



Concrete Strength Testing Technician



TECHNICIAN WORKBOOK

ACI Certification Program for
Concrete Strength Testing Technician

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PREFACE

The field of concrete technology is one of the best established in the construction industry, supported by a vast amount of research and technical data. Proper use of this body of knowledge requires individuals who understand and are qualified to implement the information, and an independent national program for training and certification of these persons is highly desirable.

The Concrete Strength Testing Technician serves as an important link in the chain of quality concrete construction. Increasing concern over the availability of skilled concrete technicians whose responsibility it is to prepare and test compressive and flexural strength specimens has led ACI to initiate a national certification program directed toward this specialty. The ACI program provides a way to establish the credentials of technicians who are qualified to conduct the standard ASTM International laboratory procedures and tests related to compressive and flexural strength of concrete specimens.

The program is designed to provide a basis for certifying experienced concrete strength testing technicians, alleviating problems related to improper strength testing practices, upgrading the quality of concrete construction, and preparing the industry for future mandatory certification. Technicians who upgrade their skills and credentials through ACI certification will increase their

own opportunities as well as contribute to the advancement of the industry.

This Technician Workbook describes the operation of the certification program for the Concrete Strength Testing Technician program and it provides study material to aid the examinee in preparing for the ACI certification examinations.

Two methods of capping cylindrical concrete specimens to provide proper bearing surfaces during testing for compressive strength are currently accepted by ASTM Standard Practice C1231/C1231M. ASTM Standard Practice C617/C617M describes proper procedures for producing bonded caps, which are formed onto the ends of a cylinder from fresh neat cement, high-strength gypsum plaster, or molten sulfur mortar and allowed to harden and bond to the end surfaces. ASTM Standard Test Method C39/C39M describes the procedure for using unbonded caps, which are a system of removable and reusable elastomeric (neoprene) caps and metal retaining rings that are placed onto the ends of the cylinder. Since both capping methods are recognized by ASTM Standard Test Method C39/C39M and ACI's Concrete Strength Testing Technician Certification program is designed for all current and potential users of ASTM International methods, ACI Certification requires knowledge and demonstration of both capping methods.

Check the ACI website for updated information and/or errata/addendums:
www.concrete.org/publications/documenterrata.aspx

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PROGRAM INFORMATION

Purpose and Importance of Certification

ACI Concrete Strength Testing Technician provides international recognition by an independent group of acknowledged concrete experts. This recognition may improve your potential for advancement and employment opportunities.

Construction projects benefit from using certified technicians to perform concrete compression and flexural strength testing. Proper performance of test procedures improves the reliability of test results and aids in the quality control of the concrete. Most importantly, proper strength testing assures accurate and timely verification of concrete that meets design specifications and identifies concrete that is substandard, which can minimize job site problems and costly delays. In the event of a dispute, the certified technician's complete and accurate test records become essential.

The growing use of end-result specifications, with reduced-payment clauses for marginal-quality materials, is a further incentive for requiring certified technicians to perform concrete testing on building projects. Proper strength testing of concrete is essential in avoiding substantial penalties and the possible required removal and replacement of low-quality concrete. Increasingly, specifications for construction projects are requiring certified testing personnel. Furthermore, certified technicians are more likely to secure the confidence of the project managers.

Overview of the ACI Program

In order to attain ACI Certification as a Concrete Strength Testing Technician, you must successfully complete both the ACI written and performance examinations (see Figure 1). While there are no prerequisites in either training or experience, the examinations are designed so that only knowledgeable technicians will pass.

Administration

The American Concrete Institute, through its Certification Programs Committee, administers the certification program. This includes the development and maintenance of all program policies and procedures, instructional materials, and examinations.

The ACI certification program is conducted by a sponsoring group, such as an ACI chapter, a state or local concrete industry association, a college or university, or other organization committed to upgrading the quality of concrete. This group is responsible for scheduling and conducting

all sessions; arrangement of facilities, material, equipment, and personnel; payment of all bills; and establishment and collection of all registration fees.

The ACI Certification Department assists the sponsoring groups in setting up the program and manages the daily operation of the program. This includes the publication and dissemination of all instructional materials and examinations, grading examinations, maintenance of certification records, and issuance of certification to successful candidates.

Definitions

ACI—The American Concrete Institute (38800 Country Club Drive, Farmington Hills, MI 48331), which developed and published instructional materials and examinations used in this program, and which certifies individuals who satisfy all requirements of this program.

ACI Certification—A formal recognition, valid for a specified period of time, which shows that a person has satisfactorily completed the certification requirements.

ACI Certification Department—The department within ACI that manages the certification programs.

ACI Concrete Strength Testing Technician—A technician who has demonstrated knowledge and ability to properly perform and record the results of four specified ASTM International procedures related to the determination of concrete compressive and flexural strength by passing the ACI certification examinations.

ASTM—ASTM International (100 Barr Harbor Drive, West Conshohocken, PA, 19428-2959), which developed and published technical standards used in this program.

Examiner—A person authorized by ACI to be in responsible charge of an examination session

JTA—Job Task Analysis; a detailed list of items of knowledge and skills that can be used as a study guide for the examination.

Recertification—A process to renew expired certification by successfully completing the then-current requirements.

Sponsoring Group—The local organization (such as an ACI chapter, trade association, public agency, private testing laboratory, or other organization) which takes responsibility for conducting the certification examination in its locality and, as a recommended option, for conducting a review course.

