BS EN 10107:2014

BSI Standards Publication

Grain-oriented electrical steel strip and sheet delivered in the fully processed state

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National foreword

This British Standard is the UK implementation of EN 10107:2014. It supersedes BS EN 10107:2005 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/108, Magnetic Alloys and Steels.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Grain-oriented electrical steel strip and sheet delivered in the fully processed state

Bandes et tôles magnétiques en acier à grains orientés livrées à l'état fini

Kornorientiertes Elektroband und -blech im schlussgeglühten Zustand

This European Standard was approved by CEN on 6 February 2014.

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Foreword

This document (EN 10107:2014) has been prepared by Technical Committee ECISS/TC 108 “Steel sheet and strip for electrical applications”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by September 2014 and conflicting national standards shall be withdrawn at the latest by September 2014.

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This document supersedes EN 10107:2005.

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1 Scope

This European Standard defines the steel grades of grain-oriented electrical strip and sheet in nominal thicknesses of 0,23 mm, 0,27 mm, 0,30 mm and 0,35 mm and specifies in particular, general requirements, magnetic properties, geometric characteristics and tolerances and technological characteristics, as well as inspection procedures.

This European Standard applies to Goss textured grain-oriented electrical strip and sheet supplied in the final annealed condition in sheets or coils, and intended for the construction of magnetic circuits.

The materials are grouped into two classes:

a) conventional grain oriented material;

b) high permeability grain oriented material.

They correspond to Clause C.22 of IEC 60404-1:2000.

2 Normative references

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

EN 10021, *General technical delivery conditions for steel products*

EN 10027-1, *Designation systems for steel — Part 1: Steel names*

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

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

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

EN 10280, *Magnetic materials — Methods of measurement of the magnetic properties of electrical sheet and strip by means of a single sheet tester*

EN 10282:2001, *Magnetic materials — Method of test for the determination of surface insulation resistance of electrical sheet and strip*

EN 10342, *Magnetic materials — Classification of surface insulations of electrical steel sheet, strip and laminations*

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

EN 60404-11:2013, *Magnetic materials — Part 11: method of test for the determination of surface insulation resistance of magnetic sheet and strip*

EN 60404-13, *Magnetic materials — Part 13: Methods of measurement of density, resistivity and stacking factor of electrical steel sheet and strip (IEC 60404-13)*

EN ISO 7799:2000, *Metallic materials — Sheet and strip 3 mm thick or less — Reverse bend test (ISO 7799:1985)*

IEC 60050-121:1998, *International Electrotechnical Vocabulary — Chapter 121: Electromagnetism*

IEC 60050-221:1990, *International Electrotechnical Vocabulary — Chapter 221: Magnetic materials and components*

IEC 60404-3, *Magnetic materials — Part 3: Methods of measurement of the magnetic properties of electrical steel strip and sheet by means of a single sheet tester*

3 Terms and definitions

For the purposes of this document, the terms and definitions of the principal terms relating to magnetic properties given in IEC 60050-121:1998 and IEC 60050-221:1990 and the following apply.

3.1
edge camber
greatest distance between a longitudinal edge of the sheet and the line joining the two extremities of the measured length of this edge

3.2
flatness
property of a sheet or of a length of strip which is characterised by the wave factor i.e. by the relation of the height of the wave to its length

3.3
number of bends
number of alternate bends possible before the appearance of the first crack in the base metal visible to the naked eye indicating the ductility of the material

3.4
internal stresses
stresses which are characterised by a deviation in relation to the line of cutting

4 Classification and designation

4.1 Classification

The steel grades covered by this European Standard are classified according to the value of maximum specific total loss in watts per kilogram and according to the nominal thickness of the material (0,23 mm; 0,27 mm; 0,30 mm; 0,35 mm).

4.2 Designation

4.2.1 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.

4.2.2 The steel names comprise the following in the order given:

a) capital letter M for electrical steel;

b) a number of one hundred times the specified value of maximum specific total loss at 1,7 T and 50 Hz, in watts per kilogram corresponding to the nominal product thickness;

c) one hundred times the nominal thickness of the product, in millimetres;

d) the characteristic letter:

   — S for conventional grain oriented products;

— P for high permeability grain oriented products.

