

# INTERNATIONAL STANDARD

**Magnetic materials –**

**Part 8-5: Specifications for individual materials – Electrical steel strip and sheet  
with specified mechanical properties and magnetic polarization**

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INTERNATIONAL  
ELECTROTECHNICAL  
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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## MAGNETIC MATERIALS –

**Part 8-5: Specifications for individual materials –  
Electrical steel strip and sheet with specified mechanical  
properties and magnetic polarization**

## FOREWORD

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International Standard IEC 60404-8-5 has been prepared by IEC technical committee 68: Magnetic alloys and steels.

This second edition cancels and replaces the first edition published in 1989. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) extension of the range of products to include the improved grades;
- b) division of "flatness" into "edge wave (wave factor)" and "residual curvature" in consistent with IEC 60404-9;
- c) change length of test specimen for determinations of geometrical characters from 2 m to 1 m.

The text of this International Standard is based on the following documents:

| CDV        | Report on voting |
|------------|------------------|
| 68/648/CDV | 68/662/RVC       |

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60404 series, published under the general title *Magnetic materials*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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## INTRODUCTION

The first edition of IEC 60404-8-5, "*Magnetic materials – Part 8: Specifications for individual materials – Section Five – Specification for steel sheet and strip with specified mechanical properties and magnetic permeability*", was published in April 1989 and has not been revised for more than 30 years. Since then, new grades of cold-rolled material of minimum proof strength  $R_{p0,2}$  greater than 400 MPa were developed and widely used. Thus, IEC TC 68 decided in 2017 at their meeting in Paris to revise this document. This revision also includes corrections to the first edition in order to improve consistency with the other parts of the IEC 60404-8 subseries.

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## MAGNETIC MATERIALS –

### **Part 8-5: Specifications for individual materials – Electrical steel strip and sheet with specified mechanical properties and magnetic polarization**

#### **1 Scope**

This part of IEC 60404 defines the grades of electrical steel strip and sheet with specified mechanical properties and magnetic polarization. In particular, it gives general requirements, mechanical properties, magnetic polarization, geometric characteristics, tolerances and technological characteristics, as well as inspection procedures.

This document applies to electrical steel strip and sheet intended for the construction of poles and rims of rotating electrical machines.

The grades are grouped into two classes according to their manufacturing process:

- hot-rolled grades;
- cold-rolled grades.

They correspond to Class D21 of IEC 60404-1.

#### **2 Normative references**

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60050-121, *International Electrotechnical Vocabulary – Part 121: Electromagnetism*

IEC 60050-221, *International Electrotechnical Vocabulary – Chapter 221: Magnetic materials and components*

IEC 60404-1, *Magnetic materials – Part 1: Classification*

IEC 60404-2, *Magnetic materials – Part 2: Methods of measurement of the magnetic properties of electrical steel strip and sheet by means of an Epstein frame*

IEC 60404-4, *Magnetic materials – Part 4: Methods of measurement of d.c. magnetic properties of iron and steel*

IEC 60404-9, *Magnetic materials – Part 9: Methods of determination of the geometrical characteristics of electrical steel strip and sheet*

ISO 404, *Steel and steel products – General technical delivery requirements*

ISO 2566-1, *Steel – Conversion of elongation values – Part 1: Carbon and low alloy steels*

ISO 6892-1, *Metallic materials – Tensile testing – Part 1: Method of test at room temperature*

ISO 10474, *Steel and steel products – Inspection documents*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-121, IEC 60050-221, IEC 60404-9 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

#### 3.1

##### **edge wave**

wave factor

variations of flatness of a length of strip or a sheet taking a form of waves at the slit edge of the product

Note 1 to entry: Edge wave is characterized by the wave factor which is the relation of the height of the wave to its length, expressed as a percentage.

