INTERNATIONAL STANDARD

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Metallic materials — Sheet and strip — Determination of forming-limit curves —

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

Matériaux métalliques — Tôles et bandes — Détermination des courbes limites de formage —

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.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 12004-4 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 2, *Ductility testing*.

This first edition of ISO 12004-1, together with ISO 12004-2, cancels and replaces ISO 12004:1997 which has been technically revised.

ISO 12004 consists of the following parts, under the general title *Metallic materials — Sheet and strip — Determination of forming-limit curves*:

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

— *Part 2: Determination of forming-limit curves in the laboratory*

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 part of ISO 12004.

2) Determination of FLCs under well-defined laboratory conditions:

   For evaluating formability, one unique FLC for the defined material is necessary. The determination of FLC has to be specific and it is necessary to use different linear strain paths. This method should be used for material characterization as described in ISO 12004-2.

Metallic materials — Sheet and strip — Determination of forming-limit curves —

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

1 Scope

This part of ISO 12004 provides guidelines for developing forming-limit diagrams and forming-limit curves for metal sheets and strips of thicknesses from 0,3 mm to 4 mm.

2 Symbols and abbreviated terms

The symbols 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 definitions

Symbol	Definition	Unit
t_o	Thickness of test piece	mm
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	—

3 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 forming-limit under the imposed strain conditions. A number of repeated tests under varying strain conditions are carried out to provide data for the forming-limit curve (FLC) for the material when these limiting strains are plotted on the forming-limit diagram (FLD) (see Figure 1).