.3	NA	-7 / +7
2	-7 / +7	-6 / +6
0.250	-5 / +5	-4 / +4
0.063	-3 / +3	-2 / +2
Soluble Binder Content	-0.6 / +0.6	-0.5 / +0.5

Deleted: Hot Rolled Asphalt Surface Course

Deleted: (Recipe Mixtures)¶

911 Asphaltic Concrete Courses- Compaction Control

1 The bulk density of the compacted courses shall be related to the "Production Mix Reference Density".
2 Four (4) pairs of 150mm diameter cores shall be cut and extracted from the finished course / layer. The field bulk density shall be determined in accordance with BS EN 12697-6, Procedure B. At least two (2) pairs shall be taken adjacent to the longitudinal joint.

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3 The field bulk density shall be the mean of the four (4) pairs of cores.

912 Close Graded Asphalt Concrete

Not Used

913 Not Used

914 Fine Graded Asphalt Concrete

Not Used

915 Coated Chippings for Application to Hot Rolled Asphalt Surfacings

Not Used

916 Open Graded Asphalt Concrete

Surface Course

Not Used

917 Not Used

918 Slurry Surfacing Incorporating Microsurfacing

1 The Contractor shall be responsible for the design of the Slurry Surfacing, choice of materials, techniques and processes based on site and traffic data specified in Appendix 7/7 and the schedule of constraints on site availability in Appendix 1/13.

2 The Contractor shall:

i. Provide a Design Proposal to achieve the performance requirements in terms of texture and maximum levels of defects as set out in this Clause and in Appendix 7/7 ensuring that the Slurry Surfacing has an initial stability such that it is capable of withstanding the normal traffic for the site when first opened.

ii. State the Estimated Design Life of the Slurry Surfacing in the Design Proposal.

iii. The Contractor shall be registered with Transport Malta.

iv. Provide a Quality Plan containing the information required by the UK 'Sector Scheme 13B for The Supply and Application of Microsurfacing' described in Appendix A or as otherwise approved by the Overseeing Organisation (equivalency criteria).

v. Carry out the Slurry Surfacing in accordance with the Design Proposal to the thickness and tolerances specified in Appendix 7/7.

3 The Contractor shall guarantee the design, materials and workmanship against defects and against failure to meet the end performance requirements for a period of two years, or as otherwise specified in Appendix 7/7, from the date of completion of the work. The Overseeing Organisation will monitor the performance levels of the Slurry Surfacing during the guarantee period, and bring any defects to the attention of the Contractor.

The System

4 The proposed Slurry Surfacing shall have been subject to a Type Approval Installation Trial (TAIT) in accordance with BS EN 12273 or as otherwise approved by the Overseeing Organisation (equivalency criteria). The Contractor shall provide, with his Design Proposal, a Data Sheet giving details of the properties of each system proposed, including the data specified in this Clause and in Appendix 7/7.

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Mixture Tests

5 The Contractor shall provide the data specified in Appendix 7/7 and such other data as he may consider useful, to enable the Overseeing Organisation to assess the suitability of his product for the sites to be treated.

Aggregates

6 The aggregate shall be crushed rock, slag, gravel, calcined bauxite or a proprietary aggregate, complying with this specification. The coarse aggregate shall have a minimum declared PSV and a maximum AAV as specified in Appendix 7/7. In the Design Proposal the Contractor shall state the aggregate characteristics and sources to be used and provide an example of the target grading curve and binder content and details of the proposed filler and fibre if used. The grading and binder content shall not differ from the proposed target values by more than the tolerances detailed in the Design Proposal.

Binder

7 The Contractor shall provide, with his Design Proposal, a Binder Data Sheet giving details of the properties of each binder proposed, including those specified in Appendix 7/7. The recovery of the binder shall be carried out in accordance with Clause 955. The test to determine Vialit Pendulum Cohesion shall be carried out in accordance with Clause 957. The Contractor shall provide rheological product identification data for modified binders in accordance with Clause 956.

Coloured Materials

8 Where required in Appendix 7/7 a coloured slurry surfacing shall be provided. All coloured slurry surfacings shall be approved by the Overseeing Organisation. They shall conform in all respects with the requirements of this Clause.

Equipment

9 The Slurry Surfacing Machine, when used, shall be capable of uniform application and the provision of a continuous surface without ridges or segregation.

Health and Safety

10 Health and Safety information and safe handling guidance shall be provided

Layer Thickness

11 When required the minimum and/or maximum thickness of the Slurry Surfacing shall be as specified in Appendix 7/7.

Preparation

12 Any necessary remedial works to the road surface and structure shall be completed either prior to the commencement of works, or as part of the Contract and agreed as acceptable by the Overseeing Organisation and the Contractor before Slurry Surfacing commences.

13 Street furniture, installations, manhole and chamber covers and where specified in Appendix 7/7 road markings and kerbs, shall be masked using self-adhesive masking material or other material firmly secured against the passage of the spreader box or the tools used for hand laying. Any packed mud or other deposits on the road surface shall be removed, all organic growth shall be removed by suitable means, and the road surface shall be swept free of all loose material.

14 A Bond Coat shall be applied prior to the Slurry Surfacing with or without grit or chippings in order to seal the existing substrate and to enhance the bond to the existing road surface unless the contractor can demonstrate that sufficient bond will be developed without its use. This treatment shall be in accordance with Clause 920 and the Contractor's method statement contained within his Design Proposal.

Traffic Safety and Management

15 Traffic Safety and Management for motorways and trunk roads shall be strictly in accordance with the requirements of Series 100 and any site specific additional requirements specified in Appendix 1/13.

Mixing

16 The Slurry Surfacing shall be mixed in a continuous flow mixing machine and discharged directly into the spreader box. Where the material is to be hand laid the Slurry Surfacing may be mixed in a batch mixer or supplied to site pre-mixed in suitable containers. The Quality Plan will detail the precautions to be taken to achieve a homogeneous mixture.

Application

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17 Application restrictions to be observed in the event of adverse weather shall be as specified in this Clause, the Contractor's Method Statement and any additional requirements specified in Appendix 7/7.

18 Transverse joints shall be formed with spreading starting and finishing on a protective strip not less than 100 mm wide at each end of the lane length or area being treated or such other method as defined in the Contractor's Method Statement to produce an equivalent standard. Transverse joints shall be formed such that there shall be no ridges or bare strips.

19 Unless otherwise agreed with the Overseeing Organisation, longitudinal joints, where the material is laid on a road, shall coincide with lane markings. Longitudinal joints shall be formed such that there shall be no ridges or bare strips.

20 Handwork around street furniture and other ironwork should meet the same performance requirements and form a homogeneous surface with the rest of the treated carriageway.

21 Footways and other confined areas may be spread by hand using squeegees and brooms. Kerb edges and other areas not being treated shall be suitably masked with self-adhesive masking material. Footways shall be finished by dragging a dampened broom transversely over the footway under its own weight or other method producing a similar macrotexture or as stated in Appendix 7/7.

22 All voids, cracks and surface irregularities shall be completely filled. Spreading shall not be undertaken on carriageways when the temperature falls below 4^{o}C or when standing water is present on the surface. In warm dry weather, the surface immediately ahead of the spreading, shall be slightly damped by mist water spray applied mechanically, or for hand laying by a hand operated pressure sprayer, unless otherwise agreed by the Overseeing Organisation.

23 The finished Slurry Surfacing shall have a uniform surface macrotexture throughout the work, without variations of macrotexture within the lane width, or from area to area.

24 The finished surface shall be free from blow holes and surface irregularities due to scraping, scabbing, score marks, dragging, droppings, excess overlapping or badly aligned longitudinal or transverse joints, damage by rain or frost, or other defects which remain 24 hours after laying. Slurry Surfacing which does not comply with this Clause or is non-uniform in surface macrotexture or colour, 24 hours after laying shall be rectified by removal and replacement, or superimposed if this is impractical, with fresh material in compliance with this Clause. Areas so treated shall be not less than 5 m long and not less than one lane wide (or the full width if less than a

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lane wide). All areas being worked on shall be kept free of traffic until the material has set sufficiently to carry the traffic.

25 The Contractor shall record the amount of Slurry Surfacing used and the area covered for each run

or section completed.

26 The Contractor shall facilitate duplicate or joint testing by the Overseeing Organisation if required.

Aftercare

27 Masking shall be removed after the Slurry Surfacing has been applied, without damage to the edge of the surfacing, and before opening the road or footway to traffic. The ironwork shall be reset, if necessary, within 48 hours of application of the Slurry Surfacing.

28 The Contractor shall remove surplus aggregate from the treated areas using a method stated in the Quality Plan. The Contractor shall monitor the Slurry Surfacing closely for a minimum period of 2 hours and if necessary the lane shall be swept again. The monitoring shall continue until the Slurry Surfacing has reached sufficient stability to carry unrestricted traffic. If there are signs of distress the Contractor shall reinstate traffic safety and management procedures or other such remedial action where necessary in order to prevent further damage.

29 Further operations to remove subsequently loosened aggregate shall be carried out over the next 48 hours. The areas treated and adjacent side roads, footways and paved areas shall be kept substantially free of loose aggregate for a period of 30 days after completion of the work.

As Built Manual

30 Not more than 30 days after completion of the work the Contractor shall provide a record of the progress of the work in the form of an "As Built Manual" incorporating all relevant information, including all test results, volumes of Slurry Surfacing used and areas covered with calculated thickness, record of traffic control carried out, weather information, unforeseen problems, a list of complaints, if any, from the general public or road users and any other information that the Overseeing Organisation may reasonably require to be included.

Performance Standards for Slurry Surfacing during the Guarantee Period

Surface Macrotexture

31 The Contractor is responsible for maintaining the surface macrotexture requirements set out in Appendix 7/7 throughout the guarantee period. The Overseeing Organisation will monitor the surface macrotexture.

The definitive test is the volumetric patch technique measured in accordance with BS EN 13036-1 except that 10 individual measurements shall be made on the nearside (inside) wheel-track of the most heavily trafficked lane or for low traffic category sites the track carrying the most stress. The average macrotexture depth of each lane kilometre, or the complete carriageway lane where this is less than 1,000 metres, shall be as specified in Appendix 7/7. The average of each set of 10 individual measurements shall be not less than 80% of the minimum permitted.

The macrotexture depths will be measured, initially, then after 11 months and before 13 months and for two year guarantee period contracts additionally after 22 months and before 24 months unless otherwise specified in Appendix 7/7. When required, the Contractor shall design the Slurry Surfacing to limit the maximum macrotexture after four weeks trafficking to that specified in Appendix 7/7.

Surface Profile

32 The surface profile of the slurry surfacing, when measured in accordance with Series 700, shall meet the requirements specified in Appendix 7/7 for both transverse and longitudinal profile.

Defects

33 The extent of area and linear defects will be monitored by the Overseeing Organisation using the visual method of assessment in accordance with BS EN 12274-8 and shall have less than the permitted maximum level of defects as described in Appendix 7/7.

34 Coloured materials shall retain their colour, to at least to the level detailed in the Certificate throughout the guarantee period.

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35 Any section failing to meet the required standard as specified in Appendix 7/7 shall be subject to remedial action by the Contractor.

919 Surface Dressing: Recipe Specification

Not Used

920 Bond Coats, Tack Coats and other Bituminous Sprays

1 Bond coats and tack coats used in conjunction with bituminous mixtures, other than those covered by Clause 942, shall be in accordance with this Clause and the requirements specified in Appendix 7/1 and 7/4.

Bond Coats

2 Bond coats shall have a British Board of Agrément HAPAS Roads and Bridges Certificate or equivalent. In the event that no such certificates have been issued, they shall have the approval of the Overseeing Organisation.

Tack Coats

3 Tack coats for bituminous mixtures shall be bitumen emulsion, as specified in BS 594987.

Bituminous Sprays

4 Bituminous sprays used to facilitate sealing and curing shall consist of either bitumen emulsion to BS EN 13808; cutback bitumen to BS 3690-1; paving grade bitumen to BS EN 12591 supplied from locations that are registered with Transport Malta; or modified bituminous products with a British Board of Agrément HAPAS Roads and Bridges Certificate or equivalent. In the event that no such certificates have been issued, modified bituminous products shall have the approval of the Overseeing Organisation.