[SOURCE: IEC 60404-9: 2018, 3.1]

#### 3.2

##### **residual curvature**

variations of flatness of a length of strip or a sheet taking a permanent curvature in the rolling direction of the product

[SOURCE: IEC 60404-9: 2018, 3.2]

#### 3.3

##### **edge camber**

greatest distance between a longitudinal edge of a length of strip or a sheet and the line joining the two extremities of the measured length of this edge

[SOURCE: IEC 60404-9: 2018, 3.3]

### 4 Classification

The grades covered by this document are classified according to the specified value of minimum proof strength  $R_{p0.2}$ , in MPa<sup>1</sup>, according to the specified value of minimum magnetic polarization at a DC magnetic field strength of 15 000 A/m, in T, and according to the nominal thickness of the product<sup>2</sup>, in mm.

### 5 Designation

The steel name comprises the following in the order given:

- a) the characteristic letters
  - "TG" for hot-rolled grades;
  - "TF" for cold-rolled grades;

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

<sup>2</sup> In the rest of the document, the word "product" is used to mean "strip and sheet".

- b) the specified value of minimum proof strength  $R_{p0,2}$ , in MPa;
- c) one hundred times the nominal thickness of the product, in mm;
- d) one hundred times the specified value of minimum magnetic polarization at a DC magnetic field strength of 15 000 A/m, in T.

EXAMPLE: TF350-100-181 for cold-rolled electrical steel strip and sheet with a minimum proof strength  $R_{p0,2}$  of 350 MPa, a nominal thickness of 1,0 mm, and a minimum magnetic polarization of 1,81 T at a DC magnetic field strength of 15 000 A/m.

## 6 General requirements

### 6.1 Production process

The production process of the steel and its chemical composition are left to the discretion of the manufacturer.

### 6.2 Form of supply

The product is supplied in coils in the case of strip and in bundles in the case of sheets.

The mass of the coils or bundles of sheets shall be agreed between the manufacturer and the purchaser at the time of enquiry and order.

The internal diameter of coils shall be agreed between the manufacturer and the purchaser at the time of enquiry and order. The recommended value for the internal diameter of coils is approximately 610 mm for hot-rolled grades, and approximately 508 mm for cold-rolled grades.

Strip shall be of constant width and wound in such a manner that the edges are superimposed in a regular manner and the side faces of the coil are substantially flat.

Coils shall be sufficiently tightly wound in order that they do not collapse under their own weight.

Strip may exhibit welds or interleaves resulting from the removal of defective zones or from the joining of several lengths to obtain the sizes of the coils required by the purchaser, if agreed between the manufacturer and the purchaser at the time of enquiry and order. If necessary, the marking of welds or interleaves may be agreed between the manufacturer and the purchaser at the time of enquiry and order.

For coils containing repair welds or interleaves, each part of the strip shall be of the same grade.

The edges of parts welded together shall not be so much out of alignment as to affect the further processing of the product.

Sheets which make up each bundle shall be stacked so that the side faces are substantially flat and approximately perpendicular to the top face.

Products supplied in sheets shall not contain any welds.

### 6.3 Delivery condition

The product is normally supplied without insulation. By agreement between the manufacturer and the purchaser at the time of enquiry and order, the product may be supplied with insulation on one or both sides. If the product is supplied with insulation, the nature of the insulation, its properties and their verification shall be agreed between the manufacturer and the purchaser at the time of enquiry and order.

Hot-rolled grades are normally supplied with an oxide scale layer unless they have been ordered pickled.

The product may be supplied lightly coated with oil by agreement between the manufacturer and the purchaser at the time of enquiry and order.

Coils supplied with trimmed edges and sheets shall not contain excessive burrs or cutting distortions which are prejudicial to the method of working of the product.

#### **6.4 Surface condition**

The surfaces shall be smooth and clean, free from grease and rust<sup>3</sup>. Dispersed defects such as scratches, blisters, cracks, etc. are only permitted if they are within the limits of the tolerances on thickness and if they are not detrimental to the correct use of the supplied product.

