

Cold rolled electrical alloyed steel sheet and strip delivered in the semi-processed state

The European Standard EN 10165:1995 has the status of a
British Standard

ICS 29.040.10; 77.140.50

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee ISE/NFE/5, Magnetic alloys and steels, upon which the following bodies were represented:

- Association of Manufacturers Allied to the Electrical and Electronic Industry (BEAMA Ltd.)
- British Steel Industry
- Department of Trade and Industry (National Physical Laboratory)
- Electricity Supply Industry in England and Wales
- Electronic Components Industry Federation
- GAMBICA (BEAMA Ltd.)
- Institute of Physics
- Rotating Electrical Machines Association (BEAMA Ltd.)
- Sunderland Polytechnic (Magnet Centre)
- Transmission and Distribution Association (BEAMA Ltd.)
- Wolfson Centre for Magnetic Technology
- Co-opted members

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National foreword

This British Standard has been prepared by Technical Committee ISE/NFE/5 and is the English language version of EN 10165:1995, published by the European Committee for Standardization (CEN).

This British Standard supersedes BS 6404-8.2:1986 which is withdrawn.

Cross-references

Publication referred to	Corresponding British Standard
	BS 4727 <i>Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms</i> Part 1: <i>Terms common to power, telecommunications and electronics</i>
IEC 50(121):1978	Group 01:1983 <i>Fundamental terminology</i>
IEC 50(221):1990	Group 07:1991 <i>Magnetic materials and components</i>
IEC 404-1:1979	BS 6404: <i>Magnetic materials</i> Part 1:1984: <i>Classification</i>
IEC 404-2:1978	Part 2:1996 <i>Methods of measurement of magnetic, electrical and physical properties of magnetic sheet and strip</i>
IEC 404-3:1992	Part 3:1992 <i>Methods of measurement of the magnetic properties of magnetic sheet and strip by means of a single sheet tester</i>
EN 10020:1988	BS EN 10020:1991 <i>Definition and classification of grades of steel</i>
EN 10021:1993	BS EN 10021:1993 <i>General technical delivery requirements for steel and iron products</i>
EN 10027-1:1992	BS EN 10027 : <i>Designation systems for steel</i> Part 1:1992 <i>Steel names, principal symbols</i>
EN 10027-2:1992	Part 2: <i>Steel numbers</i>
EN 10204:1991	BS EN 10204:1991 <i>Metallic products. Types of inspection documents</i>
EN 10251 ^a	BS EN 10251: <i>Magnetic materials. Methods of determination of the geometrical characteristics of electrical steel sheet and strip</i> ^a

^a In preparation.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 10, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

EUROPEAN STANDARD

EN 10165

NORME EUROPÉENNE

EUROPÄISCHE NORM

December 1995

ICS 29.040.10; 77.140.50

Descriptors: Cold rolled products, metal plates, magnetic alloys, magnetic circuits, alloyed steels, delivery conditions, classifications, designation, magnetic properties, geometric characteristics, physical properties, acceptance tests, quality, tests

English version

Cold rolled electrical alloyed steel sheet and strip delivered in the semi-processed state

Tôles magnétiques en acier allié laminées à
froid et livrées à l'état semi-fini

Kaltgewalztes Elektroblech und — band aus
legierten Stählen im nicht schlußgeglühten
Zustand

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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

Foreword

This European Standard has been prepared by the Technical Committee ECISS/TC 24, Electrical steel and strip qualities — Qualities, dimensions, tolerances and specific tests, of which the secretariat is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 1996, and conflicting national standards shall be withdrawn at the latest by June 1996.

According to the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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Introduction

As the final annealing of cold rolled electrical alloyed steel sheet and strip delivered in the semi-processed state is the responsibility of the purchaser, attention is drawn to the importance of this treatment for the properties of the material.

For this reason, the magnetic properties in Table 2 are given for a reference condition obtained by suitable heat treatment. To ensure that the properties in use are equivalent to those specified, it is important that the industrial treatment carried out by the purchaser is equivalent to that used to define the reference condition (see 7.1.1).

