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Indian Standard

METHODS OF TESTING ANODIC COATINGS ON ALUMINIUM AND ITS ALLOYS

(First Revision)

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Indian Standard

METHODS OF TESTING ANODIC COATINGS ON ALUMINIUM AND ITS ALLOYS

(First Revision)

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Indian Standard

METHODS OF TESTING ANODIC COATINGS ON ALUMINIUM AND ITS ALLOYS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 15 September 1983, after the draft finalized by the Metallic Finishes Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard covers methods of testing which are generally applied to anodic coatings on aluminium and its alloys used for different applications. Thickness of anodic coatings shall normally be determined by microsection or stripping method or with the help of instruments based on eddy current principle (*see* IS : 6012-1970*). In case of dispute, however, the microsection method shall be used for Grade AC 15 and thicker coatings and stripping method shall be used for thinner coatings (Grades AC 10, AC 5 and AC 2·5) specified in IS : 1868-1982† and for coatings on wire. For control purposes, thickness may be determined by breakdown voltage test if agreed to between the anodizer and the purchaser. Besides methods for testing resistance to abrasion, light fastness and sealing of anodic coatings on aluminium have been covered in this standard.

0.3 This standard was earlier published in 1969. In this revision Amendment No. 1 issued in 1976 has been included and a new non-destructive method for the assessment of quality of sealed anodic oxide coatings by measurement of admittance or impedance has been incorporated.

0.4 In the preparation of this standard, assistance has been derived from the following publications:

BS 1615 : 1972 Anodic coatings on aluminium. British Standards Institution.

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*Method for measurement of coating thickness by eddy current.

†Specification for anodic coatings on aluminium and its alloys (*second revision*).

ISO 2931-1975 Anodizing of aluminium and its alloys — Assessment of quality of sealed anodic oxide coatings by measurement of admittance or impedance. International Organization for Standardization.

0.5 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard prescribes methods for determination of thickness, resistance to abrasion, light fastness and sealing of anodic coatings on aluminium and its alloys.

2. METHODS FOR TESTING THICKNESS

2.1 Thickness of anodic coatings shall be measured by the microsection and stripping methods. The former is suitable for Grade AC 15 and thicker coatings and the latter for Grade AC 10 and thinner coatings.

2.2 Microsection Method

2.2.1 *Preparation of Section for Test* — Cut a section of the specimen at one or more points on the significant surface where a minimum thickness may be expected.

NOTE — It is advisable to determine thickness on large or irregularly shaped parts at several points.

2.2.2 *Mounting of Specimen* — The sections are mounted by moulding in a suitable material so that the anodized surface is perpendicular to the face which is to be prepared for examination. The sections are more readily prepared and viewed if sandwitched between sections of aluminium foil. The sections shall be rigidly held and there shall be no voids between the anodized surface and the mounting material.

2.2.3 *Preparation of Section* — The mounted sections are carefully prepared without damaging the anodized edge until any part of the coating which cracks or flakes during the cutting process is removed.

2.2.3.1 The surfaces may be lightly etched to improve the contrast between the coating and the adjacent metal and to remove any soft metal which may have spread over the coating.

2.2.4 *Measurement of Thickness of Coating*

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*Rules for rounding off numerical values (*revised*).

2.2.4.1 Measure the thickness of coating at any desired point on the exposed section by either of the methods described in **2.2.4.2** and **2.2.4.3.**

2.2.4.2 Measure the thickness with a filar micrometer ocular that has been calibrated in order to determine the value of the unit scale division against a scale graduated so accurately that the error will not exceed 2 percent. For example, the scale may be graduated to 0·01 mm.

2.2.4.3 Project the image of the specimen, especially of those specimen having very thin coatings, at a known and properly calibrated magnification of the ground-glass focusing plane of the camera of a metallographic microscope. Measure the width of the projected line of deposit with a graduated linear scale, the reading divided by the magnification gives the thickness of the coating.

2.2.4.4 For purpose of reference, 5 measurements shall be made at points evenly spaced over the entire significant surface of the sample.

2.3 Stripping Method

2.3.0 This method is subject to errors when used on coatings which are heavily pigmented or sealed with organic material. In such cases a separately prepared test piece may be used.

2.3.1 *Applicability* — This method is mainly applicable to Grade AC 10 and thinner coatings as specified in IS : 1868-1982*.

2.3.2 *Test Piece*

2.3.2.1 *Preparation of samples or test pieces* — The sample or test piece would be of a shape whose surface area is readily determined, and this area would be within the range 8 to 100 cm^2 and the mass of the sample shall not exceed 100 g.

2.3.3 *Stripping Solution* — The stripping solution shall consist of a solution in distilled water of:

Phosphoric acid (rd = 1·75)	3·5 percent (*v/v*)
Chromic acid (AR quality)	2·0 percent (*m/v*)

The solution should be contained in a glass beaker.

