Designation: C115 – 10

StandardTest Method for Fineness of Portland Cement by the Turbidimeter[1]

This standard is issued under the fixed designation C115; 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. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers determination of the fineness of portland cement as represented by a calculated measure of specific surface, expressed as square centimetres of total surface area per gram, or square metres of total surface area per kilogram, of cement, using the Wagner turbidimeter.[2]

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. Values in SI units [or inch-pound units] shall be obtained by measurement in SI units [or inch-pound units] or by appropriate conversion, using the Rules for Conversion and Rounding given in IEEE/ASTM SI 10 of measurements made in other units. Values are stated in SI units when inch-pound units are not used in practice.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C114 Test Methods for Chemical Analysis of Hydraulic Cement

C430 Test Method for Fineness of Hydraulic Cement by the 45-μm (No. 325) Sieve

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

IEEE/ASTM SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System

3. Significance and Use

3.1 The purpose of this test method is to determine whether or not the hydraulic cement under test meets the Wagner turbidimetric fineness requirements of the applicable hydraulic cement specification for which the test is being made. Fineness of the cement component is only one of the many characteristics that influence the strength capabilities of concrete.

4. Apparatus

4.1 *Nature of Apparatus*—The Wagner turbidimeter consists essentially of a source of light maintained at constant intensity and adjusted so that approximately parallel rays of light pass through a suspension of the cement to be tested and impinge upon the sensitive plate of a photoelectric cell. The current generated in the cell is measured by means of a microammeter and the indicated reading is a measure of the turbidity of the suspension. General considerations indicate that turbidity is in turn a measure of the surface area of the suspended sample of cement. The apparatus shall consist specifically of the parts described in 4.2-4.7 and shall be constructed in accordance with the detailed design and dimensional requirements shown in Fig. 1 and Table 1, except that the case may be either of wood or of metal.

4.2 *Turbidimeter,* mounted in a suitable wood or metal case including the following features:

4.2.1 *Source of Light*—The source of light (Fig. 1) shall consist of a concentrated-filament electric lamp of between 3 and 6 cd operated by a source of constant emf. The lamp shall be mounted rigidly in the socket. A clean, bright parabolic metallic reflector shall be rigidly mounted behind the lamp, focused so that approximately parallel rays of light will pass through the sedimentation tank and impinge upon the photoelectric cell. The light intensity shall be regulated by two rheostats of approximately 6 and 30 Ω, respectively, and they shall possess such characteristics that uniform changes in light

[1] This test method is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.25 on Fineness.

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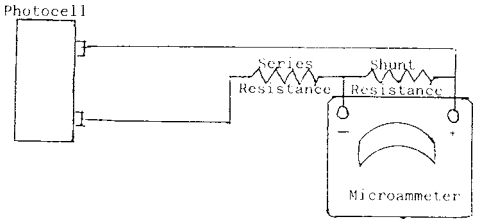
[2] The sole source of supply of the apparatus known to the committee at this time is the Wagner turbidimeter. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend. This turbidimeter was developed by L. A. Wagner, Research Associate of the Cement Reference Laboratory, National Institute of Standards and Technology, Washington, DC. A description of the apparatus and the original mathematical derivations of formulas used are given in the paper: Wagner, L. A., "A Rapid Method for the Determination of the Specific Surface of Portland Cement," *Proceedings* , ASTM, ASTEA, Vol 33, Part II, 1933, p. 553.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**



Microammeter Internal Resistance = 90 Ω
Shunt Equivalent Resistance:

$$470\ \Omega \text{ in parallel with } 100\ \Omega = \frac{470 \times 100}{470 + 100} = 82\ \Omega$$

Meter & Shunt Equivalent + Resistance:

$$90\ \Omega \text{ in parallel with } 82\ \Omega = \frac{90 \times 82}{90 + 82} = 43\ \Omega$$

Series Resistance = 90 – 43 = 47 Ω

FIG. 1 Illustrated Example of D'Arsonval Meter Circuit for I_r Determination

intensity may be obtained over the full range of resistance. The rheostats shall be mounted in parallel with each other and in series with the lamp.

