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Metallic materials — Determination of forming-limit curves for sheet and strip —

Part 1: Measurement and application of forming-limit diagrams in the press shop

Matériaux métalliques — Détermination des courbes limites de formage pour les tôles et bandes —

Partie 1: Mesurage et application des diagrammes limites de formage dans les ateliers d'emboutissage

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 2, *Ductility testing*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 459/SC 1, *Test methods for steel (other than chemical analysis),* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 12004-1:2008), which has been technically revised.

The main changes compared to the previous edition are as follows:

1) The title was changed to have three elements.
2) Clauses 2 and 3 were added from the previous edition, and the subsequent sections were renumbered.
3) The description of when to use this document (ISO 12004-1) or ISO 12004-2 was revised in the Introduction.
4) Throughout the document the use of engineering strain was clarified.
5) Subclause 6.2 was extended to include what was the subsequent Clause in the previous version.
6) The former note was moved to part of Clause 7, since it gives permission to use another method.
7) The text in Annex A and the figure captions in Annex B were clarified.

A list of all parts in the ISO 12004 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

A forming-limit diagram (FLD) is a diagram containing measured major/minor strain points on a formed part.

An FLD can distinguish between safe and necked, or failed, points. The transition from safe to failed points is defined by the forming-limit curve (FLC).

To determine the forming limit of materials, two different methods are possible.

1) Strain analysis of failed press shop components to determine component and process dependent FLCs

   In the press shop, strain paths to reach these points are generally not known. Such an FLC depends on the material, the component, and the chosen forming conditions. This method is described in this document and is not intended to determine one unique FLC for each material.

2) Determination of FLCs under well-defined laboratory conditions

   For evaluating formability, one unique FLC for each material in several strain states can be measured. The determination of FLC must be specific and uses multiple linear strain paths. The ISO 12004-2 is intended for this type of material characterization.

Metallic materials — Determination of forming-limit curves for sheet and strip —

Part 1: Measurement and application of forming-limit diagrams in the press shop

1 Scope

This document specifies a procedure for developing forming-limit diagrams and forming-limit curves for metal sheets and strips of thicknesses from 0,3 mm to 4 mm.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Symbols and abbreviated terms

The symbols and abbreviated terms used in forming-limit diagrams are specified in Table 1, and examples of grid patterns used are given in Annex B.

Table 1 — Symbols and abbreviated terms

Symbol	Definition	Unit
l_0	Original gauge length of grid pattern	mm
l_1	Final length in major strain direction	mm
l_2	Final length at 90° to major strain direction	mm
e	Engineering strain	%
e_1	Major engineering strain	%
e_2	Minor engineering strain (90° to major)	%
FLD	Forming-limit diagram	—
FLC	Forming-limit curve	—

5 Principle

A pattern of precise gauge lengths of appropriate size is applied to the flat surface of a metal sheet test piece, then the test piece is formed until fracture, and the percent change in the gauge length in the major direction and in the minor strain direction at 90° to this is measured in order to determine the