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METHOD OF TEST FOR CENTRIFUGE KEROSENE EQUIVALENT AND APPROXIMATE BITUMEN RATIO (ABR)

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Section G of this method. It is the responsibility of whoever uses this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

A. SCOPE

This procedure is used to determine an approximate bitumen ratio for a bituminous mix. The centrifuge kerosene equivalent (CKE) is used to make this determination. The CKE furnishes an index, designated as the "K factor", that indicates the relative particle roughness and surface capacity based on porosity.

B. APPARATUS

1. Centrifuge, power driven, capable of exerting an acceleration of 400 times gravity (400 G) on a 100 g sample.

   The required angular velocity (rad/s) of the centrifuge head = $1980 / \sqrt{r}$

   Where:

   r = radius in mm to center of gravity of the sample

2. Centrifuge cups, 71.4 ± 0.8 mm high by 52.4 ± 0.5 mm in diameter (see Figure 6), complete a 0.8 mm thick with perforated brass plate, having a minimum of 100 holes, 1.6 ± 0.1 mm in diameter, per 645 mm^2.

3. Balance, 500 g capacity, ± 0.1 g accuracy.

4. Metal funnels as shown in Figure 7.

5. Glass beakers (1500 mL).

6. Timer with sweep second hand.

7. 60 ± 3°C oven.

8. Hot plate or 110 ± 5°C oven.

9. Round tin pans, approximately 115 mm in diameter by 25 mm deep.

C. MATERIALS

1. Kerosene

2. AW hydraulic oil No. 10

3. Filter paper, 55 mm dia. (VWR No. 413 or equivalent)

D. NOMENCLATURE

1. "C" = Course aggregate: The portion of the sample that passes the 9.5-mm sieve and is retained on the 4.75-mm sieve.

2. "F" = Fine aggregate: The portion of the sample that passes the 4.75-mm sieve.

3. "K" factors = values determined as described below and identified as Kc, Kf and Km.

4. Kc is determined from the percent No. 10 oil retained, which represents the total effect of the coarser aggregate's absorptive properties and surface roughness.

5. Kf is determined from the following factors:

   a. Percent of kerosene retained, which represents the total effect of the absorptive properties and surface roughness of the finer aggregate.

   b. Computed surface area based on particle size and percent passing the 4.75-mm sieve.

6. Km represents the "mean" or composite value of K for a given combination of coarse and fine materials on which Kc and Kf have already been determined.

7. S.A. = Surface Area. The sum, in m^2/kg obtained by adding the products of the percent passing each sieve and its corresponding factor, and dividing by 100.

Sieve	S.A. Factors
Pass Max, Size	0.4
Pass 4.75 mm	0.4
Pass 2.36 mm	0.8
Pass 1.18 mm	1.6
Pass 600 µm	2.9
Pass 300 µm	6.1
Pass 150 µm	12.3
Pass 75 µm	32.8

All surface area factors must be used in calculations; thus, if 100 % passes the 4.75-mm sieve, include in calculations 100 x 0.4 for passing maximum size, as well as 100 x 0.4 for passing 4.75-mm sieve.

E. PREPARATION OF SAMPLE

1. Determine the oven dry bulk Sp. Gr. of the coarse aggregate (retained on the 4.75 mm sieve) and the apparent Sp. Gr. of the fine aggregate (passing the 4.75 mm sieve) using California Tests 206 and 208, respectively.

2. Design an aggregate grading to meet the desired tolerances (refer to California Test 105).

3. Calculate the Av. Sp. Gr. for the aggregate blend based upon the design grading.

$$\text{Av. Sp. Gr.} = \frac{100}{\frac{A}{A_1} + \frac{B}{B_1}}$$

A = % Coarse
A_1 = Sp. Gr. Coarse
B = % Fine
B_1 = Sp. Gr. Fine

4. Use the surface area factors designated in Section D of this procedure and calculate the surface area based upon the design grading.

5. Separate the aggregate into two size groups: "C" material (used for Kc determinations) passing the 9.5-mm and retained on the 4.75-mm sieve, and "F" material (for Kf determination) all passing the 4.75-mm sieve.

F. TEST PROCEDURES

1. Procedures for fine aggregate "F". (Prepare duplicate samples.)

   a. Quarter or split out 105 ± 2 g, representative of the material passing the 4.75-mm sieve.

   b. Place the fines on a hot plate or in a 110 ± 5°C oven and dry to constant mass.

   c. Allow to cool.

   d. Place the entire charge in a tared centrifuge cup fitted with a perforated metal disc underlying a filter paper. Bring the net mass to 100.0 g.

   e. Place the centrifuge cup and sample in a pan containing sufficient kerosene (approximately 25 mm in depth) to saturate the sample. When the specimen is thoroughly saturated (by capillary action), place the cup with sample in the centrifuge. Test in duplicate to provide a counter mass.

   f. Spin the samples for 2 min at an acceleration of 400 G.

   g. Reweigh each cup with sample to the nearest 0.1 g and subtract the original mass. Record

this difference as CKE (based on 100 g of dry aggregate). Average the results of the duplicate samples.

