Designation: C 1231/C 1231M – 00ε1

Standard Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders[1]

This standard is issued under the fixed designation C 1231/C 1231M; 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.

ε[1] NOTE—Equations in 9.2, 9.3, and X1.3 were editorially corrected August 2000.

1. Scope

1.1 This practice covers requirements for a capping system using unbonded caps for testing concrete cylinders molded in accordance with Practice C 31/C 31M or C 192/C 192M. *Unbonded neoprene caps of a defined hardness are permitted to be used for testing for a specified maximum number of reuses without qualification testing up to a certain concrete compressive strength level. Above that strength, level neoprene caps will require qualification testing. Qualification testing is required for all elastomeric materials other than neoprene regardless of the concrete strength.*

1.2 Unbonded caps are not to be used for acceptance testing of concrete with compressive strength below 1500 psi [10 MPa] or above 12 000 psi [85 MPa].

1.3 The values stated in either inch-pound or SI units shall be regarded as standard. SI units are shown in brackets. That values stated in each system may not be exact equivalents; therefore, each system must be used independently of the other, without combining the values in any way.

1.4 *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 a specific hazard statement, see Note 4.

2. Referenced Documents

2.1 *ASTM Standards:*

C 31/C 31M 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 192/C 192M Practice for Making and Curing Concrete Test Specimens in the Laboratory[2]

C 617 Practice for Capping Cylindrical Concrete Specimens[2]

D 2000 Classification System for Rubber products in Automotive Applications[3]

D 2240 Test Method for Rubber Property—Durometer Hardness[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *pad, n*—an unbonded elastomeric pad.

3.1.2 *unbonded cap, n*—a metal retainer and an elastomeric pad.

4. Significance and Use

4.1 This practice provides for using an unbonded capping system in testing hardened concrete cylinders made in accordance with Practices C 31/C 31M or C 192/C 192M in lieu of the capping systems described in Practice C 617.

4.2 The elastomeric pads deform in initial loading to conform to the contour of the ends of the cylinder and are restrained from excessive lateral spreading by plates and metal rings to provide a uniform distribution of load from the bearing blocks of the testing machine to the ends of the concrete or mortar cylinders.

5. Materials and Apparatus

5.1 Materials and equipment necessary to produce ends of the reference cylinders that conform to planeness requirements of Test Method C 39 and the requirements of Practice C 617. This may include grinding equipment or capping materials and equipment to produce neat cement paste, high strength gypsum plaster, or sulfur mortar caps.

5.2 *Elastomeric Pads*:

5.2.1 Pads shall be ½ ± 1⁄16 in. [13± 2 mm] thick and the diameter shall not be more than 1⁄16 in. [2 mm] smaller than the inside diameter of the retaining ring.

5.2.2 Pads shall be made from polychloroprene (neoprene) meeting the requirements of Classification D 2000 as follows:

Shore A Durometer	Classification D 2000 Line Call-Out
50	M2BC514

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

Current edition approved Jan. 10, 2000. Published April 2000. Originally published as C 1231–93. Last previous edition C 1231–99.

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

[3] *Annual Book of ASTM Standards*, Vol 09.02.

[4] *Annual Book of ASTM Standards*, Vol 09.01.

60	M2BC614
70	M2BC714

The tolerance on Shore A durometer hardness is ± 5. Table 1 provides requirements for use of caps made from material meeting the requirements of Classification D 2000, above.

5.2.3 Other elastomeric materials that meet the performance requirements of qualification tests in Section 8 are permitted.

5.2.4 Elastomeric pads shall be supplied with the following information:

5.2.4.1 The manufacturer's or supplier's name,

5.2.4.2 The Shore A hardness, and

5.2.4.3 The applicable range of concrete compressive strength from Table 1 or from qualification testing.

5.2.5 The user shall maintain a record indicating the date the pads are placed in service, the pad durometer, and the number of uses to which they have been subjected.

5.3 *Retainers*, shall be made of metal that will prove durable in repeated use (Note 1). The cavity in the metal retainers shall have a depth at least twice the thickness of the pad. The inside diameter of the retaining rings shall not be less than 102 % or greater than 107 % of the diameter of the cylinder. The surfaces of the metal retainer which contact the bearing blocks of the testing machine shall be plane to within 0.002 in. [0.05 mm]. The bearing surfaces of the retainers shall not have gouges, grooves, or indentations greater than 0.010 in. [0.25 mm] deep or greater than 0.05 in.^{2} [32 mm^2] in surface area.

NOTE 1—Retainers made from steel and some aluminum alloys have been found acceptable. Steel retaining rings that have been used successfully with ½-in. [13-mm] neoprene pads are shown in Fig. 1. Retainer design and metals used are subject to the performance and acceptance requirements of Section 8.

