BRITISH STANDARD

BS EN
14879-2:2006

Organic coating systems and linings for protection of industrial apparatus and plants against corrosion caused by aggressive media —

Part 2: Coatings on metallic components

The European Standard EN 14879-2:2006 has the status of a British Standard

ICS 25.220.60

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National foreword

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EUROPEAN STANDARD

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EN 14879-2

December 2006

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English Version

Organic coating systems and linings for protection of industrial apparatus and plants against corrosion caused by aggressive media - Part 2: Coatings on metallic components

Systèmes de revêtements organiques de peinture et autres revêtements rapportés pour la protection des appareils et installations industriels contre la corrosion par des milieux agressifs - Partie 2: Revêtements pour composants métalliques

Beschichtungen und Auskleidungen aus organischen Werkstoffen zum Schutz von industriellen Anlagen gegen Korrosion durch aggressive Medien - Teil 2: Beschichtungen für Bauteile aus metallischen Werkstoffen

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Foreword

This document (EN 14879-2:2006) has been prepared by CEN/BT/Task Force 130 “Organic coating systems and linings for protection of industrial apparatus and plants against corrosion caused by aggressive media”, 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of an identical text or by endorsement, at the latest by June 2007, and conflicting national standards shall be withdrawn at the latest by June 2007.

EN 14879 "Organic coating systems and linings for protection of industrial apparatus and plants against corrosion caused by aggressive media" consists of the following parts:

— *Part 1: Terminology, design and preparation of substrate*

— *Part 2: Coatings on metallic components*

— *Part 3: Coatings on concrete components*

— *Part 4: Linings on metallic components*

— *Part 5: Linings on concrete components*

— *Part 6: Combined linings with tile and brick layers*

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

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1 Scope

This European Standard specifies the requirements for and methods of testing of organic coatings which are applied to metallic process engineering equipment that will come in contact with chemical substances (liquids, solids and gases). The requirements specified here may be used for the purposes of quality control (e.g. as agreed between the contract partners or been given by national regulations).

The standard does not cover coatings as in EN ISO 12944-1, but it does apply to coatings which serve one or more of the following purposes:

— to protect the component from adverse effects of aggressive substances;

— to protect waters (e.g. ground water) against hazardous substances;

— to protect the charge from becoming contaminated by components released from the substrate material;

— to achieve a particular surface properties.

The described coatings are to be used for metallic process engineering equipment that will come in contact with chemical substances. The different coating systems are:

— laminate coating systems which contain cold-curing resins;

— trowelled coating which contain cold-curing resins;

— sprayed coating systems which contain resins (in special cases, such coatings may also be applied by brushing, rolling, flow coating, dipping, or by other means, such as providing sleeving for nozzles);

— powder coating systems which contain organic materials (powder coatings may be used as corrosion protection or for non-stick purposes).

For design and preparation of substrate see EN 14879-1.

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.

EN 59, *Glass reinforced plastics — Measurement of hardness by means of a Barcol impressor*

EN 228, *Automotive fuels — Unleaded petrol — Requirements and test methods*

EN 590, *Automotive fuels — Diesel — Requirements and test methods*

EN 13687-3, *Products and systems for the protection and repair of concrete structures — Test methods — Determination of thermal compatibility — Part 3: Thermal cycling without de-icing salt impact*

EN 14879-1:2005, *Organic coating systems and linings for protection of industrial apparatus and plants against corrosion caused by aggressive media — Part 1: Terminology, design and preparation of substrate*

prEN 14879-4, *Organic coating systems and linings for protection of industrial apparatus and plants against corrosion caused by aggressive media — Part 4: Linings on metallic components*

EN ISO 175, *Plastics — Methods of test for the determination of the effects of immersion in liquid chemicals (ISO 175:1999)*

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EN ISO 178, *Plastics — Determination of flexural properties (ISO 178:2001)*

EN ISO 291, *Plastics — Standard atmospheres for conditioning and testing (ISO 291:2005)*

EN ISO 527-3, *Plastics — Determination of tensile properties — Part 3: Test conditions for films and sheets (ISO 527-3:1995)*

EN ISO 868, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness) (ISO 868:2003)*

EN ISO 2811-1, Paints and varnishes — Determination of density — Part 1: Pyknometer method (ISO 2811-1:1997)

EN ISO 2811-2, *Paints and varnishes — Determination of density — Part 2: Immersed body (plummet) method (ISO 2811-2:1997)*

EN ISO 2815, *Paints and varnishes — Buchholz indentation test (ISO 2815:2003)*

EN ISO 3001, *Plastics — Epoxy compounds — Determination of epoxy equivalent (ISO 3001:1999)*

EN ISO 3251, Paint, varnishes and plastics — Determination of non-volatile-matter content (ISO 3251:2003)

EN ISO 3882, *Metallic and other inorganic coatings — Review of methods of measurement of thickness (ISO 3882:2003)*

EN ISO 4624, *Paints and varnishes — Pull-off test for adhesion (ISO 4624:2002)*

EN ISO 4625-1, *Binders for paints and varnishes — Determination of softening point — Part 1: Ring-and-ball method (ISO 4625-1:2004)*

EN ISO 8503-2, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 2: Method for the grading of surface profile of abrasive blast-cleaned steel — Comparator procedure (ISO 8503-2:1988)*

EN ISO 12944-4, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 4: Types of surface and surface preparation (ISO 12944-4:1998)*

ISO 813, *Rubber, vulcanized or thermoplastic — Determination of adhesion to a rigid substrate — 90° peel method*

ISO 2559, *Textile glass — Mats (made from chopped or continuous strands) — Designation and basis for specifications*

ISO 8130-2, *Coating powders — Part 2: Determination of density by gas comparison pyknometer (referee method)*

IEC 60093:1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 60167, *Methods of test for the determination of the insulation resistance of solid insulating materials*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14879-1:2005 and the following apply.

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3.1
fibre reinforced coatings
resin coatings reinforced by means of glass, carbon or synthetic fibres, for the standard named "laminate coatings"

3.2
contract partners
coating material manufacturer, component manufacturer, person(s) responsible for applying the coating, and client ordering the coated component(s)

3.3
substrate
surface on which a coating is applied

3.4
coating system (on a metallic component)
continuous film on the surface of a metallic component, comprising one or more layers, with a total system thickness of at least 100 µm

NOTE For non-stick coatings as in 5.4, the minimum total thickness is 50 µm.

3.5
coating material (for use on a metallic component)
cold- or heat-curing material, in liquid, paste or powder form, which will form a continuous film (coating) on the surface of a metallic component. Liquid coating materials may or may not contain solvents

3.6
total coating system thickness
sum of the thickness of all layers in a coating system

NOTE When specifying requirements for various aspects such as the suitability of a coating, the method of application, the component design or the surface condition of the substrate, it is expedient to differentiate between the following categories of coating system thickness:

a) up to 200 µm;

b) above 200 µm up to 1 mm;

c) above 1 mm.

4 General

4.1 Selection criteria

4.1.1 General

The stress to be encountered by a protective coating shall be known before the requirements for it can be specified. For the scope of this European Standard, the stress types detailed in 4.1.2 to 4.1.8 are the most relevant. Where necessary, grades have been used to describe different levels of stress.

4.1.2 Exposing media

Aggressive substances or water pollutants may occur as solids, fluids or gases. Their aggressive action on metallic components usually occurs when they are in a liquid state (e.g. aqueous solutions or condensates). The substances may occur at varying intervals in their pure state or as mixtures.

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These substances shall be designated using the Geneva nomenclature, IUPAC[1)] nomenclature or CAS[2)] number. They may also be designated by trivial names which have become established in the literature. Concentrations and any changes to these shall be given as a percentage by mass or volume, or as g/l, g/kg, mol/l etc. The pH value shall also be given for aqueous solutions.

All constituents, including traces and impurities, shall be named, even if they do not attack metallic components. Successive exposure shall be represented accordingly.

Table 1 lists commonly used chemicals, which may have the properties mentioned above.

1) International Union of Pure and Applied Chemistry.

2) Chemical Abstract Service.

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Table 1 — Classification of commonly used chemicals

Type of chemical	Examples	
I. Inorganic chemicals		
Inorganic, non-oxidizing acids	HCl H_2SO_4 H_3PO_4	Hydrochloric acid Sulfuric acid, up to 70 % Phosphoric acid
Inorganic, oxidizing acids	HNO_3 H_2SO_4 CrO_3, H_2CrO_4 $HClO_3$	Nitric acid Sulfuric acid, over 70 % Chromic acid Chloric acid
Inorganic acids, dissolving SiO_2	HF H_2SiF_6 HBF_4	Hydrofluoric acid Hexafluorosilicic acid (containing HF) Tetrafluoroboric acid (containing HF)
Salts	$NaCl$ $FeSO_4$ Na_2CO_3	Sodium chloride Iron(II) sulfate Sodium carbonate
Bases	$NaOH$ KOH CaO, $Ca(OH)_2$ NH_4OH	Sodium hydroxide Potassium hydroxide Calcium oxide Calcium hydroxide Ammonia solution (Ammonium hydroxide solution)
Oxidizing bases	$NaOCl$	Sodium hypochlorite
II. Organic chemicals		
Organic acids	$HCOOH$ CH_3COOH $CH_2ClCOOH$ $(COOH)_2$ $CH_3CHOHCOOH$	Formic acid Acetic acid Chloroacetic acid Oxalic acid Lactic acid
Aliphatic hydrocarbons	C_6H_{14} C_8H_{18}	Hexane Octane
Aromatic hydrocarbons	C_6H_6 $C_6H_5CH_3$ $C_6H_4(CH_3)_2$	Benzene Toluene Xylene
Alcohols	CH_3OH C_2H_5OH C_4H_9OH CH_2OHCH_2OH	Methanol Ethanol Butanol Ethanediol
Aldehydes, ketones, esters	CH_2O CH_3COCH_3 $C_2H_5COCH_3$ $CH_3COOC_2H_5$	Formaldehyde Acetone Methyl ethyl ketone (2-butanone) Ethyl acetate
Aliphatic halogenated hydrocarbons	CH_2Cl_2 C_2HCl_3 $C_2Cl_3F_3$	Dichloromethane Trichloroethylene Trichlorotrifluoroethane
Aromatic halogenated hydrocarbons	C_6H_5Cl $ClC_6H_4CF_3$	Chlorobenzene Chlorobenzotrifluoride
Aliphatic amines	CH_3NH_2 $(C_2H_5)_3N$ $NH_2C_2H_4NH_2$	Methylamine Triethylamine Ethylene diamine
Aromatic amines and pyridine	$C_6H_5NH_2$ C_5H_5N	Aniline Pyridine
Phenols	C_6H_5OH $CH_3C_6H_4OH$	Phenol Cresol
Fats, oils		Vegetable and animal fats and oils

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4.1.3 Type and frequency of fluid loading

The requirements for the protective or sealing function of a surface protection system are linked to the type and frequency of the fluid loads to which it will be exposed. Exposure shall be graded as follows.

Grade 0: no exposure to fluids;

Grade 1: constant or frequent exposure to a film of fluid, due to condensation and the like (e.g. gas ducts, stacks);

Grade 2: operational exposure to a constant flow of fluid involving no significant hydrostatic pressure (e.g. pipes);

Grade 3: constant exposure to fluid for unlimited periods (e.g. vessels).

4.1.4 Thermal loading

The thermal load caused by medium effect or other sources of heat affects the effectiveness of a surface protection system in the following way:

a) Aggressiveness of medium

Elevated temperatures increase the aggressiveness of the medium by raising the levels of its chemical reactions and diffusion, and also through the accumulation of volatile substances in the vapour space.

b) Thermal stress

Temperatures which deviate from the installation temperature cause thermal stress between the substrate and the surface protection system and may cause peeling, cracks etc. This may result from the direct action of hot or cold media, or from radiant heat and extreme ambient temperature.

The maximum thermal load shall be stated in °C.

4.1.5 Changes in temperature

Changes in temperature include:

a) temperature changes at the protective surface during exposure to fluid loads of grades 1 to 2 as in 4.1.3 caused by increased/decreased medium temperatures;

b) temperature changes as otherwise constantly heated or cooled surfaces, resulting from operational circumstances, such as start-up and shutdown.

c) process-related changes in the temperature of the medium under loading conditions corresponding to grade 3 (as in 4.1.3).

Temperature changes due to climatic influences are dealt with in 4.1.7.

The extent, direction, speed and frequency of temperature changes shall be taken into consideration when assessing their effect.

The following grades serve in assessing the effects of temperature changes, whereby details of the frequency and the duration of temperature changes are to be given for grades 1 to 4.

Grade 0: no temperature changes;

Grade 1: infrequent temperature changes up to 50 K;

Grade 2: infrequent temperature changes of more than 50 K;

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Grade 3: frequent temperature changes of not more than 50 K;

Grade 4: frequent temperature changes of more than 50 K;

Grade 5: temperature changes involving thermal shock.

4.1.6 Mechanical loading

The effectiveness of a surface protection system may be impaired through exposure to mechanical loads or hydrostatic pressure during operation or assembly. The following grades shall be used to assess such loads.

Grade 0: no loads, or hydrostatic pressure up to 0,05 bar;

Grade 1: hydrostatic pressure from 0,05 bar to 0,5 bar;

Grade 2: hydrostatic pressure greater than 0,5 bar.

4.1.7 Climatic influences

Climatic influences may affect the durability of a surface protection system, and shall be graded as follows.

