



Designation: C1602/C1602M – 22

Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete¹

This standard is issued under the fixed designation C1602/C1602M; 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 specification covers the compositional and performance requirements for water used as mixing water in hydraulic cement concrete. It defines sources of water and provides requirements and testing frequencies for qualifying individual or combined water sources. In any case where the requirements of the purchaser differ from these in this specification, the purchaser's specification shall govern.

1.2 This specification does not purport to cover methods of storage, transportation, or blending of water, or to address the development and maintenance of quality control programs sponsored or managed by the manufacturer.

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 are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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.*

¹ This specification is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.40 on Ready-Mixed Concrete.

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2. Referenced Documents

2.1 ASTM Standards:²

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C33/C33M Specification for Concrete Aggregates

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C94/C94M Specification for Ready-Mixed Concrete

C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens)

C114 Test Methods for Chemical Analysis of Hydraulic Cement

C125 Terminology Relating to Concrete and Concrete Aggregates

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency

C403/C403M Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

C1603 Test Method for Measurement of Solids in Water

2.2 ACI Documents:³

ACI 318 Building Code Requirements for Structural Concrete and Commentary

3. Terminology

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

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *combined water, n*—a mixture of two or more sources of water blended together, before or during introduction into the mixture, for use as mixing water in the production of concrete.

3.2.2 *non-potable, adj*—water sources that are not fit for human consumption, or if it contains quantities of substances

² 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.

³ Available from American Concrete Institute (ACI), 38800 Country Club Dr., Farmington Hills, MI 48331-3439, http://www.concrete.org.

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

that discolor it or make it smell or have objectionable taste but does not contain water from concrete production operations.

3.2.3 *potable water, n*—water suitable for human consumption

3.2.4 *water from concrete production operations, n*—water recovered from processes of hydraulic cement concrete production that includes wash water from mixers or that was a part of a concrete mixture; water collected in a basin as a result of storm water runoff at a concrete production facility; or water that contains quantities of concrete ingredients.

4. Requirements for Use

4.1 Mixing water shall consist of:

4.1.1 Batch water (water weighed or metered through the batch plant),

4.1.2 Ice,

4.1.3 Water added by truck operator,

4.1.4 Free moisture on the aggregates, and

4.1.5 Water introduced in the form of admixtures when this water increases the water-cementitious materials ratio by more than 0.01.

4.2 Potable water is permitted to be used as mixing water in concrete without testing for conformance with the requirements of this specification.

4.3 Mixing water that is wholly or partially composed of sources of water that are non-potable or from concrete production operations are permitted to be used in any proportions to the limits qualified to meet the requirements of **Table 1**. At the option of the purchaser and when appropriate for the construction, any of the optional limits found within **Table 2** shall be specified at the time of concrete ordering according to the section on *Ordering Information* of Specification **C94/C94M**.

4.3.1 Non-potable sources of water shall be qualified for use in accordance with **5.1**. When required by the purchaser, requirements of **5.4** shall also apply. When the non-potable water source is blended with a potable source, the qualification of the mixing water shall be at the highest percentage of the non-potable source in the combined mixing water anticipated during production.

4.3.2 Combined water blended from two or more sources, where one of the sources includes that from concrete production, shall be qualified for use in accordance with **5.2**. When required by the purchaser, requirements of **5.4** shall also apply. The combined water shall be qualified at the highest solids content in the total mixing water anticipated during

production. Mixing water containing total solids equal to or less than the level qualified by testing shall be permitted.

5. Testing and Requirements

5.1 For sources of non-potable mixing water (as defined in **3.2.2**) proposed for use as total mixing water or in the combined mixing water (as defined in **3.2.1**), the following shall apply to the total combined mixing water:

5.1.1 Water shall be tested for compliance with **Table 1** before first use and thereafter every three months or more often when there is reason to believe that a change has occurred in the characteristics of the source. Testing is permitted to be at a lower frequency, but not less than annually when results from four consecutive tests indicate compliance with **Table 1**. Testing shall be in accordance with **5.3**.

5.2 For sources of water from concrete production operations (as defined in **3.2.4**) proposed for use as the total mixing water or in the combined mixing water (as defined in **3.2.1**), the following shall apply to the total combined mixing water:

5.2.1 The density of the water from concrete production operations shall be tested at least on a daily basis in accordance with Test Method **C1603** or monitored with a hydrometer that has been verified in accordance with Test Method **C1603**. Manufacturers that use automated devices shall maintain at the production facility documentation on the procedures and calibration of systems, as needed (see **Note 1**).

NOTE 1—Blending proportions of water sources can be determined in accordance with Appendix XI of Test Method **C1603** for achieving a target solids content.

5.2.2 Combined water shall be tested for compliance with the requirements of **Table 1**, in accordance with **5.3**, at the highest solids content anticipated to be used during production in accordance with the following testing frequencies:

5.2.2.1 When the density of the combined water is less than 1.01 g/mL, the water shall be tested before first use and thereafter once every six months. Testing frequency is permitted to be reduced to once every 12 months when the results of two consecutive tests indicate compliance with the requirements of **Table 1** (see **Note 2**).

NOTE 2—This condition is intended to cover the use of clarified wash water that has been passed through a settling pond system.

5.2.2.2 When the density of the combined water is between 1.01 and 1.03, the water shall be tested before first use and thereafter monthly. Testing frequency is permitted to be reduced to once every three months when the results of four consecutive tests indicate compliance with the requirements of **Table 1** (see **Note 3**).

NOTE 3—Water density of 1.03 approximately represents a total solids content of 50 000 ppm.

