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INTERNATIONAL

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Standard Test Method for
Determination of Length Change of Concrete Due to Alkali-Silica Reaction[1]

This standard is issued under the fixed designation C 1293; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope *

1.1 This test method covers the determination, by measurement of length change of concrete prisms, of the susceptibility of an aggregate for participation in expansive alkali-silica reaction.

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

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound values in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*
C 33 Specification for Concrete Aggregates[2]
C 125 Terminology Relating to Concrete and Concrete Aggregates[2]
C 138 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete[2]
C 143/C 143M Test Method for Slump of Hydraulic–Cement Concrete[2]
C 150 Specification for Portland Cement[3]
C 157 Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete[2]
C 192/C 192M Practice for Making and Curing Concrete Test Specimens in the Laboratory[2]
C 227 Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)[2]
C 289 Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)[2]
C 294 Descriptive Nomenclature for Constituents of Concrete Aggregates[2]
C 295 Guide for Petrographic Examination of Aggregates for Concrete[2]

C 490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete[3]
C 511 Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks [3]
C 702 Practice for Reducing Samples of Aggregate to Testing Size[2]
C 856 Practice for Petrographic Examination of Hardened Concrete[2]
C 1260 Test Method for Potential Alkali Reactivity of Aggregates (Mortar Bar Method)[2]
D 75 Practice for Sampling Aggregates[3]
D 1193 Specification for Reagent Water[4]
2.2 *CSA Standards:*[5]
CSA A23.1-00 Concrete Materials and Methods of Concrete Construction, Appendix B
CSA A23.2-14A-00 Potential Expansivity of Aggregates (Procedure for Length Change due to Alkali-Aggregate Reaction in Concrete Prisms)
CSA A23.2-27A-00 Standard Practice to Identify Degree of Alkali-Reactivity of Aggregates and to Identify Measures to Avoid Deleterious Expansion in Concrete

3. Terminology

3.1 Terminology used in this standard is as given in Terminology C 125 or Descriptive Nomenclature C 294.

4. Significance and Use

4.1 Alkali-silica reaction is a chemical interaction between some siliceous constituents of concrete aggregates and hydroxyl ions (**1**).[6] The concentration of hydroxyl ion within the concrete is predominantly controlled by the concentration of sodium and potassium (**2**).

4.2 This test method is intended to evaluate the potential of an aggregate to expand deleteriously due to any form of alkali-silica reactivity (**3,4**).

4.3 When selecting a sample or deciding on the number of samples for test, it is important to recognize the variability in

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[1] This test method is under the jurisdiction of Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.26 on Chemical Reactions.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.
[3] *Annual Book of ASTM Standards*, Vol 04.01.

[4] *Annual Book of ASTM Standards*, Vol 11.01.
[5] Canadian Standards Association Standards for Concrete Construction, 173 Rexdale Blvd., Rexdale, Ontario Canada, M9W1R3.
[6] The boldface numbers in parentheses refer to the list of references at the end of this test method.

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

lithology of material from a given source, whether a deposit of sand, gravel, or a rock formation of any origin. For specific advice, see Guide C 295.

4.4 This test method is intended for evaluating the behavior of aggregates in an alkaline environment. This test method assesses the potential for deleterious expansion of concrete caused by alkali-silica reaction, of either coarse or fine aggregates, from tests performed under prescribed laboratory curing conditions that will probably differ from field conditions. Thus, actual field performance will not be duplicated due to differences in wetting and drying, temperature, other factors, or combinations of these (5).

4.5 Results of tests conducted as described herein should form a part of the basis for a decision as to whether precautions should be taken against excessive expansion due to alkali-silica reaction. This decision should be made before a particular aggregate is used in concrete construction. Criteria to determine the potential deleteriousness of expansions measured in this test are given in Appendix X1.

4.6 The basic intent of this test method is to develop information on a particular aggregate at a specific alkali level of 5.25 kg/m^3(8.85 lb/yd^3). It has been found that this high alkali level is required to detect the effects of certain deleteriously reactive aggregates (3).

4.7 When the expansions in this test method are greater than the limit shown in X1.2, the aggregate is potentially alkali-reactive. Supplemental information should be developed to confirm that the expansion is actually due to alkali-silica reaction. Petrographic examination of the concrete prisms should be conducted after the test using Practice C 856 to confirm that known reactive constituents are present and to identify the products of alkali-silica reactivity. Confirmation of alkali-silica reaction is also derived from the results of the test methods this procedure supplements (see Appendix X1).

4.8 If the supplemental tests show that a given aggregate is potentially deleteriously reactive, additional studies may be appropriate to evaluate preventive measures in order to allow safe use of the aggregate. Preventive measures are mentioned in the Appendix to Specification C 33.

5. Apparatus

5.1 The molds, the associated items for molding test specimens, and the length comparator for measuring length change shall conform to the applicable requirements of Test Method C 157 and Practice C 490, and shall have square cross sections of 75.0 ± 0.7 mm (3.00 ± 0.03 in.).

