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INTERNATIONAL STANDARD

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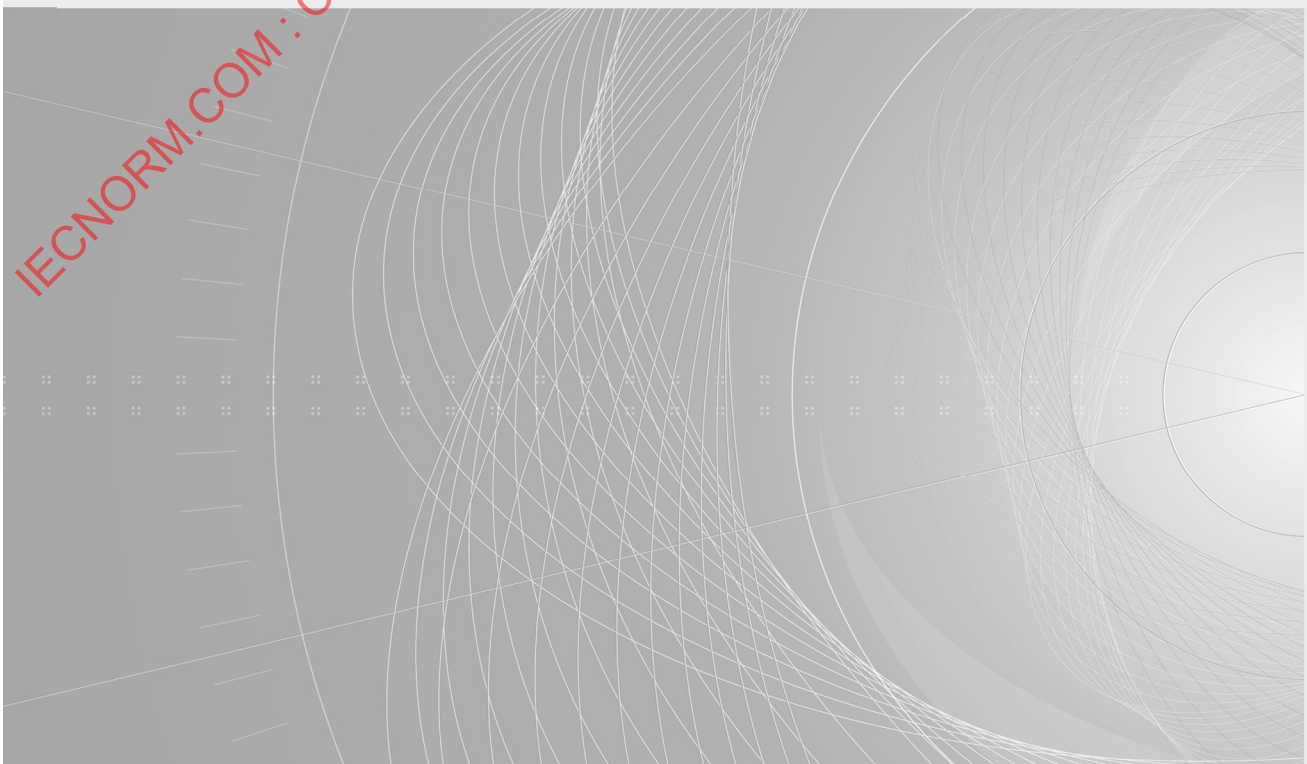
Magnetic materials –
Part 1-1: Classification – Surface insulations of electrical steel ~~sheet, strip~~ strip, sheet and laminations



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International Standard IEC 60404-1-1 has been prepared by IEC technical committee 68: Magnetic alloys and steels.

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MAGNETIC MATERIALS –

Part 1-1: Classification – Surface insulations of electrical steel ~~sheet, strip~~ strip, sheet and laminations

1 Scope

This part of IEC 60404 establishes a classification of surface insulations for electrical steel ~~sheet, strip~~ strip, sheet and laminations according to their general composition, relative insulating ability and function.

These surface insulations are either oxide layers or applied coatings.

The purpose of this classification is to create a nomenclature for the various types of surface insulations and to assist users of surface insulations by providing general information about the chemical nature and use of the surface insulations.

It is not the intent of this classification to specify insulation requirements in terms of specific values of surface insulation resistance. Such requirements are agreed between the purchaser and the steel producer, where applicable.

The classification is used in conjunction with the various specifications for cold rolled electrical steels (see the standards in the IEC 60404-8 series in Clause 2).

