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Organic coatings on aluminium and its alloys — Methods for specifying decorative and protective organic coatings on aluminium —

Part 2: Liquid coatings

Couches organiques sur l'aluminium et ses alliages — Méthodes de spécification des revêtements décoratifs et protecteurs sur aluminium —

Partie 2: Revêtements liquides

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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 79, *Light metals and their alloys*, Subcommittee SC 2, *Organic and anodic oxidation coatings on aluminium*.

A list of all parts in the ISO 18768 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

There are three major surface treatments on aluminium and its alloys:

a) anodic oxidation coatings;

b) organic coatings;

c) combined coatings of anodic oxidation coatings and organic coatings.

ISO 18768-1 and this document provide the performance requirements and test methods for b) organic coatings.

Performance requirements and test methods for a) anodic oxidation coatings are given in ISO 7599 and for c) combined coatings of anodic oxidation coatings and organic coatings in ISO 28340.

It is assumed that users are familiar with other relevant international and regional standards. Those standards should be respected, and this document adopts optional systems in such cases.

Organic coatings on aluminium and its alloys — Methods for specifying decorative and protective organic coatings on aluminium —

Part 2: Liquid coatings

1 Scope

This document specifies methods for specifying decorative and protective organic coatings on aluminium and its alloys. It defines the characteristic properties of organic liquid coatings and provides testing methods with minimum performance requirements, with reference to the application and the aggressiveness of the environment in which the painted aluminium exists.

This document is applicable to aluminium products with liquid coatings for general applications, and liquid coatings mainly processed by electrostatic liquid spraying, air spraying or airless spraying.

This document does not apply to coil coatings on aluminium.

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 1463, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method*

ISO 1519, *Paints and varnishes — Bend test (cylindrical mandrel)*

ISO 1520, *Paints and varnishes — Cupping test*

ISO 2106, *Anodizing of aluminium and its alloys — Determination of mass per unit area (surface density) of anodic oxidation coatings — Gravimetric method*

ISO 2360, *Non-conductive coatings on non-magnetic electrically conductive base metals — Measurement of coating thickness — Amplitude-sensitive eddy-current method*

ISO 2409, *Paints and varnishes — Cross-cut test*

ISO 2812-2, *Paints and varnishes — Determination of resistance to liquids — Part 2: Water immersion method*

ISO 2813, *Paints and varnishes — Determination of gloss value at 20°, 60° and 85°*

ISO 3892, *Conversion coatings on metallic materials — Determination of coating mass per unit area — Gravimetric methods*

ISO 4211-2, *Furniture — Tests for surface finishes — Part 2: Assessment of resistance to wet heat*

ISO 4211-3, *Furniture — Tests for surface finishes — Part 3: Assessment of resistance to dry heat*

ISO 4623-2, *Paints and varnishes — Determination of resistance to filiform corrosion — Part 2: Aluminium substrates*

ISO 4624, *Paints and varnishes — Pull-off test for adhesion*

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 4628-10, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 10: Assessment of degree of filiform corrosion*

ISO 6270-1, *Paints and varnishes — Determination of resistance to humidity — Part 1: Condensation (single-sided exposure)*

ISO 6270-2, *Paints and varnishes — Determination of resistance to humidity — Part 2: Condensation (in-cabinet exposure with heated water reservoir)*

ISO 6270-3, *Paints and varnishes — Determination of resistance to humidity — Part 3: Condensation (in-cabinet exposure with heated, bubbling water reservoir)*

ISO 6272-2, *Paints and varnishes — Rapid-deformation (impact resistance) tests — Part 2: Falling-weight test, small-area indenter*

ISO 7784-1, *Paints and varnishes — Determination of resistance to abrasion — Part 1: Method with abrasive-paper covered wheels and rotating test specimen*

ISO 7784-2, *Paints and varnishes — Determination of resistance to abrasion — Part 2: Method with abrasive rubber wheels and rotating test specimen*

ISO 8295, *Plastics — Film and sheeting — Determination of the coefficients of friction*

ISO 8296, *Plastics — Film and sheeting — Determination of wetting tension*

ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 15184, *Paints and varnishes — Determination of film hardness by pencil test*

ISO 17132:2007, *Paints and varnishes — T-bend test*

ISO 16474-2, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*

ISO 21227-2, *Paints and varnishes — Evaluation of defects on coated surfaces using optical imaging — Part 2: Evaluation procedure for multi-impact stone-chipping test*

ISO 28340:2013, *Combined coatings on aluminium — General specifications for combined coatings of electrophoretic organic coatings and anodic oxidation coatings on aluminium*

ASTM C207, *Standard Specification for Hydrated Lime for Masonry Purposes*

ASTM D968, *Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive*

ASTM D7869, *Standard Practice for Xenon Arc Exposure Test with Enhanced Light and Water Exposure for Transportation Coatings*

QUALICOAT Specifications 2022, *Specifications for a quality label for liquid and powder organic coatings on aluminium for architectural applications*

GSB QR AL 631-7 ST 663-7, *Measuring and Testing Methods*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
liquid coating
dry coating with a certain thickness that has effects of decorative and protective for a product, coating is formed by liquid lacquer excluding the coating whose based layer is formed by anodizing, combined coating or powder coating

3.2
reference sample
reference specimen
sample which defines the criteria for acceptable properties

Note 1 to entry: This may be agreed between the customer and the surface processor.

3.3
significant surface
part of the article covered or to be covered by the coatings, and for which the coatings are essential for service and/or appearance

3.4
test specimen
single sample of the final product to be used for testing

4 Information to be supplied by the customer to the surface processor

In order to coat the product correctly and depending on the application, the following information should be supplied by the customer to the surface processor, if necessary, in consultation with the aluminium supplier and/or the surface processor.

A summary of the references to this information is given in Annex A.

a) a reference to this document, i.e. ISO 18768-2;

b) the intended service use of the article to be coated;

c) the environmental categories of the intended service (see Clause 6);

d) the specification of the aluminium (chemical composition and temper designations) to be coated;

e) an indication of the significant surface(s) of the product to be coated;

f) the preferred position and maximum size of contact marks;

g) details of any formal sampling plans required;

h) the type of pretreatment;

i) mass loss by etching;

j) thickness of the anodic oxidation coating or mass of the chemical conversion coating used for pretreatment;

k) the type of coating process to be used;

l) the quality of appearance required;

m) the acceptable limits of colour variation by agreed reference samples;

n) the thickness of the coating;

o) the hardness of the coating;

p) the dry adhesion of the coating;

q) the wet adhesion of the coating;

r) the value range of gloss measured by equipment;

s) the distinctness of the image;

t) the impact resistance (excluding anodic oxidation coating for pretreatment);

u) the multi-impact stone chipping resistance;

v) the abrasion resistance of the coating;

w) the cupping resistance (excluding anodic oxidation coating for pretreatment);

x) the flexibility of the coating (excluding anodic oxidation coating for pretreatment);

y) the processing resistance, such as cutting, milling or drilling;

z) the permeating depths of ink into the coating;

aa) the solvent resistance;

bb) the humidity resistance;

cc) the water resistance;

dd) the temperature resistance;

ee) the surface tension of the coating;

ff) the hydrophilicity of the coating;

gg) the thermal viscosity of the coating;

hh) the resistivity;

ii) the acid resistance;

jj) the alkali resistance;

kk) the detergent resistance;

ll) the mortar resistance;

mm) the contamination resistance;

nn) the oil resistance;

oo) the corrosion resistance;

pp) the resistance to a humid atmosphere containing sulfur dioxide;

qq) the filiform corrosion resistance;

rr) the weathering resistance of the coating;

ss) the accelerated weathering resistance;

tt) the colour difference between test specimens and reference samples using a colour difference meter;

uu) the value range of the gloss measured by equipment;

vv) the sealing compounds adhesion.

5 Metal preparation and pretreatment

5.1 Material (substrate)

Aluminium and aluminium alloys are classified in accordance with ISO 209.

5.2 Pretreatment of the substrate

5.2.1 General

Before application of the coating, a pretreatment coating should be applied. This pretreatment may be one of the following:

a) anodic oxidation coating;

b) chemical conversion coating with aqueous solutions containing either chromate ions or chromate and phosphate ions, without applying an electric current;

c) an alternative pretreatment (e.g. chromium-free systems).

