International Standard ISO 5001

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Cold-reduced carbon steel sheet for vitreous enamelling

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

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Descriptors : steels, unalloyed steels, vitreous enamels, cold rolled products, metal plates, tests, mechanical properties, sampling, dimensional tolerances, form tolerances, specifications, designations.

Price based on 13 pages

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5001 was developed by Technical Committee ISO/TC 17, *Steel*, and was circulated to the member bodies in March 1978.

It has been approved by the member bodies of the following countries :

Austria	Iran	Romania
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The member bodies of the following countries expressed disapproval of the document on technical grounds :

Australia
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New Zealand

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Cold-reduced carbon steel sheet for vitreous enamelling

1 Scope and field of application

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

NOTE — For hot-rolled carbon steel sheet and cold-reduced carbon steel sheet of commercial and drawing qualities, see ISO 3573 and ISO 3574 respectively.

1.2 Sheet for vitreous enamelling is produced in thicknesses of 0,36 mm and thicker (commonly produced up to 4 mm) and in widths 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 as sheet.

NOTE — Approximate conversions to inches are given in the annex, for information only.

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 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 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)

2 References

ISO 82, *Steel — Tensile testing.*

ISO/R 85, *Bend test for steel.*

ISO 86, *Steel-Tensile testing of sheet and strip less than 3 mm and not less than 0,5 mm thick.*

ISO/R 87, *Simple bend testing of steel sheet and strip less than 3 mm thick.*

3 Definitions and other information

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.

3.2 Grades and qualities for vitreous enamelling

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

Quality	Grade	
	1	2
VE01	X	X
VE02	–	X
VE03	X	X
VE04 (non-ageing)	X	X

1) Sometimes referred to as porcelain enamelling.

3.3 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).

3.4 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 :

a) to minimize temporarily the occurence of the condition known as stretcher strain (Lüder's lines) or fluting during fabrication of finished parts;

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

c) to control shape.

3.5 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 (Lüder's lines) or fluting when the steel is formed;

b) 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 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 shall be specified in such cases where Lüder's lines are not acceptable and where roller levelling is not possible.

3.6 Surface condition

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

3.7 Surface finish

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

3.8 Oiling

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

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 cast analysis for grades 1 and 2 is subject to agreement between the manufacturer and the purchaser and a report of cast 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 cast 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 Cast analysis

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

4.3.2 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 suited to verification analysis.

4.4 Weldability

This product is easily welded. It is recommended that 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 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 1 do not apply.

4.6 Mechanical properties

Except when ordered to an identified part as explained in 4.5, at the time that the steel is made available for shipment the mechanical properties shall be as stated in table 1 when they are determined on test pieces obtained according to the requirements of 6.1 (mechanical tests). Prolonged storing of the sheet can cause a change in mechanical properties (increase in hardness and a decrease in elongation, leading to a decreasd in drawability). To minimize this effect, quality VE04 should be specified.

5 Dimensional tolerances

Dimensional tolerances applicable to steel sheet for vitreous enamelling shall be as given in tables 2 to 11 inclusive.

6 Sampling

6.1 Mechanical tests (before vitreous enamelling)

6.1.1 Tensile test

When ordered to mechanical properties, one representative sample for the tensile test required in table 1 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.

6.1.2 Bend test (when specified)

One representative sample for the bend test (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.

7 Test methods

7.1 Mechanical tests (before vitreous enamelling)

7.1.1 Tensile test

The tensile test shall be carried out in accordance with ISO 82 and ISO 86. Transverse test pieces shall be taken mid-way between the centre and edge of the sheet as rolled.

7.1.2 Bend test (when specified)

The transverse bend test piece (applicable to VE01 only) shall withstand being bent in the direction as shown in figure 1 through 180°, without cracking on the outside of the bent portion, around an inside diameter equal to the thickness of the test piece. The bend test shall be performed at ambient temperature and as described in ISO/R 85 and ISO/R 87. Small cracks on the edges of test pieces and cracks which require magnification to be visible shall be disregarded.

