Designation: D1623 – 17

Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics[1]

This standard is issued under the fixed designation D1623; 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 test method covers the determination of the tensile and tensile adhesion properties of rigid cellular materials in the form of test specimens of standard shape under defined conditions of temperature, humidity, and testing machine speed.

1.2 Tensile properties shall be measured using any of three types of specimens:

1.2.1 *Type A* shall be the preferred specimen in those cases where enough sample material exists to form the necessary specimen.

1.2.2 *Type B* shall be the preferred specimen when only smaller specimens are available, as in sandwich panels, etc.

1.2.3 *Type C* shall be the preferred specimen for the determination of tensile adhesive properties of a cellular plastic to a substrate as in a sandwich panel (top and bottom substrate) or the bonding strength of a cellular plastic to a single substrate.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

NOTE 1—There is no known ISO equivalent to this test method.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D638 Test Method for Tensile Properties of Plastics

D883 Terminology Relating to Plastics

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 Definitions of terms applying to this test method appear in Test Method D638, Annex A2.

4. Apparatus

4.1 *Testing Machine*—A testing machine that is capable of applying a constant rate of crosshead movement, comprising essentially the following:

4.1.1 *Grips*—Grips for holding the test specimen shall be the self-aligning type; that is, they must be attached to the fixed and movable members of the testing machine in such a way that they will move freely into alignment as soon as any load is applied, so that the long axis of the test specimen will coincide with the direction of the applied pull through the center line of the grip assembly. Universal-type joints immediately above and below the specimen grips are recommended. The test specimen shall be held in such a way that slippage relative to the grips is prevented, insofar as possible. For Type A specimens, use a grip assembly like the one shown in Fig. 1 and Fig. 2. For Type B specimens, one suitable grip assembly is shown in Fig. 3 and Fig. 4. For Type C specimen, a suitable grip assembly is shown in Fig. 5.

4.1.2 *Load Indicator*—A load cell or suitable load-indicating mechanism, capable of showing the total tensile load

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.22 on Cellular Materials - Plastics and Elastomers.

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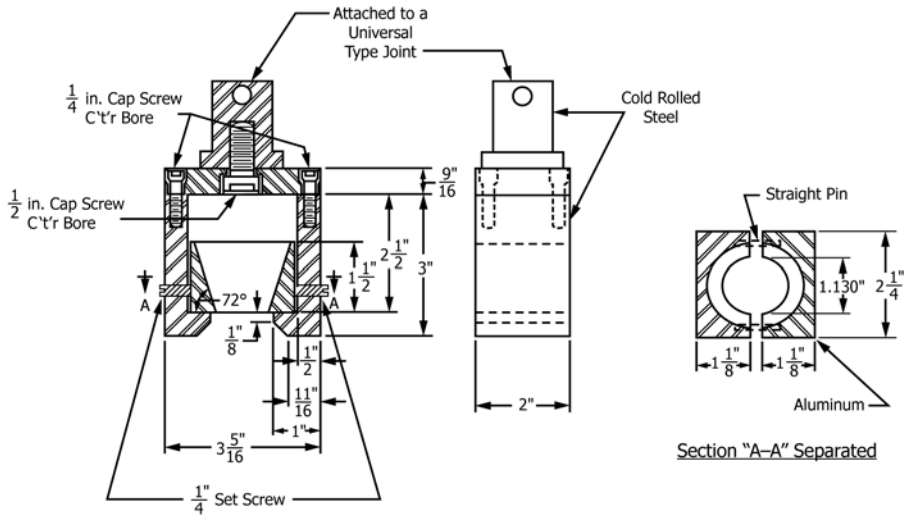
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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



Metric Equivalents

in.	⅛	¼	½	9⁄16	11⁄16	1	1.130	1½	2	2¼	2½	3	3 5⁄16
mm	3.18	6.35	12.7	14.3	17.5	25.4	28.7	38.1	50.8	57.2	63.5	76.2	84.1

