BS EN 10209:2013

BSI Standards Publication

Cold rolled low carbon steel flat products for vitreous enamelling — Technical delivery conditions

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National foreword

This British Standard is the UK implementation of EN 10209:2013. It supersedes BS EN 10209:1996 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/109, Coated and Uncoated Flat Products to be Used for Cold Forming.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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English Version

Cold rolled low carbon steel flat products for vitreous enamelling - Technical delivery conditions

Produits plats laminés à froid, en acier doux pour émaillage par vitrification - Conditions techniques de livraison

Kaltgewalzte Flacherzeugnisse aus weichen Stählen zum Emaillieren - Technische Lieferbedingungen

This European Standard was approved by CEN on 11 April 2013.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN 10209:2013) has been prepared by Technical Committee ECISS/TC 109 “Flat products for cold working - Qualities, dimensions, tolerances and specific test”, the secretariat of which 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of an identical text or by endorsement, at the latest by December 2013, and conflicting national standards shall be withdrawn at the latest by December 2013.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 10209:1996.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard applies to cold rolled non-coated low carbon steel flat products in rolled widths equal to or over 600 mm and in thicknesses equal to or less than 3 mm, delivered in sheet, wide strip, slit wide strip or cut lengths obtained from slit wide strip or sheet.

It does not apply to cold rolled narrow strip (rolling width < 600 mm) nor to cold rolled flat products for which there is a specific standard, in particular the following:

— cold-rolled low carbon steel flat products for cold forming (EN 10130);

— cold-rolled non oriented electrical steel sheet and strip delivered in fully processed state (EN 10106);

— cold rolled electrical non-alloy and alloy steel sheet and strip delivered in the semi-processed state (EN 10341);

— cold reduced blackplate (EN 10205);

— steel sheet and strip for welded gas cylinders (EN 10120);

— cold-rolled uncoated non-alloy mild steel narrow strip for cold forming (EN 10139);

— cold-rolled structural steels for general purposes;

— cold-rolled flat products made of high yield strength for cold forming (EN 10268).

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 steels - Part 1: Steel names*

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

EN 10049, *Measurement of roughness average Ra and peak count RPc on metallic flat products*

EN 10079:2007, *Definition of steel products*

EN 10131, *Cold rolled uncoated and zinc or zinc-nickel electrolytically coated low carbon and high yield strength steel flat products for cold forming - Tolerances on dimensions and shape*

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

EN ISO 377, *Steel and steel products - Location and preparation of samples and test pieces for mechanical testing (ISO 377)*

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

ISO 10113, *Metallic materials — Sheet and strip — Determination of plastic strain ratio*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 10079:2007.

4 Designation

4.1 Steel names are attributed in accordance with EN 10027-1; numerical designations are attributed in accordance with EN 10027-2.

All steels reported in Table 2 are non alloy and alloy quality steels.

4.2 Products conforming to this European Standard shall be designated, in order, in the following way:

a) product designation (e.g. strip, sheet or “slit strip cut longitudinally”);

b) number of this European Standard (EN 10209);

c) name or numerical designation of the steel, shown in Table 2;

d) where appropriate, the symbol relating to surface finish (see Table 1).

Examples of conventional designations:

Designation of a steel sheet with the symbolic designation DC01EK and the numerical designation 1.0390 with rough surface finish (*r*):

Sheet EN 10209 DC01EK *r* or

Sheet EN 10209 — 1.0390 *r*

Designation of a wide strip of steel with the symbolic designation DC06ED and the numerical designation 1.0872 with normal surface finish (*m*):

Wide strip EN 10209 — DC06ED *m* or

Wide strip EN 10209 — 1.0872 *m*.

5 Requirements

5.1 Steelmaking and manufacturing processes

Unless otherwise agreed at the time of ordering, the production methods shall be left to the discretion of the manufacturer.

The purchaser shall be informed of these processes if specified in the purchase order.

5.2 Method of deoxidation

See Table 2.

5.3 Chemical composition

The maximum values for the chemical compositions based on ladle analysis shall be as given in Table 2.

5.4 Suitability for vitreous enamelling

5.4.1 Qualities DCO1EK, DC04EK, DC05EK and DC06EK are suitable for one or two coats of conventional enamelling.

5.4.2 Qualities DC03ED, DC04ED and DC06ED are suitable for direct enamelling, as well as for the two coat – one fire process and for the special applications of two coat enamelling for sag resistance.

5.4.3 The following methods of test are defined in order to determine the suitability of the steel for enamelling:

— hydrogen permeation test (see Annex A) (alternatively, if agreed at the time of ordering, an enamelling test as described in A.2 may be specified).

NOTE These two tests enable the risk of fish scaling following enamelling to be assessed.

— iron loss test for qualities of steel for direct enamelling as described in 5.4.2 (see Annex B).

5.4.4 An enamel adherence test (see Annex C) is also defined (pretreatment and enamelling conditions shall be agreed at the time of ordering).

5.4.5 The application of the methods of test described in Annex A, Annex B and Annex C may be the subject of an agreement at the time of ordering.