After the chemical conversion coating process, the substrate is normally rinsed with deionized water (preferably below 30 µS/cm at 20 °C) and dried.

There are also some coatings used mainly for decorative purposes, which do not need to be pretreated before coating.

If a non-rinsing pretreatment is applied, the last rinsing is carried out before the conversion coating process.

5.2.2 Degreasing etching and rinsing

All surface contaminants such as greases, lubricants and residues shall be removed using alkaline or acidic solutions and/or solvents in appropriate combinations. Before the conversion stage, the substrate shall be thoroughly cleaned.

Mass loss before and after etching should be measured by the mass of a test specimen. It should be no less than 1 g/m^2 and preferably more than 2 g/m^2.

5.2.3 Anodic oxidation coating

The anodic oxidation pretreatment should be chosen so as to produce an anodic oxidation coating with a thickness of 3 µm to 10 µm without chalking and surface flaws. It shall be measured in accordance with ISO 2360. After the pretreatment, rinse the specimen with deionized water to remove the acid from the surface. The anodic oxidation coating should not be sealed.

The time between anodic oxidation pretreatment and liquid coating should be less than 72 h. If the time between the anodic oxidation pretreatment and liquid coating is more than 24 h, the anodic oxidation pretreatment should be tested by a dye spot test in accordance with ISO 2143. The intensity of the stain should be level 5.

5.2.4 Chemical conversion coatings

A chemical conversion coating shall be produced by application of the appropriate solution. Generally, chromate and phosphate are used.

The surface density of conversion coatings shall be agreed between the customer and the surface processor. In the absence of such an agreement, the mass of the chromate coating should be between 0,4 g/m^2 and 1,0 g/m^2 for chromate conversion coating and between 0,4 g/m^2 and 1,2 g/m^2 for chromate-phosphate conversion coating. It shall be measured in accordance with surface density (see 7.6.2.3).

The drying temperature should not exceed 65 °C for chromate conversion coating and 85 °C for chromate-phosphate conversion coating.

5.2.5 Alternative pretreatment

Alternative pretreatments, e.g. chromium-free system, or other processes may be specified but shall be agreed between the customer and the surface processor, taking into consideration the recommendations from the chemical supplier.

6 Categories

Symbols, typical properties and applications of the more common coating materials are shown in Table B.1. Symbols of the more common coating materials are for information only.

There are two typical environmental categories: corrosivity and UV radiation.

The corrosion protection and the adhesion of the coating on the aluminium is mainly determined by the surface pretreatment before coating. For this reason, the surface pretreatment should be selected according to the corrosivity category. It is recommended that the corrosivity category is defined in the specification.

The permanent colour stability of a coating and the decorative appearance of the coated surface depends on the UV resistance of the coating material. For this reason, the coating material should be selected based on the UV category. It is recommended that the UV category is defined in the specification.

Examples of typical applications of liquid coatings for architectural application are shown in Tables C.1 and C.2.

The corrosivity category defined by the corrosion effects given in ISO 9223 are shown in Table 1. The UV categories are shown in Table 2.

Table 1 — Description of typical atmospheric environments related to the estimation of corrosivity categories

Corrosivity category[a]	Corrosivity	Typical environments — Examples[b]	
		Indoor	Outdoor
C1	Very low	Heated spaces with low relative humidity and insignificant pollution, e.g. offices, schools, museums.	Dry or cold zone, atmospheric environment with very low pollution and time of wetness, e.g. certain deserts, Central Arctic/Antarctica.
C2	Low	Unheated spaces with varying temperature and relative humidity. Low frequency of condensation and low pollution, e.g. storage, sport halls.	Temperate zone, atmospheric environment with low pollution (SO_2 < 5 µg/m^3), e.g. rural areas, small towns. Dry or cold zone, atmospheric environment with short time of wetness, e.g. deserts, subarctic areas.

Table 1 *(continued)*

Corrosivity category[a]	Corrosivity	Typical environments — Examples[b]	
		Indoor	**Outdoor**
C3	Medium	Spaces with moderate frequency of condensation and moderate pollution from production process, e.g. food-processing plants, laundries, breweries, dairies.	Temperate zone, atmospheric environment with medium pollution (SO_2: 5 µg/m^3 to 30 µg/m^3) or some effect of chlorides, e.g. urban areas, coastal areas with low deposition of chlorides. Subtropical and tropical zone, atmosphere with low pollution.
C4	High	Spaces with high frequency of condensation and high pollution from production process, e.g. industrial processing plants, swimming pools.	Temperate zone, atmospheric environment with high pollution (SO_2: 30 µg/m^3 to 90 µg/m^3) or substantial effect of chlorides, e.g. polluted urban areas, industrial areas, coastal areas without spray of salt water or, exposure to strong effect of de-icing salts. Subtropical and tropical zone, atmosphere with medium pollution.
C5	Very high	Spaces with very high frequency of condensation and/or with high pollution from production process, e.g. mines, caverns for industrial purposes, unventilated sheds in subtropical and tropical zones.	Temperate and subtropical zone, atmospheric environment with very high pollution (SO_2: 90 µg/m^3 to 250 µg/m^3) and/or significant effect of chlorides, e.g. industrial areas, coastal areas, sheltered positions on coastline.
CX	Extreme	Spaces with almost permanent condensation or extensive periods of exposure to extreme humidity effects and/or with high pollution from production process, e.g. unventilated sheds in humid tropical zones with penetration of outdoor pollution including airborne chlorides and corrosion-stimulating particulate matter.	Subtropical and tropical zone (very high time of wetness), atmospheric environment with very high SO_2 pollution (higher than 250 µg/m^3) including accompanying and production factors and/or strong effect of chlorides, e.g. extreme industrial areas, coastal and offshore areas, occasional contact with salt spray.

NOTE 1 Deposition of chlorides in coastal areas is strongly dependent on the variables influencing the transport inland of sea salt, such as wind direction, wind velocity, local topography, wind sheltering islands outside the coast, distance of the site from the sea, etc.

NOTE 2 Extreme effect by chlorides, which is typical of marine splash or heavy salt spray, is outside of the scope of this document.

NOTE 3 Corrosivity classification of specific service atmospheres, e.g. in chemical industries, is outside of the scope of this document.

NOTE 4 Surfaces that are sheltered and not rain-washed in marine atmospheric environments where chlorides are deposited and cumulated can experience a higher corrosivity category due to the presence of hygroscopic salts.

NOTE 5 A detailed description of types of indoor environments within corrosivity categories C1 and C2 is given in ISO 11844-1. Indoor corrosivity categories IC1 to IC5 are defined and classified.

NOTE 6 Source: ISO 9223:2012, Table C.1.

[a] In environments with expected "CX category", it is recommended that the atmospheric corrosivity classification from one-year corrosion losses be determined.

[b] The concentration of sulfur dioxide (SO_2) should be determined during at least one year and is expressed as the annual average.

Table 2 — UV categories (information only)

UV category	UV radiation	Typical application environments
UV1	Low	Solar radiation intensity is mild
UV2	Medium	Solar radiation intensity is relatively strong
UV3	High	Solar radiation intensity is very strong

7 Tests

7.1 General

The required properties and quality for the products should be chosen from the following testing methods according to the agreement between the customer and the surface processor, before application. Other test methods may be agreed between the customer and the surface processor.

The sampling lot size shall be agreed between the customer and the surface processor considering the kind of products, size and quantity. Guidance on the choice of suitable sampling procedures is given in ISO 2859-1.

In the absence of such an agreement, the size of test specimens should be chosen from the following: 150 mm × 70 mm or 150 mm × 75 mm.

The surface of test specimens shall be wiped clean. For example, by using soft wet cloth with deionized water or ethanol. Use deionized water for the coating attacked by ethanol.

Acceptance tests shall be as specified by the customer.

In the absence of agreed procedures and for the resolution of disputes, the test methods given in this clause shall be used.

Tests for production control purposes shall be at the discretion of the surface processor.

In cases where different requirements are not specified for individual corrosivity categories or UV categories, the most demanding category should be applied.

7.2 Appearance

7.2.1 General

The coating shall be assessed by viewing from a distance of 5 m for parts used outside, of 3 m for parts used inside and of 0,5 m for parts used for decoration. The observing angle shall be agreed between the surface processor and the customer.