EXAMPLE M140-30S for conventional grain oriented electrical steel strip or sheet with a maximum specific total loss of 1,40 W/kg at 1,7 T , 50 Hz and a nominal thickness of 0,30 mm, supplied in the fully processed state.

5 Information to be supplied by the purchaser

5.1 Mandatory information

For material 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 10107);

d) steel name or number (see 4.2.1);

e) dimensions of sheets or strips required (including any limitations on the external diameter of a coil) (see 6.2 and 7.2.2);

f) limitations on the mass of a bundle of sheets or of a coil (see 6.2);

g) residual curvature for coils (see 7.2.6);

h) inspection procedure required including the nature of the related documents (see 8.1).

5.2 Options

A number of options are specified in this standard and listed below. If the purchaser does not indicate his wish to implement one of these options, the products shall be supplied in accordance with the basis specification of this standard (see 5.1).

1) permissibility of welds and its marking (see 6.2);

2) compatibility between fluid and coating (see 6.4);

3) plus tolerances for nominal width (see Table 3, footnote a);

4) requirement concerning residual curvature (see 7.2.6);

5) acceptance unit other than 3 t (see 8.1);

6) test temperature other than (23 ± 5) °C (see 8.4.1);

7) alternative method for determination of magnetic properties (see 8.4.2);

8) marking of the products (see Clause 9);

9) requirement concerning the minimum insulation coating resistance (see 7.3.5).

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 coils in the case of strip and bundles in the case of sheets.

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

The recommended value for the internal diameter of coils is approximately 508 mm.

Strip shall be of constant width and wound in such a manner 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 so that they do not collapse under their own weight.

Strip may exhibit welds resulting from the removal of defective zones if agreed at the time of enquiry and order. If necessary the marking of welds may be agreed at the time of enquiry and order.

For coils containing welds, 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.

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

6.3 Delivery condition

Cold rolled grain oriented electrical steel is usually supplied with an insulating coating on both sides. This coating generally consists of an EC-5-G coating on an EC-2 coating in accordance with EN 10342[1)].

6.4 Surface condition

The surfaces shall be smooth and clean, free from grease and rust [2)]. Dispersed defects such as scratches, blisters, cracks, etc., are 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 material.

The insulation coating present on the surface of the material shall be sufficiently adherent so that it does not become detached during cutting operations or heat treatment under conditions specified by the supplier.

If the product is to be immersed in a fluid, an agreement, initiated by the purchaser, should be reached to ensure compatibility between the fluid and the coating.

6.5 Suitability for cutting

The material shall be suitable for cutting accurately into the usual shapes at any point when appropriate cutting tools are used.

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1) Other types of coating exist which are used only when particularly specified.

2) Not to be confused with some colouration of the insulating coating inherent in the manufacturing process.

7 Technical requirements

7.1 Magnetic properties

7.1.1 General

The properties defined in 7.1.2 and 7.1.3 are applicable to materials in the delivery conditions defined in 6.3.

7.1.2 Magnetic polarization

The specified minimum values of the magnetic polarization determined for an alternating magnetic field strength of 800 A/m (peak value) at 50 Hz, shall be as given in Tables 1 and 2.

7.1.3 Specific total loss

The specified values of maximum specific total loss at 50 Hz shall be as given in Tables 1 and 2. They apply to test specimens cut parallel to the axis of rolling and reflect the aged condition. In the case of Epstein strips, they shall receive, after cutting, a stress relief heat treatment under conditions left to the discretion of the manufacturer.

NOTE A stress relief heat treatment is not normally applied to single sheet test specimens.

Annex A gives, for guidance, the maximum specific total loss at 60 Hz for a magnetic polarization of 1,7 T.

