

# INTERNATIONAL STANDARD

**ISO**  
**5001**

Second edition  
1993-12-01

---

---

## **Cold-reduced carbon steel sheet for vitreous enamelling**

*Tôles en acier au carbone laminées à froid pour émaillage par vitrification*



Reference number  
ISO 5001:1993(E)

## 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.

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.

International Standard ISO 5001 was prepared by Technical Committee ISO/TC 17, *Steel*, Sub-Committee SC 12, *Continuous mill flat rolled products*.

This second edition cancels and replaces the first edition (ISO 5001:1980), of which it constitutes a technical revision.

© ISO 1993

All rights reserved. No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Organization for Standardization  
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

# Cold-reduced carbon steel sheet for vitreous enamelling

## 1 Scope

**1.1** This International Standard applies to cold-reduced carbon steel sheet of commercial and drawing qualities for vitreous enamelling<sup>1)</sup>, where the surface of the sheet and chemical composition of the base metal are of prime importance.

NOTE 1 For hot-rolled carbon steel sheet and cold-reduced carbon steel sheet of commercial and drawing qualities, see ISO 3573:1986, *Hot-rolled carbon steel sheet of commercial and drawing qualities* and ISO 3574:1986, *Cold-reduced carbon steel sheet of commercial and drawing qualities* respectively.

**1.2** Sheet for vitreous enamelling is produced in thicknesses of 0,36 mm and over (usually produced up to 4 mm) and in widths of 600 mm and over, in coils and cut lengths. Sheet for vitreous enamelling less than 600 mm wide may be slit from wide sheet and will be considered as sheet.

**1.3** Commercial quality sheet (VE01) is intended for general fabricating purposes where sheet is used in the flat, or for bending or moderate forming.

**1.4** Drawing quality sheet (VE02, VE03 and VE04) is intended for drawing or severe forming. It is furnished according to the requirements of this International Standard or, with agreement when ordered, to fabricate an identified part, in which case the mechanical properties in table 1 do not apply. If strain ageing is to be minimized, grade VE04 should be specified.

Drawing qualities are identified as follows:

|      |                                                                             |
|------|-----------------------------------------------------------------------------|
| VE02 | Drawing quality                                                             |
| VE03 | Deep drawing quality                                                        |
| VE04 | Deep drawing quality special killed (extra deep drawing quality non-ageing) |

1) Sometimes referred to as porcelain enamelling.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6892:1984, *Metallic materials — Tensile testing*.

ISO 7438:1985, *Metallic materials — Bend test*.

## 3 Definition

For the purposes of this International Standard, the following definition applies.

**3.1 steel sheet for vitreous enamelling:** A product obtained from cold-reduced steel sheet having a matt finish. Proper chemical composition and processing are selected by the producer to prepare the sheet for both fabrication and vitreous enamelling.

## 4 Grades and qualities for vitreous enamelling (see table 1)

### 4.1 Grade 1

A sheet with extremely low carbon content suitable mainly for direct cover coat enamelling, and also for special applications for two-coat enamelling (sag resistance). The base metal of this grade loses strength after the enamel is fired, and if this is a problem the producer should be consulted.

## 4.2 Grade 2

A sheet suitable for two-coat enamelling.

**Table 1 — Grades and qualities for cold-reduced carbon steel sheet**

| Quality      | Grade |   |
|--------------|-------|---|
|              | 1     | 2 |
| VE01         | x     | x |
| VE02         | —     | x |
| VE03         | x     | x |
| VE04         | x     | x |
| (non-ageing) |       |   |

## 5 Designations

The designations in 1.3 and 1.4 include the qualities of sheet steel for vitreous enamelling. The designation VE represents "vitreous enamelling" similar to CR "cold reduced". The numbers 01, 02, 03 and 04 are common to other standards indicating the qualities of commercial, drawing, deep drawing and deep drawing special killed (extra deep drawing non-ageing).

## 6 General information

### 6.1 Skin-pass

A final light cold rolling of cold-reduced fully processed sheet. The purposes of skin-passing are one or more of the following:

- to minimize temporarily the occurrence of conditions known as stretcher strain (Lüder's lines) or fluting during fabrication of finished parts;
- to obtain the required surface finish for vitreous enamelling;
- to control shape.

### 6.2 Strain ageing

Steel sheet for vitreous enamelling in qualities VE01, VE02 and VE03 supplied in the skin-passed condition tends to strain age, and this may lead to the following:

- surface markings from stretcher strain (Lüder's lines) or fluting when the steel is formed;
- a deterioration in ductility.

