



Designation: E6-07a Designation: E 6 – 07b

# Standard Terminology Relating to Methods of Mechanical Testing<sup>1</sup>

This standard is issued under the fixed designation E 6; 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 reappraisal. A superscript epsilon (ε) indicates an editorial change since the last revision or reappraisal.

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

## 1. Scope

1.1 This terminology covers the principal terms relating to methods of mechanical testing of solids. The general definitions are restricted and interpreted, when necessary, to make them particularly applicable and practicable for use in standards requiring or relating to mechanical tests. These definitions are published to encourage uniformity of terminology in product specifications.

1.2 Terms relating to fatigue and fracture testing are defined in Terminology E 1823.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

- E 8 Test Methods for Tension Testing of Metallic Materials
- E 8M Test Methods for Tension Testing of Metallic Materials [Metric]
- E 796 Test Method for Ductility Testing of Metallic Foil
- E 1823 Terminology Relating to Fatigue and Fracture Testing

## 3. Index of Terms

3.1 The definitions of the following terms, which are listed alphabetically, appear in the indicated sections of 4.1.

Term	Section
accuracy	G
alignment	B
angle of bend	D
angle of twist	B
angular strain	see <b>strain</b>
axial strain	see <b>strain</b>
bearing area	F
bearing force	F
bearing strain	F
bearing strength	F
bearing stress	F
bearing yield strength	F
bend test	D
bending strain	see <b>strain</b>
bias, statistical	G
biaxial stretching	D
breaking load	B
Brinell hardness number	C
Brinell hardness test	C
calibration	G
calibration factor	G
chord modulus	see <b>modulus of elasticity</b>
compressive strength	B
compressive stress	see <b>stress</b>
compressometer	G
constraint	A
creep	E
creep recovery	E
creep rupture strength	E
creep strength	E

<sup>1</sup> This terminology is under the jurisdiction of ASTM Committee E28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.91 on Terminology except where designated otherwise. A subcommittee designation in parentheses following a definition indicates the subcommittee with responsibility for that definition.

Current edition approved June 1, 2007. Published December 2007. Originally approved 1923. Last previous edition approved 2007 as E 6 – 07a.

<sup>2</sup> 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.

deep drawing  
 deflectometer  
 direct verification  
 discontinuous yielding  
 discontinuous yielding stress  
 ductility  
 dynamic mechanical measurement  
 eccentricity  
 edge distance  
 edge distance ratio  
 elastic calibration device  
 elastic constants  
  
 elastic force-measurement device  
 elastic limit  
 elastic modulus  
 elastic true strain  
 elongation  
 engineering strain  
 engineering stress  
 extensometer  
 extensometer system  
 fatigue ductility  
 fatigue life  
 forming limit curve  
 forming limit diagram  
 fracture ductility  
 fracture strength  
 fracture stress  
 free bend  
 force  
 gage length  
 guided bend  
 hardness  
 indentation hardness  
 indirect verification  
 initial recovery  
 initial strain  
 initial stress  
 Knoop hardness number  
 Knoop hardness test  
 limiting dome height  
 linear (tensile or compressive) strain  
 load  
 lower yield strength  
 macrostrain  
 malleability  
 mandrel (in bend testing)  
  
 mechanical hysteresis  
 mechanical properties  
 mechanical testing  
 microstrain  
 modulus of elasticity  
 modulus of rigidity  
 modulus of rupture in bending  
 modulus of rupture in torsion  
 necking  
 nominal stress  
 normal stress  
 physical properties  
 pin  
 plastic true strain  
 plunger  
 precision  
 primary force standard  
 principal stress  
 Poisson's ratio  
 proportional limit  
 radius of bend  
 rate of creep  
 reduction of area  
 relaxation rate  
 relaxed stress  
 remaining stress  
 residual strain  
 residual stress  
 Rockwell hardness number

