



Designation: C1898 – 20

Standard Test Methods for Determining the Chemical Resistance of Concrete Products to Acid Attack¹

This standard is issued under the fixed designation C1898; 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 These test methods are intended to evaluate the chemical resistance of cement paste, mortar and concrete materials. This method is loosely based on Test Methods C267, however the solution is more rigorously defined and flexural strength is used. These test methods provide for the determination of changes in the following properties of the test specimens and test medium after exposure of the specimens to the medium:

- 1.1.1 Mass of specimen,
- 1.1.2 Appearance of specimen,
- 1.1.3 Appearance of test medium, and
- 1.1.4 Strength of specimens.

1.2 Guide C1894 provides a standard guide for Microbially Induced Corrosion of Concrete (MICC) products. This standard is used for assessing the chemical resistance of cementitious products to acid attack caused by MICC; however as described in the guideline document for MICC products the current document only applies for Stage III of corrosion. This document is not intended to be a guideline document for the complete evaluation of MICC or for assessing the efficacy of antimicrobial additives used to reduce MICC.

1.3 This standard supplements Test Methods C267 to improve the consistency of reported results for acids generated by MICC or other sources.

1.4 This standard does not cover tests in which acidification is achieved by bacterial activity. Testing protocols for bacterial activity are described in Guide C1894.

1.5 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to alternative units (typically inch-pound units) that are provided for information only and are not considered standard.

1.6 *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 appro-*

priate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

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:*

- C14 Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe
- C78/C78M Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
- C125 Terminology Relating to Concrete and Concrete Aggregates
- C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
- C267 Test Methods for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacing and Polymer Concretes
- C822 Terminology Relating to Concrete Pipe and Related Products
- C904 Terminology Relating to Chemical-Resistant Nonmetallic Materials
- C1768/C1768M Practice for Accelerated Curing of Concrete Cylinders
- C1894 Guide for Microbially Induced Corrosion of Concrete Products
- E4 Practices for Force Verification of Testing Machines

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this standard, refer to Terminology standards C125 and C822.

4. Significance and Use

4.1 As described in Guide C1894, the MICC is considered to be a three-stage process with the reduction in pH (Stage I) (for example, 12.5 > pH > 9-10), the establishment of biofilms which further lowers the pH (Stage II) (for example, 9-10 > pH > 4-6) and eventual deterioration due to biogenic acid exposure

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(Stage III) (for example, $< \sim 4$ pH). This document provides standard test methods to assess the effects of acid in Stage 3 for concrete.

4.2 As described in Guide **C1894**, acid immersion testing should be used with great caution in specifying concrete as this is a final stage of deterioration and the concrete may not be exposed to the conditions of this test.

4.3 The results obtained by these test methods should serve as a guide in, but not as the sole basis for, selection of a chemical-resistant material for a particular application. No attempt has been made to incorporate into this test method all the various factors that may affect the performance of a material when subjected to actual service.

5. Apparatus

5.1 *Equipment*, capable of weighing materials or specimens to $\pm 0.3\%$ accuracy.

5.2 *Equipment for Mixing*, consisting of a container of suitable size, preferably made of corrosion-resistant metal, or a porcelain pan, and a strong, sturdy spatula or trowel.

5.3 *Specimen Molds: Equipment*—Molds to manufacture concrete prisms with dimensions 50 by 50 by 200 mm (± 3 mm) for acid immersion testing.

NOTE 1—The material from which the mold is constructed must be chemically inert and have antistick properties. Polyethylene, polypropylene, polytetrafluoroethylene, and metal forms having either a sintered coating of tetrafluoroethylene or a suitable release agent compatible with the material being tested are satisfactory.

5.4 *Massing Equipment*, of adequate capacity, suitable for accurate weighing to 0.001 g.

5.5 *Micrometer*, suitable for accurate measurement to 0.03 mm (0.001 in.).

5.6 *Containers*:

5.6.1 *Wide-Mouth Glass Jars*, of sufficient capacity, fitted with plastic or plastic-lined metal screw caps for low-temperature tests involving media of low volatility.