7.2.2 Measurement

Visual inspection shall be carried out under uniform artificial light which provides an appropriate irradiance and does not influence the evaluation. The lightness on the test specimens should be over 600 lx.

The reference sample shall be agreed between the customer and the surface processor.

7.2.3 Requirement

The coating shall be free from visible defects, such as excessive roughness, runs, blisters, inclusions, craters, dull spots, pinholes, scratches or any damage breaking through to metal basis on the significant surface.

The pattern on the coating shall be distinct, have integrity and be uniform.

7.3 Colour

7.3.1 General

The colour of the coating shall be assessed by the visual method (see 7.3.2) or the instrumental method (see 7.3.3).

7.3.2 Visual method

7.3.2.1 Measurement

The colour of the coating shall be assessed by viewing from a distance agreed between the customer and the surface processor. Visual inspection shall be carried out under diffuse light, the source and strength of which shall be agreed between the customer and the surface processor. The lightness on the test specimens should be over 600 lx. Unless otherwise agreed, the colours shall be compared in diffuse daylight from the direction of higher latitudes. If the coloured coatings are to be used in artificial light, this lighting shall be used for colour comparison.

7.3.2.2 Requirement

Colour shall be judged using the standard colour samples which have been agreed between the customer and the surface producer. Colour differences may also apply upper and lower reference samples to check which have been agreed between the customer and the surface processor.

7.3.3 Instrumental method

7.3.3.1 General

This method does not apply to metallic paint finishes, textured coatings and embossed surfaces.

7.3.3.2 Measurement

For instrumental colour measurement, measure the colour difference between the test specimen and the reference sample by using a colour difference meter.

The colour may be measured by colourimetry in accordance with ISO/CIE 11664-1, ISO 11664-2, ISO/CIE 11664-3, ISO/CIE 11664-4 and CIE 15. The customer and the surface processor should agree on the measurement condition, including colorimetric system, illuminate, observation angle and geometric light system.

7.3.3.3 Requirement

The colour tolerance shall be agreed between the customer and the surface processor.

7.4 Gloss

7.4.1 Measurement

The gloss measurement should be carried out in accordance with ISO 2813 using 60° geometry. Measure three to five points and for each point get three readings. The average of the readings is taken to record as the value of each point. The test is carried out on a flat test specimen.

The test method and gloss tolerances for textured finishes shall be agreed between the customer and the surface processor.

NOTE The 60° geometry is suitable for all the coatings. However, when the gloss is below 10 and over 70, the 85° geometry or 20° geometry for each can be more appropriate.

7.4.2 Requirement

The gloss range and permissible variation shall meet the requirements below or the agreement between the customer and the surface processor.

— low gloss: 30 or less (±5);

— medium gloss: 31 to 70 (±7);

— high gloss: over 70 (±10).

7.5 Brightness (distinctness of image)

7.5.1 General

This method is used to test the decorative coating of aircraft, automobiles, precision instruments and household appliances, especially for high-class car bodies, etc.

7.5.2 Measurement

The test should be carried out as follows with the instrument.

a) Start the power switch, observe the voltmeter and adjust the voltage potentiometer to make the pointer in a position consistent with the voltmeter limit. If the adjusted pointer is still on the left side of the dividing line, the power supply should be replaced.

b) The standard mirror is placed on the table, the measuring window at the bottom of the machine is placed on the mirror, and then the power switch is activated to observe the standard plate reflected on the mirror from the visual tube, and to confirm that the number of Gd values on the plate can be clearly read.

c) The measuring window is placed on the coated layer, the power switch is activated, and the standard plate reflected on the coating is observed from the visual tube. The number can be read clearly and is called “Gd value”.

d) Repeat the measurements five times and take the average as the result.

7.5.3 Requirement

The value of the test specimens should be agreed between the customer and the surface processor.

7.6 Thickness

7.6.1 General

The thickness of the coating shall be assessed by the microscopical method (see 7.6.2.1), the eddy current method (see 7.6.2.2) or surface density (see 7.6.2.3). The surface density test can be used for anodic oxidation coating, chemical conversion coating and other coating by the agreement between the customer and the surface processor.

7.6.2 Measurement

7.6.2.1 Method 1: Microscopical method

The microscopical method shall be carried out in accordance with ISO 1463. Use microscopy to examine the cross-section of the sample.

7.6.2.2 Method 2: Eddy current method

The eddy current method shall be carried out in accordance with ISO 2360.

The thickness of the coating to be tested shall be measured on the significant surface. Take three to five readings per point. The average of the separate readings taken at one measuring area gives a measured value to be recorded.

7.6.2.3 Method 3: Surface density

The surface density shall be carried out in accordance with ISO 2106 or ISO 3892.

The mass of test specimen should not exceed 100 g. If the surface is dirty with oil, grease or other similar material, it shall be cleaned.

The test solution and test period shall be agreed between the customer and the surface processor.

7.6.3 Requirement

The thickness of the coatings is not specified because specification is based on application. The thickness of the coating processed by spraying paint should meet the requirements in Table 3.

Table 3 — Average and local thickness of spray coating

Spray coating	Average thickness µm	Local thickness µm
One-layer	≥ 20	≥ 17
Two-layer	≥ 30	≥ 25
Three-layer	≥ 40	≥ 34
Four-layer	≥ 65	≥ 55

7.7 Hardness (pencil)

7.7.1 Measurement

The hardness test shall be carried out in accordance with ISO 15184 and be evaluated by pencils. The hardest pencil that will not rupture or scratch the coatings is the so-called “pencil hardness”.

The test specimen should be left for 24 h or more in an adequate room after finishing.

7.7.2 Requirement

After the pencil hardness test, the hardness should not be less than 1H or according to the agreement between the customer and the surface processor.

7.8 Adhesion

7.8.1 General

The test specimen should be stored for 24 h or more after finishing.

The adhesion of coating shall be assessed by the scratch circular roll method (see 7.8.2), the dry adhesion (see 7.8.3), the wet adhesion test (see 7.8.4) and the pull-off test (see 7.8.5).

The scratch circular roll method is often used to test coating performance on automobiles.

The adhesion tape method is often used to test the coating with lower adhesion for decorative uses only.

The pull-off test is often used to test multi-coat systems of liquid coatings.

7.8.2 Scratch circular roll method

7.8.2.1 Measurement

The adhesion of the coating is tested using an adhesion tester. The radius of the circle sweeping by the needle shall be 5,25 mm. The needle of adhesion tester should be in contact with the coating and move 80 to 100 turns per min. The standard length of the circular roll scratch is 7,5 ± 0,5 cm. The diagram of scratch circular is given in Figure 1. Remove any paint chips on the test specimen and examine it with a fourfold magnifier.

The grade of adhesion is evaluated by checking the seven points. If point 1 is intact, the adhesion is grade 1 (the best). If only point 7 is intact, the adhesion is grade 7 (the worst).

The test specimens shall meet the requirements of 7.1 or the agreement between the customer and the surface processor. Three identical specimens are used in this test. At least the test results of two specimens shall be identical.

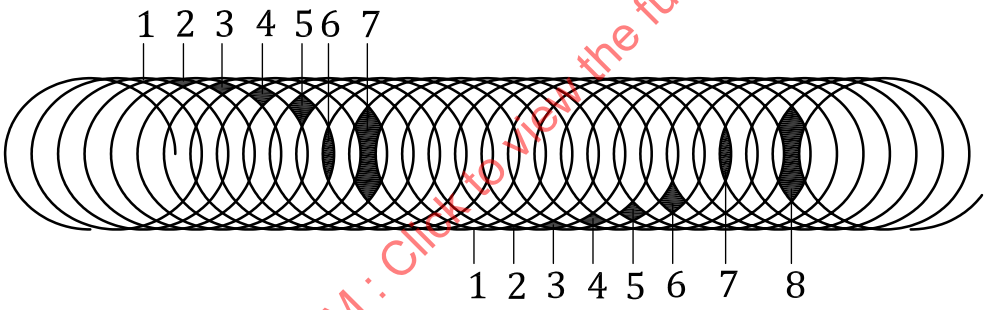


Figure 1 — Evaluation of the scratch circular roll method

7.8.2.2 Requirement

The adhesion should be agreed between the customer and the surface processor.

7.8.3 Dry adhesion test

7.8.3.1 Measurement

The dry adhesion test shall be carried out in accordance with ISO 2409.