Grade 0: no climatic influences: the component is located inside a building and is not exposed to climatic influences;

Grade 1: limited climatic influences: a roof protects the component, which is exposed to limited climatic influences;

Grade 2: full climatic influences: the component is located outside, and is fully exposed to climatic influences.

4.1.8 Additional requirements

Additional requirements may derive from special applications, and are not fully covered by this European Standard. They may refer to water protection, explosion protection, fire behaviour, decontamination, health and safety (particularly in the case of foodstuffs and drinking water), non-slip surfaces and smoothness.

4.2 Load profile

The loads described in 4.1.2 to 4.1.8 shall be recorded, together with the grades selected. The form reproduced in Annex A should be used.

Tables G.1 to G.2 list frequently occurring load profiles and suitable surface protection systems.

4.3 Requirements

4.3.1 Components

The component to be coated shall meet the requirements of EN 14879-1.

4.3.2 Coating materials

Coating materials shall be selected which ensure that the coating will meet the requirements of this standard.

The manufacturer shall provide an adequate description of the material as regards its characteristics, processing and container marking. This can include, for instance, the items listed in Annex B.

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4.3.3 Coating system

4.3.3.1 General

The coating system shall meet the requirements of this European Standard. To this end, the coating material manufacturer shall provide an adequate description of the system, including, for instance, the items listed in 4.3.3.2 to 4.3.3.8 (see for example Annex C).

4.3.3.2 Application methods

a) Laminating as in 5.1.

b) Trowelling as in 5.2.

c) Spraying as in 5.3.

d) Methods of applying powder coatings as in 5.4.

4.3.3.3 Coating system design and designation

The coating system design and designation shall be as specified in this European Standard (see Table 2).

Table 2 — Coating thickness (approximate values)

Type of coat or layer	Coating method			
—	Brushed, sprayed or rolled	Trowelled or floated	Laminate coating	Powder coatings
—	Coating thickness, in mm			
Primer	≥ 0,05	≥ 0,05	≥ 0,05	≈ 0,05
Intermediate layer [a]	-	≈ 1,0	≈ 1,0	-
Laminate layer	-	-	1,5 up to 4,0	-
Top coat	≤0,5 up to 2,0	1,5 up to 4,0	0,2 up to 2,0	0,05 up to 1,5
Sealant	-	0,1	0,2 up to 0,4	-
[a] Necessary for furane or phenolformaldehyde resins, except a thicker primer is applied.				

4.3.3.4 Surface properties

a) Colour.

b) Texture.

c) Gloss.

4.3.3.5 Mechanical properties

a) Adhesion.

b) Hardness.

c) Elongation at break.

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d) Abrasion resistance.

4.3.3.6 Physical properties

a) Thermal stability.

b) Thermal shock resistance.

c) Electrostatic dissipation capability.

d) Permeability.

4.3.3.7 Chemical resistance

Resistance to various chemical media.

4.3.3.8 Special properties

a) Electrical conductivity.

b) Resistance to radiation.

c) Decontamination.

d) Physiological safety.

4.3.4 Coated components

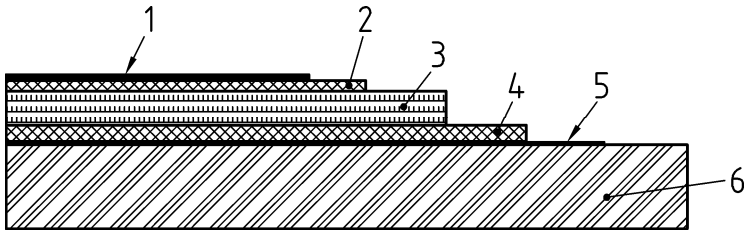
The requirements specified in this standard for coated components shall be met during packaging, handling, storage, assembly, commissioning and repair of the component.

5 Coating systems

5.1 Laminate coating systems

5.1.1 Coating system design

Depending on the coating system the laminate coating comprises of maximum 5 layers as illustrated in Figure 1.



Key
1 sealant
2 top coat
3 laminate layer
4 intermediate layer
5 primer
6 metallic substrate

Figure 1 — Coating system design

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5.1.2 Description of layers

5.1.2.1 General

The following resins may be used as binders: epoxies (EP), furanes (FU), unsaturated polyesters (UP), phenolformaldehydes (PF), or vinyl esters (VE). If different types of resins are used in one coating system, these resins shall be compatible with one another.

Table 2 gives an indication on the thickness of the layers, the total thickness shall be in accordance with the manufacturer's instructions.

5.1.2.2 Primer

The primer not only provides a bond between the metallic substrate and the coating, but also serves as temporary corrosion protection of the substrate between surface preparation and the coating process, and shall therefore cover the entire surface. The primer may be omitted in exceptional cases.

A different resin may be used for the primer than that used in subsequent layers.

5.1.2.3 Intermediate layer

A different type of resin may be used in the intermediate layer than that used in subsequent layers. The intermediate layer may either be substituted by a thicker primer or omitted.

5.1.2.4 Laminate layer

The laminate layer comprises one or more coats of a fibrous semi-finished product soaked out with one of the binders listed above (5.1.2.1), depending on service conditions.

The thickness of each coat, which depends on the mass per unit area of the semi-finished product, and the number of coats determine the total thickness of the laminate layer and thus the level of protection it provides.

The same binder shall be used in all laminate layer coats.

5.1.2.5 Top coat

The top coat serves to even out and cover the rough surface of the laminate layer, including any protruding fibres. It can be strengthened by adding a thin fleece. The top coat may be omitted.

The top coat shall contain the same type of binder as the laminate layer, although here the resin may be of a higher quality.

5.1.2.6 Sealant

The sealant lends the coating a smooth finish and should contain the same resin type as the previous coat. The sealant may be omitted.

5.1.3 General requirements

5.1.3.1 Component design and surface requirements

See EN 14879-1 for component design requirements and for requirements regarding the substrate surface.

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5.1.3.2 Coating materials

5.1.3.2.1 General

Laminate coating systems conforming to this European Standard contain binders (resins), fillers, reinforcing agents and processing aids.

5.1.3.2.2 Binders

The coating material manufacturer shall provide details of the binders used (see Annex B).

5.1.3.2.3 Fillers

Fillers shall be included in the intermediate layer and, if needed, in the top coat. Fillers shall be of inert materials such as silica sand, colloidal silicas (silicon dioxide), barite, carbon black, graphite, or short carbon fibres, and shall not diminish the effectiveness of catalysts.

5.1.3.2.4 Reinforcing agents

5.1.3.2.4.1 Laminate layer

The following materials may be used as reinforcing agents in the laminate layer:

— textile glass mats (continuous filament or chopped strand) as in ISO 2559;

— woven glass fabric as in ISO 2559;

— glass types E, E-CR and C as in ISO 2559.

The semi-finished product shall have a minimal mass per unit area, so that the binder can be fully absorbed. The plastic size and binder for the glass mat or fabric shall be compatible with the binder.

These requirements also apply to laminate layers containing fibres other than glass fibres (e.g. carbon or synthetic fibres).

5.1.3.2.4.2 Top coat

The following materials may be used as reinforcing in the top coat:

— fleece mat with C or E-CR type glass fibre, of a mass per unit area 20 g/m^2 to 50 g/m^2 with a compatible binder and finish;

— carbon fibre fleece, of a mass per unit area 20 g/m^2 to 40 g/m^2, with a compatible binder;

— synthetic fibre fleece, of a mass per unit area 20 g/m^2 to 40 g/m^2, with a compatible binder.

5.1.3.2.5 Processing aids

Processing aids (e.g. pigments and thixotrophic agents) shall neither impair curing nor reduce the chemical resistance of the coating.

5.1.3.2.6 Marking of containers

Containers shall be marked. This can be done for example according to Annex B.

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5.1.3.2.7 Safety measures for storage, processing and disposal

The manufacturer's instructions and the international and/or national regulations on dangerous substances and material shall be observed for the storage and processing of materials, as well as for the disposal of waste products.

5.1.3.3 Ambient conditions

Throughout the coating process, the temperatures of the substrate and coating materials shall be maintained within the range specified by the coating material manufacturer. All surfaces shall be maintained at a temperature at least 3 °C above the dewpoint in order to prevent condensation.

5.1.3.4 Surface preparation

Ferritic steel shall be blasted in accordance with EN ISO 12944-4, be of at least standard preparation grade Sa 2 ½, and have a 'medium (G)' profile grade as in EN ISO 8503-2. All remained abrasive particles shall be removed.

Austenitic steel shall be blasted with mineral abrasives similar to EN ISO 12944-4, and have a 'medium (G)' profile grade as in EN ISO 8503-2. The type and composition of abrasives shall be such that the development of local cells is avoided.

Nonferrous metals shall be treated according to the coating material manufacturer's instructions.

5.1.4 Coating process

5.1.4.1 Mixing

Coating material components shall be thoroughly mixed according to the manufacturer's instructions with the help of a mixing unit comprising a mixing vessel and agitator. Ensure that heat does not develop as a result of the stirring action. It is recommended that the mixture be transferred into a second vessel and mixed a second time.

Only so much coating material shall be mixed at one time as can be processed within its pot life.

5.1.4.2 Primer

The primer shall be brushed, sprayed or rolled on immediately following blast cleaning.

For large surfaces which cannot be cleaned and primed in one shift, smaller areas shall be alternatively blast-cleaned and primed, in which case the primer shall be tack-free before the next area is cleaned. In this case some overlapping of priming coat with the areas with primer previously applied shall be verified. Compliance with this requirement is not necessary for coating surfaces which will be permanently exposed to a relative humidity less than 60 %.

Subsequent layers shall be applied to the primer within the period specified by the coating material manufacturer.

5.1.4.3 Intermediate layer

The intermediate layer shall be applied to the primer with a trowel, brush or roller, or being sprayed. Subsequent layers shall be applied within the period specified by the coating material manufacturer. In case of furane or phenol-formaldehyde resins coatings, the intermediate layer shall be fully cured before the laminate layers will be applied.

5.1.4.4 Laminate layer

The laminate layer shall be applied by the hand lay-up method.

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Observing the coating material manufacturer's instructions, either apply the glass mats or fabric directly onto the primer or intermediate layer before curing, or first apply a coat of resin to the fully-cured primer or intermediate layer (add a thixotrophic agent, if necessary), and then apply the glass mat/fabric.

In either case, the laminate layer shall be carefully rolled using appropriate rollers, ensuring that the entire area of the laminate layer fully adheres to the previous layer. Next, the laminate layer shall be soaked out with the binder.

A second coat of laminate layer may be applied in the same manner while the first is still wet. If more than two coats of laminate layer are applied, the two lower ones shall be fully cured before any subsequent coats are added.

Adjacent pieces of laminate layer shall overlap by at least 50 mm and lap joints shall be staggered.

Laminate layers shall be carefully applied to edges and fillets, where the overlapping of pieces shall be avoided.

If the following layer will be applied to the cured laminate layer, any protruding fibres on the latter shall be removed.

5.1.4.5 Top coat

If the top coat is to be reinforced with a fleece mat, this last may be rolled directly onto the last coat of laminate layer before the laminate layer has cured. Afterwards, the entire system shall be fully cured.

Top coats with integrated fleeces may also be applied directly to the laminate layer once the latter has fully cured.

The laminate layer shall also be fully cured before trowelled top coats are added. Once cured, the top coat shall be dressed by grinding (i.e. to eliminate ridges caused by trowelling or runs).

5.1.4.6 Sealant

The sealant is to be applied either by brushing or rolling.

5.1.4.7 Thermal treatment

Coating systems do not require thermal treatment when at ambient temperature between 15 °C and 25 °C the curing times listed in Table 3 are maintained until commissioning.

Table 3

Resin type	EP	FU	UP	PF	VE
Curing time, in days	10	30	5	30	5

Thermal treatment using hot air at about 50 °C shortens the curing times as shown in Table 4.

Table 4

Resin type	EP	FU	UP	PF	VE
Curing time, in days	1	2	0,5	2	0,5

The times shown here are informative only; the coating material manufacturer's instructions are definitive.

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5.1.5 Requirements for the coating system

5.1.5.1 General

The following requirements apply to the cured coating system.

Laminate coatings shall be free of defects (e.g. pinholes, blisters, cracks or impurities) which could impair the performance of the coating. Bubbles up to 1 mm in diameter are unavoidable and do not reduce the effectiveness of the coating.

5.1.5.2 Total coating system thickness

The total coating system thickness shall be in accordance with the agreed nominal thickness, subject to deviations of – 30 % and + 50 %. Local material accumulation is not completely avoidable, the total thickness shall not exceed the nominal thickness by more than 50 %.

5.1.5.3 Surface properties

The coating surface colour and texture shall be appropriate for the type of coating agreed upon.

5.1.5.4 Continuity

Laminate coatings shall be continuous. Continuity shall be tested on the laminate before application of the top coat using high frequency equipment, during which there should be no breakdowns. The type of testing equipment and voltage used shall be specified by the coating manufacturer.

5.1.5.5 Mechanical characteristics

5.1.5.5.1 Adhesion

When coatings are tested for adhesion as described in EN ISO 4624, the minimum adhesion strength shall be as specified in Table 5. The thickness of test plate (substrate) shall be at least 3 mm.

Table 5

Resin type	EP	FU	UP	PF	VE
Minimum adhesion strength, in MPa	6	4	5	4	5

5.1.5.5.2 Hardness

When tested in accordance with EN 59, furane, phenol-formaldehyde, unsaturated polyester and vinyl ester resins shall have a Barcol hardness value of at least 40, epoxy resins a value of at least 30.

