Designation: C 684 – 89[ε1]

Standard Test Method for Making, Accelerated Curing, and Testing Concrete Compression Test Specimens[1]

This standard is issued under the fixed designation C 684; 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.

[ε1] NOTE—Editorial corrections were made throughout in May 1990.

1. Scope

1.1 This test method covers four procedures for making, curing, and testing specimens of concrete stored under conditions intended to accelerate the development of strength. The choice of which procedure to use should be made by the user on the basis of his experience and local condition. The four procedures are: Procedure A—Warm Water Method, Procedure B—Boiling Water Method, Procedure C—Autogenous Curing Method, and Procedure D—High Temperature and Pressure Method.

NOTE 1—All material in this test method that is not designated as belonging specifically to one of the four procedures applies to all the procedures.

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

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems 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.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 31 Practice for Making and Curing Concrete Test Specimens in the Field[2]

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens[2]

C 172 Method of Sampling Freshly Mixed Concrete[2]

C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus[3]

C 192 Practice for Making and Curing Concrete Test Specimens in the Laboratory[2]

C 470 Specification for Molds for Forming Concrete Test Cylinders Vertically[2]

C 617 Practice for Capping Cylindrical Concrete Specimens[2]

3. Summary of Test Method

3.1 Concrete specimens are exposed to elevated temperatures and to moisture conditions adequate to develop a significant portion of their ultimate strength within 48 h depending upon the procedure selected. Procedures A and B utilize storage of specimens in heated water at elevated curing temperatures without moisture loss. The primary function of the moderately heated water used in Procedure A is to serve as insulation to conserve the heat generated by hydration. The temperature level employed in Procedure B provides thermal acceleration. Procedure C involves storage of specimens in insulated curing containers in which the elevated curing temperature is obtained from heat of hydration of the cement. The sealed containers also prevent moisture loss. Procedure D involves simultaneous application of elevated temperature and pressure to the concrete container. Sampling and testing procedures are the same as for normally cured specimens (Methods C 172 and Test Method C 39 respectively).

3.2 Important characteristics of these procedures are given in Table 1.

4. Significance and Use

4.1 The accelerated curing procedures provide, for a particular combination of materials at the earliest practical time, an indication of the potential strength of the concrete. They also provide information on the variability of the production process for use in process control.

4.2 Correlation between accelerated early strength of test specimens and strength at some later age achieved by conventional curing methods depends upon the materials comprising the concrete and the specific procedure employed. Any strength value provided by companion specimens, no matter how obtained, has a dubious relation to the actual strength of the concrete in-place in the structure, and has value only as an indicator of a probability that the desired load-bearing capability has been or can be obtained in the structure by use of a particular formulation. There is, therefore, no fundamental reason why the accelerated early strength obtained from any one of the four procedures outlined in this method cannot be used in the design and evaluation of concrete strengths in the same way conventional 28-day strengths have been used in the past, with suitable changes in the expected numbers used to describe strength values. However, since the practice of using strength values obtained from standard-cured cylinders at 28 days is long established and widespread, it is recognized that many

[1] This test method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C 09.02.09 on Accelerated Strength Testing.

Current edition approved May 17, 1989. Published June 1989. Originally published as C 684 – 71 T. Last previous edition C 684 – 81.

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

[3] *Annual Book of ASTM Standards*, Vol 04.06.

TABLE 1 Brief Description of Accelerated Curing Procedures

Procedure	Molds	Accelerated Curing Medium	Accelerated Curing Temperature °F (°C)	Age Accelerated Curing Begins	Duration of Accelerated Curing	Age at Testing
A. Warm Water	reusable or single-use	water	95 (35)	immediately after casting	23½ h ± 30 min	24 h ± 15 min
B. Boiling Water	reusable or single-use	water	boiling	23 h ± 15 min after casting	3½ h ± 5 min	28½ h ± 15 min
C. Autogenous	single-use	heat of hydration	initial concrete temperature augmented by heat of hydration	immediately after casting	48 h ± 15 min	49 h ± 15 min
D. High-Temperature and Pressure	reusable	external heat and pressure	300 (149)	immediately after casting	5 h ± 5 min	5¼ ± 5 min

people will wish to use the results of strength tests on specimens cured by accelerated methods to make "predictions" of strength that might be obtained at later ages. Such predictions should be limited to concretes using the same materials as those used for establishing the correlation.