4.2.2 *Heat-Absorbing Device*—The light shall pass through a suitable heat absorbing device before entering the sedimentation tank in order that radiant heat from the beam shall be absorbed, the device being either (*1*) a water cell or (*2*) a special heat-absorbing glass filter. The water cell shall be made from 76-mm [3-in.] outside diameter seamless brass tubing, 3-mm [⅛-in.] thick wall, 102-mm [4 in.] in length with glass windows sealed in the ends. The cell shall contain a hole for filling with distilled water. The hole shall be sealed with a metal plug. The cell, when mounted on the movable shelf, may have the plug in either the top or bottom position. The heat-absorbing device shall be so arranged that essentially all rays of light entering the sedimentation tank shall first pass through the heat-absorbing device.

4.2.3 *Retarding Filter*—A light-retarding glass or other device shall be provided that will reduce the intensity of light from that corresponding to 100 µA to a reading of 20 to 30 µA. The light intensity shall be uniformly retarded over the entire area of that portion of the cell which is exposed to light during a test. The retarding filter shall be mounted in a carrier on the shield and shall be capable of being swung out of the light path by means of a handle.

4.2.4 *Sedimentation Tank*—The sedimentation tank shall be either (*1*) constructed of 5 to 6-mm [3⁄16 to ¼-in.] plate glass or borosilicate glass cemented or sealed together to form a rectangular tank, or (*2*) a molded glass tank having walls approximately 5-mm [3⁄16 in.] thick with plane surfaces. The inside dimensions of the rectangular tank shall be 51 mm by 38 mm by 203 mm [2 in. by 1½ in. by 8 in.] in height. The permissible variation on the inside dimensions of the tank shall be ±2.5 mm [0.1 in.] in length and ±0.76 mm [0.03 in.] in width. The 51-mm faces of the tank shall be equidistant within 0.25 mm [0.1 in.] at all points. A mark shall be placed on the side of the tank to indicate a volumetric content of 335 mL, which is the level to which the tank will be filled in a test. A tank filled to the mark with clear kerosine and placed in the turbidimeter light beam shall yield uniform microammeter readings, within ±0.1 µA, for the entire usable portion of the tank.

4.2.5 *Photoelectric Cell*—The means of measuring the light intensity shall be a sensitive photoelectric cell connected directly to a microammeter. A hood with a horizontal slot 13 mm [½ in.] in height by 35 mm [1⅜ in.] in width shall be mounted over the photoelectric cell. The front of the hood shall be 25 ± 1 mm [1 ± 1⁄16 in.] in front of the face of the cell. The face of the photocell shall be parallel to the tank faces within 0.5 mm [0.02 in.].

4.2.6 *Shield*—A metallic shield having a slot 16 mm [⅝ in.] in height by 38 mm [1½ in.] in width, as indicated in Fig. 1, shall be placed between the heat absorbing device and the sedimentation tank.

4.2.7 *Elevating Device*—The source of the light, the heat-absorbing device, the photoelectric cell, the retarding filter, and the shield shall be mounted on a movable shelf which may be raised or lowered by two connected lead screws, and which may be readily and accurately adjusted so that the turbidity of the suspension may be determined at any desired depth. The center of the light source, the heat absorbing device, the photocell, the center of the slots of the metal shield, and the hood shall be on a straight line which is parallel to the shelf. The sedimentation tank shall be mounted on a base which is independent of the rest of the apparatus so that the tank shall be free from vibration caused by moving the shelf. Care shall be taken that the shelf shall be level at all points of elevation and that the tank shall be normal to the shelf. The distance between the tank and the edges of the opening in the shelf shall vary not more than 0.4 mm [1⁄64 in.] between the "30–50" and "0" positions. The level of the light beam with reference to the surface of the suspension shall be indicated by a pointer which will travel along a scale mounted on the cabinet. The zero of the scale shall indicate that position at which the center lines of the slots for the light beam are at the same elevation as the surface of the liquid in the tank when filled to the 335-mL level. The lines on the scale to be marked 7.5, 10, 15, 20, 25, and 30–50, shall be located at distances from the zero mark equal to suspension depth values, *h*, in Table 2. The scale, when compared with a standard scale accurate to within 0.1 mm at all points, shall not show a deviation at any point greater than 0.25 mm and shall indicate the positions at which the pointer should be located when turbidity readings for these values of *h* are taken. The interior of the turbidimeter cabinet and the exterior surfaces of the shelf, the parabolic reflector, the heat absorbing device, the shield, and the photoelectric cell hood shall be painted with a dull flat black paint.

