Designation: C1293 – 08b (Reapproved 2015)

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

This standard is issued under the fixed designation C1293; 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 of the susceptibility of an aggregate or combination of an aggregate with pozzolan or slag for participation in expansive alkali-silica reaction by measurement of length change of concrete prisms.

1.2 The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard. When combined standards are cited, the selection of measurement system is at the user's discretion subject to the requirements of the referenced standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* (**Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2])

1.4 *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:*[3]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
C33 Specification for Concrete Aggregates
C125 Terminology Relating to Concrete and Concrete 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 Specification for Portland Cement
C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
C227 Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
C289 Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method) (Withdrawn 2016)[4]
C294 Descriptive Nomenclature for Constituents of Concrete Aggregates
C295 Guide for Petrographic Examination of Aggregates for Concrete
C490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete
C494/C494M Specification for Chemical Admixtures for Concrete
C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C702 Practice for Reducing Samples of Aggregate to Testing Size
C856 Practice for Petrographic Examination of Hardened Concrete
C989 Specification for Slag Cement for Use in Concrete and Mortars
C1240 Specification for Silica Fume Used in Cementitious Mixtures
C1260 Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
D75 Practice for Sampling Aggregates

[1] This test method is under the jurisdiction of Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.50 on Aggregate Reactions in Concrete.

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

[3] 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.

[4] The last approved version of this historical standard is referenced on www.astm.org.

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

2.2 *CSA Standards:*[5]

CSA A23.2-14A Potential Expansivity of Aggregates (Procedure for Length Change due to Alkali-Aggregate Reaction in Concrete Prisms at 38 °C)

CSA A23.2-27A Standard Practice to Identify Degree of Alkali-Reactivity of Aggregates and to Identify Measures to Avoid Deleterious Expansion in Concrete

CSA A23.2-28A Standard Practice for Laboratory Testing to Demonstrate the Effectiveness of Supplementary Cementing Materials and Lithium-Based Admixtures to Prevent Alkali-Silica Reaction in Concrete

3. Terminology

3.1 Terminology used in this standard is as given in Terminology C125 or Descriptive Nomenclature C294.

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 or combination of an aggregate with pozzolan or slag to expand deleteriously due to any form of alkali-silica reactivity (**3**,**4**).

4.3 When testing an aggregate with pozzolan or slag, the results are used to establish minimum amounts of the specific pozzolan or slag needed to prevent deleterious expansion. Pozzolan or slag from a specific source can be tested individually or in combination with pozzolan or slag from other sources.

4.4 When selecting a sample or deciding on the number of samples for test, it is important to recognize the variability in 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 C295.

4.5 This test method is intended for evaluating the behavior of aggregates in portland cement concrete with an alkali (alkali metal oxide) content of 5.25 kg/m^3 or in concrete containing pozzolan or slag with an alkali content proportionally reduced from 5.25 kg/m^3 Na_2O equivalent by the amount of pozzolan or slag replacing portland cement. 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 concrete alkali content, wetting and drying, temperature, other factors, or combinations of these (**5**).

4.6 Results of tests conducted on an aggregate 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. Results of tests conducted on combinations of an aggregate with pozzolans or slag should form a part of the basis for a decision as to whether the specific pozzolan or slag, when used in the amount tested, was effective in preventing excessive expansion. These decisions 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.

4.7 When the expansions in this test method are greater than the limit shown in X1.2, the aggregate or combination of aggregate with the tested amount of pozzolan or slag 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 C856 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 C33.

4.9 This test method does not address the general suitability of pozzolans or slag for use in concrete. These materials should comply with Specification C618, Specification C989, or Specification C1240.

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 C157/C157M and Practice C490, and the molds shall have nominal 75-mm square cross sections.

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 19 to 22-L polyethylene pails with airtight lids and approximate dimensions of 250- to 270-mm diameter at bottom, 290 to 310 mm at top, by 355 to 480 mm high. 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 above the bottom. Fill the container with water to a depth of 20 ± 5 mm 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 around the inside wall of the container from the top so that the bottom of the wick extends into the water (See Note 1).

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

[5] Available from Canadian Standards Association (CSA), 5060 Spectrum Way, Mississauga, ON L4W 5N6, Canada, http://www.csa.ca.

[6] The boldface numbers in parentheses refer to the list of references at the end of this test method.

expansion characteristics.[7] 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 water. When reporting results, note the use of an alternative container, if one is used, together with documentation proving compliance with the above.

NOTE 1—Polypropylene geotextile fabric or blotting paper are suitable materials for use as the wick.

5.3 The storage environment necessary to maintain the 38.0 °C 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 of the top and bottom of the space does not exceed 2.0 °C. 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 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 (see Note 2). Record the ambient temperature and its variation within the space to ensure compliance.

NOTE 2—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 C227 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.[7] 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.

6. Reagents

6.1 *Sodium Hydroxide (NaOH)*—USP or technical grade may be used. (**Warning—**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 Use potable tap water for mixing and storage.

7. Materials

7.1 *Cement*—Use a cement meeting the requirements for a Type I Portland cement as specified in Specification C150. 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 × 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 3).

NOTE 3—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/m^3 cement content, this corresponds to an alkali level of 5.25 kg/m^3 .

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 C1260) of less than 0.10 % at 14 days (see X1.6 for interpretation of expansion data). Use a fine aggregate meeting Specification C33 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.[7] A nonreactive coarse aggregate is defined as an aggregate that develops an expansion in the accelerated mortar bar (see Test Method C1260) of less than 0.10 % at 14 days (see X1.6 for interpretation of expansion data). Use a coarse aggregate meeting Specification C33. Test the fine aggregate using the grading as delivered to the laboratory.

