# INTERNATIONAL STANDARD

# ISO 12944-5

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## 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*

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 12944-5 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 14, *Protective paint systems for steel structures*.

This second edition cancels and replaces the first edition (ISO 12944-5:1998), which has been technically revised. The revision includes a reduction in the number of paint systems and in the number of tables. These changes have also brought about some changes in the numbering of the systems in the tables.

ISO 12944 consists of the following parts, under the general title *Paints and varnishes — Corrosion protection of steel structures by protective paint systems*:

— *Part 1: General introduction*

— *Part 2: Classification of environments*

— *Part 3: Design considerations*

— *Part 4: Types of surface and surface preparation*

— *Part 5: Protective paint systems*

— *Part 6: Laboratory performance test methods and associated assessment criteria*

— *Part 7: Execution and supervision of paint work*

— *Part 8: Development of specifications for new work and maintenance*

 

# 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 of the structure.

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

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

This International Standard — ISO 12944 — 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 is familiar with other relevant International Standards, in particular those dealing with surface preparation, as well as relevant national regulations.

Although ISO 12944 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 this standard might result in serious financial consequences.

ISO 12944-1 defines the overall scope of all parts 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 for a given project.

ISO 12944-5 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 part of ISO 12944 describes the types of paint and paint system commonly used for corrosion protection of steel structures. It also provides guidance for the selection of paint systems available for different environments (see ISO 12944-2) and different surface preparation grades (see ISO 12944-4), and the durability grade to be expected (see ISO 12944-1). The durability of paint systems is classified in terms of low, medium and high.

## 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.

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

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

ISO 4628-1, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 1: General introduction and designation system*

ISO 4628-2, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 2: Assessment of degree of blistering*

ISO 4628-3, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 3: Assessment of degree of rusting*

ISO 4628-4, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 4: Assessment of degree of cracking*

ISO 4628-5, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 5: Assessment of degree of flaking*

ISO 4628-6, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 6: Assessment of degree of chalking by tape method*

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 8501-3, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 3: Preparation grades of welds, edges and other areas with surface imperfections*

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

ISO 12944-6, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 6: Laboratory performance test methods and associated assessment criteria*

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 terms and definitions apply.

**3.1**
**high-build**
property of a coating material which permits the application of a coat of greater thickness than usually considered as normal for that type of coating

NOTE For the purposes of this part of ISO 12944, this means ⩾ 80 µm dry film thickness per coat.

**3.2**
**high-solids**
property of a coating material which contains a volume of solids greater than normal for that coating material

**3.3**
**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

**3.4**
**compatibility**
⟨between a product and the substrate⟩ ability of a product to be applied to a substrate without causing undesirable effects

**3.5**
**priming coat**
first coat of a coating system

NOTE Priming coats provide good adhesion to sufficiently roughened, cleaned metal and/or cleaned old coating, ensuring a sound base for, and offering adhesion to, the subsequent coats. They normally also provide corrosion protection during the overcoating interval and the whole service life of the paint system.

**3.6**
**intermediate coat**
any coat between the priming coat and the finishing coat/topcoat

NOTE In the English language, the term “undercoat” is sometimes used synonymously, normally for a coat applied directly before the finishing coat/topcoat.

 

**3.7**
**topcoat**
final coat of a coating system

**3.8**
**tie coat**
coat designed to improve intercoat adhesion and/or avoid certain defects during application

**3.9**
**stripe coat**
supplementary coat applied to ensure uniform coverage of critical and difficult to coat areas such as edges, welds, etc.

**3.10**
**dry film thickness**
**DFT**
thickness of a coating remaining on the surface when the coating has hardened/cured

**3.11**
**nominal dry film thickness**
**NDFT**
dry film thickness specified for each coat or for the whole paint system

**3.12**
**maximum dry film thickness**
highest acceptable dry film thickness above which the performance of the paint or the paint system could be impaired

**3.13**
**primer**
paint that has been formulated for use as a priming coat on prepared surfaces

**3.14**
**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

NOTE In many languages, the term pre-fabrication primer does not have the same meaning as in English.

**3.15**
**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

**3.16**
**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 The expression "normal storage conditions" is usually understood to mean storage between +5 °C and +30 °C.

**3.17**
**volatile organic compound**
**VOC**
any organic liquid and/or solid that evaporates spontaneously at the prevailing temperature and pressure of the atmosphere with which it is in contact

# 4 Types of paint

## 4.1 General

For the protection of steel structures against corrosion many paint systems are widely used.

Based on the corrosivity category, various examples of anticorrosive paint systems are given, in relation to the expected durability, in Tables A.1 to A.8 in Annex A, which is informative in nature. 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 available.

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 1 The information given in 4.2, 4.3 and 4.4 concerns only the chemical and physical properties of paints and not the way they are used. The limits given for drying and curing temperatures are only indicative. Variations can be expected for each type of paint, depending on its formulation.

For the purposes of application, paints can be classified as solvent-borne, water-borne or solvent-free. They are first divided into two main categories according to the manner in which they dry and cure (see 4.2 and 4.3) and then subdivided (see 4.3.2 to 4.3.5) by generic type and mechanism of cure.

NOTE 2 The main physical and mechanical properties are summarized in Annex C.

## 4.2 Reversible coatings

The film 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.

Examples of binders in this type of coating material are:

a) chlorinated rubber (CR);

b) vinyl chloride copolymers (also known as PVC);

c) acrylic polymers (AY).

The drying time will depend, among other things, on air movement and temperature. Drying can take place down to 0 °C, although at low temperatures it is much slower.

## 4.3 Irreversible coatings

### 4.3.1 General considerations

The film dries initially by solvent evaporation (where a solvent is present) followed by a chemical reaction or by coalescence (in some water-borne paints). The process is irreversible, meaning that the film cannot be dissolved in the original solvent or, in the case of a solvent-free coating, in a solvent typically used with that generic type of paint.

#### 4.3.2 Air-drying paints (oxidative curing)

In these paints, the film hardens/forms by evaporation of solvent, followed by reaction of the binder with oxygen from the atmosphere.

Typical binders are:

- alkyd;
- urethane alkyd;
- epoxy ester.

The drying time will depend, among other things, on the temperature. The reaction with oxygen can take place down to 0 °C, although at low temperatures it is much slower.

#### 4.3.3 Water-borne paints (single pack)

In this type of paint, 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.

Binders which are typically dispersed in water are:

- acrylic polymers (AY);
- vinyl polymers (PVC);
- polyurethane resins (PUR).

The drying time will depend, among other things, on air movement, relative humidity and temperature. Drying can take place down to +3 °C, although at low temperatures it is much slower. High humidity (greater than 80 % RH) also impedes the drying process.

#### 4.3.4 Chemically curing paints

##### 4.3.4.1 General considerations

In general, this type of paint consists of a base component and a curing agent component. The mixture of base and curing agent has a limited pot life (see 3.15).

The paint film dries by evaporation of solvents, if present, and cures by a chemical reaction between the base and the curing agent components.

The types given below are commonly in use.

NOTE The base component and/or the curing agent component may be pigmented.

##### 4.3.4.2 Epoxy 2-pack paints

###### 4.3.4.2.1 Base component

The binders in the base component are polymers having epoxy groups, which react with suitable curing agents.

Typical binders are:

- epoxy;
- epoxy vinyl/epoxy acrylic;
- epoxy combinations (e.g. epoxy hydrocarbon resins);

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, the topcoat should be an aliphatic polyurethane (see 4.3.4.3) or a suitable physically drying type (see 4.2) or water-borne (see 4.3.3).

#### 4.3.4.2.2 Curing agent component

Polyaminoamines (polyamines), polyaminoamides (polyamides) or adducts of these are most commonly used.

Polyamides are more suitable for primers because of their good wetting properties. Polyamine-cured coatings are generally more resistant to chemicals.

The drying time will depend, amongst other things, on air movement and on the temperature. The curing reaction can take place down to + 5 °C, and lower for specialist products.