D  
 G  
 G  
 B  
 B  
 A  
 G  
 B  
 F  
 F  
 G  
 see **modulus of elasticity** and **Poisson's ratio**  
 G  
 A  
 see **modulus of elasticity**  
 A  
 B  
 see **strain**  
 see **stress**  
 G  
 G  
 D  
 B  
 D  
 D  
 A  
 A  
 see **stress**  
 D  
 A  
 G  
 D  
 C  
 C  
 G  
 E  
 E  
 E  
 C  
 C  
 D  
 see **strain**  
 A  
 B  
 see **strain**  
 see **ductility**  
 D  
  
 A  
 A  
 A  
 see **strain**  
 A  
 see **modulus of elasticity**  
 D  
 B  
 B  
 see **stress**  
 see **stress**  
 see **mechanical properties**  
 see **mandrel (in bend testing)**  
 A  
 see **mandrel (in bend testing)**  
 G  
 G  
 see **stress**  
 A  
 A  
 D  
 E  
 B  
 E  
 E  
 E  
 see **strain**  
 see **stress**  
 C

iTeh Standards  
 (https://standards.itih.a)  
 Document Preview

ASTM E6-07b

<https://standards.itih.a/catalog/standards/sist/35c971a5-d5d2-4663-a2ad-63ba4f/astm-e6-07b>

Rockwell hardness test	C
Rockwell superficial hardness number	see <b>Rockwell hardness number</b>
Rockwell superficial hardness test semi-guided bend	C
Scleroscope hardness number	D
Scleroscope hardness test	C
secondary force standard set	C
secant modulus	G
shear fracture	A
shear modulus	see <b>modulus of elasticity</b>
shear strain	B
shear strength	A
shear stress	see <b>strain</b>
slenderness ratio	B
static fatigue strength	see <b>stress</b>
strain	B
strain gage fatigue life	see <b>creep rupture strength</b>
strain hardening	A
stress	see <b>fatigue life</b>
stress relaxation	A
stress-rupture strength	A
stress-strain diagram	E
tangent modulus	see <b>creep rupture strength</b>
tensile strength	A
tensile stress	see <b>fatigue life</b>
tension testing machine	A
testing machine	A
torque	A
torsional modulus	see <b>modulus of elasticity</b>
torsional stress	see <b>stress</b>
total elongation	B
transverse strain	see <b>strain</b>
true strain	see <b>strain</b>
true stress	see <b>stress</b>
ultimate tensile strength (UTS)	(See <b>tensile strength</b> )
uniform elongation	B
upper yield strength	B
verification	G
Vickers hardness number	C
Vickers hardness test	C
wrap-around bend	D
yield point	B
yield point elongation	B
yield strength	B (also see <b>upper yield strength</b> and <b>lower yield strength</b> )
Young's modulus	A
zero time	E

#### 4. Terminology

##### 4.1 Terms and Definitions:

#### A. GENERAL DEFINITIONS

**constraint**, *n*—any restriction to the deformation of a body. (E28.11)

**ductility**, *n*—the ability of a material to deform plastically before fracturing. (E28.02)

DISCUSSION—Ductility is usually evaluated by measuring ( 1) the elongation or reduction of area from a tension test, (2) the depth of cup from a cupping test, ( 3) the radius or angle of bend from the bend test, or ( 4) the fatigue ductility from the fatigue ductility test (see Test Method E 796).

DISCUSSION—Malleability is the ability to deform plastically under repetitive compressive forces.

**elastic limit** [FL<sup>-2</sup>], *n*—the greatest stress which a material is capable of sustaining without any permanent strain remaining upon complete release of the stress.

DISCUSSION—Due to practical considerations in determining the elastic limit, measurements of strain, using a small force rather than zero force, are usually taken as the initial and final reference.

**fracture ductility**,  $\epsilon_f$ , *n*—the true plastic strain at fracture.

**fracture strength**,  $S_f$  [FL<sup>-2</sup>], *n*—the normal stress at the beginning of fracture. Fracture strength is calculated from the force at the beginning of fracture during a tension test and the original cross-sectional area of the specimen.