4.3 The ratio of accelerated strength to conventionally obtained strength of test specimens at later ages increases with the cement content and initial mixture temperature.

5. Sampling

5.1 Sampling shall be done in accordance with Method C 172.

6. Procedure A—Warm Water Method

6.1 *Apparatus:*

6.1.1 Equipment and small tools for fabricating specimens, measuring slump, and determining air content shall conform to the applicable requirements of Practice C 31.

6.1.2 *Molds:*

6.1.2.1 Molds for specimens shall conform to the requirements for cylinder molds in Method C 31 except that cardboard molds shall not be used.

6.1.2.2 Single-used light gage metal molds with lids shall conform to the requirements of Specification C 470.

6.1.2.3 When test specimens are to be used without capping, reusable molds having machined plates which can be securely connected to both top and bottom of the mold shall be used. These plates shall provide bearing surfaces plane within 0.002 in. (0.050 mm) and also shall ensure that neither end of the cylinder when prepared for testing shall depart from perpendicularity to the axis of the specimen by more than 0.5° (approximately equivalent to ⅛ in. in 12 in. (10.4 mm/m). The mold assembly shall be sufficiently tight to permit the filled mold to be turned from the vertical filling position to a horizontal curing position without loss of mortar or damage to the test specimen.

6.1.3 *Accelerated Curing Tank:*

6.1.3.1 The tank may be of any configuration suitable for the number of cylinders to be tested and the cylinders may be arranged in any configuration provided a clearance of at least 2 in. (50 mm) between the side of the cylinder and the side of the tank and at least 4 in. (100 mm) between adjacent cylinders is maintained.

NOTE 2—A number of different tanks have been used successfully. Guidelines are shown in the Appendix.

6.1.3.2 The tank shall be capable of providing the specified water temperature. The temperature, at any point in the water shall be maintained within ±5°F (±3°C) of that specified. Depending upon the design features of the tank (and whether it is to be capable of use for Procedure B as well as for Procedure A) insulation or mechanical agitation, or both, might be necessary to meet the specified temperature requirements. Electrical immersion heaters controlled by a thermostat are the most suitable form of heating elements. Thermometers or other temperature recording devices shall be used, independent of the thermostat, to check the temperature of the water.

NOTE 3—For a particular procedure, the size of the heating element required will depend upon the size of the tank and the number of cylinders to be tested at one time. For controlling the temperature, some household thermostats may be satisfactory, but generally they are not sufficiently sensitive.

6.1.3.3 The plate supporting the cylinders shall have sufficient open perforations so as not to interfere with the circulation of the water.

6.1.3.4 A lid shall be provided where the tank is to be capable of use for Procedure B as well as Procedure A. The water level shall be checked periodically and maintained at 4 in. (100-mm) above the top of the cylinders.

NOTE 4—Provision for an overflow pipe is a convenience in controlling the maximum depth of water.

6.2 *Procedure:*

6.2.1 *Preparation of Test Specimens:*

6.2.1.1 Take samples of the concrete for the test specimens in accordance with Method C 172. Record in the job records the location at which the sampled batch is used in the structure.

6.2.1.2 Measure the slump and air content and mold the specimens as required in Practice C 31.

6.2.1.3 The test specimens shall conform to the requirements for 6 by 12-in. (152 by 305-mm) cylinders contained in Practice C 31.

