



Designation: C 917 – 98

Standard Test Method for Evaluation of Cement Strength Uniformity From a Single Source¹

This standard is issued under the fixed designation C 917; 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 is intended for use in instances where the purchaser desires information on the strength uniformity of a hydraulic cement produced at a single source. It is intended that this method normally be used for the predominant cement manufactured at a cement plant. Guidelines for sampling, testing, presentation of results, and evaluation are given.

1.2 The values stated in inch-pound units are to be regarded as the standard.

1.3 *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.*

2. Referenced Documents

2.1 ASTM Standards:

C 109/C 109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)²

C 150 Specification for Portland Cement²

C 219 Terminology Relating to Hydraulic Cement²

C 595M Specification for Blended Hydraulic Cements²

C 1157M Performance Specification for Blended Hydraulic Cement²

E 456 Terminology Relating to Quality and Statistics³

3. Terminology

3.1 *Definitions*—For definitions of terms relating to this test method refer to Terminology C 219 and Terminology E 456.

4. Significance and Use

4.1 This test method is designed to present in a standardized format information on the variability of strength of cement

from a single source over a period of time. It can be applied to all hydraulic cements covered in Specifications C 150, C 595, and C 1157M.

NOTE 1—It should be recognized that concrete strength variability is influenced by other factors in addition to cement strength variability.

5. Sampling

5.1 All sampling shall be performed by quality control or testing personnel, or someone specifically trained for this purpose.

5.2 Take random grab samples from delivery units or during the loading or unloading process. Delivery units larger than 125 tons shall be sampled during loading or unloading. If samples are taken during loading or unloading, the two or more portions which are to be composited to make a sample shall be taken during the transfer to no more than 125 tons of cement. Identify samples by the date on which the cement they represent was shipped or received.

NOTE 2—Standard statistical procedures are recommended for ensuring that samples are selected by a random procedure. These procedures can be used to select the days within a month or within a week that samples will be taken. Then the delivery unit or the time of day can be chosen randomly.

5.3 If taken from a truck or rail car, take at least two separate 5-lb (approximately 2.3-kg) grab samples and thoroughly mix together to obtain a minimum 10-lb (4.5-kg) test sample. Sample only through hatches in the top of the unit. Remove approximately a 12-in. (300-mm) layer of cement. Make a hole before obtaining a sample to avoid collecting dust collector material that may be discharged into the delivery unit after the cement flow ceases.

5.4 If taken from another point in the loading or unloading process, the sample shall consist of a minimum of two separate 5-lb (approximately 2.3-kg) grab samples thoroughly mixed together or at least 10 lb (4.5 kg) as accumulated by a continuous sampler. Take care to avoid segregation and contamination of samples taken from screws, pneumatic systems, or air slides.

5.5 When samples are taken at the cement plant and shipments or rate of production of the cement exceeds 25 000 tons (23 000 Mg) per month, take samples at a rate of at least

¹ This test method is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.27 on Strength.

Current edition approved July 10, 1998. Published December 1998. Originally published as C 917–79. Last previous edition C 917–95a.

² *Annual Book of ASTM Standards*, Vol 04.01.

³ *Annual Book of ASTM Standards*, Vol 14.02.

ten per month and at least two per week. When shipment or rate of production of the cement is less than 25 000 tons (23 000 Mg) per month, take samples at a rate of at least one per 2500 tons (2300 Mg). When samples are taken at the cement plant, in no instance shall samples be taken more frequently than one per 200 tons (180 Mg) of cement shipped or received, except that sampling of consecutive shipments is permitted when they result from randomization.

6. Procedure

6.1 Test all samples for 7 and 28-day compressive strength in accordance with Test Method C 109 using three specimens for each test age. To be comparable, all tests used in a single evaluation must be made in a single laboratory, and preferably by the same laboratory operator.

6.1.1 When separate evaluations of a single source are made by two or more laboratories, additional tests of a standard cement or exchange of portions of the same sample of cement may be necessary to determine differences in testing that are likely to be obtained in the different laboratories. Five or more batches may be necessary to obtain a valid comparison between laboratories. Statistical techniques must be used to assess the validity of differences that might be obtained. Participation in the Cement Reference Sample Program of the CCRL by both laboratories will be helpful in resolving differences that are found.

