INTERNATIONAL STANDARD

ISO 12944-5

Fourth edition
2019-09

Paints and varnishes — Corrosion protection of steel structures by protective paint systems —

Part 5: Protective paint systems

Peintures et vernis — Anticorrosion des structures en acier par systèmes de peinture —
Partie 5: Systèmes de peinture anticorrosion

Reference number
ISO 12944-5:2019(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 14, *Protective paint systems for steel structures*.

This fourth edition cancels and replaces the third edition (ISO 12944-5:2018), of which it constitutes a minor revision.

The changes compared to the previous edition are as follows:

— correction of the former doubled category "G5.02" in Tables D.1 to read "G5.02a" and "G5.02b";

— correction of the table headlines of Tables B.3 and B.4;

— some editorial changes.

A list of all parts in the ISO 12944 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Unprotected steel in the atmosphere, in water and in soil is subjected to corrosion that may lead to damage. Therefore, to avoid corrosion damage, steel structures are normally protected to withstand the corrosion stresses during the required service life required of the structure.

There are different ways of protecting steel structures from corrosion. ISO 12944 (all parts) deals with protection by paint systems and covers, in the various parts, all features that are important in achieving adequate corrosion protection. Additional or other measures are possible but require particular agreement between the interested parties.

In order to ensure effective corrosion protection of steel structures, owners of such structures, planners, consultants, companies carrying out corrosion protection work, inspectors of protective coatings and manufacturers of coating materials need to have at their disposal state-of-the-art information in concise form on corrosion protection by paint systems. It is vital that such information is as complete as possible, unambiguous and easily understandable to avoid difficulties and misunderstandings between the parties concerned with the practical implementation of protection work.

ISO 12944 (all parts) is intended to give this information in the form of a series of instructions. It is written for those who have some technical knowledge. It is also assumed that the user of ISO 12944 (all parts) is familiar with other relevant International Standards, in particular those dealing with surface preparation.

Although ISO 12944 (all parts) does not deal with financial and contractual questions, attention is drawn to the fact that, because of the considerable implications of inadequate corrosion protection, non-compliance with requirements and recommendations given in ISO 12944 (all parts) can result in serious financial consequences.

ISO 12944-1 defines the overall scope of ISO 12944. It gives some basic terms and definitions and a general introduction to the other parts of ISO 12944. Furthermore, it includes a general statement on health, safety and environmental protection, and guidelines for using ISO 12944 (all parts) for a given project.

This document gives some terms and definitions related to paint systems in combination with guidance for the selection of different types of protective paint system.

Paints and varnishes — Corrosion protection of steel structures by protective paint systems —

Part 5: Protective paint systems

1 Scope

This document describes the types of paint and paint system commonly used for corrosion protection of steel structures.

It also gives guidelines for the selection of paint systems available for different environments (see ISO 12944-2) except for corrosivity category CX and category Im4 as defined in ISO 12944-2 and different surface preparation grades (see ISO 12944-4), and the durability grade to be expected (see ISO 12944-1).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods*

ISO 2063 (all parts), *Thermal spraying — Zinc, aluminium and their alloys*

ISO 2808, *Paints and varnishes — Determination of film thickness*

ISO 3549, *Zinc dust pigments for paints — Specifications and test methods*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 8503-1, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces*

ISO 12944-1, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 1: General introduction*

ISO 12944-2, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 2: Classification of environments*

ISO 19840, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12944-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
compatibility
<for products within a paint system> ability of two or more products to be used together successfully as a paint system without causing undesirable effects

3.2
priming coat
first coat of a paint system

3.3
intermediate coat
coat between the *priming coat* (3.2) and the *topcoat* (3.6)

3.4
tie coat
coat designed to improve intercoat adhesion

[SOURCE: ISO 4618:2014, 2.262]

3.5
sealer
coating material applied to porous surface prior to painting to reduce the absorptivity

Note 1 to entry: An example for a porous surface is a thermal sprayed metal layer.

3.6
topcoat
final coat of a coating system

3.7
primer
paint that has been formulated for use as a *priming coat* (3.2) on prepared surfaces

3.8
pre-fabrication primer
fast-drying paint that is applied to blast-cleaned steel to provide temporary protection during fabrication while still allowing welding and cutting

[SOURCE: ISO 4618:2014, 2.204, modified — “primer” has been replaced by “paint”, and “protect it” has been replaced by “provide temporary protection”.]

3.9
dry film thickness
DFT
thickness of a coating remaining on the surface when the coating has hardened/cured

3.10
nominal dry film thickness
NDFT
dry film thickness (3.9) specified for each coat or for the whole paint system

3.11
maximum dry film thickness
highest acceptable *dry film thickness* (3.9) above which the performance of the paint or the paint system could be impaired

3.12
pot life
maximum time, at any particular temperature, during which a coating material supplied as separate components can successfully be used after they have been mixed together

3.13
shelf life
time during which a coating material will remain in good condition when stored in its original sealed container under normal storage conditions

Note 1 to entry: The expression “normal storage conditions” is usually understood to mean storage between +5 °C and +30 °C.