### 4.3.4.3 Polyurethane 2-pack paints

#### 4.3.4.3.1 Base component

The binders are polymers with free hydroxyl groups which react with suitable isocyanate curing agents.

Typical binders are:

- polyester;
- acrylic;
- epoxy;
- polyether;
- fluoro resin;
- polyurethane combinations (e.g. polyurethane hydrocarbon resins) (PURC).

#### 4.3.4.3.2 Curing agent component

Aromatic or aliphatic polyisocyanates are most commonly used.

Aliphatic-polyisocyanate-cured products (PUR, aliphatic) have excellent gloss-retention and colour-retention properties if combined with a suitable base component.

Aromatic-polyisocyanate-cured products (PUR, aromatic) give faster curing but are much less suitable for exterior exposure because they tend to chalk and discolour more rapidly.

The drying time will depend, among other things, on air movement and temperature. The curing reaction can take place down to 0 °C, or lower, but the relative humidity should be kept within the paint manufacturer's recommended range to ensure coatings are free from bubbles and/or pinholes.

 

#### 4.3.5 Moisture-curing paints

The film dries/forms by solvent evaporation. It cures chemically by reacting with moisture from the air.

Typical binders are:

- polyurethane (1-pack);
- ethyl silicate (2-pack);
- ethyl silicate (1-pack).

The drying time will depend, amongst other things, on the temperature, the air movement, the humidity and the film thickness. The curing reaction can take place down to 0 °C, or lower, provided that the air still contains sufficient moisture. The lower the relative humidity, the slower the curing.

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.

### 4.4 General properties of different generic types of paint

Further information is given in Annex C. This annex is intended only as an aid to selection but, if it is used, it should be used in combination with Tables A.1 to A.8 in Annex A, manufacturers' published data and experience gained from previous projects.

## 5 Paint systems

### 5.1 Classification of environments and surfaces to be painted

#### 5.1.1 Classification of environments

In accordance with ISO 12944-2, the environment is divided into the following categories:

Six atmospheric corrosivity categories:

C1 very low;

C2 low;

C3 medium;

C4 high;

C5-I very high (industrial);

C5-M very high (marine).

Three categories for water and soil:

Im1 immersion in fresh water;

Im2 immersion in sea or brackish water;

Im3 buried in soil.

### 5.1.2 Surfaces to be painted

#### 5.1.2.1 New structures

The substrates encountered in new structures are low-alloy steel of rust grade A, B and C as defined in ISO 8501-1, as well as galvanized steel and metallized steel (see ISO 12944-1). Possible preparation of the different substrates is described in ISO 12944-4. The substrate and the recommended preparation grade are given at the head of Tables A.1 to A.8 in this part of ISO 12944 for each corrosivity category. The paint systems listed in Annex A are **typical examples** of systems used in the environments defined in ISO 12944-2 when applied to steel surfaces with rust grades A to C, as defined in ISO 8501-1, or to hot-dip-galvanized steel or metallized steel. Where the steel has deteriorated to the extent that pitting corrosion has taken place (rust grade D 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.

#### 5.1.2.2 Maintenance

For maintenance of previously coated surfaces, the condition of the existing coating and the surfaces shall be checked using suitable methods, e.g. ISO 4628-1 to ISO 4628-6, to determine whether partial or complete repainting should be carried out. The type of surface preparation and protective paint system shall then be specified. The paint manufacturer should be consulted for recommendations. Test areas may be prepared to check the manufacturer's recommendations and/or the compatibility with the previous paint system.

## 5.2 Type of primer

Tables A.1 to A.8 in Annex A give information on the type of primer to be used. For the purposes of this part of ISO 12944, two main categories of primer are defined according to the type of pigment they contain:

— Zinc-rich primers, Zn (R), are those in which the zinc dust pigment content of the non-volatile portion of the paint is equal to or greater than 80 % by mass.

— Other primers (Misc.) are those containing zinc phosphate pigment or other anticorrosive pigments and those in which the zinc dust pigment content of the non-volatile portion of the paint is lower than 80 % by mass. Zinc chromate, red lead and calcium plumbates are not widely used for health and safety reasons.

For pre-fabrication primers, see Annex B.

The zinc dust pigment shall comply with ISO 3549.

NOTE 1 A method for the determination of the zinc dust pigment content of the non-volatile portion of a paint is described in ASTM D 2371.

NOTE 2 The value of 80 % zinc dust by mass in the dry film for zinc-rich primers Zn (R) is the basis for the durability given for the paint systems in the tables. Some countries have national standards with a minimum content of zinc dust for zinc-rich primers Zn (R) higher than 80 %.

 

## 5.3 Low-VOC paint systems

The examples listed in Annex A include paint systems with a low VOC content designed to meet requirements for low emission of solvents.

For each corrosivity category, separate tables indicate whether the paints for the paint systems listed are available as water-borne materials and whether they are available as a 1-pack or 2-pack. Several of the paint systems listed can include either high-solids or water-borne paints for both the primer and the topcoating materials, or a combination of high-solids and water-borne paints. For further information about VOCs, see Annex D.

## 5.4 Dry film thickness

Definitions of dry film thickness (DFT), nominal dry film thickness (NDFT) and maximum dry film thickness are given in 3.10, 3.11 and 3.12, respectively.

The film thicknesses indicated in Tables A.1 to A.8 are nominal dry film thicknesses. Dry film thicknesses are generally checked on the complete paint system. Where judged appropriate, the dry film thickness of the priming coat or of other parts of the paint system may be measured separately.

NOTE Depending on the instrument calibration, measurement method and dry film thickness, the roughness of the steel surface will have a different degree of influence on the measurement result.

The method and procedure for checking the thicknesses of dry films on rough surfaces shall be in accordance with ISO 19840, and for smooth and galvanized surfaces in accordance with ISO 2808, unless otherwise agreed between the interested parties.

Unless otherwise agreed, the following acceptance criteria, as stated in ISO 19840, shall apply:

— the arithmetic mean of all the individual dry film thicknesses shall be equal to or greater than the nominal dry film thickness (NDFT);

— all individual dry film thicknesses shall be equal to or above 80 % of the NDFT;

— individual dry film thicknesses between 80 % of the NDFT and the NDFT are acceptable provided that the number of these measurements is less than 20 % of the total number of individual measurements taken;

— all individual dry film thicknesses shall be less than or equal to the specified maximum dry film thickness.

Care shall be taken to achieve the dry film thickness and to avoid areas of excessive thickness. It is recommended that the maximum dry film thickness (individual value) is not greater than three times the nominal dry film thickness. In cases when the dry film thickness is greater than the maximum dry film thickness, expert agreement shall be found between the parties. For some products or systems, there is a critical maximum dry film thickness. Information given in the paint manufacturer's technical data sheet shall apply to such products or systems.

The number of coats and the nominal dry film thicknesses quoted in Annex A are based on the use of airless spray application. Application by roller, brush or conventional spraying equipment will normally produce lower film thicknesses, and more coats will be needed to produce the same dry film thickness for the system. Consult the paint manufacturer for more information.

## 5.5 Durability

Definitions of durability and of durability ranges are given in ISO 12944-1.

The durability of a protective paint system depends on several parameters, such as:

— the type of paint system;

— the design of the structure;

— the condition of the substrate before preparation;

— the surface preparation grade;

— the quality of the surface preparation work;

— the condition of any joints, edges and welds before preparation;

— the standard of the application work;

— the conditions during application;

— the exposure conditions after application.

The condition of an existing paint coating can be assessed by the use of ISO 4628-1, ISO 4628-2, ISO 4628-3, ISO 4628-4, ISO 4628-5 and ISO 4628-6, and the effectiveness of surface preparation work can be assessed using ISO 8501-1 and ISO 8501-3.

It has been assumed in compiling the tables in Annex A that the first major maintenance painting would normally need to be carried out for reasons of corrosion protection once the coating has reached Ri 3 as defined in ISO 4628-3. Based on this precondition, durability has been indicated in this part of ISO 12944 in terms of three ranges:

a) low (L): 2 years to 5 years;

b) medium (M): 5 years to 15 years;

c) high (H): more than 15 years.