Because of these factors, it is essential that the period between final processing at the mill and fabrication is kept to a minimum. Rotation of stock, by using the oldest material first, is important. Stocking of such steels for extended periods of time should be avoided and should not exceed six weeks for optimum performance.

For skin-passed sheet in qualities VE01, VE02 and VE03 and with due regard to the foregoing precautions, reasonable freedom can be achieved by effective roller levelling immediately prior to fabrication at the purchaser's plant. Freedom from stretcher strain and fluting for a period of six months can be achieved by the supply of skin-passed non-ageing steels. Grade VE04 shall be specified in cases where Lüder's lines are not acceptable and where roller levelling is not possible.

### 6.3 Surface condition

The surface of steel sheet for vitreous enamelling shall be reasonably free of imperfections that affect the appearance of the enamelled product.

### 6.4 Surface finish

Steel sheet for vitreous enamelling is produced in a matt finish with the degree of roughness depending on the end application.

### 6.5 Oiling

Steel sheet for vitreous enamelling may be oiled or not oiled, as required.

## 7 Conditions of manufacture

### 7.1 Steelmaking

The processes used in making the steel and in manufacturing sheet for vitreous enamelling are left to the discretion of the producer. When requested, the purchaser shall be informed of the steelmaking process being used.

### 7.2 Chemical composition

The cast analysis for grades 1 and 2 is subject to agreement between the manufacturer and purchaser, and a report of cast analysis to the purchaser or verification by the purchaser shall be in accordance with 7.3.1 and 7.3.2. Because of the extremely low carbon of grade 1, as a result of special processing, the carbon content of this grade is not subject to cast analysis. However, the purchaser may check the carbon content to ensure that there is no risk of confusion between grades 1 and 2.

### 7.3 Chemical analysis

#### 7.3.1 Cast analysis

A cast analysis of each cast of steel shall be made by the manufacturer. When requested, only manganese, phosphorus and sulfur for grade 1 shall be reported to the purchaser or his representative. For grade 2, carbon, manganese, phosphorus and sulfur shall be reported to the purchaser or his representative when requested.

#### 7.3.2 Verification analysis

A verification analysis may be made by the purchaser to verify the specified analysis of the semi-finished or finished steel and shall take into consideration any normal heterogeneity. A carbon determination for grade 1 may be made by the purchaser to verify the extremely low carbon content. Non-killed steels (such as rimmed or capped) are not technologically suitable for verification analysis.

### 7.4 Weldability

The product is easily welded. It is recommended that certain precautions may be necessary due to the very low hardness of grade 1 material.

### 7.5 Application

Steel sheet for vitreous enamelling shall be identified for fabrication by the name of the part or by the intended application. Steel sheet of drawing qualities (VE02, VE03 and VE04) may be produced to make an identified part, which shall be previously agreed upon between manufacturer and purchaser. In this case, the part name, the details of fabrication, vitreous enamelling practice, and any special requirements (freedom from stretcher strain or fluting) shall be specified and the mechanical properties of table 2 do not apply.

### 7.6 Mechanical properties

Except when ordered to an identified part as explained in 7.5, at the time that the steel is made available for shipment, the mechanical properties shall be as stated in table 2 when they are determined on test pieces obtained according to the requirements of 9.1 (mechanical tests). Prolonged storage of the sheet can cause a change in mechanical properties (increase in hardness and decrease in elongation, leading to a decrease in drawability). To minimize this effect, quality VE04 should be specified.

**Table 2 — Mechanical properties (see 7.6)**

| Base metal quality |                                 | $R_m$ , max. 1)<br>N/mm <sup>2</sup> | A min. 2)<br>% |               | Base metal 180° bend mandrel diameter |               |
|--------------------|---------------------------------|--------------------------------------|----------------|---------------|---------------------------------------|---------------|
| Designation        | Name                            |                                      | $L_0 = 50$ mm  | $L_0 = 80$ mm | $e < 3$ mm                            | $e \geq 3$ mm |
| VE01               | Commercial                      | —                                    | —              | —             | 0 (flat on itself)                    | 1a            |
| VE02               | Drawing                         | 370                                  | 31             | 30            | Does not apply                        |               |
| V03                | Deep drawing                    | 350                                  | 35             | 34            |                                       |               |
| V04                | Extra deep drawing (non-ageing) | 340                                  | 37             | 36            |                                       |               |

$R_m$  = tensile strength

A = percentage elongation after fracture

$L_0$  = gauge length on test piece

$S_0$  = original cross-sectional area of gauge length

$e$  = thickness of steel sheet, in millimetres

$a$  = thickness of bend test piece, in millimetres

1 N/mm<sup>2</sup> = 1 MPa

1) Minimum tensile strength for qualities VE02, VE03 and VE04 would normally be expected to be 270 N/mm<sup>2</sup>. All tensile strength values are determined to the nearest 10 N/mm<sup>2</sup>.