4 Classification of environments

The following five atmospheric corrosivity categories are relevant for this document:

— C1 very low;

— C2 low;

— C3 medium;

— C4 high;

— C5 very high.

The atmospheric environments defined in ISO 12944-2 are considered, except corrosivity category CX. Systems for offshore-CX environments are described in ISO 12944-9. For other CX environments, individual systems need to be defined according to the special needs of that environment.

The following three categories for water and soil are relevant for this document:

— Im1 immersion in fresh water;

— Im2 immersion in sea or brackish water;

— Im3 buried in soil.

The immersed environments defined in ISO 12944-2 are considered, except category Im4. Systems for offshore, related structures and Im4 environments are described in ISO 12944-9.

5 New work and refurbishment

5.1 New work and total refurbishment

The surfaces to be coated encountered in new structures are carbon steel of rust grade A, B and C as defined in ISO 8501-1, as well as hot dip galvanized steel and thermal-sprayed metallic coating (see ISO 12944-1). Possible surface preparation is described in ISO 12944-4. The substrate and the recommended surface preparation grade are given in Table B.1. The quality of the surface preparation is essential for the durability of a coating system. The paint systems listed in Annex C, Annex D and Annex E are typical examples of systems used in the environments listed in Clause 4 when applied to steel surfaces with rust grades A to C, as defined in ISO 8501-1, or to hot dip galvanized steel or thermal-sprayed metallic coating. Where the steel has deteriorated to the extent that pitting corrosion has taken place (rust grade D as defined in ISO 8501-1), the dry film thickness or the number of coats shall be increased to compensate for the increased surface roughness, and the paint manufacturer should be consulted for recommendations.

In principle, no corrosion protection is required for corrosivity category C1. If, for aesthetic reasons, painting is necessary, a system intended for corrosivity category C2 (with a low durability) may be chosen.

If unprotected steelwork destined for corrosivity category C1 is initially transported, stored temporarily or assembled in an exposed situation (for example, a C4/C5 coastal environment), corrosion will commence due to air-borne contaminants/salts and will continue even when the steelwork is

moved to its final category C1 location. To avoid this problem, the steelwork should either be protected during site storage or given a suitable primer coat. The dry film thickness should be appropriate for the expected storage time and the severity of the storage environment.

5.2 Partial refurbishment

Systems for partial refurbishment should be specified and agreed separately for every object between the interested parties. The paint systems listed in Annex C, Annex D and Annex E may be used, if they are suitable. In special cases, other types of systems might be required for repair works.

The necessary surface preparation of any old coating and the compatibility of the coating system to be applied should be tested in an appropriate manner before starting the repair works.

Test areas can be prepared to check the manufacturer's recommendations and/or compatibility with the previous paint system.

6 Types of paint

6.1 General

Based on the corrosivity category, various examples of paint systems, which are informative in nature, are given in Tables C.1 to C.6, Table D.1 and Table E.1 in relation to the expected durability. The systems have been included because of their proven track record, but the list is not intended to be exhaustive and other similar systems are also acceptable. Only the generic types of binders mentioned in the systems in Tables C.1 to C.6, Table D.1 and Table E.1 are described in this clause. Pigments, fillers and additives are important ingredients of a paint as well. Depending on the composition of the paint, the performance of the coating can vary strongly within a given binder technology. The binder types described in Clause 6 are only examples, other generic types of coatings can be used as well.

In addition, new technologies are continually being developed, often driven by government legislation, and these should always be considered where appropriate and where performance has been validated by

a) the track record of such technologies, and/or

b) the results of testing at least in accordance with ISO 12944-6.

NOTE Information given in 6.2 concerns only the chemical and physical properties of paints and coatings and not the way they are used. Variations can be expected for each type of paint, depending on its formulation.

6.2 Examples of generic type of paints

6.2.1 Alkyd paints (AK)

In these single pack paints, the film hardens/forms by evaporation of solvent and/or water, and by reaction of the binder with oxygen from the atmosphere.

6.2.2 Acrylic paints (AY)

Acrylic paints are single pack coating materials; water-borne and solvent-borne types are available. The film of solvent-borne acrylic paints dries by solvent evaporation with no other change of form, i.e. the process is reversible and the film can be re-dissolved in the original solvent at any time. In water-borne acrylic paints the binder is dispersed in water. The film hardens by evaporation of water and coalescence of the dispersed binder to form a film. The process is irreversible, i.e. this type of coating is not re-dispersible in water after drying.

The drying time will depend, among other things, on air movement, relative humidity and temperature.

6.2.3 Ethyl silicate paints (ESI)

Ethyl silicate zinc primers are provided as single or two pack coating materials. Their films dry/form by solvent evaporation and chemical curing by reacting with moisture from the air. Two pack coating materials consist of a liquid (containing binder) and a powder (containing zinc dust) component. The mixture of liquid and powder has a limited pot life.