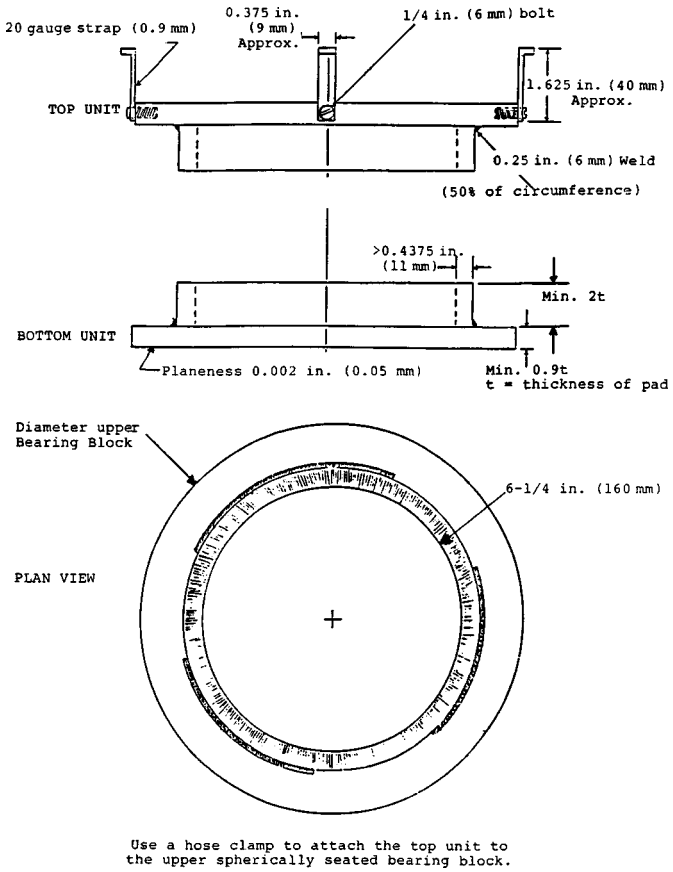

FIG. 1 Example of Steel Retaining Rings for 6 by 12 in. [150 by 300 mm] Cylinders (Nonmandatory)

6. Test Specimens

6.1 The specimens shall be either 6 by 12 in. [150 by 300 mm] or 4 by 8 in. [100 by 200 mm] cylinders made in accordance with Practices C 31/C 31M or C 192/C 192M. Neither end of a cylinder shall depart from perpendicularity to the axis by more than 0.5° (approximately equivalent to ⅛ in. in 12 in. [3 mm in 300 mm]). No individual diameter of a cylinder may differ from any other diameter by more than 2 %.

NOTE 2—One method of measuring the perpendicularly of ends of cylinders is to place a try square across any diameter and measure the departure of the longer blade from an element of the cylindrical surface. An alternative method is to place the end of the cylinder on a plane surface and support the try square on that surface.

6.2 Depressions under a straight edge measured with a round wire gage across any diameter shall not exceed 0.20 in. [5 mm]. If cylinder ends do not meet this tolerance, the cylinder shall not be tested unless irregularities are corrected by sawing or grinding.

TABLE 1 Requirements for Use of Polychloroprene(Neoprene) Pads

Cylinder Compressive Strength, psi [MPa]	Shore A Durometer Hardness	Qualification Tests Required	Maximum Reuses[A]
1 500 to 6 000 [10 to 40]	50	none	100
2 500 to 7 000 [17 to 50]	60	none	100
4 000 to 7 000 [28 to 50]	70	None	100
7 000 to 12 000 [50 to 80]	70	Required	50
Greater than 12,000 [80]		not permitted	

[A] Maximum number of reuses. Will be less if pads wear, crack or split. See Note 6.

7. Procedure

7.1 Unbonded caps are permitted to be used on one or both ends of a cylinder in lieu of a cap or caps meeting Practice C 617, provided they meet the requirements of Section 5.

7.2 Examine the pads for excessive wear or damage (Note 6). Replace pads which have cracks or splits exceeding ⅜ in. [10 mm] in length regardless of depth. Insert the pads in the retainers before they are placed on the cylinder (Note 3).

NOTE 3—Some manufacturers recommend dusting the pads and the ends of the cylinders with corn starch or talcum powder prior to testing.

NOTE 4—**Caution:** Concrete cylinders tested with unbonded caps rupture more violently than comparable cylinders tested with bonded caps. As a safety precaution the cylinder testing machine must be equipped with a protective cage. In addition, some users have reported damage to testing machines from the sudden release of energy stored in the elastomeric pads.