7.2.3 Sieve the coarse aggregate and recombine in accordance with the requirements in Table 1. Select the Table 1 grading based on the as-received grading of the sample. Coarse aggregate fractions larger than 19.0-mm sieve are not to be tested as such. When petrographic examination using Guide C295 reveals that the material making up the size fraction larger than the 19.0-mm sieve is of such a composition and lithology that no difference should be expected compared with the smaller size material, then no further attention need be paid to the larger sizes. If petrographic examination suggests the larger size material to have a different reactivity, the material should be studied for its effect in concrete according to one of the other alternative procedures described herein:

TABLE 1 Grading Requirement

Sieve Size		Mass Fraction	
Passing	Retained	Coarse	Intermediate
19.0-mm	12.5-mm	⅓	. . .
12.5-mm	9.5-mm	⅓	½
9.5-mm	4.75-mm	⅓	½

[7] The sole source of supply of non-reactive aggregates and alkali-silica reactive aggregates of known expansion characteristics (**6**) known to the committee at this time is The Petrographer, Engineering Materials Office, Ministry of Transportation, 1201 Wilson Ave., Downsview, Ontario, Canada, M3M1J8.. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee [1], which you may attend.

7.2.3.1 *Proportional Testing*—Crush material larger than the 19.0-mm sieve to pass the 19.0-mm sieve. The crushing operation shall be performed in a manner that minimizes production of material passing the 4.75-mm sieve. Grade this crushed material per the Table 1 grading, and add to the original mass of graded aggregate produced in 7.2.3 such that the ratio of crushed, graded, oversize aggregate to total graded aggregate equals the ratio of material retained on the 19.0-mm sieve to the total material retained above the 4.75-mm sieve (See Note 4).

NOTE 4—For example, if the material retained on the 19-mm sieve formed 25 % of the total material retained above the 4.75-mm sieve, then the mass of crushed and returned oversize material shall form 25 % of the total graded aggregate.

7.2.3.2 *Separated Size Testing*—Crush material larger than the 19.0-mm sieve to pass the 19.0-mm 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 *Cementitious Materials Content*—420 ± 10 $kg/m.^3$

7.3.1.1 When evaluating the susceptibility of an aggregate to expansive alkali-silica reaction, use cement as 100 % of the cementitious material.

7.3.1.2 When evaluating combinations of aggregate with pozzolan or slag, replace cement with the desired amount of pozzolan or slag on a percent by mass basis.

7.3.2 *Coarse Aggregate Content*—Use a dry mass of coarse aggregate per unit volume of concrete equal to 0.70 ± 0.02 of its dry-rodded bulk density as determined by Test Method C29/C29M for all classes of aggregates (for example, low density, normal, and high density).

7.3.3 *Water-Cementitious Materials Ratio (w/cm)*—Maintain *w/cm* in the range of 0.42 to 0.45 by mass. Adjust the *w/cm* within this range to give sufficient workability to permit satisfactory compaction of the concrete in the molds. If necessary to obtain sufficient workability within the specified *w/cm* range, use of a high-range water reducer (HRWR), meeting the requirements of Specification C494/C494M Type F is permitted. If, within the specified *w/cm* range, specimens representative of the concrete mixture cannot be fabricated due to excessive bleeding or segregation, the use of a viscosity-modifying admixture (VMA) is permitted. Report the *w/cm* ratio used and the amount, if any, of HRWR or VMA.

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× % K_2O, up to 1.25 % by mass of cement (see Note 5). Use no other admixture in the concrete except as permitted in the section on *Water-Cementitious Materials Ratio*.

NOTE 5—Example calculations 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 %:

Example A (Cement Only)	
Cementitious materials content of 1 m^3 concrete	= 420 kg
Cement content of 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:

$$2 \times 39.997/61.98 = 1.291; \tag{1}$$

Amount of NaOH required in Example A:

$$1.47 \times 1.291 = 1.898\ kg/m^3 \tag{2}$$

Example B (20 % of cement is replaced by pozzolan)	
Cementitious materials content of 1 m^3 concrete	= 420 kg
Cement content of concrete (20 % by mass pozzolan)	= 420 kg × 0.8
	= 336 kg
Amount of alkali in the concrete	= 336 kg × 0.90 %
	= 3.02 kg
Specified amount of alkali in concrete	= 336 kg × 1.25 %
	= 4.20 kg
Amount of alkali to be added to concrete	= 4.20 kg – 3.02 kg
	= 1.18 kg

The difference (1.18 kg) is the amount of alkali, expressed as Na_2O equivalent, to be added to the mix water.

Amount of NaOH required for Example B:

$$1.18 \times 1.291 = 1.523\ kg/m^3 \tag{3}$$

8. Sampling

8.1 Obtain the aggregate sample in accordance with Practice D75 and reduce it to test portion size in accordance with Practice C702.

9. Specimen Preparation

9.1 *Mixing Concrete:*

9.1.1 *General*—Mix concrete in accordance with the standard practice for making and curing concrete test specimens in the laboratory as described in Practice C192/C192M.

9.1.2 *Slump*—Measure the slump of each batch of concrete immediately after mixing in accordance with Test Method C143/C143M.

9.1.3 *Yield, and Air Content*—Determine the yield, and air content of each batch of concrete in accordance with Test Method C138/C138M. Concrete used for slump, yield, and air content tests may be returned to the mixing pan and remixed into the batch.