NOTE 1—The requirement of the 0 to 50 markings on the scale shall apply only to new Wagner Turbidimeters and not to equipment in use which meets the other requirements of this method.

4.3 *Microammeters:*

4.3.1 *D'Arsonval-Type Microammeters* shall have a range from 0 to 50 µA and shall be readable to 0.1 µA. New microammeters shall be accurate to ±0.5 % of full scale value at any part of the scale value at any part of the scale at 25 °C [77 °F]. For microammeters, in use, the accuracy shall be the same as for new instruments except that the accuracy at 40 and 50 µA shall be ±1 % of full scale. The internal resistance of the

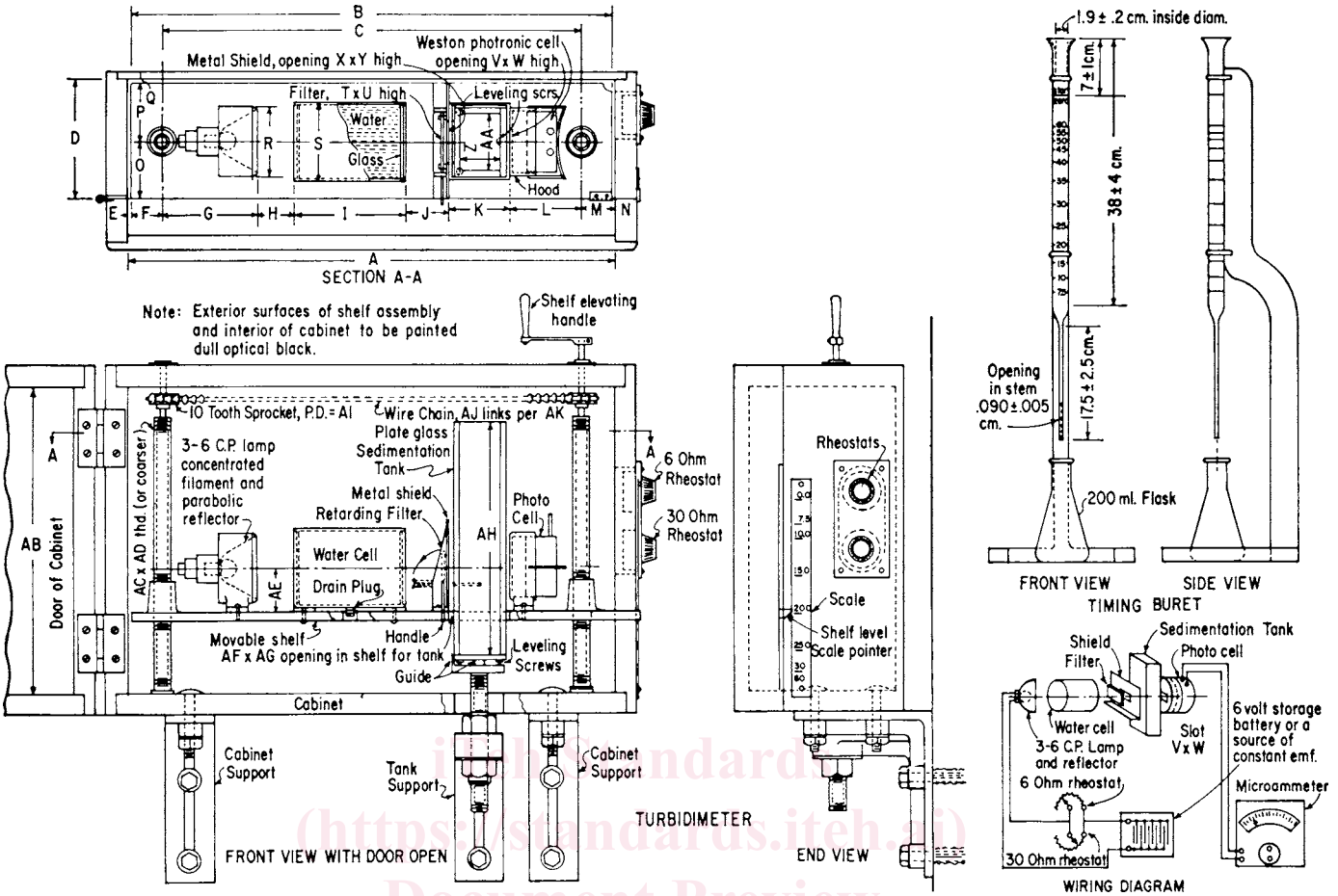


FIG. 2 Dimensional Details of Turbidimeter Fineness Test Apparatus (see Table 1)

TABLE 1 Turbidimeter Apparatus Dimensions (see Fig. 1)

Letter	mm	in.	Letter	mm	in.
A	445	17½	T	51	2
B	438	17¼	U	22.2	⅞
C	381	15	V	34.9	1⅜
D	105	4⅛	W	13	½
E	3.0	⅛	X	38	1½
F	28.6	1⅛	Y	15.9	⅝
G	85.7	3⅜	Z	38 ± 0.76	1½ ± 0.03
H	33.3	1⁵⁄₁₆	AA	51 ± 2.5	2 ± 0.10
I	102	4	AB	267	10½
J	39.7	1⁹⁄₁₆	AC	...	⅝ [A]
K	55.6	2³⁄₁₆	AD	...	11 [A]
L	65.1	2⁹⁄₁₆	AE	39.7	1⁹⁄₁₆
M	28.6	1⅛	AF	55.6	2³⁄₁₆
N	3.0	⅛	AG	66.7	2⅝
O	51	2	AH	203	8
P	51	2	AI	23.6	0.93
Q	3.0	⅛	AJ	1.38 [A]	3½ [A]
R	61.1	2¹³⁄₃₂	AK	cm [A]	in. [A]
S	69.8	2¾			

[A] These are pure numbers such as parts of a thread designation and numbers of links per unit; consequently, they do not correspond with the column titles.