5.5 Delivery condition

5.5.1 Products specified in this standard should be supplied in the skin-passed condition. If agreed at the time of ordering non-skin-passed products may be supplied.

5.5.2 The products are normally delivered oiled. In this case, both the surfaces are preserved by a layer of neutral non-drying oil, free of foreign bodies and uniformly spread in such a way that under normal conditions of packaging, transportation, handling and storage the products will show no corrosion for up to three months.

If the conditions of transportation or storage are such that special protection against corrosion is required, the purchaser shall inform the manufacturer at the time of the ordering.

The layer of oils shall be capable of being removed by alkaline solutions or normal solvents.

The choice of protective oils may be the subject of special agreement.

If the purchaser does not require the surfaces to be oiled, this shall be clearly indicated at the time of the ordering.

NOTE If the order is for unoiled products, the manufacturer is not responsible for the risk of rust. The purchaser is also advised that there is a greater risk of the appearance of light scratches during handling, transportation, and application.

5.6 Choice of properties

The products covered by this European Standard shall correspond to the requirements of Table 1 and Table 2.

Subject to agreement between the supplier and the purchaser, they may be supplied with particular suitability for the production of a specific part; in this case a maximum rejection percentage may be set by mutual agreement and acceptance on the basis of mechanical properties would not apply.

5.7 Mechanical properties

The mechanical properties given in Table 2 only apply to skin-passed products. These mechanical properties are valid for the period specified in Table 2 from the date on which the products are made available.

The date of availability shall be notified to the purchaser with reasonable prior notice compatible with the validity of the mechanical properties.

5.8 Surface characteristics

5.8.1 General

The surface characteristics consist of the surface appearance and surface finish.

5.8.2 Surface appearance

The products are supplied with a surface appearance which does not adversely affect suitability for forming, the application of an enamel coating and the uniform appearance of the enamelled surface on the exposed surface.

When supplied as wide strip and slit strip, the percentage of surface defects may be higher than when supplied as sheet and cut lengths. This shall be taken into account by the purchaser and the permissible percentage of surface defects shall be set by special agreement at the time of ordering.

Unless otherwise agreed, a single surface of the product shall comply with the specified requirements. The other surface shall be such that during subsequent treatment it does not have a deleterious effect on the better surface.

5.8.3 Surface finish

The surface finish may be normal or rough.

In the absence of a requirement in the order, products shall be supplied with the normal surface finish.

The limiting figures for average surface roughness for the two types of finish are given in Table 1.

The measurements shall be made in accordance with EN 10049.

If specially agreed at the time of ordering, other ranges for surfaces are specified for specific end uses.

Table 1 — Surface finishes and standard roughness

Surface finish	Symbol	Roughness
Normal Rough	*m* *r*	0,6 μm < R_a ≤ 1,9 μm R_a > 1,6 μm

5.9 Stretcher strain marks

All the products are generally subjected to a light skin-pass after annealing at the manufacturer's works to avoid the formation of stretcher strain marks during subsequent forming. The tendency to form such marks may reappear a certain time after the skin-pass. It is therefore in the purchaser's interest to form the products as soon as possible.

Quality DC06EK and DC06ED products do not exhibit stretcher strain marks after deformation.

For the other qualities the absence of stretcher strain marks may be guaranteed for six months after the products are made available.

5.10 Weldability

The material is specified as suitable for normal welding procedures as long as the products are degreased beforehand. The welding procedure shall be specified at the time of ordering (see 10 h).

5.11 Tolerances on dimensions and shape

Tolerances on dimensions and shape are given in EN 10131.

6 Tests

6.1 General

6.1.1 The purchaser shall specify at the time of ordering his requirements for:

— type of inspection and testing: specific or non-specific, see EN 10021;

— type of inspection document, see EN 10204.

6.1.2 Specific inspection and testing shall be carried out in accordance with 6.2, 6.3, 6.4, 6.5 and 6.6.

6.1.3 Specific inspection and testing may not be specified either for the product analysis or the surface finish.

6.2 Inspection units

The inspection unit is 30 t or a fraction of 30 t products of the same grade and nominal thickness.

When a wide coil exceeds 30 t, it constitutes a single inspection unit, as do its products.

6.3 Number of tests

For each inspection unit a tensile test shall be carried out, and if required, a determination of *r* and of the suitability for enamelling shall be performed (see Table 2 and Annex A, Annex B and Annex C).

6.4 Sampling

The requirements of EN ISO 377 and EN 10021 are supplemented by the following specific requirements.

For sheet and cut lengths the selection of products to be tested and the position of the samples in the products is left to the discretion of the inspection representative.

In the case of wide strip and slit wide strip, the sample should preferably be taken from the outer end.

If the width of the product permits, the test pieces for the tensile test shall be taken perpendicular to the direction of rolling at a distance of at least 50 mm from the edge of the product.

6.5 Test methods

6.5.1 The products shall be tested in the as-delivered condition. The tests shall be carried out at ambient temperature.

6.5.2 The tensile test shall be carried out as specified in EN ISO 6892-1 using type 2 test pieces (initial gauge length L_o = 80 mm, width b = 20 mm).

