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An American National Standard

Standard Test Methods for Tension Testing of Metallic Materials[1]

This standard is issued under the fixed designation E8/E8M; 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 These test methods cover the tension testing of metallic materials in any form at room temperature, specifically, the methods of determination of yield strength, yield point elongation, tensile strength, elongation, and reduction of area.

1.2 The gauge lengths for most round specimens are required to be 4D for E8 and 5D for E8M. The gauge length is the most significant difference between E8 and E8M test specimens. Test specimens made from powder metallurgy (P/M) materials are exempt from this requirement by industry-wide agreement to keep the pressing of the material to a specific projected area and density.

1.3 Exceptions to the provisions of these test methods may need to be made in individual specifications or test methods for a particular material. For examples, see Test Methods and Definitions A370 and Test Methods B557, and B557M.

1.4 Room temperature shall be considered to be 10 °C to 38 °C [50 °F to 100°F] unless otherwise specified.

1.5 The values stated in SI units are to be regarded as separate from inch/pound units. The values stated in each system are not exact equivalents; therefore each system must be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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]

A356/A356M Specification for Steel Castings, Carbon, Low Alloy, and Stainless Steel, Heavy-Walled for Steam Turbines
A370 Test Methods and Definitions for Mechanical Testing of Steel Products
B557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products
B557M Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products (Metric)
E4 Practices for Force Calibration and Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E83 Practice for Verification and Classification of Extensometer Systems
E345 Test Methods of Tension Testing of Metallic Foil
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E1012 Practice for Verification of Testing Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application
D1566 Terminology Relating to Rubber
E1856 Guide for Evaluating Computerized Data Acquisition Systems Used to Acquire Data from Universal Testing Machines
E2658 Practices for Verification of Speed for Material Testing Machines

3. Terminology

3.1 *Definitions of Terms Common to Mechanical Testing—*

[1] These test methods are under the jurisdiction of ASTM Committee E28 on Mechanical Testing and are the direct responsibility of Subcommittee E28.04 on Uniaxial Testing.

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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

3.1.1 The definitions of mechanical testing terms that appear in the Terminology E6 apply to this test method.

3.1.1.1 These terms include bending strain, constraint, elongation, extensometer, force, gauge length, necking, reduced section, stress-strain diagram, testing machine, and modulus of elasticity.

3.1.2 In addition, the following common terms from Terminology E6 are defined:

3.1.3 *discontinuous yielding, n—in a uniaxial test*, a hesitation or fluctuation of force observed at the onset of plastic deformation, due to localized yielding.

3.1.3.1 *Discussion*—The stress-strain curve need not appear to be discontinuous.

3.1.4 *elongation after fracture, n*—the elongation measured by fitting the two halves of the broken specimen together.

3.1.5 *elongation at fracture, n*—the elongation measured just prior to the sudden decrease in force associated with fracture.

3.1.6 *lower yield strength, LYS* $[FL^{-2}]$*—in a uniaxial test*, the minimum stress recorded during discontinuous yielding, ignoring transient effects.

3.1.7 *reduced parallel section, A, n*—the central portion of the specimen that has a nominally uniform cross section, with an optional small taper toward the center, that is smaller than that of the ends that are gripped, not including the fillets.

3.1.7.1 *Discussion*—This term is often called the parallel length in other standards.

3.1.7.2 *Discussion*—Previous versions of E8/E8M defined this term as "reduced section."

3.1.8 *reduction of area, n*—the difference between the original cross-sectional area of a tension test specimen and the area of its smallest cross section.

3.1.8.1 *Discussion*—The reduction of area is usually expressed as a percentage of the original cross-sectional area of the specimen.

3.1.8.2 *Discussion*—The smallest cross section may be measured at or after fracture as specified for the material under test.

3.1.8.3 *Discussion*—The term reduction of area when applied to metals generally means measurement after fracture; when applied to plastics and elastomers, measurement at fracture. Such interpretation is usually applicable to values for reduction of area reported in the literature when no further qualification is given. **(E28.04)**

3.1.9 *tensile strength*, S_u $[FL^{-2}]$, *n*—the maximum tensile stress that a material is capable of sustaining.

