Méthode d'analyse des mélanges bitumineux

Gouvernement du Québec
Ministère des Transports

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Direction de la recherche et du contrôle

INTRODUCTION

Le présent cahier contient une photocopie des méthodes d'essais ASTM concernant les mélanges bitumineux. En outre, les plus récentes modifications apportées à ces normes par le Laboratoire Central sont présentées avant chacune des normes. Ces modifications s'ajoutent ou remplacent celles déjà publiées dans le livre "Analyse des Mélanges Bitumineux au Québec" dont des extraits sont présentés à chacune des méthodes respectivement.

Les méthodes photocopiées sont tirées du volume 15-1978 de l'ASTM.

C-127-77	Densité et absorption du gros granulat
C-128-73	Densité et absorption du petit granulat
C-136-73	Analyse au tamis du petit et du gros granulat
D-75-71	Echantillonnage de granulats
D-140-70	Echantillonnage de produits bitumineux
D-979-74	Echantillonnage de revêtements bitumineux
D-1559-76	Compactage, Stabilité Marshall et déformation
D-2041-78	Densité théorique maximale d'un mélange bitumineux
D-2172-75	Extraction du bitume d'un mélange bitumineux
D-2489-67	Degré d'enrobement des granulats d'un mélange bitumineux
D-2726-73	Densité bulk d'un mélange bitumineux compacté (saturé - surface sèche)
D-3203-75	% d'air dans un mélange bitumineux compacté
E-11-70	Spécifications sur les tamis servant aux essais
	Récupération du bitume: Méthode de la ville de Montréal et Méthode ASTM D-1856-75 (Abson)
	Calcul d'un mélange: Méthode du Laboratoire Central et méthode de l'Asphalt Institute
	Retention de bitume: Méthode du Laboratoire Central

Ces méthodes d'essais et leurs modifications sont celles en vigueur au Ministère des Transports du Québec. Elles ont été groupées dans un cahier afin de faciliter la tâche de ceux qui analysent les mélanges bitumineux.

Toute personne utilisant ces méthodes d'essais et leurs modifications, qui aurait des commentaires ou des suggestions de corrections, est priée de les faire parvenir par écrit à:

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Ce dernier, étant membre du comité D-04 de l'ASTM qui traite de ces méthodes d'essais, pourra alors en faire part et leur validité y sera ainsi discutée.

C 127

AMERICAN NATIONAL STANDARD **ANSI/ASTM C 127 - 77**

Standard Test Method for

SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE[1]

This Standard is issued under the fixed designation C 127; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the determination of bulk and apparent specific gravity, 73.4/73.4 F (23/23 C), and absorption of coarse aggregate. Bulk specific gravity is the characteristic generally used for calculations of the volume occupied by the aggregate in portland-cement concrete.

1.2 This method determines (after 24 h in water) the bulk specific gravity and the apparent specific gravity as defined in Definitions E 12, the bulk specific gravity on the basis of weight of saturated surface-dry aggregate, and the absorption as defined in Definitions C 125.

2. Applicable Documents

2.1 *ASTM Standards:*

C 125 Definitions of Terms Relating to Concrete and Concrete Aggregates[2]

C 670 Recommended Practice for Preparing Precision Statements for Test Methods for Construction Materials[2]

C 702 Reducing Field Samples of Aggregates to Testing Size[3]

E 12 Definitions of Terms Relating to Density and Specific Gravity of Solids, Liquids, and Gases[3]

Manual of Concrete Testing[3]

3. Apparatus

3.1 *Balance*—A weighing device having a capacity of 5 kg or more, as required for the sample size selected; sensitive and readable to 0.5 g or 0.0001 times the sample weight, whichever is greater; and accurate within 0.1 percent of the test load at any point within the range used for this test. Within any 500-g range of test load, a difference between readings shall be accurate within 0.5 g or 0.0001 times the sample weight, whichever is greater.

3.2 *Sample Container*—A wire basket of No. 6 (3-mm), or finer mesh, or a bucket, of approximately equal breadth and height, with a capacity of 4000 to 7000 cm^3 for 1½ in. (38.1 mm) nominal maximum size aggregate or smaller, and a larger capacity container in the range from 8000 to 16000 cm^3 for the testing of large maximum size aggregate.

3.3 Suitable apparatus for suspending the sample container in water from the center of the scale pan or balance.

4. Test Specimen

4.1 Thoroughly mix the sample of aggregate to be tested and reduce it to the approximate quantity needed by use of a sample splitter or by quartering (Note 1). Reject all material passing a No. 4 (4.75-mm) sieve. In many instances it may be desirable to test a coarse aggregate in several separate size fractions; and if the sample contains more than 15 percent retained on the 1½-in. (38.1-mm) sieve, test the plus 1½ in. fraction or fractions separately from the smaller size fractions. The minimum weight of sample to be used is given below; when an aggregate is tested in separate size fractions, use the sample size corresponding to the nominal maximum size of each fraction:

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[1] This method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete.

Current edition approved Jan. 14, 1977. Published March 1977. Originally published as C 127 - 36 T. Last previous edition C 127 - 73.

[2] *Annual Book of ASTM Standards*, Parts 14 and 15.

[3] *Annual Book of ASTM Standards*, Part 14.

Nominal Maximum Size, in. (mm)	Minimum Weight of Sample, kg
½ (12.5) or less	2
¾ (19.0)	3
1 (25.0)	4
1½ (38.1)	5
2 (50)	8
2½ (63)	12
3 (75)	18
3½ (90)	25

NOTE 1—The process of quartering and the correct use of a sample splitter are discussed in the Manual of Concrete Testing and in Method C 702.

5. Procedure

5.1 After thoroughly washing to remove dust or other coatings from the surface of the particles, dry the sample to constant weight at a temperature of 212 to 230 F (100 to 110 C), cool in air at room temperature for 1 to 3 h, and then immerse in water at room temperature for a period of 24 ± 4h.

NOTE 2—Where the absorption and specific gravity values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirement for initial drying to constant weight may be eliminated, and, if the surfaces of the particles in the sample have been kept continuously wet until test, the 24-h soaking may also be eliminated. Values for absorption and for specific gravity in the saturated-surface-dry condition may be significantly higher for aggregate not oven dried before soaking than for the same aggregate treated in accordance with 5.1. Therefore, any exceptions to the procedure of 5.1 should be noted on reporting the results.

5.2 Remove the specimen from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually. Take care to avoid evaporation of water from aggregate pores during the operation of surface-drying. Weigh the specimen in the saturated surface-dry condition. Record this and all subsequent weights to the nearest 0.5 g or 0.0001 times the sample weight, whichever is greater.

5.3 After weighing, immediately place the saturated-surface-dry specimen in the sample container and determine its weight in water at 73.4 ± 3 F (23 ± 1.7 C), having a density of 0.997 ± 0.002 g/cm³. Take care to remove all entrapped air before weighing by shaking the container while immersed.

NOTE 3—The container should be immersed to a depth sufficient to cover it and the test specimen during weighing. Wire suspending the container should be of the smallest practical size to minimize any possible effects of a variable immersed length.

5.4 Dry the specimen to constant weight at a temperature of 212 to 230 F (100 to 110 C), cool in air at room temperature 1 to 3 h, and weigh.

6. Bulk Specific Gravity

6.1 Calculate the bulk specific gravity, 73.4/73.4 F (23/23 C), as defined in Definitions E 12, as follows:

$$\text{Bulk sp gr} = A/(B - C)$$

where:

A = weight of oven-dry specimen in air, g,
B = weight of saturated-surface-dry specimen in air, g, and
C = weight of saturated specimen in water, g.

7. Bulk Specific Gravity (Saturated-Surface-Dry Basis)

7.1 Calculate the bulk specific gravity, 73.4/73.4 F (23/23 C), on the basis of weight of saturated-surface-dry aggregate as follows:

$$\text{Bulk sp gr (saturated-surface-dry basis)} = B/(B - C)$$

8. Apparent Specific Gravity

8.1 Calculate the apparent specific gravity, 73.4/73.4 F (23/23 C), as defined in Definitions E 12, as follows:

$$\text{Apparent sp gr} = A/(A - C)$$

9. Absorption

9.1 Calculate the percentage of absorption, as defined in Definitions C 125, as follows:

$$\text{Absorption, percent} = [(B - A)/A] \times 100$$

10. Calculation of Average Values

10.1 When the sample is tested in separate size fractions the average value for bulk specific gravity, bulk specific gravity (saturated-surface-dry basis), or apparent specific gravity can be computed as the weighted average of the values as computed in accordance with Section 6, 7, or 8 using the following equation:

$$G = \cfrac{1}{\cfrac{P_1}{100\,G_1} + \cfrac{P_2}{100\,G_2} + \ldots \cfrac{P_n}{100\,G_n}}$$

(see Appendix X1)

where:

G = average specific gravity. Either bulk-dry, saturated-surface-dry, or apparent specific gravities can be averaged in this manner.

$G_1, G_2, \ldots G_n$ = appropriate specific gravity values for each size fraction depending on the type of specific gravity being averaged.

$P_1, P_2, \ldots P_n$ = weight percentages of each size fraction present in the original sample.

10.2 For absorption the average value is the weighted average of the values as computed in Section 9, weighted in proportion to the weight percentages of the size fractions in the original fraction as follows:

$$A = (P_1A_1/100) + (P_2A_2/100) + \ldots (P_nA_n/100)$$

where:

A = average absorption, percent,

$A_1, A_2, \ldots A_n$ = absorption percentages for each size fraction, and

$P_1, P_2, \ldots P_n$ = weight percentages of each size fraction present in the original sample.

11. Precision

11.1 For normal weight aggregate with less than 3 percent absorption, the precision indexes are as follows:

	Standard Deviation (1S)[A]	Difference Between Two Tests (D2S)[A]
Multilaboratory:		
Bulk specific gravity	0.014	0.040
SSD specific gravity	0.010	0.028
Approximate specific gravity	0.011	0.031
Absorption, %	0.18	0.51
Single-operator:		
Bulk specific gravity	0.011	0.031
SSD specific gravity	0.008	0.023
Approximate specific gravity	0.007	0.020
Absorption, %	0.15	0.42

[A] These numbers represent, respectively, the (1S) and (D2S) limits as described in Recommended Practice C 670.

APPENDIX

X1. DEVELOPMENT OF EQUATIONS

X1.1 The derivation of the equation is apparent from the following simplified cases using two solids. Solid 1 has a weight W_1 in grams and a volume V_1 in millilitres; its specific gravity (G_1) is therefore W_1/V_1.

Solid 2 has a weight W_2 and volume V_2, and $G_2 = W_2/V_2$. If the two solids are considered together, the specific gravity of the combination is the total weight in grams divided by the total volume in millilitres:

$$G = (W_1 + W_2)/(V_1 + V_2)$$

Manipulation of this equation yields the following:

$$G = \frac{1}{\dfrac{V_1 + V_2}{W_1 + W_2}} = \frac{1}{\dfrac{V_1}{W_1 + W_2} + \dfrac{V_2}{W_1 + W_2}}$$

$$G = \frac{1}{\dfrac{W_1}{W_1 + W_2}\left(\dfrac{V_1}{W_1}\right) + \dfrac{W_2}{W_1 + W_2}\left(\dfrac{V_2}{W_2}\right)}$$

However, the weight fractions of the two solids are:

$$W_1/(W_1 + W_2) = P_1/100 \text{ and } W_2/(W_1 + W_2) = P_2/100$$

and,

$$1/G_1 = V_1/W_1 \text{ and } 1/G_2 = V_2/W_2$$

Therefore,

$$G = 1/[(P_1/100)(1/G_1) + (P_2/100)(1/G_2)]$$

An example of the computation is given in Table X1.

TABLE X1 Example of Calculation of Average Values of Specific Gravity and Absorption for a Coarse Aggregate Tested in Separate Sizes

Size Fraction, in. (mm)	Percent in Original Sample	Sample Weight Used in Test, g	Bulk Specific Gravity (SSD)	Absorption, percent
No. 4 to ½ (12.5)	44	2213.0	2.72	0.4
½ to 1½ (37.5)	35	5462.5	2.56	2.5
1½ to 2½ (63)	21	12593.0	2.54	3.0

Average Specific Gravity (SSD)

$$G_{SSD} = \frac{1}{\dfrac{0.44}{2.72} + \dfrac{0.35}{2.56} + \dfrac{0.21}{2.54}} = 2.62$$

Average Absorption

$$A = (0.44)(0.4) + (0.35)(2.5) + (0.21)(3.0) = 1.7 \text{ percent}$$

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103, which will schedule a further hearing regarding your comments. Failing satisfaction there, you may appeal to the ASTM Board of Directors.

C 128

Designation: C 128 – 73

American National Standard A37.6-1975
Approved Oct. 7, 1975
American National Standards Institute

Standard Test Method for
SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATE[1]

This Standard is issued under the fixed designation C 128; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the determination of bulk and apparent specific gravity, 73.4/73.4 F (23/23 C), and absorption of fine aggregate. Bulk specific gravity is the characteristic generally used for calculations of the volume occupied by the aggregate in portland-cement concrete.

1.2 This method determines (after 24 h in water) the bulk specific gravity and the apparent specific gravity as defined in the ASTM Definitions E 12, Terms Relating to Density and Specific Gravity of Solids, Liquids and Gases,[2] the bulk specific gravity on the basis of weight of saturated surface-dry aggregate, and the absorption as defined in ASTM Definitions C 125, for Terms Relating to Concrete and Concrete Aggregates.[3]

NOTE 1—The values stated in U.S. customary units are to be regarded as the standard.

2. Apparatus

2.1 *Balance*—A balance or scale having a capacity of 1 kg or more, sensitive to 0.1 g or less, and accurate within 0.1 percent of the test load at any point within the range of use for this test. Within any 100-g range of test load, a difference between readings shall be accurate within 0.1 g.

2.2 *Pycnometer*—A flask or other suitable container into which the fine aggregate test sample can be readily introduced and in which the volume content can be reproduced within ±0.1 cm^3. The volume of the container filled to mark shall be at least 50 percent greater than the space required to accommodate the test sample. A volumetric flask of 500 cm^3 capacity or a fruit jar fitted with a pycnometer top is satisfactory for a 500-g test sample of most fine aggregates.

2.3 *Mold*—A metal mold in the form of a frustum of a cone with dimensions as follows: 40 ± 3 mm inside diameter at the top, 90 ± 3 mm inside diameter at the bottom, and 75 ± 3 mm in height, with the metal having a minimum thickness of 0.8 mm.

2.4 *Tamper*—A metal tamper weighing 12 ± ½ oz (340 ± 15 g) and having a flat circular tamping face 1 ± ⅛ in. (25 ± 3 mm) in diameter.

3. Preparation of Test Specimen

3.1 Obtain approximately 1000 g of the fine aggregate from the sample by use of a sample splitter or by quartering (Note 2). Dry it in a suitable pan or vessel to constant weight at a temperature of 212 to 230 F (100 to 110 C). Allow it to cool to comfortable handling temperature, cover with water, and permit to stand for 24 ± 4 h (Note 3). Decant excess water with care to avoid loss of fines, spread the sample on a flat surface exposed to a gently moving current of warm air, and stir

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[1] This method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete Aggregates.

Current edition approved Oct. 29, 1973. Published December 1973. Originally published as C 128 – 36. Last previous edition C 128 – 68.

[2] *Annual Book of ASTM Standards*, Part 14.

[3] *Annual Book of ASTM Standards*, Parts 14 and 15.

frequently to secure uniform drying. Continue this operation until the test specimen approaches a free-flowing condition. Then place a portion of the partially dried fine aggregate loosely into the mold, held firmly on a smooth nonabsorbent surface with the large diameter down, lightly tamp the surface 25 times with the tamper, and lift the mold vertically. If surface moisture is still present, the fine aggregate will retain the molded shape. Continue drying with constant stirring and test at frequent intervals until the tamped fine aggregate slumps slightly upon removal of the mold. This indicates that it has reached a surface-dry condition (Note 4). If desired, mechanical aids such as tumbling or stirring may be employed to assist in achieving the saturated surface-dry condition.

NOTE 2—The process of quartering and the correct use of a sample splitter are discussed in the Manual of Concrete Testing.[2]

NOTE 3—Where the absorption and specific gravity values are to be used in proportioning concrete mixtures with aggregates used in their naturally moist condition, the requirement for initial drying to constant weight may be eliminated and, if the surfaces of the particles have been kept wet, the 24-h soaking may also be eliminated. Values for absorption and for specific gravity in the saturated-surface-dry condition may be significantly higher for aggregate not oven dried before soaking than for the same aggregate treated in accordance with 3.1.

NOTE 4—The procedure described in Section 3 is intended to ensure that the first cone test trial will be made with some surface water in the specimen. If the fine aggregate slumps on the first trial, it has been dried past the saturated and surface-dry condition. In this case thoroughly mix a few cubic centimeters of water with the fine aggregate and permit the specimen to stand in a covered container for 30 min. The process of drying and testing for the free-flowing condition shall then be resumed.

4. Procedure

4.1 Immediately introduce into the pycnometer 500.0 g (Note 5) of the fine aggregate, prepared as described in Section 3, and fill with water to approximately 90 percent of capacity. Roll, invert, and agitate the pycnometer to eliminate all air bubbles. Adjust its temperature to 73.4 ± 3 F (23 ± 1.7 C), if necessary, by immersion in circulating water and bring the water level in the pycnometer to its calibrated capacity. Determine total weight of the pycnometer, specimen, and water (Note 6). Record this and all other weights to the nearest 0.1 g.

NOTE 5—An amount other than 500 g, but not less than 50 g, may be used provided that the actual weight is inserted in place of the figure "500" wherever it appears in the formulas of 5.1, 6.1, 7.1 and 8.1. If the weight used is less than 500 g, limits on accuracy of weighing and measuring must be scaled down in proportion.

NOTE 6—As an alternative, the quantity of water necessary to fill the pycnometer may be determined volumetrically using a buret accurate to 0.15 cm³. The total weight of the pycnometer, specimen, and water is then computed as follows:

$$C = 0.9976\,V_a + 500 + W$$

where:

C = weight of pycnometer filled with the specimen plus water, g,

V_a = volume of water added to pycnometer, cm³, and

W = weight of the pycnometer empty, g.

4.2 Remove the fine aggregate from the pycnometer, dry to constant weight at a temperature of 212 to 230 F (100 to 110 C), cool in air at room temperature for ½ to 1½ h, and weigh.

4.3 Determine the weight of the pycnometer filled to its calibration capacity with water at 73.4 ± 3 F (23 ± 1.7 C).

NOTE 7—If a volumetric flask is used and is calibrated to an accuracy of 0.15 cm³ at 20 C, the weight of the flask filled with water may be calculated as follows:

$$B = 0.9976\,V + W$$

where:

B = weight of flask filled with water, g,

V = volume of flask, cm³, and

W = weight of the flask empty, g.

5. Bulk Specific Gravity

5.1 Calculate the bulk specific gravity, 73.4/73.4 F (23/23 C), as defined in ASTM Definitions E 12, as follows:

$$\text{Bulk sp gr} = A/(B + 500 - C)$$

where:

A = weight of oven-dry specimen in air, g,

B = weight of pycnometer filled with water, g, and

C = weight of pycnometer with specimen and water to calibration mark, g.

6. Bulk Specific Gravity (Saturated Surface-Dry Basis)

6.1 Calculate the bulk specific gravity, 73.4/73.4 F (23/23 C), on the basis of weight of saturated surface-dry aggregate as follows:

$$\text{Bulk sp gr (saturated surface-dry basis)} = 500/(B + 500 - C)$$

7. Apparent Specific Gravity

7.1 Calculate the apparent specific gravity, 73.4/73.4 F (23/23 C), as defined in Definitions E 12, as follows:

$$\text{Apparent sp gr} = A/(B + A - C)$$

8. Absorption

8.1 Calculate the percentage of absorption, as defined in Definitions C 125, as follows:

$$\text{Absorption, percent} = [(500 - A)/A] \times 100$$

9. Precision

9.1 Data from carefully conducted tests on normal weight aggregate at one laboratory yielded the following for tests on the same specimen. Different specimens from the same source may vary more.

9.1.1 For specific gravity, single-operator and multi-operator precision (2S limits) less than ±0.02 from the average specific gravity. Differences greater than 0.03 between duplicate tests on the same specimen by the same or different operators should occur by chance less than 5 percent of the time (D2S limit less than 0.03).

9.1.2 For absorption, single-operator precision ±0.31 from the average percent absorption 95 percent of the time (2S limits). Multi-operator tests are probably less precise. The difference between tests by the same operator on the same specimen should not exceed 0.45 more than 5 percent of the time (D2S limit).

C 136

1.4 GRANULOMÉTRIE

Pour le tamisage le Laboratoire recommande le système mécanique de type "RO-TAP" car une étude comparative de différents modèles a démontré sa supériorité tant au point de vue précision de l'essai que durabilité et facilité d'entretien de l'appareil lui-même.

De plus, avec cet appareil, la granulométrie en série est facilitée en pouvant spécifier un temps fixe à l'agitation soit 20 minutes, contrairement au temps variable de l'ASTM[2].

2.8 GRANULOMÉTRIE ASTM C 136

2.8.01 Définition

- C'est le classement en pourcentage des particules de différentes grosseurs qui composent un mélange d'agrégats secs.

2.8.02 Appareils

- Une balancé sensible à 0.1% du poids de l'échantillon d'analyse.
- Une colonne de tamis comprenant les tamis suivants: 1", 3/4", 1/2", 3/8", No. 4, No. 8, No. 16, No. 30, No. 50, No. 100, No. 200.
- Un système mécanique d'agitation des tamis de type "Ro-Tap".

2.8.03 Procédé

- Vérifier si les tamis sont propres, en bon état, et en ordre croissant de bas en haut.
- Après le séchage de l'échantillon, vider dans la colonne de tamis le contenu du plat ayant servi à l'essai d'extraction.
- Tamiser à la main en plaçant une assiette sous chacun des tamis, les particules retenues sur les tamis 3/4", 1/2", 3/8" et No. 4.

  N.B.: On secoue le tamis en l'agitant verticalement et horizontalement afin que l'agrégat soit constamment en mouvement sur la toile. On tamise ainsi jusqu'à ce que pas plus de 1% du poids du résidu traverse le tamis en une minute.
- Agiter les tamis inférieurs au No. 4 mécaniquement pendant 20 minutes (figure 14).
- Peser séparément chaque fraction.

  N.B.: Le total de ces pesées ne doit pas être différent de plus ou moins 5 g. du poids de l'échantillon (poids des agrégats après séchage dans l'essai d'extraction du bitume).

2.8.04 Calculs

- Le poids retenu sur chacun des tamis est exprimé en pourcentage retenu, et en pourcentage cumulatif passant.

  N.B.: Le poids de filler récupéré (par 2.7) est ajouté au passant le tamis #200.
- Additionner les pourcentages cumulatifs passants des dix premiers tamis pour obtenir le total granulométrique.
- Reproduire sur un graphique les résultats de la granulométrie en utilisant les pourcentages cumulatifs passants.

Standard Test Method for
SIEVE OR SCREEN ANALYSIS OF FINE AND COARSE AGGREGATES[1]

This Standard is issued under the fixed designation C 136; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the determination of the particle size distribution of fine and coarse aggregates by sieving or screening.

2. Summary of Method

2.1 A weighed sample of dry aggregate is separated through a series of sieves or screens of progressively smaller openings for determination of particle size distribution.

3. Apparatus

3.1 *Balance*—A balance or scale accurate within 0.1 percent of the test load at any point within the range of use.

3.2 *Sieves or Screens*—The sieves or screens shall be mounted on substantial frames constructed in a manner that will prevent loss of material during sieving. Suitable sieve sizes shall be selected to furnish the information required by the specifications covering the material to be tested. The sieves shall conform to ASTM Specification E 11, for Wire-Cloth Sieves for Testing Purposes.[2]

3.3 *Oven*—An oven of appropriate size capable of maintaining a uniform temperature of 230 ± 9 F (110 ± 5 C).

4. Test Sample

4.1 The sample of aggregate to be tested for sieve analysis shall be thoroughly mixed and reduced by use of a sample splitter or by quartering (Note 1) to an amount suitable for testing. Fine aggregate shall be moistened before reduction to minimize segregation and loss of dust. The sample for test shall be approximately of the weight desired when dry and shall be the end result of the reduction method. Reduction to an exact predetermined weight shall not be permitted.

NOTE 1—The process of quartering and the correct use of a sample splitter are described in the "Manual of Concrete Testing."[3]

4.2 *Fine Aggregate*—The test sample of fine aggregate shall weigh, after drying, approximately the following amount:

Aggregate with at least 95 percent passing a No. 8 (2.36-mm) sieve	100 g
Aggregate with at least 85 percent passing a No. 4 (4.75-mm) sieve and more than 5 percent retained on a No. 8 sieve	500 g

In no case, however, shall the fraction retained on any sieve at the completion of the sieving operation weigh more than 4 g/in.^2 of sieving surface.

NOTE 2—This amounts to 200 g for the usual 8-in. (203-mm) diameter sieve. The amount of material retained on the critical sieve may be regulated by (*1*) the introduction of a larger-opening sieve immediately above the critical sieve, or (*2*) selection of a sample of proper size.

4.3 *Coarse Aggregate*—The weight of the test sample of coarse aggregate shall conform with the following:

Maximum Nominal Size, Square Openings, in. (mm)	Minimum Weight of Sample, kg
⅜ (9.5)	2
½ (12.5)	4
¾ (19.0)	8

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[1] This method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C 09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete Aggregates.

Current edition approved Sept. 24, 1976. Published November 1976. Originally published as C 136 – 38 T. Last previous edition C 136 – 71.

[2] *Annual Book of ASTM Standards*, Parts 14 and 15.

[3] *Annual Book of ASTM Standards*, Part 14.

Maximum Nominal Size, Square Openings, in. (mm)	Minimum Weight of Sample, kg
1 (25.0)	12
1½ (38.1)	16
2 (50)	20
2½ (63)	25
3 (75)	45
3½ (90)	70

NOTE 3—It is recommended that sieves mounted in frames of 16-in. (406-mm) diameter or larger be used for testing coarse aggregate.

4.4 In the case of mixtures of fine and coarse aggregates, the material shall be separated into two sizes on the No. 4 (4.75-mm) sieve. The samples of fine and coarse aggregate shall be prepared in accordance with 4.2 and 4.3.

5. Procedure

5.1 Dry the sample to constant weight at a temperature of 230 ± 9 F (110 ± 5 C).

5.2 Nest the sieves in order of decreasing size of opening from top to bottom and place the sample on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving described in 5.3.

5.3 Continue sieving for a sufficient period and in such manner that, after completion, not more than 1 weight percent of the residue on any individual sieve will pass that sieve during 1 min of continuous hand sieving performed as follows: Hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand. Strike the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times/min, turn the sieve about one sixth of a revolution at intervals of about 25 strokes. In determining sufficiency of sieving for sizes larger than the No. 4 (4.75-mm) sieve, limit the material on the sieve to a single layer of particles. If the size of the mounted testing sieves makes the described sieving motion impractical, use 8-in. (203-mm) diameter sieves to verify the sufficiency of sieving.

5.4 Dry sieving alone is usually satisfactory for routine testing of normally graded aggregates. However, when accurate determination of the total amount passing the No. 200 (75-μm) sieve is desired, first test the sample in accordance with ASTM Method C 117, Test for Materials Finer than No. 200 (75-μm) Sieve in Mineral Aggregates by Washing.[2] Add the percentage finer than the No. 200 sieve determined by that method to the percentage passing the No. 200 sieve by dry sieving of the same sample. After the final drying operation in Method C 117, dry-sieve the sample in accordance with 5.2 and 5.3.

5.5 Determine the weight of each size increment by weighing on a scale or balance conforming to the requirements specified in 3.1, to the nearest 0.1 percent of the weight of the sample.

6. Calculation

6.1 Calculate percentages on the basis of the total weight of the sample, including any material finer than the No. 200 sieve determined in accordance with Method C 117.

7. Report

7.1 The report shall include the following:

7.1.1 Total percentage of material passing each sieve, or

7.1.2 Total percentage of material retained on each sieve, or

7.1.3 Percentage of material retained between consecutive sieves, depending upon the form of the specifications for use of the material under test. Report percentages to the nearest whole number, except for the percentage passing the No. 200 (75-μm) sieve, which shall be reported to the nearest 0.1 percent.

8. Precision

8.1 For coarse aggregate with a nominal maximum size of ¾-in. (19.0 mm) the precision indexes are given in Table 1; the values are given for different ranges of percentage of aggregate retained between two consecutive coarse aggregate sieves:

TABLE 1 Precision

	Percent in Size Fraction Between Two Consecutive Coarse Aggregate Sieves	Coefficient of Variation (1S%), Percent[b]	Standard Deviation (1S), Percent[a]	Difference Between Two Tests	
				Percent of Avg (D2S%)[b]	(D2S) Percent[a]
Multilaboratory	0 to 3	35	–	99	–
	3 to 10	–	1.2	–	3.4
	10 to 20	–	1.7	–	4.8
	20 to 50	–	2.2	–	6.2
Single-Operator	0 to 3	30	–	85	–
	3 to 50	–	1.4	–	4.0

[a] These numbers represent, respectively, the (1S) and (D2S) limits as described in ASTM Recommended Practice C 670 for Preparing Precision Statements for Test Methods for Construction Materials.[3]

[b] These numbers represent, respectively, the (1S%) and (D2S%) limits as described in Recommended Practice C 670.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103, which will schedule a further hearing regarding your comments. Failing satisfaction there, you may appeal to the ASTM Board of Directors.

D 75

Standard Methods of
SAMPLING AGGREGATES[1]

This Standard is issued under the fixed designation D 75; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 These methods cover sampling of coarse and fine aggregates for the following purposes (Note 1):

1.1.1 Preliminary investigation of the potential source of supply,

1.1.2 Control of the product at the source of supply,

1.1.3 Control of the operations at the site of use, and

1.1.4 Acceptance or rejection of the materials.

NOTE 1—Sampling plans and acceptance and control tests vary with the type of construction in which the material is used. The preliminary investigation and sampling of potential aggregate sources and types occupies a very important place in determining the availability and suitability of the largest single constituent entering into the construction. It influences the type of construction from the standpoint of economics and governs the necessary material control to ensure durability of the resulting structure from the aggregate standpoint.

2. Applicable Documents

2.1 *ASTM Standards:*

D 2234 Collection of a Gross Sample of Coal[2]

E 105 Recommended Practice for Probability Sampling of Materials[3]

E 122 Recommended Practice for Choice of Sample Size to Estimate the Average Quality of a Lot or Process[3]

E 141 Recommended Practice for Acceptance of Evidence Based on the Results of Probability Sampling[4]

3. Securing Samples

3.1 *General*:

3.1.1 Sampling is equally as important as the testing, and the sampler shall use every precaution to obtain samples that will show the true nature and condition of the materials which they represent.

3.1.2 Samples for preliminary investigation tests are obtained by the party responsible for development of the potential source. Samples of materials for control of the production at the source or control of the work at the site of use are obtained by the manufacturer, contractor, or other parties responsible for accomplishing the work. Samples for tests to be used in acceptance or rejection decisions by the purchaser are obtained by the purchaser or his authorized representative.

3.1.3 Where practicable, samples to be tested for quality shall be obtained from the finished product. Samples from the finished product to be tested for abrasion loss shall not be subject to further crushing or manual reduction in particle size in preparation for the abrasion test unless the size of the finished product is such that it requires further reduction for testing purposes.

3.2 *Inspection:*

3.2.1 The material shall be inspected to determine discernible variations. The seller shall provide suitable equipment needed for proper inspection and sampling.

3.3 *Sampling*:

3.3.1 *Sampling from the Conveyor Belt*—Select units to be sampled by a random method from the production. Obtain at least three approximately equal increments, selected at random, from the unit being sampled and combine to form a field sample whose mass equals or exceeds the minimum recommended in 3.4.2. Stop the conveyor belt

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[1] This specification is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.30 on Methods of Sampling.

Current edition effective Nov. 22, 1971. Originally issued 1920. Replaces D 75 - 59 (1968).

[2] *Annual Book of ASTM Standards*, Part 26.

[3] *Annual Book of ASTM Standards*, Parts 15 and 41.

[4] *Annual Book of ASTM Standards*, Part 41.

while the sample increments are being obtained. Insert two templates, the shape of which conforms to the shape of the belt in the aggregate stream on the belt, and space them such that the material contained between them will yield an increment of the required weight. Carefully scoop all material between the templates into a suitable container and collect the fines on the belt with a brush and dust pan and add to the container.

3.3.2 *Sampling from a Flowing Aggregate Stream* (*Bins or Belt Discharge*)—Select units to be sampled by a random method from the production. Obtain at least three approximately equal increments, selected at random from the unit being sampled, and combine to form a field sample whose mass equals or exceeds the minimum recommended in 3.4.2. Take each increment from the entire cross section of the material as it is being discharged. It is usually necessary to have a special device constructed for use at each particular plant. This device consists of a pan of sufficient size to intercept the entire cross section of the discharge stream and hold the required quantity of material without overflowing. A set of rails may be necessary to support the pan as it is passed under the discharge stream. Take samples only from bins that are full, or nearly so, to minimize the chance of obtaining segregated material.

NOTE 2—The unit selected for sampling should not include the initial discharge from a conveyor or newly filled bin.

3.3.3 *Sampling from Stockpiles*—Avoid sampling from stockpiles whenever possible, particularly when the sampling is done for the purpose of determining aggregate properties that may be dependent upon the grading of the sample. If, on the other hand, circumstances make it mandatory to obtain samples from a stockpile of coarse aggregate or a stockpile of combined coarse and fine aggregate, design a sampling plan for the specific case under consideration. This approach will allow the sampling agency to use a sampling plan that will give a confidence in results obtained therefrom that is agreed upon by all parties concerned to be acceptable for the particular situation.

3.3.4 *Sampling from Roadway* (*Bases and Subbases*)—Sample units selected by a random method from the construction. Obtain at least three approximately equal increments, selected at random from the unit being sampled, and combine to form a field sample whose mass equals or exceeds the minimum recommended in 3.4.2. Take all increments from the roadway for the full depth of the material, taking care to exclude any underlying material. Clearly mark the specific areas from which each increment is to be removed; a metal template placed over the area is a definite aid in securing approximately equal increment weights.

3.4 *Number and Masses of Field Samples:*

3.4.1 The number of field samples (obtained by one of the methods described in 3.3) required depends on the criticality of, and variation in, the properties to be measured. Designate each unit from which a field sample is to be obtained prior to sampling. The number of field samples from the production should be sufficient to give the desired confidence in test results.

NOTE 3—Guidance for determining the number of samples required to obtain the desired level of confidence in test results may be found in Method D 2234, Recommended Practice E 105, Recommended Practice E 122, and Recommended Practice E 141.

3.4.2 The field sample masses cited are tentative. The masses must be predicated on the type and number of tests to which the material is to be subjected and sufficient material obtained to provide for the proper execution of these tests. Standard acceptance and control tests are covered by ASTM standards and specify the portion of the field sample required for each specific test. Generally speaking, the amounts specified in Table 1 will provide adequate material for routine grading and quality analysis. Extract test portions from the field sample by splitting or other appropriate methods.

4. Shipping Samples

4.1 Transport aggregates in bags or other containers so constructed as to preclude loss or contamination of any part of the sample, or damage to the contents from mishandling during shipment.

4.2 Shipping containers for aggregate samples shall have suitable individual identification attached and enclosed so that field reporting, laboratory logging, and test reporting may be facilitated.