6.1.2 When two laboratories exchange portions of the same sample and prepare single batches, results from the two laboratories shall not differ by more than 18.7 % of the average of the two laboratories (see Test Method C 109 multilaboratory d2s). If a larger number of samples are exchanged the difference in average strength shall not exceed $18.7/\sqrt{n}$ % of the overall average strength, where n is the number of samples exchanged and tested by each laboratory. A more precise calculation is outlined in Appendix X1.

6.2 Mix duplicate batches of mortar to determine the effect of testing variations on the uniformity of results made in a single laboratory. Make duplicate batches on a day different from the original batch of mortar.

6.2.1 When a uniformity testing program is started on shipments from a single source, make duplicate batches of mortar from every third cement sample. When duplicate tests have been made from a minimum of five cement samples, calculate the average range, $\bar{R}$, for the available duplicates, then calculate standard deviation and coefficient of variation for testing according to 7.1.3 and 7.1.4, respectively. Increase the number of duplicate batches used in the calculation until the results of ten cement samples are used in the calculation. After that time, use only the ten most recent results of duplicate testing in the calculation of the standard deviation and coefficient of variation for testing. See Table 1.

6.2.2 When at least ten sets of duplicate batches have been made and the coefficient of variation for testing is less than 4.0 %, the frequency of testing duplicate batches may be reduced to one out of ten consecutive cement samples. Resume testing one sample out of three if the coefficient of variation later exceeds 4.0 %. If the coefficient of variation for testing

exceeds 5.5 %, the data are of questionable precision, and laboratory procedures and equipment should be thoroughly examined.

6.2.3 Use the results of duplicate tests indicating acceptable precision to estimate the single-laboratory testing variation for all other types of cement tested in that laboratory during the same period of time, provided that duplicate tests have been made on at least one sample per month.

7. Calculation

7.1 The calculations shall include the following:

7.1.1 *Average Strength:*

$$\bar{X} = \frac{X_1 + X_2 + \dots + X_n}{n} \quad (1)$$

where:

$\bar{X}$ = average strength,
 $X_1, X_2, \dots, X_n$ = strength of individual tests, each of which is composed of the average of three cubes in accordance with Test Method C 109, and
 n = number of individual samples.

7.1.2 *Total Standard Deviation:*

$$S_t = \sqrt{\frac{(X_1 - \bar{X})^2 + (X_2 - \bar{X})^2 + \dots + (X_n - \bar{X})^2}{(n - 1)}} \quad (2)$$

where:

S_t = standard deviation, psi.

7.1.3 *Standard Deviation For Testing:*

$$S_e = 0.862\bar{R}$$

S_e = standard deviation estimated from tests of duplicate batches mixed in a single laboratory,
 R = range, the difference between the strengths of the duplicate batches from a single sample (all numbers are positive),
 $\bar{R}$ = average of the individual ranges, R , for the preceding ten tests of duplicate batches. See 6.2.1 if fewer than ten ranges are available, and
0.862 = range coefficient for duplicate tests of the same sample of cement.

7.1.4 *Coefficient of Variation for Testing:*

$$V_e = 100 S_e / \bar{X}$$

where:

V_e = coefficients of variation estimated from tests of duplicate batches mixed in a single laboratory, and
 $\bar{X}$ = average of the strengths of the duplicate batches from which $\bar{R}$ is calculated.

7.1.5 *Standard Deviation Corrected For Testing Variations:*

$$S_c = \sqrt{S_t^2 - S_e^2} \quad (3)$$

where:

S_c = net standard deviation of cement corrected for testing error,



S_t = total standard deviations for all tests included in the calculation, and
 S_e = standard deviation of duplicate tests run on split sample to evaluate testing error.

The addition of the subscript 28 or 7 indicates the type of strength data used in the calculation.

NOTE 3—Values for averages and standard deviations can be calculated by other methods that are available in STP 15 D.⁴ Electronic calculators are available for obtaining these statistics directly.