Manufacture and Product Data

5 Bond coats, tack coats and bituminous sprays shall be manufactured in plants registered with Transport Malta. The Contractor shall complete the binder data sheet specified in Appendix 7/4 and supply a copy to the Overseeing Organisation prior to the application of the product.

Preparation

6 Any limitations on area availability and timing or other constraints for the work shall be as specified in Appendix 1/13. Before spraying is

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commenced, the surface shall be free of all loose material and standing water. Surface preparation shall be carried out in accordance with BS 594987, or for certified products, in accordance with the BBA/HAPAS Certificate or equivalent; and shall comply with any requirements specified in Appendix 7/4. When specified in Appendix 7/4, street furniture, ironwork and drop-kerbs shall be masked using self-adhesive masking material before application starts and removed on completion of the works.

Application

7 Application shall be by metered mechanical spraying equipment, spray tanker or spraying device integral with the paving machine. The spraying equipment used shall not cause permanent deformation in the surface. For small or inaccessible areas, application may be by hand held sprayer with the agreement of the Overseeing Organisation.

8 The target rates of spread of bond coats or tack coats below bituminous mixtures shall be as recommended in BS 594987. For other applications, unmodified bitumen emulsions shall be sprayed at the rate of spread specified in BS 434-2 or as otherwise stated in Appendix 7/4. Proprietary materials shall be sprayed at the appropriate rate set out in the BBA/HAPAS Certificate or equivalent for the product.

Accuracy of Application

9 Spray application shall be uniform. Before spraying begins, the Contractor shall provide the Overseeing Organisation with a test certificate showing the results for rate of spread and accuracy of spread. These tests shall be carried out in accordance with BS EN 12272-1 either by an appropriate organisation, accredited in accordance with sub-Clauses 105.3 and 105.4 for those tests, or by the Contractor where this forms part of his Quality Plan. The certificate shall demonstrate that the spraying device has been tested, using the product to be used in the Contract, not more than six weeks before commencement of the work. The tolerance on the specified rate of spread shall not exceed ±20% and the coefficient of variation of the transverse distribution shall not exceed 15%. During the works the Contractor shall repeat the tests for rate of spread and accuracy of application at the frequency specified in Appendix 1/5. The results shall be reported verbally to the Overseeing Organisation within 24 hours of carrying out a test and in writing within 7 days. Where application is by hand held sprayer, the rate of spread shall be measured by calculating the volume applied per square metre and evenness shall be visually assessed.

Joints

10 There shall be no bare strips or areas having less than the minimum permitted rate of spread. Transverse joints shall have an overlap not wider than 300 mm. Longitudinal joints shall have an overlap to ensure that the minimum permitted rate of spread is achieved across the joint. For quartering (using part of the spraybar) the longitudinal joint overlap width may be extended to a maximum of 300 mm. Paver integral sprayers shall provide a wet edge to ensure spray overlap under adjacent overlays such that the minimum permitted rate of spread is achieved across the longitudinal joint. Where the longitudinal spray overlap causes the effective rate of spread to be increased by more than 50% of the specified rate, then the width of overlap shall not be greater than 100 mm and shall be outside the location of the wheel tracks for the lane.

Overlaying Concrete Surfaces

11 The Contractor shall submit evidence of the suitability of the bond or tack coats he intends to use when overlaying concrete surfaces to the Overseeing Organisation prior to the commencement of the work.

Blinding Material for Bituminous Sprays

12 When specified in Appendix 7/4, blinding material shall consist of hard clean crushed fine aggregate containing not more than 15% by mass retained on a 6.3 mm sieve. It shall be distributed over the sprayed area and left. Blinding used on cementitious materials shall be light in colour to minimise solar gain. All loose material on a sprayed surface including non-adhered blinding material shall be removed prior to the application of an overlay.

Chipping to Prevent Binder Pickup

13 When chippings are used to prevent tack or bond coat pickup on vehicle tyres, they shall consist of hard, clean aggregate 2/4 mm or 2/6 mm G_c 85/35. The rate of application of aggregate shall be the minimum necessary and shall be distributed by metered mechanical means. Bond coat shall be

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visible after aggregate application to ensure bond is still achieved between the pavement layers.

Bond Testing

14 The value for interlayer bond testing using 150mm diameter cores shall comply with the following:

The peak shear stress at the interface between asphalt layers measured using the Modified Leutner Shear Test (see clause 954) 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.

921 Surface Texture of Bituminous Surface Courses

Microtexture

1 The low-speed microtexture of the road surface for the road construction classes HD and I to VI (Note 1) when measured by the method in BS EN 13036-4 (Pendulum Test) shall comply with the following:

i. Minimum value at completion: ≥ 64
ii. Minimum value after 4 years of service: ≥ 60

Macrotexture

2 When specified in Appendix 7/1, the initial surface macrotexture for bituminous surface courses shall be measured using the volumetric patch method described in BS EN 13036-1 and the procedures in BS 594987, clause 8.2.

3 Texture depth shall be measured by 10 individual measurements taken at approximately 5 m spacing along a diagonal line across the lane width. Unless otherwise specified in Appendix 7/1, at least one set of 10 measurements shall be made for each 250 m section of carriageway lane. The average texture depth for each set of 10 individual measurements and the average texture depth of each 1,000 m section (or complete carriageway lane where this is less than 1,000 m) shall not be less than the appropriate values shown in Table 9/3, unless otherwise specified in Appendix 7/1.

SCRIM

4 When specified in Appendix 7/1 the SCRIM of the road surface for the wearing course of construction classes HD and I to VI (Note 1) measured by the SCRIM method as described in the UK DMRB standard HD 28/04. must not fall below the following limit values for the single value of a 100m section:

At completion:

- SC(50) = 0.55

After 4 years of service:

- SC(50) = 0.52

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. minimum load ≥ 14kN; shear way 2 – 5mm;¶
<#>Binder Course to Base Course bond:¶
. minimum load ≥ 10kN; shear way 1 – 4.5mm;¶

Comment [JBr14]: See HD28/04, A3.3

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5. The requirement to Skid Resistance is not applied for residential areas, or parking areas or pedestrian areas.

Note 1: See Transport Malta Specifications for Road Works (Design and Construction), Volume 7.

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Table 9/3: Requirements for Initial Texture Depth for Roads (Excluding Roads classified as Residential*)

Road Type – Speed limit	Surfacing type	Average per 1,000 m section, mm	Average for a set of 10 measurements, mm
Roads			
Posted speed limit > 70 km/h but ≥ 80km/h	Thin surface course systems to Clause 942 with an upper (*D*) aggregate size of 14mm or less	Not less than 1.3	Not less than 1.0
	All other surfacings	Not less than 1.5	Not less than 1.2
Posted speed limit ≤ 70 km/h	Thin surface course systems to Clause 942 with an upper (*D*) aggregate size of 14mm or less	Not less than 1.0	Not less than 0.9
	All other surfacings	Not less than 1.2	Not less than 1.0
Roundabouts			
Roundabouts on roads with posted speed limit > 70 km/h but ≥ 80km/h	All surface course materials	Not less than 1.2	Not less than 1.0
Roundabouts on roads with posted speed limit ≤ 70 km/h	All surface course materials	Not less than 1.0	Not less than 0.9

*Note: By the Overseeing Organisation

922 Surface Dressing: Design, Application and End Product Performance

Not Used

923 Not Used

924 High Friction Surfaces

1 High friction surfacing systems shall have current British Board of Agrément HAPAS Roads and Bridges Certificates or approved equivalent.

2 A high friction surfacing system with a current British Board of Agrément HAPAS Roads and Bridges Certificate or equivalent shall only be installed by a Contractor approved by the BBA and the Certificate Holder as an Approved Installer for that system.

3 The high friction surfacing system BBA/ HAPAS Type Classification required for each location shall be as specified in Appendix 7/1.

Aggregate

4 Aggregate used in high friction surfacing systems shall have a minimum declared PSV category specified in Appendix 7/1 in accordance with BS EN 13043, clause 4.2.3. The resistance to abrasion of coarse aggregate shall have a maximum AAV specified in Appendix 7/1 in accordance with BS EN 13043, clause 4.2.4. The Contractor shall provide, before work commences, test certificates, issued by an appropriate organisation accredited in accordance with sub-Clauses 105.3 and 105.4 for those tests, not more than six months previously, showing conformity with the requirements.

Installation and Quality Control Procedures

5 The installation and quality control procedures shall be in accordance with the British Board of Agrément Roads and Bridges Certificate for each system and the current method statement agreed by the BBA (or equivalent). The results of all quality control checks carried out on site by the Contractor

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and quality assurance information compiled in accordance with the requirements of the Certificate, including results from BBA surveillance visits, shall be made available to the Overseeing Organisation on request.

System Coverage

6 For each location where high friction surfacing is applied, the total quantities of each system component used, the measured area of the surface treated and the calculated coverage rate in kg/m^2 shall be reported to the Overseeing Organisation within three days of completion at that location. For systems in which aggregate is broadcast over a film of binder applied to the surface, the calculated coverage rate shall be that of the binder film and shall not include the mass of the aggregate.

Guarantee

7 The Contractor shall guarantee the high friction surfacing materials and workmanship for a period of two years from the date of opening the surfacing to traffic. This guarantee shall exclude defects arising from damage caused by settlement, subsidence or failure of the carriageway on which the surfacing has been applied, but shall cover failure to meet the minimum requirements set out in Table 4 of the UK BBA/ HAPAS 'Guidelines Document for the Assessment and Certification of High Friction Surfaces for Highways'.

925 Testing of Bituminous Mixtures

1 The sampling and testing of bituminous mixtures shall comply with BS EN 12697, except where otherwise specified in this Series.

2 If testing additional to that required by BS EN 13108–20, BS EN 13108–21, the UK Sector 14 (or equivalent) or the relevant Transport Malta SRW Clause is necessary it shall be as specified in Appendix 7/1 or 1/5.

926 In Situ Recycling: The Repave Process

Not Used

927 Not Used

928 Not Used

929 Base and Binder Course Asphalt Concrete (Design Mixtures)

Not Used

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¶
Heating and Scarifying¶
¶
2 Surfaces to be treated shall be heated by plant with heating surfaces insulated and fully enclosed. The heated-width of surfacing shall exceed the scarified width by at least 75 mm on each side, except against the edge of the carriageway or kerb face. When new surfacing material is spilt onto the road surface it shall be removed before the existing surface is heated and scarified. Areas of unscarified material shall not exceed 50 mm x 50 mm.¶
¶
3 The depth of scarification shall be such that the bottom of the scarified layer is parallel to and below the finished road surface level by the thickness of surface course material specified in Appendix 7/5. A tolerance of ± 6 mm is permissible.¶
¶
4 Where ironwork and other obstructions occur, these shall be suitably protected or removed and the void covered. Surface dressings and large areas of road markings shall be removed by milling, planing, scarifying or similar.¶
¶
5 The heated surface shall be evenly scarified to comply with the requirements of sub-Clause 3 of this Clause. When ironwork is left in place or raised, the adjacent areas shall be scarified by other means, with the material either left in place or removed, prior to passage of the machine. If ironwork needs to be re-levelled, on completion of work, the new surface course material shall be used to make good the road surface for a maximum width of 200 mm around the ironwork.¶
¶
6 During the reheating process the surface temperature of the road shall not exceed 200°C for more than 5 minutes.¶
¶
New Surfacing¶
¶
7 New surface course shall confor ... [2]

Deleted: **1** Designed base and binder course asphalt concrete shall be asphalt concrete conforming to¶
BS EN 13108-1, "Asphalt Concrete Mixes Schedule A" and requirements specified in Appendix 7/1. The mixture designation shall be the following:¶
¶
Base Mixtures: . AC 32 Base 50/70¶
Binder Mixture¶
AC¶
Column Break
2 The volumetric properties of mixtures shall be as specified in BSI PD 66 ... [3]

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939 Not Used

930 EME2 Base and Binder Course Asphalt Concrete

Not Used

940 Not Used

931 Not used

941 Not Used

942 Thin Surface Course Systems

932 Not used

1 Thin surface course systems shall have a British Board of Agrément HAPAS Roads and Bridges Certificate applicable to the combination(s) of traffic level and site classification specified in Appendix 7/1.