Table 1 — Technological and magnetic properties of conventional products

Steel grade		Nominal thickness	Maximum specific total loss [W/kg] at 50 Hz and		Minimum magnetic polarization[a] for H = 800 A/m	Minimum stacking factor
Steel name	Steel number	mm	1,5 T	1,7 T	T	
M110-23S	1.0863	0,23	0,73	1,10	1,78	0,945
M120-23S	1.0864	0,23	0,77	1,20	1,78	0,945
M127-23S	1.0860	0,23	0,80	1,27	1,75	0,945
M120-27S	1.0868	0,27	0,80	1,20	1,78	0,950
M130-27S	1.0866	0,27	0,85	1,30	1,78	0,950
M140-27S	1.0865	0,27	0,89	1,40	1,75	0,950
M120-30S	1.9858	0,30	0,83	1,20	1,78	0,955
M130-30S	1.0859	0,30	0,85	1,30	1,78	0,955
M140-30S	1.0862	0,30	0,92	1,40	1,78	0,955
M150-30S	1.0861	0,30	0,97	1,50	1,75	0,955
M135-35S	1.9854	0,35	0,97	1,35	1,78	0,960
M145-35S	1.9855	0,35	1,03	1,45	1,78	0,960
M155-35S	1.9856	0,35	1,07	1,55	1,78	0,960
M165-35S	1.0856	0,35	1,11	1,65	1,75	0,960

[a] 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:

$$J = B - \mu_0 H$$

where

J is the magnetic polarization;

B is the magnetic flux density;

μ_0 is the magnetic constant: $4\ \pi\ x10^{-7}$ H m^{-1};

H is the magnetic field strength.

NOTE The difference between B and J at 800 A/m amounts up to 0,001 T.

Table 2 — Technological and magnetic properties of high permeability products

Steel grade		Nominal thickness	Maximum specific total loss [W/kg] at 50 Hz and 1,7 T	Minimum magnetic polarization[a] for H = 800 A/m T	Minimum stacking factor
Steel name	Steel number	mm			
M85-23P[b]	1.0822	0,23	0,85	1,88	0,945
M90-23P[b]	1.0835	0,23	0,90	1,88	0,945
M95-23P	1.0836	0,23	0,95	1,88	0,945
M100-23P	1.0879	0,23	1,00	1,85	0,945
M90-27P[b]	1.0838	0,27	0,90	1,88	0,950
M95-27P[b]	1.0839	0,27	0,95	1,88	0,950
M100-27P	1.9840	0,27	1,00	1,88	0,950
M110-27P	1.9841	0,27	1,10	1,88	0,950
M100-30P[b]	1.0852	0,30	1,00	1,88	0,955
M105-30P	1.0886	0,30	1,05	1,88	0,955
M110-30P	1.9887	0,30	1,10	1,88	0,955
M115-35P	1.0855	0,35	1,15	1,88	0,960
M125-35P	1.0854	0,35	1,25	1,88	0,960

[a] 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:

$$J = B - \mu_0 H$$

where

J magnetic polarization;

B magnetic flux density;

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

H magnetic field strength;

NOTE The difference between B and J at 800 A/m amounts up to 0,001 T.

[b] This grade may be delivered in the domain refined condition.

7.2 Geometric characteristics and tolerances

7.2.1 Thickness

The nominal thicknesses of the material are 0,23 mm; 0,27 mm; 0,30 mm and 0,35 mm.

For thickness tolerance, a distinction is made between:

a) the allowable tolerance on the nominal thickness within the same acceptance unit;

b) the difference in thickness in a sheet or in a length of strip in a direction parallel to the direction of rolling;

c) 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.

At any point, the allowable tolerance on the nominal thickness within the same acceptance unit shall not exceed ± 0,030 mm except for the 0,23 mm thickness for which this tolerance shall not exceed ± 0,025 mm. The additional thickness due to welds with respect to the measured thickness of the steel strip or sheet shall not exceed 0,050 mm.

The difference in thickness in a sheet or in a length of strip of 1,5 m in a direction parallel to the direction of rolling shall not exceed 0,030 mm.

In addition, for material with a width greater than 150 mm, the difference in thickness in a direction perpendicular to the direction of rolling shall not exceed 0,020 mm, the measurements being made at least 40 mm from the edges.

7.2.2 Width

The available nominal widths are ≤ 1 000 mm.

The material can be supplied either in a width chosen from the specific range of the manufacturer, or in the finally used width.

Width tolerances:

a) for material supplied in a width selected from the specific range of the manufacturer, the tolerances permitted shall be $\binom{+2}{0}$ mm,

b) for material supplied in the finally used width, the tolerances of Table 3 shall apply.

Table 3 — Tolerances on nominal width

Dimensions in millimetres

Nominal width *l*	Tolerance[a]
l ≤ 150	0 - 0,2
150 < *l* ≤ 400	0 - 0,3
400 < *l* ≤ 750	0 - 0,5
l > 750	0 - 0,6
[a] By agreement at the time of enquiry and order, the tolerances on the nominal width can be all positive.	