The durability range is not a "guarantee time". Durability is a technical consideration that can help the owner set up a maintenance programme. A guarantee time is the subject of clauses in the contract and is not within the scope of this part of ISO 12944. There are no rules that link the two periods of time. See also 6.2. The guarantee time is usually shorter than the durability range.

Paint systems classified between 5 years and 15 years durability are all classified as "medium". It is essential that users are aware of the wide extent of the medium durability range and take this into consideration when developing specifications.

Maintenance is often required at more frequent intervals because of fading, chalking, contamination or wear and tear, or for aesthetic or other reasons.

## 5.6 Shop and site application

To ensure maximum performance of a paint system, the majority of the coats of the system or, if possible, the complete system, should preferably be applied in the shop. The advantages and disadvantages of shop application are as follows:

| **Advantages** | **Disadvantages** |
|---|---|
| a) Better control of application | a) Possible limitation of the size of the building components |
| b) Controlled temperature | b) Possibility of damage due to handling, transport and erection |
| c) Controlled relative humidity | c) Maximum overcoating time could be exceeded |
| d) Easier to repair damage | d) Possible contamination of the last coat |
| e) Greater output | |
| f) Better waste and pollution control | |

 

After completion of fabrication on site, any damage shall be repaired in accordance with the specification.

NOTE Places where repairs have been carried out will always remain more or less visible. This is one reason why it is better to put a topcoat over the whole surface on site when aesthetic aspects are important.

Site application of the coating system will be strongly influenced by the daily weather conditions, which will also have an influence on the expected lifetime.

If preloaded bearing-type connections are to be painted, paint systems shall be used which do not lead to an unacceptable decrease in the preloading force. The paint systems selected and/or the precautions taken for such connections will depend on the type of structure and on subsequent handling, assembly and transportation.

# 6 Tables for protective paint systems

## 6.1 Reading the tables

The tables given in Annex A give **examples** of paint systems for different environments. The shading used in alternate lines is there purely for ease of reading. The dark-grey shading in the “Expected durability” columns indicates the anticipated durability for that system. The paints used for all these systems shall be suitable for the highest corrosion stress of the given corrosivity or immersion category. The specifier shall ensure that documentation, or a statement from the paint manufacturer, is available confirming the suitability or the durability of a paint system for use in a given corrosivity or immersion category. If required, the suitability or durability of the paint system shall be demonstrated by experience and/or laboratory performance test methods in accordance with ISO 12944-6 or as otherwise agreed.

The paint systems have been listed in the tables using two different principles:

a) Tables A.1, A.7 and A.8 list systems for more than one corrosivity category (Table A.1 is referred to hereafter as the “summary table”). These systems have been arranged according to the binder used in the topcoat. This arrangement is more convenient when the performance properties of the topcoat are used as the basis for system selection, and for comparison of the overall durability of paint systems for more than one corrosivity category when the corrosivity category is not known exactly.

b) Tables A.2, A.3, A.4, A.5 and A.6 (referred to in the following as “individual tables”) list systems for one corrosivity category only (considering C5-I and C5-M as a single category). The systems have been arranged according to the type of priming coat. This arrangement is convenient for users who know exactly the corrosivity category of the environment to which their structure will be exposed.

NOTE The paint systems listed have been chosen as “typical systems”. This has led to some systems being listed that are not necessarily typical or available in some countries. It has been concluded, however, that a simple overview cannot be given, nor can all options be covered.

If a specifier intends to make use of the paint systems listed in the tables, he should first decide whether he will use paint systems from the summary table or from individual tables because the system numbering is different in the two types of table.

## 6.2 Parameters influencing durability

In practice, some systems have a proven durability much longer than 15 years, and a number of such cases have proven track records of more than 25 years. In general terms, increasing the total dry film thickness and the number of coats will extend the durability of a paint system. In addition, the choice of a system designed for a corrosivity category “higher” than the one envisaged will provide higher durability when such a system is used in a lower-corrosivity environment.

Category C5-I covers, in general terms, the atmospheres that could be encountered at various industrial locations. Special care should be taken when writing coating specifications for items of equipment or steelwork that could suffer from specific chemical spillages, leaking pipes or heavy air-borne contamination.

During their specified shelf life (see 3.16), paints can be used without their age having any influence on application of the paint or on the performance of the resulting coating.

## 6.3 Designation of the paint systems listed

A paint system given in Tables A.1 to A.8 is designated by its system number given in the left-hand column in each table. The designation shall be given in the following form (example taken from Table A.2 for paint system No. A2.08): **ISO 12944-5/A2.08**.

In cases where coats with different binders are given under one and the same paint system number, the designation shall include the binder used in the priming coat(s) and that used in the subsequent coat(s) and shall be given in the following form (example taken from Table A.2 for paint system No. A2.06): **ISO 12944-5/A2.06-EP/PUR**.

If a paint system cannot be allocated to one of the systems listed in Tables A.1 to A.8, full information regarding surface preparation, generic type, number of coats, nominal dry film thickness, etc., shall be given in the same way as indicated in the tables.

## 6.4 Guidelines for selecting the appropriate paint system

— Determine the corrosivity category of the environment (macroclimate) where the structure will be located (see ISO 12944-2).

— Establish whether special conditions (microclimate) exist which can result in a higher corrosivity category (see ISO 12944-2).

— Look in Annex A for the relevant table. Tables A.2 to A.5 give proposals for different generic types of paint system for corrosivity categories C2 to C5, while Table A.1 gives an overview of the contents of Tables A.2 to A.5.

— Identify in the table paint systems with the required durability.

— Select the optimum one, taking into account the surface preparation method that will be used.

— Consult the paint manufacturer in order to confirm the choice and to determine what commercially available paint system(s) correspond to the paint system selected.

 

# Annex A
(informative)

# Paint systems

The paint systems given in Tables A.1 to A.8 are only **examples**. Other paint systems having the same performance are possible. If these examples are used, it shall be ensured that the paint systems chosen comply with the indicated durability when execution of the paint work takes place as specified. See also 5.5.

Every other line has been shaded to improve readability.

