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Standard Test Method for Autoclave Expansion of Hydraulic Cement¹

This standard is issued under the fixed designation C 151/C 151M; 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 determination of the autoclave expansion of hydraulic cement by means of a test on a neat cement specimen.

~~1.2 The values stated in inch-pound units are to be regarded as the standard.~~

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the 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.* For specific precaution statements, see the section on Safety Precautions.

2. Referenced Documents

2.1 *ASTM Standards:*²

C 187 Test Method for Normal Consistency of Hydraulic Cement

C 305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency

C 490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete

C 511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes

C 856 Practice for Petrographic Examination of Hardened Concrete

C 1005 Specification for Reference Masses and Devices for Determining Mass and Volume for Use in the Physical Testing of Hydraulic Cements

C 1157 Performance Specification for Hydraulic Cement

3. Significance and Use

3.1 The autoclave expansion test provides an index of potential delayed expansion caused by the hydration of CaO, or MgO, or both, when present in hydraulic cement.³

4. Interferences

4.1 Pozzolans containing fine-grained quartz have been reported to cause excessive expansion under autoclave test conditions due to alkali-silica reaction that will not occur under normal service conditions.⁴ When excessive expansion of paste containing pozzolans occurs, it is recommended that the specimens be examined (See Practice C 856) for evidence of alkali-silica reaction (Note 1).

NOTE 1—If the excessive expansion has resulted from alkali-silica reaction under autoclave conditions, the pozzolan can be evaluated for alkali reactivity using the procedure described in Performance Specification C 1157.

¹ This test method is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.31 on Volume Change. Current edition approved July 1, 2005-2009. Published July 2005-January 2009. Originally approved in 1940. Last previous edition approved in 2000-2005 as C 151 – 09.

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 Gonnerman, H. F., Lerch, W. and Whiteside, T. M., "Investigations of the Hydration Expansion Characteristics of Portland Cements," *Portland Cement Association Research Department Bulletin 45*, 1953, pp. 1-168; Portland Cement Association Research Department Bulletin 45, pp. 1-168, 1953.

⁴ Wang, H., "Autoclave Soundness Test Mischaracterizes Cement-Fly Ash Blends by Introducing Alkali-Quartz Reaction," *Cement, Concrete, and Aggregates*, Vol. 24, No. 2, 2002, pp. 68-72, 2002.

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

5. Apparatus

5.1 *Weighing Devices and Weights*, for determining the mass of materials conforming to the requirements of Specification C 1005.

5.2 *Glass Graduates*, 200 or 250-mL capacity, and conforming to the requirements of Practice C 490.

5.3 *Molds*, 1 by 1-in. (25.4 by 25.4 mm) cross section, conforming to the requirements of Practice C 490, conforming to the requirements of Practice C 490 for test specimens used in the determination of length change of cement paste.

5.4 *Flat Trowel*, having a straight-edged steel blade 4 to 6 in. (100 to 150 mm) in length, conforming to the requirements of Test Method C 187.