⁴ Manual on Presentation of Data and Control Chart Analysis, ASTM STP 15 D, ASTM 1976.

TABLE 1 Calculation of Standard Deviation for Testing

Date	Sample Number	7-Day Data				Average ^A		Range ^B		$\bar{R}$ ^C		S_e ^D		V_e ^E	Note
		Test a		Test b		psi	(MPa)	psi	(MPa)	psi	(MPa)	psi	(MPa)		
		psi	(MPa)	psi	(MPa)										
01 /06	3	4900	(33.7)	4960	(34.2)	4930	(34.0)	60	(0.41)	...	...	...	...	...	...
01 /16	6	4580	(31.5)	4670	(32.2)	4625	(31.8)	90	(0.62)	...	...	...	...	...	...
01 /30	9	4650	(32.0)	4850	(33.4)	4750	(32.7)	200	(1.37)	...	...	...	...	...	...
02 /05	12	4400	(30.3)	4510	(31.1)	4455	(30.7)	110	(0.75)	...	...	...	...	...	...
02 /13	15	4380	(30.2)	4300	(29.6)	4340	(29.9)	80	(0.55)	108	(0.74)	93	(0.64)	2.02 %	Av. 5
02 /21	18	4700	(32.4)	4770	(32.8)	4735	(32.6)	70	(0.48)	102	(0.70)	88	(0.60)	1.89 %	Av. 6
03 /04	21	4470	(30.8)	4610	(31.7)	4540	(31.3)	140	(0.96)	107	(0.73)	92	(0.64)	2.00 %	Av. 7
03 /14	24	4030	(27.7)	3970	(27.3)	4000	(27.5)	60	(0.41)	101	(0.69)	87	(0.60)	1.92 %	Av. 8
03 /19	27	4970	(34.2)	4820	(33.2)	4895	(33.7)	150	(1.03)	107	(0.73)	92	(0.63)	2.01 %	Av. 9
03 /27	30	4550	(31.3)	4530	(31.2)	4540	(31.3)	20	(0.13)	96	(0.67)	84	(0.58)	1.84 %	Av. 10 (6)
04 /30	40	4750	(32.7)	4920	(33.9)	4835	(33.3)	170	(1.17)	109	(0.75)	94	(0.65)	2.06 %	Av. last 10
05 /31	50	5030	(34.6)	4820	(33.2)	4925	(33.9)	210	(1.44)	121	(0.83)	104	(0.72)	2.27 %	Av. last 10
06 /29	60	4830	(33.3)	4720	(32.5)	4775	(32.9)	110	(0.75)	112	(0.77)	97	(0.67)	2.10 %	Av. last 10
07 /28	70	4400	(30.3)	4460	(30.7)	4430	(30.5)	60	(0.41)	107	(0.73)	92	(0.64)	2.00 %	Av. last 10
08 /30	80	4550	(31.3)	4460	(30.7)	4505	(31.0)	90	(0.62)	108	(0.74)	93	(0.64)	2.02 %	Av. last 10
09 /25	90	4930	(34.0)	5000	(34.4)	4965	(34.2)	70	(0.48)	108	(0.74)	93	(0.64)	2.01 %	Av. last 10
10 /26	100	4950	(34.1)	4820	(33.2)	4885	(33.6)	130	(0.89)	107	(0.73)	92	(0.64)	1.97 %	Av. last 10
11 /25	110	4670	(32.2)	4720	(32.5)	4695	(32.3)	50	(0.34)	106	(0.73)	91	(0.63)	1.93 %	Av. last 10
12 /21	120	4450	(30.6)	4520	(31.1)	4485	(30.9)	70	(0.48)	96	(0.67)	84	(0.58)	1.80 %	Av. last 10

