

# Australian Standard<sup>®</sup>

AS 1012.9:2014

## Methods of testing concrete

### Method 9: Compressive strength tests— Concrete, mortar and grout specimens

#### 1 SCOPE

This Standard sets out the method for determining the compressive strength of concrete test specimens prepared in accordance with the provisions of AS 1012.8.1, AS 1012.8.3, AS 1012.14 or AS 1012.19.

NOTE: This Standard may involve hazardous materials, operations, and equipment. The Standard does not purport to address all of the safety problems associated with its use. The user of this Standard should establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

#### 2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

1012	Methods of testing concrete
1012.1	Method 1: Sampling of fresh concrete
1012.8	Method 8: Method for making and curing concrete
1012.8.1	Method 8.1: Compression and indirect tensile test specimens
1012.8.3*	Method 8.3: Method for making and curing grout and mortar specimens
1012.14	Method 14: Method for securing and testing cores from hardened concrete for compressive strength
1012.19	Method 19: Accelerated curing of concrete compression test specimens (laboratory or field)—Hot water and warm water methods
2193	Methods for calibration and grading of force-measuring systems of testing machines
3972	Portland and blended cements
5100	Bridge design
5100.4	Part 4: Bearings and deck joints

#### 3 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

##### 3.1 Designer

The person, persons or organization responsible for the design of the structure.

##### 3.2 Concrete supplier

The person, persons or organization responsible for the supply of the concrete mix.

\* To be published.

## 4 ACCEPTANCE OF SPECIMENS

### 4.1 Moulded cylinder specimens

Moulded cylinder specimens shall be accepted for testing if they have been moulded in accordance with AS 1012.8.1 and are free from defects likely to affect their strength.

Where specimens liable to rejection are tested, all apparent defects shall be noted in accordance with Clauses 11 and 12 herein.

Uncapped specimens shall be liable to rejection if any of the following conditions exist:

- (a) Either end of a cylinder is convex by more than 5 mm.
- (b) Aggregate or other bulges protrude from either end by more than 5 mm.
- (c) Any edge is broken away in such a manner that the radial or vertical break is more than 10 mm from the edge line and the corresponding circumferential break, or sum of circumferential breaks, exceeds 10% of the circumference of the cylinder.
- (d) Small depressions or other irregularities are present which would cause filled sulphur mixture caps complying with Clause 6.2.1 to be more than 6 mm thick over more than approximately 25% of the surface, except that such specimens shall not be liable to rejection if they are to be capped in accordance with Clause 6.2.4(a).
- (e) Either end of a cylinder is not at right angles to the axis and the departure from squareness exceeds 2° (approximately 5 mm in 150 mm).
- (f) The diameter at any cross-section deviates from either end diameter by more than 2 mm.
- (g) The height is less than 1.95 times the diameter.
- (h) Any apparent defect is considered liable to affect the test results.

### 4.2 Cored specimens

The relevant criteria of AS 1012.14 shall be used to determine acceptability of cored specimens.

### 4.3 Cube specimens

The sides of the cube specimens which are to be loaded shall be at right angles and be flat to within 0.05 mm.

## 5 PREPARATION OF TEST SPECIMENS

Test specimens shall be prepared as follows:

- (a) If the surfaces of test specimens that are to be brought into contact with the platens of the testing machine are not plane within 0.05 mm they shall be either—
  - (i) capped (moulded cylinders or cores); or
  - (ii) ground plane within 0.05 mm. (See Appendix A).

The ends of the specimens that will be in contact with the platens shall be parallel within 2°.

- (b) An uncapped end of a cylinder specimen, which is to be placed in contact with the testing machine platen that is not spherically seated, or the surface of a cap similarly placed, shall not depart from perpendicularity to the axis of the specimen by more than 0.5° (approximately 3 mm in 300 mm).
- (c) Before capping, all loose particles and laitance shall be removed from the ends of the cylinder.

- (d) Specimens that are to be tested in the wet condition shall be kept moist during the time taken for inspection, measuring, capping and crushing. The maximum period of time a specimen is kept outside standard moist-curing conditions shall not exceed 2 h.
- (e) Cored specimens that are to be tested in the dry condition shall be tested within 2 h of removal from the conditioning environment.