2.3.4 *Procedure* — Weigh the clean and dry anodized test piece to the nearest milligram and immerse in the boiling stripping solution taking care that it is not in contact with any other metal. Wash the test piece in hot distilled water, dry and reweigh. Repeat the process until reasonably

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*Specification for anodic coatings on aluminium and aluminium alloys (*second revision*).

constant mass is obtained. Normally total time of immersion may not last for more than 10 minutes. Certain alloys, for example, those containing magnesium and copper, are attacked by the solution and will continue to lose mass slowly, if left immersed.

2.3.5 The loss in mass shall be taken as the mass of the anodic coating.

NOTE — The solution may be used a number of times but the aluminium content should not exceed 1 gm/lit.

2.3.6 *Calculation* — The average thickness shall be calculated by means of the following formula:

$$T = \frac{10\,M}{A\,D}$$

where

T = thickness of coating in micrometres;
M = mass in mg of coating;
A = surface area of coating in cm^2; and
D = density of the coating in g/cm^3 taken as 2·4 for unsealed coatings and 2·6 for coatings sealed in aqueous solution.

NOTE — The density of the anodic coatings depends upon the alloy in question, the anodizing and the sealing process adopted.

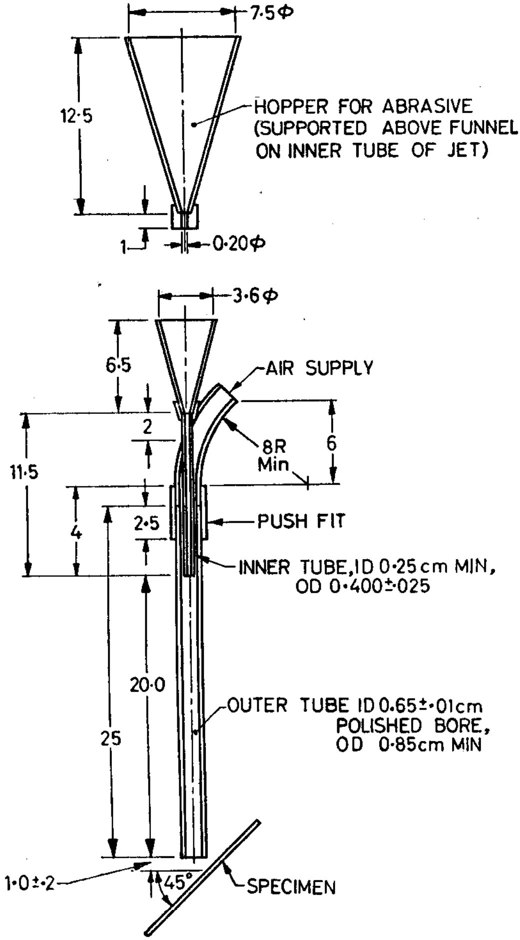
3. METHOD FOR DETERMINATION OF RESISTANCE TO ABRASION

3.0 It is not a referee test for abrasion resistance. Any method which is agreed to between the anodizer and the purchaser should be related to the type of abrasion expected in service. The method given below may be used for control purposes.

3.1 Test Piece — The test piece should be reasonably flat and of such a size that it may be readily subjected to the test. If necessary, portions may be cut from an article.

3.2 Procedure

3.2.1 The jet is clamped with the abrasive hopper directly above it in cabinet designed to contain the abrasive to be used while providing support for the specimen in such a position that it may be observed during testing. The side tube of the jet is connected to a supply of dry compressed air through a valve and a flow meter (range 10 to 100 litres of air/minute). The dimensions are specified in Fig. 1. The two tubes should be sealed rigid and co-axial.



All dimensions in centimetres.

Fig. 1 Abrasion Resistance Assessment by Jet Test

3.2.2 The abrasive powder is silicon-carbide of the grade commercially marketed as IS sieve 106 micrometres, free from moisture and passed through a IS sieve 150 micrometres test sieve in accordance to IS : 460 (Part 1)-1978* to ensure freedom from any large particles or fibres which would interfere with the rate of flow. The abrasive power of the powders alters slowly with use and each batch should be discarded after being used 25 times.

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*Specification for test sieves: Part 1 Wire cloth test sieves (*second revision*).

3.2.3 The air-flow rate is set at the specified value (normally 40 litres/minute) and a weighed amount of abrasive is placed in the hopper. The air-flow is adjusted, if necessary, during the test. When a small dark spot appears in the centre of the abraded area, the test is terminated by covering the delivery tube of the hopper with the thumb. The remaining abrasive is weighed and the weight used to penetrate the film is calculated. The end point may be checked by an electrical conductivity test to ensure that the film is penetrated; the pressure of the probe shall be controlled. The funnel shall never have a build up of abrasive.

