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## Copper and copper alloys – Determination of spring bending limit on strip

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## Koppar och kopparlegeringar – Bestämning av fjäderböjgräns på band

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ICS 77.150.30

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**EN 12384**

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Descriptors: copper, copper alloys, flexural tests, determination, modulus of elasticity, elastic limit

English version

**Copper and copper alloys – Determination of spring  
bending limit on strip**

Cuivre et alliages de cuivre – Détermination  
de la limite élastique en flexion de bande

Kupfer und Kupferlegierungen – Bestimmung  
der Federbiegegrenze von Bändern

This European Standard was approved by CEN on 13 December 1998.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

**CEN**

European Committee for Standardization  
Comité Européen de Normalisation  
Europäisches Komitee für Normung

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## Foreword

This European Standard has been prepared by Technical Committee CEN/TC 133 "Copper and copper alloys", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 1999, and conflicting national standards shall be withdrawn at the latest by July 1999.

Within its programme of work, Technical Committee CEN/TC 133 requested CEN/TC 133/WG 2 "Rolled flat products" to prepare the following standard:

EN 12384 Copper and copper alloys - Determination of spring bending limit on strip

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

## 1 Scope

This European Standard specifies test methods to determine the modulus of elasticity  $E$  and the spring bending limit  $\sigma_{FB}$ , of strip in thicknesses from 0,05 mm up to and including 1,0 mm.

This standard applies to strip specified in EN 1654.

## 2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

EN 1654

Copper and copper alloys – Strip for springs and connectors

NOTE: Informative references to documents used in the preparation of this standard and cited at the appropriate places in the text, are listed in a bibliography, see annex B.

## 3 Definitions

For the purposes of this standard, the following definitions apply:

### 3.1 modulus of elasticity $E$

Relationship between stress and strain in the elastic range. In accordance with this European Standard it is calculated on the basis of the linear beam flexure theory, from the equation:

$$E = \frac{F}{4 \times w \times s} \times \left(\frac{l}{t}\right)^3 \quad (1)$$

where:

$E$  is the modulus of elasticity (Young's modulus), in Newtons per square millimetre;

$F$  is the force, in Newtons;

$l$  is the distance between the supports, in millimetres;

$s$  is the deflection, in millimetres;

$t$  is the thickness of the strip, in millimetres;

$w$  is the width of the test piece, in millimetres.

### 3.2 spring bending limit $\sigma_{FB}$

Stress value up to which the material may be subjected to flexural stress without a given small plastic deformation being exceeded. It is defined as the outer fibre stress in a test piece of thickness  $t$  which, when resting on supports with a distance between them of:

$$l = 100 \sqrt{k \times t} \quad (2)$$

where:

$k$  is a constant, 0,8 mm;

$l$  is the distance between the supports, in millimetres;

$t$  is the thickness of the strip, in millimetres;

and relieved of load, shows a permanent deflection  $s_{bl}$  of 50  $\mu\text{m}$ . It is calculated on the basis of equation (3).

$$\sigma_{FB} = \frac{6 \times E \times t \times s^*}{l^2 \sqrt{1 + 17 (s^*/l)^{2,4}}} \quad (3)$$

where:

$\sigma_{FB}$  is the spring bending limit, in Newtons per square millimetre;

$E$  is the modulus of elasticity as defined in 3.1;

$s^*$  is the forced deflection which, given the distance between supports specified in this standard on the basis of equation (2), results in a permanent deflection of 50  $\mu\text{m}$ .

NOTE: Equation (3) is an approximation. In accordance with W. Kutschera [1], at the extreme low end of the thickness range within the scope of this standard, the deviation from the real value of spring bending limit would be 1,2 % max.

## 4 General principle

The test takes the form of a bend test with the test piece supported on two supports near the ends of the test piece, and a load applied midway between the supports.

Elastic deflection is measured to determine the modulus of elasticity and permanent deflection is measured to determine the spring bending limit.

## 5 Details of the test

For technical and metrological reasons the given range of thicknesses is divided for test purposes into range A (see table 1) for strip with thicknesses from 0,15 mm up to and including 1,0 mm, and range B (see table 1) for strip with thicknesses from 0,05 mm up to and including 0,20 mm.

Where the two ranges overlap, i.e. for thicknesses from 0,15 mm up to and including 0,20 mm the results of testing are the same.

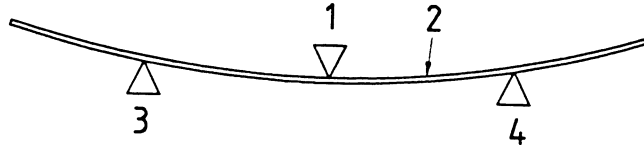
Unless explicitly referring to them separately, the requirements of clauses 6 to 9 apply to both ranges.

## 6 Apparatus

### 6.1 General

The test set-up (see figure 1) shall consist of two supports, which are able to slide, and a deflectometer, which comprises a weight for applying load and a deflection device. The deflectometer shall act on the test piece at its centre between the supports.

NOTE: Equation (3) is applicable to deflections up to  $s^* = 0,46 \times l$ .



- 1 loading nose
- 2 test piece
- 3 support with straight, horizontal edge
- 4 support with curved edge

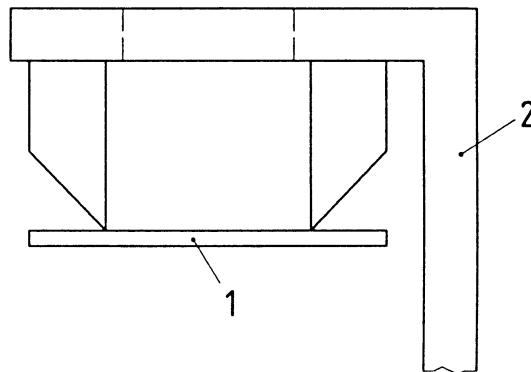
**Figure 1: Test set-up (schematic)**

## 6.2 Supports

The supports shall be two steel blocks, 10,2 mm wide and of right-angled triangular section. Sharp supporting edges shall be formed by a 60° angle of the triangular section, with edge radius less than 0,03 mm. One of the supporting edges shall be straight and the other one convex with a radius of curvature of 15 mm perpendicular to the right angle triangular section. The distance between the supports shall be continuously adjustable, symmetrically to the axis of loading, to within 0,1 mm in a range from 15 mm up to and including 100 mm.

## 6.3 Loading nose

The loading nose used for applying the load and producing the deflection shall be in contact with the test piece at two points (see figure 2). The two points at which the load is applied shall lie to the left and right of the longitudinal axis of the test piece. The centre of the test piece shall be left free to permit measurement of the deflection.



- 1 test piece
- 2 loading nose

**Figure 2: Loading nose (schematic)**

## 6.4 Loading weight

The loading weight required for determining the modulus of elasticity shall have a mass of 100,0 g  $\pm$  1,0 g for range A (see table 1) test pieces and 10,0 g  $\pm$  0,10 g for range B (see table 1) test pieces.

## 6.5 Permanent deflection

The permanent deflection required for calculating the spring bending limit shall be produced by progressive forced deflection and relief. Increments of 0,667 mm have been found to be expedient.