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Standard Specification for Chemical Admixtures for Concrete[1]

This standard is issued under the fixed designation C494/C494M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers materials for use as chemical admixtures to be added to hydraulic-cement concrete mixtures ~~in the field~~ for the purpose or purposes indicated for the eight types as follows:

1.1.1 *Type A*—Water-reducing admixtures,

1.1.2 *Type B*—Retarding admixtures,

1.1.3 *Type C*—Accelerating admixtures,

1.1.4 *Type D*—Water-reducing and retarding admixtures,

1.1.5 *Type E*—Water-reducing and accelerating admixtures,

1.1.6 *Type F*—Water-reducing, high range admixtures,

1.1.7 *Type G*—Water-reducing, high range, and retarding admixtures, and

1.1.8 *Type S*—Specific performance admixtures.

1.2 ~~This specification stipulates tests of an admixture with suitable concreting materials as described in 11.1 – 11.3 or with cement, pozzolan, aggregates, and an air-entraining admixture proposed for specific work (11.4).~~ Unless specified otherwise by the purchaser, ~~the tests~~ test specimens for qualifying an admixture shall be made using concreting materials as described in 11.1 – 11.3.

NOTE 1—~~It~~ As discussed in Appendix X2, it is recommended that, whenever practicable, supplementary tests be made by the purchaser using the cement, pozzolan, aggregates, air-entraining admixture, and the mixture proportions, batching sequence, and other physical conditions proposed for the specific work ~~(11.4)~~ because the specific effects produced by chemical admixtures may vary with the properties and proportions of the other ingredients of the concrete. For ~~instance,~~example, Types F and G admixtures may exhibit much higher water reduction in concrete mixtures having higher cement ~~factors~~contents than that listed in 12.1.1.

~~Mixtures having a high range water reduction generally display a higher rate of slump loss. When high-range admixtures are used to impart increased workability (6 to 8-in. slump [150 to 200-mm]), the effect may be of limited duration, reverting to the original slump in 30 to 60 min depending on factors normally affecting rate of slump loss. The use of chemical admixtures to produce high-slump (flowing) concrete is covered by Specification C1017/C1017M.~~

NOTE 2—The purchaser should ~~ensure~~verify that the admixture supplied for use in the work is equivalent in composition to the admixture subjected to test under this specification (see Section 6, Uniformity and Equivalence).

NOTE 3—Admixtures that contain ~~relatively large~~ sufficient amounts of chloride may accelerate corrosion of ~~prestressing steel.~~steel reinforcement. Compliance with the requirements of this specification does not constitute assurance of acceptability of the admixture for use in ~~prestressed~~reinforced concrete.

1.3 This specification provides for three levels of testing.

1.3.1 *Level 1*—During the initial approval stage, proof of compliance with the performance requirements defined in Table 1 demonstrates that the admixture meets the requirements of this specification. Proof of compliance shall be based on comparisons of the average test results from the batches of test concrete and the average test results from the batches of reference concrete. Admixtures (except for Types B, C, E, and S) shall qualify for provisional compliance ~~when the~~ if the time of setting, length change, and durability factor meet the physical requirements and any of the alternative compressive strength requirements shown in parentheses in Table 1 are ~~met.~~ met through the date of provisional acceptance (see Note 4). If subsequent test results at six months or one year fail to meet the ~~standard~~ requirement of at least 100 % of reference strength, the provisional compliance of the admixture to this standard is withdrawn and all users of the admixture shall be notified immediately. Uniformity and equivalence tests of Section 6 shall be carried out to provide results against which later comparisons ~~can~~shall be ~~made (see~~ made. ~~Note 4).~~

[1] This specification is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.23 on Chemical Admixtures.

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

NOTE 4—Allowing for provisional compliance while retaining longer term compressive strength requirements promotes more rapid qualification of new materials, but also provides assurance that new admixture technologies will not exhibit unexpected longer term performance. The alternative compressive strength requirements in Table 1 are based on statistical analysis of 103 Specification C494/C494M evaluation tests. The alternative requirements shown in parentheses correspond to a 99 % probability of passing strength requirements at subsequent test ~~age requirements.~~ages,[2] if any one of the requirements is met. There is no requirement that all be met.

1.3.2 *Level 2*—Limited retesting is described in 5.2 – 5.2.2. Proof of compliance with the requirements of Table 1 demonstrates continued conformity of the admixture with the requirements of the specification.

1.3.3 *Level 3*—For acceptance of a lot or for measuring uniformity within or between lots, ~~when~~if specified by the purchaser, the uniformity and equivalence tests of Section 6 shall be used.

1.4 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~~are not ~~be~~necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the ~~other. Combining~~other, and values from the two systems ~~may result in non-conformance with the standard.~~shall not be combined. Some values have only SI units because the inch-pound equivalents are not used in practice.