3.2.4 A series of at least three such determinations shall be made and their average calculated. The result is normally expressed in grams per micrometre of coatingt hickness. With thick coatings the weight removed per unit weight of abrasive in unit time may be a more convenient measure of the surface abrasion resistance. The abrasion resistance of anodic coatings may vary throughout the thickness of the coating.

4. METHOD FOR TESTING LIGHT FASTNESS

4.0 Principle of Method — The method consists in exposing the samples to light and observing the change in colour in relation to a given test standard.

NOTE — Exposure to artificial source of light rather than to daylight is a common practice; this is undoubtedly useful where speed is essential. The test pieces have, however, to be exposed to artificial source of light under prescribed conditions as fading depends upon various factors, such as humidity and temperature of the surrounding atmosphere, the substrate as well as the type of lamp used. A low-pressure mercury vapour lamp should not be used as its emission spectrum is very different from that of daylight; if used, it would lead to incorrect results.

4.1 Apparatus — For the tests in artificial light, fadometers are used.

4.2 Standard Patterns — ' Standard Patterns ' is a series of cloth pieces dyed in standard colours of known relative fastness to light which have been specified in **5** of IS : 686-1957*.

NOTE — A set of standard patterns of light fastness No. 1 to 8 geometric grey scale may be obtained from the Indian Standards Institution.

4.3 Source of Light — Natural and artificial.

NOTE — If natural light is used, care should be taken to avoid contamination of the anodized surface and of the standard pattern by atmospheric deposits, rain, dew or other agents that might influence the test by causing a chemical reaction on the samples and the standard patterns shall be covered with a single piece of glass sheet. If artificial light is used, the samples should be exposed at equal distance from the source of light around which they rotate, so as to neutralize any variation in distribution from the light source. Neither the standard pattern nor the test piece shall be allowed to attain a temperature exceeding 50°C during the test.

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*Method for determination of colour fastness of textile material to daylight.

4.4 Procedure — Place the cuttings of No. 1 to 8 standard patterns together with a test piece cut from the dyed aluminium to be tested the surrounding field being uniform grey of a brightness slightly less than the darkest member of the scale. Illuminate the surfaces with north sky light in the Northern Hemisphere, south sky light in the Southern Hemisphere, or equivalent source of illumination of 540 lux or more, the light being incident upon the surfaces at approximately 45° and the direction of viewing approximately perpendicular to the plane of the surfaces. Expose the samples for a sufficient time to produce a colour change equal to grade 3 on the geometric grey scale either on the test piece or No. 8 standard pattern, whichever takes place first.

4.5 Marking — The exposed surface of the test piece and of the standard patterns shall be half masked, with an opaque material during the test, to facilitate detection of fading.

4.6 Allocation of Light Fastness Number

4.6.1 After exposure, the test piece shall be compared in daylight with the standard patterns by visual inspection. The test piece shall then be allocated the light fastness number of the standard pattern that shows the same contrast as Grade 3 on the geometric grey scale.

4.6.1.1 If No. 8 standard pattern fades before there is any colour change in the sample, the sample should be allocated the light fastness No. 8.

NOTE 1 — There are certain dyestuffs used on anodized aluminium which show a slight change of colour after a short period of exposure to the test and which thereafter have a resistance to further fading marking their employment attractive in the anodizing field. The initial slight change of colour may involve darkening or a slightly bluer or more yellow. This type of change might not be objected to if the work to be dyed is to be uniformly exposed to light when in service.

NOTE 2 — It is recommended that such colours should be allocated two light fastness numbers. For example, Fig. 7 (2) would indicate that a slight change occurs after a period of exposure to light corresponding to No. 2 standard pattern, and thereafter the resistance to fading is equal to No. 7 standard pattern.

5. METHODS FOR TESTING SEALING

5.0 Four methods for testing sealing of anodic coatings have been prescribed. Sulphur dioxide method which ensures retention of good appearance of anodic coatings subject to external exposure, particularly in the more severe environments; marking resisting method for testing sealing of anodic coating in milder environments; sodium sulphite immersion test for routine control, by measurement of admittance or impedance suitable for use as a production control test and for use as an acceptance test when there is agreement between the manufacturer and the purchaser have been prescribed.

5.1 Sulphur Dioxide Method

5.1.1 *Temperature of Test* — The test is conducted at a temperature of 25°C ± 2°C. Precautions shall be taken against rapid temperature fluctuations in the course of a test.

5.1.2 *Attacking Medium* — The attacking medium is moist air of relative humidity less than 100 percent but not less than 95 percent containing 0·5 to 2·0 percent sulphur dioxide by volume.

5.1.3 *Duration of Test* — 24 hours.