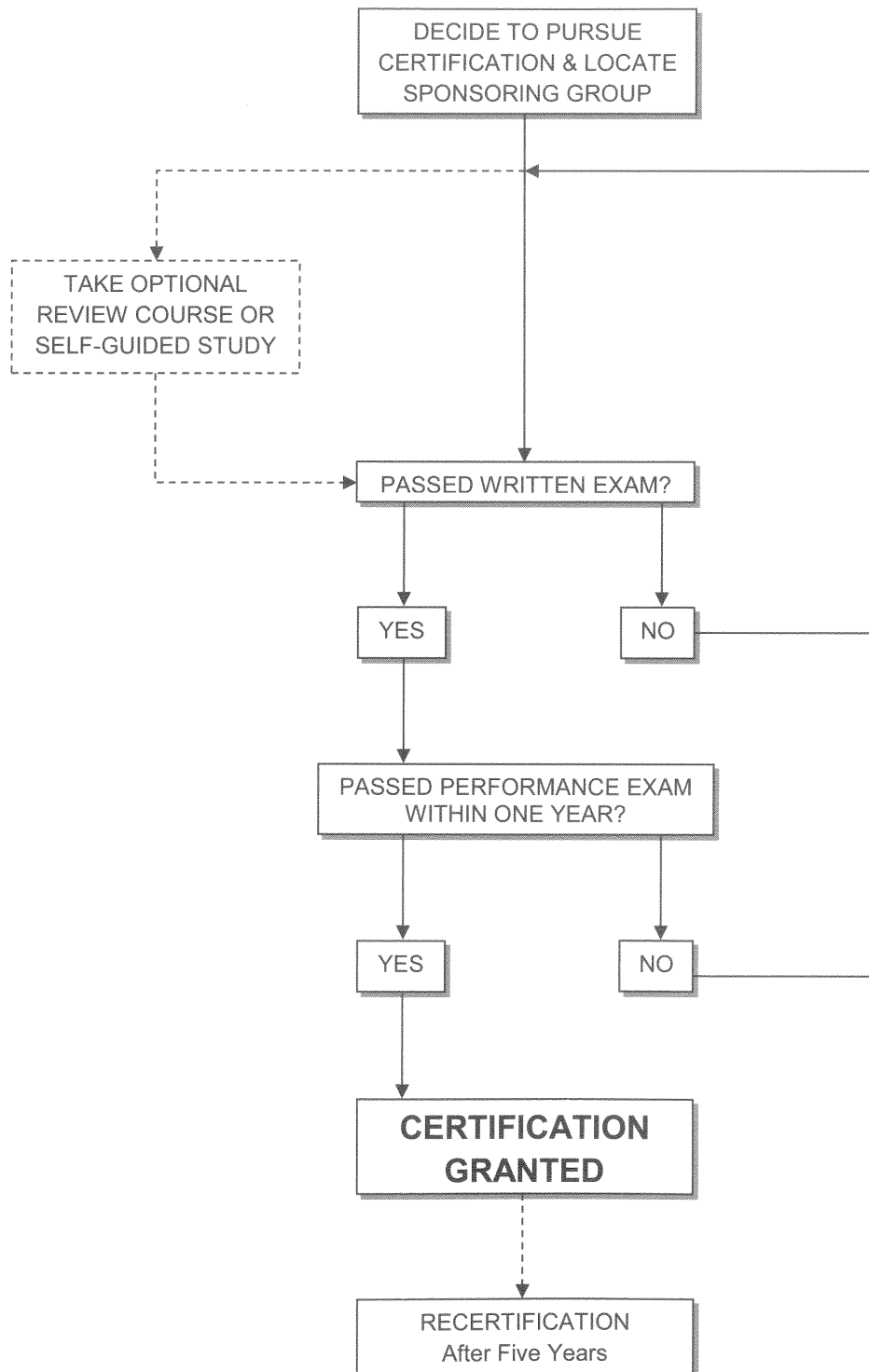


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**ACI CONCRETE STRENGTH
TESTING TECHNICIAN
CERTIFICATION PROCESS**

Figure 1



Supplemental Examiner—A person who assists the Examiner by administering the performance examination.

Trial—In the performance examination, one of two attempts allowed for the examinee to successfully perform each step of the procedure.

Proctor—A person authorized to assist the Examiner in conducting the written examination.

Resource Material

This technician workbook is the primary resource for Concrete Strength Testing Technician and contains the essential resource material you need to prepare for the examinations.

Program Information contains general information about this ACI certification program and describes all policies, procedures, and requirements.

Technical Sections is divided into four parts, each containing a brief outline, introduction, reprint of the ASTM standard, study questions, and performance examination checklist, when applicable.

The ASTM standards covered in this program are:

- C617/C617M Standard Practice for Capping Cylindrical Concrete Specimens
- C1231/C1231M Standard Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders
- C39/C39M Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
- C78/C78M Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

Study Material contains the Job Task Analysis (JTA), a sample exam, and answers to the study questions and sample exam, to aid your individual study.

Job Task Analysis (JTA)

The JTA is a detailed list of fundamental job elements, including the items of knowledge and skills required to successfully perform a job's functions. These elements are further distinguished in the JTA between general knowledge (understanding concepts), working knowledge (knowing facts or values), and physical proficiency (performing a physical task).

The written and performance examinations for Concrete Strength Testing Technician are designed to assess these fundamental job elements. Therefore, the JTA may also serve as a guide when studying/preparing for certification; it outlines the expected knowledge and skill base of a Concrete Strength Testing Technician and governs the areas of competency assessed by the written and performance examinations for this program.

The JTA for this certification program can be found in **Study Material**.