1.5 The text of this standard ~~references~~ refers to notes and footnotes ~~which~~that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.6 The following precautionary caveat pertains only to ~~the~~ test method ~~sections,~~ Sections 11 – 18 of this Specification: *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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.* (**Warning—***Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to exposed skin and tissue upon prolonged exposure.*[3])

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[4]

C33/C33M Specification for Concrete Aggregates
C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
C78/C78M Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
C125 Terminology Relating to Concrete and Concrete Aggregates
C127/C127M Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate
C128/C128M Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate
C136/C136M Test Method for Sieve Analysis of Fine and Coarse Aggregates
C138/C138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
C143/C143M Test Method for Slump of Hydraulic-Cement Concrete
C150/C150M Specification for Portland Cement
C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
C183/C183M Practice for Sampling and the Amount of Testing of Hydraulic Cement
C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
C231/C231M Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C260/C260M Specification for Air-Entraining Admixtures for Concrete
C403/C403M Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance
C666/C666M Test Method for Resistance of Concrete to Rapid Freezing and Thawing
~~C1017/C1017M~~C1753/C1753M ~~Specification for Chemical Admixtures for Use in Producing Flowing Concrete~~Practice for Evaluating Early Hydration of Hydraulic Cementitious Mixtures Using Thermal Measurements
D75/D75M Practice for Sampling Aggregates
D891 Test Methods for Specific Gravity, Apparent, of Liquid Industrial Chemicals
D1193 Specification for Reagent Water
E100 Specification for ASTM Hydrometers
E178 Practice for Dealing With Outlying Observations
E1252 Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis
Manual of Aggregate and Concrete Testing

[2] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1030. Contact ASTM Customer Service at service@astm.org.

[3] See Section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol. 04.02.

[4] 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.

2.2 *American Concrete Institute Standard:*
ACI 211.1–91 (2009) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete[5]

3. Terminology

3.1 For definitions of terms used in this specification, refer to Terminology C125.

3.2 ~~*Definitions:*~~*Definitions of Terms Specific to This Standard:*

3.2.1 *accelerating admixture, n*—an admixture that ~~accelerates the setting and early~~ increases the rate of reaction of cementitious materials thus reducing time of setting and increasing the rate of early-age strength development of concrete.

3.2.2 *reference concrete, n*—concrete made without the admixture being evaluated and used as the basis for evaluating the performance of the admixture.

3.2.3 *retarding admixture, n*—an admixture that ~~retards the~~ decreases the rate of reaction of cementitious materials thus increasing time of setting of concrete.

3.2.4 *test concrete, n*—concrete containing the admixture being evaluated.

3.2.4.1 *Discussion—*

In the text of this specification, the wording "category of concrete" refers to whether the concrete mixture is the reference concrete or the test concrete.

3.2.5 *water-reducing admixture, n*—an admixture that ~~reduces~~ either increases the ~~quantity of mixing water required to produce concrete of a given consistency.~~slump of freshly mixed concrete without increasing the water content or that maintains the slump with a reduced amount of water due to factors other than air entrainment.

3.2.6 *water-reducing admixture, high range, n*—an admixture that reduces the quantity of mixing water required to produce concrete of a given ~~consistency~~slump by 12 % or greater.

3.2.7 *water-reducing and accelerating admixture, n*—an admixture that reduces the quantity of mixing water required to produce concrete of a given ~~consistency and accelerates the setting and early strength development of concrete.~~slump, reduces the time of setting, and increases the rate of early-age strength development.

3.2.8 *water-reducing and retarding admixture, n*—an admixture that reduces the quantity of mixing water required to produce concrete of a given ~~consistency~~slump and ~~retards~~increases the time of setting of concrete.

3.2.9 *water-reducing, ~~high range,~~ high-range, and retarding admixture, n*—an admixture that reduces the quantity of mixing water required to produce concrete of a given ~~consistency~~slump by 12 % or greater and ~~retards~~increases the time of setting of concrete.

3.2.10 *specific performance admixture, n*—an admixture that provides a desired performance characteristic(s) other than reducing water content, or changing the time of setting of concrete, or both, without any adverse effects on fresh, hardened and durability properties of concrete as specified herein, excluding admixtures that are used primarily in the manufacture of dry-cast concrete ~~products (see~~ products.~~Note 5).~~

~~Note 5—Other specific performance characteristics include, but are not limited to, shrinkage reduction, mitigation of alkali-silica reaction, and viscosity modification. Admixtures used for the purposes of reducing water content or changing the time of setting of concrete are classified within the Type A through Type G grouping. Plasticizing, water-repellent, and efflorescence-controlling admixtures are examples of admixtures that are used in the manufacture of dry-cast concrete products.~~

3.2.10.1 *Discussion—*

Other specific performance characteristics include, but are not limited to, shrinkage reduction, mitigation of alkali-silica reaction, and viscosity modification. Admixtures used for the purposes of reducing water content or changing the time of setting of concrete are classified within the Type A through Type G grouping. Plasticizing, water-repellent, and efflorescence-controlling admixtures are examples of admixtures that are used in the manufacture of dry-cast concrete products.

4. Ordering Information

4.1 The purchaser shall specify the type of chemical admixture desired, and in the case of a Type S admixture the specific performance characteristic(s) required.

5. General Requirements

5.1 For initial compliance with this specification, test concrete ~~in which each type of admixture~~ made with one of the admixtures shown in 1.1 ~~is used~~ shall conform to the respective requirements prescribed in Table 1.

[5] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.aci-int.org.

5.2 The purchaser is allowed to require a limited retesting to confirm current compliance of the admixture to specification requirements. The limited retesting ~~will cover~~ covers physical properties and performance of the admixture.

5.2.1 The physical properties retesting shall consist of uniformity and equivalence tests for infrared analysis, residue by oven ~~drying and specific gravity.~~drying, and relative density (specific gravity).

5.2.2 The performance property retesting shall consist of water content of fresh concrete, setting time, and compressive strength at 3, 7, and 28 days. ~~Purchasers having special requirements are allowed to require additional tests currently in this standard.~~

5.3 At the request of the purchaser, ~~when the admixture is to be used in prestressed concrete, the~~ the manufacturer shall state in writing the chloride content of the ~~admixture and whether or not chloride has been added during its manufacture.~~admixture.