933 Not Used

2 Thin surface course systems that are mixed hot as asphalt shall be produced in plants that are registered to the BS EN ISO 9001 'Sector Scheme 14 for the Production of Asphalt Mixes' as described in Appendix A. Thin surface course systems that are produced using surface dressing techniques shall be produced by companies that are registered to the BS EN ISO 9001 'Sector Scheme 13A for The Supply and Application of Surface Dressings to Road Surfaces' as described in Appendix A. Thin surface course systems that are produced using slurry surfacing techniques or any other technique not covered above shall be produced by companies registered to the relevant BS EN ISO 9001 sector scheme if such a scheme is in place as described in Appendix A. The composition of thin surface course systems produced under a sector scheme shall not be tested under this contract other than for audit purposes unless some obvious variation in production occurs (e.g. binder drainage is observed for the first time).

934 Not Used

935 Not Used

936 Not Used

Test Certificates and Material Samples

937 Stone Mastic Asphalt (SMA) Binder

3 The Contractor shall provide a copy of the British Board of Agrément HAPAS Roads and Bridges Certificate for the system together with the associated Quality Plan and Installation Method Statement. The thin surface course system shall be manufactured, transported and laid in accordance with these documents. In particular, the material shall be manufactured at a plant that has been notified to the British Board of Agrément by the Certificate Holder,

Not Used

938 Porous Asphalt

Not Used.

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Deleted: **7** Compaction shall be controlled and monitored in accordance with the general requirements of BS 594987 9.5.1 and the specific requirements of this Clause.¶
8 Compaction shall be continuously assessed using an indirect density gauge in accordance with BS 594987 9.4.2 with readings taken at 20 m intervals in alternate wheel-tracks. Gauge readings shall also be taken at each core location specified in sub-Clauses 12 and 14. Each gauge shall be individually calibrated on each mixture from each mixing plant and the calibrations shall be continually checked and updated based on correlations between gauge readings and core densities at the same locations.¶
¶
9 For each location, the in situ void content shall be determined in accordance with BS EN 12697-8 using the bulk density from the gauge reading and a maximum density taken from the mixture type testing data and updated with values from testing in accordance with sub-Clause 12.¶
¶
10 The average in situ void content calculated from any six consecutive indirect gauge readings shall not exceed 7%.¶
¶
11 In the event of a failure to meet the requirements in sub-Clause 10, cores shall be taken at each location and void contents determined as described in sub-Clause 12 and the evaluation of the extent of any non-conformity shall be based on these. If it is necessary to remove and replace any material to restore conformity this shall be in lengths not less than 15 m unless otherwise agreed by the Overseeing Organisation.¶
¶
12 For the material from each mixing plant, a pair of cores shall be taken from the wheel-tracks every 1,000 metres laid and the void content shall be determined in accordance with BS 594987, clause 9.5.1.3.¶
¶
13 The average in situ air voids for each core pair shall not exceed 7%.¶
¶
14 For the material from each mixing plant a pair of cores shall be taken every 250 metres laid, centred 100 mm from the final joint position at any unsupported edge and the air void shall be determined in accordance with BS 594987, clause 9.5.1.3.¶
¶
... [4]

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prior to the commencement of work to this Clause, and shall be laid by an installer approved by the Certificate Holder.

4 When required for audit purposes the component materials (including, where relevant, their nominal sizes) and their relative proportions and/or spread rates for use in the Permanent Works shall be notified to the Overseeing Organisation. The component materials listed shall include, as appropriate, coarse aggregates, fine aggregates, filler, additives (including fibres), binder, modifier and bond coat, and shall be subdivided into layers if applied using surface dressing or slurry surfacing techniques. Where a thin surface course system is not produced under a sector scheme as defined in sub-Clause 2, the Quality Plan and Quality System shall be acceptable to the British Board of Agrément.

5 Coarse aggregate shall be crushed rock or steel slag complying with Clause 901 when tested in accordance with the procedures of BS EN 13043. The coarse aggregate shall additionally have the following properties:

i. Polished Stone Value (PSV) - as specified in Appendix 7/1 - BS EN 13043, clause 4.2.3.
ii. Aggregate Abrasion Value (AAV) - as specified in Appendix 7/1 - BS EN 13043, clause 4.2.4.
iii. Los Angeles Coefficient (LA) - not greater than LA_{30}. - BS EN 13043, clause 4.2.2.
iv. Flakiness Index (FI) - not more than FI_{20}. - BS EN 13043, clause 4.1.6.

The Contractor shall supply the Overseeing Organisation with test certificates stating the properties of the aggregate to be used.

6 If required, samples of aggregate, bond coat or binder, modified or unmodified bitumen from either the spray bar or storage tank or mixed bituminous materials from the pavement surface or other suitable sampling point shall be supplied to the Overseeing Organisation.

Performance Levels

7 The wheel-tracking levels of the thin surface course system, as recorded on the British Board of Agrément HAPAS Roads and Bridges Certificate, shall be Level 3 unless otherwise specified in Appendix 7/1. For thin surface course systems whose maximum thickness is less than 20 mm and no deformation resistance information is given, Level 3 is assumed.

8 If required, the road/tyre noise level of the thin surface course system shall be specified as 0, 1, 2 or 3 in Appendix 7/1.

Layer Thickness

9 When required, the minimum and/or maximum compacted thickness of the thin surface course system shall be as specified in Appendix 7/1.

10 Where necessary, existing surfaces shall be regulated in accordance with Clause 907, prior to laying surfacing material to this Clause. Evidence that the deformation resistance of material used for

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regulation is capable of complying with the requirements of sub-Clause 7 shall be provided to the Overseeing Organisation except that, if the combined maximum thickness of the regulating material and/or of the thin surface course system is more than 20 mm, evidence of

the deformation resistance of the combined layers shall be provided.

Surface preparation

11 Surface preparation shall be in accordance with the Installation Method Statement provided in accordance with sub-Clause 3. Notwithstanding:

i. Existing surfaces shall be cleaned using steel brooms and suction sweeping or other appropriate means. The surface may be moist but not wet; standing water shall not be present. All mud, dust, dirt and other debris and organic material shall be removed.

ii. Ironwork shall be lifted to its final level before surfacing is carried out except where the installation method statement specifically states otherwise. Unless raised prior to surfacing, ironwork and reflecting road studs shall be located for lifting and resetting after completion of surfacing works. Fire hydrants and other safety related ironwork shall be uncovered immediately after completion of rolling. Gullies shall be covered prior to surfacing.

iii. Where possible, existing road markings shall be removed.

Transportation

12 Transportation of the thin surface course system and/or its components shall be in accordance with the Installation Method Statement provided in accordance with sub-Clause 3. Notwithstanding, hot bituminous materials shall be transported in accordance with sub-Clause 903.6.

Surface Macrotexture – Untrafficked

13 The macrotexture depth of the thin surface course system after compaction has been completed and before opening to traffic shall be in accordance with Clause 921.

Surface Macrotexture - Performance

Guarantee

14 For a period of two years from the date of opening to traffic the Contractor shall guarantee that the average macrotexture, measured using the volumetric patch technique described in BS EN 13036-1, will be maintained above 1.0 mm or the minimum permitted value specified in Appendix 7/1, for each lane kilometre or the complete carriageway lane where this is less than 1,000 m. When necessary, to demonstrate compliance, the macrotexture shall be measured in accordance with

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BS EN 13036-1 in the most heavily trafficked lane at 10 m intervals. The average value of a set of 10 individual measurements taken along the centre of the most heavily worn wheel-track shall not be less than 1.0 mm or the minimum permitted value specified in Appendix 7/1.

Surfacing Integrity – Performance Guarantee

15 On the trunk road including motorway network the Contractor shall guarantee the integrity of the surfacing and the workmanship for a period of five years from the date of opening to traffic, unless otherwise specified in Appendix 7/1.

16 The five-year guarantee shall include for defects such as fretting, ravelling, stripping and loss of chippings. The guarantee shall exclude defects arising from accidental damage or damage caused by settlement, subsidence or failure of the underlying carriageway on which the surfacing material has been laid.

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

Not Used

944 Not Used

945 Weather Conditions for Laying of Hot Bituminous Mixtures

1 The Contractor shall take account of the weather conditions when planning his working methods. The Contractor's working methods shall comply with all weather-related requirements of BS 594987 and any additional requirements of this clause. When laying is to be undertaken during winter, the contractor shall work to a Quality Plan that allows for the specific issues raised by winter and/or night time working.

2 Hot bituminous materials laid less than 50 mm thick, other than those supplied to Clause 942, shall be laid within the wind speed and temperature constraints of Figure 9/1.

Thin Surface Course Systems

3 The weather conditions for laying thin surface course systems shall comply with those identified as being acceptable in the British Board of Agrément HAPAS Roads and Bridges Certificate for the system together with the associated Quality Plan and Installation Method Statement.

Hot Rolled Asphalt With Pre-Coated Chippings

Not Used

Wind Speed

5 When measurements are required for assessment by the Overseeeing Organisation, wind speed shall be measured by anemometer positioned near the laying site to accurately reflect conditions at the laying site. The anemometer shall be fitted with a digital accumulative device.

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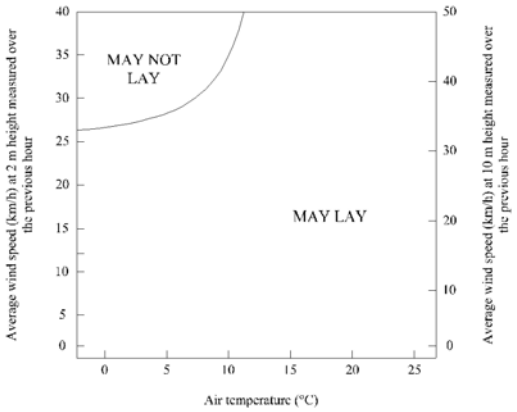
FIGURE 9/1: Wind Speed and Air Temperature Laying Restrictions for Layers less than 50 mm Thick



946 Patching and Repairs to Potholes and Depressions (Including Emergency Patching)

General

1 Patching is defined as replacement of surface course, binder course and base where the materials are laid in small areas.

2 The existing defective surfacing and/or temporary filling of trenches and depressions shall be broken out so as to provide a cavity with straight vertical edges.

3 Joint edges shall be formed as specified in sub-Clause 903.22.

4 All loose material shall be removed off site.

5 Replacement material shall be as specified in Appendix 7/1.

6 Bond coat shall be applied in accordance with Clause 920.

7 All construction layers shall be laid and compacted such that on completion each layer shall be at the same level as the adjacent course.

8 Alternatively patching may be carried out using proprietary in-situ recycling repair systems incorporating indirect infra red heating having an appropriate British Board of Agrément HAPAS Roads and Bridges Certificate or equivalent.

Emergency Patching

General

9 Emergency patching shall be carried out with approved kits of proprietary Emergency Patching Materials (EPM) complying with this clause.

Surface Preparation and Usage

10 The surface of the road shall be brushed mechanically or by hand with a stiff broom to remove loose material. Any standing water shall be brushed away, but the surface may remain damp.

11 Installation shall not be undertaken unless weather conditions are such that the repair material will have at least 30 minutes in which to cure and harden.

Components of the Emergency patching material Kit

12 Each kit shall comprise the materials and tools necessary to carry out an emergency repair to the surface of a road.

13 Each kit shall contain all the constituents which, when mixed together, will satisfy the performance requirements set out in this clause. It shall contain sufficient coarse aggregate with a minimum Los Angeles Coefficient ≤ LA_{40}..

