



Designation: E2218 – 23

Standard Test Method for Determining Forming Limit Curves¹

This standard is issued under the fixed designation E2218; 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.

1. Scope

1.1 This test method gives the procedure for constructing a forming limit curve (FLC) for a metallic sheet material by using a hemispherical deformation punch test and a uniaxial tension test to quantitatively simulate biaxial stretching and deep drawing processes.

1.1.1 Fig. 1 shows an example of a forming limit curve on a schematic forming limit diagram (FLD).

1.2 FLCs are useful in evaluating press performance by metal fabrication strain analysis.

1.3 The method applies to metallic sheet from 0.5 mm (0.020 in.) to 3.3 mm (0.130 in.).

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.5 *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.*

1.6 *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

A568/A568M Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for

E6 Terminology Relating to Methods of Mechanical Testing

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.

E8/E8M Test Methods for Tension Testing of Metallic Materials

E517 Test Method for Plastic Strain Ratio r for Sheet Metal

E646 Test Method for Tensile Strain-Hardening Exponents (n -Values) of Metallic Sheet Materials

E2208 Guide for Evaluating Non-Contacting Optical Strain Measurement Systems

3. Terminology

3.1 The terms accuracy, gauge length, necking, precision, strain hardening, engineering strain, and true strain are used as defined in Terminology E6.

3.2 *Definitions of Terms Common to Mechanical Testing:*

3.2.1 *forming limit curve, FLC, n* —an empirically derived curve showing the biaxial strain levels beyond which localized through-thickness thinning (necking) and subsequent failure occur during the forming of a metallic sheet.

3.2.1.1 *Discussion*—The forming limit curve is sometimes referred to as the “forming limit.”

3.2.2 *forming limit diagram, FLD, n* —a graph on which the measured major (e_1) and associated minor (e_2) strain combinations are plotted to develop a forming limit curve.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *biaxial stretching, n* —a mode of metal sheet forming in which positive strains are observed in all in-plane directions at a given location.

3.3.1.1 *Discussion*—See Fig. 2.

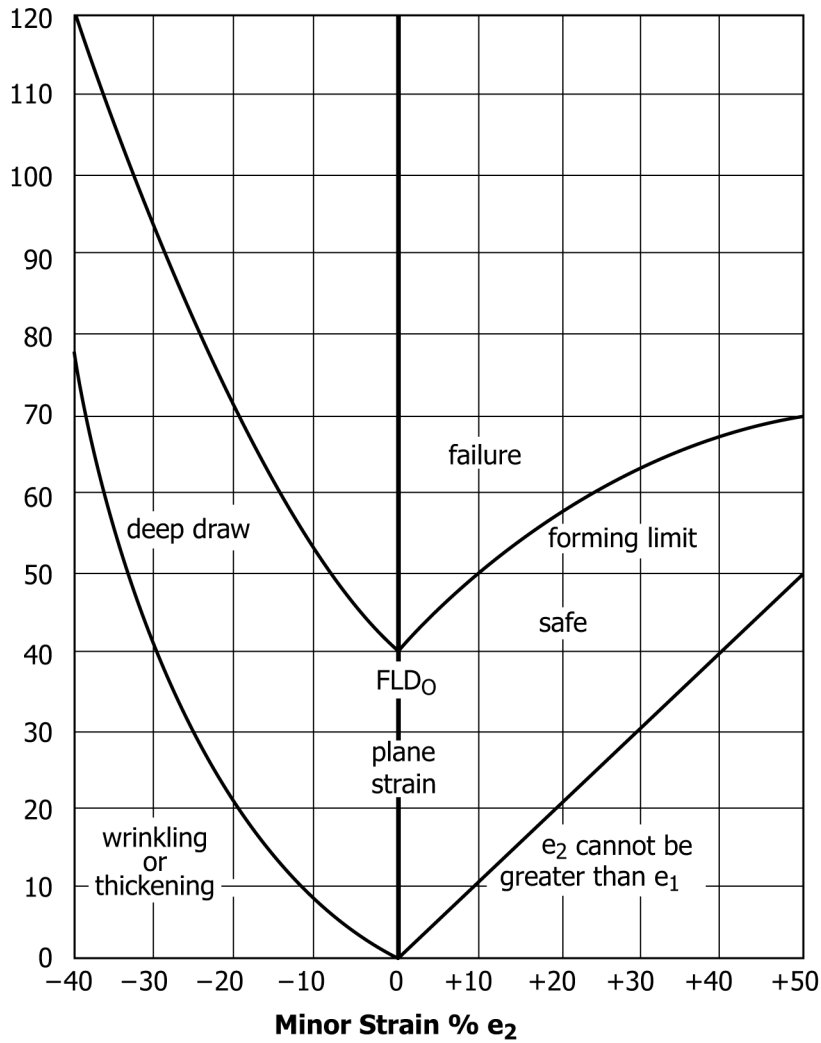
3.3.2 *deep drawing, n* —a sheet metal forming operation in which strains on the test specimen surface are positive in the direction of the punch travel (e_1) and negative at 90° to that direction.