6.5.3 Surface roughness shall be measured in accordance with EN 10049.

6.5.4 The determination of the plastic strain ratio *r* shall be carried out in accordance with ISO 10113.

6.5.5 The tests for suitability for enamelling (see 5.4.3) shall be carried out in accordance with

— Annex A for the fish scaling resistance test;

— Annex B for the mass loss due to pickling test;

— Annex C for the adherence test.

6.5.6 For the determination of the chemical composition the corresponding European Standards shall apply in cases of dispute.

6.6 Retests

The requirements of EN 10021 shall apply. For coils, in the event of the test results giving rise to dispute, the samples for retests shall be taken at intervals of at least one lap but also at a maximum distance of 20 m from the appropriate end.

6.7 Inspection documents

If agreed at the time of ordering, an inspection document chosen from those given in EN 10204 shall be supplied (see also 6.1.1).

7 Identification

All materials shall be identified with at least the following information:

— the conventional designation as described in Clause 4;

— the coil or bundle number;

— the supplier's mark.

Typically, the identification is applied by either a label or using an easily removable non-corrosive ink on the inspected surface. Other identification requirements shall be agreed at the time of ordering.

8 Packaging

The packaging requirements shall be agreed at the time of ordering.

9 Disputes

With regard to any claims and actions, EN 10021 shall apply.

10 Information to be supplied by the purchaser at the time of ordering

To permit the manufacturer to supply products conforming to this standard, the following information should be given in the order:

a) the full designation as given in Clause 4;

b) nominal dimensions and quantities;

c) if the products are to be supplied non skin-passed,

d) if the products are to be delivered with mill edges or sheared edges;

e) limits on mass and sizes of coils and individual bundles;

f) intended application for the products;

g) enamelling process used (see Annex D);

h) if the products are to be welded, indication of the method to be used;

i) if the products are to be supplied as suitable for making a specific part;

j) if inspection documents are requested and type;

k) if an external inspection is to be carried out at the manufacturer's works;

l) if oiling is not required;

m) detailed description of all other special requirements;

n) any special requirements for packaging and marking;

o) the position of the surface of better surface finish quality.

Table 2 — Characteristics [a i]

Designation in accordance with EN 10027–1	Designation in accordance with EN 10027–2	Method of deoxidation	Validity of mechanical properties and absence of stretcher strain marks	R_e MPa max [b c l]	R_m MPa [l]	A_{80} % min [d l]	$\bar{r}$ average min [e l]	Chemical composition (ladle analysis) % max					C content (product analysis) % max
								C	Ti	Mn	P	S	
DC01EK	1.0390	Fully killed [f]	6 months [f]	270	270/390	30		0.08		0.60	0,045	0,050	
DC04EK	1.0392	Fully killed	6 months	220[k]	270/350	36		0.08		0,50	0,030	0,050	
DC05EK	1.0386	Fully killed	6 months	220[k]	270/350	36	1.5	0.08		0,50	0,025	0,050	
DC06EK	1.0869	Fully killed	6 months	190	270/350	38	1.6	0.02	0.30[h]	0,50	0,020	0,050	
DC03ED	1.0399	Fully killed [f]	6 months [f]	240	270/370	34		[j]		0,40	0,035	0,050	0,004
DC04ED	1.0394	Fully killed	6 months	210[g]	270/350	38		[j]		0,40	0,030	0,050	0,004
DC06ED	1.0872	Fully killed	6 months	190	270/350	38	1.6	0.02	0.30[h]	0,35	0,020	0,050	

a The mechanical properties apply only to skin-passed product.

b The value for yield stress is the R_p 0,2 % for products which do not present a definite yield point and the lower yield stress (R_{el},) for the others. When the thickness is less than or equal to 0,7 mm and greater than 0,5 mm, the value for yield stress is increased by 20 MPa. For thicknesses less than or equal to 0,5 mm, the value is increased by 40 MPa.

c For design purposes, the lower limit of R_e for qualities DCO1EK, DC04EK, DC05EK, DC03ED and DC04ED may be assumed to be 140 MPa and for qualities DC06EK and DC06ED as 120 MPa.

d When the thickness is less than or equal to 0,7 mm, and greater than 0,5 mm, the minimum elongation value after fracture is reduced by 2 units. For thicknesses equal to or less than 0,5 mm, the minimum value is reduced by 4 units.

e The value of *r average* only applies to products of thicknesses equal to or greater than 0,5 mm. When the thickness is over 2,0 mm, the value of *r average* is reduced by 0,2 units.

f Subject to agreement at the time of ordering, other deoxidation methods may be used. If so, the periods for validity of the mechanical properties and the absence of stretcher strain marks shall be agreed at the time of ordering.

g If the thickness is greater than or equal to 1,5 mm, the maximum value for the yield stress may reach 225 MPa.

h Titanium may be replaced by niobium if agreed upon at the time of ordering. Carbon and nitrogen shall be completely bound.

i Subject to agreement at the time of ordering, other steels may be supplied which have the same mechanical properties. If so, the chemical composition of these steels shall be agreed at the time of ordering.

j The decarburisation of qualities DC03ED and DC04ED can take place in the solid or the liquid phase. The carbon content, determined by product analysis after decarburisation shall be 0,004 % maximum. If agreed at the time of ordering, qualities DC03ED and DC04ED may contain for example titanium, niobium or boron.

k At the request of the purchaser, the DC04EK and DC05EK qualities may be supplied with $R_e \leq 210$ MPa and $A_{80} \geq 38$ % in the 0,7 mm to 1,5 mm thicknesses. It is therefore for the manufacturer to select the surface roughness within the range of normal roughness options.

l The mechanical property values refer to the perpendicular testing direction.