14 Each kit shall contain full and detailed instructions, including if necessary a cd/dvd video or a series of still photographs, to ensure that inexperienced operatives can prepare and lay the emergency patching material correctly without difficulty.

15 No individual part of a kit shall weigh more than 20 kg.

Performance Requirements for the Patching Material

16 The repair material shall have the following characteristics:

i. It shall be capable of being mixed and spread by hand in thickness from 3 mm to 30 mm.

It shall cure to a strength such that it is capable of being trafficked by heavy vehicles without damage within 30 minutes of installation when laid at surface temperatures between 3ºC and 40ºC.

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ii. None of the material shall debond or delaminate from the existing surface of the road for a period of at least 7 days from installation. Any subsequent delaminated material shall not be of sufficient size as to cause a hazard to traffic.

iii. It shall retain surface applied aggregate.

iv. It shall have a minimum shelf life of 12 months.

17 The performance shall be demonstrated at a site installation trial and by laboratory evaluation.

18 Products shall be independently certified to show compliance with this Clause.

Laboratory Evaluation of Patching Material

19 Test specimens shall be prepared by coating a substrate manufactured with material complying with the BBA Guidelines Document for the Assessment and Certification of High-Friction Surfacing for Highways. The coating shall be in the range 3 mm to 6 mm thick.

Tensile Adhesion

20 A tensile adhesion test shall be carried out not more than 48 hrs after sample preparation. A minimum value of 0.2 N/mm^2 shall be achieved.

Retained Skid Resistance after Scuffing

21 A scuffing test shall be carried out in accordance with BBA Guidelines Document for the Assessment and Certification of High-Friction Surfacing for Highways except that the test temperature shall be 30ºC and the test shall be carried out not more than 48 hours after sample preparation.

22 A minimum retained Pendulum Test Value of 55 and a minimum retained texture depth of 0.9 mm shall be achieved.

Erosion Index

23 Following the scuffing test carried in accordance with sub-Clause 21, the Erosion Index shall be less than 5.

Repairs to potholes and depressions

24 Temporary repairs to small areas of surface courses including holes for road stud sockets shall be carried out in accordance with Appendix 7/22. Alternatively patching may be carried out using proprietary in-situ repair systems incorporating indirect infra red heating having an appropriate British Board of Agrément HAPAS Roads and Bridges Certificate or equivalent.

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25 Temporary filling to depressions shall be carried out using a proprietary material specifically formulated to treat such depressions, all in accordance with sub-Clause 2 to sub-Clause 23 of this clause.

26 Permanent filling to depressions shall be carried out using material or recycling systems complying with Series 900 or having an appropriate British Board of Agrément HAPAS Roads and Bridges Certificate.

947 In Situ Cold Recycled Bitumen Bound Material

Not Used

948 Ex Situ Cold Recycled Bound Material

Not Used

949 Not Used

950 Surface Preservation Systems

Not Used

951 Not Used

952 Price Reduction

The Overseeing Organization may carry out price reductions in respect of non complying layer thickness, bitumen content, compaction degree and regularity according to the formulae indicated in the "Notes of Guidance" to this Series.

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

1 The test method to assess the durability of bituminous materials using the Saturation Ageing Tensile Stiffness (SATS) shall be as described in the UK Manual of Contract Documents for Highway Works, Volume 1, Series 900, clause 953, 1 to 27 (Amendment - August, 2008).

954 Method for Laboratory Determination of Interface Properties using the Modified Leutner Shear Test

Scope

1 This Clause specifies a laboratory test method to assess the bonding between adjacent asphalt pavement layers using cylindrical samples. It is also appropriate for asphalt applied to concrete.

Terms and Definitions

2 For the purposes of this Clause the terms and definitions given in BS 6100 shall apply, together with the following:

i. Peak Shear Stress: The maximum value of shear stress, determined as the maximum force divided by the initial cross sectional area of a specimen when tested as described in this Clause.

ii. Displacement at Peak Shear Stress: The displacement at the maximum value of shear stress of a specimen when tested as described in this Clause.

iii. Shear Stiffness Modulus: The peak shear stress divided by the displacement at the peak shear stress of a specimen when tested as described in this Clause.

Principle of Test

3 Cylindrical test specimens of nominal mm diameter shall be subjected to direct shear loading at 20°C using the modified Leutner shear test. The maximum shear stress (in MPa) at the interface between layers shall be determined.

Test Apparatus and Materials

4 The following test apparatus and materials shall be used:

i. Shear test apparatus, as shown in Figure 9/5, composed of a base body (A) on which are fixed the sample support (B) and the lower shear ring (D). The upper shear ring (C) is attached to the

Deleted: **Terms and Definitions**¶
¶
2 For the purposes of this Clause the terms and definitions given in BS 6100 shall apply, together with the following.¶
¶
<#>*Maximum Density*: Mass per unit volume, without air voids, of a bituminous mixture at known test temperature. ¶
¶
<#>*Dry Bulk Density*: Mass per unit volume, including the air voids, of a specimen at known test temperature. ¶
¶
<#>*Saturation before Conditioning*: The saturation of the mixture, determined as the calculated percentage of air voids filled with water after partial vacuum saturation, prior to conditioning as described in this Clause. ¶
¶
<#>*Unconditioned Stiffness*: The stiffness modulus of the mixture as determined in accordance with BS EN 12697-26, Annex C, prior to conditioning as described in this Clause. ¶
¶
<#>*Conditioned Stiffness*: The stiffness modulus of the mixture as determined in accordance with BS EN 12697-26, Annex C, after conditioning as described in this Clause. ¶
¶
<#>*Stiffness Ratio*: The ratio of the conditioned stiffness to the unconditioned stiffness ¶
¶
<#>*Saturation after Conditioning*: The saturation of the mixture, determined as the calculated percentage of air voids filled with water after conditioning as described in this Clause. ¶
¶
Principle of Test¶
¶
3 Nominally identical test specimens are subjected to moisture saturation by using a vacuum system. They are then transferred into a pressurised vessel partially filled with water, where they are subjected to a conditioning procedure at 85°C temperature and 2.1 MPa pressure for 65 hours. The stiffness ratios of the individual specimens situated above the water are ¶ … [5]

Deleted: **<sp>Sample Preparation**¶
¶
6 Test specimens shall be cores of 100 +0, -5 mm diameter and 60 ± 5 mm thickness. Specimens shall be cored from a slab manufactured using a laboratory roller compactor in accordance with BS EN 12697-33 to a void content of 8% ± 2%. The slab shall be produced using the recipe for the bituminous mixture … [6]

Deleted: **<sp>Scope**¶
¶

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upper body (E), which is movable along the guiding bars (F). The gap between shear rings (C and D) is 5 mm.

ii. Loading frame capable of achieving a constant vertical displacement rate of 50.0 ± 2 mm per minute and a maximum load of at least 50kN.

iii. Data logging system to record load and displacement during the test.

iv. Metal extension, as shown in Figure 9/6.

v. Stiff adhesive, such as epoxy resin, with sufficient strength to avoid failure within the adhesive or at the adhesive/asphalt material interface.

Sample Preparation

5 Test specimens shall be cores of 150 ± 2 mm diameter; the minimum thickness of the layers above and below the interface to be tested shall be 15 mm and 60 mm respectively. Specimens shall be cored from an in-service pavement or from a slab manufactured using a laboratory roller compactor in accordance with BS EN 12697-35 and BS EN 12697-33. If the thickness of the layer above the interface is between 15 and 30 mm, a metal extension shall be glued on top of the layer above the interface.

Procedure

6 The diameter and thickness of the specimen shall be determined to the nearest mm.

7 The specimen shall be placed into a suitable temperature controlled conditioning environment at 20 ± 0.5 °C for a minimum of 5 hours.

8 The appropriate shear rings, to form a loose fit around the specimen (for example, 151 mm diameter shear rings for a 150 mm diameter specimen), shall be selected and attached to the Leutner test frame.

9 The specimen shall be placed into the test apparatus and the interface aligned, (Figure 9/5 (G)), between the upper and lower shear rings (Figure 9/5 (C and D)). If a metal extension is used, the specimen shall be placed into the test apparatus so that the direction of the grooves is perpendicular to the direction of the applied shear load.

10 Tighten the sample support using a suitable spanner.

11 The test apparatus shall be placed into the loading frame and adjusted until the upper shear ring (Figure 9/5 (C)) nearly touches the specimen.

12 Start the data logging system (to record load and displacement) and commence shear loading. The loading rate shall be 50.0 ± 2 mm per minute.

13 Record the load (F) to the nearest 0.1 kN and the displacement (δ) to the nearest 0.1 mm.

14 Stop the shear loading when the test frame reaches its limit of 7 mm displacement. The length of time between removal of the specimen from the temperature controlled conditioning environment and completion of testing shall not exceed 15 minutes.

15 After the test has been completed, the apparatus shall be dismantled and the specimen removed.

16 Both sections of the specimen shall be observed (especially the interface) for any visual cracks and unusual appearance (i.e. crushed aggregates on edges). Record any comments as necessary.

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Calculation and Expression of Results

17 Calculate the shear stress as follows:

$$\tau = \frac{F}{\pi r^2}$$

Where:

τ	=	shear stress in (MPa)
F	=	load (in kN)
r	=	initial radius of specimen (in mm)

18 Produce a shear stress versus shear displacement graph (an example is shown in Figure 9/7) using the recorded data.

19 Determine the following parameters from the graph:

i. τ_{max} = peak shear stress, MPa, expressed to the nearest 0.1

ii. δ_{max} = displacement at peak shear stress, mm, expressed to the nearest 0.1

iii. k = shear stiffness modulus = τ_{max}/δ_{max}, MPa/mm, expressed to the nearest 0.1

Test Report

20 The test report shall contain not less than the following information:

i. A reference to this test method and test conditions.
ii. Material descriptions for both layers.
iii. Type and amount of tack (bond) coat (if known).
iv. For each specimen tested, report:

- specimen diameter, expressed to the nearest mm
- layer thicknesses, expressed to the nearest mm
- maximum load (F), expressed to the nearest 0.1 kN
- peak shear stress (τ_{max}), expressed to the nearest 0.1 MPa
- displacement at peak shear stress(δ_{max}), expressed to the nearest 0.1 mm
- shear stiffness modulus (k), expressed to the nearest 0.1 MPa/mm
- any cracks or other damage.

v. The test temperature, expressed to the nearest 0.5°C

vi. The use (or otherwise) of a metal extension.