2. Procedure for coarse aggregate, "C". (Prepare duplicate samples.)

   a. Quarter or split out 105 ± 2 g, representative of the passing 9.5-mm and retained 4.75-mm sieve material.

   b. Dry the sample on a hot plate or in a 110 ± 5°C oven to a constant mass and allow to cool.

   c. Weigh out 100.0 g and place in funnel (described under "Apparatus").

   d. Completely immerse specimen in No. 10 hydraulic oil for 5 min ± 5 s.

   e. Drain for 2 min ± 5 s at 25 ± 5°C with the funnel axis vertical.

   f. Place the funnel containing the sample in a 60 ± 3°C oven for 15 min ± 5 s to allow for additional draining with the funnel axis vertical.

   g. Pour the sample from the funnel into a tared pan, cool, and reweigh sample to the nearest 0.1 g. Subtract the original mass and record the difference as percent oil retained (based on 100 g of dry aggregate). Average the results of the duplicate samples.

3. Determination of approximate bitumen ratio, ABR.

   a. Use the chart shown in Figure 1 for determination of "Kf."

      (1) If the specific gravity (as determined by CT 208) for "F" is greater than 2.70 or less than 2.60, make a correction for percent of kerosene retained using the following formula:

      Percent of kerosene retained x (Sp. Gr. "F" / 2.65) = CKE corrected for Sp. Gr.

      (2) Start in the lower left-hand corner of Figure 1 with the value for CKE corrected for specific gravity. Follow a straightedge horizontally to the right to the intersection with the calculated surface area and hold that point. Move vertically upward to the intersection with the percent passing the 4.75-mm sieve and hold that point. Then follow the straightedge horizontally to the right. The value obtained will be the surface constant for the passing 4.75 mm fraction "F", and is known as "Kf".

   b. Use the chart shown in Figure 2 for the determination of "Kc".

      (1) If the specific gravity (as determined by CT 206) for "C" is greater than 2.70 or less than 2.60, apply a correction to the oil retained using the formula at the top of the chart in Figure 2.

      (2) Start at the bottom of the chart in Figure 2 with the corrected percent of oil retained. Follow a straightedge vertically to the intersection with the diagonal line and hold that point. Then follow the straightedge horizontally to the left. The value obtained will be the surface constant for the retained fraction "C", and is known as "Kc".

      (3) Figure 2 is the only chart needed to complete the determination of the bitumen ratio for open graded mixes. Using the following formula:

      Kc ■ 1.5 + 4.0 =
      Approximate Bitumen Ratio for open graded mixes

      No correction need be applied for asphalt viscosity.

   c. Use the chart shown in Figure 3 to combine Kf and Kc to determine "Km".

      (1) Km = Kf + "correction to Kf"

      The "correction to Kf" value obtained from Figure 3 is positive if (Kc-Kf) is positive, and is negative if (Kc-Kf) is negative.

(2) The determination of Km is shown in the following example:

Kc = 1.0, Kf = 1.8,
S.A. = 5.1 m^2/kg,
passing 4.75 mm = 60 %.

Using Figure 3, start in the lower left-hand corner with S.A. = 5.1 m^2/kg. Follow a straightedge horizontally to 40 % (percentage of coarse aggregate) and hold that point. Follow the straightedge vertically to the intersection with 0.8 (the difference between Kc and Kf) and hold that point. The follow the straightedge horizontally to the right to a "correction to Kf". In this example, the correction is 0.2. Because Kc - Kf is negative, the correction is negative; therefore, Km = 1.8 - 0.2 = 1.6. If Kc had been 1.8, and Kf 1.0, Kc -Kf would have been positive (+ 0.8), and the correction (0.2) would have been positive. In this case, Km would be 1.0 +0.2 = 1.2.

d. Use Figure 4 to determine the approximate bitumen ratio, ABR. Start in upper left-hand corner
with S.A., follow a straightedge horizontally to the right to the intersection with the average specific gravity and hold that point. Proceed vertically downward to the intersection with known Km and hold that point. Then follow the straightedge horizontally to the right. The value obtained will be the bitumen ratio for liquid asphalts SC-250, MC-250, and RC-250. A correction must be made for heavier liquid or paving asphalts.

e. Figure 5 is used for correcting the bitumen requirement for the above-mentioned heavier liquid or paving asphalts. By means of a straightedge, connect the point on scale "A" that represents the grade of bitumen to be used with the point on scale "B" representing the S.A. of the aggregate. Through the point of intersection on line "C" place a straightedge to connect with the previously determined bitumen ratio value on scale "D". The intersection of the straightedge with scale "E" then represents the bitumen ratio corrected for viscosity of bitumen.