3.1.9.1 *Discussion*—Tensile strength is calculated from the maximum force during a tension test carried to rupture and the original cross-sectional area of the specimen.

3.1.10 *uniform elongation*, El_u *[%]—the elongation determined at the maximum force sustained by the test specimen just prior to necking or fracture, or both.

3.1.10.1 *Discussion*—Uniform elongation includes both elastic and plastic elongation.

3.1.11 *upper yield strength, UYS* $[FL^{-2}]$*—in a uniaxial test*, the first stress maximum (stress at first zero slope) associated with discontinuous yielding at or near the onset of plastic deformation.

3.1.12 *yield point elongation, YPE, n—in a uniaxial test*, the strain (expressed in percent) separating the stress-strain curve's first point of zero slope from the point of transition from discontinuous yielding to uniform strain hardening.

3.1.12.1 *Discussion*— If the transition occurs over a range of strain, the YPE end point is the intersection between *(a)* a horizontal line drawn tangent to the curve at the last zero slope and *(b)* a line drawn tangent to the strain hardening portion of the stress-strain curve at the point of inflection. If there is no point at or near the onset of yielding at which the slope reaches zero, the material has 0 % YPE.

3.1.13 *yield strength, YS* or S_y $[FL^{-2}]$, *n*—the engineering stress at which, by convention, it is considered that plastic elongation of the material has commenced.

3.1.13.1 *Discussion*—This stress may be specified in terms of (*a*) a specified deviation from a linear stress-strain relationship, (*b*) a specified total extension attained, or (*c*) maximum or minimum engineering stresses measured during discontinuous yielding.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *referee test, n*—test made to settle a disagreement as to the conformance to specified requirements, or conducted by a third party to arbitrate between conflicting results. **D1566, D11.08**

4. Significance and Use

4.1 Tension tests provide information on the strength and ductility of materials under uniaxial tensile stresses. This information may be useful in comparisons of materials, alloy development, quality control, and design under certain circumstances.

4.2 The results of tension tests of specimens machined to standardized dimensions from selected portions of a part or material may not totally represent the strength and ductility properties of the entire end product or its in-service behavior in different environments.

4.3 These test methods are considered satisfactory for acceptance testing of commercial shipments. The test methods have been used extensively in the trade for this purpose.

5. Apparatus

5.1 *Testing Machines*—Machines used for tension testing shall conform to the requirements of Practices E4. The forces used in determining tensile strength and yield strength shall be within the verified force application range of the testing machine as defined in Practices E4. Where verification of the testing machine speed is required, Practices E2658 shall be used unless otherwise specified.

5.2 *Gripping Devices:*

5.2.1 *General*—Various types of gripping devices may be used to transmit the measured force applied by the testing machine to the test specimens. To ensure axial tensile stress within the gauge length, the axis of the test specimen should coincide with the center line of the heads of the testing machine. Any departure from this requirement may introduce bending stresses that are not included in the usual stress computation (force divided by cross-sectional area).

NOTE 1—The effect of this eccentric force application may be illustrated by calculating the bending moment and stress thus added. For a standard 12.5 mm [0.500 in.] diameter specimen, the stress increase is 1.5 percentage points for each 0.025 mm [0.001 in.] of eccentricity. This error increases to 2.5 percentage points/ 0.025 mm [0.001 in.] for a 9 mm [0.350 in.] diameter specimen and to 3.2 percentage points/ 0.025 mm [0.001 in.] for a 6 mm [0.250 in.] diameter specimen.

NOTE 2—Alignment methods are given in Practice E1012.