TABLE 1 **Size of Samples**

Maximum Nominal Size of Aggregates[a]	Approximate Minimum Mass of Field Samples, lb (kg)[b]
Fine Aggregate	
No. 8 (2.36 mm)	25 (10)
No. 4 (4.75 mm)	25 (10)
Coarse Aggregate	
3/8 in. (9.5 mm)	25 (10)
1/2 in. (12.5 mm)	35 (15)
3/4 in. (19.0 mm)	55 (25)
1 in. (25.0 mm)	110 (50)
1 1/2 in. (38.1 mm)	165 (75)
2 in. (50 mm)	220 (100)
2 1/2 in. (63 mm)	275 (125)
3 in. (75 mm)	330 (150)
3 1/2 in. (90 mm)	385 (175)

[a] For processed aggregate the maximum nominal size of particles is the largest sieve size listed in the applicable specification, upon which any material is permitted to be retained.

[b] For combined coarse and fine aggregates (for example, base or subbase) minimum weight shall be coarse aggregate minimums plus 25 lb (10 kg).

D 140

Standard Methods of

SAMPLING BITUMINOUS MATERIALS[1]

This Standard is issued under the fixed designation D 140; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 These methods apply to the sampling of bituminuous materials at points of manufacture, storage, or delivery.

NOTE 1—The values stated in U.S. customary units are to be regarded as the standard. The metric equivalents of U.S. customary units may be approximate.

2. Purpose

2.1 Sampling is as important as testing, and every precaution shall be taken to obtain samples that will show the true nature and condition of the materials.

2.2 Samples may be taken for either of the following two purposes:

2.2.1 To represent as nearly as possible an average of the bulk of the materials sampled, or

2.2.2 To ascertain the maximum variation in characteristics which the material possesses.

3. Selection of Samples

3.1 Whenever practicable, bituminous materials shall be sampled at the point of manufacture or storage, and at such time as to allow the tests controlling acceptance or rejection to be made in advance of shipment.

3.2 When the samples cannot be taken at the point of manufacture or storage, they shall be taken from the shipment immediately upon delivery.

4. Size of Samples

4.1 The sample size of liquid materials shall be as follows:

4.1.1 For routine laboratory examination, 1 qt (1 dm^3) (emulsions, 1 gal (4 dm^3)),

4.1.2 From bulk storage, 1 gal, or

4.1.3 From barrels or drums, 1 qt.

4.2 The sample size of semisolid or solid materials shall be as follows:

4.2.1 From barrels, drums, or cakes, 2 to 3 lb (1 to 1.5 kg), or

4.2.2 From crushed or powdered material in bulk or bags, 2 to 3 lb (1 to 1.5 kg).

5. Containers

5.1 *Type of Containers:*

5.1.1 Containers for liquid bituminous materials, except emulsions, shall be wide-mouth cans with lined screw caps or triple-seal friction-top cans.

5.1.2 Containers for emulsified bituminous materials shall be wide-mouth jars or bottles made of plastic, or wide-mouth plastic-lined cans with lined screw caps, or plastic-lined triple-seal friction-top cans.

5.1.3 Containers for crushed or powdered bituminous materials shall be triple-seal friction-top cans or plastic sacks placed in other containers suitable for handling.

5.2 *Size of Containers:*

5.2.1 The size of the container shall correspond to the required amount of sample.

6. Protection and Preservation of Samples

6.1 Sample containers shall be new. They shall not be washed or rinsed, or wiped with an oily cloth. If they contain evidence of solder flux, or if they are not clean and dry, they shall not be used. Top and container

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[1] These methods are under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and are the direct responsibility of Subcommittee D04.30 on Methods of Sampling.

Current edition effective Feb. 27, 1970. Originally issued 1922. Replaces D 140 - 66 T.

shall fit together tightly.

6.2 Care shall be taken to prevent the sample from becoming contaminated. Immediately after filling, the container shall be tightly and positively sealed.

6.3 The filled sample container shall not be submerged in solvent, nor shall it be wiped with a solvent saturated cloth. If cleaning is necessary use a clean dry cloth.

6.4 Samples of emulsions shall be protected from freezing by correct packaging.

6.5 Samples shall not be transferred from one container to another except where required by the sampling procedure.

6.6 Immediately after filling, sealing, and cleaning, the sampling containers shall be properly marked for identification with a suitable marking pencil on the container itself, not on the lid. Linen tags also may be used for identification if they can be securely fastened to the container in such a manner as to ensure that they will not be lost in transit. Linen tags shall not be attached to containers by using the lids to secure them.

7. Sampling at Place of Manufacture

7.1 *Vertical Tanks Not Capable of Being Agitated* (*Liquid Materials or Materials Made Liquid by Heating*) (5001 bbl (800 m^3) or more capacity)—Three sampling methods are recommended (Note 2):

7.1.1 *Sampling-Valve Method*—Valves shall be located, with easy and safe access provided, on the side of the tank with the first in the top third of the tank, but no higher than 3 ft (1 m) from the top; the second in the middle third of the tank; and the third in the bottom third of the tank, but no lower than 3½ ft (1.1 m) from the bottom. A recommended design of the sampling valve is shown in Fig. 1.

NOTE 2—During sampling by any of the methods described all filling inlets and discharge outlets to the tank shall be closed.

7.1.1.1 A minimum of 1 gal (4 dm^3) of the product shall be drawn from each sample valve and discarded before taking the sample for test, and

7.1.1.2 1 qt (1 dm^3) to 1 gal shall be drawn from each sample valve for test.

7.1.2 *Thief Sampler Method* (not suitable for asphalt cements)—Samples shall be taken in the top, middle, and lower sections at levels indicated in 7.1.1, of the tank by lowering a thief sampler into the material. A satisfactory type with instructions for use is shown in Fig. 2.

NOTE 3—Most bituminous materials in the liquid state are of such viscous and adhesive character that, after normal emptying of a container by pouring, the container retains enough material to cause significant contamination of any second samples secured before the container was thoroughly cleaned. The aforementioned properties of bituminous materials also make container cleaning a difficult, tedious, and time-consuming task.

NOTE 4—The thief sampler described in Fig. 2 may be used for repetitive sampling because significant sample contamination by previous contents is avoided by the self-cleaning action provided by the passage of material through the tube-shaped thief sampler which is open at both ends. The practice of raising and lowering the sampler 3 or 4 times through a distance of several feet at the sampling depth is recommended.

7.1.3 *Throw-Away Container Method*—Samples shall be taken at top, middle, and lower levels by lowering into the material a container in a suitable weighted holding device. The essential feature of the method is to use a clean container to take the sample, pour this sample into another clean container, and throw away the container used to take the sample from the tank. A satisfactory type with instructions on how to use the device is shown in Fig. 3.

7.1.4 The three samples from bulk storage tanks may be tested separately for consistency to detect stratification. They may be combined, thoroughly mixed, and a 1-qt to 1-gal sample may be taken for other tests that may be required for determining average characteristics of the material.

7.2 *Bulk Storage Tanks* (*Liquid Materials or Materials Made Liquid by Heating*) *Equipped with Mechanical Agitators*—When the tank is equipped with operating mechanical agitators which, by observation through the sampling or inspection hatch, are performing adequate mixing of the tank contents, a single sample taken by any of the methods described in 7.1.1, 7.1.2, or 7.1.3 will be satisfactory to use for test purposes.

8. Sampling from Tank Cars, Vehicle Tanks, Distributor Trucks or Recirculating Storage Tanks

8.1 The sample may be taken from the sample valve or tap if the tanks are provided with them. When such sampling devices are required, they are to be built into the tank itself. A sampling device of this type is shown in Fig. 1. Before the sample is taken, 1 gal (4 dm^3) shall be drawn from the sample valve and discarded.

8.2 Samples of liquid materials and materials made liquid by heating may be taken by the dip method using a clean wide-mouth or friction-top can in a suitable holder as shown in Fig. 4. A clean container must be used to take each sample, and the material sampled shall then be transferred to another new and clean container for retention or testing sample.

8.3 A detachable fitting, similar in design to the one shown in Fig. 5 may be inserted in the discharge line. Before the sample is taken 1 gal shall be drawn from this sampling valve and discarded.

9. Sampling from Tankers and Barges

9.1 For liquid materials (including all cutbacks made liquid by heating) top, middle, and lower samples shall be taken using the methods as described in 7.1.2 and 7.1.3.

9.2 For all other materials made liquid by heating, a top sample only shall be taken by the dip, thief, or throw-away container method.

10. Sampling from Pipe Lines During Loading or Unloading

10.1 When tankers and barges are being loaded or unloaded samples may conveniently be taken from the pipe line through which the material is flowing by insertion of a sampling pipe into a rising section of the pipe line on the discharge side of the pump or in a completely filled line in which gravity creates the materials flow. A suitable in-line sampling pipe is shown in Fig. 5. The sampling pipe shall be not more than one eighth the diameter of the pipe line and its opening should be turned to face the flow of the liquid. This pipe shall be provided with a valve or plug cock and shall discharge into a sample receiver. At least three 1-gal (4-dm^3) samples shall be taken at uniform intervals throughout the entire loading or unloading. At the completion of the loading or unloading, the individual 1-gal samples shall be combined, thoroughly mixed without altering its characteristics, and a 1-gal sample taken therefrom.

10.2 When sampling tankers and barges 25,000 bbl (4000 m^3), or less, capacity, at least five 1-gal samples shall be taken at uniform intervals throughout the entire loading or unloading (25,000 bbl, or larger, capacity requires at least ten 1-gal samples). At completion of the loading or unloading the individual 1-gal samples shall be combined, thoroughly mixed in a manner designed to not alter its characteristics, and a 1-gal sample taken therefrom.

11. Sampling from Drums or Barrels

11.1 After thorough mixing, samples of liquid bituminous material from barrels or drums shall be secured by tube or thief sampling by taking 1 qt (1 dm^3) of material from packages selected at random according to Section 12.

12. Sampling Semisolid or Uncrushed Solid Materials

12.1 *Drums, Barrels, Cartons, and Bags*—Where the lot of material to be sampled is obviously from a single run or batch of the producer, one package shall be selected at random and sampled as described below. Where the lot of material to be sampled is not obviously from a single run or batch of the producer, or where the single samples selected as described above fails on test to conform to the requirements of the specifications, a number of packages shall be selected at random equivalent to the cube root of the total number of packages in the lot. The following table is given, showing the number of samples to be selected for shipments of various sizes.

Packages in Shipment	Packages Selected
2 to 8	2
9 to 27	3
28 to 64	4
65 to 125	5
126 to 216	6
217 to 343	7
344 to 512	8
513 to 729	9
730 to 1000	10
1001 to 1331	11

Samples shall be taken from at least 3 in. (76 mm) below the surface and at least 3 in.

from the side of the container. A clean hatchet may be used if the material is hard enough to shatter and a broad, stiff putty knife if the material is soft. When more than one package in a lot is sampled, each individual sample shall be not less than $^1/_4$ lb (0.1 kg) in weight. When the lot of material is obviously from a single run or batch of the producer, all samples from the lot shall be melted and thoroughly mixed, and an average 1-gal (4-dm^3) sample taken from the combined material for examination. In case more than a single run or batch of the producer is present and the batches can be clearly differentiated, a composite 1-gal sample shall be prepared for examination from each batch. Where it is not possible to differentiate between the various batches, each sample shall be examined separately.

13. Sampling Crushed or Powdered Materials

13.1 *Bulk Storage*—Solid bituminous materials in crushed ASTM fragments or powder shall be sampled in accordance with ASTM Method D 346, Collection and Preparation of Coke Samples for Laboratory Analysis.[2] The gross sample shall be not less than 50 lb (25 kg) from which shall be selected the 2 to 3-lb (1 to 1.5-kg) sample for test.

13.2 *Drums, Barrels, Bags and Cartons*—Where the crushed or powdered material is in barrels, drums, or bags, a number of packages shall be selected at random as described in Section 12. A sample at least 1$^1/_2$ lb (0.7 kg) in weight shall be selected from near the center of each container to yield a gross sample weighing not less than 50 lb (22.7 kg) from which the 2 to 3-lb (1 to 1.5-kg) sample for test shall be selected as prescribed in Method D 346.

14. Sampling at Point of Shipment Delivery

14.1 Sampling of bituminous materials shall be done as soon as practicable after the bituminous material has arrived at plant site, storage site, or job destination or at the time of unloading.

14.2 The required number of samples shall be taken from each delivery of bituminous material. In the case of small delivery units such as distributors, the samples shall be taken to represent a maximum of 10,000 gal (40 m^3).

14.3 Sampling shall be done by one of the three following methods:

14.3.1 In accordance with Section 7.

14.3.2 By bleeding through a sample valve or tap in the transfer line during the unloading of the approximate middle third of the load, or

14.3.3 By means of a sampling device inserted to a level of approximately the middle third of the load or tank.

14.4 Tests for material acceptability shall be made on one of the samples taken. The other samples are to be retained for confirmation in the event the first sample tested should fail to comply with requirements.

15. Precautions

15.1 Because of the numerous types and grades of bituminous materials that are alternately shipped and stored in the same or similar containers, the opportunity for contaminating these containers with residues, precipitates, or cleaning solvents is ever present. Numerous opportunities also exist for obtaining samples which are not strictly representative of the material or are contaminated after removal. Therefore it is incumbent upon the producer, transporter, user, and sampler to exercise continuous precaution in the sampling and handling of these materials.

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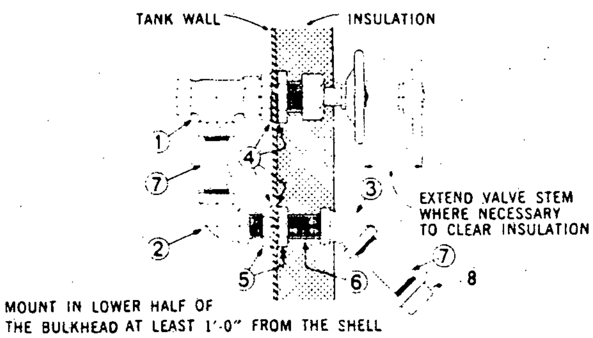
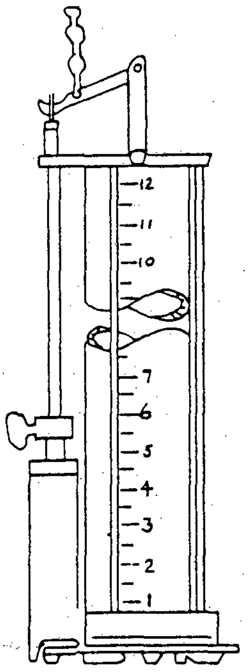
[2] *Annual Book of ASTM Standards*, Part 26.



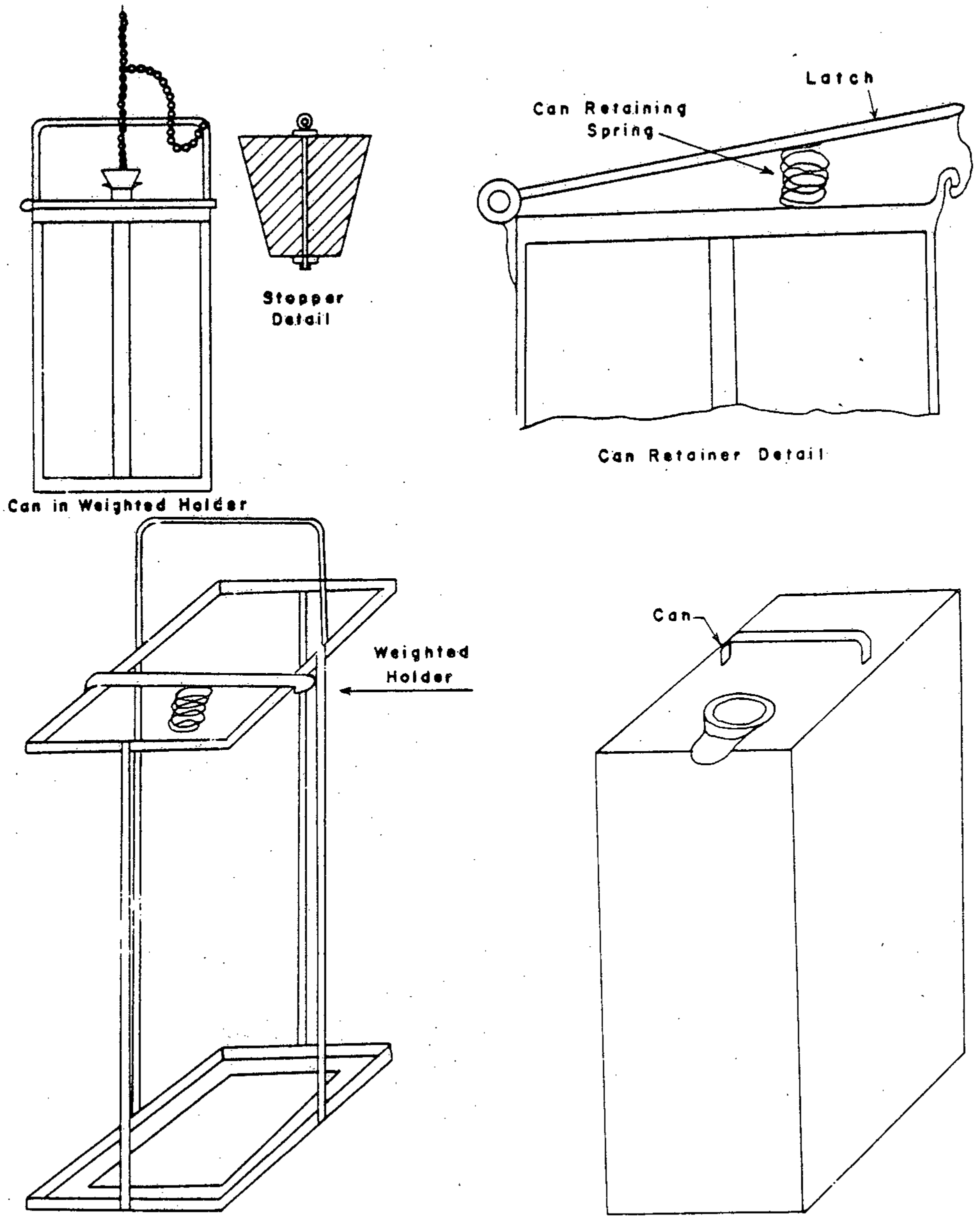
REF. No.	DESCRIPTION	No. REQ.
1	¾″ 'VOGT' P-9844 STEEL ANGLE VALVE OR SIMILAR, PANEL MOUNTED	1
2	¾″ STEEL OR MALL. IRON 90° ELBOW	1
3	¾″ STEEL OR MALL. IRON 45° ELBOW	1
4	ASBESTOS GASKETS SNUG ON THREAD OR WOUND WITH YARN	4
5	¾″ 150± SCREWED M. I. LOCKNUT	2
6	¾″ x 3½″ ± PARALLEL THREADED STEEL PIPE NIPPLE (CUT FROM ¾″ STD. TANK NIPPLE IF OTHERWISE UNOBTAINABLE)	1
7	¾″ x 3″ THREADED STEEL PIPE NIPPLE	2
8	¾″ MALL. IRON PIPE CAP	1

FIG. 1 Typical Submerged Sampling Device.



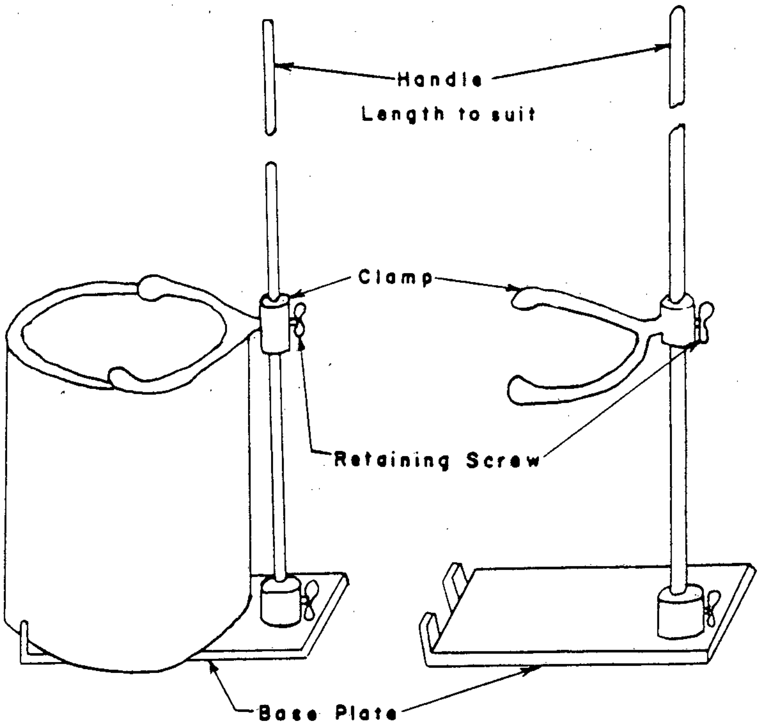
NOTE—This type sampler is lowered into the tank with bottom valve open (there is no top closure). When the desired depth is reached, the lowering chain is given a snap tug which closes the bottom valve. The sampler is then withdrawn from the tank and the contents transferred to the sample container. This sampler may be used for repetitive sampling in the same tank.

FIG. 2 Thief Sampler.



NOTE—This type sampler is lowered into the tank with the stopper in place. When the desired depth is reached, the stopper is removed by means of the attached wire, cord, or chain and the container allowed to fill. Complete filling is indicated by the cessation of bubbles of air from the can at the surface of the liquid. The sampler is then withdrawn from the tank and the contents poured into the clean sampler container. A clean can (bottle) must be used for each sample taken.

FIG. 3 Throw-Away Container Sampler.



NOTE—Sampler with can secured in place is rapidly lowered into tank to desired depth and allowed to fill with sample. The sampler is then withdrawn from the tank and the contents transferred to the sample container. A clean container *must* be used to take each sample.

FIG. 4 Dip Sampler.

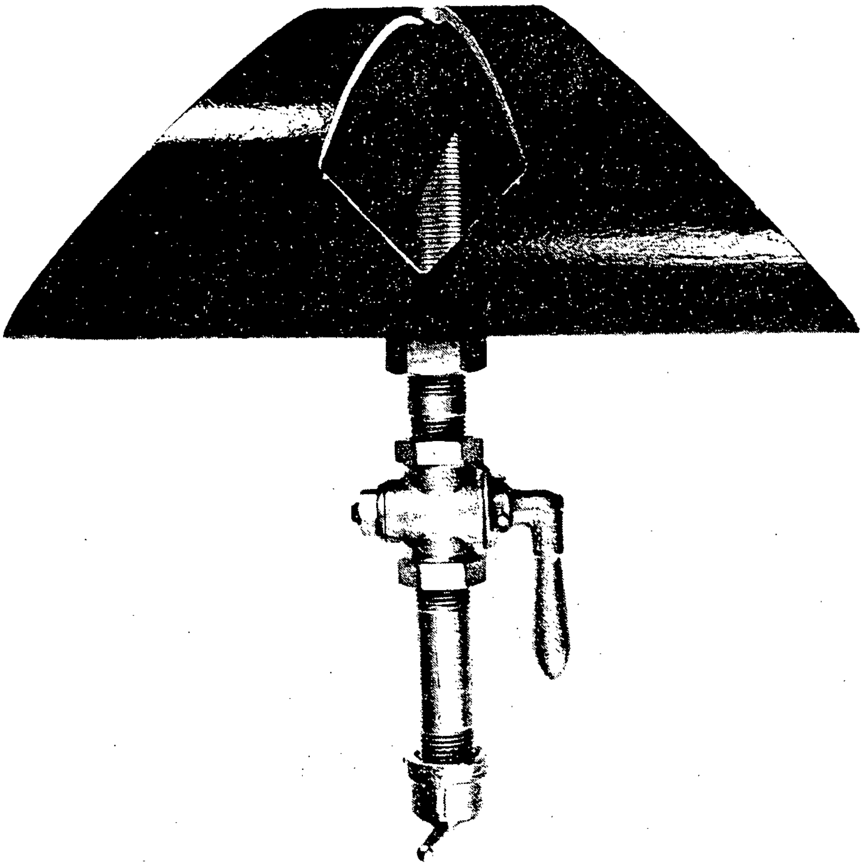


FIG. 5 In-Line Asphalt Sampling Device.

D 979

ECHANTILLONNAGE DU BETON BITUMINEUX EN LABORATOIRE

Définition et but de l'essai:

L'echantillonnage a pour but de prélever une fraction d'un matériau telle que la partie prélevée soit représentative de l'ensemble de l'échantillon.

Le résultat obtenu en laboratoire ne sera valable que si l'échantillon envoyé représente le mélange produit.

Il est indispensable que la quantité de mélange reçu en laboratoire soit supérieure à la quantité nécessaire pour les essais à effectuer. Ceci permet, soit de recommencer l'essai pour confirmer les premiers résultats, soit de compléter l'étude par d'autres essais non prévus à l'origine si le mélange présente certaines particularités.

Appareils:

- Echantillonneur, séparant en deux parties égales une quantité de mélange déterminé. (figures 1 et 4)

- Une trémie réceptrice permettant de distribuer également le mélange (figure 2)

- Balance d'une capacité minimum de 10 kg précision 1 g

- Une spatule de 28 mm X 200 mm permettant de nettoyer les chutes.

- Lampes infrarouges non essentielles mais recommandées dans certains cas.

Procédé:

- Pour obtenir la quantité nécessaire en vue de réaliser le ou les essais prévus, peser l'échantillon reçu et porter sa température à 93°C.

- Agir méthodiquement afin de séparer ou d'échantillonner le moins souvent possible à partir du poids total du mélange.

- Placer l'échantillon dans la trémie et ouvrir à la même ouverture que les chutes, soit 38 mm.

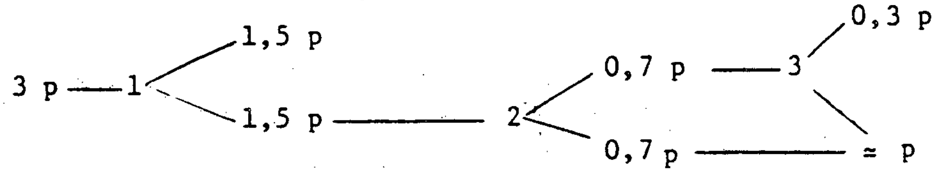
- Séparer jusqu'à la quantité désirée selon l'exemple suivant:

Si p est le poids nécessaire pour l'essai et que P est le poids initial:

$P > 4$ p Il est préférable de quarter d'abord une fois

$P \simeq 4$ p faire deux séparations successives

$P \simeq 3$ p 1° faire trois (3) séparations



$P \simeq 2$ p faire une séparation

$P \simeq 1{,}5$ p faire les séparations 2 et 3 du cas précédent $P \simeq 3$ p

$P < 1{,}5$ p il est inutile de faire des séparations successives, il est préférable de prendre la totalité pour l'essai.

Réf.: Laboratoire Central des Ponts et Chaussées
Echantillonnage en laboratoire des sols et granulats
Paris 1970

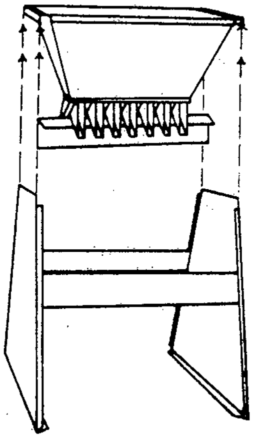


Figure 1

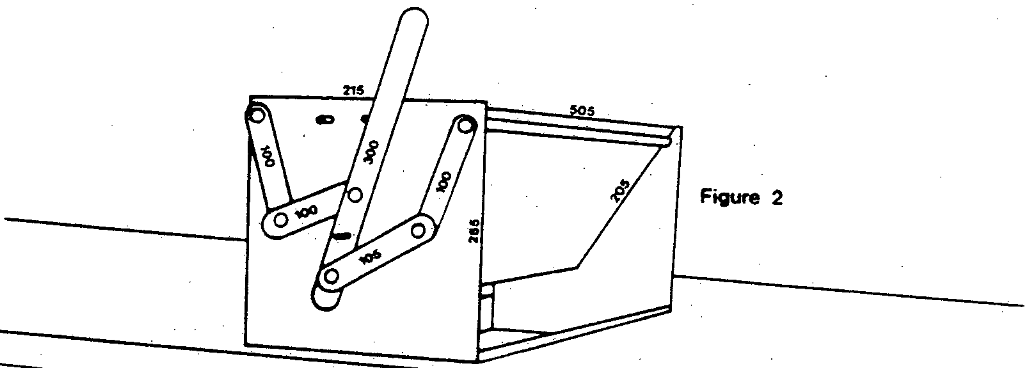


Figure 2

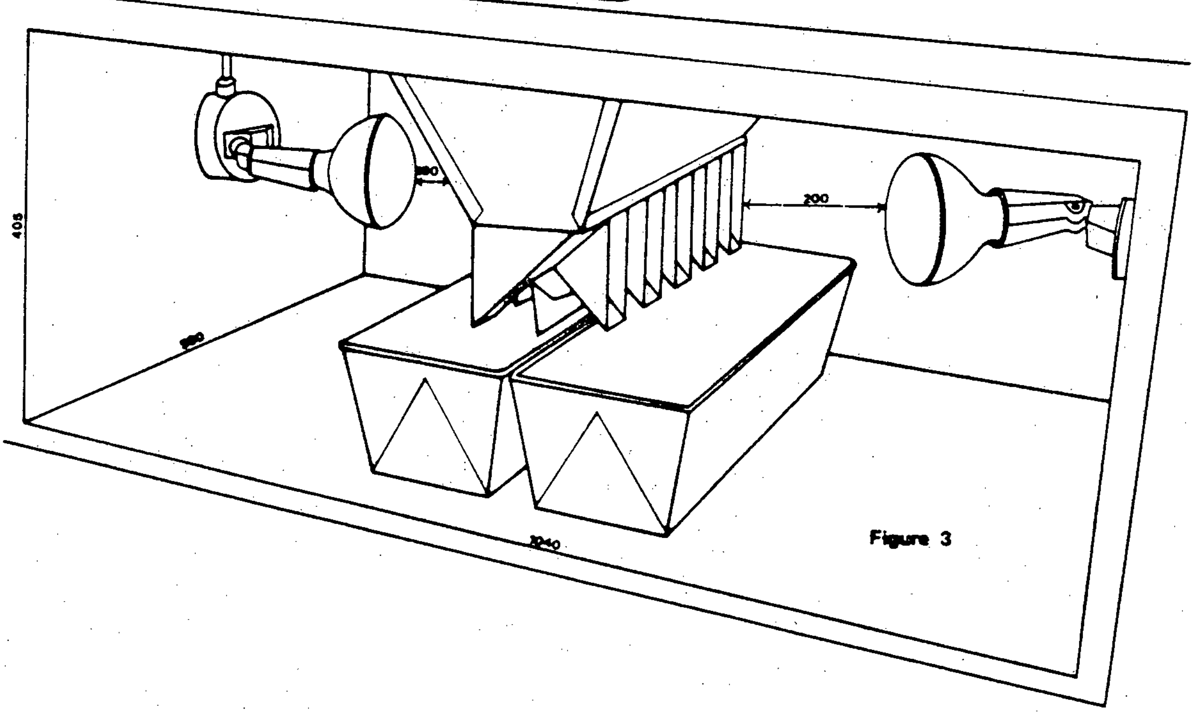
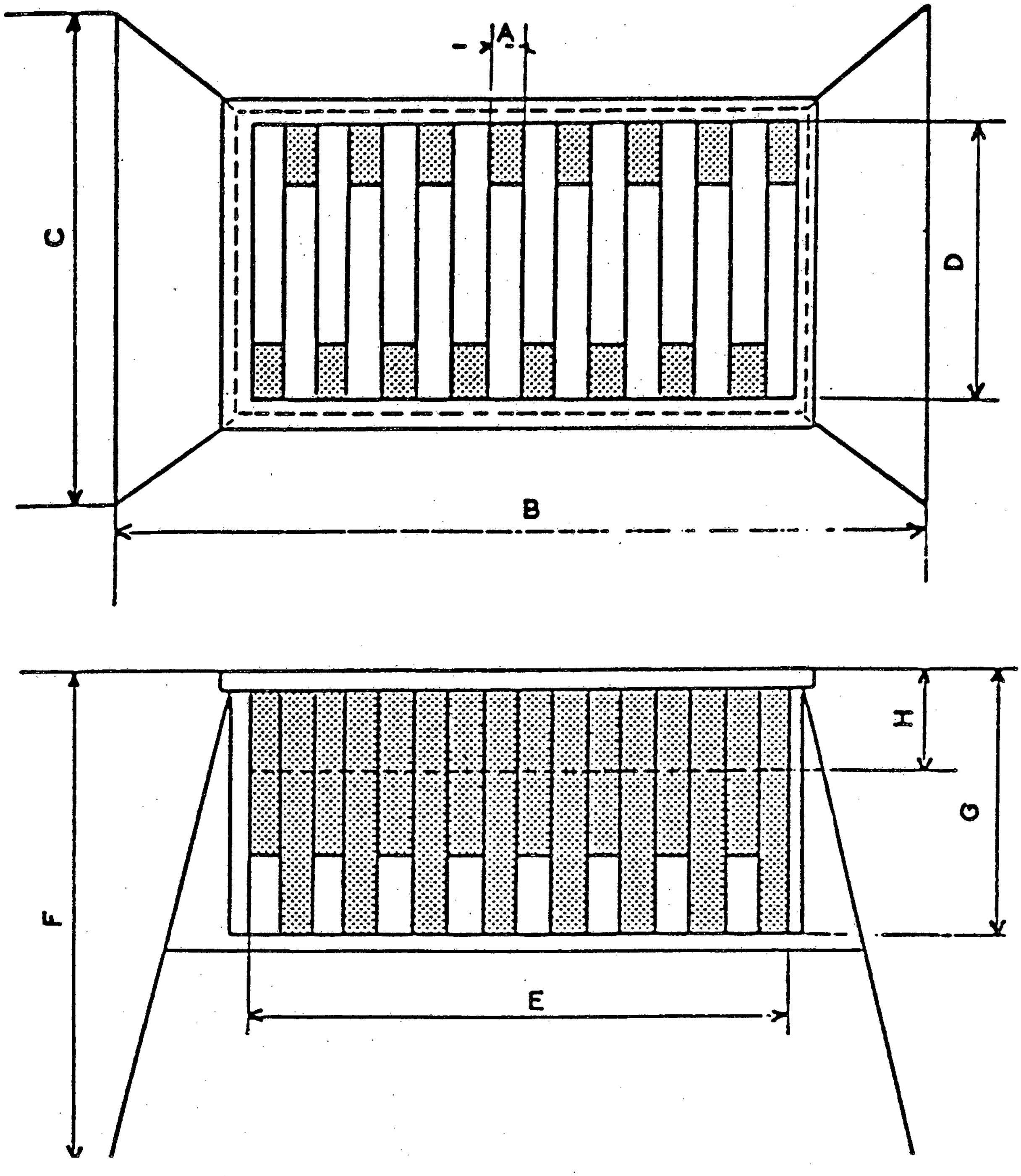


Figure 3

ÉCHANTILLONNEURS



	A	B	C	D	E	F	G	H
Echantillonneur 38 mm	38	550	390	240	390	390	280	90

FIGURE 4

Standard Methods for
SAMPLING BITUMINOUS PAVING MIXTURES[1]

This Standard is issued under the fixed designation D 979; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 These methods cover sampling of bituminous paving mixtures at points of manufacture, storage, or delivery.

2. Applicable Documents

2.1 *ASTM Standards:*

D 2234 Collection of a Gross Sample of Coal[2]

E 105 Recommended Practice for Probability Sampling of Materials[3]

E 122 Recommended Practice for Choice of Sample Size to Estimate the Average Quality of a Lot or Process[3]

E 141 Recommended Practice for Acceptance of Evidence Based on the Results of Probability Sampling[4]

3. Securing Samples

3.1 *General:*

3.1.1 Sampling is equally as important as the testing, and the sampler shall take every precaution to obtain samples that will yield an acceptable estimate of the nature and conditions of the materials which they represent.