## Table A.1 — Paint systems for low-alloy carbon steel for corrosivity categories C2, C3, C4, C5-I, C5-M

**Substrate: Low-alloy carbon steel**

**Surface preparation: For Sa 2½, from rust grade A, B or C only (see ISO 8501-1)**

| System No. | Priming coat(s) | | | | Subsequent coat(s) | Paint system | | Expected durability (see 5.5 and ISO 12944-1) | | | | | | | | | | | | | | | Corresponding systems in Table | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Binder [d] | Type of primer [a] | No. of coats | NDFT µm [b] | Binder | No. of coats | NDFT µm [b] | C2 | | | C3 | | | C4 | | | C5-I | | | C5-M | | | | | | | |
| | | | | | | | | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | A.2 | A.3 | A.4 | A.5 (I) | A.5 (M) |
| A1.01 | AK, AY | Misc. | 1-2 | 100 | — | 1-2 | 100 | ■ | ■ | | | | | | | | | | | | | | A2.04 | | | | |
| A1.02 | EP, PUR, ESI | Zn (R) | 1 | 60 [e] | — | 1 | 60 | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | A2.08 | A3.10 | | | |
| A1.03 | AK | Misc. | 1-2 | 80 | AK | 2-3 | 120 | ■ | ■ | | ■ | | | | | | | | | | | | A2.02 | A3.01 | | | |
| A1.04 | AK | Misc. | 1-2 | 80 | AK | 2-4 | 160 | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | A2.03 | A3.02 | | | |
| A1.05 | AK | Misc. | 1-2 | 80 | AK | 3-5 | 200 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | A3.03 | A4.01 | | |
| A1.06 | EP | Misc. | 1 | 160 | AY | 2 | 200 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | A4.06 | | |
| A1.07 | AK, AY, CR [c], PVC | Misc. | 1-2 | 80 | AY, CR, PVC | 2-4 | 160 | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | A2.03<br>A2.05 | A3.05 | | | |
| A1.08 | EP, PUR, ESI | Zn (R) | 1 | 60 [e] | AY, CR, PVC | 2-3 | 160 | ■ | ■ | ■ | ■ | ■ | | ■ | | | | | | | | | | A3.12 | A4.10 | | |
| A1.09 | AK, AY, CR [c], PVC | Misc. | 1-2 | 80 | AY, CR, PVC | 3-5 | 200 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | A3.04<br>A3.06 | A4.02<br>A4.04 | | |
| A1.10 | EP, PUR | Misc. | 1-2 | 120 | AY, CR, PVC | 3-4 | 200 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | ■ | | | | | | | | A4.06 | A5I.01 | |
| A1.11 | EP, PUR, ESI | Zn (R) | 1 | 60 [e] | AY, CR, PVC | 2-4 | 200 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | A3.13 | A4.11 | | |
| A1.12 | AK, AY, CR [c], PVC | Misc. | 1-2 | 80 | AY, CR, PVC | 3-5 | 240 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | A4.03<br>A4.05 | | |
| A1.13 | EP, PUR, ESI | Zn (R) | 1 | 60 [e] | AY, CR, PVC | 3-4 | 240 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | A4.12 | | |
| A1.14 | EP, PUR, ESI | Zn (R) | 1 | 60 [e] | AY, CR, PVC | 4-5 | 320 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | A5I.06 | |
| A1.15 | EP | Misc. | 1-2 | 80 | EP, PUR | 2-3 | 120 | ■ | ■ | | ■ | | | | | | | | | | | | A2.06 | A3.07 | | | |
| A1.16 | EP | Misc. | 1-2 | 80 | EP, PUR | 2-4 | 160 | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | A2.07 | A3.08 | | | |
| A1.17 | EP, PUR, ESI | Zn (R) | 1 | 60 [e] | EP, PUR | 2-3 | 160 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | A3.11 | A4.13 | | |
| A1.18 | EP | Misc. | 1-2 | 80 | EP, PUR | 3-5 | 200 | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | A3.09 | | | |
| A1.19 | EP, PUR, ESI | Zn (R) | 1 | 60 [e] | EP, PUR | 3-4 | 200 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | A4.14 | | |

**Table A.1** (*continued*)

**Substrate: Low-alloy carbon steel**

**Surface preparation: For Sa 2½, from rust grade A, B or C only (see ISO 8501-1)**

| System No. | Priming coat(s) | | | | Subsequent coat(s) | Paint system | | Expected durability (see 5.5 and ISO 12944-1) | | | | | | | | | | | | | | | Corresponding systems in Table | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Binder [d] | Type of primer [a] | No. of coats | NDFT µm [b] | Binder | No. of coats | NDFT µm [b] | C2 | | | C3 | | | C4 | | | C5-I | | | C5-M | | | | | | | |
| | | | | | | | | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | A.2 | A.3 | A.4 | A.5 (I) | A.5 (M) |
| A1.20 | EP, PUR, ESI | Zn (R) | 1 | 60 [e] | EP, PUR | 3-4 | 240 | | | | | | | | | | | | | | | | | | A4.15 | A5I.04 | A5M.05 |
| A1.21 | EP | Misc. | 1-2 | 80 | EP, PUR | 3-5 | 280 | | | | | | | | | | | | | | | | | | A4.09 | | |
| A1.22 | EP, PUR | Misc. | 1 | 150 | EP, PUR | 2 | 300 | | | | | | | | | | | | | | | | | | | A5I.03 | A5M.01 |
| A1.23 | EP, PUR, ESI | Zn (R) | 1 | 60 [e] | EP, PUR | 3-4 | 320 | | | | | | | | | | | | | | | | | | | A5I.05 | A5M.06 |
| A1.24 | EP, PUR | Misc. | 1 | 80 | EP, PUR | 3-4 | 320 | | | | | | | | | | | | | | | | | | | A5I.02 | A5M.02 |
| A1.25 | EP, PUR | Misc. | 1 | 250 | EP, PUR | 2 | 500 | | | | | | | | | | | | | | | | | | | | A5M.04 |
| A1.26 | EP, PUR | Misc. | 1 | 400 | — | 1 | 400 | | | | | | | | | | | | | | | | | | | | A5M.03 |
| A1.27 | EPC | Misc. | 1 | 100 | EPC | 3 | 300 | | | | | | | | | | | | | | | | | | | | A5M.08 |
| A1.28 | EP, PUR | Zn (R) | 1 | 60 [e] | EPC | 3-4 | 400 | | | | | | | | | | | | | | | | | | | | A5M.07 |

| Binders for priming coat(s) | Paints (liquid) | | | Binders for topcoat(s) | Paints (liquid) | | |
|---|---|---|---|---|---|---|---|
| | No. of components | | Water-borne possible | | No. of components | | Water-borne possible |
| | 1-pack | 2-pack | | | 1-pack | 2-pack | |
| AK = Alkyd | X | | X | AK = Alkyd | X | | X |
| CR = Chlorinated rubber | X | | | CR = Chlorinated rubber | X | | |
| AY = Acrylic | X | | X | AY = Acrylic | X | | X |
| PVC = Poly(vinyl chloride) | X | | | PVC = Poly(vinyl chloride) | X | | |
| EP = Epoxy | | X | X | EP = Epoxy | | X | X |
| ESI = Ethyl silicate | X | X | X | PUR = Polyurethane, aliphatic | X | X | X |
| PUR = Polyurethane, aromatic or aliphatic | X | X | X | EPC = Epoxy combination | | X | |

[a] Zn (R) = Zinc-rich primer, see 5.2. Misc. = Primers with miscellaneous types of anticorrosive pigment.

[b] NDFT = Nominal dry film thickness. See 5.4 for further details.

[c] It is recommended that compatibility be checked with the paint manufacturer.

[d] It is recommended for ESI primers that one of the subsequent coats be used as a tie coat.

[e] It is also possible to work with an NDFT from 40 µm to 80 µm provided the zinc-rich primer chosen is suitable for such an NDFT.

## Table A.2 — Paint systems for low-alloy carbon steel for corrosivity category C2

**Substrate: Low-alloy carbon steel**

**Surface preparation: For Sa 2½, from rust grade A, B or C only (see ISO 8501-1)**

| System No. | Priming coat(s) | | | | Subsequent coat(s) | Paint system | | Expected durability | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Binder | Type of primer [a] | No. of coats | NDFT [b] in µm | Binder type | No. of coats | NDFT [b] in µm | Low | Med | High |
| A.2.01 | AK | Misc. | 1 | 40 | AK | 2 | 80 | ■ | | |
| A2.02 | AK | Misc. | 1-2 | 80 | AK | 2-3 | 120 | ■ | ■ | |
| A2.03 | AK | Misc. | 1-2 | 80 | AK, AY, PVC, CR [c] | 2-4 | 160 | ■ | ■ | ■ |
| A2.04 | AK | Misc. | 1-2 | 100 | — | 1-2 | 100 | ■ | ■ | |
| A2.05 | AY, PVC, CR | Misc. | 1-2 | 80 | AY, PVC, CR [c] | 2-4 | 160 | ■ | ■ | ■ |
| A2.06 | EP | Misc. | 1-2 | 80 | EP, PUR | 2-3 | 120 | ■ | ■ | |
| A2.07 | EP | Misc. | 1-2 | 80 | EP, PUR | 2-4 | 160 | ■ | ■ | ■ |
| A2.08 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | — | 1 | 60 | ■ | ■ | ■ |

| Binder for priming coat(s) | Type | Water-borne possible | Binder for subsequent coat(s) | Type | Water-borne possible |
|---|---|---|---|---|---|
| AK = Alkyd | 1-pack | X | AK = Alkyd | 1-pack | X |
| CR = Chlorinated rubber | 1-pack | | CR = Chlorinated rubber | 1-pack | |
| AY = Acrylic | 1-pack | X | AY = Acrylic | 1-pack | X |
| PVC = Poly(vinyl chloride) | 1-pack | | PVC = Poly(vinyl chloride) | 1-pack | |
| EP = Epoxy | 2-pack | X | EP = Epoxy | 2-pack | X |
| ESI = Ethyl silicate | 1- or 2-pack | X | PUR = Polyurethane, aliphatic | 1- or 2-pack | X |
| PUR = Polyurethane, aromatic or aliphatic | 1- or 2-pack | X | | | |

[a] Zn (R) = Zinc-rich primer, see 5.2. Misc. = Primers with miscellaneous types of anticorrosive pigments.