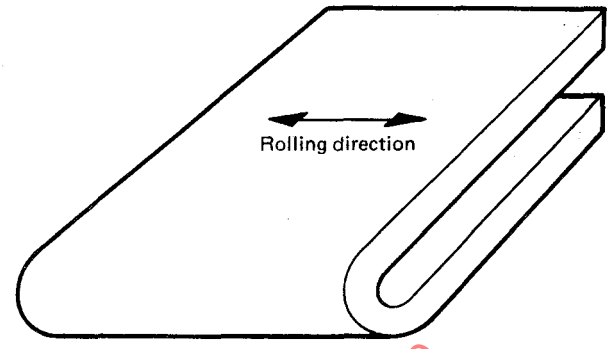

Figure 1 — Transverse bend test piece (after bending)

8 Retests

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

9 Resubmission

9.1 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.

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

10 Workmanship

The steel sheet for vitreous enamelling in cut lengths shall be free from amounts of 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.

11 Inspection and acceptance

11.1 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.

11.2 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.

12 Coil size

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

13 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) 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.

14 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 (for example, steel sheet for vitreous enamelling, grade 1 for direct cover coat, commercial quality, VE01 (see 1.3 and 3.2.1);

c) the dimensions of the product and quantity required;

d) the application (name of part) (see 4.5);

e) the drawing qualities (VE02, VE03 and VE04), ordered to fabricate an identified part (see 1.4 and 4.5);

f) whether oiled or not oiled (see 3.8);

g) the coil size requirements (see 12);

h) the report of the cast analysis, if required (see 4.3.1);

j) details of fabrication including vitreous enamelling process, or special requirements (stretcher strain or fluting);

k) inspection and tests for acceptance prior to shipment from the producer's works, if required (see 11.1).

NOTE — 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.

Table 1 — Mechanical properties[1] (see 4.6)

Base metal quality		R_m, max.[2]	A min. %[3]		Base metal 180° bend mandrel diameter	
Designation	Name	N/mm²	$L_o = 50$ mm	$L_o = 80$ mm	$e < 3$	$e \geqslant 3$
VE01	Commercial	—	—	—	0 (flat on itself)	1 a
VE02	Drawing	370	31	30	Does not apply	
VE03	Deep drawing	350	35	34		
VE04	Extra deep drawing non ageing	340	37	36		

1) R_m = tensile strength

A = percentage elongation after fracture

L_o = gauge length on test piece

S_o = original cross-sectional area of gauge length

e = thickness of steel sheet, in millimetres

a = thickness of bend test piece

1 N/mm² = 1 MPa

2) Minimum tensile strength for qualities VE02, VE03 and VE04 would normally be expected to be 270 N/mm². All tensile strength values are determined to the nearest 10 N/mm².

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

Table 2 — Standard thickness tolerances for coils[1] and cut lengths

Unless otherwise stated on the order, the thickness tolerances for all qualities of steel shall be in accordance with table 2. When required, special tolerances in accordance with table 3 shall be the subject of agreement.

Values in millimetres

Specified widths	Thickness tolerances[2], 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	0,07	0,08	0,09	0,10	0,12	0,14	0,16	0,18	0,20	0,23
Over 1 200 up to and including 1 500	0,08	0,09	0,10	0,11	0,13	0,15	0,17	0,20	0,23	0,25
Over 1 500 up to and including 1 800	—	0,10	0,11	0,13	0,14	0,17	0,19	0,22	0,23	0,27
Over 1 800	—	0,12	0,13	0,14	0,16	0,19	0,21	0,24	0,26	0,29

1) 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.

2) Thickness is measured at any point on the sheet not less than 40 mm from a side edge.

Table 3 — Special thickness tolerances for coils[1] and cut lengths

Unless otherwise stated on the order, the thickness tolerances for all qualities of steel shall be in accordance with table 2.
When required, special tolerances in accordance with table 3 shall be the subject of agreement.