## 6 CAPPING

### 6.1 General

Where capping is required, the specimens shall be tested using either—

- (a) a moulded capping, prepared in accordance with Clause 6.2; or
- (b) a restrained natural rubber capping system complying with the requirements of Clause 6.3, provided compressive strength is expected to be greater than 10 MPa and less than 80 MPa.

### 6.2 Moulded capping materials

#### 6.2.1 General

Moulded caps shall be as thin as practicable, but not thicker than 6 mm. Only one layer of capping material shall be used on each surface requiring capping, but small depressions may be filled prior to capping. Moulded capped surfaces shall not depart from a plane by more than 0.05 mm.

#### 6.2.2 Preparation of capping materials

Moulded capping materials shall consist of one of the following, subject to the limitations on use set out in Clause 6.4:

- (a) *Filled sulphur mixtures* Mixtures of sulphur and at least 10% by volume of fine filler material such as fly ash, finely ground silica or fire clay, or cement may be prepared. The sulphur mixture shall be used at a temperature that ensures a suitable viscosity for capping.
- (b) *Portland cement mortar* Mortar made from a mixture of one part of Portland cement and one part of fine sand, provided that the water-cement ratio does not exceed 0.35, may be prepared. The Portland cement shall be fresh, free from lumps, and shall comply with the requirements of AS 3972.

The sand-cement mixture shall be mixed with water to form a stiff paste which shall be allowed to stand for not less than 0.5 h and not more than 2 h before use, to minimize shrinkage of the cap.

- (c) *High-alumina cement mortar* Mortar made from one part of high-alumina cement and one part of fine sand, provided that the water-cement ratio does not exceed 0.35, may be prepared. The high-alumina cement shall be fresh and free from lumps.

The sand-cement mixture shall be mixed with water to form a stiff paste which shall be allowed to stand for not less than 0.5 h and not more than 2 h before use, to minimize shrinkage of the cap.

- (d) *Cement pastes* Portland cement or high-alumina cement paste or mixtures of these may be used to prepare caps if the cement used is fresh and free from lumps.

The cement shall be mixed with water to form a stiff paste and used within 2 h.

- (e) *Special gypsum plasters* Special high-strength gypsum plaster may be used to prepare a capping paste after being tested in the following manner:

- (i) The plaster-water mixture, prepared in the same proportions as those used for capping, shall be compacted into a cube mould using a spatula. The dimensions from the sides of the cube shall be between 50 mm and 75 mm.
- (ii) The specimen shall be demoulded after 0.5 h, stored in air, and tested 1 h after casting.

### 6.2.3 *Plates and equipment*

The plates and equipment used for moulded capping shall comply with the following requirements:

- (a) Cement mortar or paste, and special gypsum plaster caps shall be formed against plate-glass, or a machined metal plane plate, at least 6 mm thick. The diameter of all such plates shall be at least 25 mm larger than the nominal diameter of the specimen, and the surfaces shall not depart from a plane by more than 0.05 mm.
- (b) Caps made from sulphur mixtures shall be formed against a metal plate in which a recess has been machined. The thickness of the metal in the recessed area shall be at least 10 mm. The base of the recess shall be a circle whose diameter is approximately 5 mm greater than the nominal diameter of the specimen. The side of the recess shall slope to facilitate removal. The recessed area shall not depart from a true plane to an extent that results in caps with surfaces which themselves depart from a plane by more than 0.05 mm.
- (c) Capping plates shall be thinly coated with mineral oil to prevent adhesion of the capping material to the plate.
- (d) Alignment devices shall be used in conjunction with the plates to ensure that the specified perpendicularity of the cap to axis of the specimen is obtained.

### 6.2.4 *Capping procedure*

Concrete cylinders prepared in the laboratory may be capped with cement mortar after the concrete has ceased settling in the mould, generally 2 h to 4 h after moulding.

Hardened concrete cylinders and cores shall be capped in accordance with the following procedures:

- (a) Where a cement mortar or paste, or special gypsum plaster cap is to be applied, ensure that the end of the cylinder is in the saturated surface-dry condition just prior to capping.