#### **6.5 Suitability for cutting**

The product shall be able to be cut or punched without causing premature wear of tools. The product shall be suitable for cutting or punching accurately into the usual shapes at any point when appropriate cutting or punching tools and technologies are used.

A special requirement concerning suitability for cutting or punching of the product may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order.

#### **6.6 Suitability for welding**

A special requirement concerning suitability for welding of the product may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order.

### **7 Technical requirements**

#### **7.1 Mechanical properties**

The specified values of minimum proof strength  $R_{p0.2}$ , minimum tensile strength  $R_m$  and minimum percentage elongation after fracture  $A$  shall be as given in Table 1 and Table 2.

#### **7.2 Magnetic polarization**

The specific values of minimum magnetic polarization at DC magnetic field strengths of 5 000 A/m and 15 000 A/m shall be as given in Table 1 and Table 2.

The values of peak magnetic polarization at AC magnetic field strengths of 5 000 A/m and 15 000 A/m (expressed as peak values) and at frequencies of 50 Hz or 60 Hz may be used instead, provided the specified values of minimum magnetic polarization given in Table 1 and Table 2 are satisfied.

Other values at a magnetic field strength lower than 15 000 A/m may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order, instead of the values at a magnetic field strength of 15 000 A/m.

<sup>3</sup> This should not be confused with some coloration of the insulation coating inherent to the manufacturing process.

**Table 1 – Mechanical and magnetic characteristics for hot-rolled grades**

| Steel name <sup>a</sup> | Minimum proof strength<br>$R_{p0,2}$<br>MPa | Minimum tensile strength<br>$R_m$<br>MPa | Minimum percentage elongation after fracture for an original gauge length $L_0$<br>$A$<br>% |                         | Minimum magnetic polarization <sup>c</sup> at a DC magnetic field strength<br>$J$<br>T |                         |
|-------------------------|---------------------------------------------|------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------|----------------------------------------------------------------------------------------|-------------------------|
|                         |                                             |                                          | $L_0 = 80 \text{ mm}$                                                                       | $L_0 = 5,65 \sqrt{S_0}$ | 5 000 A/m                                                                              | 15 000 A/m <sup>d</sup> |
| TG250-...-180           | 250                                         | 350                                      | 22                                                                                          | 26                      | 1,60                                                                                   | 1,80                    |
| TG300-...-180           | 300                                         | 400                                      | 20                                                                                          | 24                      | 1,60                                                                                   | 1,80                    |
| TG350-...-179           | 350                                         | 450                                      | 18                                                                                          | 22                      | 1,55                                                                                   | 1,79                    |
| TG400-...-179           | 400                                         | 500                                      | 16                                                                                          | 19                      | 1,55                                                                                   | 1,79                    |
| TG450-...-179           | 450                                         | 550                                      | 14                                                                                          | 17                      | 1,54                                                                                   | 1,79                    |
| TG500-...-179           | 500                                         | 600                                      | 12                                                                                          | 14                      | 1,53                                                                                   | 1,79                    |
| TG550-...-178           | 550                                         | 650                                      | 12                                                                                          | 14                      | 1,52                                                                                   | 1,78                    |
| TG600-...-178           | 600                                         | 700                                      | 10                                                                                          | 12                      | 1,50                                                                                   | 1,78                    |
| TG650-...-178           | 650                                         | 750                                      | 10                                                                                          | 12                      | 1,48                                                                                   | 1,78                    |
| TG700-...-178           | 700                                         | 800                                      | 10                                                                                          | 12                      | 1,46                                                                                   | 1,78                    |

<sup>a</sup> is one hundred times the nominal thickness of the product, in millimetres. Other steel names may be agreed between the manufacturer and the purchaser at the time of enquiry and order.