Annex A
(normative)

Methods for determining the resistance to fish scaling of a steel sheet for enamelling

A.1 Hydrogen permeation test

A.1.1 Field of application

The test pieces shall be 0,5 mm to 3 mm thick.

A.1.2 Principle

Generate hydrogen electrolytically on one side of a degreased sheet. The time between the start of electrolysis and the determination of hydrogen having passed to the other side of the sheet shall be defined as the hydrogen permeation time. A long permeation time shall indicate good resistance to fish scaling.

A.1.3 Apparatus

— E. Buchel and L. Leontaritis measuring apparatus.

— Electrolyte made up of 6 % (volume fraction) by volume of H_2S0_4 (60 ml of H_2S0_4 concentrated in 940 ml of distilled water) with 0,25 g/l of $HgCl_2$ and 0,5 g/l of As_20_3. The solution shall be freshly made for each test (the chemical products being of analytical quality).

— Highly alkaline degreasing agent, suitable for steel sheets, containing silicates.

— Deionised water.

— 10 - 15 % (mass fraction) hydrochloric acid

A.1.4 Sampling

At least 4 samples (70 mm to 90 mm wide and not less than 100 mm long) shall be taken from each delivery. It should be noted that the most susceptible parts to fish scaling are those at the edges of the coil.

A.1.5 Preparation

Bath No. 1: Degreasing

30 g/l ± 5 g/l of degreasing agent in deionised water. The bath shall be changed daily. Use glass hooks for the installation. Bath temperature: 70 °C to 75 °C. Time = 5 min, stirring with a magnetic stirrer.

Bath No. 2: Cold rinsing

By spraying (or immersion) with mains water for 30 s.

Bath No. 3: Degreasing

Identical to Bath No. 1, but with 20 g/l ± 5 g/l of degreasing agent.

Bath No. 4: Hot rinsing

By spraying (or immersion) with mains water at 65 °C for 30 s.

Bath No. 5: Cool rinsing

In running water for 2 min.

A.1.6 Checks on the degreasing quality

Alter Bath No. 5, take a sample as a control sample and treat in the following way (this control sample will not be used to determine the-hydrogen permeation time).

A.1.6.1 Immerse the control sample in a 10 % to 15 % solution of hydrochloric acid (100 g/l to 150 g/l HCl) at room temperature for 15 s

A.1.6.2 Rinse with mains water, having immersed the sample completely in deionised water

A.1.6.3 Observe the film of water which runs over the sample when it is held vertically for 15 s to 20 s. The water shall run over the surface evenly. The water film shall not be broken

A.1.6.4 If the water film test is not positive, increase the degreasing time. The samples shall be regarded as unusable if a total degreasing time of over 30 min is required

A.1.7 Permeation test procedure

Following preparation, fix the test sample on an electrolysis machine, the lower and upper parts of which shall be made of transparent polymethyle metacrylate in the form of a funnel, having an aperture 40 mm in diameter at the level of the sample (on both the upper surface and lower surface of the sample).

Connect the lower part to a capillary tube having an internal diameter of 1 mm ± 0,1 mm (see Figure A.2).

Fill the lower part and the capillary tube with coloured or not coloured water.

Fill the upper part with the electrolytic solution mentioned above. The test sample shall constitute the cathode and a perforated platinum disc the anode.

The electrolysis current (6 V, d.c., current density 0,125 A/cm^2) shall be supplied by a rectifier. Immerse a glass coil in the electrolyte and connect it to a circuit with a thermostat in order to maintain a constant temperature of 25 °C ± 0,5 °C.

Maintain the contact between the sample and the electrolyte for at least 10 min in order for it to reach the correct temperature, this time being called the “stabilisation” time.

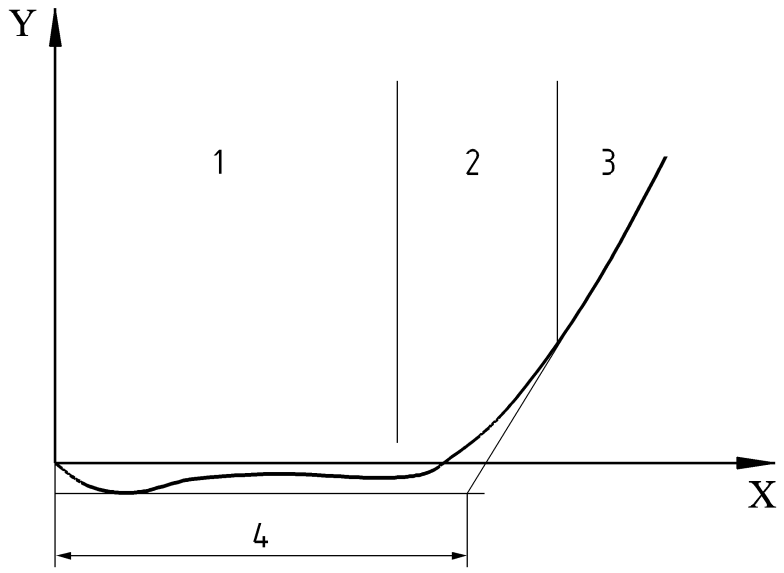
Adjust the starting level of the liquid in the capillary tube using a piston in the lower part of the apparatus.