Preparation for the Examinations

ACI recommends that you attend a review course prior to the examinations, if offered by the sponsoring group. Sponsoring groups typically have access to resources (laboratory equipment and time, video training materials, etc.) that an individual does not. Course content and instructional time varies between sponsoring groups depending upon local needs.

Examinees are not required to participate in a review course, but preparing for the examinations without the benefit of the review course is not recommended. If a review course is not offered, or if you choose not to enroll in the course when offered, you should prepare a course of self-study.

Remember that your individual study, with or without the review course, can mean the difference between passing and failing the examinations.

Examinations

To achieve Concrete Strength Testing Technician certification, both a written and performance examination must be passed. You may be required to show photo identification to gain admittance to the examinations.

Written Examination

The Concrete Strength Testing Technician written examination covers all four ASTM standards listed under **Resource Material**. Questions are derived directly from the text as well as special applications which you may or may not encounter on a construction project. There are no questions on general concrete technology on the examination.

The examination is **closed-book**; access to technical materials or notes during the examination is not allowed.

The examination consists of 40 multiple-choice questions, divided into 4 sections, each covering an individual standard. Each section has 8 to 10 questions. A maximum of 1 hour (60 minutes) is allowed to complete the entire examination.

To pass the examination, **both** of the following criteria must be met:

1. At least 60% of the questions in each of the four sections must be answered correctly (e.g., 5 correct out of 8 equals 63%).
2. At least 70% of all questions on the examination must be answered correctly (e.g., 28 correct out of 40 equals 70%).

Calculations may be required for some questions; you may bring a simple-function pocket calculator to the examination. You may not share a calculator with another examinee during the examination.

ACI uses an optical reader to scan all personal data and written examination answer sheets. Two No. 2 pencils and a clean eraser are recommended for the written examination.

This examination may be conducted verbally if requested; please make arrangements with the sponsoring group prior to the examination date.

Performance Examination

The ACI Concrete Strength Testing Technician performance examination covers all four ASTM standards listed under **Resource Material**, with Practice C1231/C1231M and Test Method C39/C39M combined into one procedure. You will be judged on your ability to correctly perform all required steps for each procedure based on the criteria in the Performance Examination Checklists. In instances where performance is not feasible, you will be prompted to verbally describe the step(s). Checklists are provided in **Study Material** to aid your study, but are revised periodically and may not be inclusive of the current examination.

Omission or incorrect performance on one or more steps of a procedure will constitute failure of that trial. You are allowed up to two trials on the day of the examination for each procedure. Failure of any procedure after two trials will constitute failure of the performance examination. All seven procedures must be passed at the same time to pass the performance examination.

You are required to perform the correct steps for each procedure in the direct presence of the examiner or a supplemental examiner. You may not refer to notes or any other written material during the trial. Talking is not prohibited, however the examiner is not allowed to respond to any questions, or offer coaching of any kind.

Immediately following completion of each trial, the examiner will tell you whether you passed or failed that trial. If a failure has occurred, the

examiner will tell you which steps were performed or described (for verbal steps only) incorrectly. The examiner will not stop the trial at the point an error is made, or express approval or disapproval (verbal or nonverbal).

If, during a trial, you feel that you have made an error, you may request to suspend that trial and immediately begin the procedure over. If a trial is suspended voluntarily, it will not be counted as a failure of the trial. You may voluntarily suspend one trial per procedure.

The performance exam is physically demanding. If you feel you are risking personal injury in performing, or are unable to perform the procedures in the performance examination due to diminished physical capacity or physical disability, please inform the sponsoring group in advance of the examination date so alternative arrangements may be made.

Challenges

If you encounter a test question that appears to be unclear, incorrect, or unfair, please describe your complaint on the Question Challenge Form included with your examination.

You must mark a response on your answer sheet that best answers the question. All questions have been formulated from the ASTM standards; any challenge based on a reference from an outside document will not be considered unless the reference agrees with the ASTM standard. If your explanation is found to be valid, scores will be adjusted accordingly.

All questions for the written examination and checklists for the performance examination are developed by the Laboratory Technician Certification Committee and maintained at ACI Headquarters by the ACI Certification Department. Neither the examiner nor the sponsoring group have any jurisdiction over the content or the scoring of the written and performance examinations. However, since the performance examination is slightly more subjective in nature than the written examination, the examiner or supplemental examiner does have the authority to interpret some of the procedures on the performance examination.

Re-Examination

Failure of the written examination by either the subtest or overall score criteria will require re-examination on the entire written examination, not just on the failed subtest(s). All subtests must be passed at the same time.

Failure of a performance examination on one or more of the required procedures will require re-examination on the entire performance

examination, not just on the failed procedure(s). All procedures must be passed at the same time.

A re-examination on either exam may be taken at any time, together or independently of one another; however, both exams must be passed within one year to be considered for certification.

It is your responsibility to request re-examination. To do so, contact the examiner and/or sponsoring group to arrange a convenient time, location, and appropriate fee. If you require further assistance, contact the ACI Certification Department.

Appeals

All ACI certification policies, procedures, requirements, and examination materials have been developed through the voluntary consensus process and carefully reviewed for accuracy and fairness. However, an appeal process is available in the event that you feel that some aspect of the examination administration is unclear, incorrect, or unfair (see **Challenges** for examination content disputes). If a complaint is found to be valid, ACI will adjust grades accordingly.

The first level of appeal rests with the examiner. This person is a registered professional engineer with sufficient education and experience in concrete testing and inspection to be approved by ACI as their local representative for this program.