7.3 Center the unbonded cap or caps on the cylinder and place the cylinder on the lower bearing block of the testing machine. Carefully align the axis of the cylinder with the center of thrust of the testing machine by centering the upper retaining ring on the spherically seated bearing block. As the spherically seated block is brought to bear on the upper retaining ring, rotate its movable portion gently by hand so that uniform seating is obtained. After application of load, but

before reaching 10 % of the anticipated specimen strength, check to see that the axis of the cylinder is vertical within a tolerance of ⅛in. in 12 in. [3.2 mm in 300 mm] and that the ends of the cylinder are centered within the retaining rings. If the cylinder alignment does not meet these requirements, release the load, check compliance with 6.1, and carefully recenter the specimen. Reapply load and recheck specimen centering and alignment. A pause in load application to check cylinder alignment is permissible.

7.4 Complete the load application, testing, calculation, and reporting of results in accordance with Test Method C 39.

NOTE 5—Because of the violent release of energy stored in pads, the broken cylinder rarely exhibits conical fracture typical of capped cylinders and the sketches of types of fracture in Test Method C 39 are not descriptive. Occasionally, unbonded capped cylinders may develop early cracking, but continue to carry increasing load. For this reason cylinders must be tested to complete failure.

8. Qualification of Unbonded Capping Systems and Verification of Reuse of Pads

8.1 Table 1 specifies the conditions under which polychloroprene (neoprene) unbonded pads must be qualified under this section depending on the concrete strength and the Shore A hardness. Unbonded pads made of other elastomeric materials must be qualified using the procedures in this section.

8.2 When qualification tests are required they must be made by either the supplier or user of the unbonded pads. The user of the pads must retain a copy of the current qualification test report to demonstrate compliance with this practice. See X1.1.

8.3 The compressive strength of molded cylinders tested with unbonded caps shall be compared with that of companion cylinders tested with ends ground or capped to meet requirements of Test Method C 39 and Practice C 617.

8.4 To be acceptable, tests must demonstrate that at a 95 % confidence level ($\alpha = 0.05$), the average strength obtained using unbonded caps is not less than 98 % of the average strength of companion cylinders capped or ground in accordance with 8.3.

8.4.1 When required, qualification tests shall be made prior to use of an unbonded cap system at both the highest and lowest strength levels anticipated to establish an acceptable range of cylinder strength for use. Qualification tests in accordance with 8.5 shall be made on initial use of an unbonded cap at both the highest and lowest strength levels anticipated to establish an acceptable range of cylinder strength for use. In practice individual cylinders shall not have strengths more than 10 % greater than the high strength level or more than 10 % less than the low strength level qualified or specified in Table 1. Qualification tests shall be repeated whenever there is a change in the design or dimensions of the retaining rings, or when there is a change in pad composition or thickness, or the Shore A hardness changes by more than five units. Initial qualification tests shall include verification that after the specified maximum number of reuses the pads meet the requirements of 8.4.

8.4.2 When tests are made to establish a permissible number of reuses exceeding those in Table 1, only those tests or reuses which are within 2000 psi [14 MPa] of the highest strength level to be qualified will be included in the reuse count. Laboratories must maintain records of the number of times pads are reused.

NOTE 6—Pad life depends on the hardness and type of pad material, the strength of the concrete, the difference between the outside diameter of the cylinder and the inside diameter of the retaining ring, the unevenness and roughness of the ends of the cylinder, and other factors. Based on available information, scuffing or abrasion of the perimeter of the pad is normal, provided it does not reduce the thickness of the pad around the perimeter. Cracks or splits in the pad are reported to materially reduce cylinder strength. Replace pads which have cracks exceeding ⅜in. [10 mm] in length, regardless of depth (see 7.2).

8.5 *Specimen Preparation for Qualification and Pad Reuse Testing*:

8.5.1 Pairs of individual cylinders shall be made from a sample of concrete and cured as nearly alike as possible: one cylinder per pair is to be tested after grinding or capping in accordance with 8.3 and the other is to be tested using the unbonded cap system.

8.5.2 A minimum of 10 pairs of cylinders shall be made at both the highest and lowest strength levels desired or anticipated (Note 7). The “strength level” is the average of the strengths of the 20 or more cylinders whose strengths are within a range of 1000 psi [7 MPa] (Note 8). More than one pair of cylinders can be made from a single concrete sample, but cylinders must come from a minimum of two samples made on different days for each concrete strength level (Note 9).

NOTE 7—If the Practice C 617 capped and unbonded capped specimens produce equal strengths, the number of pairs of cylinders that will be needed to demonstrate compliance will range from 9 to more than 60 depending on the variability of test results. If the two capping systems produce equal strengths, about 10 % of laboratories will require more than 60 tests and 10 % of the laboratories will require 9 tests to demonstrate statistical compliance.