6.2.2 *Curing:*

6.2.2.1 Cover the top of the specimen with a rigid plate to prevent loss of mortar to the water bath (Note 5).

6.2.2.2 Immediately place the specimen into the curing tank (Note 5). The water at the time of immersion and throughout the curing period shall be 95 ± 5°F (35 ± 3°C). The temperature of the curing water after immersion of the cylinders shall not drop more than 5°F (3°C) and shall return to 95 ± 5°F within 15 min.

6.2.2.3 The temperature of the curing water should be continuously recorded or periodically measured throughout the curing period.

6.2.2.4 After curing for 23½ h ± 30 min, remove the cylinder from the tank and demold the cylinder.

NOTE 5—If the cylinders are cast in molds meeting the requirements of 6.1.2.3 they may be stored horizontally, otherwise they are to be stored in the curing tank with the long axis vertical.

6.2.3 *Capping and Testing:*

6.2.3.1 The ends of specimens that are not plane within 0.002 in. (0.05 mm) or which depart from perpendicularity to the central axis by more than 0.5° (approximately equivalent to ⅛ in. in 12 in. (10.4 mm/m)) shall be capped as specified in Practice C 617.

6.2.3.2 When tested in accordance with provisions of Practice C 617, the capping material shall develop at the age of 30 min a strength equal to or greater than the strength of the cylinders to be tested.

6.2.3.3 Do not test specimens sooner than 30 min after capping.

6.2.3.4 Test the cylinder for strength in accordance with the requirements of Test Method C 39 at the age of 24 h ± 15 min.

7. Procedure B—Boiling Water Method

7.1 *Apparatus:*

7.1.1 The requirements for small tools and molds are the same as those stated in 6.1.1.

7.1.2 The tank shall conform to the requirements specified in 6.1.3.

NOTE 6: **Caution**—The use of boiling water imposes the need for safety measures to prevent scalding or eye burns resulting from sudden escape of steam upon opening the cover and immersion of or dropping the cylinders into the boiling water. Lifting tongs are suggested.

7.2 *Procedure:*

7.2.1 *Preparation of Test Specimens*—Specimens shall be prepared in accordance with 6.2.1.

7.2.2 *Initial Curing*—Cover the cylinders to prevent loss of moisture and store so that they will not be disturbed or subjected to vibration or jarring. In the storage area the temperature adjacent to the cylinders shall be maintained at 70 ± 10°F (21 ± 6°C). Protection and storage shall conform to the requirements of Practice C 31.

NOTE 7—Strict attention to the protection and storage of the cylinder during this initial period is necessary for meaningful results because of the short total curing period.

7.2.3 *Accelerated Curing:*

7.2.3.1 Place the covered cylinder molds in the water tank at 23 h ± 15 min after molding. The temperature of the water at the time of immersion and throughout the curing period shall be at boiling (Notes 5 and 8). The temperature of the water shall return to boiling within 15 min after the cylinders are immersed.

NOTE 8—In confined places the temperature of the water may be kept just below the boiling point to avoid excessive evaporation. The temperature at which water boils varies because of differences in elevation above sea level. Differences in strengths caused by the differences in temperatures are not believed to be significant, but comparison of results among areas so affected should be supported by appropriate correlations and interpreted with the knowledge of the temperature variations.

7.2.3.2 The temperature of the curing water should be continuously recorded or measured at regular intervals throughout the curing period.

7.2.3.3 After curing for 3½ h ± 5 min remove the cylinder from the boiling water, remove the mold, and allow the cylinder to cool for not less than 1 h at room temperature prior to capping.

7.2.4 *Capping and Testing*—Cap and test the cylinders in accordance with 6.2.3 except that the age at time of test shall be 28½ h ± 15 min.

8. Procedure C—Autogenous Method

8.1 *Apparatus:*

8.1.1 The requirements for small tools and molds are the same as those stated in 6.1.1.

NOTE 9—Metal, reusable molds with end plates and clamps may be impracticable.