Make six parallel cuts which are 1 mm, 2 mm or 3 mm apart from each other through the coating and make similar cuts crossing at a right angle to the first six cuts to make 25 squares.

Then put adhesive tape on the cut area of the test specimen. Immediately pull the tape off perpendicularly from the test specimen.

For the adhesive tape, an equivalent product to IEC 60454-2 can be used.

7.8.3.2 Requirement

The dry adhesion of the coating should be grade 0 or according to the agreement between the customer and the surface processor.

7.8.4 Wet adhesion test

7.8.4.1 Measurement

7.8.4.1.1 Method 1: Hot water

Cross-cut the test specimen, immersing the test specimen in deionized water (maximum 10 µS at 20 °C) for 24 h at 38 °C. Remove and dry it. Apply an adhesive tape to the surface, ensuring that no air is trapped. After 1 min, remove the tape at an angle of 45° with a sharp even pull.

7.8.4.1.2 Method 2: Boiling water

The boiling water immersion and cross-cut test is the test method to evaluate the appearance change of the test specimens caused by the boiling water as well as the resulting adhesion.

This test shall be carried out as follows.

a) Pour deionized water into an about 150 mm depth vessel to 80 mm depth and heat the beaker. Keep the temperature of the water over 95 °C. Immerse the test specimens in the vessel at a position of depth 60 mm from the surface of the water;

b) After immersion for 2 h, promptly take the test specimens and within 5 min evaluate the appearance of the significant surface for wrinkles, cracks and noticeable colour changes. Exclude from the evaluation the coating on the peripheral part of the test specimens and parts that were within 10 mm of the surface of the water.

c) If there were no defects, the cross-cut test in accordance with ISO 2409 shall be applied and it shall be evaluated. Test specimens for which defects occurred on the significant surface shall be rejected.

7.8.4.2 Requirement

There shall be no blistering in excess of 2 (S2) in accordance with ISO 4628-2. There shall not be any defects or detachment. Some colour change is acceptable.

7.8.5 Pull-off test

7.8.5.1 Measurement

The pull-off test shall be carried out in accordance with ISO 4624.

7.8.5.2 Requirement

The coating should not show any sign of detachment.

7.9 Impact resistance

7.9.1 General

The impact resistance shall be carried out on the coated side (the uncoated side may also be selected by agreement between the customer and the surface processor).

7.9.2 Measurement

The impact resistance test of the coatings shall be carried out in accordance with ISO 6272-2.

This test shall be carried out as follows:

— weight diameter: 15,9 mm ± 0,06 mm;

— impact energy: 2,5 Nm;

— material and thickness of test specimen: 5005-H24/H14 (0,8 mm to 1 mm), unless otherwise approved by the customer.

Whether the impact is applied to the coated surface or the reverse side of test specimen shall be agreed between the customer and the surface processor.

Whether the tape pull-off test is applied after applying the impact test shall be agreed between the customer and the surface processor. For C3 to CX, the pull-off test is recommended after the impact test.

7.9.3 Requirement

The coating shall be no cracking unless allowed by agreement between the customer and the surface processor. No detachment is allowed after applying the tape pull-off test.

7.10 Multi-impact stone chipping resistance

7.10.1 General

This method is often used to test coatings for transportation application.

7.10.2 Measurement

The multi-impact stone chipping test shall be carried out in accordance with ISO 21227-2.

The evaluation area should be 70 mm × 70 mm or according to the agreement between the customer and the surface processor.

7.10.3 Requirement

The stone chipping rating should be agreed between the customer and the surface processor.

7.11 Abrasion resistance

7.11.1 General

The test specimen should be left for 24 h or more after finishing.

The abrasion resistance of coating shall be assessed by the falling sand test (see 7.11.2), the rotating, abrasive rubber-wheel test (see 7.11.3) or the friction coefficient (see 7.11.4).

7.11.2 Falling sand test

7.11.2.1 Measurement

The falling sand test shall be carried out in accordance with ASTM D968.

7.11.2.2 Requirement

The abrasion should be agreed between the customer and the surface processor. For a PVDF liquid coating, the abrasion coefficient should not be less than 1,6 l/µm.

7.11.3 Rotating, abrasive rubber-wheel test

7.11.3.1 Measurement

The Taber test shall be carried out in accordance with ISO 7784-1 or ISO 7784-2.

The abrasive wheel shall be re-dressed before the test and every 500 cycles.

The required cycles of the abrasive test shall be agreed between the customer and the surface processor.

7.11.3.2 Requirement

The mean value of the losses in mass of the test specimens should be agreed between the customer and the surface processor.

7.11.4 Friction coefficient

7.11.4.1 Measurement

This method determines the coefficients of starting and sliding friction of coatings when sliding over itself or other substances.

The friction coefficient test shall be carried out in accordance with ISO 8295.

7.11.4.2 Requirement

The friction coefficient of the coating should be agreed between the customer and the surface processor.

7.12 Cupping test

7.12.1 Measurement

The cupping test of coatings shall be carried out in accordance with ISO 1520. Visually inspect the coating around the bulge. In the case of applying the tape pull-off test, immediately cover the adhesive tape on the impacted surface of the test specimen after the cupping test, pressing down firmly to eliminate air bubbles under the tape, and immediately pull the tape off perpendicularly from the test specimen. Then evaluate the adhesion of coatings.

The press depth of the cupping test shall be 5 mm or according to the agreement between the customer and the surface processor.

For the adhesive tape, an equivalent product to IEC 60454-2 can be used.

7.12.2 Requirement

The coating shall be no cracking unless allowed by agreement between the customer and the surface processor. No detachment is allowed after applying the tape pull-off test.

7.13 Flexibility

7.13.1 General

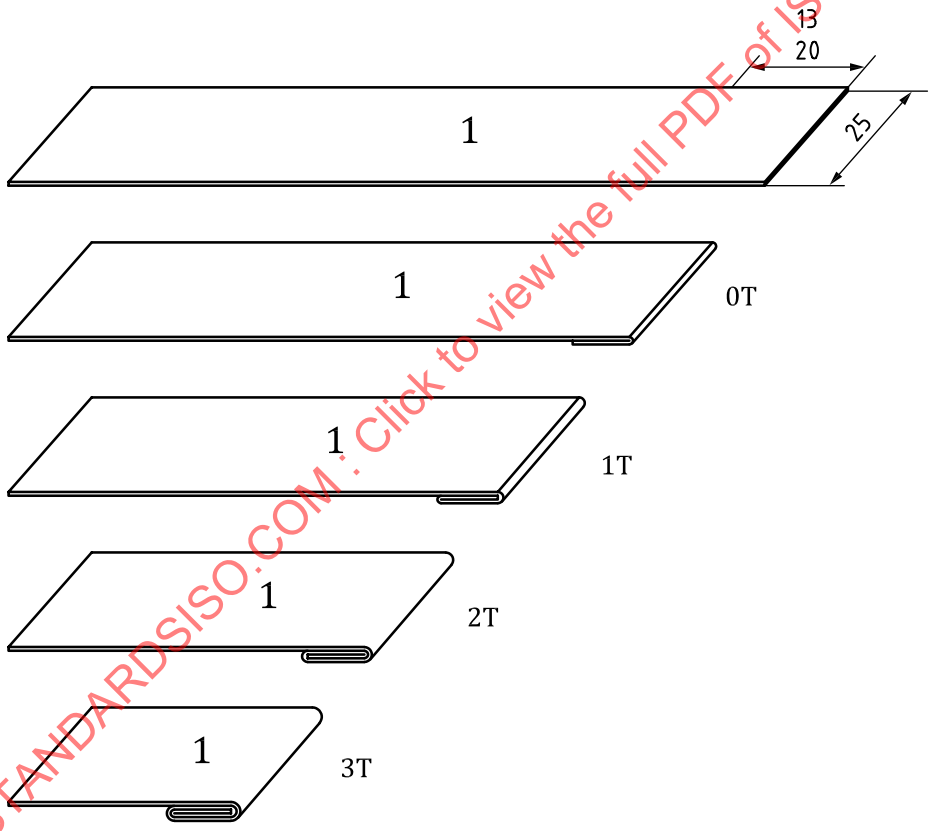
The flexibility of the coating shall be assessed by the T-bend test (see 7.13.2) or the cylindrical mandrel bend test (see 7.13.3).

