Designation: E517 – 24

Standard Test Method for Plastic Strain Ratio *r* for Sheet Metal[1]

This standard is issued under the fixed designation E517; 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.

1. Scope*

1.1 This test method covers special tension testing for the measurement of the plastic strain ratio, *r*, of sheet metal intended for deep-drawing applications.

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

1.3 *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.*

1.4 *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]

E6 Terminology Relating to Methods of Mechanical Testing

E8/E8M Test Methods for Tension Testing of Metallic Materials

E83 Practice for Verification and Classification of Extensometer Systems

E92 Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

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

3. Terminology

3.1 *Definitions of Terms Common to Mechanical Testing:*

3.1.1 The definitions relating to tension testing appearing in Terminology E6 shall apply to this test method. Some of those important terms include discontinuous yielding, gauge length, axial strain, true strain, reduced section, yield-point elongation, and upper yield strength.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *axial gauge length, l_i, n*—a gauge length aligned with the long axis of the specimen.

3.2.1.1 *Discussion*—The specific measurement to be used for the axial gauge length is based on which procedure (*Manual*, *Automatic*, or *Combined*) and specimen type are used.

3.2.1.2 *Discussion*—Since "gauge length" is by definition the original length, the final length associated with the axial gauge length would be the final axial length, l_f.

3.2.1.3 *Discussion*—In uniaxial testing, dimensions aligned with the longitudinal or long axis of the specimen are frequently referred to as "axial" dimensions, for example, axial gauge length. The word "longitudinal" describes the long-axis direction of the specimen and has no assumed relationship to the rolling direction of the sheet metal being tested.

3.2.2 *earing tendency, delta r or Δr, n*—measure of the tendency of sheet to draw in nonuniformly and to form ears in the flange of deep-drawn cylindrical parts in the directions of higher values of *r* (see 10.4).

3.2.2.1 *Discussion*—In cold-reduced and annealed low-carbon steel sheet, r_0 and r_{90} are usually greater than r_{45}, while in hot-rolled steels r_{45} can be greater. Other earing tendencies occur; thus, for some materials the earing tendency can be better represented by $r_{max} - r_{min}$.

3.2.3 *plastic strain ratio, r, n*—in sheet metal that has been strained by uniaxial tension sufficiently to induce plastic flow, the ratio of the true strain that has occurred in a transverse direction (ε_w) perpendicular to the direction of applied stress and in the plane of the sheet, to the concomitant true strain in the thickness direction (ε_t).

3.2.3.1 *Discussion*—The plastic strain ratio, *r*, is numerically equal to

$$r = \varepsilon_w/\varepsilon_t \quad (1)$$

[1] This test method is under the jurisdiction of ASTM Committee E28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.02 on Ductility and Formability.

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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**

where:

ε_w = true transverse strain, and
ε_t = true thickness strain.

3.2.3.2 *Discussion*—Due to difficulty in measuring thickness changes with sufficient precision, in practice an equivalent relationship is commonly used, based on axial and transverse strain measurements (see 9.1.2).

3.2.3.3 *Discussion*—The term "transverse" describes the width direction of the specimen and has no assumed relationship to the rolling direction of the sheet metal being tested.

3.2.4 *reduced parallel section, n*—the central portion of the specimen that has a nominally uniform cross section, that is smaller than that of the ends that are gripped, not including the fillets.

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

3.2.4.2 *Discussion*—This term is very similar to the Terminology E6 term "reduced parallel section", except in this standard the tolerance on the reduced parallel section parallelism is much tighter, as shown in Fig. 1.

3.2.5 *transverse gauge length, w_i, n—in sheet products*, a gauge length aligned across the width of the specimen and perpendicular to the axial gauge length.

3.2.5.1 *Discussion*—The specific measurement to be used for the transverse gauge length is based on which procedure (*Manual*, *Automatic*, or *Combined*) and specimen type are used.

3.2.5.2 *Discussion*—Since "gauge length" is by definition the original length, the final length associated with the transverse gauge length would be the final transverse length, w_f.

3.2.5.3 *Discussion*—Since the thickness of the specimen is also referred to in this test method, the symbol *w* is used for the transverse length rather than *t* to prevent confusion with the measurements in the thickness direction.

3.2.5.4 *Discussion*—The term "transverse" describes the width direction of the specimen and has no assumed relationship to the rolling direction of the sheet metal being tested.

3.2.6 *transverse strain, n—in sheet products*, linear strain in the plane of the specimen perpendicular to the longitudinal axis of the specimen.

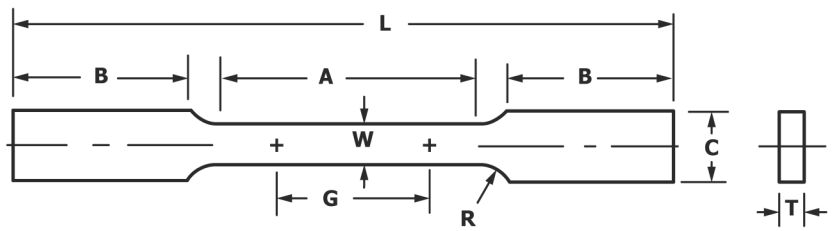
3.2.6.1 *Discussion*—This definition of transverse strain, in sheet products, is a more specific version of the term "transverse strain" as defined in Terminology E6, but transverse strain in sheet products is limited to the width direction of the specimen.

3.2.6.2 *Discussion*—The true transverse strain is denoted as ε_w in this standard.

3.2.6.3 *Discussion*—The terms "transverse" and "longitudinal" describe the in-plane directions of the specimen and have no assumed relationship to the rolling direction of the sheet metal being tested.

3.2.7 *thickness strain, n—in sheet products*, linear strain through the thickness of the specimen perpendicular to the longitudinal axis of the specimen.

3.2.7.1 *Discussion*—This definition of thickness strain, in sheet products, is a more specific version of the term "transverse strain" as defined in Terminology E6, but thickness strain in sheet products is limited to the thickness direction of the specimen.



Dimensions

		Specimen A			
		Standard		Alternative	
		in.	mm	in.	mm
G	Axial gauge mark spacing	2.00 ± 0.01	50 ± 0.25	1.00 ± 0.005	25 ± 0.13
W	Width (Note 1 and Note 2)	0.500 ± 0.01	12.5 ± 0.25	0.500 ± 0.01	12.5 ± 0.25
T	Thickness	thickness of material		thickness of material	
R	Radius of fillet, min	½	13	½	13
L	Overall length, min	8	200	7¼	180
A	Length of reduced parallel section, min	3	75	2¼	60
B	Length of grip section, min	2	50	2	50
C	Width of grip section, approximate	¾	20	¾	20

NOTE 1—The edges of the reduced parallel section shall be machined parallel over length, *G*, within a tolerance of 0.0005 in. (0.01 mm).

NOTE 2—The ends of the reduced parallel section shall not differ in width by more than 0.005 in. or (0.1 mm). However, the width within the length *G* shall conform to 8.3.

FIG. 1 Rectangular Tension Test Specimens with Reduced Parallel Section, Specimen A