1 Scope

This European Standard defines the grades of cold rolled electrical non-oriented alloyed¹⁾ steel sheet and strip delivered in the semi-processed condition, that is without final heat treatment, of 0,50 mm and 0,65 mm nominal thickness. It specifies general requirements, the magnetic properties, the geometric characteristics and tolerances, technological characteristics as well as the inspection procedure.

This European Standard applies to material intended for the construction of magnetic circuits.

These magnetic materials correspond to clause C.21 of IEC 404-1.

2 Normative references

This European Standard incorporates by dated or undated references, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

IEC 50 (121), *International Electrotechnical Vocabulary (IEV) — Chapter 221: Electromagnetism*.

IEC 50 (221), *International Electrotechnical Vocabulary (IEV) — Chapter 221: Magnetic materials and components*.

IEC 404-1, *Magnetic materials — Part 1: Classification*.

IEC 404-2, *Magnetic materials — Part 2: Methods of measurement of magnetic, electrical and physical properties of magnetic sheet and strip*.

IEC 404-3, *Magnetic materials — Part 3: Methods of measurement of the magnetic properties of magnetic sheet and strip by means of a single sheet tester*.

EN 10020, *Definition and classification of grades of steel*.

EN 10021, *General technical delivery requirements for steel and steel products*.

EN 10027-1, *Designation systems for steel — Part 1: Steel name principal symbols*.

EN 10027-2, *Designation systems for steel — Part 2: Numerical system*.

EN 10204, *Metallic products — Types of inspection documents*.

EN 10251, *Magnetic materials — Methods of determination of the geometrical characteristics of magnetic steel sheet and strip*.

EURONORM 118²⁾, *Methods for determination of magnetic characteristics of magnetic sheets by means of the 25 cm Epstein frame*.

3 Definitions

The definitions of the principal terms relative to magnetic properties employed in this European Standard are given in IEC 50 (121) and IEC 50 (221).

In addition, for the purposes of this European Standard, the following definitions apply:

3.1

edge camber

the greatest distance between one longitudinal edge of a length of strip and the line joining the two extremities of the measured length corresponding to this edge

3.2

flatness

the property of a sheet or a length of strip which is characterized by the wave factor i.e. the relation of the height of the wave to its length

3.3

residual curvature

the permanent curvature in the direction of rolling present in the coil in the delivery condition

¹⁾ Alloyed steel is that steel the basic constituent of which is iron containing alloying elements in amounts equal to or greater than the values fixed by EN 10020.

²⁾ Until this EURONORM is transformed into a European Standard, it can either be implemented or reference made to the corresponding national standards

4 Classification

The grades covered by this European Standard are classified according to the value of maximum specific total loss in watts per kilogram at 1,5 T and according to the nominal thickness of the material (0,50 mm or 0,65 mm).

5 Designation

5.1 For the steel grades covered by this European Standard, the steel names are allocated in accordance with EN 10027-1; the steel numbers are allocated in accordance with EN 10027-2.

5.2 The steel name comprises the following in the order given:

- 1) the letter M for electrical steel;
- 2) one hundred times the specified value of maximum specific total loss at 1,5 T and 50 Hz, in watts per kilogram and corresponding to the nominal product thickness;
- 3) one hundred times the nominal thickness of the material, in millimetres;
- 4) the characteristic letter E for alloyed electrical sheet or strip delivered in the semi-processed state.

EXAMPLE: M520-65E for electrical alloyed steel sheet or strip with a maximum specific total loss at 1,5 T of 5,20 W/kg at 50 Hz and a nominal thickness of 0,65 mm supplied in the semi-processed state.

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

The mass of bundles of sheets or of coils shall be agreed at the time of ordering.

The most usual values for internal diameter of coils are approximately 500 mm and 600 mm. The recommended value is approximately 500 mm. The external diameter shall be agreed at the time of ordering.

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

Strip shall be of constant width and wound in such a way that the edges are superimposed in a regular manner and that 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 can occasionally exhibit welds or interleaves resulting from the removal of defective zones, subject to prior agreement between the parties. If necessary, marking of welds or interleaves may be agreed at the time of ordering.

For coils containing 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 material.