**force** [F], *n*— in mechanical testing, a vector quantity of fundamental nature characterized by a magnitude, a direction, a sense, and a discrete point of application, that acts externally upon a test object and creates stresses in it. (E28.91)

DISCUSSION—Force is a derived unit of the SI system. Units of force in the SI system are newtons (N).

DISCUSSION—Where applicable, the noun **force** is preferred to **load** in terminology for mechanical testing.

**least count,  $n$** —the smallest change in indication that can customarily be determined and reported.

DISCUSSION—In machines with close graduations it may be the value of a graduation interval; with open graduations or with magnifiers for reading, it may be an estimated fraction, rarely as fine as one tenth, of a graduated interval; and with verniers it is customarily the difference between the scale and vernier graduation measured in terms of scale units. If the indicating mechanism includes a stepped detent, the detent action may determine the least count.

**load [F],  $n$** — in mechanical testing, an external force or system of forces or pressures, or both, that act upon the test object. **(E28.91)**

DISCUSSION—**Load** is a deprecated term and, where applicable, it should be replaced by **force**, particularly where it is used as a noun. For reasons of editorial simplicity or traditional usage, replacement of **load** by **force** may not always be desirable when used as a verb, adjective, or other part of speech (for example, to load a specimen, loading rate, load cell).

**mechanical hysteresis,  $n$** —the energy absorbed in a complete cycle of loading and unloading. **(E28.03)**

DISCUSSION—A complete cycle of loading and unloading includes any stress cycle regardless of the mean stress or range of stress.

**mechanical properties,  $n$** —those properties of a material that are associated with elastic and inelastic reaction when force is applied, or that involve the relationship between stress and strain.

DISCUSSION—These properties have often been referred to as “physical properties,” but the term “mechanical properties” is preferred.

**mechanical testing,  $n$** —determination of the properties or the mechanical states of a material that are associated with elastic and inelastic reactions to force or that involve relationships between stress and strain. **(E28.91)**

**modulus of elasticity [FL<sup>-2</sup>],  $n$** —the ratio of stress to corresponding strain below the proportional limit.

DISCUSSION—The stress-strain relations of many materials do not conform to Hooke’s law throughout the elastic range, but deviate therefrom even at stresses well below the elastic limit. For such materials the slope of either the tangent to the stress-strain curve at the origin or at a low stress, the secant drawn from the origin to any specified point on the stress-strain curve, or the chord connecting any two specified points on the stress-strain curve is usually taken to be the “modulus of elasticity.” In these cases the modulus should be designated as the “tangent modulus,” the “secant modulus,” or the “chord modulus,” and the point or points on the stress-strain curve described. Thus, for materials where the stress-strain relationship is curvilinear rather than linear, one of the four following terms may be used:

(a) *initial tangent modulus* [FL<sup>-2</sup>],  $n$ —the slope of the stress-strain curve at the origin.

(b) *tangent modulus* [FL<sup>-2</sup>],  $n$ —the slope of the stress-strain curve at any specified stress or strain.

(c) *secant modulus* [FL<sup>-2</sup>],  $n$ —the slope of the secant drawn from the origin to any specified point on the stress-strain curve.

(d) *chord modulus* [FL<sup>-2</sup>],  $n$ —the slope of the chord drawn between any two specified points on the stress-strain curve below the elastic limit of the material. **(E28.03)**

DISCUSSION—Modulus of elasticity, like stress, is expressed in force per unit of area (pounds per square inch, etc.).

**Poisson’s ratio,  $\mu$ ,  $n$** —the negative of the ratio of transverse strain to the corresponding axial strain resulting from an axial stress below the proportional limit of the material. **(E28.03)**

DISCUSSION—Poisson’s ratio may be negative for some materials, for example, a tensile transverse strain will result from a tensile axial strain.

DISCUSSION—Poisson’s ratio will have more than one value if the material is not isotropic.