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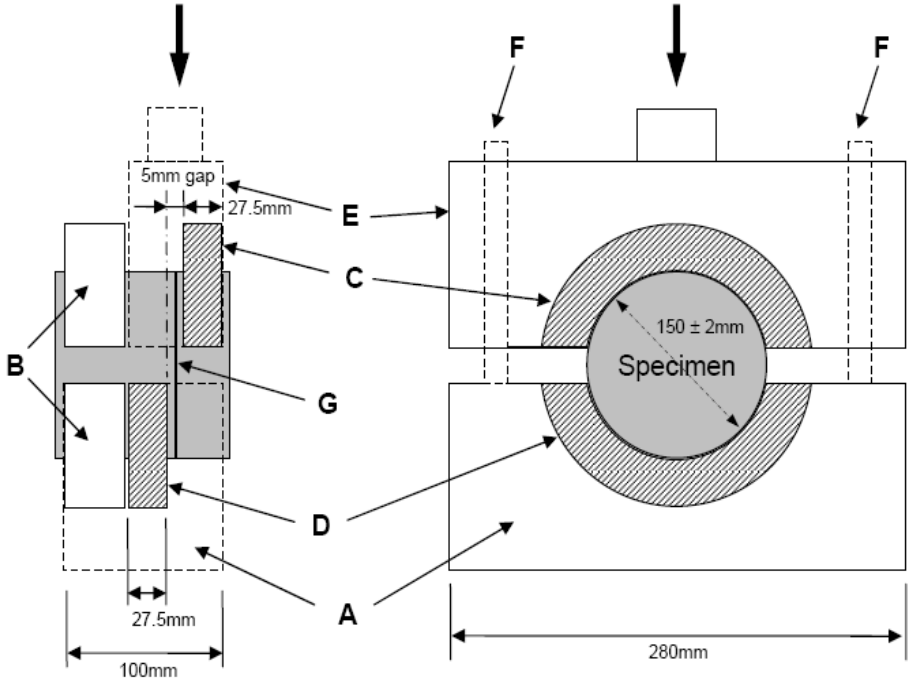

A – base body
B – sample support
C – upper shear ring
D – lower shear ring
E – upper body
F – guiding bar
G – specimen interface

Figure 9/5: Schematic Diagram of the Modified Leutner Shear Test Apparatus

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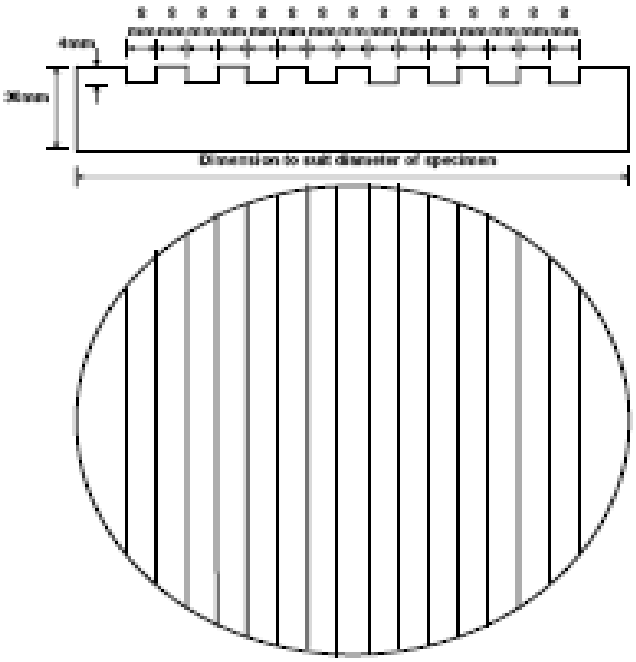

Figure 9/6: (09/08) **Schematic Drawing of the Metal Extension**

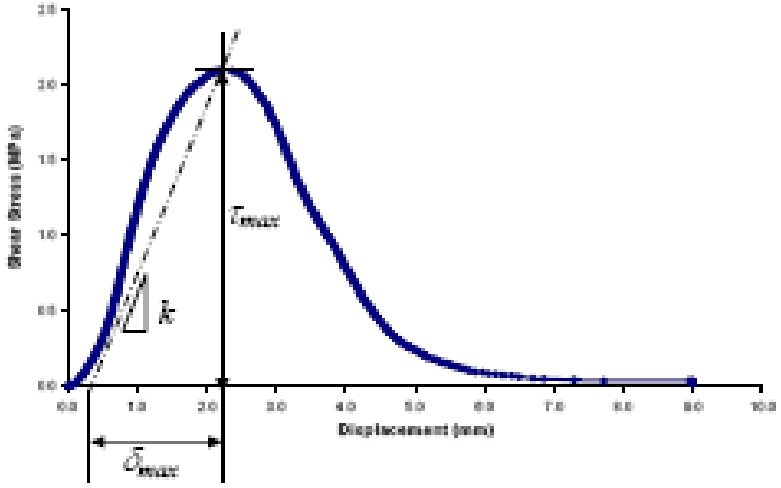

Figure 9/7 Example of the Shear Stress vs. Displacement Data Plot

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955 Binder Recovery using the Rapid Recovery Test (RRT) and Accelerated Ageing using the Modified Ageing Rolling Thin Film Oven test (RTFOT)

1 The procedure for Binder Recovery using the Rapid Recovery Test (RRT) and Accelerated Ageing using the Modified Rolling Thin Film Oven Test (RTFOT) shall be as described in the UK Manual of Contract Documents for Highway Works, Volume 1, Series 900, clause 955, 1 to 6 (Amendment - August, 2008).

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

1 The procedure for Determination of the Complex Shear (Stiffness) Modulus (G*) and Phase Angle (δ) of Bituminous Binders using a Dynamic Shear Rheometer (DSR) shall be as described in the UK Manual of Contract Documents for Highway Works, Volume 1, Series 900, clause 955, 1 to 6 (Amendment - August, 2008).

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

1 The procedure for Determination of Cohesion of Bitumen and Bituminous Binders shall be as described in the UK Manual of Contract Documents for Highway Works, Volume 1, Series 900, clause 955, 1 to 6 (Amendment - August, 2008).

958 Modified Binder Storage Stability Test

1 The procedure for the determination of the susceptibility of a pre-blended modified binder to separation or instability during prolonged storage at high temperature shall be as indicated in the UK Manual of Contract Documents for Highway Works, Volume 1, Series 900, clause 958, 1 to 5 (Amendment of August, 2008).

Deleted: Scope¶

Deleted: 1 (08/08) This Clause describes the test method for the determination of the Complex Shear (Stiffness) Modulus (G*) and Phase Angle (δ) of a bituminous binder over a range of temperatures and frequencies when tested in harmonic, sinusoidal oscillatory shear mode using a dynamic shear rheometer (DSR) with parallel plate test geometry and where both plates are controlled at the same temperature. Two methods are described. The first is the conventional equilibrated temperature method using frequency sweeps and is detailed in the Institute of Petroleum (IP) test method IP PM CM/02 and with the amendments stated in this Clause shall be used for Type Approval (type testing) purposes. The second is the temperature sweep method, where the temperature of the binder is raised at a known rate and tested at a fixed frequency. The second test, which requires less time to perform, may be used for quality control purposes.¶
¶
2 (08/08) This Clause is applicable to unmodified and polymer modified binder as supplied, after the Rolling Thin Film Oven Test (RTFOT), after an Ageing Test or as recovered from a mixture. Bituminous binders containing fine mineral or organic matter or fibres may also be tested. For cutback bitumens, bituminous¶
emulsions and polymer variants the binder shall be sampled from the delivery and a recovered binder prepared in accordance with Clause 955.¶
¶
(08/08) Definitions¶
¶
3 (08/08) For the purposes of this Clause the following definitions apply:¶
¶
Complex Shear Modulus (G*) (sometimes referred to as Complex Stiffness Modulus): ratio of peal ... [7]

Deleted: This Clause specifies the procedure for obtaining a quantity of 'Recovered Binder' from modified or unmodified cutback or emulsion binder (Rapid Recovery Test - RRT) and an extended procedure for obtaining a quantity of 'Aged Binder' (Modified Ageing Rolling Thin Film Oven T ... [8]

Deleted: Figure 9/9: Screw¶
(iv) A spatula for removing the binder from the bottle (a flat blade or paddle shape, see photograph, has been found suitable). ¶
¶
¶
<sp>¶ ... [9]

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1 Where milling is required, it shall be carried out in accordance with Clause 709, and as described in Appendix 7/5.

Heating and Scarifying

2 Surfaces to be treated shall be heated by plant with heating surfaces insulated and fully enclosed. The heated-width of surfacing shall exceed the scarified width by at least 75 mm on each side, except against the edge of the carriageway or kerb face. When new surfacing material is spilt onto the road surface it shall be removed before the existing surface is heated and scarified. Areas of unscarified material shall not exceed 50 mm x 50 mm.

3 The depth of scarification shall be such that the bottom of the scarified layer is parallel to and below the finished road surface level by the thickness of surface course material specified in Appendix 7/5. A tolerance of ± 6 mm is permissible.

4 Where ironwork and other obstructions occur, these shall be suitably protected or removed and the void covered. Surface dressings and large areas of road markings shall be removed by milling, planing, scarifying or similar.

5 The heated surface shall be evenly scarified to comply with the requirements of sub-Clause 3 of this Clause. When ironwork is left in place or raised, the adjacent areas shall be scarified by other means, with the material either left in place or removed, prior to passage of the machine. If ironwork needs to be re-levelled, on completion of work, the new surface course material shall be used to make good the road surface for a maximum width of 200 mm around the ironwork.

6 During the reheating process the surface temperature of the road shall not exceed 200°C for more than 5 minutes.

New Surfacing

7 New surface course shall conform to the requirements as described in Appendix 7/5.

8 The new surfacing material shall be laid on, and compacted with the re-profiled surfacing, which shall be at a temperature within the range of 70°C to 150°C.

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1 Designed base and binder course asphalt concrete shall be asphalt concrete conforming to BS EN 13108-1, "Asphalt Concrete Mixes Schedule A" and requirements specified in Appendix 7/1. The mixture designation shall be the following:

Base Mixtures: AC 32 Base 50/70
Binder Mixture
AC

Column Break

2 The volumetric properties of mixtures shall be as specified in BSI PD 6691, clause B.3.2 for designed base mixtures and BSI PD 6691, clause B.3.3 for designed binder course mixtures.

3 When specified in Appendix 7/1, the volumetric properties of the mixture shall be monitored by determining the void content of cores compacted to refusal. Core pairs and samples of loose mix shall be taken every 500 lane metres and tested in accordance with BS 594987, clauses C.2.1, C.2.2, C.3, C.4.1 and C.4.2. If the mean air void content at refusal of any three consecutive pairs of cores falls below 0.5%, the mixture target composition shall be reviewed and the type test revalidated in accordance with BS 594987, Annex C.

Deformation Resistance

4 The resistance to permanent deformation of the mixture shall be in accordance with the appropriate class selected from Table D.2 of PD 6691, as specified in Appendix 7/1.

5 When specified in Appendix 7/1, the resistance to permanent deformation of material laid in the permanent works shall be monitored by testing in accordance with clauses D 3.1, 3.2 and 3.3 of BS 594987 Annex D. Six cores shall be taken from the first kilometre length of material from each mixing plant and thereafter one further core from each subsequent lane kilometre. Results shall be assessed on successive rolling means of sets of six consecutive results and shall be deemed to conform if the mean is no greater than the specified value and individual values not more than 50% greater than the specified value.

Stiffness

6 Stiffness of the mixture shall be assessed in accordance with BS 594987, Annex E.

Mixtures with 40/60 grade binder shall conform to
category $S_{min\ 1800}$ as defined in BS EN 13108-1, clause 5.4.2.

Mixtures with 30/45 grade binder shall conform to
category $S_{min\ 2800}$ as defined in BS EN 13108-1, clause 5.4.2.

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7 Compaction shall be controlled and monitored in accordance with the general requirements of BS 594987 9.5.1 and the specific requirements of this Clause.
8 Compaction shall be continuously assessed using an indirect density gauge in accordance with BS 594987 9.4.2 with readings taken at 20 m intervals in alternate wheel-tracks. Gauge readings

shall also be taken at each core location specified in sub-Clauses 12 and 14. Each gauge shall be individually calibrated on each mixture from each mixing plant and the calibrations shall be continually checked and updated based on correlations between gauge readings and core densities at the same locations.[JBr1]

9 For each location, the in situ void content shall be determined in accordance with BS EN 12697-8 using the bulk density from the gauge reading and a maximum density taken from the mixture type testing data and updated with values from testing in accordance with sub-Clause 12.

10 The average in situ void content calculated from any six consecutive indirect gauge readings shall not exceed 7%.[JBr2]

11 In the event of a failure to meet the requirements in sub-Clause 10, cores shall be taken at each location and void contents determined as described in sub-Clause 12 and the evaluation of the extent of any non-conformity shall be based on these. If it is necessary to remove and replace any material to restore conformity this shall be in lengths not less than 15 m unless otherwise agreed by the Overseeing Organisation.

12 For the material from each mixing plant, a pair of cores shall be taken from the wheel-tracks every 1,000 metres laid and the void content shall be determined in accordance with BS 594987, clause 9.5.1.3.