5.4 At the request of the purchaser, the manufacturer shall provide data to substantiate the specific performance characteristic(s) stated by the manufacturer for a Type S admixture.

5.5 Tests for uniformity and equivalence, as indicated in Section 6, shall be made on the initial sample and the results retained for reference and comparison with the results of tests of samples taken from elsewhere within the lot or subsequent lots of ~~admixture supplied for use in the work.~~admixture.

5.6 At the request of the purchaser, the manufacturer shall state in writing that the infrared analysis spectrum, residue by oven drying, and ~~specific gravity~~ relative density (specific gravity) of the ~~admixture supplied for use in the work~~ supplied admixture are within the limits in Section 6 when compared with the initial sample tested under Level 1 of this specification.

6. Uniformity and Equivalence

6.1 ~~When~~If specified by the purchaser, the uniformity of a lot, or the equivalence of different lots from the same source shall be established by ~~the use of the~~ complying with the following requirements:

6.1.1 *Infrared Analysis*—The infrared absorption spectra of the initial sample and the test sample, obtained as specified in 18.1, shall be ~~essentially similar.~~ equivalent. Two infrared absorption spectra are considered equivalent if the same infrared absorption frequencies at the same relative intensities are present in both spectra. Refer to Appendix X3 for additional guidance.

6.1.2 *Residue by Oven Drying* (Liquid Admixtures)—When dried as specified in 18.2, the oven-dried residues of the initial sample and of subsequent samples shall be within ±12 % of the mid-point of the manufacturer's stated range, but not exceeding the manufacturer's stated ~~limits (see~~ limits.~~Note 6~~).

NOTE 5—As an example, for an admixture produced with a residue range from 27 to 35 %, the manufacturer would provide maximum acceptable limits of 27.3 to 34.7 %, representing ±12 % of the mid-point of the limits, where the mid-point is 31.0 %.

6.1.3 *Residue by Oven Drying* (Nonliquid Admixtures)—When dried as specified in 18.3, the oven-dried residues of the initial sample and of the subsequent samples shall be within a range of variation not greater than ±4 percentage points.

6.1.4 ~~*Specific Gravity*~~ *Relative Density (Specific Gravity)* (Liquid Admixtures)—When tested as specified in 18.4, the ~~specific gravity~~ relative density (specific gravity) of the initial sample and subsequent test samples shall not differ from the mid-point of the manufacturer's stated range by more than 10 % of the difference between the mid-point of the manufacturer's stated range and that of reagent water. If 10 % of the difference between the ~~specific gravity~~ relative density (specific gravity) of the initial sample and water is less than 0.01, use the value 0.01 as the maximum allowable difference. Reagent water conforming to Specification D1193, Types III or IV, and prepared by distillation ion exchange, reverse osmosis, electrodialysis, or a combination of these procedures is adequate.

6.2 ~~When~~If the nature of the admixture or the analytical capability of the purchaser make some or all of these procedures unsuitable, other requirements for uniformity and equivalence from lot to lot or within a lot shall be established by agreement between the purchaser and the manufacturer.

7. Packaging and Marking

7.1 ~~When~~If the admixture is delivered in packages or containers, the proprietary name of the admixture, the type under this specification, and the net ~~weight~~mass or volume shall be plainly marked thereon. Similar information shall be provided in the shipping advices accompanying packaged or bulk shipments of admixtures.

8. Storage

8.1 The admixture shall be stored in such a manner as to permit ~~easy~~ access for ~~proper~~ inspection and identification of each shipment, and in ~~a suitable weathertight building~~ an environment that will protect the admixture from dampness and freezing.

9. Sampling and Inspection

9.1 ~~Every facility~~The purchaser shall be provided the ~~purchaser~~opportunity for ~~careful~~ sampling and inspection, either at the point of manufacture or at the site of the work, as specified by the purchaser.

9.2 Samples shall be either "grab" or "composite" samples, as specified or required by this specification. A grab sample is one obtained in a single operation. A composite sample is one obtained by combining three or more grab samples.

TABLE 1 Physical Requirements[A, B]