<sup>b</sup> These values shall be obtained on a tensile test specimen of type 2,  $L_0 = 80 \text{ mm}$ , for products with thickness less than 3 mm and on a proportional test specimen,  $L_0 = 5,65\sqrt{S_0}$ , for products with thickness equal to or greater than 3 mm, the values may be converted each other in accordance with ISO 2566-1. Where  $L_0$  is the original gauge length marked on the test specimen, in mm, and  $S_0$  is the original cross-sectional area of the test specimen, in mm<sup>2</sup> (See 8.3.1).

<sup>c</sup> It has been common practice for many years to give values of magnetic flux density. In fact the Epstein frame is used to determine magnetic polarization (intrinsic flux density) which is defined as follows in accordance with IEC 60050-121:

$$J = B - \mu_0 H$$

where

$J$  is the magnetic polarization;

$B$  is the magnetic flux density;

$\mu_0$  is the magnetic constant:  $4 \pi \times 10^{-7} \text{ H} \cdot \text{m}^{-1}$ ;

$H$  is the magnetic field strength.

<sup>d</sup> Other values at a magnetic field strength lower than 15 000 A/m may be agreed between the manufacturer and the purchaser at the time of enquiry and order, instead of the values at a magnetic field strength of 15 000 A/m.

**Table 2 – Mechanical and magnetic characteristics for cold-rolled grades**

| Steel name <sup>a</sup> | Minimum proof strength<br><br>$R_{p0,2}$<br>MPa | Minimum tensile strength<br><br>$R_m$<br>MPa | Minimum percentage elongation after fracture for an original gauge length $L_0 = 80$ mm<br><br>$A$<br>% | Minimum magnetic polarization <sup>b</sup> at a DC magnetic field strength |                                     |
|-------------------------|-------------------------------------------------|----------------------------------------------|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------------|
|                         |                                                 |                                              |                                                                                                         | $J$<br>T<br>5 000 A/m                                                      | $J$<br>T<br>15 000 A/m <sup>c</sup> |
| TF250-...-183           | 250                                             | 325                                          | 16                                                                                                      | 1,6                                                                        | 1,83                                |
| TF300-...-182           | 300                                             | 375                                          | 15                                                                                                      | 1,55                                                                       | 1,82                                |
| TF350-...-181           | 350                                             | 425                                          | 13                                                                                                      | 1,52                                                                       | 1,81                                |
| TF400-...-180           | 400                                             | 450                                          | 10                                                                                                      | 1,5                                                                        | 1,8                                 |
| TF450-...-179           | 450                                             | 550                                          | 10                                                                                                      | 1,48                                                                       | 1,79                                |
| TF500-...-178           | 500                                             | 600                                          | 10                                                                                                      | 1,46                                                                       | 1,78                                |

<sup>a</sup> is one hundred times the nominal thickness of the product, in millimetres. Other steel names may be agreed between the manufacturer and the purchaser at the time of enquiry and order.

<sup>b</sup> It has been common practice for many years to give values of magnetic flux density. In fact the Epstein frame is used to determine magnetic polarization (intrinsic flux density) which is defined as follows in accordance with IEC 60050-121:

$$J = B - \mu_0 H$$

where

$J$  is the magnetic polarization;

$B$  is the magnetic flux density;

$\mu_0$  is the magnetic constant:  $4 \pi \times 10^{-7} \text{ H} \cdot \text{m}^{-1}$ ;

$H$  is the magnetic field strength.

<sup>c</sup> Other values at a magnetic field strength lower than 15 000 A/m may be agreed between the manufacturer and the purchaser at the time of enquiry and order, instead of the values at a magnetic field strength of 15 000 A/m.

### 7.3 Geometrical characteristics and tolerances

#### 7.3.1 Thickness

The nominal thicknesses of the product are the following:

- hot-rolled grades: 1,6 mm, 1,8 mm, 2,0 mm, 2,5 mm, 3,0 mm, 3,2 mm and 4,5 mm;
- cold-rolled grades: 0,5 mm, 1,0 mm, 1,6 mm, 1,8 mm and 2,0 mm.