13 The average in situ air voids for each core pair shall not exceed 7%.[JBr3]

14 For the material from each mixing plant a pair of cores shall be taken every 250 metres laid, centred 100 mm from the final joint position at any unsupported edge and the air void shall be determined in accordance with BS 594987, clause 9.5.1.3.

15 The average in situ void content for each of these pairs shall not exceed 9%.[JBr4]

16 In the event of non-conformity with sub-Clauses 13 or 15 then density readings with indirect gauges and, if necessary, further cores shall be taken to establish the extent. If it is necessary to remove and replace any material to restore conformity, this shall be in lengths not less than 15 m unless otherwise agreed by the Overseeing Organisation.

17 Each core extracted shall be examined for evidence of excessive voids below the depth to which the indirect density gauge penetrates. If excessive voids are observed, further cores shall be taken to determine its extent.

18 Two copies of the final indirect density test results obtained and their correlation with in situ air void contents shall be passed to the Overseeing Organisation within 72 hours.

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Terms and Definitions

2 For the purposes of this Clause the terms and definitions given in BS 6100 shall apply, together with the following.

Maximum Density: Mass per unit volume, without air voids, of a bituminous mixture at known test temperature.

Dry Bulk Density: Mass per unit volume, including the air voids, of a specimen at known test temperature.

Saturation before Conditioning: The saturation of the mixture, determined as the calculated percentage of air voids filled with water after partial vacuum saturation, prior to conditioning as described in this Clause.

Unconditioned Stiffness: The stiffness modulus of the mixture as determined in accordance with BS EN 12697-26, Annex C, prior to conditioning as described in this Clause.

Conditioned Stiffness: The stiffness modulus of the mixture as determined in accordance with BS EN 12697-26, Annex C, after conditioning as described in this Clause.

Stiffness Ratio: The ratio of the conditioned stiffness to the unconditioned stiffness

Saturation after Conditioning: The saturation of the mixture, determined as the calculated percentage of air voids filled with water after conditioning as described in this Clause.

Principle of Test

3 Nominally identical test specimens are subjected to moisture saturation by using a vacuum system. They are then transferred into a pressurised vessel partially filled with water, where they are subjected to a conditioning procedure at 85°C temperature and 2.1 MPa pressure for 65 hours. The stiffness ratios of the individual specimens situated above the water are averaged to determine the sensitivity of the material to ageing and moisture. The whole process is referred to as the Saturation Ageing Tensile Stiffness (SATS) test. The average stiffness ratio is the SATS Durability Index of the mix components.

Materials

The following materials shall be used:

Distilled water (or water of equivalent purity), freshly de-aired and cooled.

Self-adhesive aluminium foil: Capable of adhering to and covering the specimen with an impervious coating.

Absorbent paper towelling.

Test Apparatus

5 The following test apparatus as shown in Figures 9/2 to 9/4 shall be used:

Vacuum desiccator and vacuum pump, including manometer or calibrated vacuum gauge as described in BS EN 12697-5.

Balance with sufficient capacity and accurate to 1.0g.

Pressure Vessel having the form and dimensions specified in Figure 9/2, similar to that described in BS EN 14769, and of sufficient capacity to accommodate 5 test specimens, of dimensions as described in sub-Clause 6 of this Clause, for a full test.

Test equipment capable of performing the Indirect Tensile Stiffness Modulus (ITSM) test on compacted bituminous mixture specimens in accordance with BS EN 12697-26, Annex C.

Specimen tray, having the form and dimensions specified in Figure 9/3, to accommodate 5 test specimens for a full test. The tray shall sit in the pressure vessel on top of a porous disc as shown in Figure 9/4.

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Sample Preparation

6 Test specimens shall be cores of 100 +0, -5 mm diameter and 60 ± 5 mm thickness. Specimens shall be cored from a slab manufactured using a laboratory roller compactor in accordance with BS EN 12697-33 to a void content of 8% ± 2%. The slab shall be produced using the recipe for the bituminous mixture to be tested except that a standard 10/20 penetration grade binder complying with TRL Report TRL 636 Annex A shall be substituted. Five nominally identical specimens are required for the full test. The cores shall be obtained by sawing approximately equal amounts from each end of the core taken from the slab which should be approximately 100 mm thick.

Procedure

7 The maximum density of the bituminous mixture under test shall be determined as described in BS EN 12697-5.

8 The dry bulk density of each compacted specimen shall be determined as described in BS EN 12697-6, Procedure C; self-adhesive aluminium foil shall be used to seal the specimen during immersion. Remove the foil after the test.

9 The air voids of each specimen shall be calculated as described in sub-Clause 22. Any specimen whose calculated air voids are outside the range 8 ± 2% shall be rejected and replaced with further samples of suitable void content.

10 The unconditioned (initial) stiffness modulus shall be determined at 20 ± 0.5°C in the Nottingham Asphalt Tester (NAT). Designate this as ITSMU.

11 Determine the dry mass of each specimen using the balance and designate this as Md.

12 The specimens shall be partially saturated by placing them in the vacuum desiccator and covering them with distilled water at 20 ±1°C. After sealing the apparatus, a vacuum shall be applied such that a residual pressure of between 40 and 70 kPa is reached in the vacuum desicator within 60 seconds. The residual pressure of between 40 and 70 kPa shall be maintained for 30 ± 2 minutes.

13 Remove each specimen from the vacuum desiccator, remove any water on its surface using the absorbent paper towelling and determine its wet mass. Designate this as Mw. The percent saturation (S) shall be determined as described in sub-Clause 23. Any specimens whose

calculated saturation is greater than or equal to 80% shall be rejected and replaced with a core with a saturation of less than 80%.

14 Partly fill the pressure vessel with water. The water level shall be between the 4th and 5th specimen after loading the samples, as shown in Figure 9/4. Freshly distilled water only shall be used (do not re-use). The vessel and water shall be controlled to the target temperature for at least 2 hours before the conditioning procedure commences.

15 The specimens shall be placed into the vessel, using the specimen tray which shall be centrally placed in the chamber of the vessel, the cover closed and the pressure gradually increased from atmospheric pressure to 2.1 MPa over a period of 20 minutes. The conditioning procedure shall then be performed, as described in BS EN 14769, at 2.1 ± 0.1 MPa pressure and the target temperature of 85 ± 1°C for 65 ± 1h.

16 After the test period of 65 h has elapsed, adjust the target temperature to 30ºC. Leave the vessel for approximately a further 24 h to cool to the adjusted temperature of 30ºC. Do not release the pressure.

17 When the pressure vessel display temperature has reduced to 30ºC (i.e., after the 24 h cooling period), the heater shall be turned off and the pressure shall be slowly released from the vessel. The pressure release mechanism shall be adjusted so that the pressure returns to atmospheric pressure over a period of 20 to 30 minutes (linear reduction). The cover shall then be opened and all the specimens extracted, on the tray, from the vessel.

18 Each specimen shall be surface dried using the absorbent paper towelling, and its wet mass measured within 3 minutes of removing the specimens from the pressure vessel. Designate this mass as M_{w2}. The saturation after the conditioning procedure (S_a) shall be calculated as described in sub-Clause 24.

19 The specimens shall be observed for any visual cracks and unusual appearance (eg. colour of binder or aggregates). Record any comments as appropriate.

20 The specimens shall be placed into the ITSM cabinet or other suitable temperature controlled conditioning environment at 20 ± 0.5°C in preparation for ITSM testing, as described in BS EN 12697-26, Annex C.

21 The stiffness modulus shall be determined as described in BS EN 12697-26, Annex C within 8h after turning off the heater on the pressure vessel. Designate this as $ITSM_C$.

Calculation and Expression of Results

Dry Bulk Density and Calculated Air Voids

22 Calculate the dry bulk density of each specimen (in Mg/m^3) as follows:

$$\text{Dry Bulk Density } (G_{mb}) = \frac{A}{(B-C)-(\frac{B-A}{D})}$$

where:

A = the mass of the dry specimen in air (in g)

B = the mass of the coated specimen in air (in g)

C = the mass of the coated specimen in water (in g)

D = the density* of the self-adhesive aluminium foil in Mg/m³

** The material described in sub-Clause 4 (ii) has been found to have a typical density of 1.650Mg/m³*

The specimen dry bulk density shall be expressed to the nearest 0.001 Mg/m³

The air voids of each specimen (in %) shall be calculated as follows:

$$\text{Air Voids} = \frac{G_{mm}-G_{mb}}{G_{mm}} \times 100$$

where:

G_{mm} is the maximum density determined in accordance with BS EN 12697-5

G_{mb} is the dry bulk density determined in accordance with BS EN 12697-6, Procedure C.

The calculated air voids shall be expressed to the nearest 0.1%.

Saturation before Conditioning

23 Calculate the saturation before conditioning as follows:

$$S = \frac{M_w - M_d}{\frac{M_d}{G_{mb}} - \frac{M_d}{G_{mm}}} \times 100$$

where:

S = percent saturation before conditioning
M_d = mass of dry specimen, g
M_w = mass of wet specimen, g
G_{mb} = dry bulk density and

G_{mm} = maximum density

The saturation before conditioning shall be expressed to the nearest 1%.

Saturation after Conditioning

24 Calculate the saturation after conditioning as follows:

$$S_a = \frac{M_{w2} - M_d}{\frac{M_d}{G_{mb}} - \frac{M_d}{G_{mm}}} \times 100$$

where:

S_a = percent saturation after conditioning
M_d = mass of dry specimen, g
M_{w2} = mass of wet specimen (g) after conditioning
G_{mb} = dry bulk density and
G_{mm} = maximum density

The saturation after conditioning shall be expressed to the nearest 1%.

Stiffness Ratio

25 Calculate the stiffness ratio as follows:

$$ITSM_R = \frac{ITSM_C}{ITSM_U}$$

where:

$ITSM_R$ = stiffness ratio,
$ITSM_C$ = conditioned stiffness
$ITSM_U$ = unconditioned stiffness

The stiffness ratio shall be expressed to the nearest 0.01.

Test Report

26 The test report shall contain not less than the following information:

Name of laboratory carrying out the test.
Date of test.
Unique reference.
A reference to this test method and test conditions.
Maximum density of the mixture tested, to the nearest 0.001 Mg/m³.
For each specimen tested, report:
Dry bulk density (G_{mb}), to the nearest 0.001 Mg/m³.
Per cent air voids (V_v), to the nearest 0.1%.
Per cent saturation (S) before conditioning, to the nearest 1%.
Per cent saturation after conditioning, (S_a), to the nearest 1%.
Unconditioned stiffness ($ITSM_U$) to the nearest 100 MPa.
Conditioned stiffness ($ITSM_C$) to the nearest 100 MPa.
Stiffness ratio ($ITSM_R$), to the nearest 0.01.
Any cracks or unusual appearance.
For the mixture tested, the stiffness ratio of the four individual specimens above the water shall be averaged and the average value reported.
To support ongoing research, the stiffness ratio of the individual specimens tested shall also be plotted against the corresponding saturation value after conditioning. The graph shall have linear axes for stiffness ratio (y axis) and saturation after conditioning (x axis). The scales of the graph shall cover a range of stiffness ratio of at least 0-1.0 and of saturation after conditioning of 0-100%.

27 The test report and graph, uniquely identified, shall be provided to the Overseeing Organisation with the Contractor's Proposal.

1 (08/08) This Clause describes the test method for the determination of the Complex Shear (Stiffness) Modulus (G*) and Phase Angle (δ) of a bituminous binder over a range of temperatures and frequencies when tested in harmonic, sinusoidal oscillatory shear mode using a dynamic shear rheometer (DSR) with parallel plate test geometry and where both plates are controlled at the same temperature. Two methods are described. The first is the conventional equilibrated temperature method using frequency sweeps and is detailed in the Institute of Petroleum (IP) test method IP PM CM/02 and with the amendments stated in this Clause shall be used for Type Approval (type testing) purposes. The second is the temperature sweep method, where the temperature of the binder is raised at a known rate and tested at a fixed frequency. The second test, which requires less time to perform, may be used for quality control purposes.