Alter a stabilisation time of 10 min, establish the electrolysis current, this is the initial time of the permeation curve.

On the upper surface of the test sample, electrolysis shall cause supersaturation of hydrogen. Part of this hydrogen shall pass through the sheet and displace the liquid by an equivalent volume.

The volume of hydrogen which has passed through is recorded by the level of liquid in the capillary tube, followed by a photoelectric cell connected to a recording devise. On the basis of this recording, the start of the hydrogen passage (t_o) may be established using the tangent method (Figure A.1).

Instead of the photo-electric method, one can also use an optical method, in which the time for the appearance of the first H_2 at the back side of the sheet steel sample is measured (t_o). A third method is using a Hydrogen sensor at the back side.



Key

X time
Y hydrogen volume
1 charging period
2 transition state
3 stationary state
4 permeation time

Figure A.1 — Permeation curve

A.1.8 Evaluation

Calculate the hydrogen permeation value using the following formula:

$$TH_1 = \frac{15\, t_0}{d^2} \quad \text{(A.1)}$$

or

$$TH_2 = \frac{t_0}{d^2} \quad \text{(A.2)}$$

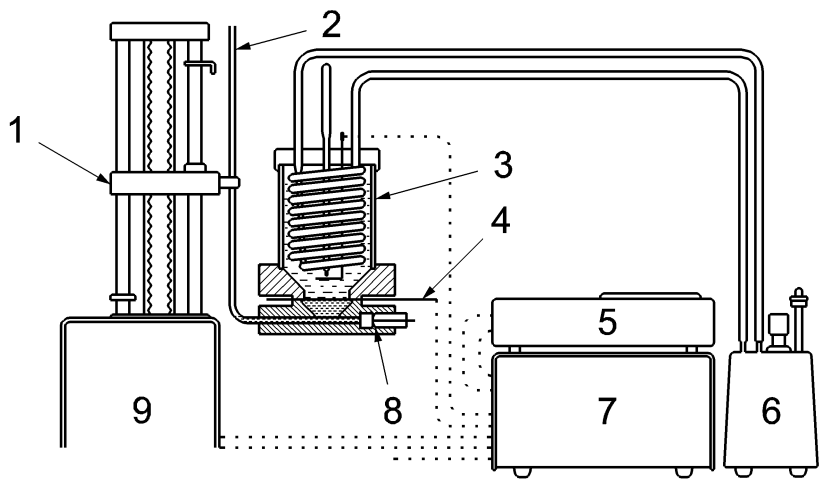
where

— t_o is the hydrogen permeation time in minutes (precision of 0,1 min)

— d is the sheet thickness in mm (precision of 0,01 mm).

The minimum TH_1 value is 100 according to Formula (A.1) and the minimum value of TH_2 is 6,7 according to Formula (A.2) in order to have satisfactory resistance to fish scaling.

For boron and titanium steels, experience shows that given our current level of knowledge no reliable correlation can be made between permeation time and the appearance of fish scaling. For these steels, interpretation of the results of the hydrogen permeation test shall be the subject of agreement at the time of ordering.



Key

1 photo electric sensor
2 measuring capillary
3 electrolysis container
4 test sheet
5 continuous recorder
6 bath with thermostat
7 feed tank
8 piston
9 level tracker

Figure A.2 — Apparatus for recording the hydrogen permeability of sheets

A.2 Fish scaling test using special enamel

In order to determine resistance to fish scaling, another test may be used. A laboratory enamelling process with fixed parameters and using special enamel for the fish scaling test may be admissible.

Generally, an enamel thickness of 100 µm is applied. The enamel adherence should be poor: level 3 to 5. Visual examination for fish scaling should be carried out 24 h after the enamel has been fired.

Annex B
(normative)

Method for determining mass loss (iron loss) due to pickling for steel grades for direct enamelling in accordance with 5.4.2

B.1 Principle

A test specimen is pickled in sulphuric acid (70 g/l) with a specific concentration of Fe^{2+}. The loss of mass is measured and converted into g/m^2 of surface of the sheet.

B.2 Apparatus

— Kitchen paper.

— High precision balance (precision to 1 mg).

— One litre beaker, low form, external diameter 106 mm, height 145 mm.

— Heating plate with magnetic stirrer.

— Laboratory thermostat.

— Glass hooks.

— Sprayer.

— Hydrochloric acid, analytical quality.

— Sulphuric acid, analytical quality.

— Steel sheet to be tested.

— Highly deionised water, maximum conductivity of 30 μS/crn.