microammeter shall be between 50 and 150 Ω . The microammeter shall not be mounted upon a working surface containing or consisting of iron or steel, or near other magnetic influence.

4.3.2 *Digital Microammeter:*

NOTE 2—A meter with a range of 199.9 μA is satisfactory for use and enables the operator to read the theoretical I_0 directly without supplementary devices. The high internal resistance of the digital microammeter does not affect the linearity of readings at the light intensity levels encountered in a Wagner turbidimetric determination of fineness.

4.4 *Source of Current*—A 6-V automobile starting and lighting storage battery or a source of constant emf shall be used for supplying current to the lamp.

TABLE 2 Values of *h*, *d*, and h/d^2 to be Used in Calibration of the Turbidimeter Apparatus

Particle Diameter, *d*, μm	Depth of Suspension, *h*, cm	h/d^2
50	15	0.00600
45	15	0.00741
40	15	0.00938
35	15	0.01224
30	15	0.01667
25	13.1	0.0210
20	10	0.0250
15	6.6	0.0293
10	3.3	0.0330
7.5	2.1	0.0373

4.5 *Sieve*—The sieve shall conform to the requirements of Test Method C430.

4.6 *Stirring Apparatus*—The stirring apparatus shall consist of either (*1*) a cylindrical brush, 19 mm [¾ in.] in diameter and about 45 mm [1¾ in.] in length, with an end approximately fitting the contour of the bottom of a 22-mm [⅞-in.] diameter test tube, or (*2*) any other stirring device that will be equally efficient in dispersion as measured by specific surface determinations on a standard sample. The stirring apparatus shall rotate at a speed of approximately 3500 r/min.