5.5 *Autoclave*, consisting of a high-pressure steam vessel provided with a thermometer well. The autoclave shall be equipped with automatic controls and a rupture disk with a bursting pressure of ~~350 psi (2.4 MPa)~~ 2.4 MPa [350 psi] $\pm 5\%$. In locations where the use of a rupture disk is not permitted, the autoclave shall be equipped with a safety valve. In addition, the autoclave shall be equipped with a vent valve to allow the escape of air during the early part of the heating period and to release any steam pressure remaining at the end of the cooling period. The pressure gage shall have a nominal capacity of ~~600 psi (4.1 MPa)~~ 4.0 MPa [600 psi], a dial with a nominal diameter of ~~4½ in. (114 mm)~~ 115 mm [4½ in.] and shall be graduated from 0 to ~~600 psi (4.0 MPa)~~ 0 to 5.1 MPa [600 psi] with scale divisions not exceeding ~~5 psi (0.03 MPa)~~ 0.03 MPa [5 psi]. The error in the gage shall not exceed ~~± 3 psi (± 0.02 MPa)~~ ± 0.02 MPa [± 3 psi] at the operating pressure of ~~295 psi (2 MPa)~~ 2 MPa [295 psi]. The capacity of the heating unit shall be such that with maximum load (water plus specimens) the pressure of the saturated steam in the autoclave may be raised to a gage pressure of 2 MPa [295 psi] in 45 to 75 min from the time the heat is turned on. The automatic control shall be capable of maintaining the gage pressure at ~~295 \pm 10 psi (20.07 MPa [295 \pm 0.07 MPa])~~ 10 psi] for at least 3 h. A gage pressure of ~~295 \pm 0.07 MPa [295 \pm 10 psi]~~ corresponds to a temperature of ~~420 \pm 2 °F (216 \pm 2 °C)~~ 3 °F]. The autoclave shall be designed to permit the gage pressure to drop from 2 MPa to less than 0.07 MPa [295 psi to less than 10 psi] in 1½ h after the heat supply has been shut off.

5.5.1 *Rupture Disk*—The rupture disk shall be made of a material having a tensile strength that is relatively insensitive to temperature in the range ~~68 to 420 °F (20 to 216 °C)~~ 420 °F [68 to 216 °C] and that is electrochemically compatible with the pipe leading to it and to its holder.⁵

5.6 *Length Comparator*—The comparator used for measuring length change of specimens shall conform to the requirements of Practice C 490.

6. Temperature and Humidity

6.1 *Molding Room*—Maintain the temperature of the molding room, dry materials and mixing water, and the relative humidity of the molding room within the limits of Practice C 490.

6.2 *Moist Storage Facilities*—Maintain the temperature and humidity of the moist storage facilities to the requirements of Specification C 511.

7. Safety Precautions

7.1 The pressure gage shall have a capacity of ~~600 psi (4.1 MPa)~~ 4.0 MPa [600 psi]. A gage with too small or too large a capacity may be a hazard, since for pressure above the specified maximum working pressure, with a smaller capacity gage, the pressure may be off scale, and with a larger capacity gage, the arc of movement may be too small to invite attention. The operator shall be sure the gage hand has not passed the maximum graduation on the scale.

7.2 Test the pressure gage for proper operation. Always use a thermometer together with the pressure gage, so as to provide a means of detecting any failure of the pressure gage to operate properly, and to indicate any unusual condition.

7.3 Maintain the automatic control in proper working order at all times.

7.4 Set the safety valve to relieve the pressure at about 6 to 10 % above the maximum of ~~305 psi (2.1 MPa)~~ 2.1 MPa [305 psi] specified in this test method, that is, at about ~~330 psi (2.3 MPa)~~ 2.3 MPa [330 psi]. Unless the manufacturer has given specific instructions as to maintenance of the safety valve, test the valve twice each year.⁶ Test with a gage testing device, or by adjusting the automatic controls to allow the autoclave to reach a pressure of about 2.3 MPa [330 psi], at which pressure the safety valve will either open or be adjusted to open. Direct the safety valve discharge away from the operator.

NOTE 2—Unexpected combinations of conditions may occur. For example, in one case the automatic control had failed, the safety valve had become stuck, and the gage hand, which at first glance appeared to be at about zero, had passed the maximum graduation and had come to stop on the wrong side of the pin. This condition of the gage was finally detected and the pressure, then of an unknown magnitude, was released before failure could occur in the apparatus.

7.5 Wear heavy leather work gloves to prevent burning of the hands when removing the top of the autoclave at the end of the test. Direct the vent valve away from the operator. When removing the autoclave lid, tilt it so that any steam escaping from beneath the lid will be discharged away from the operator. Care shall be taken to avoid scalding by any liquid that may have been used in the autoclave well.

⁵ A list of suppliers of autoclave rupture disks and gaskets is maintained at ASTM Headquarters.

⁶ A list of facilities for testing autoclave safety valves is maintained at ASTM Headquarters.