8.1.2 *Container:*

8.1.2.1 The container shall consist of thermal insulation meeting heat retention requirements of 8.1.3.1 and closely surrounding the concrete test cylinder.

8.1.2.2 The container shall be capable of being opened to permit insertion and withdrawal of the cylinder and where required shall have an outer casing and inner liner to protect the insulation from mechanical damage.

8.1.2.3 The container may be provided with a maximum or minimum recording thermometer which shall not be insulated from the test cylinder (see Note 11).

8.1.2.4 Provisions shall be made to keep the container securely closed during the specified curing period.

8.1.2.5 The container shall be capable of holding either one or two cylinders.

NOTE 10—Drawings and guidelines for construction of suitable containers are included in the Appendix. Any configuration is acceptable so long as it meets the performance requirements of 8.1.

8.1.3 *Proving Test Requirements:*

8.1.3.1 *Heat Retention*—Place a watertight container with internal dimensions of 12 by 6 in. (300 by 150 mm) in diameter in the curing container and then fill to within ¼ in. (6 mm) of the brim with water at a temperature of 180°F (82°C). Insert a thermocouple into the water and measure the initial temperature of the water with an electrical potentiometer. Then seal the water container with a cap or plastic bag and close the autogenous container. When the autogenous curing container is stored in still air at 70 ± 2°F (21 ± 1°C) the water temperature shall be as follows:

Elapsed Time, h	°F	°C
12	152 ± 5	67 ± 3
24	136 ± 6	58 ± 3
48	114 ± 7	45 ± 4
72	100 ± 8	38 ± 4

8.1.3.2 *Tightness Test for Gasket Heat Seal*—When the autogenous curing container is immersed in water to a depth of 6 in. (150 mm) above the joint between the separable parts, no air shall escape through the heat seal within a period of 5 min.

8.1.3.3 *Stability of the Container*—The container or any part thereof shall not display embrittlement, fracturing, or distortion when maintained in an ambient temperature of −20°F (−29°C) for 72 h, nor softening or distortion when maintained at an ambient temperature of 140°F (60°C) for 72 h. The gasket type heat seal shall immediately fully recover its original thickness after 50 % compression under the temperature conditions specified above.

8.2 *Procedure:*

8.2.1 *Preparation of Test Specimens*—Prepare specimens in accordance with 6.2.1.

8.2.2 *Curing:*

8.2.2.1 Immediately after molding, cover the mold with a metal plate or a tightly fitted cap and place in a heavy-duty plastic bag from which as much of the entrapped air as possible is expelled prior to tying the neck. (Alternatively, a moisture-tight plastic cap may be used.) The plastic bag should be of sufficient weight and strength to resist punctures and serve as a lifting grip for placing and removing the cylinder from the autogenous container.

8.2.2.2 Reset the maximum-minimum thermometer (if used) and secure the container lid after the specimen is in place.

8.2.2.3 Record the time of molding to the nearest 15 min and the temperature of the fresh concrete clearly on the outside of the container.

8.2.2.4 For at least 12 h after molding the container shall not be moved, disturbed, or subjected to vibration or jarring and shall be stored out of the sun, preferably at a temperature of 70 ± 10°F (21 ± 6°C).

8.2.2.5 At the age of 48 h ± 15 min after the time at which the cylinder was molded, remove the cylinder from the container and demold. Allow to stand for 30 min at room temperature.

8.2.2.6 Record the maximum and minimum temperatures in the container indicated on the thermometer.

NOTE 11—Comparison of the maximum and minimum temperatures with the recorded temperature of the fresh concrete will provide an indication of abnormal or interrupted curing which may cause high or low strength results.

8.2.3 *Capping and Testing*—Cap and test the cylinders in accordance with 6.2.3 except that the age at the time of test shall be 49 h ± 15 min.