5.1.4 *Procedure* — After degreasing by swabbing with a suitable organic solvent, the specimens are suspended in the attacking medium on non-metallic supports. The surfaces of the specimens shall not be less than 25 mm apart and not less than 25 mm from any wall of the cabinet. After removal, the specimens should be lightly rubbed with a soft damp cloth to remove superficial bloom.

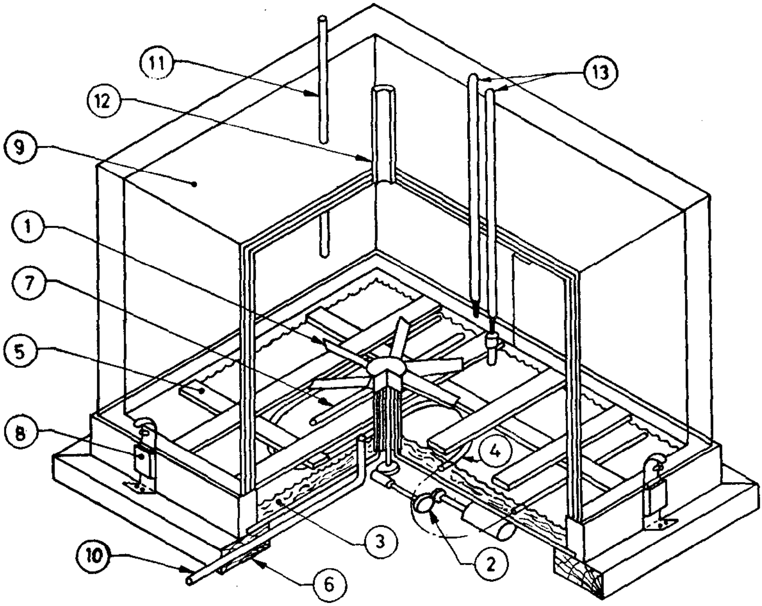
5.1.5 *Suggested Apparatus*

5.1.5.1 Apparatus which will give the required conditions is described under **5.1.5.2**, but cabinets of larger capacity or modified construction may be used, provided the test conditions to which the specimens are submitted are the same.

5.1.5.2 The cabinet is preferably made of a transparent plastics material, the greater part of the base of which forms a shallow tray container a layer of water 37 to 50 mm deep. Provision should be made for heating the water so as to control the cabinet temperature within the specified limits. A plastic fan revolving at about 150 revolutions per minute placed a few centimetres above the level of the water in the base is essential to circulate the atmosphere and maintain the required relative humidity. The remainder of the cabinet may be conveniently made as illustrated in Fig. 2. The cabinet should be shielded from draughts and local sources of heat.

5.1.5.3 A rigid support for the water reservoir of the wet bulb thermometer may be thought inconvenient, owing to the danger of its striking the test specimens as the cover is placed on the base. If preferred, the wick and small reservoir may be firmly attached to the thermometer bulb, with no other support so that they may be withdrawn together while the cover is being manipulated. It is essential, however, that the bulbs of thermometers be near the centre of the testing region while tests are in progress.

5.1.5.4 The specimens under test should be supported on a plastic stand inside the cabinet. The significant surfaces may be inclined at any angle, although it may be desirable to choose the same method of support for similar articles, and to position the parts in the cabinet as they would be in service. There should be a few centimetres of clear space between the water in the base and the bottom of the specimens. The stand may be made to rest directly on the base of the cabinet or on the strips protecting the heater.



1. Impeller
2. Geared drive from electric motor
3. Water (approx 50 mm deep)
4. Heater element in glass tube
5. Heater element protection strips
6. Wooden base
7. Thermostatic controller
8. Spring clip for cover 10 required
9. Double thickness transparent cover, outer 5 mm thick, inner 2·5 mm thick, 5 mm gap
10. Sulphur dioxide inlet tube
11. Sampling tube
12. Outlet tube
13. Wet and dry thermometers (humidity)

Internal dimensions:

Length = 750 mm
Width = 600 mm
Heigh (from protection strip) = 600 mm

FIG. 2 TEST CABINET FOR SULPHUR DIOXIDE

5.1.5.5 Since the volume of water in the reservoir is about 20 litres and the heater has a rating of only 200 W, the temperature of the water would be at least 20°C at the start of the test in order to avoid a long delay in attaining the specified temperature. The specimens should not be too cold when placed in the cabinet, or heavy condensation might take place in the early stages of the test.

5.1.5.6 Nothing is shown of the arrangement adopted for gauging the flow of sulphur dioxide into the cabinet. A sample capillary and 'U' tube flowmeter is satisfactory for this purpose, the sulphur dioxide being obtained from a siphon or cylinder. Sufficient sulphur dioxide should be passed in during the first 10 or 15 minutes of a test to raise the concentration to the value required, but the first determination should be delayed about an hour to allow equilibrium to be attained between dissolved and gaseous sulphur dioxide. The composition of the test atmosphere should be checked subsequently at intervals, but if the cabinet is reasonably leak-proof, the concentration of sulphur dioxide will often remain within the specified limits throughout a task without further additions being necessary.