If the examiner cannot satisfy your complaint, appeals are handled in order by the following people or groups:

1. Sponsoring Group
2. Director of Certification

3. Certification Appeals Committee
4. Committee C620—Laboratory Technician Certification
5. Certification Programs Committee

Note: Members of the Certification Appeal Committee include the Director of Certification, the Chair of the Certification Programs Committee, and the Chair of Committee C620.

Appeals submitted directly to ACI must be received, in writing, within 60 days of the receipt of the examination at ACI Headquarters. Appeals that are not made during the examination session will not be considered.

Recertification

Your ACI certification as a Concrete Strength Testing Technician expires five years from the date that you complete the certification requirements. Your original certification and subsequent recertification periods run concurrently, not consecutively.

Recertification is granted by successfully completing the then-current written and performance examinations.

Americans with Disabilities Act (ADA)

If you have a disability and require special accommodations, please contact ACI Headquarters for further information on how to proceed. All requests for special accommodations under ADA are handled on a case-by-case basis and must be made allowing enough time for evaluation and appropriate action by ACI.

TECHNICAL SECTIONS

Each section consists of:

- Introduction
- Reprint of ASTM Standard
- Study Questions
- Performance Checklist

SECTION 1

ASTM C617/C617M

Standard Practice for Capping Cylindrical Concrete Specimens

Introduction

This practice covers apparatus, materials, and procedures for capping freshly molded concrete cylinders with neat cement and also capping of hardened cylinders and drilled cores with high-strength gypsum plaster or sulfur mortar.

The purpose of the cap is to provide smooth, parallel, uniform bearing surfaces for the specimen during compressive strength testing. Irregular surfaces will adversely affect the strength of the specimen and result in an inaccurate representation of the strength of the in-place concrete.

Use of sulfur mortar for capping involves fumes that must be properly vented and high temperature material that must be handled with caution. Proper safety procedures and protective clothing must be used.

High-strength concrete specimens may require grinding of the bearing surfaces if an adequately strong capping method is not available. Normal-strength concrete specimens may also be ground, but the cost usually makes this impractical.



Standard Practice for Capping Cylindrical Concrete Specimens¹

This standard is issued under the fixed designation C617/C617M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This practice covers apparatus, materials, and procedures for capping freshly molded concrete cylinders with neat cement and hardened cylinders and drilled concrete cores with high-strength gypsum paste or sulfur mortar.

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 4.3.1 and 6.2.4.1.

2. Referenced Documents

2.1 ASTM Standards:²

- C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
- C150 Specification for Portland Cement
- C472 Test Methods for Physical Testing of Gypsum, Gypsum Plasters and Gypsum Concrete
- C595 Specification for Blended Hydraulic Cements
- C1231/C1231M Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders

2.2 ANSI Standard:³

- B46.1 Standard for Surface Texture (Surface, Roughness, Waviness and Lay)

3. Significance and Use

3.1 This practice describes procedures for providing plane surfaces on the ends of freshly molded concrete cylinders, hardened cylinders, or drilled concrete cores when the end surfaces do not conform with the planeness and perpendicularity requirements of applicable standards. Practice C1231/C1231M describes alternative procedures using unbonded caps or pad caps.

4. Capping Equipment

4.1 *Capping Plates*—Neat cement caps and high-strength gypsum-paste caps shall be formed against a glass plate at least 6 mm [$\frac{1}{4}$ in.] thick, a machined metal plate at least 11 mm [0.45 in.] thick, or a polished plate of granite or diabase at least 75 mm [3 in.] thick. Sulfur mortar caps shall be formed against similar metal or stone plates except that the recessed area which receives molten sulfur shall not be deeper than 12 mm [$\frac{1}{2}$ in.]. In all cases, plates shall be at least 25 mm [1 in.] greater in diameter than the test specimen and the working surfaces shall not depart from a plane by more than 0.05 mm [0.002 in.] in 150 mm [6 in.]. The surface roughness of newly finished metal plates shall not exceed that set forth in Table 4 of American National Standard B46.1, or 3.2 μ m [125 μ in.] for any type of surface and direction of lay. The surface, when new, shall be free of gouges, grooves, or indentations beyond those caused by the finishing operation. Metal plates that have been in use shall be free of gouges, grooves, and indentations greater than 0.25 mm [0.010 in.] deep or greater than 30 mm² [0.05 in.²] in surface area.

NOTE 1—A Rockwell hardness of 48 HRC is suggested for capping plates of devices used to form sulfur mortar caps.

4.2 *Alignment Devices*—Suitable alignment devices, such as guide bars or bull's-eye levels, shall be used in conjunction with capping plates to ensure that no single cap will depart from perpendicularity to the axis of a cylindrical specimen by

¹ This practice is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.61 on Testing for Strength.

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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 Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

more than 0.5° (See Note 2). The same requirement is applicable to the relationship between the axis of the alignment device and the surface of a capping plate when guide bars are used. In addition, the location of each bar with respect to its plate must be such that no cap will be off-centered on a test specimen by more than 2 mm [$\frac{1}{16}$ in.].

NOTE 2—A deviation from perpendicularity of 0.5° is equal to a slope of approximately 1 mm in 100 mm [$\frac{1}{8}$ in. in 12 in.].

4.3 Melting Pots for Sulfur Mortars—Pots used for melting sulfur mortars shall be equipped with automatic temperature controls and shall be made of metal or lined with a material that is nonreactive with molten sulfur.

4.3.1 Warning—Melting pots equipped with peripheral heating will ensure against accidents during reheating of cooled sulfur mixture that have a crusted-over surface. When using melting pots not so equipped, a build-up of pressure under the hardened surface crust on subsequent reheating may be avoided by use of a metal rod that contacts the bottom of the pot and projects above the surface of the fluid sulfur mix as it cools. The rod should be of sufficient size to conduct enough heat to the top on reheating to melt a ring around the rod first and thus avoid the development of pressure. A large metal ladle can be substituted for the rod.