2) For material up to and including 0,6 mm in thickness, the elongation values in the table shall be reduced by 1. Minimum elongation values on a gauge length of  $L_0 = 5,65\sqrt{S_0}$  may be the subject of agreement between the interested parties.

## 8 Dimensional tolerances

Dimensional tolerances applicable to steel sheet for vitreous enamelling shall be as given in tables 3 to 12.

## 9 Sampling

### 9.1 Mechanical tests (before vitreous enamelling)

#### 9.1.1 Tensile test

When ordered according to mechanical properties, one representative sample for the tensile test required in table 2 shall be taken from each lot of sheet for shipment. A lot consists of 50 tonnes or less of sheet of the same quality rolled to the same thickness and condition.

#### 9.1.2 Bend test (when specified)

One representative sample for the bend test (quality VE01) shall be taken from each lot of sheet for shipment. A lot consists of all sheets of the same quality rolled to the same thickness and condition.

## 10 Test methods

### 10.1 Mechanical test (before vitreous enamelling)

#### 10.1.1 Tensile test

The tensile test shall be carried out in accordance with ISO 6892. Transverse test pieces shall be taken midway between the centre and edge of the sheet as rolled.

#### 10.1.2 Bend test (when specified)

The transverse bend test piece (applicable to VE01 only) shall withstand being bent through 180° in the direction shown in figure 1, around an inside diameter equal to the thickness of the test piece, without cracking on the outside of the bent portion. The bend test shall be performed at ambient temperature and is described in ISO 7438. Small cracks on the edges of test pieces, and cracks which require magnification to be visible, shall be disregarded.

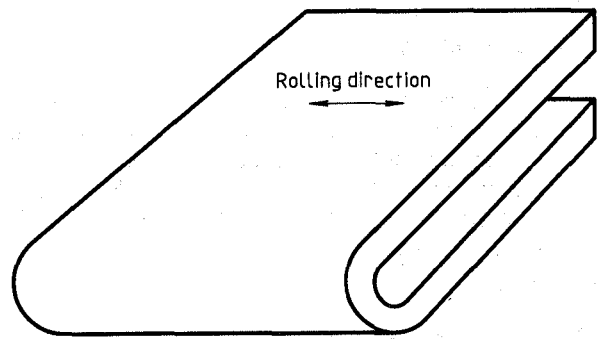


Figure 1 — Transverse bend test piece (after bending)

## 11 Retests

If a test does not give the specified results, two more test pieces shall be taken at random from the same lot. Both retests shall conform to the requirements of this International Standard, otherwise, the lot shall be rejected.

## 12 Resubmission

**12.1** The manufacturer may resubmit for acceptance the products that have been rejected during earlier inspection because of unsatisfactory properties, after he has subjected them to a suitable treatment (selection, heat treatment) which, on request, will be indicated to the purchaser. In this case, the tests should be carried out as if they applied to a new batch.

**12.2** The manufacturer has the right to present the rejected products to a new examination for compliance with the requirements for another grade.

## 13 Workmanship

The steel sheet for vitreous enamelling in cut lengths shall be free from laminations, surface flaws and other imperfections that are detrimental to subsequent appropriate processing. Processing for shipment in coils does not afford the manufacturer the opportunity to observe readily or to remove defective portions, as can be carried out on the cut-length product.

## 14 Inspection and acceptance

**14.1** While not usually required for products covered by this International Standard, when the purchaser specifies that inspection and tests for acceptance be observed prior to shipment from the manufacturer's works, the manufacturer shall afford the purchaser's inspector all reasonable facilities to

determine that the steel is being furnished in accordance with this International Standard.

**14.2** Steel that is reported to be defective after arrival at the user's works shall be set aside, properly and correctly identified and adequately protected. The supplier shall be notified in order that he may properly investigate.

## 15 Coil size

When steel sheet for vitreous enamelling is ordered in coils, a minimum inside diameter (I.D.) or range of acceptable inside diameters shall be specified. In addition, the maximum outside diameter (O.D.) and maximum acceptable coil mass shall be specified.