5.1.5.7 To test the composition of the gas in the cabinet, the inlet side of an absorption tube of about 10 ml capacity is connected to the cabinet and the outlet side to the top of a 100-ml burette, filled with water and used as an aspirator. A quantity of 0·5 ml of 0·1 N iodine solution is placed in the absorption tube and distilled water added to fill the tube. A drop of starch solution is added. Gas from the cabinet is then drawn through the absorption tube by allowing water to run out of the burette at a suitable rate, and the volume required to decolourize the solution, making allowances for the capacity of that portion of the connection tube which contains no sulphur dioxide, is read off. The concentration C of sulphur dioxide in the corrosive atmosphere is given by the equation:

$$C = \frac{5\,600}{100\,v + 56} \text{ percent by volume}$$

Where v is the volume in ml of air collected in the burette. For the concentration specified it is sufficiently accurate to use the equation:

$$C = \frac{56}{v} \text{ percent by volume}$$

5.1.5.8 Since the air moves relatively slowly past the wet bulb, the difference in temperature between the two thermometers is only a rough guide to the relative humidity inside the cabinet. For comparative purposes, however, it is satisfactory in region of the specified testing conditions, to employ the relationship; relative humidity = (100 – 10 T) percent, where T is the difference in temperature in Celsius (centigrade) degrees between the dry and wet bulb thermometers.

5.1.5.9 On completion, the solution at the bottom of the cabinet is preferably run off through a drain hole into a solution of sodium hydroxide to absorb the sulphur dioxide and the gas in the cabinet is removed by drawing or blowing it out into a ventilation duct.

5.1.5.10 *Criterion for failure* — Bad sealing is revealed as a heavy white bloom in the coating and on the surface of the anodized test piece. Slight surface bloom may be neglected. Poorly sealed films may be completely removed.

5.2 Marking Test

5.2.1 *Reagents*

5.2.1.1 *Dye solution* — Dissolve one gram of anthraquinone violet R or corresponding dyestuff, listed below, in 50 ml of water:

Ahcoquinone violet B, BR
Alizarine violet A
Alizarine violet R, 3R, 4R
Anthraquinone violet
Anthraquinone violet (biological stain)
Anthraquinone violet D, 3RA
Anthraquinone violet RN, 3RN
Anthraquinone 3 R
Calcocid alizarine violet NC
Solway violet BN, BR
Tertracid light violet A
Tertrochrome violet A

5.2.2 *Procedure*

5.2.2.1 The test shall be made on an area of test piece the surface of which has not been contaminated by handling. Two separate drops of the dye solution shall be applied at room temperature to the anodized surface of the test piece and allowed to stand for five minutes. The test piece shall be rinsed in running water and the test area cleaned with cotton or a light abrasive (magnesia or pumice powder) and finally rinsed with water. After rinsing in water, the test piece shall be dried, without rubbing, by means of filter paper. The piece shall be deemed to have passed the test if no colour remains.

5.2.2.2 Where the anodized material has to be proof against staining by a specific solution, that solution shall be used as the test solution instead of or in addition to anthraquinone violet R, or corresponding dyestuff used.

5.3 Sodium Sulphite Immersion Test

5.3.1 *Test Solution* — Dissolve 10 g of anhydrous sodium sulphite per litre of water. Add glacial acetic acid to give a *p*H of 3·5 to 4·0 followed by dilute sulphuric acid (5 N) to give a *p*H of 2·5 to 3·0 at room temperature. The test solution shall be prepared afresh for each test.

5.3.2 *Procedure* — Dry the surface by rubbing with dry cloth. In case the surface is greasy, clean it with a suitable organic solvent. Immerse the specimen in dilute nitric acid (50 percent by volume) for 10 minutes. Rinse thoroughly in running water and then in distilled and deionized water, dry and weigh (M_1). Immerse the specimen for 20 minutes in the test solution at 90° to 92°C. Rinse thoroughly in distilled or deionized water, dry and re-weigh (M_2). The sample shall be deemed to have passed the test, if the weight loss ($M_1 - M_2$) does not exceed 0·2 mg/cm^2 of anodized surface.

5.3.3 *Maintenance of Bath* — Unless very large parts are to be tested, the bath should be made up afresh for each test.