5.2.2 *Wedge Grips*—Testing machines usually are equipped with wedge grips. These wedge grips generally furnish a satisfactory means of gripping long specimens of ductile metal and flat plate test specimens such as those shown in Fig. 1. If, however, for any reason, one grip of a pair advances farther than the other as the grips tighten, an undesirable bending stress may be introduced. When liners are used behind the wedges, they must be of the same thickness and their faces must be flat and parallel. For best results, the wedges should be supported over their entire lengths by the heads of the testing machine. This requires that liners of several thicknesses be available to cover the range of specimen thickness. For proper gripping, it is desirable that the entire length of the serrated face of each wedge be in contact with the specimen. Proper alignment of wedge grips and liners is illustrated in Fig. 2. For short specimens and for specimens of many materials it is generally necessary to use machined test specimens and to use a special means of gripping to ensure that the specimens, when under load, shall be as nearly as possible in uniformly distributed pure axial tension (see 5.2.3, 5.2.4, and 5.2.5).

5.2.3 *Grips for Threaded and Shouldered Specimens and Brittle Materials*—A schematic diagram of a gripping device for threaded-end specimens is shown in Fig. 3, while Fig. 4 shows a device for gripping specimens with shouldered ends. Both of these gripping devices should be attached to the heads of the testing machine through properly lubricated spherical-seated bearings. The distance between spherical bearings should be as great as feasible.

5.2.4 *Grips for Sheet Materials*—The self-adjusting grips shown in Fig. 5 have proven satisfactory for testing sheet materials that cannot be tested satisfactorily in the usual type of wedge grips.

5.2.5 *Grips for Wire*—Grips of either the wedge or snubbing types as shown in Fig. 5 and Fig. 6 or flat wedge grips may be used.

5.3 *Dimension-Measuring Devices*—Micrometers and other devices used for measuring linear dimensions shall be accurate and precise to at least one half the smallest unit to which the individual dimension is required to be measured.

5.4 *Extensometers*—Extensometers used in tension testing shall conform to the requirements of Practice E83 for the classifications specified by the procedure section of this test method. Extensometers shall be used and verified to include the strains corresponding to the yield strength and elongation at fracture (if determined).

5.4.1 Extensometers with gauge lengths equal to or shorter than the nominal gauge length of the specimen (dimension shown as "*G*-Gauge Length" in the accompanying figures) may be used to determine the yield behavior. For specimens without a reduced section (for example, full cross sectional area specimens of wire, rod, or bar), the extensometer gauge length for the determination of yield behavior shall not exceed 80 % of the distance between grips. For measuring elongation at fracture with an appropriate extensometer, the gauge length of the extensometer shall be equal to the nominal gauge length required for the specimen being tested.

6. Test Specimens

6.1 *General:*

6.1.1 *Specimen Size*—Test specimens shall be either substantially full size or machined, as prescribed in the product specifications for the material being tested.

6.1.2 *Location*—Unless otherwise specified, the axis of the test specimen shall be located within the parent material as follows:

6.1.2.1 At the center for products 40 mm [1.500 in.] or less in thickness, diameter, or distance between flats.

6.1.2.2 Midway from the center to the surface for products over 40 mm [1.500 in.] in thickness, diameter, or distance between flats.

6.1.3 *Specimen Machining*—Improperly prepared test specimens often are the reason for unsatisfactory and incorrect test results. It is important, therefore, that care be exercised in the preparation of specimens, particularly in the machining, to maximize precision and minimize bias in test results.

6.1.3.1 The reduced section including the fillets of prepared specimens should be free of cold work, notches, chatter marks, grooves, gouges, burrs, rough surfaces or edges, overheating, or any other condition which can deleteriously affect the properties to be measured.

NOTE 3—Punching or blanking of the reduced section may produce significant cold work or shear burrs, or both, along the edges which should be removed by machining.

6.1.3.2 Within the reduced parallel section of rectangular specimens, edges or corners should not be ground or abraded in a manner which could cause the actual cross-sectional area of the specimen to be significantly different from the calculated area.