NOTE 12—Capping and testing may be performed at ages different from that specified in 8.2.3. Agencies using the procedure have for convenience established relationships between test results at 24, 72, and 96 h with those obtained by standard moist curing. However, at 24 h, the relationship is less satisfactory than those obtained by accelerated autogenous curing for 48, 72, or 96 h. Where the curing period is other than that specified in 8.2.3, the age at testing should be the curing period plus 1 h. The tolerance of ±15 min should still apply.

9. Procedure D—High Temperature and Pressure Method

9.1 *Apparatus:*

9.1.1 Small tools shall be in accordance with 6.1.1.

9.1.2 *Curing Apparatus*—The curing apparatus shall consist of a loading system to apply the specified pressure to the concrete and special molds to maintain the concrete specimens at the specified temperature during the curing period. The curing apparatus can be of any configuration suitable for the number of cylindrical specimens to be tested. Appendix X1 gives details of a successful curing apparatus designed for curing three specimens.

9.1.2.1 *The loading system* shall be capable of maintaining a pressure of 1500 ± 25 psi (10.3 + 0.2 MPa) on the concrete in the molds.

9.1.2.2 *Molds*—The molds, preferably made of stainless steel, shall be cylinders that can be sealed with top and bottom metal plugs that can be removed at the end of the curing period. Molds shall be capable of raising and maintaining the concrete temperature at 300 ± 5°F (149 ± 3°C). The process of raising the temperature shall take 30 ± 5 min. Molds shall be sealed securely throughout the entire curing period of 5 h. The molds shall maintain the maximum temperature of 300 ± 5°F (149 ± 3°C) for the first 3 h of the curing period, and the pressure shall be maintained at 1500 ± 25 psi (10.3 ± 0.2 MPa) for the entire 5-h curing period. Provision shall be made to check the temperature within each mold to ascertain that the temperature of the concrete satisfies the temperature requirements stated herein.

NOTE 13: **Caution**—The use of high temperature and pressure imposes the need for safety measures to prevent scalding or eye burns resulting from sudden escape of steam upon removal of plugs from the molds. It is suggested that the plugs be removed by prying in a direction away from the operator.

9.2 *Procedure:*

9.2.1 *Preparation of Test Specimens:*

For the curing apparatus described in Appendix X1, the molds are 3 × 6 in. (76 × 152 mm) cylinders and they shall be sealed with their bottom plugs before filling with concrete.

9.2.1.1 Procedure D is limited to concrete containing maximum size aggregates of 1 in. (25 mm). Concrete containing aggregate larger than 1 in. shall be wet sieved to remove the larger than 1 in. aggregate.

9.2.1.2 Place the concrete in the molds in two equal layers and rod each layer 10 times in accordance with Practice C 31. Screed the top level of the concrete with a special tool (item 26 of Fig. X13) to achieve the level of concrete required to receive the top metal plug that shall transmit the designated pressure of 1,500 ± 25 psi (10.3 ± 0.2 MPa) to the concrete in the mold.

9.2.2 *Curing:*

9.2.2.1 Immediately after molding, cover each mold with a metal plug that shall seal the concrete inside the mold during the curing process.

9.2.2.2 Stack the molds vertically on top of each other and place them in the loading apparatus described in 9.1.2. Apply and maintain a pressure of 1500 ± 25 psi (10.3 ± 0.2 MPa) on the concrete within the molds.

9.2.2.3 Begin the heating cycle specified in 9.1.2.1. The curing period begins when the heat is started.

9.2.2.4 Maintain the curing period for 5 h ± 5 min and keep the molds securely sealed during this period. Maintain the maximum temperature of 300 ± 5°F (149 ± 3°C) for the first 3 h of the curing period but keep the pressure at 1500 ± 25 psi (10.3 ± 0.2 MPa) for the entire curing period of 5 h ± 5 min.

9.2.2.5 At the end of the curing period, remove the cylinder molds from the loading apparatus and extrude the specimens from the molds.