The drying time will depend, among other things, on temperature, air movement, humidity and film thickness. The lower the relative humidity, the slower the curing will be.

It is important that the paint manufacturer's instructions regarding the limits for relative humidity and wet and dry film thickness are complied with in order to avoid bubbles, pinholes or other defects in the coating. In particular, limitations on NDFT have to be considered, due to the risk of cracking if the limits are exceeded.

6.2.4 Paints for epoxy coatings (EP)

Paints for epoxy coatings are two pack coating materials. The paint dries by evaporation of solvents, if present, and cures by a chemical reaction between a base and a curing agent component. The mixture of base and curing agent has a limited pot-life.

The binders in the base component are polymers having epoxy groups, e.g. epoxy, epoxy vinyl/epoxy acrylic or epoxy combinations (e.g. epoxy hydrocarbon resins).

The curing agent component can consist of e.g. polyamines, polyamides or adducts.

The drying time will depend, among other things, on air movement and on the temperature.

Formulations can be solvent-borne, water-borne or solvent-free.

Most epoxy coatings chalk when exposed to sunlight. If colour or gloss retention is required, a suitable topcoat should be applied.

6.2.5 Paints for polyurethane coatings (PUR)

Single pack polyurethane paints dry initially by solvent evaporation (where solvent is present) and by a chemical reaction with moisture from the air. The process is irreversible, meaning that the coating cannot be dissolved in the original solvent. Aromatic as well as aliphatic types of polyurethane coatings are available. Aromatic types are not recommended for top coats, as they tend to chalk.

Two pack paints for polyurethane coatings dry by evaporation of solvents, if present, and cure by a chemical reaction between a base and a curing agent component. The mixture of base and curing agent has a limited pot-life.

The binders of the base component are polymers with free hydroxyl groups e.g. polyester, acrylic, epoxy, polyether, fluoro resin, which react with suitable isocyanate curing agents. They can be combined with non-reactive binders, e.g. hydrocarbon resins.

The curing agent component contains an aromatic or aliphatic polyisocyanate.

A special type of PUR is based on fluoropolymers.

Paints for fluoropolymer/vinyl ether co-polymer (FEVE) coatings are two pack coating materials, and both water-borne and solvent-borne types are available. Solvent-borne paints dry by solvent evaporation and cure by a chemical reaction between a base resin and a curing component. Paints for FEVE coatings are ambient curable coating materials cross-linked with isocyanate hardener.

The resin of the base component is fluoropolymer with free hydroxyl groups which reacts with suitable isocyanate curing agents.

The drying time will depend, among other things, on air movement, relative humidity and temperature.

6.2.6 Paints for polyaspartic coatings (PAS)

The two pack paints for polyaspartic coatings dry by evaporation of solvents, if present, and cure by a chemical reaction between a base and a curing agent component. The mixture of base and curing agent has a limited pot life.

The process is irreversible, meaning that the coating cannot be dissolved in the original solvent.

The binders of the base component are aminofunctional aspartates which react with suitable polyisocyanates. They can be combined with non-reactive binders, e.g. hydrocarbon resins.

The curing agent component contains an aliphatic polyisocyanate.

The drying time will depend, among other things, on air movement, relative humidity and temperature.

6.2.7 Paints for polysiloxane coatings (PS)

Paints for polysiloxane coatings can be either one or two component coating materials.

Polysiloxanes are part inorganic using silicone resin and part organic using a modified resin that is typically acrylic, acrylate or epoxy based.

Single component paints dry initially through solvent evaporation and then chemical reaction with moisture from the air. As in the case of one component paints for polyurethane coatings the reaction is irreversible, meaning that the film cannot be dissolved in the original solvent.

Two component paints dry by a combination of solvent evaporation and a chemical curing reaction between the base component and curing agent. The mixed material will have a limited pot life.

7 Paint systems

7.1 Priming coats and type of primers

7.1.1 General

As the first coat of coating systems, priming coats shall provide adhesion to sufficiently roughened, cleaned metal. The priming coat shall also provide adhesion to the subsequent coats.

In Tables C.1 to C.6 and Table D.1 coating systems with a minimum of one coat are described. In these cases, the priming coat shall act as a topcoat too.

Annex A provides an overview of abbreviated terms and descriptions.

7.1.2 Types of primer

Tables C.1 to C.6 give information on the type of primer to be used. For the purposes of this document, two main categories of primer are defined according to the type of pigment they contain.

— Zinc-rich primers, Zn (R), are those forming a coat with a zinc dust pigment content equal to or greater than 80 % by mass in dry film.

— Other primers (miscellaneous) are all other categories of primers.

For pre-fabrication primers, see Annex F.

The zinc dust pigment shall comply with ISO 3549.

NOTE 1 Due to the potentially high margin of error in ASTM D6580 laboratory determination of metallic zinc content in zinc primers, it is acceptable for paint manufacturers to declare the theoretical zinc dust content based on formulation. This can be confirmed between partners by declaration of formulation (in confidence) or by audit.

