



Standard Test Method for Plastic Strain Ratio r for Sheet Metal¹

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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. 0.05.

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

2. Referenced Documents

2.1 *ASTM Standards:*²

E6 Terminology Relating to Methods of Mechanical Testing

E8 Test Methods for Tension Testing of Metallic Materials

E83 Practice for Verification and Classification of Extensometer Systems

E92 Test Method for Vickers Hardness of Metallic Materials (Withdrawn 2010)³

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 Specific to This Standard:*

3.1.1 *delta r* (Δr)—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 r value (see 10.4).

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.

³ The last approved version of this historical standard is referenced on www.astm.org.

3.1.1.1 *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} may be greater. Other earing tendencies occur; thus, for some materials the earing tendency may be better represented by $r_{\max} - r_{\min}$.

3.1.2 *plastic-strain ratio* r (in sheet metal that has been strained by uniaxial tension sufficiently to induce plastic flow) is the ratio of the true strain that has occurred in a width direction w perpendicular to the direction of applied stress and in the plane of the sheet, to the concomitant true strain in the thickness direction t . Thus, r is numerically equal to

$$r = \epsilon_w / \epsilon_t \quad (1)$$

where:

ϵ_w = width strain, and

ϵ_t = thickness strain.

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

3.1.3 r_m —weighted average of r values obtained in three directions: 0° (parallel), 45° (diagonal), and 90° (transverse) to the rolling direction (see 10.3).

3.1.3.1 *Discussion*—Some materials may show significantly different values of r for other test directions, in which case an average value may include these when special note is made and another subscript is used to avoid confusion with r_m as defined in 3.1.3. Symbols which are often used interchangeably with r_m are $\bar{r}$ and $r\text{-Bar}$.

3.1.4 *yield point elongation* (for a material that has a yield point) is the total strain associated with discontinuous yielding.

3.2 The definitions relating to tension testing appearing in Terminology E6 shall apply to this test method.

4. Significance and Use

4.1 The plastic strain ratio r is a parameter that indicates the ability of a sheet metal to resist thinning or thickening when subjected to either tensile or compressive forces in the plane of the sheet. It is a measure of plastic anisotropy and is related to the preferred crystallographic orientations within a polycrystalline metal. This resistance to thinning or thickening contributes to the forming of shapes, such as cylindrical flat-bottom cups, by the deep-drawing process. The r value, therefore, is considered a measure of sheet metal drawability. It