For thickness tolerance, a distinction is made between:

- the deviation from the nominal thickness within an acceptance unit;
- the difference in thickness in a length of strip or sheet in a direction parallel to the direction of rolling;
- the difference in thickness in a direction perpendicular to the direction of rolling. This tolerance applies only to products with a width greater than 150 mm.

At any point, the deviation from the nominal thickness within an acceptance unit shall not exceed the tolerances of Table 3 and Table 4 corresponding to hot-rolled grades and cold-rolled grades respectively.

**Table 3 – Tolerance on nominal thickness for hot-rolled grades**

| Proof strength<br>$R_{p0,2}$<br>MPa | Nominal width<br>$w$<br>mm | Tolerance on nominal thickness $t$ (mm) |                  |                  |                |                |
|-------------------------------------|----------------------------|-----------------------------------------|------------------|------------------|----------------|----------------|
|                                     |                            | mm                                      |                  |                  |                |                |
|                                     |                            | $1,5 < t \leq 2$                        | $2 < t \leq 2,5$ | $2,5 < t \leq 3$ | $3 < t \leq 4$ | $4 < t \leq 5$ |
| $R_{p0,2} \leq 300$                 | $w \leq 600$               | $\pm 0,16$                              | $\pm 0,17$       | $\pm 0,17$       | $\pm 0,17$     | $\pm 0,18$     |
|                                     | $600 < w \leq 1\,200$      | $\pm 0,18$                              | $\pm 0,20$       | $\pm 0,21$       | $\pm 0,23$     | $\pm 0,27$     |
|                                     | $w > 1\,200$               | $\pm 0,20$                              | $\pm 0,22$       | $\pm 0,23$       | $\pm 0,25$     | $\pm 0,28$     |
| $300 < R_{p0,2} \leq 400$           | $w \leq 600$               | $\pm 0,18$                              | $\pm 0,19$       | $\pm 0,19$       | $\pm 0,19$     | $\pm 0,20$     |
|                                     | $600 < w \leq 1\,200$      | $\pm 0,23$                              | $\pm 0,25$       | $\pm 0,26$       | $\pm 0,29$     | $\pm 0,34$     |
|                                     | $w > 1\,200$               | $\pm 0,25$                              | $\pm 0,28$       | $\pm 0,29$       | $\pm 0,31$     | $\pm 0,35$     |
| $R_{p0,2} > 400$                    | $w \leq 600$               | $\pm 0,22$                              | $\pm 0,24$       | $\pm 0,24$       | $\pm 0,24$     | $\pm 0,24$     |
|                                     | $600 < w \leq 1\,200$      | $\pm 0,29$                              | $\pm 0,31$       | $\pm 0,32$       | $\pm 0,36$     | $\pm 0,43$     |
|                                     | $w > 1\,200$               | $\pm 0,31$                              | $\pm 0,35$       | $\pm 0,36$       | $\pm 0,39$     | $\pm 0,44$     |

**Table 4 – Tolerance on nominal thickness for cold-rolled grades**

| Nominal width<br>$w$<br>mm | Tolerance on nominal thickness $t$ (mm) |                    |                  |                  |                    |                  |                  |                  |
|----------------------------|-----------------------------------------|--------------------|------------------|------------------|--------------------|------------------|------------------|------------------|
|                            | mm                                      |                    |                  |                  |                    |                  |                  |                  |
|                            | $0,4 < t \leq 0,6$                      | $0,6 < t \leq 0,8$ | $0,8 < t \leq 1$ | $1 < t \leq 1,2$ | $1,2 < t \leq 1,5$ | $1,5 < t \leq 2$ | $2 < t \leq 2,5$ | $2,5 < t \leq 3$ |
| $w \leq 600$               | $\pm 0,04$                              | $\pm 0,05$         | $\pm 0,05$       | $\pm 0,07$       | $\pm 0,07$         | $\pm 0,08$       | $\pm 0,08$       | $\pm 0,10$       |
| $600 < w \leq 1\,200$      | $\pm 0,08$                              | $\pm 0,09$         | $\pm 0,10$       | $\pm 0,12$       | $\pm 0,14$         | $\pm 0,16$       | $\pm 0,18$       | $\pm 0,20$       |
| $w > 1\,200$               | $\pm 0,09$                              | $\pm 0,10$         | $\pm 0,11$       | $\pm 0,13$       | $\pm 0,15$         | $\pm 0,17$       | $\pm 0,20$       | $\pm 0,23$       |