7.2.3 Length

The tolerances on the length of sheets in relation to the length ordered shall be $^{+0,5}_{0}$ %, but with a maximum of + 6 mm.

7.2.4 Edge camber

The verification of edge camber does not apply to material of width less than or equal to 150 mm. The edge camber shall not exceed 0,5 mm for a measuring length of 1,5 m.

7.2.5 Flatness (wave factor)

The verification of the flatness does not apply to material of width less than or equal to 150 mm. The wave factor (see 8.4.3.4), expressed as a percentage, shall not exceed 1,5 %.

7.2.6 Residual curvature

A requirement concerning residual curvature may be specified by agreement when ordering, for material of width greater than 150 mm.

In this case, the distance between the bottom edge of the test piece and the supporting plate shall not exceed 35 mm for sheets and shall be subject to agreement for coils.

7.2.7 Burr height

The determination of the burr height applies only to material delivered in the width in which it will finally be used. The measured burr height shall not exceed 0,025 mm.

7.3 Technological characteristics

7.3.1 Density

The density of the material is not specified.

The conventional value of density used to calculate the magnetic properties and the stacking factor shall be 7,65 kg/dm^3.

7.3.2 Stacking factor

The minimum values shall be as specified in Tables 1 and 2.

7.3.3 Number of bends

The specified minimum number of bends is 1. This value applies to test specimens cut parallel to the direction of rolling.

7.3.4 Internal stresses

The material shall be, as far as possible, free from internal stresses.

The verification of internal stress is not applicable to material of width less than 500 mm (slit material). The measured gap shall not exceed 1 mm (see 8.3.3.3).

7.3.5 Insulation coating resistance

The measured insulation coating resistance, representing the surface resistance offered to the passage of current across the coating, shall be not less than 500 Ωmm²/side (5 Ωcm²/side) and may be agreed at time of enquiry and order (see 5.2, Option 9).

8 Inspection and testing

8.1 General

The materials specified by this European Standard can be ordered with non-specific or 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 supplied material.

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

Each acceptance unit shall comprise 3,0 t or the remaining fraction thereof of the same grade and the same nominal thickness. Different acceptance units may be adopted by special agreement.

For coils of more than 3,0 t, each coil shall constitute an acceptance unit.

Except by special agreement the same rules apply to the inspection of internal stresses, suitability for cutting, surface insulation resistance and tolerances of shape and dimensions.

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

8.2 Sampling

Test samples shall be taken from each acceptance unit.

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

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

By choosing a suitable order for the execution of the 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 in accordance with EN 60404-2 shall consist of a minimum of 24 Epstein strips having the following dimensions:

a) length 280 mm to 320 mm, the lengths being equal within a tolerance of ± 0,5 mm;

b) width 30 mm ± 0,2 mm.

All the test strips shall be cut parallel to the direction of rolling. The permitted tolerance for the angle between the direction of rolling and the direction of cutting is ± 1°.

As far as possible, the selection of test strips shall be made uniformly across the width of the product. The test strips shall be carefully cut without deformation. Cutting or punching shall be carried out only with well sharpened tools.

Before the measurements, the test strips shall be subjected to a stress relief heat treatment in accordance with the manufacturer's specification.

In the case of measurements of specific total loss on aged test pieces, these shall be heated at 225 °C ± 5 °C for a duration of 24 h and shall be cooled to ambient temperature.

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 length of strip of about 1,5 m.

For the measurement of the residual curvature, the test specimen shall consist of a sample of (500 $^{+2,5}_{0}$) mm in length and of width equal to the delivery width of the sheet or strip.

8.3.3 Technological characteristics

8.3.3.1 Stacking factor

The test specimen shall consist of a least 24 strips of the same size; in case of dispute the test shall be made with 100 strips. They shall have a width of at least 20 mm and a surface area of at least 5 000 mm^2, their widths being equal within a tolerance of ± 0,1 mm as well as their lengths. The test strips shall be carefully deburred before the test.

8.3.3.2 Number of bends

Five test specimens at least 20 mm wide shall be taken from outside the welding zones, parallel to the direction of rolling, with a view to making the bend perpendicular to the direction of rolling. The edge of the material shall not constitute one side of the test specimen.