G. SAFETY AND HEALTH

Personnel should use heat resistant gloves when working with hot materials. Use proper lifting techniques when handling bags of aggregate. Reasonable care should be exercised to avoid being burned by hot asphalt, aggregate or equipment.

Prior to sampling, handling materials or testing, Caltrans personnel are required to read Part A (Section 5.0), Part B (Section 5.0, 6.0 and10.0) and Part C (Section 1.0) of Caltrans' Laboratory Safety Manual and the Materials Safety Data Sheets (MSDS) for all materials used. Users of this method do so at their own risk.

H. NOTES

When there is 20 % or less coarse material in a sample, the Kc is not used; therefore, the Kf and Km are the same.

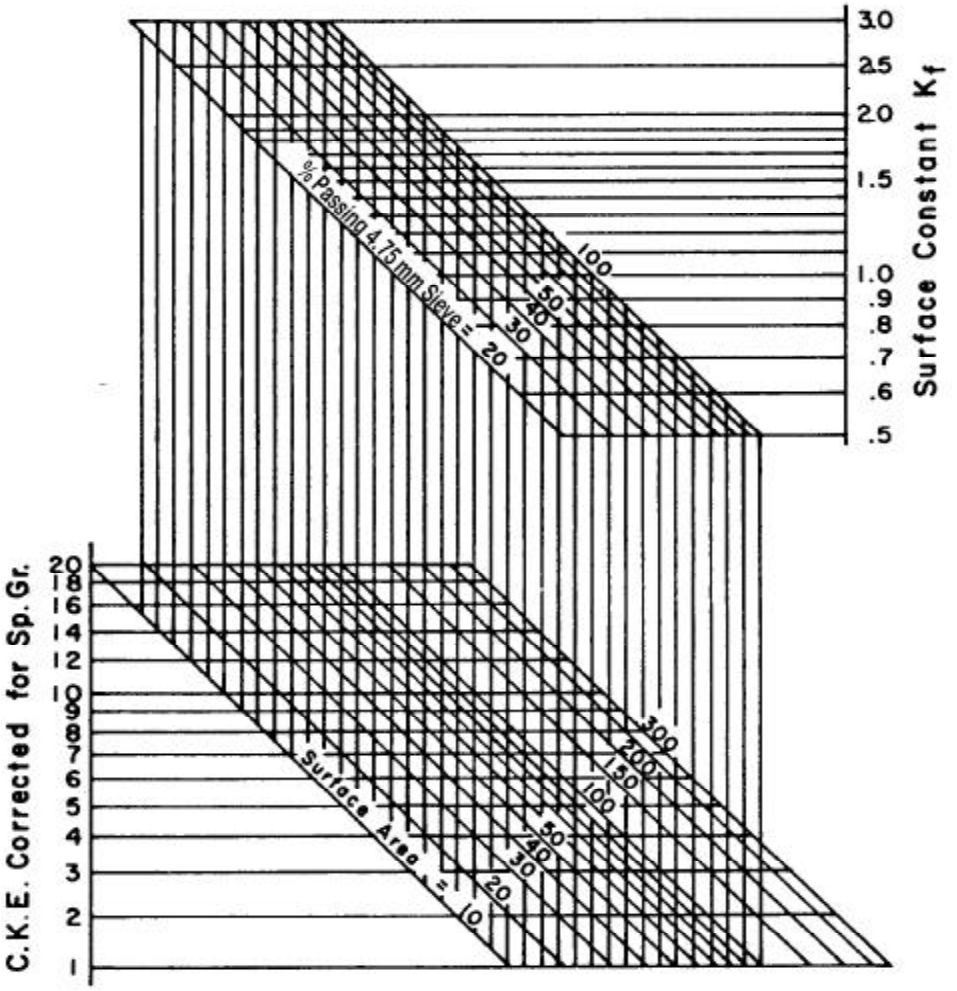
I. REPORTING OF RESULTS

Report Kf, Kc and the approximate bitumen ratio obtained in terms of percentage of dry mass of aggregate.