FIG. 1 Details of Grips for Tension Test on Type A Specimen

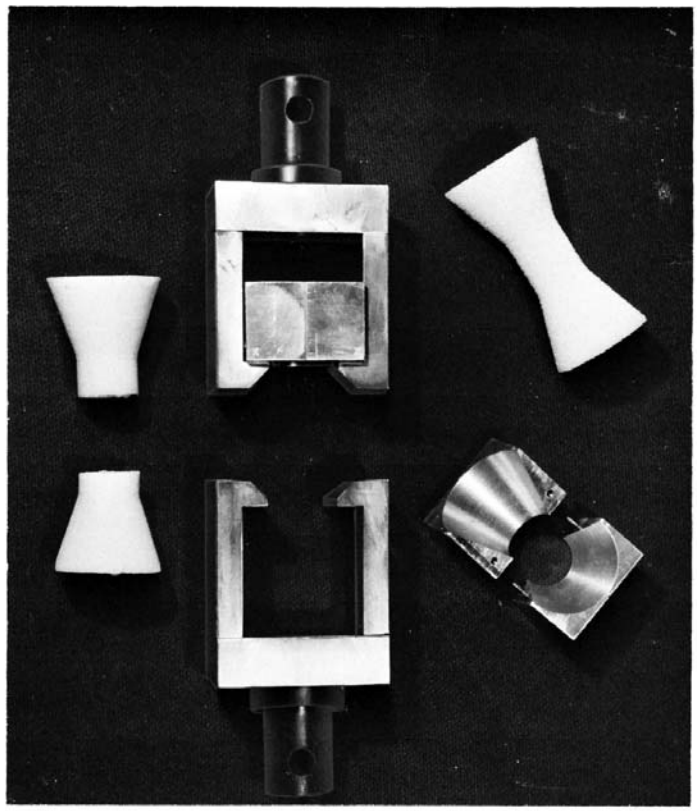
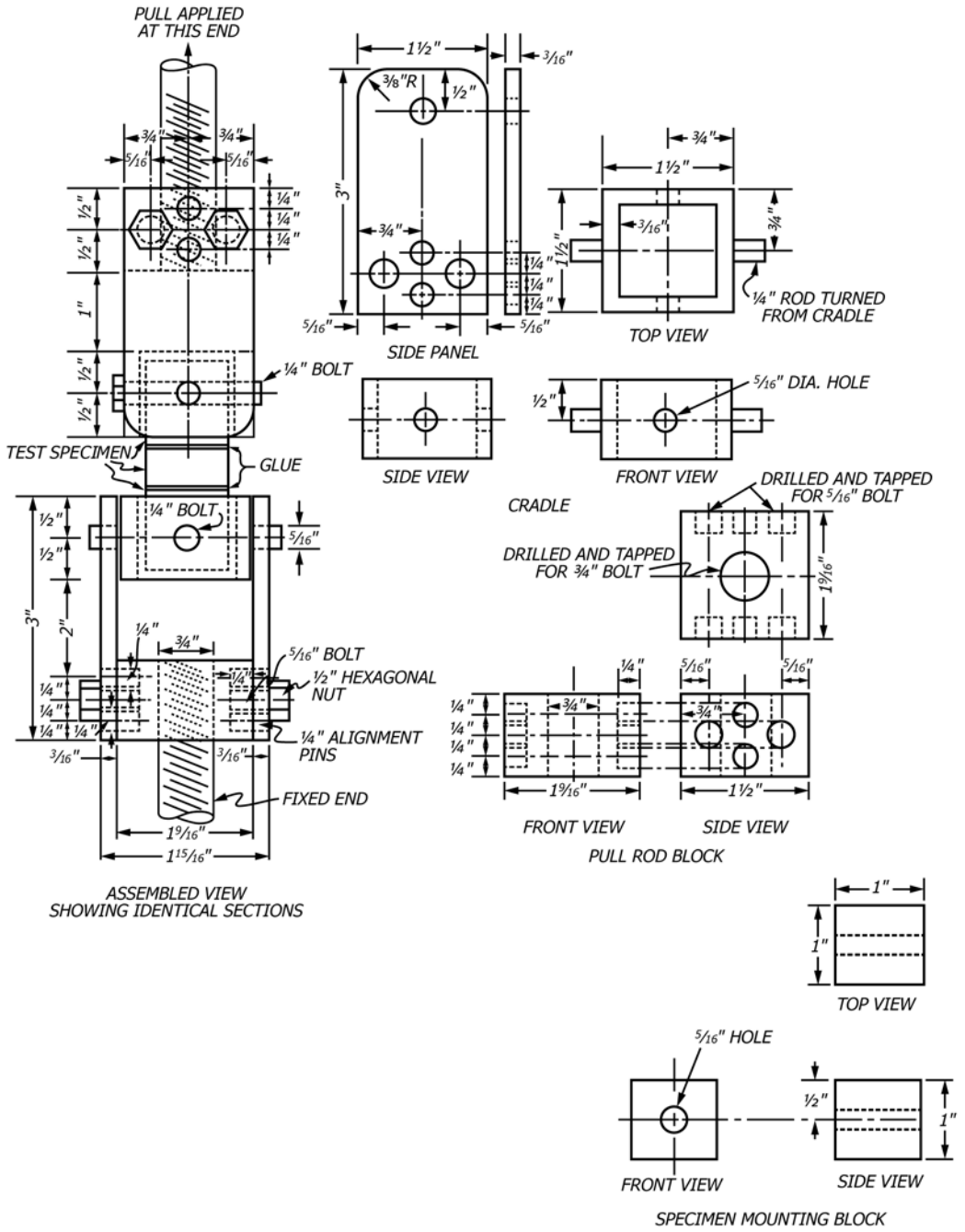


