



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 reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This 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 stretch and deep drawing processes.

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 inch-pound equivalents are approximate.

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

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
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

¹ This 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.

Current edition approved Oct. 1, 2015. Published December 2015. Originally published in 2002. Last previous edition approved in 2014 as E2218–14^{ε1}. DOI: 10.1520/E2218-15

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. Terminology

3.1 Terminology E6 shall apply including the special terms used in this method shown in 3.2.

3.2 Definitions:

3.2.1 *biaxial stretching*—a mode of metal sheet forming in which positive strains are observed in all directions at a given location.

3.2.1.1 *Discussion*—See Fig. 1.

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

3.2.2.1 *Discussion*—Deep drawing, see Fig. 1, 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 blank into the cavity of the die. Strain conditions that can cause wrinkling or thickening are shown in Fig. 2.

3.2.2.2 *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.

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

3.2.3.1 *Discussion*—See Fig. 2.

3.2.4 *forming limit curve (FLC)*—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.

3.2.4.1 *Discussion*— See Fig. 3.

3.2.4.2 *Discussion*—The curve of Fig. 3 is considered the forming limit for the material when the metal is subjected to a stamping press operation. It was obtained for a drawing quality aluminum killed steel sheet. The curve of Fig. 3 correlates with the upper curve of Fig. 2, a generic curve representing a metallic sheet material with a FLD₀ of 40 %.

3.2.4.3 *Discussion*—The strains are given in terms of percent major and minor strain measured after forming a series of test specimen blanks by using a grid pattern. The gauge lengths before and after forming the part are measured to obtain the