[b] NDFT = Nominal dry film thickness. See 5.4 for further details.

[c] It is recommended that compatibility be checked with the paint manufacturer.

[d] It is recommended for ESI primers that one of the subsequent coats be used as a tie coat.

[e] It is also possible to work with an NDFT from 40 µm to 80 µm provided the zinc-rich primer chosen is suitable for such an NDFT.

## Table A.3 — Paint systems for low-alloy carbon steel for corrosivity category C3

**Substrate: Low-alloy carbon steel**

**Surface preparation: For Sa 2½, from rust grade A, B or C only (see ISO 8501-1)**

| System No. | Priming coat(s) | | | | Subsequent coat(s) | Paint system | | Expected durability | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Binder | Type of primer [a] | No. of coats | NDFT [b] in µm | Binder type | No. of coats | NDFT [b] in µm | Low | Med | High |
| A3.01 | AK | Misc. | 1-2 | 80 | AK | 2-3 | 120 | | | |
| A3.02 | AK | Misc. | 1-2 | 80 | AK | 2-4 | 160 | | | |
| A3.03 | AK | Misc. | 1-2 | 80 | AK | 3-5 | 200 | | | |
| A3.04 | AK | Misc. | 1-2 | 80 | AY, PVC, CR [c] | 3-5 | 200 | | | |
| A3.05 | AY, PVC, CR [c] | Misc. | 1-2 | 80 | AY, PVC, CR [c] | 2-4 | 160 | | | |
| A3.06 | AY, PVC, CR [c] | Misc. | 1-2 | 80 | AY, PVC, CR [c] | 3-5 | 200 | | | |
| A3.07 | EP | Misc. | 1 | 80 | EP, PUR | 2-3 | 120 | | | |
| A3.08 | EP | Misc. | 1 | 80 | EP, PUR | 2-4 | 160 | | | |
| A3.09 | EP | Misc. | 1 | 80 | EP, PUR | 3-5 | 200 | | | |
| A3.10 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | — | 1 | 60 | | | |
| A3.11 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | EP, PUR | 2 | 160 | | | |
| A3.12 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | AY, PVC, CR [c] | 2-3 | 160 | | | |
| A3.13 | EP, PUR | Zn (R) | 1 | 60 [e] | AY, PVC, CR [c] | 3 | 200 | | | |

| Binder for priming coat(s) | Type | Water-borne possible | Binder for subsequent coat(s) | Type | Water-borne possible |
|---|---|---|---|---|---|
| AK = Alkyd | 1-pack | X | AK = Alkyd | 1-pack | X |
| CR = Chlorinated rubber | 1-pack | | CR = Chlorinated rubber | 1-pack | |
| AY = Acrylic | 1-pack | X | AY = Acrylic | 1-pack | X |
| PVC = Poly(vinyl chloride) | 1-pack | | PVC = Poly(vinyl chloride) | 1-pack | |
| EP = Epoxy | 2-pack | X | EP = Epoxy | 2-pack | X |
| ESI = Ethyl silicate | 1- or 2-pack | X | PUR = Polyurethane, aliphatic | 1- or 2-pack | X |
| PUR = Polyurethane, aromatic or aliphatic | 1- or 2-pack | X | | | |

[a] Zn (R) = Zinc-rich primer, see 5.2. Misc. = Primers with miscellaneous types of anticorrosive pigment.

[b] NDFT = Nominal dry film thickness. See 5.4 for further details.

[c] It is recommended that compatibility be checked with the paint manufacturer.

[d] It is recommended for ESI primers that one of the subsequent coats be used as a tie coat.

[e] It is also possible to work with an NDFT from 40 µm up to 80 µm provided the zinc-rich primer chosen is suitable for such an NDFT.

## Table A.4 — Paint systems for low-alloy carbon steel for corrosivity category C4

**Substrate: Low-alloy carbon steel**

**Surface preparation: For Sa 2½, from rust grade A, B or C only (see ISO 8501-1)**

| System No. | Priming coat(s) | | | | Subsequent coat(s) | Paint system | | Expected durability | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Binder | Type of primer [a] | No. of coats | NDFT [b] in µm | Binder type | No. of coats | NDFT [b] in µm | Low | Med | High |
| A4.01 | AK | Misc. | 1-2 | 80 | AK | 3-5 | 200 | ■ | | |
| A4.02 | AK | Misc. | 1-2 | 80 | AY, CR, PVC [c] | 3-5 | 200 | ■ | | |
| A4.03 | AK | Misc. | 1-2 | 80 | AY, CR, PVC [c] | 3-5 | 240 | ■ | ■ | |
| A4.04 | AY, CR, PVC | Misc. | 1-2 | 80 | AY, CR, PVC [c] | 3-5 | 200 | ■ | | |
| A4.05 | AY, CR, PVC | Misc. | 1-2 | 80 | AY, CR, PVC [c] | 3-5 | 240 | ■ | ■ | |
| A4.06 | EP | Misc. | 1-2 | 160 | AY, CR, PVC [c] | 2-3 | 200 | ■ | | |
| A4.07 | EP | Misc. | 1-2 | 160 | AY, CR, PVC [c] | 2-3 | 280 | ■ | ■ | ■ |
| A4.08 | EP | Misc. | 1 | 80 | EP, PUR | 2-3 | 240 | ■ | ■ | |
| A4.09 | EP | Misc. | 1 | 80 | EP, PUR | 2-3 | 280 | ■ | ■ | ■ |
| A4.10 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | AY, CR, PVC [c] | 2-3 | 160 | ■ | | |
| A4.11 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | AY, CR, PVC [c] | 2-4 | 200 | ■ | ■ | |
| A4.12 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | AY, CR, PVC [c] | 3-4 | 240 | ■ | ■ | ■ |
| A4.13 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | EP, PUR | 2-3 | 160 | ■ | | |
| A4.14 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | EP, PUR | 2-3 | 200 | ■ | ■ | |
| A4.15 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | EP, PUR | 3-4 | 240 | ■ | ■ | ■ |
| A4.16 | ESI | Zn (R) | 1 | 60 [e] | — | 1 | 60 | ■ | | |

| Binder for priming coat(s) | Type | Water-borne possible | Binder for subsequent coat(s) | Type | Water-borne possible |
|---|---|---|---|---|---|
| AK = Alkyd | 1-pack | X | AK = Alkyd | 1-pack | X |
| CR = Chlorinated rubber | 1-pack | | CR = Chlorinated rubber | 1-pack | |
| AY = Acrylic | 1-pack | X | AY = Acrylic | 1-pack | X |
| PVC = Poly(vinyl chloride) | 1-pack | | PVC = Poly(vinyl chloride) | 1-pack | |
| EP = Epoxy | 2-pack | X | EP = Epoxy | 2-pack | X |
| ESI = Ethyl silicate | 1- or 2-pack | X | PUR = Polyurethane, aliphatic | 1- or 2-pack | X |
| PUR = Polyurethane, aromatic or aliphatic | 1- or 2-pack | X | | | |

[a] Zn (R) = Zinc-rich primer, see 5.2. Misc. = Primers with miscellaneous types of anticorrosive pigments.

[b] NDFT = Nominal dry film thickness. See 5.4 for further details.