5.4 Admittance or Impedance Test

5.4.1 *Definitions*

5.4.1.1 The admittance Y is the inverse of the complex apparent resistance Z (impedance) which, in an alternating current circuit, is represented by the vectoril sum of the actual resistance R and the reactants X_c.

$$Y = \frac{1}{Z} \qquad \ldots(1)$$

$$|Z| = \sqrt{X_c^2 + R^2} \qquad \ldots(2)$$

where

R = resistence, in ohms;

$X_c = \frac{1}{2\pi fC}$ is the reactance;

f = frequency of the alternating current; and

C = capacitance;

5.4.2 *Principal of the method*

5.4.2.1 An anodic oxide coating on aluminium may be represented as an electrical diagram made up of a certain number of ohmic and capacity resistances mounted in series and/or parallel in an alternating current circuit. The numerical value of these resistances depends on the following variables:

a) basis metal (for example, composition, size and distribution of intermettallic compounds, and surface condition);

b) type of sealing process (for example steam, hot water, nickel or cobalt salts);

c) thickness and density of anodic oxide layer (depending upon electrolyte, type of current, current density, electrolyte temperature, etc);

d) dyeing or pigmentation processes used to colour the anodic oxide coating; and

e) time and conditions of storage between sealing and measurement.

5.4.3 *Apparatus*

5.4.3.1 Device for measuring admittance over a range of 3 to 300 μS or impedance in the range of 3 to 3 000 kΩ with sufficient precision. Both instruments should measure at a frequency of 1 kHz and be equipped with two electrodes, one of which makes contact with the basis metal of the sample, and the other being a pencil like probe in the electrolyte.

5.4.4 *Cell Containing the Electrolyte*

5.4.4.1 *For admittance test* — It is suitably formed by a rubber ring of 13 mm internal diameter and about 5 mm thickness, the surface of which is self adhesive. This type of cell has an internal area of 133 mm^2.

5.4.4.2 *For impedance test* — It is suitably formed by a glass tube 9 mm in outside diameter by 9 cm, with rubber gasket for ensuring sealing on test sample. This type of cell has an internal area of 12·9 mm^2.

5.4.4.3 *Electrolyte* — In the form of an aqueous 35 g/l solution of potassium sulphate or sodium chloride.

5.5 Test Sample

5.5.1 All anodized products, whatever their shape and dimensions, may be tested provided that it is possible at the point of measurement to determine the thickness of the oxide layer, to apply the electrolyte-filled cell to it and, if necessary, to determine the surface area of the measurement.

5.6 Test Procedure

5.6.1 The test should be carried out preferably within 1 to 4 h after sealing and cooling to room temperature, and in any case within 48 h.

5.6.2 Degrease the test area of the test sample using a suitable organic solvent. If a silicone, wax preservative or lacquer has been applied after sealing, such degreasing may not be adequate. Satisfactory cleaning may be achieved by first using an organic solvent followed by rubbing with a paste or magnesium oxide or pumice powder and water until no water break occurs.

5.6.3 Screw one electrode into the sample so that it makes good electrical contact with the basis metal. Carefully fix the cell on the test area. If the area of the cell is modified by the geometric shape of the test sample, it is necessary to determine the new dimensions. Fill the cell with the electrolyte (**5.4.4.3**). At each point of measurement, use a new sealing ring and fresh solution. If the test is to be carried out on an oblique or vertical surface, it is necessary to introduce into the cell a cotton wool plug soaked in the electrolyte; alternatively, a cell of special design may be used.

5.6.4 Immerse the other electrode in the solution and measure the admittance or impedance. Choose the range of measurement, as far as possible, so that the pointer is situated in the upper one third of the scale.

5.6.5 Carry out the measurement at a temperature between 10 and 35°C. Take the reading at least 2 min after the introduction of the electrode into the cell. If at the end of these 2 min the reading continues to increase in the case of admittance, or decrease in the case of impedance, take a final reading after a further 3 min.

5.6.6 After the admittance or impedance has been measured determine the thickness of the oxide layer at the point of measurement.

NOTE — Cells which are not perfectly attached and therefore not water-tight give an inaccurate reading.

5.7 Expression of Results

5.7.1 In order to allow comparison of measured values, the value to be retained shall be the result of three conversions of the measured value:

a) Conversion required to relate the measured value to a measuring area of 133 mm^2 (in the case where it is not possible to use this area and if the actual measuring area is between 10 and 50 mm^2 for the measurement of impedanee and between 100 and 200 for the measurement of admittance).

b) Conversion required according to the ambient temperature in °C.

c) Conversion required to relate the measured admittance or impedance to a conventional layer thickness of 20 μm.

5.7.2 These three conversions are carried out by means of the following formulae:

Admittance

i) $Y_1 = Y_m \times \frac{133}{A}$

ii) $Y_2 = Y_1 \times f_1$

iii) $Y_3 = Y_2 \times \frac{e-3}{17}$

Impedance

i) $Z_1 = Z_m \times \frac{A}{133}$

ii) $Z_2 = Z_1 \times f_2$

iii) $Z_3 = Z_2 \times \frac{17}{e-3}$

where

Y_m = measured admittance value, in microsiemens;
Z_m = measured impedance value, in kilohms;
A = actual measuring area, in mm²;
Y_3 = corrected admittance value;
Z_3 = corrected impedance value;
e = thickness of the layer, in micrometres; and
f_1 and f_2 = coefficients depending upon the temperature (T°C) as shown in Fig. 3.