NOTE: A quantity of mortar [see Clause 6.2.2(b)] is placed on the prepared end of the cylinder, carefully worked into the surface with a small trowel and then shaped to form a low dome. Care should be taken not to entrap any air in the mortar during the forming process. A plate is then placed on the mortar dome and firmly forced onto the cylinder surface until complete coverage of the cylinder is obtained and a cap of suitable thinness is achieved. A glass plate may be used to detect air bubbles, which would lead to later rejection of the cap.

- (b) Where a cap of sulphur mixture is to be applied, dry the surface to be capped by blowing ambient or heated air across the surface. Ensure that the drying does not extend below the surface of the specimen by more than the minimum amount required to provide a dry surface for adhesion of the sulphur mixture.

NOTE: To assist in bonding a sulphur-mixture cap, a thin layer of shellac solution may be applied to the end of the specimen.

### 6.2.5 *Cap inspection*

The moulded cap shall be inspected as follows:

- (a) Before each specimen is placed in the compression testing machine, lightly tap the cap with a suitable implement.

NOTE: The handle of a medium-size screwdriver has been found to be suitable.

- (b) Remove any cap that makes a hollow sound and replace it with a conforming cap before the specimen is tested.
- (c) Check the planeness and squareness of all mortar caps. Sulphur caps should be checked daily for planeness and squareness on a random basis. At least one cap in twenty from each set of moulding equipment shall be checked each working day.

NOTE: An engineer's square with a small notch cut in it to clear the edge of the cap may be used for this purpose. The long arm of the square should be placed parallel to the axis of the cylinder.

### 6.3 Restrained natural rubber capping system

#### 6.3.1 Capping system

Moulded concrete cylinders of nominal 150 mm and 100 mm diameter may be capped and tested with a restrained natural rubber pad.

The capping system shall consist of a circular natural rubber pad inside a restraining device such as shown in Figure 1. Other materials may be used for the restraining device provided they give equivalent results.

The pad shall be either of the following:

- (a) For a nominal 150 mm diameter cylinder—160 mm nominal diameter (e.g. snug fit to the restraining device) and a uniform thickness between 12 mm and 15 mm.
- (b) For a nominal 100 mm diameter cylinder—110 mm nominal diameter (e.g. snug fit to the restraining device) and a uniform thickness between 12 mm and 15 mm.

NOTES:

- 1 Natural rubber as described in AS 5100.4 with a nominal Shore A Durometer hardness of 50 to 65 is satisfactory. For higher strength concretes, it has been found that harder rubbers may be used.
- 2 Under certain conditions and with certain testing machines, there may be an increase of sudden failures when the rubber capping system is used.

#### 6.3.2 Procedure

The procedure shall be as follows:

- (a) Apply capping system immediately prior to testing.
- (b) Ensure that the rubber pad, cylinder and steel restraining device are concentric.
- (c) Ensure that the concrete cylinder is not in contact with the steel restraining device.

NOTE: Dimensions in brackets apply to nominal 100 mm diameter cylinders.