3.1.2 Samples for the development of preliminary data are obtained by the party responsible for development of the data. Samples for control of the product at the source of manufacture, storage, or at the site of use, are obtained by the manufacturer, contractor, or other parties responsible for accomplishing the work. Samples for tests to be used in acceptance or rejection decisions by the purchaser are obtained by the purchaser or his authorized representative.

3.2 *Inspection*—The material shall be inspected to determine discernible variations. The seller shall provide equipment needed for safe and appropriate inspection and sampling.

3.3 *Sampling:*

3.3.1 *Sampling from a Conveyor Belt*—Stop the conveyor belt while the increments are being obtained. Insert two templates, the shape of which conforms to the shape of the belt, across the bituminous mixture. Space the templates so that the material contained between them will yield an increment of the required weight. Carefully scoop all material between the templates into a suitable container.

3.3.2 *Sampling from Truck Transports*—Select the units to be sampled by a random method from the production. Obtain at least three approximately equal increments, selected at random from the unit being sampled, and combine to form a field sample whose quantity equals or exceeds the minimum recommended in 3.4.2. The increments may be obtained by placing containers in the transport at the appropriate time to catch the increments as the truck is loaded, or by collecting the increments with a scoop or shovel.

3.3.3 *Sampling from the Roadway Prior to Compaction*—Select the units to be sampled by a random method from the material in place. Obtain at least three approximately equal increments, selected at random from the unit being sampled, and combine to form

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[1] These methods are under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and are the direct responsibility of Subcommittee D04.30 on Methods of Sampling.

Current edition approved June 28, 1974. Published September 1974. Originally published as D 979 – 48 T. Last previous edition D 979 – 51 (1968).

[2] *Annual Book of ASTM Standards*, Part 26.

[3] *Annual Book of ASTM Standards*, Parts 15 and 41.

[4] *Annual Book of ASTM Standards*, Part 41.

a field sample whose quantity equals or exceeds the minimum recommended in 3.4.2. Take all increments from the roadway for the full depth of the material, taking care to exclude any underlying material. Clearly mark the specific areas from which each increment is to be removed. Templates which are placed before the mixture is spread will be a definite aid in securing approximately equal increment weights.

3.3.4 *Sampling from Roadway after Compaction*—Select the units to be sampled by a random method from the material in place. Obtain at least two approximately equal increments, selected at random from the unit being sampled, test each increment and average the test results to determine the acceptability. Take all increments from the roadway for the full depth of the material, taking care to exclude any underlying material. Each increment shall be obtained by coring, sawing, or other methods in such manner as to ensure a minimum disturbance of the material.

3.4 *Number and Quantities of Field Samples:*

3.4.1 The number of field samples (obtained by one of the methods described in 3.3) required depends on the criticality of, and variation in, the properties to be measured. Designate each unit from which a field sample is to be obtained prior to sampling. The number of field samples from the production should be sufficient to give the desired confidence in test results.

NOTE—Guidance for determining the number of samples required to obtain the desired level of confidence in test results may be found in Method D 2234, Recommended Practice E 105, Recommended Practice E 122, and Recommended Practice E 141.

3.4.2 A guide to the quantity of material in field samples is given in Table 1. The quantities depend on the type and number of tests to which the material is to be subjected, and sufficient material must be obtained to provide for the proper execution of these tests. Standard control and acceptance tests are covered by ASTM Standards and specify the portion of the field sample required for each specific test. Generally, the amounts specified in Table 1 will provide adequate material for routine testing. Extract test portions from the field sample by mixing and quartering on a clean, smooth surface.

4. Shipping Samples

4.1 Transport samples in containers so constructed as to preclude loss or contamination of any part of the sample, or damage to the contents from mishandling during shipment.

4.2 Samples shall have individual identification attached giving the information required by the sample user. Typical information that may be useful could include, but not necessarily be limited to the following:

4.2.1 Job for which the material is to be used, giving project number, highway route number, county, and other pertinent geographical information,

4.2.2 Source of sample, including for plant-mixed samples the name of owner or operator of plant, location of plant, type of plant, size of batch, and identification of bitumen and mineral aggregates used in the mixture,

4.2.3 Point at which sampled, for samples taken from roadway, both by station number and location transversely in pavement; also whether sampled from completed pavement, windrow, etc.,

4.2.4 Quantity represented,

4.2.5 By whom sampled and title,

4.2.6 Date of most recent mixing, if road-mixed,

4.2.7 Date sampled,

4.2.8 By whom submitted and address,

4.2.9 Purpose for which sample was taken, and

4.2.10 To whom report is to be made.

TABLE 1 Guide for Estimating Quantity of Sample

Maximum Nominal Size of Aggregates[a]	Approximate Weight of Uncompacted Mixture, min, lb (kg)	Approximate Area of Compacted Mixture, min, in.^{2} (cm^2)
No. 8 (2.36-mm)	4 (1.8)	36 (232)
No. 4 (4.75-mm)	4 (1.8)	36 (232)
⅜-in. (9.5-mm)	8 (3.6)	36 (232)
½-in. (12.5-mm)	12 (5.4)	64 (413)
¾-in. (19.0-mm)	16 (7.3)	100 (645)
1-in. (25.0-mm)	20 (9.1)	144 (929)
1½-in. (38.1-mm)	25 (11.3)	144 (929)
2-in. (50-mm)	35 (15.9)	225 (1453)

[a] The maximum normal size of aggregate is the largest sieve size listed in the applicable specification upon which any material is permitted to be retained.

D 1559

ASTM D 1559

STABILITE MARSHALL + DEFORMATION

Les modifications apportées à la norme ASTM sont décrites dans "Analyse des Mélanges Bitumineux au Québec". De plus, nous avons ajouté la modification suivante: Pour obtenir un indice de déformation (fluage) précis on doit utiliser deux indicateurs de déformation au lieu d'un.

1.1 COMPACTAGE

Le Laboratoire Central spécifie 60 coups au lieu de 50 pour diverses raisons.

À la suite d'essais faits en laboratoire, on constate qu'après 50 coups la densité bulk n'augmente plus. Par ailleurs il faut compenser pour l'usure des marteaux et l'erreur possible dans le comptage des coups. Or, en faisant le compactage à 60 coups, on peut se permettre d'avoir une course réduite de 1 po., un marteau pesant 1/2 lb. de moins, une précision de deux coups sur le comptage et obtenir encore une énergie suffisante pour un compactage maximum.

En effet, l'énergie de compactage à 60 coups, marteau de 10 lb., hauteur de chute de 18 po. est égale à 10,800 lb/po. Celle à 50 coups, même poids et même hauteur de chute égale 9,000 lb./po. Une diminution de 1 lb. sur le poids du marteau, 1 po. sur la hauteur de chute et de 2 coups sur le comptage réduit l'énergie respectivement de 540,600 et 360 lb./po. soit un total de 1,500 lb./po. À 60 coups, même avec ces erreurs, il reste encore 9,300 lb./po.

La méthode Marshall, telle qu'elle est utilisée au Québec, n'est applicable qu'aux mélanges à base de bitume routier et de granulats de dimension ne dépassant pas 1 po (25,4 mm). La méthode peut être employée pour l'étude en laboratoire et pour le contrôle en chantier.

2.1 MARSHALL STANDARD

2.1.01 Préparation de l'échantillon

Porter la température de tout l'échantillon reçu à 200°F (93°C) et prelever par inquartation les quantités nécessaires pour chacun des essais suivants:

Compactage:	environ 1 200 g
Densité maximum:	environ 500 g
Extraction du bitume:	environ 1 000 g

N.B.: La température de 200°F (93°C) est suffisante pour effectuer les essais de densité maximum et d'extraction du bitume.

2.2 COMPACTAGE ASTM D 1559

2.2.01 Préparation de l'éprouvette

Placer au four la partie destinée au compactage, jusqu'à ce qu'elle atteigne la température de 300°F (149°C), pour les bitumes de 85 à 200 de pénétration. Pour les bitumes plus mous, suivre la procédure de l'article 3.3 ASTM D 1559

2.2.02 Appareils

- Un socle en bois à section carrée de 8 po X 8 po, dimensions minimales, (203,2 mm X 203,2 mm) X 18 po (457,2 mm) de hauteur, recouvert d'une plaque métallique de 12 po (304,8 mm X 304,8 mm) le tout placé sur un plancher rigide (béton de ciment).
- Un ensemble de compactage constitué par une plaque de base, un moule et une hausse. Le moule doit avoir 4 po (101,6 mm) de diamètre intérieur et environ 3 po (76,2 mm) de hauteur; la plaque de base et la hausse peuvent être adaptées à l'une ou l'autre extrémité du moule.
- Un marteau de compactage d'un poids de 10 lb (4,536 kg) constitué par une plaque circulaire de 3 7/8 po (98,4 mm) de diamètre et conçu pour une chute libre de 18 po (45,042 cm)
- Un support pour le moule de compactage constitué par un dispositif à ressort permettant de maintenir solidement le moule en place.
- Un dispositif de démoulage constitué d'un verin hydraulique et une pres-

2.2.03 Procédé

- Avant le compactage, nettoyer parfaitement et chauffer la face du marteau et les moules.

- Placer au fond du moule un disque de papier. Introduire la quantité de mélange (soit environ 1 200 g. préalablement chauffé à 300°F.) dans le moule.
- Retirer le moule, le placer avec l'éprouvette en position contraire à celle du compactage, et laisser refroidir à la température de la pièce avant de démouler.

- Poser soigneusement l'éprouvette sur une surface bien au niveau et lisse, afin d'éviter toutes déformations jusqu'au moment de l'essai.

- Laisser refroidir les éprouvettes à la température ambiante avant de procéder aux essais.
  N.B.: On ne doit pas effectuer de densité ou de stabilité dans la même journée que les éprouvettes sont compactées. L'éprouvette compactée doit avoir une hauteur de 2½po. ± ⅛po. (63 mm ± 3 mm).
- Donner 15 coups de spatule autour du moule et 10 coups au centre; lisser le sommet du mélange qui doit être légèrement bombé et placer un autre disque de papier.
  N.B.: La tige à bout arrondi de ¼ po. (6,35 mm) est à déconseiller car elle favorise la ségrégation.

- Appliquer 60 coups de marteau de chaque côté si le marteau utilisé est mécanique avec plaque de base tournante et 75 coups pour un marteau manuel ou mécanique avec plaque de base fixe.

2.5 STABILITE ET DEFORMATION ASTM D 1559

2.5.01 Définition

- La stabilité est la résistance à la déformation d'une éprouvette sous l'effet d'une charge. Elle est exprimée en livres.

2.5.02 Appareils

- Un stabilimètre Marshall mû électriquement et conçu pour appliquer des charges, aux éprouvettes, à une vitesse constante de deux pouces par minute (50,8 mm par minute) et pourvu d'un anneau dynamométrique étalonné pour déterminer la charge appliquée, avec une précision de plus ou moins 11 kg.
- Un extensiomètre pour enregistrer la déformation produite par la charge maximum appliquée.
- Un bain à température constante muni de 1 ou 2 thermomètres pour indiquer précisément la température de l'eau et d'un support ou tablette perforé supportant les briquettes à au moins 2 po (51 mm) du fond.

  N.B.: Un système d'agitation d'eau aidera grandement à maintenir la température de l'eau uniformément dans le bain.
- Deux mâchoires semi-cylindriques, dont une est munie de tiges de guidage.

2.5.03 PROCEDE

- Une fois la densité bulk connue, immerger l'éprouvette dans le bain pendant 30 minutes à la température de 140°F (60°C)
- Nettoyer parfaitement les parois intérieures des mâchoires, huiler légèrement les tiges de guidage pour permettre à la mâchoire supérieure de glisser librement sans se coincer.
- Vérifier si l'indicateur à cadran est solidement fixé et réglé à "0" avant de commencer l'essai.
- Retirer l'éprouvette du bain et sécher soigneusement la surface. Placer dans la mâchoire inférieure l'éprouvette et centrer. Placer ensuite la

mâchoire supérieure et centrer l'appareillage complet sur la presse. Placer l'indicateur de déformation et l'ajuster à "0".

N.B.: L'opération, c'est-à-dire l'essai de stabilité et de déformation, doit être terminée moins de 30 secondes après la sortie de l'éprouvette du bain. L'indicateur de déformation doit être maintenu en place jusqu'au moment ou la charge maximale commence à décroitre.

2.5.04 Calculs

— Faire la correspondance entre la lecture relevée au moment de l'essai et la charte de calibration; multiplier la nouvelle lecture par le facteur de correction correspondant au volume brut de l'éprouvette.

1 Facteur de correction (Stabilité Marshall)

Volume brut en cm^3	Epaisseur approx. en pouces	Facteur de correction
200-213	1	5.56
214-225	1 1/16	5.00
226-237	1 1/8	4.55
238-250	1 3/16	4.17
251-264	1 1/4	3.85
265-276	1 5/16	3.57
277-289	1 3/8	3.33
290-301	1 7/16	3.03
302-316	1 1/2	2.78
317-328	1 9/16	2.50
329-340	1 5/8	2.27
341-353	1 11/16	2.08
354-367	1 3/4	1.92
368-379	1 13/16	1.79
380-392	1 7/8	1.67
393-405	1 15/16	1.56
406-420	2	1.47
421-431	2 1/16	1.39
432-443	2 1/8	1.32
444-456	2 3/16	1.25
457-470	2 1/4	1.19
471-482	2 5/16	1.14
483-495	2 3/8	1.09
496-508	2 7/16	1.04
509-522	2 1/2	1.00
523-535	2 9/16	0.96
536-546	2 5/8	0.93
547-559	2 11/16	0.89
560-573	2 3/4	0.86
574-585	2 13/16	0.83
586-598	2 7/8	0.81
599-610	2 15/16	0.78
611-625	3	0.76

- La stabilité obtenue avec le facteur de correction correspond à la stabilité qu'aurait une éprouvette de 2 1/2" d'un mélange identique.
- La relation volume-épaisseur est basée sur une éprouvette de 2 1/2".
- L'épaisseur en po. (de l'éprouvette) peut être fourni par l'équation suivante: E : 0.004854 x V

où E : épaisseur en po. de l'éprouvette
V : volume en cm^3 de l'éprouvette

AMERICAN NATIONAL STANDARD ANSI/ASTM D 1559 - 76

Standard Test Method for
RESISTANCE TO PLASTIC FLOW OF BITUMINOUS MIXTURES USING MARSHALL APPARATUS[1]

This Standard is issued under the fixed designation D 1559; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the measurement of the resistance to plastic flow of cylindrical specimens of bituminous paving mixture loaded on the lateral surface by means of the Marshall apparatus. This method is for use with mixtures containing asphalt cement, asphalt cut-back or tar, and aggregate up to 1-in. (25.4-mm) maximum size.

2. Apparatus

2.1 *Specimen Mold Assembly*—Mold cylinders 4 in. (101.6 mm) in diameter by 3 in. (76.2 mm) in height, base plates, and extension collars shall conform to the details shown in Fig. 1. Three mold cylinders are recommended.

2.2 *Specimen Extractor*, steel, in the form of a disk with a diameter not less than 3.95 in. (100 mm) and ½ in. (13 mm) thick for extracting the compacted specimen from the specimen mold with the use of the mold collar. A suitable bar is required to transfer the load from the ring dynamometer adapter to the extension collar while extracting the specimen.

2.3 *Compaction Hammer*—The compaction hammer (Fig. 2) shall have a flat, circular tamping face and a 10-lb (4536-g) sliding weight with a free fall of 18 in. (457.2 mm). Two compaction hammers are recommended.

NOTE 1—The compaction hammer may be equipped with a finger safety guard as shown in Fig. 2.

2.4 *Compaction Pedestal*—The compaction pedestal shall consist of an 8 by 8 by 18-in. (203.2 by 203.2 by 457.2-mm) wooden post capped with a 12 by 12 by 1-in. (304.8 by 304.8 by 25.4-mm) steel plate. The wooden post shall be oak, pine, or other wood having an average dry weight of 42 to 48 lb/ft^3 (0.67 to 0.77 g/cm^3). The wooden post shall be secured by four angle brackets to a solid concrete slab. The steel cap shall be firmly fastened to the post. The pedestal assembly shall be installed so that the post is plumb and the cap is level.

2.5 *Specimen Mold Holder*, mounted on the compaction pedestal so as to center the compaction mold over the center of the post. It shall hold the compaction mold, collar, and base plate securely in position during compaction of the specimen.

2.6 *Breaking Head*—The breaking head (Fig. 3) shall consist of upper and lower cylindrical segments or test heads having an inside radius of curvature of 2 in. (50.8 mm) accurately machined. The lower segment shall be mounted on a base having two perpendicular guide rods or posts extending upward. Guide sleeves in the upper segment shall be in such a position as to direct the two segments together without appreciable binding or loose motion on the guide rods.

2.7 *Loading Jack*—The loading jack (Fig. 4) shall consist of a screw jack mounted in a testing frame and shall produce a uniform vertical movement of 2 in. (50.8 mm)/min. An electric motor may be attached to the jacking mechanism.

NOTE 2—Instead of the loading jack, a mechanical or hydraulic testing machine may be used

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[1] This method is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.20 on Mechanical Tests of Bituminous Mixes.

Current edition approved April 30, 1976. Published September 1976. Originally published as D 1559 - 58. Last previous edition D 1559 - 75.

provided the rate of movement can be maintained at 2 in. (50.8 mm)/min while the load is applied.

2.8 *Ring Dynamometer Assembly*—One ring dynamometer (Fig. 4) of 5000-lb (2267-kg) capacity and sensitivity of 10 lb (4.536 kg) up to 1000 lb (453.6 kg) and 25 lb (11.340 kg) between 1000 and 5000 lb (453.6 and 2267 kg) shall be equipped with a micrometer dial. The micrometer dial shall be graduated in 0.0001 in. (0.0025 mm). Upper and lower ring dynamometer attachments are required for fastening the ring dynamometer to the testing frame and transmitting the load to the breaking head.

NOTE 3—Instead of the ring dynamometer assembly, any suitable load-measuring device may be used provided the capacity and sensitivity meet the above requirements.

2.9 *Flowmeter*—The flowmeter shall consist of a guide sleeve and a gage. The activating pin of the gage shall slide inside the guide sleeve with a slight amount of frictional resistance. The guide sleeve shall slide freely over the guide rod of the breaking head. The flowmeter gage shall be adjusted to zero when placed in position on the breaking head when each individual test specimen is inserted between the breaking head segments. Graduations of the flowmeter gage shall be in 0.01-in. (0.25-mm) divisions.

NOTE 4—Instead of the flowmeter, a micrometer dial or stress-strain recorder graduated in 0.001 in. (0.025 mm) may be used to measure flow.

2.10 *Ovens or Hot Plates*—Ovens or hot plates shall be provided for heating aggregates, bituminous material, specimen molds, compaction hammers, and other equipment to the required mixing and molding temperatures. It is recommended that the heating units be thermostatically controlled so as to maintain the required temperature within 5 F (2.8 C). Suitable shields, baffle plates or sand baths shall be used on the surfaces of the hot plates to minimize localized overheating.

2.11 *Mixing Apparatus*—Mechanical mixing is recommended. Any type of mechanical mixer may be used provided it can be maintained at the required mixing temperature and will produce a well-coated, homogeneous mixture of the required amount in the allowable time, and further provided that essentially all of the batch can be recovered. A metal pan or bowl of sufficient capacity and hand mixing may also be used.

2.12 *Water Bath*—The water bath shall be at least 6 in. (152.4 mm) deep and shall be thermostatically controlled so as to maintain the bath at 140 ± 1.8 F (60 ± 1.0 C) or 100 ± 1.8 F (37.8 ± 1 C). The tank shall have a perforated false bottom or be equipped with a shelf for supporting specimens 2 in. (50.8 mm) above the bottom of the bath.

2.13 *Air Bath*—The air bath for asphalt cut-back mixtures shall be thermostatically controlled and shall maintain the air temperature at 77 F ± 1.8 F (25 ± 1.0 C).

2.14 *Miscellaneous Equipment:*

2.14.1 *Containers* for heating aggregates, flat-bottom metal pans or other suitable containers.

2.14.2 *Containers* for heating bituminous material, either gill-type tins, beakers, pouring pots, or saucepans may be used.

2.14.3 *Mixing Tool*, either a steel trowel (garden type) or spatula, for spading and hand mixing.

2.14.4 *Thermometers* for determining temperatures of aggregates, bitumen, and bituminous mixtures. Armored-glass or dial-type thermometers with metal stems are recommended. A range from 50 to 400 F (9.9 to 204 C), with sensitivity of 5 F (2.8 C) is required.

2.14.5 *Thermometers* for water and air baths with a range from 68 to 158 F (20 to 70 C) sensitive to 0.4 F (0.2 C).

2.14.6 *Balance*, 2-kg capacity, sensitive to 0.1 g, for weighing molded specimens.

2.14.7 *Balance*, 5-kg capacity, sensitive to 1.0 g, for batching mixtures.

2.14.8 *Gloves* for handling hot equipment.

2.14.9 *Rubber Gloves* for removing specimens from water bath.

2.14.10 *Marking Crayons* for identifying specimens.

2.14.11 *Scoop*, flat bottom, for batching aggregates.

2.14.12 *Spoon*, large, for placing the mixture in the specimen molds.

3. Test Specimens

3.1 *Number of Specimens*—Prepare at least three specimens for each combination of aggregates and bitumen content.

3.2 *Preparation of Aggregates*—Dry aggregates to constant weight at 221 to 230 F (105 to

110 C) and separate the aggregates by dry-sieving into the desired size fractions.[2] The following size fractions are recommended:

1 to ¾ in. (25.0 to 19.0 mm)
¾ to ⅜ in. (19.0 to 9.5 mm)
⅜ in. to No. 4 (9.5 mm to 4.75 mm)
No. 4 to No. 8 (4.75 mm to 2.36 mm)
Passing No. 8 (2.36 mm)

3.3 *Determination of Mixing and Compacting Temperatures:*

3.3.1 The temperatures to which the asphalt cement and asphalt cut-back must be heated to produce a viscosity of 170 ± 20 cSt shall be the mixing temperature.

3.3.2 The temperature to which asphalt cement must be heated to produce a viscosity of 280 ± 30 cSt shall be the compacting temperature.

3.3.3 From a composition chart for the asphalt cut-back used, determine from its viscosity at 140 F (60 C) the percentage of solvent by weight. Also determine from the chart the viscosity at 140 F (60 C) of the asphalt cut-back after it has lost 50 percent of its solvent. The temperature determined from the viscosity temperature chart to which the asphalt cut-back must be heated to produce a viscosity of 280 ± 30 cSt after a loss of 50 percent of the original solvent content shall be the compacting temperature.

3.3.4 The temperature to which tar must be heated to produce Engler specific viscosities of 25 ± 3 and 40 ± 5 shall be respectively the mixing and compacting temperature.

3.4 *Preparation of Mixtures:*

3.4.1 Weigh into separate pans for each test specimen the amount of each size fraction required to produce a batch that will result in a compacted specimen 2.5 ± 0.05 in. (63.5 ± 1.27 mm) in height (about 1200 g). Place the pans on the hot plate or in the oven and heat to a temperature not exceeding the mixing temperature established in 3.3 by more than approximately 50 F (28 C) for asphalt cement and tar mixes and 25 F (14 C) for cut-back asphalt mixes. Charge the mixing bowl with the heated aggregate and dry mix thoroughly. Form a crater in the dry blended aggregate and weigh the preheated required amount of bituminous material into the mixture. For mixes prepared with cutback asphalt introduce the mixing blade in the mixing bowl and determine the total weight of the mix components plus bowl and blade before proceeding with mixing. Care must be exercised to prevent loss of the mix during mixing and subsequent handling. At this point, the temperature of the aggregate and bituminous material shall be within the limits of the mixing temperature established in 3.3. Mix the aggregate and bituminous material rapidly until thoroughly coated.

3.4.2 Following mixing, cure asphalt cut-back mixtures in a ventilated oven maintained at approximately 20 F (11.1 C) above the compaction temperature. Curing is to be continued in the mixing bowl until the precalculated weight of 50 percent solvent loss or more has been obtained. The mix may be stirred in a mixing bowl during curing to accelerate the solvent loss. However, care should be exercised to prevent loss of the mix. Weigh the mix during curing in successive intervals of 15 min initially and less than 10 min intervals as the weight of the mix at 50 percent solvent loss is approached.

3.5 *Compaction of Specimens:*

3.5.1 Thoroughly clean the specimen mold assembly and the face of the compaction hammer and heat them either in boiling water or on the hot plate to a temperature between 200 and 300 F (93.3 and 148.9 C). Place a piece of filter paper or paper toweling cut to size in the bottom of the mold before the mixture is introduced. Place the entire batch in the mold, spade the mixture vigorously with a heated spatula or trowel 15 times around the perimeter and 10 times over the interior. Remove the collar and smooth the surface of the mix with a trowel to a slightly rounded shape. Temperatures of the mixtures immediately prior to compaction shall be within the limits of the compacting temperature established in 3.3.

3.5.2 Replace the collar, place the mold assembly on the compaction pedestal in the mold holder, and unless otherwise specified, apply 50 blows with the compaction hammer with a free fall in 18 in. (457.2 mm). Hold the axis of the compaction hammer perpendicular to the base of the mold assembly during compaction. Remove the base plate and collar,

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[2] Detailed requirements for these sieves are given in ASTM Specification E 11, for Wire-Cloth Sieves for Testing Purposes see *Annual Book of ASTM Standards*, Parts 15 and 41.

and reverse and reassemble the mold. Apply the same number of compaction blows to the face of the reversed specimen. After compaction, remove the base plate and place the sample extractor on that end of the specimen. Place the assembly with the extension collar up in the testing machine, apply pressure to the collar by means of the load transfer bar, and force the specimen into the extension collar. Lift the collar from the specimen. Carefully transfer the specimen to a smooth, flat surface and allow it to stand overnight at room temperature. Weigh, measure, and test the specimen.

NOTE 5—In general, specimens shall be cooled as specified in 3.5.2. When more rapid cooling is desired, table fans may be used. Mixtures that lack sufficient cohesion to result in the required cylindrical shape on removal from the mold immediately after compaction may be cooled in the mold in air until sufficient cohesion has developed to result in the proper cylindrical shape.

4. Procedure

4.1 Bring the specimens prepared with asphalt cement or tar to the specified temperature by immersing in the water bath 30 to 40 min or placing in the oven for 2 h. Maintain the bath or oven temperature at 140 ± 1.8 F (60 ± 1.0 C) for the asphalt cement specimens and 100 ± 1.8 F (37.8 ± 1.0 C) for tar specimens. Bring the specimens prepared with asphalt cut-back to the specified temperature by placing them in the air bath for a minimum of 2 h. Maintain the air bath temperature at 77 ± 1.8 F (25 ± 1.0 C). Thoroughly clean the guide rods and the inside surfaces of the test heads prior to making the test, and lubricate the guide rods so that the upper test head slides freely over them. The testing-head temperature shall be maintained between 70 to 100 F (21.1 to 37.8 C) using a water bath when required. Remove the specimen from the water bath, oven, or air bath, and place in the lower segment of the breaking head. Place the upper segment of the breaking head on the specimen, and place the complete assembly in position on the testing machine. Place the flowmeter, where used, in position over one of the guide rods and adjust the flowmeter to zero while holding the sleeve firmly against the upper segment of the breaking head. Hold the flowmeter sleeve firmly against the upper segment of the breaking head while the test load is being applied.

4.2 Apply the load to the specimen by means of the constant rate of movement of the load jack or testing-machine head of 2 in. (50.8 mm)/min until the maximum load is reached and the load decreases as indicated by the dial. Record the maximum load noted on the testing machine or converted from the maximum micrometer dial reading. Release the flowmeter sleeve or note the micrometer dial reading, where used, the instant the maximum load begins to decrease. Note and record the indicated flow value or equivalent units in hundredths of an inch (twenty-five hundredths of a millimetre) if a micrometer dial is used to measure the flow. The elapsed time for the test from removal of the test specimen from the water bath to the maximum load determination shall not exceed 30 s.

NOTE 6—For core specimens, correct the load when thickness is other than 2½ in. (63.5 mm) by using the proper multiplying factor from Table 1.

5. Report

5.1 The report shall include the following information:

5.1.1 Type of sample tested (laboratory sample or pavement core specimen).

NOTE 6—For core specimens, the height of each test specimen in inches (or millimetres) shall be reported.

5.1.2 Average maximum load in pounds-force (or newtons) of at least three specimens, corrected when required,

5.1.3 Average flow value, in hundredths of an inch, twenty-five hundredths of a millimetre, of three specimens, and

5.1.4 Test temperature.

TABLE 1 Stability Correlation Ratios[a]

Volume of Specimen, cm³	Approximate Thickness of Specimen, in.[b]	mm	Correlation Ratio
200 to 213	1	25.4	5.56
214 to 225	1 1/16	27.0	5.00
226 to 237	1 1/8	28.6	4.55
238 to 250	1 3/16	30.2	4.17
251 to 264	1 1/4	31.8	3.85
265 to 276	1 5/16	33.3	3.57
277 to 289	1 3/8	34.9	3.33
290 to 301	1 7/16	36.5	3.03
302 to 316	1 1/2	38.1	2.78
317 to 328	1 9/16	39.7	2.50
329 to 340	1 5/8	41.3	2.27
341 to 353	1 11/16	42.9	2.08
354 to 367	1 3/4	44.4	1.92
368 to 379	1 13/16	46.0	1.79
380 to 392	1 7/8	47.6	1.67
393 to 405	1 15/16	49.2	1.56
406 to 420	2	50.8	1.47
421 to 431	2 1/16	52.4	1.39
432 to 443	2 1/8	54.0	1.32
444 to 456	2 3/16	55.6	1.25
457 to 470	2 1/4	57.2	1.19
471 to 482	2 5/16	58.7	1.14
483 to 495	2 3/8	60.3	1.09
496 to 508	2 7/16	61.9	1.04
509 to 522	2 1/2	63.5	1.00
523 to 535	2 9/16	64.0	0.96
536 to 546	2 5/8	65.1	0.93
547 to 559	2 11/16	66.7	0.89
560 to 573	2 3/4	68.3	0.86
574 to 585	2 13/16	71.4	0.83
586 to 598	2 7/8	73.0	0.81
599 to 610	2 15/16	74.6	0.78
611 to 625	3	76.2	0.76

[a] The measured stability of a specimen multiplied by the ratio for the thickness of the specimen equals the corrected stability for a 2½-in. (63.5 mm) specimen.

[b] Volume-thickness relationship is based on a specimen diameter of 4 in. (101.6 mm).

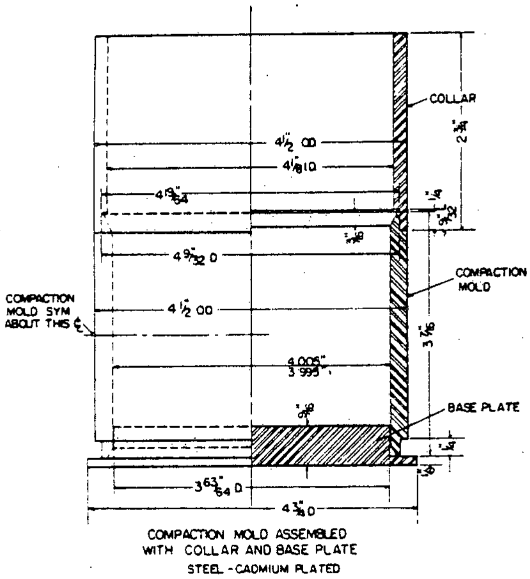


FIG. 1 Compaction Mold.

Table of Equivalents for Figs. 1 and 3

U.S. Customary Units, in.	Metric Equivalents, mm	U.S. Customary Units, in.	Metric Equivalents, mm	U.S. Customary Units, in.	Metric Equivalents, mm	U.S. Customary Units, in.	Metric Equivalents, mm
0.005	0.11	11/16	17.5	2 5/16	58.7	4 1/8	104.8
1/32	0.8	3/4	19.0	2 1/2	63.5	4 9/32	108.7
1/16	1.6	7/8	22.2	2 3/4	69.8	4 19/64	109.1
1/8	3.2	15/16	23.8	2 7/8	73.0	4 1/2	114.3
3/16	4.8	1	25.4	3	76.2	4 5/8	117.5
1/4	6.4	1 1/8	28.6	3 1/4	82.6	4 3/4	120.6
9/32	7.1	1 1/4	31.8	3 7/16	87.3	5 1/16	128.6
3/8	9.5	1 3/8	34.9	3 7/8	98.4	5 1/8	130.2
0.496	12.6	1 1/2	38.1	3 63/64	101.2	5 3/4	146.0
0.499	12.67	1 5/8	41.3	3.990	101.35	6	152.4
1/2	12.7	1 3/4	44.4	3.995	101.47	6 1/4	158.8
9/16	14.3	2	50.8	4	101.6	7 5/8	193.7
5/8	15.9	2 1/4	57.2	4.005	101.73	27	685.8

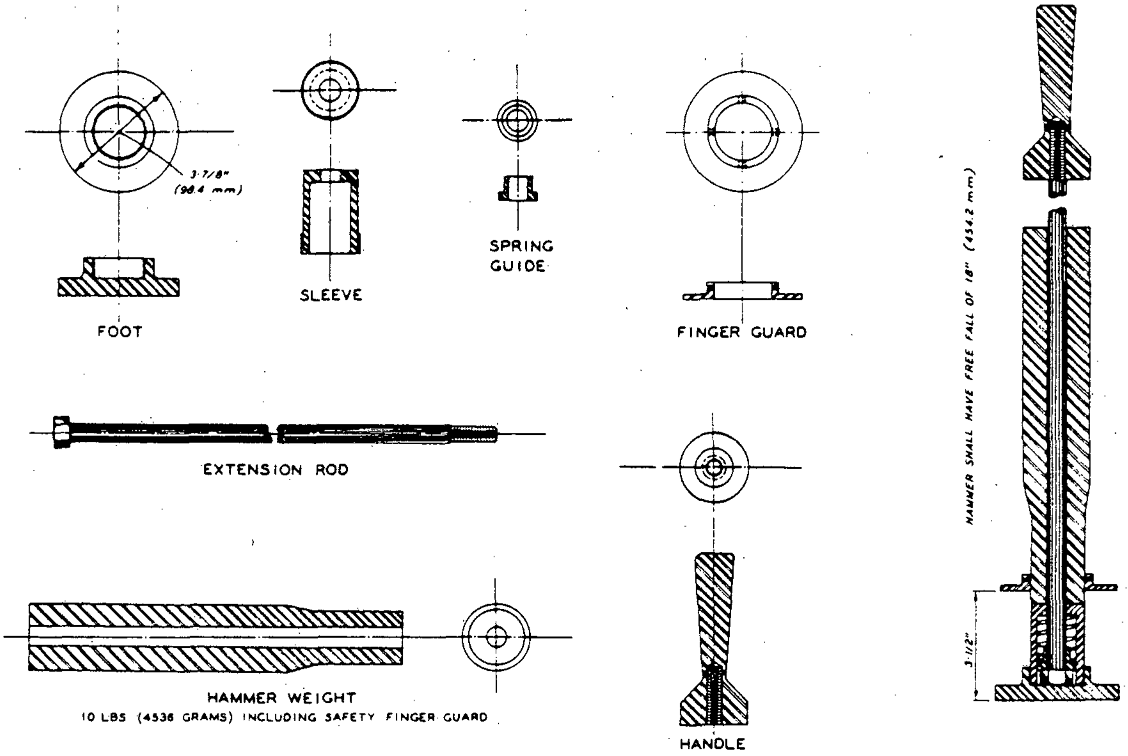
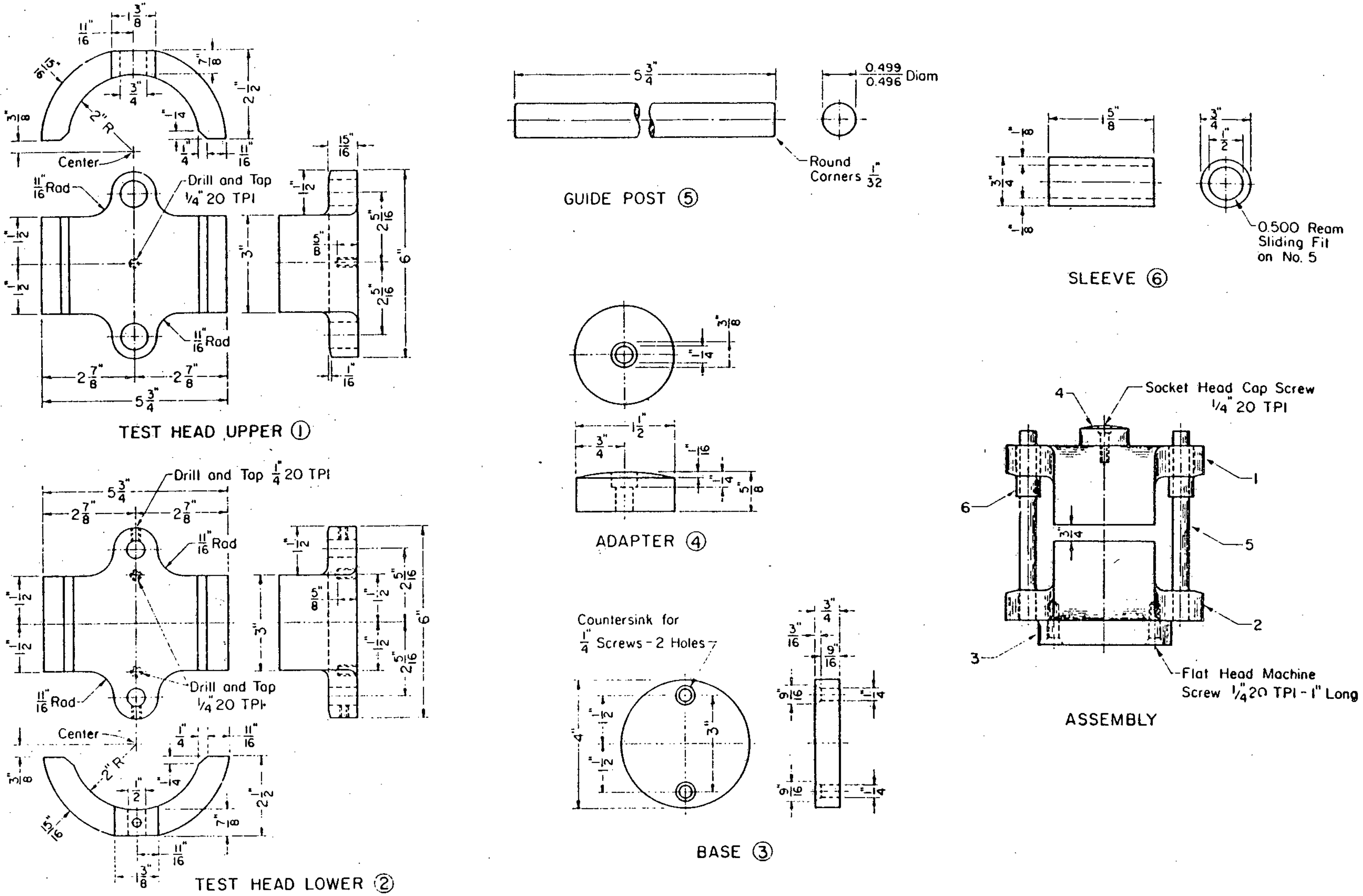


FIG. 2 Compaction Hammer.



