



# Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction<sup>1</sup>

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 ( $\epsilon$ ) 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 *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.<sup>2</sup>)*

1.3 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.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>3</sup>

- 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)
- 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

### 2.2 CSA Standards:<sup>4</sup>

- 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

<sup>1</sup> 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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<sup>2</sup> Section on Safety Precautions, *Manual of Aggregate and Concrete Testing, Annual Book of ASTM Standards*, Vol. 04.02.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>4</sup> Available from Canadian Standards Association (CSA), 5060 Spectrum Way, Mississauga, ON L4W 5N6, Canada, <http://www.csa.ca>.

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

to Avoid Deleterious Expansion in Concrete  
CSA A23.2-28A Standard Practice for Laboratory Testing to  
Demonstrate the Effectiveness of Supplementary Cement-  
ing 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).<sup>5</sup> 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<sup>3</sup> or in concrete containing pozzolan or slag with an alkali content proportionally reduced from 5.25 kg/m<sup>3</sup> Na<sub>2</sub>O 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 con-

struction. 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 expansion characteristics.<sup>6</sup> The expansion efficiency is confirmed when expansions at one year obtained using the alternative container are within 10 % of those obtained using

<sup>5</sup> The boldface numbers in parentheses refer to the list of references at the end of this test method.

<sup>6</sup> 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 <sup>1</sup>, which you may attend.

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.<sup>6</sup> 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<sub>2</sub>O equivalent (Na<sub>2</sub>O equivalent is calculated as percent Na<sub>2</sub>O + 0.658 × percent K<sub>2</sub>O). 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<sub>2</sub>O equivalent, to 1.25 % by mass of cement (see Note 3).

NOTE 3—The value of 1.25 % Na<sub>2</sub>O 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<sup>3</sup> cement content, this corresponds to an alkali level of 5.25 kg/m<sup>3</sup>.

### 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.<sup>6</sup> 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:

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).

**TABLE 1 Grading Requirement**

| Sieve Size |          | Mass Fraction |              |
|------------|----------|---------------|--------------|
| Passing    | Retained | Coarse        | Intermediate |
| 19.0-mm    | 12.5-mm  | 1/3           | ...          |
| 12.5-mm    | 9.5-mm   | 1/3           | 1/2          |
| 9.5-mm     | 4.75-mm  | 1/3           | 1/2          |

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**— $420 \pm 10 \text{ kg/m}^3$ .

**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  $0.70 \pm 0.02$  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  $\text{Na}_2\text{O}_e = \% \text{Na}_2\text{O} + 0.658 \times \% \text{K}_2\text{O}$ , 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                   | = 420 kg                              |
| content of 1 m <sup>3</sup> concrete     |                                       |
| Cement content of concrete               | = 420 kg                              |
| Amount of alkali in the concrete         | = $420 \text{ kg} \times 0.90 \%$     |
|                                          | = 3.78 kg                             |
| Specified amount of alkali in concrete   | = $420 \text{ kg} \times 1.25 \%$     |
|                                          | = 5.25 kg                             |
| Amount of alkali to be added to concrete | = $5.25 \text{ kg} - 3.78 \text{ kg}$ |
|                                          | = 1.47 kg                             |

The difference (1.47 kg) is the amount of alkali, expressed as  $\text{Na}_2\text{O}$  equivalent, to be added to the mix water. Factor to convert  $\text{Na}_2\text{O}$  to NaOH:

| (Na <sub>2</sub> O + H <sub>2</sub> O → 2 NaOH) |                  |
|-------------------------------------------------|------------------|
| Compound                                        | Molecular Weight |
| Na <sub>2</sub> O                               | 61.98            |
| NaOH                                            | 39.997           |

Conversion factor:

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

Amount of NaOH required in Example A:

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

Example B (20 % of cement is replaced by pozzolan)

|                                                    |                                       |
|----------------------------------------------------|---------------------------------------|
| Cementitious materials                             | = 420 kg                              |
| content of 1 m <sup>3</sup> concrete               |                                       |
| Cement content of concrete (20 % by mass pozzolan) | = $420 \text{ kg} \times 0.8$         |
|                                                    | = 336 kg                              |
| Amount of alkali in the concrete                   | = $336 \text{ kg} \times 0.90 \%$     |
|                                                    | = 3.02 kg                             |
| Specified amount of alkali in concrete             | = $336 \text{ kg} \times 1.25 \%$     |
|                                                    | = 4.20 kg                             |
| Amount of alkali to be added to concrete           | = $4.20 \text{ kg} - 3.02 \text{ kg}$ |
|                                                    | = 1.18 kg                             |

The difference (1.18 kg) is the amount of alkali, expressed as  $\text{Na}_2\text{O}$  equivalent, to be added to the mix water.

Amount of NaOH required for Example B:

$$1.18 \times 1.291 = 1.523 \text{ kg/m}^3 \quad (3)$$

## 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.

9.2 Prepare three specimens of the type required for concrete in Test Method **C157/C157M** from one batch of concrete (see **Note 6**).