4.3.1.1 Use sulfur melting pots in a hood to exhaust the fumes to outdoors. Heating over an open flame is dangerous because the flash point of sulfur is approximately 207°C [405°F] and the mixture can ignite due to overheating. If the mixture starts to burn, covering will snuff out the flame. Recharge the pot with fresh material after the flame has been extinguished.

5. Capping Materials

5.1 The strength of the capping material and the thickness of the caps shall conform to the requirements of Table 1.

5.1.1 If sulfur mortar, high strength gypsum paste and other materials except neat cement paste are to be used to test concrete with a strength greater than 50 MPa [7000 psi] and their compressive strength is less than the cylinder compressive strength, the manufacturer or the user of the material must provide documentation:

5.1.1.1 That the average strength of 15 cylinders capped with the material is not less than 98 % of the average strength of 15 companion cylinders capped with neat cement paste or 15 cylinders ground plane to within 0.05 mm [0.002 in.].

TABLE 1 Compressive Strength and Maximum Thickness of Capping Materials

Cylinder Compressive Strength MPa [psi]	Minimum Strength of Capping Material	Maximum Average Thickness of Cap	Maximum Thickness Any Part of Cap
3.5 to 50 MPa [500 to 7000 psi] greater than 50 MPa [7000 psi]	35 MPa [5000 psi] or cylinder strength whichever is greater	6 mm [$\frac{1}{4}$ in.]	8 mm [$\frac{5}{16}$ in.]
	Compressive strength not less than cylinder strength, except as provided in 5.1.1	3 mm [$\frac{1}{8}$ in.]	5 mm [$\frac{3}{16}$ in.]

5.1.1.2 That the standard deviation of the strengths of the capped cylinders is not greater than 1.57 times that of the standard deviation of the reference cylinders.

5.1.1.3 That the cap thickness requirements were met in the qualification tests, and

5.1.1.4 Of the hardening time of the caps used in the qualification tests.

5.1.2 Additionally, the qualification test report must include the compressive strength of 50 mm [2 in.] cubes of the material qualified and of neat cement paste cubes, if used. Capping materials conforming to these requirements is permitted to be used for cylinders with strengths up to 20 % greater than the concrete tested in these qualification tests. The manufacturer must requalify lots of material manufactured on an annual basis or whenever there is a change in the formulation or the raw materials. The user of the material must retain a copy of the qualification results, and the dates of manufacture of material qualified and of the material currently being used.

NOTE 3—Table 2 is an example of a report of test results to qualify a capping material.

5.1.3 The compressive strength of capping materials shall be determined by testing 50 mm [2 in.] cubes following the procedure described in Test Method C109/C109M. Except for sulfur mortars, molding procedures shall be as in Test Method C109/C109M unless other procedures are required to eliminate large entrapped air voids. See Test Methods C472 for alternative compaction procedures. Cure cubes in the same environment for the same length of time as the material used to cap specimens.

5.1.4 The strength of the capping material shall be determined on receipt of a new lot and at intervals not exceeding three months. If a given lot of the capping material fails to conform to the strength requirements, it shall not be used, and strength tests of the replacement material shall be made weekly until four consecutive determinations conform to specification requirements.

5.2 Neat Hydraulic Cement Paste:

5.2.1 Make qualification tests of the neat hydraulic cement paste prior to use for capping to establish the effects of water-cement ratio and age on compressive strength of 50 mm [2 in.] cubes.

NOTE 4—The cements used generally conform to Specification C150 Types I, II or III; however, Specification C595 blended cements, calcium aluminate or other hydraulic cements producing acceptable strength may be used.

5.2.2 Mix the neat cement paste to the desired consistency at a water-cement ratio equal to or less than that required to produce the required strength, generally 2 to 4 h before the paste is to be used (Note 5). Remix as necessary to maintain acceptable consistency (Note 6). Some retempering of the paste is acceptable if the required water-cement ratio is not exceeded. Optimum consistency is generally produced at water-cement ratios of 0.32 to 0.36 by mass for Type I and Type II cements and 0.35 to 0.39 by mass for Type III cements.

NOTE 5—Freshly mixed pastes tend to be too stiff to form unacceptable caps. The 2 to 4 h period is generally appropriate for portland cements.



TABLE 2 Example of Report of Qualification of a Capping Material

NOTE 1—Manufacturer: Testing Supplies Co.
 Capping Material: Super Strong AAA-Sulfur mortar
 Lot: 12a45 Date Tested: 11/3/XX
 Signed by: _____ (testing agency and responsible official)

Item	Capping Material	Control Cylinders	Ratio Cap/Control	Criteria	Pass/Fail
Concrete Cylinder Test Data					
Type of capping material	Sulfur	Ground			
Average Concrete Strength, psi	11 061	11 008	1.005	>0.98	Pass
Standard Deviation, psi	376	250	1.504	≤1.57	Pass
Number of cylinders tested	15	15			
Cap age when cylinders tested	7 days	na			
Capping Material Test Data					
Average cap thickness, in.	0.11	na			
Compressive strength of 2 in. cubes, psi	12 195				
Cube age when tested.	7 days				
Maximum concrete strength qualified, psi				1.2 Av. Str = 13 273 ^A	

^A Nominally a specified strength of 11 000 psi and perhaps somewhat higher.