	Type A, ~~Water~~Water-Reducing ~~Reducing~~	Type B, Retarding	Type C, ~~Accelerating~~ Accelerating ~~ating~~	Type D, ~~Water~~Water-Reducing ~~Reducing~~ and Retarding	Type E, ~~Water~~Water-Reducing ~~Reducing~~ and Accelerating	Type F, ~~Water~~Water-Reducing, ~~Reducing,~~High-Range ~~High Range~~	Type G, ~~Water~~Water-Reducing, ~~Reducing,~~High-Range ~~High Range~~ and Retarding	Type S Specific Performance
~~Water content, max, % of control~~	~~95~~	~~...~~	~~...~~	~~95~~	~~95~~	~~88~~	~~88~~	~~...~~
Water content, max, % of reference[A]	95	...	...	95	95	88	88	...
~~Time of setting, allowable deviation from control, h:min:~~								
Time of setting, allowable deviation from reference, h:min:								
Initial: at least	...	1:00 later	1:00 earlier	1:00 later	1:00 earlier	...	1:00 later	
not more than	1:00 earlier nor 1:30 later	3:30 later	3:30 earlier	3:30 later	3:30 earlier	1:00 earlier nor 1:30 later	3:30 later	1:00 earlier nor 1:30 later
Final: at least	...	...	1:00 earlier	...	1:00 earlier	...	...	
not more than	1:00 earlier nor 1:30 later	3:30 later	...	3:30 later	...	1:00 earlier nor 1:30 later	3:30 later	1:00 earlier nor 1:30 later
~~Compressive strength, min, % of control:~~[B]								
Compressive strength, min, % of reference:[C]								
1 day	...	...	...	...	...	140	125	...
3 days	110	90	125	110	125	125	125	90
7 days	110	90	100	110	110	115	115	90
~~28 days~~	~~110 (120)~~[C]	~~90~~	~~100~~	~~110 (120)~~[C]	~~110~~	~~110 (120)~~[C]	~~110 (120)~~[C]	~~90~~
28 days	110 (120)[D]	90	100	110 (120)[D]	110	110 (120)[C]	110 (120)[D]	90
~~90 days~~	~~(117)~~[C]	~~n/a~~	~~n/a~~	~~(117)~~[C]	~~n/a~~	~~(117)~~[C]	~~(117)~~[C]	~~n/a~~
90 days	(117)[D]	n/a	n/a	(117)[D]	n/a	(117)[C]	(117)[D]	n/a
~~6 months~~	~~100 (113)~~[C]	~~90~~	~~90~~	~~100 (113)~~[C]	~~100~~	~~100 (113)~~[C]	~~100 (113)~~[C]	~~90~~
6 months	100 (113)[D]	90	90	100 (113)[D]	100	100 (113)[C]	100 (113)[D]	90
1 year	100	90	90	100	100	100	100	90
~~Flexural strength, min, % control:~~[B]								
Flexural strength, min, % reference:[C]								
3 days	100	90	110	100	110	110	110	90
7 days	100	90	100	100	100	100	100	90
28 days	100	90	90	100	100	100	100	90
~~Length change, max shrinkage (alternative requirements):~~[D]								
Length change, max shrinkage (alternative requirements):[E]								
~~Percent of control~~	~~135~~	~~135~~	~~135~~	~~135~~	~~135~~	~~135~~	~~135~~	~~135~~
Percent of reference	135	135	135	135	135	135	135	135
~~Increase over control~~	~~0.010~~	~~0.010~~	~~0.010~~	~~0.010~~	~~0.010~~	~~0.010~~	~~0.010~~	~~0.010~~
Increase over reference	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
~~Relative durability factor, min~~[E]	~~80~~	~~80~~	~~80~~	~~80~~	~~80~~	~~80~~	~~80~~	~~80~~
Relative durability factor, min % of reference[F]	80	80	80	80	80	80	80	80

[A] Requirements in this table apply to the averages of three or more test results for each category of concrete. Comparisons are not to be made between pairs of single test results of reference and test concretes. The indicated maximum water contents are not to be interpreted as requiring exactly that amount; they are maximum values and testing at lower water content is permitted. Further, there is no requirement that either test or reference concretes be prepared at the same water contents. Because requirements in this specification apply to the average test results for each category of concrete, adjustment of mixtures within the tolerances of this specification are permitted if necessary to make the averages fall within requirements.

[B] The values in the table include allowance for normal variation in test results. The ~~object~~objective of the 90 % compressive strength requirement for a Type B ~~and~~and Type S admixture is to require a level of performance comparable to that of the reference ~~concrete.~~concrete while allowing for variability in test results.

[C] The compressive and flexural strength of the concrete containing the admixture under test at any test age shall be not less than 90 % of that attained at any previous test age. The objective of this limit is to require that the compressive or flexural strength of the concrete containing the admixture under test shall not decrease with age.
[D] Alternative requirement. If the physical requirements are met and any of the measured relative strengths are greater than the requirement in parentheses, the admixture shall be considered provisionally ~~qualified~~ to meet the requirements of this specification until the one-year strength test results are obtained.
[E] Alternative requirements, see 17.1.4~~,~~. The % of ~~control~~reference limit applies ~~when~~if length change of ~~control~~ reference concrete is 0.030 % or greater; increase over ~~control~~reference limit applies ~~when~~if length change of ~~control~~ reference concrete is less than 0.030 %.
[F] This requirement is applicable only ~~when~~if the admixture is ~~to be used~~intended for use in air-entrained concrete ~~which~~that may be exposed to freezing and thawing while wet.

9.3 For the purposes of this specification, it is recognized that samples will be taken for two reasons:

9.3.1 ~~*Quality*~~*Compliance Tests*—A sample ~~taken~~obtained for the purpose of ~~evaluating the quality~~ demonstrating compliance of a source or lot of admixture ~~will be required to meet all~~ shall meet the applicable requirements of this ~~specification. Samples~~ specification as described in 5.1 through 5.2.2. The sample used to determine conformance with the requirements of this specification shall be ~~composites~~ a composite of grab samples taken from ~~sufficient~~multiple locations ~~to ensure~~ such that the composite sample will be representative of the lot.

9.3.2 *Uniformity and Equivalence Tests*—~~When~~If specified by the purchaser, ~~a sample~~ samples taken for the purpose of evaluating the uniformity of a single lot, or equivalence of different lots from one source shall be tested as provided in Section 6. Such samples shall be composite samples from individual lots ~~when~~if different lots from the same source are being compared. ~~When~~If the uniformity of a single lot is being ~~determined,~~evaluated, grab samples shall be used.

9.4 *Liquid Admixtures*—Liquid admixtures shall be agitated ~~thoroughly immediately prior to~~ to a homogeneous condition before sampling. Grab samples taken for ~~quality~~compliance or uniformity ~~tests~~testing shall represent a unit shipment or a single production lot. Each grab sample shall have a volume of at least ~~1 pt [0.5 L]. A minimum of~~ 0.5 L [1 pt]. At least three grab samples shall be taken. Composite samples shall be prepared by ~~thoroughly~~ mixing the selected grab samples ~~selected~~ and sampling the resultant homogeneous mixture ~~sampled~~ to provide at least ~~1 gal [4 L] for quality~~4 L [1 gal] for compliance tests. Grab samples shall be taken from different locations ~~well~~ distributed throughout the quantity to be represented.