When using other methods to test hardness, minimum values are subject to agreement.

5.1.5.5.3 Elongation at break

For all resin types, elongation at break shall be at least 0,2 %. Bend testing shall be on the lines of EN ISO 178, tensile testing on the lines of EN ISO 527-3.

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5.1.5.5.4 Abrasion resistance

The ability of coatings to resist abrasion and impacts depends on the materials used and coating thickness. Abrasion and impact resistance shall be as indicated in the manufacturer's data sheets.

5.1.5.6 Physical characteristics

5.1.5.6.1 Electrostatic dissipation capability

Laminate coatings are not generally conductive, although electrostatic dissipation coatings may be required in certain applications, in which case continuity testing as specified in 5.1.5.4 is not permitted.

5.1.5.6.2 Thermal stability

When not otherwise specified by the manufacturer, laminate coatings subject to chemical stress may be exposed to temperatures ranging from – 20 °C to + 80 °C.

5.1.5.6.3 Thermal shock resistance

Laminate coatings are sensitive to thermal shocks.

5.1.5.7 Chemical resistance

Laminate coatings shall be resistant to the specified chemical loads. Annex D can be used as a guide for chemicals at ambient temperature.

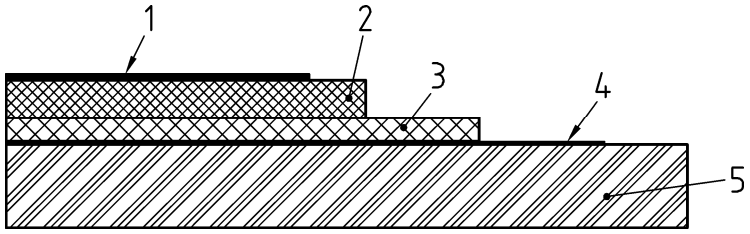
5.1.5.8 Other characteristics

Requirements for other characteristics of coating materials, such as toxicity, resistance to radiation or decontamination are subject to agreement.

5.2 Trowelled coating systems

5.2.1 Coating system design

Depending on the coating system the trowelled coating comprises of maximum 4 layers as illustrated in Figure 2.



Key
1 sealant
2 trowelled layer
3 intermediate layer
4 primer
5 metallic substrate

Figure 2 — Coating system design

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5.2.2 Description of layers

5.2.2.1 General

The following resins may be used as binders: epoxies (EP), furanes (FU), phenol-formaldehydes (PF), polyurethanes (PUR), unsaturated polyesters (UP) or vinyl esters (VE). If different types of resins are used in one coating system, these resins shall be compatible with one another.

Table 2 gives an indication on the thickness of the layers, the total thickness shall be in accordance with the manufacturer's instructions.

5.2.2.2 Primer

The primer not only provides a bond between the metallic substrate and the coating, but also serves as temporary corrosion protection of the substrate between surface preparation and the coating process, and shall therefore cover the entire surface. The primer may be omitted in exceptional cases.

A different resin may be used for the primer than that used in subsequent layers. One-component synthetic resins may also be used.

5.2.2.3 Intermediate layer

The intermediate layer in the case of subsequent coating layers containing furane or phenolformaldehyde resins, inhibits a reaction between the acid catalyst and the metallic substrate.

A different type of resin may be used in the intermediate layer than that used in subsequent layers. The intermediate layer may either be substituted by a thicker primer or omitted.

5.2.2.4 Trowelled layer

The trowelled layer is to be applied in one or more coats, each coat being 0,5 mm to 1,5 mm thick, and shall contain one of the binders listed above, as well as additives such as fillers or processing aids depending upon service conditions.

5.2.2.5 Sealant

The sealant lends the coating a smooth finish and should contain the same resin type as the previous coat. The sealant may be omitted.

5.2.3 General requirements

5.2.3.1 Component design and surface condition

See EN 14879-1 for component design requirements and for requirements regarding the substrate surface.

5.2.3.2 Coating materials

5.2.3.2.1 General

Trowelled coating systems conforming to this standard contain binders (resins), fillers, reinforcing agents and processing aids.

5.2.3.2.2 Binders

The coating material manufacturer shall provide details of the binders used (see Annex B).

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5.2.3.2.3 Fillers

Fillers shall be included in the intermediate layer, the trowelled layer and, if necessary, the sealant in order to influence the chemical and/or physical properties of the layer in question. Fillers shall be compatible with all resin(s) used in the coating system.

Fillers shall be of inert materials such as glass flakes, silica sand, colloidal silicas (silicon dioxide), barite, carbon black, graphite or mica.

5.2.3.2.4 Processing aids

Processing aids (e.g. pigments and thixotrophic agents) shall neither impair curing nor reduce the chemical resistance of the coating.

5.2.3.2.5 Marking of containers

Containers shall be marked, for example according to Annex B.

5.2.3.2.6 Safety measures for storage, processing and disposal

The manufacturer's instructions and the international and/or national regulations on dangerous substances and materials shall be observed for the storage and processing of materials, as well as for the disposal of waste products.

5.2.3.3 Ambient conditions

Throughout the coating process, the temperatures of the substrate and coating materials shall be maintained within the range specified by the coating material manufacturer. All surfaces shall be maintained at a temperature at least 3 °C above the dew point in order to prevent condensation.

5.2.3.4 Surface preparation

Ferritic steel shall be blasted in accordance with EN ISO 12944-4, be of at least standard preparation grade Sa 2 ½, and have a 'medium (G)' profile grade as in EN ISO 8503-2. All remained abrasive particles shall be removed.

Austenitic steel shall be blasted with mineral abrasives similar to EN ISO 12944-4, and have a 'medium (G)' profile grade as in EN ISO 8503-2.

The type and composition of abrasives shall be such that the development of local cells is avoided.

Non-ferrous metals shall be treated according to the coating material manufacturer's instructions.

5.2.4 Coating process

5.2.4.1 Mixing

Coating material components shall be thoroughly mixed according to the manufacturer's instructions with the help of a mixing unit comprising a mixing vessel and agitator. Ensure that heat does not develop as a result of the stirring action. It is recommended that the mixture be transferred into a second vessel and mixed a second time.

Only so much coating material shall be mixed at one time as can be processed within its pot life.

5.2.4.2 Primer

The primer shall be brushed, sprayed or rolled on immediately following blast cleaning.

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For large surfaces which cannot be cleaned and primed in one shift, smaller areas shall be alternatively blast-cleaned and primed, in which case the primer shall be tack-free before the next area is cleaned. In this case some overlapping of priming coat with the areas with primer previously applied shall be verified. Compliance with this requirement is not necessary when coating surfaces which will be exposed to a low relative humidity less than 60 %.

Subsequent layers shall be applied to the primer within the period specified by the coating material manufacturer.

5.2.4.3 Intermediate layer

The intermediate layer shall be applied to the primer with a trowel, brush or roller, or sprayed. Subsequent layers shall be applied within the period specified by the coating material manufacturer. In case of furane or phenol-formaldehyde resin coatings, the intermediate layer shall be fully cured before the trowelled coating layer will be applied.

5.2.4.4 Trowelled layer

The trowelled layer is to be applied in one or in several coats.

Before the application of subsequent layers, the curing time specified by the manufacturer shall be observed.

It may be necessary to use special techniques such as rolling when applying flaky fillers in order to embed and orientate them properly into the resin.

Exposed areas such as edges cannot always be sufficiently protected by trowelled layers; therefore, reinforcing agents such as glass fibre mats may be necessary.

5.2.4.5 Sealant

The sealant is to be applied either by brushing, rolling or spraying.

5.2.4.6 Thermal treatment

Coating systems do not require thermal treatment when at ambient temperatures between 15 °C and 25 °C the curing times listed in Table 6 are maintained until commissioning.

Table 6

Resin type	EP	FU	PF	PUR	UP	VE
Curing time, in days	10	30	30	10	5	5

Thermal treatment using hot air at about 50 °C shortens the curing times as shown in Table 7.

Table 7

Resin type	EP	FU	PF	PUR	UP	VE
Curing time, in days	1	2	2	2	0,5	0,5

The times shown here are informative only; the coating material manufacturer's instructions are definitive.

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5.2.5 Requirements for the coating system

5.2.5.1 General

The following requirements apply to the cured coating system.

Trowelled coatings shall be free of defects (e.g. pinholes, blisters, cracks or impurities) which could impair the performance of the coating.

5.2.5.2 Total coating system thickness

The total coating system thickness shall be in accordance with the agreed nominal thickness, subject to the limit deviations specified in Table 8.

Table 8

Limit deviation	Nominal thickness mm		
	Up to 2	Above 2 up to 4	Above 4
Lower	25 %	25 %	25 %
Upper	50 %	40 %	30 %

Local material accumulations are not completely avoidable. Their thickness shall not exceed the nominal thickness by more than 50 %.

5.2.5.3 Surface properties

The coating surface shall be even, although flat grooves caused by the trowelling are permissible.

The coating surface colour and texture shall be appropriate for the type of coating agreed upon.

5.2.5.4 Continuity

Trowelled coatings shall be continuous. Continuity shall be tested on the trowelled layer before application of the sealing coat using high frequency equipment, during which there should be no breakdowns. The type of testing equipment and voltage used shall be specified by the coating manufacturer.

5.2.5.5 Mechanical characteristics

5.2.5.5.1 Adhesion

When coatings are tested for adhesion as described in EN ISO 4624, the minimum adhesion strength shall be as specified in Table 9. The thickness of test plate (substrate) shall be at least 3 mm.

Table 9

Resin type	EP	FU	PF	PUR [a]	UP	VE
Minimum adhesion strength, in MPa	6	4	4	3	4	4
[a] Peeling force, in N/mm, according to ISO 813.						

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5.2.5.5.2 Hardness

When tested in accordance with EN 59, unsaturated polyesters and vinyl ester resins shall have a Barcol hardness value of at least 35, furane, phenol-formaldehyde and epoxy resins a value of at least 30. Polyurethane resins shall have a Shore A hardness value of at least 70.

When using other methods to test hardness, minimum values are subject to agreement.

5.2.5.5.3 Elongation at break

For all resin types, elongation at break shall be at least 0,2 %. Bend testing shall be on the lines of EN ISO 178, tensile testing on the lines of EN ISO 527-3.

5.2.5.5.4 Abrasion resistance

The ability of coatings to resist abrasion and impacts depends on the materials used and coating thickness. Abrasion and impact resistance shall be as indicated in the manufacturer's data sheets.

5.2.5.6 Physical characteristics

5.2.5.6.1 Electrostatic dissipation capability

Trowelled coatings are not generally conductive, although electrostatic dissipation coatings may be required in certain applications, in which case continuity testing as specified in 5.2.5.4 is not permitted.

5.2.5.6.2 Thermal stability

When not otherwise specified by the manufacturer, trowelled coatings may be exposed to temperatures up to the maximum limits listed in Table 10.

Table 10

Resin type	EP	FU	PF	PUR	UP	VE
Liquid/max. temp., in °C	70	100	100	60	80	100
Dry/max. temp., in °C	100	150	150	80	140	160

5.2.5.6.3 Thermal shock resistance

Trowelled coatings are sensitive to shock changes in temperature.

5.2.5.7 Chemical resistance

Trowelled coatings shall be resistant to chemicals. Annex D lists several resin types according to their resistance to various chemicals at ambient temperature.

5.2.5.8 Other characteristics

Requirements for other properties of coating materials, such as resistance to radiation, or decontamination are subject to agreement.

Requirements regarding non-toxicity have to be handled according to national regulations.

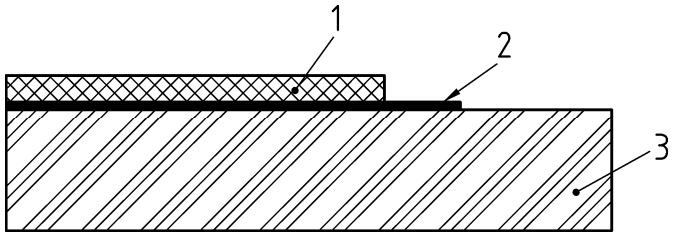
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5.3 Sprayed coating

5.3.1 Coating system design

Depending on the coating system the sprayed coating comprises of one or more layers as illustrated in Figure 3.



Key
1 coating
2 primer
3 metallic substrate

Figure 3 — Coating system design

5.3.2 Description of layers

5.3.2.1 General

The following resins may be used as binders.

Cold-curing resins: Epoxies (EP), polyurethanes (PUR), unsaturated polyesters (UP) and vinyl esters (VE).

Heat-curing resins: Phenolformaldehyde (PF), Epoxies (EP) and polyurethanes (PUR).

If different types of resins are used in one coating system, these resins shall be compatible with one another.

Table 2 gives an indication on the thickness of the layers, the total thickness shall be in accordance with the manufacturer's instructions.

5.3.2.2 Primer

The primer not only provides a bond between the metallic substrate and the coating, but also serves as temporary corrosion protection of the substrate between surface preparation and the coating process, and shall therefore cover the entire surface.

A different resin may be used for the primer than that used for subsequent layers. The primer may be omitted.

5.3.2.3 Coating

The coating itself may comprise several layers. The thickness of each layer and the processing time shall be as specified by the coating material manufacturer.

The last layer may be specially formulated for special service conditions. Layers applied in different work steps should be of different colours.

Table 11 gives suggested values for the coating system thickness and number of layers for various resins.