Date	Sample Number	28-Day Data				Average ^A		Range ^B		$\bar{R}$ ^C		S_e ^D		V_e ^E	Note
		Test a		Test b		psi	(MPa)	psi	(MPa)	psi	(MPa)	psi	(MPa)		
		psi	(MPa)	psi	(MPa)										
01 /06	3	6370	(43.9)	6620	(45.6)	6495	(44.7)	250	(1.72)	...	...	...	...	...	...
01 /16	6	6250	(43.1)	6020	(41.5)	6135	(42.3)	230	(1.58)	...	...	...	...	...	...
01 /30	9	6050	(41.7)	6120	(42.2)	6085	(41.9)	70	(0.48)	...	...	...	...	...	...
02 /05	12	6020	(41.5)	6230	(42.9)	6125	(42.2)	210	(1.44)	...	...	...	...	...	...
02 /13	15	5600	(38.6)	5420	(37.3)	5510	(38.0)	180	(1.24)	188	(1.29)	162	(1.12)	2.67 %	Av. 5
02 /21	18	5500	(37.9)	5530	(38.1)	5515	(38.0)	30	(0.20)	162	(1.11)	139	(0.96)	2.33 %	Av. 6
03 /04	21	6320	(43.5)	6280	(43.3)	6300	(43.4)	40	(0.27)	144	(0.99)	124	(0.86)	2.06 %	Av. 7
03 /14	24	5920	(40.8)	6010	(41.4)	5965	(41.1)	90	(0.62)	138	(0.94)	119	(0.82)	1.97 %	Av. 8
03 /19	27	6300	(43.4)	6050	(41.7)	6175	(42.5)	250	(1.72)	150	(1.03)	129	(0.89)	2.14 %	Av. 9
03 /27	30	6350	(43.7)	6410	(44.2)	6380	(44.0)	60	(0.41)	141	(0.97)	122	(0.84)	2.00 %	Av. 10 (6)
04 /30	40	6050	(41.7)	5940	(40.9)	5995	(41.3)	110	(0.75)	127	(0.87)	109	(0.75)	1.82 %	Av. last 10
05 /31	50	6670	(46.0)	6530	(45.0)	6600	(45.5)	140	(0.96)	118	(0.81)	102	(0.70)	1.68 %	Av. last 10
06 /29	60	6350	(43.7)	6190	(42.6)	6270	(43.2)	160	(1.10)	127	(0.87)	109	(0.75)	1.80 %	Av. last 10
07 /28	70	6500	(44.8)	6300	(43.4)	6400	(44.1)	200	(1.37)	126	(0.86)	109	(0.75)	1.78 %	Av. last 10
08 /30	80	6200	(42.7)	6150	(42.4)	6175	(42.5)	50	(0.34)	113	(0.77)	97	(0.67)	1.58 %	Av. last 10
09 /25	90	6630	(45.7)	6540	(45.1)	6585	(45.4)	90	(0.62)	119	(0.82)	103	(0.71)	1.63 %	Av. last 10
10 /26	100	6230	(42.9)	6010	(41.4)	6120	(42.2)	220	(1.51)	137	(0.94)	118	(0.81)	1.88 %	Av. last 10
11 /25	110	5920	(40.8)	6020	(41.5)	5970	(41.1)	100	(0.68)	138	(0.95)	119	(0.82)	1.90 %	Av. last 10
12 /21	120	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Notes: Initially one out of three samples are tested in duplicate until at least ten duplicate test results are available.

^A Average of the test results a and b.

^B Absolute difference between tests a and b.

^C Average range is calculated for a minimum of 5 duplicate tests. Subsequently, ranges of the ten most recent duplicate tests are averaged.

^D Standard Deviation for testing is calculated as in 7.1.3: $S_e = 0.862 \times \bar{R}$.

^E Coefficient of Variation for testing is calculated as in 7.1.4: $V_e = 100 S_e / \bar{X}$. Note that $\bar{X}$ is the average strength of the duplicate batches from which $\bar{R}$ is determined.

8. Report

8.1 Sufficient information shall be provided to identify the cement sampled including:

- 8.1.1 Name of manufacturer and location,
- 8.1.2 Type of cement or other identification,
- 8.1.3 Location of sampling,
- 8.1.4 Laboratory designation, and

8.1.5 Period of time represented by the report.

8.2 For ongoing programs the minimum period covered by the report shall include all strength tests made in the preceding three months, but in no instance less than that period of time necessary to include 28-day strength tests of 20 consecutive samples.