## 16 Marking

Unless otherwise stated, the following minimum requirements for identifying the steel shall be legibly stencilled on the top of each lift or shown on a tag attached to each coil or shipping unit:

- a) the manufacturer's name or identifying brand;
- b) the number of this International Standard;
- c) the quality designation number;
- d) the grade;
- e) the order number;
- f) the product dimensions;
- g) the lot number;
- h) the mass.

## 17 Information to be supplied by the purchaser

To specify adequately requirements under this International Standard, inquiries and orders shall include the following information:

- a) the number of this International Standard;
- b) the name and designation of the material;

## EXAMPLE

steel sheet for vitreous enamelling, grade 1 for direct cover coat, commercial quality, VE01 (see 1.3 and 4.1);

- c) the dimensions of the product and the quantity required;
- d) the application (name of part) (see 7.5);
- e) the drawing qualities (VE02, VE03 and VE04), ordered to fabricate an identified part (see 1.4 and 7.5);
- f) whether oiled or not (see 6.5);
- g) the coil size requirements (see clause 15);
- h) the report of the cast analysis, if required (see 7.3.1);
- i) details of fabrication including vitreous enamelling process, or special requirements (stretcher strain or fluting);
- j) inspection and tests for acceptance prior to shipment from the producer's works, if required (see 14.1).

NOTE 2 A typical ordering description is as follows:

International Standard ISO 5001, steel sheet for vitreous enamelling, grade 2 for direct cover coat, drawing quality VE02, 1,0 × 1 200 mm × coil, 25 000 kg, for stove tops.

## 18 Additional information

When cold-reduced sheet is specified to stretcher-levelled standards of flatness and not resquared, the allowance over specified dimensions in width and length given in table 12 apply. Under these conditions, the allowances for width and length are added by the manufacturer to the specified width and length and the tolerances given in tables 5 and 6 apply on the basis of the new size established. The camber tolerances in table 7 do not apply.

When sheet is not to have grip or entry marks within the specified length, the purchaser shall specify "grip or entry marks outside specified length". When sheet may have grip or entry marks within the specified length, the purchaser shall specify "grip or entry mark inside specified length".

Table 3 — Standard thickness tolerances for coils and cut lengths

Values in millimetres

| Specified widths                     | Thickness tolerances <sup>1)</sup> , over and under, for specified thicknesses |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                |
|--------------------------------------|--------------------------------------------------------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|--------------------------------|
|                                      | up to and including 0,4                                                        | over 0,4 up to and including 0,6 | over 0,6 up to and including 0,8 | over 0,8 up to and including 1,0 | over 1,0 up to and including 1,2 | over 1,2 up to and including 1,6 | over 1,6 up to and including 2,0 | over 2,0 up to and including 2,5 | over 2,5 up to and including 3,0 | over 3,0 up to and including 4 |
| 600 up to and including 1 200        | 0,04                                                                           | 0,05                             | 0,07                             | 0,08                             | 0,09                             | 0,11                             | 0,13                             | 0,15                             | 0,18                             | 0,20                           |
| Over 1 200 up to and including 1 500 | 0,05                                                                           | 0,06                             | 0,08                             | 0,09                             | 0,10                             | 0,12                             | 0,14                             | 0,16                             | 0,18                             | 0,21                           |
| Over 1 500 up to and including 1 800 | —                                                                              | 0,08                             | 0,09                             | 0,10                             | 0,12                             | 0,14                             | 0,16                             | 0,18                             | 0,21                             | 0,23                           |

## NOTES

1 Unless otherwise stated on the order, the thickness tolerances for all qualities of steel shall be in accordance with this table. When required, special tolerances in accordance with table 4 shall be the subject of agreement.

2 The thickness tolerances for sheets in coil form are the same as for sheets supplied in cut lengths but, in cases where welds are present, the tolerances shall be double those given over a length of 15 m in the vicinity of the weld.

1) Thickness is measured at any point on the sheet not less than 25 mm from a side edge.