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Table 11

Resin type	EP	EP (heat-cured, solventfree)	PUR	PUR (heat-cured, solventfree)	UP	VE	PF
Coating system thickness, in mm	1,0	2,0	≤ 0,5	2,0	1,0	1,2	≤ 0,5
Number of layers	Several	One	Several	One	Several	Several	Several

5.3.3 General requirements

5.3.3.1 Component design and surface condition

See EN 14879-1 for component design requirements and for requirements regarding the substrate surface.

5.3.3.2 Coating materials

5.3.3.2.1 General

Coating systems conforming to this standard are to contain binders (resins), and may contain solvents, fillers or additives.

5.3.3.2.2 Binders

Binders are either cold curing or heat curing resins. The coating material manufacturer shall provide details of the binders used in each layer (see Annex B).

5.3.3.2.3 Solvents

When using solvents (which provide the coating material with the necessary viscosity), the coating material manufacturer's instructions are to be observed.

5.3.3.2.4 Fillers, processing aids and pigments

Fillers, processing aids and pigments used to influence the chemical and physical characteristics of the coating system shall be inert to the chemicals to which the coating will be exposed and compatible with all resin(s) used in the coating system. Materials used for these purposes include glass flakes, silica sand, colloidal silicas (silicon dioxide), barite, carbon black, graphite, mica, and ferric oxide.

5.3.3.2.5 Marking of containers

Containers shall be marked. This can be done for example according to Annex B.

5.3.3.2.6 Safety measures for storage, processing and disposal

The manufacturer's instruction and the international and/or national regulations on dangerous substances and materials shall be observed for the storage and processing of materials, as well as for the disposal of waste products.

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5.3.3.3 Ambient conditions

Throughout the coating process, the temperatures of the substrate and coating materials shall be maintained within the range specified by the coating material manufacturer. All surfaces shall be maintained at a temperature at least 3 °C above the dewpoint in order to prevent condensation.

5.3.3.4 Surface preparation

Ferritic steel shall be blasted in accordance with EN ISO 12944-4, be of at least standard preparation grade Sa 2 ½, and have a 'medium (G)' profile grade as in EN ISO 8503-2. All remained abrasive particles shall be removed.

Austenitic steel shall be blasted with mineral abrasives similar to EN ISO 12944-4, and have a 'medium (G)' profile grade as in EN ISO 8503-2.

The type and composition of abrasives shall be such that the development of local cells is avoided.

Non-ferrous metals shall be treated according to the coating material manufacturer's instructions.

5.3.4 Application

5.3.4.1 General

Coating materials shall be either mixed and applied in batches or applied using continuous-spray equipment.

5.3.4.2 Mixing

5.3.4.2.1 Batch mixing

For batch mixing, a mixing unit comprising a mixing vessel and agitator shall be used. Ensure that heat does not develop as a result of the stirring action. It is recommended that the mixture be transferred into a second vessel and mixed a second time.

Only so much coating material shall be mixed at one time as can be processed within its pot life.

5.3.4.2.2 Continuous mixing

The mixing of the components in a dual-component sprayer happens in the mixing tube backwards to the spray gun. If necessary, heated dual-component sprayers may be used.

The mixture should be checked before spraying begins to ensure that the components have been thoroughly mixed.

5.3.4.3 Primer

The primer shall be brushed, sprayed or rolled on immediately following blast cleaning.

For large surfaces which cannot be blast cleaned and primed in one work shift, smaller areas shall be alternately blast cleaned and primed, in which case the primer shall be tack-free before the next area is blast-cleaned. In this case some overlapping of priming coat with the areas with primer previously applied shall be verified. Compliance with this requirement is not necessary when coating surfaces which will be exposed to a low relative humidity less than 60 %.

Subsequent layers shall be applied to the primer within the period specified by the coating material manufacturer.

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5.3.4.4 Coating

The coating itself is to be applied in one or more work steps either manually or with the help of special equipment. Before the application of subsequent layers, the waiting time for each layer specified by the manufacturer shall be observed.

5.3.4.5 Thermal treatment

5.3.4.5.1 Coatings containing cold-curing resins

In general, however, coating systems do not require thermal treatment when at ambient temperatures between 15 °C and 25 °C the curing times listed in Table 12 are maintained until commissioning.

Thermal treatment may be carried out in special cases to enhance the chemical resistance of the coating system.

Table 12

Resin type	EP	PUR	UP	VE
Maximum curing time, in days	7	7	5	5

The times shown here are informative only, the coating material manufacturer's instructions are definitive.

Thermal treatment using hot air at a temperature greater than 50 °C shortens the curing times as shown in Table 13.

Table 13

Resin type	EP	PUR	UP	VE
Curing time, in days	1	2	0,5	0,5

5.3.4.5.2 Coatings containing heat-curing resins

Coatings containing heat-curing resins require heat-curing at component temperatures up to about 200 °C for up to two hours. These values are informative only; the coating material manufacturer's instructions are definitive.

5.3.5 Requirements for the coating system

5.3.5.1 General

The following requirements apply to the cured coating system.

5.3.5.2 Coating defects

Coatings shall be free of defects (e.g. pinholes, blisters, cracks or impurities) which could impair the performance of the coating.

5.3.5.3 Coating system thickness

The total coating system thickness shall be in accordance with the agreed nominal values, subject to the limit deviations specified in Table 14. If local material accumulation cannot be avoided, the actual thickness shall not exceed the nominal value by more than 50 %.

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Table 14

Limit deviation	Nominal thickness, in mm	
	Up to 2	Above 2 up to 4
Lower	25 %	25 %
Upper	50 %	40 %

5.3.5.4 Surface properties

The coating surface shall be even and its colour and texture shall be appropriate for the type of coating agreed upon.

5.3.5.5 Continuity

Coatings shall be continuous. This requirement shall be deemed satisfied if in a high-voltage test no break-down occurs (see prEN 14879-4).

Types of equipment and test voltage have to be defined by the manufacturer of the coating material.

5.3.5.6 Mechanical characteristics

5.3.5.6.1 Adhesion

When coatings are tested for adhesion as described in EN ISO 4624, the minimum adhesion strength shall be as specified in Table 15. The thickness of test plate (substrate) shall be at least 3 mm.

Table 15

Resin type	EP	PUR[a]	UP	VE	PF
Minimum adhesion strength, in MPa	6	3	5	5	15
[a] Peeling force, in N/mm, according to ISO 813.					

5.3.5.6.2 Hardness

When tested in accordance with EN 59, coatings based on unsaturated polyester and vinyl ester resins shall have a Barcol hardness value of 35, while those based on phenol-formaldehyde and epoxy resins shall have a value of 30.

Coatings based on polyurethane resins shall have a Shore A hardness value of about 70 and PUR elastified epoxy coatings shall have a Shore A hardness value of about 85.

When using other methods to test hardness, minimum values are subject to agreement.

5.3.5.6.3 Elongation at break

When testing resins on the lines of EN ISO 178 (bend test) or on the lines of EN ISO 527-3 (tensile test), elongation at break shall be at least 0,2 %.

5.3.5.6.4 Abrasion resistance

The ability of coatings to resist abrasion and impacts depends on the materials used and coating thickness. Abrasion and impact resistance shall be as indicated in the manufacturer's data sheets.

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5.3.5.7 Physical characteristics

5.3.5.7.1 Electrostatic dissipation capability

Coatings in accordance with this standard are not generally conductive, although electrostatic dissipation coatings may be required in certain applications, in which case continuity testing as specified in 5.3.5.5 is not permitted.

5.3.5.7.2 Thermal stability

When not otherwise specified by the manufacturer, coatings may be exposed to temperatures up to the maximum limits given in Table 16.

Table 16

Resin type	EP	PUR	UP	VE	PF
Liquid/max. temp., in °C	80	60	80	100	120
Dry/max. temp., in °C	100	80	160	180	180

5.3.5.7.3 Thermal shock resistance

Coatings according to this standard are sensitive to shock changes in temperature.

5.3.5.8 Chemical resistance

Coatings shall be resistant to chemicals. Annex D lists several resin types according to their resistance to various chemicals at ambient temperature.

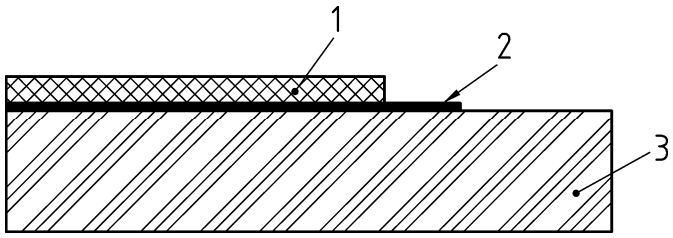
5.3.5.9 Special characteristics

Requirements for other characteristics of coating materials, such as toxicity, resistance to radiation, or ease of decontamination are subject to agreement.

5.4 Powder coating

5.4.1 Coating system design

Depending on the coating system the powder coating comprises of one or more layers as illustrated in Figure 4.



Key
1 coating
2 primer
3 metallic substrate

Figure 4 — Coating system design

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5.4.2 Description of layers

5.4.2.1 General

There are three main types of powdered coatings (material symbols as in EN ISO 1043-1 and ISO 1629):

a) thermosetting powders based on epoxy (EP), unsaturated polyester (UP), phenol-formaldehyde (PF) resins, or Novolak;

b) thermoplastic powders based on polyamide PA11 or PA12, PVC or polyethylene (PE);

c) fluoroplastic powders (e.g. PVDF, E/CTFE, TFE/PFA, FEP/PFA).

If different types of material are used in one coating system, these shall be compatible with one another.

Table 2 gives an indication on the thickness of the layers, the total thickness shall be in accordance with the manufacturer's instructions.

5.4.2.2 Primer

The primer not only provides a bond between the metallic substrate and the coating, but also serves as temporary corrosion protection during the coating process.

A different resin may be used for the primer than for subsequent layers. The primer may be omitted.

5.4.2.3 Coating

The coating itself may comprise several layers. They can be applied by either electrostatic spraying or fluid-bed dipping. The thickness of each layer and processing time shall be as specified by the coating material manufacturer.

The top layer may be specially formulated for special purposes. Layers applied in different work steps may be of different colours. The coating and primer should be of different colours.

Table 17 describes several widely used coating systems.

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Table 17

Thermosetting powders			
Coating material based on	EP	UP	Novolak
Total coating system thickness, in µm	200 to 700	125 to 500	125 to 500
Primer present	Usually	Always	Always
Thermoplastic powders			
Coating material based on	PA11, PA12	PVC	PE
Total coating system thickness, in µm	125 to 1 500	700	1 200
Primer present	Always	Usually	Usually
Fluoroplastic powders			
Coating material based on	PVDF	E/CTFE	PFA
Total coating system thickness, in µm	500 to 1 200	500 to 1 500	50 to 120 [a]
Primer present	Always	Always	Usually
[a] Non-stick coatings.			

5.4.3 Component design and surface condition

5.4.3.1 Component design

See EN 14879-1 for component design requirements.

Care should be taken when components having widely varying wall thicknesses, which may result in application problems and varying thickness of the coating.

5.4.3.2 Surface requirements

See EN 14879-1 for requirements regarding the substrate surface.

If it is suspected that the substrate is contaminated, it is to be examined for soluble salts, especially chlorides and sulphates. In case of organic impurities, the substrate is to be cleaned thermally before blasting. Before applying the coating, ensure that the blasted substrate is dust-free.

5.4.4 Coating materials

5.4.4.1 General

The applicator's quality system documentation shall include all necessary information regarding the coating materials.

5.4.4.2 Fillers, processing aids and pigments

Fillers, processing aids and pigments used to alter the chemical and physical characteristics of the coating system shall be inert to the chemicals to which the coating will be exposed and compatible with all resins used in the coating system. Materials used for these purposes include colloidal silicas (silicon dioxide), carbon black, graphite, mica, and ferric oxide.

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5.4.4.3 Marking of containers

Containers shall be marked. This can be done for example according to Annex B.

5.4.4.4 Safety measures for storage, processing and disposal

The manufacturer's instructions and the international and/or national regulations on dangerous substances and materials shall be observed for the storage and processing of materials, as well as for the disposal of waste products. Special attention shall be paid to prevention of dust explosions and ignition hazards.

5.4.5 Ambient conditions

The primer or coating shall be applied immediately after the substrate has been blast-cleaned; if this is not possible, the ambient conditions shall be suitably adjusted. All surfaces shall be maintained at a temperature at least 3 °C above the dewpoint in order to prevent condensation.

5.4.6 Surface preparation

Ferritic steel shall be blast-cleaned in accordance with EN ISO 12944-4, be of at least standard preparation grade Sa 2 ½, and have a 'medium (G)' profile grade as in EN ISO 8503-2. All remained abrasive particles shall be removed.

Austenitic steel shall be blast-cleaned with mineral abrasives similar to EN ISO 12944-4, and have a 'medium (G)' profile grade as in EN ISO 8503-2.

The type and composition of abrasives shall be such that the development of local cells is avoided.

Nonferrous metals shall be treated according to the coating material manufacturer's instructions.

5.4.7 Application

5.4.7.1 Fluid-bed dipping

The preheated component is dipped in a fluidised bed of the powdered coating material. The stored heat in the component causes the powder to fuse, forming a homogeneous, smooth film. Temperatures should be selected in such a manner that incomplete fusion or thermal damage to the coat (often identifiable as discoloration or blistering) are avoided.