6.1.3.3 For brittle materials, large radius fillets at the ends of the reduced parallel section should be used.

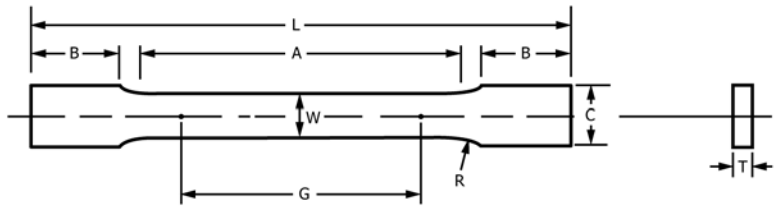
6.1.3.4 The cross-sectional area of the specimen should be smallest at the center of the reduced parallel section to ensure fracture within the gauge length. For this reason, a small taper is permitted in the reduced parallel section of each of the specimens described in the following sections.

6.1.4 *Specimen Surface Finish*—When materials are tested with surface conditions other than as manufactured, the surface finish of the test specimens should be as provided in the applicable product specifications.

NOTE 4—Particular attention should be given to the uniformity and quality of surface finish of specimens for high strength and very low ductility materials since this has been shown to be a factor in the variability of test results.

6.1.5 *Specimen Grip Section Symmetry*—Symmetry tolerances for grip sections of specimens (relative to centerlines of reduced parallel sections) are given within Fig. 1 and Fig. 7.

NOTE 5—Symmetry of grip sections of machined specimens relative to the centerlines of reduced parallel sections can affect alignment, stress-strain curves, and test results, especially when the grip sections of



	Dimensions		
	Standard Specimens		Subsize Specimen
	Plate-Type, 40 mm [1.500 in.] Wide	Sheet-Type, 12.5 mm [0.500 in.] Wide	6 mm [0.250 in.] Wide
	mm [in.]	mm [in.]	mm [in.]
G—Gauge length (Note 1 and Note 2)	200.0 ± 0.2 [8.00 ± 0.01]	50.0 ± 0.1 [2.000 ± 0.005]	25.0 ± 0.1 [1.000 ± 0.003]
W—Width (Note 3 and Note 4)	40.0 ± 2.0 [1.500 + 0.125, -0.250]	12.5 ± 0.2 [0.500 ± 0.010]	6.0 ± 0.1 [0.250 ± 0.005]
T—Thickness (Note 5)		thickness of material	
R—Radius of fillet, min (Note 6)	25 [1]	12.5 [0.500]	6 [0.250]
L—Overall length, min (Note 2, Note 7, and Note 8)	450 [18]	200 [8]	100 [4]
A—Length of reduced parallel section, min	225 [9]	57 [2.25]	32 [1.25]
B—Length of grip section, min (Note 9)	75 [3]	50 [2]	30 [1.25]
C—Width of grip section, approximate (Note 4 and Note 9)	50 [2]	20 [0.750]	10 [0.375]

NOTE 1—For the 40 mm [1.500 in.] wide specimen, punch marks for measuring elongation after fracture shall be made on the flat or on the edge of the specimen and within the reduced parallel section. Either a set of nine or more punch marks 25 mm [1 in.] apart, or one or more pairs of punch marks 200 mm [8 in.] apart may be used.

NOTE 2—When elongation measurements of 40 mm [1.500 in.] wide specimens are not required, a minimum length of reduced parallel section (*A*) of 75 mm [2.25 in.] may be used with all other dimensions similar to those of the plate-type specimen.

NOTE 3—For the three sizes of specimens, the ends of the reduced parallel section shall not differ in width by more than 0.10 mm, 0.05 mm or 0.02 mm [0.004 in., 0.002 in. or 0.001 in.], respectively. Also, there may be a gradual decrease in width from the ends to the center, but the width at each end shall not be more than 1 % larger than the width at the center.

NOTE 4—For each of the three sizes of specimens, narrower widths (*W* and *C*) may be used when necessary. In such cases the width of the reduced parallel section should be as large as the width of the material being tested permits; however, unless stated specifically, the requirements for elongation in a product specification shall not apply when these narrower specimens are used.