4.7 *Timing Buret*—The time of settling for the different-sized particles shall be obtained by use of a buret from which kerosine is allowed to flow. The buret shall consist of a glass tube having a capillary tube fused into the lower end. The upper end of the large tube shall be flared to serve as a funnel for introducing kerosine into the tube. The buret shall conform to the limiting dimensions given in Table 3. The graduation lines on the buret shall be complete circles. A filter made of 45-μm (No. 325) wire cloth shall be used with the timing buret and a cover shall be placed over the top of the buret when it is not in use.

4.8 *Weights and Weighing Devices,* shall conform to the requirements of Methods C114.

5. Materials

5.1 *Suspending Liquid*—Clear white kerosine shall be used with the turbidimeter apparatus. The kerosine shall not be reused.

6. Test Specimen or Sample

6.1 *Size of Test Sample*—Select the size of the sample of cement for test so that the initial microammeter reading is between 12 and 20 μA.

TABLE 3 Buret Dimensions[A]

	Dimension, cm	Permissible Variation, cm
Length of large tube	38	±4
Inside diameter of large tube	1.9	±0.2
Length of capillary	17.5	±2.5
Diameter of capillary	0.09	±0.005
Top of buret to zero line	7	±1

[A] Since glass tubing of desired dimensions is not always obtainable, the wide permissible variations listed above allow selection of dimensions to produce a buret having a duration of flow which will permit calibration as described in 7.1.1.

NOTE 3—The following approximations will be helpful in many instances in selecting the size of sample: 0.25 g for normal fineness cements and 0.20 g for high fineness cements.

7. Calibration

7.1 *Calibration of Turbidimeter*—Calibrate the turbidimeter apparatus in accordance with the following procedure:

7.1.1 *Calibration of Buret Scale:*

7.1.1.1 For calibration of the buret scale use a kerosine having a known viscosity and density for the temperature at which the calibration is to be made. Density and viscosity of the kerosine should be determined. Calculate the times of flow from the buret that correspond to the times of settling for the different sized particles, from the following equation:

$$t = [1{,}837{,}000\eta/(\rho_1 - \rho_2)] \times (h/d^2) \quad (1)$$

where:

t = time of settling, or time of flow, s,
η = viscosity of kerosine at the temperature of calibration, P,
ρ_1 = density of cement particles, Mg/m^3 (g/cm^3) = 3.15 for portland cement (Note 4),
ρ_2 = density of kerosine, Mg/m^3 at the temperature of calibration,
h = depth of suspension to level of light, cm, and
d = diameter of particle, μm.

Values of h/d^2 are given in Table 2.

7.1.1.2 Fill the buret with kerosine at the calibrating temperature, start a timing clock at the instant the kerosine in the buret drains past the zero line, and mark on the buret the levels reached by the draining kerosine for each of the time intervals, *t*, calculated as described above. At these marks, etch permanent lines and numbers on the buret indicating the corresponding diameters (Note 5). The construction and the graduation of the buret shall be such that at the temperature of calibration the time required for the kerosine to pass the permanent lines of the buret agrees with the calculated time of settling within 1 percent, except that the permissible variation shall be not less than 1 s.

NOTE 4—The density of portland cement does not vary greatly and in this work it is considered constant at 3.15. A variation of 0.15 from this value when substituted in Stokes' law gives a variation of 2.5 % in the diameter of the particle measured.

NOTE 5—By using the calibrated buret the apparatus may be used within the normal range of room temperatures without further correction, the change in rate of flow of the kerosine from the buret automatically compensating for change in viscosity of the suspension due to temperature. The temperature of the kerosine in the buret and that of the suspension should be kept the same within 0.5 °C [1 °F]. This condition will ordinarily exist if the supply of kerosine is kept in the same room as the apparatus.

Care must be taken to ascertain that only clean kerosine is used in the buret, and, in addition, the capillary should be examined frequently to make sure that no small pieces of lint or other foreign material have become lodged in it.

7.1.2 *Calibration of No. 325 (45-μm) Sieve*—Calibration shall be made in accordance with Method C430, basing the percentage sieve correction on the difference between the test residue obtained and the assigned residue value indicated by the electroformed sheet sieve fineness specified for the standard sample, expressed as a percentage of the test residue.