NOTE 14—Polypropylene plastic liners can be used inside the molds to facilitate extrusion of the cured concrete from the molds.

9.2.3 *Capping and Testing:*

9.2.3.1 Normally the specimens do not need to be capped for testing since the curing pressure produces suitably plane bearing surfaces. If the end surfaces do not meet the requirements of 6.2.3.1, then they shall be capped as specified in Practice C 617.

9.2.3.2 *Testing*—Test the cylinders in accordance with 6.2.3, using a compression testing machine satisfying the requirements of Test Method C 39. The loading apparatus

used for the curing period can also be designed to function as a suitable compression testing machine (see Appendix X1).

9.2.3.3 Test the cylinders for strength within 15 min after removing the mold. When capping is required, test the specimens 30 min after capping.

10. Interpretation of Results

10.1 Strength requirements in existing specifications and codes are not based upon accelerated curing; therefore, use of results from this method in the prediction of specification compliance of strengths at later ages must be applied with great caution. As stated in Section 11 the variability of the method is the same or less than that from traditional methods. Thus, results can be used in rapid assessment of variability for process control and signalling the need for indicated adjustments. On the other hand, the magnitude of the strength values obtained is influenced by the specific combination of materials so that the use of the results from either conventional tests at any arbitrary age or those from this method must be supported by experience or correlations developed by the specific agency for the existing local conditions and materials. Factors influencing relationships between measured strengths and those of concrete in place are no different from those affecting conventional strength tests.

11. Report

11.1 The report shall include the following:

11.1.1 Identification number.

11.1.2 Diameter (and length, if not standard) in inches or millimetres,

11.1.3 Cross-sectional area, in square inches or square centimetres,

11.1.4 Maximum load, in pounds-force or newtons,

11.1.5 Compressive strength calculated to the nearest 10 psi (0.069 MPa),

11.1.6 Type of fracture, if other than the usual cone,

11.1.7 Defects in either the specimen or the caps,

11.1.8 Age of the specimens,

11.1.9 Accelerated curing method used,

11.1.10 Initial mix temperature to the nearest °F (°C),

11.1.11 Maximum and minimum temperature to the nearest °F (°C) if Procedure C was used.

11.1.12 Method of transportation used for shipping the specimens to the laboratory, and

11.1.13 Ambient temperature of the specimen or the container during storage for Procedures B and C.

12. Precision and Bias

12.1 The single-laboratory coefficient of variation has been determined as 3.6 % for a pair of 6 × 12-in. (152 × 305-mm) cylinders, as used in Methods A, B, and C, and 6.7 % for 3 × 6-in. (76 × 152-mm) cylinders, as used in Method D cast from the same batch. Therefore, results of two properly conducted strength tests by the same laboratory on two individual cylinders made with the same materials should not differ more than 10 % of their average for 6 × 12-in. cylinders and 16.2 % for 3 × 6-in. cylinders.

12.2 The single-laboratory, multiday coefficient of variation has been determined as 8.7 % for 6 × 12-in. (152 × 305-mm) cylinders as used in Methods A, B and C and 20 % for 3 × 6-in. (76 × 152-mm) cylinders as used in Method D for the average of pairs cast from single batches mixed on 2 days. Therefore, results of two properly conducted strength tests each consisting of the average of two cylinders from the same batch made in the same laboratory on the same materials should not differ by more than 25 % of their average for 6 × 12-in. cylinders and 50 % for 3 × 6-in. cylinders.

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APPENDIX

Nonmandatory Information

XI. CURING APPARATUS

X1.1 Accelerated Curing Tank

X1.1.1 Curing tanks similar to that shown in Fig. X1.1 have been used successfully.

X1.1.1.1 Properly designed cabinets will ensure an almost uniform temperature throughout the tank without the need for a mechanical stirrer. The immersion heaters should be located centrally in the plan, as near to the bottom of the tank as possible. The water above the heater will then be kept in circulation by convection currents.