5.2 The storage container options required to maintain the prisms at a high relative humidity are described in 5.2.1.

5.2.1 *Recommended Container*—The recommended containers are 22-L (5.8-gal) polyethylene pails with airtight lids and approximate dimensions of 250- to 270-mm (9.8- to 10.6-in.) diameter at bottom, 290 to 310 mm (11.4 to 12.2 in.) at top, by 450 to 480 mm (17.7 to 18.9 in.) high.[7] Prevent significant loss of enclosed moisture due to evaporation with airtight lid seal. Place a perforated rack in the bottom of the storage container so that the prisms are 30 to 40 mm (1.2-1.6 in.) above the bottom. Fill the container with water to a depth of 20 ± 5 mm (0.8 ± 0.2 in.) above the bottom. A significant moisture loss is defined as a loss greater than 3 % of the original amount of water placed at the bottom of the pail. Place a wick of absorbent material consisting of polypropylene fibers around the inside wall of the container from the top so that the bottom of the wick extends into the reagent water.

5.2.2 *Alternative Containers*—Alternative storage containers may be used. Confirm the efficiency of the alternative storage container with an alkali-reactive aggregate of known expansion characteristics.[8] The expansion efficiency is confirmed when expansions at one year obtained using the alternative container are within 10 % of those obtained using the recommended container. Alternative storage containers must contain the required depth of reagent water. When reporting results, note the use of an alternative container, if one is used, together with documentation proving compliance with the above.

5.3 The storage environment necessary to maintain the 38.0°C (100.4°F) reaction accelerating storage temperature consistently and homogeneously is described in 5.3.1.

5.3.1 *Recommended Environment*—The recommended storage environment is a sealed space insulated so as to minimize heat loss. Provide a fan for air circulation so the maximum variation in temperature measured within 250 mm (9.8 in.) of the top and bottom of the space does not exceed 2.0°C (3.6°F). Provide an insulated entry door with adequate seals so as to minimize heat loss. Racks for storing containers within the space are not to be closer than 30 mm (1.2 in.) to the sides of the enclosure and are to be perforated so as to provide air flow. Provide an automatically controlled heat source to maintain the temperature at 38.0 ± 2.0°C (100.4 ± 3.6°F) (see Note 1). Record the ambient temperature and its variation within the space to ensure compliance.

NOTE 1—It has been found to be good practice to monitor the efficiency of the storage environment by placing thermocouples inside dummy concrete specimens inside a dummy container within the storage area. The storage room described in Test Method C 227 generally will be satisfactory.

5.3.2 *Alternative Storage Environment*—Use of an alternative storage environment is permitted. Confirm the efficiency of the alternative storage container with an alkali-reactive aggregate of known expansion characteristics.[8] The expansion efficiency is confirmed when expansions at one year obtained using the alternative storage environment are within 10 % of those obtained using the recommended environment. When reporting the results, note the use of an alternative storage environment, if one is utilized, together with documentation proving compliance with the above.

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[7] Polyethylene pails used in the food industry have been found to be suitable. Twenty two-L pails (Model Nos.: pail, 5251; lid, 63493), are available from IPL Products Ltd., 348 Park Street, Suite 201, East Building, North Reading, Mass. 01864.

[8] Non-reactive aggregates and alkali-silica reactive aggregates of known expansion characteristics (6) are available from The Petrographer, Engineering Materials Office, Ministry of Transportation, 1201 Wilson Ave., Downsview, Ontario, Canada, M3M1J8.

6. Reagents

6.1 *Sodium Hydroxide (NaOH)*—USP or technical grade may be used. (**Precaution:** Before using NaOH, review: (*1*) the safety precautions for using NaOH; (*2*) first aid for burns; and (*3*) the emergency response to spills as described in the manufacturers Material Safety Data Sheet or other reliable safety literature. NaOH can cause severe burns and injury to unprotected skin and eyes. Always use suitable personal protective equipment including: full-face shields, rubber aprons, and gloves impervious to NaOH (Check periodically for pinholes.).)

6.2 *Water*:

6.2.1 Unless otherwise indicated, references to water are understood to mean potable tap water.

6.2.2 The references to reagent grade water are understood to mean reagent water as defined by Type III or IV in Specification D 1193.

7. Materials

7.1 *Cement*—Use a cement meeting the requirements for a Type I Portland cement as specified in Specification C 150. The cement must have a total alkali content of 0.9 ± 0.1 % Na_2O equivalent (Na_2O equivalent is calculated as percent Na_2O + $0.658 \times$ percent K_2O). Determine the total alkali content of the cement either by analysis or by obtaining a mill run certificate from the cement manufacturer. Add NaOH to the concrete mixing water so as to increase the alkali content of the mixture, expressed as Na_2O equivalent, to 1.25 % by mass of cement (see Note 2).