[c] It is recommended that compatibility be checked with the paint manufacturer.

[d] It is recommended for ESI primers that one of the subsequent coats be used as a tie coat.

[e] It is also possible to work with an NDFT from 40 µm up to 80 µm provided the zinc-rich primer chosen is suitable for such an NDFT.

## Table A.5 — Paint systems for low-alloy carbon steel for corrosivity categories C5-I and C5-M

**Substrate: Low-alloy carbon steel**

**Surface preparation: For Sa 2½, from rust grade A, B or C only (see ISO 8501-1)**

| System No. | Priming coat(s) | | | | Subsequent coat(s) | Paint system | | Expected durability | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Binder | Type of primer [a] | No. of coats | NDFT [b] in µm | Binder type | No. of coats | NDFT [b] in µm | Low | Med | High |
| **C5-I** | | | | | | | | | | |
| A5I.01 | EP, PUR | Misc. | 1-2 | 120 | AY, CR, PVC [c] | 3-4 | 200 | ■ | | |
| A5I.02 | EP, PUR | Misc. | 1 | 80 | EP, PUR | 3-4 | 320 | ■ | ■ | ■ |
| A5I.03 | EP, PUR | Misc. | 1 | 150 | EP, PUR | 2 | 300 | ■ | ■ | |
| A5I.04 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | EP, PUR | 3-4 | 240 | ■ | ■ | |
| A5I.05 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | EP, PUR | 3-5 | 320 | ■ | ■ | ■ |
| A5I.06 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | AY, CR, PVC [c] | 4-5 | 320 | ■ | ■ | ■ |
| **C5-M** | | | | | | | | | | |
| A5M.01 | EP, PUR | Misc. | 1 | 150 | EP, PUR | 2 | 300 | ■ | ■ | |
| A5M.02 | EP, PUR | Misc. | 1 | 80 | EP, PUR | 3-4 | 320 | ■ | ■ | ■ |
| A5M.03 | EP, PUR | Misc. | 1 | 400 | — | 1 | 400 | ■ | ■ | |
| A5M.04 | EP, PUR | Misc. | 1 | 250 | EP, PUR | 2 | 500 | ■ | ■ | ■ |
| A5M.05 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | EP, PUR | 4 | 240 | ■ | ■ | |
| A5M.06 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | EP, PUR | 4-5 | 320 | ■ | ■ | ■ |
| A5M.07 | EP, PUR, ESI [d] | Zn (R) | 1 | 60 [e] | EPC | 3-4 | 400 | ■ | ■ | ■ |
| A5M.08 | EPC | Misc. | 1 | 100 | EPC | 3 | 300 | ■ | ■ | |

| Binder for priming coat(s) | Type | Water-borne possible | Binder for subsequent coat(s) | Type | Water-borne possible |
|---|---|---|---|---|---|
| EP = Epoxy | 2-pack | X | EP = Epoxy | 2-pack | X |
| EPC = Epoxy combination | 2-pack | | EPC = Epoxy combination | 2-pack | |
| ESI = Ethyl silicate | 1- or 2-pack | X | PUR = Polyurethane, aliphatic | 1- or 2-pack | X |
| PUR = Polyurethane, aromatic or aliphatic | 1- or 2-pack | X | CR = Chlorinated rubber | 1-pack | |
| | | | AY = Acrylic | 1-pack | X |
| | | | PVC = Poly(vinyl chloride) | 1-pack | |

[a] Zn (R) = Zinc-rich primer, see 5.2. Misc. = Primers with miscellaneous types of anticorrosive pigments.

[b] NDFT = Nominal dry film thickness. See 5.4 for further details.

[c] It is recommended that compatibility be checked with the paint manufacturer.

[d] It is recommended for ESI primers that one of the subsequent coats be used as a tie coat.

[e] It is also possible to work with an NDFT from 40 µm up to 80 µm provided the zinc-rich primer chosen is suitable for such an NDFT.

## Table A.6 — Paint systems for low-alloy carbon steel for immersion categories Im1, Im2 and Im3

**Substrate: Low-alloy carbon steel**

**Surface preparation: For Sa 2½, from rust grade A, B or C only (see ISO 8501-1)**

**Low-durability systems are not recommended and therefore no examples of these are shown.**

| System No. | Priming coat(s) | | | | Subsequent coat(s) | Paint system | | Expected durability | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Binder | Type of primer [a] | No. of coats | NDFT [b] in µm | Binder type | No. of coats | NDFT [b] in µm | Low | Med | High |
| A6.01 | EP | Zn (R) | 1 | 60 [e] | EP, PUR | 3-5 | 360 | | | |
| A6.02 | EP | Zn (R) | 1 | 60 [e] | EP, PURC | 3-5 | 540 | | | |
| A6.03 | EP | Misc. | 1 | 80 | EP, PUR | 2-4 | 380 | | | |
| A6.04 | EP | Misc. | 1 | 80 | EPGF, EP, PUR | 3 | 500 | | | |
| A6.05 | EP | Misc. | 1 | 80 | EP | 2 | 330 | | | |
| A6.06 | EP | Misc. | 1 | 800 | — | — | 800 | | | |
| A6.07 | ESI [d] | Zn (R) | 1 | 60 [e] | EP, EPGF | 3 | 450 | | | |
| A6.08 | EP | Misc. | 1 | 80 | EPGF | 3 | 800 | | | |
| A6.09 | EP, PUR | Misc. | — | — | — | 1-3 | 400 | | | |
| A6.10 | EP, PUR | Misc. | — | — | — | 1-3 | 600 | | | |

| Binder for priming coat(s) | Type | Water-borne possible [f] | Binder for subsequent coat(s) | Type | Water-borne possible [f] |
|---|---|---|---|---|---|
| EP = Epoxy | 2-pack | X | EP = Epoxy | 2-pack | X |
| ESI = Ethyl silicate | 1- or 2-pack | X | EPGF = Epoxy glass flake | 2-pack | |
| PURC = Polyurethane combination | 2-pack | | PURC = Polyurethane combination | 2-pack | |
| PUR = Polyurethane, aromatic or aliphatic | 1- or 2-pack | X | PUR = Polyurethane, aromatic or aliphatic | 1- or 2-pack | X |

a Zn (R) = Zinc-rich primer, see 5.2. Misc. = Primers with miscellaneous types of anticorrosive pigments.

b NDFT = Nominal dry film thickness. See 5.4 for further details.

d It is recommended for ESI primers that one of the subsequent coats be used as a tie coat.

e It is also possible to work with an NDFT from 40 µm up to 80 µm provided the zinc-rich primer chosen is suitable for such an NDFT.

f Water-borne products are in general not suitable for immersion.

## Table A.7 — Paint systems for hot-dip-galvanized steel for corrosivity categories C2 to C5-I and C5-M

**Substrate: Hot-dip-galvanized steel**

**ISO 12944-4 gives some examples of surface preparation. The type of surface preparation depends on the type of paint system, and should be stated by the paint manufacturer.**

| System No. | Priming coat(s) | | | Subsequent coat(s) | Paint system | | Expected durability [g] (see 5.5 and ISO 12944-1) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Binder | No. of coats | NDFT [b] in µm | Binder type | No. of coats | NDFT [b] in µm | C2 | | | C3 | | | C4 | | | C5-I | | | C5-M | | |
| | | | | | | | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| A7.01 | — | — | — | PVC | 1 | 80 | | | | | | | | | | | | | | | |
| A7.02 | PVC | 1 | 40 | PVC | 2 | 120 | | | | | | | | | | | | | | | |
| A7.03 | PVC | 1 | 80 | PVC | 2 | 160 | | | | | | | | | | | | | | | |
| A7.04 | PVC | 1 | 80 | PVC | 3 | 240 | | | | | | | | | | | | | | | |
| A7.05 | — | — | — | AY | 1 | 80 | | | | | | | | | | | | | | | |
| A7.06 | AY | 1 | 40 | AY | 2 | 120 | | | | | | | | | | | | | | | |
| A7.07 | AY | 1 | 80 | AY | 2 | 160 | | | | | | | | | | | | | | | |
| A7.08 | AY | 1 | 80 | AY | 3 | 240 | | | | | | | | | | | | | | | |
| A7.09 | — | — | — | EP, PUR | 1 | 80 | | | | | | | | | | | | | | | |
| A7.10 | EP, PUR | 1 | 60 | EP, PUR | 2 | 120 | | | | | | | | | | | | | | | |
| A7.11 | EP, PUR | 1 | 80 | EP, PUR | 2 | 160 | | | | | | | | | | | | | | | |
| A7.12 | EP, PUR | 1 | 80 | EP, PUR | 3 | 240 | | | | | | | | | | | | | | | |
| A7.13 | EP, PUR | 1 | 80 | EP, PUR | 3 | 320 | | | | | | | | | | | | | | | |