X1.1.1.2 For a tank containing two or three cylinders, two coupled elements (1500 and 5000 W) have been found suitable for use with Procedure B. While the smaller elements will maintain the specified curing, the larger element is required as a booster to reestablish boiling within the specified time after the cylinders have been immersed. Where the tank is to be used solely for Procedure A, while the above heaters are also suitable, a single element (3000 W) has also been found suitable. With the latter heater the tank, when used for Procedure A, may be of larger dimensions to hold more than two or three cylinders.

X1.1.1.3 The overflow pipe, closely fitting lid, and exterior insulation are not essential for curing tanks used only for Procedure A.

X1.2 Autogenous Curing Container

X1.2.1 A satisfactory container is shown in Fig. X1.2.

X1.2.1.1 The space for the maximum-minimum thermometer (if required) and the means of opening the container, securing when closed, and lifting are not shown.

X1.2.1.2 A heat seal is required at the joint face between the separable parts of the container. This may be a labyrinth or a gasket type seal provided the requirements of 8.1.3.1, 8.1.3.2, and 8.1.3.3 are met. A suitable gasket is flexible polyurethane foam (2 lb/ft^3 or 32 kg/m^3) maintained when closed at 50 % compression.

X1.2.1.3 Foamed-in-place closed-cell polyurethane having a density of between 2 and 3 lb/ft^3 (32 and 48 kg/m^3) and thermal conductivity equal to or less than 0.15 Btu-in./h·ft^2·°F (0.002 W/m·K) in accordance with Test Method C 177 has been found to be a suitable insulating material at the thicknesses specified to meet the heat retention requirements of 8.1.1.

X1.2.1.4 The maximum-minimum thermometer (if used) should cover a range from 20 to 150°F (−7 to 66°C) in 1° increments.

X1.3 High Temperature and Pressure Equipment

X1.3.1 A satisfactory apparatus for Method D is shown in Fig. X1.3.

X1.3.1.1 Properly designed molds will ensure an almost uniform temperature throughout the concrete. The heater wires are normally spaced closer together near the edges of the mold and further apart in its central region.

X1.3.1.2 For a 3 × 6 in. (76 × 152 mm) cylindrical mold a heating element of 100 W will raise and maintain the specified temperature during the curing period. Regular fiber glass insulation with a rating of R 20 was found to be sufficient for the suggested heating element and curing cycle. Each mold has its own electrical circuitry so that if one fails

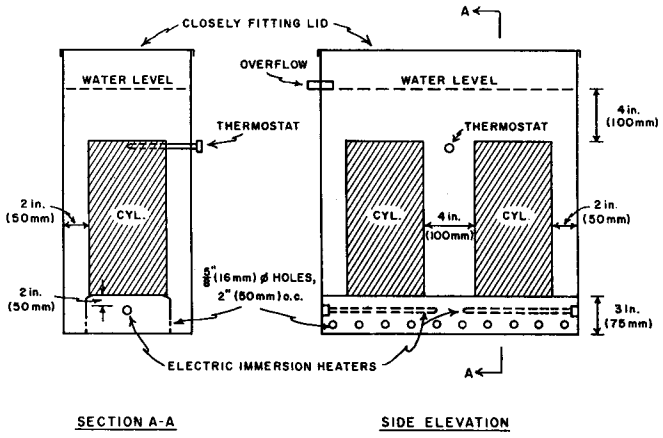


FIG. X1.1 Suggested Design for Accelerated Curing Water Tank (Example is for two test specimens)