2 (08/08) This Clause is applicable to unmodified and polymer modified binder as supplied, after the Rolling Thin Film Oven Test (RTFOT), after an Ageing Test or as recovered from a mixture. Bituminous binders containing fine mineral or organic matter or fibres may also be tested. For cutback bitumens, bituminous

emulsions and polymer variants the binder shall be sampled from the delivery and a recovered binder prepared in accordance with Clause 955.

(08/08) Definitions

3 (08/08) For the purposes of this Clause the following definitions apply:

Complex Shear Modulus (G*) (sometimes referred to as Complex Stiffness Modulus): ratio of peak stress to peak strain in harmonic, sinusoidal oscillation mode.

Phase Angle (δ): the phase difference between stress and strain in harmonic, sinusoidal oscillation mode.

Isotherm: an equation or curve on a graph representing the behaviour of the material at a constant temperature.

Linear region is defined as the range of strain over which the strain is directly proportional to the applied stress.

High Equi-stiffness Temperature (T_{2kPa}): the temperature at which G* is equal to 2 kPa at 0.4 Hz determined from the plot of G* vs. temperature.

Low Equi-stiffness Temperature (T_{2MPa}): the temperature at which G* is equal to 2 MPa at 0.4 Hz determined from the plot of G* vs. temperature.

$G^*_{(pen)}$: the Complex Stiffness Modulus at 25°C and frequency 0.4 Hz.

$\delta_{(low)}$: the Phase Angle from the temperature equilibrated data at 5°C and at a frequency of 0.4 Hz.

$\delta_{(high)}$: the Phase Angle from the temperature equilibrated data at 60°C and at a frequency of 0.4 Hz.

Black Diagram: a graph of the magnitude of G* against δ.

Zero-Shear-Viscosity: the limiting value of viscosity of a visco-elastic liquid at a given temperature and a very low shear rate such that the material in deforming does not build up any structural changes and maintains equilibrium in the linear region.

(08/08) Apparatus

4 (08/08) The apparatus for the test is detailed in IP PM CM/02. The rheometer and the temperature control system shall be calibrated and traceable to national standards, where applicable, at intervals not exceeding 13 months.

(08/08) Determination of Complex Shear (Stiffness), Modulus (G*) and Phase Angle (δ)

5 (08/08) Determination of G* and δ for binders used to manufacture products at temperatures above 120°C (for example asphalt) shall be as described in the IP method, except that the target strain shall be set within the range 0.005 and 0.02 and the sample preparation shall be Method A. For binders used at lower temperatures such as bituminous emulsions, or where volatile flux oil is present (for example cutback bitumen), the maximum 100°C and preferably less than 85°C. The IP Method shall be amended as follows:

(08/08) Method for Emulsions and Cutbacks:

Sample preparation: Warm the recovered binder obtained using Clause 955 sufficiently to be able to remove small quantities from the bulk using a suitable spatula or other tool (A temperature around the softening point or the High Equi-stiffness Temperature (T_{2kPa}°C) is usually found to be suitable). The binder shall not be heated above 100°C and not stored for longer than 1 hour at the target temperature. The binder shall be sealed with silicone release paper and/or metal foil to minimise ageing and loss of volatiles.

Sample loading: Weigh a pre-calculated amount of binder, to suit the geometry, directly onto one of the rheometer plates or onto a silicone-based material for subsequent transfer to one of the plates. The time for transfer shall be recorded.

Sample gapping: The plates shall be at the same temperature prior to setting the gap. The required gap shall be set immediately and no trimming is required.

Allow the sample and both plates to equilibrate at a temperature above the softening point or T_{2kPa}°C for at least 15 minutes prior to commencement of the test.

If the recovered binder is heavily modified such that the elastic properties prevent normal loading of the sample then a higher temperature shall be selected as near to 100°C as possible and this shall be reported in the test report.

(08/08) Data Acceptability Criteria

7 (08/08) The acceptability criteria detailed in the IP Method shall be used for different test geometries or for at least two samples.

8 (08/08) If the acceptability criteria are not met for two samples then a third verification test shall be carried out, the shortened procedure may be used (25°C and frequency sweep) for the second and subsequent samples. If the acceptability criteria are met for the first and third tests, the results of the first test shall be accepted. If the acceptability criteria are met for the second and third tests, discard the results for the first test and continue testing the third sample by the full procedure used for the first sample, these results are verified by the second test. If none of the three tests are within the acceptability criteria then the mean of the results obtained in two full tests shall be reported with a note that the acceptability criteria could not be met.

(08/08) Temperature Sweep Test Procedure for

Quality Control

9 (08/08) After equilibration of the sample above the softening point or the High Equi-stiffness Temperature (T_{2kPa}°C) for at least 15 minutes a temperature sweep shall be carried out from the lowest test temperature to at least 60°C or T_{2kPa}°C whichever is the higher. The test frequency shall be 0.4 Hz (± 0.04 Hz). G* and Phase Angle (δ) shall be measured at temperature intervals not greater than 5.5°C. The rate of temperature increase shall be 2.5 °C per minute or a lesser-fixed rate, which shall be stated with tolerances (not greater than ± 0.5 °C).

10 (08/08) The plot of G* and Phase Angle (δ) against temperature may be used to compare a sample with a type test for the product by the equilibrated temperature method. If the value for G* is within ± 30% and Phase Angle (δ) within ± 10 degrees at 25°C then the data is deemed to be valid for comparison. If not, then a second sample shall be tested, if the values for G* are within ± 30% and Phase Angle (δ) are within ± 10 degrees for 90% of the results for the first test the data is deemed to be valid and different to the type test. If the supplier has reasoned that higher tolerances are necessary for the particular product at Type Approval (type testing) stage these shall be used instead for comparison. The supplier may also state the sample preparation technique to be used for this comparison.

11 (08/08) Alternatively the equilibrated temperature data from frequency sweeps (the IP method) may be used, although the number of equilibrated temperature tests at 0.4 Hz will need to be increased (5°C intervals).

12 (08/08) If required the temperature sweep shall be carried out with a reducing temperature from 80°C to the lowest test temperature in addition to the normal test, this shall be noted in the test report.

(08/08) Expression of Results

13 (08/08) A table of results, based on the individual test results, shall be produced which shall include the following information at each temperature:

Test temperature ºC.

Test frequency Hz.

Strain %.

Phase Angle (δ) Degrees.

Complex Stiffness Modulus (G*) Pascals.

14 (08/08) A graph of G* against temperature shall be produced, in decades from 101 to 108 Pa as a curve at 0.4 Hz ± 0.04 Hz with a linear temperature x-axis of -10°C to 90°C.

15 (08/08) A graph of Phase Angle (δ) against temperature shall be produced from 20 to 90 degrees ascending with a linear temperature x-axis of -10°C to 90°C at a frequency of 0.4 Hz ± 0.04 Hz.

16 (08/08) A graph of G* against Phase Angle (δ) (Black Diagram) shall be produced in decades from 101 to 108 Pa with a linear x-axis of 90 to 20 degrees descending.

17 (08/08) Plots of isotherms for G* against frequency tested at each test temperature shall be produced in decades from 101 to 108 Pa with an x-axis in decades of frequency from 10-2 Hz to 101 Hz.

18 (08/08) Plots of isotherms for Phase Angle (δ) against frequency tested at each test temperature shall be produced from 20 to 90 degrees with an x-axis in decades of frequency from 10-2 Hz to 101 Hz.

19 (08/08) The x-axes of the graphs shall have dimensions of at least 200 mm and the y-axes at least 150 mm.

20 (08/08) The following test values shall be reported:

T_{2kPa}: the High Equi-stiffness temperature.

T_{2Mpa}: the Low Equi-stiffness temperature.

$G^*_{(5°C)}$: the value of G* at the equilibrated temperature of 5°C and 0.4 Hz.

$G^*_{(pen)}$: the value of G* at the equilibrated temperature of 25°C and 0.4 Hz.

$G^*_{(60°C)}$: the value of G* at the equilibrated temperature of 60°C and 0.4 Hz.

$\delta_{(low)}$: the value of δ at low temperature 5°C and loading time of 0.4 Hz.

$\delta_{(high)}$: the value of δ at high temperature 60°C and loading time of 0.4 Hz.

Zero-Shear-Viscosity at 45°C (ZSV_{45}) and 60°C (ZSV_{60}) calculated from the procedure outlined in a paper by Baumgaertel, M. and Winter, H.H., "Determination of discrete relaxation and retardation time spectra from dynamic mechanical data", Rheol Acta 28:511-519 (1989) or equivalent method with procedure outlined.

The complex stiffness modulus (G*) shall be reported to three significant figures, phase angle to the nearest 0.1 of a degree and temperature to 0.1 °C.

(08/08) Test Report

21 (08/08) The test report shall contain at least the following information:

A reference to this test procedure.

Place of test.

The rheometer type, model and test geometries (plates and gaps) used.

The compliance limitations of the machine/ geometry (including whether software corrections have been applied in terms of the maximum sample stiffness at which the result

reported will be in error by less than 10%). The limitations shall be reported for each plate geometry used to obtain the results reported.

The type and identification of the product tested.

Sample thermal history: how, when and where the sample was taken; the size of the sample and whether it was sub-divided; the period it was stored and the conditions of storage; and whether it was treated by RTFOT and/or Ageing Test or was a recovered binder from emulsion or cutback in accordance with Clause 955, or recovered from an asphalt, with the recovery test method detailed.

Strain conditions of the test at 25°C and 0.4 impact of the pendulum. The determination shall be Hz and at the extremes of the temperature performed at not less than six different temperatures

and frequency ranges used to provide data. covering the range over which the binder has a cohesion

Sample loading method, temperature and time for transfer.

Frequency sweep direction for the IP method.

Temperature sweep direction for the method if used and target rate of change with tolerances.

The results of the test as set out under this Clause.

Whether the Data Acceptability Criteria in this Clause were met.

Any deviation, by agreement, or otherwise, from the procedure specified.

Date of test.

Name of the person responsible for the test.

22 (08/08) The test report and graphs, uniquely identified shall be provided to the Overseeing Organisation with the Contractor's Proposal.

23 (08/08) A copy of the data in digital format suitable for graphical production shall be provided to the Overseeing Organisa

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This Clause specifies the procedure for obtaining a quantity of 'Recovered Binder' from modified or unmodified cutback or emulsion binder (Rapid Recovery Test - RRT) and an extended procedure for obtaining a quantity of 'Aged Binder' (Modified Ageing Rolling Thin Film Oven Test). 'Aged Binder' may be prepared directly from 'Recovered Binder' or from other binder samples. Binders used to manufacture hot mix asphalt are first subjected to a 'short term ageing test' (RTFOT) to simulate the effects of manufacture, transport and laying. The Modified Ageing RTFOT is suitable for all bituminous binders and rapidly provides homogeneous samples at different ages so that a plot of a relevant characteristic with ageing may be generated.

Definitions

2 For the purposes of the procedure specified in this Clause, 'Recovered Binder' shall be defined as: the material remaining after treatment of the original product under the conditions specified by the Rapid Recovery Test method (RRT). 'Aged Binder' shall be defined as: the material remaining after the Ageing protocol specified by the Modified Ageing RTFOT method.

Principle of the Rapid Recovery test (RRT) for Bituminous Emulsions, Cutbacks or Fluxed Binders - polymer modified or unmodified

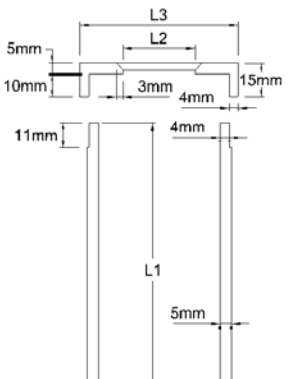
3 (08/08) A thin film of binder is rotated in polytetrafluoroethylene bottles using the rolling thin film oven test apparatus (RTFOT), as described in BS EN 12607-1, to evaporate water from bituminous emulsion and/or the light solvent or highly volatile fraction from cutback, fluxed or other binder. Special screws are used to disturb the binder and maintain a homogenous material during breaking and/or curing. Nitrogen gas instead of air is jetted over the film of emulsion, cutback or fluxed binder and a lower
temperature is used in order to minimise ageing effects and simulate the condition of the binder soon after application (it is assumed that these binders when used are not subjected to the high temperature mixing associated with an asphalt plant where the appropriate test is the RTFOT using air at 163ºC).