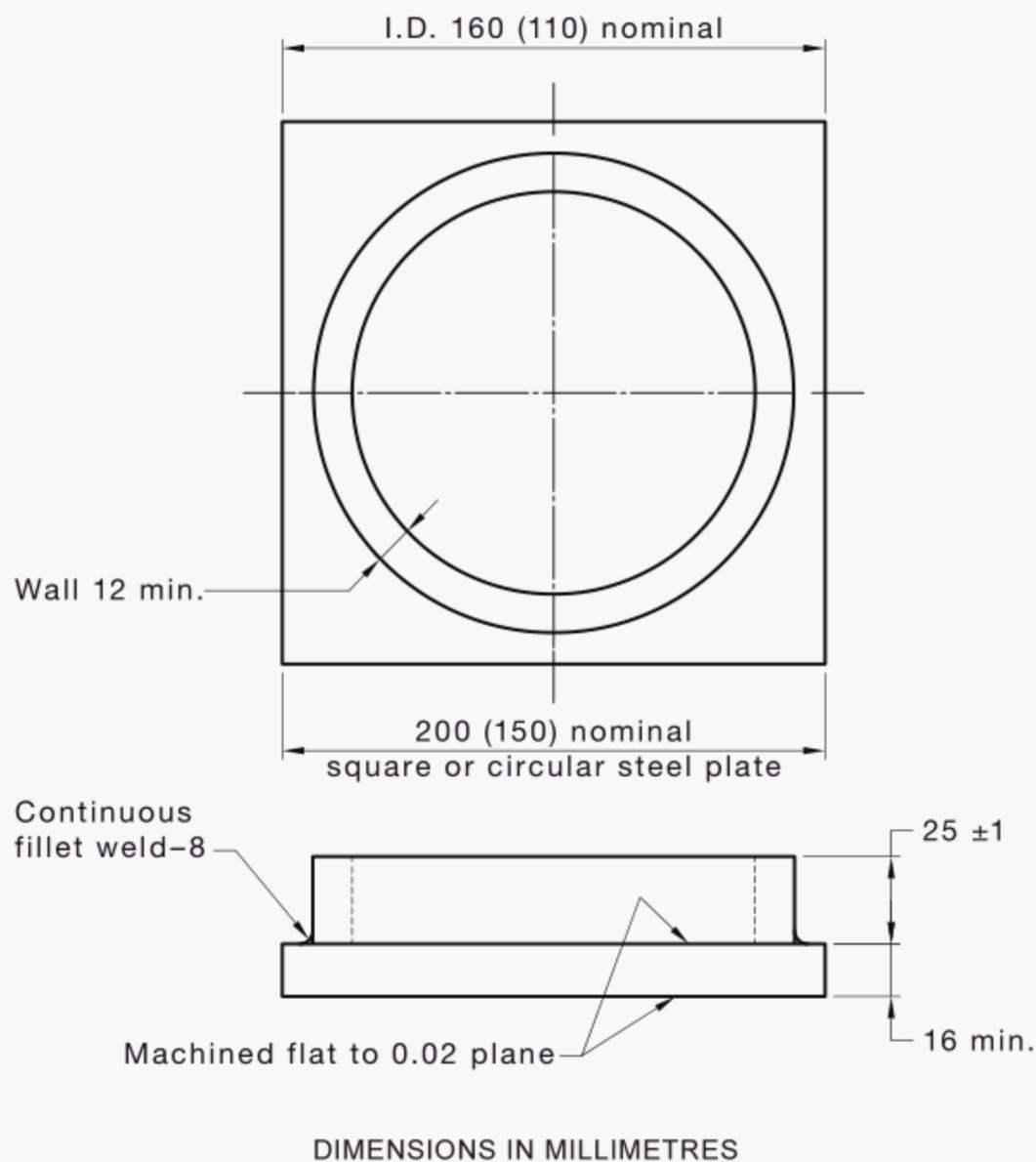


FIGURE 1 TYPICAL STEEL RESTRAINING DEVICE

### 6.3.3 Inspection

The capping system shall be inspected regularly for damage or wear. The initial use of pads will cause some deformation and flow of the rubber. However, this shall not be a reason for rejecting the pad.

The rubber pads may be reused provided that—

- (a) they are not torn or split; and
- (b) they are capable of providing contact over the whole area of the cylinder end.

### 6.4 Capping methods

Capping methods complying with Clause 6.2 or Clause 6.3 shall be used only under the conditions set out in Table 1.

**TABLE 1**  
**CAPPING METHODS**

Capping material	Capping method		
	Expected compressive strength, MPa		
	≤50	>50 ≤80	>80
Filled sulphur mixtures	Cap shall be at least 1 h old and compressive strength of sulphur mixture shall exceed 35 MPa when tested as a 50 mm to 75 mm cube specimen after 2 h hardening*	Cap shall be at least 2 h old and compressive strength of sulphur mixture shall exceed 35 MPa when tested as a 50 mm to 75 mm cube specimen after 2 h hardening*	Cap shall be at least 2 h old and compressive strength of sulphur mixture shall exceed 50 MPa when tested as a 50 mm to 75 mm cube specimen after 2 h hardening*
Portland cement mortar	Cap to be cured under standard moist-curing as in AS 1012.8.1, for at least 72 h	Cap to be cured under standard moist-curing as in AS 1012.8.1, for at least 6 days	Cap to be cured under standard moist-curing as in AS 1012.8.1, for at least 6 days. Compressive strength of mortar shall exceed 50 MPa when tested as a 50 mm to 75 mm cube after 6 days moist-curing†
High-alumina cement mortar	Cap to be cured under standard moist-curing as in AS 1012.8.1, for at least 24 h	Not permitted	Not permitted
Cement pastes	A cap of high-alumina cement and mixtures of high-alumina cement and Portland cement to be cured for at least 18 h and a cap of Portland cement to be cured for at least 48 h under the standard moist-curing as in AS 1012.8.1	A cap of high-alumina cement and mixtures of high-alumina cement and Portland cement to be cured for at least 18 h and a cap of Portland cement to be cured for at least 48 h under the standard moist-curing as in AS 1012.8.1	Not permitted
Special gypsum plasters	Cap shall be at least 1 h old and compressive strength of the plaster mixture shall exceed 35 MPa when tested in accordance with Clause 6.2.2(e)	Not permitted	Not permitted
Restrained natural rubber capping system‡	Permitted for >10 MPa	Permitted	Not permitted