FIG. 2 Grip Assembly for Type A Specimen

exerted on the test specimen when held in the grips, shall be used. Choose an indicator that will permit precision to within ±1 %.

4.1.3 *Extension Indicator*—If measurement of the extension is desired, use a suitable instrument for determining the distance between two fixed points on the test specimen, or



Metric Equivalents

in.	3/16	¼	½	5/16	¾	1	1½	1 9/16	2	3
mm	4.76	6.35	12.7	7.9	19.1	25.4	38.1	39.7	50.8	76.2

FIG. 3 Details of Grips for Tension on Type B Specimen

similarly by grip separation or extensometer, at any time during the test, shall be used.

4.2 *Specimen Cutter*—For Type A specimens, use a suitable lathe cutter (see Fig. 6).

5. Test Specimen

5.1 All surfaces of the specimen shall be free of large visible flaws or imperfections. If it is necessary to place gauge marks on the specimen, do this in such a way as not to affect the

FIG. 4 Grip Assembly for Type B Specimen

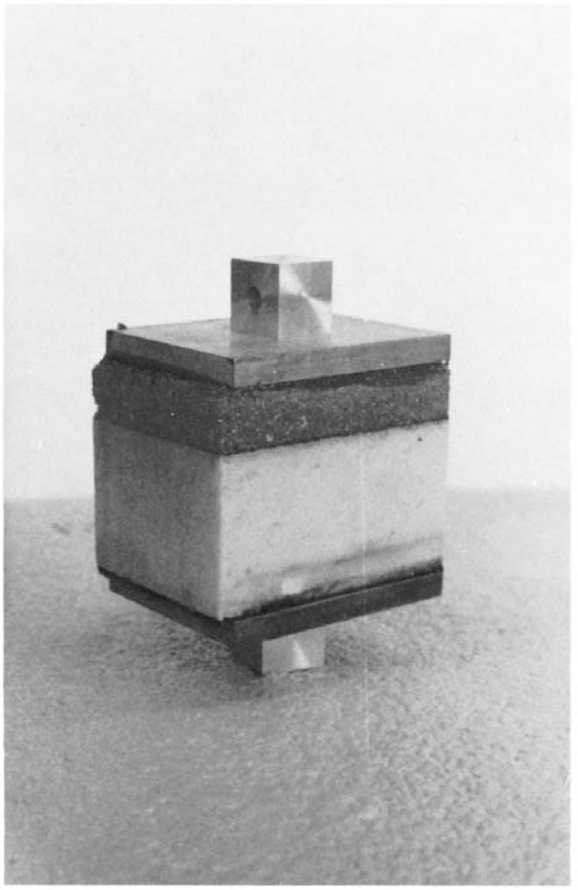
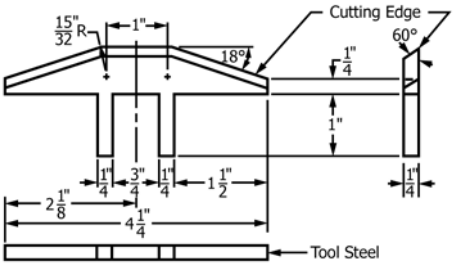


FIG. 5 Grip Assembly for Type C Specimen

surfaces of the test specimen. Gauge marks shall not be scratched, punched, or impressed on the specimen.

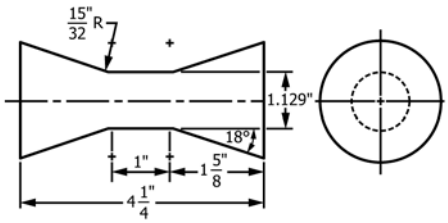
5.2 When testing materials that are suspected to be anisotropic, prepare duplicate sets of specimens having their long axes parallel and perpendicular to the direction of the cell orientation.

5.3 *Preparation of Type A Specimens*—The recommended Type A test specimen shall conform to the dimensions given in Fig. 7. It shall be prepared by normal molding procedures wherever possible, but the "skin" effect which results cannot be eliminated and will cause a variance in the final result. Another method of preparation of the specimen, which would eliminate the "skin effect" variable, is to machine the desired geometry on a small lathe, using a cutter like the one shown in Fig. 6. Insert a 50 by 50 by 150-mm (2 by 2 by 6-in.) block of the