The difference in thickness in a 1 m length of strip or sheet in a direction parallel to the direction of rolling shall not exceed:

- 8 % of the nominal thickness  $t$  for  $t \leq 1,5$  mm;
- 5 % of the nominal thickness  $t$  for  $t > 1,5$  mm.

The difference in thickness in a direction perpendicular to the direction of rolling shall not exceed the values given in Table 5 and Table 6 corresponding to hot-rolled grades and cold-rolled grades respectively.

**Table 5 – Maximum difference in thickness in a direction perpendicular to the direction of rolling for hot-rolled grades**

| Proof strength<br>$R_{p0,2}$<br>MPa | Maximum difference in thickness in a direction perpendicular to the direction of rolling for nominal width $w$ (mm) |                       |              |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------|-----------------------|--------------|
|                                     | mm                                                                                                                  |                       |              |
|                                     | $150 \leq w \leq 600$                                                                                               | $600 < w \leq 1\,200$ | $w > 1\,200$ |
| $R_{p0,2} \leq 450$                 | 0,06                                                                                                                | 0,08                  | 0,10         |
| $R_{p0,2} > 450$                    | 0,12                                                                                                                | 0,14                  | 0,16         |

**Table 6 – Maximum difference in thickness in a direction perpendicular to the direction of rolling for cold-rolled grades**

| Proof strength<br>$R_{p0,2}$<br>MPa | Nominal thickness<br>$t$<br>mm | Maximum difference in thickness in a direction perpendicular to the direction of rolling for nominal width $w$ (mm) |                       |              |
|-------------------------------------|--------------------------------|---------------------------------------------------------------------------------------------------------------------|-----------------------|--------------|
|                                     |                                | mm                                                                                                                  |                       |              |
|                                     |                                | $150 \leq w \leq 600$                                                                                               | $600 < w \leq 1\,200$ | $w > 1\,200$ |
| $R_{p0,2} \leq 350$                 | $t \leq 0,7$                   | 0,03                                                                                                                | 0,04                  | 0,05         |
|                                     | $t > 0,7$                      | 0,04                                                                                                                | 0,05                  | 0,06         |
| $R_{p0,2} > 350$                    | $t \leq 0,7$                   | 0,04                                                                                                                | 0,05                  | 0,06         |
|                                     | $t > 0,7$                      | 0,06                                                                                                                | 0,07                  | 0,08         |

**7.3.2 Width**

The commonly available nominal widths are less than or equal to 1 500 mm.

For products supplied with trimmed edges, the tolerances of Table 7 shall apply.