(Table of Equivalents same as for Fig. 1.)

FIG. 3 Breaking Head.

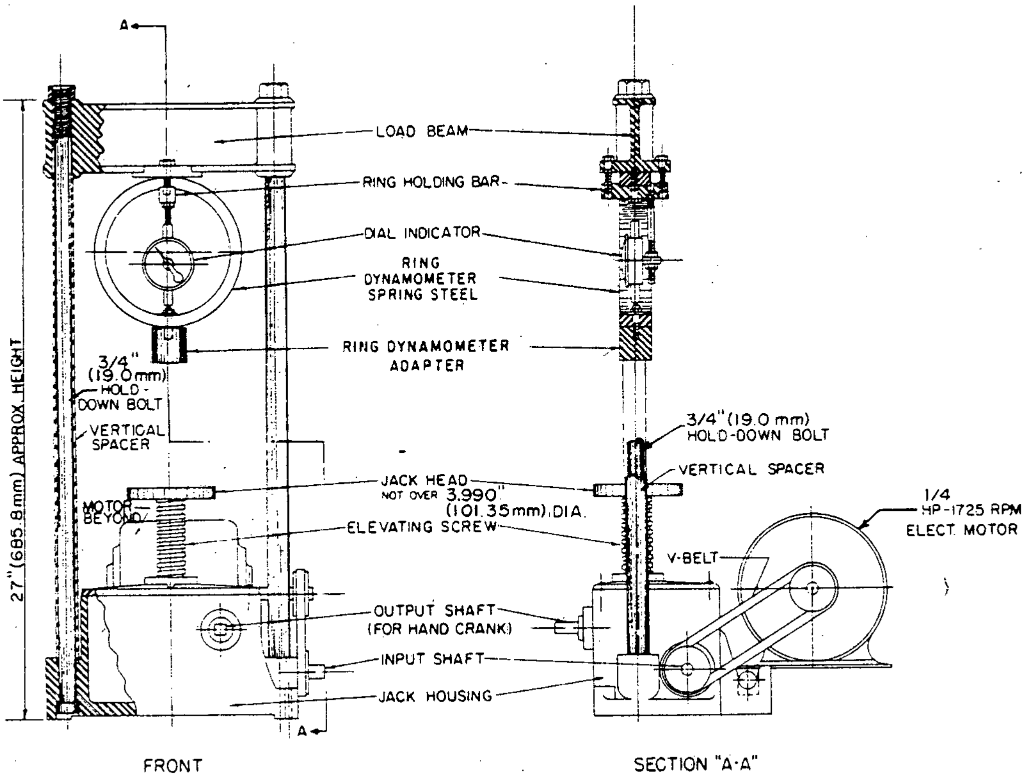


FIG. 4 Compression Testing Machine.

1.2 DENSITE MAXIMUM

L'ASTM indique un temps sous vide de 15 minutes avec une variation possible de plus ou moins 2 minutes. Le Laboratoire Central spécifie 20 minutes, parce qu'à la suite d'études il a été démontré que 15 minutes ne permettent pas d'obtenir une densité maximum.
De plus, le graphique 6 montre clairement qu'une agitation mécanique continuelle permet d'atteindre la densité maximum, alors que la méthode préconisée par l'ASTM ne le permet pas.

Enfin, l'ASTM indique que la lecture du poids dans l'eau doit se faire après une immersion de 10 minutes, or une étude a démontré que 3 minutes sont nécessaires et suffisantes, mais qu'un temps plus long n'apporte qu'un changement de 1/10 de 1%, pour des temps de 3 à 6 minutes et aucun changement appréciable après 6 minutes.

Quantités à utiliser:
Le tableau indiquant les quantités à utiliser est inscrit dans la méthode ASTM D 2041 article 6.2

Le récipient (fiole genre cruche à jus) recommandé peut contenir 500 g à 1000 g selon le type de mélange.

2.4 Densité Maximum RICE (ASTM D 2041)

2.4.01 Définition

— La densité maximum est le rapport du poids dans l'air d'un spécimen sur son volume minimum, mesurable en laboratoire.

2.4.02 Appareils

— Une balance ayant une capacité d'au moins 3 000 g et une sensibilité supérieure à 0,1 g.

— Une fiole, genre cruche à jus, d'une capacité d'au moins 1 000 ml.

N.B.: Elle doit être suffisamment forte pour résister au vide partiel. L'embouchure doit être régulière et polie pour donner un joint étanche. La fiole est étanchée par un bouchon de caoutchouc et relié à une autre fiole (pour empêcher l'eau d'atteindre la pompe) puis à la pompe à vide par un boyau de caoutchouc.

— Une pompe à vide ou un aspirateur d'eau pour évacuer l'air du contenant.

— Un système de mesure du vide.

2.4.03 Procédé

- Placer l'échantillon d'environ 500 g dans une grande tôle et laisser refroidir à la température ambiante.
- Séparer les particules de l'échantillon sans briser les particules minérales, de sorte que les agglomérations d'un agrégat fin ne soient pas plus grosses que ¼ po. (64 cm ou 6,4 mm).
- Placer le mélange dans la fiole et peser dans l'air. Ajouter une certaine quantité d'eau (température de la pièce) pour couvrir l'échantillon.
- Chasser l'air emprisonné en assujettissant le contenu à un vide partiel (pression inférieure à 3 cm de mercure, minimum 28 sur l'indicateur de vacuum) pendant 20 minutes sur un **agitateur mécanique** (Photos 3 et 4)
- Peser ensuite la fiole avec son contenu dans l'eau en prenant soin de l'incliner légèrement pour éviter la formation d'un coussin d'air sous la fiole lors de son entrée dans l'eau.

  N.B.: En inclinant la fiole, prendre soin que l'air ambiant ne vienne pas en contact avec le mélange. De plus, la lecture du poids dans l'eau ne doit se faire qu'après une immersion d'au moins 3 minutes.

2.4.04 Calculs

—
$$Dm = \frac{A - B}{(A - B) - (C - D)}$$

où A = Poids de la fiole + mélange dans l'air
B = Poids de la fiole dans l'air
C = Poids de la fiole + mélange dans l'eau
D = Poids de la fiole dans l'eau
Dm = Densité maximum

AMERICAN NATIONAL STANDARD **ANSI/ASTM D 2041 - 78**

Standard Test Method for
THEORETICAL MAXIMUM SPECIFIC GRAVITY OF BITUMINOUS PAVING MIXTURES[1]

This Standard is issued under the fixed designation D 2041; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the determination of the theoretical maximum specific gravity of uncompacted bituminous paving mixtures. The method also includes a rapid test version for relative specific gravity suitable for use in a field or plant laboratory.

2. Applicable Document

2.1 *ASTM Standard:*

D 979 Sampling Bituminous Paving Mixtures[2]

3. Definition

3.1 *specific gravity—as determined by this method*, the ratio of the mass of a given volume of material at 25°C (or stated temperature) to the mass of an equal volume of water at the same temperature.

4. Apparatus

4.1 *Container:*

4.1.1 Four variations of the vacuum saturation technique using containers of different size and functional design are described. The container may be:

4.1.1.1 *Type A*—A glass, plastic, or metal bowl having a capacity of at least 1000 ml,

4.1.1.2 *Type B*—A volumetric flask having a capacity of at least 1000 ml,

4.1.1.3 *Type C*—An intermediate-size heavy-wall glass pycnometer having a capacity of approximately 4000 ml, or

4.1.1.4 *Type D*—A large-size plastic pycnometer having a capacity of at least 10 000 ml.

4.1.2 The container size depends on the minimum sample size requirements as given in 6.2.

4.1.3 Containers shall be sufficiently strong to withstand an essentially full vacuum and shall have covers as follows:

4.1.3.1 A cover fitted with a rubber gasket and a hose connection, for use with the bowl (Type A).

4.1.3.2 A rubber stopper with a hose connection, for use with the volumetric flask (Type B).

4.1.3.3 A suitable vacuum connection assembly consisting of a vacuum gage, release valve, and tubing connector, plus a tapered stopper device for maintaining consistent volume regulation, for use with the pycnometer (Type C or D).

4.1.4 A small piece of fine wire mesh covering the hose opening will minimize the possibility of loss of fine material. Because of the mass involved, approximately 20 kg (44 lb), the large-size pycnometer container (Type D) should be equipped with suitable handles to facilitate transport and shaking while under vacuum to assist bubble release. Construction should permit visual observation of the effects of vacuum and shaking.

NOTE 1—The bottom section of a 1.4-litre (1.5-qt) capacity, borosilicate glass, double-boiler unit makes a satisfactory bowl (Type A).

NOTE 2—Polycarbonate plastic has been found

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[1] This method is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials, and is the direct responsibility of Subcommittee D04.21 on Specific Gravity and Density of Bituminous Mixtures.

Current edition approved March 10, 1978. Published May 1978. Originally published as D 2041 - 64 T. Last previous edition D 2041 - 71 (1976).

[2] *Annual Book of ASTM Standards*, Parts 15 and 19.

to be a suitable material, when properly fabricated, for the large-size plastic pycnometer (Type D). Tests have shown it to be safe for use under essentially full vacuum over a temperature range from 15 to 80°C (60 to 175°F).

4.2 *Balance*, with ample capacity, and with sufficient sensitivity to enable the specific gravity of samples of uncompacted paving mixtures to be calculated to at least four significant figures; that is, to at least three decimal places. For the bowl method (Type A), the balance shall be equipped with a suitable suspension apparatus and holder to permit weighing the sample while suspended from the center of the scale pan of the balance.

NOTE 3 — Since there are no more significant figures in the quotient (specific gravity) than appear in either the dividend (the weight of the sample in air) or in the divisor (the weight of water displaced), this means that the balance must have a readability capable of providing weights to at least four figures. Specific recommendations are: a balance capable of weighing 1500 g to an accuracy of 0.1 g for the 1000-ml bowl (Type A) or flask (Type B) containers; a balance capable of weighing 10 kg to an accuracy of 0.5 g for the 4000-ml glass pycnometer (Type C); a balance capable of weighing 20 kg to an accuracy of 1 g for the 10 000-ml plastic pycnometer (Type D).

4.3 *Vacuum Pump or Water Aspirator*, capable of evacuating air from the container to a residual pressure of 30 mm Hg (4.0 kPa) or less. A water aspirator or vacuum pump with less capability may be used for the rapid test version (Section 12).

4.4 *Manometer or Vacuum Gage*, suitable for measuring the specified vacuum.

4.5 *Water Bath:*

4.5.1 For Type A, B, or C containers, a constant-temperature water bath of suitable size for the container to be used. For Type D, the large-size plastic pycnometer, no water bath is required.

4.5.2 When using the weighing-in-water technique (7.4.1), a water bath suitable for immersion of the suspended container and deaerated sample is required.

4.6 *Miscellaneous* — A suitable trap (Erlenmeyer flask) installed in the line is recommended to prevent water from entering the vacuum pump. Also, use of a plastic twistcock valve in the line adjacent to the flask or pycnometer will minimize loss of water during shaking and provide quick disconnection in case of foaming or malfunction. For use with glass containers, a rubber or resilient plastic mat is required as a safety precaution to avoid impact on a hard surface while under vacuum.

5. Calibration of Flask and Pycnometers

5.1 Calibrate the volumetric flask (Type B) by accurately determining the mass of water at 25 ± 0.5°C (77 ± 0.9°F) required to fill it. Accurate filling of the flask may be ensured by the use of a glass cover plate.

5.1.1 For the weighing-in-water method (7.4.1), the flask (Type B) may be calibrated to allow for temperature adjustment by determining its mass immersed in water over the range of water bath temperatures likely to be encountered in service, as shown in Fig. 1.

5.2 Calibrate the 4000-ml heavy-wall glass or the metal pycnometer (Type C) by accurately determining the mass of water at 25 ± 0.5°C (77 ± 0.9°F) required to fill it. Allow some water to overflow through the capillary tube while inserting the capillary stopper. Make certain that the capillary tube is filled to the top and that no air bubbles are present after the glass pycnometer is kept immersed in the constant-temperature water bath for 1 h.

5.3 Calibrate the large-size plastic pycnometer (Type D) by accurately determining the mass of water required to fill it over a range of temperatures from about 20 to 65°C (70 to 150°F), and construct a calibration curve of weight versus temperature as shown in Fig. 2. Care should be taken to follow exactly the same procedure in calibration as in conducting a test. The domed lid is latched in place and the pycnometer (Type D) nearly filled with water. Leave about 50 mm (2 in.). The release of air bubbles may be facilitated by applying vacuum and by jarring (dropping first one side then the other of the pycnometer (Type D) about 10 mm (½ in.) on the bench surface). This vacuum application and bubble release procedure should take about 10 min, so that the temperature equilibrium between the shell and the water approximates that attained when running a test. The final water is then gently poured in until the level is about one half up into the neck. Any air bubbles caught against the dome that cannot be released by jarring or by swirling the water may be "pricked" or pushed to the surface with a bent wire. Insert the vented stopper using only enough force to just seat the stopper and immediately wipe the excess water off the top. The outside of the pycnometer (Type D) is then wiped dry, the full pycnometer weighed, and the temperature of the water measured.

NOTE 4—The shape of the calibration curve is a function of two opposing factors which can be rationally defined. As the temperature is increased, the container itself expands (adding mass—"pyc" line in Fig. 3) and the density of the contained water decreases (resulting in loss of mass—"water" line in Fig. 3). These relationships are shown in Fig. 3 for a typical large-size pycnometer (Type D). The "water" curve may be constructed by multiplying the volume at 25°C (77°F) by the difference in density of water at 25°C, which is 0.9970, and at the calibration temperature.

Difference due to water expansion

$$= V_{25}\,(0.9970 - dw)$$

$$\text{Since } V_{25} = \frac{W_{25}}{0.9970}$$

$$V_{25}\,(0.9970 - dw) \text{ reduces to } w_{25}\left(1 - \frac{dw}{0.9970}\right)$$

where:

V_{25} = volume of water to fill container at 25°C (77°F), cm^3,

W_{25} = mass of water to fill container at 25°C (77°F), g, and

dw = density of water at calibration temperature, Mg/m^3.

The rate of change in capacity of the container due to thermal expansion of the pycnometer itself is essentially constant over the temperature range from 20 to 65°C (70 to 150°F). Thus, the "pyc" line in Fig. 3 can be drawn through the 0 at 25°C (77°F) point knowing only the slope of the straight line relationship. The slope can be established by averaging at least five calibration weighings at some elevated temperature, adding the loss due to water expansion and subtracting the mass at 25°C, W_{25}, to give the gain in capacity due to expansion of the container. The difference in mass divided by the difference in temperature is the slope of the "pyc" line. For a polycarbonate pycnometer of about 13 500-ml capacity, the slope thus established was 2.75 g/°C (1.53 g/°F). This is believed to be typical and reasonably constant.

The bending of the calibration curve (Fig. 2) due to these offsetting thermal factors thus minimizes experimental error due to temperature effects in the normal working range, 25°C, for both the volumetric flask (Type B) and the pycnometer containers (Types C and D). Defining the calibration curve makes it possible to correct for temperature, rather than "bring-to-temperature," thereby eliminating the cost of a water bath and making it feasible to improve accuracy by testing larger samples and to materially reduce testing time.

5.4 While calibration of the flask (Type B) or of either pycnometer (Types C or D) need be done only once, the calibration should be checked occasionally, particularly at 25°C (77°F). The equipment must be kept clean and free of any accumulation that would change mass if the volume calibration is to remain constant. Care should be taken to use suitable solvents, especially with plastic containers, and glass vessels should not be subjected to high vacuum if they have been scratched or damaged in any way.

6. Sampling

6.1 Obtain the sample in accordance with Method D 979.

6.2 The size of the sample shall conform to the following requirements. Samples larger than the capacity of the container may be tested a portion at a time.

Size of Largest Particle of Aggregate in Mixture, mm (in.)	Minimum Sample Size, g
50.0 (2)	6000
37.5 (1½)	4000
25.4 (1)	2500
19.1 (¾)	2000
12.5 (½)	1500
9.5 (⅜)	1000
4.75 (No. 4)	500

7. Procedure

7.1 Separate the particles of the sample, taking care not to fracture the mineral particles, so that the particles of the fine aggregate portion are not larger than 6.4 mm (¼ in.). If the mixture is not sufficiently soft to be separated manually, place it in a large, flat pan and warm in an oven only until it can be so handled. See also Section 12, for alternative handling possible with the large-size plastic pycnometer (Type D).

7.2 Cool the sample to room temperature, place in a container, and weigh. Designate the net mass of sample as *A*. Add sufficient water at approximately 25°C (77°F) to cover the sample. With the large-size plastic pycnometer (Type D), the sample does not have to be cooled and the added water at any convenient temperature may be brought up into the domed lid about halfway to minimize evacuation time.

7.3 Remove entrapped air by subjecting the contents to a partial vacuum, 30 mm Hg (4 kPa) or less absolute pressure, for 5 to 15 min (see Note 5). (A partial vacuum of 30 mm Hg (4 kPa) absolute pressure is approximately equivalent to 730 mm Hg or 28.7 in. Hg reading on a vacuum gage at sea level.) Agitate the container and contents either continuously by mechanical device or manually by vigorous shaking at intervals of about 2 min. Glass vessels should be handled on a resilient surface, such as a rubber or plastic mat, and not on a hard surface, to avoid impact while under vacuum. Vacuum should be applied and released gradually by using the bleed valve.

NOTE 5—Lean mixes require less and rich mixes may require more time or agitation, or both. In general, the minimum time required to dispel all of the free air is best. Additional time may induce error due to water getting under the bituminous coating (Section 9). For any given mix, optimum time may be established by trial reduction of test time until further reduction yields lower specific gravities.

7.4 Immediately after removal of the entrapped air (7.3), proceed with one of the following determinations:

7.4.1 *Weighing in Water*—Suspend the bowl (Type A) or flask (Type B) and contents in the water bath and determine the mass after 10 ± 1 min immersion. Measure the water bath temperature, and if different from 25 ± 1°C (77 ± 1.8°F) correct the mass to 25°C using the calibration temperature adjustment developed in 5.1.1. Designate the net mass of sample in water at 25°C as °C.

7.4.2 *Pycnometer Measurements at 25°C (77°F)*—Fill the flask (Type B) or pycnometer (Type C) with water and bring contents to a temperature of 25 ± 1°C (77 ± 1.8°F) in the water bath. Determine the mass of the container (and contents), completely filled in accordance with 5.2, 10 ± 1 min after completing 7.3. Designate this mass as E.

7.4.3 *Large-Size Plastic Pycnometer (Type D) Determination*—Fill the pycnometer with water of approximately the same temperature as the contents, insert the vented stopper, and dry the outside using the same technique as in 5.3. The elapsed time for gently pouring in the final water and drying shall be the same as the calibration time within ±1 min. Determine the mass of the pycnometer completely filled and designate this total mass as G. Remove the vented stopper and record the temperature of the water.

8. Calculation

8.1 Calculate the specific gravity of the sample as follows:

8.1.1 *Weighing in Water:*

$$\text{sp gr} = \frac{A}{A - C} \tag{1}$$

where:

A = mass of dry sample in air, g, and

C = mass of sample in water, g.

8.1.2 *Pycnometer Determination at 25°C (77°F):*

$$\text{sp gr} = \frac{A}{A + D - E} \tag{2}$$

where:

A = mass of dry sample in air, g,

D = mass of container filled with water at 25°C (77°F), g, and

E = mass of container filled with water and sample at 25°C (77°F), g.

8.1.3 *Large-Size Plastic Pycnometer (Type D) Determinations:*

8.1.3.1 If the test temperature is within +1.7 or −2.8°C (+3 or −5°F) of 25°C (77°F), that is, between 22.2 and 26.7°C (72 and 80°F), Eq 2 may be used to calculate specific gravity within 0.001 points or less error due to thermal effects.

8.1.3.2 If the test temperature differs significantly from 25°C (77°F), correct for thermal effects as follows:

$$\text{sp gr} = \frac{A}{(A + F) - (G + H)} \times \frac{dw}{0.9970} \tag{3}$$

where:

A = mass of dry sample in air, g,

F = mass of pycnometer (Type D) filled with water at test temperature (Fig. 2), g,

G = mass of pycnometer (Type D) filled with water and sample at test temperature, g,

H = correction for thermal expansion of bitumen (Fig. 4), g,

dw = density of water at test temperature, Curve D in Fig. 5, Mg/m^3, and

0.9970 = density of water at 25°C (77°F), Mg/m^3.

The ratio (dw/0.9970) is Curve R in Fig. 5.

NOTE 6—This general procedure for correcting for thermal effects should also be applicable to corresponding measurements made with other suitable containers.

9. Supplemental Procedure for Mixtures Containing Porous Aggregate Not Completely Coated

9.1 If the pores of the aggregates are not thoroughly sealed by a bituminous film, they may become saturated with water during the evacuation procedure. To determine if this has occurred, proceed as follows after completing the procedure in accordance with 7.4.1, 7.4.2, or 7.4.3. Drain water from the sample. To prevent loss of fine particles, decant water through a towel held over the top of the container. Break several large pieces of aggregate and examine broken surfaces for wetness.

9.2 If the aggregate has absorbed water, spread the sample before an electric fan to remove surface moisture. Weigh at 15-min intervals, and when the loss in mass is less than 0.05 % for this interval, the sample may be considered to be surface dry. This procedure requires about 2 h and shall be accompanied by intermittent stirring of the sample. Break conglomerations of mixture by hand. Take care to prevent loss of particles of mixture.

9.3 To calculate the specific gravity of the sample, substitute the final surface-dry mass for A in the denominator of Eqs 1, 2, or 3.

10. Report

10.1 The report shall include the following:

10.1.1 Specific gravity of the mixture to the third decimal place as: sp gr 25/25°C.

10.1.2 Type of mixture.

10.1.3 Size of sample.

10.1.4 Number of samples.

10.1.5 Type of container.

10.1.6 Type of procedure.

11. Precision

11.1 Criteria for judging the acceptability of specific gravity test results obtained by this method are given in the following table:

Test and Type Index	Standard Deviation (1S)	Acceptable Range of Two Results (D2S)
Test results obtained without use of Section 9[A]		
Single-operator precision	0.0040	0.011
Multilaboratory precision	0.0064	0.019
Test results obtained with use of Section 9 applicable for bowl determination only[B]		
Single-operator precision	0.0064	0.018
Multilaboratory precision	0.0193	0.055

[A] Basis of estimate: 3 replicates, 5 materials, 5 laboratories.

[B] Basis of estimate: 2 replicates, 7 materials, 20 laboratories.

11.2 The figures given in Column 2 are the standard deviations that have been found to be appropriate for the conditions of test described in Column 1. The figures given in Column 3 are the limits that should not be exceeded by the difference between the results of two properly conducted tests. Multilaboratory precision has not been verified for the 4000-ml pycnometer (Type C) or for the large-size plastic pycnometer (Type D).

12. Rapid Test Version for Relative Specific Gravity

12.1 Since the large-size plastic pycnometer may be safely used in a plant laboratory and since a relative specific gravity may be a convenient means of monitoring the uniformity of production of bituminous mixtures, a rapid test version of Method D 2041 is offered. This version permits lower vacuum (water aspirator or vacuum pump) and shorter evacuation time. Such measurements cannot represent the zero air voids condition and, therefore, are not suitable for determination of air voids in field or laboratory-compacted pavement samples. On the other hand, if a vacuum of 30 mm Hg (4 kPa) is attained for the 5 to 15 min specified, the results are valid theoretical maximum specific gravities since the hot dispersion technique given in 12.2 is equivalent to letting the sample cool and breaking conglomerates by hand as in 7.1 and 7.2.

12.2 *Procedure for Rapid Test Version:*

12.2.1 The pycnometer is previously calibrated as outlined in Section 5.

12.2.2 Tare the hot sample (approximately 6000 g) directly from the truck into water in the pycnometer, latch dome in place, and disperse sample by shaking vigorously using a back-and-forth rolling motion with the pycnometer tipped up about 30 deg and with the skirt still in contact with the bench. Measurement of sample mass by weighing the sample container before and after transferring the test portion to the pycnometer negates possible error due to water evaporation loss.

12.2.3 Add additional water to bring the level about midway up into the dome and apply vacuum for about 5 min. The time required under vacuum will depend on the mix and on the test conditions (vacuum, shaking, etc.), but once established, should be maintained with ±0.5 min for repeat tests. See Notes 5 and 7.

NOTE 7—The degree of vacuum specified in 7.3 may not be attainable in plant laboratories using a water aspirator, particularly when testing hot samples. Consistent and repeatable results can be obtained, however, if the test conditions remain reasonably constant at some point over an absolute pressure range from 0 to 250 mm Hg (0 to 34 kPa) and final water temperature up to 70°C (160°F). If the specific gravity test results thus obtained are to be used to monitor asphalt content, the specific gravity of the combined aggregates to be used in the calculations must be that value established in the same plant and under the same test conditions.

12.2.4 The rest of the procedure is the same as 7.4.3. Fill with water, insert vented stopper, wipe water off the stopper (once) and dry the outside using the same technique as during calibration. Weigh and take the temperature.

12.3 *Calculation*—Use Eq 3 in 8.1.3.2.

NOTE 8—This rapid test version makes it possible for a plant laboratory technician to get a reading on a specific gravity of the mix within a total elapsed time of 10 min or less, which is sufficiently accurate to reflect a significant change in the specific gravity of any of the aggregate fractions or the bitumen or in the relative proportions of each ingredient in the mixture. The bias, if any, is small and essentially constant for a given operator in a given plant. Limited data show the precision (repeatability) to be comparable to that reported in 11.1 for results obtained on smaller test portions using the flask and bowl containers without use of Section 9, that is, standard deviation = 0.004 or less for surface and binder mixes, 0.007 or less for base course mixes.

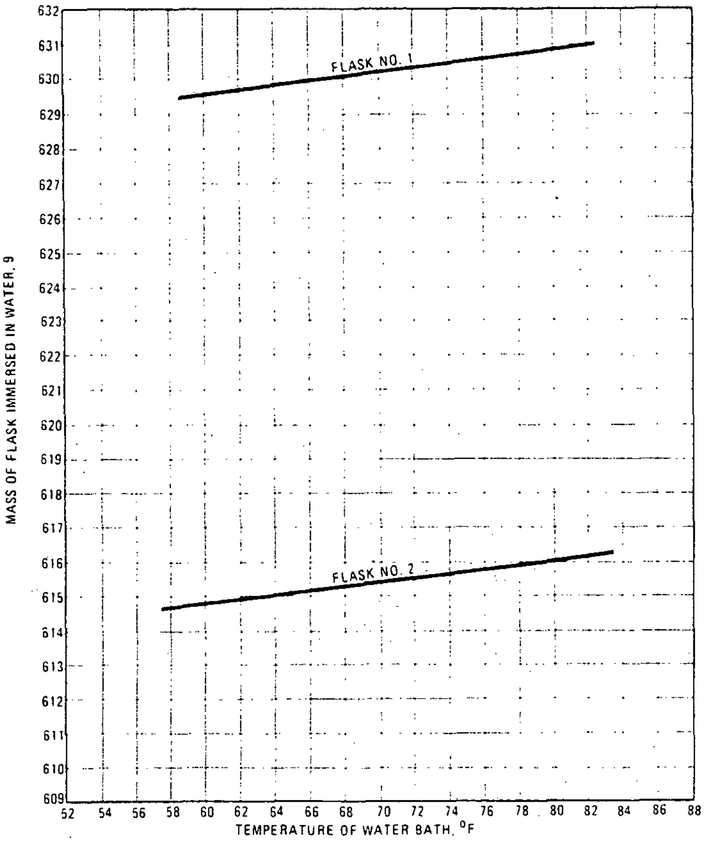

FIG. 1 Example Calibration Curve for Volumetric Flask (B).

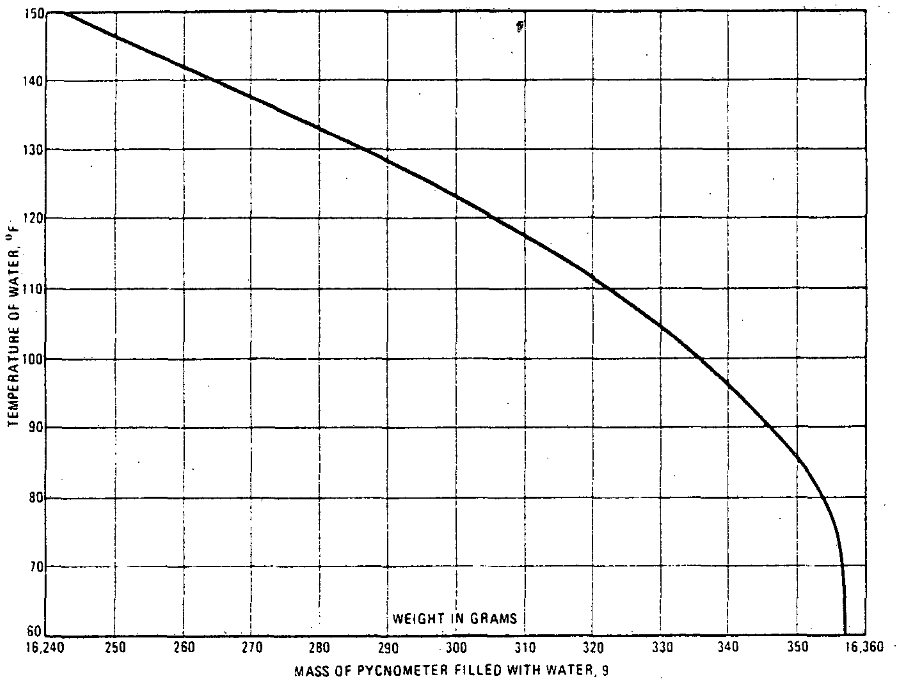

FIG. 2 Example Calibration Curve for Pycnometer (D).

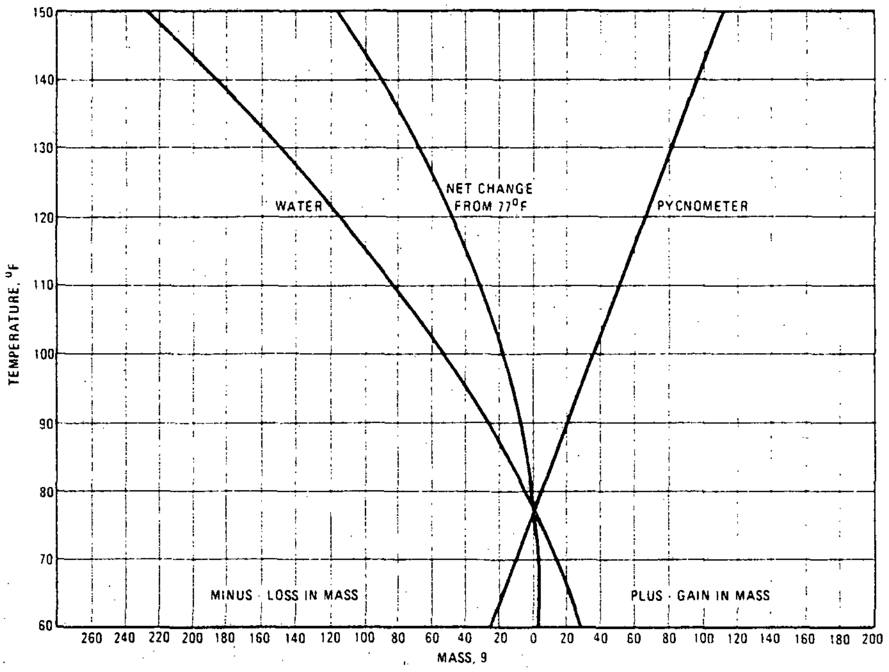

FIG. 3 Effect of Change in Density of Water and Volume of Pycnometer (D) with Change in Temperature.