\* To prepare a suitable cube specimen of sulphur mixture, it is advisable to place the molten mixture in thin layers (about 3 mm to 6 mm) in a mould that has been preheated to about 50°C allowing each layer to partly solidify before the next layer is added.

† Where tests at early ages are required or non-standard curing conditions, such as steam-curing, are adopted, the mortar capping material should be checked under the curing conditions proposed to ensure that it achieves a strength in excess of 50 MPa. The cap should be applied to the specimen prior to the commencement of the curing.

‡ See Clause 6.1.

## 7 TESTING MACHINES

The testing machine shall comply with the following requirements:

- (a) The machine shall meet the requirements for Grade A machines defined in AS 2193 for the relevant range of compressive forces.
- (b) The machine shall be power operated and capable of applying compressive forces increasing continuously at the rate of loading and in the manner specified in Clause 8.
- (c) The machine shall be fitted with a load pacer which can operate at a rate of loading specified in Clause 8.
- (d) The machine shall be fitted with two steel compression platens with hardened faces (see Note 1). The upper platen shall incorporate a spherical seat and the lower platen shall be movable along a vertical line only. The size of each platen shall be such that at least 10 mm clearance is provided between the edge of the specimen and the edge of the platen.
- (e) The bearing surface of each platen that is in contact with the specimen or cap shall not depart from a plane by more than 0.02 mm at any time during service. It shall not depart from a plane by more than 0.01 mm when new or after re-machining (see Note 2).
- (f) The centre of curvature of the spherical seat shall be on the vertical axis of the upper platen and shall be within 6 mm of the platen face. The upper platen shall be capable of limited movement and tilting by at least 3° in any direction. The spherical seat shall be free from grit and other foreign matter and shall be lubricated at all times (see Note 3).

After the initial tilting of the upper platen to take up the end condition of the specimens, the upper platen shall lock in place during subsequent loading.

- (g) The lower platen shall be provided with means for the accurate centring of specimens. Finely scribed markings shall be provided for the centring of specimens. These markings shall be disregarded when a platen is examined for planeness.

Auxiliary steel platens of thickness not less than 15 mm, which meet the requirements of normal platens in respect to hardness, planeness and lateral dimensions, may be interposed between the specimen and the platen.

### NOTES:

- 1 The bearing faces of the platens used for compression testing of concrete should have a Rockwell hardness of not less than 55 HRC.
- 2 The planeness of a platen may be determined by placing a toolmaker's straightedge on the platen and a light on the side of the straightedge remote from the observer's eye. A gap of 0.02 mm is clearly discernible in these circumstances. The gap may be measured by feeler gauges or shims.
- 3 Where the spherical seating is accessible, it should be cleaned regularly and lubricated with a thin film of light non-polar oil. A light mineral oil as used in sewing machines is an accepted lubricant for spherical seats. Where the spherical seating is sealed, the manufacturer's recommendations for correct maintenance of the seating should be followed.
- 4 Testing machines vary considerably with respect to both longitudinal and lateral stiffness. The effect of these characteristics on compressive test results has not been fully established and therefore requirements for longitudinal and lateral stiffness have not been specified in Clause 6.