5.2.2.3 When the density of the combined water exceeds 1.03, the water shall be tested weekly or more often when there is reason to believe that there is a change in the water characteristics for compliance with the requirements of **Table 1**. Testing frequency is permitted to be reduced to once every month when the results of two months of consecutive tests indicate compliance with the requirements of **Table 1**.

TABLE 1 Performance Requirements for Mixing Water

	Limits
Compressive strength, min % control at 7 days ^A	90
Time of setting, deviation from control, h: min ^A	From 1:00 earlier to 1:30 later

^A Comparisons shall be based on fixed proportions for concrete or mortar mixtures. The control mixture shall be made with potable water. The test mixture shall be made with the mixing water that is being evaluated (see **Annex A1**).

TABLE 2 Optional Chemical Limits for Combined Mixing Water^A

	Limits	Test Method
Maximum concentration in combined mixing water, ppm ^B		
A. Chloride as Cl ⁻ , ppm		
1 in prestressed concrete, bridge decks, or otherwise designated	500 ^C	C114 ^D
2 other reinforced concrete in moist environments or containing aluminum embedments or dissimilar metals or with stay-in-place galvanized metal forms	1 000 ^C	C114 ^D
B. Sulfate as SO ₄ , ppm	3 000	C114 ^D
C. Alkalies as (Na ₂ O + 0.658 K ₂ O), ppm	600	C114 ^D
D. Total solids by mass, ppm	50 000	C1603

^A Specification limits from this table are not prohibited from being specified as individual items or as a whole in accordance with the section on Ordering Information of Specification **C94/C94M**.

^B ppm is the abbreviation for parts per million.

^C The requirements for concrete in ACI 318 shall govern when the manufacturer can demonstrate that these limits for mixing water can be exceeded. For conditions allowing the use of calcium chloride (CaCl₂) accelerator as an admixture, the chloride limitation is permitted to be waived by the purchaser.

^D Test Methods **C114** includes reference and alternative test methods to measure the concentration of chlorides, sulfates, and alkalis in solutions prepared from dissolving cementitious materials. Use the applicable test methods in Test Methods **C114** to measure these constituents. The laboratory performing these tests is not required to conform to the method qualification requirements of Test Methods **C114**. Alternative instrumental and wet chemistry methods not listed in Test Methods **C114** that measure the concentration of these chemical species in solution are permitted. When alternative methods are used, the test method used shall be included in the report.

5.2.2.4 Testing for water with density exceeding 1.05 shall be the same as that of 5.2.2.3 whether the water includes or does not include an extended set control admixture (see Note 4).

NOTE 4—Water density exceeding approximately 1.05, where the solids are essentially composed of cementitious materials, may require the use of extended set control admixtures to maintain compliance with the requirements of Table 1. The producer should have a documented process in place to verify the effectiveness of the admixtures and dosages employed.

5.3 Testing to verify compliance with the requirements of Table 1 shall be conducted in accordance with Annex A1. A test batch with the mixing water to be qualified shall be compared with a control batch prepared with potable water (see Note 5). One of options 5.3.1, 5.3.2 or 5.3.3 shall be used:

5.3.1 *Using Samples from Production Batches:*

5.3.1.1 Concrete specimens from production batches for strength tests shall be cast and standard cured in accordance with Practice **C31/C31M**. Compressive strength test results for each batch shall be the average of at least two standard specimens made from a composite sample.

5.3.2 *Using Laboratory Concrete batches:*

5.3.2.1 Laboratory concrete batches shall be prepared in accordance with Practice **C192/C192M**. Specimens for compressive strength shall be prepared and cured in accordance with Practice **C192/C192M**. Compressive strength test results for each batch shall be the average of at least two standard specimens.

5.3.3 *Using Laboratory Mortar Batches:*

5.3.3.1 For mortar batches use concrete sand complying with Specification **C33/C33M**. Mortars shall be prepared in accordance with Practice **C305** with one part portland cement and 2.25 parts sand by mass and a w/cm of 0.50 ± 0.02. Batch size shall be at least 20 % greater than the quantity required for strength test specimens and time of setting tests.

5.3.3.2 Prepare at least three 50-mm [2-in.] mortar cubes for each batch. Strength test specimens shall be standard cured in accordance with Test Method **C109/C109M**.

5.3.4 Strength of concrete cylindrical specimens shall be determined at 7 days in accordance with Test Method **C39/C39M**.

5.3.5 Strength of mortar cubes shall be determined at 7 days in accordance with Test Method **C109/C109M**.

5.3.6 Time of setting shall be measured in accordance with Test Method **C403/C403M**.

5.4 For the optional requirements in Table 2, the manufacturer shall maintain documentation of the chemical concentrations of chlorides, sulfates and alkalies in the sources of non-potable water or water from concrete production operations. These tests shall be conducted before first use and thereafter once every 6 months, or more often when there is reason to believe that a change has occurred in the characteristics of the source. Unless otherwise specified and when required by the purchaser, the requirements of Table 2 shall apply to the combined water as in accordance with 4.3.1 and 4.3.2. This information shall be provided to the purchaser on request (see Note 5).

NOTE 5—The sampling of total combined water in its final form from either the batch plant or transportation unit is impractical. Therefore, for the purposes of testing for compliance to the requirements of Table 1 and Table 2, it is acceptable to sample, proportion, and combine the individual sources of water to produce a test sample that is representative of the actual combined mixing water used in production. For concentrations of chlorides, sulfates, and alkalies, it is acceptable to perform measurements on the non-potable water source or on water from concrete production and to calculate the concentration in the combined water.

6. Keywords

6.1 combined water; density; extended set control admixture; mixing water; recycled water