References
California Tests 105, 206, and 208

End of Text
(California Test 303 contains12 Pages)

CHART FOR DETERMINING K_f FROM C.K.E.



$$\text{C.K.E. Corrected} = \text{C.K.E.} \times \frac{\text{Sp. Gr. fine}}{2.65}$$

NOTE: Do not confuse this correction to C.K.E. with that used in Fig. 4

FIGURE 1

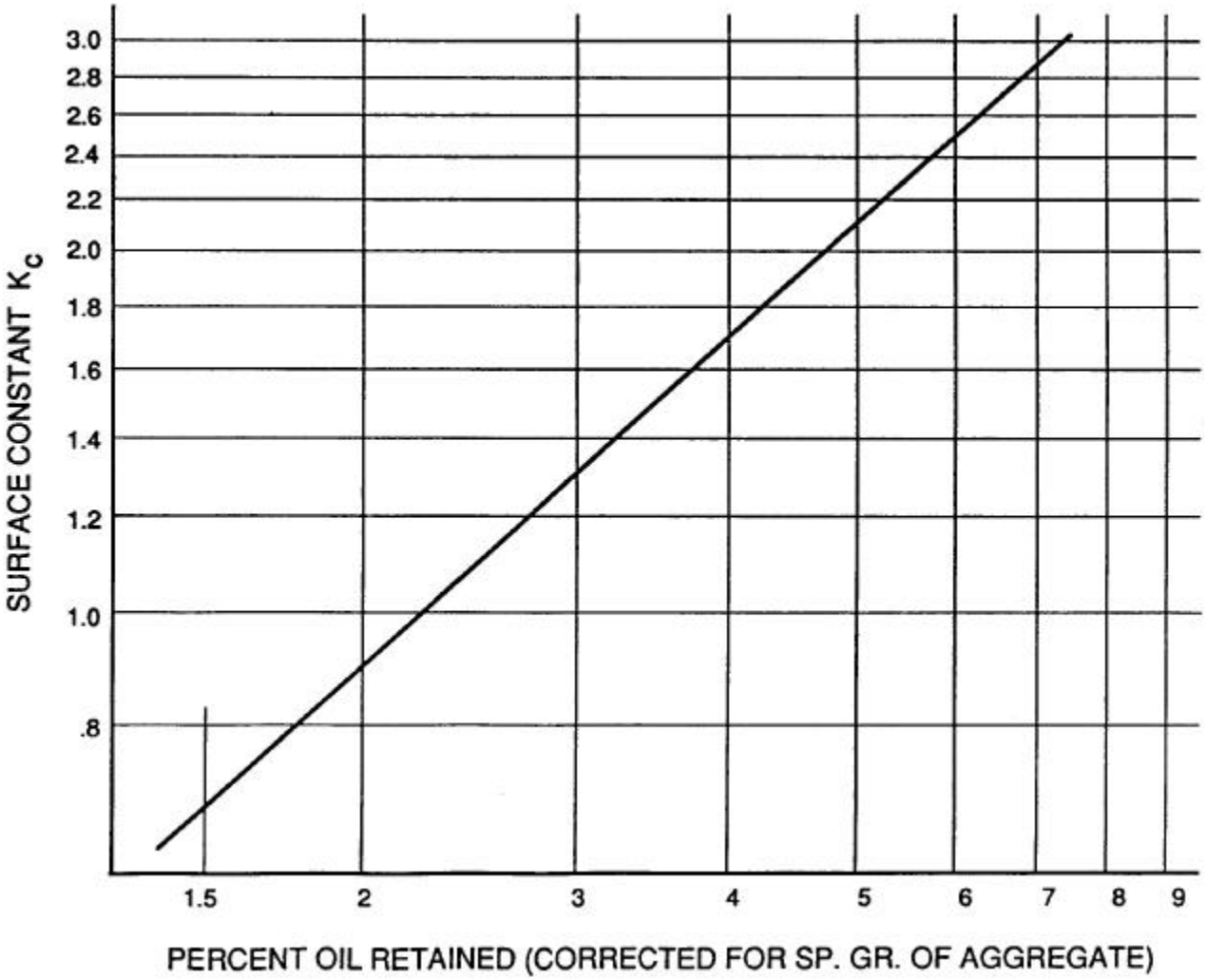
CHART FOR DETERMINING K_C

FROM

COARSE AGGREGATE SBSORPTION

Material Used { Aggregate passing 9.5 mm, retained on 4.75 mm sieve
AW Hydraulic Oil No. 10

$$\% \text{ oil retained corrected} = \% \text{ oil retained} \times \frac{\text{Sp. Gr. of aggregate}}{2.65}$$



Percent Oil Retained (Corrected for Sp. Gr. of Aggregate)

FIGURE 2

CHART FOR COMBINING K_f AND K_c TO DETERMINE K_m

If $(K_c - K_f)$ is neg., corr. is neg.
If $(K_c - K_f)$ is pos., corr. is pos.
$K_m = K_f$ + corr. to K_f