9.4.1 Admixtures in bulk storage tanks shall be sampled equally from the upper, intermediate, and lower levels by means of drain cocks in the sides of the tanks or a weighted sampling bottle fitted with a stopper that can be removed after the bottle is lowered to the desired depth.

9.4.2 Samples shall be ~~packaged~~stored in ~~impermeable,~~ airtight containers ~~which~~that are resistant to attack by the admixture.

9.5 ~~*Nonliquid*~~*Non-liquid Admixtures*—Grab samples taken for ~~quality~~compliance or uniformity ~~tests~~testing shall represent not more than ~~2 tons~~ 2 Mg [2 ~~Mg~~tons] of admixture and ~~shall weigh at least 2 lb [have a mass of at least 1 kg]. A minimum of~~ each grab sample shall be at least 1 kg [2 lb]. At least four grab samples shall be taken. Composite samples shall be prepared by ~~thoroughly~~ mixing the grab samples selected and the resultant homogeneous mixture sampled to provide at least ~~5 lb [2.5 kg]~~ 2.5 kg [5 lb] for the composite sample. Grab samples shall be taken from different locations ~~well~~ distributed throughout the quantity to be represented.

9.5.1 Samples of packaged admixtures shall be obtained by means of a tube sampler as described in Practice C183/C183M.

9.5.2 Samples shall be ~~packaged~~stored in moisture-proof, airtight containers.

9.6 Samples shall be ~~thoroughly~~ mixed ~~before testing to ensure uniformity. When~~ to a homogeneous condition before testing. If recommended by the manufacturer, the entire sample of a ~~nonliquid~~non-liquid admixture shall be dissolved in water ~~prior to~~ before testing.

10. Rejection

10.1 For initial compliance testing, the purchaser is allowed to reject the admixture if it fails to meet any of the applicable requirements for this specification.

10.2 For limited retesting, the purchaser ~~is allowed~~ has the right to reject the admixture if it fails to meet any of the requirements of the Uniformity and Equivalence Section and of the applicable parts of Table 1.

10.3 An admixture stored at the point of manufacture, for more than six months ~~prior to~~ before shipment, or an admixture in local storage in the hands of a vendor for more than six months, after completion of tests, shall be retested before use ~~when~~if requested by the purchaser and ~~is allowed to be rejected~~ the purchaser has the right to reject the admixture if it fails to conform to any of the applicable requirements of this specification.

10.4 Packages or containers varying more than 5 % from the specified ~~weight~~mass or volume are allowed to be rejected. If the average ~~weight~~mass or volume of 50 packages taken at random is less than that specified, the entire shipment is allowed to be rejected.

10.5 ~~When~~If the admixture is to be used in non-air-entrained concrete, ~~it shall be rejected when the purchaser desires~~ the purchaser has the right to reject the admixture if the test concrete containing it has an air content greater than ~~3.5 %; when~~3.5 %. If the admixture is to be used in air-entrained concrete, ~~it can be rejected~~ the purchaser has the right to reject the admixture if the test concrete containing it has an air content greater than 7.0 %.

TEST METHODS

NOTE 6—These tests are based on arbitrary stipulations ~~which~~that make possible highly standardized testing in the laboratory and are not intended to simulate actual job conditions. Refer to Appendix X1 for a discussion of the required testing program and how test results are evaluated. Testing personnel should be certified to perform the required tests.

11. Materials

~~TESTS NOT FOR A SPECIFIC USE~~

11.1 *Cement*—The cement used in any series of tests shall be ~~either the cement proposed for a specific use in accordance with a~~ a ~~11.4, a~~ Type I or Type II cement conforming to Specification C150/C150M, or a blend of two or more ~~cements, in equal parts.~~ cements. Each cement of the blend shall conform to the requirements of either Type I or Type ~~II,~~ II of Specification C150/C150M. If ~~when using a cement other than that proposed for specific work,~~ the air content of the reference concrete made without an air-entraining admixture, tested as prescribed in 14.3, is more than 3.5 %, select a different cement, or blend, so that the air content of the ~~concrete will be 3.5 % or less.~~reference concrete does not exceed 3.5 %.

11.2 *Aggregates*—~~Except when tests are made in accordance with~~ The ~~11.4 using the aggregates proposed for a specific use, the~~ fine and coarse aggregates used in any series of tests shall come from single lots of ~~well-graded, sound~~ materials that conform to the requirements of Specification C33/C33M, except that the grading of the aggregates shall conform to the ~~following requirements:~~requirements in 11.2.2 and 11.2.3:

11.2.1 *Physical Properties*—Determine the relative density and absorption of the coarse aggregate in accordance with Test Method C127/C127M and of the fine aggregate in accordance with Test Method C128/C128M.

11.2.2 *Fine Aggregate ~~Grading:~~ Grading*—Determine the grading and fineness modulus of the fine aggregate in accordance with Test Method C136/C136M. The grading shall conform to the following requirements:

~~Sieve~~	~~Weight Percent Passing~~
~~No. 4 [4.75 mm]~~	~~100~~
~~No. 16 [1.18 mm]~~	~~65 to 75~~
~~No. 50 [300 µm]~~	~~12 to 20~~
~~No. 100 [150 µm]~~	~~2 to 5~~

Sieve	Mass Percent Passing
4.75 mm (No. 4)	100
1.18 mm (No. 16)	65 to 75
300 µm (No. 50)	12 to 20
150 µm (No. 100)	2 to 5

11.2.3 *Coarse Aggregate Grading*—The coarse aggregate shall meet the requirements for size number 57 of Specification C33/C33M. ~~Take care~~ Use accepted practices in loading and delivery to avoid segregation.

