INTERNATIONAL STANDARD

ISO 5001

Fourth edition
2007-07-01

Cold-reduced carbon steel sheet for vitreous enamelling

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

Reference number
ISO 5001:2007(E)

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Published in Switzerland

Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

This fourth edition cancels and replaces the third edition (ISO 5001:1999), which has been technically revised.

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, where the surface of the sheet and chemical composition of the base metal are of prime importance.

1.2 Sheet for vitreous enamelling is produced in thicknesses of 0,35 mm and thicker (commonly up to 3 mm) and in widths of 600 mm and wider in coils and cut lengths. Sheet for vitreous enamelling less than 600 mm wide may be slit from wide sheet and will be considered sheet.

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

1.4 Drawing-quality sheet (VE02, VE03, VE04 and VE05) is intended for drawing and severe forming. It is furnished to all requirements of this International Standard or, by agreement when ordered, to fabricate an identified part, in which case the mechanical properties of Table 1 do not apply. If strain ageing is to be minimized, grade VE04 or VE05 should be specified.

Drawing qualities are identified as follows:

VE02 — drawing quality;

VE03 — deep-drawing quality;

VE04 — deep-drawing quality aluminium-killed (see 4.7);

VE05 — extra-deep-drawing quality (stabilized interstitial-free).

1.5 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, 04 and 05 are common to other standards, indicating the qualities of commercial, drawing, deep-drawing, deep-drawing aluminium-killed and extra-deep-drawing stabilized interstitial-free.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6892, *Metallic materials — Tensile testing at ambient temperature*

ISO 16162, *Continuously cold-rolled steel sheet products — Dimensional and shape tolerances*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
steel sheet for vitreous enamelling
product obtained from cold-reduced steel sheet having a matte finish and for which proper chemical composition and processing are selected by the producer to prepare the sheet for both fabrication and vitreous enamelling

3.2 Grades and qualities for vitreous enamelling

3.2.1
grade 1
extremely low carbon sheet suitable for direct cover coat enamelling and also for two-coat enamelling for special applications (sag resistance)

NOTE The base metal of this grade loses strength after firing the enamel, and if this is a problem the producer should be consulted.

3.2.2
grade 2
sheet suitable for two-coat enamelling

3.3
skin pass
final light cold rolling of cold-reduced fully processed sheet, the purpose of which is one or more of the following:

a) to temporarily minimize the occurrence of stretcher strains (Lüders' lines) or fluting during fabrication of finished parts;

b) to obtain the required surface finish for vitreous enamelling;

c) to control shape.

4 Conditions of manufacture

4.1 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.

4.2 Chemical composition

The heat analysis for grades 1 and 2 shall be subject to agreement between the manufacturer and the purchaser, and a report of the heat analysis to the purchaser or verification by the purchaser shall be in accordance with 4.3.1 and 4.3.2. 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 heat analysis; however, the purchaser may check the carbon content to ensure no misapplication between grades 1 and 2.

4.3 Chemical analysis

4.3.1 Heat analysis

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

4.3.2 Product analysis

A product analysis may be made by the purchaser to verify the specified analysis of the semi-finished or finished steel. It 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 steels) are not technologically suited to product analysis.

4.4 Weldability

The product is easily welded. Certain precautions may be advisable due to the very low hardness of grade 1 material.

4.5 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 quality (VE02, VE03, VE04 or VE05) may be produced to make an identified part previously agreed upon between manufacturer and purchaser. In this case, the part name, the details of fabrication, the vitreous enamelling practice and any special requirements (freedom from stretcher strain or fluting) shall be specified and the mechanical properties of Table 1 do not apply.

4.6 Mechanical properties

Except when ordered as an identified part as explained in 4.5, the mechanical properties of the steel, at the time the steel is made available for shipment, shall be as stated in Table 1. The properties shall be determined on test pieces obtained in accordance with the requirements of Clause 6. 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 or VE05 should be specified.