5.4.7.2 Electrostatic spraying

The powdered coating material is placed in a vessel, aerated and fed through a hose to a spray gun by means of compressed air. The material is electrostatically charged while spraying. The charged powder adheres to the substrate, which has been earthed, and the coating is fused into a homogeneous film by heating.

5.4.7.3 Flame spraying

With this method, the powdered material is heated in the spray-gun while spraying. The particles melt before they hit the pre-treated, preheated substrate.

5.4.8 Requirements for the coating system

5.4.8.1 General

Coatings shall adhere well to the substrate, shall form a closed film, and shall be free of defects (e.g. pinholes, blisters, cracks or impurities) which could impair the performance of the coating.

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5.4.8.2 Coating system thickness

The coating system thickness shall be in accordance with the agreed nominal value, subject to the limit deviations specified in Table 18. Local material accumulation cannot be avoided. Their actual thickness shall not exceed the nominal value by more than 50 %; such areas are not permissible on or near flanges.

Table 18

Limit deviation	Nominal thickness, in µm		
	125 to 500	Above 500 up to 1 000	Above 1 000
Lower	10 %	15 %	15 %
Upper	50 %	40 %	40 %

5.4.8.3 Surface properties

The coating surface shall be even and its colour and texture shall be appropriate for the type of coating agreed upon.

5.4.8.4 Continuity

Coatings shall be continuous. This requirement shall be deemed satisfied if in a high-voltage test no breakdown occurs (see prEN 14879-4).

Continuity testing is not required for non-stick coatings, as they are microporous.

5.4.8.5 Mechanical characteristics

5.4.8.5.1 Adhesion

The adhesion strength shall be at least 10 MPa in accordance with EN ISO 4624. The thickness of test plate (substrate) shall be at least 3 mm.

5.4.8.5.2 Elongation at break

For all powder coatings, elongation at break shall be at least 0,2 % at operating temperature.

5.4.8.5.3 Abrasion resistance and impact resistance

The ability of coatings to resist abrasion and impacts depends on the materials used and coating thickness. Abrasion and impact resistance shall be as indicated in the manufacturer's data sheets.

5.4.8.6 Physical properties

5.4.8.6.1 Permeability

Powder coatings are not impermeable to gas and vapours. The permeability of such coatings depends on the materials used, the coating thickness and the application method used.

5.4.8.6.2 Electrostatic dissipation capability

Powder coatings are not generally conductive, although electrostatic dissipation coatings may be required in certain applications, in which case continuity testing as specified in 5.4.8.4 is not permitted.

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5.4.8.6.3 Thermal stability

Powder coatings are to be resistant to specific thermal stresses.

Unless otherwise specified by the manufacturer, powder coatings may be exposed to temperatures up to the maximum limits given in Table 19.

Table 19

Resin type	Thermosetting powders				Thermoplastic powders				Fluoroplastic powders		
	EP	UP	PF	Novolak	PA 11	PA 12	PE	PVC	PVDF	E/CTFE	PFA
Liquid/max. temp., in °C	60	80	100	80	85	85	60	80	80	90	—
Dry/max. temp., in °C	100	160	160	100	100	100	80	80	150	160	180

Powder coatings are not sensitive to gradual changes in temperature.

5.4.8.7 Chemical resistance

Powder coatings shall be resistant to the specified chemical stresses.

5.4.8.8 Other characteristics

Requirements for other properties of coating materials, such as ageing, coating life, toxicity, resistance to radiation or decontamination are subject to agreement.

5.5 Protection of existent coatings

5.5.1 General

As coatings have a low elongation at break and are impact-sensitive not only at ambient temperature, but especially at low temperatures, they should be handled with care. Deformation of the metallic substrate can damage the coating.

The coating material manufacturer's instructions regarding the handling of coated components shall be observed throughout the coating process, during storage, when the component is commissioned and whenever any repairs are made.

If exterior paintings have to be applied, it is recommended that exterior blasting and priming shall be carried out prior to the application of the powder coating. Exterior paintings shall be compatible with the powder coating as regards adhesion at locations where the two coating types meet.

5.5.2 Packaging and handling

The packaging of coated components will not only depend on the mechanical stresses the component will undergo during handling, but also on the size, mass and stiffness of the components themselves, on the type of lifting aids and transport equipment used, on assembly site conditions, and whether transshipment is necessary. Since coatings on exposed areas (flanges, edges etc.) are especially susceptible to damage, these areas shall be protected during transport.

The use of reinforcements, bracing or transport racks may also be necessary. Chains and steel cables are to be used with spacers to prevent them from scratching the coating.

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When handling coated components, extreme temperatures (especially those below 0 °C), sudden changes in temperature, as well as exposure to direct sunlight shall be avoided. After transport, the coating shall be checked for soundness.

5.5.3 Storage

Whether or not storage in closed areas or the use of covers is necessary depends on the sensitivity of the coating to cold, heat, changes in temperature or exposure to sunlight.

When components are stored for long periods outdoors, additional protection against undercoating layers corrosion (tunnelling) at the coating/substrate interface (e.g. at flange facings) shall be provided.

5.5.4 Assembly

The requirements specified in 5.5.1 above shall also be observed during assembly. Coated surfaces shall not be ground, scarfed or welded.

Gaskets shall be selected taking into account the maximum permissible compressive stress to which the coating as well as the gasket can be subjected, as well as the material's chemical resistance.

After assembly, the coating shall be checked for soundness.

5.5.5 Repair

5.5.5.1 General

Coatings may be repaired with appropriate materials, taking the coating system design into consideration. Repairs shall be carried out according to the coating manufacturer's instructions.

5.5.5.2 Powder coatings

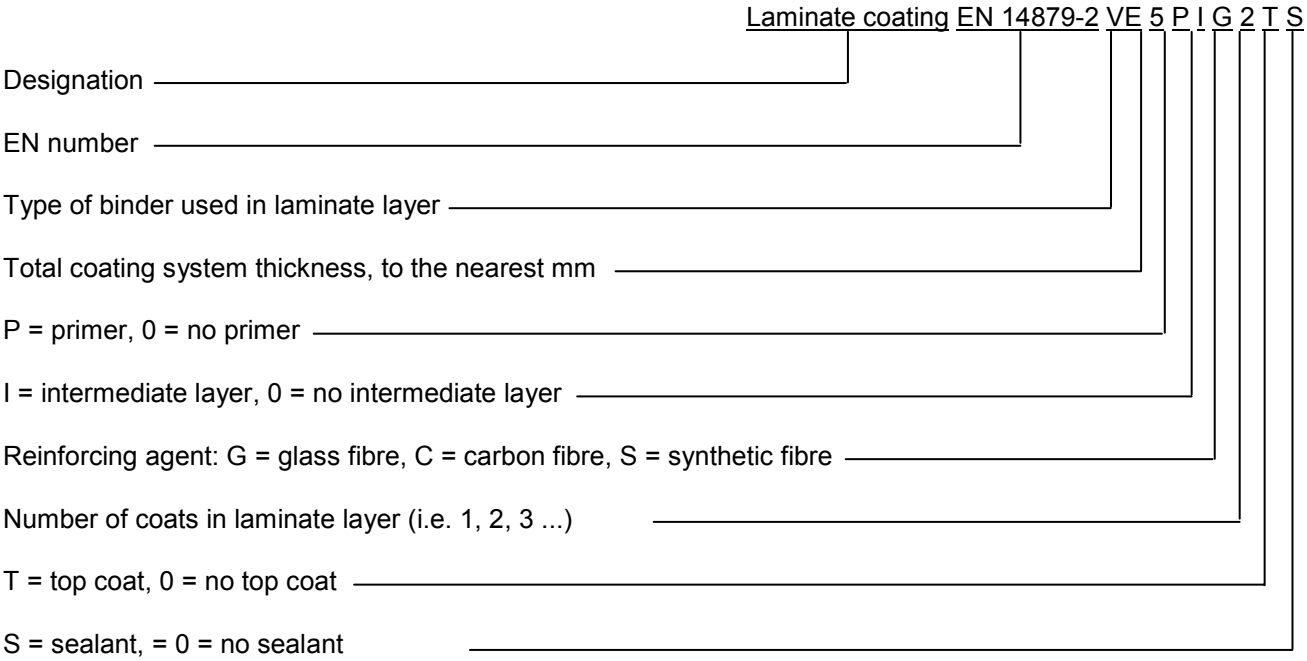
Small areas of the coating may be repaired using the same kind of material according to the coating manufacturer's instructions. Repairs to the coating made after the component has been commissioned are possible only in rare cases. If other materials are used for repairs, these materials shall be selected according to the chemical environment to which the coating will be exposed.

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6 Designation

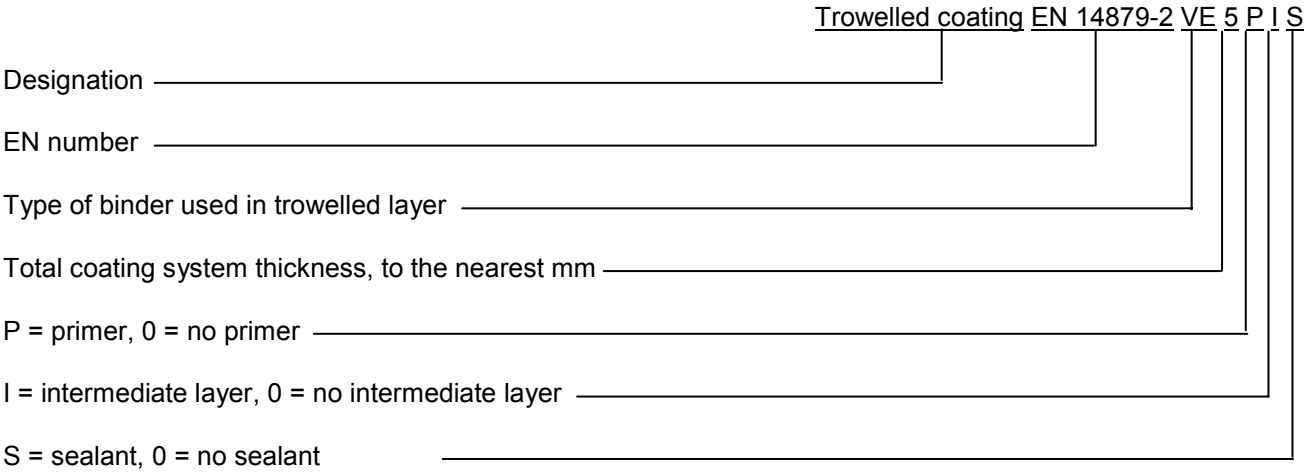
6.1 Laminate coating

EXAMPLE Designation of a laminate coating system containing vinyl ester resin (VE) as a binder, with a total thickness of 5 mm, including a primer, an intermediate layer, two coats of glass fibre laminate layer, a top coat and a sealant:



6.2 Trowelled coating

EXAMPLE Designation of a trowelled coating system containing vinyl ester resins (VE) as a binder, with a total thickness of 5 mm, including a primer, an intermediate layer and a sealant:



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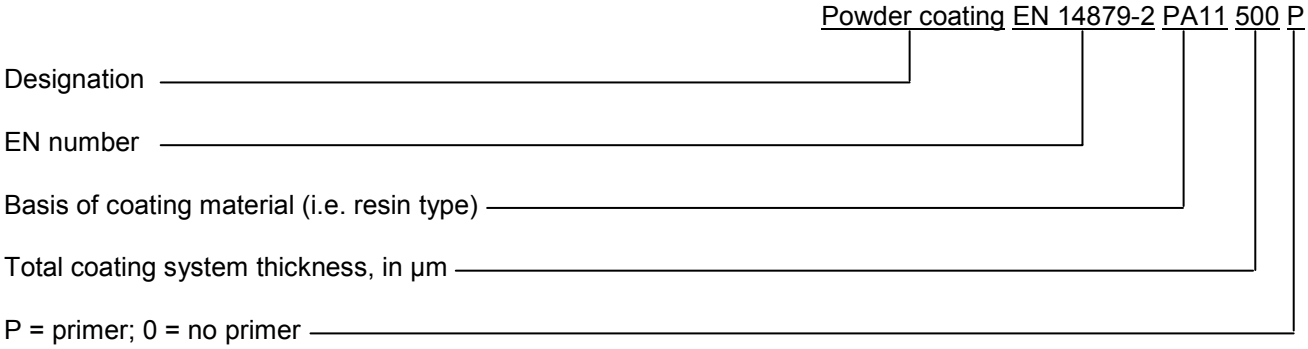
6.3 Sprayed coating

EXAMPLE Designation of a sprayed coating system containing vinyl ester resin (VE) as a binder, with a total thickness of 1,0 mm and including a primer:



6.4 Powder coating

EXAMPLE Designation of a thermoplastic powder coating containing polyamide PA11, with a total thickness of 0,5 mm (500 µm) and including a primer:



7 Testing

7.1 General

The nature and scope of testing, and any necessary documentation are to be specified on a case-by-case basis. Criteria which are to be agreed include:

a) requirements

b) permissible deviations from specified requirements for the coating;

c) tests;

d) test equipment;

e) date of test;

f) test environmental conditions.

7.2 Suitability testing

Suitability testing shall be carried out in accordance with Clause 8.

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7.3 Receiving inspection of coating material

7.3.1 General

The applicator of the coating material shall inspect the material upon receipt as specified in 7.3.2. Inspections as in 7.3.3 and 7.3.4 may be carried out randomly. If necessary, inspections as in 7.3.6 to 7.3.8 shall be carried out, or further special inspections shall be performed as needed.