11.2.4 *Preparation of Coarse Aggregate*—~~The coarse aggregate~~ Coarse aggregate from the same lot shall be used for each ~~set~~batch of reference concrete and ~~comparable test admixture-treated concrete shall be essentially the same. Therefore, a set of test concrete consists of one~~each batch of test concrete. The quantity of concrete for Level I testing includes at least three batches of the reference concrete and at least three batches of each test concrete being evaluated. If reference concrete and ~~as many test admixture-containing concretes as are intended to be compared to that one reference. Thus,~~ companion test concrete batches are made the same day, it is permitted to use the same reference concrete to evaluate more than one test concrete. The quantity of coarse aggregate for one set ~~shall consist of enough material for one reference concrete, the test admixture-containing concrete to be compared with that reference and the sample for grading analysis testing.~~of tests shall be sufficient to make all batches of concrete and provide a sample for performing a sieve analysis.

11.2.4.1 Obtain tared containers, one for each batch of concrete to be made and one for the sieve analysis sample. One or more spare containers are recommended in case a concrete batch has to be discarded. Prepare coarse aggregate for a ~~set, comprising a sample large enough for concrete trials,~~ set as follows: Fill tared ~~containers, one each for a sample, a batch of reference concrete and one or more test concretes to the required mass from the aggregate stockpile.~~ containers so that each batch will contain similar particle grading. Accomplish this by ~~starting with a scoopful into the first container and repeat this procedure~~taking scoopfuls from the stockpile and placing them successively into each container until all containers have their required mass. ~~Repeat the process for each of the three or more sets needed. One or more spare sets may be needed.~~ See the Appendix of Practice D75/D75M, Sampling from Stockpiles, and the ~~Manual~~ *Manual of Aggregate and Concrete Testing* for guidance ~~for conditions and procedures.~~on procedures to mitigate segregation.

11.2.5 *Verification of Grading*—Test the coarse aggregate samples representing each set ~~by~~ in accordance with Test Method C136/C136M ~~requirements for the sieves shown below.~~ . Discard any set for which the sample does not comply with size ~~57. Average test results for samples which comply with size 57 for each sieve size. Discard any set for which the sample deviates from this average by more than the amount shown in column 3. Continue the process of preparation,~~57 requirements of Specification C33/C33M~~testing and averaging until sufficient sets of aggregate within tolerance are obtained.~~ .

Sieve	Specification C33/C33M, No. 57 Percent Passing	Maximum variation from average/passing
1½ in. [37.5-mm]	100	0.0
1.00 in. [25.0-mm]	95 to 100	1.0
½ in. [12.5-mm]	25 to 60	4.0
No. 4 [4.75-mm]	0 to 10	4.0
No. 8 [2.36-mm]	0 to 5	1.0

NOTE 7—All of the The results required for demonstrating compliance under this specification are dependent depend on the uniformity of the aggregate samples prepared and used. Careful, skilled and well-supervised work is essential.

11.3 *Air-Entraining Admixture*—Except when tests are made in accordance with The 11.4 using the air-entraining admixture proposed for specific work, the air-entraining admixture air-entraining admixture used in the concrete mixtures specified in Section 1212 shall be a material such that when used to entrainconform to Specification C260/C260Mthe specified amount of air in the concrete mixture will give concrete of satisfactory resistance to freezing and thawing. The material to be so used will be designated by the person or agency for whom the testing is to be performed. If no material is designated, "neutralized Vinsol resin." shall be used. Accomplish neutralization by treating 100 parts of Vinsol resin with 9 to 15 parts of NaOH by mass. In an aqueous solution, the ratio of water to the resinate shall not exceed 12 to 1 by mass.

TESTS FOR SPECIFIC USES

11.4 *Materials for Tests*—The effects of a chemical admixture on the time of setting and water requirement of concrete are known to vary with the time of its addition during the batching and mixing sequence. To test a chemical admixture for use in specific work, the cement, pozzolan, aggregates, and air-entraining admixture used shall be representative of those proposed for use in the work. Add the chemical admixture in the same manner and at the same time during the batching and mixing sequence as it will be added on the job. Proportion the concrete mixtures to have the cement content specified for use in the work. If the maximum size of coarse aggregate is greater than 1 in. [25.0 mm], screen the concrete over a 1-in. [25.0-mm] sieve prior to fabricating the test specimens.

11.4.1 *Other Use Conditions*—Other conditions are known to affect the overall suitability of the concrete mixture for specific intended uses. These include the temperature of the materials or the surroundings, the humidity, the length of time between mixing and placing, the amount of mixing activity and other factors. These physical conditions may be incorporated into the tests with intention for indicating the potential interactions. These tests would be only for guidance. After incorporation of such test conditions it would not be suitable to expect compliance with this specification requirement.

11.4 *Preparation and Batching*—Prepare all material and make all weighings as prescribed inweigh all materials in accordance with Practice C192/C192M.

12. Proportioning of Concrete Mixtures

12.1 *Proportions*—Except when tests are being made for specific uses, all concrete Concrete shall be proportioned using ACI 211.1–91211.1 to conform to the requirements described in 12.1.1 – 12.1.4. After evaluation of the trial mixtures, aggregate proportions shall be adjusted as needed to obtain workable, cohesive mixtures with the correct yield to obtain the required contents. Unless otherwise specified, the admixture shall be added with the first increment of mixing water that is added to the mixer.cement contents.