NOTE 6—The required consistency of the paste is determined by the appearance of the cap when it is stripped. Fluid paste results in streaks in the cap. Stiff paste results in thick caps.

5.3 High-Strength Gypsum Cement Paste:

5.3.1 No fillers or extenders may be added to neat high-strength gypsum cement paste subsequent to the manufacture of the cement. (Note 7) Qualification tests shall be made to determine the effects of water-cement ratio and age on compressive strength of 50 mm [2 in.] cubes. Retarders may be used to extend working time, but their effects on required water-cement ratio and strength must be determined. (Note 8)

NOTE 7—Low-strength molding plaster, plaster of paris, or mixtures of plaster of paris and portland cement are unsuitable for capping.

NOTE 8—The water-gypsum cement ratio should be between 0.26 and 0.30. Use of low water-cement ratios and vigorous mixing will usually permit development of 35 MPa [5000 psi] at ages of 1 or 2 h. Higher water-gypsum cement ratios extend working time, but reduce strength.

5.3.2 Mix the neat gypsum cement paste at the desired water-cement ratio and use it promptly since it sets rapidly.

5.4 Sulfur Mortar:

5.4.1 Proprietary or laboratory prepared sulfur mortars are permitted if allowed to harden a minimum of 2 h before testing concrete with strength less than 35 MPa [5000 psi]. For concrete strengths of 35 MPa [5000 psi] or greater, sulfur mortar caps must be allowed to harden at least 16 h before testing, unless a shorter time has been shown to be suitable as specified in 5.1.1.

5.4.2 *Determination of Compressive Strength*—Prepare test specimens using a cube mold and base plate conforming to the requirements of Test Method C109/C109M and a metal cover plate conforming in principle to the design shown in Fig. 1 (Note 9). Bring the various parts of the apparatus to a temperature of 20 to 30°C [68 to 86°F], lightly coat the surfaces that will be in contact with the sulfur mortar with mineral oil, and assemble near the melting pot. Bring the temperature of the molten-sulfur mortar in the pot within a range of 130 to 145°C [265 to 290°F], stir thoroughly, and begin casting cubes. Using a ladle, or other suitable pouring device, quickly fill each of the three compartments until the

molten material reaches the top of the filling hole. Allow sufficient time for maximum shrinkage, due to cooling, and solidification to occur (approximately 15 min) and refill each hole with molten material (Note 10). After solidification is complete, remove the cubes from the mold without breaking off the knob formed by the filling hole in the cover plate. Remove oil, sharp edges, and fins from the cubes and check the planeness of the bearing surfaces in the manner described in Test Method C109/C109M. After storage at room temperature to the desired age, but not less than 2 h, test cubes in compression following the procedure described in Test Method C109/C109M, and calculate the compressive strength.

NOTE 9—If desired, a 3-mm [$\frac{1}{8}$ in.] thick plate of thermosetting plastic (such as phenol formaldehyde), provided with three appropriately spaced filling holes, may be inserted between the cover plate and the mold to slow the rate of cooling of test specimens.

NOTE 10—The second filling helps to prevent the formation of a large void or shrinkage pipe in the body of a cube. However, such defects may occur no matter how much care is exercised, and it therefore is advisable to inspect the interior of tested sulfur mortar cubes for homogeneity whenever the strength values obtained are significantly lower than anticipated.

6. Capping Procedures

6.1 *Freshly Molded Cylinders*—Use only neat portland cement pastes (Note 11) to cap freshly molded cylinders. Make caps as thin as practicable. Do not apply the neat paste to the exposed end until the concrete has ceased settling in the molds, generally from 2 to 4 h after molding. During the molding of the cylinder, strike off the upper end even with or slightly below the plane of the rim of the mold. Remove free water and laitance from the top of the specimen immediately before capping. Form the cap by placing a conical mound of paste on the specimen and then gently pressing a freshly oiled capping plate on the conical mound until the plate contacts the rim of the mold. A very slight twisting motion may be required to extrude excess paste and minimize air voids in the paste. The capping plate must not rock during this operation. Finally, cover the capping plate and mold with a double layer of damp burlap and a polyethylene sheet to prevent drying. Removal of