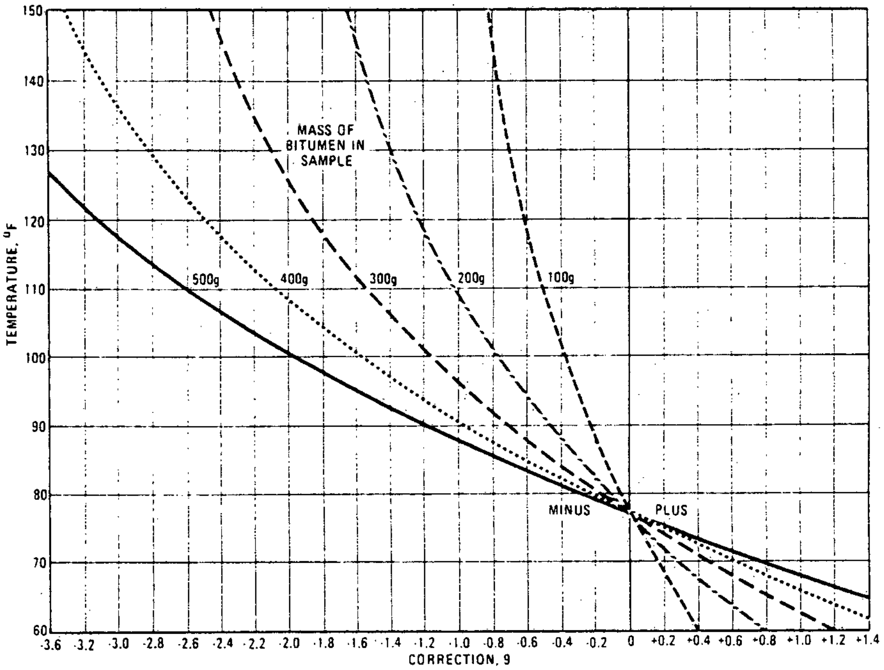

FIG. 4 Correction Curves for Thermal Expansion of Bitumen, *H*, in Eq. 3.

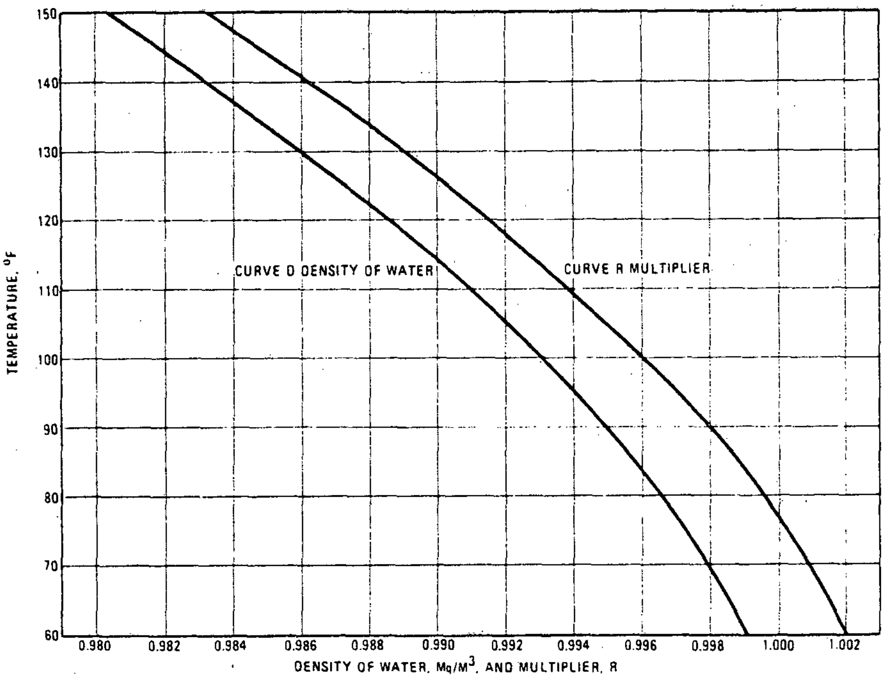

FIG. 5 Curves D and R for Eq. 3.

D 2172

Gouvernement du Québec
Ministère des Transports
Laboratoire Central

EXTRACTION DU BITUME (ASTM-D-2172)

Les modifications apportées à la norme ASTM sont décrites dans "Analyse des Mélanges Bitumineux au Québec" aux pages 17 et 33.

De plus, les modifications suivantes s'appliquent:

- Le plat et le papier filtre sont préchauffés sous des lampes infrarouges ou dans une étuve à 102°C ±2°C pendant un minimum de quinze (15) minutes avant de les peser.

Le poids des granulats, après séchage, s'obtient par la pesée des granulats avec le plat et le filtre immédiatement après les avoir retirés de sous les lampes infrarouges ou de l'étuve.

Il est important de noter que si l'on utilise la méthode volumétrique pour la perte en filler, une période de trempage d'au moins 10 minutes est nécessaire au premier lavage; pour les autres lavages, une période de trempage de 5 minutes peut être suffisante.

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RL/mg

1.3 Extraction du bitume

Des études effectuées au Laboratoire du Ministère des Transports durant l'année 1971 ont permis d'apporter des modifications importantes à la méthode décrite dans l'ASTM[1].

Deux types d'appareils furent utilisés, le centrifuge (méthode A) et celui dit à reflux (méthode B). Le centrifuge fut employé selon la méthode ASTM[1] (augmentation progressive de la vitesse jusqu'à 3 600 tr/mn et période de trempage ne dépassant pas 1 heure) et selon la méthode usuelle du Laboratoire du Ministère (ajustement dès le départ de la vitesse à 2 200 tr/mn, sans trempage) (Graphique 7). De plus, deux méthodes de correction pour la perte de filler lors de l'extraction ont été utilisées: celle de l'ASTM[1] (cendres) et celle du Laboratoire utilisant un centrifuge.

Le tableau suivant donne les résultats du pourcentage moyen de bitume, basés sur 20 analyses, et l'écart type obtenu avec chacune des méthodes d'extraction mentionnées plus haut.

MÉTHODES D'EXTRACTION	ASTM	REFLUX	LABORATOIRE
% bitume retrouvé	7.99	7.22	7.84
écart	.497	.197	.277
% bitume corrigé (ASTM)	6.99	7.03	6.97
écart	.138	.132	.102
% bitume corrigé (centrifuge)	7.24	7.05	7.19
écart	.247	.097	.099

La teneur en bitume des échantillons analysés avait été établie à 7% lors de leur fabrication en laboratoire. Comme la sensibilité des balances était de 0,1 g. la teneur établie avait donc une précision de 0,01% puisque les échantillons pesaient 1 000 g.

Les résultats démontrent que l'appareil à reflux donne, sans la correction, les résultats les plus près de la valeur réelle, et les moins variables. Également, ils montrent la supériorité de la méthode du Laboratoire sur celle de l'ASTM[1] quant à l'extraction du bitume.

Cette étude démontre également la nécessité de mesurer la perte de filler à travers les filtres, surtout si l'extraction est faite au centrifuge.

Cette mesure permet, non seulement de déterminer plus justement la teneur en bitume d'un mélange, mais encore elle diminue les variations inhérentes à l'essai lui-même.

2.6 EXTRACTION DU BITUME ASTM D 2172

2.6.01 Définition

— L'extraction consiste à séparer les deux principaux constituants d'un mélange bitumineux (agrégats et bitume) afin d'en connaitre les proportions et d'autres caractéristiques.

2.6.02 Appareils

— Un centrifuge d'une capacité de 3,600 tr/mn.

— Plat pour centrifuge d'une capacité de 1,000 g.

— Papier filtre s'adaptant sur le plat.

— Balance d'une capacité minimum de 5,000 g. et plus, ayant une précision de 0.2 g.

— Une plaque chauffante ou lampe infrarouge permettant le séchage de l'échantillon.

— Ventilation adéquate permettant d'évacuer les vapeurs du solvant.

2.6.03 Procédé

— Peser le plat du centrifuge avec le papier filtre.

- Peser le plat du centrifuge, le papier filtre et environ 1000 g de mélange.
- Faire centrifuger, en utilisant à chaque lavage environ 250 cc de trichloréthylène. Répéter ces lavages jusqu'à ce que le liquide reste incolore.
- Ajuster la vitesse du centrifuge à 2 200 tr/mn.

  N.B.: Pour la méthode de récupération du filler avec centrifuge il n'est pas recommandé de laisser tremper le mélange lors du premier lavage, parce que le trichlore deviendra plus concentré en bitume et celui-ci est le principal agent transporteur de particules fines.
- Faire sécher jusqu'à poids constant. (environ 30 minutes sous des lampes infrarouges).

  N.B.: Il est très important de faire sécher les granulats dans le plat du centrifuge afin d'éviter une perte de granulats lors de la manipulation.
- Peser ensemble le plat, les granulats et le filtre
- Mesurer la perte de filler selon la méthode décrite au paragraphe 2.7.

2.6.04 CALCULS

Bm: $\frac{C}{a} \times 100$

Gag: $\frac{C}{(b + f)} \times 100$

où: Bm : Pourcentage de bitume par rapport au poids du mélange
Bag: Pourcentage du bitume par rapport au poids des granulats
a : Poids du mélange (avant centrifugation)
b : Poids des granulats (après centrifugation et séchage)
C : a - (b + f) : poids du bitume
f : Poids du filler perdu

N.B.: On exprime le résultat avec deux décimales

2.7 Récupération de filler

2.7.01 Définition

— Cette opération consiste à centrifuger le liquide provenant de l'extraction afin d'en déterminer le contenu en filler et corriger ainsi le pourcentage de bitume trouvé.

2.7.02 Appareils

— Un centrifuge modèle "UV International" possèdant une vitesse maximum de 5 800 tr /mn, équipé d'un compteur de tours d'une possibilité de 0 à 6 000 tr /mn, d'une minuterie automatique (Photo 9)

— Des bouteilles à centrifuger d'une capacité de 8 oz. (227,28 cm^3).

— Un cylindre gradué d'une capacité de 2 000 ml

— Une balance électrique d'une capacité de 1 000 g. pouvant donner des lectures précises au centième de gramme.

2.7.03 Procédé

— Verser tout le trichlore récupéré de l'extracteur dans un cylindre gradué et mesurer le volume total de liquide.

— Agiter la solution minutieusement et prélever deux aliquots de 100 ml.

— Verser dans des bouteilles de centrifuge précédemment pesées.

— Équilibrer les quatre bouteilles avant de les introduire dans le centrifuge.

— Centrifuger les bouteilles pendant 2 minutes à 2 000 tr /mn.

N.B.: Le temps nécessaire à l'appareil pour atteindre la vitesse de 2 000 tr /mn est supérieur à 2 minutes.

— Enlever la solution tout en gardant environ 1 po. de solution dans le fond de la bouteille.

— Ajouter d'autre solvant propre et centrifuger pendant 2 minutes à 2 000 tr /mn.

— Transvider la solution tout en gardant environ 1 po: (25,4 mn) de solution dans le fond de la bouteille.

— Sécher le filler contenu dans la bouteille, au four à une température de 230°F (110°C) jusqu'à poids constant.

— Calculer le poids du filler en fonction du volume total du trichlore extrait (voir exemple de calcul page 38).

N.B.: Certains échantillons peuvent nécessiter trois lavages.

TABLEAU 2

RÉCUPÉRATION DE FILLER (MÉTHODE DE CENTRIFUGE)

ÉCHANTILLON NO: D 042

	A. Volume total du liquide récupéré	1.400
(1)	B. Poids de la bouteille et du filler	189.05
	C. Poids de la bouteille No. 25	188.89
	D. Poids du filler (B-C)	.16
(2)	E. Poids de la Bouteille et du filler	243.42
	F. Poids de la bouteille No. 26	243.21
	G. Poids du Filler (E-F)	.21
	H. Poids moyen du filler $\left(\frac{D+G}{2}\right)$	.186
	I. Poids total du filler $\left(\frac{H\ x\ \ }{100\ ml.}\right)$	2.606

REMARQUES . . . .

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Date. . . . . .19. . . . . . .Analysé par . . . .

METHODE VOLUMETRIQUE POUR MESURER LE FILLER PASSANT LE FILTRE LORS DE L'EXTRACTION DU BITUME

1- DEFINITION ET RESTRICTIONS

1.1 Définition:

Cette méthode consiste à déterminer, par mesure de la masse totale du liquide provenant du lavage d'un mélange bitumineux, la masse du filler entraînée par le bitume lors de l'extraction afin de connaître la teneur réelle en bitume du mélange.

1.2 Restrictions

1.2.1. La densité du trichloroéthylène, à une température donnée, ne doit pas être inférieure de 0.0020 à la valeur indiquée au tableau II pour cette température.

1.2.2 La quantité de solvant utilisée pour l'extraction du bitume ne doit pas être supérieure à 1000 ml, pour ne pas affecter la précision de la méthode. (1)

Note 1- Un temps de trempage initial plus long peut aider à satisfaire cette restriction.

2- EQUIPEMENT

2.1 Ballon:

Fond plat, col court, joint rodé 24/40, capacité de 1000 ml.

2.2 Bouchon:

De pycnomètre pouvant s'adapter sur joint rodé 24/40 .

2.3 Thermomètre:

Gradué à 0.1°C, longueur 370 mm, échelle de 20 à 50°C.

2.4 Balance:

Electrique d'une capacité minimale de 2kg, pouvant donner des lectures précises au dixième de gramme.

3- PROCEDURE

3.1 Volume du ballon:

Peser le ballon vide avec le bouchon, l'emplir d'eau distillée jusqu'au joint rodé et prendre la température de l'eau. Combler avec de l'eau distillée jusqu'à ce que celle-ci sorte par le bouchon, essuyer le surplus écoulé sur le ballon et peser. Calculer le volume du ballon en utilisant le volume de 1g d'eau à la température notée au moment de la pesée (tableau I).

Une formule pouvant aider à déterminer le volume du ballon est donnée en page 5.

3.2 Densité du trichloroéthylène:

Emplir le ballon de trichloroéthylène et noter sa température; combler avec du trichloroéthylène jusqu'à ce que celui-ci sorte par par le bouchon, essuyer le surplus écoulé sur le ballon et peser. La densité du trichloroéthylène doit être effectuée à chaque jour d'utilisation; cette densité doit être la moyenne de deux (2) déterminations et elle s'exprime avec 5 chiffres significatifs.

Lorsque la densité du trichloroéthylène, à une température donnée, est différente de celle indiquée au tableau II pour la même température, ON DOIT TENIR COMPTE DE CETTE DIFFERENCE pour toutes les autres températures. Il faut donc ajouter ou soustraire selon le cas, cette différence à la valeur indiquée au tableau II. Cependant, conformément à l'article 1.2.1, si la différence est en moins et qu'elle excède 0.0020, on ne peut pas utiliser la méthode volumétrique.

3.3 Mesure du filler:

Recueillir directement dans le ballon tout le trichloroéthylène ayant servi au lavage de l'échantillon. Ajouter du trichloroéthylène jusqu'au joint rodé et prendre la température du contenu du ballon; ajouter de nouveau du trichloroéthylène, jusqu'à ce que celui-ci sorte par l'ouverture du bouchon, essuyer le surplus écoulé sur le ballon et peser le tout immédiatement.

Note: Lors des mesures de température, la bulle du thermomètre doit être placée au centre du ballon.

4- CALCULS

4.1 Calculer la masse du filler à l'aide de la formule suivante:

$$M_f = \left(\frac{D_f}{Df - Db} \right) \left[M_{bf} - D_b \left(V - \frac{M_{to} - M_{bf}}{D_t} \right) \right]$$

Mf	Masse du filler
Df	Densité du filler; utiliser 2.70 pour les fillers de densité comprise entre 2.50 et 2.90
D_b	Densité du bitume; utiliser 1.02 pour les bitumes de densité comprise entre 1.015 et 1.025
M_{bf}	Masse du bitume et du filler à l'extraction
M_{to}	Masse totale: bitume + filler + trichloroéthylène
V	Volume du ballon
D_t	Densité du trichloroéthylène à la température notée

4.2 On peut calculer directement le poids du bitume en utilisant la formule présentée à la page 8.

Ministère des Transports
Service du laboratoire central

MÉLANGES BITUMINEUX

ntillon

N° de rapport

VOLUMETRIE DU BALLON ET DENSITE DU TRICHLOROETHYLENE

A. Poids du ballon + bouchon + eau ______

B. Poids du ballon + bouchon ______

C. Volume du ballon non corrigé (A − B) ______

D. Volume du ballon corrigé (C x vol. 1g eau à temp. donnée) ______

E. Poids du ballon + bouchon + trichloroéthylene ______

F. Poids du ballon + bouchon ______

G. Poids du trichloroéthylene (E − F) ______

H. Densité du trichloroéthylene (G − D) ______

Température du trichloroéthylene (°C) ______

Température de l'eau (°C) ______

Analyste ______ Date ______ 19 ______

1015 (76)

VOLUME DE 1 g. D'EAU EN FONCTION DE LA TEMPERATURE °C

20.0	1.00177	24.0	1.00268	28.0	1.00376
20.1	1.00179	24.1	1.00271	28.1	1.00379
20.2	1.00181	24.2	1.00273	28.2	1.00382
20.3	1.00183	24.3	1.00276	28.3	1.00385
20.4	1.00186	24.4	1.00278	28.4	1.00388
20.5	1.00188	24.5	1.00281	28.5	1.00391
20.6	1.00190	24.6	1.00283	28.6	1.00394
20.7	1.00192	24.7	1.00286	28.7	1.00397
20.8	1.00194	24.8	1.00288	28.8	1.00399
20.9	1.00196	24.9	1.00291	28.9	1.00402
21.0	1.00198	25.0	1.00293	29.0	1.00405
21.1	1.00201	25.1	1.00296	29.1	1.00409
21.2	1.00203	25.2	1.00299	29.2	1.00412
21.3	1.00205	25.3	1.00301	29.3	1.00415
21.4	1.00207	25.4	1.00304	29.4	1.00418
21.5	1.00209	25.5	1.00306	29.5	1.00421
21.6	1.00212	25.6	1.00309	29.6	1.00424
21.7	1.00214	25.7	1.00312	29.7	1.00427
21.8	1.00216	25.8	1.00314	29.8	1.00430
21.9	1.00218	25.9	1.00317	29.9	1.00433
22.0	1.00221	26.0	1.00320	30.0	1.00436
22.1	1.00223	26.1	1.00323	30.1	1.00439
22.2	1.00225	26.2	1.00325	30.2	1.00442
22.3	1.00227	26.3	1.00328	30.3	1.00446
22.4	1.00230	26.4	1.00331	30.4	1.00449
22.5	1.00232	26.5	1.00333	30.5	1.00452
22.6	1.00234	26.6	1.00336	30.6	1.00455
22.7	1.00237	26.7	1.00339	30.7	1.00458
22.8	1.00239	26.8	1.00342	30.8	1.00461
22.9	1.00241	26.9	1.00345	30.9	1.00465
23.0	1.00244	27.0	1.00347	31.0	1.00468
23.1	1.00246	27.1	1.00350		
23.2	1.00249	27.2	1.00353		
23.3	1.00251	27.3	1.00356		
23.4	1.00253	27.4	1.00359		
23.5	1.00256	27.5	1.00361		
23.6	1.00258	27.6	1.00364		
23.7	1.00261	27.7	1.00367		
23.8	1.00263	27.8	1.00370		
23.9	1.00266	27.9	1.00373		

DENSITE DU TRICHLORETHYLENE EN FONCTION DE LA TEMPERATURE °C

TEMP.	DENSITE	TEMP.	DENSITE	TEMP.	DENSITE
20.0	1.4605	26.0	1.4506	32.0	1.4407
20.1	1.4603	26.1	1.4504	32.1	1.4405
20.2	1.4601	26.2	1.4502	32.2	1.4403
20.3	1.4600	26.3	1.4501	32.3	1.4402
20.4	1.4598	26.4	1.4499	32.4	1.4400
20.5	1.4596	26.5	1.4497	32.5	1.4398
20.6	1.4595	26.6	1.4496	32.6	1.4397
20.7	1.4593	26.7	1.4494	32.7	1.4395
20.8	1.4592	26.8	1.4492	32.8	1.4393
20.9	1.4590	26.9	1.4491	32.9	1.4392
21.0	1.4588	27.0	1.4489	33.0	1.4390
21.1	1.4587	27.1	1.4488	33.1	1.4388
21.2	1.4585	27.2	1.4486	33.2	1.4387
21.3	1.4583	27.3	1.4484	33.3	1.4385
21.4	1.4582	27.4	1.4483	33.4	1.4384
21.5	1.4580	27.5	1.4481	33.5	1.4382
21.6	1.4578	27.6	1.4479	33.6	1.4380
21.7	1.4577	27.7	1.4478	33.7	1.4379
21.8	1.4575	27.8	1.4476	33.8	1.4377
21.9	1.4573	27.9	1.4474	33.9	1.4375
22.0	1.4572	28.0	1.4473	34.0	1.4374
22.1	1.4570	28.1	1.4471	34.1	1.4373
22.2	1.4568	28.2	1.4469	34.2	1.4371
22.3	1.4567	28.3	1.4468	34.3	1.4369
22.4	1.4565	28.4	1.4466	34.4	1.4368
22.5	1.4563	28.5	1.4464	34.5	1.4366
22.6	1.4562	28.6	1.4463	34.6	1.4364
22.7	1.4560	28.7	1.4461	34.7	1.4363
22.8	1.4559	28.8	1.4459	34.8	1.4361
22.9	1.4557	28.9	1.4458	34.9	1.4360
23.0	1.4555	29.0	1.4456		
23.1	1.4554	29.1	1.4455		
23.2	1.4552	29.2	1.4453		
23.3	1.4550	29.3	1.4451		
23.4	1.4549	29.4	1.4450		
23.5	1.4547	29.5	1.4448		
23.6	1.4545	29.6	1.4446		
23.7	1.4544	29.7	1.4445		
23.8	1.4542	29.8	1.4443		
23.9	1.4540	29.9	1.4441		
24.0	1.4539	30.0	1.4440		
24.1	1.4537	30.1	1.4438		
24.2	1.4535	30.2	1.4436		
24.3	1.4534	30.3	1.4435		
24.4	1.4532	30.4	1.4433		
24.5	1.4530	30.5	1.4431		
24.6	1.4529	30.6	1.4430		
24.7	1.4527	30.7	1.4428		
24.8	1.4526	30.8	1.4426		
24.9	1.4524	30.9	1.4425		
25.0	1.4522	31.0	1.4423		
25.1	1.4521	31.1	1.4422		
25.2	1.4519	31.2	1.4420		
25.3	1.4517	31.3	1.4418		
25.4	1.4516	31.4	1.4417		
25.5	1.4514	31.5	1.4415		
25.6	1.4512	31.6	1.4413		
25.7	1.4511	31.7	1.4412		
25.8	1.4509	31.8	1.4410		
25.9	1.4507	31.9	1.4408		

EQUATION VERIFIEE:

$y = mx + b$

y = densité

x = température

$y = -0.00165x + 1.4935$

après étude statistique

coefficient corrélation

0.998748

sur 35 points.

Gouvernement du Québec
Ministère des Transports
Service de laboratoire central

MÉLANGES BITUMINEUX

tillon

N° de rapport

Calcul du % de bitume Méthode volumétrique

A. Poids du ballon + bitume + filler + trichloroéthylène	1796.3
B. Poids du ballon (no. 1)	260.0
C. Poids du bitume + filler + trichloroéthylène (A - B)	1536.3
D. Poids du bitume + filler (essais d'extraction)	70.2
E. Poids du trichloroéthylène (C - D)	1466.1
F. Volume du ballon (no. 1)	1077.4
G. Volume du trichloroéthylène (E/D_t)	1009.29
H. Volume du bitume + filler (F - G)	68.11
I. Poids du bitume= $K\left[(D_f \times H) - D\right]$	69.01
J. Poids du filler (D - I) (reporter au passant #200)	1.19

$$K \quad \frac{D_b}{D_f - D_b} \qquad \frac{1.02}{2.7 - 1.02} \qquad \boxed{0.607}$$

D_b (Densité du bitume) 1.02

D_f (Densité du filler) 2.70

D_t (Densité du trichloroéthylène) 1.4526

Température du trichloroéthylène (°C) 24.8

ste ______ Date ______ 19 ______

015 (76)

AMERICAN NATIONAL STANDARD ANSI/ASTM D 2172 - 75

Standard Test Methods for
QUANTITATIVE EXTRACTION OF BITUMEN FROM BITUMINOUS PAVING MIXTURES[1]

This Standard is issued under the fixed designation D 2172; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 These methods cover the quantitative determination of bitumen in hot-mixed paving mixtures and pavement samples.

NOTE 1—Although bitumen, by definition, is material soluble in carbon disulfide, trichloroethylene is used in this method for safety reasons. 1,1,1-trichloroethane or benzene may also be used.

2. Applicable Documents

2.1 *ASTM Standards:*

D 95 Test for Water in Petroleum Products and Bituminous Materials by Distillation[2]

D 836 Specification for Industrial Grade Benzene[3]

3. Summary of Methods

3.1 The paving mixture is extracted with trichloroethylene (or 1,1,1-trichloroethane or benzene) using the extraction equipment applicable to the particular method. The bitumen content is calculated by difference from the weight of the extracted aggregate, moisture content, and ash from an aliquot part of the extract.

4. Apparatus

4.1 *Oven*, capable of maintaining the temperature at 210 to 220 F (99 to 104 C).

4.2 *Pan*, flat, 12 in. (305 mm) long, 8 in. (203 mm) wide and 1 in. (25 mm) deep.

4.3 *Balance*, capable of weighing 5000 g to an accuracy of 0.2 g.

4.4 *Balance*, capable of weighing 15 000 g to an accuracy of 1.0 g.

4.5 *Hot Plate*, electric, 700-W, low, medium, and high settings.

4.6 *Small-Mouth Graduate*, 1000 or 2000-ml capacity.

4.7 *Ignition Dish*, 125-ml capacity.

4.8 *Desiccator*.

4.9 *Analytical Balance*.

5. Reagents

5.1 *Ammonium Carbonate*—Saturated solution of reagent grade ammonium carbonate ($(NH_4)_2CO_3$).

5.2 *Benzene*, conforming to ASTM Specification D 836.

5.3 *1,1,1-Trichloroethane*, conforming to Federal Specification O-T-620a (Int. Amd. 3).

5.4 *Trichloroethylene*, Technical Grade, Type 1, Federal Specification O-T-634, latest revision.

NOTE 2—These solvents[a] should be used only under a hood in a well-ventilated area, since they are all toxic to some degree as indicated below:

Solvent[a]	Max Acceptable Concentration for 8-h exposure, ppm
Benzene	25
Trichloroethylene	200
1,1,1-Trichloroethane	500

[a] Data from Accident Prevention Manual for Industrial Operations, 4th Edition, National Safety Council.

6. Preparation of Sample

6.1 If the mixture is not sufficiently soft to

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[1] These methods are under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.25 on Analysis of Bituminous Mixtures.

Current edition approved Sept. 26, 1975. Published November 1975. Originally published as D 2172 - 63 T. Last previous edition D 2172 - 72.

[2] *Annual Book of ASTM Standards*, Part 15.

[3] *Annual Book of ASTM Standards*, Part 29.

separate with a spatula or trowel, place it in a large, flat pan and warm to 240 F (116 C) only until it can be handled. Separate the particles of the mixture as uniformly as possible using care not to fracture the mineral particles. Normally, 1000-g samples are used for extraction. For routine testing, smaller samples may be used when the maximum size aggregate therein is less than ¼ in. (6.4 mm). The precision of the method becomes less as the aggregate size increases, due to variation in samples. This procedure may be used on mixtures containing aggregate larger than 1 in. (25.4 mm) by using samples weighing at least 3000 g. They may be tested by extracting 1000 g at a time.

7. Water Determination

7.1 Weigh 500 g of the sample into a metal still conforming to ASTM Method D 95, and determine water content by this procedure.

METHOD A

8. Apparatus

8.1 In addition to the apparatus listed in Section 3, the following apparatus is required for Method A:

8.1.1 *Extraction Apparatus*, consisting of a bowl approximating that shown in Fig. 1 and an apparatus in which the bowl may be revolved at controlled variable speeds up to 3600 rpm. The apparatus shall be provided with a container for catching the solvent thrown from the bowl and a drain for removing the solvent. The apparatus preferably shall be provided with explosion-proof features and installed in a hood to provide ventilation.

NOTE 3—Similar apparatus of larger size may be used.

8.1.2 *Filter Rings*, to fit the rim of the bowl.

9. Procedure

9.1 Determine the moisture content of the sample in accordance with Section 7.

9.2 Weigh a 1000 to 2500-g sample into the bowl.

9.3 Cover the sample in the bowl with trichloroethylene, 1,1,1-trichloroethane, or benzene and allow sufficient time for the solvent to disintegrate the sample (not over 1 h). Place the bowl containing the sample and the solvent in the extraction apparatus. Dry and weigh filter ring and fit it around the edge of the bowl. Clamp the cover on bowl tightly and place a beaker under the drain to collect the extract.

9.4 Start the centrifuge revolving slowly and gradually increase the speed to a maximum of 3600 rpm or until solvent ceases to flow from the drain. Allow the machine to stop, add 200 ml of trichloroethylene, 1,1,1-trichloroethane, or benzene and repeat the procedure. Use sufficient 200-ml solvent additions (not less than three) so that the extract is clear and not darker than a light straw color. Collect the extract and the washings in a suitable graduate.

9.5 Remove the filter ring from the bowl and dry in air. Remove as much of the mineral matter adhering to the ring as possible and add to the aggregate in the bowl. Dry the ring to constant weight in an oven at 210 to 220 F (99 to 104 C). Dry the contents of the bowl on a steam bath and then to constant weight in an oven at 210 to 220 F (99 to 104 C).

9.6 Record the volume of the total extract in the graduate. Agitate the extract thoroughly and immediately measure approximately 100 ml into a previously weighed ignition dish. Evaporate to dryness on a steam bath. Ash residue at a dull red heat (500 to 600 C), cool, and add 5 ml of saturated ammonium carbonate $(NH_4)_2CO_3$) solution per gram of ash. Digest at room temperature for 1 h. Dry in an oven at 100 C to constant weight, cool in desiccator, and weigh.

10. Calculations

10.1 Calculate the weight of ash in the total volume of extract as follows:

$$\text{Total ash, g} = G\,[V_1/(V_1 - V_2)]$$

where:

G = ash in aliquot, g,
V_1 = total volume, ml, and
V_2 = volume after removing aliquot, ml.

10.2 Calculate the percentage of bitumen in the sample as follows (Note 4):

$$\text{Bitumen content of dry sample, percent} = [(W_1 - W_2) - (W_3 + W_4)/(W_1 - W_2)] \times 100$$

where:

W_1 = weight of sample,
W_2 = weight of water in sample,
W_3 = weight of extracted mineral matter, and
W_4 = weight of ash in extract.

NOTE 4—Add the increase in weight of the filter ring to the weights of the recovered aggregate and the ash in the recovered bitumen.

METHOD B

11. Apparatus

11.1 In addition to the apparatus listed in Section 4, the following apparatus is required for Method B:

11.1.1 *Extraction Apparatus*, as shown in Fig. 2.

11.1.2 *Glass Jar*, cylindrical, plain 6-in. (152-mm) outside diameter, 18-in. (45-mm) high, made of heat-resistant glass. The glass jar shall be free of cracks, scratches, or any evidence of flaws that might contribute to breakage during the heating period.

11.1.3 *Cylindrical Metal Frames*, two, 5-in. (127-mm) outside diameter and 6¾ in. (171 mm) high. The lower frame shall have legs 1⅞ in. (48 mm) high to support the frame above the solvent level. The upper frame shall have stub legs which fit in recesses provided in the top rim of the lower frame. Both frames shall contain 10 to 12-mesh metal cones with a base of 4½ in. (115 mm) in diameter and 6¾-in. (172 mm) side length, mounted inside the top rim of each frame. A bail handle shall be provided on the inside of the top rim of each frame.

11.1.4 *Condenser*, 6¼ in. (159 mm) in diameter with a 2½-in. (64-mm) radius truncated hemispherical condensing surface and a truncated conical top, equipped with ¼-in. (6.4-mm) inside diameter tubing water inlet and outlet assembled so that no lead-soldered joint comes in direct contact with the condensing solvent vapor.

11.1.5 *Filter Paper*, medium-grade, fast filtering, 330 mm in diameter.

11.1.6 *Asbestos-Coated Wire*, ⅛-in. (3.2-mm) thick asbestos or similar insulating pad.

12. Procedure

12.1 Determine the moisture content of the sample in accordance with Section 7.

12.2 Dry and weigh two sheets of filter paper. Fold each sheet separately on its diameter and fold twice again, one fold being made over the other to make three segments. Open to form a hollow three-ply cone with a single one-ply seam and place in wire cones of extractor frames.

12.3 Weigh each frame with filter paper in the cone to the nearest 0.5 g. Record these weights, identifying each frame by number.

12.4 Place approximately 500-g sample in each of the filter-paper-lined cones and weigh loaded frames to the nearest 0.5 g.

12.5 Pour 500 ml of trichloroethylene, 1,1,1-trichloroethane, or benzene into the glass jar and place the frame with the supporting legs in the jar. The solvent level must be below the tip of the cone in this frame. Place the top frame on the bottom frame so that the stub legs fit into the round holes in the top rim of the lower frame.

12.6 Place the loaded jar on the electric hot plate and cover the jar with a condenser. Circulate a gentle steady flow of cold water through the condenser. Adjust the heat so that the solvent boils gently and a steady flow of condensed solvent drips into the top cone. Take care to adjust the heat so that the filter cones do not overflow. Continue extraction until the solvent running from the tip of the lower cone appears a light straw color when viewed against a white background. Shut off the heat but not the condenser water, and allow to stand until cool enough to handle. Direct contact between the glass jar and the hot plate should be avoided. A ⅛-in. (3.2-mm)-thick asbestos pad, asbestos-coated wire, or similar insulation should be placed between the jar and the surface of the hot plate.

12.7 Remove the frames with filter paper and extracted aggregate from jar. Dry in air, and then to constant weight in an oven at 210 to 220 F (99 to 104 C).

12.8 Transfer the extract to a 1000-ml graduate. Rinse the jar with solvent until clean and add solvent to the extract. Record the total volume. Determine the total ash in the extract as described in 9.6.

13. Calculations

13.1 Calculate the total weight of ash as described in 10.1.

13.2 Calculate the percentage of bitumen as described in 10.2.

METHOD C

14. Apparatus

14.1 In addition to the apparatus listed in Section 4, the following apparatus is required for Method C:

14.1.1 *Extraction Apparatus*, consisting of a metal container, condenser lid, and stand similar to that shown in Figs. 3 and 4.

14.1.2 *Basket*, for sample, as shown in Fig. 3. A No. 4 or heavier screen shall be placed in the basket to support the sample.

14.1.3 *Filter Cloth*,[4] of approximately 185 mesh, placed over the No. 4 screen and shaped to cover the inside of the basket completely.

15. Procedure

15.1 Determine the moisture content of the sample in accordance with Section 7.

15.2 Weigh 3500 to 11,000 g of sample in tared basket assembly to the nearest 1 g and place in extractor. Pour 1150 to 1250 ml of trichloroethylene, 1,1,1-trichloroethane, or benzene over the sample. Place extractor lid tightly in place and allow water to circulate freely in top. Apply heat from either a gas burner or electric hot plate.

15.3 Reflux the sample from 1.5 to 3 h until all bitumen is extracted from the aggregate. Shut down the extractor after 1.5 h and inspect the sample. Mix the sample with a trowel and continue extraction to completion.

NOTE 5—The sample is completely extracted when, upon inspection, no discoloration is found either on the aggregate or on the surface of the trowel which has thoroughly mixed the sample.

15.4 Drain the extract from the extractor and wash clean with fresh solvent. Combine the extract and the washings in a 2000-ml graduate. Remove sample basket, dry in air and then to constant weight on a hot plate at 210 to 220 F (99 to 104 C). Determine ash in recovered bitumen as described in 9.6.

16. Calculation

16.1 Calculate the total weight of ash as described in 10.1.

16.2 Calculate the percentage of bitumen as described in 10.2.

METHOD D

17. Apparatus

17.1 In addition to the apparatus listed in Section 4, the following apparatus is required for Method D:

17.1.1 *Extraction Apparatus*, Fig. 5, consisting of an extraction kettle of metal or borosilicate glass, fitted with a perforated basket and a condenser top. The underside of the condenser shall be covered with numerous rounded knobs to distribute the condensed solvent uniformly over the surface of the sample. The suspension of the basket shall be arranged to support the basket ½ in. (12.7 mm) above the bottom of the kettle, for immersion of sample in the solvent, and 4 in. (102 mm) above the bottom of the kettle for refluxing.