7.13.2 T-bend test

7.13.2.1 Measurement

The bend test is used to measure the flexibility of the coatings. The test shall be carried out in accordance with ISO 17132:2007, 8.3.4. The test should be carried out on a material at ambient temperature. In case of dispute, the test shall be carried out at a temperature of 23 °C ± 2 °C and at a relative humidity of 50 % ± 5 %. The bend test should be carried out in the rolling direction. If the transverse direction is used it shall be specified in the report. The method demonstrated in Figure 2 may be used to carry out the bending.

Dimensions in millimetres



Key

1 coating surface

Figure 2 — T bending method

Measured bend radii are governed by the choice of metal substrate, temper, thickness and coating material. Therefore, when limit values are required, these shall be agreed between the customer and the surface processor and stated on the order in accordance with the shape and folds of the finished product.

7.13.2.2 Requirement

Bending values should not exceed 3T or be agreed between the customer and the surface processor.

7.13.3 Cylindrical mandrel bend test

7.13.3.1 Measurement

The cylindrical mandrel bend test shall be carried out in accordance with ISO 1519.

Whether the tape pull-off test is applied after applying the impact test shall be agreed between the customer and the surface processor. For C3 to CX, the pull-off test is recommended after the test.

7.13.3.2 Requirement

The bending value should be agreed between the customer and the surface processor.

The coating shall be no cracking unless allowed by agreement between the customer and the surface processor. No detachment is allowed after applying the tape pull-off test.

7.14 Processing resistance

7.14.1 Measurement

The processing resistance test shall be carried out using sharpened tools suitable for aluminium, e.g. by cutting, milling and/or drilling the test specimen.

The test method shall be agreed between the customer and the surface processor.

7.14.2 Requirement

The quality should be assessed with the degree of defects of the coating. As an example of evaluation, the quality can be assessed with the degree of cracking or detachment occurred in the coating. The quality assessment should be agreed between the customer and the surface processor. In the absence of such an agreement, the evaluation should be no cracking or chipping when sharp tools are used.

7.15 Permeating depths of ink

7.15.1 Measurement

7.15.1.1 Method 1: Manual abrasion method

Measure the thickness of the coating with the eddy current method (see 7.6). Use abrasive paper to remove the ink entirely and clean the surface with water. Measure the thickness of the coating again and calculate the difference value of the thickness, which is the permeating depths of ink.

7.15.1.2 Method 2: Rotating, abrasive rubber-wheel test

Measure the thickness of the coating with the eddy current method (see 7.6). Remove the ink entirely with the method illustrated in Method 1 (see 7.15.1.1). Measure the thickness of the coating again and calculate the difference value of the thickness, which is the permeating depths of ink.

7.15.2 Requirement

Permeating depths of ink should be according to the requirements of the thickness of the coating.

7.16 Chemical resistance

7.16.1 General

Chemical resistance shall be assessed by the method of acid resistance (see 7.16.2), alkali resistance (see 7.16.3), detergent resistance (see 7.16.4), mortar resistance (see 7.16.5), contamination resistance (see 7.16.6) and oil resistance (see 7.16.7).

The test method shall be selected based on the service environment.

7.16.2 Acid resistance

7.16.2.1 General

Acid resistance tests given in 7.16.2.2 to 7.16.2.5 shall be selected according to the application by agreement between the customer and the surface processor.

7.16.2.2 Hydrochloric acid resistance

7.16.2.2.1 Measurement

7.16.2.2.1.1 Method 1: Dropping method

Prepare an HCl solution with hydrochloric acid (ρ_{20} = 1,19 g/ml) and deionized water as the volume proportion of 1:9. Apply 10 drops of HCl solution to the coating surface of the test specimen and cover with a watch glass. Keep it at a temperature of between 18 °C to 27 °C for 15 min. Wash off the acid solution on the test specimen with tap water and dry. Then inspect the coating surface visually.

7.16.2.2.1.2 Method 2: Immersion method

The immersion method shall be carried out in accordance with ISO 28340:2013, 7.2.12.2. Place a ring, which is 32 mm in diameter and 30 mm in height and which shall be made of a material such as glass or plastic resistant to corrosion, on the surface of the test specimen with petrolatum or wax, and seal the outside part of the ring to prevent a leak of the test solution. Then fill the solution, which is prepared in the same way as the liquid drop test, up to a half of the ring and cover the top of the ring with glass or plastic. Keep it at room temperature for 15 min. Wash off the acid solution on the test specimen thoroughly with tap water and dry. Then inspect the coating surface visually.

7.16.2.2.2 Requirement

The surface of the coating should not have defects such as colour changes, blisters, detachment and other obvious changes.

7.16.2.3 Nitric acid resistance

7.16.2.3.1 Measurement

7.16.2.3.1.1 Method 1: Nitric acid of vapour phase test

Fill a 237 ml wide-mouth bottle one-half full of nitric acid (ρ_{20}=1,4 g/dm^3), ACS reagent grade. Place the test specimen completely over the mouth of the bottle painted side down, for 15 min. The solution and the test should be at 18 °C to 27 °C with a relative humidity less than 50 %. Rinse the test specimen with tap water, wipe it dry and conduct a visual inspection after a period of 1 h.

7.16.2.3.1.2 Method 2: Nitric acid of liquid phase test

Slightly erase the dirt on the surface of the test specimen with alcohol. Use Vaseline®[1)] or paraffin to fix the cylinder (recommended size is 32 mm in diameter and 30 mm in height), which is made of glass or synthetic resin, onto the surface of the test specimen and seal the outside part of the cylinder to prevent a leak of the test liquid. Prepare an HNO_3 (50 g/l) solution with analytical pure HNO_3 (ρ_{20}=1,4 g/dm^3) and deionized water. Keep the test specimen horizontal, fill the HNO_3 solution up to a half of the cylinder height, cover the top of the cylinder with the plate of glass or synthetic resin and keep it at 20 °C ± 2 °C during the test. After 15 min, remove the glass ring from the test specimen and rinse with tap water and dry. Then visually inspect the surface of coatings.

7.16.2.3.2 Requirement

For the nitric acid of vapour phase test, compare the acid-exposed and unexposed surfaces, and the colour change. ΔE^*_{ab} should be no more than 5.

For the nitric acid of liquid phase test, the surface of the coating should not have defects such as colour changes, blisters, detachment and other obvious changes.

7.16.2.4 Acetic acid resistance

7.16.2.4.1 Measurement

Pour an acetic acid solution (20 g/kg) into a vessel and put an approximately 100 cm length of the test specimen into the solution. The 2/3 of the test specimen shall be immersed in the solution, while not being in contact with the bottom of the vessel. Boil the solution, then keep it at room temperature for 2 h. Rinse the test specimen with water and wipe it clean. Examine the coating with a fourfold magnifier.

7.16.2.4.2 Requirement

After the acetic acid resistance test, the surface of the coating shall not have defects such as blisters, detachments, colour changes or wrinkles.

7.16.2.5 Citric acid resistance

7.16.2.5.1 Measurement

Pour a citric acid solution (20 g/kg) into a sealed container and put an approximately 100 cm length of the test specimen into the solution. The 2/3 of the test specimen shall be immersed in the solution, while not being in contact with the bottom of the vessel. Boil the solution, then keep it at room temperature for 2 h. Rinse the test specimen with water and wipe it clean. Examine the coating with a fourfold magnifier.

7.16.2.5.2 Requirement

After the citric acid resistance test, the surface of coating should not have blisters, detachments, colour changes or wrinkle defects.

7.16.3 Alkali resistance

7.16.3.1 Measurement

The alkali resistance test shall be carried out in accordance with ISO 28340:2013, 7.2.12.2. Place a ring, which is 32 mm in diameter and 30 mm in height and which is made of a material such as glass or plastic resistant to corrosion, on the surface of the test specimen with petrolatum or wax, and seal

1) Vaseline® is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

the outside part of the ring to prevent a leak of the test solution. Then fill the solution up to a half of the ring and cover the top of the ring with glass or plastic. Keep it at 20 °C ± 2 °C for 24 h. Wash off the alkaline solution on the test specimen thoroughly with tap water and dry. Then inspect the coating surface visually.