6.3 Delivery condition

Material supplied with trimmed edges shall not have any burrs which will adversely affect its further application or use.

As the result of the method of manufacture and delivery in the form of coils, material may, in the delivery condition, exhibit residual curvature in the rolling direction as well as certain internal stresses. Precautions shall be taken by the user to reduce or eliminate the effect of these factors on the application or use of the material.

The material is usually supplied without an insulating coating.

6.4 Surface condition

The surfaces shall be uniform and clean. Dispersed defects such as scratches, blisters, cracks, etc., are permitted if they are within the limits of tolerance on thickness and if they are not detrimental to the correct use of the supplied material.

The surface condition and in particular the roughness of the material can be agreed at time of ordering.

6.5 Suitability for cutting

The material shall be able to be cut or punched without causing premature wear of tools; it shall be able to be cut at any point and in the usual shapes thus ensuring accurate working with the correct cutting tools. If there are special requirements with regard to a suitability test for cutting or punching, these shall be established by agreement between the manufacturer and the purchaser.

7 Technical requirements

7.1 Magnetic properties

7.1.1 Reference condition

The magnetic properties (magnetic polarization and specific total loss) only apply to test specimens in the reference condition which is obtained by the following heat treatment.

Test strips shall be subjected to a heat treatment in a decarburizing atmosphere at the temperature specified in Table 2 and shall be maintained for 2 h at this temperature. The heating rate shall not exceed 200 °C/h. The cooling rate from the temperatures specified in Table 2 to 550 °C shall not exceed 120 °C/h. The gas necessary for decarburization shall consist of 20 vol. % H₂, 80 vol. % N₂ with water vapour, the dew-point being + 20 °C at atmospheric pressure. The establishment of the decarburizing atmosphere requires the removal of air from the annealing furnace before raising the temperature. This removal is effected by continuously purging the furnace with an inert protective gas. The flow and pressure of the decarburizing gas shall be regulated to ensure good decarburization at any point on the test specimen and a complete renewal of the atmosphere in the furnace several times during the heat treatment.

It is desirable that the test strips do not have any contact with each other.

7.1.2 Magnetic polarization

The specified minimum values for the magnetic polarization for magnetic field strengths H of 2 500 A/m, 5 000 A/m and 10 000 A/m shall be as given in Table 2.

The magnetic polarization shall be determined in an alternating magnetic field (expressed as a peak value) at 50 Hz.

7.1.3 Specific total loss

The specified values of maximum specific total loss, in watts per kilogram, shall be as given in Table 2. The values of specific total loss are specified for a magnetic polarization of 1,5 T.

The test shall be made in an alternating magnetic field at 50 Hz.

Annex A gives for guidance only the maximum specific total loss for a magnetic polarization of 1,0 T at 50 Hz and for a magnetic polarization of 1,5 T at 60 Hz.

7.1.4 Anisotropy of loss and of magnetizing field

The anisotropy of loss and of magnetizing field can be the subject of special agreement between the parties when ordering.

7.2 Geometric characteristics and tolerances

7.2.1 Thickness

The nominal thicknesses of the material are 0,50 mm and 0,65 mm.

For thickness tolerance, a distinction is made between:

- the allowable tolerance on the nominal thickness within the same acceptance unit;
- the difference in thickness in a sheet or in a length strip 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 materials with a width greater than 150 mm.

The allowable tolerance on the nominal thickness within the same acceptance unit shall be $\pm 8\%$ of the nominal value. The additional thickness due to welds, with respect to the measured thickness of the steel sheet and strip, shall not exceed 0,050 mm.

The difference in thickness in a sheet or in a length of strip (see 8.3.2) in a direction parallel to the direction of rolling shall not exceed 8 % of nominal thickness.

The difference in thickness in a direction perpendicular to the direction of rolling shall not exceed 0,020 mm for the thickness 0,50 mm and 0,030 mm for the thickness of 0,65 mm. This tolerance applies only to materials with a width greater than 150 mm. For narrow strips other agreements may be reached.

7.2.2 Width

The available nominal widths are less than or equal to 1 250 mm.