17.1.2 *Cloth Filter Sacks*, with an elastic hem for lining the basket.

18. Procedure

18.1 Determine the moisture content of the sample in accordance with Section 7.

18.2 Insert a filter sack in the extraction basket and weigh these with the tare pan to determine the total tare weight. Weigh into the filter sack an approximately 500-g representative portion of the paving mixture if the maximum aggregate size is less than ½ in. (12.7 mm). For larger size aggregate use an approximately 1000-g sample.

18.3 Attach the suspension rod to the loaded basket and set the assembly into the extraction kettle. Pour approximately 600 ml of trichloroethylene, 1,1,1-trichloroethane, or benzene over the sample. Set the condenser cover in place on the kettle. Provide a flow of cold water through the condenser lid. Raise the basket to immersion level, for example ½ in. (13 mm) above the bottom of kettle, by inserting the support pin through the upper hole of the suspension rod. Place the extractor on the hot plate and adjust the heating rate so that solvent is maintained at a gentle boil,

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[4] A 16XX Swiss Stencil Cloth, available from the Atlas Silk Screen Supply Co., 1733 Milwaukee Ave., Chicago, Ill. 60647, is suitable for this purpose.

avoiding vigorous boiling which might wash fines over sides of basket.

18.4 Continue heating with the sample in immersion position for 15 to 30 min and then raise basket to refluxing level. Increase the heat and maintain active boiling until solvent dripping from basket appears light straw in color when viewed against a white background. If a stainless steel kettle is used, lift out the basket and the condenser cover assembly for examination of the solvent.

18.5 Remove the extractor from the hot plate and allow to cool for several minutes. Lift out the basket and condenser assembly. Cover the kettle, remove the filter sack, distribute its contents onto the tared pan in which the sample was originally weighed. Place the filter sack on top of recovered aggregate. Dry on a steam bath and then in an oven at 210 to 220 F (99 to 104 C) to constant weight. Transfer extract to 1000-ml graduate. Wash extractor clean with solvent and add washings to extract.

19. Calculations

19.1 Calculate the total weight of ash as described in 10.1.

19.2 Calculate the percentage of bitumen as described in 10.2.

20. Precision

20.1 The following data should be used for judging the acceptability of results (95 percent probability).

20.1.1 Duplicate results by the same operator should be considered suspect if they differ by more than the following amounts:

	Repeatability
Standard deviation, percent	0.12
Bitumen content, percent	0.34

20.1.2 The result submitted by one laboratory should not be considered suspect unless it differs from that of another laboratory by more than the following amounts:

	Reproducibility
Standard deviation, percent	0.20
Bitumen content, percent	0.56

NOTE 6—The precision statement is derived from the following test data:

	Repeatability and Reproducibility
Number of samples	4
Number of laboratories	10
Number of replicates per test	3

EXPLANATORY NOTE

NOTE: *Determination of Tar*—For paving mixtures in which tar is used as the binder, the tar content can be determined by the following modification of Method A:

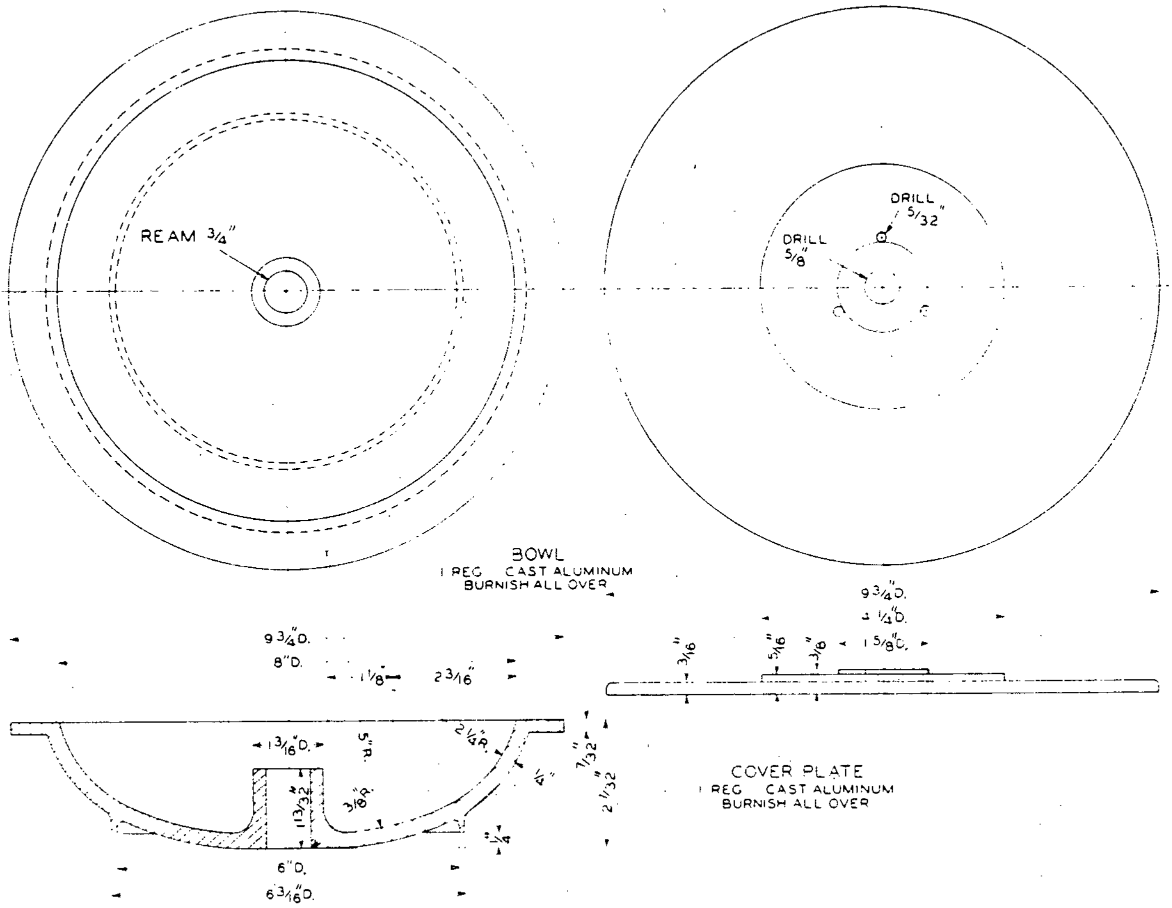
Cover the sample in the bowl with crystal-free creosote and place the bowl for 1 h on a hot plate or in an oven maintained at 240 F (116 C) Proceed in accordance with 9.3 and 9.4 except to use two 200-ml additions of creosote previously heated to 240 F (116 C). After draining the third portion of hot creosote, allow the bowl and contents to cool to a temperature well below the boiling point of benzene. Treat the sample in the bowl with three 200-ml additions of benzene, following the same procedure.

Continue in accordance with 9.5 and 9.6, except evaporate the aliquot portion of the solvent (9.6) on the steam bath until the benzene is removed. Then evaporate the remaining solvent to dryness on a hot plate and ash as directed in 9.6.

Calculate the percentage of tar in the sample in accordance with 10.2.

TABLE 1 Metric Equivalents for Figures

U.S. Customary Units, in.	Metric Equivalent, cm	U.S. Customary Units, in.	Metric Equivalent, cm	U.S. Customary Units, in.	Metric Equivalent, cm
1/8	0.32	1 11/16	4.3	5 7/8	14.9
3/16	0.48	1 3/4	4.4	6	15.2
7/32	0.56	2 3/16	5.5	6 1/8	15.5
1/4	0.63	2 7/32	5.6	6 3/16	15.7
5/16	0.79	2 5/16	5.9	6 1/4	15.9
3/8	0.95	2 1/2	6.4	6 1/2	16.5
1/2	1.27	2 5/8	6.9	7 3/8	18.7
5/8	1.59	2 13/16	7.2	8	20.7
3/4	1.9	3	7.6	9 3/4	24.7
1	2.5	3 3/4	9.6	10	25.4
1 1/8	2.86	4	10.2	10 1/8	25.7
1 3/16	3.02	4 1/4	10.8	12	30.5
1 13/32	3.57	5	12.7	14	35.5
1 1/2	3.8	5 7/16	13.8	14 1/2	37
1 5/8	4.1				



NOTE—See Table 1 for metric equivalents.

FIG. 1 Extraction Unit Bowl.

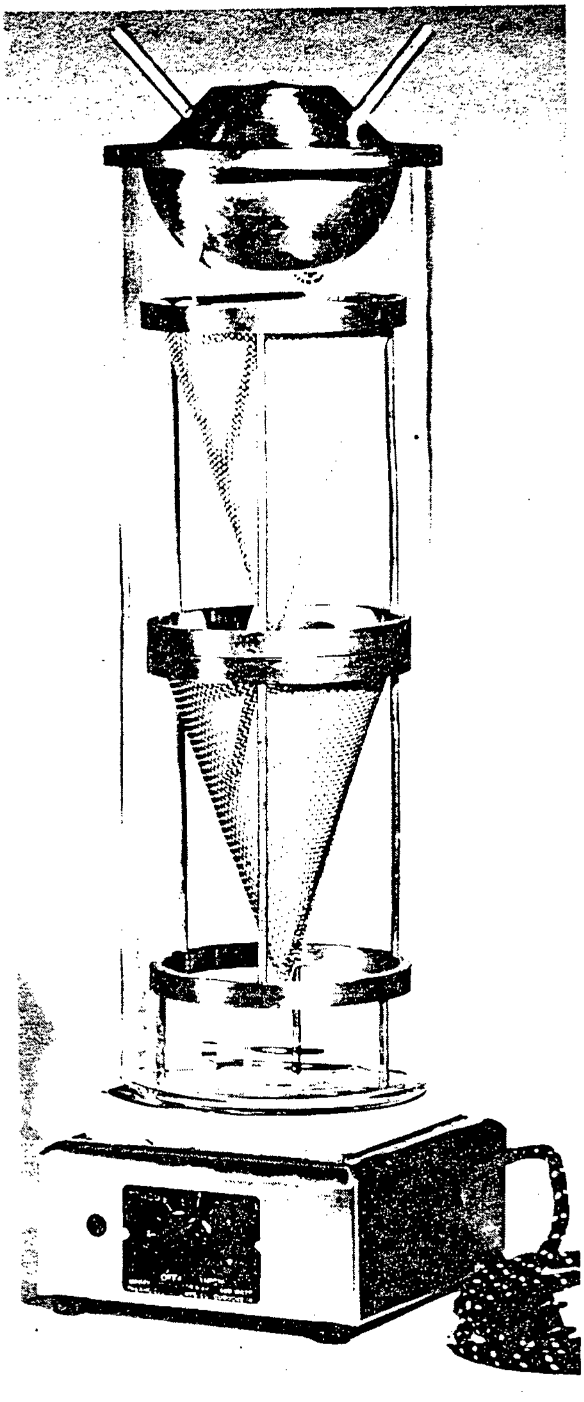
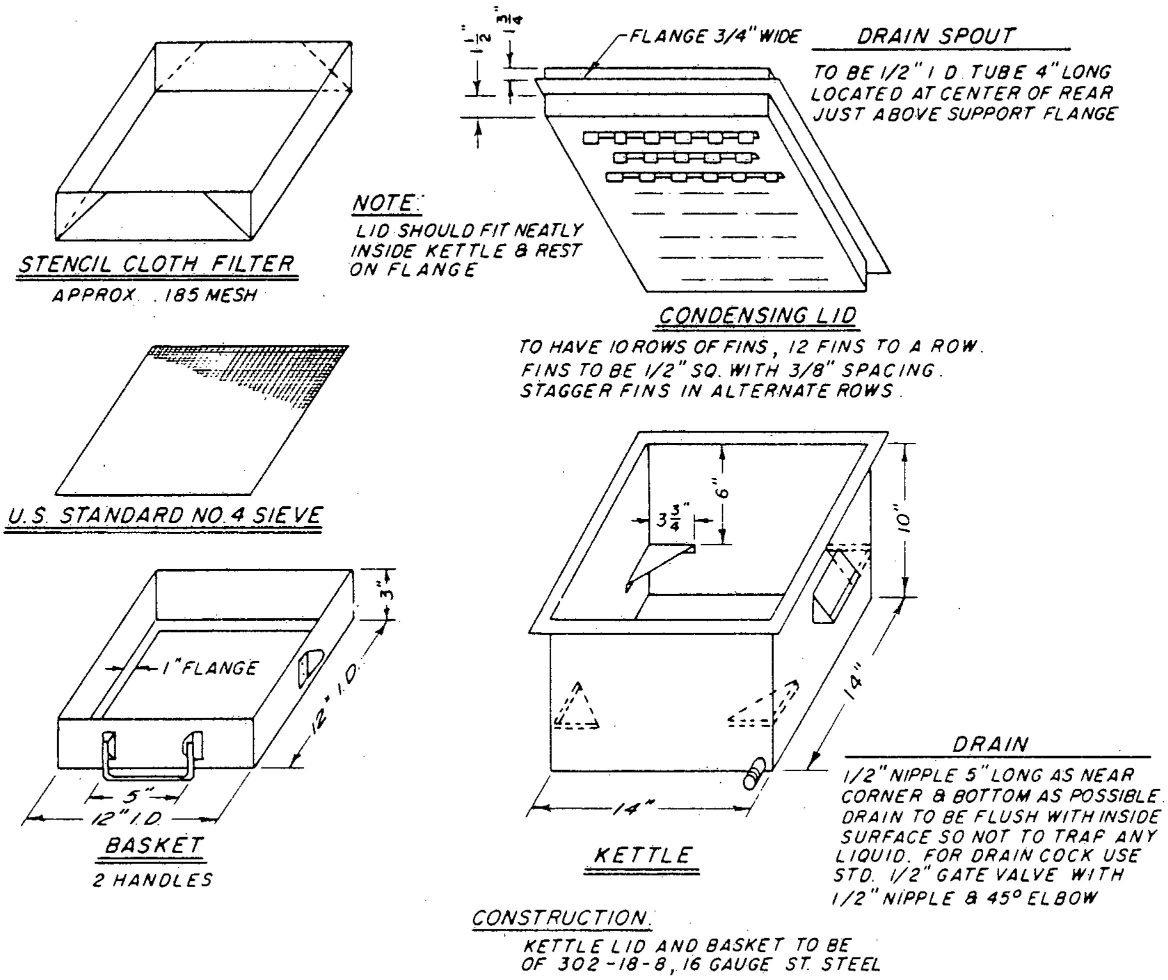
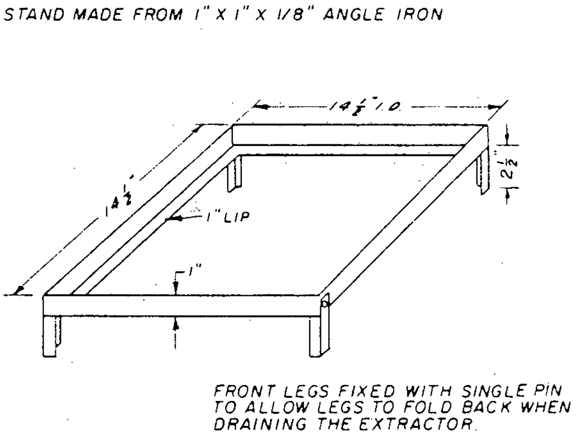


FIG. 2 Extraction Apparatus.



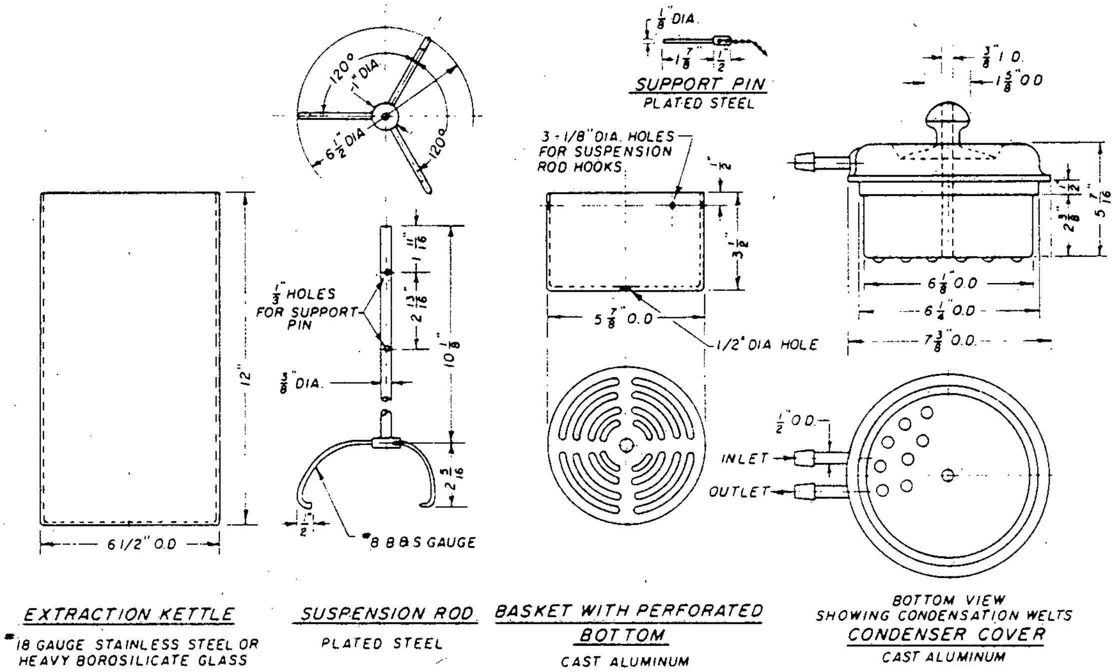
NOTE—See Table 1 for metric equivalents.

FIG. 3 Extractor Unit.



NOTE—See Table 1 for metric equivalents.

FIG. 4 Stand for Extractor Unit.



NOTE—See Table 1 for metric equivalents.

FIG. 5 Extractor Unit.

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D 2489

Designation: D 2489 - 67 (Reapproved 1974)

Standard Test Method for
DEGREE OF PARTICLE COATING OF BITUMINOUS-AGGREGATE MIXTURES[1]

This Standard is issued under the fixed designation D 2489; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers determination of the degree of particle coating in a bituminous-aggregate mix, on the basis of the percentage of coarse aggregate particles that are completely coated. Determination of the percentages of coated particles for varying mixing times may be used to establish the least mixing time required to produce satisfactory coating of the aggregate for a given set of conditions.

2. Apparatus

2.1 *Sieves*, 9.5 mm (⅜ in.) and 4.75 mm (No. 4). The sieves shall conform to ASTM Specification E 11, for Wire-Cloth Sieves for Testing Purposes.[2]

2.2 *Stop Watch*, for checking actual mixing time.

2.3 *Thermometer*, range at least 10 C (50 F) to 204.4 C (400 F).

2.4 *Sample Shovel*.

2.5 *Sample Trays*.

3. Sampling

3.1 *Batch Plant*—Permit the plant to operate at an established mixing time per batch (timed by stop watch).

3.2 *Continuous Plant*—Establish a mixing time by use of the following formula:

pug mill contents, kg (or lb)/
pug mill output, kg/s (or lb/s)

3.3 Samples should be taken at the site of the bituminous mixing plant, immediately after discharge from the pug mill, from three alternate truck loads of mixture (see ASTM Method D 979, Sampling Bituminous Paving Mixtures).[2]

3.4 The amount of material required to perform the test is approximately 2270 to 3630 g (5 to 8 lb).

4. Procedure

4.1 Sieve each sample immediately, while it is still hot, on a 9.5 mm (⅜ in.) sieve or 4.75 mm (No. 4) sieve for material with maximum 9.5 mm (⅜ in.) size. Take a sample large enough to yield between 200 to 500 coarse particles retained on the 9.5 mm (⅜ in.) or 4.75 mm (No. 4) sieve. Do not overload the sieves. If necessary sieve the sample in two or three operations. Shaking should be reduced to a minimum to prevent recoating of uncoated particles.

4.2 Place particles on a clean surface in a one-particle layer and start count immediately.

4.3 Very carefully examine each particle

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[1] This method is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.23 on Plant-Mix Bituminous Surfaces and Bases.

Current edition approved Sept. 8, 1967. Originally issued 1966. Replaces D 2489 - 66 T.

[2] *Annual Book of ASTM Standards*, Part 15.

under direct sunlight, fluorescent light or similar light conditions. If even a tiny speck of uncoated stone is noted, classify the particle as "partially uncoated." If completely coated, classify the particle as "completely coated."

5. Calculation

5.1 The required computation is as follows:

$$\% \text{ of coated particles} = (\text{no. of completely coated particles}/\text{total no. of particles}) \times 100$$

D 2726

2.3 Densité brute réelle (ASTM D 2726)

2.3.01 Définition

— La densité brute est le rapport du poids dans l'air de l'éprouvette sèche et compactée sur son volume total.

2.3.02 Appareils (Photo 2)

— Une balance ayant une capacité d'au moins 3 000 g. et une sensibilité de 0,1 g. ou moins.

— Un panier de métal pouvant contenir l'éprouvette compactée.

— Un contenant avec un débit d'eau contrôlé pour immerger le panier dans l'eau et maintenir un niveau d'eau constant. L'eau devra être changée au moins une fois par semaine.

— Un dispositif en métal permettant la suspension du panier à la balance.

2.3.03 Procédé et calculs

— Déterminer le volume brut de l'éprouvette par la différence entre le poids dans l'air de l'éprouvette compactée (saturée) et son poids dans l'eau.

Designation: D 2726 - 73

Standard Test Method for
BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES USING SATURATED SURFACE-DRY SPECIMENS[1]

1. Scope

1.1 This method covers the determination of bulk specific gravity of specimens of compacted bituminous mixtures, and directly the bulk specific gravity in accordance with ASTM Definitions E 12, Terms Relating to Density and Specific Gravity of Solids, Liquids, and Gases.[2]

1.2 This method should be used only with dense-graded or practically nonabsorptive compacted mixtures.

1.3 The bulk specific gravity of the compacted bituminous mixtures may be used in calculating the unit weight of the mixture.

2. Apparatus

2.1 *Balance*, with ample capacity, and with sufficient sensitivity to enable bulk specific gravities of the specimens to be calculated to at least four significant figures, that is, to at least three decimal places. It shall be equipped with a suitable suspension apparatus and holder to permit weighing the specimen while suspended from the center of the scale pan of the balance.

NOTE 1—Since there are no more significant figures in the quotient (bulk specific gravity) than appear in either the dividend (the weight of the specimen in air) or in the divisor (the volume of the specimen, obtained from the difference in weight of the saturated surface dry specimen in air and in water), this means that the balance must have a sensitivity capable of providing both weight and volume values to at least four figures. For example, a sensitivity of 0.1 g would provide four significant figures for weights in the range from 130.0 g to 999.9 g when the specific gravity is 2.300.

2.2 *Water Bath*, for immersing the specimen in water while suspended under the balance, equipped with an overflow outlet for maintaining a constant water level.

3. Test Specimens

3.1 Test specimens may be either laboratory-molded bituminous mixtures or from bituminous pavements.

3.2 *Size of Specimens*—It is recommended, (*1*) that the diameter of cylindrically molded or cored specimens, or the length of the sides of sawed specimens, be at least equal to four times the maximum size of the aggregate; and (*2*) that the thickness of specimens be at least one and one half times the maximum size of the aggregate.

3.3 Pavement specimens shall be taken from pavements with core drill, diamond or carborundum saw, or by other suitable means.

3.4 Care shall be taken to avoid distortion, bending or cracking of specimens during and after removal from pavements or mold. Specimens shall be stored in a safe, cool place.

3.5 Specimens shall be free of foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil.

3.6 If desired, specimens may be separated from other pavement layers by sawing or other

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[1] This method is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.21 on Specific Gravity and Density of Bituminous Mixtures.

Current edition approved May 31, 1973. Published July 1973. Originally published as D 2726 – 68T. Last previous edition D 2726 – 71T.

[2] *Annual Book of ASTM Standards*, Parts 14 and 41.

satisfactory means.

4. Procedure

4.1 *For Specimens That Contain Moisture:*

4.1.1 *Weight of Specimen in Water*—Immerse the specimen in a water bath at 25 C (77 F) for 3 to 5 min and then weigh in water. Designate this weight as *C*.

4.1.2 *Weight of Saturated Surface-Dry Specimen in Air*—Surface dry the specimen by blotting quickly with a damp towel and then weigh in air. Designate this weight as *B*.

4.1.3 *Weight of Oven Dry Specimen*—Oven dry the specimen to constant weight at approximately 110 C (230 F) (15 to 24 h is usually sufficient). Allow the specimen to cool and weigh in air. Designate this weight as *A*.

4.2 *For Specimens That Contain Moisture and Solvent:*

4.2.1 *Weight of Specimen in Water*—Immerse the specimen in a water bath at 25 C (77 F) for 3 to 5 min and then weigh in water. Designate this weight as *C*.

4.2.2 *Weight of Saturated Surface Dry Specimen in Air*—Surface dry the specimen by blotting quickly with a damp towel and then weigh in air. Designate this weight as *B*.

4.2.3 *Weight of Thoroughly Dry Specimen in Air*—Immediately subject the saturated surface dry specimen to ASTM Method D 1461, Test for Moisture or Volatile Distillates in Bituminous Paving Mixtures,[3] for determination of water using a representative portion if the entire specimen is too large for the still. Designate as weight *A* the weight *B* minus the weight of the moisture determined.

4.3 *For Thoroughly Dry Specimens:*

4.3.1 *Weight of Dry Specimen in Air*—Weigh the specimen after it has been standing in air at room temperature for at least 1 h. Designate this weight as *A*.

4.3.2 *Weight of Specimen in Water*—Immerse the specimen in a water bath at 25 C (77 F) for 3 to 5 min and then weigh in water. Designate this weight as *C*.

4.3.3 *Weight of Saturated Surface-Dry Specimen in Air*—Surface dry the specimen by blotting quickly with a damp towel and then weigh in air. Designate this weight as *B*.

5. Calculation

5.1 Calculate the bulk specific gravity of the specimen as follows:

$$\text{Bulk sp gr} = A/(B - C)$$

where:

A = weight of the dry specimen in air, g,
B = weight of the saturated surface-dry specimen in air, g, and
C = weight of the specimen in water, g.

6. Precision

6.1 Duplicate specific gravity results by the same operator should not be considered suspect unless they differ by more than 0.02.

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[3] *Annual Book of ASTM Standards*, Part 15.

D 3203

Designation: D 3203 - 75

Standard Test Method for
PERCENT AIR VOIDS IN COMPACTED DENSE AND OPEN BITUMINOUS PAVING MIXTURES[1]

This Standard is issued under the fixed designation D 3203; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers determination of the percent air voids in compacted dense and open bituminous paving mixtures.

2. Applicable Documents

2.1 *ASTM Standards:*

D 1188 Test for Bulk Specific Gravity of Compacted Bituminous Mixtures, Using Paraffin-Coated Specimens[2]

D 2041 Test for Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures[2]

D 2726 Test for Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens[2]

3. Definitions

3.1 *air voids*—the pockets of air between the bitumen-coated aggregate particles in a compacted bituminous paving mixture.

3.2 *dense bituminous paving mixtures*—bituminous paving mixtures in which the air voids are less than 10 % when compacted.

3.3 *open bituminous paving mixtures*—bituminous paving mixtures in which the air voids are 10 % or more when compacted.

3.3.1 For borderline cases, a bituminous paving mixture shall be designated an open bituminous paving mixture if the calculated percent air voids, based on either 4.1 or 4.2, is 10 % or more.

4. Procedure

4.1 For dense bituminous paving mixtures, determine the bulk specific gravity of the compacted mixture either by Method D 1188 or by Method D 2726. Determine the theoretical maximum specific gravity by Method D 2041 on a comparable bituminous mixture to avoid the influence of differences in gradation, asphalt content, etc.

4.2 For open bituminous mixtures, determine the density of a regularly shaped specimen of compacted mixture from its dry mass (in grams) and its volume (in cubic centimetres), obtained from its dimensions with each dimension based on the average of triplicate measurements spaced to provide representative values. Convert the density to bulk specific gravity by dividing by 0.99707 g/cm^3 or 997 kg/m^3, the density of water at 25°C (77°F). Determine the theoretical maximum specific gravity by Method D 2041 on a comparable bituminous mixture to avoid the influence of differences in gradation, asphalt content, etc.

4.3 For referee purposes, determine both the bulk specific gravity and the theoretical maximum specific gravity on aliquot portions of the same sample of compacted bituminous paving mixture.

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[1] This method is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.21 on Specific Gravity and Density of Bituminous Mixtures.

Current edition approved April 25, 1975. Published June 1975. Originally published as D 3203 - 73. Last previous edition D 3203-73.

[2] *Annual Book of ASTM Standards*, Part 15.

5. Calculations

5.1 Calculate the percent air voids in a compacted bituminous paving mixture as follows:

Percent air voids
= 100 (1-(bulk sp gr/theoretical maximum sp gr))

E 11

AMERICAN NATIONAL STANDARD ANSI/ASTM E 11 - 70 (Reapproved 1977)

Standard Specification for
WIRE-CLOTH SIEVES FOR TESTING PURPOSES[1]

This Standard is issued under the fixed designation E 11; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

This specification has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This specification covers sieves wherein a screening medium of woven-wire cloth is mounted in a frame for use in precision testing in the classification of materials according to particle size (Notes 1 to 4). Methods of checking and calibrating sieves are included as information in the Appendix.

NOTE 1—Some industries may possibly require more restrictive specifications for sieves for special testing purposes. Where such high precision is required, "Matched Sieves"[2] have proven useful. "Matched Sieves" are selected for comparability to a set of "Master Sieves" by a sieving test of the particular material used by an industry.

NOTE 2—Complete instructions and procedures on the use of test sieves are contained in *ASTM STP 447, Manual on Test Sieving Methods*. This manual also contains a list of all ASTM published standards on sieve analysis procedures for specific materials or industries.

NOTE 3—Attention is called to ASTM Method C 430, Test for Fineness of Hydraulic Cement by the No. 325 (45-μm) Sieve,[3] which contains requirements for 2-in. (50-mm) diameter sieves used in the mineral industry, especially the cement group.

NOTE 4—For other types of sieves see ASTM Specification E 323, for Perforated-Plate Sieves for Testing Purposes,[4] and ASTM Specification E 161, for Precision Electroformed Sieves.[4]

2. Wire-Cloth Sieves

2.1 The openings of the wire cloth of successive standard sieves progress from a base of 1 mm in the ratio of approximately $\sqrt[4]{2/1}$. In selecting sieves from this series it is customary to take each sieve in a given range, every second sieve, or every fourth sieve.

2.2 Wire cloth for standard sieves shall be woven from brass, bronze, or other suitable wire with a plain weave, except that cloth with openings of 63 μm (No. 230) and finer may be woven with a twill weave. The wire shall not be coated or plated.

2.3 Wire cloth shall conform to the dimensional requirements of Table 1. The average opening (distance between parallel wires), both in the warp and shoot directions, measured separately, shall conform to the value in column 1, within the permissible variation in average opening given in column 4. The maximum individual opening shall not exceed the value given in column 6. Not more than 5 percent of the openings shall exceed the value given in column 5. The average diameter of the warp and of the shoot wires, taken separately, of the cloth of any sieve shall be that given in column 7, within the permissible range given in Footnote *a*. All measurements of openings and wire diameters shall be made on the wire cloth mounted in the completed sieve.

2.4 Both the warp and shoot wires shall be crimped in such a manner that they will be rigid when in use.

2.5 There shall be no punctures or other obvious defects in the cloth.

3. Frames

3.1 *General Requirements*—Frames for wire cloth sieves shall be constructed of non-

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[1] This specification is under the jurisdiction of ASTM Committee E-29 on Particle Size Measurement and is the direct responsibility of Subcommittee E29.01 on Sieves.
Current edition effective May 29, 1970. Originally issued 1925. Replaces E 11 - 61.

[2] Available from W. S. Tyler, Inc., Mentor, Ohio 44060.

[3] *Annual Book of ASTM Standards*, Part 13.

[4] *Annual Book of ASTM Standards*, Part 41.

corrosive material such as brass or stainless steel in such a manner as to be permanently rigid. Pans and covers shall be so made as to nest with the sieves. The wire cloth shall be mounted on the frame without distortion, looseness, or waviness. To prevent the material being sieved from catching in the joint between the wire cloth and the frame, the joint shall be smoothly filled with solder or so made that the material will not be trapped.

3.2 *Standard Frames*—The standard sieve frame shall be circular, 8.0 in. (203.2 mm) in diameter, of seamless construction. The permissible variation on the mean inside diameter 0.2 in. (5.08 mm) below the top of the frame shall be +0.03 in. (0.762 mm). The bottom of the frame or "sieve skirt" shall be so constructed as to have an easy sliding fit in any sieve conforming to the above permissible variation, and in no case shall this outside diameter be less than 7.970 in. (202.438 mm) nor more than 8.000 in. (203.20 mm). The height of the sieve from the top of the frame to the wire-cloth surface shall be either 2 in. (50.8 mm), designated as full-height, or 1 in. (25.4 mm), designated as half-height. The joint or fillet shall be so constructed as to allow a minimum clear sieving surface 7.5 in. (190.5 mm) in diameter.

3.3 *Nonstandard Frames*—Frames of sieves having nominal openings of less than 25 mm but greater than 4.00 mm may be either of the standard size or of larger dimensions as may be specified in individual cases. Frames of sieves having nominal openings of 25 mm or more should be larger than the standard size. The use of special size and shape frames for special purposes is not precluded. For some purposes, sieve frames larger than the standard size may be either square, rectangular, or circular, and for nominal openings 25 mm and coarser may be made of metal or hardwood. The use of special size and shape frames, however, should be discouraged where the standard frames could be used, because the results are not necessarily comparable.

3.4 *Three-Inch Sieves*—Frames 3 in. (76.2 mm) in inside diameter should not be used for sieves with openings larger than 150 µm (No. 100). The tolerances on the diameter of the sieve frames shall be the same as for the standard size covered in 3.2. The depth of the sieve from the top of the frame to the cloth shall normally be 1.25 in. (31.75 mm), but not less than 0.75 in. (19.05 mm).

