

**Metallkatted. Ülevaade plastsuse  
mõõtemetoditest**

Metallic coatings - Review of methods of  
measurement of ductility

## EESTI STANDARDI EESSÕNA

## NATIONAL FOREWORD

<p>Käesolev Eesti standard EVS-EN ISO 8401:1999 sisaldab Euroopa standardi EN ISO 8401:1994 ingliskeelset teksti.</p> <p>Käesolev dokument on jõustatud 12.12.1999 ja selle kohta on avaldatud teade Eesti standardiorganisatsiooni ametlikus väljaandes.</p> <p>Standard on kättesaadav Eesti standardiorganisatsioonist.</p>	<p>This Estonian standard EVS-EN ISO 8401:1999 consists of the English text of the European standard EN ISO 8401:1994.</p> <p>This document is endorsed on 12.12.1999 with the notification being published in the official publication of the Estonian national standardisation organisation.</p> <p>The standard is available from Estonian standardisation organisation.</p>
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

<p><b>Käsitlusala:</b> Standard määrab kindlaks peamised meetodid alla 200 µm paksuste galvaaniliselt, autokataküütilise sadestamisega vms protsessiga valmistatud metallkattede plastsuse määramiseks.</p>	<p><b>Scope:</b></p>
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------

**ICS** 25.220.40

**Võtmesõnad:** katsed, katted, mehaanilised katsed, metallkatted, plastsus, plastsuskatsed

ICS 17.040.20

Descriptors: Metal coatings, ductility, testing.

**English version**

**Metallic coatings**

**Review of methods of measurement of ductility  
(ISO 8401:1986)**

Revêtements métalliques; vue d'ensemble sur les méthodes de mesure de la ductilité (ISO 8401:1986)

Metallische Schutzschichten; Überblick über Verfahren zur Messung der Duktilität (ISO 8401:1986)

This European Standard was approved by CEN on 1994-10-26 and is identical to the ISO Standard as referred to.

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, 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

**Central Secretariat: rue de Stassart 36, B-1050 Brussels**

## Foreword

International Standard

ISO 8401:1986 Metallic coatings; review of methods of measurement of ductility

which was prepared by ISO/TC 107 'Metallic and other inorganic coatings' of the International Organization for Standardization, has been adopted by Technical Committee CEN/TC 262 'Protection of metallic materials against corrosion' as a European Standard.

CEN/TC 262 had decided to submit ISO 8401:1986 for Formal Vote. The result was positive.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, and conflicting national standards withdrawn, by April 1995 at the latest.

In accordance with the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard:

Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

## Endorsement notice

The text of the International Standard ISO 8401:1986 was approved by CEN as a European Standard without any modification.

## Contents

	Page
<b>1</b> Scope and field of application .....	<b>3</b>
<b>2</b> Definitions .....	<b>3</b>
<b>3</b> Tests on unsupported foils .....	<b>3</b>
<b>3.1</b> Tensile testing .....	<b>4</b>
<b>3.2</b> Bending (micrometer bend test) .....	<b>4</b>
<b>3.3</b> Folding (vice-bend test) .....	<b>5</b>
<b>3.4</b> Hydraulic bulging .....	<b>5</b>
<b>3.5</b> Mechanical bulging .....	<b>6</b>
<b>4</b> Tests on coatings on substrates .....	<b>6</b>
<b>4.1</b> Tensile testing .....	<b>7</b>
<b>4.2</b> Three-point bend testing .....	<b>7</b>
<b>4.3</b> Four-point bend testing .....	<b>7</b>
<b>4.4</b> Cylindrical mandrel bending .....	<b>8</b>
<b>4.5</b> Spiral mandrel bending .....	<b>8</b>
<b>4.6</b> Conical mandrel bending .....	<b>8</b>
<b>4.7</b> Mechanical bulging .....	<b>8</b>
<b>5</b> Selection of test method .....	<b>9</b>
<b>6</b> Test report .....	<b>9</b>
<b>Annexes</b>	
<b>A</b> Methods of producing foils .....	<b>10</b>
<b>B</b> Calculation of ductility when increasing the surface area of a foil (bulging) .....	<b>11</b>
<b>C</b> Calculation of ductility and tensile strength in the hydraulic bulge test .....	<b>12</b>
<b>D</b> Calculation of ductility in the mechanical bulge test .....	<b>13</b>
<b>Bibliography</b> .....	<b>33</b>

## 1 Scope and field of application

**1.1** This International Standard specifies general methods of measuring the ductility of metallic coatings of thickness below 200 µm prepared by electroplating, autocatalytic deposition or other processes (see the note).

The methods of measuring the ductility of metallic coatings can be divided into two main categories:

- tests on unsupported foils (separated from the substrate);
- tests of coatings on substrates.

**NOTE** — When specific methods of testing are included in International Standards for individual coatings, they should be used in preference to the methods described in this International Standard and should be agreed upon beforehand by the supplier and the purchaser.

**1.2** In the testing of unsupported foils separated from the substrate (see figure 1), the foils may consist of one or more metallic layers. Therefore it is possible to measure the ductility of composites and to determine the influence of individual layers on overall ductility. Methods of testing of unsupported foils are described in clause 3. Methods of producing foils for testing are discussed in annex A.

**1.3** In the testing of coatings on substrates (see figure 2), it is especially important to determine the exact point of crack initiation of the top layer. Attention is drawn to different methods of discerning this point, by normal or corrected-to-normal vision or with a lens. See the guidance in the individual methods. These methods can also be used to detect embrittlement of the substrate that may have resulted from the coating process. Methods of testing of coatings on substrates are described in clause 4.

**1.4** Although ductility is a property of the material and independent of the dimensions of the test piece, thickness of the coating may have an influence on the value of linear elongation ( $\Delta l/l_0$ ).

**1.4.1** Very thin layers have different properties as the build-up of the initial layers will be influenced by the properties of the substrate (epitaxy). High internal stresses may be incorporated into the initial layers and these may affect ductility.

**1.4.2** It is essential that the test piece has uniform thickness, as thinner spots will give rise to premature cracking. Also, the

current density is lower at thinner parts and higher at thicker parts of electroplated test pieces; in this way current density differences may result in different ductilities. The current density applied should be maintained as uniform as possible over the test piece, and its value reported.

## 2 Definitions

For the purpose of this International Standard, the following definitions apply.

**2.1 ductility:** The ability of a metallic or other coating to undergo plastic or elastic deformation, or both, without fracture or cracking.

**2.2 linear elongation:** The ratio of the elongation,  $\Delta l$ , to a definite initial length,  $l_0$ , of the test piece. This is taken as a measure of ductility.

Often this ratio is expressed as a percentage.

### NOTE ON MEASURES OF DUCTILITY

Normally the test pieces are elongated. With some bending tests, the outer layer of the test piece, i.e. the plating, is elongated (see figure 3). In bulge tests, however, the surface of the foil is enlarged, requiring calculation of linear elongation from the reduction in the thickness. Using the component of deformation (stretching) in only one axis would give false information about the ductility of the material (see figure 4). In those cases the thinning of the foil, as calculated from the increase in the surface area, is a better measure of the ductility of the material (see annex B).

## 3 Tests on unsupported foils

These techniques involve measurement of a foil which has been separated from the substrate (see figure 1). In this case, the foil to be tested can also consist of several layers so as to allow measurement of the influence of undercoats on the ductility of the foil sandwich. Examples are gold flash on gold/copper alloys and chromium-plated nickel deposits. Methods of producing unsupported foils are given in annex A.

Five methods are described.