For the width tolerances, a distinction is made between material supplied with edges in the as-rolled condition and material delivered with trimmed edges.

For materials supplied with trimmed edges, the tolerances of Table 1 shall apply:

Table 1 — Tolerances on nominal width

Nominal width l (mm)	Tolerance (mm)
$l \leq 150$	+ 0,2 0
$150 < l \leq 300$	+ 0,3 0
$300 < l \leq 600$	+ 0,5 0
$600 < l \leq 1\,000$	+ 1,0 0
$1\,000 < l \leq 1\,250$	+ 1,5 0

NOTE By agreement when ordering, the tolerances on the nominal width can be all minus values.

For materials supplied with as-rolled edges, the width tolerances on nominal width shall be $+5_0$ mm.

7.2.3 Length

The tolerance on length for sheets in relation to length ordered shall be $+0,5_0$ %, but with a maximum of + 6 mm.

7.2.4 Edge camber

A distinction is made between material supplied with edges in the as-rolled condition and material supplied with trimmed edges.

For material supplied with edges in the as-rolled condition the edge camber shall not exceed 6 mm over a length of 2 m.

For material supplied with trimmed edges, the edge camber shall not exceed 4 mm over a length of 2 m.

7.2.5 Flatness (wave factor)

Flatness (wave factor) is specified only for material supplied with trimmed edges. The wave factor (see 8.4.2.4), expressed as a percentage, shall not exceed 2.

7.3 Density

The density of the material is not specified.

The conventional value of density used to calculate the magnetic properties shall be as given in Table 2.

8 Inspection and testing

8.1 General

The material defined by this European Standard can be ordered with or without specific inspection in accordance with EN 10021. However, as a dispensation from EN 10021, in the case of an order without inspection, the manufacturer shall supply a certificate giving the specific total loss of the delivered material.

In the case of an order with specific inspection, the type of inspection document in accordance with EN 10204 shall be specified when ordering. In this case the delivery is divided into acceptance units.

Each acceptance unit shall comprise 20 t or the remaining fraction thereof of the same grade and the same nominal thickness. Different acceptance units can be adopted by special agreement.

8.2 Selection of samples

Test samples shall be taken from each acceptance unit.

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

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

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

8.3 Preparation of test specimens

8.3.1 Magnetic properties

For the measurement of magnetic polarization and specific total loss, the test specimen for the 25 cm Epstein frame shall consist of a minimum of 16 Epstein strips having the following dimensions:

- length 280 mm to 310 mm, the lengths being equal within a tolerance of $\pm 0,5$ mm,
- width 30 mm $\pm 0,2$ mm.

Half the test strips shall be cut parallel to the direction of rolling and the other half perpendicular, giving an even distribution across the width of the material. The test strips shall be carefully cut without deformation. The cutting or punching shall be made only with well sharpened tools.

The maximum tolerance between the direction of cutting in relation to the direction specified shall be $\pm 5^\circ$.

When the width of the material is insufficient for a sample of test strips to be taken across the width, the test strips shall be taken in the direction of rolling only.

8.3.2 Geometrical characteristics and tolerances

For the measurement of thickness, width, flatness, and edge camber, the test specimen shall consist of a sheet or a 2 m length of strip.

8.4 Test methods

For each specified property one test shall be carried out per acceptance unit. Unless otherwise specified, the test shall be made at a temperature of $(23 \pm 5)^\circ\text{C}$ and in the as-delivered condition, with the exception of magnetic properties which shall be determined after a reference heat treatment.

8.4.1 Magnetic properties

The test shall be made using a 25 cm Epstein frame in accordance with EURONORM 118.

NOTE As an alternative to the Epstein method, the single sheet tester described in IEC 404-3 may be used by agreement between the supplier and purchaser. In this case, the specified values to be obtained with the single sheet tester may also be subject to agreement.