12.1.1 The cement content shall be 517 ± of each batch, based on actual yield, shall be 307 ± 3 kg/m^3 [517 ± 5 lb/yd^3 [307 ±]. The average cement content of the batches of test concrete shall be within 3 kg/m^3]. [5 lb/yd^3] of the average cement content of the batches of reference concrete.

12.1.2 For the first trial mixture, refer to the table on volume of coarse aggregate per unit volume of concrete in ACI 211.1–91211.1 for guidance on the amount of coarse aggregate to use, given thea nominal maximum size of the aggregate25.0 mm [1 in.] and the fineness modulus of the fine aggregate being used.

12.1.3 For the non-air-entrained mixtures, the air content used in calculating the proportions shall be 1.5, as shown in Table number 5.3.3 of ACI 211.1–91. 1.5 %. For the air-entrained mixtures, the air content used for this purpose shall be 5.5.5.5 %.

12.1.4 Adjust the water content to obtain a slump of 390 ± 15 mm [3½ ± ½ in. [90 ± 15 mm].in.]. The workability of the concrete mixture shall be suitable for consolidation by hand rodding and the concrete mixture shall have the minimum water content possible. Achieve these conditions by final adjustments in the proportion of fine aggregate to total aggregate or in the amount of total aggregate, or both, while maintaining the yield and slump in the required ranges.

12.2 *Conditions—Adding Admixture to Test Concrete*—Prepare concrete mixtures both with and without the admixture under test. Refer herein to the concrete mixture without the chemical admixture as the reference or control concrete mixture. Except in the case of Except for a Type S admixture, add the admixture in the manner recommended by the manufacturer and in the amount necessary to comply with the applicable requirements of the specifications for water reduction or time of setting, or both. WhenIf desired by the person or agency for whom the tests are being performed, the admixture is allowed to be added in an amount such as to produce a specific time of setting of the concrete mixture within the limits of the applicable provisions of this specification. A Type S admixture shall be tested at a dosage within the range recommended by the manufacturer for field use.

12.2.1 *Non-Air-Entrained Concrete*—~~When~~If the admixture is to be tested for use only in non-air-entrained concrete, the average air ~~content~~contents of ~~both the mixture containing the admixture under test~~ the test concrete and the reference concrete ~~mixture shall be 3.5 % or less,~~ shall not exceed 3.5 %, and the difference between the average air contents of the two ~~mixtures~~categories shall not exceed ~~1.0.~~ 1.0 percentage point. If necessary, the air-entraining admixture shall be added to the reference concrete ~~mixture.~~ to obtain an air content within 1 percentage point of the test concrete. Tests for resistance to cyclic freezing and thawing shall not be made.

12.2.2 *Air-Entrained Concrete*—If the admixture is to be tested for use ~~only in air-entrained concrete, the air-entraining admixture shall be added to the reference concrete mixtures and, if necessary, to the concrete mixtures containing the admixture under test in sufficient amounts to produce air contents in the range 3.5 to 7.0 %, except that for tests for resistance~~ in air-entrained concrete that will be exposed to freezing and ~~thawing, the range~~ thawing while wet, the air content of the reference concrete and test concrete shall be 6.0 ± 1.0 %. ~~In both cases the~~ The difference between the average air content from the batches of the reference ~~mixtures~~concrete and the average air content from the batches of the ~~concrete containing the admixture under test shall not exceed 0.5 %.~~test concrete shall not exceed 0.5 percentage points. Air contents of individual pairs of batches of test and reference concretes are not required to fall within the 0.5 % requirement. Tests for resistance to cyclic freezing and thawing shall be conducted in accordance with Test Method C666/C666M, Procedure A.

13. Mixing

13.1 Machine mix the concrete ~~as prescribed in~~in accordance with Practice C192/C192M.

14. Tests and Properties of Freshly Mixed Concrete

14.1 Samples of freshly mixed concrete from at least three separate batches for each ~~condition~~category of concrete shall be tested in accordance with the methods described in 14.2 – 14.5.

14.2 *Slump*—Test Method C143/C143M.

14.3 *Air Content*—Test Method C231/C231M.

14.4 *Density of Fresh Concrete*—Test Method C138/C138M.

14.5 *Time of Setting*—Test Method C403/C403M, except that the temperature of each of the ingredients of the concrete mixtures, just ~~prior to~~ before mixing, and the temperature at which the time-of-setting specimens are stored during the test period shall be ~~73 ± 3 °F [23.0 ± 2.0 °C].~~23.0 ± 2.0 °C [73.5 ± 3.5 °F]. Compare the average of the results from the specimens of the test ~~mixtures~~concrete with the average of the results from the specimens of the reference ~~mixtures.~~concrete.

14.6 *Water Content:*

14.6.1 Report the water-cement ratio of the concrete, computed to the nearest 0.001, as follows: Determine the net ~~water content of~~ mass of water in the batch as the ~~weight~~mass of water in the batch in excess of that present as absorbed water in the aggregates. ~~Calculate the actual volume of concrete in the batch by determining the density of concrete in the batch as prescribed in Test Method C138/C138M.~~ Determine the water-cement ratio by dividing the net ~~weight~~mass of water by the ~~weight~~mass of cement in the batch.

14.6.2 Calculate the volume of concrete in the batch by dividing the total mass of the materials in the batch by the density measured in accordance with Test Method C138/C138M. Record the volume to the nearest 0.001 m^3 [0.1 ft^3].