4. Label Marking

4.1 Each sieve shall bear a label marked with the following information:

4.1.1 U.S.A. Standard Sieve,

4.1.2 ASTM designation E 11,

4.1.3 Standard sieve designation (from Table 1, Column 1),

4.1.4 Name of manufacturer on distributor, and

4.1.5 Alternative sieve designation (From Table 1, Column 2) Optional.

TABLE 1 Nominal Dimensions, Permissible Variations for Wire Cloth of Standard Test Sieves (U.S.A. Standard Series)

Sieve Designation		Nominal Sieve Opening, in.[c]	Permissible Variation of Average Opening from the Standard Sieve Designation	Maximum Opening Size for Not More than 5 percent of Openings	Maximum Individual Opening	Nominal Wire Diameter, mm[a]
Standard[b]	Alternative					
(1)	(2)	(3)	(4)	(5)	(6)	(7)
125 mm	5 in.	5	±3.7 mm	130.0 mm	130.9 mm	8.0
106 mm	4.24 in.	4.24	±3.2 mm	110.2 mm	111.1 mm	6.40
100 mm[d]	4 in.[d]	4	±3.0 mm	104.0 mm	104.8 mm	6.30
90 mm	3 1/2 in.	3.5	±2.7 mm	93.6 mm	94.4 mm	6.08
75 mm	3 in.	3	±2.2 mm	78.1 mm	78.7 mm	5.80
63 mm	2 1/2 in.	2.5	±1.9 mm	65.6 mm	66.2 mm	5.50
53 mm	2.12 in.	2.12	±1.6 mm	55.2 mm	55.7 mm	5.15
50 mm[d]	2 in.[d]	2	±1.5 mm	52.1 mm	52.6 mm	5.05
45 mm	1 3/4 in.	1.75	±1.4 mm	46.9 mm	47.4 mm	4.85
38.1 mm	1 1/2 in.	1.5	±1.1 mm	39.1 mm	39.5 mm	4.59
31.5 mm	1 1/4 in.	1.25	±1.0 mm	32.9 mm	33.2 mm	4.23
26.5 mm	1.06 in.	1.06	±0.8 mm	27.7 mm	28.0 mm	3.90
25.0 mm[d]	1 in.[d]	1	±0.8 mm	26.1 mm	26.4 mm	3.80
22.4 mm	7/8 in.	0.875	±0.7 mm	23.4 mm	23.7 mm	3.50
19.0 mm	3/4 in.	0.750	±0.6 mm	19.9 mm	20.1 mm	3.30
16.0 mm	5/8 in.	0.625	±0.5 mm	16.7 mm	17.0 mm	3.00
13.2 mm	0.530 in.	0.530	±0.41 mm	13.83 mm	14.05 mm	2.75
12.5 mm[d]	1/2 in.[d]	0.500	±0.39 mm	13.10 mm	13.31 mm	2.67
11.2 mm	7/16 in.	0.438	±0.35 mm	11.75 mm	11.94 mm	2.45
9.5 mm	3/8 in.	0.375	±0.30 mm	9.97 mm	10.16 mm	2.27
8.0 mm	5/16 in.	0.312	±0.25 mm	8.41 mm	8.58 mm	2.07
6.7 mm	0.265 in.	0.265	±0.21 mm	7.05 mm	7.20 mm	1.87
6.3 mm[d]	1/4 in.[d]	0.250	±0.20 mm	6.64 mm	6.78 mm	1.82
5.6 mm	No. 3 1/2[e]	0.223	±0.18 mm	5.90 mm	6.04 mm	1.68
4.75 mm	No. 4	0.187	±0.15 mm	5.02 mm	5.14 mm	1.54
4.00 mm	No. 5	0.157	±0.13 mm	4.23 mm	4.35 mm	1.37
3.35 mm	No. 6	0.132	±0.11 mm	3.55 mm	3.66 mm	1.23
2.80 mm	No. 7	0.111	±0.095 mm	2.975 mm	3.070 mm	1.10
2.36 mm	No. 8	0.0937	±0.080 mm	2.515 mm	2.600 mm	1.00
2.00 mm	No. 10	0.0787	±0.070 mm	2.135 mm	2.215 mm	0.900
1.70 mm	No. 12[e]	0.0661	±0.060 mm	1.820 mm	1.890 mm	0.810
1.40 mm	No. 14	0.0555	±0.050 mm	1.505 mm	1.565 mm	0.725
1.18 mm	No. 16	0.0469	±0.045 mm	1.270 mm	1.330 mm	0.650
1.00 mm	No. 18	0.0394	±0.040 mm	1.080 mm	1.135 mm	0.580
850 µm[f]	No. 20	0.0331	±35 µm	925 µm	970 µm	0.510
710 µm	No. 25	0.0278	±30 µm	775 µm	815 µm	0.450
600 µm	No. 30	0.0234	±25 µm	660 µm	695 µm	0.390
500 µm	No. 35	0.0197	±20 µm	550 µm	585 µm	0.340
425 µm	No. 40	0.0165	±19 µm	471 µm	502 µm	0.290
355 µm	No. 45	0.0139	±16 µm	396 µm	425 µm	0.247
300 µm	No. 50	0.0117	±14 µm	337 µm	363 µm	0.215
250 µm	No. 60	0.0098	±12 µm	283 µm	306 µm	0.180
212 µm	No. 70	0.0083	±10 µm	242 µm	263 µm	0.152
180 µm	No. 80	0.0070	±9 µm	207 µm	227 µm	0.131
150 µm	No. 100	0.0059	±8 µm	174 µm	192 µm	0.110
125 µm	No. 120	0.0049	±7 µm	147 µm	163 µm	0.091
106 µm	No. 140	0.0041	±6 µm	126 µm	141 µm	0.076
90 µm	No. 170	0.0035	±5 µm	108 µm	122 µm	0.064
75 µm	No. 200	0.0029	±5 µm	91 µm	103 µm	0.053
63 µm	No. 230	0.0025	±4 µm	77 µm	89 µm	0.044
53 µm	No. 270	0.0021	±4 µm	66 µm	76 µm	0.037
45 µm	No. 325	0.0017	±3 µm	57 µm	66 µm	0.030
38 µm	No. 400	0.0015	±3 µm	48 µm	57 µm	0.025

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[a] The average diameter of the warp and of the shoot wires, taken separately, of the cloth of any sieve shall not deviate from the nominal values by more than the following:

Sieves coarser than 600 µm	5 percent
Sieves 600 to 125 µm	7 1/2 percent
Sieves finer than 125 µm	10 percent

TABLE 1 ***Concluded***

[A] These standard designations correspond to the values for test sieve apertures recommended by the International Standards Organization, Geneva, Switzerland.

[B] Only approximately equivalent to the metric values in Column 1.

[C] These sieves are not in the standard series but they have been included because they are in common usage.

[D] These numbers (3½ to 400) are the approximate number of openings per linear inch but it is preferred that the sieve be identified by the standard designation in millimeters or µm.

[E] 1000 µm = 1 mm.

APPENDIX

A1. METHODS OF CHECKING WIRE-CLOTH SIEVES TO DETERMINE WHETHER OR NOT THEY CONFORM TO SPECIFICATION

A1.1 Except for the very coarse sieves, the most reliable method of determining the average opening is to calculate it from the value obtained for the average diameter of the wires and the number of wires per unit of length. The value for the average diameter of the wires is obtained by measuring 5 to 10 wires that are evenly spaced across the sieve. The number of measurements depends upon the uniformity of the wire and the closeness of the measurements to the limits permitted. All measurements must be made in both the warp and shoot directions and considered separately.

A1.1.1 *Sieves 125 to 11.2-mm*—Measure 1 to 5 openings and wires with a vernier caliper or flat "go", "no-go" gages.

A1.1.2 *Sieves 13.2 to 3.35-mm*—Determine the mesh by measuring the distance occupied by at least 10 openings and 10 wires and measure the diameter of at least 5 wires. Use a measuring microscope (linear comparator) with an 80-mm objective lens in the microscope.

NOTE A1—These microscopes should have a tube length of about 160 mm and a 10 × eyepiece.

A1.1.3 *Sieves 4.0 to 2.0-mm*—Determine the average opening and wire diameter in the same manner as in A1.1.2 except that a 67-mm objective lens is used in the microscope. (Note A1).

A1.1.4 *Sieves 2.8 to 1.0-mm*—Same as in A1.1.2 except that a 60-mm objective lens is used in the microscope (Note A1).

A1.1.5 *Sieves 850 to 425-µm*—Determine the mesh by means of the "Moire effect" and measure the diameter of at least 5 wires with a microscope (Note A1) fitted with a split-image eyepiece and a 48-mm objective lens.

A1.1.6 *Sieves 425 to 106-µm*—Same as in A1.1.5 except that the microscope (Note A1) should be fitted with a 32-mm objective lens.

A1.1.7 *Sieves 125 to 38-µm*—Same as in A1.1.5 except that the microscope (Note A1) should be fitted with a 16-mm objective lens.

A1.1.8 Determine the maximum openings and the number of openings larger than the intermediate permissible variation in both the warp and shoot directions. Make measurements with the same devices used to measure wire diameters. Use a mechanism to hold the sieve and slowly move it under the microscope for a distance of at least 150 mm. Scan the openings along a diameter of the sieve and measure excessively large openings. If the openings are larger than the intermediate permissible variation they should be counted and the percentage calculated.

A1.1.9 Measurements needed in A1.1.5 through A1.1.8 can also be made with projection equipment having suitable magnification.

A1.2 With round "go", "no-go" gages check the dimension of the frames.

A1.3 Determine the magnification of optical devices with calibrated stage micrometers.

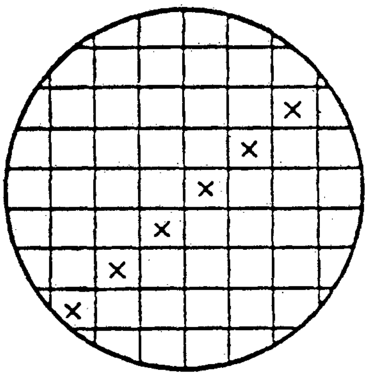
A1.4 Determine the mesh count by means of the "Moire effect," also known as "picket-fence interference," with accurately graduated glass scales.[2] For the 75-µm sieve, for instance, a glass scale with approximately 200 lines to the inch is used. The opaque lines are about equal in width to the space between the lines and must be uniformly spaced. When a scale such as this is laid on woven-wire cloth having a mesh per unit length approximating the number of lines per unit length on the scale, and a strong light is placed beneath, dark bands will appear which in a unit length are equal in number to the difference between the mesh of the cloth and the graduation of the scale. If the scale is moved lengthwise, in a direction perpendicular to the lines, the dark bands will also move. If these bands move in the same direction as the motion of the scale, the mesh of the sieve is less; if the motion is in the opposite direction, the mesh is greater than the number of lines on the scale. If some bands move in one direction and some in the other, the number moving in each direction must be counted separately, and the algebraic sum taken as the number of bands. For sieves 850-µm (No. 20) to 212-µm (No. 70) inclusive, the best results are obtained with a transparent line about the width of a wire diameter ruled on an opaque background. For sieves coarser than these it is usually necessary to count the wires by the aid of a hand lens, using a steel scale as the standard. Scales should be calibrated before being used in testing sieves.

A1.5 The National Bureau of Standards accepts wire-cloth sieves 5.6-mm and finer for test to determine conformity to specifications.

A2. METHODS OF CALIBRATING WIRE-CLOTH SIEVES

A2.1 A wire-cloth sieve may be calibrated by plotting the frequency of occurrence of the size of the openings as indicated in the following procedure: Six fields are chosen in such a manner that none of the openings to be measured will have common wires. In each field the openings to be measured should lie in a diagonal direction across the sieve (see Fig. A1). The openings in three of the fields should lie in a direction at right angles to those in the other three fields. Measure at least 50 openings in each field. Measure each opening between the warp wires and the shoot wires and separately tabulate and plot the readings.

A2.2 For routine checking of sieves and for determining the effective sieve opening a method employing glass spheres is recommended. These glass spheres should not be used to determine conformity to specifications. Glass spheres for sieve calibration may be obtained from the Supply Division, National Bureau of Standards, Washington, D.C. 20234. Four of these standard reference materials are now available: SRM 1019a for calibrating sieves No. 8 to 35; SRM 1018a for calibrating sieves No. 20 to 70; SRM 1017a for calibrating sieves No. 50 to 170; and SRM 1004 for calibrating sieves No. 140 to 400. Detailed instructions for the use of the glass spheres for calibrating sieves are furnished with each sample.



NOTE—Only the indicated openings are measured.

FIG. A1 Method of Selecting Openings for Plotting of Different Sizes of Openings.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103, which will schedule a further hearing regarding your comments. Failing satisfaction there, you may appeal to the ASTM Board of Directors.

RÉCUPÉRATION
DU BITUME

1.5 RÉCUPÉRATION DU BITUME

La méthode recommandée n'est pas celle de l'ASTM[1] D1856 mais plutôt celle du laboratoire de la Ville de Montréal[3] qui est aussi précise et plus facile d'utilisation.

2.9 RECUPERATION DU BITUME

2.9.01 Définition

— La récupération de bitume consiste à distiller le liquide provenant de l'essai d'extraction, afin d'en séparer le solvant (trichloréthylène) et le bitume pour soumettre ce dernier à différents essais.

2.9.02 Appareils

— Ballon à distiller d'une capacité de 1,000 ml.

— Thermomètre gradué de 20° F à 760° F (—7° C à 393° C).

— Une extension d'environ 6 po. (152 mm).

— Un joint à trois ouvertures, angle de 75°.

— Un refroidisseur de 400 mm. de longueur.

— Un ballon de 500 ml pour recevoir le distillat.

— Un poêle à distillation avec un contrôle de température précis (Voir figure 15).

2.9.03 Procédé

— Extraire le bitume du mélange à l'aide d'un centrifuge ou autre méthode décrite dans ASTM D 2172.

— Centrifuger le produit récupéré pendant 2 minutes à une vitesse de 2.000 tr/mn dans des bouteilles prévues à cette fin.

— Le temps nécessaire à l'appareil pour atteindre 2.000 tr/mn est supérieur à 2 minutes.

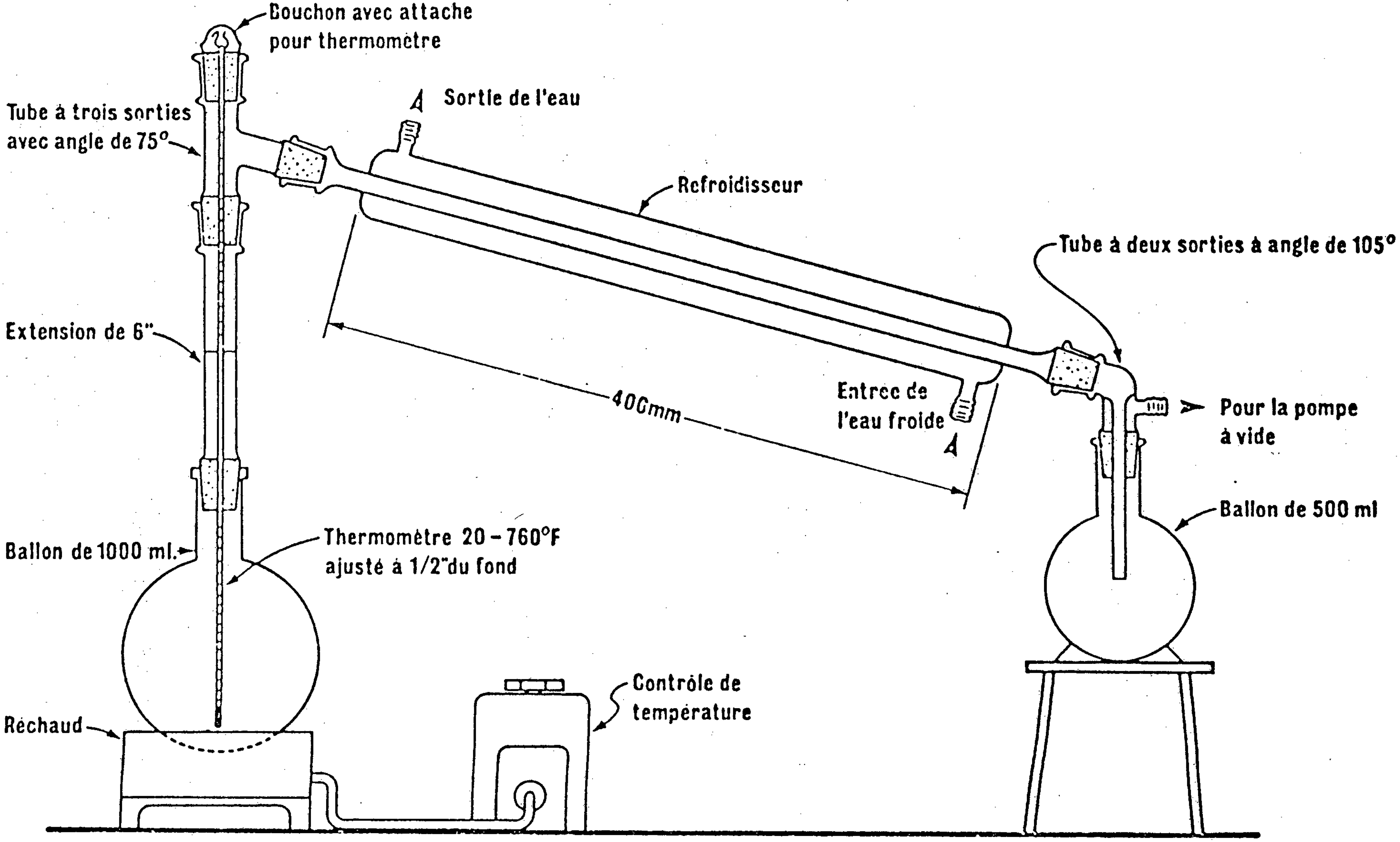
— Verser 400 ml du liquide récupéré dans un flacon à distiller de 1.000 ml. Débuter la distillation en mettant 5 à 10 po. (127 mm à 254 mm) de vacuum jusqu'à ce qu'une grande partie du produit volatil soit évaporée, puis monter le vacuum jusqu'à 28 po. (71.1 cm) pendant 5 minutes, tout en gardant la température inférieure à 200° F (93° C). Baisser lentement le vide et enlever le trichlore propre ainsi récupéré.

— Remonter le vide à 28 po. ou mieux et garder la température à 350° F (177° C) pendant 1 heure ou 500° F (260° C) pendant 1/2 heure.

— Baisser lentement le vide et démonter l'appareil, conserver le bitume récupéré pour les essais.

N.B.: Les essais sur le bitume récupéré devront être faits dans la même journée que la distillation.

Fig. 15 Montage pour la distillation et la récupération du bitume.



<ins>Tous les joints sont 24/40</ins>

Designation: D 1856 - 75

Standard Test Method for
RECOVERY OF ASPHALT FROM SOLUTION BY ABSON METHOD[1]

This Standard is issued under the fixed designation D 1856; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the recovery by the Abson Method of bitumen from asphaltic mixtures with nitration grade benzene conforming to Specification D 835 or reagent grade trichloroethylene[2] (Note 1). The bitumen is recovered with properties substantially the same as those it possessed in the asphaltic mixture and in quantity sufficient for further testing.

NOTE 1—The bitumen may be extracted from an aggregate-asphalt mixture in accordance with Method D 2172. The precision data in Note 2 of Method D 2172 was determined by use of Method A (Centrifuge Method) using trichloroethylene as a solvent. There is some experimental evidence that slightly lower penetration values may result in the asphalt recovered by hot extraction methods.

2. Applicable Documents

2.1 *ASTM Standards:*

D 96 Tests for Water and Sediment in Crude Oils[3]

D 835 Specification for Refined Benzene-485 (Nitration Grade)[4]

D 2172 Test for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures[5]

E 1 Specification for ASTM Thermometers[6]

3. Apparatus

3.1 *Centrifuge*, batch unit capable of exerting a minimum centrifugal force of 770 times gravity[7] or continuous unit capable of exerting a minimum force of 3000 times gravity. The apparatus specified in Method D 96 may also be used.

3.2 *Centrifuge Tubes*—A supply of 8-oz (250-ml) wide-mouth bottles, or centrifuge tubes as shown in Figs. 1 or 2 of Method D 96.

3.3 *Distillation Assembly*, as shown in Fig. 1, and consisting of the following items:

3.3.1 *Extraction Flasks*—Two 250-ml, wide-mouth, heat-resistant flasks; one for distillation and the other for the receiver.

3.3.2 *Glass Tubing*—Heat-resistant glass tubing, having 10-mm inside diameter and gooseneck shaped (as shown in Fig. 1) for connecting the flask to the condenser.

3.3.3 *Inlet Aeration Tube*,[8] at least 180 mm in length, having a 6-mm outside diameter with a 10-mm bulb carrying six staggered side holes approximately 1.5 mm in diameter.

3.3.4 *Electric Heating Mantle*, with variable transformer, oil bath or fluidized sand bath, to fit a 250-ml flask.

3.3.5 *Water-Jacketed Condenser*, Allihn type, with 200-mm minimum jacket length, or equivalent.

3.3.6 *Thermometer*—An ASTM Low Distil-

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[1] This method is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.25 on Analysis of Bituminous Mixtures.

Current edition approved June 2, 1975. Published September 1975. Originally published as D 1856-61. Last previous edition D 1856-69.

[2] Trichloroethylene, Technical Grade, Type I, Federal Specification O-T-634, latest revision may be used, but it is recommended that for each new supply of the solvent a blank should be run on an asphalt of known properties. In case of dispute, benzene should be used.

[3] *Annual Book of ASTM Standards*, Part 23.

[4] *Annual Book of ASTM Standards*, Part 29.

[5] *Annual Book of ASTM Standards*, Part 15.

[6] *Annual Book of ASTM Standards*, Parts 25 and 44.

[7] An "International" No. 2 centrifuge operating at 1900 rpm or an "SMM Continuous Centrifuge" exerting a force of 3000 times gravity at 9000 rpm, have been found satisfactory for this purpose.

[8] Kimball tube No. 49055 has been found satisfactory for this purpose.

lation Thermometer 7 F or 7 C, as specified, having a range from 30 to 580°F or −2 to 300°C, respectively, and conforming to the requirements in Specification E 1.

3.3.7 *Gas Flowmeter*,[9] as shown in Fig. 1, or any type capable of indicating a gas flow of up to 1000 ml/min.

3.3.8 *Corks*, No. 20, drilled as shown in Fig. 1.

3.3.9 *Flexible Elastomeric Tubing*, resistant to chlorinated solvents and benzene, having sufficient length and size to connect the aeration tube to flowmeter, and equipped with a pinch clamp or stopcock to close aeration tube prior to introducing carbon dioxide.

3.3.10 *Separatory Funnel*,[10] 125-ml capacity.

4. Reagent

4.1 *Carbon Dioxide Gas*—A pressurized tank, with pressure-reducing valve or other convenient source.

5. Sample

5.1 The sample shall consist of the solution from a previous extraction of a sample of sufficient weight to result in approximately 75 to 100 g of recovered bitumen.

6. Procedure

6.1 The entire procedure, from the start of the extraction to the final recovery, must be completed within 8 h.

6.2 Centrifuge the solution from the previous extraction for a minimum of 30 min at 770 times gravity in either 8-oz (250-ml) wide-mouth bottles or centrifuge tubes in batch apparatus specified. If a continuous centrifuge is used, the extract solution shall be charged at a rate not to exceed 150 ml/min, while the unit is operating at a speed calculated to produce a centrifugal force of not less than 3000 times gravity.

6.3 Concentrate the solution to about 200 ml by any primary distillation operation using a flask large enough to hold all the solution from the extraction. Transfer the residue from the primary distillation flask, using several washes of solvent to rinse all of the residue into the 250-ml distillation flask. Assemble the apparatus as shown in Fig. 1, except position the bottom of the aeration tube above the surface of the solution. Continue distillation until the temperature reaches 275°F (135°C), at which time lower the aeration tube so that the bulb is in contact with the bottom of the flask, and introduce carbon dioxide gas at a low rate (approximately 100 ml/min) to provide agitation and prevent foaming. If foaming or bumping occurs, introduce carbon dioxide intermittently at the beginning of the distillation at a rate of 100 ml/min to prevent this. When the temperature reaches 315 to 320°F (157 to 160°C), increase the carbon dioxide gas flow to approximately 900 ml/min. Maintain this gas flow rate for 10 min while also maintaining the temperature of the residue in the flask at 320 to 330°F (160 to 166°C). If, after 10 min, dripping of condensed solvent from the delivery tube is still occurring, maintain the gas flow and temperature until 5 min after the dripping ceases in order to flush solvent vapors from the flask. At the end of this period, discontinue gas flow and heat.

6.3.1 *Alternative Procedure*—Assemble the apparatus as shown in Fig. 1 with the separatory funnel in the thermometer hole in the cork. (It may be advantageous to insert the separatory funnel in a separate hole drilled in the cork stopper.) Raise the aeration tube so that the bulb is above the surface of the solution. Fill the separatory funnel with the centrifuged solution and open the stopcock to fill the flask approximately one half full of solvent mixture. Apply low heat to the flask and start distillation. Adjust the funnel stopcock to introduce fresh solvent at a rate that will keep the flask approximately one half full during distillation, adding additional solvent mixture to the funnel until all solvent has been introduced into the distillation flask. Wash the solvent mixture container and funnel with fresh solvent to transfer all asphalt into the distillation flask. Continue distillation until the temperature reaches 275°F (135°C), at which time lower the aeration tube so that the bulb is in contact with the bottom of the flask and introduce carbon dioxide gas at a low rate (approximately 100

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[9] The Monostat Corp. "Flowmeter" No. 9144 has been found satisfactory for this purpose.

[10] Kimball separatory funnel No. 29030 has been found satisfactory for this purpose.

ml/min) to provide agitation and prevent foaming. If foaming or bumping occurs, introduce carbon dioxide intermittently at the beginning of the distillation at a rate of 100 ml/min to prevent this. When the temperature reaches 315 to 320°F (157 to 160°C), increase the carbon dioxide gas flow to approximately 900 ml/min. Maintain this gas flow rate for 10 min while also maintaining the temperature of the residue in the flask at 320 to 330°F (160 to 166°C). If, after 10 min, dripping of condensed solvent from the delivery tube is still occurring, maintain the gas flow and temperature until 5 min after the dripping ceases in order to flush solvent vapors from the flask. At the end of this period, discontinue the gas flow and heat.

6.4 If the residue in the flask is highly viscous at 325°F (163°C), so that dispersion of the carbon dioxide in the residue is restricted and the recovered asphalt is expected to have a penetration at 77°F (25°C) of less than 30, maintain the carbon dioxide gas flow and temperature for 20 to 22 min.

6.5 The residue can be heated to reliquefy and portions taken for penetration, softening point, ductility, ash content, and kinematic and absolute viscosity determinations, as required. Ash content should be reported with other test data on residue. Ash contents of recovered asphalt greater than 1 % may affect the accuracy of the penetration ductility, softening point, and viscosity tests.

NOTE 2—Determination of the weight of asphalt recovered serves as a check to assure that all of the solvent has been removed when this weight is compared with the weight of asphalt extracted as determined by Method D 2172. The weight of the recovered asphalt should be corrected for the ash content determined.

7. Precision

7.1 Repeatability and reproducibility tests have not been established in accordance with standard ASTM practice. However, a series of eight samples, tested in duplicate by four laboratories in 1971 in a cooperative test program under the direction of ASTM Subcommittee D04.25 provided the information given in Note 3, on the accuracy of this method when applied to asphalt cement having physical test properties within the following ranges:

Penetration	23 to 73
Kinematic viscosity at 275°F (135°C)	350 to 660 cSt
Softening point, ring-and-ball	118 to 138°F

NOTE 3—The task force data, on precision tests on residues recovered by Method D 1856:

Number of samples	8
Number of laboratories	4
Number of replicates, per sample per laboratory	2
Within-Laboratory Standard Deviations:	
Penetration, 77°F	1.836
Kinematic viscosity, at 275°F (135°C), cSt	37.65
Softening point, ring-and-ball, °F	1.501
Between-Laboratory Standard Deviations:	
Penetration, 77°F	3.090
Kinematic viscosity, at 275°F (135°C), cSt	54.94
Softening point, ring-and-ball, °F	3.803

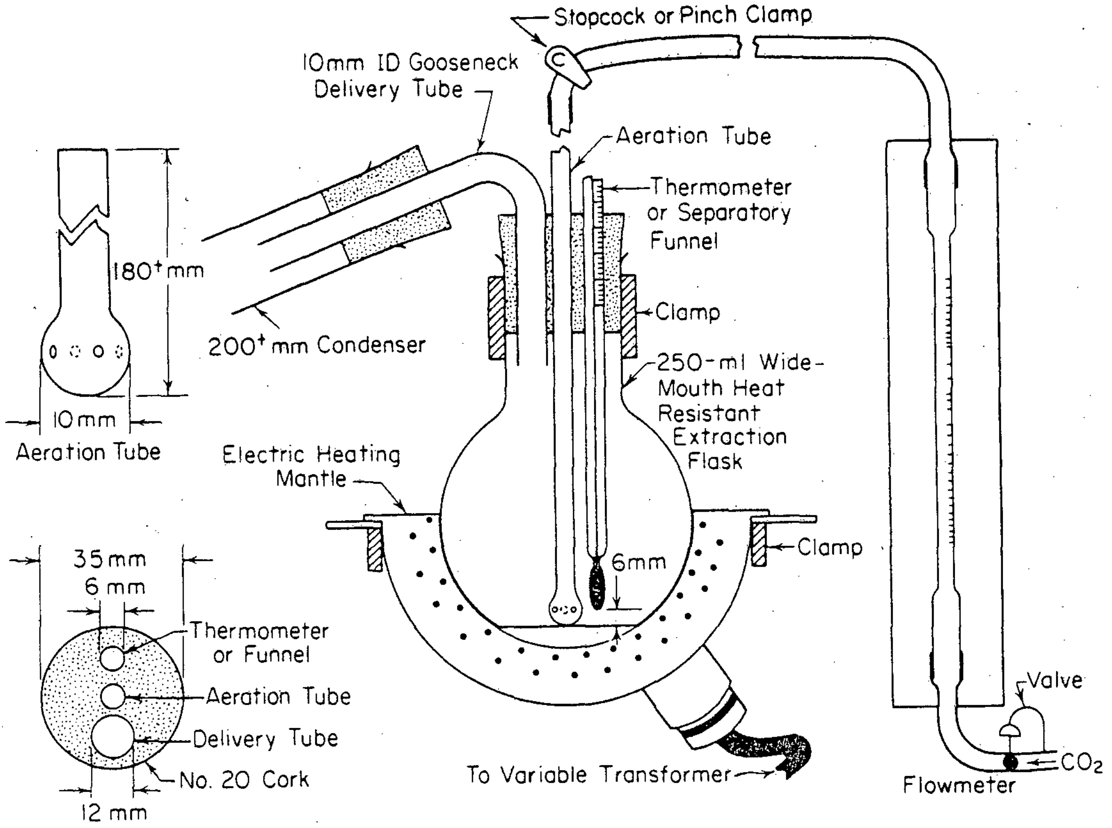


FIG. 1 Distillation Assembly for Bitumen Recovery.

CALCUL D'UN MÉLANGE

Partie 3

3.1 Détermination du pourcentage optimum de bitume

3.1.01 Définition

— Cette opération fait partie du design d'un mélange. Elle consiste à trouver le pourcentage de bitume que devrait contenir un mélange pour atteindre certaines normes de vide, de stabilité.

N.B.: Les matériaux proposés doivent satisfaire aux prescriptions indiquées dans le cahier des charges. Les mélanges d'agrégats doivent satisfaire aux conditions granulométriques prescrites.

3.1.02 Appareils

— Récipients métalliques (genre plats à pain) destinés à chauffer les agrégats.

— Des thermomètres gradués de 50°F à 450°F (10°C à 230° C) pour les agrégats et le bitume.

— Un malaxeur mécanique genre "Hobart C. 100", avec deux bols de malaxage et deux agitateurs à fils métalliques. (Photo 12)

— Une balance électrique d'une capacité minimum de 5 000 g. et d'une sensibilité de 0,1 g.

— Récipient pour chauffer et verser le bitume.

— Une étuve d'une capacité de chauffage minimum de 400° F (205°C).

3.1.03 Procédé

— Pour déterminer la teneur optimum en bitume correspondant à une granulométrie donnée, préparer une série d'éprouvettes d'essai pour différentes teneurs en bitume, de façon que les courbes représentant les résultats des essais indiquent une valeur optimum bien définie.

— Effectuer les essais avec des teneurs en bitume s'élevant régulièrement de 0,5% et comprenant au moins deux points au-dessus et deux points au-dessous de la valeur optimum. Pour fixer les teneurs à utiliser dans les essais de laboratoire, il faut d'abord déterminer la teneur témoin ou de départ: le total granulométrique des pourcentages cumulatifs passant de dix tamis plus 120 divisé par 100 i.e. la formule "LERO"[4]. Afin d'obtenir des données suffisantes, préparer au moins trois éprouvettes pour chaque teneur en bitume considérée. L'étude d'un mélange préparé à chaud pour six teneurs différentes exige donc 18 éprouvettes d'essai. Il faut pour chaque éprouvette 1,100 g. d'agrégats.

— Placer à l'étuve toutes les fractions granulométriques de l'agrégat dans des récipients distincts et porter à une température comprise entre 350 °F et 375 °F (177 °C et 190 °C).

— Amener le bitume à une température comprise entre 250° F et 280°F (121°C et 138°C). Ne pas maintenir le bitume à cette température plus d'une heure, ne pas utiliser de bitume réchauffé.

— Placer le bol de malaxage (préalablement sali avec du mélange bitumineux) sur la balance. Verser les agrégats dans le bol et faire la tare.

— Mélanger parfaitement les agrégats et former un cratère dans le mélange. Transvider le poids du bitume désiré.

— Mélanger parfaitement le bitume et les agrégats jusqu'à ce que le bitume soit uniformément réparti (environ 1 minute avec un malaxeur mécanique).

N.B.: La température du mélange préparé ne doit jamais être inférieure à 285°F (140°C) pour le compactage. Dans le cas contraire placer le mélange au four pour qu'il atteigne la température de 300°F (149°C).

— Sur chaque éprouvette, procéder au compactage et aux essais suivants:
— Densité brute.
— Densité maximum (rice)
— Stabilité Marshall et déformation

N.B.: On peut aussi effectuer des essais d'extraction de bitume pour chaque groupe, comme vérification.

3.1.04 Calculs

— Prendre la moyenne des densités brutes pour toutes les éprouvettes d'une teneur en bitume donnée, les valeurs manifestement erronées ne seront pas en compte dans le calcul de la moyenne.

— Même procédé pour les densités maximum, les stabilités, les déformations, les pourcentages de vide, les poids unitaires et les pourcentages de vide dans les agrégats (VAM).

— Construire des graphiques (Graphique 9) dont les courbes donneront les caractéristiques physiques du mélange en fonction de la teneur en bitume et des résultats des données suivantes (Tableau 3).

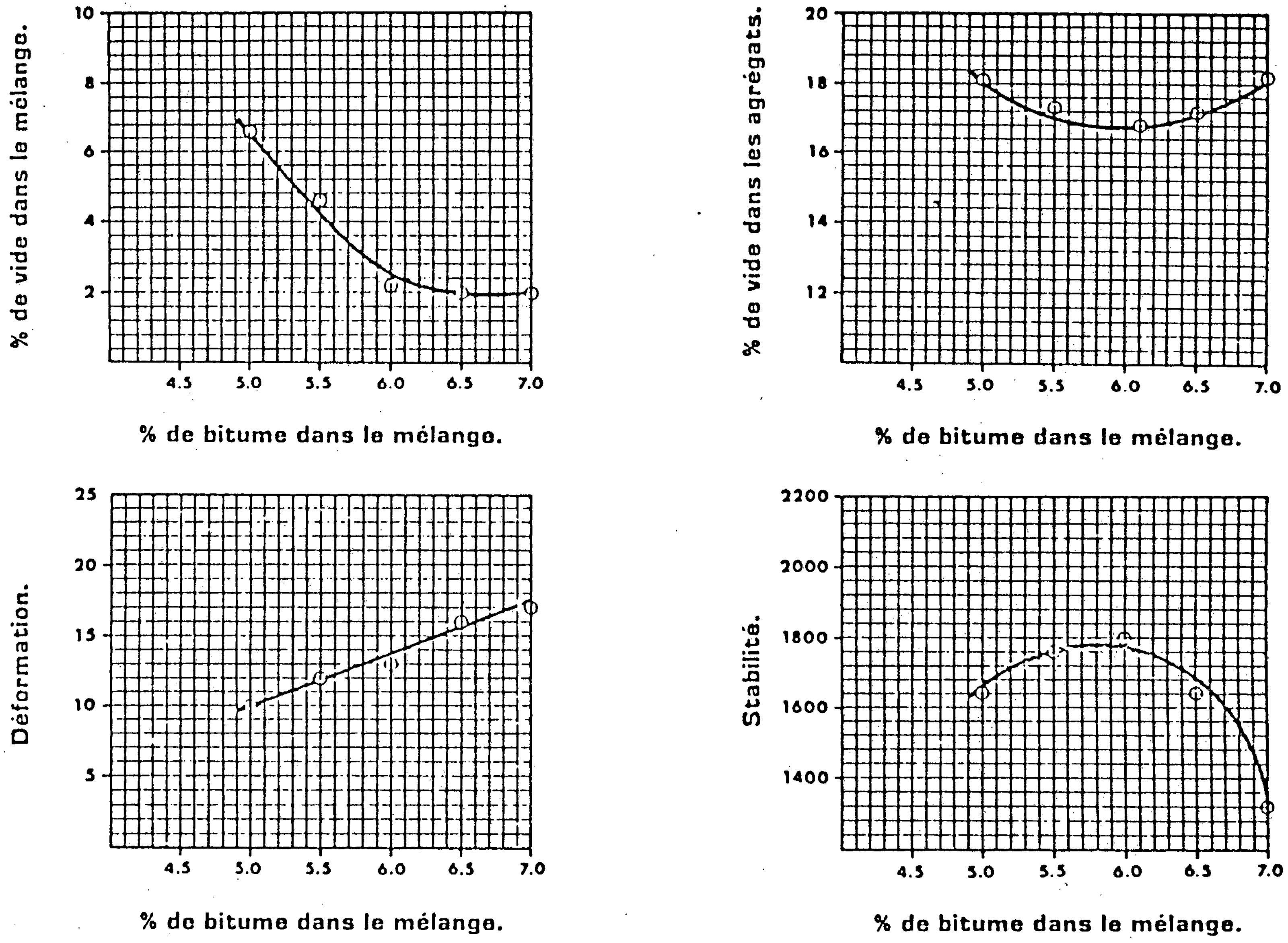
a = La stabilité Marshall
b = L'indice de déformation
c = Le pourcentage de vide dans le mélange
d = Le pourcentage de vide dans les agrégats (VAM)
e = Le poids unitaires ou densité BRUTE.