NOTE 8—Note that the range of strengths permitted in qualification testing to define the strength level is 1000 psi [7 MPa], but that in counting number of reuses only cylinders within a range of 2000 psi [14 MPa] are included in the reuse count.

NOTE 9—Cylinders for qualification tests can be from pairs of cylinders tested in routine laboratory operations and, in most instances, special trial batches should not be required for qualification tests.

9. Calculation

9.1 For each strength level, compute the difference in strength for each pair of cylinders, and compute the average strength of the cylinders with reference caps and the average strength of the cylinders with unbonded caps, as follows:

$$d_i = x_{pi} - x_{si} \quad (1)$$

$$\bar{x}_s = (x_{s1} + x_{s2} + x_{s3} \ldots + x_{sn})/n$$

$$\bar{x}_p = (x_{p1} + x_{p2} + x_{p3} \ldots + x_{pn})/n$$

where:

d_i = difference in strength of a pair of cylinders computed as the strength of unbonded capped cylinder minus the strength of the cylinder prepared according to Practice C 617 (may be positive or negative),

x_{pi} = cylinder strength using unbonded cap,

x_{si} = cylinder strength using Practice C 617,

n = number of pairs of cylinders tested for the strength level,
$\bar{x}_s$ = average strength of Practice C 617 capped cylinders for a strength level, and
$\bar{x}_p$ = average strength of unbonded cap cylinders for a strength level.

9.2 Compute the average difference, $\bar{d}$, and standard deviation of the difference, s_d, for each strength level, as follows:

$$\bar{d} = (d_1 + d_2 \ldots + d_n)/n \quad (2)$$

$$s_d = [\Sigma(d_i - \bar{d})^2/(n-1)]^{1/2}$$

9.3 To comply with this practice the following relationship must be satisfied:

$$\bar{x}_p \geq 0.98\,\bar{x}_s + (ts_d)/(n)^{1/2} \quad (3)$$

where t is the value of "students t" for $(n-1)$ pairs at $\alpha = 0.05$ from the following table:

$(n-1)$	$t(\alpha = 0.05)^A$
9	1.833
14	1.761
19	1.729
100	1.662

[A] Use linear interpolation for other values of $(n-1)$ or refer to appropriate statistical tables.

10. Keywords

10.1 cap; compressive strength; concrete; concrete test; elastomeric; neoprene; pad cap; rubber; unbonded cap

APPENDIX

(Nonmandatory Information)

X1. SAMPLE REPORT AND CALCULATION

X1.1 *Sample Report:*

X1.1.1 *Pad Material*—Lot 3742, Shore A = 52, Thickness 0.51 in.

X1.1.2 *Retaining Ring*—Set A manufactured 1-87.

X1.1.3 Concrete Cylinders: Job 1207, Nos. 1–10, January 2 to 5, 1987.

X1.1.4 *Sulfur Mortar*—Lot 3420. Compressive Strength of 6985 psi [48.2 MPa].

X1.1.5 All Tests 28 days age.

X1.2 *Summary*—

xs = 3679 psi [25.35 MPa]:
xp = 3663 psi [25.26 MPa];
sd = 46.06 psi [0.328 MPa];
n = 10:
t = 1.833.

X1.3 *Calculation*—Using equation in 9.3:

$$3663 >/= (0.98)(3679)+(1.833)(46.06)/(10)^{1/2}$$

$$3663 > 3632 \text{ (}\textit{system qualifies at } 3670 \textit{ psi}\text{)}$$

Metric:

$$25.26 >/= (0.98)(25.35) + (1.833)(0.328)/(10)^{1/2}$$

$$25.26 > 25.03 \text{ (}\textit{System Qualifies}\text{)}$$

Cylinder Pair	Neoprene Pad		Sulfur Cap		Difference, d	
	psi	MPa	psi	MPa	psi	MPa
1	3605	24.9	3580	24.7	25	0.20
2	3605	24.9	3690	25.4	-85	-0.50
3	3585	24.7	3595	24.7	-10	0.00
4	3570	24.6	3625	25.0	-55	-0.40
5	3625	25.0	3640	25.1	-15	-0.10
6	3660	25.2	3740	25.8	-80	-0.60
7	3750	25.9	3720	25.6	30	0.30
8	3725	25.7	3720	25.6	5	0.10
9	3700	25.5	3725	25.7	-25	-020
10	3805	26.2	3755	25.9	50	0.30
Average xp	3663	25.26	xs 3679	25.35	d -16	-0.090
Std. Dev.					sd 46.06	0.328

X1.4 *Keywords*—caps; capping cylinders; compressive strength; pads; strength; unbonded capping system