Test Apparatus

The following test apparatus shall be used:

(i) RTFOT apparatus to BS EN 12607-1.

(ii) Eight identifiable bottles manufactured from polytetrafluoroethylene (PTFE) with threaded screw top lid (or other fixing system) with internal dimensions and aperture diameter (L2) as shown below:



Bottle dimensions	
L1	129 ± 1.2 mm
L2	31.75 ± 1.2 mm

L3	70 ± 1.2 mm
L4	64.0 ± 1.2 mm
Note: All other dimensions are approximate.	

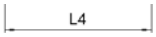


Figure 9/8: PTFE bottle

The taper in throat is 45^{o}+ 5^{o}

(iii) Eight screws manufactured from high quality stainless steel (surgical quality) complying with BS EN 10088-3, designation 1.4404 to a 'fine machined finish'. All screws shall have dimensions: diameter 12.2 mm ± 0.2 mm and length 120 mm ± 0.5 mm and have between 20 and 21 turns with a pitch of 6 mm ± 0.2 mm. The depth of cut shall be 2 mm ± 0.2 mm with a semi-circular profile - see photograph. The minimum weight of a screw shall be 70 g. The direction of screw shall be such that the binder sample is drawn to the closed end of the bottle when the bottle containing the screw is rotated in the carousel.

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Figure 9/9: Screw

(iv) A spatula for removing the binder from the bottle (a flat blade or paddle shape, see photograph, has been found suitable).

Figure 9/10: Spatula

(v) A balance accurate to 0.05 g.

(vi) A timer capable of timing 100 minutes, accurate to

1 second in five minutes and for the Modified Ageing RTFOT a timer capable of timing 25 hours to the same accuracy.

(vii) Nitrogen gas supply and air supply.

(viii) An oven to pre-heat the bottles to the maximum

storage temperature of the binder (for example 140ºC ± 5ºC for cutback surface dressing binders).

(ix) A microwave oven of medium power to remove

final traces of water from emulsion binders (650 watts has been found to be suitable).

Test Procedure for Recovery of Bituminous

Emulsion, Cutback and Fluxed Binders

5 The test procedure for 'Recovery' of bituminous binders shall be as follows:

The RTFOT oven shall be set to maintain a temperature of 85ºC ± 2ºC and the oven temperature allowed to stabilise.

The PTFE bottles (including lids) with stainless steel screws, shall each be weighed to 0.1 g and pre-heated in an oven to 85ºC ± 2ºC.

The binder sample shall be freshly decanted from the thoroughly stirred main sample, which shall have been sampled in accordance with 'BS EN 58'. The temperature of the binder sample shall not be less than 70% of the normal application temperature in degrees Celsius and shall be recorded (for example high binder content surface dressing emulsion may require a minimum of 60ºC or a polymer modified cutback binder 130ºC). The sample history if known shall be recorded.

Any sub-sample, which shall be not less than 250 ml, shall be thoroughly stirred to ensure homogeneity immediately prior to decanting into the bottles, taking care to minimise loss of water content and/or any volatile oil. Gentle heating may be necessary to a maximum of the normal application temperature in order to obtain a homogenous sample.

19 g ± 0.5 g of binder sample shall be weighed out into each pre-heated bottle with screw. The weight of each bottle with screw and binder shall be recorded to 0.1 g.

Immediately after weighing the bottles with screws and binder sample they shall be rolled on the bench to ensure distribution of the binder round the bottle before mounting in the carousel of the pre-heated RTFOT apparatus.

Rotate the carousel with the nitrogen gas supply jet switched on, set up and calibrated as detailed in BS EN 12607-1. Nitrogen gas flow shall be

4,000 ± 200 ml/min. Start the timer.

The period between weighing the bottles with binder and mounting of all the bottles and the start of the rotation of the carousel shall not exceed 20 minutes.

After 75 minutes ± 1 minute the rotating carousel shall be stopped and the time shall be noted.

Establishing the microwave Heating procedure for bituminous Emulsions only (not needed if proceeding to the modified ageing RtFot without sampling)

Remove two bottles with their screws and binder from the carousel, weigh them and record the weight loss to 0.1 g. Remove the screw from a bottle and return as much as possible of the binder sample clinging to the screw back into the bottle. The lids may need to be removed and replaced. Re-weigh the bottles. Place the two bottles with the binder sample and any reclaimed binder sample from their respective screws in the microwave oven together with a glass beaker containing water as a heat sink (around 200 ml has been found to be suitable to prevent spitting and overheating of the sample) and set a cycle time (two minutes has been found to be suitable in a medium power microwave). The cycle time shall be such that the temperature of the sample does not exceed 90ºC as measured at the end of each cycle. After heating, re-weigh and record the weight loss as before. The time taken to

weigh the bottles after the first cycle shall be recorded as the 'rest period' and used between further cycles (generally about two minutes). Cycles shall be repeated until the recorded weight loss is within 0.05 g of that of the previous cycle (generally just one or two cycles are

required). Report the average percentage binder weight loss to 0.2%. Record the number of cycles and cycle time. The individual results shall be within 2.0% of the mean or the test repeated.

If the binder sample has been shown to possess a high flash point (greater than any localised temperature experienced in the test) and/or the screws are used in such a way as to minimise any risk of sparking or arcing (electrical discharge) then the screws may be left in the bottles during the microwave heating procedure.

Except where the bottles are to be subsequently used for the Modified Ageing RTFOT, remove the other six bottles from the carousel. Repeat the procedure as for the two bottles using the same rest period, but with one cycle time less. If an estimate of binder content is needed then record the weight loss to 0.1 g.

The whole of this procedure shall not exceed 30 minutes. If more binder from the same main sample is to be 'Recovered' then the procedure to establish the cycle time need not be repeated unless significant changes to the binder in storage are expected (for example the water content may change).

Note: It has been found to be advantageous to place the bottles on their sides in the microwave oven. This allows the binder to drain collecting to one side of the bottle, which is more easily removed with the scraper.

Test procedure for Recovery of bituminous Emulsion, Cutback and Fluxed binders (continued)

The weight loss after 'Recovery' shall be recorded by weighing two bottles.

The 'Recovered Binder' shall be scraped from the bottles and screws.

Unless the 'Recovered Binder' is to be treated by the Modified Ageing RTFOT it shall be transferred, before it cools to ambient, to other test apparatus such as a Dynamic Shear Rheometer (Clause 956) or Vialit Cohesion Pendulum Tester (Clause 957), in order to minimise further changes to the binder.

If the 'Recovered Binder' is to be stored or transferred to another location for testing, it shall be placed on a silicone sheet or in a warmed penetration pot (at a temperature not greater than 90ºC) and the binder surface sealed using aluminium foil or other suitable material to prevent further loss of volatiles and minimise exposure to air. 'Recovered Binder' shall be stored at a temperature of between 0ºC and 5ºC.

During transfer 'Recovered' samples shall not be subjected to temperatures greater than ambient and the delay before testing shall not exceed 120 hours.

The thermal history shall be recorded.

Modified ageing Rolling thin Film oven test

(RTFOT)

Principle of the Modified Ageing RTFOT

6 (08/08) A thin film of binder is rotated in bottles using the rolling thin film oven test apparatus, as described in BS EN 12607-1. Special screws are used to disturb the binder and maintain a homogenous material during 'Ageing'. Air is jetted over the film of binder for a much longer period than in the conventional test and a lower temperature used in order to simulate the 'ageing' of the binder in the road after application. The binder tested may be 'Recovered Binder', or Binder after RTFOT, either using the procedure detailed in this Clause or BS EN 12607-1, or other binder sample.

The Modified Ageing RTFOT shall be carried out as follows:

Bituminous Emulsion, Cutback and Fluxed binders

Stabilising

The bottles containing the samples after the Rapid Recovery Test, with screws remaining, shall be treated in the Modified Ageing RTFOT maintaining a temperature of (135ºC ± 2ºC) with the same nitrogen gas supply at 4,000 ± 200 ml/min. After 1 hour ± 5mins two bottles shall be removed and shall be weighed to 0.1g. If the weight loss is less than 2.0% of the 'Recovered Binder' then the ageing protocol shall commence by switching to an air supply at 4,000 ± 200 ml/min. If not then the bottles shall be placed back in the carousel with the nitrogen supply maintained and the weight loss recorded for these two bottles after each hour until the weight loss has stabilised to less than 2.0% of the previous binder weight.

If the same binder from the same main sample is to be 'Stabilised' after 'Recovery' then the procedure to establish the stabilising time need not be repeated unless there are expected significant changes to the binder sample in storage.

Ageing

The samples shall be rotated in the air supply and two bottles removed if required for testing after three periods: 3hrs ± 10mins; 8hrs ± 10mins; and 22hrs ± 10mins.

The bottles and screws shall be scraped to transfer the binder samples to the appropriate test equipment or, if required to be used later, placed on a silicone sheet, or in a penetration pot, and sealed and stored at between 0ºC to 5ºC. 'Aged Binder' is deemed to be the sample from the 8 hr period.

The combined test may be run continuously without interruption from the beginning of the Rapid Recovery Test, except for change in temperature and changeover from nitrogen gas to air supply and any 'Recovered Binder' samples removed for testing.

For the continuous treatment of samples (combined test) there is no need for the microwave procedure to be used.

Binders for Manufacturing Asphalt or other Hot Mixed Materials

The initial conditioning test is to simulate the changes to the properties of the binder caused by the high temperatures during manufacture, transport and laying. The screws accelerate the process, and are necessary to maintain a homogeneous material especially when testing polymer modified binders, which tend to form a skin and separate into phases.

The standard 'short term ageing test' RTFOT shall be carried out in accordance with BS EN 12607-1, at the same test temperature of 163ºC but with the following exceptions: a test time of 45 mins ± 1 min; PTFE bottles with screws inserted shall replace the glass bottles; 19 g ± 0.5 g of binder shall be weighed out into each preheated bottle; weighing of bottles to determine weight loss shall be carried out within 2 mins of removal from the carousel without the need to be placed in a desiccator; and bottles and screws shall be scraped to remove the 'short term aged binder'.

The RTFOT treated binder shall be tested for weight change by removing two of the bottles and weighing within 2 mins ± 1 min. If required for testing the 'short term aged binder' shall be removed by scraping and transferred to the appropriate test equipment or, if required to be used later, placed on a silicone sheet, or in a heated penetration pot (maximum 170ºC), and sealed and stored at between 0ºC to 5ºC.

The remaining samples shall then be subjected to the Modified Aging RTFOT.

The temperature is reduced/set to (135ºC ± 2ºC) and the Modified Ageing RTFOT carried out:

The air supply shall be set at 4,000 ± 200 ml/min.

Start the timer.

The samples shall be rotated in the air supply and two bottles removed if required for testing after three periods: 4 hrs ± 10 mins; 8 hrs ± 10 mins; and 22 hrs ± 10 mins.

Note: It has been found to be advantageous to place the bottles on their sides. This allows the binder to drain to one side of the bottle, which is more easily removed with the scraper.

The bottles and screws shall be scraped to transfer the binder to the appropriate test equipment or, if required to be used later, placed on a silicone sheet, or in a heated penetration pot (maximum 170ºC), and sealed and stored at between 0ºC to 5ºC.

'Aged Binder' is deemed to be the sample from the 8 hr period.

The combined test may be run continuously without interruption from the beginning, except for the reduction in temperature after 45 mins from 163ºC to 135ºC and at that time removal of bottles for test after RTFOT if required.

During transfer 'Aged' samples shall not be subjected to temperatures greater than ambient and the delay before testing shall not exceed 120 hours.

The thermal history of the sample shall be recor