Table 1 — Mechanical property requirements [a] (see 4.7)

Base metal quality		R_m [b] max. MPa	A [c] min. %		$\bar{r}$ [d] min.	$\bar{n}$ [e] min.
Designation	Name		L_0 = 80 mm	L_0 = 50 mm		
VE01	Commercial [f]	410	27	28	—	—
VE02	Drawing	370	30	31	—	—
VE03	Deep-drawing	350	34	35	—	—
VE04	Deep-drawing aluminium-killed	350	36	37	—	—
VE05	Extra-deep-drawing stabilized interstitial-free	350	38	38	1,6	0,20

[a] R_m tensile strength

A percent elongation after fracture

L_0 gauge length on test piece

$\bar{r}$ plastic strain ratio (indicator of the drawability of the product)

$\bar{n}$ tensile strain hardening exponent (indicator of the stretchability of the product)

[b] For qualities VE02, VE03 and VE04, the minimum tensile strength would normally be expected to be 270 MPa. All tensile strength values are determined to the nearest 10 MPa. For design purposes, the lower limit may be assumed to be 140 MPa for VE01, VE02, VE03 and VE04 and 120 MPa for VE05.

[c] For material up to and including 0,6 mm in thickness, the elongation values in the table shall be reduced by 1.

[d] $\bar{r}$ can also be written as r bar.

[e] $\bar{n}$ can also be written as n bar.

[f] Mechanical properties are not generally determined for commercial-quality products and the values in this table are for information only.

NOTE 1 MPa = 1 N/mm^2.

4.7 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:

a) surface markings from stretcher strain (Lüders' lines) or fluting when the steel is formed;

b) deterioration in ductility.

Steel sheet for vitreous enamelling in quality VE04 supplied in the skin-passed condition may be subject to strain ageing under certain conditions.

Strain ageing can be caused by either carbon or nitrogen atoms which exist in a supersaturated solid solution and diffuse to dislocation sites, this diffusion depending on time and temperature. The addition of aluminium in sufficient quantities causes the removal of nitrogen from solid solution as particles of aluminium nitride. This practice tends to minimize room temperature ageing due to nitrogen and results in the general understanding that cold-rolled aluminium-killed steel is free of ageing concerns generally associated with VE04. However, carbon, which is usually not retained in solid solution with the slow cooling typical of batch annealing, can be retained in solid solution during the continuous-annealing process. If the annealing process and steel chemistry are not properly controlled, such material with carbon remaining in solid solution after continuous annealing may result and such material will strain age at room temperature and the problems noted above can occur. Chemical stabilization, as with VE05, prevents this problem as does proper processing with VE04 material.

Because of these factors, it is essential that the period between final processing at the mill and fabrication be 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 for optimum performance should not exceed six weeks.

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 or VE05 shall be specified in such cases where Lüders' lines are not acceptable and where roller levelling is not possible.

4.8 Surface condition

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

4.9 Surface finish

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

4.10 Surface quality

4.10.1 General

Products shall be supplied with either surface quality A or surface quality B.

4.10.2 Surface quality A (unexposed)

Imperfections such as pores, slight imperfections, small marks, minor scratches and slight colouring which do not affect the formability or the application of surface coatings are permitted.

4.10.3 Surface quality B (exposed)

The better surface shall be free of imperfections which might affect the uniform appearance of quality coating. The other surface shall at least conform to surface quality A.

In the case of delivery of coil and slit coil, the percentage of defects may be greater than in the case of delivery in sheet or cut lengths. This shall be taken into account by the purchaser, and the percentage of admissible surface defects may be agreed at the time of the enquiry and order. Unless otherwise agreed, one of the surfaces of the product shall comply with the specified requirements. The other surface shall be such that, during subsequent treatment, it does not have a deleterious effect on the better surface.

4.11 Oiling

As a deterrent to rusting, a coating of oil is usually applied to the product. The oil is not intended as a drawing or forming lubricant and shall be easily removable using degreasing chemicals. The product may be ordered unoiled, if required, in which case the supplier shall have limited responsibility if oxidation occurs.

5 Dimensional tolerances

Dimensional tolerances applicable to steel sheet for vitreous enamelling shall be as given in ISO 16162.