| Type of binder | No. of components | Water-borne possible | Binder for subsequent coat(s) | No. of components | Water-borne possible |
|---|---|---|---|---|---|
| AY = Acrylic | 1-pack | X | AY = Acrylic | 1-pack | X |
| PVC = Poly(vinyl chloride) | 1-pack | | PVC = Poly(vinyl chloride) | 1-pack | |
| EP = Epoxy | 2-pack | X | EP = Epoxy | 2-pack | X |
| PUR = Polyurethane, aromatic or aliphatic | 1- or 2-pack | X | PUR = Polyurethane, aliphatic | 1- or 2-pack | X |

[b] NDFT = Nominal dry film thickness. See 5.4 for further details.

[g] The durability is in this case related to the adhesion of the paint system to the hot-dip-galvanized substrate.

 

## Table A.8 — Paint systems for thermally sprayed metal surfaces for corrosivity categories C4, C5-I, C5-M and Im1 to Im3

**Substrate: Thermally sprayed metal (zinc, zinc/aluminium alloys and aluminium)**

**Surface preparation: See ISO 12944-4:1998, Clause 13.**

**It is recommended that sealing or application of the first coat of the paint system be carried out within 4 h.**

**If used, sealers should be compatible with the subsequent paint system.**

| System No. | Sealer coat | | | Subsequent coat(s) | Paint system | | Expected durability [g] (see 5.5 and ISO 12944-1) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Binder | No. of coats | NDFT [b] in µm | Binder type | No. of coats | NDFT [b] in µm | C4 | | | C5-I | | | C5-M | | | Im1 to Im3 | | |
| | | | | | | | L | M | H | L | M | H | L | M | H | L | M | H |
| A8.01 | EP, PUR | 1 | NA [h] | EP, PUR | 2 | 160 | ■ | ■ | ■ | ■ | | | ■ | ■ | | | | |
| A8.02 | EP, PUR | 1 | NA [h] | EP, PUR | 3 | 240 | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | | | |
| A8.03 | EP | 1 | NA [h] | EP, EPC | 3 | 450 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| A8.04 | EP, PUR | 1 | NA [h] | EP, EPC | 3 | 320 | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ |

| Type of binder | No. of components | Water-borne possible [f] | Binder for subsequent coat(s) | No. of components | Water-borne possible [f] |
|---|---|---|---|---|---|
| EP = Epoxy | 2-pack | X | EP = Epoxy | 2-pack | X |
| EPC = Epoxy combination | 2-pack | | EPC = Epoxy combination | 2-pack | |
| PUR = Polyurethane, aromatic | 1- or 2-pack | X | PUR = Polyurethane, aliphatic | 1- or 2-pack | X |

[b] NDFT = Nominal dry film thickness. See 5.4 for further details.

[f] Water-borne products are in general not suitable for immersion.

[g] The durability is in this case related to the adhesion of the paint system to the thermally sprayed substrate.

[h] NA = not applicable. The dry film thickness of the sealer coat will not significantly contribute to the total dry film thickness of the system.

 

# Annex B
(informative)

## Pre-fabrication primers

Pre-fabrication primers are applied as thin films to freshly blast-cleaned steel to provide temporary corrosion protection during the period of fabrication, transportation, erection and storage of the steel structure. The pre-fabrication primer is then overcoated with a final paint system which normally includes a further priming coat. The compatibility of several generic types of pre-fabrication primer with primers of various paint systems is indicated in Table B.1 and the suitability of the same pre-fabrication primers in various exposure conditions, when used with a related paint system, is indicated in Table B.2.

Pre-fabrication primers should have the following properties:

a) They should be suitable for spray application to produce an even coating of usually 15 µm to 30 µm dry film thickness.

b) They should dry very quickly. Priming is normally carried out in line with an automatic blast-cleaning unit which can process the products at a line speed of 1 m to 3 m per minute.

c) The mechanical properties of the coat obtained should be adequate to permit normal handling techniques involving roll beds, magnetic cranes, etc.

d) The coating obtained should provide protection for a limited period.

e) Normal fabrication procedures such as welding or gas cutting should not be significantly impeded by the priming coat. Pre-fabrication primers are normally certified with regard to cutting and welding quality and health and safety.

f) The fumes emitted from the primer during welding or cutting operations should not exceed the relevant occupational-exposure limits.

g) The coated surface should require a minimum of surface preparation before the application of the paint system, provided that the surface is in a good condition. The surface preparation required will have to be determined before subsequent painting starts.

h) The coated surface should be suitable for overcoating with the intended paint system. The coat should not (normally) be considered as a priming coat.

NOTE 1 Normally, the pre-fabrication primer is not a part of the paint system. It might need to be removed.

NOTE 2 For cleaning and preparation recommendations, see ISO 12944-4.

NOTE 3 For further information, see EN 10238.

**Table B.1 — Compatibility of pre-fabrication primers with paint systems**

| Pre-fabrication primer | | Compatibility of generic type of pre-fabrication primer with primer of paint system | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Binder type | Anticorrosive pigment | Alkyd | CR | Vinyl/PVC | Acrylic | Epoxy [a] | Polyurethane | Zinc silicate |
| Alkyd | Miscellaneous | √ | NC | NC | √ | NC | NC | NC |
| Poly(vinyl butyral) | Miscellaneous | √ | √ | √ | √ | NC | NC | NC |
| Epoxy | Miscellaneous | √ | √ | √ | √ | √ | √ | NC |
| Epoxy | Zinc dust | NC | √ | √ | √ | √ | √ | NC |
| Silicate | Zinc dust | NC | √ | √ | √ | √ | √ | √ [b] |
| Acrylic (water-borne) | Miscellaneous | NC | √ | NC | √ | NC | √ | NC |

NOTE Paint formulations vary. Checking compatibility with the paint manufacturer is recommended.

√ = In principle compatible

NC = In principle not compatible

[a] Including epoxy combinations, e.g. hydrocarbon resins.

[b] Sweep-blasting is required.

**Table B.2 — Suitability of pre-fabrication primers, used with a related paint system, in various exposure conditions**

| Pre-fabrication primer | | Suitability to exposure conditions | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Immersion | |
| Binder type | Anticorrosive pigment | C2 | C3 | C4 | C5-I | C5-M | without cathodic protection | with cathodic protection |
| Alkyd | Miscellaneous | √ | √ | √ | NS | NS | NS | NS |
| Poly(vinyl butyral) | Miscellaneous | √ | √ | √ | NS | NS | NS | NS |
| Epoxy | Miscellaneous | √ | √ | √ | √ | √ | √ | NS |
| Epoxy | Zinc dust | √ | √ | √ | √ | √ | √ | NS |
| Silicate | Zinc dust | √ | √ | √ | √ | √ | √ | √ |
| Acrylic (water-borne) | Miscellaneous | √ | √ | √ | NS | NS | NS | NS |

NOTE Paint formulations vary. Checking compatibility with the paint manufacturer is recommended.