7.3.2 Container marking

The container marking shall be checked to ensure it agrees with the information given in the order and delivery documents.

7.3.3 Viscosity or flow time

Depending on the viscosity range of the material, either the flow time shall be determined as in EN ISO 2431, or the viscosity shall be determined at a defined velocity gradient as in EN ISO 3219.

7.3.4 Density

The density of liquid coating materials shall be determined as in EN ISO 2811-1 and EN ISO 2811-2, while that of powder materials shall be determined as in ISO 8130-2.

7.3.5 Colour

The colour of the material shall be determined by visual examination.

7.3.6 Non-volatile matter content

The non-volatile matter content shall be determined as in EN ISO 3251, the time-temperature combination being subject to agreement.

7.3.7 Gel time

The gel time shall be determined as in EN ISO 3001 by analogy, although test details are to be agreed.

7.3.8 Binders

Infrared spectroscopy (or pyrolysis infrared spectroscopy) may be used to determine the type of binder the coating material contains, or to identify the coating material supplied, by testing either the fresh binder or a dried film of the binder material.

7.4 Testing of coating systems during application

7.4.1 General

Testing of coating systems during application include the tests according to 7.4.2 to 7.4.5. In addition to this, during application, work samples may be prepared and tested.

7.4.2 Suitability of component for coating

Before applying the coating, the person responsible for this shall make sure that the component is suitable for receiving the coating system in terms of design and surface preparation as described in EN 14879-1. The surface condition, cleanliness and roughness shall be checked in accordance with EN ISO 12944-4 and EN ISO 8503-2.

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7.4.3 Ambient conditions

It shall be ensured that the required ambient conditions are maintained throughout the application process (i.e. from surface preparation to curing); these conditions shall be documented.

7.4.4 Application method

The applicator shall make sure that the specified method is used, including the given mixing method, processing time, pot life and post-curing method, and that the coating system is of the specified design.

7.4.5 Thickness of coating layers

The thickness of each coating layer shall be determined to ensure it meets the specified requirements, by measuring either the wet film thickness as in EN ISO 3882, the dry film thickness of coatings on magnetic substrates as in EN ISO 2178, or using the eddy current method for coatings on non-magnetic substrates, as in EN ISO 2360.

7.5 Acceptance testing

7.5.1 General

Acceptance testing of the coated component shall be carried out together as agreed between the coating manufacturer and the client or his representative. A test report is to be drawn up.

If destructive testing has been agreed, these tests shall be performed on work samples prepared during the application process. Acceptance testing may comprise the tests described in 7.5.2 and 7.5.3.

7.5.2 Acceptance testing of coated component

7.5.2.1 Surface properties

The surface properties of the coating shall be assessed visually without magnifying lens.

7.5.2.2 Coating thickness

The coating thickness shall be measured using a non-destructive method, e.g. as in EN ISO 2808, EN ISO 2064, EN ISO 2178, EN ISO 2360 or EN ISO 3882.

7.5.2.3 Continuity

Continuity testing shall be performed as in 8.1.2.3.

7.5.2.4 Hardness

Hardness tests should be carried out on test plates

7.5.2.5 Electrostatic dissipation capability

The earth leakage resistance shall be tested as in Annex E or EN 1081.

7.5.3 Acceptance testing of specimens

7.5.3.1 Hardness

Hardness shall be tested as in 8.1.2.5.

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7.5.3.2 Adhesion

Adhesion shall be tested as in 8.1.2.4.

7.5.3.3 Coating system design

The coating system design shall be checked as in 8.1.2.2.

7.6 Routine testing

In case no national regulations exist, the coating manufacturer and the client or his representative (inspection body) shall agree on a routine testing schedule in order to evaluate the protective function of the coating. The following details shall be specified:

a) frequency of testing;

b) scope of testing and test criteria;

c) test method;

d) test procedure;

e) auxiliary equipment to be used;

f) cleaning and drying methods.

7.7 Inspection report

An inspection report shall be drawn up, for which the specimen form in Annex H may be used.

8 Suitability verification and tests

8.1 Requirements

8.1.1 General

The following tests apply exclusively to the suitability of the surface protection systems for the area of application according to Clause 4.

Verification of suitability can be given by

a) laboratory examinations by a testing laboratory or

b) proof of facts established by experience of the owner or manufacturer or

c) a combination of both a) and b).

For the verification of suitability according to a), the specimens with the respective material for the laboratory test shall be prepared in agreement with the testing laboratory. The identity of the materials shall be adequately proven to the testing laboratory by specification of physical-chemical parameters. Individual proof can also be given to the testing laboratory by certified reference objects.

The following can be considered as proof of experience according to b):

— laboratory examinations with recorded and reproducible results;

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— reference objects which are proven executed with the surface protection system the suitability of which is to be verified;

— resistance lists the basic conditions of which are known and can be proven by laboratory tests.

8.1.2 Laboratory testing

8.1.2.1 General

The test methods described in 8.1.2.2 to 8.1.2.13 shall be used to assess the suitability of the coating. The duration of testing shall be sufficiently long, although it may be shortened by intensifying the test conditions. Note, however, that this could lead to false evaluations.

Laboratory tests shall be carried out either on coated plates or on samples of the upper coat which will be in contact with the medium.

8.1.2.2 Coating system design

The colour, position, thickness and homogeneity of each layer, as well as the surface properties of the coating shall be determined. They shall comply with the information given by the manufacturer.

8.1.2.3 Continuity

Continuity testing of a non-conductive coating on a conductive substrate shall generally be carried out using high-voltage equipment with a constant direct current, a pulsed direct current or an alternating current, depending on the coating thickness. The equipment, voltage type, test voltage, electrode type and accuracy of the indicating device shall be specified by the coating manufacturer. Testing shall be as in prEN 14879-4 by analogy.

When the coating is conductive, continuity testing — if at all possible — shall be as specified by the coating manufacturer.

8.1.2.4 Adhesion

Adhesion shall preferably be determined in a pull-off test analogous to that specified in EN ISO 4624. For thin coatings (≤ 250 µm), a cross-cut test as in EN ISO 2409 may be carried out, subject to agreement. The mode of failure shall be made according to EN ISO 4625-1.

8.1.2.5 Hardness

The hardness of coatings with a thickness over 1 mm shall be tested using a Barcol impressor as in EN 59. For coatings with a thickness under 1 mm, the hardness test method shall be agreed upon.

8.1.2.6 Elongation at break

The method for testing elongation at break (e.g. using three-point loading) shall be agreed upon on a case-by-case basis.

8.1.2.7 Chemical resistance

Coated test plates shall be exposed (according to 8.2.2.4.1, Test method A) to the test liquid in such a manner that about half of the specimen's area is immersed in the liquid, while the other half is in contact with the vapour formed by the liquid. When coatings are exposed only to gas or vapour, the test arrangement shall be modified accordingly.

In addition, testing by conditioning specimens (according to 8.2.2.4.2, Test method B) in the test liquid may be agreed, depending on the type of coating.

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In all cases, the test liquid, and the exposure temperature and time shall be agreed upon.

To assess chemical resistance, the following shall be determined:

a) changes to the coating detectable by visual and tactile examination;

b) changes in hardness;

c) changes in thickness; where possible, changes in the coating material mass;

d) changes in adhesion, where possible.

8.1.2.8 Permeability

Specimens shall be plates coated on one side, which shall be exposed to the test medium (liquid, gas or vapour), while the uncoated side is cooled. The test medium, its temperature and temperature gradient, and the duration of test shall be agreed upon.

To assess permeability, the following shall be determined:

a) visually detectable changes, such as blisters, swelling or colour changes;

b) changes in hardness;

c) changes in adhesion;

d) changes to the substrate surface.

8.1.2.9 Thermal stability

Thermal stability shall be determined either by conditioning coated plate specimens at the test temperature in a controlled atmosphere, or by means of thermal analysis (e.g. differential scanning calorimetry (DSC)). Test parameters and duration are to be agreed upon.

To assess thermal stability, the following shall be determined:

a) changes to the coating detectable by visual and tactile examination;

b) changes in hardness;

c) changes in adhesion.

8.1.2.10 Thermal shock resistance

Testing shall be analogous to thermal stability testing, with the type and length of the temperature cycles being subject to agreement.

8.1.2.11 Abrasion resistance

Testing of abrasion resistance shall be agreed upon.

8.1.2.12 Electrical dissipation capability

The earth leakage resistance shall be tested according to Annex E or EN 1081.

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8.1.2.13 Other properties

Testing of other properties shall be agreed upon, depending on the expected service conditions. Test parameters and the required test criteria shall be specified.

8.1.3 In-service testing (field tests)

Proof of suitability of new coatings or of new fields of application for existing coatings can be obtained by means of in-service testing of either reference areas on the coating or on coated plate specimens, with comparable operating conditions.

Details of the coating application method, the assembly of coated components, and the site of the assembly, as well as the operating conditions and any tests carried out are to be documented.

The test duration, number and size of reference areas or specimens, test site and tests to be performed are to be agreed upon, although the test shall be at least 28 days long.

At least the following tests shall be performed:

a) visual examination;

b) coating thickness measurement;

c) high-voltage continuity testing (where possible);

d) hardness testing;

e) adhesion testing and examination of substrate (where possible).

8.1.4 Testing on reference objects

Reference objects shall have been executed with the coating to be assessed. Operating conditions for these reference objects and for the actual coating shall be comparable. Documentation of the objects shall be complete and representative.

8.2 Tests

8.2.1 Sample bodies

8.2.1.1 Steel test plates

Steel plates size 120 mm $\times$ 120 mm $\times$ 3 mm (minimum) are to be coated with the coating to be tested. The layer and the total thickness of the applied coating shall comply with manufacturer specifications.

8.2.1.2 Free film

For the test on the free film (top coat), the coating material shall be applied according to manufacturer specifications in at least application layer thickness on a level base which allows the coating film to be removed after the film has formed. A suitable base shall be selected according to the coating material; PTFE and PPH foil or photo paper are possible for example. Separators shall not be used.

8.2.2 Fluid load, resistance and tightness

8.2.2.1 General

The test takes normally place at + (40 $\pm$ 2) °C after at least 16 h pre-conditioning of the cured test samples in normal climate 23/50-2 (see ISO 554).

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For higher operating temperatures, the test shall be made at the temperatures of the operating medium.

The chemical resistance of the coating against the thermal load caused by the media according to 8.2.3.1 is proven with this test.

8.2.2.2 Test fluids

The media test is to be conducted with the fluid against which the coating shall be tight and resistant.

If fluids can be classified in fluid groups with the specified concentration limits for proof of suitability for material/media combinations according to Annex F, the test with the test fluid specified there suffices.

8.2.2.3 Evaluation of the test results

The requirements are considered met when the coating shows no visible signs of change (with the exception of changes in colour and gloss) in the visual inspection after exposure to the liquid and no test fluid has penetrated the coating.

Changes in hardness shall be determined by measuring with a suitable method, e.g. Shore D according to EN ISO 868, Barcol according to EN 59, impression resistance according to Buchholz according to EN ISO 2815. The measurements are made 1 h after removing the test fluid as well as after 24 h conditioning in a normal climate 23/50-2 (see ISO 554). In the case of reversible changes, the measurement of the hardness can be made after 7 days conditioning with reassessment of the hardness.

The method for assessing the change in hardness of a coating shown in Figure 5 can be used as decision guidance.

The assessment of the free film after testing the fluid load according to test method B is made by evaluating changes in mass, colour and hardness for example. The change in hardness of the coating shall be measured by a suitable method (e.g. Shore D, Barcol, Buchholz hardness).

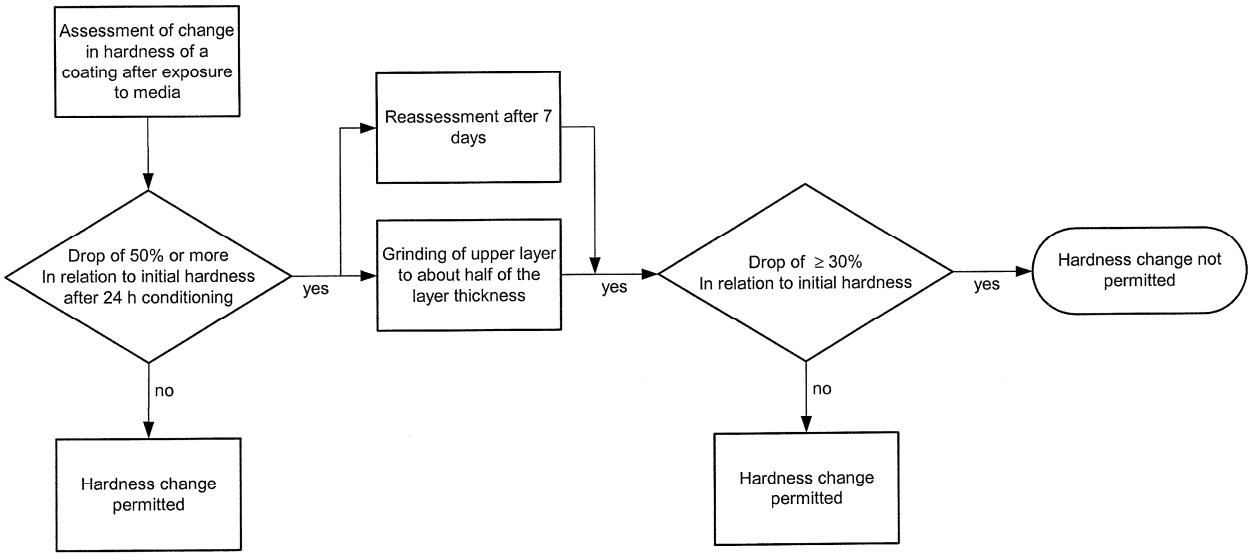


Figure 5 — Assessment of change in hardness of a coating after fluid load

8.2.2.4 Test methods

8.2.2.4.1 Test method A

A test device in accordance with EN 977 or a comparable test set-up in which test plates according to 8.2.1.1 shall be installed in such a way that both the effect of the fluid phase and the vapour phase can be tested at

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the same time is suitable as a test set-up. The ratio of the volume of the test fluid in cm^3 to the surface of the coating exposed to the fluid in cm^2 shall be at least 8 : 1. The duration of exposure to the fluid is 90 days. It shall be performed at the planned operating temperatures with the tempered test fluid.

