



Standard Terminology Relating to Methods of Mechanical Testing¹

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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:

E 8 Test Methods for Tension Testing of Metallic Materials²

E 8M Test Methods for Tension Testing of Metallic Materials [Metric]²

E 796 Test Method for Ductility Testing of Metallic Foil²

E 1823 Terminology Relating to Fatigue and Fracture Testing²

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
angle of bend	D
angle of twist	B
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axial strain	see strain
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bearing force	F
bearing strain	F
bearing strength	F
bearing stress	F
bearing yield strength	F
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Brinell hardness number
Brinell hardness test
calibration
calibration factor
chord modulus
compressive strength
compressive stress
compressometer
constraint
creep
creep recovery
creep rupture strength
creep strength
deflectometer
discontinuous yielding
ductility
edge distance
edge distance ratio
elastic constants

elastic limit
elastic true strain
elongation
engineering strain
engineering stress
extensometer
extensometer system
fatigue ductility
fatigue ductility exponent
fatigue life
fracture ductility
fracture strength
fracture stress
free bend
force
gage length
guided bend
hardness
indentation hardness
initial recovery
initial strain
initial stress
Knoop hardness number
Knoop hardness test
linear (tensile or compressive) strain
load
lower yield strength
macrostrain
malleability
mandrel (in bend testing)
maximum elongation
mechanical hysteresis
mechanical properties
mechanical testing
microstrain
modulus of elasticity
modulus of rigidity

C
C
G
G
see **modulus of elasticity**
B
see **stress**
G
A
E
E
E
G
B
A
F
F
see **modulus of elasticity** and **Poisson's ratio**
A
A
B
see **strain**
see **stress**
G
G
B
B
B
A
A
see **stress**
D
A
G
D
C
C
E
E
E
C
C
see **strain**
A
B
see **strain**
see **ductility**
D
B
A
A
A
see **strain**
A
see **modulus of elasticity**

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

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² *Annual Book of ASTM Standards*, Vol 03.01.



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Rockwell hardness test	C
Rockwell superficial hardness number	see Rockwell hardness number
Rockwell superficial hardness test	C
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true stress	see strain
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yield strength	B
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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 $[FL^{-2}]$, *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, ϵ_f , *n*—the true plastic strain at fracture.

fracture strength, S_f $[FL^{-2}]$, *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 much to be preferred.

mechanical testing, *n*—the determination of mechanical properties.





modulus of elasticity [FL^{-2}], 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^{-2}], n —the slope of the stress-strain curve at the origin.

(b) *tangent modulus* [FL^{-2}], n —the slope of the stress-strain curve at any specified stress or strain.

(c) *secant modulus* [FL^{-2}], n —the slope of the secant drawn from the origin to any specified point on the stress-strain curve.

(d) *chord modulus* [FL^{-2}], n —the slope of the chord drawn between any two specified points on the stress-strain curve.

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

Poisson's ratio, μ , n —the absolute value of the ratio of transverse strain to the corresponding axial strain resulting from uniformly distributed axial stress below the proportional limit of the material. **(E28.03)**

DISCUSSION—Above the proportional limit, the ratio of transverse strain to axial strain will depend on the average stress and on the stress range for which it is measured and, hence should not be regarded as Poisson's ratio. If this ratio is reported, nevertheless, as a value of "Poisson's ratio" for stresses beyond the proportional limit, the range of stress should be stated.

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

proportional limit [FL^{-2}], 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—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^{-2}], n —the ratio of shear stress to corresponding shear strain below the proportional limit of the material. **(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, μ , 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)**

elastic true strain, ϵ_e , n —elastic component of the true strain.

engineering strain, e , n —a dimensionless value that is the change in length (ΔL) 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, ϵ_p , n —the inelastic component of true strain.