The alkali solution comprises saturated calcium hydroxide or 5 g/l sodium hydroxide. The alkali solution shall be selected by agreement between the customer and the surface processor.

7.16.3.2 Requirement

Each test specimen should be evaluated by determining the ratio of the area of corrosion pits and/or blister to the area of the test specimen or the chart rating in accordance with ISO 8993.

When saturated calcium hydroxide is used as the test solution, the coating surface should have no change.

When 5 g/l sodium hydroxide is used as the test solution, the protective rate shall exceed Grade 9,5.

7.16.4 Detergent resistance

7.16.4.1 Measurement

Immerse the test specimen into the test solution for 72 h, keep it at a temperature 38 °C, then rinse it in deionized water and wipe it dry. Then apply the tape pull-off test.

The test solution (30 g/l) is prepared using the detergent shown in Table 4 and deionized water.

For the adhesive tape, an equivalent product to IEC 60454-2 can be used.

Table 4 — Contents of detergent

Composition	Content (g/kg)
Tetrasodium pyrophosphate	530
Sodium sulfate anhydyous	190
Sodium linear alkylarylsulfonate	200
Sodium metasilicate hydrated	70
Sodium carbonate anhydrous	10
Totals	1 000

7.16.4.2 Requirement

The surface of the coating should not have defects such as blisters, detachment and other obvious changes.

7.16.5 Mortar resistance

7.16.5.1 Measurement

7.16.5.1.1 Method 1

Prepare mortar by mixing 15 g of hydrate lime, 41 g of cement and 244 g of sand with sufficient tap water to make a soft paste. Apply four portions of this mortar, about 15 mm in diameter and about 6 mm thick, to the coating on the test specimen. Place the test specimen in an environment of 38 °C ± 3 °C and 95 % RH ± 5 % RH for 24 h.

7.16.5.1.2 Method 2

Prepare mortar by mixing 7,5 g of building lime (conforming to ASTM C207) and 225 g of dry sand, both passing through a 10 mesh wire screen with sufficient water, approximately 100 g, to make a soft paste. Immediately apply wet pats of mortar about 1 300 mm^2 in area and 12 mm in thickness to coated specimens which have been aged at least 24 h after coating. Immediately expose test sections for 24 h to 100 % RH at 38 °C.

At the end of this period, dislodge the mortar by hand from the surface of the coating and remove any residue with a damp cloth. Allow to dry and examine the coating with normal or corrected vision.

7.16.5.2 Requirement

The mortar should be easily removed and there should be no detachments of the coating nor any staining. As the example of evaluation, the quality may be assessed with the following:

— no mechanical damage to the coating;

— no change in appearance and colour of the coating (except for coatings with metallic or metalized effect).

The quality assessment shall be agreed between the customer and the surface processor.

7.16.6 Contamination resistance

7.16.6.1 General

The contamination medium, contact duration and temperature for the test shall be agreed between the customer and the surface processor.

Contamination mediums such as toothpastes, alcoholic beverages, body wash solutions, cosmetics, teas and possible contacting chemical liquids are often selected for test.

7.16.6.2 Measurement

This test shall be carried out as follows.

a) Wipe the surface clean.

b) Drop two or three drops of contamination onto the surface of two specimens.

c) Put a glass cover onto one of the test specimens.

d) When the contact duration which has been agreed between the customer and the surface processor is reached, clean the surface with reagent.

e) After 1 h, visually examine the surface of the test specimen from a 400 mm distance.

f) The grade is evaluated according to Table 5.

Table 5 — Evaluation of contamination resistance test

Grade	Surface
5	No change
4	Slightly change of the gloss and/or colour
3	Some change of the gloss and/or colour
2	Obvious change of the gloss and/or colour
1	Deformation and/or bubble on the surface

7.16.6.3 Requirement

The contamination resistance of the coating should be agreed between the customer and the surface processor.

7.16.7 Oil resistance

7.16.7.1 Measurement

Completely immerse the test specimen into the mechanical oil or gasoline. The type of the mechanical oil or gasoline should be agreed between the customer and the surface processor. Keep the test specimen at room temperature for 24 h or for an agreed time, then examine the surface of the coating.

7.16.7.2 Requirement

The surface of coating should not have blisters, detachments, colour changes or wrinkle defects.

7.17 Solvent resistance

7.17.1 General

The solvent resistance of coating shall be assessed by the wipe method (see 7.17.2.1) or the immersion method (see 7.17.2.2).

7.17.2 Measurement

7.17.2.1 Method 1: Wipe method

At an ambient temperature, wipe on the test specimen surface along a straight path 100 times at a return rate of once per second (one back and forth is defined as once), with a 1 kg heavy hammer wrapped with at least six layers of medical gauze absorbed in butanone (the contact area of the head of hammer and the surface of the test specimen is about 150 mm^2). Keep the gauze wet during the test. Inspect visually the surface of the coating after the test.

7.17.2.2 Method 2: Immersion method

The test solution is ethyl alcohol solution of 75 % concentration.

Immerse the test specimen into the test solution for 72 h, then rinse it in deionized water, dry and examine the coating with normal or corrected vision.

7.17.3 Requirement

For the wipe method, the base material should not be exposed.

For the immersion method, the surface of the coating should not have defects such as detachment, colour changes and other obvious changes.

7.18 Corrosion resistance

7.18.1 General

One or more of the corrosion resistance tests given in 7.18.2 to 7.18.7 shall be selected according to the application by agreement between the customer and the surface processor.

The copper-accelerated acetic acid salt spray (CASS) test is intended to be a quick test to detect defects (pinhole, discontinuities, etc.) in the coating. All these tests allow for comparing relative performance

between coatings by different material or different paint method. Their result should be used with reservations when assessing real performance. ISO/TR 16335 states that results from continuous salt spray testing seldom correlate well with in-service performance and that those tests are not useful for most fields of application unless for quality control of the same product.

7.18.2 Neutral salt spray (NSS) test

7.18.2.1 Measurement

The NSS test shall be carried out in accordance with ISO 9227.

When calculating the ratio of the corrosion pits area, it is recommended to use a magnifying glass (10 to 15 magnification with scale). When the test specimens in standard size are tested, it can evaluate the area of the test specimen except 25 mm from the up and down edges and 10 mm from the right and left edges.

The cut incision(s) with a width of 1 mm shall be made to cut the coating down to the metal.

The test shall be carried out on three (replicate) test specimens.

The method of making cuts including cross-cuts shall be agreed between customer and the surface processor.

The test period shall be agreed between the customer and the surface processor.

7.18.2.2 Requirement

The quality shall be assessed with the degree of change in colour or blisters in accordance with ISO 4628-2 and the width of infiltration on both sides of the cut incisions. The corrosion rating shall be assessed in accordance with ISO 8993 if rating the pitting area is feasible in liquid coated aluminium. The quality shall be assessed in accordance with the agreement between the customer and the surface processor.

EXAMPLE

— flat portions: blistering ≤ 2 (S2);

— cut portions: infiltration ≤ 2 mm (width);

— corrosion: rating number ≥ 8.

7.18.3 Acetic acid salt spray (AASS) test

7.18.3.1 Measurement

The AASS test shall be carried out in accordance with ISO 9227.

The cut incision(s) with a width of 1 mm shall be made to cut the coating down to the metal.

The test shall be carried out on three (replicate) test specimens.

The method of making cuts including cross-cuts shall be agreed between the customer and the surface processor.

The test period shall be agreed between the customer and the surface processor.

7.18.3.2 Requirement

The quality shall be assessed with the degree of change in colour or blisters in accordance with ISO 4628-2 and the width of infiltration on both sides of the cut incisions. The corrosion rating shall be assessed in accordance with ISO 8993 if rating the pitting area is feasible in liquid coated aluminium.

The quality shall be assessed in accordance with the agreement between the customer and the surface processor.

EXAMPLE

— flat portions: blistering ≤ 2 (S2);

— cut portions: infiltration ≤ 4 mm (width);

— corrosion: rating number ≥ 8.

7.18.4 Copper-accelerated acetic acid salt spray (CASS) test

7.18.4.1 Measurement

The CASS test shall be carried out in accordance with ISO 9227.

The test period and the form of evaluation shall be agreed between the customer and the surface processor.