8.2.2.4.2 Test method B

The test shall be made based on EN ISO 175. Immersion of the specimens in the test fluid at 23 °C or the planned operating temperature takes place up to weight constancy but at least 28 days. The changes in hardness and mass shall be recorded whereby the measurements shall be made after 7, 14, 21 and 28 days. Weight constancy is assumed when the change in mass between the last two measurements is < 0,5 %.

8.2.3 Thermal loading

8.2.3.1 Thermal loading due to effect of the media

A special test is not necessary when the tests of the media effect for the respective application according to 8.2.2.2 are performed at the given temperatures.

8.2.3.2 Influence of other heat sources

The requirements are covered by the tests according to 8.2.6.1 ageing by heat.

8.2.4 Temperature change loading

The behaviour of a coating under exposure to often media-related and/or weather-related temperature change load shall be proven with the test according to 8.2.6.2. This test also covers load of temperature shock at the same time.

8.2.5 Adhesion strength

The test is conducted according to the pull-off method based on EN ISO 4624. Divergent from EN ISO 4624 a core drill can be used to drill to a depth of 10 mm into the substrate. The test panels should have a minimum thickness of 5 mm. Five tests each are made on two unloaded test plates which have been coated according to the intended purpose according to 8.2.1.1.

In addition to the test conditions (die geometry, test set-up, adhesive, pull-off speed, position and labelling of the test points), the adhesion strength (mean value and individual values) shall be specified to 0,1 N/mm^2. The separation case shall be described according to EN ISO 4624.

8.2.6 Ageing behaviour

8.2.6.1 Ageing by heat

To test the ageing behaviour, coated test panels according to 8.2.1.1 shall be stored for 7 days at the planned operating temperature.

Then the test panels shall be assessed visually. It should be determined whether the coating or parts thereof have lifted or cracks are visible in the coating.

8.2.6.2 Ageing by temperature change load

At expected weather-related temperature fluctuation load of the coating, i.e. when using the coating outdoors and with frequently expected changes in temperature, the temperature fluctuation load is to be carried out based on EN 13687-3.

Test panels according to 8.2.1.1 should be used as test panels. The test panels shall be visually assessed after 20 temperature change cycles. It should be determined whether the coating or parts thereof have lifted from it or cracks are visible in the coating.

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The minimum adhesion strength shall also correspond with the minimum values according to 8.2.5 after temperature fluctuation loading.

8.2.7 Dissipation capability

8.2.7.1 General

The dissipation resistance is tested according to Annex E, the volume resistance according to IEC 60093 and the insulation resistance (surface resistance) according to IEC 60167 immediately after 24 h conditioning of the samples in normal climate 23/50-2 with a DC voltage of 100 V (see ISO 554). Treatment of the samples with organic solvents should be ruled out.

EN 1081 can also be applied.

8.2.7.2 Measurement of the dissipation resistance

8.2.7.2.1 Homogeneously conductive coating structure

In a homogeneously conductive coating structure, the measurement of the dissipation resistance is made according to Annex E on a test plate according to 8.2.1.1.

8.2.7.2.2 Sample areas

If there are any doubts as to the transferability of the measuring results determined on the specimens mentioned before, the measurement of the dissipation resistance may be executed on a practice-orientated test with the coating structure desired by the manufacturer.

8.2.7.2.3 Test run

The dissipation resistance is to be tested with a DC voltage of about 100 V as an electrical resistance between a circular electrode with a measuring area of 20 cm^2 placed on the coating system without protective ring and grounding.

The coating system shall be rubbed down with a dry cloth at the place to be tested and a damp piece of blotting paper with a diameter of 50 mm placed on it (enough layers shall be used to level uneven floors) on which the measuring electrode is placed. A measurement shall be made at least one position per 1 m^2 of coating.

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Annex A
(informative)

Specimen form

The note in the margin on page 1 prohibiting reproduction of any part of the standard does not apply to the following specimen form.

Specimen form

Load profile as in EN 14879-2 for coatings on metallic components

The form is to be completed separately for each part.

Plant _____

Structure to be protected

O Tank O Reaction vessel O Container O Others

Part to be protected

O Floor O Wall O Ceiling O Pipe O Sump

Application

O Storage O Filling O Loading/Unloading O Production O Treatment O Use

Load

1. Chemicals (use a separate sheet if necessary, see Table 1 for examples): _____

_____

_____

_____

_____

_____

_____

_____

_____

2. Grade of fluid load (4.1.3) _____

_____

_____

_____

3. Steam/Condensate: O yes O no

Gas O yes O no

4. Grade of thermal load (4.1.4) _____

_____

_____

5. Grade of temperature change (4.1.5) _____

_____

6. Grade of mechanical loading (4.1.6) _____

_____

7. Grade of exposure to climatic influences (4.1.7) _____

_____

_____

8. Additional requirements: _____

_____

_____

_____

_____

_____

_____

Signature: _____ **Date:** _____

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Annex B
(informative)

Information to be given by the coating material manufacturer

Table B.1 — Information to be given by the coating material manufacturer

Material characteristics	Binder used
	Solids content (expressed as percentage by volume or mass)
	Non-volatile matter content
	Viscosity or flow time
	Density
	Colour
	Mixing ratio
	Gel time
	Minimum shelf life and storage conditions
	Reference to hazards involved (e.g. marking in accordance with national regulations
Processing	Ambient conditions (e.g. ambient temperature, material temperature, dew point, relative humidity)
	Safety requirements for storage, processing and disposal
	Surface preparation of component material (e.g. ferritic steel, austenitic steel, non-ferrous metals)
	Mixing ratio and procedure
	Coating method (laminating, trowelling, spraying)
	Pot life and relevant temperature
	Thermal treatment
	Curing time and relevant temperature
	Processing time (for processes with several steps)
	Repairs
Container marking	Identification of manufacturer or supplier
	Product designation, trade name
	Classification
	Batch number
	Date of manufacture
	Minimum shelf life
	Colour
	Storage conditions
	Weight and volume

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Annex C
(informative)

Information to be given by the coating manufacturer

Table C.1 — Information to be given by the coating manufacturer

Application methods	Laminating as in 5.1
	Trowelling as in 5.2
	Spraying as in 5.3
	Methods of applying powder coatings as in 5.4
Coating design and designation	As in 5.1 to 5.4
Surface properties	Colour
	Texture
	Gloss
Mechanical characteristics	Adhesion
	Hardness
	Elongation at break
	Abrasion resistance
Physical characteristics	Thermal stability
	Thermal shock resistance
	Dissipation of electrostatic charges
	Permeability
Chemical resistance	Resistance to various chemical media
Other characteristics	Electrical conductivity
	Resistance to radiation
	Decontamination
	Physiological safety

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Annex D
(informative)

Resistance of resins to various chemicals at ambient temperature

Table D.1 — Resistance of resins to various chemicals at ambient temperature

Group	Chemical type	Examples		Resin type					
				EP	UP	VE	FU [a]	PF	PUR [b]
1	Inorganic, non-oxidizing acids	HCl H_2SO_4 H_3PO_4	Hydrochloric acid Sulfuric acid, up to 70 % Phosphoric acid	O	+	+	+	+	+
2	Inorganic, oxidizing acids	HNO_3 H_2SO_4 CrO_3, H_2CrO_4 $HClO_3$	Nitric acid Sulfuric acid, above 70 % Chromic acid Chloric acid	-	+	+	-	-	-
3	Inorganic, silica-dissolving acids	HF H_2SiF_6 HBF_4	Hydrofluoric acid Hexafluorosilicic acid (contains HF) Tetrafluoroboric acid (contains HF)	+	+	+	+	+	+
4	Organic acids	HCOOH CH_3COOH $CH_2ClCOOH$ $(COOH)_2$ $CH_3CHOHCOOH$	Formic acid Acetic acid Chloroacetic acid Oxalic acid Lactic acid	-	+	+	+	+	-
5	Salts	NaCl $FeSO_4$ Na_2CO_3	Sodium chloride Iron(II) sulfate Sodium carbonate	+	+	+	+	+	+
6	Bases	NaOH KOH CaO, $Ca(OH)_2$ NH_4OH	Sodium hydroxide Potassium hydroxide Calcium oxide, calcium hydroxide Ammonia solution (ammonium hydroxide solution)	+	O	+	+	O	O
7	Oxidising bases	NaOCl	Sodium hypochlorite	-	+	+	-	-	O
8	Aliphatic hydrocarbons	C_6H_{14} C_8H_{18}	Hexane Octane	+	+	+	+	+	O
9	Aromatic hydrocarbons	C_6H_6 C_7H_8 $(CH_3)_2C_6H_4$	Benzene Toluene Xylene	-	-	+	+	+	-
10	Alcohols	CH_3OH C_2H_5OH C_4H_9OH CH_2OHCH_2OH	Methanol Ethanol Butanol Ethanediol	-	+	+	+	+	O
11	Aldehydes, ketones, esters	CH_2O CH_3COCH_3 $C_2H_5COCH_3$ $CH_3COOC_2H_5$	Formaldehyde Acetone Methyl ethyl ketone (2-butanone) Ethyl acetate	-	-	O	+	+	-
12	Aliphatic halogenated hydrocarbons	CH_2Cl_2 C_2HCl_3 $C_2Cl_3F_3$	Dichloromethane Trichloroethylene Trichlorotrifluoroethane	-	-	O	+	+	-
13	Aromatic halogenated hydrocarbons	C_6H_5Cl $ClC_6H_4CF_3$	Chlorobenzene Chlorobenzotrifluoride	-	-	O	+	+	-
14	Aliphatic amines	CH_3NH_2 $(C_2H_5)_3N$ $NH_2C_2H_4NH_2$	Methylamine Triethylamine Ethylenediamine	-	O	+	+	+	-
15	Aromatic amines and pyridine	$C_6H_5NH_2$ C_5H_5N	Aniline Pyridine	-	-	+	+	+	-
16	Phenols	C_6H_5OH $CH_3C_6H_4OH$	Phenol Cresol	-	-	O	+	+	-
17	Fats, oils	—	Vegetable and animal fats, oils	O	+	+	+	+	+

The information provided here is informative only.

Key to symbols: + Recommended – Not recommended

O Recommended only under certain circumstances (e.g. when in contact with chemicals of a low concentration, or when temporarily in contact with chemicals)

[a] for laminate and trowelled coating only

[b] for trowelled and sprayed coating only

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Annex E
(normative)

Testing the dissipation capability

E.1 General

E.1.1 Dissipation resistance

The dissipation resistance shall be measured between a circular electrode of 50 mm diameter on the top of a sample and the grounding band integrated in the conductive layer.

E.1.2 Ground dissipating resistance

The ground dissipating resistance shall be measured between a circular electrode of 50 mm in diameter placed on the surface protection system and ground.

E.2 Testing the dissipation resistance of test samples

E.2.1 Instruments

— resistance measuring instrument according to IEC 60093 with 100 V (DC);

— climate cabinet for conditioning of the samples;

— circular measuring electrode of 50 mm diameter without protection ring;

— blotting paper or conductive rubber foil according to 7.7 of IEC 60093:1980 with 50 mm diameter.

E.2.2 Test procedure

The test samples shall be conditioned for 24 h in normal climate EN ISO 291, 23/50-2 prior to testing (see ISO 554).

The measurement shall be made at (23 ± 2) °C.

A piece of blotting paper moistened with tap water or a foil of conductive rubber with a diameter of 50 mm should be placed on the surface of the specimen as a contact agent, the electrode placed flush and pressed down during the measurement with a force of about 10 N.

The resistance shall be measured between the electrode and the grounding band whereby the measuring positions shall be selected so that they are as far as possible away from the grounding band.

E.2.3 Test report

The following shall be specified in the test report:

a) type of surface protection system;

b) material;

c) manufacturer;

d) colour;

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e) thickness of surface protection system;

f) dissipation resistance, single and mean value;

g) conditioning conditions;

h) date of the test.

E.3 Measuring the ground dissipation resistance on the laid surface protection system

E.3.1 Instruments

See D.2.1 as well as equipment for temperature and relative humidity.

E.3.2 Preparation

The surface protection system shall be rubbed down with a dry cloth at the measuring point prior to testing.

E.3.3 Test procedure

The measurements can be carried out 4 weeks after applying the surface protection system at the earliest. The measurements can only be made on areas on which you can walk or drive (except container linings).

The blotting paper moistened with tap water or the rubber foil shall be placed on the prepared measuring point, the electrode placed flush and pressed down during the measurement with a force of about 10 N.

The ground dissipation resistance is measured between the electrode and the ground potential.

The number of measurements shall be selected according to Table E.1.