— Calibrated thermometer.

— Highly alkaline degreasing agent, suitable for steel sheets, containing silicates (Baths No. 1 and 3).

— Alkaline solution for Bath No. 9 (Henkel P3 T320 or similar product).

— Electric hot air dryer.

B.3 Sampling

The size of the sample sheet shall be 100 mm × 100 mm. Flat undeformed samples shall be used and shall be taken from a point at least 150 mm from the edge of the coil.

Only samples without traces of corrosion, or mechanical damage on their surface shall be used. They shall not have any burr. A 6 mm diameter hole shall be made for the hooks.

B.4 Preparation

The test pieces shall be dried and cleaned with the kitchen paper.

B.5 Weighing

The test piece shall be weighed on an analytical balance to the nearest mg (value P1).

B.6 Cleaning

Bath No. 1: Degreasing

Highly alkaline product 30 g/l ± 5 g/l containing silicates, suitable for steel sheets.

Fill the preparation bath with deionised water. Change the bath daily. Use glass hooks for securing the samples. Set the bath temperature between 70 °C and 75 °C; carry out degreasing for 5 min ± 15 s, stirring with a magnetic stirrer.

Bath No. 2: Cold rinsing

By spraying (or immersion) with mains water for 30 s.

Bath No. 3: Degreasing

Identical to Bath No. 1, but with 20 g/l ± 5 g/l of degreasing agent.

Bath No. 4: Hot rinsing

By spraying (or immersion) with mains water at 65 °C for 30 s.

Bath No. 5: Cool rinsing

In running water for 2 min.

B.7 Checks on degreasing quality

- After Bath No. 5, take a sample as a control sample and treat in the following way (this control sample will not be used to determine the mass loss due to pickling).
- Immerse the control sample in a 10 % to 15 % (mass fraction) solution of hydrochloric acid (100 g/l to 150 g/l HCL) at room temperature for 15 s.
- Rinse with mains water, alter having immersed the sample completely in deionised water.
- Observe the film of water which runs over the sample when it is held vertically for 15 s to 20 s. The water shall run over the surface evenly. The water film shall not be broken.
- If the water film is not positive, increase the degreasing time. The samples shall be regarded as unusable if a total degreasing time of over 30 min is required.

B.8 Pickling

Bath No. 6: Temperature setting

Immerse the test pieces in a water bath at 70 °C.

Bath No. 7: Pickling

Pickling condition: 70 g/l of H_2SO_4, 70 °C ± 0,3 °C, 7 min ± 5 s, stir with a magnetic stirrer.

Fe^{2+} concentration: 2 g/l ± 0,2 g/l.

Prepare the bath in the following way: add 40 ml of H_2SO_4 (density 1,84) to 150 ml of deionised water. Then, make up to 1000 ml with water. Having increased the temperature of the solution to the pickling temperature of 70 °C, dissolve 2 g ± 0,2 g of the steel sheet identical to the sheet to be tested having been subjected to treatments C6 and C7 (dissolution approximately 20 min.) to attain an Fe^{2+} concentration of 2 g/l ± 0,2 g. Check the concentrations of sulphuric acid and Fe^{2+}.

Change the pickling bath after pickling a maximum of three test pieces. Do not use the new bath more than three days alter it has been prepared.

Bath No. 8: Cold rinsing

Spraying (or immersion) in mains water for 15 s.

Bath No. 9: Neutralisation

Immerse the samples in the alkaline solution (for example, 6 g/l of Na_2CO_3 ± 0,7 g/l of $Na_2B_40_7$, at 50 °C, for 2 min).

Bath No. 10: Hot rinsing

Spraying (or immersion) in mains water at 65 °C for 30 s.

B.9 Drying

Dry with an electric hot air drier.

B.10 Weighing

After cooling to room temperature, weigh the test pieces immediately (value P_2).

B.11 Evaluation

Calculate the loss due to pickling P (g/m^2/surface) on the basis of the difference in the two weights divided by the total surface area of the test piece (0,02 m^2):

$$P = \frac{P_1 - P_2}{0{,}02} \, (g / m^2 / surface)$$

Indicate the values of each test and the mean obtained on the basis of not less than 3 test pieces. A maximum scatter of 10 % is permissible. If it is greater, repeat the test.

Annex C
(normative)

Method for determining the adherence level of enamel applied to a steel sheet

C.1 Field of application

The test pieces shall be flat, not deformed and have a thickness of between 0,60 mm and 3 mm.

C.2 Principle

The sample of enamelled sheet shall be deformed by a punch with an hemispheric tip onto which falls a 1,5 kg mass, dropped from a height which is a function of the thickness of the sheet prior to enamelling.

C.3 Apparatus

— Impact testing machine as shown in Figure C.1.

— Document showing the reference photos of the five adherence levels of each of the three types (conventional ground coat enamelling, conventional ground coat enamelling + white cover coat and direct-on vitreous enamelling) given in Figure C.2.

C.4 Description of the apparatus

The impact testing machine is shown in Figure C.1.

The piece which strikes the punch shall have a mass of 1,5 kg.

The punch tip shall be hemispherical and have a 22 mm diameter.