Values in millimetres

Specified widths	Thickness tolerances[2], 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

1) 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.

2) Thickness is measured at any point on the sheet not less than 40 mm from a side edge.

Table 4 — Width tolerances for coils and cut lengths, not resquared

Values in millimetres

Specified widths	Tolerance
Up to and including 1 200	$+\frac{5}{0}$
Over 1 200 up to and including 1 500	$+\frac{7}{0}$
Over 1 500	$+\frac{9}{0}$

Table 5 — Length tolerances for cut lengths, not resquared

Specified lengths	Tolerance
Up to and including 3 000	$+\frac{20}{0}$ mm
Over 3 000 up to and including 6 000	$+\frac{30}{0}$ mm
Over 6 000	$+\frac{0,5}{0}$ %

Table 6 — Camber tolerances for coils and cut lengths, not resquared

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

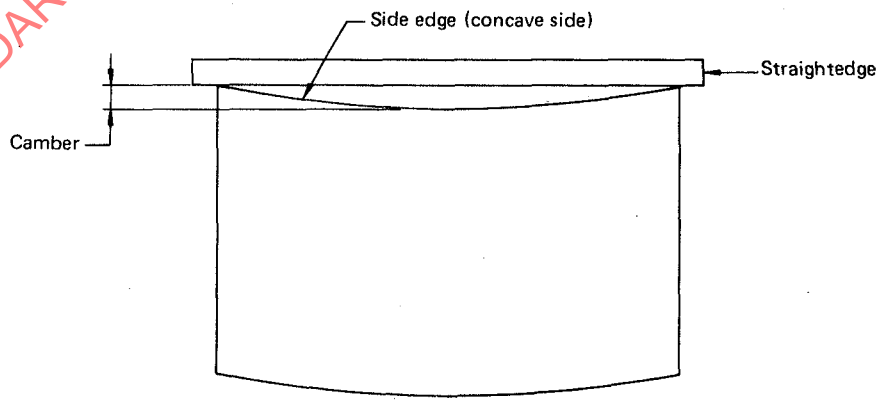

Figure 2 — Measurement of camber

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

Table 7 — Out-of-square tolerance for cut lengths, not resquared

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

Table 8 — Out-of-square tolerances for resquared sheet[1)]

Values in millimetres

Specified lengths	Specified widths	Out-of-square tolerance
Up to and including 3 000	Up to and including 1 200	$^{+2}_{0}$
	Over 1 200	$^{+3}_{0}$
Over 3 000	All widths	$^{+3}_{0}$

1) When measuring material to resquared tolerances, consideration may have to be given to extreme variations in temperature.

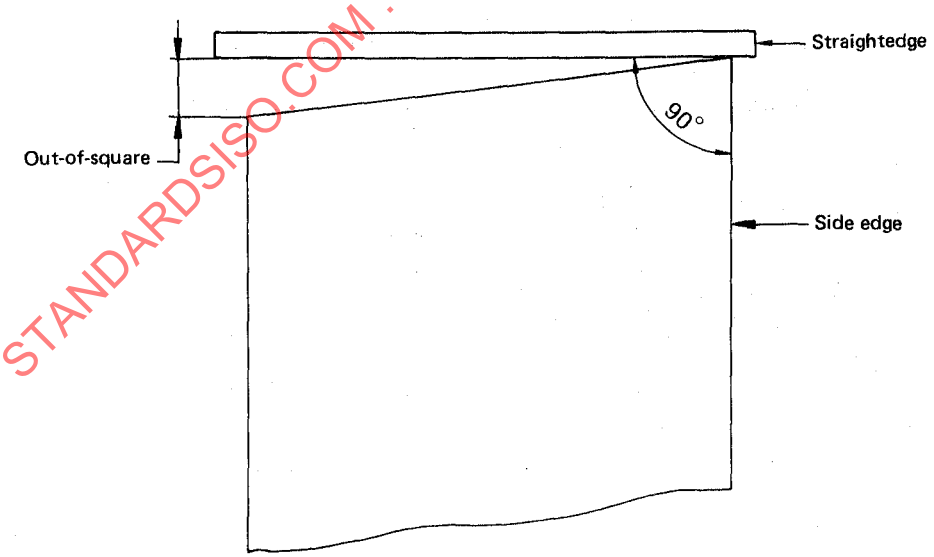

Figure 3 — Measurement of out-of-square

Out-of-square is the greatest deviation of an end edge from a straight line at right angles to a side and touching one corner, the measurement being taken as shown in figure 3. It can also be measured as one-half the difference between the diagonals of the cut length sheet.