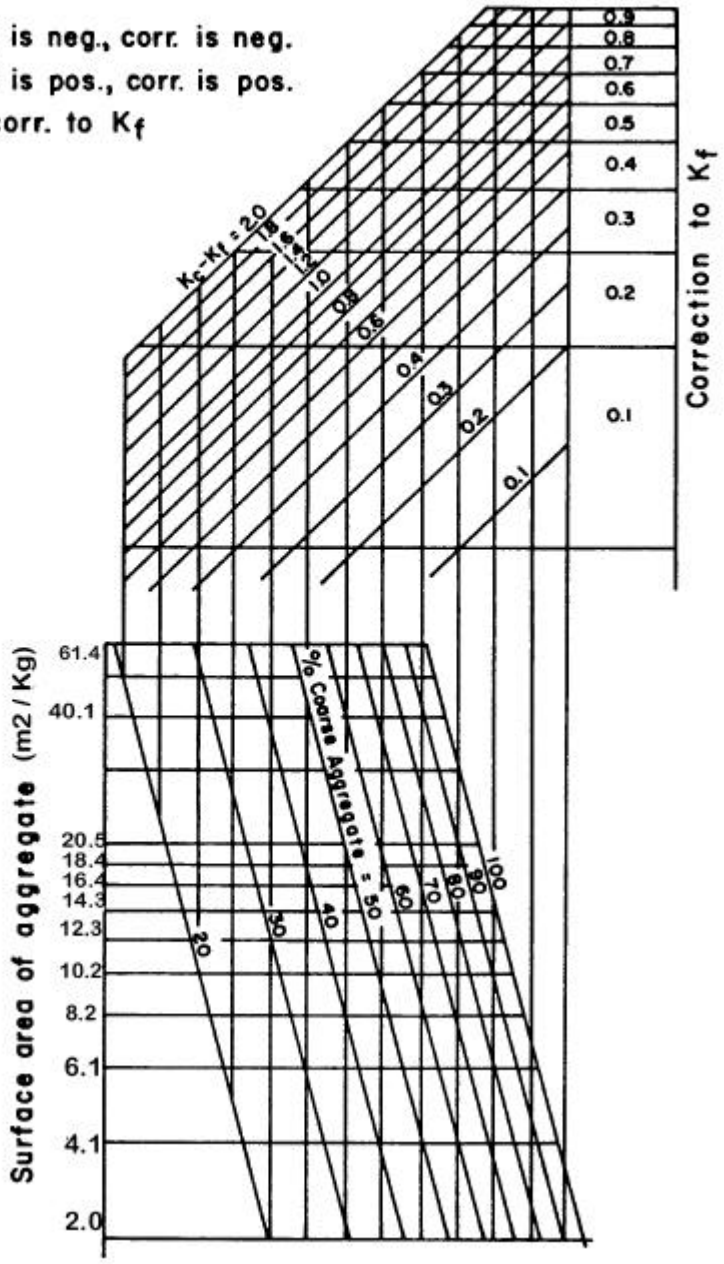


FIGURE 3

CHART FOR COMPUTING APPROXIMATE BITUMEN RATIO (ABR) FOR DENSE GRADED BITUMINOUS MIXTURES

PROCEDURE

Find surface area on scale A. Proceed horizontally to curve corresponding to Av. Sp. Gr. Of aggregate, then down to Curve corresponding to Km then horizontally to scale B for Approximately Bitumen Ratio.

ABR = kg of oil per 100 kg of aggregate and applies directly to oil of SC-250, MC-250 and RC-250 grades. A correction must be made for heavier liquid or paving asphalts. Figure 5