The diameter of the hole punched into the base shall be 20,6 mm and the radius of the entrance to this hole shall be 2 mm.

C.5 Procedure

First clean the enamelled test sheet with kitchen paper and fix it between the base and the support.

Position the 1,5 kg weight at height "*h*", which shall be a function of the thickness of the sheet prior to enamelling and is given in Table C.1 below.

Table C.1 — Drop height *h*

0,6 mm ≤ thickness ≤ 0,8 mm	h = 300 mm
0,8 mm < thickness ≤ 1,2 mm	h = 500 mm
1,2 mm < thickness ≤ 3 mm	h = 750 mm

Drop the weight.

Remove the punched sample having raised the support which is attached to the guide tube.

No further splintering of the enamel shall be expected before the adherence level is evaluated.

C.6 Adherence level evaluation

C.6.1 Flat pieces

Assessment of the result is made solely on the amount of enamel which is retained adhered to the substrate after the impact test - fracture of the deformed adhered enamel will always occur, even on class 1 (excellent) classification.

Class “1” corresponds to an excellence adherence level and Class “5” is very poor.

Class 1: excellent: the impact surface is completely covered with enamel although fracturing will may have occurred.

Class *2:* very good: the impact surface is almost completely covered with fractured enamel with some slight evidence of the substrate visible.

Class *3:* fair: the impact surface still has some coverage with fractured enamel, but large areas of the substrate may be visible.

Class 4: poor: the impact surface is almost completely bare with only residual traces of fractured enamel.

Class 5: very poor: the impact surface is completely bare with a sharp delineation of the enamel - substrate interface

The adherence level evaluation shall be evaluated by comparing the appearance of the impact on the enamelled test sheet with the reference photographs (Figure C.2).

C.6.2 Thinner sheet steel < 0,6 mm

If thinner thicknesses have to be tested, agreement shall be reached between the purchaser and supplier prior to the test about the equipment to be used.

Interpretation of the test results shall also be agreed upon prior to the test.

Except for the interpretation and test equipment, this Annex C remains valid.

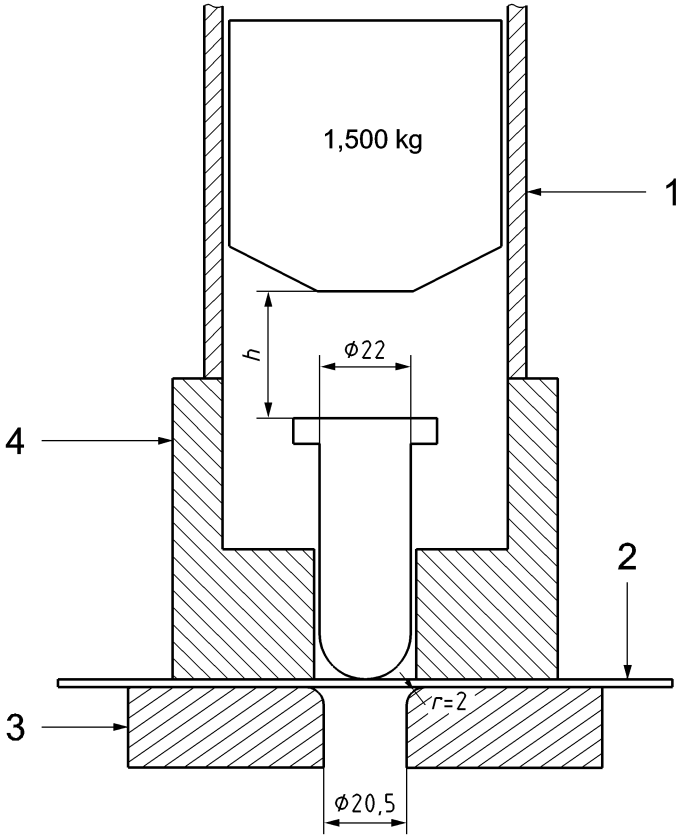
C.6.3 Deformed pieces

If deformed pieces have to be tested, agreement shall be reached between the purchaser and supplier prior to the test about the equipment to be used.

Interpretation of the test results shall also be agreed upon prior to the test.

Except for the interpretation and test equipment, this Annex C remains valid.