14.6.3 Calculate the water content, in units of kg/m^3 [lb/ft^3], of each batch by dividing the net mass of water in the batch by the volume of the batch. Calculate the relative water content of the ~~concrete containing the admixture under test~~ test concrete as a percentage of the water content of the reference concrete ~~as follows: Divide~~ by dividing the average water content of ~~all~~the batches of ~~concrete containing the admixture under test~~ the test concrete by the average water content of ~~all~~the batches of the reference concrete and ~~multiply~~multiplying the quotient by ~~100.~~100 %.

15. Preparation of Test Specimens

15.1 ~~Make~~ As required by Section 16, make specimens for tests of hardened concrete, representing each test and ~~age of test and each condition of concrete being compared,~~ test age from at least three separate ~~batches, and the minimum number of specimens shall~~batches for each category of concrete. Table 2 ~~be as prescribed in~~shows the minimum number ~~Table 2. On a given day make~~ of specimens to be made from three batches of each category (see Note 8). Make at least one specimen for each test and test age ~~of test~~ from each ~~condition~~batch of concrete, except make at least two specimens for the freezing and thawing test from each ~~condition~~batch of concrete. ~~If desired, the~~ The preparation of all specimens can be completed in one, two, or three days of mixing, provided the same number of batches of test concrete and ~~its~~ reference concrete are made on the same day.

NOTE 8—More than the minimum number of specimens should be prepared for tests of hardened concrete to provide replacements for specimens that may be found to be faulty or not consolidated properly (see 15.2).

15.2 ~~*Manifestly Faulty*~~*Examination of Specimens*—Visually examine ~~each group of specimens representing a given test or a given age of test, including tests of freshly mixed concrete, before or during the test, or both, whichever is appropriate. Discard any specimen~~ all specimens after removal from their molds. If any specimen is found to be ~~manifestly faulty by such examination~~

TABLE 2 Types and Minimum Number of Specimens and Tests

Test	Number of Types of Specimens[A]	Number of Test Ages	Number of Conditions of Concrete[B]	Batches for Each Category of Specimens, min Concrete	Number of S
Water content	...	1	2	C	
Water content	1	2	3	A	
Slump	1	1	2	C	
Slump	1	2	3	A	
Air content	1	1	2	C	
Air content	1	2	3	A	
Time of setting	1	D	2	6	
Time of setting	B	2	3	6	
Compressive strength					
Types B, C, and E	1	5	2	30	
Types B, C, E, and S	5	2	3	30	
Types A, D, and S	1	6	2	36	
Types A and D	6[C]	2	3	36	
Types F and G	1	7	2	42	
Types F and G	7[C]	2	3	42	
Flexural strength	1	3	2	18	
Flexural strength	3	2	3	18	
Freezing and thawing	1	1	2	12	
Freezing and thawing	1	2	3	12[D]	
Length change	1	1	2	6	
Length change	1	2	3	6	

[A] See Section 14 and 16.2.
[B] See 12.2.
[A] Determined on each batch of concrete mixed.
[B] See 14.4 14.5.
[C] Includes test ages for demonstrating provisional compliance.
[D] Two specimens per batch. For other tests of hardened concrete, one specimen per test age for each batch.

without faulty, it shall be discarded (see Note 9 testing. Visually examine all specimens representing). In addition, measure and record the mass of each type of specimen. Note any specimen that appears to have a low mass, which may indicate inadequate consolidation. Visually examine specimens after testing and note any unexpected conditions. If test results for such noted specimens are statistical outliers, discard the results for those specimens. Use Practice E178 a given test at a given age after testing, and should any specimen be found to be manifestly faulty the test results thereof shall be disregarded. Should to establish if a test result is a statistical outlier. It is permitted to substitute outliers with test results from replacement specimens. The test result reported for each category of concrete and test age shall be the average of the individual test determinations of the specimens tested. If one specimen or one test determination is discarded without replacement, it shall be the average of the remaining test determinations. If more than one specimen representing a given test at a given age be is found manifestly faulty either before or after testing, the entire test testing and replacement specimens are not available, the test results shall be disregarded and repeated. The test result reported shall be the average of the individual test results of the specimens tested or, in the event that one specimen or one result has been discarded, it shall be the average of the test results of the remaining specimens. the test shall be repeated.

NOTE 9—Examples of faulty specimens include specimens with evidence of incomplete consolidation, specimens damaged during mold removal, or defective placement of gage studs in length change prisms.

16. Test Specimens of Hardened Concrete

16.1 *Number of Specimens*—Six or more Make at least three batches for each category of concrete to be compared. For each batch, make at least two test specimens for the freezing and thawing test and three or more test specimens tests and at least one test specimen for each other type of test and age of test specified test age indicated in Table 2 shall be made for each condition of concrete to be compared. . The number of test ages for compressive strength includes test ages for demonstrating provisional compliance.

16.2 *Types of Specimens*—Specimens made from concrete with and without the chemical admixture under test shall be prepared in accordance with the following:

16.2.1 *Compressive Strength*—Make and cure test specimens 150 by 300 mm [6 by 12 in.] or 100 by 200 mm [4 by 8 in.] cylinders in accordance with Practice C192/C192M.

16.2.2 *Flexural Strength*—Make and cure test specimens beams with a cross-section of 75 by 75 mm [3 by 3 in.] in accordance with Practice C192/C192M.

16.2.3 *Resistance to Freezing and Thawing*—Test specimens shall consist of prisms Prisms shall be made and cured in accordance with the applicable requirements of Practice C192/C192M. Test specimen Prism dimensions shall be as required by