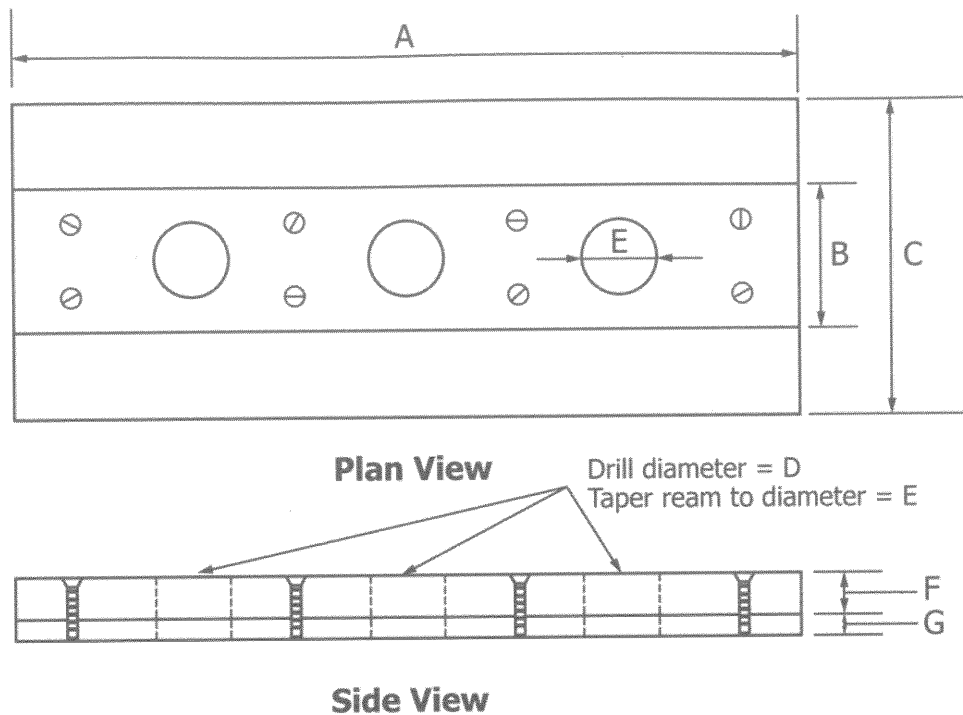


TABLE 1 Table of Dimensions

Label	A	B	C	D	E	F	G
Dimension, mm [in.]	255 [10]	45 [1 3/4]	100 [4]	22 [7/8]	24 [1 5/16]	12 [1/2]	6 [1/4]

FIG. 1 Sketch of Cover Plate for 50-mm [2-in.] Cube Mold

the capping plate after hardening may be accomplished by tapping the edge with a rawhide hammer in a direction parallel to the plane of the cap.

NOTE 11—Type I neat cement caps generally require at least 6 days to develop acceptable strength and Type III neat cement caps at least 2 days. Dry concrete specimens will absorb water from freshly mixed neat cement paste and produce unsatisfactory caps. Neat cement paste caps will shrink and crack on drying and, therefore, should be used only for specimens that are to be moist cured continuously until time of testing.

NOTE 12—High-strength gypsum caps soften and deteriorate on contact with water and cannot be used on freshly mixed concrete or stored in a moist room for more than very brief periods.

6.2 Hardened Concrete Specimens:

6.2.1 *General*—If an end of a specimen has a coating or deposit of oily or waxy materials that would interfere with the bond of the cap, remove such coatings or deposits. If necessary, the ends of a specimen may be slightly roughened with a steel file or wire brush to produce proper adhesion of the cap. If desired, capping plates may be coated with a thin layer of mineral oil or grease to prevent the capping material from adhering to the surface of the plate.

6.2.2 *End Condition*—The distance of any point on an uncapped end from a plane that passes through the highest point of the end surface and is perpendicular to the axis of the cylinder shall not exceed 3 mm [1/8 in.] (Note 13). If the end exceeds this limit, the end of the cylinder shall be cut, lapped or ground prior to capping.

NOTE 13—This provision is to control the difference between the thickest and thinnest parts of a cap. The distance may be checked using a square with one blade touching the cylinder parallel to the cylinder axis

and the other blade touching the highest point on the end of the cylinder. The distance between the blade of the square and the lowest point on the end of the cylinder is measured.

6.2.3 *Capping with High-Strength Gypsum Paste or Neat Cement Paste*—Mix the paste as described in 5.2 and 5.3. Do not exceed the water-cement ratio determined in qualification tests. Form the caps as described in 6.1 using capping plates described in 4.1 to achieve the alignment required in 4.2 (Note 14). Generally, capping plates may be removed within 45 min with gypsum cement pastes and after 12 h with neat cement paste, without visibly damaging the cap.

NOTE 14—A number of methods have been used to obtain the desired perpendicularity of the cap to the axis of the cylinder. A mound of paste can be placed on a capping plate and the specimen lowered into it. A bull's-eye level on the top of the cylinder helps obtain alignment. A mound of paste can be placed on top of the cylinder and a capping plate pressed into it, again using the bull's-eye level. A better system is to make a half-height mold with a vertical split so that it can be slipped over the hardened cylinder. A clamp is used to position the mold and to ensure the required cap thickness. The mound of paste can then be placed either on a capping plate or on top of the cylinder and pressed until the plate contacts the mold. As Noted earlier, very stiff paste may require excessive pressure and produce thick or defective caps.

6.2.4 *Capping with Sulfur Mortar*—Prepare sulfur mortar for use by heating to a temperature between 130 to 145°C [265 to 290°F] as determined by an all-metal thermometer inserted near the center of the mass. Check the temperature at approximately hourly intervals during capping. Empty the pot and recharge with fresh material at intervals to ensure that the oldest material in the pot has not been used more than five times. When capping concrete cylinders with a compressive



strength of 35 MPa [5000 psi] or greater, it is not permitted to reuse compound recovered from the capping operation or old caps. Fresh sulfur mortar must be dry at the time it is placed in the pot as dampness may cause foaming. Keep water away from molten sulfur mortar for the same reason. The capping plate or device should be warmed before use to slow the rate of hardening and permit the production of thin caps. Oil the capping plate lightly and stir the molten sulfur mortar immediately prior to pouring each cap. The ends of moist cured specimens shall be dry enough at the time of capping to preclude the formation of steam or foam pockets under or in the cap larger than 6 mm [$\frac{1}{4}$ in.] in diameter. Replace caps with steam pockets or voids larger than 6 mm [$\frac{1}{4}$ in.] (Note 15). To ensure that the cap is bonded to the surface of the specimen, the end of the specimen shall not be oiled prior to the application of the cap. When using a vertical device, pour the mortar onto the surface of the capping plate, lift the cylinder above the plate and contact the cylinder sides with the guides, slide the cylinder down the guides onto the capping plate while keeping constant contact with the alignment guides. The cylinder end should continue to rest on the capping plate with cylinder sides in positive contact with the alignment guides until the mortar has hardened. Use sufficient material to cover the cylinder end after the sulfur mortar solidifies.