**Table 7 – Tolerance on nominal width of products supplied with trimmed edges**

| Nominal width<br>$w$<br>mm | Tolerance <sup>a</sup><br>mm |                                                   |                    |                  |
|----------------------------|------------------------------|---------------------------------------------------|--------------------|------------------|
|                            | Hot-rolled grades            | Cold-rolled grades for nominal thickness $t$ (mm) |                    |                  |
|                            |                              | $t \leq 1,5$                                      | $1,5 < t \leq 2,5$ | $2,5 < t \leq 3$ |
| $w \leq 50$                | + 0,6<br>0                   | + 0,4<br>0                                        | + 0,5<br>0         | + 0,7<br>0       |
| $50 < w \leq 100$          | + 0,6<br>0                   | + 0,4<br>0                                        | + 0,6<br>0         | + 0,9<br>0       |
| $100 < w \leq 200$         | + 1,0<br>0                   | + 0,5<br>0                                        | + 0,7<br>0         | + 1,0<br>0       |
| $200 < w \leq 400$         | + 1,4<br>0                   | + 0,6<br>0                                        | + 0,9<br>0         | + 1,2<br>0       |
| $400 < w \leq 600$         | + 1,8<br>0                   | + 1,0<br>0                                        | + 1,0<br>0         | + 1,2<br>0       |
| $600 < w \leq 1\,200$      | + 6,0<br>0                   | + 5,0<br>0                                        | + 5,0<br>0         | + 5,0<br>0       |
| $w > 1\,200$               | + 8,0<br>0                   | + 7,0<br>0                                        | + 7,0<br>0         | + 7,0<br>0       |

<sup>a</sup> By agreement between the manufacturer and the purchaser at the time of enquiry and order, the tolerance on the nominal width can be all negative tolerances.

For products supplied with as-rolled edges, the tolerances on the geometric characteristics shall be subject to agreement between the manufacturer and the purchaser at the time of enquiry and order.

**7.3.3 Length**

The verification of length does not apply to the products supplied in coils.

For products supplied in sheets, the tolerances of Table 8 shall apply.

**Table 8 – Tolerance on nominal length of sheets**

| Nominal length $l$<br>mm | Tolerance<br>mm     |
|--------------------------|---------------------|
| $l \leq 1\,000$          | +10<br>0            |
| $l > 1\,000$             | +(1 % of $l$ )<br>0 |

**7.3.4 Edge wave (wave factor)**

The verification of edge wave does not apply to products of width less than or equal to 100 mm, of thickness greater than 1 mm and products supplied with as-rolled edges.

For products supplied in coils, the wave factor shall not exceed 2 %.

A special requirement concerning edge wave (wave factor) may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order of products supplied in coils.

A height of edge wave may be specified by agreement between the manufacturer and the purchasers at the time of enquiry and order of products, instead of the wave factor.

**7.3.5 Residual curvature**

The verification of residual curvature does not apply to the products supplied in coils.

For products supplied in sheets, the maximum distance between the lower face of the test specimen and the flat surface table shall not exceed the values given in Table 9 and Table 10 corresponding to hot-rolled grades and cold-rolled grades respectively.

A special requirement concerning residual curvature may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order of products of width greater than 100 mm.

**Table 9 – Maximum distance between the lower face of a test specimen and the flat surface table for hot-rolled grades**

| Proof strength<br>$R_{p0,2}$<br>MPa | Maximum distance between the lower face of the test specimen<br>and the flat surface table for nominal thickness $t$ (mm)<br>mm |         |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|---------|
|                                     | $t \leq 2$                                                                                                                      | $t > 2$ |
| $R_{p0,2} \leq 350$                 | 6                                                                                                                               | 5       |
| $350 < R_{p0,2} \leq 500$           | 7                                                                                                                               | 6       |
| $R_{p0,2} > 500$                    | 8                                                                                                                               | 7       |

**Table 10 – Maximum distance between the lower face of a test specimen and the flat surface table for cold-rolled grades**

| Proof strength<br>$R_{p0,2}$<br>MPa | Maximum distance between the lower face of the test specimen and the flat surface table for nominal thickness $t$ (mm) |                    |           |
|-------------------------------------|------------------------------------------------------------------------------------------------------------------------|--------------------|-----------|
|                                     | mm                                                                                                                     |                    |           |
|                                     | $t \leq 0,7$                                                                                                           | $0,7 < t \leq 1,2$ | $t > 1,2$ |
| 250                                 | 10                                                                                                                     | 9                  | 8         |
| 300                                 | 10                                                                                                                     | 9                  | 8         |
| 350                                 | 15                                                                                                                     | 12                 | 8         |
| 400                                 | 15                                                                                                                     | 12                 | 8         |

For products supplied in sheet of a specified length, the maximum distance between the lower face of the sheet and the flat surface table may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order.