Table 2 — Technological and magnetic properties

Designation according to		Nominal thickness (mm)	Reference heat treatment temperature (°C) (± 10 °C)	Maximum specific total loss ^a (W/kg) at 50 Hz at 1,5 T	Minimum magnetic polarization (T) in an alternating magnetic field for a magnetic field strength ^{ab} (A/m)			Conventional density (kg/dm ³)
EN 10027-1	EN 10027-2				2 500	5 000	10 000	
M340-50E	1.0841	0.50	840	3.40	1.54	1.62	1.72	7.65
M390-50E	1.0842		840	3.90	1.56	1.64	1.74	7.70
M450-50E	1.0843		790	4.50	1.57	1.65	1.75	7.75
M560-50E	1.0844		790	5.60	1.58	1.66	1.76	7.80
M390-65E	1.0846		840	3.90	1.54	1.62	1.72	7.65
M450-65E	1.0847		840	4.50	1.56	1.64	1.74	7.70
M520-65E	1.0848		790	5.20	1.57	1.65	1.75	7.75
M630-65E	1.0849		790	6.30	1.58	1.66	1.76	7.80

^aThese values are valid only for test specimens in the reference condition (see 7.1.1)

^bIt 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:

$$J = B - \mu_0 H$$

where

J = magnetic polarization

B = magnetic flux density

μ_0 = magnetic constant: $4 \pi \cdot 10^{-7} \text{ H m}^{-1}$

H = magnetic field strength

in accordance with IEC 50(121).

8.4.2 Geometrical characteristics and tolerances

8.4.2.1 Thickness

The measurement of thickness shall be made using a micrometer with a resolution of 0,001 mm.

For wide material, the measurements shall be made at least 40 mm from trimmed edges and at least 50 mm from edges in the as-rolled conditions. For narrow strips, special agreements can be made when ordering.

8.4.2.2 Width

The width shall be measured perpendicular to the longitudinal axis of the product.

8.4.2.3 Edge camber

The edge camber shall be determined in accordance with EN 10251.

8.4.2.4 Flatness (wave factor)

The wave factor shall be determined in accordance with EN 10251. Only complete waves shall be taken into account and during this determination, the residual curvature shall not be taken into account.

8.5 Retests

When a test does not give the specified result, this test shall be repeated on double the number of test specimens from other sheets of the acceptance unit or on other strips from the coils. The delivery shall be considered to conform with the order if all results of additional tests are in accordance with the requirement of this standard.

After re-treatment, the manufacturer has the right to present again for test acceptance units which had not been found to comply with the order.

9 Marking, labelling and packaging

Marking, labelling and packaging of the products may be agreed at the time of ordering.

10 Complaints

Internal or external defects shall justify a complaint only if they are clearly prejudicial to the method of working or the judicious use of the material.

The purchaser shall give to the manufacturer the opportunity of convincing himself of the fairness of the claim by presenting the material in dispute and evidence for the complaint.

In all cases, the terms and conditions of complaints shall be made in accordance with EN 10021.

11 Information to be supplied by the purchaser

For materials to comply adequately with the requirements of this standard, the purchaser shall include the following information in his enquiry or order:

- a) quantity;
- b) type of product (strip or sheet);
- c) number of this European Standard (EN 10165);
- d) name or number of the steel grade (see 5.1);
- e) dimensions of sheets or strip required (including any limitations on the external diameter of a coil) (see 6.2 and 7.2.2);
- f) any limitation on the mass of a bundle of sheets or of a coil (see 6.2);
- g) any special requirements for marking of welds or interleaves (see 6.2);
- h) any special requirement concerning the surface finish (see 6.4);
- i) the inspection procedure required including the nature of the related documents (see 8.1);
- j) any special requirement about single sheet testing (see 8.4.1).

Annex A (informative)

Non-specified magnetic properties

Designation according to		Maximum specific total loss W/kg	
EN 10027-1	EN 10027-2	1,0 T at 50 Hz	1,5 T at 60 Hz
M340-50E	1.0841	1,42	4,32
M390-50E	1.0842	1,62	4,97
M450-50E	1.0843	1,92	5,67
M560-50E	1.0844	2,42	7,03
M390-65E	1.0846	1,62	5,07
M450-65E	1.0847	1,92	5,86
M520-65E	1.0848	2,22	6,72
M630-65E	1.0849	2,72	8,0

List of references

See national foreword.

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