5.6.2 *Erlenmeyer Flasks*, of sufficient capacity, each fitted with standard-taper joints and a reflux condenser attachment for use with volatile media.

5.6.3 *Containers*, as described in 5.6.1 and 5.6.2 having an inert coating on their inner surfaces, or containers of a suitable inert material for use with media which attack glass.

5.7 *Testing Machine*—May be of any type of sufficient capacity which will meet the requirements of Test Method **C78/C78M**.

5.8 *Equipment*—A benchtop pH meter with an accuracy of ± 0.01 .

6. Test Media

6.1 Two test media shall be used: a sulfuric acid concentration resulting in a pH of 2.00 and a pH of 0.50 (**Note 2**).

6.2 pH of the test Media shall be prepared to ± 0.03 .

NOTE 2—The pH of the solution can be modified to better simulate anticipated service life conditions however this must be noted and reported.

7. Test Specimens

7.1 The number of specimens required is dependent upon the number of test media to be employed, the number of different temperatures at which testing is performed, and the frequency of test intervals. The test specimens shall consist of sets of a minimum of three prisms for one medium at a single temperature and for each test interval. In addition, one set of at least three specimens shall be available for test immediately following the conditioning period, and other sets of at least three, equivalent to the number of test temperatures, for the total test period. Calculate the total number of specimens required as follows:

7.2 Make all specimens for a single determination from a single mix.

7.3 The specimens will be prisms (with dimensions 50 by 50 by 200 mm (± 3 mm)).

8. Preparation of Specimens

8.1 *Specimen Preparation*—Specimens shall be made in accordance with Practice **C192/C192M**.

9. Conditioning

9.1 Cure the specimens in the mold in a moist cabinet maintained at a temperature of $23 \pm 2^\circ\text{C}$, ($73 \pm 4^\circ\text{F}$) and a relative humidity of not less than 98 % or under wet mats, for 28 days, with the specimens being removed from the molds at the age of 24 h.

10. Test Conditions

10.1 The testing temperature shall be $23 \pm 2^\circ\text{C}$ ($73 \pm 4^\circ\text{F}$) (**Note 3**).

NOTE 3—The testing temperature can be modified to better simulate anticipated service life conditions however this must be noted and reported.

10.2 Test medium as described in Section 6.

10.2.1 A solution-to-sample volume ratio of 4.2:1 shall be used.

10.2.2 The samples were elevated from the bottom of the containers to prevent uneven exposure.

10.2.3 The pH of the solution shall be measured every 7 days and replaced with newly prepared solution.

10.2.4 The solutions are not agitated or stirred during each 7 day immersion cycle.

11. Procedure

11.1 *Measurement of Specimens*:

11.1.1 Immediately following the conditioning period, measure the cross-sectional dimensions of all test specimens to the nearest 250 μm (0.01 in.) using a micrometer. Take two measurements for each dimension at mid-height and perpendicular to the load axis and average them.

11.2 *Exposure, Weighing, and Visual Inspection of Test Specimens*—Following the conditioning period, record the mass of all the specimens to the nearest 0.001 g on an analytical balance and record the values. Prior to immersion, record a brief description of the color and surface appearance

of the specimens and the color and clarity of the test medium. Place the massed specimens in a suitable container or containers, taking care to prevent the faces from coming in contact with each other. The total number of specimens per container is not limited except by the ability of the container to hold the specimens, plus the required amount of test medium per specimen. Add sufficient quantity of the test medium to completely immerse each specimen, and place the closed container in a constant-temperature oven adjusted to the required temperature or in a suitably adjusted liquid bath. Examine the specimens after 1, 7, 14, 28, 56, and 84 days of immersion to determine the rate of attack.

NOTE 4—Other inspection periods may be employed, and the test method may be terminated prior to 84 days if desired.

11.2.1 At each interval the samples shall be removed from their respective containers and brushed with a stiff-bristle plastic brush to remove loose material.