### 7.3.6 Edge camber

The verification of edge camber does not apply to products of width less than or equal to 150 mm and products supplied with as-rolled edges.

The edge camber shall not exceed 5 mm.

## 7.4 Technological characteristics

### 7.4.1 Density

The density of the product is not specified.

The conventional value of density used to calculate the magnetic polarization shall be 7,85 kg/dm<sup>3</sup>.

Other values may be agreed between the manufacturer and the purchaser at the time of enquiry and order.

## 8 Inspection and testing

### 8.1 General

The products defined by this document can be ordered with or without specific inspection in accordance with ISO 404. However, as a dispensation from ISO 404, in the case of an order without specific inspection, the manufacturer shall supply an inspection document type 3.1 according to ISO 10474 giving the proof strength  $R_{p0,2}$  and the magnetic polarization of the supplied product.

In the case of an order with specific inspection, the type of inspection document in accordance with ISO 10474 shall be specified when ordering. In this case, the delivery is divided into acceptance units.

The acceptance units shall be adopted by special agreement between the manufacturer and the purchaser at the time of enquiry and order.

Except by special agreement, the same rules apply to the inspection of suitability of cutting, suitability of welding and tolerances on geometrical characteristics.

When the products are delivered in the form of slit coils, the test results applying to the parent coil of the acceptance unit shall apply.

## 8.2 Selection of test samples

Test samples shall be taken from each acceptance unit.

The first internal turn and the last external turn of a coil shall be considered as wrapping and not as representative of the quality of the rest of the coil. The selection shall be made from the first internal or external turns, excluding the wrapping turn and outside any welding zones or interleaves.

In the case of sheets, the selection shall be made preferably from the upper part of the bundle.

By choosing a suitable order for the execution of the tests, the same sample shall serve to verify the various properties.

## 8.3 Preparation of test specimens

### 8.3.1 Mechanical properties

For the determination of mechanical properties, the type of test specimen shall be in accordance with ISO 6892-1:

- a tensile test specimen of type 2 ( $L_0 = 80$  mm) for products with a nominal thickness less than 3 mm;
- a proportional test specimen ( $L_0 = 5,65\sqrt{S_0}$ ) with a rectangular cross-section for products with a nominal thickness equal to or greater than 3 mm.

The test specimen shall be cut perpendicular to the direction of rolling within a tolerance of  $\pm 5^\circ$ . If the width of the product is insufficient for the sample to be taken across the width, the test specimen shall be taken parallel to the direction of rolling.

### 8.3.2 Magnetic polarization

For the measurement of magnetic polarization, the type of test specimen is a function of the test method used.

For products with the nominal thickness greater than 2 mm, the test method and the test specimen may be specified by agreement between the manufacturer and the purchaser at the enquiry and order.

For products with the nominal thickness less than or equal to 2 mm, the test specimen shall consist of Epstein test strips for the 25 cm Epstein frame. The minimum number of Epstein test strips is given in Table 11.

**Table 11 – Minimum number of Epstein test strips**

| Nominal thickness $t$<br>mm | Minimum number of<br>Epstein test strips |
|-----------------------------|------------------------------------------|
| $t \leq 1,0$                | 16                                       |
| $1,0 < t \leq 1,6$          | 12                                       |
| $1,6 < t \leq 2,0$          | 8                                        |

The Epstein test strips shall have the following dimensions:

- length 280 mm to 320 mm, the lengths being equal within a tolerance of  $\pm 0,5$  mm;
- width 30 mm within a tolerance of  $\pm 0,2$  mm.