Metric Equivalents						
in.	¼	15/32	¾	1½	2⅛	4¼
mm	6.35	11.9	19.1	38.1	54.0	108.0

FIG. 6 Cutter for Preparing Type A Specimen



Metric Equivalents				
in.	1.129	15/32	1⅝	4¼
mm	28.7	11.9	41.3	108.0

FIG. 7 Dimensions of Type A Specimen

material to be tested into the four-jaw chuck, which had been previously centered. Prepare the other end of the block to receive the 60° tapered end of the tailstock center. Set the lathe at its highest speed. The appropriate rate of entry of the cutter blade will depend on the density of the foam. Advance the cutter until it reaches a stop, at which time the diameter of the specimen test section shall be 28.7 mm (1.130 in.), giving a 645 mm^2 (1 $in.^2$) cross sectional area. Using a band saw, cut off the excess sample end (up to the taper). The lathe assembly and completed specimen are shown in Fig. 6 and Fig. 7. The recommended gauge length shall be 25.4 mm (1 in.) with a radius of curvature of 11.9 mm (15⁄32 in.) at each end joining it to the grip surface, which is at an angle of 18° to the center line. However, in no case shall the gauge length be less than 12.7 mm (½ in.).

NOTE 2—If specimens exhibit excessive slippage in the jaws, a lower than actual tensile strength could possibly be obtained. Where this occurs, it is recommended that a 6.35-mm (¼-in.) shoulder be left on the specimen ends next to the tapered area, or the specimen ends be dipped momentarily in a molten paraffin wax prior to test (temperature not in excess of 80°C (176°F), or both.