11.2.2 Clean the specimens by three quick rinses in running cold tap water and quick dry by blotting with a paper towel between each rinse. For each test specimen prepared after final blotting, allow the specimen to dry for ½ h before massing. Mass all specimens to the nearest 0.001 g.

11.2.3 Note any indication of surface attack on the specimen, any discoloration of the test medium, and the formation of any sediment.

11.3 *Changing of Test Medium*—The solution shall be replaced every 7 days.

11.4 *Flexural Testing of Specimens:*

11.4.1 Determine the flexural strength for one set of specimens after each desired inspection period for each medium and each test temperature and for one set of specimens after aging in water for the total test period at the test temperature.

11.4.2 The elapsed time between the removal of the specimens from the test medium and testing should be uniform for all specimens.

11.4.3 Perform the flexural tests at $23 \pm 2^\circ\text{C}$ ($73 \pm 4^\circ\text{F}$).

11.4.4 Perform the flexural tests, using third-point loading, in compliance with Test Method **C78/C78M** (Note 5). Load the test specimen to failure and record the maximum load. Calculate the flexural strength using the specimen dimensions from immediately before the specimen was placed in the test medium.

NOTE 5—Surface damage may require a strong plaster of paris (for example, Hydrostone or equivalent) or an equivalent material to be applied to the locations where the beam comes in contact with the loading rollers.

11.4.5 *Change in Strength*—Calculate to the nearest 0.01 % the percentage decrease or increase in strength of the specimen during immersion for each examination period, taking the strength after conditioning as 100 %.

$$\text{Change in flexural strength (\%)} = [(S_1 - S_2)/S_1] \times 100\% \quad (1)$$

where:

S_1 *average flexural* = strength of a set of specimens following the conditioning period in MPa (psi), and

S_2 *average flexural* = strength of a set of specimens following the test period in MPa (psi).

11.4.5.1 Construct a graph employing the percentage of change in average strength of the specimens broken at a given examination period after immersion in a particular test medium at a given temperature, plotting the percentage of change in strength as the ordinate and the test period, in days, as the abscissa.

11.4.5.2 The absolute strength should be shown for the initial specimen (100 % value) and the final specimen. These values should be noted parenthetically near the plot point of each value.

11.5 *Mass Change of Tested Specimens:*

11.5.1 *Mass Change*—Calculate to the nearest 0.01 % the percentage loss or gain in mass of the specimens during immersion for each examination period, taking the conditioned weight as 100 % as follows (Note 6):

$$\text{Change in mass (\%)} = [(W - C)/C] \times 100\% \quad (2)$$

where:

C = conditioned mass of specimen, g, and

W = mass of specimen after immersion, g.

NOTE 6—A result showing a plus (+) sign shall indicate a gain in weight and a minus (–) sign shall indicate a loss.

11.5.1.1 Construct a graph employing the average percentage of mass change of all the specimens at a given examination period after immersion in a particular test medium at a given temperature, plotting the percentage of mass change as the ordinate and the test period, in days, as the abscissa

12. Interpretation of Results

12.1 *Mass Change*—The rate of weight change with time is of more significance than the actual value at any time. A plot of the test results will indicate whether a particular material will approach constant mass in time or will continue to change in weight as the test progresses.

12.2 *Appearance of Specimen*—Visual inspection of the exposed specimen for surface cracks, loss of gloss, etching, pitting, softening, etc., is very important in cases where initial mass changes are high.

12.3 *Appearance of Test Medium*—Discoloration of the test medium and the formation of sediment are significant factors. An initial discoloration coupled with a high mass loss may indicate extraction of soluble components.

12.4 *Change in Flexural Strength*—The rate of flexural strength change with time is of more significance than the actual value at any time. A plot of the test results will indicate whether a particular material will approach constant flexural strength in time or will continue to change as the test progresses.

13. Report

13.1 Report the following information:

13.1.1 Mixture proportions by mass.

13.1.2 Any deviations from the prescribed conditioning procedures.