2 Normative references

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

IEC 60050 (221), *International Electrotechnical Vocabulary (IEV) - Chapter 221: Magnetic materials and components*

~~IEC 60404-8-2:1998, *Magnetic materials – Part 8-2: Specifications for individual materials – Cold-rolled electrical alloyed steel sheet and strip delivered in the semi-processed state*~~

IEC 60404-8-3~~:1998~~, *Magnetic materials – Part 8-3: Specifications for individual materials – Cold-rolled ~~electrical non-alloyed steel sheet and strip~~ non-oriented electrical steel strip and sheet delivered in the semi-processed state*

IEC 60404-8-4~~:1998~~, *Magnetic materials – Part 8-4: Specifications for individual materials – Cold-rolled non-oriented electrical steel ~~sheet and strip~~ strip and sheet delivered in the fully-processed state*

IEC 60404-8-5~~:1989~~, *Magnetic materials – Part 8-5: Specifications for individual materials – ~~Specification for steel sheet and strip with specified mechanical properties and magnetic permeability~~ Electrical steel strip and sheet with specified mechanical properties and magnetic polarization*

IEC 60404-8-7~~:1998~~, *Magnetic materials – Part 8-7: Specifications for individual materials – Cold-rolled grain-oriented electrical steel ~~sheet and strip~~ strip and sheet delivered in the fully-processed state*

IEC 60404-8-8~~:1991~~, *Magnetic materials – Part 8-8: Specifications for individual materials – ~~Specification for thin magnetic steel strip for use at medium frequencies~~ Thin electrical steel strip and sheet for use at medium frequencies*

IEC 60404-11~~:1999~~, *Magnetic materials – Part 11: ~~Method of test for the determination of surface insulation resistance of magnetic sheet and strip~~ Methods of measurement of the surface insulation resistance of electrical steel strip and sheet*

3 Terms and definitions

For the purposes of this document, the terms and definitions ~~of the principal terms~~ given in IEC 60050~~(~~-221~~)~~ ~~and in IEC 60404-8-2,~~ and in IEC 60404-8-3, IEC 60404-8-4, IEC 60404-8-5, IEC 60404-8-7, IEC 60404-8-8 and IEC 60404-11 apply.

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4 Classification of surface insulations of electrical steel ~~sheet, strip~~ strip, sheet and laminations

Table 1 gives the classification of surface insulations of electrical steel ~~sheet, strip~~ strip, sheet and laminations.

Table 1 – Classification of surface insulations of electrical steel ~~sheet, strip~~ strip, sheet and laminations

Insulation designation	Insulation description – Characteristics – Typical application, limits of use
EC-0	An oxide layer that is formed naturally on the steel surface during electrical steel manufacture. This oxide layer is thin, tightly adherent and provides sufficient surface insulation resistance for many types of small cores. This oxide layer will withstand normal stress relief annealing temperatures. If subjected to a user's anneal after stamping, the surface insulation resistance of this oxide layer may be affected by the oxidizing potential of the anneal. It is not appropriate to specify the surface insulation resistance for this type of insulation
EC-1	An oxide layer that is created on the surface of the steel laminations by contact with an oxidizing furnace atmosphere at the end of the heat treatment cycle following the stamping of the laminations. This oxide layer is usually bluish to grey in colour. This oxide layer is primarily relevant to steel ~~sheet, strip~~ strip, sheet and laminations in the semi-processed state. It is not appropriate to specify the surface insulation resistance for this type of insulation
EC-2	An inorganic insulation coating predominantly comprised of magnesium silicate. This type of coating is formed on the surface of grain oriented electrical steel by the reaction of the annealing separator with the steel surface during high temperature annealing. This type of coating is often referred to as "mill glass" or "glass", even though the coating is not technically a glass. This type of coating is very abrasive. Steels coated with this type of coating only are not typically used for stamped laminations. The primary application of this type of coating is for materials used in wound core transformers.