Table 9 — Standard flatness tolerances for cut lengths[1)]

Values in millimetres

Specified thicknesses	Specified widths	Flatness tolerance[2)]
Up to and including 0,7	Up to and including 1 200	15
	Over 1 200 up to and including 1 500	18
	Over 1 500	22
Over 0,7 up to and including 1,2	Up to and including 1 200	12
	Over 1 200 up to and including 1 500	15
	Over 1 500	19
Over 1,2	Up to and including 1 200	10
	Over 1 200 up to and including 1 500	12
	Over 1 500	17

1) This table also applies to sheet cut to length from coils by the customer when adequate flattening procedures are performed.

2) Maximum deviation from a flat horizontal surface. With the sheet lying under its own weight on a flat surface, the maximum distance between the lower surface of the sheet and the flat horizontal surface is the maximum deviation from flatness.

Table 10 — Special flatness tolerances for cut lengths, roller levelled or stretcher levelled

Values in millimetres

Specified thicknesses	Specified widths	Flatness tolerance[1)]
Up to and including 0,7	Up to and including 1 200	6
	Over 1 200 up to and including 1 500	7
	Over 1 500	8
Over 0,7 up to and including 1,2	Up to and including 1 200	5
	Over 1 200 up to and including 1 500	6
	Over 1 500	7
Over 1,2	Up to and including 1 200	4
	Over 1 200 up to and including 1 500	5
	Over 1 500	6

1) Maximum deviation from a flat horizontal surface. With the sheet lying under its own weight on a flat surface, the maximum distance between the lower surface of the sheet and the flat horizontal surface is the maximum deviation from flatness.

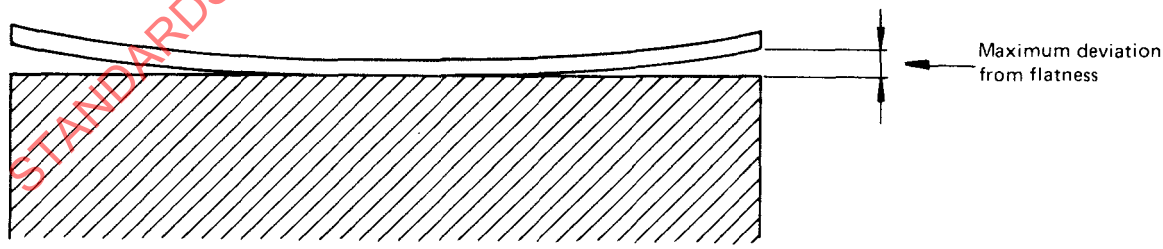

Figure 4 — Measurement of flatness

When cold-reduced sheet is specified to stretcher-levelled standards of flatness and not resquared, the allowances over specified dimensions in width and length given in table 11 apply. Under these conditions, the allowance for width and length are added by the manufacturer to the specified width and length and the tolerances given in tables 4 and 5 apply on the basis of the new size established. The camber tolerances in table 6 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 11 — Width and length allowances[1] for sheet, stretcher levelled

Values in millimetres

Specified lengths	Allowances over specified dimensions		
	Widths	Lengths	
		Grip or entry marks outside specified length	Grip or entry marks inside specified length
Up to and including 3 000	19	100	75
Over 3 000 up to and including 4 000	25	100	75
Over 4 000	32	125	100

1) Allowances for sheet exceeding 5 000 mm in length shall be the subject of agreement.