Note 2—The value of 1.25 % Na_2O equivalent by mass of cement has been chosen to accelerate the process of expansion rather than to reproduce field conditions. At the 420 kg/m³ (708 lb/yd³) cement content, this corresponds to an alkali level of 5.25 kg/m³ (8.85 lb/yd³).

7.2 *Aggregates*:

7.2.1 To evaluate the reactivity of a coarse aggregate, use a nonreactive fine aggregate. A nonreactive fine aggregate is defined as an aggregate that develops an expansion in the accelerated mortar bar, (see Test Method C 1260) of less than 0.10 % at 14 days (see X1.5 for interpretation of expansion data). Use a fine aggregate meeting Specification C 33 with a fineness modulus of 2.7 ± 0.2.

7.2.2 To evaluate the reactivity of a fine aggregate, use a nonreactive coarse aggregate. Prepare the nonreactive coarse aggregate according to 7.2.3.[8] A nonreactive coarse aggregate is defined as an aggregate that develops an expansion in the accelerated mortar bar (see Test Method C 1260) of less than 0.10 % at 14 days (see X1.5 for interpretation of expansion data). Use a coarse aggregate meeting Specification C 33. Test the fine aggregate using the grading as delivered to the laboratory.

7.2.3 Sieve all coarse aggregates to which this test method is applied and grade in accordance with the requirements in Table 1. Coarse aggregate fractions larger than 19.0-mm (¾-in.) sieve are not to be tested as such. When petrographic examination using Guide C 295 reveals that the material making up the size fraction larger than the 19.0-mm (¾-in.) sieve is of such a composition and lithology that no difference should be expected compared with the smaller size material,

TABLE 1 Grading Requirement

Sieve Size		Mass (%)
Passing	Retained	
19.0-mm (¾-in.)	12.5-mm (½-in.)	33
12.5-mm (½-in.)	9.5-mm (⅜-in.)	33
9.5-mm (⅜-in.)	4.75-mm (No. 4)	33

then no further attention need be paid to the larger sizes. If petrographic examination suggests the larger size material to be more reactive, the material should be studied for its effect in concrete according to one or the other alternative procedures described herein:

7.2.3.1 *Proportional Testing*—Crush material larger than the 19.0-mm (¾-in.) sieve to pass the 19.0-mm (¾-in.) sieve. Grade the material passing the 19.0-mm (¾-in.) sieve as per the Table 1 grading, and proportionally add back to the original minus 19.0-mm (¾-in.) grading so as to include the oversized material in a mass proportion equal to its original grading percentage.

7.2.3.2 *Separated Size Testing*—Crush material larger than the 19.0-mm (¾-in.) sieve to pass the 19.0-mm (¾-in.) sieve, grade that material as per Table 1 and test in concrete as a separate aggregate.

7.3 *Concrete Mixture Proportions*—Proportion the concrete mixture to the following requirements:

7.3.1 *Cement Content*—420 ± 10 kg/m³(708 ± 17 lb/ yd³).

7.3.2 *Volume of Coarse Aggregate Per Unit of Volume of Concrete*—Use a coarse aggregate oven-dry-rodded unit volume of 0.70 ± 0.2 % for all classes of aggregates (for example, low density, normal, and high density).

7.3.3 *Water-Cement Ratio (w/c)*—Maintain w/c in the range of 0.42 to 0.45 by mass. Adjust the w/c within this range to give sufficient workability to permit satisfactory compaction of the concrete in the molds. Report the w/c ratio used.

7.3.4 *Admixture (NaOH)*—Dissolve in the mixing water and add as required to bring the alkali content of the concrete mixture, expressed as Na_2O_e = % Na_2O + $0.658 \times$ % K_2O, up to 1.25 % by mass of cement (see Note 3). Use no other admixture in the concrete.

Note 3—A sample calculation for determining the amount of NaOH to be added to the mixing water to increase the alkali content of the cement from 0.90 % to 1.25 %:

Cement content of 1 m³ concrete	= 420 kg
Amount of alkali in the concrete	= 420 kg × 0.90 %
	= 3.78 kg
Specified amount of alkali in concrete	= 420 kg × 1.25 %
	= 5.25 kg
Amount of alkali to be added to concrete	= 5.25 kg – 3.78 kg
	= 1.47 kg

The difference (1.47 kg) is the amount of alkali, expressed as Na_2O equivalent, to be added to the mix water. Factor to convert Na_2O to NaOH: since

$$(Na_2O + H_2O \rightarrow 2\ NaOH)$$
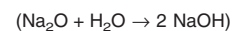
Compound	Molecular Weight
Na_2O	61.98
NaOH	39.997

Conversion factor:

$$2 \times 39.997/61.98 = 1.291; \quad (1)$$

Amount of NaOH required:

$$1.47 \times 1.291 = 1.898\ \text{kg/m}^3 \quad (2)$$

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