Table E.1 — Number of measurements of the ground dissipation resistance

Area of the laid surface protection system m²	Number of measurements
below 10	1 measurement/1 m²
10 to 100	10 to 20 measurements
above 100	10 measurements/100 m²

— Ground dissipation resistance: at ambient temperature, the following maximum measured values are permitted:

— up to 50 % relative humidity: $1 \times 10^8\ \Omega$;

— above 50 % to 70 % relative humidity: $1 \times 10^7\ \Omega$;

— above 70 % relative humidity: $1 \times 10^6\ \Omega$.

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E.3.4 Test report

The following shall be specified in the test report:

a) type of surface protection system;

b) material;

c) manufacturer;

d) colour;

e) thickness of the surface protection system;

f) application date;

g) location and position of the surface protection system;

h) temperature and relative humidity;

i) number of measuring points;

j) ground dissipation resistance for every measuring point, in ohms;

k) scale drawing with the measuring points and the corresponding measuring results;

l) substrate data;

m) deviations from this European Standard;

n) date of the test.

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Annex F
(normative)

Test fluid groups for verification of suitability for material/media combinations

Table F.1 — Test fluid groups for verification of suitability for material/media combinations

No	Group	Test fluid
1	Petrol according to EN 228 with a maximum alcohol content of 5 %	47,5 vol.-% [a] toluene 30,4 vol.-% [a] isooctane (2,2,4-trimethylpentane) 17,1 vol.-% [a] n-heptane 3,0 vol.-% [a] methanol 2,0 vol.-% [a] tert. butanol under-layered with water 1:1
1a	Petrol according to EN 228 with a maximum alcohol content of 20 % (including 1)	42,3 vol.-% [a] toluene, 25,3 vol.-% [a] isooctane (2,2,4-trimethylpentane) 12,7 vol.-% [a] diisobutylene 4,2 vol.-% [a] ethanol 15,0 vol.-% [a] methanol 0,5 vol.-% [a] water under-layered with water 1:1
2	Aviation fuels	a) Aviation fuel 100 LL b) 50 vol.-% [a] toluene 30 vol.-% [a] isooctane (2,2,4-trimethylpentane) 15 vol.-% [a] diisobutylene 5 vol.-% [a] ethanol c) Aviation turbine fuel Jet-A1 with additives (Nato-Code F-34) each under-layered with water 1:1
3	Heating fuel oil EL unused combustion engine oils, unused vehicle gear oils, aliphatic and aromatic hydrocarbons with an aromatic content of ≤ 20 wt.-% [b] and a flash point of > 55 °C	Test mixture: 80 vol.-% [a] Diesel fuel according to EN 590 20 vol.-% [a] 1-methylnaphthalene under-layered with volume part of 0,5 wt.-% [a] Sodium chloride solution
3a	Diesel fuel according to EN 590 with a maximum content of 5 % Biodiesel (including 3)	76 vol.-% [a] Diesel fuel according to EN 590 19 vol.-% [a] 1-methylnaphthalene 5 vol.-% [a] Rape-oil fatty acid methyl ester (RME) under-layered with volume part of 0,5 wt.-% [a] Sodium chloride solution
3b	Diesel fuel according to EN 590 with a maximum content of 20 % Biodiesel (including 3 and 3a)	64 vol.-% [a] Diesel fuel according to EN 590 16 vol.-% [a] 1-methylnaphthalene 20 vol.-% [a] Rape-oil fatty acid methyl ester (RME) under-layered with volume part of 0,5 wt.-% [b] Sodium chloride solution
4	All hydrocarbons as well as used combustion engine oils and used vehicle gear oils with the exception of raw oils, benzene and benzene mixtures	60 vol.-% [a] toluene, 30 vol.-% [a] xylene, 10 vol.-% [a] methylnaphthalene under-layered with water 1:1 vol.-% [a]

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Table F.1 (*concluded*)

No	Group	Test fluid
5	Raw oils	10,0 wt.-% [b] Iso-octane ASTM 10,0 wt.-% [b] toluene 20,0 wt.-% [b] heating fuel oil EL 10,0 wt.-% [b] 1-methylnaphthalene (min. 96 %) 47,7 wt.-% [b] heating fuel oil S 0,2 wt.-% [b] thiophene (99 %) 0,3 wt.-% [b] dibenzene sulfide 0,5 wt.-% [b] dibutyl disulfide (97 %) 1,0 wt.-% [b] naphthene acid mixture (acid factor 230) 0,1 wt.-% [b] phenol 0,2 wt.-% [b] pyridine Mixed with 2,0 wt.-% water under-layered with volume part of 0,5 wt.-% Sodium chloride solution
6	— used combustion engine oils and — used vehicle gear oils with a flash point > 55 °C	80 wt.-% [b] motor oil based on mineral oil 10 wt.-% [b] toluene 9,9 wt.-% [b] water 0,1 wt.-% [b] anionic tenside sodium dodecylsulfate
7	all alcohol and glycol ethers (including 7a and 7b)	methanol
7a	single and multiple value alcohol (up to max. 48 vol.-% [a] methanol), glycol ether (including 7b)	48 vol.-% [a] methanol, 48 vol.-% [a] isopropanol, 4 vol.-% [a] water
7b	single and multiple valued alcohol ≥ C_2	48 vol.-% [a] ethanol 48 vol.-% [a] isopropanol 4 vol.-% [a] water
8	all halogen hydrocarbons (including 8a)	Two-phase mixture of 1:1 volume parts dichloromethane (methylene chloride) and 0,3 wt.-% [b] Hydrochloric acid
8a	aliphatic halogen hydrocarbons ≥ C_2 and aromatic halogen hydrocarbons	Two-phase mixture of 1:1 volume parts trichloroethylene and 0,3 wt.-% [b] Hydrochloric acid
9	all organic esters and ketone	50 vol.-% [a] ethyl acetate 50 vol.-% [a] methylisobutylketone to be tested with and without under-layer of water
10	Biodiesel	Rape-oil fatty acid methyl ester (RME) (summer quality)
11	aqueous solutions of organic acids (carboxylic acids) to 10 % as well as their salts (in aqueous solution)	10 wt.-% [b] aqueous acetic acid
12	mineral acids up to 20 % as well as acetic hydrolyzing inorganic salts in aqueous solution (pH < 6), except hydrofluoric acid and oxidizing acids and their salts	Hydrochloric acid (20 %)
13	inorganic lies as well as alkaline hydrolyzing inorganic salts in aqueous solution (pH > 8), except ammonia solutions and oxidizing salt solutions (e.g. hypochlorite)	a) Sodium hydroxide (20 %) b) Sodium hydroxide (1 %)
14	aqueous solutions of inorganic non-oxidizing salts with a pH value between 6 and 8	aqueous sodium chloride solution (20 %)

[a] vol.-%: volume fraction

[b] wt.-%: mass fraction

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Annex G
(informative)

Selection criteria for surface protection systems

G.1 Load profiles and suitable protection for gutters, trenches, pipes etc.

Table G.1 gives load profiles for plant parts located inside or outside, and which are designed for exposure to flowing fluids. In open plant parts, traffic may cause additional mechanical loading, and long-term surface protection is required for both open and covered parts. Such parts are typically exposed to media at a hydrostatic pressure of up to 0,05 bar.

Table G.1 — Load profiles and suitable surface protection for elements exposed to flowing fluids

Chemicals as in Table 1	Grade of fluid load (as in 4.1.3)	Temperature, in °C	Grade of temperature change (as in 4.1.5)	Grade of mechanical load (as in 4.1.6)	Grade of climatic influences (as in 4.1.7)	Type of surface protection		
						Coating	Lining	Composite
I and II	2	20	1	0 to 1	0 to 2	A	A	R
I and II	2	50	1	0 to 1	0 to 2	A	A	R
I and II	2	50	3	0 to 1	0 to 2	A	A	R
I and II	2	70	1 and 2	0 to 1	0 to 2	A	A	R
I and II	2	70	3 and 4	0 to 1	0 to 2	N	A	R

Key to symbols:
R: recommended surface protection
A: possible alternative surface protection, depending on the durability of the system
N: not recommended as surface protection

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G.2 Load profiles and suitable protection for containers

Table G.2 gives load profiles for containers with continual, long-term exposure to fluids, and also to hydrostatic pressure and mechanical loading caused by agitators. Examples of such containers are:

— sewage tanks;

— neutralization basins;

— sedimentation tanks;

— settling tanks.

Table G.2 — Load profiles and suitable surface protection for containers exposed to long-term hydrostatic pressure and mechanical loading

Chemicals as in Table 1	Grade of fluid load (as in 4.1.3)	Temperature, in °C	Grade of temperature change (as in 4.1.5)	Grade of mechanical load (as in 4.1.6)	Grade of climatic influences (as in 4.1.7)	Type of surface protection		
						Coating	Lining	Composite
I	3	20	1	0	0 to 2	R	R	A
I	3	50	1	0	0 to 2	A	R	A
I	3	50	3	0	0 to 2	A	R	A
II	3	50	1	0	0 to 2	A	A	A
II	3	50	3	0	0 to 2	A	A	R
II	3	70	1 to 4	0	0 to 2	A	A	R
I and II	3	20	1	1	0 to 2	R	R	A
I	3	50	1	1	0 to 2	A	R	A
I	3	50	3	1	0 to 2	A	R	A
II	3	50	1	1	0 to 2	A	A	R
II	3	50	3	1	0 to 2	A	A	R
II	3	70	1 to 4	1	0 to 2	A	A	R
I and II	3	20	1	2	0 to 2	A	R	R
I	3	50	1	2	0 to 2	A	R	R
I	3	50	3	2	0 to 2	A	R	R
II	3	50	1	2	0 to 2	A	A	R
II	3	50	3	2	0 to 2	A	A	R
I and II	3	70	1 to 4	2	0 to 2	A	A	R
I and II	3	20 to 70	5	0; 1; 2	0 to 2	A	A	R

Key to symbols:
R: recommended surface protection
A: possible alternative surface protection, depending on the durability of the system
N: not recommended as surface protection

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Annex H
(informative)

Sample form for acceptance inspection report

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Acceptance inspection report for coatings on metallic parts	
Client:	Order No.:
Project:	
Type of plant part:	
Type of lining:	
Tests	Test results
A. Checks prior to application	
1. Visual check of surface	
B. In-process checks	
1. Ambient temperatures and humidity	
2. Checking application steps	
C. Checks after completion of application	
1. Ambient conditions	Ambient temperature: _____ Temperature of member: _____ Relative humidity: _____
2. Visual check	
3. Coating thickness	
Nominal value: _____ mm	Actual value: _____ mm
4. Checking for defects	
Type of equipment used:	
Test voltage: _____ kV	
D. Testing carried out on test panels	
1. Shore/Barcol hardness:	
Type of equipment used: _____	
Nominal value: _____ Shore A/Shore D/Barcol	Actual value: _____ Shore A/Shore D/Barcol
2. Adhesion test:	
Equipment used: _____	
Nominal value: _____ N/mm^2	Actual value: _____ N/mm^2
Comments:	

Test site:					
Date					

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A-Deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN/CENELEC member.

Comments on EN 14789-2 – National legislative/administrative deviations:

In Germany construction products for stationary plants for the storage, filling and loading/unloading of water-hazardous substances require national technical verification with respect to section 1 No. 2 *Wasserbau-prüfverordnung (*'Model Water Construction Products Code').

A Verification of applicability (e.g. a *allgemeine bauaufsichtliche Zulassung (*'national technical approval')) is required for interior coatings for containers and pipes and for coatings which are used for other facilities in plants for the storage, filling and loading/unloading of water-hazardous substances.

Regulations for the application of these products in Germany are given by water legislation (*Verordnungen über Anlagen zum Umgang mit wassergefährdenden Stoffen* ('Acts for plants for the handling of water-hazardous substances')).

Further application rules for coatings for metallic facilities used for the handling of water-hazardous substances are laid down in the *Technische Regeln wassergefährdender Stoffe* "technical rules water-hazardous substances" especially in

TRwS 779 Allgemeine Technische Regelungen ('General Technical Rules') and

TRwS 786 Ausführung von Dichtflächen ('Execution of liquid-tight areas').

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[2] prEN 14879-5:2005, *Organic coating systems and linings for protection of industrial apparatus and plants against corrosion caused by aggressive media — Part 5: Linings on concrete components*

[3] EN ISO 12944-1, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 1: General introduction (ISO 12944-1:1998)*

[4] ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications*

[5] ISO 1629, *Rubbers and latices — Nomenclature*

[6] DIN 53393, *Testing of Textile Glass-reinforced Plastics; Behaviour to the Effect of Chemicals*

[7] EN 977, *Underground tanks of glass-reinforced plastics (GRP) — Method for one side exposure to fluids*

[8] EN 1081, *Resilient floor coverings — Determination of the electrical resistance*

[9] EN ISO 2409, *Paints and varnishes — Cross-cut test (ISO 2409:1992)*

[10] EN ISO 2808, *Paints and varnishes — Determination of film thickness (ISO 2808:1997)*

[11] EN ISO 2064, *Metallic and other inorganic coatings — Definitions and conventions concerning the measurement of thickness (ISO 2064:1996)*

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[14] EN ISO 2431, *Paints and varnishes — Determination of flow time by use of flow cups (ISO 2431:1993, including Technical Corrigendum 1:1994)*

[15] EN ISO 3219, *Plastics — Polymers/resins in the liquid state or as emulsions or dispersions — Determination of viscosity using a rotational viscometer with defined shear rate (ISO 3219:1993)*

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