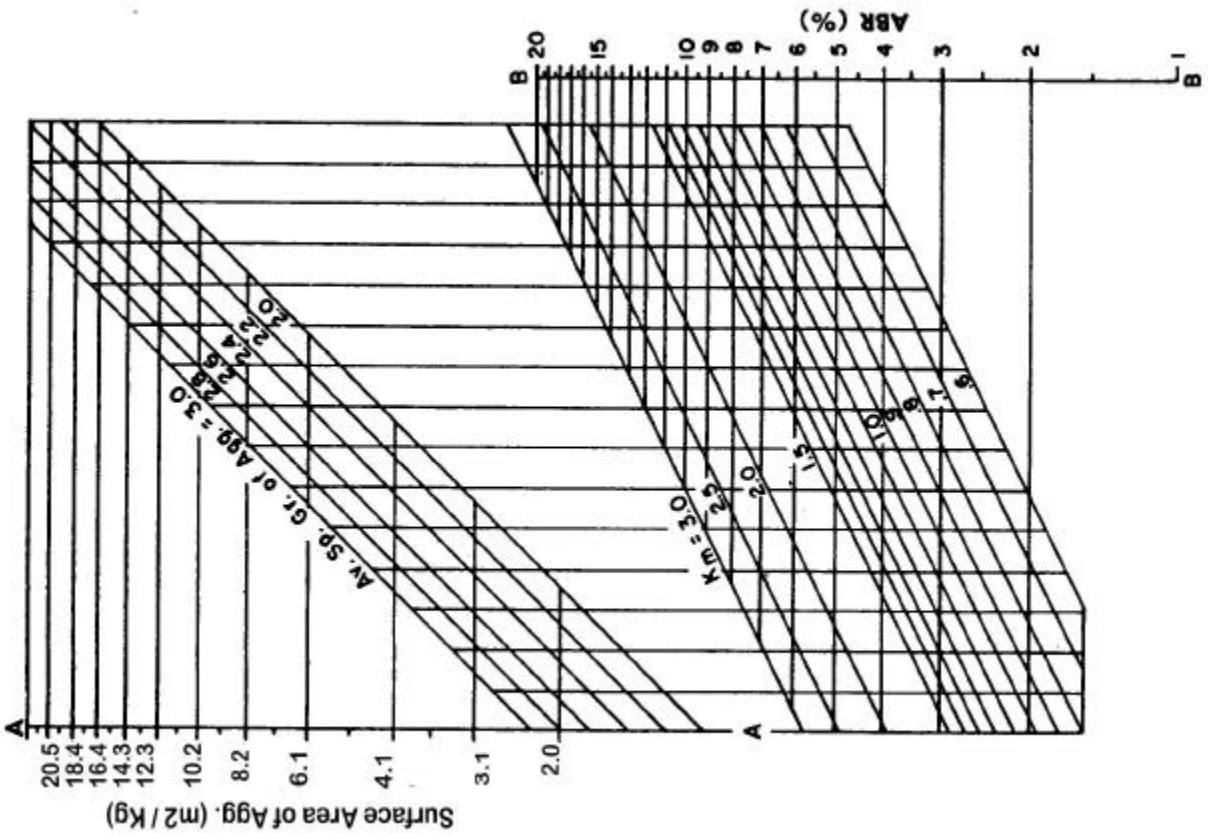


FIGURE 4

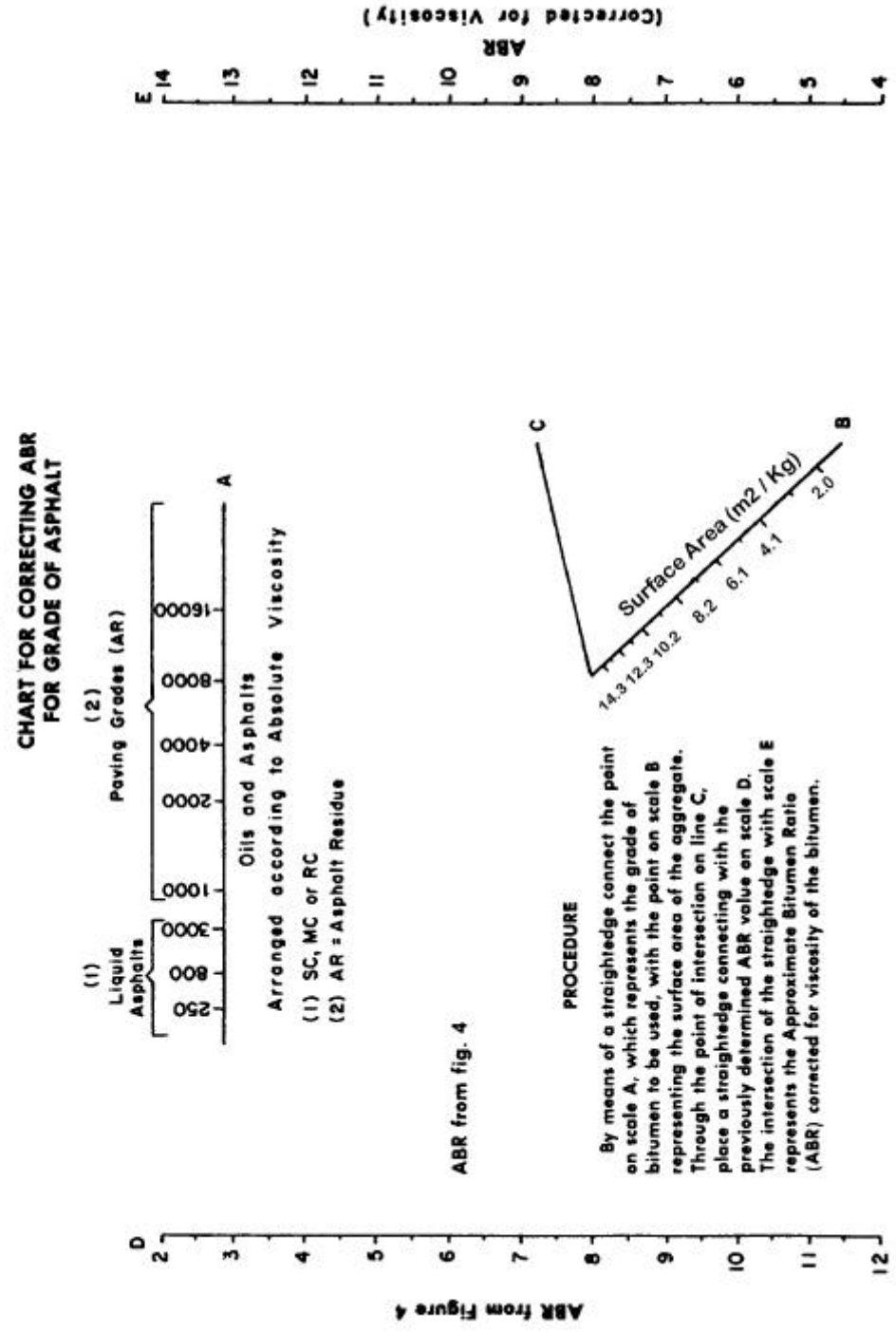


CHART FOR CORRECTING ABR
FOR GRADE OF ASPHALT
(1)
Liquid
Asphalts
(2)
Paving Grades (AR)
250
800
3000
1000
2000
4000
8000
16000
A
Oils and Asphalts
Arranged according to Absolute Viscosity
(1) SC, MC or RC
(2) AR = Asphalt Residue
ABR from fig. 4
PROCEDURE
By means of a straightedge connect the point on scale A, which represents the grade of bitumen to be used, with the point on scale B representing the surface area of the aggregate. Through the point of intersection on line C, place a straightedge connecting with the previously determined ABR value on scale D. The intersection of the straightedge with scale E represents the Approximate Bitumen Ratio (ABR) corrected for viscosity of the bitumen.
C
B
Surface Area (m2 / Kg)
14.3 12.3 10.2 8.2 6.1 4.1 2.0
D
2 3 4 5 6 7 8 9 10 11 12
ABR from Figure 4
E
14 13 12 11 10 9 8 7 6 5 4
ABR
(Corrected for Viscosity)