TABLEAU 3

COMPILATION DE DONNÉES POUR LA DÉTERMINATION DU POURCENTAGE OPTIMUM DE BITUME

% DE BITUME		POIDS (en grammes)			VOLUME	DENSITÉ		VOLUME (% total)		VAM	POIDS	STABILITÉ		DÉF.
agrégats	mélange	air saturé	air sec	eau	BRUTE	brute	maximum	bitume	vides		UNITAIRE	mesurée	corrigée	
	a	b	c	d	e	f	g	h	i	j	k	l	m	n
					b-d	c/e		$\frac{f \times a}{1.01}$	$\frac{g-f}{g}$	h + i	f x 62.4			
5.26	5.0	1209.2	1208.5	717.2	492.0	2.456	2.630					154	1679	10
		1215.9	1215.1	720.4	495.5	2.452	2.629					148	1613	9
		1212.8	1212.1	719.0	493.8	2.454	2.624					151	1646	11
	moyenne					2.455	2.628	12.2	6.6	18.8	153.2		1646	10
5.82	5.5	1213.6	1213.0	724.9	488.7	2.482	2.608					170	1853	12
		1216.8	1216.2	727.4	489.4	2.485	2,610					153	1668	14
		1215.0	1214.5	726.9	488.1	2.488	2.608					160	1744	11
	moyenne					2.485	2.608	13.4	4.6	18.0	155.3		1755	12
6.38	6.0	1220.4	1219.2	735.7	484.7	2.515	2.588					166	1809	12
		1225.2	1224.9	739.2	486.0	2.520	2.587					163	1777	13
		1220.8	1220.2	737.1	483.7	2.522	2.589					165	1799	14
	moyenne					2.519	2.587	15.0	2.5	17.5	157.4		1795	15
6.95	6.5	1221.8	1221.1	735.9	485.9	2.513	2.564					157	1711	16
		1234.2	1233.7	744.0	490.2	2.516	2.560					144	1570	16
		1226.0	1225.4	738.8	487.2	2.515	2.566					151	1646	17
	moyenne					2.515	2.567	16.2	1.9	18.1	157.1		1642	16
7.53	7.0	1229.4	1228.7	737.0	492.4	2.495	2.546					121	1319	17
		1221.1	1220.5	731.7	489.4	2.494	2.549					119	1297	18
		1225.9	1225.0	734.0	491.9	2.490	2.550					120	1308	17
	moyenne					2.493	2.548	17.3	2.0	19.3	155.8		1308	17

Fig. 18 Diagrammes de design.



3.1.05 Interprétation des résultats

— La stabilité Marshall augmente avec la teneur en bitume pour ensuite décroître.

— L'indice de déformation augmente avec la teneur en bitume.

— Le poids unitaire du mélange augmente avec la teneur en bitume, pour ensuite décroître. Habituellement le poids unitaire maximum est atteint pour une teneur en bitume légèrement supérieure à celle donnant la stabilité maximum.

— Le pourcentage de vide dans le mélange diminue à mesure que la teneur en bitume augmente pour atteindre une valeur minimum.

— Pour obtenir la teneur en bitume optimum, considérer les cinq graphiques précédemment cités. À l'aide de ces graphiques, déterminer les teneurs en bitume qui donneront:

a) La stabilité maximum
b) Le poids unitaire maximum
c) Le pourcentage de vide dans le mélange se rapprochant le plus de la moyenne des limites prévues au devis
d) L'indice de déformation se rapprochant le plus de la moyenne des limites prévues au devis
e) Le VAM égal ou supérieur à celui prévu au devis.

— La teneur optimum de bitume dans le mélange est alors la moyenne arithmétique des valeurs déterminées précédemment. Cependant, la teneur choisie ne doit pas correspondre à un VAM inférieur à celui prévu.

ChapterV

ANALYSIS OF COMPACTED PAVING MIXTURES

5.01 GENERAL—The analytical procedures described in this chapter apply either to paving mixtures that have been compacted in the laboratory, or to undisturbed samples that have been cut from a pavement in the field. When a paving mixture is compacted in the laboratory, the compactive effort should provide a density equal to the density *the mixture will ultimately attain under traffic* following compaction by rolling during construction.

By analyzing a compacted paving mixture for air voids (V_a), voids in the mineral aggregate (VMA), and effective asphalt content (P_{be}) some indication of the probable service performance of the pavement is provided. The efficacy of compaction, either during construction or after years of service can be determined by comparing the specific gravity of an undisturbed sample cut from a pavement with the laboratory compacted specific gravity of the same paving mixture.

Three different aggregate specific gravity values are used at the present time for analyzing paving mixtures, bulk specific gravity (G_{sb}), apparent specific gravity (G_{sa}), and effective specific gravity (G_{se}).

The Asphalt Institute recommends that VMA values for compacted paving mixtures should be calculated in terms of the aggregate's bulk specific gravity, G_{sb}. The bulk specific gravity, with an allowance for the portion of the asphalt binder lost by absorption into the aggregate particles, or the equivalent of this procedure, should be the basis for calculating the air voids in a compacted asphalt paving mixture. The effective asphalt content (P_{be}) of a paving mixture is the total asphalt content minus the portion of the total asphalt content that is lost by absorption into the aggregate particles.

Values for voids in the mineral aggregate (VMA) and air voids (V_a) are expressed as percent by volume of the sample of paving mixture being analyzed. Depending on how asphalt content is specified, the effective asphalt content may be expressed either as percent by weight of the total weight of the sample of paving mixture being examined, or as percent by weight of the aggregate in the paving mixture sample.

Because air voids and voids in mineral aggregate are volume quantities and therefore cannot be weighed, a paving mixture must first be designed or analyzed on a volume basis. For design purposes, this volume approach can easily be changed over to a weight basis to provide a job-mix formula.

Table V-1 illustrates that the type of aggregate specific gravity employed for the analysis of a given sample of compacted paving mixture can have a very marked effect on the values reported for air voids and for voids in mineral aggregate. These differences are enough to make it appear that a mixture may satisfy the design criteria for air voids and VMA if one aggregate specific gravity is used for analysis, but that it fails to meet them if another specific gravity is employed. Consequently, specifications for paving mixture design and construction should be quite clear in stating precisely how air voids and VMA are to be determined.

5.02 DEFINITIONS–Mineral aggregate is porous and can absorb water and asphalt to a variable degree. Furthermore, the ratio of water to asphalt absorption varies with each aggregate. Three methods of measuring aggregate specific gravity that are in current use take these variations into consideration. They are ASTM bulk, ASTM apparent, and effective specific gravities, and these are defined as follows:

> *Bulk Specific Gravity,* G_{sb}–the ratio of the weight in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. *See* Figure V-1.
>
> *Apparent Specific Gravity,* G_{sa}–the ratio of the weight in air of a unit volume of an impermeable material at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. *See* Figure V-1.
>
> *Effective Specific Gravity,* G_{se}–the ratio of the weight in air of a unit volume of a permeable material (excluding voids permeable to asphalt) at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. *See* Figure V-1.

As the terms *effective asphalt content* (P_{be}), *air voids* (V_a), and *voids in the mineral aggregate* (VMA) will be used throughout this chapter, they should be defined.

> *Voids in the Mineral Aggregate,* VMA–the volume of intergranular void space between the aggregate particles of a compacted paving mixture that includes the air voids and the effective asphalt content, expressed as a percent of the total volume of the sample. *See* Figure V-1.

Effective Asphalt Content, P_{be}—the total asphalt content of a paving mixture minus the portion of asphalt that is lost by absorption into the aggregate particles. *See* Figure V-1.

Air Voids, V_a—the total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as percent of the bulk volume of the compacted paving mixture. *See* Figure V-1.

TABLE V-1—INFLUENCE OF TYPE OF SPECIFIC GRAVITY ON DETERMINATION OF VMA AND AIR VOIDS

Bulk Specific Gravity of Compacted Mixture, G_{mb}	2.436
Density of Compacted Mixture, W_{pcf}, lb per cu ft (kg/m^3)	152.0 (2435)
Asphalt Content, percent by weight of total mix	5.93
Asphalt Absorbed by Aggregate Particles, W_{ba} lb per 100 lb (kg/45 kg) Aggregate	0.8 (.36)
Specific Gravity of Asphalt Cement, G_b	1.011

Laboratory Number	Specific Gravity Employed For Aggregate		Allowance For Absorption of Asphalt by Aggregate	Void Properties Compacted Mixture	
				Percent Voids in Mineral Aggregate	Percent Air Voids
No. 1	ASTM Bulk	2.651	Yes	13.56	1.08
No. 2	ASTM bulk	2.651	No	13.56	-0.73
No. 3	ASTM bulk (sat. surf. dry)	2.716	Yes	15.63	3.15
No. 4	ASTM bulk (sat. surf. dry)	2.716	No	15.63	1.34
No. 5	ASTM apparent	2.834	No	19.14	4.85
No. 6	Effective	2.708	No	15.37	1.08

Figure V-2 depicts the volume relationships between aggregate, air voids, voids in mineral aggregate, total asphalt content, asphalt lost by absorption into the aggregate particles, and effective asphalt content.

NOTE:

The accuracy of determinations of specific gravity for mix design is important.

Unless specific gravities are determined to four significant figures (three decimal places) an error in air voids value of as much as 0.8 percent can occur. Therefore, The Asphalt Institute recommends the use of weigh scales whose sensitivity will allow the weighing of a mix batch of from 1000 to 5000 grams to an accuracy of 0.1 gram.

Additionally desk calculators rather than slide rules should be used for all calculations.

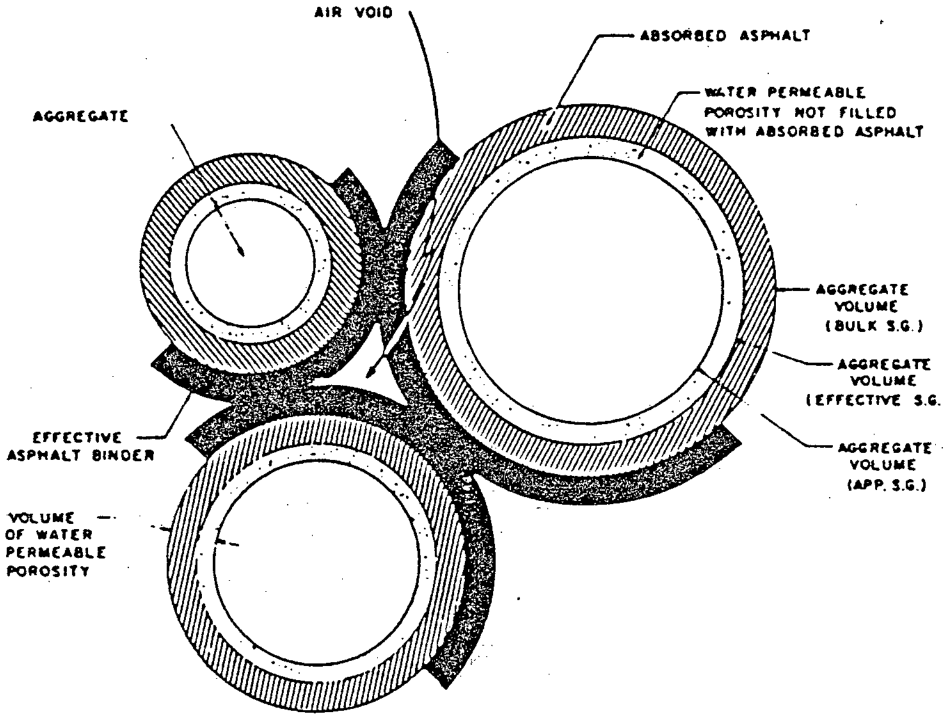
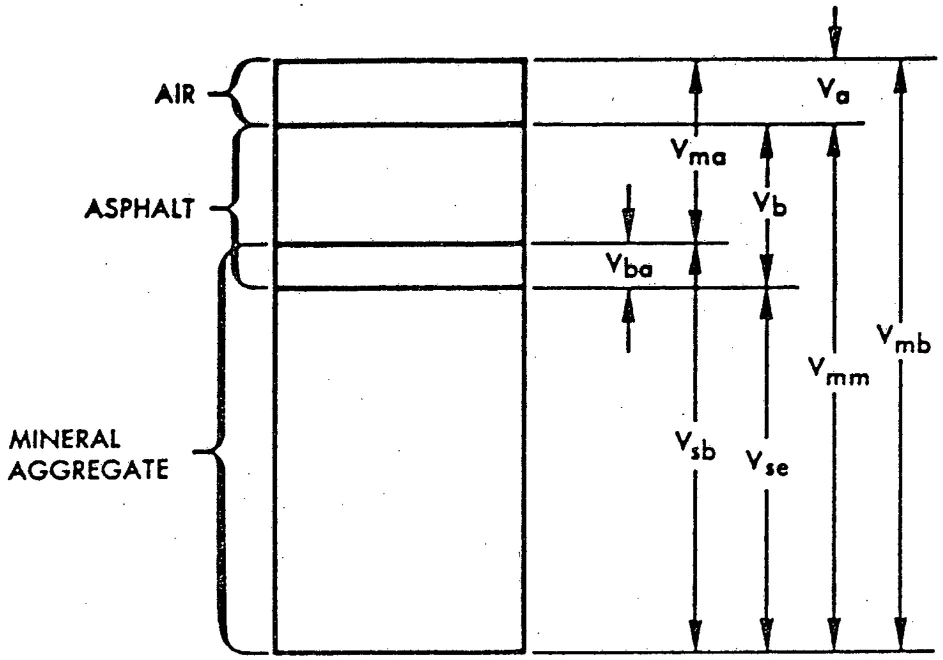


Figure V-1—Illustrating VMA, air voids and effective asphalt content in compacted asphalt paving mixture



V_{ma} = Volume of voids in mineral aggregate
V_{mb} = Bulk volume of compacted mix
V_{mm} = Voidless volume of paving mix
V_a = Volume of air voids
V_b = Volume of asphalt
V_{ba} = Volume of absorbed asphalt
V_{sb} = Volume of mineral aggregate (by bulk specific gravity)
V_{se} = Volume of mineral aggregate (by effective specific gravity)

Figure V-2—Representation of volumes in a compacted asphalt specimen

5.03 OUTLINE OF PROCEDURE—FOR ANALYZING A COMPACTED PAVING MIXTURE—

(a) Measure the bulk specific gravities of the coarse aggregate (AASHO T 85 or ASTM C 127) and of the fine aggregate (AASHO T 84 or ASTM C 128).

(b) Measure the specific gravity of the asphalt cement (AASHO T 228 or ASTM D 70) and of the mineral filler (AASHO T 100 or ASTM D 854).

(c) Calculate the bulk specific gravities of the aggregate combination in the paving mixture.

(d) Measure the maximum specific gravity of the loose paving mixture (ASTM D 2041).

(e) Measure the bulk specific gravity of the compacted paving mixture (ASTM D 1188 or ASTM D 2726).

(f) Calculate the effective specific gravity of the aggregate.

(g) Calculate asphalt absorptions of the aggregate.

(h) Calculate the effective asphalt content of the paving mixture.

(i) Calculate the percent voids in the mineral aggregate in the compacted paving mixture.

(j) Calculate the percent air voids in the compacted paving mixture.

Equations for the above calculations are found in Articles 5.05 through 5.11 and their application may be expedited by use of the appropriate worksheet, Figure V-3 or V-4.

5.04 PAVING MIXTURE DATA FOR SAMPLE CALCULATIONS–The following tabulation illustrates the basic data for a sample of paving mixture. These design data are used in the sample calculation employed throughout the remainder of the chapter.

TABLE V-2–BASIC DATA FOR SAMPLE OF PAVING MIXTURE

(a) Constituents

Material	Specific Gravity				Mix Composition	
		Bulk	AASHO Method	ASTM Method	Percent By Weight of Total Mix	Percent By Weight of Total Aggregate
Asphalt Cement	1.010(G_b)	—	T 228	D 70	6.96(P_b)	7.48(P_b)
Coarse Aggregate		2.606(G_1)	T 85	C 127	51.45(P_1)	55.30(P_1)
Fine Aggregate		2.711(G_2)	T 84	C 128	34.24(P_2)	36.80(P_2)
Mineral Filler	2.697(G_3)	—	T 100	D 854	7.35(P_3)	7.90(P_3)

(b) Paving Mixture

Bulk specific gravity of compacted paving mixture sample, G_{mb}

(ASTM D 2726) ——— 2.344

Maximum specific gravity of paving mixture sample, G_{mm}

(ASTM D 2041) ——— 2.438

5.05 BULK SPECIFIC GRAVITIES OF AGGREGATE–When the total aggregate consists of separate fractions of coarse aggregate, fine aggregate, and mineral filler, all having different specific gravities, the bulk and apparent specific gravities for the total aggregate are calculated as follows:

(a) *Bulk Specific Gravity*, G_{sb}

$$G_{sb} = \frac{P_1 + P_2 + \ldots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots + \frac{P_n}{G_3}} \qquad (1)$$

where

G_{sb} = bulk specific gravity for the total aggregate

P_1, P_2, P_n = percentages by weight of aggregates, 1, 2, n; and

G_1, G_2, G_n = bulk specific gravities of aggregates 1, 2, n.

The bulk specific gravity of mineral filler is difficult to determine accurately at the present time. However, if the apparent specific gravity of the filler is used instead, the error is usually negligible.

Calculation using the data in Table V-2:

$$G_{sb} = \frac{51.450 + 34.240 + 7.350}{\frac{51.450}{2.606} + \frac{34.240}{2.711} + \frac{7.350}{2.697}} = \frac{93.040}{19.743 + 12.630 + 2.725} = 2.651$$

5.06 EFFECTIVE SPECIFIC GRAVITY OF AGGREGATE–When based on the maximum specific gravity of a paving mixture, G_{mm}, the effective specific gravity of G_{se}, of the aggregate includes all void spaces in the aggregate particles except those that absorb asphalt. It is determined as follows:

$$G_{se} = \frac{P_{mm} - P_b}{\frac{P_{mm}}{G_{mm}} - \frac{P_b}{G_b}} \qquad (2)$$

where

G_{se} = effective specific gravity of aggregate

P_{mm} = total loose mixture, percent by total weight of mixture = 100 percent

P_b = asphalt, percent by total weight of mixture

G_{mm} = maximum specific gravity of paving mixture (no air voids), ASTM D 2041 (Refer to Article 5.07)
G_b = specific gravity of asphalt

Calculation using the data in Table V-2:

$$G_{se} = \frac{100 - 6.960}{\frac{100}{2.438} - \frac{6.960}{1.010}} = \frac{93.040}{34.126} = 2.726$$

NOTE:

The volume of asphalt binder absorbed by an aggregate is almost invariably less than the volume of water absorbed. Consequently, the value for the effective specific gravity of an aggregate should be between its bulk and apparent specific gravities. When the effective specific gravity falls outside these limits, its value must be assumed to be incorrect. The calculations, the maximum specific gravity of the total mix by ASTM D 2041, and the composition of the mix in terms of aggregate and total asphalt content should then be rechecked for the source of the error.

If the apparent specific gravity of the coarse aggregate is 2.759 and the apparent specific gravity of the fine aggregate is 2.905 for the sample of paving mix in Table V-2, the apparent specific gravity, G_{sa}, of the total aggregate can be calculated by the same formula as the bulk by using the apparent specific gravity of each aggregate constituent. For this example, then, the calculated apparent specific gravity, G_{sa}, is

$$G_{sa} = \frac{51.450 + 34.240 + 7.350}{\frac{51.450}{2.759} + \frac{34.240}{2.905} + \frac{7.350}{2.697}} = \frac{93.040}{33.159} = 2.806$$

In the example the three specific gravities are as follows:

Bulk Specific Gravity, G_{sb}	2.651
Effective Specific Gravity, G_{se}	2.726
Apparent Specific Gravity, G_{sa}	2.806

5.07 MAXIMUM SPECIFIC GRAVITIES OF MIXTURES WITH DIFFERENT ASPHALT CONTENTS—In designing a paving mixture with a given aggregate, the maximum specific gravities, G_{mm}, at different asphalt contents are needed to calculate the percentage of air voids for each asphalt content. While the same maximum specific gravity can be determined for each asphalt content by ASTM test method D 2041, the precision of the test is best when the mixture has close to the optimum asphalt content. Also, it is preferable to measure the maximum specific gravity in duplicate or triplicate.

After averaging the results from these tests and calculating the effective specific gravity of the aggregate, the maximum specific gravity for any other asphalt content can be obtained as shown below. For all practical purposes, the effective specific gravity of the aggregate is constant because the asphalt absorption does not vary appreciably with variations in asphalt content.

$$G_{mm} = \frac{P_{mm}}{\dfrac{P_s}{G_{se}} + \dfrac{P_b}{G_b}} \qquad (3)$$

where

G_{mm} = maximum specific gravity of paving mixture (no air voids)

P_{mm} = total loose mixture, percent by total weight of mixture = 100 percent

P_s = aggregate, percent by total weight of mixture

P_b = asphalt, percent by total weight of mixture

G_{se} = effective specific gravity of aggregate

G_b = specific gravity of asphalt

Calculation using specific gravity data from Table V-2, effective specific gravity, G_{se}, determined in Article 5.06 and an asphalt content, P_b, of 7.46 percent:

$$G_{mm} = \frac{100}{\dfrac{92.540}{2.726} + \dfrac{7.460}{1.010}} = \frac{100}{41.333} = 2.419$$

5.08 ASPHALT ABSORPTION—Absorption is expressed as a percentage by weight of aggregate rather than as a percentage by total weight of mixture. Asphalt, P_{ba}, absorption is determined as follows:

Asphalt absorption –

$$P_{ba} = 100\frac{G_{se} - G_{sb}}{G_{sb}G_{se}}G_b \quad (4)$$

where

P_{ba} = absorbed asphalt, percent by weight of aggregate
G_{se} = effective specific gravity of aggregate
G_{sb} = bulk specific gravity of aggregate
G_b = specific gravity of asphalt

Calculation using bulk and effective specific gravities determined in Articles 5.05 and 5.06 and asphalt specific gravity from Table V-2.

$$P_{ba} = 100\frac{2.726 - 2.651}{2.651 \times 2.726}1.010 = 100\frac{0.075}{7.227}1.010 = 1.05$$

5.09 EFFECTIVE ASPHALT CONTENT OF A PAVING MIXTURE–The effective asphalt content, P_{be}, of a paving mixture is the total asphalt content minus the quantity of asphalt lost by absorption into the aggregate particles. It is the portion of the total asphalt content that remains as a coating on the outside of the aggregate particles, and is the asphalt content on which service performance of an asphalt paving mixture depends. The formula is:

$$P_{be} = P_b - \frac{P_{ba}}{100}P_s \quad (5)$$

where

P_{be} = effective asphalt content, percent by total weight of mixture
P_b = asphalt, percent by total weight of mixture
P_{ba} = absorbed asphalt, percent by weight of aggregate
P_s = aggregate, percent by total weight of mixture

Calculation using data from Table V-2 and Article 5.08:

$$P_{be} = 6.96 - \frac{1.05}{100} 93.04 = 6.96 - 0.98 = 5.98$$

5.10 PERCENT VMA IN COMPACTED PAVING MIXTURE–The voids in the mineral aggregate, VMA, are defined as the intergranular void space between the aggregate particles in a compacted paving mixture that includes the air voids and the effective asphalt content, expressed as a percent of the total volume. The VMA is calculated on the basis of the bulk specific gravity of the aggregate and is expressed as a percentage of the bulk volume of the compacted paving mixture. Therefore, the VMA can be calculated by subtracting the volume of the aggregate determined by its bulk specific gravity from the bulk volume of the compacted paving mixture. The method of calculation is illustrated as follows:

If mix composition is determined as percent by weight of total mixture:

$$\text{VMA} = 100 - \frac{G_{mb} P_s}{G_{sb}} \qquad (6)$$

where

VMA = voids in mineral aggregate (percent of bulk volume)

G_{sb} = bulk specific gravity of aggregate

G_{mb} = bulk specific gravity of compacted mixture (ASTM D 2726)

P_s = aggregate, percent by total weight of mixture

Calculation using data from Table V-2 and Article 5.05:

$$\text{VMA} = 100 - \frac{2.344 \times 93.04}{2.651} = 100 - 82.27 = 17.73$$

Or if mix composition is determined as percent by weight of aggregate:

$$\text{VMA} = 100 - \frac{G_{mb}}{G_{sb}} \times \frac{100}{100 + P_b} 100 \qquad (7)$$

where

P_b = asphalt, percent by weight of aggregate

Calculation using data from Table V-2 and Article 5.05:

$$VMA = 100 - \frac{2.344}{2.651} \times \frac{100}{100 + 7.48} 100 = 100 - 82.27 = 17.73$$

5.11 CALCULATION OF PERCENT AIR VOIDS IN COMPACTED MIXTURE–The air voids, P_a, in a compacted paving mixture consist of the small air spaces *between* the coated aggregate particles. The percentage of air voids in a compacted mixture can be determined by the following equation:

$$P_a = 100 \frac{G_{mm} - G_{mb}}{G_{mm}} \qquad (8)$$

where

P_a = air voids in compacted mixture, percent of total volume

G_{mm} = maximum specific gravity of paving mixture (as determined in Article 5.07 or as determined directly for a paving mixture by ASTM Method D 2041)

G_{mb} = bulk specific gravity of compacted mixture

Calculation using data from Table V-2:

$$P_a = 100 \frac{2.438 - 2.344}{2.438} = \frac{9.400}{2.438} = 3.85$$

GUIDE

NOTE 1: DEGRE DE COMPACTAGE

Dans le but d'améliorer le degré de compactage des mélanges bitumineux, il est fortement recommandé de:

a) Viser une teneur moyenne en vides entre 2.5 et 3.0%.

b) Viser une compactibilité minimum de 1.5 pour les mélanges 1, 2, 3 et de 2.0 pour les mélanges 4, 5, 6 et 7.

La compactibilité d'un mélange est calculée à partir de la formule suivante:

$$C = \frac{1000 \times \text{fluage}}{\% \text{ vide} \times \text{stabilité}}$$

NOTE 2: LOT D'ECHANTILLONS

Le lot d'échantillons dont il est fait mention dans la présente section de ce devis se définit comme suit:

> "Un lot désigne toute quantité définie de matériaux dont on veut en évaluer la qualité. Le lot est défini en fonction de l'ampleur du contrat et/ou de la production journalière et/ou de la portion exécutée du contrat et/ou de toute autre notion que le propriétaire juge valable. Normalement, un lot comprend entre 750 et 3000 tonnes de béton bitumineux".

NOTE 3: SURFACE MOYENNE DES GRANULATS ET FILM DE BITUME EFFECTIF

La surface moyenne des granulats pour une formule de mélange donné se détermine en multipliant le pourcentage passant de chacun des tamis par le "facteur de surface spécifique".

Nous reproduisons ici le tableau de l'Asphalt Institute concernant les "facteurs de surface spécifique" des granulats ainsi qu'un exemple de calcul.

FACTEURS DE SURFACE SPECIFIQUE

% passant Tamis No	3/4" (19mm)	3/8" (9.52mm)	No 4	No 8	No 16	No 30	No 50	No 100	No 200
Facteur de surface spécifique $pi^2/lb (m^2/kg)$	*	*	2 (.41)	4 (.82)	8 (1.64)	14 (2.87)	30 (6.14)	60 (12.29)	160 (32.77)

* Pour la partie retenue sur le tamis No 4 dans le mélange, nous assumons que la surface spécifique a une valeur de 2 (.41).

Le tableau suivant démontre la méthode de calcul pour déterminer la surface moyenne des granulats.

Tamis No	% passant	x	Facteur S.S.	=	Surface spécifique
3/4" (19.0 mm)	100		------		2.0 (0.41)
3/8" (9.52 mm)	90		------		
# 4	75		2 (.41)		1.5 (0.31)
# 8	60		4 (.82)		2.4 (0.49)
# 16	45		8 (1.64)		3.6 (0.74)
# 30	35		14 (2.87)		4.9 (1.00)
# 50	25		30 (6.14)		7.5 (1.54)
# 100	18		60 (12.29)		10.8 (2.21)
# 200	10		160 (32.77)		16.0 (3.28)
	Surface spécifique totale				48.7 pi^2/lb (9.98 m^2/kg)

A partir de la surface spécifique totale des granulats, nous déterminons l'épaisseur moyenne du film de bitume effectif en utilisant la formule suivante:

$$\text{F.B.E.} : \frac{\text{K X \% bitume effectif}}{\text{S.S.T. X (1 - \% bitume effectif)}}$$

ou F.B.E. : Epaisseur moyenne du film de bitume effectif en microns (μ)

K : Constante valant 4789

S.S.T. : Surface spécifique totale des granulats en pied carré par libre

bitume effectif : % bitume total - $\frac{\text{(absorption en eau)}}{2}$

A titre d'exemple et en utilisant les données suivantes, nous obtenons ce qui suit:

S.S.T. : 48,7 pi^2/lb

% bitume total : 6,0%

% absorption en eau des granulats : 0,6%

% bitume effectif : 5,7%

$$\text{F.B.E.} : \frac{4789 \text{ X } 0{,}057}{48{,}7 \text{ X } (1-0{,}057)}$$

F.B.E. : 5,94 μ ou 5,94 X 10^{-6} m

La densité du bitume utilisé dans ces calculs est de 1,02

NOTE 4: TEXTURE DU MELANGE VERSUS EPAISSEUR

Dans le but d'obtenir le meilleur fini possible sur la route, il est tout indiqué que l'entrepreneur tienne compte de l'épaisseur du mélange spécifié à poser pour la présentation de sa formule de mélange.

NOTE 5: POURCENTAGE DE PARTICULES PASSANT LE TAMIS #200

Dans le but d'éviter de combler une partie trop importante des vides dans le mélange avec des particules fines, il est fortement recommandé de maintenir à un maximum de 10% le rapport entre les particules passant le tamis No 8 et les particules passant le tamis No 200.

RÉTENTION
DE BITUME

DETERMINATION DU FACTEUR DE RETENTION EN BITUME LORS DE L'ESSAI D'EXTRACTION DU BITUME PAR LA METHODE CENTRIFUGE

DEFINITION:

Cette opération consiste à trouver le pourcentage de bitume que retiennent les granulats lors de l'essai d'extraction(1) par la méthode centrifuge(2).

Note 1: La méthode de récupération ou du calcul de la perte, en filler est celle dite volumétrique et le séchage des granulats après lavage se fait à l'aide de lampes infrarouges.

APPAREILS:

- Récipients métalliques (genre plats à pain) destinés à chauffer les granulats.
- Des thermomètres gradués de 10°C à 230°C pour les granulats et le bitume.
- Une balance électrique d'une capacité minimum de 5 Kg et une sensibilité de 0.1 g.
- Récipient pour chauffer et verser le bitume.
- Une étuve d'une capacité de chauffage minimum de 200°C.
- Un extracteur à bitume (centrifuge) d'une capacité de 3 600 tr/mn.

- Bol pour extracteur d'une capacité de 1000 g minimum.

- Papier filtre s'adaptant sur le bol.

- Lampe infrarouge permettant le séchage de l'échantillon de 103°C ± 3°C.

- Spatule dont la lame a une largeur d'environ 25 mm et une longueur de 150 mm.

PROCEDE:

La détermination du facteur de retention correspondant à un type de granulat donné comprend les étapes suivantes:

- Préparer pour chaque formule de mélange, une série de trois (3) éprouvettes d'essai.

- Placer à l'étuve toutes les fractions granulométriques des granulats dans des récipients distincts et porter à une température de 180°C ± 10°C.

- Amener le bitume à une température de 130°C ± 10°C.

- Placer le bol de l'extracteur (chaud) sur la balance, le peser, verser les granulats dans le bol et peser.(3)

- Transvider la masse du bitume désiré, peser, placer le filtre asséché et peser. Mélanger parfaitement avec la spatule préalablement pesée, les granulats et le bitume jusqu'à ce que le bitume soit uniformément réparti (environ 2 minutes). Nettoyer la spatule sur les rebords du bol et la peser, son poids ne doit pas avoir augmenté de plus de 0,1 g.

- Peser le tout après malaxage. Cette pesée sert de contrôle en la comparant avec celle relevée avant malaxage.

- Attendre, si nécessaire, que la température du mélange préparé soit inférieur à 105°C pour procéder à l'essai d'extraction.

- Poursuivre l'essai d'extraction selon la méthode du Laboratoire Central qui utilise la méthode volumétrique pour déterminer la perte en filler.

Calcul:
La masse du bitume retenu est déterminée en soustrayant de la teneur en bitume mis dans le mélange, la teneur en bitume trouvée lors de l'essai d'extraction. La moyenne des trois résultats est rapportée.

Précision:
La différence maximale acceptable entre le plus haut et le plus bas résultat parmi les trois est de 0,10%.

Note 2: Cette méthode de calcul du bitume retenu peut être utilisée avec d'autres méthodes d'extraction mais la procédure d'extraction doit alors être la même que cette autre méthode.

Note 3: Pour les laboratoires ne possédant pas de bols d'extracteur suffisamment grands pour y effectuer le malaxage, on peut y remédier en utilisant un plat auxiliaire plus grand en appliquant les modifications suivantes: transvider le mélange du plat auxiliaire dans le bol d'extracteur. A l'aide du trichloroéthylène devant servir au premier lavage, nettoyer à fond le plat auxiliaire et vider dans le bol d'extracteur; si nécessaire répéter cette opération au deuxième lavage.

FACTEUR DE RETENTION - FORMULE DE TRAVAIL

Entrepreneur

Type de mélange   Nature des granulats

A. Masse du bol (chaud)

B. Masse du bol + granulats

C. Masse des granulats (B - A)

D. Masse du plat + granulats + bitume

E. Masse du bitume (D - B)

F. Masse du mélange (D - A)

G. Masse du bol + granulats + bitume + filtre asséché

H. Masse du bol + granulats + bitume
(cette pesée s'effectue après malaxage)

I. Masse du bol + granulats + filtre
(cette pesée s'effectue après séchage)

K. Masse de la perte par lavage (G - I)

L. Masse du filler perdu (méthode volumétrique)

M. Masse du bitume retrouvé (K - L)

N. Masse du bitume retenu (E - M)

O. Facteur de retention (N/F X 100)

1. Masse de la spatule avant malaxage
2. Masse de la spatule après malaxage
3. Différence devra être de 0.1 g et -

ANALYSTE   DATE