NOTE 15—Periodically, the sulfur mortar cap should be examined after testing for air or steam pockets in the cap. Before testing, the cap can be tapped with a coin or rubbed with a light metal implement to see if a hollow sound can be detected. Caps with hollow areas should be removed and recapped.

6.2.4.1 **Warning**—Hydrogen sulfide gas may be produced during capping when sulfur mortar is contaminated with organic materials such as paraffin or oil. The gas is colorless and has a notoriously bad odor of rotten eggs; however, the odor should not be relied upon as a warning sign, since the sensitivity to the odor disappears rapidly on exposure. High concentrations are lethal and less concentrated dosages may produce nausea, stomach distress, dizziness, headache, or irritation of the eyes. For this and other reasons, the melting pot must be located under a hood with an exhaust fan and that capping area must be well ventilated.

6.2.5 Daily Check:

6.2.5.1 During each day's capping operation, check the planeness of the caps prior to compression testing on at least three specimens, selected at random, representing the start,

middle, and end of the run. Check planeness with a straight-edge and feeler gage, making a minimum of three measurements on different diameters to ensure that the surface of the caps do not depart from a plane by more than 0.05 mm [0.002 in.]. Check also for hollow areas (Note 15). Record the results of these determinations in the quality control documentation for the laboratory. If caps fail to satisfy the planeness requirement or have hollow areas, remove and reapply the caps.

6.2.5.2 During each day's compressive strength testing operation, check the thickness of caps on at least three specimens, selected at random, from the start, middle, and end of that day's operation. After completing the compression test, recover at least six pieces of capping material from the top of the selected specimen (Note 16). The pieces shall be selected at random and be distributed over the entire area of the cap. The selected pieces shall have debonded completely from the concrete. Measure and record the thicknesses of the pieces to the nearest 0.2 mm [0.01 in.] using a micrometer, caliper or other thickness measurement device. Compare the average and maximum thicknesses with the values in Table 1. Record the results of the thickness determinations in the quality control documentation for the laboratory.

NOTE 16—Caps may be removed by using a hammer and sharp chisel. Place the chisel tip at the bond line and nearly parallel with the plane of the cap so as to create a wedging action when the chisel is struck with the hammer. Recovery of the entire cap may be simplified by placing duct tape over the cap prior to attempting its removal. The tape will keep the pieces of capping material from being dispersed during removal and will simplify the selection of pieces uniformly distributed over the cap area.

7. Protection of Specimens After Capping

7.1 Maintain moist cured specimens in a moist condition between the completion of capping and the time of testing by returning them to moist storage or wrapping them with a double layer of wet burlap. Do not store specimens with high-strength gypsum paste caps immersed in water or for more than 4 h in a moist room. Protect gypsum paste caps from dripping water.

7.2 Do not test capped specimens before the capping material has sufficient time to develop the strength required in 5.1.

8. Keywords

8.1 capping; concrete; compressive strength; cores; cylinders; gypsum cement paste; neat hydraulic cement paste; sulfur mortar

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this practice since the last issue, C617/C617M – 12, that may impact the use of this practice. (Approved April 1, 2015.)

(1) Revised 5.4.2 and 6.2.4.

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STUDY QUESTIONS

Practice C617/C617M – 15 Capping Cylindrical Concrete Specimens

1. These procedures for capping enable concrete cylinders and cores to meet the standard practice's requirements for _____ and _____.
2. Equipment needed for the capping process includes capping _____, _____ devices, and _____ pots.
3. Plates for neat cement and high-strength gypsum plaster caps should be made of _____, _____, or _____.
4. Sulfur mortar cap plates should be formed against _____ or _____ plates.
5. The purpose of the guide bar or bull's eye level is to ensure that caps remain perpendicular to the axis of the cylinder within 0.5 degrees. True or False?
6. To avoid accidents during reheating of cooled sulfur, use melting pots that have _____.
7. The technician should use a stiff layer of _____ to cap fresh concrete cylinders.
8. Hardened concrete cylinders should be capped with _____, _____, or _____.
9. Plaster of paris and mixtures of plaster of paris and portland cement are examples of suitable high-strength plasters. *True or False?*
10. Sulfur mortars and high-strength gypsum cement cubes must demonstrate a minimum compressive strength of _____ or _____, whichever is greater.
11. The cement paste should be applied to the freshly molded cylinder from _____ hours after molding. This is to allow for _____ of the concrete specimen.
12. The strength of the paste depends on:
 - A. The water-cement ratio
 - B. Time
 - C. The equipment used
 - D. Type of cement
13. A slight twisting action will help eliminate _____ and air _____ when the capping plate is placed onto the mound of paste.
14. Neat cement paste caps should not be used on dry specimens because the caps may _____ and _____ when dry.
15. The technician should remove all _____ or _____ materials from the ends of hardened concrete cylinders before capping.
16. _____ the pot and recharge with fresh material at intervals to ensure that the oldest material in the pot has not been used more than _____ times.

STUDY QUESTIONS

17. When capping concrete cylinders with a compressive strength of 35 MPa [5000 psi] or greater, it is permitted to reuse compound recovered from the capping operation or old caps. *True or False?*
18. To avoid _____, the sulfur mortar should be dry when it is added to the pot. It should be kept away from _____ when heating.
19. The melting pot for the sulfur mortar must be located under a(n) _____ with a(n) _____ for _____.
20. Hydrogen sulfide gas, which may be produced during capping, may be _____ in high concentrations. In lower concentrations, the gas may result in _____, _____, _____, and _____.