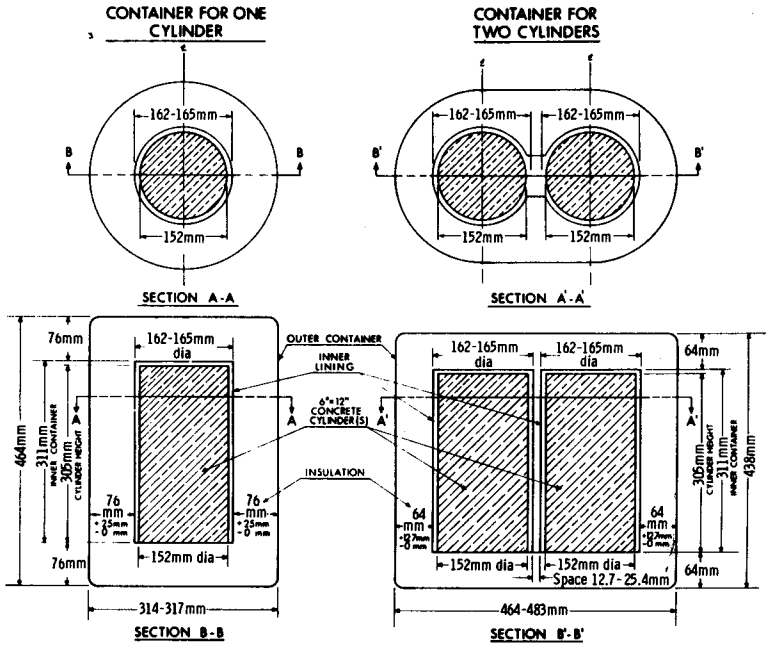
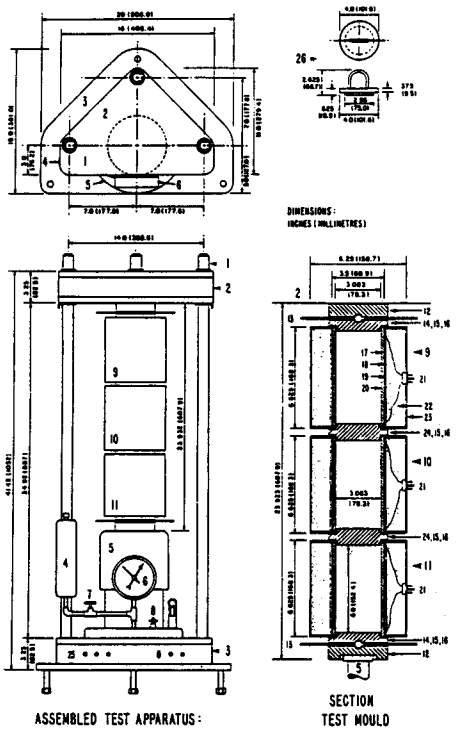


FIG. X1.2 Autogenous Curing Container for One or Two Cylinders (Basic Requirements)

to function two molds will remain to cure two specimens in a satisfactory manner. The electrical system shall preferably have current indicators, a timer, and a buzzer in order to make the curing procedure automatic and simple to monitor.

X1.3.1.3 The hydraulic jack and accumulator shall be equipped with a pressure gauge to indicate the pressure being applied to the concrete in the molds. The accumulator shall be calibrated so that it will maintain the required pressure of 1,500 ± 25 psi (10.3 ± 0.2 MPa).

X1.3.1.4 If it is desired to use the apparatus to test the specimens, then the apparatus shall be designed to function as a compression testing machine satisfying the requirements of Test Methods C 39.



NOMENCLATURE

1. Connecting rods
2. Head member
3. Base
4. Accumulator
5. Hydraulic jack
6. Pressure gage
7. Accumulator valve
8. Valve for jack
9. Sample container
10. Sample container
11. Sample container
12. Head bearing disc
13. Heat shield
14. Cap and piston
15. Gasket
16. O-ring
17. Sample cylinder core of mold
18. Heater wire
19. Wire insulation
20. Plastic liner
21. Electric connector
22. Fibreglass insulation
23. Container covering
24. Double piston closures
25. Electric assembly, timer, and circuitry
26. Screed

FIG. X1.3 Suggested Design for High-Temperature and Pressure Curing Apparatus

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