Table 4 — Special thickness tolerances for coils and cut lengths

Values in millimetres

| Specified widths                     | Thickness tolerances <sup>1)</sup> , over and under, for specified thicknesses |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                |
|--------------------------------------|--------------------------------------------------------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|--------------------------------|
|                                      | up to and including 0,4                                                        | over 0,4 up to and including 0,6 | over 0,6 up to and including 0,8 | over 0,8 up to and including 1,0 | over 1,0 up to and including 1,2 | over 1,2 up to and including 1,6 | over 1,6 up to and including 2,0 | over 2,0 up to and including 2,5 | over 2,5 up to and including 3,0 | over 3,0 up to and including 4 |
| 600 up to and including 1 200        | 0,040                                                                          | 0,045                            | 0,055                            | 0,065                            | 0,075                            | 0,090                            | 0,110                            | 0,125                            | 0,140                            | 0,165                          |
| Over 1 200 up to and including 1 500 | 0,045                                                                          | 0,055                            | 0,065                            | 0,075                            | 0,085                            | 0,110                            | 0,125                            | 0,140                            | 0,155                            | 0,180                          |
| Over 1 500 up to and including 1 800 | —                                                                              | —                                | 0,075                            | 0,085                            | 0,100                            | 0,120                            | 0,140                            | 0,155                            | 0,170                            | 0,190                          |
| Over 1 800                           | —                                                                              | —                                | 0,080                            | 0,095                            | 0,105                            | 0,135                            | 0,150                            | 0,165                            | 0,185                            | 0,200                          |

## NOTES

1 Unless otherwise stated on the order, the thickness tolerances for all qualities of steel shall be in accordance with table 3. When required, special tolerances in accordance with this table shall be the subject of agreement.

2 The thickness tolerances for sheets in coil form are the same as for sheets supplied in cut lengths but, in cases where welds are present, the tolerances shall be double those given over a length of 15 m in the vicinity of the weld.

1) Thickness is measured at any point on the sheet not less than 25 mm from a side edge.

**Table 5 — Width tolerances for coils and cut lengths, not resquared**

Values in millimetres

| Specified widths                     | Tolerance |
|--------------------------------------|-----------|
| Up to and including 1 200            | +5<br>0   |
| Over 1 200 up to and including 1 500 | +7<br>0   |
| Over 1 500                           | +9<br>0   |

**Table 6 — Length tolerances for cut lengths, not resquared**

| Specified lengths                    | Tolerance   |
|--------------------------------------|-------------|
| Up to and including 3 000            | +20<br>0 mm |
| Over 3 000 up to and including 6 000 | +30<br>0 mm |
| Over 6 000                           | +0,5<br>0 % |

**Table 7 — Camber tolerances for coils and cut lengths, not resquared (see figure 2)**

| Form        | Camber tolerance             |
|-------------|------------------------------|
| Coils       | 20 mm in any 5 000 mm length |
| Cut lengths | 0,4 % × length               |

**Table 8 — Out-of-square tolerance for cut lengths, not resquared (see figure 3)**

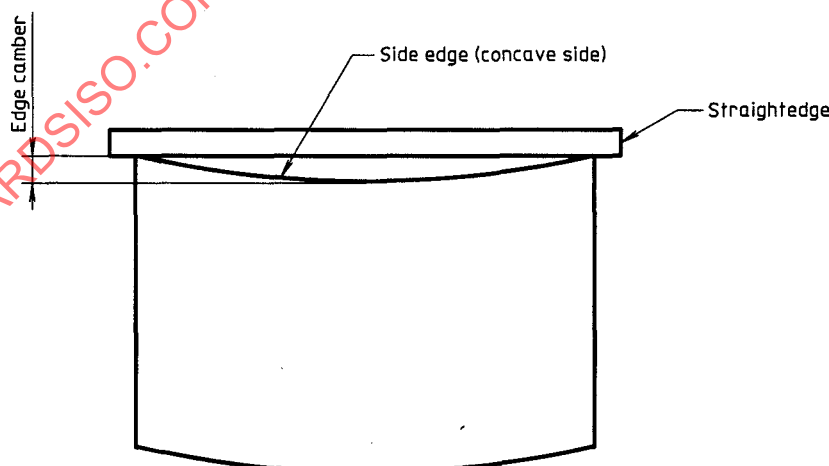
| Dimensions                    | Out-of-square tolerance |
|-------------------------------|-------------------------|
| All thicknesses and all sizes | 1,0 % × width           |

**Table 9 — Out-of-square tolerances for resquared sheet**

Values in millimetres

| Specified lengths         | Specified widths          | Out-of-square tolerance |
|---------------------------|---------------------------|-------------------------|
| Up to and including 3 000 | Up to and including 1 200 | +2<br>0                 |
|                           | Over 1 200                | +3<br>0                 |
| Over 3 000                | All widths                | +3<br>0                 |

NOTE — When measuring material ordered to resquared tolerances, consideration may have to be given to extreme variations in temperature.



NOTE — Camber is the greatest deviation of a side edge from a straight line, the measurement being taken on the concave side with a straightedge.

**Figure 2 — Measurement of camber**