7.18.4.2 Requirement

The quality shall be assessed with the degree of change in colour or blisters in accordance with ISO 4628-2 and the width of infiltration on both sides of the cut incisions. The corrosion rating shall be assessed in accordance with ISO 8993 if rating the pitting area is feasible in liquid coated aluminium.

EXAMPLE

— flat portions: blistering ≤ 2 (S2);

— cut portions: infiltration ≤ 3 mm (width);

— corrosion: rating number ≥ 8.

7.18.5 Cyclic corrosion test

7.18.5.1 Measurement

The cyclic corrosion test is carried out in accordance with ASTM G85-19, Annex A5, dilute electrolyte cyclic fog/dry test.

The test period shall be agreed between the customer and the surface processor.

7.18.5.2 Requirement

The quality shall be assessed with the degree of change in colour or blisters in accordance with ISO 4628-2 and the width of infiltration on both sides of the cut incisions. The corrosion rating shall be assessed in accordance with ISO 8993 if rating the pitting area is feasible in liquid coated aluminium. The quality shall be assessed in accordance with the agreement between the customer and the surface processor.

EXAMPLE

— cut portions: infiltration ≤ 2 mm (width);

— corrosion: rating number ≥ 8.

7.18.6 Filiform corrosion resistance test

7.18.6.1 General

The filiform corrosion resistance test is applied for C4 to CX, and by agreement for C3.

7.18.6.2 Measurement

The filiform corrosion test shall be carried out in accordance with ISO 4623-2.

The method to produce corrosion shall be selected by vapour (in accordance with ISO 4623-2) or by dripping (in accordance with QUALICOAT Specifications 2022).

The test condition shall be agreed between the customer and the surface processor. In the absence of such an agreement, the test period should be 1 000 h.

7.18.6.3 Requirement

Using a ruler, determine the length of the longest filament L (mm) in accordance with ISO 4628-10.

The quality assessment shall be agreed between the customer and the surface processor. In the absence of such an agreement the following quality assessment should be used.

Assess by the length of filament.

— M (the average length of filament) ≤ 2 mm;

— L (the longest filament) ≤ 4 mm.

7.18.7 Resistance to humid atmosphere containing sulfur dioxide

7.18.7.1 Measurement

The contact test with humid atmosphere containing sulfur dioxide (Kesternich test) should be carried out accordance with ISO 22479.

The volume of SO_2 and the number of cycles should be agreed between the customer and the surface processor. In the absence of such an agreement, it should be SO_2 and 24 cycles, using method B specified in ISO 22479.

7.18.7.2 Requirement

The single infiltration on both sides of the scratch should not exceed 1 mm. The other area of the coating should have no colour change or blister.

7.19 Humidity resistance

7.19.1 Condensation resistance

7.19.1.1 Measurement

The condensation test shall be tested using the test method specified in ISO 6270-1, ISO 6270-2 and ISO 6270-3. The test condition should be agreed between the customer and the surface processor.

In the absence of such an agreement, the test period should use the following hours:

— 1 000 h for C1 to C4;

— 2 000 h for C5 to CX.

If required, the adhesion test shall be carried out after the evaluation (see the methods described in 7.8.4 and 7.8.5).

7.19.1.2 Requirement

The surface of the coating should not have defects such as detachment, blisters and other obvious changes by visual examination, but some colour change is permissible. The adhesion shall be agreed between the customer and the surface processor.

7.19.2 High temperature and high RH test

7.19.2.1 Measurement

The high temperature and high RH test shall be tested in a temperature and humidity chamber at 85 °C ± 2 °C and 85 % RH ± 5 % RH. The test period should be agreed between the customer and the surface processor. After 2 h standing, observe the surface of the coating.

7.19.2.2 Requirement

The surface of the coating should not have defects such as detachment, blisters and other obvious changes by visual examination, but some colour change is permissible.

7.19.3 Wet heat resistance test

7.19.3.1 Measurement

The wet heat resistance test shall be carried out in accordance with ISO 4211-2. The test temperature and humidity should be agreed by the customer and the surface processor.

If required, the adhesion test shall be carried out after evaluation (see the methods described in 7.8.4 and 7.8.5).

7.19.3.2 Requirement

The coating should not have blisters, detachments, colour changes or wrinkles. The adhesion shall be agreed between the customer and the surface processor.

7.19.4 Thermocycling resistance test

7.19.4.1 Measurement

One test cycle of thermocycling resistance test is as follows.

a) Put the test specimen into 90 °C ± 2 °C and 20 % RH ± 3 % RH temperature and humidity chamber for 24 h.

b) Take out the test specimen and place it at room temperature for 0,5 h, then put it into a −40 °C ± 2 °C refrigerator for 24 h.

c) Take out the test specimen and place it at room temperature for 0,5 h, then put it into a 70 °C ± 2 °C and 95 % RH ± 3 % RH temperature and humidity chamber for 3 h.

d) Take out the test specimen and place it at room temperature for 0,5 h, then put it into a 70 °C ± 2 °C and 95 % RH ± 3 % RH temperature and humidity chamber for 3 h.

e) Take out the test specimen and place it at room temperature for 0,5 h, then put it into a −40 °C ± 2 °C refrigerator for 1,5 h.

f) Take out the test specimen and place it at room temperature for 0,5 h.

The test cycles shall be agreed between the customer and the surface processor.

After finishing all the test cycles, take out the specimen and place it at room temperature for 2 h, then visually examine the coating.

If required, the adhesion test shall be carried out after the evaluation (see the methods described in 7.8.4 and 7.8.5).

7.19.4.2 Requirement

The coating should not have cracking or blistering. The adhesion should be agreed between the customer and the surface processor.

7.20 Water resistance

7.20.1 Water immersion method

7.20.1.1 Measurement

The water immersion method shall be carried out in accordance with ISO 2812-2.

The immersion period shall be 240 h or according to the agreement between the customer and the surface processor.

If required, the adhesion test shall be carried out after the evaluation (see the methods described in 7.8.4 and 7.8.5).

7.20.1.2 Requirement

The surface of the coating should not have defects such as peeling, detachment, blisters or wrinkles. The adhesion shall be agreed between the customer and the surface processor.

7.20.2 Autoclave test

7.20.2.1 Measurement

Add deionized water to an autoclave with an internal diameter of about 200 mm to a depth of 25 mm and perpendicularly place a 50 mm specimen. Heat the autoclave until steam escapes. The weight valve shall be adjusted to produce an internal pressure of 0,1 MPa ± 0,01 MPa. Continue heating for 1 h. The temperature of autoclave should be 100 °C, 121 °C or 127 °C according to the applications, or to the agreement between the customer and the surface processor. Cool the autoclave, take the test specimen out and wipe it dry and cool it to an ambient temperature. Visually inspect the coating surface (except the edges of the test specimen).

7.20.2.2 Requirement

There shall be no blistering in excess of 2 (S2) in accordance with ISO 4628-2. There shall not be any defects or detachment. Some colour change is acceptable.

7.20.3 Boiling water resistance

7.20.3.1 Measurement

Pour deionized water into an about 150 mm depth vessel to 80 mm depth and heat the beaker. Keep the temperature of the water over 95 °C, and immerse the test specimens in the vessel at a position of depth 60mm from the surface of the water.

After immersion for 2 h, promptly take the test specimens and within 5 min evaluate the appearance of the significant surface for wrinkles, cracks and noticeable colour change. Exclude from the evaluation the coating on the peripheral part of the test specimens and parts that were within 10 mm of the surface of the water.

7.20.3.2 Requirement

There shall be no blistering in excess of 2 (S2) in accordance with ISO 4628-2. There shall not be any defects or detachment. Some colour change is acceptable.

7.21 Temperature resistance

7.21.1 Dry heat resistance test

7.21.1.1 Measurement

The dry heat resistance test shall be carried out in accordance with ISO 4211-3. The test temperature should be agreed by the customer and the surface processor.

7.21.1.2 Requirement

The surface of the coating should not have defects such as blisters, detachments, colour changes or wrinkles.

7.21.2 Roasting resistance test

7.21.2.1 Measurement

The test specimen is placed in an oven at 98 °C ± 5 °C. After 168 h roasting, the test specimen is taken out and cooled to room temperature, and the surface of the coating is observed visually.

7.21.2.2 Requirement

The surface of the coating should not have defects such as detachments and colour changes.