5.4 *Preparation of Type B Specimens*—Type B test specimens shall be rectangular, round or square and shall have a minimum cross-sectional area of 645 mm^2 (1 $in.^2$). Specimen top and bottom surfaces shall be parallel. Bond the specimen mounting (or grip assembly) blocks to the top and bottom surfaces of the test specimens by a suitable method, which does not affect the material under test, taking care to assure that the bonding pressure is not great enough to cause compression of the specimen. The adhesive curing temperature shall be low enough to cause no effect on the specimen to be tested.

5.5 *Preparation of Type C Specimens:*

5.5.1 Type C test specimens shall be square or rectangular, with a minimum length and width dimension equal to, or greater than, the thickness.

5.5.2 Care and caution shall be exercised in preparing the specimen so that the bond between the cellular plastic and the substrate is not affected. The speed of the saw blade, the number of teeth per inch, and other cutting variables shall be considered in specimen preparation, in order to avoid excess vibrations or heat buildup, which could weaken the bond between the cellular plastic and the substrate.

5.5.3 When adhesion test involves only one surface, the other side shall be trimmed to provide a smooth, parallel bonding surface.

5.5.4 Bond the specimen mounting (or grip assembly) blocks to the top and bottom of the test specimen by a suitable method that does not affect the material being tested.

6. Conditioning

6.1 *Conditioning*—Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 10 % relative humidity for not less than 24 h prior to testing.

6.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 10 % relative humidity, unless otherwise specified.

7. Number of Test Specimens

7.1 A minimum of three specimens shall be tested. Specimens that break at some obvious flaw shall be discarded and retests made, unless such flaws constitute a variable that is to be studied.

8. Speed of Testing

8.1 The standard speed of testing shall be such that rupture occurs in 3 to 6 min. A suggested rate of crosshead movement is 1.3 mm (0.05 in.)/min for each 25.4 mm (1 in.) of test section gauge length.

9. Procedure

9.1 Measure the cross-sectional dimensions of the test specimen to the nearest 0.025 mm (0.001 in.) at several points, and record the minimum value. Calculate the specimen's cross-sectional area from these dimensions.

9.2 Zero the load indicator with all of the upper hardware in place, but no specimen attached. If Type B or C specimens are used, zero the load indicator with all of the upper hardware in place, including the specimen with top and bottom mounting blocks attached.

9.3 Place the specimen into the grip assembly as defined in 4.1.1, and adjust the entire assembly to align it with the central axis of the specimen and the testing machine. (If a Type A specimen is used, tighten the ¼ in. set screws in the sides of the holders so that the split collars are held firmly together and are in axial alignment with the specimen and testing machine.)

9.4 Determine and record the load at the moment of specimen breaking. If an extensometer is used, a complete stress-strain curve may be obtained thereby. Also determine and record the extension at the moment of rupture of the specimen.

10. Calculation

10.1 *Tensile Strength*—Calculate the tensile strength by dividing the breaking load in kilonewtons (or pounds-force) by the original minimum cross-sectional area of the specimen in square metres (or square inches). Express the result in kilopascals (kilonewtons per square metre) (or pounds-force per square inch) to two significant figures.

10.2 *Elongation*—Calculate the percent elongation, when determined, by dividing the extension at the moment of specimen breaking by the original distance between gauge

marks, or similarly by grip separation, and multiplying by 100. Report the percent elongation to two significant figures.

10.3 Calculate the standard deviation (estimated) as follows and report it to two significant figures:

$$s = \sqrt{\left(\sum X^2 - n\bar{X}^2\right)/(n-1)} \quad (1)$$

where:

s = estimated standard deviation,
X = value of a single observation,
n = number of observations, and
$\bar{X}$ = arithmetic mean of the set of observations.

11. Report

11.1 The report shall include the following:

11.1.1 Complete identification of the material tested, including type, source, code numbers, form, principal dimensions, previous history, etc.