## 8 TESTING PROCEDURE

The test procedure shall be carried out as follows:

- (a) Perform the measuring and testing operations as promptly as possible after removal of the test specimen from the curing environment.
- (b) Test all specimens in a wet condition unless otherwise specified. Wipe surplus water off specimens before measuring and testing operations begin. Dimensions shall be determined by either of the following, as appropriate:
  - (i) Cylinders—Unless the diameter and the height have been measured and recorded previously, determine the diameter of a cylinder or core specimen by measuring two diameters to at least the nearest 0.2 mm at right angles to each other, near the centre of the length of the specimen. If electronic measuring devices are used, the angle of measurement shall be in the range of 90° to 120°. In addition, measure the height over the full dimension, including moulded caps, to at least the nearest 1 mm.
  - (ii) Cubes—measure and record the sides of the cubes which are to be loaded to at least the nearest 1 mm.
- (c) Clean the platens of the testing machine with a clean rag and a suitable solvent at the beginning of each working day, and during the day whenever necessary, to ensure that they are free from films of oil or any other material. Keep the platens free from particles of grit.
- (d) Wipe or brush free loose particles of grit from uncapped bearing surfaces of specimens.
- (e) Using a clean rag, wipe all traces of lubricant from the specimen faces which contact the platen.
- (f) Place the specimen in the machine. Carefully align the axis of the specimen with the centre of thrust of the spherically seated platen. Where a rubber capping system is used, place it concentrically with the specimen.
- (g) Ensure that the hydraulically activated platen is floating.
- (h) Bring the upper platen and the capped specimen together so that uniform bearing is obtained.
- (i) Apply the force without shock and increase continuously at a rate equivalent to  $20 \pm 2$  MPa compressive stress per minute until no increase in force can be sustained. Record the maximum force applied to the specimen as indicated by the testing machine.
- (j) If an abnormal test result is obtained, fully break the specimen to facilitate further examination.

## 9 CALCULATION

The compressive strength of the specimen shall be calculated by dividing the maximum force applied to the specimen by the cross-sectional area. This area shall be calculated from the average of the two measured diameters of cylinders or side dimensions of cubes.

## 10 RECORDS

The following information concerning each test specimen shall be recorded:

- (a) Identification of the concrete.
- (b) Job site or laboratory where tested.

- (c) Date and time of test.
- (d) Moisture condition of specimen, as received.
- (e) Any apparent defects of the specimen, as received.
- (f) Age of the specimen at the date of test, if known.
- (g) Height of specimen, to nearest 1 mm.
- (h) Each measured diameter of the specimen, to nearest 0.2 mm.
- (i) Maximum force applied to the specimen.
- (j) Compressive strength of the specimen.
- (k) Type of cap, if used.
- (l) Any apparent defects of the caps after testing, or any other significant factors noted before, during or after testing.
- (m) Identification of testing operator.
- (n) Reference to this Standard, i.e. AS 1012.9.

## 11 REPORT

In the event of a report being prepared, the following information shall be reported:

- (a) Identification of the concrete.
- (b) Date and location of test.
- (c) Age of the specimen, if known.
- (d) Specimen type and size (e.g. 100 mm or 150 mm diameter cylinder).
- (e) Compressive strength of the specimen, to the nearest 0.5 MPa, except where the strength is less than 10 MPa, in which case it shall be reported to the nearest 0.1 MPa.
- (f) Any apparent defects of the specimen or the caps, any relevant comments on the moisture condition of the specimen, as received, or any other significant factor(s) noted before, during or after testing.
- (g) Reference to this Standard, i.e. AS 1012.9.
- (h) Such other information contained in the sampling records (see AS 1012.1) as may be requested.

APPENDIX A  
GRINDING  
(Informative)

**A1 GENERAL**

The surface of test specimens that are brought into contact with the platens can be ground plane to within 0.05 mm using an appropriate grinding machine.

**A2 GRINDING PROCEDURE**

All specimens should be placed onto the machines receiver using a standard consistent method (e.g. with the seam facing up). If the machine allows for multiple specimens always keep the receiver full utilizing a dummy specimen if necessary. Ensure water flow is adequate to keep the specimen end wet.

**A3 END INSPECTION**

Ground ends should be checked daily for planeness & squareness on a random basis. At least one specimen in twenty from each grinding machine used shall be checked each working day.

NOTE: An engineer's square can be used with the long arm of the square placed parallel to the axis of the specimen.

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