**proportional limit [FL<sup>-2</sup>],  $n$** —the greatest stress which a material is capable of sustaining without any deviation from proportionality of stress to strain (Hooke’s law).

DISCUSSION—Many experiments have shown that values observed for the proportional limit vary greatly with the sensitivity and accuracy of the testing equipment, eccentricity of loading, the scale to which the stress-strain diagram is plotted, and other factors. When determination of proportional limit is required, the procedure and the sensitivity of the test equipment should be specified.

**set,  $n$** —strain remaining after complete release of the force producing the deformation.

DISCUSSION—Due to practical considerations, such as distortion in the specimen and slack in the strain indicating system, measurements of strain at a small force rather than zero force are often taken.

DISCUSSION—Set is often referred to as permanent set if it shows no further change with time. Time elapsing between removal of force and final reading of set should be stated.

**shear modulus,  $G$  [FL<sup>-2</sup>],  $n$** —the ratio of shear stress to corresponding shear strain below the proportional limit, also called *torsional modulus* and *modulus of rigidity*. **(E28.03)**

DISCUSSION—The value of the shear modulus may depend on the direction in which it is measured if the material is not isotropic. Wood, many plastics and certain metals are markedly anisotropic. Deviations from isotropy should be suspected if the shear modulus differs from that determined by substituting independently measured values of Young’s modulus,  $E$ , and Poisson’s ratio,  $\mu$ , in the relation:

$$G = E/[2(1 + \mu)]$$

DISCUSSION—In general, it is advisable in reporting values of shear modulus to state the range of stress over which it is measured.

**strain,  $e$ ,  $n$** — the per unit change, due to force, in the size or shape of a body referred to its original size or shape. Strain is a nondimensional quantity, but it is frequently expressed in inches per inch, metres per metre, or percent.

DISCUSSION—In this standard, “original” refers to dimensions or shape of cross section of specimens at the beginning of testing.

DISCUSSION—Strain at a point is defined by six components of strain: three linear components and three shear components referred to a set of coordinate axes.

DISCUSSION—In the usual tension, compression, or torsion test it is customary to measure only one component of strain and to refer to this as “the strain.” In a tension or a compression test this is usually the axial component.

DISCUSSION—Strain has an elastic and a plastic component. For small strains the plastic component can be imperceptibly small.

DISCUSSION—Linear thermal expansion, sometimes called “thermal strain,” and changes due to the effect of moisture are not to be considered strain in mechanical testing.

*angular strain, n*—use *shear strain*.

*axial strain, n*—linear strain in a plane parallel to the longitudinal axis of the specimen. **(E28.04)**

*bending strain, n*—the difference between the strain at the surface of the specimen and the axial strain. **(E28.03, E28.10)**

*elastic true strain,  $\epsilon_e, n$* —elastic component of the true strain.

*engineering strain,  $e, n$* —a dimensionless value that is the change in length ( $\Delta L$ ) per unit length of original linear dimension ( $L_0$ ) along the loading axis of the specimen; that is,  $e = (\Delta L)/L_0$ . **(E28.02)**

*linear (tensile or compressive) strain, n*—the change per unit length due to force in an original linear dimension. **(E28.04)**

DISCUSSION—An increase in length is considered positive.

*macrostrain, n*—the mean strain over any finite gage length of measurement large in comparison with interatomic distances. **(E28.13)**

DISCUSSION—Macrostrain can be measured by several methods, including electrical-resistance strain gages and mechanical or optical extensometers. Elastic macrostrain can be measured by X-ray diffraction.

DISCUSSION—When either of the terms *macrostrain* or *microstrain* is first used in a document, it is recommended that the physical dimension or the gage length, which indicate the size of the reference strain volume involved, be stated.

*microstrain, n*—the strain over a gage length comparable to interatomic distances. **(E28.13)**

DISCUSSION—These are the strains being averaged by the macrostrain measurement. Microstrain is not measurable by existing techniques. Variance of the microstrain distribution can, however, be measured by X-ray diffraction.