NOTE 5—The dimension *T* is the thickness of the test specimen as provided for in the applicable material specifications. Minimum thickness of 40 mm [1.500 in.] wide specimens shall be 5 mm [0.188 in.]. Maximum thickness of 12.5 mm and 6 mm [0.500 in. and 0.250 in.] wide specimens shall be 19 and 6 mm [0.750 and 0.250 in.], respectively.

NOTE 6—For the 40 mm [1.500 in.] wide specimen, a 13 mm [0.500 in.] minimum radius at the ends of the reduced parallel section is permitted for steel specimens under 690 MPa [100 000 psi] in tensile strength when a profile cutter is used to machine the reduced section.

NOTE 7—The dimension shown is suggested as a minimum. In determining the minimum length, the grips must not extend in to the transition section between Dimensions *A* and *B*, see Note 9.

NOTE 8—To aid in obtaining axial force application during testing of 6 mm [0.250 in.] wide specimens, the overall length should be as large as the material will permit, up to 200 mm [8.00 in.].

NOTE 9—It is desirable, if possible, to make the length of the grip section large enough to allow the specimen to extend into the grips a distance equal to two thirds or more of the length of the grips. If the thickness of 12.5 mm [0.500 in.] wide specimens is over 10 mm [0.375 in.], longer grips and correspondingly longer grip sections of the specimen may be necessary to prevent failure in the grip section.

NOTE 10—For the three sizes of specimens, the ends of the specimen shall be symmetrical in width with the center line of the reduced parallel section within 2.5 mm, 1.25 mm and 0.13 mm [0.10 in., 0.05 in. and 0.005 in.], respectively. However, for referee testing and when required by product specifications, the ends of the 12.5 mm [0.500 in.] wide specimen shall be symmetrical within 0.2 mm [0.01 in.].

NOTE 11—For each specimen type, the radii of all fillets shall be equal to each other within a tolerance of 1.25 mm [0.05 in.], and the centers of curvature of the two fillets at a particular end shall be located across from each other (on a line perpendicular to the centerline) within a tolerance of 2.5 mm [0.10 in.].

NOTE 12—Specimens with sides parallel throughout their length are permitted, except for referee testing, provided: *(a)* the above tolerances are used; *(b)* an adequate number of marks are provided for determination of elongation; and *(c)* when yield strength is determined, a suitable extensometer is used. If the fracture occurs at a distance of less than 2 W from the edge of the gripping device, the tensile properties determined may not be representative of the material. In acceptance testing, if the properties meet the minimum requirements specified, no further testing is required, but if they are less than the minimum requirements, discard the test and retest.