11.1.2 Type of specimen used: Type A, Type B, or Type C.

11.1.3 Conditioning procedure used, if different from that specified in 6.1.

11.1.4 Atmospheric conditions in test room, if different from those specified in 6.2.

11.1.5 Number of specimens tested, if different from that specified in Section 7.

11.1.6 Rate of crosshead movement.

11.1.7 Tensile or tensile adhesion strength of each specimen, average value and standard deviation.

11.1.8 Percent elongation of each specimen, average value and standard deviation. Indicate method used to measure extension (either gauge marks, grip separation or extensometer).

11.1.9 Date of test.

12. Precision and Bias

12.1 Tables 1 and 2 are based on a round robin conducted in 2000 using Type B specimens in accordance with Practice E691, involving three materials tested by six laboratories. For each material, all of the samples were prepared at one source, but the individual Type B specimens were prepared at the laboratories that tested them. Each laboratory obtained six test results for each material. Precision, characterized by repeatability (S_r and r) and reproducibility (S_R and R), have been determined as shown in Tables 1 and 2. (**Warning—**The explanation of r and R are only intended to present a meaningful way of considering the approximate precision of this test method. The data in Tables 1 and 2 should not be applied to acceptance or rejection of materials, as these data apply only to the materials tested in the round robin and are unlikely to be rigorously representative of other lots, formulations, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E691 to generate data specific to their materials and laboratory.)

NOTE 3—The precision data presented in Tables 1 and 2 were obtained using the test conditions defined in this test method in 2000. The test conditions in 2000 were 23 ± 2°C and 50 % ± 5 % relative humidity. If a material specification defines other test conditions, this precision data shall not be assumed to apply.

12.2 *Bias*—There are no recognized standards by which to estimate bias for this test method.

13. Keywords

13.1 rigid cellular plastics; tensile adhesion; tensile strength

TABLE 1 Tensile, kPa Type B Specimens

	(Six Laboratories)				
Material	Avg.	S_r[A]	S_R[B]	r[C]	R[D]
A	184.8	22.8	43.1	63.8	120.9
B	340.6	57.8	141.5	161.9	396.3
C	188.9	25.4	53.0	71.2	148.3

[A] S_r = within-laboratory standard deviation for the indicated material. It is obtained by pooling the within-laboratory standard deviations of the test results from all of the participating laboratories.
[B] S_R = between-laboratory reproducibility, expressed as standard deviation.
[C] r = within-laboratory critical interval between two results = 2.8 × S_r.
[D] R = between-laboratory critical interval between two results = 2.8 × S_R.

TABLE 2 Elongation by Crosshead Travel, % Type B Specimens

(Six Laboratories)					
Material	Avg.	S_r[A]	S_R[B]	r[C]	R[D]
A	12.0	2.3	6.9	6.6	19.3
B	7.1	1.5	6.7	4.1	18.7
C	8.4	1.6	7.1	4.5	19.9

[A] S_r = within-laboratory standard deviation for the indicated material. It is obtained by pooling the within-laboratory standard deviations of the test results from all of the participating laboratories.
[B] S_R = between-laboratory reproducibility, expressed as standard deviation.
[C] r = within-laboratory critical interval between two results = 2.8 × S_r.
[D] R = between-laboratory critical interval between two results = 2.8 × S_R.

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D1623 - 09) that may impact the use of this standard. (May 1, 2017)

(1) Editorial changes in punctuation and wording to clarify the procedures.
(2) In 5.4, changed "grip assembly blocks" to "specimen mounting blocks," consistent with Fig. 3.
(3) Changed conditioning and test conditions % relative humidity tolerance from ±5 % to 10 % (6.1 and 6.2). Note 3, amended to state that humidity tolerance was 50 % ± 5 % at the time the precision data was acquired.
(4) In 9.2, previously, for Type B specimens, load indicator zeroed with upper hardware and upper specimen mounting block in place. This was changed to direct, for both Type B and C specimens, that the load indicator be zeroed with the upper hardware in place and the specimen, with top and bottom mounting blocks attached, in upper grip.