The test specimens shall be carefully cut without deformation.

8.3.3.3 Internal stresses

The test specimen shall consist of a sheet or 1,5 m length of strip.

8.3.3.4 Insulation coating resistance

For products ≥ 600 mm width, four strips shall be selected over the whole width of the material. The width of each strip depends on the method to be used, e.g. 50 mm for the test method in accordance with EN 10282:2001 or EN 60404-11:2013.

For products less than 600 mm wide, the selection for inspection of insulation coating resistance, shall be agreed at the time of enquiry and order.

8.4 Test methods

8.4.1 General

For each specified property one test shall be carried out per acceptance unit. Unless otherwise specified, the tests shall be made at a temperature of (23 ± 5) °C.

8.4.2 Magnetic properties

The test shall be made using a 25 cm Epstein frame in accordance with EN 60404-2.

In the case of some domain-refined material (see Table 2, footnote b), the test shall be made according to the single sheet method of EN 10280 or IEC 60404-3 according to the instructions of the manufacturer. The single sheet test specimen is not heat treated.

As an alternative to the Epstein Method, the single sheet tester described in EN 10280 or IEC 60404-3 can be used by agreement between the manufacturer and purchaser. In this case, the specified values to be obtained with the single sheet tester should also be agreed.

8.4.3 Geometrical characteristics and tolerances

8.4.3.1 Thickness

The measurement of thickness shall be made at any point located more than 40 mm from the edges. For materials of a width less than 80 mm, the measurement of thickness shall be made along the longitudinal axis of the sheet. This measurement shall be made using a micrometre with a resolution of 0,001 mm.

8.4.3.2 Width

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

8.4.3.3 Edge camber

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

8.4.3.4 Flatness (wave factor)

The wave factor shall be determined in accordance with EN 10251.

8.4.3.5 Residual curvature

The residual curvature in the longitudinal direction of the strip shall be determined in accordance with EN 10251.

8.4.3.6 Burr height

The burr height shall be determined in accordance with EN 10251.

8.4.4 Technological characteristics

8.4.4.1 Stacking factor

The stacking factor shall be measured in accordance with EN 60404-13.

8.4.4.2 Number of bends

The test consists of bending the test specimen through 90° alternately to each side of its initial position, following the method of bending defined by EN ISO 7799:2000. The radius of bending chosen shall be 5 mm.

A bend of 90° from the initial position with return to the initial position counts as one bend.

The test shall be stopped on the appearance in the base metal of the first crack visible to the naked eye. The last bend shall not be counted.

8.4.4.3 Internal stresses

The internal stresses shall be determined in accordance with EN 10251.

8.4.4.4 Insulation coating resistance

The measurement of the surface insulation resistance shall be according to Method A of EN 10282:2001 or to Method A of EN 60404-11:2013.

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 requirements 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 enquiry and order.

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 in accordance with EN 10021.

Annex A
(informative)

Maximum specific total loss at 60 Hz and 1,7 T

Table A.1 — Maximum specific total loss at 60 Hz and 1,7 T

Steel grade		Maximum specific total loss at 60 Hz and 1,7 T [W/kg]
Steel name	Steel number	
to Table 1		
M110-23S	1.0863	1,45
M120-23S	1.0864	1,58
M127-23S	1.0860	1,67
M120-27S	1.0868	1,58
M130-27S	1.0866	1,71
M140-27S	1.0865	1,84
M120-30S	1.9858	1,58
M130-30S	1.0859	1,71
M140-30S	1.0862	1,84
M150-30S	1.0861	1,97
M135-35S	1.9854	1,78
M145-35S	1.9855	1,91
M155-35S	1.9856	2,04
M165-35S	1.0856	2,17
to Table 2		
M85-23P	1.0822	1,12
M90-23P	1.0835	1,18
M95-23P	1.0836	1,25
M100-23P	1.0879	1,32
M90-27P	1.0838	1,18
M95-27P	1.0839	1,25
M100-27P	1.9840	1,32
M110-27P	1.9841	1,45
M100-30P	1.0852	1,32
M105-30P	1.0886	1,38
M110-30P	1.9887	1,45
M115-35P	1.0855	1,51
M125-35P	1.0854	1,65

Bibliography

[1] IEC 60404-1:2000, *Magnetic materials — Part 1: Classification*

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