NOTE — This test is intended for quick non-destructive assessment of quality of sealing of anodic film. This method is suitable for production control and also as an acceptance test when this is an agreement between the purchaser and anodizer. The test has, however, the limitation that it is possible to perform, if there is sufficient area (a circle of about 20 mm diameter) and the film thickness is higher than 3/µm.

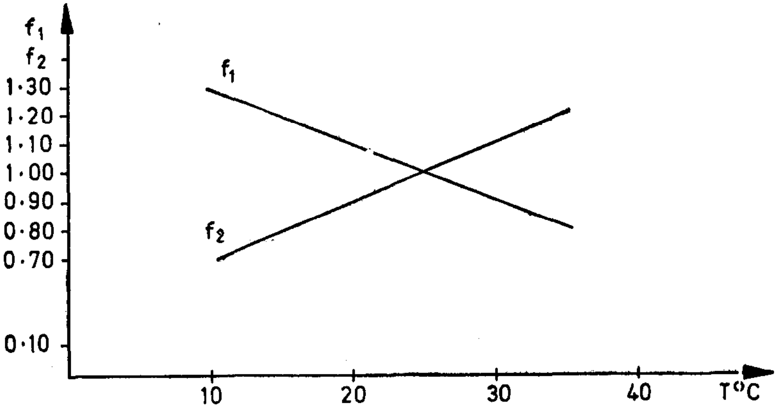


FIG. 3 VARIATION OF COEFFICIENTS f_1 AND f_2 AS A FUNCTION OF TEMPERATURE (IN °C)

INDIAN STANDARDS

ON

METALLIC FINISHES

IS:

Electroplating

1068-1968	Electroplated coatings of nickel and chromium on iron and steel (*first revision*)
1337-1980	Electroplated coatings of hard chromium on iron and steel (*second revision*)
1359-1977	Electroplated coatings of tin (*second revision*)
1378-1979	Oxidized copper finishes (*second revision*)
1572-1968	Electroplated coatings of cadmium on iron and steel (*first revision*)
1573-1970	Electroplated coatings of zinc on iron and steel (*first revision*)
1772-1972	Electroplated coatings of copper (*first revision*)
1773-1982	Brass plating (*first revicion*)
1992-1979	Electroplated coatings of lead (*first revision*)
4827-1968	Electroplated coatings of nickel and chromium on copper and copper alloys
4828-1968	Electroplated coatings of nickel and chromium on aluminium and aluminium alloys
4942-1968	Electroplated coatings of nickel and chromium on zinc and zinc alloys
8376-1977	Electroplated coatings of nickel and chromium on plastics for decorative purposes
9839-1981	Chromate conversion coatings on electroplated zinc and cadmium coatings
10209-1982	Electroplated coatings of tin-lead alloy (solder)

Precious Metals

1067-1981	Electroplated coatings of silver for decorative and protective purposes (*first revision*)
1771-1970	Electroplated coatings of silver for general engineering purposes (*first revision*)
3226-1982	Electroplated coatings of gold for general engineering purposes (*first revision*)
4252-1982	Electroplated coatings of gold for decorative purposes (*first revision*)

Anodic Coatings

1868-1968	Anodic coatings on aluminium (*first revision*)
6057-1970	Hard anodic coatings on aluminium
6651-1972	Anodized aluminium for automobile use
8375-1977	Test for checking continuity of anodic coatings

Sprayed Coatings

5905-1970	Sprayed aluminium and zinc coating on iron and steel

Anodes

1958-1967	Fabricated nickel anodes for electroplating (*first revision*)
1959-1961	Silver anodes for electroplating
2384-1963	Tin anodes for electroplating
2601-1964	Brass anodes for electroplating
2602-1964	Cadmium anodes for electroplating
2603-1964	Copper anodes for electroplating
2604-1979	Lead anodes for electroplating (*first revision*)
2605-1964	Zinc anodes for electroplating
2606-1979	Alloy lead anodes for chromium plating (*first revision*)

IS:

Code of Practice

1340-1977	Code of practice for chromate conversion coating on zinc and cadmium coated articles and zinc base alloys (*first revision*)
1985-1980	Recommended practice for preparation of iron and steel for electroplating:
	Part I High carbon steel (*first revision*)
	Part II Low carbon steel (*first revision*)
	Part III Iron castings (*first revision*)
1986-1981	Code of practice for hard chromium plating on iron and steel for general engineering purposes (*first revision*)
2450-1963	Recommended practice for plating on aluminium and its alloys
3194-1980	Recommended practice for cleaning of metals prior to electroplating (*first revision*)
3655-1966	Recommended practice for electroplating
3656-1968	Code of recommended practice for mechanical polishing
5925-1970	Recommended practice for silver plating for general engineering purposes
6586-1972	Recommended practice for metal spraying for protection of iron and steel
7088-1973	Recommended practice for anodizing of aluminium and its alloys
9531-1980	Recommended practice for preparation of copper and copper base alloys for electroplating
10173-1982	Recommended practice for preparation of zinc alloy dies castings for electroplating

Methods of Test

3203-1982	Methods of testing local thickness of electroplated coatings (*first revision*)
5523-1968	Methods of testing anodic coatings on aluminium
5528-1968	Methods of testing corrosion resistance of electroplated and anodized coatings by copper accelerated acetic acid salt spray (CASS) test
6002-1970	Method for evaluation of results of accelerated corrosion tests
6910-1973	Method of testing corrosion resistance of electroplated and anodized coatings by acetic acid salt spray
6012-1970	Method of measurement of coating thickness by eddy current
8038-1976	Corrosion resistance of nickel-chromium plating by the corrodkote test
8435-1977	Method for measurement of metallic coatings on plastics
8436-1977	Method for thermal cycling test for evaluation of electroplated plastics
8554-1977	Method of checking insulation of anodized coating by measurement of break-down potential
8602-1977	Method of testing chromate coatings on zinc and cadmium surface
9530-1980	Method of testing microhardness of electroplated coating
9838-1981	Method for the determination of coating mass per unit area of conversion coatings on metallic material by gravimetric method
9844-1981	Method of testing corrosion resistance of electroplated and anodized aluminium coatings by neutral salt spray test

Miscellaneous

2679-1964	Recommendations for equipment for electroplating
3554-1966	Glossary of terms relating to electroplating

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	$1 \text{ N} = 1 \text{ kg.m/s}^2$
Energy	joule	J	$1 \text{ J} = 1 \text{ N.m}$
Power	watt	W	$1 \text{ W} = 1 \text{ J/s}$
Flux	weber	Wb	$1 \text{ Wb} = 1 \text{ V.s}$
Flux density	tesla	T	$1 \text{ T} = 1 \text{ Wb/m}^2$
Frequency	hertz	Hz	$1 \text{ Hz} = 1 \text{ c/s } (\text{s}^{-1})$
Electric conductance	siemens	S	$1 \text{ S} = 1 \text{ A/V}$
Electromotive force	volt	V	$1 \text{ V} = 1 \text{ W/A}$
Pressure, stress	pascal	Pa	$1 \text{ Pa} = 1 \text{ N/m}^2$

AMENDMENT NO. 1 APRIL 1995
TO
IS 5523 : 1983 METHODS OF TESTING ANODIC COATINGS ON ALUMINIUM AND ITS ALLOYS

(*First Revision*)

(*Page* 4, *clause* **2.1**) — Substitute the following for the existing clause:

'**2.1** Thickness of anodic coatings shall be measured by the microsection, stripping methods or with the help of Eddy current. The former is suitable for Grade AC 15 and thicker coatings and stripping method is suitable for Grade AC 10 and thinner coatings. The Eddy current method is suitable for any thickness from 3 to 150 microns.'

(*Page* 6, *clause* **2.3.6**) — Add the following after this clause:

"**2.4 Eddy Current Method**

2.4.1 Eddy current test instruments which employ a probe coil carrying a radio frequency alternating current may be used. This probe is placed close to the surface of the test specimen and the electromagnetic field of the coil induces an Eddy current in the specimen by virtue of the skin effect, the Eddy current is confined to surface layer. The frequency is so chosen that the Eddy current varies with the thickness of coating, if the coating and the base metal differ appreciably in conductivity or in magnetic properties.

2.4.2 Eddy current test instruments be used to measure single layers of non-conducting coating on aluminium. Since the method depends on the conductivity of the anodic coating, it will give accurate results only if the coating to be measured has a uniform known conductivity.

2.4.3 The method of measurement of coating thickness by Eddy current shall be as given in IS 6012 : 1992 'Measurement of coating thickness by Eddy current method (*first revision*)'."

(*Page* 9, *clause* **5.0**) — Add the following 'Note' below this clause:

'NOTE — In case of sulphur dioxide method and sodium sulphite immersion test, the test specimen shall be masked at the bare edges with suitable material such as stop-off lacquer.'

(*Page* 14, *clause* 5.3.2, *lines* 1 *to* 3) — Substitute the following for the existing:

'The surface area to be tested is degreased with a suitable solvent. A few drops of 50 percent (*v*/*v*) nitric acid is placed on the test area for 10 minutes. The test area is rinsed well and dried.'

(MTD 20)

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