NOTE 6—It has been found useful to cast an additional (4th) prism that can be removed from the test and used for petrographic examination at any time.

9.3 **Initial Conditioning**—Cure, store, and remove molds in accordance with Test Method **C157/C157M**.

## 10. Procedure

10.1 **Initial Comparator Reading**—Follow the procedure of Test Method **C157/C157M**, except do not place in saturated lime water. Make initial length reading at the time of removal from the mold at an age of  $23.5 \pm 0.5 \text{ h}$ . Thereafter, keep the specimens at  $38.0 \pm 2 \text{ }^\circ\text{C}$  in storage containers in accordance with **5.2**.

10.2 **Subsequent Comparator Readings**—Stand the specimen on end. Specimens shall not be in contact with water in the reservoir within the storage container. Seal the container and place container in a  $38.0 \pm 2 \text{ }^\circ\text{C}$  storage environment. At no time should the storage container be in contact with the walls

or floor of the  $38.0 \pm 2^\circ\text{C}$  storage environment and there shall be an adequate flow of air around the container.

10.2.1 When the specimens are 7 days old, take a comparator reading after removal of the container and contents from the storage environment according to 10.2.2. Subsequent readings are required at the ages of 28 and 56 days, as well as 3, 6, 9, and 12 months when testing an aggregate for susceptibility to expansive alkali-silica reaction and additionally at 18 and 24 months when testing combinations of aggregates with pozzolans or slag. Additional readings beyond those required for the specific application are suggested at 6-month intervals.

10.2.2 Remove the containers holding the prisms from the  $38.0 \pm 2.0^\circ\text{C}$  temperature environment and place in a moist cabinet or moist room that is in compliance with Specification C511 for a period  $16 \pm 4$  h before reading.

10.3 Fabricate all specimens placed in a given storage container at the same time so that all specimens in that container are due for comparator reading at the same time.

10.4 Identify the specimens so as to place the specimens in the comparator with the same end up. After the comparator reading of the prism, replace the specimen in the storage container but invert the upper end as compared with the previous storage period. In this way the prisms are not stored through two consecutive storage periods with the same ends up.

## 11. Calculation

11.1 Calculate the change in length between the initial comparator reading of the specimen and the comparator reading at each time interval to the nearest 0.001 % of the effective gage length and record as the length change of the prism for that period. Calculate the average length change in percentage for the group of prisms at the age.

11.2 Data from at least three bars must be available at any age to constitute a valid test at that age.

## 12. Report

12.1 Report the following information:

12.1.1 Type and source of coarse and fine aggregates, and the coarse aggregate grading used,

12.1.2 Type and source of portland cement,

12.1.3 The alkali content of the cement as percent potassium oxide ( $\text{K}_2\text{O}$ ), sodium oxide ( $\text{Na}_2\text{O}$ ), and calculated percent  $\text{NaO}_e$ ,

12.1.4 Type, source, and amount (percent by mass of cementitious material) of any pozzolan or slag used,

12.1.5 The amount, if any, of high-range water reducer or viscosity-modifying admixture used,

12.1.6 Concrete mixture proportions based on SSD aggregates, and corrected for yield,

12.1.7 The amount of sodium hydroxide ( $\text{NaOH}$ ) added to the mixing water, expressed as percent sodium oxide ( $\text{Na}_2\text{O}$ ) equivalent by mass of the cement,

12.1.8 The w/cm based on saturated, surface dry (SSD) aggregates,

12.1.9 The slump, with mass yield and air content of the concrete batched,

12.1.10 The average length change in percent at each reading of the prisms along with the individual length change in percentage for each prism,

12.1.11 Any significant features revealed by examination of the concrete prisms either during the test or at the end of the test (for example, cracks, gel formation, or peripheral reaction rims on aggregate particles), and

12.1.12 Type of storage container and  $38.0 \pm 2.0^\circ\text{C}$  storage environment used to store the concrete prisms if they differ from those specified in 5.2.1 and 5.3.1.

## 13. Precision and Bias

### 13.1 Multi-Laboratory Precision:

13.1.1 *Average Expansion Less Than 0.014 %*—The multi-laboratory standard deviation of a single test result (mean of measurements of three prisms) for average expansion less than 0.014 % has been found to be 0.0032 % (CSA A23.2-14A).<sup>4</sup> Therefore, results of two properly conducted tests in different laboratories on the same aggregate should not differ by more than 0.009 %, nineteen times out of twenty.

13.1.2 *Average Expansion Greater Than 0.014 %*—The multi-laboratory coefficient of variation of a single test result (mean of measurements of three prisms) for average expansion greater than 0.014 % has been found to be 23 % (CSA A23.2-14A).<sup>4</sup> Therefore, results of two properly conducted tests in different laboratories on the same aggregate should not differ from each other by more than 65 % of their average, nineteen times out of twenty.