FIGURE 5

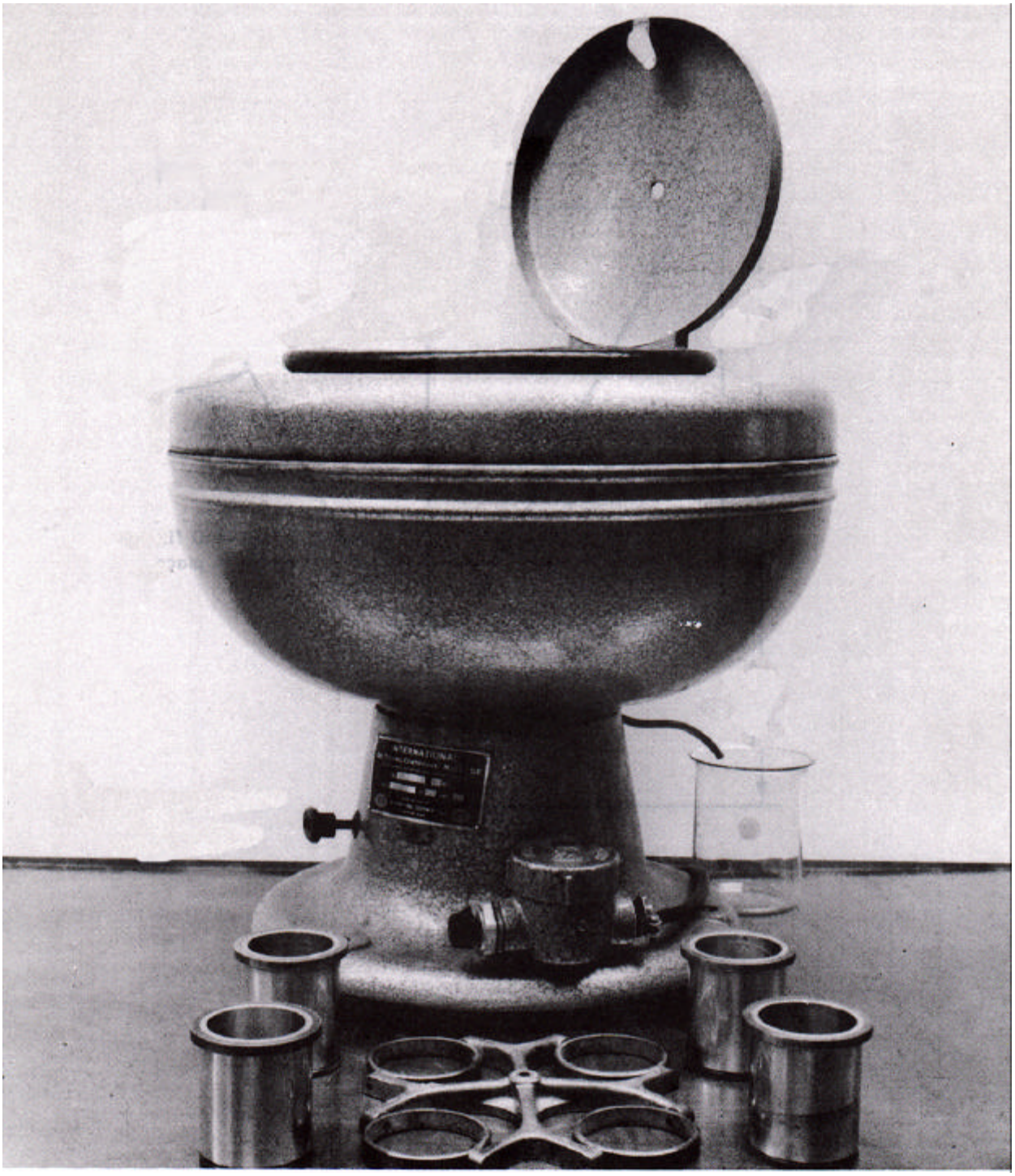


FIGURE 6

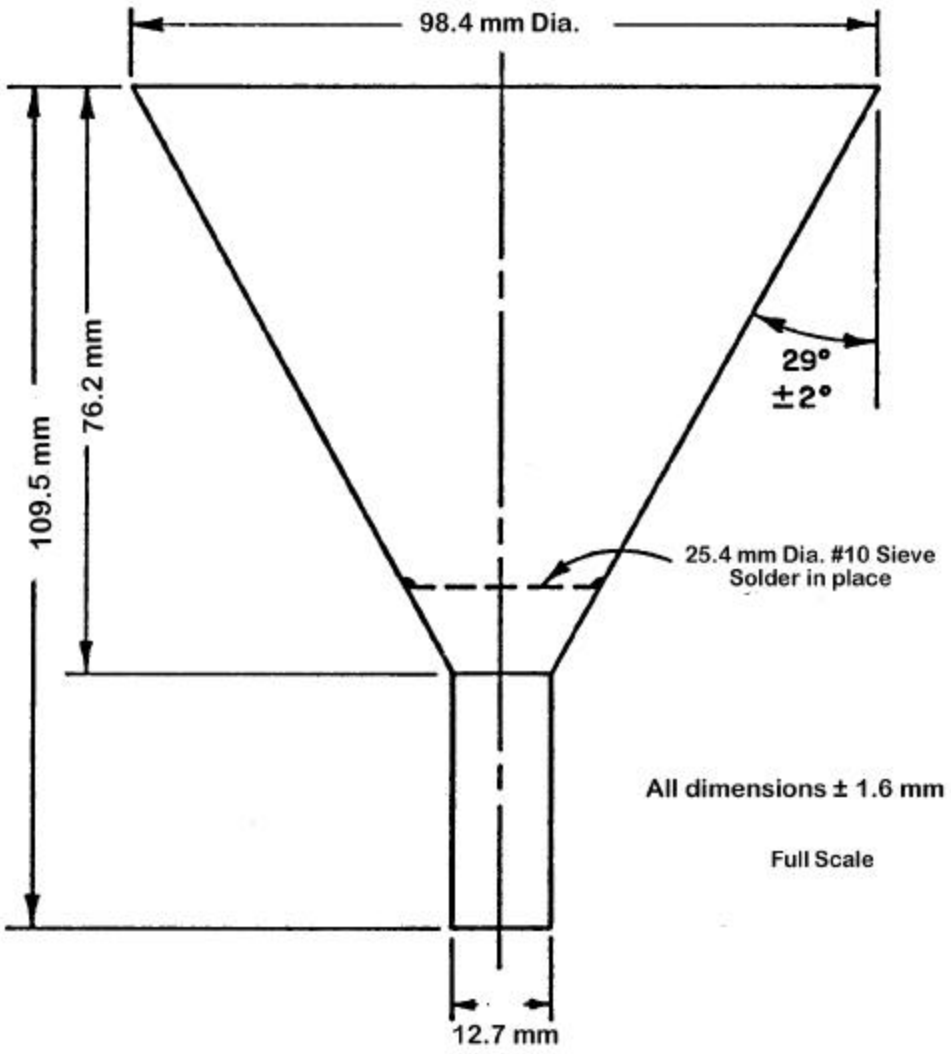

98.4 mm Dia.
109.5 mm
76.2 mm
29°
±2°
25.4 mm Dia. #10 Sieve
Solder in place
All dimensions ± 1.6 mm
Full Scale
12.7 mm

FIGURE 7