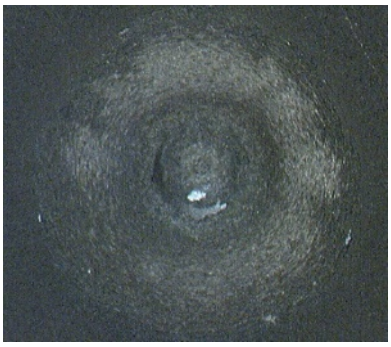
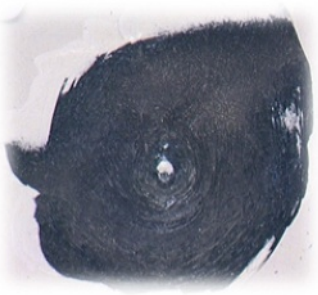
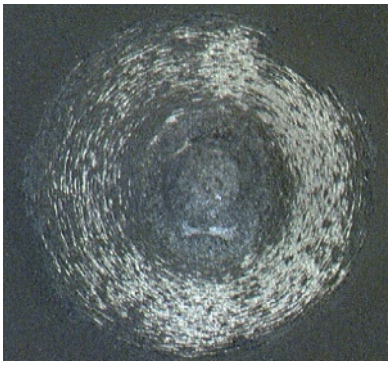
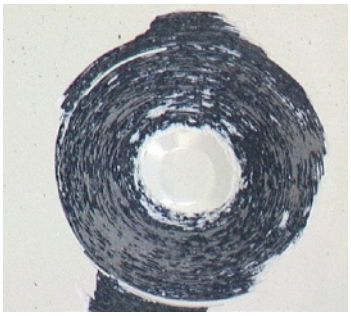
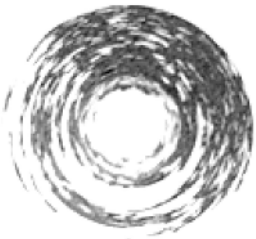
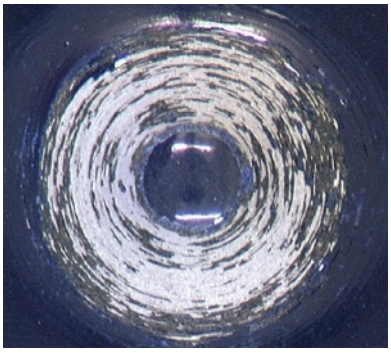
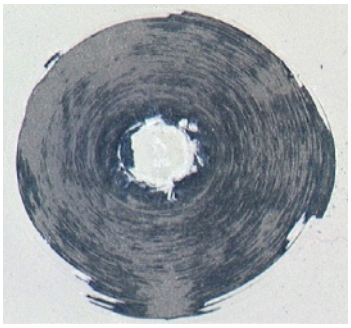
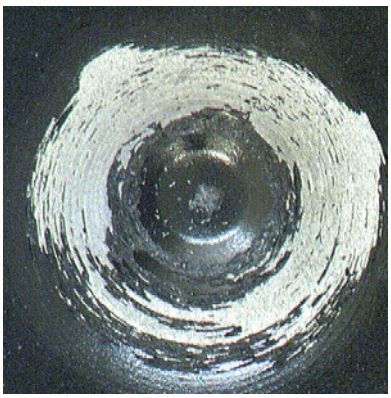
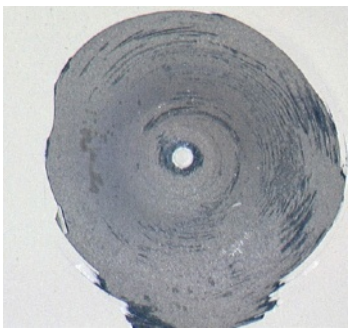
Dimensions in millimetres



Key

1 guide tube
2 enamelled test specimen
3 base
4 support

Figure C.1 — Impact testing machine

Class	Direct-on enamelling	2 coats/1 fire enamelling	Direct-on over Nickel pre-treatment
1			
2			
3			
4			

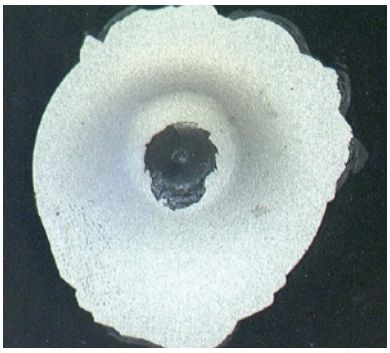
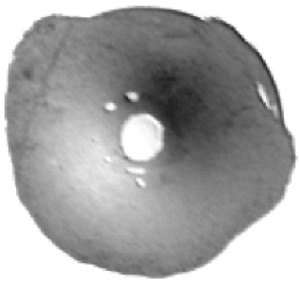
5			

Figure C.2 — Enamel adherence test; impact test

Annex D
(informative)

Characteristics for the selection of enamelling steel grades

Customer: _____

Enameller: _____

Purpose: _____

Enamelling process Application

wet process powder

Ground coat and conventional enamelling (ground and cover coat 2 fire) ☐ ☐

Ground coat without pickling (with subsequent cover coat enamelling) ☐ ☐

Ground coat without pickling (acid-resistant visible ground coat) ☐ ☐

Two coat/one fire enamelling without pickling ☐ ☐

Direct-on cover coat enamelling with pickling and nickel-dip without

adhesive oxides in the frit ☐ ☐

Other processes: _____

Enamel type: _____

Firing temperature: _____°C Firing time: _____ min

Sheet pretreatment	**Kind of acid**	**Concentration**		**Temperature °C**	**Time min**
		%	g/l		
1st pickling (rust removal)					
2nd pickling (intensive)					
Pickling additives					

Fe loss: min. _____ max: _____ g/m^2 surface

Nickel deposition	**pH - value**	**Concentration**		**Temperature °C**	**Time min**
		%	g/l		
Exchange process					
Reduction process					
Additions to the bath					

Ni deposit: min. _____max: _____ g/m^2 surface

Date: _____ Dept: _____ Name: _____ Tel: _____

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