	This type of coating will withstand normal stress relief annealing temperatures. It is not appropriate to specify the surface insulation resistance for this type of coating
EC-3	An organic varnish/enamel coating that is applied to the steel surface. This type of coating is preferably used for fully processed non-oriented electrical steels. This type of coating generally improves the punchability[b] of the steel and, hence, is quite suitable for the production of stamped laminations. This type of coating may adversely affect weldability[b] and will not withstand normal stress relief annealing temperatures. The coating is normally suitable for operating temperatures up to about 180 °C. The user should take into account any problems due to coating off-gassing during welding or exposure of the steel coated with this type of coating to elevated temperatures. It may be appropriate to specify the surface insulation resistance[a] of this type of coating
EC-3-B	An EC-3 coating, usually applied by the steel manufacturer, having a self-bonding function used for bonding of stacks of stamped laminations. This type of coating, applied on the steel strip or sheet surface, is in a reactive state in the as-delivered condition of the steel. It turns into a fully cured state, bonding adjacent laminations in a stack and no longer reactive, after applying a pressure to the stack at an elevated temperature for a certain time[c]. This type of coating can be applied on top of other types of coating, e.g. EC-5 or EC-6.
EC-4	A coating formed by phosphating or some other chemical treatment of the steel surface followed by a curing treatment at elevated temperature. This type of coating is used in applications requiring moderate levels of surface insulation resistance. This type of coating will withstand normal stress relief annealing temperatures but some reduction of the surface insulation resistance may result. It may be appropriate to specify the surface insulation resistance[a] of this type of coating before stress relief annealing
EC-4-AS	A thinner EC-4 coating primarily used for preventing sticking during heat treatment of electrical steel laminations. This type of coating is often referred to as "anti-stick". It is not appropriate to specify the surface insulation resistance or the thickness[b] of this type of coating
EC-5	A class of inorganic or mostly inorganic coatings similar to EC-4 coating to which ceramic fillers and/or film forming inorganic components have been added to increase the quality of the surface insulation of the coating. This class consists of four coatings: EC-5-G, EC-5-N, EC-5-P and EC-5-AS
EC-5-G	An EC-5 coating specific to grain oriented electrical steel. This type of coating is generally phosphate or silicate based. This type of coating is normally applied on top of an EC-2 coating where increased surface insulation resistance is required, e.g. sheared laminations of grain oriented electrical steels for cores of power transformers. The coating will withstand a stress relief annealing treatment at temperatures up to 845 °C. In some cases, the EC-5-G coating is applied directly to the surface of grain oriented steel without the EC-2 interface, but then there may be some reduction in the surface insulation resistance. It may be appropriate to specify the surface insulation resistance[a] of this type of coating
EC-5-N	An EC-5 coating specific to non-oriented electrical steels. The coating will withstand normal stress relief annealing temperatures but some reduction of surface insulation resistance may result. The coating will withstand burn-off treatments in the temperature range from 300 °C to 550 °C, used to remove stator winding insulation during rebuilding of stator cores. The user should take into account any problems due to coating decomposition or off-gassing during welding or exposure of steel coated with this type of coating to elevated temperatures. It may be appropriate to specify the surface insulation resistance[a] of this type of coating before stress relief annealing

EC-5-P	An EC-5 coating to which organic components have been added to enhance punchability[b]. The ceramic fillers in EC-5 coatings may have been reduced or removed. The applications, uses and properties of this type of coating are similar to those of the EC-5-G and EC-5-N coatings. On grain oriented electrical steels, this type of coating is generally used for punching quality without an EC-2 coating when it may not have such a high surface insulation resistance as an EC-5-G coating can achieve. The user should take into account any problems due to coating decomposition or off-gassing during welding or exposure of the steel coated with this type of coating to elevated temperatures. It may be appropriate to specify the surface insulation resistance[a] of this type of coating
EC-5-AS	A thinner EC-5-N or EC-5-P coating primarily used for preventing sticking during heat treatment of electrical steel laminations. This type of coating is often referred to as "anti-stick". It is not appropriate to specify the surface insulation resistance or the thickness[b] of this type of coating
EC-6	An organic-based coating to which inorganic fillers have been added to increase the surface insulation resistance of the coating. This type of coating is typically used for fully processed non-oriented electrical steels, especially for application in large diameter rotating machines such as power station generators. The coating generally improves the punchability[b] of the steel and, hence, is suitable for the production of stamped laminations. The coating will withstand burn-off treatments in the temperature range from 300 °C to 550 °C, used to remove stator winding insulation during rebuilding of stator cores but it is not considered to be a coating that will withstand normal stress relief annealing temperatures. The user should take into account any problems due to coating decomposition or off-gassing during welding or exposure of the steel coated with this type of coating to elevated temperatures. It may be appropriate to specify the surface insulation resistance[a] of this type of coating

[a] The surface insulation resistance should be determined according to IEC 60404-11. A requirement for the surface insulation resistance may be agreed between the steel producer and the purchaser.

[b] Any requirement for this property and the corresponding method of evaluation should be agreed between the steel producer and the purchaser.

[c] Methods for assessing the properties and quality of the coating in the as-delivered, active, state and the fully cured, bonded state, can be agreed between the manufacturer and the purchaser. This includes the proper bonding process.

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IEC 60404-8-5, *Magnetic materials – Part 8-5: Specifications for individual materials – Electrical steel strip and sheet with specified mechanical properties and magnetic polarization*

IEC 60404-8-7, *Magnetic materials – Part 8-7: Specifications for individual materials – Cold-rolled grain-oriented electrical steel strip and sheet delivered in the fully-processed state*

IEC 60404-8-8, *Magnetic materials – Part 8-8: Specifications for individual materials – Thin electrical steel strip and sheet for use at medium frequencies*

IEC 60404-11, *Magnetic materials – Part 11: Methods of measurement of the surface insulation resistance of electrical steel strip and sheet*

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