7.21.3 Low-temperature resistance test

7.21.3.1 Measurement

7.21.3.1.1 Method 1

The test specimen is stored in a −40 °C ± 2 °C refrigerator for 30 min. Keep the test specimen at room temperature, then visually examine the surface.

7.21.3.1.2 Method 2

This test shall be carried out as follows.

a) Put the test specimen to be tested on the coating surface, then remove it into the refrigerator at −18 °C ± 2 °C for 24 h, then take it out.

b) Scratch the surface of the test specimen with a pencil in accordance with ISO 15184. The hardness of pencil shall be agreed between the customer and the surface processor.

c) Clean the test specimen, and visually examine the coating surface.

7.21.3.2 Requirement

7.21.3.2.1 Method 1

The surface of the coating should not have defects such as blisters, detachments, colour changes or wrinkles.

7.21.3.2.2 Method 2

The surface of the coating should not have defects such as detachments and colour changes.

7.22 Surface tension

7.22.1 General

This method is generally used to test coatings with self-cleaning requirements.

7.22.2 Measurement

The surface tension of the coating shall be carried out in accordance with ISO 8296.

7.22.3 Requirement

The surface tension of the coating should be agreed between the customer and the surface processor.

7.23 Hydrophilicity

7.23.1 General

This method is generally used to test coatings with self-cleaning requirements.

7.23.2 Measurement

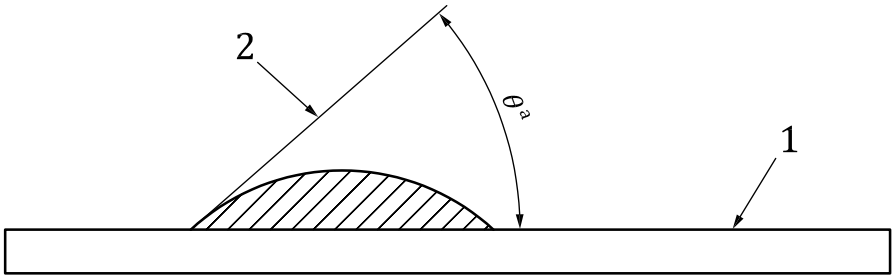
7.23.2.1 General

The size of the test specimens shall be in accordance with 7.1 or the agreement between the customer and the surface processor.

The hydrophilia test shall be carried with the instrumental method (see 7.23.2.2) or the microsyringe method (see 7.23.2.3).

7.23.2.2 Method 1: Instrumental method

Fill the microsyringe with deionized water. Put one test specimen on the operating platform of the contact angle meter and drip three water drops (5 µl to 20 µl) in turn on the different positions of the significant surface. Allow to stand for 40 s to 60 s, adjust the platform, rotate the adjusting knob and ensure the water drop is in the middle position of the eye piece view. Draw a tangent line of the water drop and the test specimen, which is given in Figure 3. Measure the contact angles. The average value of the average angle of three drops is the hydrophilic angle.



Key

1 test specimen

2 tangent line of the drop and the coating

a Contact angle.

Figure 3 — Contact angle diagram

7.23.2.3 Method 2: Microsyringe method

Push deionized water to the tip of microsyringe. Then, drop 10 µl of water onto the surface of the test specimen from a 10 mm height. Measure the diameter of the water drop with a vernier caliperin after 40 s to 60 s. The diameter of the drop converts into the hydrophilic angle in accordance with Table 6.

The average angle of three test specimens is the hydrophilic angle.

Table 6 — Drop diameter and hydrophilic angle

Integral number of drop diameter mm	Hydrophilic angle o									
	0	1	2	3	4	5	6	7	8	9
	Decimal number of drop diameter mm									
3	—				89,0	85,0	82,0	79,0	74,0	71,0
4	66,0	63,0	61,0	59,0	57,0	54,5	52,0	49,0	46,0	45,0
5	42,0	40,5	38,0	36,5	34,5	32,0	31,0	30,0	29,0	27,0
6	26,0	24,0	23,5	23,0	22,5	20,0	19,5	19,0	18,0	17,0
7	16,0	15,0		14,0	13,0	12,0		11,5	11,0	10,0
8	90	8,5	8,0	7,0	5,5	4,5		2,5	—	

7.23.3 Requirement

The test value of the hydrophily angle should be agreed between the customer and the surface processor.

7.24 Thermal viscosity

7.24.1 General

This method is generally used for power supply appliances.

7.24.2 Measurement

The thermal viscosity test is carried out in a heating furnace, to heat the test specimen to 125 °C ± 3 °C. Place two test specimens into the heating furnace for 2 h so that the coatings are in contact with each

other. Cool down to room temperature and separate the test specimens apart. Visually examine the coating.

7.24.3 Requirement

The coating should not have any sticky traces.

7.25 Resistivity

7.25.1 General

This method is generally used for electronic and electrical applications.

7.25.2 Measurement

The resistivity of the coating is measured by a dielectric strength tester, to be scratched on the test specimen at 1 m/s and 800 V ± 10 V positive rod. Monitor the change on the tester.

7.25.3 Requirement

The resistivity of the coating should be agreed between the customer and the surface processor.

7.26 Weathering resistance

7.26.1 General

Either outdoor exposure test (see 7.26.2) or accelerated weathering resistance test (see 7.26.3) shall be carried out according to the agreement between the customer and the surface processor.

7.26.2 Outdoor exposure

7.26.2.1 Measurement

When testing corrosion performance, ISO 8565 provides additional guidelines.

Outdoor corrosion testing exposure is carried out mainly to assess the efficacy of the pretreatment and is more significant for architectural applications.

The exposure site shall be selected by agreement between the customer and the surface processor depending on the purpose of UV exposure or corrosion resistance.

A typical exposure site for UV exposure is South Florida (USA), and other exposure sites include Lisbon (Portugal) and Sanary-sur-Mer (France).

The exposure sites for the corrosion resistance (outdoor exposure) testing are Hoek van Holland (the Netherlands), Brest (France), Sines (Portugal) and Bohus-Malmön Kvarnvik (Sweden).

Miyako-Jima Island (Japan) and Hainan Island (China) are both used for UV exposure and corrosion resistance.

The test period shall be agreed between the customer and the surface processor. In the absence of such an agreement, the test period should use the following years for UV exposure:

— 1 year for UV1 with mild UV exposure;

— 5 years for UV2 with strong UV exposure;

— 10 years for UV3 with very strong UV exposure.

For corrosion resistance testing, consider a minimum of two years exposure at one of the sites indicated above.

7.26.2.2 Requirement

After the natural weathering test, assessment items and degrees are selected by agreement between the customer and the surface processor. The examples of the assessment of the test results are:

— colour change: $\Delta E^*_{ab} \leq 5{,}0$;

— gloss retention: ≥ 50 %;

— thickness loss rate: ≤ 10 %.

7.26.3 Accelerated weathering resistance

7.26.3.1 General

The accelerated weathering resistance shall be assessed by the xenon-arc exposure test.

7.26.3.2 Measurement

The xenon-arc exposure test shall be carried out in accordance with method A given in ISO 16474-2 or ASTM D7869. The type of temperature and the type of xenon-arc lamp shall be recorded in the test report.

The test period shall be agreed between the customer and the surface processor. In the absence of such an agreement, the test period should use the following hours:

— 1 000 h for UV1 with mild UV exposure;

— 2 000 h for UV2 with strong UV exposure;

— 4 000 h for UV3 with stronger UV exposure.

Except at the time of the xenon-arc lamp exchange, filter exchange and cleaning of the chamber, it is desirable not to stop the exposure test. When exchanging and cleaning parts, perform the processes in as short a time as possible.

Spray water shall be deionized and its conductivity shall be not higher than 2 µS/cm at 25 °C.

NOTE It is very important to adequately control the purity of spray water. If impurities, particularly silicates, are not removed from the water by proper treatment, exposed test specimens can develop spots or contamination that are not representative of degradation occurring during outdoor exposure.

7.26.3.3 Requirement

The colour change, gloss retention ratio and chalking of the coatings should be agreed between the customer and the surface processor.

An example of the assessment of the test results in terms of gloss retention is:

— the gloss retention ratio of the coating: ≥ 75 % for UV category 1, 2 and 3.

7.27 Sealing compounds adhesion

7.27.1 Measurement

The sealing compounds adhesion test shall be carried out in accordance with GSB QR AL 631-7 ST 663-7.