3.3.2.1 *Discussion*—Deep drawing, see Fig. 2, occurs in the walls of a drawn cylinder or the corner walls of a deep drawn part when the flange clamping force is sufficient to restrain metal movement and wrinkling, while permitting the punch to push the center area of the test specimen into the cavity of the die. Strain conditions that can cause wrinkling or thickening are shown in Fig. 1.

3.3.2.2 *Discussion*—In forming a square pan shape, metal from an area of the flange under a reduced clamping force is pulled into the die to form the side wall of the part.

3.3.3 *FLD_o, n* —the location on the forming limit curve that has the lowest major strain (e_1).

**Major Strain
% e_1**



NOTE 1—The upper curve represents the forming limit curve. Strains below the lower curve do not occur during forming metallic sheet products in the most stamping press operations. Curves to the left of % $e_2 = 0$ are for constant area of the test specimen surface.

FIG. 1 Schematic Forming Limit Diagram

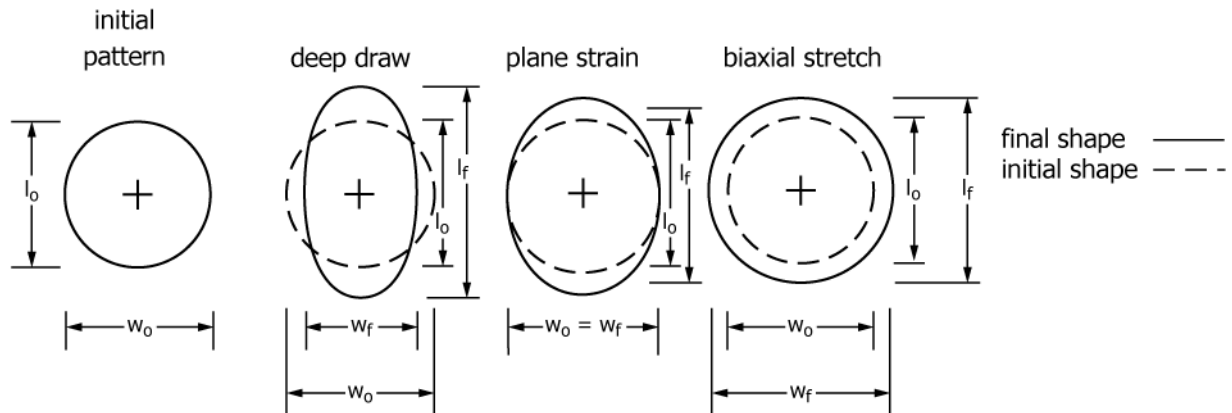


FIG. 2 Possible Changes in the Shape of the Circular Grid Pattern Gauge Length Measurement Units Caused by Forming Operations on Metallic Sheet Products