FIG. 1 Rectangular Tension Test Specimens

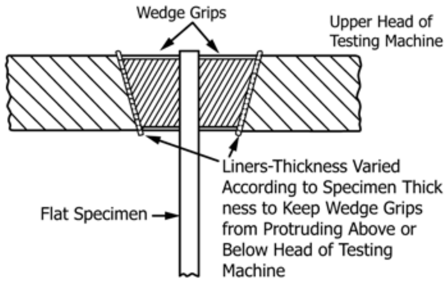


FIG. 2 Wedge Grips with Liners for Flat Specimens

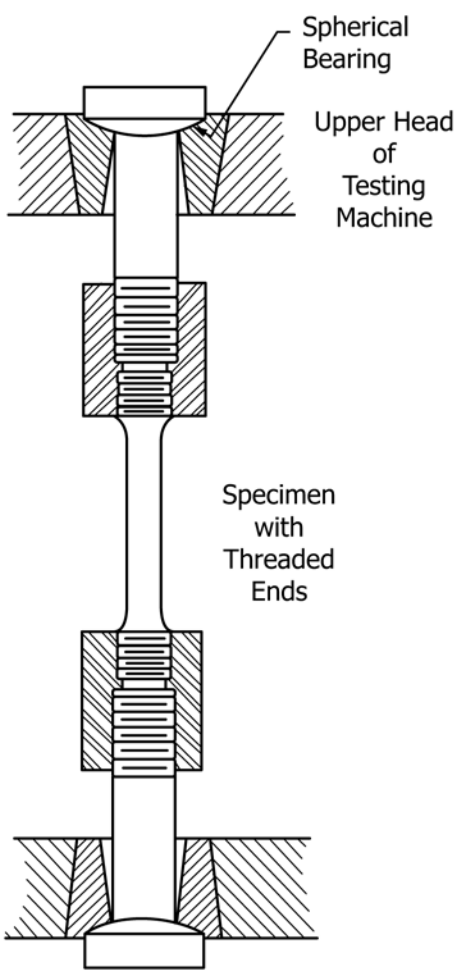


FIG. 3 Gripping Device for Threaded-End Specimens

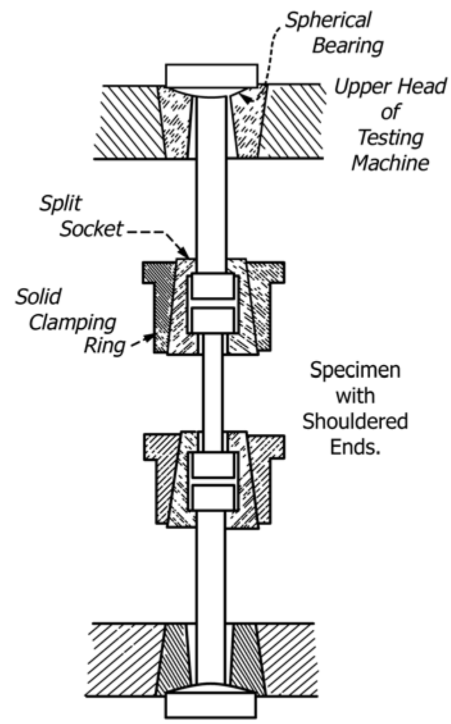


FIG. 4 Gripping Device for Shouldered-End Specimens

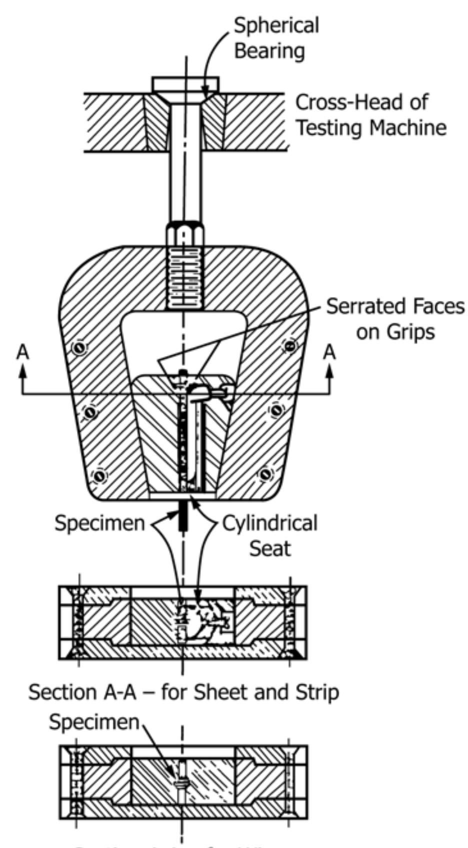


FIG. 5 Gripping Devices for Sheet and Wire Specimens

rectangular specimens are used to locate the specimens within the testing machine. Tighter tolerances, such as those given by Note 10 of Fig. 1 for referee testing, can be used to maintain alignment where asymmetry of specimen grip sections could otherwise result in the reduced parallel section being offset, oriented at an angle, or both, relative to the axis of force application.

NOTE 6—Effects of specimen symmetry and misalignment errors can be minimized by use of certain types of gripping systems or backstops.

6.2 *Plate-Type Specimens*—The standard plate-type test specimen is shown in Fig. 1. This specimen is used for testing metallic materials in the form of plate, shapes, and flat material having a nominal thickness of 5 mm [0.188 in.] or over. When product specifications so permit, other types of specimens may be used, as provided in 6.3, 6.4, and 6.5.