DISCUSSION—When either of the terms *macrostrain* or *microstrain* is first used in a document, it is recommended that the physical dimension or the gage length, which indicate the size of the reference strain volume involved, be stated.

*plastic true strain,  $\epsilon_p, n$* —the inelastic component of true strain.

*residual strain, n*—strain associated with residual stress. **(E28.13)**

DISCUSSION—Residual strains are elastic.

*shear strain, n*—the tangent of the angular change, due to force, between two lines originally perpendicular to each other through a point in a body. **(E28.04)**

*transverse strain, n*—linear strain in a plane perpendicular to the axis of the specimen.

DISCUSSION—Transverse strain may differ with direction in anisotropic materials.

*true strain,  $\epsilon, n$* —the natural logarithm of the ratio of instantaneous gage length,  $L$ , to the original gage length,  $L_0$ ; that is,  $\epsilon = \ln (L/L_0)$  or  $\epsilon = \ln (1+e)$ . **(E28.02)**

*strain hardening, n*—an increase in hardness and strength caused by plastic deformation. **(E28.02)**

**stress** [ $FL^{-2}$ ], *n*—the intensity at a point in a body of the forces or components of force that act on a given plane through the point. Stress is expressed in force per unit of area (for example, pounds-force per square inch, megapascals.).

DISCUSSION—As used in tension, compression, or shear tests prescribed in product specifications, stress is calculated on the basis of the original dimensions of the cross section of the specimen. This stress is sometimes called “engineering stress,” to emphasize the difference from true stress.

*compressive stress* [ $FL^{-2}$ ], *n*—normal stress due to forces directed toward the plane on which they act. **(E28.04)**

*engineering stress,  $S$*  [ $FL^{-2}$ ], *n*—the normal stress, expressed in units of applied force,  $F$ , per unit of original cross-sectional area,  $A_0$ ; that is,  $S = F/A_0$ . **(E28.02)**

*fracture stress* [ $FL^{-2}$ ], *n*—the true normal stress on the minimum cross-sectional area at the beginning of fracture.

DISCUSSION—This term usually applies to tension tests of unnotched specimens.

*nominal stress* [ $FL^{-2}$ ], *n*—the stress at a point calculated on the net cross section by simple elastic theory without taking into account the effect on the stress produced by geometric discontinuities such as holes, grooves, fillets, and so forth.

*normal stress* [ $FL^{-2}$ ], *n*—the stress component perpendicular to a plane on which the forces act.

*principal stress (normal)* [ $FL^{-2}$ ], *n*—the maximum or minimum value of the normal stress at a point in a plane considered with respect to all possible orientations of the considered plane. On such principal planes the shear stress is zero.

DISCUSSION—There are three principal stresses on three mutually perpendicular planes. The states of stress at a point may be:

(1) *uniaxial* [ $FL^{-2}$ ], *n*—a state of stress in which two of the three principal stresses are zero,

- (2) *biaxial* [FL<sup>-2</sup>], *n*—a state of stress in which only one of the three principal stresses is zero, or  
 (3) *triaxial* [FL<sup>-2</sup>], *n*—a state of stress in which none of the principal stresses is zero.  
 (4) *multiaxial* [FL<sup>-2</sup>], *n*—biaxial or triaxial.

*residual stress* [FL<sup>-2</sup>], *n*—stress in a body which is at rest and in equilibrium and at uniform temperature in the absence of external and mass forces. (E28.13)

*shear stress* [FL<sup>-2</sup>], *n*—the stress component tangential to the plane on which the forces act. (E28.04)

*tensile stress* [FL<sup>-2</sup>], *n*—normal stress due to forces directed away from the plane on which they act. (E28.04)

*torsional stress* [FL<sup>-2</sup>], *n*—the shear stress in a body, in a plane normal to the axis of rotation, resulting from the application of torque. (E28.03)