√ = Suitable

NS = Not suitable

# Annex C
(informative)

# General properties

**Table C.1 — General properties of different generic types of paint**

| **Suitability**<br>■ Good<br>▲ Limited<br>● Poor<br>— Not relevant | **Poly(vinyl chloride)**<br>(PVC) | **Chlorinated rubber**<br>(CR) | **Acrylic**<br>(AY) | **Alkyd**<br>(AK) | **Polyurethane, aromatic**<br>(PUR, aromatic) | **Polyurethane, aliphatic**<br>(PUR, aliphatic) | **Ethyl zinc silicate**<br>(ESI) | **Epoxy**<br>(EP) | **Epoxy combination**<br>(EPC) |
|---|---|---|---|---|---|---|---|---|---|
| Gloss retention | ▲ | ▲ | ▲ | ▲ | ● | ■ | — | ● | ● |
| Colour retention | ▲ | ▲ | ■ | ▲ | ● | ■ | — | ● | ● |
| Resistance to chemicals: | | | | | | | | | |
| Water immersion | ▲ | ■ | ▲ | ● | ▲ | ● | ▲ | ■ | ■ |
| Rain/condensation | ■ | ■ | ■ | ▲ | ■ | ▲ | ■ | ■ | ■ |
| Solvents | ● | ● | ● | ▲ | ■ | ▲ | ■ | ■ | ▲ |
| Solvents (splash) | ● | ● | ● | ■ | ■ | ■ | ■ | ■ | ■ |
| Acids | ▲ | ■ | ▲ | ▲ | ■ | ▲ | ● | ▲ | ■ |
| Acids (splash) | ■ | ■ | ▲ | ▲ | ■ | ■ | ● | ■ | ■ |
| Alkalis | ▲ | ▲ | ▲ | ▲ | ▲ | ▲ | ● | ■ | ■ |
| Alkalis (splash) | ■ | ■ | ▲ | ▲ | ■ | ■ | ● | ■ | ■ |
| Resistance to dry heat: | | | | | | | | | |
| up to 70 °C | ● | ● | ▲ | ■ | ■ | ■ | ■ | ■ | ■ |
| 70 °C to 120 °C | — | — | ▲ | ■ | ■ | ■ | ■ | ■ | ▲ |
| 120 °C to 150 °C | — | — | ▲ | ● | ▲ | ● | ■ | ▲ | ▲ |
| $>$ 150 °C but $\leqslant$ 400 °C | — | — | — | — | — | — | ■ | — | — |
| Physical properties: | | | | | | | | | |
| Abrasion resistance | ● | ● | ● | ▲ | ■ | ▲ | ■ | ■ | ▲ |
| Impact resistance | ▲ | ▲ | ▲ | ▲ | ■ | ▲ | ▲ | ■ | ▲ |
| Flexibility | ■ | ■ | ■ | ▲ | ▲ | ■ | ● | ▲ | ▲ |
| Hardness | ▲ | ▲ | ▲ | ■ | ■ | ▲ | ■ | ■ | ■ |

NOTE The information given in Table C.1 has been drawn from a wide cross-section of sources and is intended to provide a general indication of the properties of the different generic types of paint available. Variations will occur within resin groups, and some products are specifically formulated to provide exceptional resistance to certain chemicals or conditions. Always consult the paint manufacturer when any given paint is chosen for a particular application.

# Annex D
(informative)

# Volatile organic compounds (VOCs)

A VOC is any volatile organic compound, present in a specific volume of a paint or related material, which evaporates under specific conditions into the atmosphere during and after application. The VOC content is expressed in g/litre.

NOTE 1 For Europe, an organic compound is considered to be a VOC if, at a temperature of 293,15 K, it has a vapour pressure of 0,01 kPa or more. For the USA, the conditions are not specified, but those organic compounds which are regarded as VOCs are identified as such.

VOCs are considered as air pollutants and most participate in photo-chemical reactions. For this reason, manufacturers have been obliged to reduce the amounts of VOCs in paints to acceptable levels to minimize the air pollution.

Specifiers and users of coating systems should be aware of this and of the fact that strict regulations are in force on VOC emissions in many places in the world today. They are requested to seek information about current rules in the country where the coating systems will be used.

If VOC regulations are in force, they will typically refer to the total VOC emission from the work site and/or the VOC level in the paint.

The emission of VOCs from coatings into the environment can be reduced in two main ways:

a) by choosing suitable coating systems (selection of products with lower VOC contents);

b) for coating systems applied in confined spaces (workshops), by passing the exhaust air from the paint shop ventilation through special filters that adsorb the VOCs or through incinerators that oxidize the VOCs to carbon dioxide and water.

VOC reduction through the choice of suitable products is often the only practical/economical option, and there are basically three possible products: a high-solids solvent-borne product, a solvent-free product or a water-borne product. It is also possible to use a combination of the three.

When selecting a coating system based on high-solids products or solvent-free products, care should be taken in the application of these products as they can be difficult to apply at the nominal dry film thicknesses specified in Annex A. These paints often have to be spray-applied at a higher dry film thickness than that recommended to ensure that they form a coherent continuous film.

Although an equivalent total film thickness can be achieved in fewer coats, this might not provide the same level of protection since the number of coats applied has an influence on the level of protection — more coats equals better protection. Therefore it is recommended that, to compensate for fewer coats, the total film thickness be increased when a high-solids or solvent-free product is used.

When selecting a coating system based on water-borne paints, the success of the application will greatly depend on the ventilation and the climatic conditions, usually to a greater extent than for solvent-borne products (see also 4.2, 4.3.2 and 4.3.3).

Table D.1 indicates the VOC contents of different generic paint types and the possibilities for reduction.

 

**Table D.1 — VOC contents of different generic paint types**

| Generic type of paint | Typical VOC range g/litre | Water-borne alternative available? | High-solids alternative available? | Solvent-free alternative [a] available? |
|---|---|---|---|---|
| Poly(vinyl chloride) copolymer | > 500 | YES | NO | NO |
| Chlorinated rubber | > 500 | NO | NO | NO |
| Acrylic | > 500 | YES | NO | NO |
| Alkyd | 330 to 500 | YES | YES | NO |
| Polyurethane (aromatic) | 0 to 500 | YES | YES | YES |
| Polyurethane (aliphatic) | 0 to 500 | YES | YES | YES |
| Epoxy | 0 to 700 | YES | YES | YES |
| Zinc silicate | 350 to 650 | YES | YES | NO |

[a] 100 % solids/no volatile content.

NOTE 2 Water-borne paints may also contain VOCs. The level will typically be in the range 0 g/litre to 120 g/litre.

Water-borne paint systems are suitable for almost all atmospheric corrosivity categories, especially as topcoats. For immersion, high-solids and/or solvent-free paints are generally more suitable.

A special case is the interior of buildings which need repair or refurbishment. Such indoor painting activities are a good example of the use of water-borne coating systems or water-borne topcoats, as it is relatively easy to meet the demands for the necessary temperature and ventilation. The very low or zero VOC content ensures environmental benefits and reduced health and safety hazards during the painting operation. When water-borne coatings are used for such maintenance, paint application can often proceed without affecting other activities in the vicinity.

During new-construction work, it might be advisable to use mechanically stronger paint systems in order to minimize damage during transport and erection. In such cases, it is nevertheless recommended that the topcoat of the paint system for these structures be of a water-borne type or that the topcoat be of a type that is compatible with a water-borne type (for later repair and maintenance).

In this context, compatible means that the paint can later be overcoated with a water-borne topcoat with a minimum of surface preparation (removal of contamination only). It should be understood that, depending on the expected exposure conditions, other suitable alternatives, like high-solids and solvent-free paints, could also be considered.

NOTE 3 The slow release of e.g. coalescent agents from some water-borne paints can, in certain cases, have an effect in a confined space.

 

# Bibliography

[1] ASTM D 2371, *Standard Test Method for Pigment Content of Solvent-Reducible Paints*

[2] EN 10238, *Automatically blast-cleaned and automatically prefabrication-primed structural steel products*

 

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