### 13.2 Within-Laboratory Precision:

13.2.1 *Average Expansion Less Than 0.02 %*—For average expansions of less than 0.02 %, the multi-specimen, within-laboratory standard deviation has been found to be 0.0025 % (CSA A23.2-14A). Therefore, the range (difference between highest and lowest) of the three individual prism measurements used in calculating an average test result should not exceed 0.008 %, nineteen times out of twenty.

13.2.2 *Average Expansion Greater Than 0.02 %*—For average expansions of more than 0.02 %, the multi-specimen, within-laboratory coefficient of variation has been found to be 12 % (CSA A23.2-14A). Therefore, the range (difference between highest and lowest) of the three individual prism measurements used in calculating an average test result should not exceed 40 % of the average, nineteen times out of twenty.

13.3 *Bias*—Since there is no accepted reference material for determining the bias of this test method, no statement is being made.

## 14. Keywords

14.1 aggregate; alkali-silica reactivity; concrete; length change ; pozzolan; slag

## APPENDIX

### (Nonmandatory Information)

#### X1. Interpretation of Results

X1.1 The question of whether or not criteria based on the results obtained using this test method should be used for acceptance of materials for use as concrete aggregate will be dealt with, if deemed appropriate, in Specification **C33**.

X1.2 Work has been reported from which it may be inferred that an aggregate might reasonably be classified as potentially deleteriously reactive if the average expansion of three concrete specimens is equal to or greater than 0.04 % at one year **(7)** (CSA A23.2-27A-00 Table 1).

X1.3 It is reasonable to conclude that the amount of pozzolan or slag used in combination with an aggregate is at least the minimum needed to prevent excessive expansion in field concrete if the average expansion is less than 0.04 % at two years (CSA A23.2-28A-02).

X1.4 A history of satisfactory field performance in concrete is the best method of evaluating the potential for an aggregate to cause premature deterioration of concrete due to alkali-silica reaction. When field performance of an aggregate in concrete is to be accepted, the following conditions should be met **(8)**:

X1.4.1 The cement content and alkali content of the cement should be the same or higher in the field concrete than is proposed in the new structure.

X1.4.2 The concrete examined should be at least 10 years old.

X1.4.3 The exposure conditions of the field concrete should be at least as severe as those in the proposed structure.

X1.5 This test method supplements the results of other test methods. The results of the other test methods are usually reported before the results of this test method are available. Standards that this test method supplements include: Test Method **C227**, Guide **C295**, Test Method **C289**, and Test

Method **C1260**. It is recommended that the relevant procedure(s) be performed concurrently with this test method and any discrepancies between the results explained. Care should be exercised in the interpretation of these other test method results **(9-14)**.

X1.6 The use of this test method should especially be considered when other test methods may be inadequate. Some examples of such problems are as follows: The potential reactivity of various varieties of quartz may not be accurately determined by Test Method **C227** since the test method may produce a false-negative result **(3)**. False-negative results are possible with a number of aggregates such as slow-late expanding argillaceous greywackes, strained quartz and microcrystalline quartz associated with strained quartz **(3,4,13)**. False-negative results are also possible due to storage conditions **(9)**, reactive aggregate levels far above or below pessimism **(3)** or insufficient alkali to accelerate the test **(3)**. The potential reactivity of various varieties of quartz may not be accurately determined by Test Method **C1260** since the test method may produce a false-positive result with a number of marginally reactive aggregates **(13)**. Test Method **C1260** may also give a false-negative result with aggregates suspected of containing deleterious strained quartz **(14)**.

X1.7 If the data generated with other test methods and supplemented with information from this test method judge an aggregate to be “not potentially deleteriously alkali-silica reactive,” no restrictions are usually required with the use of that aggregate in order to protect against expansion due to alkali-silica reaction **(7)** (see **Note X1.1**).

X1.8 Additional interlaboratory testing data is provided in Ref **(15)**.

NOTE X1.1—In critical structures such as those used for nuclear containment or large dams, where slight expansions cannot be tolerated, a lower expansion limit may be required.

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## SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this test method since the last issue, C1293 – 08a, that may impact the use of this test method. (Approved December 1, 2008)

- (1) Revised 1.3.
- (3) Deleted old 12.1.13.
- (2) Revised 7.2.3, 12.1.1, and Table 1.

Committee C09 has identified the location of selected changes to this test method since the last issue, C1293 – 08, that may impact the use of this test method. (Approved February 1, 2008)

- (1) Revised 1.3, 5.1, 7.2.3, and 7.2.3.1.
- (4) Removed all informational inch-pound units throughout to conform to ASTM Form and Style.
- (2) Added new 12.1.13 and Note 4.
- (3) Revised Table 1.

Committee C09 has identified the location of selected changes to this test method since the last issue, C1293 – 06, that may impact the use of this test method. (Approved January 15, 2008)

- (1) Revised 7.3.2.

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