*true stress*,  $\sigma$  [FL<sup>-2</sup>], *n*—the instantaneous normal stress, calculated on the basis of the instantaneous cross-sectional area, *A*; that is,  $\sigma = F/A$ ; if no necking has occurred,  $\sigma = S(1+e)$ . (E28.02)

**stress-strain diagram**, *n*—a diagram in which corresponding values of stress and strain are plotted against each other. Values of stress are usually plotted as ordinates (vertically) and values of strain as abscissas (horizontally). (E28.04)

**tension testing machine, CTR (constant rate of traverse)**, *n*—a mechanical device for applying a load (force) to a specimen and in which the force is measured by means of a pendulum. (E28.01)

**testing machine (force-measuring type)**, *n*—a mechanical device for applying a force to a specimen. (E28.01)

**torque** [FL], *n*—a moment (of forces) that produces or tends to produce rotation or torsion. (E28.03)

**Young's modulus**, *E* [FL<sup>-2</sup>], *n*—the ratio of tensile or compressive stress to corresponding strain below the proportional limit of the material. (E28.03)

## B. TENSION, COMPRESSION, SHEAR, AND TORSION TESTING

**alignment**, *n*—the condition of a testing machine and load train (including the test specimen) that influences the introduction of bending moments into a specimen during tensile loading. (E28.04)

**angle of twist (torsion test)**, *n*—the angle of relative rotation measured in a plane normal to the torsion specimen's longitudinal axis over the gage length. (E28.03)

**breaking force**[F], *n*—the force at which fracture occurs. (E28.04)

DISCUSSION—When used in connection with tension tests of thin materials or materials of small diameter for which it is often difficult to distinguish between the breaking force and the maximum force developed, the latter is considered to be the breaking force.

**compressive strength** [FL<sup>-2</sup>], *n*—the maximum compressive stress which a material is capable of sustaining. Compressive strength is calculated from the maximum force during a compression test and the original cross-sectional area of the specimen. (E28.04)

DISCUSSION—In the case of a material which fails in compression by a shattering fracture, the compressive strength has a very definite value. In the case of materials which do not fail in compression by a shattering fracture, the value obtained for compressive strength is an arbitrary value depending upon the degree of distortion which is regarded as indicating complete failure of the material.

**discontinuous yielding**, *n*—a hesitation or fluctuation of force observed at the onset of plastic deformation, due to localized yielding. (E28.04)

DISCUSSION—The stress-strain curve need not appear to be discontinuous.

**discontinuous yielding stress**, *n*—the peak stress at the initiation of the first measurable serration on the curve of stress-versus strain. (E28.10)

**eccentricity**, *n*—the distance between the line of action of the applied force and the axis of symmetry of the specimen in a plane perpendicular to the longitudinal axis of the specimen. (E28.04)

**elongation**, *El*, *n*—the increase in gage length of a body subjected to a tension force, referenced to a gage length on the body. Usually elongation is expressed as a percentage of the original gage length. (E28.04)

DISCUSSION—The increase in gage length may be determined either *at* or *after* fracture, as specified for the material under test.

DISCUSSION—The term elongation, 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 of elongation reported in the literature when no further qualification is given.

DISCUSSION—In reporting values of elongation the gage length shall be stated.

DISCUSSION—Elongation is affected by: specimen geometry; length, width, thickness of the gage section and adjacent regions; and test procedure, such as alignment and speed of pulling.

**fatigue life**, *N<sub>f</sub>*, *n*—the numbers of cycles of stress or strain of a specified character that a given specimen sustains before failure of a specified nature occurs. (E28.04) (E28.01)

**strain gage fatigue life**, *n*—the number of fully reversed strain cycles corresponding to the onset of degraded gage performance, whether due to excessive zero shift or other detectable failure mode. (E28.14) (E28.01)

**lower yield strength**, *LYS* [FL<sup>-2</sup>], *n*—the minimum stress recorded during discontinuous yielding, ignoring transient effects. See Figs. 1 and 2. (E28.04)